SPC Technical Studies - Table of Contents

Technical Study 1

Assessment of the vulnerability of Pacific Island communities and economies to the effects of climate change on fisheries

Prepared by the Pacific Community (SPC) in support of the Feasibility Study for the Funding Proposal for the regional GCF Programme entitled "Adapting tuna-dependent Pacific Island communities and economies to climate change"

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Acknowledgements

This study was compiled based on commissioned analyses. Information on the projected effects of climate change on coastal fisheries production and the gaps in fish supply needed for good nutrition of the populations in the 14 Pacific Island countries participating in the regional GCF Programme by 2030 under the high emissions scenario (SSP5-8.5) was contributed by staff from SPC and Conservation International, based on SPC's 2011 assessment of the vulnerability of tropical Pacific fisheries and aquaculture to climate change https://coastfish.spc.int/component/content/article/412-vulnerability-of-tropical-pacifc-fisheries-and-aquaculture-to-climate-change.html (for the reasons explained in Section 1.1).

Information on the projected effects of climate change on coastal fisheries production and the gaps in fish supply by 2050 under both the moderate (SSP2-4.5) and the high (SSP5-8.5) emissions scenarios based on the latest available modelling was contributed by a team of experts assembled by 'Pacific Coasts I Climate I Oceans (C_2O)'. This team was comprised of Johanna Johnson, David Welch, Kerrie Youngs, Britt Basel, Dieter Tracey, Katie Sambrook, Elizabeth Fulton, Julia Blanchard, Bradley Moore, Denisse Fierro-Arcos, Jessica Zamborain-Mason, Andrew Halford and Bianca Molinari.

Information on the projected effects of moderate and high emissions scenarios on the distribution of the tropical Pacific tuna resources that underpin the economies of nine of the 14 countries participating countries, and deliver a range of socio-economic benefits to the other five countries, was contributed by staff members from SPC and experts from SPC's partner organisations. This team was comprised of Patrick Lehodey, Inna Senina, Simon Nicol, Johann Bell, Beatriz Calmettes, Romain Forestier, Thomas Gorgues, Christophe Menkes, John Hampton, Matthieu Lengaigne, Alex Sen Gupta and Peter Williams. The information in this section draws extensively on the on the paper published in Nature Sustainability entitled 'Pathways to sustaining tuna-dependent Pacific Island economies during climate change' by Bell et al. (2021) and the book chapter by Lehodey et al. (in press) 'Implications of climate change for oceanic fisheries in the tropical Pacific Islands region' within SPC's updated climate change vulnerability assessment entitled 'Climate change implications for fisheries and aquaculture in the Pacific Islands region' to be published in 2025.

Executive Summary

Fisheries have long played a significant role in sustaining both communities and economies throughout the Pacific Islands region (Gillett, 2002, 2007, 2016; Gillett and Fong 2023; Dalzell et al. 1996). Coastal fisheries have traditionally been a cornerstone of food security (SPC 2008; Bell et al. 2009) and underpin livelihoods by providing significant local cash flow (Gillett and Tauati 2018). The economic development of many Pacific Island countries depends heavily on access fees paid by industrial fishing fleets to catch tuna within their exclusive economic zones (EEZs) (SPC 2019; Bell et al. 2021; Ruaia et al. 2022).

The declines in coastal fisheries resources due to a range of factors are of significant concern to Pacific Island countries participating in this regional GCF Programme focused on tuna (hereafter 'Programme'). To address these challenges, the region has developed two important strategies: the *Regional Roadmap for Sustainable Pacific Fisheries* (FFA and SPC 2015) and the *New Song for Coastal Fisheries* (SPC 2015). It is widely recognised that these strategies need to be updated, in part to be better informed by climate change because ocean warming and acidification pose a threat to the fish species associated coastal habitats, particularly coral reefs, which have traditionally provided the majority of fish consumed by Pacific Island communities (Pratchett et al. 2011; IPCC 2018; Bell et al. 2018a,b).

In addition, the numerous tuna-dependent Pacific Island economies are increasingly concerned about the projected effects of climate-driven tuna redistribution on their essential government revenue (Bell et al. 2021). The reason for this concern is that even though they have developed a world-leading co-operative fisheries management scheme to sustain their tuna resources, known as the 'Vessel Day Scheme' (Aqorau et al. 2018; Clarke et al. 2021), which is responsive to the effects of climatic variability (El Niño Southern Oscillation) on the access fees they receive from industrial fishing fleets, ocean warming is expected to progressively drive tuna from their jurisdictions (EEZs) into the high seas.

The purpose of GCF Technical Study 1 is to update the components of SPC's initial assessment of the vulnerability of Pacific Island communities and economies[1] related to projected alterations in the productivity of coastal fisheries, and redistribution of the region's rich tuna resources, due to climate change. This updated vulnerability assessment is organised to correspond with the two main components of the Funding Proposal for the regional GCF Programme: Component A 'Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change'; and Component B 'Adaptations to reduce risks to Pacific Island economies from climate-driven tuna redistribution'.

Vulnerability of communities to gaps in coastal fisheries production

The literature cited in this Study demonstrates how climate variability and climate change regularly disrupt the productivity of coastal fisheries in the Pacific Islands region, and the potential implications for Pacific Island communities that depend on these resources for food and livelihoods.

By 2030 under a continued high (SSP5-4.5) greenhouse gas (GHG) emissions scenario, this Study concludes that eight of the participating countries fall into the category where coastal fisheries production will not have the capacity to provide the fish needed for good nutrition of the national

[1] https://coastfish.spc.int/component/content/article/412-vulnerability-of-tropical-pacifc-fisheries-and-aquaculture-to-climate-change.html

population due to the indirect and direct effects of climate change. The remaining six countries have a surplus of fish capable of providing the recommended protein intake in principle but in all cases these countries face severe problems in economically distributing enough of the coastal fisheries catch to meet dietary requirements in areas with relatively high population density. In such locations, increasing access to tuna through the use of nearshore fish aggregating devices (FADs) (Technical Study 3)[2], and improving the supply of bycatch from industrial fishing operations in those countries where tuna catches are transhipped or landed (Technical Study 5)[3], is needed to increase the availability of fish for domestic consumption.

The combined indirect and direct impacts of GHG emissions increase considerably by 2050 under both moderate (SSP2-4.5) and high (SSP5-8.5) scenarios. However, the modelling done to identify these impacts also shows that there will be substantial spatial and temporal variability across the Pacific Island region by 2050 due largely to variation in future percentage change in fish availability and population growth among countries. In the case of several countries, it is also evident that the influence of population growth on future availability of fish per person is greater than the effects of climate change.

Ultimately, the contribution of coastal fisheries production to food security will depend on how accessible the available fish is to the population, which will be determined by the distribution and density of population and the geographic characteristics of the country, including the locations of coral reefs. It is expected that many of the participating countries will face a major challenge to maintain the traditional levels of per capita fish consumption by 2050 under both SSP2-4.5 and SSP5-8.5 due to these factors. This is even the case in those countries with large areas of coral reef relative to the national population, where a high proportion of the population live in urban areas and it is uneconomical to transport fish from remote coral reef to the urban communities.

Key recommended adaptations to be implemented during the regional GCF Programme to help fill the gap in fish supply centre around increasing access to tuna to supply the protein needed for national food security. These adaptations are summarised below.

- Facilitation of improved preparedness of countries to cope with the likelihood of significant inter-annual variability and long-term declines in coastal fisheries biomass and catches, and compounding impacts from episodic events, such as marine heat waves. Specific adaptations to reduce such impacts include:
    - Expansion of the use of nearshore FADs to diversify catches of coastal small-scale fishers to include greater proportions of tuna and other nearshore pelagic fish, and to divert fishing effort from coastal habitats to reduce pressure on vulnerable coastal fish stocks.
    - Improved post-harvest methods that prolong the shelf-life of tuna and other pelagic fish (e.g., preservation methods using smoke curing, salting and drying).
    - Exploration of the potential for alternative fisheries that could be sustainably harvested, such as small fish pelagic species (e.g., mackerel, anchovies, pilchards, sardines, flying fish, scads, fusiliers), and squid, including fishing for some of these species when they associate with FADs.

[2] Technical Study 3 https://fame1.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme
[3] Technical Study 5 https://fame1.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

- Continued investment in the development and implementation of standardized data collection systems and tools appropriate for measuring the catches of coastal fish species in the Pacific context, e.g., IKASAVEA[4], including for use in monitoring catches made around FADs.

- Active education and awareness-raising among government authorities and communities about (i) the role of coastal habitats in sustaining healthy fisheries resources, and the interconnectivity of habitats; (ii) the consequences of poor land use and fishing practices on coastal habitats and fish stocks; and (iii) the expected further impacts of climate change of coastal fisheries production and the need to rely on replacing much of the previous coastal fish catch with tuna and other nearshore pelagic fish to maintain the traditional benefits of fish for good nutrition. Importantly, the increased engagement with communities should ensure approaches are appropriate to the national context and be locally led and understood.

Vulnerability of economies to climate-driven tuna redistribution

The likely responses of the tuna resources that support Pacific Island economies to climate change has been evaluated during two recent studies (Bell et al. 2021 and Lehodey et al. in press). These outcomes of these studies have been used to the assess the vulnerability of tuna dependent Pacific Island economies to increased GHG emissions. In both of these studies, the Spatial Ecosystem and Populations Dynamics Model' (SEAPODYM) (Lehodey et al. 2008) was used to assess how high, RCP8.5 (SSP5-8.5 equivalent), and moderate, RCP4.5 (SSP2-4.5 equivalent), emissions scenarios are likely to affect the biomass of 1) the three tropical tuna species (skipjack, yellowfin and bigeye tuna) caught by purse-seine fishing that underpin economies in nine Pacific Island countries[5]; and 2) South Pacific albacore targeted by longline fishing in the EEZs of five subtropical Pacific Island countries[6].

The SEAPODYM simulations indicated that the total biomass of the three tuna species caught by purse-seine in the EEZs of the nine tuna-dependent Pacific Island countries would decrease by an average of ~13% (range = -5% to -20%), and increase by an average of ~23% (range = 13% to 32%) in the central part of the eastern Pacific Ocean (EPO), by 2050 under RCP8.5. Redistribution of the biomass of these species was far less pronounced under RCP4.5, decreasing by only an average of 1% (range = -9% to +8%) in the combined EEZs but also increasing substantially, by an average of ~18% (range = +9% to +32%), in the central EPO by 2050.

The modelling for South Pacific albacore has been limited to the RCP8.5 to date. Under this scenario, the projected average changes in biomass had some similarities to the projections for the other three tuna species, i.e., biomass is expected to decrease in the EEZs of four of the five Pacific Island countries in the subtropical Pacific and increase in the EPO by 2050.

The projected changes in total biomass of skipjack, yellowfin and bigeye tuna due to RCP8.5 are expected to result in an average 20% decrease (range = -30% to -10%) in total purse-seine catch from the combined EEZs of the nine tuna-dependent countries by 2050, and an average 27% increase (range = +15% to +37%) in the central EPO. Under RCP4.5, purse-seine catch from the combined EEZs of the tuna-dependent countries is expected to decrease by an average of 3% (range = -12% to +9%), and increase in the central EPO by an average of 18% (range = +7% to +34%).

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[4] https://fame.spc.int/resources/tools/ikasavea

[5] Cook Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu.

[6] Fiji, Niue, Samoa, Tonga and Vanuatu.

The average estimated changes in purse-seine catch under RCP8.5 could reduce total annual fishing access fees earned by the tuna-dependent economies by an average of USD 90 million per year (range = USD 40-140 million) by 2050. Losses in access fees are estimated to occur in all countries under RCP8.5, and reduce total government revenue by up to 13% (range = -8% to -18%) for individual countries, by 2050. Under RCP4.5, the average change in access fees for all tuna-dependent economies represents a loss of USD 12 million (range = -USD 54 million to +USD 48 million) per year by 2050. Due to the more limited loss of access fees under RCP4.5, total government revenue in 2050 is estimated to decrease by an average of 1% or less in only three of the countries by 2050.

The projected climate-driven redistribution of tuna biomass also poses potential risks for sustainable management of the world's largest tuna fishery because the monitoring, control and surveillance systems required to combat illegal, unreported and unregulated fishing, and impose penalties for non-compliance, are more difficult to implement in high-seas areas than within EEZs under the purview of coastal states. With continued GHG emissions, the onus will be on the Western and Central Pacific Fisheries Commission (WCPFC) to exert tighter controls on fishing for the four tuna species by all vessels operating within its Convention Area.

Sustainable management of tropical Pacific tuna resources will also be challenged by the substantial projected increases in average tuna biomass in the EPO high-seas area, particularly under RCP8.5. This will necessitate closer collaboration between WCPFC and the Inter-American Tropical Tuna Commission (IATTC) to address three priority issues: 1) development of a formal mechanism for cooperation to enable effective and efficient joint decision-making and action by the two regional fisheries management organisations; 2) further cooperative scientific research and modelling to better understand how the shared tuna stocks will respond to climate change, and to inform stock assessments and harvest strategies; and 3) definition of appropriate limits on fishing for each stock in a way that ensures they are compatible across the two organisations.

It is important to note that the projections summarised above need to be regarded as preliminary due to the considerable uncertainties still associated with the SEAPODYM. Improvements need to be made to the modelling to reduce these uncertainties and develop an 'Advanced warning system' (AWS) that Pacific Island countries can use with confidence to design policies and adaptations that build climate resilience into their tuna fisheries and economies. These improvements fall into four main categories: 1) operational oceanography for regional-scale application in the Pacific to inform SEAPODYM; 2) higher spatial and temporal resolution forecasts and projections of tuna biomass; 3) fleet dynamics and economic models to provide short-, medium- and long-term policy evaluation and adaptation formulation; and 4) observational data to validate EEZ-scale outputs of SEAPODYM and the fleet dynamics and economic models.

These improvements are expected to enable the spatial resolution of SEAPDOYM simulations to be increased from 2° x 2° to at least 1° x 1°, and forecasts to be available on a scale of 0.5 to 10-years, allowing economists to develop sophisticated fleet dynamics models that predict near-term changes in fishing effort and catch within and among EEZs. In turn, such predictions will enable countries to understand the attractiveness of their EEZs to industry with much greater certainty, and to adjust access fees accordingly.

The improvements to be made through developing the recommended AWS will also provide much greater certainty about the extent to which tuna biomass and fishing effort are likely to be redistributed from the combined EEZs of the tuna-dependent economies to high-seas areas, where the countries do not yet have much control of fishing operations. This information will be vital to developing the adaptations that the tuna-dependent countries will need to retain the present-day benefits they receive from their tuna resources, regardless of the effects of climate change on the distribution of the fish. Such adaptations will need to centre around the international negotiations required to raise awareness of the vital importance of tuna to the economies of Pacific Island countries and the need to find equitable solutions to the problems that climate-driven tuna redistribution will cause.

Comprehensive collection of tissue samples from tuna species during development of the AWS will also help address key questions about the extent and nature of the spatial population structure of each tuna species. Where strong spatial structuring exists, the improved SEAPODYM modelling approach could then be applied to each stock and, if multiple stocks occur in countries with large EEZs, the accuracy of projected changes in biomass within the EEZ will be improved by integrating the results from the simulations for each stock. Such information will also cast new light on the extent to which discrete tuna stocks may be shared by WCPFC and IATTC, empowering the two RFMOs to manage shared tuna resources more effectively.

1. Introduction

1.1 Purpose and approach

The purpose of GCF Technical Study 1 is to update the components of SPC's initial assessment of the vulnerability of Pacific Island communities and economies to climate change[7] related to projected alterations in the productivity of coastal fisheries, and redistribution of the region's rich tuna resources, due to climate change (as described in the Terms of Reference for the Study in the GCF Project Preparation Facility application in Appendix A).

This updated vulnerability assessment is organised to correspond with the two main components of the GCF Funding Proposal: Component A 'Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change'; and Component B 'Adaptations to reduce risks to Pacific Island economies from climate-driven tuna redistribution'.

The assessment for Component A focuses on the vulnerability of coastal communities in the 14 countries participating in the GCF Regional Tuna Programme (hereafter 'Programme) to food insecurity due to the combined effects of population growth and climate-driven decreases in productivity of coastal fisheries, given their traditional dependence on fish for dietary protein (SPC 2008, Bell et al. 2009, Gillett and Fong 2023, Sharp and Andrew 2024). The vulnerability of coastal communities is assessed by comparing future projected availability of fish[8] due to climate change with the fish needed to supply the basic protein requirements for good nutrition per capita identified in Technical Study 2[9].

The vulnerability assessment for Component B focuses on the projected effects of climate change on the distributions of the tropical tuna species (skipjack, yellowfin and bigeye tuna and South Pacific albacore) that underpin the economies of nine of the 14 participating countries (Ruaia et al. 2022). Although the assessment for Component B needs to be regarded as preliminary due to the considerable uncertainties still associated with the best currently available modelling framework, it identifies the potential for changes in the distribution of tropical tuna resources to reduce government revenue for the tuna-dependent countries (SPC 2019, Bell et al. 2021).

In Component A, vulnerability of coastal communities linked the availability of fish per capita due to climate change is assessed for two different periods – 2030 and 2050 – and in two different ways. Assessment of coastal fisheries production in 2030 is limited to a high emissions scenario (SSP5-8.5 equivalent) based on expert opinion, whereas modelling is used to make assessments of vulnerability for the SSP2-4.5 and SSP5-8.5 emissions scenarios in 2050. The reason for relying on expert opinion for the 2030 assessment for Component A, rather than modelling, is that any modelled changes by 2030 relative to the most recent baseline for coastal fisheries production, i.e., 2021 in Gillett and Fong (2023), are very likely to fall within the variability for the historical period, resulting in little or no change in mean state estimated by the simulated projections. The assessment for 2030 in Component A is included to provide the framework for assessing the adaptations designed to increase tuna for local consumption towards the end of the implementation period for the Programme. Although the projected effects on coastal fisheries production by 2030 are modest, the more rigorous analyses for SSP2-4.5 and SSP5-8.5 in 2050 clearly show the impending effect of climate change on the traditionally important contribution of coastal fisheries production to dietary protein requirements, and the need for immediate investments to

7 https://coastfish.spc.int/component/content/article/412-vulnerability-of-tropical-pacifc-fisheries-and-aquaculture-to-climate-change.html

8 'Fish' in this context is comprised of demersal and nearshore pelagic species, and invertebrates, as described by Pratchett et al. (2011).

9 Technical Study 2 https://fame1.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

increase access to tuna for domestic consumption to maximise the food security benefits of this resource in the near future.

For Component B, the 'Spatial ecosystem and populations dynamics model' (SEAPODYM) (Lehodey et al. 2008) is used to assess the effects of climate change on the distribution of the tropical tuna species under the SSP2-4.5 and SSP5-8.5 emissions scenarios for 2050.

1.2 Structure

This Study is comprised of another eight sections spread across Components A and B. Within Component A, Section 2 provides a brief background to the nature of coastal fisheries in the Pacific Island region, the habitats that support them, the key threats to the coastal fish habitats and stocks, and the role that coastal fisheries have traditionally played in food security to set the stage for vulnerability assessments in 2030 and 2050. Section 3 summarises the methods used to assess the vulnerability of coastal fisheries production to climate change and the gaps in fish supply for all participating countries under SSP5-8.5 in 2030 and under SSP2-4.5 and SSP5-8.5 in 2050, providing the rationale for Component A of the GCF Programme. Section 4 describes the results of the vulnerability assessments for climate-driven changes in coastal fisheries production in 2030 and 2050, and assesses the vulnerability of coastal communities in terms of gaps in fish supply needed for good nutrition expected to occur in all participating countries by 2030 and 2050. Component A concludes with an overview and recommendations (Section 5), and the list of supporting references.

For Component B, Section 6 provides a brief background to the nature of oceanic fisheries in the Pacific Island region, which are dominated by the catches of tropical tuna species, and the importance of catches made by industrial fishing fleets to the economies of nine of the 14 participating countries. Section 7 summarises the methods used to assess the effects of climate change on the distributions of the tropical tuna species to date under SSP2-4.5 and SSP5-8.5 equivalent emissions scenarios by 2050. Section 8 provides the results of the assessments and the steps needed to reduce uncertainty in the current modelling to provide the rationale for Component B of the GCF Programme. Component B concludes with an overview and recommendations (Section 9), and the list of supporting references.

Appendices with additional information related to Component A (Appendices A–E) and Component B (Appendix F) are provided at the end of the document.

2. Background to importance of coastal fisheries to participating countries

2.1 The role of coastal fisheries

Fisheries have long played a significant role in sustaining both communities and economies throughout the Pacific Islands region (Gillett, 2002, 2007, 2016; Gillett and Fong 2023, Dalzell et al. 1996). Coastal fisheries have traditionally been a cornerstone of food security (SPC 2008; Bell et al. 2009) and underpin many livelihoods by providing significant local cash flow (Gillett and Tauati 2018).

Coastal fishing is generally conducted in habitats adjacent to land masses (e.g., coral reefs and associated habitats), using a variety of fishing methods and accessed either by land or using small local vessels (Dalzell et al. 1996, Pratchett et al. 2011). Over 500 different species are targeted across the region (Preston 2005), comprising demersal reef fish, nearshore pelagic species, and invertebrates. Although the catch quantities and value derived from oceanic fisheries in the region dwarfs coastal fisheries production, the cultural, nutritional, and socio-economic importance of coastal fishery resources to Pacific Island communities at the local scale is immeasurable (Preston 2005; Gillett and Tauati 2018). Nutritionally, it is reported that coastal marine resources provide 50-90% of animal protein for Pacific

Islanders (Bell et al. 2009, 2018a; Johnson et al. 2017; Gillett and Tauati 2018;), as well as other key macro- (e.g., fatty acids) and micro-nutrients (e.g., minerals and vitamins (Viana et al. 2023).

Recent estimates (Gillett and Fong 2023) indicate fish consumption across PICTs averages between 38 and 78 kg per person per year (i.e., more than 2 to 4 times average global fish consumption). However, there can be large variations in fish consumption, exceeding >100 kg per person per year for communities on smaller atolls (e.g., in Kiribati), and with lower consumption in some of the larger countries with significant inland populations, such as PNG, where national per capita consumption is on par with average global levels at ~15 kg per year (Sarkodie and Owusu 2023).

This socio-economic importance of coastal fisheries was never more evident than during the recent COVID-19 pandemic lockdowns, when loss of employment for thousands of people left fishing as a primary source of food and income for many families, especially in countries highly dependent on tourism (Gillett and Fong 2023; Ferguson et al. 2021).

The declines in coastal fisheries resources due to a range of factors are of significant concern to all Pacific Island countries and territories (PICTs). To address these challenges, the region has developed two important strategies: the Regional Roadmap for Sustainable Pacific Fisheries (FFA and SPC 2015) and the New Song for Coastal Fisheries (SPC 2015). It is widely recognised that these strategies need to be updated, in part to be better informed by the impending impacts of climate change.

2.2 Habitats supporting coastal fisheries

The main habitats that support coastal fisheries in the 14 Pacific Island countries participating in the GCF Programme include coral reefs, seagrass meadows and mangrove forests. These habitats form a connected mosaic, with mangroves typically located along the shore and seagrass meadows and coral reefs extending away from the coast (Waycott et al. 2011; Guannel et al. 2016). Collectively, these habitats are important for coastal fisheries due to their role in providing food, shelter, and nursery areas for juvenile fish and invertebrates, as well as cover and feeding grounds for adult demersal fish and invertebrate species that move among the different habitats during different life history stages (Adkins et al. 2015; Guannel et al 2016; Sambrook et al 2019). The connectivity between this often-continuous mosaic of habitats sustains a high diversity of commonly-harvested species targeted by Pacific communities for food and income (Guannel et al. 2016; Veitayaki et al. 2017).

Collectively, the 14 participating countries have ~74,000 km^2 of coastal habitats, dominated by coral reefs (Table 2.1) (Souter et al. 2021a). These habitats support a high biodiversity of fish species, and species richness decreases from the west to east of the region, with the greatest species richness occurring in Papua New Guinea (PNG) and Solomon Islands, which are also part of the Coral Triangle – the most diverse and biologically complex marine ecosystem in the world (Sanciangco et al. 2013). The estimated coastal habitat area for each of the participating countries demonstrates the extent of coral reefs, seagrass meadows and mangrove forests, and the relative importance of the different habitats in supporting coastal fisheries (Table 2.1).

In general, coastal habitats in the Pacific Islands region are in relatively good condition (Souter et al. 2021b; McKenzie et al. 2021), however, there are many drivers of change and increasing threats to their condition.

Table 2.1 Estimated area (km^2) of coastal habitats in 2022 in each Pacific Island country participating in the GCF Programme. Data sources: WRI – World Resources Institute; WCMC – World Conservation Monitoring Centre [UNEP]; GMW – Global Mangrove Watch. FSM = Federated States of Micronesia; PNG = Papua New Guinea. Blank cells indicate that the habitat does not occur in the country. Source: Welch et al. (forthcoming).

Country	Estimated habitat area in 2022 (km^2)		
	Coral reef (WRI data)	Seagrass meadow (WCMC data)	Mangrove forest (GMW data)
Cook Islands	530.8		<0.1
FSM	4,957.0	1,594.6	87.9
Fiji	6,741.7	1,745.6	488.1
Kiribati	3,061.2	499.6	1.5
Marshall Islands	3,581.0	529.3	0.3
Nauru	15.4		
Niue	44.7		
Palau	972.3	732.2	56.9
PNG	14,686.6	9,347.4	4,524.7
Samoa	404.2	988.7	2.3
Solomon Islands	6,790.6	1,261.7	526.5
Tonga	1,670.4	3,703.4	10.4
Tuvalu	1,238.2	-	0.1
Vanuatu	1,813.0	1,244.7	15.8
Total	**46,506.9**	**21,647.1**	**5,714.7**

2.2.1 Coral reefs

Coral reefs are the best studied coastal habitat in the region, covering over 46,000 km^2 in the 14 participating countries (Table 2.1). An assessment of their status and trends in the region (Souter at el. 2021a), focused on two indicators – live hard coral cover and macroalgae cover. Based on 440,000 observations since 1987 in 15 PICTs, results show that prior to 1998, average hard coral cover was relatively high and stable between 37.0% and 37.7%. In 2019, this had declined to 31.3%. The impacts of the 1998 El Niño in the Pacific Islands region were evident in a 2.3% decline in average coral cover between 1999 and 2001, and El Niño events in 2015 and 2016 caused considerable coral mortality across the region, which was apparent in the 2.7% decline in average coral cover between 2015 and 2017. The average cover of macroalgae on the other hand remained relatively low (15%) and stable between 1987 and 1999, followed by a progressive increase over the last two decades, peaking at 20.8% in 2018 (Souter et al. 2021a).

2.2.2 Seagrass meadows

The 14 participating countries have extensive seagrass meadows, totalling almost 22,000 km^2 in area (World Conservation Monitoring Centre data), with 16 species found across the region (McKenzie et al. 2021). The greatest area and species diversity is in Melanesia, with PNG having the highest diversity (13 species), with species diversity progressively decreasing eastwards resulting in only two species of seagrass occurring in French Polynesia (McKenzie et al. 2021). Seagrass condition in 65% of PICTs was assessed based on 57 datasets of meadow extent and ecosystem trends, and was categorised as increasing, decreasing or undetermined (McKenzie et al. 2021). Seagrass meadows are under increasing threats from anthropogenic activities, especially land use change, further exacerbated by pressures from climate change (Waycott et al. 2011, Grech et al. 2012; Cullen-Unsworth and Unsworth 2013). However, in a global context, current evidence suggests the Pacific Islands region remains a location with relatively low pressures and more resilient seagrass (McKenzie et al. 2021).

2.2.3 Mangrove forests

There are ~6,000 km^2 of mangroves in the region (Global Mangrove Watch), representing ~3.8% of the world's mangrove forests (Senilolia et al. 2014). Some of the largest areas occur in Fiji, PNG, and Solomon Islands. Although several areas of mangroves are diverse and assessed to be in relatively good condition (e.g., in PNG which hosts 43 species), other locations only have small remnant forests due to infrastructure development (e.g., the airport area in Pohnpei, Federated States of Micronesia, which is located on a low-lying mangrove island) and reclamation (e.g., in Fiji, where mangrove forest area is estimated to have declined from 42,462 ha in 1999 to 37,000 ha in 2009 largely due to land reclamation; Ellison and Fiu 2010). In many PICTs, mangroves have been observed to migrate landward as a natural response to rising sea level. In cases where this natural landward migration is constrained by topography or the presence of seawalls and other man-made structures, mangrove areas reduce over time, with continued sea-level rise and other climate change impacts threatening mangroves into the future (Waycott et al. 2011; Veitayaki et al. 2017).

2.2.4 Overview of the status of coastal habitats

Since the 1970s, the decline of coastal habitats has accelerated globally, including in the Pacific Islands region (Albert et al. 2017; Guannel et al. 2016; Hassenruck et al. 2015). This is due to poor land management and coastal development and delivering increased sedimentation and pollutants from coastal catchments, and destructive and illegal fishing practices (Dutra et al. 2021; Veitayaki et al. 2017; Johnson et al. 2020). Climate change, however, is now also a prominent driver affecting coastal habitats, through higher sea surface temperatures (SST) and marine heatwaves, sea-level rise, ocean acidification, more intense storms and cyclones, El Niño Southern Oscillation (ENSO) events, and the synergistic effects between drivers (Aronson and Precht 2016; Souter et al. 2021b; Johnson et al. 2020). These impacts on the condition of coastal habitats are accelerating as the climate continues to change (Dutra et al. 2021).

2.3 Characteristics and significance of coastal fisheries

Methods of fishing in the coastal zone of PICTs can be broken into two groups – those with and without the use of a vessel. Gleaning, netting, line, and spear fishing can all be conducted on nearshore habitats in the absence of a vessel. Gleaning is an especially important activity that women participate in and which contributes significantly to food security and income for their families (Ram-Bidesi 2015; Gillett and Tauati 2018; Grantham et al 2020; Lau et al 2023). Recent work in Fiji also highlights that gleaning activities by women across a wide diversity of habitats supports household resilience in the aftermath of disasters, including cyclone Winston in 2016 (Chaston Radway et al 2016; Kopf et al 2020). As gleaning is often undertaken as a group activity, it also represents an opportunity for women to socialise, bond, and spend time in nature (e.g. Grantham et al 2020) – a critical finding supported by work among women fishers in Palau (Ferguson 2021). The significance of women's contribution to coastal fisheries is highlighted through the "Women in Fisheries" bulletin produced by the Pacific Community[10].

In smaller and/or poorer communities, fishing vessels are usually canoes that are paddled or sailed to the fishing grounds. Most motorised fishing vessels used in nearshore coastal fisheries are globally known as

[10] https://coastfish.spc.int/en/publications/bulletins/women-in-fisheries

pangas,[11] dinghies or long boats which are narrow, open fibreglass vessels (5–7 m length) that are easily powered by a low horsepower outboard engine between 20–40 hp. The costs of such vessels and their engines has often been heavily subsidised by national governments or development assistance agencies to promote accessibility to artisanal fishing by communities (Paules and Fache 2016).

As coastal demersal fish resources have become progressively over-exploited, there is now considerable effort being made to increase the use of nearshore anchored Fish Aggregation Devices (FADs) to provide access to more sustainable nearshore pelagic fisheries sources and to potentially relieve some fishing pressure from coastal habitats, especially coral reefs (Bell et al. 2015, 2018b). As a complement to FAD programmes, training methods have been developed to to upskill coastal communities in the techniques required to maximise the opportunities provided by increasing access to fish in nearshore pelagic environments (e.g. Bertram et al. 2023).

Coastal fishing activities in the Pacific Islands region have traditionally contributed heavily to the subsistence needs of communities (Table 2.2). However, approximately 30% of fishing households also earn an income from selling surplus fish and invertebrates caught from coastal and nearshore waters (Gillett and Fong 2023). Although fish markets across the region trade a wide diversity of fish and invertebrates, some species are more heavily targeted than others because they command the best prices. For finfish, surgeonfish (Acanthuridae), emperors (Lethrinidae), snappers (Lutjanidae), and groupers (Serranidae), especially larger species, are highly valued and consequently, they are also the taxa most heavily fished (Pratchett et al. 2011). For invertebrates, sea cucumber and lobster species command premium prices and hence are heavily targeted. Sea cucumber fisheries across the Pacific Islands region are especially valued and seen as a ready source of cash income for communities. Market prices in Asia for the dried sea cucumber product (bêche-de-mer) remain perennially high for many species, creating a continuous demand which has resulted in overfishing and illegal fishing (Purcell et al 2016; Conand 2018). The COVID-19 pandemic also motivated officials in several PICTs to open previously closed sea cucumber fisheries, further exacerbating the documented declines in stocks of these species (e.g., Purcell et al. 2016).

The significance of coastal fisheries to the Pacific Islands region is further demonstrated by the financial contributions of subsistence and commercial catches to gross domestic product (GDP) of PICTs (Table 2.2). Gillett and Fong (2023) estimated that coastal commercial and subsistence production for 2021 was 173,924 tonnes, which is 10% of regional fishery production and worth an estimated USD450 million. The volume for all coastal fisheries (commercial and subsistence) in PNG is the largest in the region and represents about one quarter of the regional total (Gillett and Fong 2023).

2.4 Pressures on coastal fisheries and management responses

Overfishing has been a sustained problem across most PICTs, as elsewhere across the globe (Gillett and Tauati 2018; Karcher et al. 2020). In the Pacific Islands region, it has been driven mainly by the rapid growth of human populations, the need for coastal communities to earn cash in increasingly 'monetised' societies, greater demand for export commodities, increased access to 'modern' fishing gears and a lack of alternative livelihoods (Sulu et al. 2015). Exploitation of coastal fisheries resources is strongly linked to economic development at the national level, and availability of alternative income opportunities at the community level (Thebaud et al. 2023). Coastal communities with limited access to alternative livelihoods are most vulnerable because of their high dependence on coastal fisheries resources, as

[11] Originally developed by the Yamaha Corporation with the support of a World Bank project in the 1970s and since widely disbursed throughout the Americas, Africa, Asia and the Pacific Islands region.

demonstrated by the direct relationship between small-scale artisanal invertebrate catches and daily cash expenditure (Franz et al. 2023).

The intrinsic role of marine systems in sustaining coastal communities has been given greater global relevance in recent years, with a focus on development of sustainable food systems and in particular, blue food systems (e.g., Tigchelaar et al. 2022). Regionally, coastal fisheries are receiving increasing attention by governments through the development of key regional policies and strategies, e.g., The New Song for Coastal Fisheries (SPC 2015). There is also recognition that data and effective data collection systems that inform coastal fisheries management decision-making have been lacking (Welch 2021; Gillett and Fong, 2023). The lack of data to service the regional policies is providing a catalyst for governments across the region to support modernisation and improvement in the collection of coastal fisheries data to underpin critically needed improvements in effective management. An example of this renewed focus is the IKASAVEA e-data system developed by the SPC Fisheries, Aquaculture and Marine Ecosystems Division, https://fame.spc.int/resources/tools/ikasavea

While better data collection of fisheries harvest characteristics will help to provide a pathway to better management and sustainable use of coastal fisheries stocks, it is equally important to recognise the dependency of coastal fisheries species on their coral reef, seagrass and mangrove habitats. Healthy habitats are a fundamental precursor to sustainable fishing in the coastal zone. While overfishing has long been identified as the major factor for decreasing quality of fisheries stocks across the region, habitat degradation is interacting with overfishing at ever greater scales because of climate change (Wilson et al. 2010; Rogers et al. 2017).

Local disturbances, including coastal development, pollution, sedimentation, reclamation, and destructive fishing practices (Brown et al. 2017; Harborne et al. 2017), are compounded by larger-scale disturbances caused by “natural” events, such as cyclones and outbreaks of the coral feeding crown-of-thorns starfish *Acanthaster planci*[18–19]. Warming seas have now elevated mass-bleaching of hard corals to unprecedented levels with global-scale impacts becoming more frequent (Eakin et al. 2019). The frequency and intensity of marine heatwaves across the Pacific Islands region are expected to increase even under low emissions scenarios (Holbrook et al. 2022). These types of events are predicted to be part of the future for PICTs, resulting in reduced productivity of coastal ecosystems upon which Pacific Island communities depend (Lotze et al. 2019; Johnson et al. 2020; Tittensor et al. 2021).

Coastal fisheries and fishing will remain a critical component of the Pacific way of life, even with climate-induced changes. There will, however, need to be a renewed focus on reducing and/or eliminating local-scale disturbances and embedding more sustainable fishing approaches to adapt to the changes that are happening as a result of the changing climate.

Table 2.2 Trends in estimated annual catches of coastal fisheries in Pacific Island countries participating in the GCF Programme and their estimated value from 2007 to 2021. Coastal fisheries catch estimates are for subsistence and commercial catch combined. The percentage of the total catch and total catch value attributed to subsistence use is also given for 2021. Source: Gillett (2009); Gillett (2016); Gillett and Fong (2023).

Country	**Catch (tonnes)**			**Proportion of 2021 catch derived from subsistence fishing**	**Estimated total value of coastal fish catch (USD)**			**Proportion of total value in 2021 from subsistence catch**
	2007	**2014**	**2021**		**2007**	**2014**	**2021**	
Melanesia								
Fiji	26,900	27,000	30,100	0.61	67,562,500	67,171,717	65,094,340	0.58
Papua New Guinea	35,700	41,500	46,000	0.87	62,500,000	117,315,176	98,575,499	0.81
Solomon Islands	18,250	26,468	30,000	0.83	14,287,582	45,875,819	50,310,559	0.80
Vanuatu	3,368	3,906	4,400	0.70	7,917,308	13,014,340	16,494,208	0.58
Micronesia								
Federated States of Micronesia	12,600	5,280	5,000	0.68	23,292,000	13,800,000	17,500,000	0.60
Kiribati	20,700	19,000	19,000	0.58	47,058,824	31,718,852	44,202,898	0.49
Marshall Islands	3,750	4,500	4,200	0.71	7,212,000	10,350,000	9,400,000	0.64
Nauru	650	373	240	0.42	1,501,681	2,036,713	1,673,913	0.33
Palau	2,115	2,115	2,400	0.58	5,354,000	6,500,000	10,909,800	0.49
Polynesia								
Cook Islands	400	426	430	0.65	2,279,412	2,890,625	2,653,061	0.59
Niue	150	165	169	0.95	676,471	1,252,969	1,234,694	0.93
Samoa	8,624	10,000	11,000	0.50	34,461,434	30,230,126	37,837,837	0.41
Tonga	6,500	6,900	7,000	0.50	17,469,307	28,118,279	24,780,702	0.41
Tuvalu	1,215	1,435	1,500	0.77	2,849,212	1,868,238	3,182,971	0.64
Total	**154,722**	**163,936**	**173,924**	**0.71**	**366,057,963**	**453,342,144**	**449,593,345**	**0.62**

2.5 Status of coastal fisheries

In fisheries, the term "status" refers to the size of the fished population and/or fishing levels relative to sustainable levels (reference points). Based on the size of the fished population (biomass or abundance), the status of the fishery reflects the extent to which fishing, among other impacts, has reduced the population's ability to replenish itself and may be assessed as overfished or sustainably fished. Based on the levels of fishing effort, the status reflects whether the amount of fishing is likely to be causing the fished population to be declining, stable or increasing and may be assessed as being subject to overfishing or sustainable fishing levels. Ensuring a fishery is sustainable and not subject to overfishing is critical to continued harvests in the long term, but importantly, will also affect its ability to withstand the impacts that climate change and other stressors will bring (Bellwood et al. 2004; Gaines et al. 2018; Barange 2019; Free et al. 2020). Further, the effects of fishing appear to exacerbate ecological responses to climate change (Poloczanska et al. 2016). Fisheries that are sustainable will have a greater resilience to climate change.

Although strategic efforts to estimate the status of coastal fisheries to date have been limited Welch 2021), several relatively recent projects have determined the status[12] for some target species (Moore et al. 2015a,b; Nadon 2019; Prince et al. 2019; Kaly et al. 2020; Bosserelle et al. 2021; Jaugeon et al. 2023). Several studies have also explored multi-species or ecosystem-level approaches to assess the status of Pacific coastal resources (e.g. Houk et al. 2018). A recent global study estimating system-level coastal resource biomass of key coral reef target finfish species found that nine PICTs had biomass levels at or above the biomass at which maximum sustainable yields (MSY) can be achieved (Zamborain-Mason et al. 2023). However, many studies also suggest that overfishing is occurring and that some stocks are already overfished in some locations (Kinch et al. 2008; Govan et al. 2013; Gillett et al. 2014; Pakoa et al. 2014; Williams et al. 2015; Welch 2016; Houk et al. 2018; Welch et al. 2019; Kaly et al. 2020; Zamborain-Mason et al. 2023). Widespread anecdotal information supports these findings. For example, reports from Port Resolution on Tanna Island, Vanuatu, identify localized extinction of green snail, trochus, and giant clam (D. Welch, unpublished data). Further compounding these concerns is the frequent lack of management controls on the harvest of coastal fish in Pacific Island nations, or where controls are implemented, inadequate local capacity and resourcing limits their effectiveness (Govan et al. 2013, Gillett et al. 2014;).

Generally, however, knowledge of the status of key coastal fish stocks throughout the Pacific Islands region remains limited due to a range of factors, including lack of appropriate data collections and a lack of technical capacity in the region to conduct stock assessments (Welch 2021). Therefore, understanding the current status of fished populations among PICTs will help to enable fisheries scientists and managers to better understand how coastal fisheries will cope with projected climate change and inform appropriate adaptation actions. Further, the impacts of future climate change on coastal fisheries will likely be substantially influenced by management actions that are implemented now and maintained into the future (Gaines et al. 2018; Barange 2019; Free et al. 2020).

2.6 Current knowledge of effects of climate variability and change

2.6.1 Coastal marine habitats

The coastal ecosystems in the Pacific Islands region have evolved to survive within a specific range of prevailing climatic conditions – the coping range (Jones and Mearns 2005; Hoegh-Guldberg et al. 2007).

[12] Depending on methods used, use of the term status here refers to overfished or not overfished based on population size methods, and/or subject to overfishing or not subject to overfishing based on fishing mortality rate methods, or proxies for these.

Any changes in these climate conditions will influence coastal habitats and the fisheries resources and human communities they support. There are documented impacts of changing climate on coastal habitats, including coral reefs, seagrass meadows, and mangroves. Climate impacts act separately and synergistically with local anthropogenic impacts (Abelson 2020), and since they provide critical habitat for different life history stages of many estuarine and reef species, any habitat changes will have implications for the species they support.

Coral reefs are susceptible to ocean warming and acidification, changing ocean currents, more intense cyclones and storms, and increased sedimentation from higher rainfall, deforestation and agricultural runoff. Increasing sea surface temperature (SST) is causing widespread coral bleaching and mass mortality worldwide, including on reefs in the Pacific Islands region (Obura and Mangubhai 2011; Hughes et al. 2017; Eakin et al. 2019; Raymundo et al. 2019; Townhill 2020), driving changes in the structure and function of coral reef assemblages (Hughes et al. 2018; Holbrook et al. 2022). Increases in global warming above 1.5 °C are expected to result in net erosion of coral reefs throughout the tropics (IPCC 2018; Hoegh-Guldberg et al. 2018, 2019). A global assessment found that thermal bleaching is expected to become an annual event on Pacific reefs under a high emissions scenario by ca. 2040 (on average) (UNEP 2017). Notably, the range spans from 2038 (Federated States of Micronesia) to 2058 (Pitcairn Islands).

Ocean acidification can also affect corals, reducing calcification rates (Fabricius et al. 2011; Doney et al. 2020), impacting growth (Guo et al. 2020), and making coral reefs more susceptible to damage. Ocean acidification is expected to slow the rate of reef accretion and enhance erosion over the coming decades (Silverman et al. 2009). For example, optimal coral calcification rates occur at 2–3 °C below the bleaching temperature threshold (Evenhuis et al. 2015). But when corals bleach, calcification is suppressed because photosynthetic products from zooxanthellae are essential for the calcification process and their expulsion from corals reduces these products (Evenhuis et al. 2015). Similarly, corals exposed to nutrients, turbidity, sedimentation or pathogens are more susceptible to thermal stress (Wiedenmann et al. 2013), or less able to survive and recover from bleaching or other acute disturbances (Riegl et al. 2015; Wenger et al. 2020). In more acidic seawater, reefs are expected to be more susceptible to other pressures, such as eutrophication, coral disease, storms and bleaching (Meissner et al. 2012; van Hooidonk et al. 2014).

Seagrass meadows are degraded through several local impacts, including sand extraction, deforestation and catchment agriculture, coastal development and poor water quality, with climate change exacerbating these impacts (Waycott et al. 2011). Changes in nutrient dynamics and light penetration in coastal waters due to flood events have been shown to impact seagrass growth and reproduction (Orth et al. 2006), as have the combined stresses of light and temperature (Adams et al. 2020). Chronic elevated nutrients have been reported to lower the availability of light to seagrass due to increased growth of algae and epiphytes on the plants (Burkholder et al. 2007). Chronic and pulsed increases in suspended sediments that increase turbidity can also limit light and result in reduced productivity and seagrass loss (Waycott and McKenzie 2010). Tropical seagrasses are heavily influenced by weather patterns, including flood and cyclone events that have the potential to physically damage meadows, particularly in shallow areas (Waycott et al. 2011). The dynamics of tropical seagrasses mean that while ocean warming may limit growth, elevated CO_2 concentrations can increase thermal tolerance (Zimmerman 2021), providing some inherent resilience (McKenzie and Yoshida 2020). Seagrass also buffers pH decline in seawater and therefore may play an important role in ecosystem resilience to climate change, providing opportunities through conservation management to maintain the coastal mosaic of habitats that support fisheries.

Mangroves are highly exposed to sea-level rise due to their location on the coastal fringe of islands, and any decline in mangroves can be expected to exacerbate extreme high tide flooding, storm surge and shoreline erosion from more intense storms and cyclones (Duke et al. 2021). Mangroves have the ability to adapt to projected sea-level rise, if sediment accretion is fast enough and landward barriers, such as roads, retaining walls and buildings, do not constrain landward migration. Higher atmospheric CO_2 concentrations and greater rainfall in some sub-regions could enhance the potential for mangroves to expand landward by increasing their productivity (Waycott et al. 2011). Ultimately, the pace of sea-level rise under high emissions is expected to be greater than the ability of mangroves to migrate (Lovelock et al. 2015), particularly if landward migration is constrained by structures.

Drought, sea level change, and MHW events can also cause significant mangrove dieback (Lovelock et al. 2017; Duke et al. 2021), and changes in rainfall and river flow can affect coastal wetland and mangrove fish and invertebrate species, particularly recruitment success, growth, and catchability (Leahy and Robins 2021). In addition, more intense storms will impact mangrove forests through the physical processes of erosion, burial, wind throw and lightning strikes. Projected changes in rainfall, particularly the amplification of the seasonal cycle, has implications for mangrove growth, depending on whether the rainfall changes coincide with the peak mangrove growing season (Duke et al. 2021).

2.6.2 Coastal marine fish and invertebrates

Global changes in the atmosphere due to increased anthropogenic carbon emissions have had significant effects on the oceans, which in turn have affected marine species. Although there is a growing body of evidence documenting impacts of climate change on marine species, observations for the Pacific Islands region are scarce. This is largely due to limited data collection and limited local studies (Poloczanska et al. 2016, Free et al. 2019;). Despite this, global experimental research on tropical coastal fisheries species, improved modelling, and localised observations are providing a better understanding of the likely consequences for marine species due to the direct and indirect effects of a changing climate (Pratchett et al 2011; Cheung and Pauly 2016; Poloczanska et al. 2016). Understanding these ecological impacts is crucial to forecasting the consequences for human communities in PICTs that rely on these resources, thereby providing a basis for identifying the critical actions needed now to mitigate negative impacts. A recent review paper found that, for a large range of different tropical species, observations of marine impacts due to climate change are increasingly consistent with modelled projections (Pinsky et al. 2020). Therefore, while much of the current knowledge of tropical coastal fish responses to climate change is based on relatively few observations, model accuracy in projecting likely consequences suggest they are representative.

The abiotic effects of climate change on fish and invertebrate species comprising coastal fisheries include warming waters, ocean acidification, altered ocean circulation and current patterns, changes to freshwater hydrological regimes, altered precipitation patterns, episodic extreme weather events, hypoxia, and sea-level rise (Sydeman et al. 2015; Poloczanska et al. 2016; Hoegh-Guldberg et al. 2017). The direct effects of these environmental changes for coastal fishes include physiological, behavioural, and demographic responses (Roessig et al. 2004, Doney et al. 2012, Pörtner et al. 2014). Indirect effects include changes to the availability, structure and connectivity of the coastal habitats described in Section 2.2, as well as other biotic interactions such as predator-prey relationships, food web dynamics, and competition (Sydeman et al. 2015). The response of coastal fish and invertebrates to climate change differs depending on taxon, location, physiological tolerance, and life history stage (Poloczanska et al. 2016). These factors influence dispersal ability, food and habitat preferences, physiological tolerance thresholds, behavioural patterns, and life history characteristics and stages – which might include spawning migrations, survival of pelagic larval stages, and ontogenetic shifts between different habitat types. Together, the outcomes of these direct and indirect ecological effects may cause significant changes to population and community dynamics for a wide range of fish and invertebrate species targeted by coastal fisheries.

Field observations collected during the 2015/16 El Niño event in the central equatorial region of the Pacific showed the ecological consequences from increased SST (Brainard et al. 2018). At the remote Jarvis Island, an unincorporated territory of the United States and part of the northern Line Islands, anomalously elevated SST was documented during what was described as an "unprecedented" El Niño event and resulted in "…the longest, most widespread, and most damaging global coral bleaching event on record" causing significant coral mortality. The study reported declines in total fish biomass and declines in planktivore fish populations as a consequence of this particular event and proposed that these impacts were likely due to the interactive effects caused by the El Niño event, which caused anomalously low chlorophyll-a and high SST, and the lack of a La Niña event following El Niño (Brainard et al. 2018). These results support projections from multiple modelling studies that predict declines in the productivity of tropical marine systems with concomitant declines in fish biomass as a consequence of climate change (Table 2.3).

Increasing SST currently appears to be the single most influential driver of ecological responses in the marine environment because it influences animals both directly as well as indirectly by interacting and influencing multiple marine ecosystem processes and habitats. For example, rising SST results in changes to ocean mixing and upwelling which results in changes to phytoplankton blooms, biological productivity, and the biomass of marine species (Le Borne et al., 2011, Lehodey et al, 2011; Cheung and Pauly 2016). Tropical equatorial areas are predicted to be the most affected by temperature-induced range shifts towards higher latitudes, since most tropical fish species have relatively narrow thermal tolerances and are already at or near their thermal limit (Poloczanska et al. 2016). Although not well documented for individual tropical species, marine finfish globally have been shown in recent decades to be range shifting towards the poles at an average rate of 10s of kilometres per decade (Poloczanska et al. 2013). In the tropics, and particularly near the equator, range shifts will result in reduced species diversity, and localised depletions and extinctions, thereby altering community structure, trophic interactions and how ecosystems function (Cheung and Pauly 2016).

A recent study showed that the frequency and duration of marine heatwave (MHW) events have increased over the past 40 years (Holbrook et al. 2022). For the period 1982–2019, a total of 82, 91, and 89 MHW events were documented in Fiji, Palau, and Samoa, respectively. The duration of each event varied across these countries, but longer events were more likely to occur in recent years. Coral bleaching was reported in all PICTs as a result of these MHW events and in some cases, there was also significant coral mortality. Mortality of hundreds of coastal fish and invertebrates was reported in Fiji for several of the MHW events, with the February-March 2016 event also impacting adjacent waters in Kiribati and Vanuatu, resulting in the mortality of coastal marine species (Holbrook et al. 2022). Learning from analogous systems, a well-studied MHW event in Western Australia found significant localised declines in the abundance of some fish species and subsequent changes in biodiversity and community structure (Wernberg et al. 2013, Chandrapavan et al. 2019). Further, MHW events are likely to become more frequent under climate change (Holbrook et al. 2022).

There are relatively few studies that demonstrate the likely effects of ocean acidification on tropical marine species. Some recent studies indicated that changes in survival and behaviour of coral reef fish species can be expected, however, the results of some of these studies have recently been brought into question. Therefore, the effects of ocean acidification on coral reef fish remains uncertain and is one research area that requires further attention. Ocean acidification has been shown to affect the development of shells, exoskeletons, and spicules in some invertebrates (Dickinson et al. 2021), suggesting that ocean acidification may have significant negative consequences for invertebrates. The interactive effects of multiple concurrent changes due to climate change add complexity and greater uncertainty in predicting consequences. Studies that have explored the interaction of different environmental stressors combined with indirect effects are sparse (Poloczanska et al. 2016). However, the available studies generally show that interactions of predicted changes are likely to result in increased levels of impact (Poloczanska et al. 2013; Cheung and Pauly 2016). Specific changes observed in recent decades include earlier timing for life history events (phenology) such as spawning and migration (Poloczanska et al. 2013).

Ecosystem models are crucial tools for projecting the potential effects of climate change on marine ecosystems and species, that incorporate indirect and complex interactive processes within and among trophic groups and/or species. Recent advances in the development and improvement of spatially-explicit marine ecosystem model ensembles include coupling these with global climate-ocean-biogeochemical models to simulate how physiological responses to changing habitats (e.g. warming) and food web responses to changes in primary production could affect potential marine animal biomass and fisheries (Cheung et al. 2010; Blanchard et al. 2012; Asch et al. 2018; Tittensor et al. 2018). Although it is recognized that improvements in models and their theoretical basis is needed (Tittensor et al. 2018; Heneghan et al. 2021), their combined use through an ensemble approach allows the prediction of community and ecosystem responses, that accounts for model uncertainties, and ultimately better inform likely consequences for resources users. Despite high uncertainty in some regions, various models consistently predict declines in primary production across the Pacific Islands region, a key determinant of potential coastal fish biomass and catch potential (Cheung et al. 2010; Barange et al. 2014; Free et al. 2019; Williams et al. 2015; Eriksson et al. 2017; Asch et al. 2018; Lam et al. 2020; Tittensor et al. 2021). Further, productivity and fish biomass are projected to decrease the most at low to mid latitudes under climate change, with considerable regional variation (e.g. Lam et al. 2020). Moreover, changes in species composition and catches of tropical fisheries in response to warming waters and altered primary productivity, consistent with projections, have already been observed in several locations (Lam et al. 2020).

Table 2.3 Observed impacts of climate drivers on fish and invertebrates that support coastal fisheries. Source: Welch et al. (forthcoming).

Climate driver	Observed impacts on fish & invertebrates	Example references
Increasing SST	Reduced growth and smaller body size	Munday et al. 2008, Dahlke et al. 2020, Johansen et al. 2014, 2015, Pratchett et al. 2017, Byrne & Przeslawski et al. 2013, Le Moullac et al. 2016a, Lam et al. 2020, Cheung et al. 2013, Cheung and Pauly 2016, Huang et al. 2021
	Altered reproductive success, change in the timing of life history events (e.g. spawning, migration), shorter larval duration	Donelson et al. 2010, Pankhurst & Munday 2011, Pratchett et al. 2013, Dahlke et al. 2020, Raventos et al. 2021, Plagányi et al. 2013, Cheung and Pauly 2016, Pratchett et al. 2017
	Range shifts toward higher latitudes or to deeper water, altered food webs and species composition, declines in species richness, localised extinctions	Vergés et al. 2014, Hyndes et al. 2016, Chamberlain et al. 2023, Cheung and Pauly 2016, Cheung et al 2013a (from Cheung and Pauly)
Ocean acidification	Reduced development and growth rates, weaker skeletons (for calcifying invertebrates), increased vulnerability to predation and risk of disease	Ishimatsu et al. 2008, Przeslawski et al. 2008, Tan & Zheng 2020, Dickinson et al. 2021, Le Moullac 2016b
	Altered reproductive success	Kroeker et al. 2013, Watson 2015
	Altered behavior affecting function and survival	Pistevos et al. 2015, Rodriguez-Dominguez et al. 2018, Gherardi et al. 2013
Changing ocean circulation & currents	Changes in larval transport and dispersal patterns, changes in connectivity among populations, altered distributions, altered food webs, altered conditions for site attached species	Cowen et al. 2006, Wilson et al. 2016, Munday et al. 2008, Cetina-Heredia et al. 2015, Munday et al. 2009, Adam et al. 2014, Booth et al. 2017
Primary and secondary productivity	Changes in metabolism, growth, survival, reproductive output and success, lower abundance and population biomass, size-structure, altered food webs	Hauser et al. 2015, Häder & Gao 2017, Przeslawski et al. 2008, Munday et al. 2008, Lam et al. 2020, Free et al. 2019, Williams et al. 2015, Barange et al. 2014
Episodic events (marine heat waves, coral bleaching, cyclones)	Acute temperature stress, hypoxia, relocation, mortality, habitat alteration and degradation, reduced productivity, population and biomass declines, opens up the potential for species turnover or establishment of new or invasive species	Dunstan et al. 2018, Nati et al. 2021, Chamberlain et al. 2023, Magel et al. 2020, Lecchini et al. 2020, McClanahan et al. 2009, Mies 2019, Andréfouët et al. 2018, Raymundo et al. 2019, Jones et al. 2004, Wilson et al. 2006, Przeslawski et al. 2008, Chamberlain et al. 2023, Magel et al. 2020, Coker et al. 2009, Sambrook et al. 2019, 2020, Unsworth et al. 2018, Fulton et al. 2020, Floren et al. 2021, Unsworth et al. 2007, Taylor & Mills 2013, Honda et al. 2016
Interactions between multiple environmental changes	Additive, synergistic and antagonistic effects on different life stages and taxa – increased metabolism, reduced reproductive success, altered predation rates, changes in behaviour, reduced survival, lower biomass, reduced productivity, altered community structure and ecosystem function	Kroeker et al. 2017, Byrne et al. 2013a, Byrne & Przeslawski 2013, Fulton 2011, Free et al. 2019, Williams et al. 2015, Barange et al. 2014, Heneghan et al. 2021

3. Methods used for Component A

3.1 Assessing the vulnerability of coastal fisheries and gap in fish supply by 2030

For the reasons given in Section 1, the assessment of projected changes in coastal fisheries production due to climate change in each of the 14 participating countries by 2030 does not involve modelling. Instead, it based on the expert opinion documented in Pratchett et al. (2011), which used the estimated coastal fisheries production for each country in 2007 (Gillett 2009) as the baseline.

Pratchett et al. (2011) separated coastal fish resources into demersal fish, nearshore pelagic fish, and invertebrates and then assessed the vulnerability of each group to the indirect and direct effects of ocean warming and acidification. Indirect effects included the projected changes to the array of habitats that support coastal fish species, particularly coral reefs (Hoegh-Guldberg et al. 2011) but also mangroves, seagrasses and intertidal bare substrata (Waycott et al. 2011). The direct effects included changes to SST, ocean acidification, ocean currents (and their effects on the nutrient supplies supporting food webs throughout the water column) and dissolved oxygen (Ganachaud et al. 2011, LeBorgne et al. 2011). In the case of the demersal fish species, which dominate coastal fisheries production, Pratchett et al. (2011) based their assessment of the impact of climate change of the integrated responses of three groups of demersal fish – coral-dependent, reef-associated, and generalist species.

Pratchett et al. (2011) concluded that there was limited scope for a high emissions scenario to have significant impact on coastal fisheries production by 2035, and that most of the climate-driven changes would occur as indirect effects due to degradation to coral reefs and other coastal habitats providing shelter and feeding areas for coastal fish species caused by increases in greenhouse gas (GHG) emissions, rather than through the direct effects of relatively moderate changes to environmental conditions on the survival, reproduction and recruitment of fish and invertebrate species. Overall, the analysis based on expert opinion concluded that there would be a 2 to 5% decline in demersal fish production by 2035 under a high emissions scenario (SRES A2, which approximates SSP5-8.5). We have taken the midpoint of this range (3.5%) as the estimated impact of SSP5-8.5 on demersal fish by 2030.

Pratchett et al. (2011) relied on the modelling for the effects of ocean warming on the distribution of tuna available at the time (Lehodey et al. 2011) to assess the impact of increased GHG gases on the local productivity of nearshore pelagic fish. This modelling indicated that Pacific Island countries in the west of the region were likely to lose tuna biomass, and those in the east of the region would gain biomass. However, more recent, improved modelling of the effects of climate change on the distribution of tuna (see Component B) indicate that this may not be the case. Instead, it can be concluded from the relatively large size of the reference biomass of tuna in the EEZs of all 14 participating countries (Bell et al. 2021, Supplementary Tables 5 and 9), compared to the requirements of the national population for tuna for food security, that climate-driven changes to tuna biomass under SSP5-8.5 by 2030 are unlikely to change catchability of these species for coastal communities. Accordingly, the contribution of nearshore pelagic fish to coastal fisheries production is not considered to be vulnerable under this scenario.

The vulnerability of the invertebrates contributing to coastal fisheries production for human consumption, i.e., bivalve and gastropod molluscs and crustaceans found in intertidal and shallow subtidal habitats, is considered to be negligible under a high emissions scenario by 2035 (Pratchett et al. 2011).

The respective vulnerabilities of demersal fish, nearshore pelagic fish and invertebrates described above have been combined to provide an estimate of total coastal fish production available for human consumption in each country.

To estimate the extent of gaps/surplus in fish supply required for good nutrition of the national population expected to occur in each of the 14 participating countries by 2030 under continued high GHG emissions, the following inputs were used.

- Whole weight equivalent of fish (kg) needed per capita per year to provide 50% of dietary protein, based on recommendations from the World Health Organisation and Pacific Community, obtained from Technical Study 2, Table 17. *(A)*

- Annual coastal fish production by 2030, estimated applying the methods above, converted to fish availability per capita (kg) using the estimated population of each country by 2030 (in the case of Papua New Guinea, the population was limited to 5 km from the coast, given that coastal fish production is unlikely to be distributed any further inland, as explained in Annex 23). *(B)*

- Annual per capita consumption (kg) of canned fish, obtained from Technical Study 2 and Bell et al. (2019), converted into live fish weight based on a recovery rate of 60% of edible parts as canned fish. *(C)*

The gap/surplus in fish supply (kg) needed or good nutrition in each country was calculated then calculated as:

Per capita fish needed for good nutrition, minus per capita availability of coastal fish production combined with per capita canned fish consumption, i.e., A – (B+C)

Countries were then classified into two groups: 1) those where coastal fisheries production had the potential to provide the dietary protein requirements, but where difficulties can be expected in distributing the fish required to urban centres due to the distances involved in transporting the fish from its source in coastal (rural) areas to urban centres; and 2) where total coastal fish production would be insufficient to meet the needs of the total population, even if it could be transported to urban centres economically.

<u>Sources of error</u>:

- The 'nearshore pelagic fish' (NSP) category of coastal fisheries production is comprised not only of tuna but also other large pelagic species such as mahi mahi, wahoo and rainbow runner. Thus, the modelling done for tuna is not representative of the entire contribution of NSP to coastal fisheries production. However, tuna is estimated to comprise at least 50%, and up to > 75%, of NSP in 7 of the 14 participating countries, and between 25 and 50% in the remaining 7 countries (Pratchett et al. 2011).

- A small proportion of the invertebrate species harvested in the participating countries are targeted for export (trochus, sea cucumbers and pearl shell) and therefore the catch of these species does not contribute to domestic food security[13]. Across the region, exported invertebrates are estimated to represent only 2-3% of coastal fisheries production (Pratchett et al. 2011; Bell et al. 2018a). For the 14 participating countries, invertebrates targeted for export represent an average of 14% of the total invertebrate catch, with the remainder comprised of intertidal and shallow subtidal species.
- The whole weight equivalent of fish (kg) needed per capita per year to provide 50% of dietary protein, based on recommendations from the World Health Organisation and Pacific Community is based on finfish only. It is calculated using an estimated recovery of 60% or edible flesh per kg whole weight, and an average protein content of ~23% (see Technical Study 2 for details). It was not practical to include invertebrates in this calculation because the average percentage of edible portion is difficult to estimate, given the range in shell weights among the wide variety of bivalve, gastropod and crustacean species consumed across the region, and the limited number of invertebrate species in the Pacific Nutrient Database[14].

Taken together, the sources of error summarised above are not expected to alter the classification of countries into Groups 1 and 2 with respect to the gap/surplus of fish needed for good nutrition in 2030.

3.2 Assessing the vulnerability of coastal fisheries and gap in fish supply by 2050

The projected impacts of climate change on coastal fisheries production, and the gap in fish supply for coastal communities, by 2050 under the SSP2-4.5 and SSP5-8.5 emissions scenarios was assessed by combining the indirect and direct effects of the changing climate on fish assemblages in coastal waters. These two emissions scenarios are described in the shared socioeconomic pathways (SSP) from the IPCC Sixth Assessment Report. The methods described below encompass evaluating the effects of the two emission scenarios by 2050 on 1) the habitats supporting coastal fisheries; 2) the biomass of coastal fisheries species; 3) the catch of coastal fisheries species available for human consumption; and 4) the gap in fish supply recommended for good nutrition.

3.2.1 Assessing the impacts on coastal fish habitats by 2050

The vulnerability of coastal habitats to the impacts of climate change was assessed using a structured semi-quantitative vulnerability assessment framework (Johnson et al. 2024) and a method applied previously in the Pacific Islands region (Bell et al. 2011; Johnson et al. 2016) and in adjacent regions (Northern Australia, Welch et al. 2014; Torres Strait islands, Johnson and Welch 2016; Arafura and Timor Seas, Johnson et al. 2021). The results from these spatial analyses were used to categorise the vulnerability of coastal habitats along a continuous scale from low to very high. Calculations of pixels and area of vulnerability were

[13] Although meat may be extracted from harvested molluscs for subsistence consumption.
[14] https://sdd.spc.int/digital_library/pacific-nutrient-database-pndb

quantified based on five categories using the average of the vulnerability score across all pixels, and the standard deviation of all scores about the mean. These five categories are defined as follows:

- Very high: vulnerability ≥ average + 2 standard deviations
- High: average + 1 standard deviation≤ vulnerability < average + 2 standard deviations
- Med-High: average ≤ vulnerability < average + 1 standard deviation
- Low-Med: average - 1 standard deviation≤ vulnerability < average
- Low: < average - 1 standard deviation

The analysis of habitat vulnerability determined the likely area of the respective habitat types that will be impacted under climate change scenarios SSP2-4.5 and SSP5-8.5 by 2050. That is, the analysis does not identify actual impacts, but the area of habitats expected to experience degradation based on vulnerability to climate change. The results are inputs for the indirect effects in the analyses of coastal fisheries. Therefore, for the purposes of this analysis, we assumed that total habitat area will decline by the area assessed as having 'very high' and 'high' vulnerability (Table 4.2). It is expected that the direction of change (i.e., habitat decline) will continue to 2090 with increasing magnitude over time, resulting in greater percentage of habitat degradation or loss.

See Appendix B for details of the uncertainty, assumptions, limitations, and knowledge gaps associated with this methodology.

3.2.2 Assessing the impacts on biomass of coastal fish species by 2050

As mentioned above, the vulnerability of coastal fish assemblages (defined here to include both finfish and invertebrates) was assessed by combining the indirect and direct effects of the climate change. The indirect effects are those that affect the environment supporting coastal fish species (e.g., changes in habitat area) and interactions with other organisms, measured as described in Section 3.2.1, whereas the direct effects were defined as changes in environmental conditions directly experienced by fish (e.g., increases in SST). Projected changes in catch were based on the latest (2021) estimates for each of the 14 countries participating in the GCF Programme made by Gillett and Fong (2023). A significant improvement on the assessments for 2050 compared to 2030 was the use of ecosystem model ensembles forced by climate models to estimate future changes in fish biomass (see the Fisheries and Marine Ecosystem Model Intercomparison Project, FishMIP[15]) for the two emissions scenarios (see Appendix C for details). Although impacts under these two scenarios were explored out to 2100, the focus is on the analyses of projected impacts by 2050. This approach also provides quantitative estimation of uncertainty in projections. See Appendix B for details of the various types of uncertainty, together with assumptions, limitations, and knowledge gaps associated with this methodology.

3.2.3 Assessing the impacts on the coastal fisheries catch by 2050

We assessed the projected impacts of climate change on coastal fisheries using a similar approach to the 2011 assessment that combines the effects of both direct and indirect impacts on fish. That is, we used the projected changes in available fish biomass (direct effects) and combined this with the projected changes in habitat area (indirect effects) to derive projected changes in catch levels for each PICT. Projected changes in catch were based on the latest (2021) catch estimates derived for each PICT by Gillett and Fong (2023). To estimate catch for the different island groups in Kiribati we used the

[15] https://fishmip.org

latest population estimates from the 2020 national census and simply partitioned catch based on the per capita amount. The estimated populations in 2020 for each island group were: Gilbert Island group – 108,145, Line Island group – 11,252, and Phoenix Island group – 41 (MOF, 2020).

Projected catches for each PICT were estimated by:

- Dividing the current estimated coastal fisheries catch (tonnes; Gillett and Fong, 2023) with the current estimated habitat area (km^2; see habitat section above) to derive an estimate of current yield (catch per area of habitat; tonnes/km^2/year). We used the combined area of coral reef and seagrass meadows habitats. Coral reef fishes and invertebrate species are well known to extensively use habitats other than coral reefs during some or all of their life history stages (Sambrook et al 2019). However, we chose to use coral reef and seagrass meadows habitats given the very low relative area of mangrove habitats among PICT. We therefore assumed that projected changes in either habitat would affect coastal fish. The only exception was PNG where we also included the area and projected changes for mangrove habitat area because a) it accounted for a relatively high proportion of overall coastal habitat area (~16%); mangrove habitat area in all other PICTs was significantly lower (<=6%), and b) some of PNGs key coastal fishery species utilise these mangrove habitats during key aspects of their life cycles (e.g. barramundi, mud crab).

- For each of the climate scenarios for 2050 (SSP2-4.5 and SSP5-8.5) we applied the average of relative change (%) in fish biomass between 2046 and 2055 to the current (2021) yield to estimate the projected yield.

- The projected catch (tonnes) was estimated by multiplying the projected yield with the projected habitat area. This was expressed as the projected catch and the projected change (%) in catch.

See also Appendix D documenting an assessment of the current resilience of coastal fisheries to climate change.

3.2.4 Assessing the gap in recommended fish supply for food security by 2050

The projected coastal fish catch in each of the 14 countries in 2050 under both emission scenarios was converted to fish availability per capita in kg/person per year. This was done by dividing the total projected catch under each emissions scenario by the predicted coastal population in 2050, calculated using the percentage of the total population in coastal areas (based on Andrew et al. 2019) and applied to the 2050 national population estimates (Pacific Data Hub, 2023). The availability of fish per capita was then compared with the minimum annual consumption rate (kg) of fish per person needed to provide the protein required for good nutrition in each country from Technical Study 2 (noting that these data do not currently include invertebrate consumption) to estimate the shortfall/surplus of coastal fish available to meet the dietary requirements of the population in 2050 under both emission scenarios.

4. Vulnerability of coastal fisheries production to climate change

4.1 Vulnerability of contribution of coastal fish to food security by 2030

The expected availability of coastal fisheries production for domestic consumption in each of the 14 countries participating in the GCF Programme, based on expert opinion as Described in Section 3, is summarised in Table 4.1.

Table 4.1 Estimated availability of coastal fisheries catch in 2030 under an SSP5-8.5 equivalent emissions scenario for each Pacific Island country participating in the GCF Programme. This analysis combines the expected effects of increased greenhouse gas emissions on the three main categories of coastal fisheries (see footnotes to table). The percentage contribution of each category to total estimated catch in 2030 is also provided.

Country	Projected catch (tonnes) in 2030						
	Demersal fish[1]	%	Nearshore pelagic fish[2]	%	Invertebrates[3]	%	Total coastal fisheries
Melanesia							
Fiji	16,839	64	5,270	20	4,180	16	26,289
PNG	14,012	40	13,760	39	7,420	21	35,192
Solomon Is	8,613	48	5,750	32	3,575	20	17,938
Vanuatu	1,669	50	753	23	885	27	3,307
Micronesia							
FSM	6,070	49	3,560	29	2,750	22	12,380
Kiribati	14,547	72	4,250	21	1,375	7	20,172
Marshall Is	2,332	64	1,080	29	253	7	3,665
Nauru	299	47	310	49	30	5	639
Palau	917	44	680	33	485	23	2,082
Polynesia							
Cook Is	141	36	240	61	14	4	395
Niue	60	40	75	51	13	9	148
Samoa	4,264	50	2,550	30	1,655	20	8,469
Tonga	5,061	80	650	10	605	10	6,316
Tuvalu	808	68	326	27	52	4	1,186
Total	**75,633**	**55**	**39,254**	**28**	**23,292**	**17**	**138,179**

1. Calculated as estimated catch in 2007 (based on information in Gillett 2009, converted to demersal fish catch by Pratchett et al. 2011), reduced by 3.5% (mid-range of projected 2% to 5% decrease by 2035 relative to 2000–2010 under a high emissions scenario by Pratchett et al. 2011) (see Methods)

2. No change to estimated catch in 2007 (based on information in Gillett 2009, converted to nearshore pelagic fish (NSP) catch by Pratchett et al. 2011) because even though there may be some decreases in NSP catch by 2030 relative to 2007, the estimated tuna biomass in the exclusive economic zone of each country is expected to be high enough to maintain catches at 2007 levels (see references to tuna biomass for each country in supplementary materials for Bell et al. 2021).

3. No change to estimated catch in 2007 (based on information in Gillett 2009, converted to invertebrate fish catch by Pratchett et al. 2011) because the catch is dominated by intertidal and shallow subtidal species expected be affected negligibly by a high emissions scenario by 2035 (Pratchett et al. 2011).

The gap/surplus in fish supply required for good nutrition of the national population in each participating country by 2030 under continued high GHG emissions, is summarised in Table 4.2.

Table 4.2 Gap/surplus in fish supply (kg whole weight) required to provide the national population in each participating country (except Papua New Guinea) with 50% of their recommended intake of dietary protein in 2030.

Country	National population 2030	Coastal fish catch per year (t) 2030	Coastal fish catch per capita per year (kg) 2030	Canned fish per capita converted to whole weight (kg)[1]	Total fish available per capita per year (kg)	Fish needed for nutrition per capita per year (kg)[2]	Gap in fish supply per capita per year (kg)
Melanesia							
Fiji	920,980	26,289	29	13	42	65	- 23
PNG[4]	2,273,165	35,192	15	3	18	52	- 34
Solomon Is	892,093	17,938	20	6	26	52	- 26
Vanuatu	363,200	3,307	9	9	18	57	- 39
Micronesia							
FSM	106,507	12,380	116	4	120	63	+ 57
Kiribati	138,935	20,172	145	5	150	65	+ 85
Marshall Is	53,983	3,665	68	9	77	60	+ 17
Nauru	12,588	639.15	51	2	53	67	- 14
Palau	17,930	2,082	116	7	123	68	+ 55
Polynesia							
Cook Is	15,889	394.89	25	4	29	82	- 53
Niue	1,393	147.83	106	14	120	80	+ 40
Samoa	209,369	8,469	40	13	53	70	- 17
Tonga	97,257	6,316	65	4	69	73	- 4
Tuvalu	11,250	1,186	105	6	111	68	+ 43

- From Technical Study 2 (Table 6), and Bell et al. (2019) converted to whole fish weight.
- From Technical Study 2 (Table 17).
- Note that countries with (+) have a surplus of fish in principal but see Table 9 in Annex 23 for explanations about why these countries have requested FADs under the GCF Programme.
- Population within 5 km of the coast only.

On the basis of the analysis summarised in Table 4.2, eight of the participating countries fall into the category where coastal fisheries production by 2030 will not have the capacity to provide the fish needed for good nutrition of the national population. The remaining six countries have a surplus of fish capable of providing the recommended protein intake in principal but in all cases these countries face severe problems in economically distributing enough of the coastal fisheries catch from its source to meet dietary requirements in areas with relatively high population density. In such locations, increasing access to tuna through the use of FADs and improving the supply of tuna and bycatch from the unloading and transhipment activities of industrial fishing operations (where possible) is needed to increase fish supply.

4.2 Vulnerability of contribution of coastal fish to food security by 2050

4.2.1 Projected changes in habitat area

The results for the modelling of projected changes in the areas of coastal fish habitats for the two emissions scenarios in 2050 were spatially variable among and within the 14 Pacific Island countries participating in the GCF Programme (Table 4.3). Those with the greatest projected percentage decline of coral reefs by 2050 under both emissions scenarios are Nauru and Samoa. Coral reef decline is largely driven by increasing SST and pH declines, with well-documented impacts on hard corals due to thermal bleaching and acidification undermining reef structure (Hoegh-Guldberg et al. 2017).

Although the mechanisms for seagrass sensitivity to thermal stress are poorly understood, it is believed that thermal risk is a combination of: (1) exposure of shallow-water seagrasses to MHW events, and (2) shifts in the photosynthesis/respiration balance (i.e., increases in SST and air temperature results in increased respiration, driving increased stress and declines (Olsen et al. 2018). Nevertheless, while the drivers of change to seagrass habitats in the Pacific Islands region potentially includes marine heatwaves later in the century, i.e. by 2090, the main drivers are likely to be turbidity and sedimentation that hinders photosynthesis, and more intense cyclones and storms that physically damage shallow meadows. The participating Pacific Island countries with the greatest projected percentage declines of seagrass by 2050 under both emissions scenarios are PNG, Samoa, and Vanuatu (Table 4.3).

Mangrove vulnerability is driven by increasing air temperatures, sea-level rise, and anthropogenic threats such as catchment activity (deforestation and agriculture) and pollution. The results for mangroves show that the participating countries with the greatest projected percentage declines in mangrove area by 2050 under both emissions scenarios are FSM, and Samoa (Table 4.3).

Table 4.3 Total percentage area of each coastal habitat type assessed as having a 'very high' or 'high' vulnerability under the SSP2-4.5 and SSP5-8.5 emission scenarios by 2050 in each of the Pacific Island countries participating in the GCF Regional Tuna Programme. These values represent the estimated percentage decline in area for each habitat type due to climate change. Blank cells indicate the country does not have that coastal habitat type.

Country	Coral reef		Seagrass		Mangrove	
	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Cook Islands	5.37	6.09				
FSM	1.01	1.15	56.51	64.00	4.80	5.43
Fiji	11.83	13.40	4.59	5.19	17.52	19.84
Kiribati	13.77	15.59	0	0	9.29	10.53
Marshall Islands	1.90	2.15	0	0	6.62	7.50
Nauru	44.15	50.00	0	0		
Niue	16.56	18.75	0	0		
Palau	0	0	0	0	2.01	2.27
Papua New Guinea	15.14	17.15	14.51	16.43	20.74	23.49
Samoa	77.60	87.88	88.30	100.00	36.19	40.98
Solomon Islands	9.11	10.32	0	0	3.53	4.00
Tonga	24.65	27.91	0	0	0	0
Tuvalu	0	0	0	0		
Vanuatu	23.26	26.35	0	0	20.27	22.95

Results for Samoa are notable due to the particularly high projected declines for all habitat types. A sensitivity analysis shows that coastal habitats in Samoa have low adaptative capacity and high sensitivity due to the influence of rivers on water quality.

4.2.2 Projected changes in fish biomass

The indirect and direct impacts of climate change are projected to result in declines in coastal fish biomass in most of the 14 Pacific Island countries participating in the GCF Programme, noting that there is also high variability spatially and temporally. When aggregating across all the models used to make the projections, overall, the largest declines in biomass are projected to be in those countries closest to the equator and in the western Pacific region, expanding to higher latitudes and in an easterly direction (Figure 4.1).

Although biomass is projected to decline between 20–30 % in some parts of the equatorial western Pacific by 2050, it is important to note that the spatial variability means that impacts within a country's EEZ may also be highly variable. For example, even under the lower emission scenario by 2050 some coastal areas of PNG are expected to experience biomass declines of up to 30 % while other areas are expected to experience very little change, or even modest increases in biomass in some cases (Figure 4.1). Given the spatial variability in these projections, the modest increases may or may not benefit fisheries catches in the respective countries. It is important to note that the projected changes are relative to a reference period of 2010–2020[16].

Aggregating results across EEZs to give annual trends in the predicted exploitable coastal fish biomass for each of the 14 participating countries highlights the uncertainty of the projections (Figures 4.2 – 4.4). This is due to the fact that the different models do not always agree on the magnitude of change, something that is not clear from the maps (Figure 4.1). Looking at the median and range for the trends, it appears that predicted coastal fisheries biomass tend to continue a declining trend into the future regardless of the climate change scenario, with some countries showing greater declines than others, and declines occurring at different timeframes (Figures 4.2 – 4.4). Several of the 14 participating countries are projected to experience only modest declines in biomass for most of the time series under either emission scenario (e.g., median trends for Fiji, Niue and Vanuatu) (Figures 4.2 – 4.4, Table 4.4). The wide range of projections suggest that exceptions to a general decline may be possible in some countries where there may be no apparent overall change in biomass projected over the future time series or even some increases.

Figures 4.2 – 4.4 highlight high inter-annual variability, reflecting differences between the models but also the potential for increased natural variability in environmental conditions. This is important to recognise because it may result in higher than usual inter-annual variability in catches from coastal fisheries, and in some cases these may be significant. For example, in several countries, biomass is projected to change by 20–30% in time periods as short as 1–2 years. It is also not possible to predict if these rapid changes in fishable biomass will be experienced across the whole jurisdiction or at local scales. These projections do not incorporate sudden onset or episodic climate (or other) events, such as marine heatwaves, cyclones, tsunamis, or large flood events. To be well prepared for future conditions, this type of variability should be factored into adaptation strategies for each participating country.

The range in predicted values in Figures 4.2 – 4.4 become increasingly greater further into the future the projections are made, which reflects the increasing uncertainty in the models at predicting changes over longer timeframes. This is the reality of current modelling capacity and, it simply isn't clear which processes will dominate, how specific species will respond (by acclimating to conditions, changing

[16] Similar recent modelling studies have used variable, but usually earlier, reference periods generally resulting in higher projected declines, e.g., Cheung et al. (2010), Asch et al. (2018), Lam et al. (2020).

behaviour, etc.) or how changes in species composition and abundance will buffer overall ecosystem productivity. Different models make different assumptions, and this leads to different projections. This emphasises the importance of focusing on the nearer-term (2050) projections, where confidence is higher, while also recognising that trends over the longer term are affected by decisions taken now, captured by different SSP/RCP scenarios.

It is also important to consider both the spread and the median of the projection results. The median values give an indication of where there is more model agreement, whereas the range in upper and lower estimates reflects the level of uncertainty in modelling outputs, but also possible future outcomes. The upper estimate can be treated as "best case", median as "most plausible" and lowest estimate as "worst case". Therefore, adaptation strategies should consider the full potential magnitude of projected change in the future, as well as the likely inter-annual variability in coastal fish biomass in the future.

Although the projected declines in biomass continue in the longer term, given the uncertainties around the model projections, the analysis here focuses on the projected impacts on coastal fisheries in the medium-term outlook of 2050. The future out to 2050 is also more tangible to current generations and decision makers (Table 4.4, Figures 4.2 – 4.4).

Table 4.4 The average (median), upper and lower values across the model ensemble of projected percentage change in coastal fisheries biomass for each country participating in the GCF Programme by 2050 under SSP2-4.5 and SSP5-8.5 emissions scenarios. Averages calculated using median value of the ensemble for the 20-year period around 2050 (2041–2060). Source: Welch et al. (forthcoming).

Country	Projected change in biomass (%)					
	SSP2-4.5			SSP5-8.5		
	Average	Lower	Upper	Average	Lower	Upper
Melanesia						
Fiji	-0.8	-22.6	+13.3	-2.5	-29.1	+13.7
Papua New Guinea	-18.0	-49.8	-2.1	-24.0	-55.5	-2.6
Solomon Islands	-15.8	-43.3	-1.8	-18.1	-52.6	-0.5
Vanuatu	-2.2	-23.8	+10.4	-2.8	-30.9	+12.8
Micronesia						
FSM	-18.4	-47.6	-1.0	-24.2	-51.1	-1.3
Kiribati – Gilbert Islands	-6.4	-25.9	+4.9	-9.0	-32.3	+9.5
Kiribati – Line Islands	-6.2	-16.9	+7.7	-9.5	-23.4	+11.1
Kiribati – Phoenix Islands	-7.0	-19.7	+3.6	-10.4	-25.8	+6.7
Marshall Islands	-9.9	-38.8	+3.0	-14.5	-42.8	+1.8
Nauru	-10.7	-33.8	+1.8	-13.4	-40.4	+4.4
Palau	-19.9	-43.9	-2.3	-28.4	-48.0	-2.9
Polynesia						
Cook Islands	-6.8	-21.7	+2.7	-11.0	-25.2	+2.3
Niue	-2.6	-25.8	+27.2	-3.9	-29.7	+31.5
Samoa	-9.9	-31.0	+0.8	-12.3	-35.9	+0.8
Tonga	-0.5	-23.4	+19.0	-4.7	-27.3	+16.1
Tuvalu	-15.7	-33.3	-0.6	-19.1	-42.5	+2.7

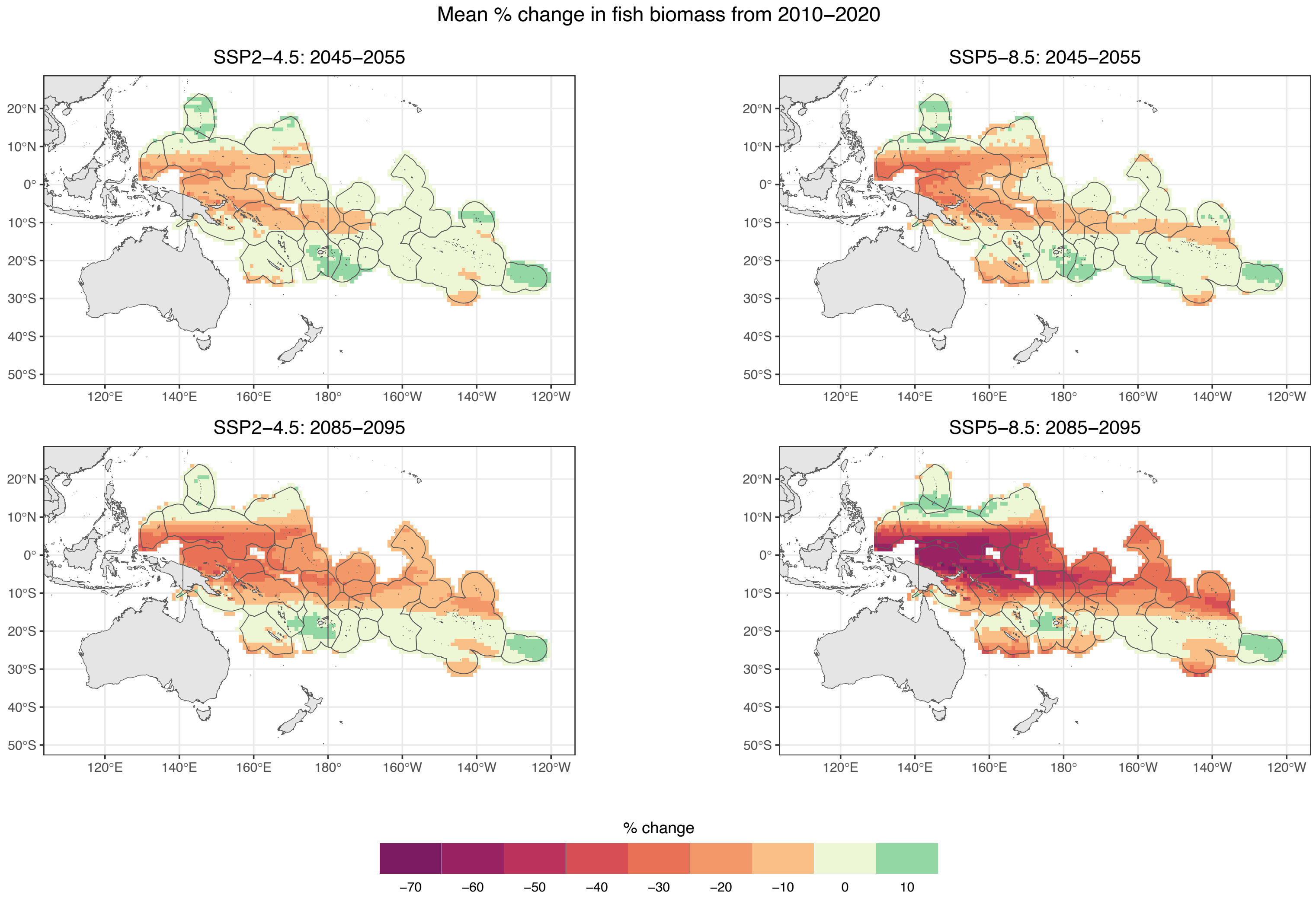

Figure 4.1 Spatial distribution of the projected relative (percentage) change in coastal fisheries biomass for each of the Pacific Island countries and participants in the GCF Programme (and other countries and territories in the region) and their exclusive economic zone (EEZ) area. Projections shown for two time periods 2050 (2045-2055) and 2090 (2085-2095) under the two climate change emission scenarios SSP2-4.5 and SSP5-8.5. The reference period used is 2010-2020. Source: Welch et al. (forthcoming).

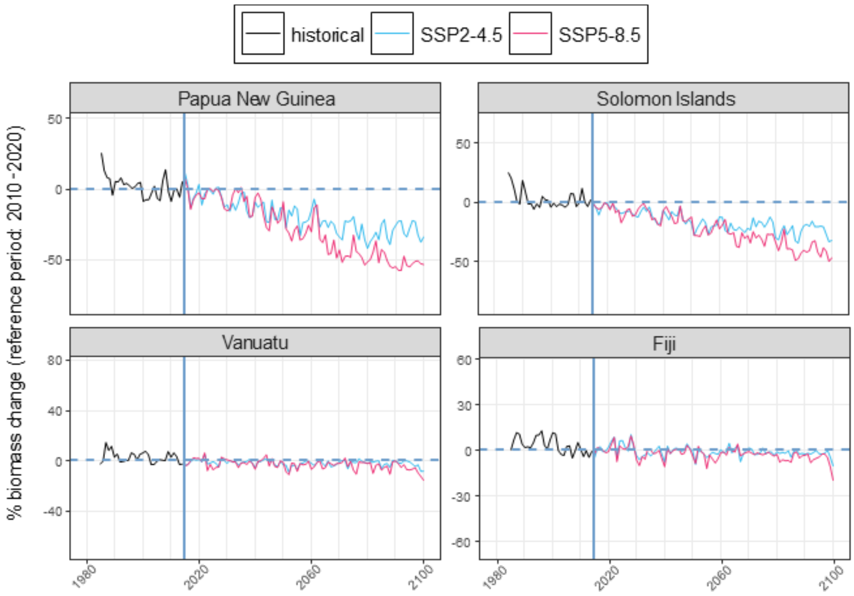

Figure 4.2 Trends in model ensemble median relative (%) change in coastal fishery biomass for Pacific Island countries participating in the GCF regional tuna programme in Melanesia for the historical period of 1985–2014 (black line) and projected changes up to 2100 for the climate change emission scenarios of SSP2-4.5 (blue line) and SSP5-8.5 (pink line). The blue line indicates the period separating historical from projected periods. The SSP2-4.5 scenario represents averaged projections of SSP1-2.6 & SSP5-8.5. Source: Welch et al. (forthcoming)

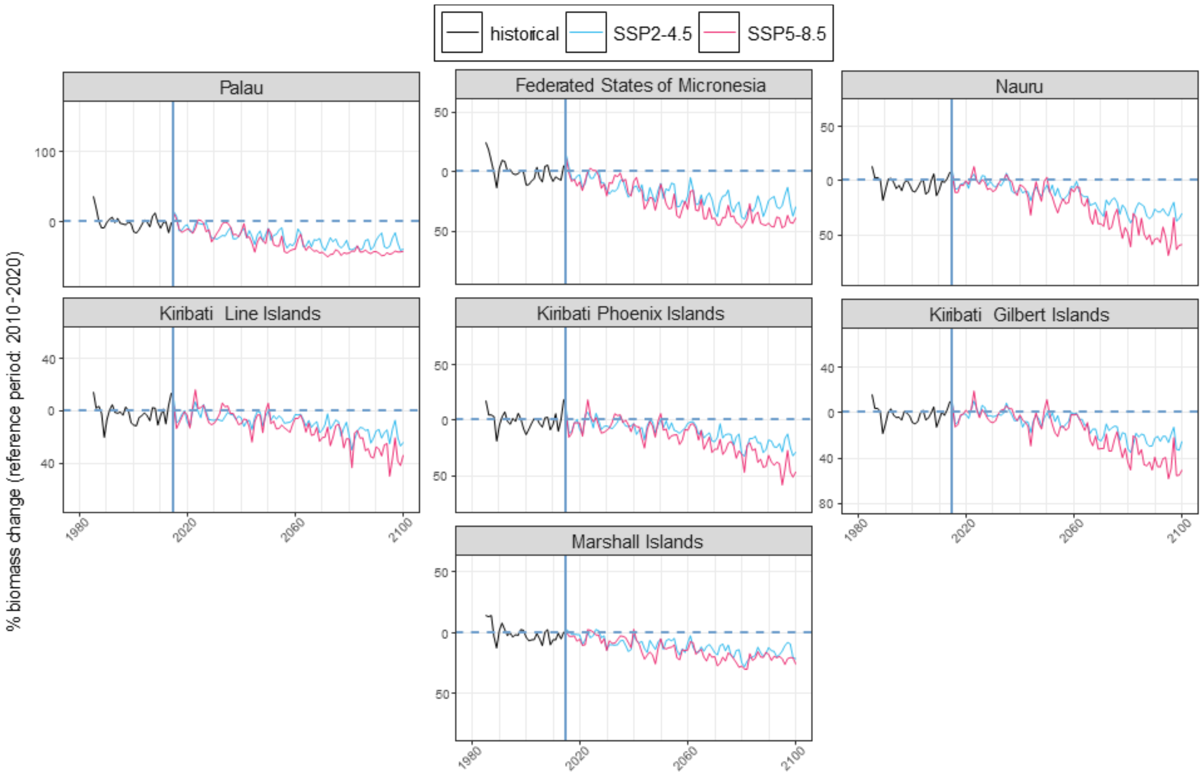

Figure 4.3 Trends in the model ensemble median relative (%) change in coastal fishery biomass for Pacific Island countries participating in the GCF regional tuna programme in Micronesia for the historical period of 1985-2014 (black line) and projected changes up to 2100 for the two climate change emission scenarios of SSP2-4.5 (blue line) and SSP5-8.5 (pink line). The blue line indicates the period separating historical from projected time periods. The SSP2-4.5 scenario represents averaged projections of SSP1-2.6 and SSP5-8.5. Source: Welch et al. (forthcoming).

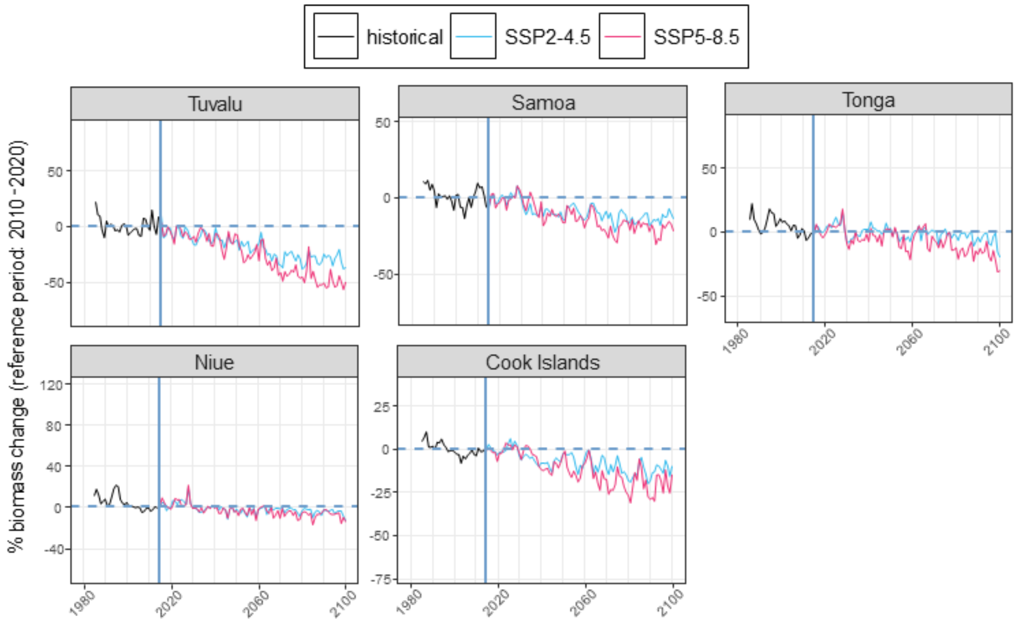

Figure 4.4 Trends in model ensemble median relative (%) change in coastal fishery biomass for Pacific Island countries participating in the GCF regional tuna programme in Polynesia for the historical period of 1985-2014 (black line) and projected changes up to 2100 for SSP2-4.5 (blue line) and SSP5-8.5 (pink line) emissions scenarios. The blue line indicates the period separating historical from projected time periods. The SSP2-4.5 scenario represents averaged projections of SSP1-2.6 and SSP5-8.5. Source: Welch et al. (forthcoming).

4.2.3 Projected changes in coastal fish catch

To fully understand the consequences of climate change on future coastal fisheries production in the 14 Pacific Island countries participating in the GCF Programme it is important to understand the capacity of coastal fisheries systems to cope with, and respond to, the projected impacts. While there are several potential stressors, overfishing is one of the most pervasive. For example, fished populations subjected to overfishing have been found to be more likely to be negatively impacted by higher SST (Free et al. 2019). Therefore, a key indicator of resilience is the effectiveness of management of coastal fisheries, now and in the future. Appendix D provides an analysis of the potential resilience of coastal fisheries in all participating countries. This analysis provides the context for the projected changes in coastal fish catch due to climate change.

On average, across all participating countries, incorporating projected changes in habitat results in a larger overall impact on projected catches relative to projected changes in biomass alone, catches of coastal fisheries resources will decline, in some cases significantly (Figure 4.5; Table 4.5). In particular, even under the lower emissions scenario (SSP2-4.5), FSM, the Line Islands in Kiribati, Nauru, Niue, Palau, PNG, Samoa, Solomon Islands, and Vanuatu, are predicted to experience significant reductions in coastal fisheries catch by 2050. Once again, it should be noted that the variability and uncertainty in projected changes in biomass is high and transferred to estimates of changes in catch (Figure 4.5). Furthermore, the uncertainty associated with estimated changes in habitat and current catch estimates is not incorporated.

While we have focused on the period to 2050, it is also worth noting that for many Pacific Island countries, the projected decline in biomass appears to accelerate from around 2060 (Figures 4.2 – 4.4).

One of the key assumptions of the analysis of projected impacts on catch is that the characteristics of coastal fisheries in each participating country, such as fisher activity and efficiency, market demand, and the current management situation, remains constant into the future (see Barange 2019). Although changes in habitat area were considered in estimating projected changes in catch, it is assumed that estimates of projected catch are proportional to projected changes in biomass; this is unlikely to be the case (Barange 2019). All assumptions, caveats and uncertainties in the analyses are presented in Appendix D.

Table 4.5 Projected change (percentage) in habitat area, average biomass of coastal fish species, and coastal fish catch by 2050 under SSP2-4.5 and SSP5-8.5 emissions scenarios for each Pacific Island country participating in the GCF Programme. Projected habitat changes in 2050 were based on expected declines in coral reef and seagrass areas combined, except for PNG which also included mangrove area declines. Projected change in catch is relative to the recorded coastal fisheries catch from each country in 2021 (Gillett and Fong 2023). See Appendices B and C for further details. Source: Welch et al. (forthcoming).

Country	Projected change in coastal habitats (%) 2050		Projected change in coastal fish biomass (%) 2050		Baseline catch (tonnes) 2021	Projected change in annual catch (%) 2050	
	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5		SSP2-4.5	SSP5-8.5
Melanesia							
Fiji	-13.0	-14.7	-0.8	-2.5	30,100	-13.7	-16.9
PNG	-16.9	-19.1	-18.0	-24.0	46,000	-31.8	-38.5
Solomon Is	-8.2	-9.3	-15.8	-18.1	30,000	-22.7	-25.8
Vanuatu	-22.0	-25.0	-2.2	-2.8	4,400	-23.8	-27.0
Micronesia							
FSM	-1.9	-2.2	-18.4	-24.2	5,000	-20.0	-25.9
Kiribati–Gilbert Is	-1.67	-1.89	-6.4	-9.0	17,204	-7.9	-10.7
Kiribati–Line Is	-62.4	-70.67	-6.2	-9.5	1,790	-64.7	-73.4
Kiribati–Phoenix Is	0	0	-7.0	-10.4	7	-7.0	-10.4
Marshall Is	-2.5	-2.8	-9.9	-14.5	4,200	-12.2	-17.0
Nauru	-44.2	-50.0	-10.7	-13.4	240	-50.1	-56.7
Palau	-0.9	-1.0	-19.9	-28.4	2,400	-20.6	-29.1
Polynesia							
Cook Is	-5.4	-6.1	-6.8	-11.0	430	-11.8	-16.4
Niue	-16.6	-18.8	-2.6	-3.9	169	-18.8	-21.9
Samoa	-48.2	-54.6	-9.9	-12.3	11,000	-53.3	-60.2
Tonga	-7.7	-8.7	-0.5	-4.7	7,000	-8.1	-13.0
Tuvalu	0	0	-15.7	-19.1	1,500	-15.7	-19.1

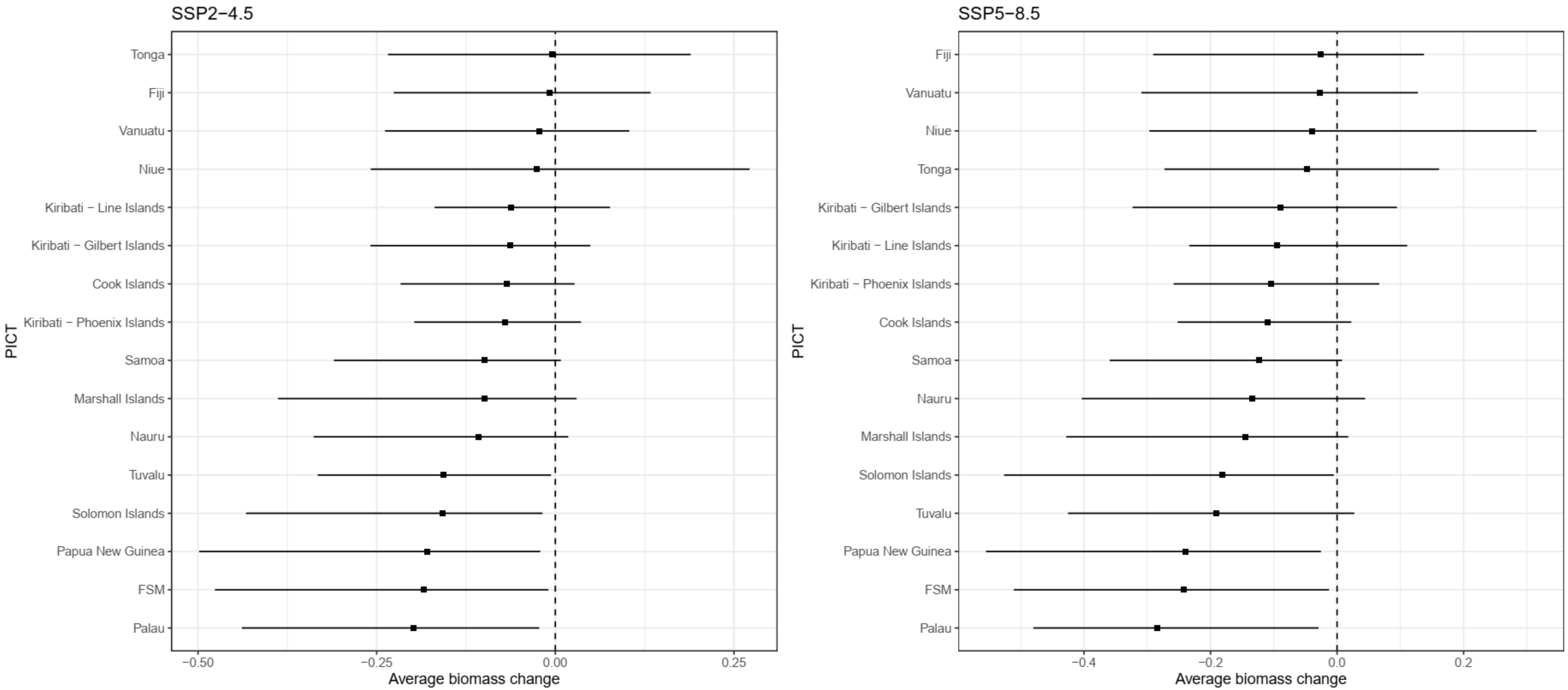

Figure 4.5 Projected average biomass change (%) for each Pacific Island country participating in the GCF for 2050 and under the SSP2-4.5 (left panel) and SSP5-8.5 (right panel) emission scenarios. The lines for projected change in biomass represent the upper and lower bounds of estimates. FSM = Federated States of Micronesia. Source: Welch et al. (forthcoming).

4.2.4 Gaps in coastal fish supply driven by climate change

The projected effects of climate change on coastal fisheries ultimately affects the food security for Pacific Island communities. The extent of this influence depends on several variables, and this analysis explores whether protein derived from coastal fisheries resources is likely to meet consumption needs under different climate change scenarios in the 14 Pacific Island countries participating in the GCF Programme.

Populations in the 14 Pacific Island countries participating in the GCF Programme. have historically been largely subsistence-based with food security heavily dependent on coastal fisheries for protein[17] (SPC 2008, Bell et al. 2009). Consequently, this analysis is focused on the contribution of coastal fisheries resources to the recommended consumption of dietary protein needed for good nutrition (see Technical Study 2 for details), much of which still comes from subsistence fishing.

The future availability of coastal fisheries resources for each Pacific Island country is based on the projected changes in catch, relative to the coastal fish catch in 2021 reported by Gillett and Fong (2023) (Table 4.5). For the analysis of the contribution of coastal fisheries resources to the recommended consumption of dietary protein needed for good nutrition (see Technical Study 2 for details), the data on future projected catches have been converted to a per capita basis. Assuming that fisheries are managed in a similar way to current practices, the amount of fish available per person will decline in all 14 participating countries under SSP2-4.5 and SSP5.8.5 (Table 4.6).

Analysis of the combined effects of reduced catch due to increased GHG emissions and changes in population size within 5 km of the coast (Table 4.6) to identify the future gap (or surplus) in the supply of coastal fish per capita relative to the fish supply recommended for good nutrition by WHO and SPC (see Table 17 in Study 2) is provided in Table 4.7. This analysis shows that nine countries will have a gap in recommended fish availability by 2050 under both SSP2-4.5 and SSP5-8.5. Five countries will retain a surplus in fish supply by 2050. However, as discussed under Section 4.1, most of these countries face severe problems in distributing fish from remote coral reefs to population centres, requiring expansion of the use of FADs to improve the supply of fish for urban communities.

[17] With the exception of the large inland population of PNG.

Table 4.6 Per capita availability of coastal fish in kg (whole weight) per person per year in 2021 for the population living within 5 km of the coast for 14 Pacific Island countries. Also shown at the projected changes in fish availability per capita per year under the SSP5-8.5 emissions scenario in 2030, and under the SSP2-4.5 and SSP5-8.5 emissions scenarios in 2050. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Country	2021			2050 SSP2-4.5			2050 SSP5-8.5		
	Population within 5 km of coast [1]	Coastal fish catch (tonnes) [2]	Fish per capita (kg) [3]	Population within 5 km of coast [1]	Coastal fish catch (tonnes) [4]	Fish per capita (kg) [3]	Population within 5 km of coast [1]	Coastal fish catch (tonnes) [4]	Fish per capita (kg) [3]
Cook Is	15,526	430	28	15,786	379	24	15,786	359	23
Fiji	682,783	30,100	44	720,731	25,976	36	720,731	25,013	35
FSM	105,757	5,000	47	98,668	4,000	41	98,668	3,705	38
Kiribati	120,740	19,000	157	181,852	16,397	90	181,852	15,846	87
Marshall Is	54,516	4,200	77	52,461	3,688	70	52,461	3,486	66
Nauru	11,835	240	20	14,425	120	8	14,425	104	7
Niue	1,283	169	132	1,139	137	121	1,139	132	116
Palau	17,960	2,400	134	16,439	1,906	116	16,439	1,702	104
PNG	1,915,831	46,000	24	3,169,670	31,372	10	3,169,670	28,290	9
Samoa	193,855	11,000	57	224,510	5,137	23	224,510	4,378	20
Solomon Is	662,511	30,000	45	1,213,589	23,190	19	1,213,589	22,260	18
Tonga	99,526	7,000	70	93,311	6,433	69	93,311	6,090	65
Tuvalu	10,673	1,500	141	11,830	1,265	107	11,830	1,214	103
Vanuatu	283,213	4,400	16	477,620	3,353	7	477,620	3,212	7

- Based on Andrew N.L. et al. (2019) Coastal proximity of populations in 22 Pacific Island Countries and Territories. PLoS One, 14 (9), e0223249-1-e0223249-15
- As estimated by Gillett and Fong (2023)
- Whole fish (not just edible portion)
- Projected catch from Table 4.5

Table 4.7 The gap (-) or surplus (+) in fish supply (whole weight) by 2050 relative to recommended consumption of fish per capita per year in the 14 Pacific Island countries participating in the GCF Programme expected to occur under SSP2-4.5 and SSP5-8.5. FSM = Federated States of Micronesia; PNG = Papua New Guinea.

Country	SSP2-4.5			SSP5-8.5		
	Recommended consumption per capita per year (kg) [1]	Fish available per capita (kg) [2]	Gap or surplus per capita (kg) [2]	Recommended consumption per capita per year (kg) [1]	Fish available per capita (kg) [2]	Gap or surplus per capita (kg) [2]
Cook Is	83	24	-59	83	23	-60
Fiji	67	36	-31	67	35	-32
FSM	65	41	-24	65	38	-27
Kiribati	67	90	+23	67	87	+20
Marshall Is	62	70	+8	62	66	+4
Nauru	67	8	-59	67	7	-60
Niue	78	121	+43	78	116	+38
Palau	68	116	+48	68	104	+36
PNG	53	10	-43	53	9	-44
Samoa	70	23	-47	70	20	-50
Solomon Is	53	19	-34	53	18	-35
Tonga	75	69	-6	75	65	-10
Tuvalu	70	107	+37	70	103	+33
Vanuatu	58	7	-51	58	7	-51

- From Table 17 in Study 2, based on proportion of men, women and children in the population, their average body weights, the fact that fish is ~23% protein, 60% recovery of edible flesh per kg, and WHO/SPC recommendations that fish provides 50% of the protein intake of 0.7 g per kg of body weight per day. Values are kg of whole fish.
- Whole fish (not just edible portion) availability from Table 4.6.

5. Overview and recommendations

5.1 Vulnerability of coastal fisheries production and fish supply for local consumption

The vulnerability assessment undertaken for Component A of the GCF Programme, based on consideration of the indirect and direct effects of climate change, shows that although there is spatial variability among and within participating countries, climate change has a high likelihood of causing declines in coastal habitats, coastal fisheries biomass and catches of coastal fisheries resources into the future. Although the impacts are expected to be modest by 2030 under SSP5-8.5, the assessment shows clearly that impacts will continue and accelerate, and that projected declines in coastal fisheries production are likely to be significant in many of the participating countries by 2050, even under SSP2-4.5.

The projections to 2050 highlight the potential for progressive, deleterious impacts of reduced coastal fisheries productivity on food security and livelihoods. Furthermore, significant inter-annual variability in the projected changes in fish catch coupled with the projected increase in episodic events, such as those due to marine heat waves, suggests that some of the climate-driven changes in coastal fisheries production could be sudden. The overall impact of changes to the contributions that coastal fisheries make to food security and livelihoods will depend on the effectiveness of adaptations to maintain the capacity for coastal areas to sustain demersal fish and invertebrates.

Although progress has been made since SPC's initial assessment of the vulnerability of tropical Pacific fisheries and aquaculture in 2011, including development of relevant regional supporting policies and strengthening of community-based coastal resource management, effective measures to sustain coastal resources remain limited. The strong likelihood is that continued declines in coastal fish catch will widen the gap that is already occurring between the fish required for good nutrition of coastal communities and sustainable fish harvests from coral reefs and other coastal habitats driven by rapid population growth in many of the participating countries. Climate change will exacerbate the gap in fish supply, which provides a powerful incentive for the participating countries to improve the sustainability of coastal fisheries to minimise the gap. This can be done by 1) maintaining sufficient spawning biomass to replenish stocks regularly, and 2) reducing the impacts of poor land use on coastal habitats. Both actions will maximise the autonomous capacity of coastal fish and invertebrate species to adapt to the indirect and direct effects of climate change.

Even so, many of the participating countries will face a major challenge to maintain the traditional levels of per capita fish consumption due to the combined effects of population growth and climate change, particularly by 2050 under both SSP2-4.5 and SSP5-8.5. The Programme activities to assist countries to make FADs an integral part of the national infrastructure for food security, to increase the availability of unloaded and transhipped tuna and bycatch from commercial fishing operations for local consumption and to maximise the shelf-life of tuna and other fish species through development of post-harvest methods, will lay the foundation for progressive expansion of these adaptations as the impacts of climate change continue to increase.

5.2 Key recommendations

Several recommended adaptations have already been made about how to minimise loss of coastal fisheries production during climate change and how to fill the gap in fish supply by increasing access to tuna to supply the protein needed for national food security (Bell et al. 2018a). Those recommendations have been reinforced and expanded by this vulnerability analysis. The recommendations directly relevant to the GCF Programme are summarised below. The full set of recommendations is provided in Appendix E.

- Facilitation of improved preparedness of countries to cope with the likelihood of significant inter-annual variability and long-term declines in coastal fisheries biomass and catches, and compounding impacts from episodic events, such as marine heat waves. Specific adaptations to reduce such impacts include:
    - Expansion of the use of anchored FADs to diversify catches to include greater proportions of tuna and other nearshore pelagic fish, and to divert fishing effort from coastal habitats to reduce pressure on vulnerable coastal fish stocks.
    - Improved post-harvest methods that prolong the shelf-life of tuna and other pelagic fish (e.g., preservation methods using smoke curing, salting and drying).
    - Exploration of the potential for alternative fisheries that could be sustainably harvested, such as small fish pelagic species (e.g., mackerel, anchovies, pilchards, sardines, flying

fish, scads, fusiliers), and squid, including fishing for some of these species when they associate with FADs.

- Continued investment in the development and implementation of standardized data collection systems and tools appropriate for measuring the catches of coastal fish species in the Pacific context (e.g., IKASAVEA), including for use in monitoring catches made around FADs.

- Active education and awareness-raising among government authorities and communities about (i) the role of coastal habitats in sustaining healthy fisheries resources, and the interconnectivity of habitats; (ii) the consequences of poor land use and fishing practices on coastal habitats and fish stocks; and (iii) the expected further impacts of climate change of coastal fisheries production and the need to rely on replacing much of the previous coastal fish catch with tuna and other nearshore pelagic fish to maintain the traditional benefits of fish for good nutrition. Importantly, the increased engagement with communities should ensure approaches are appropriate to the national context and be locally led and understood.

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Note that this Section also includes references cited in the Executive Summary, Introduction and Appendices A – E.

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Component B

6. Background on the nature and importance of industrial tuna fisheries in the Pacific Island region

6.1 Target species, fisheries characteristics and harvest level trends

The industrial tuna fisheries in the Pacific Islands region are dominated by skipjack, yellowfin and bigeye tuna, and South Pacific albacore (which has two separate stocks in the north and south Pacific Ocean). Together, these four tropical tuna species represent >90% of the total catch taken by both foreign and domestic industrial fishing fleets in the Western and Central Pacific Ocean (WCPO) (Williams and Ruaia 2023). The remainder of the catch is comprised predominantly of billfish, sailfish and oceanic sharks.

The largest of the two main industrial tuna fisheries is commonly referred to as the 'surface fishery', which is dominated by purse-seine and pole-and-line vessels (Figure 6.1) targeting skipjack tuna and the smaller size classes of yellowfin tuna (<80 cm fork length, FL) in the tropical and subtropical WCPO for canning. Since the 1990s, the use of fish aggregating devices (FADs) to attract and temporarily retain schools of tuna has been widely adopted by purse-seine vessels. Today, half of the total purse-seine catch is taken around FADs (Williams and Ruaia 2023).

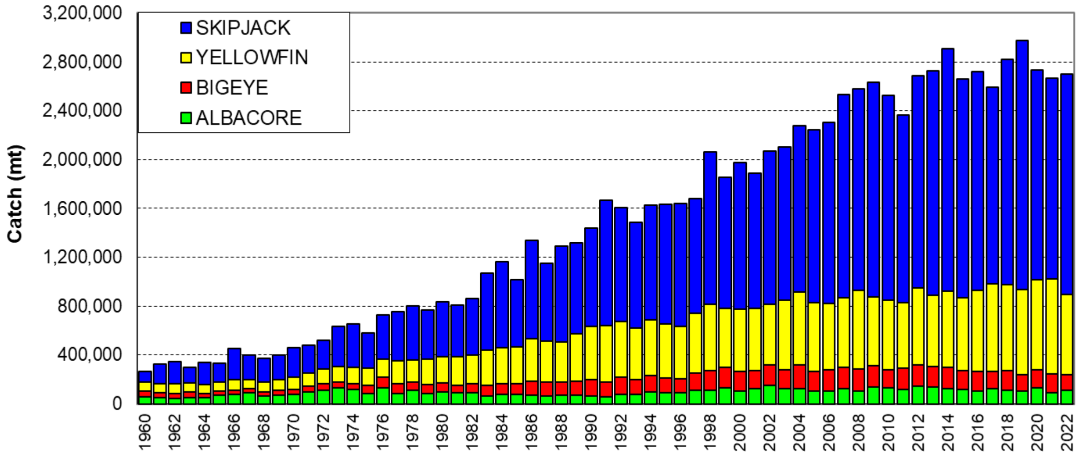


Figure 6.1 Catch (mt) of tuna from the Western and Central Pacific Ocean since 1960 made by purse seine, longline, pole-and-line and other gear types (Source Williams and Ruaia 2023).

The second of the two main industrial tuna fisheries is based on longline vessels that target larger bigeye tuna (> 90 cm FL) and yellowfin tuna (>70 cm FL) in equatorial waters for the Japanese sashimi trade and other high-value markets. In subtropical waters (between 20^{o} and 40^{o} latitude north and south), the longline fishery catches mainly albacore for canning, but also a proportion of high-value yellowfin and bigeye tuna. Although the longline fishery now accounts for only 8–10% of the total catch in the WCPO (Figure 6.1), the landed value is similar to that of the purse-seine catch (Williams and Ruaia 2023). This fishery includes large distant-water freezer longliners targeting either tropical (yellowfin and bigeye tuna) or subtropical (albacore tuna) species, and smaller offshore vessels that are usually domestically-based, with ice or chill capacity. There are several foreign and domestic longline fleets based in Pacific Island countries and territories (PICTs). The domestic small vessels catching albacore have achieved an increasing share of the annual catch in their exclusive economic zones (EEZs), representing approximately 50–60% of the catches of this species in recent years. As a result, South Pacific albacore is an important resource for PICTs located in subtropical waters unable to benefit from the large surface tuna resource in the equatorial region (see Section 6.4).

Collectively, the industrial tuna fisheries operating in the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area (CA) harvested 2.6 to 3.0 million tonnes per year over the last 10 years (Figure 6.3) (Hare et al. 2022). Skipjack tuna, which is caught mainly by purse-seine fishing, dominates the catch (Figure 6.3). Recent trends observed in tuna fisheries of the WCPO are provided by Williams and Ruaia (2023) and a summary of trends in tuna catches from the WCPO in the last decade is given in Box 6.1.

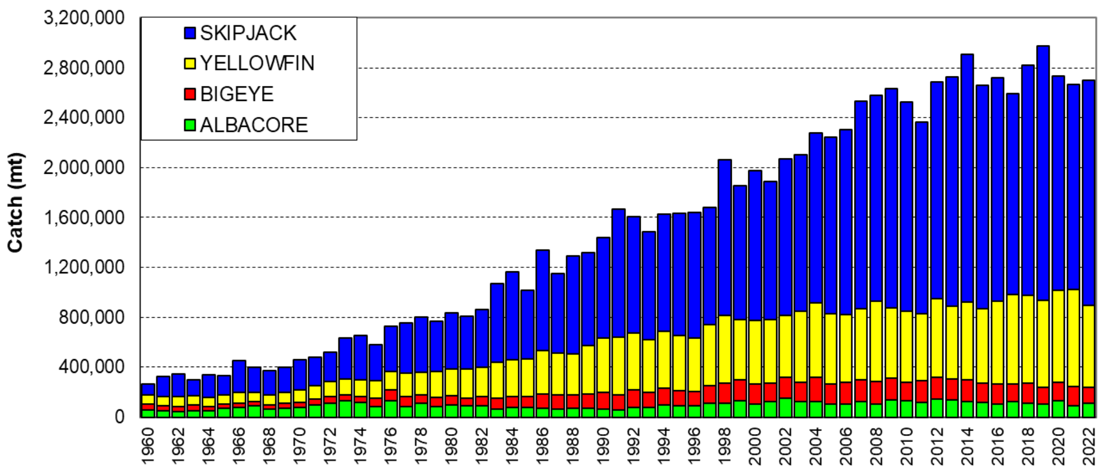


Figure 6.3 Catch (mt) of skipjack, yellowfin and bigeye tuna, and South Pacific albacore, in the Western and Central Pacific Ocean since 1960 (Source: Williams and Ruaia 2023).

Box 6.1 Summary of trends in tuna fisheries in the WCPO from 2012–2022

- Total catches by the purse-seine fishery have been stable, whereas the pole-and-line catch has declined (Figure 6.3).
- Conservation measures have been implemented to reduce the use of FADs to limit the catch of smaller (juvenile) bigeye and yellowfin tuna associated with FADs.
- Catches of tuna in the EEZs of PICTs are stable, albeit with ENSO-related interannual variability (Table 6.1).
- The number of purse-seine fishing vessels flagged by PICTs has increased, whereas the vessels flagged by distant water fishing nations has decreased.
- The number of longline vessels has decreased, although fishing effort represented by the total number of hooks has remained stable, with the exception of a decrease in 2020–2021 (potentially due to the COVID-19 pandemic).
- Longline catches have decreased since 2020, correlated to the decrease in effort (potentially due to the COVID-19 pandemic).
- Observer coverage of both purse-seine and longline fleets has increased as required by the WCPFC, except during the COVID-19 pandemic years of 2020 and 2021.
- Skipjack tuna catch has remained relatively stable, with a record high harvest in 2019 (above 2 million tonnes) followed by lower annual catches (~1.7 million tonnes) since then, potentially due to the COVID-19 pandemic in 2020 and 2021.
- Yellowfin tuna catch has been steadily increasing to around 700,000 tonnes per year since 2016 (from ~500,000 tonnes in 2000). This is primarily due to an increase in catch from purse-seine vessels (and other fishing gears used by Indonesian fleets). Yellowfin tuna catch by longline has been decreasing.
- Bigeye tuna catch by purse-seine has remained stable, Much of the longline catch is taken in the central Pacific, contiguous with the important traditional bigeye tuna longline area in the eastern Pacific, but has continued to decline since 2011, with the catch from 2021–2022 (~54,000 tonnes) being the lowest since 1984.
- South Pacific albacore catch has been increasing since 2009, with >90% coming from longline fleets since the mid-2000s. The highest catches have been taken during the last decade, fluctuating between 70,000 and 95,000 tonnes per year, with 45% caught from the EEZs of PICTs.
- Approximately 50% of the total tuna catch from the WCPO continues to come from the EEZs of PICTs, but mainly those in equatorial waters (see Section 6.4)

6.2 Status of stocks and estimated current sustainable production

The status of tuna stocks in the WCPO is assessed regularly by the regional fisheries management organisation, i.e., the WCPFC, using models that describe the population dynamics of each species, which can be taken by multiple fisheries. The most sophisticated of these models integrate catches from the various fleets, fish size and tagging data using quantitative methods to estimate stock size and fisheries parameters. The models are used to monitor the status of the four species of tuna to determine whether the stocks are able to support Maximum Sustainable Yield (MSY) or whether a stock is estimated to have crossed key management thresholds. The key indicators used to monitor stocks are:

1) 'Target' and 'Limit' reference points measured in terms of spawning biomass depletion, i.e., the ratio of spawning biomass in any year to the spawning biomass for that year, or an average of years, estimated to have occurred in the absence of fishing; and

2) the status of the spawning biomass (SB) in relation to the spawning biomass expected to result in maximum sustainable yield (SB_{MSY}).

Recent stock assessments suggest higher than average levels of recruitment over the last decade for skipjack, yellowfin and bigeye tuna, which has helped maintain spawning biomass above SB_{MSY}, despite increasing fishing mortality.

The MSY estimates from the most recent WCPFC stock assessments are:

- 2,933,000 t per year for skipjack tuna (Castillo-Jordan et al. 2022)
- 698,000 t per year for yellowfin tuna (Magnusson et al. 2023)
- 162,000 t per year for bigeye tuna (Day et al. 2023)
- 106,000 t per year for South Pacific albacore (Castillo-Jordan et al. 2021)

As a result of sound management (see Section 6.4), none of the four tropical tuna species caught in the WCPO have been overfished, nor are they currently subject to overfishing (Hare et al. 2022). The outcomes of the responsible tuna management arrangements implemented in the region are illustrated by sustained purse-seine catches. Over the last decade or so, annual purse-seine catches from the EEZs of PICTs have deviated little from the 10-year average of 1.4 million tonnes (coefficient of variation = 9%) (Bell et al. 2021).

6.3 Observed effects of climate variability on tuna

The dynamics of oceanic ecosystems and tuna populations are linked to multiple scales of climate variability, involving interconnected mechanisms between atmosphere and ocean. The El Niño Southern Oscillation (ENSO) is the most conspicuous climate signal in the Pacific Ocean, with large changes in distribution and migration patterns of marine fish such as tuna occurring in response to ENSO events (Lehodey et al. 2020). The largest of these changes in distribution is the east-west redistribution of skipjack tuna in the equatorial Pacific (Lehodey et al. 1997). The changes in skipjack tuna catch distributions have been associated with the effects of ENSO on the displacement of the easterly front of the Western Pacific Warm Pool (hereafter 'warm pool'), often characterised by the 29°C isotherm. In the far western Pacific, interannual variability in skipjack tuna catches is also partly linked to the oscillation of the Indian Ocean Dipole (IOD), another interannual mode of variability (Sagi et al. 1999; Webster et al. 1999). Although the major climate signals influencing tuna dynamics and fisheries in the WCPO are ENSO and IOD, the Pacific Decadal Oscillation (PDO) and Interdecadal Pacific Oscillation (IPO) also play a role. Further details of the climate signals driving variability in tuna catches are provided below and in Appendix F, and summarised in Box 6.2.

6.3.1 El Niño Southern Oscillation

It is now evident that although development of each ENSO phase involves common ocean-atmosphere patterns, each event varies in intensity and impact (Timmerman et al. 2018). Even so, changes in skipjack tuna distribution associated with ENSO have been confirmed over the last decade through tagging and fishing data and estimated using the Spatial Ecosystem and Population Dynamics Model (SEAPODYM) (Williams and Reid 2018; Senina et al. 2020).

Outputs from SEAPODYM suggest that the eastward extension and westward contraction in the distribution of skipjack tuna and their fisheries during El Niño and La Niña phases (Figure 6.4), respectively, are driven by changes in sea temperature, currents and prey distribution in the upper ocean (0–1,000 m). The positive (negative) impact of El Niño (La Niña) on the recruitment of skipjack tuna at basin scale has also been estimated by independent stock-assessment models (Figure 6.4), which show that the relationship is more evident when removing the upward long-term trend in the recruitment time series.

For yellowfin and bigeye tuna, and South Pacific albacore, that are longer-lived species, the potential impact of climate variability on recruitment is less evident because the low and high recruitment peaks associated with the climate signal are moderated as mortality and growth processes accumulate more and more variability in older cohorts. Nevertheless, an opposite relationship between recruitment of South Pacific albacore and ENSO events – with La Niña (El Niño) being more favorable (unfavorable) – has been observed in the stock assessment recruitment series incorporating the Southern Oscillation Index (Fournier et al. 1998). The most recent assessment also estimated an exceptionally low recruitment in 2016–17 that coincided with a powerful El Niño event peaking in the second half of 2015, given that age of South Pacific albacore recruitment to fisheries in the Pacific Ocean is around 1 year. If the observed relationship proves to be robust, the 2020–23 series of La Niña events would be expected to be favourable for recruitment of South Pacific albacore, with effects being detected through higher fisheries catch rates in the 1–2 subsequent years for surface fisheries targeting immature fish, and later years for the longline fisheries targeting adults.

6.3.2 Other variables influencing the distribution of tuna

The ways in which the five other variables – the PDO, IPO, size of the warm pool, primary productivity and dissolved oxygen levels – interact with ENSO and/or affect the distribution of tuna are explained Appendix F.

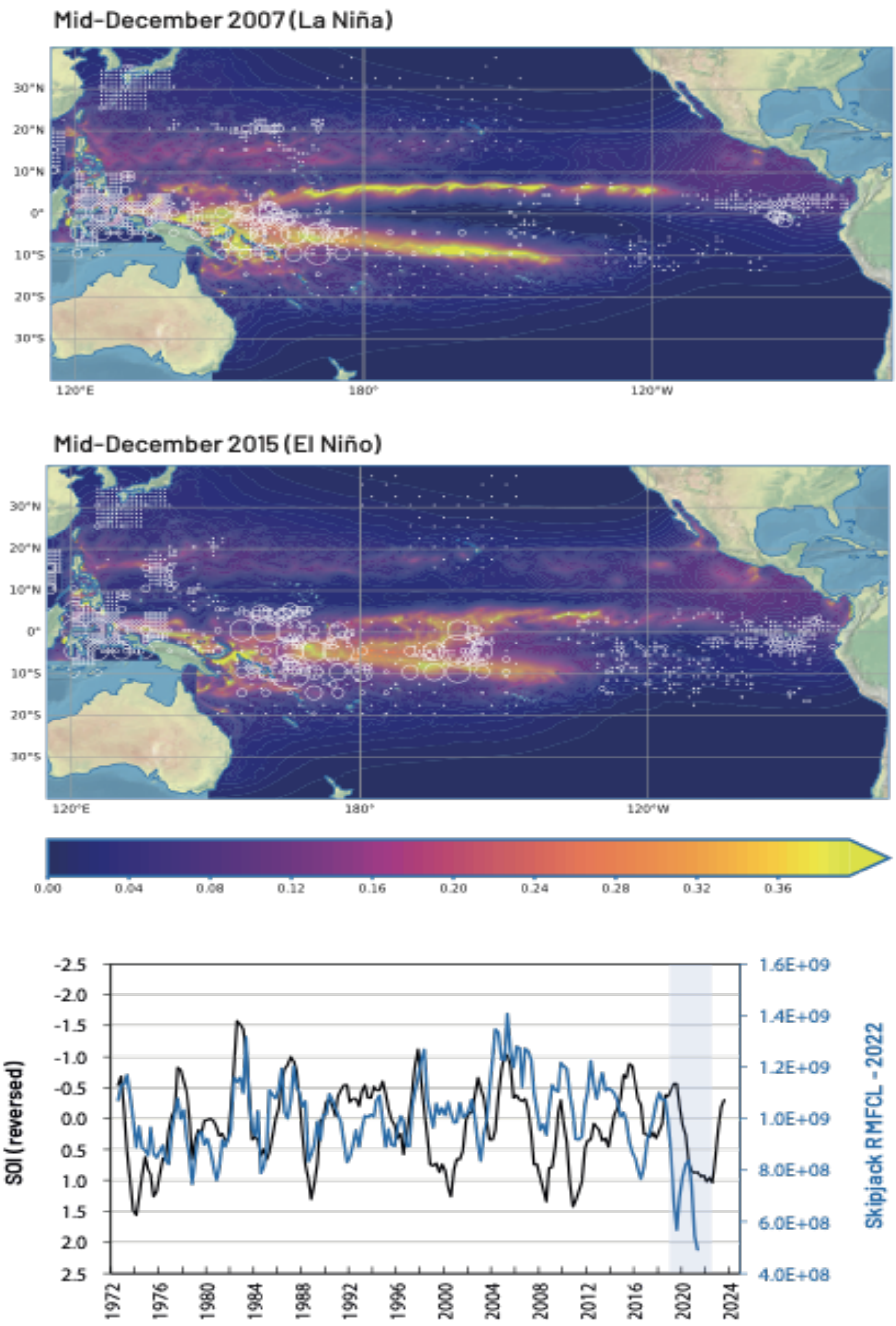


Figure 6.4. Influence of ENSO on skipjack tuna distribution and recruitment in the Pacific Ocean. Top two panels: distribution of skipjack tuna biomass predicted with SEAPODYM (colour scale in tonnes per km^2) and observed location of catch (circles) during typical La Niña and El Niño events. Bottom panel: Comparison of a de-trended (i.e., after removing the increasing long-term trend) time series of skipjack tuna recruitment index estimated in 2022 with the model MUTIFAN-CL used for a WCPFC stock assessment study and the Southern Oscillation Index (SOI reversed axis). A high negative (positive) SOI index indicates El Niño (La Niña). Note that, typically, standard stock assessment models do not reliably estimate the most recent years of recruitment (shaded) due to the absence of information on future adult stock.

Box 6.2 Summary of the main observed trends in Pacific climate variability and tuna

- Influence of ENSO on skipjack tuna distribution – there is an eastward extension (westward contraction) of the species' distribution and the targeted fisheries during El Niño (La Niña) phases. This has been observed in both fishing and tagging data since the 1990s and simulated by SEAPODYM with quantitative estimation of model parameters.
- There is a positive (negative) impact of El Niño (La Niña) events on the recruitment of skipjack tuna estimated by the WCPFC stock assessment model. In addition, an increasing trend in recruitment has been positively correlated with the expansion of the warm pool since the mid1980s.
- A negative (positive) impact of El Niño (La Niña) events on the recruitment of South Pacific albacore is evident in the latest stock assessment, suggesting a dip in recruitment in 2016–2017 as a likely result of the 2015 El Niño event.
- A rare series of three consecutive La Niña years occurred between mid-2020 and mid-2023 that could lead to larger than usual fluctuations in the skipjack tuna and South Pacific albacore populations.
- The frequency of ENSO events is modulated by the Interdecadal Pacific Oscillation (IPO), with more frequent El Niño (La Niña) episodes occurring during a positive (negative) IPO phase.
- A negative IPO phase since 1999 has reduced the impact of climate warming, and intensified trade winds. Its influence on primary production, the phytoplankton community and zooplankton biomass, as observed at the oceanographic station ALOHA and from satellite ocean colour data, needs to be clarified. Any such variability will have direct consequences on survival rates of tuna larvae and the food web supporting tuna stocks.
- Extension/contraction of the Oxygen Minimum Zone in the eastern Pacific and oxygen content in the equatorial region is influenced by IPO variability and associated changes in wind, mixing and primary production. These changes very likely impact the overall distributions of tuna species according to their specific oxygen requirements.
- A shift to a warm IPO phase in the coming years is expected, resulting in increasing global mean temperature, weakening of trade winds, and a decrease in productivity. However, future changes may be less than those projected by the existing climate models, which currently incorporate SST gradient biases between the east and west equatorial Pacific.

6.4 The role of industrial tuna fisheries in Pacific Island economies

Fishing for tuna plays a vital role in the economic development of many Pacific Island countries (Ruaia et al. 2022). However, in the case of nine of the countries participating in the regional GCF Programme, the contributions of tuna to their economies are so significant that these countries can be considered to be 'tuna-dependent' (Bell et al. 2021). More than 95% of all tuna caught from the jurisdictions of the 22 PICTs comes from the combined EEZs of these nine countries (Table 6.1), and access fees paid by industrial fishing fleets provide an average of 32% (range = 3-71%) of their (non-grant) government revenue (Figure 6.5). These extraordinary benefits have been secured mainly through co-operative management of the purse-seine fishery within the combined EEZs of eight of the nine tuna-dependent countries under the Parties to the Nauru Agreement (PNA) Vessel Day Scheme (VDS) (Box 6.3).

The socio-economic importance of tuna has been recognised by Pacific Island Leaders in their *Regional Roadmap for Sustainable Pacific Fisheries* (FFA and SPC 2015), which aims to sustain harvests, add value to catches, increase employment associated with tuna fishing and processing, and allocate more tuna for local food security. The *Roadmap's* sustainability goal is being achieved (see Section 6.2), largely due to co-operative management by PNA members (Box 6.3) under the auspices of the WCPFC. Co-operative management of the purse-seine fishery has also enabled tuna-dependent economies to adapt to the profound effects of the El Niño-Southern Oscillation (ENSO) on the extent of the warm pool (Section 6.3.1) and the associated distribution of the abundant skipjack tuna (Lehodey et al. 1997, 2011) (Box 6.3). The benefit of this adaptation is that it has stabilised the pre-existing, large, inter-annual variability in the contribution of tuna-fishing access fees to national economies (Aqorau et al. 2018; Clarke et al. 2021).

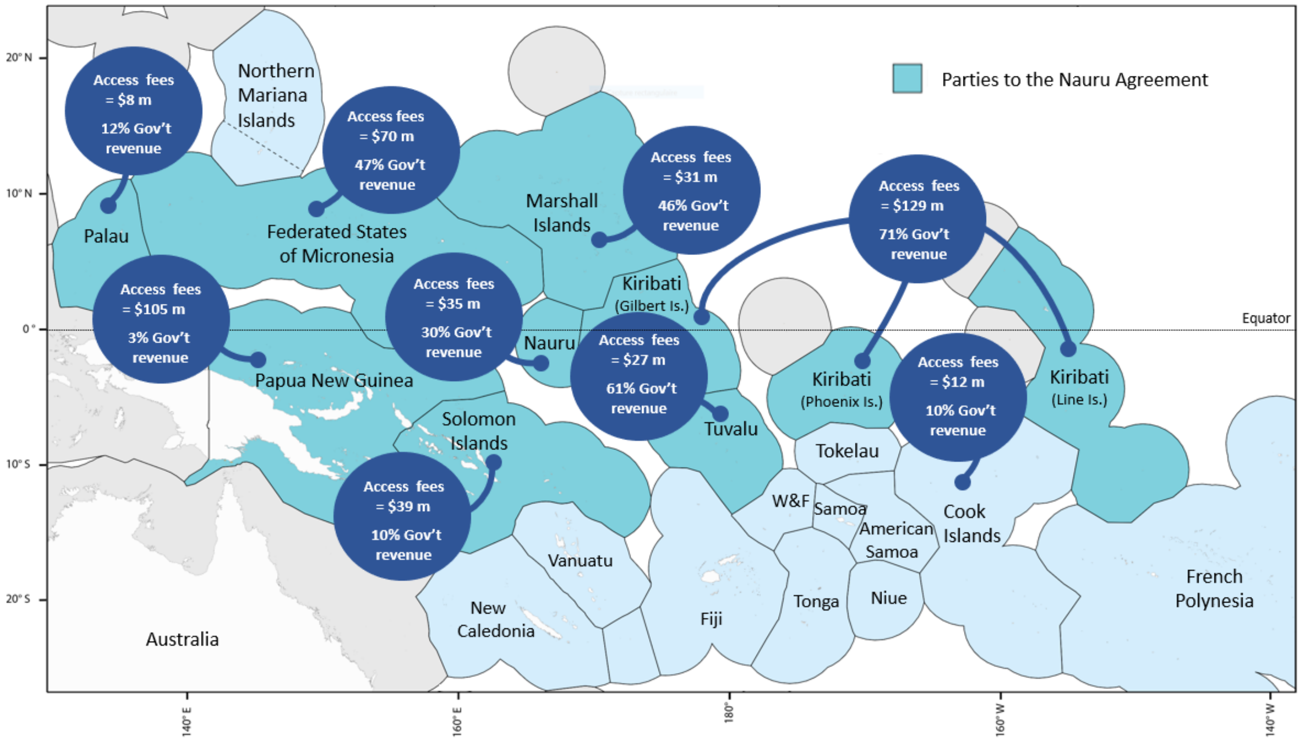


Figure 6.5 Average annual tuna-fishing access fees (US$) for the 6-year period 2015−2020 earned by the nine participating countries with tuna-dependent economies, with the average percentage contributions of access fees to total government revenue (excluding grants). The eight countries that also participate in the Parties to the Nauru Agreement (PNA) Vessel Day Scheme (VDS) (Box 6.3) are also shown (source: Pacific Islands Forum Fisheries Agency.

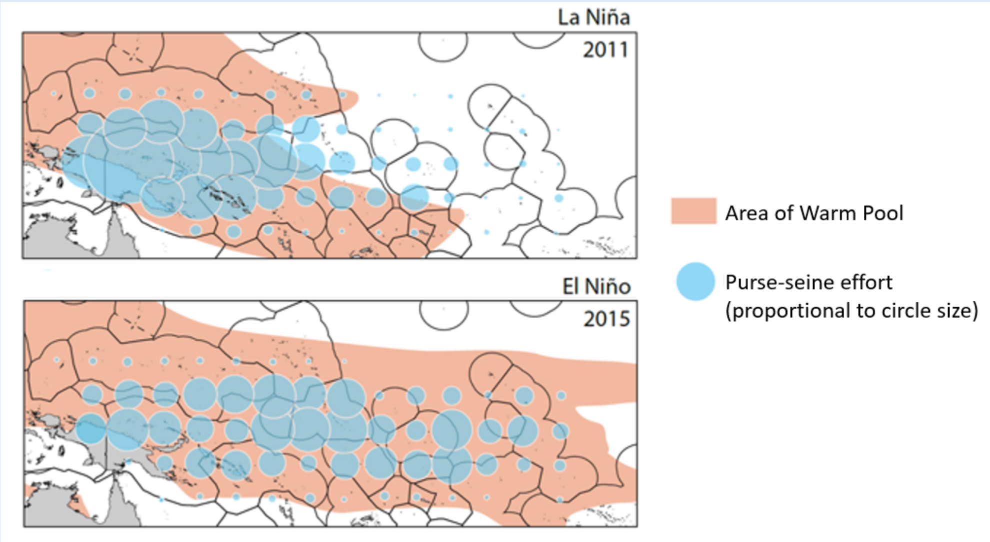
Table 6.1 Total annual catch in tonnes (t) for all tuna species, by all fishing methods, from the combined exclusive economic zones (EEZs) of all 22 Pacific Island countries (PICTs) between 2013 and 2022. PICTs have been divided into the nine tuna-dependent countries participating in the regional GCF Programme and the other 13 PICTs in the region (Other PICTs), including the other five countries participating in the GCF Programme. The average total tuna catch from the EEZ of each PICT for the 10-year period, and the average percentage (%) of the total regional tuna catch taken from each EEZ, are also shown. For Kiribati, data are presented for the total EEZ for the nation, and for each of three separate EEZ areas (in grey) comprising the total EEZ (source: Oceanic Fisheries Programme, Pacific Community).

PICT	Year										Average total catch (t)	%
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022		
Tuna-dependent participating countries												
Cook Is	16,650	20,310	24,578	13,878	24,048	40,071	35,944	17,125	6,486	12,353	21,144	1.4
FSM[1]	220,521	143,951	172,307	200,960	194,802	297,975	172,906	202,857	117,475	238,453	196,221	12.7
Kiribati	299,526	744,155	648,783	413,619	386,650	401,710	690,057	356,418	356,408	238,241	453,557	29.3
Gilbert Is	(191,165)	(443,047)	(318,802)	(334,893)	(266,157)	(288,642)	(562,579)	(274,921)	(312,180)	(183,917)	(317,630)	20.5
Line Is	(31,894)	(63,779)	(189,433)	(32,617)	(30,869)	(35,562)	(72,538)	(36,910)	(24,546)	(29,596)	(54,774)	3.5
Phoenix Is	(76,467)	(237,330)	(140,549)	(46,109)	(89,625)	(77,505)	(54,939)	(44,586)	(19,682)	(24,728)	(81,152)	5.2
Marshall Is	46,352	88,657	37,845	90,895	33,143	36,453	13,765	47,293	66,431	44,344	50,518	3.3
Nauru	163,812	179,776	67,193	115,738	82,316	174,916	105,693	135,819	150,172	79,556	125,499	8.1
Palau	3,209	4,995	1,574	6,134	20,599	9,560	6,654	898	1,308	693	5,562	0.4
PNG[2]	619,155	345,452	190,766	351,641	392,152	376,702	379,793	481,288	482,065	712,236	433,125	28.0
Solomon Is	131,741	88,479	126,373	165,261	171,928	89,868	72,035	109,735	121,892	155,074	123,239	8.0
Tuvalu	57,016	99,163	76,931	124,199	57,607	90,160	120,528	89,831	78,596	61,427	85,546	5.5
Subtotal	**1,557,981**	**1,714,937**	**1,346,350**	**1,482,324**	**1,363,245**	**1,517,415**	**1,597,374**	**1,441,263**	**1,380,832**	**1,542,377**	**1,494,410**	96.5
Other PICTs	46,270	58,065	83,806	45,764	77,991	68,058	39,116	48,036	31,570	36,439	**53,557**	3.5
TOTAL	**1,604,251**	**1,773,003**	**1,430,156**	**1,528,089**	**1,441,237**	**1,585,473**	**1,636,490**	**1,489,299**	**1,412,402**	**1,578,816**	**1,547,967**	**100.0**

Box 6.3 The Parties to the Nauru Agreement (PNA) Vessel Day Scheme*

The Pacific Island countries that are the Parties to the Nauru Agreement (PNA) (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu) have developed a system for jointly managing the purse-seine fishery targeting skipjack tuna within their combined exclusive economic zones (EEZs) called the Vessel Day Scheme (VDS).

The 'cap and trade' VDS sets the total annual purse-seine fishing effort within the combined EEZs of PNA members at ~45,000 fishing days and allocates these days to members based on individual EEZ areas and their past 8-10 years of fishing effort history. The VDS provides a trading mechanism among PNA members, allowing them to respond to the profound effects of the El Niño Southern Oscillation (ENSO) on the Western Pacific Warm Pool and the prime fishing grounds for skipjack tuna. During La Niña events, the best catches of skipjack tuna are made in the west of the region (see top panel in the diagram below), whereas during El Niño events fishing is most efficient up to 4,000 km to the east (see bottom panel). During La Niña events, the VDS enables countries in the west to buy fishing days from members in the east, enabling fleets to keep fishing in the west. The reverse occurs during El Niño events. Therefore, regardless of where the tuna are caught, all PNA members receive access fees every year. In this way, the VDS evens out the previously high inter-annual variability in access fees received by PNA members and helps stabilize government revenue for tuna-dependent economies.



The various provisions of the VDS, i.e., transferability of fishing days among PNA members, 'pooling' of days by groups of members, and 'roaming' of vessels from PNA member countries among their collective EEZs, also provide non-confrontational adaptations to the progressive redistribution of skipjack tuna within the combined EEZs of PNA members due to ocean warming (Aqorau et al. 2018; Clarke et al. 2021). However, the VDS does not encompass adaptations for climate-driven redistribution of tuna from the EEZs of PNA members to high-seas areas.

*Source: Bell et al. (2021)

7. Methods used for Component B

7.1 Assessing climate-driven tuna redistribution by 2050

The 'Spatial Ecosystem and Populations Dynamics Model' (SEAPODYM) framework (Lehodey et al. 2008) was used to assess how high, RCP8.5 (SSP5-8.5 equivalent), and moderate, RCP4.5 (SSP2-4.5 equivalent), emissions scenarios are likely to affect the distribution of the four tropical tuna species by 2050 (10-year average 2046–2055).

Full details of the modelling approach are provided in Appendix G. Some of the key features, considerations and implications of the modelling approach are provided below.

- The SEAPODYM framework describes the spatial dynamics of tuna species as well as micronekton biomass distributions at basin and global scales, under the influence of both fishing and environmental effects.
- The model first simulates the prey dynamics (Lehodey et al. 2010) (food webs) and then the age-structured population dynamics of tuna with different rules according to life stage (Lehodey et al. 2008; Senina et al. 2020).
- Several developments to the framework have occurred in the last few years to improve the modelling of spawning and feeding habitats and behaviours, fishing mortality and model parameter estimations from various datasets of observations, including fishing catch and effort, size frequencies of catches, and tagging data.
- A phase of model parameter optimisation over the historical period 1980–2010 provided reference parameter estimates prior to running the projections.
- To account for uncertainty associated with different Earth System Model projections, forcings from four models were selected (Table 7.2) based on their ability to best capture ENSO-type variability (Bellenger 2014).
- The ensemble of models provides simulations that couple physical and biogeochemical processes with pelagic ecosystem biological and tuna-specific dynamics under moderate (RCP4.5) and high (RCP8.5) emissions scenarios. These simulations are based on the CMIP5 climate model forcings.
- Earth System Model physical and biogeochemical outputs using the latest CMIP6 scenarios cannot yet be used for the tuna simulations. This is due to the inevitable delay associated with processing the model forcings, including a phase of bias correction, that need to be followed by a phase of revision of the tuna models, for which the parameters need to be re-estimated. Nonetheless, the moderate and high emissions scenarios used are equivalent to those generated under CMIP6 for SSP2-4.5 and SSP5-8.5.
- The impacts of climate change on the distributions of the tropical tuna species in the Pacific Ocean are analysed by extracting the mean of tuna biomass for adults and recruits from the four-simulation ensemble for different areas, i.e., the EEZs of Pacific Island countries and international waters (high-seas areas).
- The vulnerability analysis of the four main tuna species exploited in the WCPO was carried out based on a review of potential impacts, the simulation results from the tuna models, and using multidisciplinary expertise.

Table 7.2 Earth System Models used to account for atmospheric forcing uncertainty in the modelling of the projected responses of tuna abundance and distribution to climate change.

Code	CMIP5 model
IPSL	IPSL-CM5A-MR (Institut Pierre Simon Laplace, France)
MIROC	MIROC-ESM (Model for Interdisciplinary Research on Climate, Japan)
MPI	MPI-ESM-MR (Max Planck Institute for Meteorology, Germany)
GFDL	GFDL-ESM2G (Geophysical Fluid Dynamics Laboratory, USA)

7.2 Assessing the vulnerability of tuna catches by 2050

Projecting changes to the productivity of the fisheries targeting the four tuna species described in Section 6.1 requires the definition of fishing scenarios relying on various socio-economic, technical, and political hypotheses, which are extremely challenging to define over the coming few decades. Although there are ongoing initiatives to create such scenarios (Maury et al. 2017), this assessment is limited to a preliminary analysis of the possible effects of changes in tuna biomass under RCP8.5 and RCP4.5 by 2050 on purse-seine catches in the EEZs of the nine participating countries with tuna-dependent economies. On a multi-annual average basis, it is assumed that the projected changes to tuna biomass will result in approximately proportional changes in catch (Bell et al. 2021).

Because purse-seine catches are comprised of different proportions of skipjack, yellowfin and bigeye tuna, and because each species is projected to have a different response to ocean warming, changes in purse-seine catches under each emissions scenario by 2050 were estimated as the weighted mean responses of all three tuna species combined. These estimates were derived from the average relative abundance of each species in purse-seine catches in the EEZs of each country and the projected percentage change in biomass of each species under each emission scenario (see Supplementary Table 3 in Bell et al. 2021).

The weighted average percentage changes in biomass of all tuna species combined were then applied to 10-year average purse-seine catches from the EEZs of the nine countries to estimate the changes in purse-seine catches for these jurisdictions. In the case of Kiribati, which has three separate EEZ areas (Figure 6.5), the change in catch for each EEZ area was estimated as described above and then amalgamated to produce the overall estimated change in purse-seine catch for the country.

The projected percentage change in total purse-seine catch differs from the percentage change in total tuna biomass due to variation in the relative contributions of the three tuna species to total catch and to total biomass.

7.3 Assessing vulnerability of economies to projected changes in catch by 2050

To assess the potential effects of climate-driven redistribution of tuna on the economies of the nine tuna-dependent countries, it was assumed that estimated changes in purse-seine catch within their EEZs due to the climate-driven redistribution of tuna biomass described above would result in a proportional change in access fees earned from purse-seine fishing and associated operations.

To estimate the effects of RCP8.5 and RCP4.5 on the capacity of Pacific Island governments to earn access fees from industrial tuna fishing, and the contributions of these access fees to total government revenue excluding grants (hereafter 'government revenue'), the annual averages of government revenue, tuna-fishing access fees earned by the nine countries, and the average percentage contribution of access fees to their government revenue (see Supplementary Table 2 in Bell et al. 2021) were used as a baseline. The projected changes in total purse-seine catch in each EEZ for RCP8.5 and RCP4.5 were then applied to the average annual access fees received to estimate the change in value of access fees by 2050 for each emissions scenario. The change in access fees was used to adjust government revenue in 2050 under both emissions scenarios, assuming that the relative contributions of the various sources of government revenue remain the same. For both emissions scenarios, the estimated government revenue and access fees in 2050 were used to calculate the percentage contribution of tuna-fishing access fees to government revenue in 2050. Finally, percentage contributions of average annual access fees to recent government revenue, and projected revenue in 2050 were compared to estimate the potential changes to these contributions under RCP8.5 and RCP4.5 by 2050.

The estimated percentage changes in government revenue for each of the nine tuna-dependent economies do not account for i) management responses; ii) variation in the value of access to particular EEZs and the willingness of fleets to pay for this access due to the effects of changes in tuna biomass on catchability of each species, levels of fishing effort/catch rates, or changes to the price of tuna or cost of landing the tuna; and iii) the impact of tuna redistribution on the degree of control that these countries exert over fisheries targeting tuna. The latter factor is expected to be particularly important. For example, substantial movement of tuna from the EEZs of PNA countries into high-seas areas would be expected to limit the effectiveness of the Vessel Day Scheme (Aqorau 2009) by reducing the degree of control over the fishery exerted by PNA members.

Overall, it is important to note that the simple approach used to assess the potential effects of tuna redistribution on government revenue is intended only to provide indicative information on the magnitude of these impacts. To obtain more robust estimates of climate-driven changes in government revenue, significantly more complex bio-economic analyses will be required, beginning with, for example, a fleet-dynamics analysis to investigate the potential response of purse-seine vessels to redistribution of tuna and the flow-on effects on access fees.

8. Vulnerability of tuna fisheries and dependent economies

8.1 Projected redistribution of tuna caught by purse-seine fishing by 2050

The projected climate-driven redistribution of the three tuna species caught by purse-seine fishing (skipjack, yellowfin and bigeye tuna) under RCP8.5 by 2050 is shown in Figure 8.1. The expected vulnerabilities of these species to the effects on increased GHG emissions on the tropical Pacific Ocean are summarised in Appendix H.

The modelling depicted in Figure 8.1 indicates that their total biomass in the combined jurisdictions of the tuna-dependent Pacific Island countries would decrease by an average of ~13% (range = -5% to -20%) (Figure 8.2a), and by up to ~30% in the majority of the individual EEZ areas (see Supplementary Table 5 in Bell et al. 2021). Conversely, tuna biomass is projected to increase by an average of ~23% (range = 13% to 32%) in the central eastern Pacific Ocean (EPO-C, Figure 8.2a), the high-seas area where most tuna are caught (see Supplementary Table 4 in Bell et al. 2021). These projected changes in tuna biomass by 2050 generally reflect the contrasting responses of sea surface temperature, primary production and the prey organisms of tuna to RCP8.5 in the WCPO and EPO (see Supplementary Figures 3 and 4 in Bell et al. 2021).

The projected effects of the moderate RCP4.5 emissions scenario (hereafter RCP4.5) on redistribution of tuna biomass are far less pronounced (Figures 8.1 and 8.2a). Under this scenario, total biomass of tuna in the combined EEZs of the tuna-dependent countries decreases by only an average of 1% (range = -9% to +8%), and decreases occur on average in only three EEZ areas (see Supplementary Table 7 in Bell et al. 2021). In contrast, the projected effects of RCP4.5 on tuna biomass in high-seas areas are similar to those for RCP8.5, i.e., there is an average increase of ~18% (range = +9% to +32%) in EPO-C (Figure 8.2a). A possible explanation for the significant increases in tuna biomass in high-seas areas under RCP4.5 by 2050 is the stronger response to increased GHG emissions by the food web supporting tuna in the EPO than in the WCPO (see Supplementary Figure 4 in Bell et al. 2021).

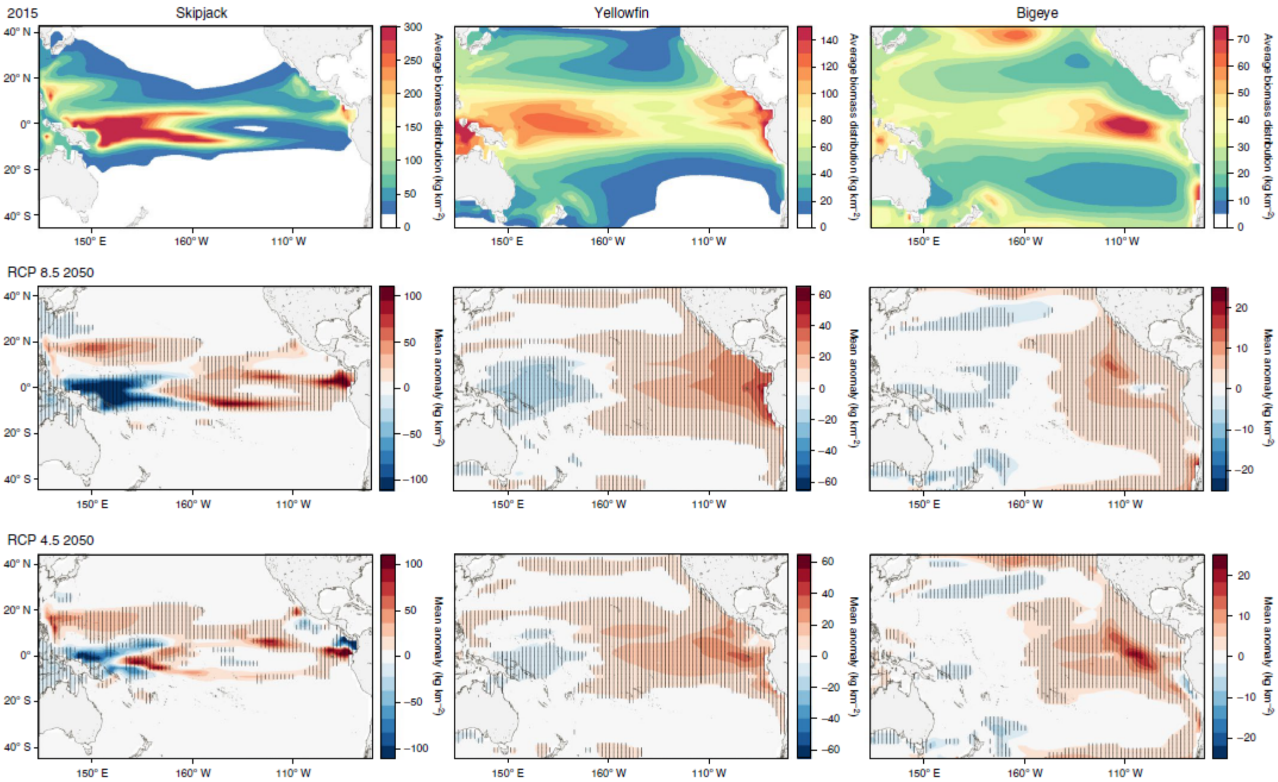


Figure 8.1 Projected effects of climate change on the distributions of the three tuna species caught by purse-seine fishing in the Pacific Ocean. Average biomass distributions (kg km^{-2}) of skipjack, yellowfin and bigeye tuna in the Pacific Ocean basin for 2015 (2011–2020) (top row) and mean anomalies (kg km^{-2}) from the average 2015 biomass distribution of each tuna species projected to occur by 2050 (2044–2053) under two emissions scenarios, RCP 8.5 (middle row) and RCP 4.5 (bottom row). Shading indicates areas where projections from all four ESMs (Section 7) agree in the sign of change, excluding near-zero changes (white zones). (Source: Bell et al. 2021).

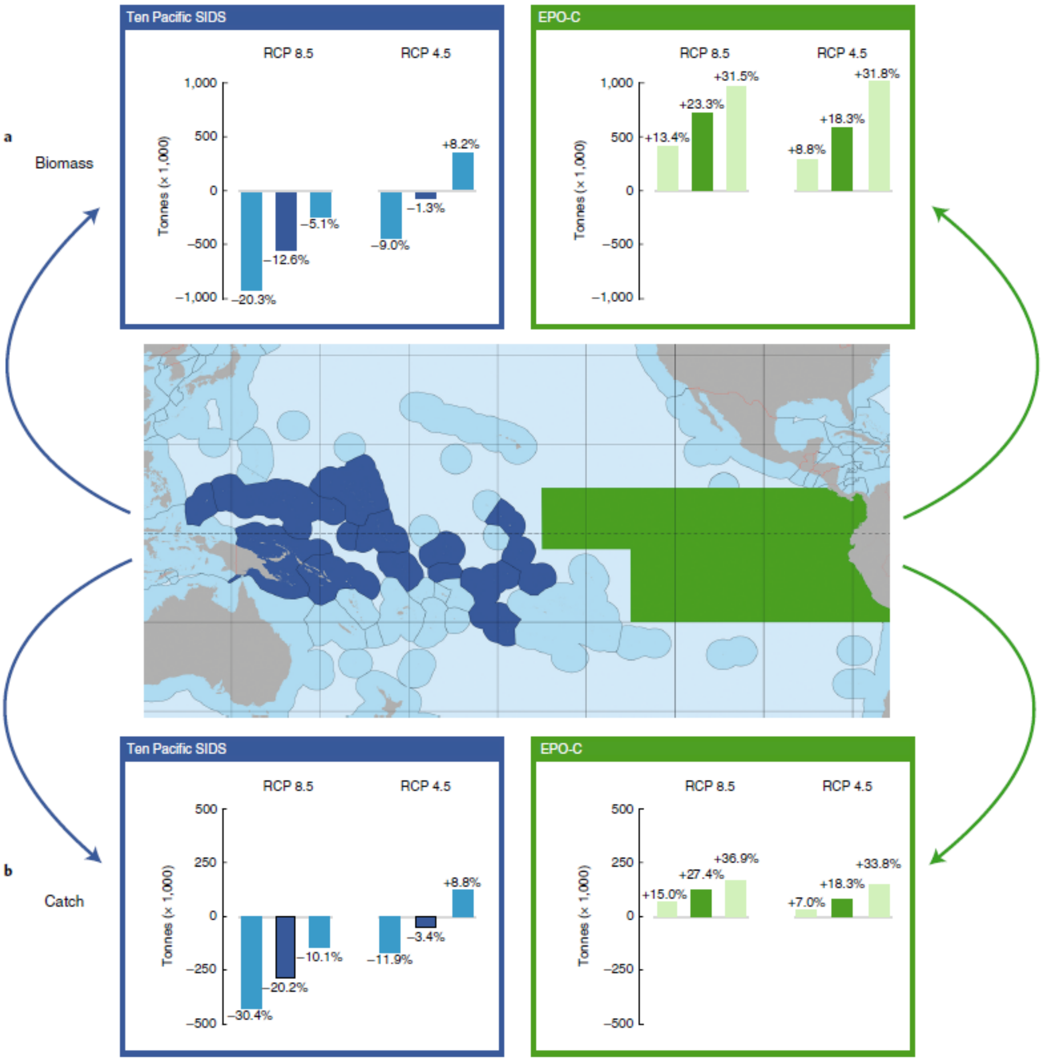


Figure 8.2 Redistribution of tuna biomass and purse-seine catch from the combined EEZs of the tuna-dependent Pacific Island countries to the central eastern Pacific Ocean. **a**, Projected changes in total biomass of skipjack, yellowfin and bigeye tuna in the combined EEZs and EPO-C under the RCP 8.5 and RCP 4.5 emissions scenarios in 2050 relative to the average biomass from these areas in 2009–2018. **b**, Projected changes in total purse-seine catch in the combined EEZs and EPO-C under the RCP 8.5 and RCP 4.5 emissions scenarios in 2050 relative to the average catch from these areas in 2009–2018. The dark column in each histogram represents the average change from the four ESMs. The columns on either side of the average represent the maximum and minimum changes projected by the range of ESMs. Note that the information presented includes data from the territory of Tokelau. (Source: Bell et al. 2021).

8.2 Projected changes in purse-seine catches of tuna by 2050

The projected changes in tuna biomass due to increased GHG emissions are expected to affect purse-seine catches of tuna from the EEZs and high-seas areas (Section 7). By 2050 under RCP8.5, the total purse-seine catch from the combined EEZs of the tuna-dependent countries is estimated to decrease by an average of 20% (range = -30% to -10%), i.e., 284,000 tonnes (range = -428,000 to -143,000 tonnes), but increase by an average of 27% (range = +15% to +37%), i.e., 125,000 tonnes (range = +69,000 to +169,000 tonnes) in EPO-C (Table 8.1, Figure 8.2b).

The projected changes in purse-seine catch by 2050 under RCP4.5 also follow the patterns in tuna biomass, decreasing by an average of 3% (range = -12% to +9%), i.e., 47,000 tonnes (range = -165,000 to +124,000 tonnes) in the combined EEZs of the tuna-dependent countries, and increasing in EPO-C by an average of 18% (range = +7% to +34%), i.e., 84,000 tonnes (range = +32,000 to +154,000 tonnes) (Table 8.1, Figure 8.2b).

8.3 Projected changes in government revenue

The estimated changes in purse-seine catch under RCP8.5 could reduce total annual fishing access fees earned by the tuna-dependent economies by an average of USD 90 million (range = USD 40-140 million) per year compared to the average annual revenue received between 2015 and 2018 (Table 8.2, see also Supplementary Table 15 in Bell et al. 2021). Losses in access fees are estimated to occur in all countries under RCP8.5, and reduce total government revenue by up to 13% (range = -8% to -18%) for individual Pacific SIDS, by 2050 (Table 8.2, see also Supplementary Table 15 in Bell et al. 2021).

Under RCP4.5, the average change in access fees for all tuna-dependent economies represents a loss of USD 12 million (range = -USD 54 million to +USD 48 million) per year (Table 8.2, see also Supplementary Table 16 in Bell et al. 2021). Due to the more limited loss of access fees under RCP4.5, total government revenue in 2050 is estimated to decrease by an average of 1% or less in only three of the countries (Table 8.2, see also Supplementary Table 16 in Bell et al. 2021).

The estimates of reduced access fees, and flow-on losses in government revenue, due to climate-driven redistribution of tuna include a number of assumptions (Section 7) but, overall, are likely to be conservative because they do not account for the control that the PNA members exert in the marketplace. At present, the PNA members command high access fees due to the fact that ~90% of the catch from the purse-seine fishing grounds within the Pacific Island region of the WCPO comes from their combined EEZs. However, if there is significant movement of fish from the EEZs to high-seas areas, the tuna-dependent countries would be unlikely to obtain the same daily rates for fees. Any such effects are also likely to occur to some extent under RCP4.5, which is projected to reduce catches in the combined EEZs of the countries by ~50,000 tonnes, and increase catches in high-seas areas by more than 100,000 tonnes (Table 8.1).

Table 8.1 10-year (2009-2018) average purse-seine tuna catches in tonnes (t) from a) the exclusive economic zones (EEZs) of tuna-dependent Pacific Island countries, and b) high-seas areas (see Supplementary Figure 1 in Bell et al. 2021), together with average projected changes to these catches by 2050 in tonnes and percentage terms under the RCP8.5 and RCP4.5 emissions scenarios. Highlighted rows are the three EEZ areas of Kiribati, which have been integrated to produce the total for Kiribati. Note that the information presented includes data from the territory of Tokelau

Area	Average catch (t)	RCP8.5 - 2050			RCP4.5 - 2050		
		Catch (t)	Change (t)	Change (%)	Catch (t)	Change (t)	Change (%)
• **EEZs of tuna-dependent Pacific Island countries**							
Cook Islands	11,080	10,640	-440	-4.0	12,065	+985	+ 8.9
FSM	178,587	155,407	-23,180	-13.0	173,773	-4,815	-2.7
Kiribati	396,048	363,520	-32,528	-8.2	423,251	+ 27,202	+6.9
Gilbert Islands	(260,073)	(225,177)	(-34,896)	(-13.4)	(278,023)	(+17,950)	(+6.9)
Phoenix Islands	(94,696)	(92,140)	(-2,557)	(-2.7)	(101,132)	(+6,435)	(+6.8)
Line Islands	(41,279)	(46,203)	(+4,924)	(+11.9)	(44,096)	(+2,817)	(+6.8)
Marshall Islands	37,003	36,728	-275	-0.7	37,778	+ 775	+2.1
Nauru	110,794	86,886	-23,908	-21.6	117,059	+6,266	+5.7
Palau	2,655	2,646	-9	-0.3	2,738	+ 82	+3.1
Papua New Guinea	461,032	308,404	-152,628	-33.1	389,654	-71,378	-15.5
Solomon Islands	116,877	86,399	-30,477	-26.1	106,740	-10,137	-8.7
Tokelau	21,392	17,954	-3,438	-16.1	22,610	+1,218	+ 5.7
Tuvalu	73,080	55,992	-17,088	-23.4	75,589	+2,509	+ 3.4
Total	**1,408,548**	**1,124,577**	**-283,971**	**-20.2**	**1,361,257**	**-47,291**	**-3.4**
• **High-seas areas**							
I1	15,330	11,396	-3,934	-25.7	13,541	-1,790	-11.7
I2	23,083	16,413	-6,670	-28.9	20,738	-2,345	-10.2
I3	47	60	+13	+27.8	61	+14	+29.8
I4	21,443	21,773	+ 330	+1.5	22,727	+1,284	+6.0
I5	23,231	28,021	+4,790	+20.6	26,194	+2,963	+12.8
I6	16,211	16,868	+657	+4.1	17,800	+1,589	+9.8
I7	16.7	18	+1.3	+9.0	17	+0.2	+1.3
I8	2.2	3	+0.8	+15.5	3	+ 0.4	+20.2
I9	33.2	41	+7.8	+24.7	36	+3	+8.9
H4	20,893	17,796	-3,097	-14.8	23,308	+2,415	+11.6
H5	46,517	49,502	+2,985	+6.4	48,360	+1,842	+4.0
EPO-N	84,175	100,443	+16,268	+19.3	98,130	+ 13,955	+16.6
EPO-C	457,664	583,082	+125,418	+27.4	541,194	+ 83,530	+18.3
EPO-S	3,293	4,339	+1,046	+31.8	3,747	+ 454	+13.8
Total	**711,939**	**849,755**	**+137,816**	**+19.4**	**815,856**	**+103,917**	**+14.6**

(Source: Bell et al. 2021).

Even at conservative levels, the estimated losses in fishing access fees are expected to have significant implications for economic development. They would coincide with the need for increased financial resources and flexibility to adapt to climate change, including sustained government facilitation of community-based initiatives (McNamara et al. 2020). The projected reductions in tuna biomass and catch are also expected to affect the ability of many of tuna-dependent countries to harmonise the employment, value-adding and food security goals of the *Roadmap* for *Sustainable Pacific Fisheries*, and achieve sustainable development (Pecl et al. 2017; Lam et al. 2020). With a lower biomass of tuna within their EEZs, several of the participating countries may need to use to a greater proportion of their tuna resources for local consumption (see Component A), further limiting the scope for earning access fees and potentially reducing the supply of tuna that supports employment in national canneries.

Table 8.2 Average government revenue (excluding grants), tuna-fishing access fees, and the percentage of government revenue derived from access fees, for tuna-dependent Pacific Island economies between 2015-2018, together with estimated changes in purse-seine tuna catch, access fees, and the percentage contribution of access fees to government revenue, by 2050 under the RCP8.5 and RCP4.5 emissions scenarios. See Supplementary Tables 15 and 16 in Bell et al. 2021 for ranges of estimated percentage changes in access fees and government revenue by 2050. Note that the information presented includes data from the territory of Tokelau. (Source: Bell et al. 2021).

Country	Average 2015-2018			Change by 2050 (RCP8.5)			Change by 2050 (RCP4.5)		
	Gov't revenue (USD million)	Access fees (USD million)	Gov't revenue (%)	Purse-seine tuna catch (%)[1]	Access fees (USD million)	Gov't revenue (%)	Purse-seine tuna catch (%)[1]	Access fees (USD million)	Gov't revenue (%)
Cook Is.	126.1	13.5	10.6	-4.0	-0.5	-0.4	+8.9	+1.2	+1.0
FSM*	150.6	68.4	47.6	-13.0	-8.9	-5.9	-2.7	-1.8	-1.2
Kiribati	181.7	128.3	70.6	-8.2	-10.5	-5.8	+6.9	+8.9	+4.9
Marshall Is.	66.1	31.0	47.8	-0.7	-0.2	-0.3	+2.1	+0.7	+1.0
Nauru	98.6	29.5	31.1	-21.6	-6.4	-6.5	+5.7	+1.7	+1.7
Palau	75.2	7.1	9.4	-0.3	-0.02	-0.03	+3.1	+0.2	+0.3
PNG**	3360.8	134.3	4.0	-33.1	-44.4	-1.3	-15.5	-20.8	-0.6
Solomon Is.	429.0	41.3	9.6	-26.1	-10.8	-2.5	-8.7	-3.6	-0.8
Tokelau	16.0	13.4	84.2	-16.1	-2.1	-13.4	+5.7	+0.8	+4.8
Tuvalu	47.4	25.6	53.9	-23.4	-6.0	-12.6	+3.4	+0.9	+1.9
TOTAL		492.4			-89.9			-12.0	

8.4 Projected changes in biomass of South Pacific albacore by 2050

South Pacific albacore is not taken by purse-seine fishing and therefore features most prominently in the five participating countries in subtropical waters where industrial tuna fishing is generally limited to longline fishing (Fiji, Niue, Samoa, Tonga and Vanuatu), as mentioned in Section 6.1.

The modelling to date for South Pacific albacore has been limited to the RCP8.5 emissions scenario. Under this scenario, the projected changes in biomass have some similarities to the projections for the other three tuna species in that biomass is expected to increase in the EPO (Figure 8.3) and decrease throughout much of the WCPO. Biomass of South Pacific albacore is expected to decrease in the EEZs of four of the five Pacific Island countries in the subtropical Pacific that only benefit from the species; the exception is Tonga (Table 8.3). The particular vulnerabilities of South Pacific albacore to the projected changes in ocean variables by 2050 are summarised in Appendix H.

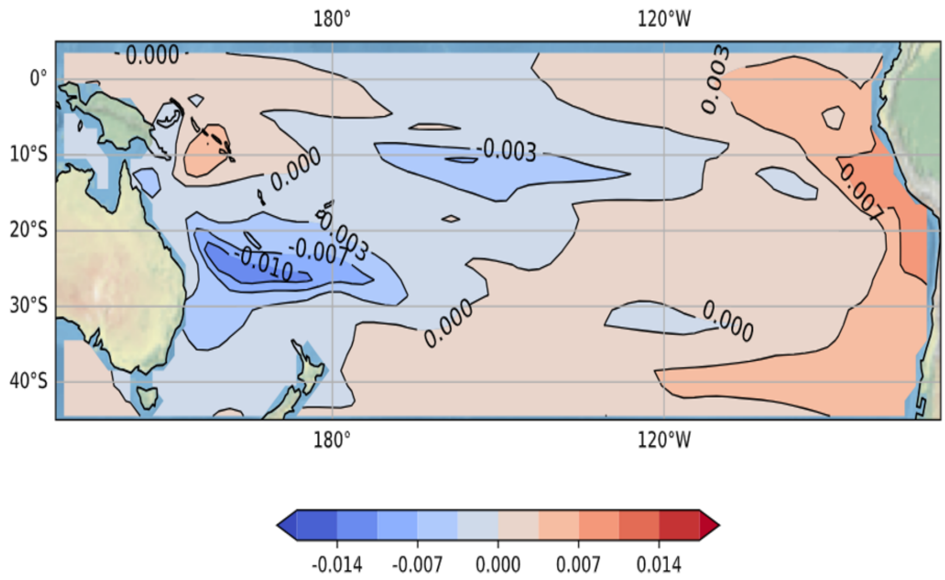


Figure 8.3 Projected differences (negative = blue; positive = red) between future (2046-2055) and historical (2001-2010) periods of mean distributions of total biomass in tonnes km^{-2} of South Pacific albacore across the Pacific Ocean under RCP8.5. The projection uses the high emissions scenario (RCP8.5) from the ensemble simulation. Source: Lehodey et al. (in press).

Table 8.3 Projected impact of RCP8.5 emissions scenario on biomass of South Pacific albacore over the decade 2046–2055 (2050) relative to the 2001–2010 in a) the exclusive economic zones (EEZs) of the 14 countries participating in the Programme; and b) high-seas areas (see Supplementary Figure 1 in Bell et al. 2021 for the locations of these areas). Source: Lehodey et al. (in press)

a)

EEZ	Biomass change (%)
Cook Islands	-5
Federated States of Micronesia	15
Fiji	-10
Kiribati-Gilbert	14
Kiribati-Phoenix	-7
Kiribati-Lines	8
Marshall Islands	0
Nauru	15
Niue	-4
Palau	38
Papua New Guinea	17
Samoa	-5
Solomon Islands	18
Tonga	8
Tuvalu	0
Vanuatu	-9

b)

High-seas area	Biomass change (%)
I1	4
I2	12
I3	
I4	-3
I5	-3
I6	
I7	-1
I8	-9
I9	-10
H4	5
H5	7
EPO-N	
EPO-C	8
EPO-S	19

8.5 Implications for fisheries management

The projected climate-driven redistribution of tuna biomass and purse-seine catches also have potential implications for sustainable management of the world's largest tuna fishery. In a scenario where a lower proportion of tuna resources is under the jurisdiction of the PNA VDS (Box 6.3), the sustainability of tuna catches could be at greater risk because the monitoring, control and surveillance required to combat illegal, unreported and unregulated fishing, and impose penalties for non-compliance, are more difficult in high-seas areas (MRAG 2016). This is because responsibility for compliance with fishing regulations on the high seas rests with the states that 'flag' fishing vessels (often resulting in self-regulation), whereas compliance within EEZs is under the purview of coastal states. With continued GHG emissions, the onus will be on WCPFC to implement tighter controls on fishing for tropical tuna species by all vessels operating in high-seas areas of the WCPO.

Sustainable management of tropical Pacific tuna resources will also be challenged by the substantial projected increases in average tuna biomass in the EPO-C high-seas area. particularly under RCP8.5 (Figure 8.2a, Table 8.1). This will necessitate closer collaboration between WCPFC and the regional fisheries management organisation (RFMO) for the EPO, the Inter-American Tropical Tuna Commission (IATTC). The shared governance arrangements between WCPFC and IATTC that are already in place for the overlap in their convention areas (see Supplementary Figure 1 in Bell et al. 2021) will need to be expanded and strengthened to avoid the problems that have accompanied management of climate-driven shifts in fish distribution in other jurisdictions (Pinsky et al. 2018; Oremus et al. 2020).

The top priority issues to be addressed during development of an expanded framework for cooperation between WCPFC and IATTC have been described by Goodman et al. (2022) and include: 1) a formal mechanism for cooperation to enable effective and efficient joint decision-making and action by the two RFMOs; 2) further cooperative scientific research and modelling to better understand how the shared tuna stocks will respond to climate change, and to inform stock assessments and harvest strategies; and 3) definition of appropriate limits on fishing for each stock in a way that ensures they are compatible across the two organisations.

9. Overview and recommendations

9.1 Vulnerability of economies to climate-driven tuna redistribution

The world-leading tuna management practices within the EEZs of the nine tuna-dependent Pacific Island countries have resulted in large and consistent combined catches of the four tropical tuna species during the last decade. These catches demonstrate that the sustainability goal of *the Regional Roadmap for Sustainable Pacific Fisheries* is being achieved. The purse-seine catch of skipjack, yellowfin and skipjack tuna from the combined EEZs of the nine countries, which averages around 1.4 million tonnes per year, delivers extraordinary economic benefits to these countries – tuna fishing access fees contribute an average of 32% of their non-grant government each year.

Climate-driven redistribution of tuna from the EEZs of these countries into high-seas areas threatens to disrupt the tuna-dependent economies. Projection from preliminary modelling indicate that there could be a collective decline in tuna biomass of 13% per year under a high emissions scenario

(RCP8.5) by 2050. In turn, the decline in biomass could result in an average 20% reduction in tuna purse-seine catch each year, a collective annual average loss of $90 million in fishing access fees, and average losses in government revenue of up to 13% per year for individual countries.

Preliminary modelling also indicates the biomass of South Pacific albacore is likely to decline under the RCP8.5 emissions scenario by 2050 in the EEZs of four of the five subtropical countries where this species provides socio-economic benefits through longline fishing.

The projected climate-driven redistribution of tuna biomass from EEZs into high-seas areas also poses a risk to the sustainable management of the purse-seine and longline fisheries in the WCPO because monitoring, control and surveillance of tuna fishing is typically weaker in high-seas areas than in the EEZs. Sustainable management of tropical Pacific tuna resources is also at risk from projected increases in average tuna biomass in the central EPO. This is due to the limited extent of existing arrangements between WCPFC and IATTC to jointly manage shared tuna stocks (Goodman et al. 2022).

9.2 Recommended activities to minimise the impacts of tuna redistribution

A key recommendation from this assessment is that the considerable uncertainties still associated with the SEAPODYM framework (Bell et al. 2021, Lehodey et al. in press) need to be reduced substantially and embodied in an 'Advanced warning system' (AWS) that Pacific Island countries can use to design policies and adaptations that build climate resilience into the contributions of tuna to their economies. These improvements fall into four main categories:

1) operational oceanography for regional-scale application in the Pacific;
2) higher spatial and temporal resolution forecasts and projections of tuna biomass;
3) fleet dynamics and economic models to provide short-, medium- and long-term policy evaluation and adaptation formulation; and
4) observational data to validate EEZ-scale outputs of SEAPODYM and the fleet dynamics and economic models. Details of these improvements to be made to the modelling are provided in Appendix I.

Improvements that enable the spatial resolution of SEAPDOYM simulations to be increased from 2° x 2° to at least 1° x 1°, and forecasts to be available on a scale of 0.5 to 10-years, would allow economists to develop sophisticated fleet dynamics models that predict near-term changes in fishing effort and catch within and among EEZs. In turn, such predictions would enable countries to understand the attractiveness of their EEZs to industry with much greater certainty and to adjust access fees accordingly.

The improvements described above would also provide much greater certainty about the extent to which tuna biomass and fishing effort are likely to be redistributed from the combined EEZs of the tuna-dependent economies (where 95% of the tuna from the entire Pacific Island region is currently caught) to high-seas areas, where the countries do not yet have much control of fishing operations. This information will be vital to developing the adaptations that the tuna-dependent countries need to retain the present-day benefits they receive from their tuna resources, regardless of the effects of climate change on the distribution of the fish. Such adaptations will need to centre around the international negotiations required to raise awareness of the vital importance of tuna to the economies of Pacific

Island countries and the need to find equitable solutions to the problems that climate-driven tuna redistribution will cause.

Comprehensive collection of tissue samples from tuna species during development of the AWS would also address the key questions identified by Moore et al. (2020a,b) about the extent and nature of the spatial population structure of each tuna species. Where strong spatial structuring exists, the improved SEAPODYM modelling approach could then be applied to each stock and, if multiple stocks occur in countries with large EEZs, the accuracy of projected changes in biomass would be improved by integrating the results from simulations of each stock. Such information would also cast new light on the extent to which discrete tuna stocks may be shared by WCPFC and IATTC, empowering the two RFMOs to manage shared tuna resources more effectively (Goodman et al. 2022).

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Note that references listed here also include those cited in Appendices F to I.

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Appendices

Note that references included in Appendices A-E are included in the References for Component A

Note that references included in Appendix F-I are included in the References for Component B

Appendix A. Terms of Reference for Technical Study 1

Scope of work and objectives

A fundamental building block for all GCF Funding Proposals is the climate change rationale for the proposed programme activities. SPC has co-ordinated a comprehensive assessment of the vulnerability of fisheries resources, and the communities and economies that depend on them, to climate change (https://www.spc.int/cces/climate-book/spc-publications-on-climate-change#tab-682-2). However, that vulnerability assessment is now 10 years old. The purpose of Study 1 is to update the components of the SPC vulnerability assessment related to the direct and indirect effects of climate change on coastal fisheries resources, and on the distribution of tuna resources, to document the climate rationale for the Programme.

In particular, the following assessments relevant to Components A and B of the Programme have been completed.

Component A

(i) Update the SPC 2011 analysis of the vulnerability of coastal fisheries resources (particularly coral reef fish and invertebrates) in the Pacific Island region to the effects of ocean warming and acidification on coastal fisheries production. This analysis should consider both the direct effects on the target species, and the indirect effects on growth and survival on these species expected to occur as a result of climate-driven degradation of coral reefs. The results of the analysis should then be used to update the SPC 2011 assessment of the implications of the projected decrease in coral reef fish production for the food security of coastal communities in the 14 Pacific Island countries participating in the Programme .

(ii) The updated vulnerability assessment should incorporate relevant information from the recent literature to focus on the latest estimates for the degradation of coral reef habitats (in terms of percentage live coral cover), decreases in average coastal (mainly coral reef fish) fish production (in tonnes per km2) due to the direct and indirect effects of climate change, and increases in the gap in fish supply for food security (in kg of fish per person per year), projected to occur under the SSP2-4.5 and SSP5-8.5 (or equivalent) greenhouse gas emission scenarios by 2030 and 2050. These estimates should be updated, where possible, for each of the 14 participating countries.

(iii) Assessments of the gap in supply of fish needed for food security for each participating country under the two emission scenarios by 2030 and 2050 should use the best estimates of national per capita fish consumption and the predicted population for each country in 2030 and 2050 available from SPC's Statistics for Development Division.

(iv) The relative vulnerability of the 14 participating countries to shortages of fish needed for food security should be estimated using the general approach developed by IPCC based on 'exposure', 'sensitivity', 'potential impact' and 'adaptive capacity', as described in Sections 1.8.3 and 12.7 of the 2011 SPC vulnerability assessment (see url above).

(v) The gap in fish supply to be filled by tuna and other oceanic fish species (hereafter grouped as 'tuna') in 2030 and 2050 under SSP2-4.5 and SSP5-8.5 respectively to meet the recommended minimum annual per capita fish consumption of 35 kg per person per year (or current levels if higher) of fish consumption. The total amount of tuna required to fill the gap in fish supply across all 14 countries combined in 2030 and 2050 should also be calculated.

(vi) Estimates of the total number of people in the 14 participating countries that will need increased access to tuna for food security in 2030 and 2050.

Component B

(i) Update the analysis of the vulnerability of the nine tuna-dependent Pacific Island countries to climate-driven tuna redistribution summarised in SPC Policy Brief 32/2019 (https://pacificdata.org/data/dataset/oai-www-spc-int-7a76dd87-9a72-4985-b789-9a2a69971a4c) and the Working Paper from the 14th Scientific Committee of the Western and Central Pacific Fisheries Commission entitled 'Impact of climate change on tropical Pacific tuna and their fisheries in Pacific Islands waters and high-seas areas (https://www.wcpfc.int/node/30981). The update should include the more recent analysis done for the paper entitled 'Pathways to sustaining tuna-dependent Pacific Island economies under climate change' to be published by Nature Sustainability.

(ii) The updated assessment of the vulnerability of the nine tuna-dependent economies should incorporate the results of the most recent modelling of the redistribution of the three species of tuna caught by purse-seine (skipjack, yellowfin and bigeye tuna) across the tropical Pacific Ocean under the SSP2-4.5 (in addition to SSP5-8.5) greenhouse gas emission scenarios by 2050.

(iii) Vulnerability of each tuna-dependent economy in 2050 should be assessed in terms of percentage changes to 10-year (2009-2018) average purse-seine catches within their EEZs and percentage changes in 4-year (2015-2018) annual average:

- earnings from tuna-fishing access fees;
- contribution of access fees to total (non-grant) government revenue; and
- total (non-grant) government revenue.

(iv) The relative vulnerability of the nine tuna-dependent economies to tuna redistribution should be estimated using the general approach based on 'exposure', in 'sensitivity', 'potential impact' and 'adaptive capacity', as described in Sections 1.8.3 and 12.4 of the 2011 SPC vulnerability assessment (see url above). See also Annex 1 to the Concept Note for the GCF regional tuna programme for possible ways of summarizing the relative vulnerability of each economy.

(v) The number of people presently living in tuna-dependent Pacific Island countries, and projected to be living there in 2050, should be estimated (taking into account the extent to which the large inland population of PNG can or cannot be considered to depend on national revenue earned from tuna access fees).

Appendix B. Uncertainty, assumptions and limitations, and knowledge gaps

Caveats, assumptions and uncertainties

Although the analyses conducted used the most recent data, knowledge and state-of-the-art modelling approaches, certain assumptions were necessary and there were unavoidable inherent uncertainties in the outputs. Brander (2015) discusses the compounding effects of multiple layers of uncertainty and the importance of accurately acknowledging these in climate change studies. For the modelling analyses to assess changes in coastal fisheries production by 2050 under SSP2-4.5 and SSP5-8.5, and the implications for availability of fish per capita for food security, several inputs were obtained from different sources, each with their own biases and error. A significant improvement to the 2011 assessment is the quantitative characterisation of much (not all) of the uncertainty. Below are the major caveats, assumptions and uncertainties in the analyses for 2050.

1. The assessment does not include conventional species taken in Pacific oceanic fisheries (principally tuna, sharks and billfish). This was done to minimise overlap with the assessment of oceanic fisheries (Component B), and to focus on the predominant species taken by coastal communities.

2. Ecosystem models do not discriminate species groups as done with the 2011 assessment (i.e., demersal fish, nearshore pelagic fish and invertebrates). Although the ecosystem models do include all species, to ensure projections were based only on coastal species targeted by coastal fisheries, a size-based filter for biomass that only included animals from 10 g – 10 kg was used. This ensured the inclusion of small invertebrates collected for food and a review of recent SPC market and creel survey data from coastal fisheries catches in the 14 participating countries indicated that a maximum size of 10 kg was likely to include ~99.99% of coastal fish. Further, this upper size limit ensured that any inclusion of species associated with oceanic fisheries was minimised.

3. Catch estimates for each country were taken from Gillett and Fong (2023) who reviewed all available data to derive these estimates for 2021, which we used as the baseline to estimate future catches under the two emission scenarios. These authors consider the uncertainty in catch data is considered to be high as well as being highly variable among countries. For example, national estimates of coastal fisheries production are often based largely on extrapolation of fish consumption per person derived from household income and expenditure surveys (HIES).

4. Estimates of projected catch assume a linear relationship between projected changes in biomass and catchability. Although possible, based on surplus production theory, this assumption is unlikely (Beverton and Holt, 1957). Projected changes in future catches also assumes that the effort and catch-per-unit-effort (CPUE) characteristics of coastal fisheries in each country that generate current catch levels are maintained to 2050.

5. Current catch estimates were used in conjunction with current habitat area to estimate current coastal fisheries yield for each country which, in turn, was used to estimate future catches by taking into account projected relative changes in biomass and projected changes in habitat area. It should be noted that estimated projected changes in habitat area was not estimated directly, rather it was assumed to be correlated to the percentage of each coastal habitat type (coral reef and seagrass) in the high and very high vulnerability categories under the different emissions scenarios by 2050. That is, for a given scenario, the future total area of seagrass habitat was projected to decline by the total percentage of seagrass area assessed as having very high and high vulnerability to climate change. The same method was applied separately to coral reefs. The total projected

habitat area inputted to the analysis for estimating projected catch combined the future area of both coral reef and seagrass habitats, after climate-driven declines in area. This assumption has not been tested.

6. The habitat assessment included the three major coastal habitats that are most important for coastal finfish and invertebrate species: coral reefs, seagrass meadows and mangrove forests. Changes in habitat area was an important component of the analysis to derive projections of future coastal fisheries catches in each country. Although SPC's 2011 vulnerability assessment also used this approach, it only incorporated coral reef habitats. In contrast, this current assessment combined the area of coral reef and seagrass meadows to capture available habitat area in 2050. Seagrass meadows are often associated with reef flats, a sub-habitat type that is used extensively by coastal fish and invertebrates and may otherwise be under-represented. Therefore, combining these two habitat types better captures the full area used by all life history stages of coastal finfish and invertebrates, particularly the juvenile stage. A notable exception was PNG, where mangrove area was included because it accounts for ~16% of the three main habitats by area; mangrove habitat area in all other participating countries was significantly lower (<=6%) and therefore not included.

7. The approaches used in the analyses to derive information about the likely status, and therefore the resilience of coastal resources, were also subject to uncertainties. Whole-of-system biomass related metrics (estimates of MMSY, B_{MMSY} and B_0) for the stock status analyses were estimated based on local underwater visual census (UVC) which only included finfish species from 25 families above 10 cm in total length. Further, the timing of the UVC data used was predominantly pre-2010, and the number and location of these survey data were sometimes limited, making their representativeness highly uncertain. Single species stock assessments predominantly used data-limited methods, considered less reliable, and the selection of species for assessment does not appear to be systematic. Therefore, it is not known if assessment results are representative of coastal fisheries in each respective country.

8. The multi-species assessment based on current yields compared to MMSY resulted in the vast majority of the participating countries with yields significantly below MMSY. Without effort data, it was not possible to determine whether low yields were a consequence of overfished reef fish stocks (decreasing part of the surplus production curve; i.e., surplus<catch<MMSY) or whether fishing levels were low and overfishing was not occurring (increasing part of the surplus production curve; i.e., catch<surplus). See Appendix D for further information.

Appendix C. Ensemble of models used to assess the vulnerability of coastal fish biomass

We assessed the projected impacts of climate change on coastal fisheries using a similar approach to the 2011 assessment that combines the effects of both direct and indirect impacts on fish and invertebrates. That is, we estimated the projected changes in available fish biomass (direct effects) and combined this with the projected changes in habitat area (indirect effects) to derive projected changes in catch levels for each PICT. Projected changes in catch were based on the latest (2021) catch estimates derived for each PICT by Gillett and Fong (2023). A significant improvement on the 2011 assessment was the use of ecosystem model ensembles forced by climate models to estimate projected changes in fish biomass (see the Fisheries and Marine Ecosystem Model Intercomparison Project, FishMIP; https://fishmip.org) for each of climate change scenarios. This represents a less subjective analysis approach that also provides quantitative estimation of uncertainty in projections.

Estimating projected changes in fish biomass

To generate projected changes in fish and invertebrate biomass (hereafter referred to collectively as 'fish') for the 14 PIC we used biomass estimates produced by six different fisheries models forced by both Geophysical Fluid Dynamics Laboratory (GFDL) and Institut Pierre-Simon Laplace (IPSL) general circulation models. This was implemented in R using the workflow available online[18]. This workflow uses relationships observed on coral reefs between coral cover and fish biomass, as well as projections of coral cover in the Great Barrier Reef and fish biomass in the Pacific from the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP; https://fishmip.org). We consider the use of ecosystem model ensembles forced by climate models to estimate changes in fish biomass to be a significant improvement on the 2011 assessment as it represents a less subjective analysis approach that also provides quantitative estimation of uncertainty in projections. Herein is a summary of the modelling approach adopted.

The six fisheries models used to generate biomass estimates and projections for PIC were:

APECOSM: Apex Predators ECOSystem Model, which represents the spatialized dynamics of open ocean pelagic ecosystems in the global ocean.

BOATS: BiOeconomic mArine Trophic Size-spectrum model simulates the global fishery as a coupled ecological-economic system.

DBPM: The Dynamic Benthic Pelagic Model is a dynamic size spectrum model for modelling the coupling "pelagic" size-based predators and "benthic" detritivores that share a unstructured resource pool (detritus).

EcoTroph: EcoTroph models the functioning of marine ecosystems as flows of biomass from low to high trophic levels, so as to quantify easily the impacts of fishing at an ecosystem scale.

Macroecological: A static equilibrium model, which uses ecological and metabolic scaling theory to predict mean size composition and abundance of animals (including fish).

ZooMSS: The Zooplankton Model of Size Spectra is a functional size-spectrum model of the marine ecosystem to resolve phytoplankton, nine (9) zooplankton functional groups (heterotrophic flagellates

[18] https://github.com/Fish-MIP/Extract_PICTs/blob/main/Scripts/04_Biomass_projections_SouthPacific.md

and ciliates, omnivorous and carnivorous copepods, larvaceans, euphausiids, salps, chaetognaths and jellyfish) and three size-based fish groups.

The GitHub workflow documents the steps taken:

- Biomass projections using coral cover relationships

Several relationships between coral cover, structural complexity and fish biomass have been established in the literature. We used the relationships of Graham and Nash (2013) and ReefMod (Bozec & Mumby 2019), which describe structural complexity as a function of coral cover (Equation 1), and fish biomass as a function of coral cover (Equations 2, 3 and 4), respectively:

Equation 1 (from Graham & Nash 2013):

$$struct_{complexity} = 3e^{-7} \times coral_{cover}^4 - 5e^{-5} \times coral_{cover}^3 + 0.0022 \times coral_{cover}^2 + 1.3892$$

Equation 2: *ReefMod lower bound*

$$fish_{biomass} = 12.716 \times coral_{cover} + 146.75$$

Equation 3: *ReefMod median*

$$fish_{biomass} = 13.56 \times coral_{cover} + 732.15$$

Equation 4: *ReefMod upper bound*

$$fish_{biomass} = 14.285 \times coral_{cover} + 1325.7$$

Applying these relationships, we incorporated outputs from ReefMod which predicted mean coral coverage from 2024 to 2100 for the Great Barrier Reef (GBR) under five emissions scenarios: SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. This study was used as it represents the only downscaled modelling of changes in coral cover under different climate change scenarios for the Pacific region that could be used to estimate any bias in biomass estimates generated using the global FISH-MIP models (see Step 3 below).

- Biomass estimation using FishMIP models

Global monthly biomass estimates for the historical period (2010-2020) and two emission scenarios SSP1-2.6 and SSP5-8.5 covering the period between 2015 and 2100 were obtained from the six FishMIP models forced by both GFDL and IPSL general circulation models. Annual time series per PICT were calculated for each of the FishMIP models. Given that Kiribati's EEZ is divided into three distinct and geographically separate island groups (Phoenix, Gilbert and Line Islands) that are likely to be subject to different environmental regimes and changes, biomass estimates were generated separately for each island group.

- Estimating biases from ReefMod data

For scenarios SSP1-2.6 and SSP5-8.5, we compared the biomass estimates calculated from ReefMod (step 1) and the FishMIP model ensemble for the GBR only (step 2 above) to help estimate the bias of the FishMIP global model ensemble. The code and equations used for this are given in the GitHub workflow.

- Bias corrected biomass projections calculated from FishMIP ensembles

The bias estimates obtained in step 3 above were used to estimate a corrected mean ensemble biomass value for each PICT under the two emission scenarios: SSP1-2.6 and SSP5-8.5. However, the bias corrections were not applied per year. Instead, for each scenario, we used bias estimates to calculate the minimum, mean, median, and maximum values.

- Calculating biomass estimates under scenario SSP2-4.5

FishMIP models provide biomass estimates under a low emissions (SSP1-2.6) and a high emissions (SSP5-8.5) scenario. None of them provide biomass estimates under the moderate emissions scenario (SSP2-4.5) which is one of the scenarios agreed for this revised assessment. We derived a rough estimate of biomass projections under SSP2-4.5 by calculating the mean between the low (SSP1-2.6) and high (SSP5-8.5) emissions scenarios. We justify the use of this approach based on the ReefMod data, which includes estimates of coral cover under the three scenarios of interest: SSP1-2.6, SSP2-4.5, and SSP5-8.5 (Figure S1). Further, we attempted to apply corrections to the projected biomass estimates for the moderate emissions scenario, however the results appeared to be unlikely.

The averaged coral cover is closer to coral cover under the medium scenario (SSP2-4.5) than either of the two other scenarios. Although this approach is simple, it should be noted that before 2060 the averaged values tend to underestimate coral cover and after 2060 coral cover is overestimated, particularly after 2085. This approach allows us to estimate fish biomass under the SSP2-4.5 scenario for FishMIP models, however it is likely that similar biases will appear in biomass estimates.

- Convert to relative change in biomass

Predicted biomass estimates were then converted to provide estimates of annual percentage change in biomass relative to the reference period 2010–2020.

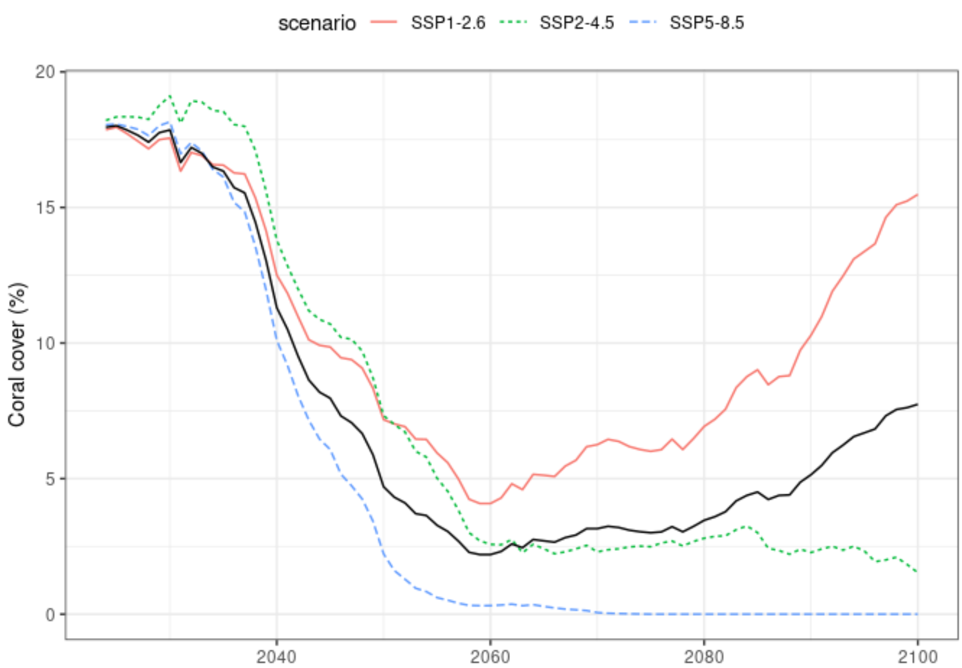

Figure S1. *Predicted coral cover from the ReefMod GBR project for the low (SSP1-2.6, red line), medium (SSP2-4.5, green dashed line) and high (SSP5-8.5, blue dashed line) emissions scenarios. The black line represents the averaged coral cover for the high and low scenarios.*

Appendix D. Current resilience of coastal fisheries to climate change

To fully understand the consequences of climate change on Pacific Island country coastal fisheries into the future it is important to understand the capacity of coastal fishery systems to cope with, and respond to, the projected impacts. While there are several potential stressors, overfishing is one of the most pervasive and likely in most Pacific Island countries. For example, fished populations subjected to overfishing have been found to be more likely to be negatively impacted by higher SST (Free et al. 2019). Therefore, a key indicator of resilience is the effectiveness of management of coastal fisheries, now and in the future. Management effectiveness can often be reflected by the current condition, or status of the fished populations (Gaines et al. 2018).

As noted above, regular and reliable assessment of the status of fished populations of coastal resources among Pacific Island countries has been hampered in the past (Welch 2021). However, recent data collections, advances in modelling and an FAO review have provided information that potentially provides greater insight into the status of coastal fisheries stocks among some of the Pacific Island countries where relevant data are available (Zamborain-Mason et al. 2023; Welch et al. in press). Zamborain-Mason et al. (2023) developed sustainable reference points and assessments based on reef fish multispecies estimates of maximum yield, thought to be a better approximation of sustainable production from multi-species fisheries such as Pacific coastal fisheries (e.g. Houk et al. 2018). Using surplus production models and underwater visual survey data they provided estimates for coral reef fisheries of multispecies maximum sustainable yield (MMSY) and biomass levels at which multispecies maximum sustainable yield is expected to be reached (B_{MMSY}). Using their approach in this current assessment we derived estimates of these metrics specific to each Pacific Island country where relevant data were available to assist in assessing multi-species stock status.

Overall stock status was variable across the different approaches and Pacific Island country (Table 1 below). Compared to estimated unfished reef fish biomass (B_0), estimates of current biomass[19] suggested coastal fisheries resources were overfished (i.e. < 0.5 of B_0 assuming a Graham-Schaefer surplus production function) in 4 of the 14 countries assessed. When comparing the yield based on current estimated catch with MMSY for each of the 14 Pacific Island countries, two (Nauru and Samoa) were shown to currently be subject to catching above MMSY. All other countries had current yields below MMSY (Table 1). Catch values above MMSY suggest the system is subject to overfishing and reef fish populations are expected to decline. Catches below MMSY indicate that fish stocks (on average) in those countries are unlikely to be subject to overfishing (i.e. catch<surplus). The low yields reported in some countries may be of some concern for meeting food security needs. For Pacific Islands with very small human populations, relatively low yields may not be an issue providing that the available fish per capita, not just from coastal fisheries, meets minimum health levels (Tigchelaar et al. 2024). However, low yields where food security is not currently being met may be potentially problematic. Reasons for low yield include inefficiencies in management and/or how fishing is conducted (Barange 2019). Although current relatively low yields may be due in part to inefficient fishing practices and/or management, they may also be due to other factors including, for example, low and/or variable coastal productivity or disconnects between high productivity zones and human population centres.

Although there are data missing for some countries, it is important to consider that variability could be influenced by sampling representativeness. For example, multispecies assessments are based on

[19] Underwater visual survey data used to generate PICT-specific estimates of current biomass was available for 17 of the 22 PICT (see Supplementary Materials for details).

detecting signals across the overall ecological system and are based on data that may not be representative for each PICT (Zamborain-Mason et al. 2023).

Table 1. Compilation of derived estimates of stock 'status' for coastal fisheries among Pacific Island countries participating in the GCF Programme using a multi-species approach. Whole-of-system level estimates are based on reef fish biomass and current catches and include B/B0 and current yield/MMSY. N.B. B/B0 <0.5 = overfished based on a Graham-Schaefer surplus production model; Yield/MMSY >1.0 = subject to overfishing (noting that overfishing may still be occurring for values <1.0).

Country	B/B_0	Yield/MMSY
Melanesia		
Fiji	0.99	0.60
Papua New Guinea	0.30	0.36
Solomon Islands	1.12	0.81
Vanuatu	n.a.	0.24
Micronesia		
Federated States of Micronesia	0.29	0.22
Kiribati	0.40	0.51
Marshall Islands	0.48	0.18
Nauru	n.a.	2.61
Palau	1.10	0.39
Polynesia		
Cook Islands	0.72	0.14
Niue	n.a.	0.63
Samoa	0.57	1.32
Tonga	0.82	0.26
Tuvalu	0.42	0.20

Current catch levels relative to estimated sustainable levels for most PICT may indicate inefficiencies in fishing practices and/or management (Barange 2019), however, this is not possible to confirm based on current catches alone. Without greater spatial resolution, it is not possible to say from these analyses whether assessment results are localised (e.g. driven by sampled sites or stocks) or widespread within each PICT. However, several studies have correlated proximity to human populations with sharp declines in coastal fish biomass, even at relatively low population densities (e.g. Williams et al. 2015). Future work should aim to increase assessment resolutions (e.g. using updated and representative data). Regardless, our overall results demonstrate that the resilience of some PICT coastal fish populations to climate change may be compromised and will likely exacerbate impacts without management intervention (Gaines et al 2018; Free et al 2020; Zamborain-Mason et al. 2023).

Appendix E. Recommendations stemming from Component A

The recommended adaptations to help ensure that the fisheries resources available to the countries participating in the GCF Programme are used in ways that maximise the benefits for food security and livelihoods are summarised below.

- Implementation of cost-effective coastal fisheries management systems that are tailored to the local context. This requires the supporting management framework and associated activities to be aligned with local resourcing and technical capacity to be successful in the long-term (Welch 2024). Although management systems may be similar for finfish and invertebrate fisheries, specific management approaches for these two resources should be developed separately. Key elements of a management framework needed are:
    - An appropriate long-term data collection system that is systematic, representative and strategic in providing relevant information that supports decision-making.
    - A structured framework that routinely uses coastal fisheries data to understand the status of coastal fisheries resources and identifies key threats, using approaches that match national technical capacity. Traditional knowledge from elders on the historical condition of fish populations can complement other assessments and should be collated for each country, as should the observations of elders of change through time (including not only species abundance, but their distribution, size and co-location or not with habitat).
    - A process that ensures assessment outcomes are actioned through the implementation of adaptive management.
- Adoption of an ecosystem-approach to management of coastal fisheries that considers and reduces impacts of indirect influences on the health of coastal ecosystems arising from upstream sources. This may include the development of robust policies and implementation of best practices across all industries and activities within catchments to minimise the release of land-based pollutants, and sedimentation caused by coastal development, infrastructure construction, agriculture, forestry and land clearing.
- Restoration and protection of habitats that support coastal fisheries resources, including coral reefs, seagrass meadows and mangrove forests to enhance their resilience to climate change and minimise the indirect impacts of habitat loss on fish biomass and catches.
- Facilitation of improved preparedness of countries to cope with the likelihood of significant inter-annual variability and long-term declines in coastal fisheries biomass and catches, and compounding impacts from episodic events, such as marine heat waves. Specific adaptations to reduce such impacts include:
    - Expansion of the use of anchored FADs to diversify catches to include greater proportions of tuna and other nearshore pelagic fish, and to divert fishing effort from coastal habitats to reduce pressure on vulnerable coastal fish stocks.

- Develop improved post-harvest methods that prolong the shelf-life of FAD-caught fish (e.g. preservation methods using smoke curing, salting, and drying).
- Exploration of the potential for alternative fisheries that could be sustainably harvested such as small pelagic species (e.g. mackerel, anchovies, pilchards, sardines, flying fish, scads, fusiliers), and squid, including those species that also associate with FADs.
- Scale-up the development of environmentally-friendly, pond-based aquaculture where food security is projected to decline under future projections (Tigchelaar et al. 2024), and where access to nearshore pelagic fish species using FADs is limited.

- Continued investment in the development and implementation of standardized coastal data collection systems and tools appropriate for the Pacific context (e.g. IKASAVEA), including for use in monitoring catches made around FADs.

- Active education and awareness-raising among government authorities and communities about (i) the role of coastal habitats in sustaining healthy fisheries resources, and the interconnectivity of habitats; (ii) the consequences of poor land use and fishing practices on coastal fish stocks; and (iii) the expected further impacts of climate change of coastal fisheries production and the need to rely on replacing much of the previous coastal fish catch with tuna and other nearshore pelagic fish to maintain the traditional benefits of fish for good nutrition. Importantly, the increased engagement with communities should be locally led and should ensure approaches are appropriate to local contexts and locally understood.

- Continued improvement of climate and ecosystem models, and the collection of the information needed to inform these models. In particular, downscaled projections that skilfully capture past changes due to the combined effects of climate and fishing are needed to better inform future spatial distribution of coastal fish biomass and corresponding sustainable fisheries management (Blanchard et al. 2024). In addition, models that provide projections disaggregated to key species groupings (e.g., demersal finfish, nearshore pelagic finfish, invertebrates) will facilitate effective decision-making (Schoeman et al. 2023). Improved data on coastal habitat area in each country will also help inform the capacity of coastal fisheries resources to support catches for food security.

Appendix F. Other sources of ocean variability interacting with ENSO and influencing tuna distribution [20]

Interdecadal variability

The Interdecadal Pacific Oscillation (IPO) is a multi-decadal climate fluctuation, with phases lasting 20–30 years (Power et al. 1999; Henley et al. 2015). The IPO is strongly correlated to the Pacific Decadal Oscillation (PDO), a similar climate pattern for the Northern Hemisphere that was first identified in salmon fisheries data (Mantua et al. 1997). As for ENSO, the IPO results in interactions between the ocean and the atmosphere. The strength of trade winds and the atmospheric Pacific Ocean circulation, also known as Pacific Walker circulation, are tightly coupled to the east-west sea surface temperature (SST) gradient along the equatorial Pacific. Strengthening of the Pacific Walker circulation and trade winds have been observed since the 1950s, likely linked to the IPO shift to a negative phase in 1999, which has increased the zonal SST gradient over the tropical Pacific (Li et al. 2019; Wu et al. 2021). The northeast trade wind has been particularly intense since the establishment of the last negative phase in 1999 (Yang et al. 2022). These different wind regimes are associated with anomalies in water temperature, ocean productivity, dissolved oxygen concentration and oceanic circulation that can impact early life history, recruitment and distribution of tuna and, therefore, the fisheries targeting them.

The amplitude and frequency of ENSO events show decadal modulation in relation to the IPO (and PDO) phases, however, the physical mechanisms are not fully understood (Webster et al. 1999). Nevertheless, the integration of this environmental variability across several years of recruitment can generate multi-decadal regimes of high and low productivity in a fish population, all the more easily detectable when the species has a long lifespan. South Pacific albacore (with a lifespan of 12 years), would be a good candidate for detecting such a mechanism with decadal series of more frequent favourable (La Niña) or unfavourable (El Niño) recruitment years (Figure 1).

One estimate of the state of the IPO is the tripole index. It is based on the difference between the average SST anomaly over the central equatorial Pacific and the northwest and southwest Pacific (Figure 1). Phases of the IPO are associated with abrupt shifts in North Pacific sea-level pressure and contrasting anomaly patterns in temperature, precipitation and atmospheric circulation over the eastern and western Pacific. The positive (negative) phase of the IPO is associated with anomalously warm (cool) SST in the tropical Pacific Ocean and anomalously cool (warm) SST in the subtropical north and south Pacific Ocean. Faster than average warming periods superimposed on the long-term increases in the global mean SST have been associated with the IPO (Henley et al. 2015; Bordbar et al. 2019). The negative IPO phase since 1999 temporarily masked the trend of global warming, a phenomenon known as the 'Hiatus', but the warming trend has resumed since 2012. After 23 years of negative IPO, the probability of shifting to a positive phase in the coming few years is increasing. This would be accompanied by accelerated global warming (Bordbar et al. 2019; Wu et al. 2021; Meehl et al. 2016, 2024).

[20] Source: Lehodey et al. (in press)

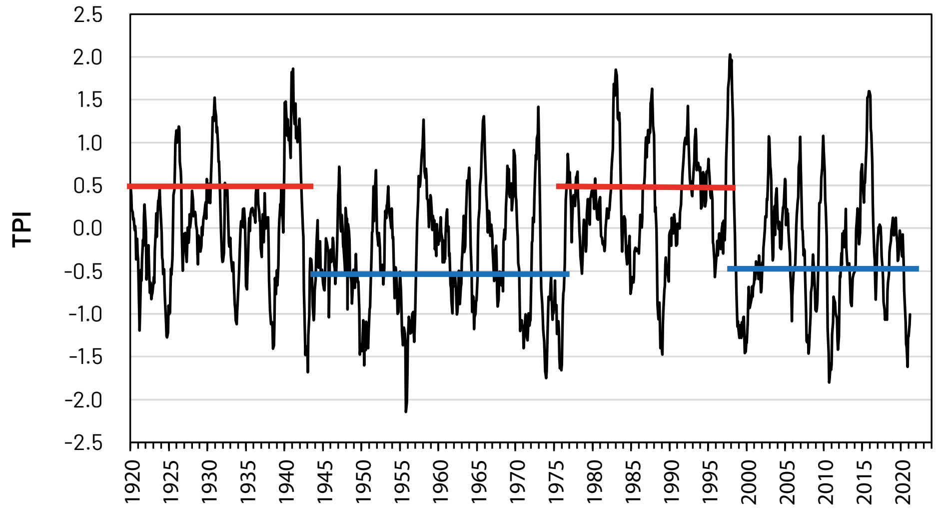

Figure 1. Tripole index (TPI) time series of the Interdecadal Pacific Oscillation (IPO). Red and blue lines show warm & cold regimes respectively. Data available: https://psl.noaa.gov/data/atmoswrit/corr/timeseries/

Earth climate models predict that increasing greenhouse gas (GHG) emissions should lead to a weakening of the Pacific Walker circulation and reduce the west to east warm-to-cool SST gradient across the equatorial Pacific. However, observations since the 1950s show opposite trends (Henley and King 2017; Seagar et al. 2019; Yang et al. 2022). There is uncertainty about the contributions of climate change and IPO to increased trade winds over the last decade. Based on a series of simulations assessing the fundamental mechanisms of the tropical ocean-atmosphere system, Seager et al. (2019) showed that the exaggerated warming of the eastern tropical Pacific in climate model simulations is the consequence of a bias in the equatorial cold-tongue, resulting in relative humidity that is too high and wind speed that is too low. Their simulation results suggest that "*rising CO_2 should cause more warming over the western than eastern Pacific, driving stronger trade winds that shoal the thermocline, which cools the cold tongue, further strengthening the zonal SST gradient and, hence, the trade winds. Delayed warming of the thermocline could oppose this positive feedback but, to date, has not cancelled it.*" Until climate models improve representation of the physical mechanisms in the tropical Pacific, a continuation of the La Niña-like trend in tropical Pacific SST should be considered.

Warm pool

Climate change is driving a continued increase in the size of the warm pool (Roxy et al. 2019); a trend predicted by Earth climate models (Figure 6.6). The warm pool is the core habitat of skipjack tuna, and the relationship between recruitment of skipjack and ENSO variability has been influenced by ocean warming and the expansion of the surface area of the warm pool since the mid 1980s. It is possible that the long-term trend in ocean warming may modulate and dampen the negative effect of La Niña events on skipjack tuna recruitment. This is suggested by the time-series of recruitment for this species, which shows an increasing trend similar to that of the warm pool expansion (Figure 6.7). The mechanisms at play that influence recruitment success of skipjack tuna are likely related to changes in temperature and productivity. However, this is difficult to demonstrate in the absence of large-scale sampling of larvae/juveniles of this species.

Figure 2. *Mean observed (black line) and projected (orange and red lines) surface area of the warm pool using SST temperature (>29°C) per decade, based on OSTIA product (https://doi.org/10.48670/moi-00168) using in-situ and satellite data for observations in 1991–2000 (dotted black line) and 2011–2020 (continuous black line), and projections by the Institut Pierre-Simon Laplace (IPSL) Earth Climate Models under medium emissions scenario SSP2-4.5 for two future time periods (orange and red lines).*

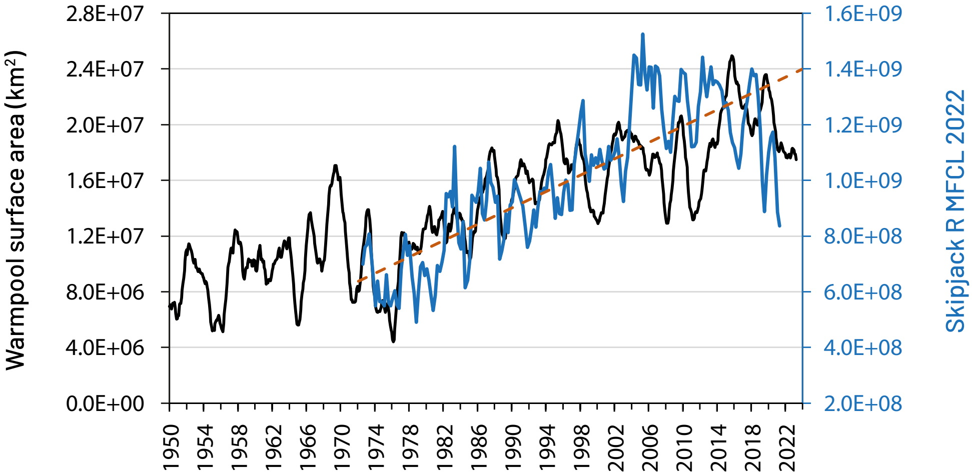

Figure 3. Skipjack tuna recruitment time-series for the Western Central Pacific Ocean from the most recent stock assessment (Eveson et al. 2020) and evolution of the size of the warm pool defined by SST >29°C (HadISST monthly data file[i] from http://www.metoffice.gov.uk/hadobs/hadisst).

Primary productivity

The oceanographic station ALOHA in the north Pacific oligotrophic subtropical gyre (22°45’N, 158°W), north of Hawaii, provides the longest time-series of *in situ* ocean physical and biogeochemical observations (Figure 6.8). Within this time-series, a positive trend in primary production has been observed since 1989 (+37%) in the lower portion (depth range 75–125 m) of the euphotic zone, i.e., the illuminated surface layer of the ocean where photosynthesis takes place

(Karl 2021). However, it is also possible that at least part of the observed changes reflects the shift between the IPO phases since the 1980s (Figure 6.8). The trend is also observed in suspended particulate carbon and zooplankton abundance. At the scale of the entire ocean basin, a positive trend is also observed in satellite ocean colour data. Sharma et al. (2019) reanalysed all the available Sea-viewing Wide Field-of-view Sensor (SeaWiFS) satellite time-series data (1997–2010) using backscattering-based phytoplankton functional types and found that, globally, the biomass and the percent of large (small) phytoplankton had increased (decreased). They link the increasing biomass trends to increased winds and relevant mixing length scale. These trends are confirmed by another recent study (Cael et al. 2023) showing that the remote-sensing reflectance of the Moderate Resolution Imaging Spectroradiometer (MODIS) ocean colour satellite data (2002–2022) also has significant positive trends attributed to climate warming for 56% of the global surface ocean, mainly in regions around the equator to 40^{o} of latitude. Based on these studies, overall, the tropical oceans have become warmer and *"greener"* in the past 20 years. Further research is needed to separate decadal variability in production from the overall influence of climate change.

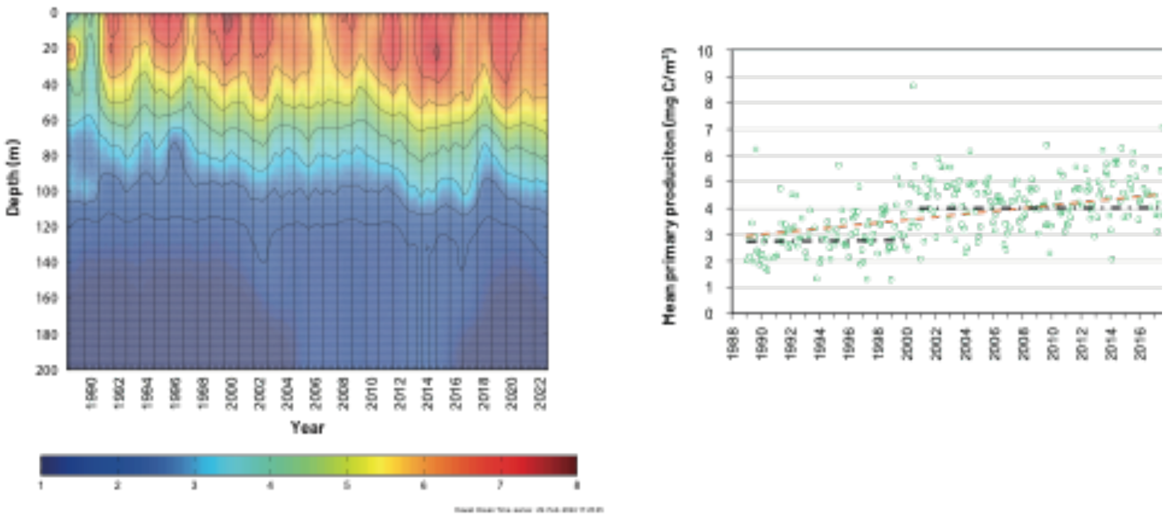

Figure 4. Primary production observed in the Pacific Ocean at Station ALOHA, north of Hawaii (1989–2021) https://hahana.soest.hawaii.edu/hot/hot-dogs/ppcontour.html. Left panel: Contour plot of ^{14}C-based primary production over time and depth; warmer and cooler colours indicate greater and lower primary production levels (mg C m^{-3} d^{-1}), respectively. Right panel: Vertically integrated total primary production (mg C m^{-3}) with linear trend (orange dashed line) and the Interdecadal Pacific Oscillation (IPO) phases (black dashed line).

Several mechanisms are proposed to explain why these trends oppose almost all biogeochemical model outputs projecting lower primary production in the future (Bopp et al. 2022). The inputs of nutrients or limiting elements for the growth of phytoplankton might have increased due to either the reinforced trade winds and mixing, deeper vertical diffusion linked to increasing convection, increased deposition of limiting elements (e.g., iron) through atmospheric pollution and transport, or changes in ocean circulation and lateral transport (Sharma et al. 2019; Karl et al. 2021). Also, diazotroph production (due to very small surface phytoplankton or microbes that can use atmospheric nitrogen to compensate the absence of nitrate in the water) could have increased in oligotrophic waters (Bopp et al. 2022; Lory et al. 2022). Additionally, phytoplankton plasticity in the use of carbon relative to phosphorus could be underestimated in most biogeochemical models. This was tested by Kwon et al. (2022) who projected increases in net primary production as the ocean warms and becomes more stratified. Finally, a possible mechanism of downward and upward migration of phytoplankton that would facilitate biological nutrient pumping has also been proposed (Wirtz et al. 2022).

Oxygen levels

The future of dissolved oxygen concentration in the ocean is also of particular concern for the habitat of tuna, given their high sensitivity to this parameter (Brill 1994). *In situ* observations indicate that the global ocean has been losing oxygen (O_2) since the middle of the last century (Oschlies et al. 2018, 2019). In the open ocean, the O_2 inventory has decreased by 0.5–3% and areas of relatively depleted oxygen known as the Oxygen Minimum Zones (OMZ) are expanding (Schmidtko et al. 2017; Gregoire et al. 2021). While the oxygen solubility in water decreases with increasing temperature, oxygen content also results from a balance between respiration by marine organisms, ventilation by ocean circulation and mixing processes. Although observations and model simulations agree on the declining trend under the effect of ocean warming, inconsistent regional estimates of the rate of O_2 loss (i.e., deoxygenation) have been noted. However, an analysis of the most recent climate and biogeochemical model simulation outputs (Takano et al. 2023) shows that the trend in the upper ocean global O_2 inventory for the latest observations based on the World Ocean Database 2018 (-0.98×10^{14} mol/decade) is in line with the CMIP6 historical multi-model mean, although this recent observations-based trend estimate is weaker than previously reported trends.

Part of the observed changes in oxygen seem to be linked to multidecadal variability (Poupon et al. 2023). The Pacific Ocean has the largest OMZ, centred on the equator and extending subsurface from the coasts of North and South America toward the central equatorial Pacific. The expansion of the subsurface OMZ is of particular concern for adult tuna, which inhabit deeper layers than the juveniles. Data to monitor the changes in oxygen content in the Equatorial Undercurrent are sparse. Stramma et al. (2020) showed that in an area of 5N–5S and 165–175W, a negative linear trend in oxygen content has occurred across the 50–300 m depth layer since 1950. These changes have been observed to be modulated by multidecadal variability that temporarily counteracts climate warming-induced deoxygenation in the region. Changes in winds at multi-decadal to centennial time scales over the tropical Pacific can lead to fluctuations of oxygen content because wind drives upwelling, biological productivity, and thus O_2 demand within the OMZ (Deutsch et al. 2014). Based on these mechanisms and biogeochemical climate model outputs (Duteil et al. 2018; Poupon et al. 2023), a shift to a positive phase of IPO and associated weakening of trade winds could limit the expansion or even contract the ocean's largest anoxic zone despite a global O_2 decline (Takano et al. 2023). The mechanisms and drivers of oxygen changes and their variation with region and depth are complex and require improved knowledge and observation to better quantify the contribution of multiple direct (solubility) and indirect (circulation, mixing, biology) effects.

Appendix G. Details of modelling approach to assess changes in tuna distribution by 2050

Overview

The methods used to assess the vulnerability of tropical Pacific tuna resources to redistribution by climate change centred around the use of the Spatial Ecosystem and Population Dynamics Model (SEAPODYM) (Lehodey et al. 2008, 2010, Senina et al. 2008), informed by projected changes to the tropical Pacific Ocean derived from four Earth System Models. SEAPODYM simulates the spatial dynamics of tuna under the effects of fishing and key environmental variables (temperature, primary production, oceanic currents and dissolved oxygen), and the predicted distributions of tuna prey in three layers of the water column between the surface and a depth of ~1000 m. This modelling framework synthesises current knowledge on the biology, ecology, and population dynamics of the key life stages of tuna species (from larvae to mature fish) in their oceanic ecosystem, and has been validated against the observations described below. The assumption is made that the relationships and mechanisms inherent in SEAPODYM will remain valid over the next few decades.

The modelling methods described here are taken from Bell et al. (2021) and relate to the responses of tuna biomass to the IPCC RCP8.5 and RCP4.5 emissions scenarios for 2050 in the EEZs of the nine tuna-dependent countries participating in the GCF Programme. The same methods were applied by Bell et al. (2021) to other Pacific Island countries and territories (including the other five participating countries) and to high-seas areas in the Western and Central Pacific Ocean (WCPO) and Eastern Pacific Ocean (EPO).

Projections for RCP4.5 were estimated based on examining changes in the RCP8.5 simulation at the times when CO_2 concentrations reach those equivalent to RCP4.5 in 2050. Estimating the effects of the moderate emissions scenario in this way was necessary because appropriate ocean forcings, with bias-corrected physical and biogeochemical variables, do not yet exist for RCP4.5.

Details of specific components of the modelling approach are provided below.

Ocean forcings

The NEMO ocean framework (Madec 2017), which includes an online coupling with the biogeochemical component PISCES in a 2° latitude x 2° longitude configuration (Aumont et al. 2015; Lee et al. 2016) was used to simulate the historical oceanic environment (hindcast simulation). This historical simulation was forced by the Drakkar Forcing Sets 5.2 (DFS5.2) (Dussin et al. 2014) based on a corrected set of the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis ERA-INTERIM during the period 1979-2011. Salinity, temperature and biogeochemical tracer concentrations (nitrate, phosphate, iron, silicate, alkalinity, dissolved oxygen and dissolved organic and inorganic carbon) were initialized from the World Ocean Atlas climatology (WOA09) (Garcia et al. 2010), and previous model climatology for iron and dissolved organic carbon (Menkes et al. 2016). To minimize any substantial numerical drift in the simulations related to a nonequilibrated initial state, a spin-up of the ocean model and biogeochemical model for 66 years cycling was applied twice over the DFS5.2 forcing sets (Lee et al. 2016).

Overall, the model simulates basin-scale, historical sea surface temperature (SST) and salinity distribution, together with seasonal and interannual (El Niño-Southern Oscillation - ENSO) variability with good fidelity (Nicol et al. 2014). Classical biases are associated with the coarse (2°) resolution, e.g., the latitudinal position, of the Kuroshio Current. In the tropical Pacific, there is a cold bias of -1°C in the central equatorial zone (between 170°W and 100°W), and a warm bias of +1°C in the eastern part of the basin (east of 90°W). Despite some local discrepancy between simulation outputs and satellite-derived chlorophyll concentration around islands and near the American coasts, simulated mean chlorophyll in the equatorial Pacific Ocean is close to observed values (Nicol et al. 2014; Menkes et al. 2016).

For future ocean projections, several Earth System Models (ESMs) were first selected from the CMIP5 inter-comparison project (Taylor et al. 2012), based on the ability of the models to produce accurate ENSO variability in the Pacific (Bellenger et al. 2014). The four ESMs selected were: IPSL-CM5A (Dufresne et al. 2013), MIROC (Watanabe et al. 2011), GFDL-ESM2G (Dunne et al. 2012) and MPI-MR (Mauritsen et al. 2012). Atmospheric fields were then extracted from these models for the period 2011-2100 under RCP8.5 to simulate 'business-as-usual' climate anomalies to build forcing sets for the NEMO-PISCES ocean model.

All ESMs display large biases in their representation of Pacific climate, including the important South Pacific Convergence Zone (Dutheil, et al. 2019; Brown et al. 2020). These atmospheric biases propagated uncertainties associated with future atmospheres into the coupled, dynamical-biogeochemical oceanic framework. For example, they result in prominent distortions in the extension and position of the warm pool (Brown et al. 2014), and can be expected to affect modelling of the open ocean ecosystem up to the higher trophic levels (Lehodey et al. 2013).

To mitigate the mean state model biases in the selected ESMs, a 'pseudo-warming' anomaly approach was used to force the ocean model. To do this, the long-term tendencies for atmospheric temperature, zonal and meridional wind speeds, radiative heat fluxes, relative humidity and precipitation were extracted from the ESM atmospheres using a 31-year wide Hanning procedure to filter out variability on timescales less than 15 years.

For each ESM, these low-frequency trends were then superimposed onto a repeating 30-year historical forcing (i.e., repeated three times to span the 21st century). This method produced 90 years of atmospheric forcing for the NEMO-PISCES model over the period 2010-2100. This procedure enabled a realistic climatology and high-frequency variability from observations subject to long-term trends due to climate change based on the ESMs to be retained (see Supplementary Figure 7 in Bell et al. 2021).

For consistency, the control simulation of NEMO-PISCES was also produced over three, repeated, 30-year historical periods to correct any long-term trend generated internally without climate change forcing.

It is important to note that use of all ESM acronyms (e.g., IPSL) in the following text refers to NEMO-PISCES or SEAPODYM simulations derived from the ESM anomaly forcing, and not to the ESM models themselves.

The four NEMO-PISCES simulations of future ocean conditions produced contrasting results in terms of dynamics and biogeochemistry (see Supplementary Figure 8 in Bell et al. 2021). In particular, there was strong warming in the IPSL and MIROC simulations and weaker warming for GFDL and especially MPI. Spatial patterns in ocean warming produced by the NEMO-PISCES simulations differed mostly in intensity and not so much in spatial structure.

Using NEMO-PISCES outputs to produce SEAPODYM forcings

The outputs of NEMO-PISCES were used to provide environmental forcing variables for SEAPODYM, the model used to project the responses of the key life stages of skipjack, yellowfin and bigeye tuna to climate change. The following physical and biochemical forcing variables were used in SEAPODYM applications: three-dimensional temperature, dissolved oxygen (O_2) concentration, zonal/meridional currents and primary production, and two-dimensional euphotic depth. Prior to running SEAPODYM, these forcing variables were interpolated to a regular 2° Arakawa A grid and placed in the center of the grid cells. Primary production was then vertically integrated throughout the water column, whereas the other 3D variables were integrated within three pelagic layers, defined according to the euphotic depth to provide the mean 2D fields for each variable per layer. Selected environmental variables from the historical ocean reanalysis and from four climate-driven ocean outputs are shown in Supplementary Figure 3 in Bell et al. (2021).

These integrated variables were then used to force the SEAPODYM-LMTL (Lower and Mid-Trophic Level) sub-model. SEAPODYM-LMTL relies on primary production, temperature and ocean currents to simulate the biomass of six functional groups of micronekton, i.e., mid-trophic-level prey organisms of tunas (see Supplementary Figure 4 in Bell et al. 2021), residing or migrating through three pelagic layers within the upper 1000 m of the water column (the epipelagic layer, and upper and lower mesopelagic layer), with depths linked to the depth of euphotic layer Z as 1.5Z, 4.5Z and 10Z (1000 m). The definition of these pelagic layers is derived from the diurnal vertical distributions of micronekton species (Lehodey et al. 2015).

Optimal parametrization of SEAPODYM during historical period

The parameterization of SEAPODYM for each tuna species is highly sensitive to ocean forcing, i.e., in its average state it is free from systematic biases, and it represents interannual variability and ENSO correctly. This sensitivity enables the model to reproduce observed variability within large, geo-referenced datasets of tuna catches and length distributions reflecting changes in fish abundance (Lehodey et al. 2013) The environmental forcings in this study were obtained from the historical NEMO-PISCES reference simulations using a realistic atmospheric reanalysis, i.e., one based on a consistent set of atmospheric observations. Historical fishing datasets used to achieve model optimal parametrizations were compiled from the combination of data provided by SPC for the WCPO and by IATTC for the EPO. The model spatial resolution was 2° x 2° and the resolution for time and age dimensions was one month. The skipjack tuna reference model was obtained by integrating all available geo-referenced data, i.e., catch, length-frequency of catch, and tagging release-recapture data into a likelihood function and obtaining the solution using the maximum likelihood estimation (MLE) approach (see Supplementary Note 7 in Bell et al. 2021). The initial habitat and movement parameters for bigeye and yellowfin tuna were also estimated by integrating tagging data into the model, however, the final parameterisations of the reference models for these two species were based mainly on fisheries data. The methodology, and optimal reference solutions obtained for skipjack, yellowfin and bigeye tuna, and model validations with statistical metrics, are described in other publications documenting the use of SEAPODYM (Senina et al. 2018, 2020a,b).

The structures of the populations of the three tuna species in December 2010 (the last time-step of the reanalysis) were used to set the initial conditions for the projections starting in 2011. A second historical simulation was run to remove the effects of fishing mortality (see Supplementary Figures 9 and 10 in Bell et al. 2021) to establish the initial conditions for the unfished tuna populations. In these latter simulations, the stocks increase and reach an equilibrium state in a time that is defined by the life span of the species and the estimated stock–recruitment relationship. We assume that at the end of the 30-year reanalysis (December 2010), stocks of all three tropical tuna species are at their virgin (unfished) state and influenced by environmental variability only.

Projections of climate change impacts on tuna

Previous studies on the impact of climate change on tropical tuna species in the Pacific Ocean produced projections based on the full-field NEMO-PISCES output from a single ESM (IPSL) under the IPCC 'business as usual' scenario (Lehodey et al. 2010, 2011, 2013, 2015; Bell et al. 2013). These projections were subject to biases, resulting in poor coherence between historical and projected environmental forcings, and abrupt changes and biases when switching from a historical reanalysis to a projected time-series. To reduce this problem, we used an approach based on the four projected climates from NEMO-PISCES outputs (See Supplementary Methods in Bell et al. 2021).

Simulations of the SEAPODYM tuna model were run with parameters from the reference MLE models for the three tuna species, with forcings from the four NEMO-PISCES and mid-trophic simulations, under the RCP8.5 scenario to project tuna population dynamics until mid-century. We estimated the virgin biomass of each species in the decade 2011-2020 and computed the relative change in biomass by 2050 (2044-2053) as follows:

$$\delta_B(2050) = \frac{1}{N}\sum_{t=2011}^{2020}\left(\frac{B(t+\Delta t)}{B(t)} - 1\right) \qquad (1)$$

where Δt is the time interval corresponding to 33 years, N is the number of monthly time steps in the selected time period (120 months between 2011 and 2020). We chose to average over 10 years at 33-year intervals to compare two distant periods with the same atmospheric variability, thus removing the possible effects of interannual variation and allowing better detection of the climate change signal.

The relative biomass change $\delta_B(2050)$ was computed for the EEZs of Pacific countries and territories, and all high-seas areas in the WCPO and EPO (See Supplementary Figure 1 in Bell et al. 2021).

Sensitivity analyses to explore uncertainty

We analysed the impacts of climate change on skipjack, yellowfin and bigeye tuna with an ensemble of simulations focusing on the greatest sources of uncertainty in the NEMO-PISCES variables and in SEAPODYM (see Supplementary Figure 11 and Supplementary Table 21 in Bell et al. 2021). The methods used to explore these uncertainties, and the rationale for these analyses, are explained in the Supplementary Methods in Bell et al. (2021).

Modelling tuna distribution under lower emissions scenarios

The simulations based on RCP8.5 project a redistribution of tuna biomass by 2050 as globally-averaged surface temperature rises to 2°C above pre-industrial levels by mid century. To evaluate possible effects of the moderate GHG emission scenario on tuna redistribution, we also estimated the responses of tropical tuna species to conditions similar to RCP4.5 by 2050.

In the absence of ocean forcings and SEAPODYM outputs for RCP4.5, we used estimates based on the RCP8.5 simulations using a 'time-shift' approach (Herger et al. 2015). This method consists of identifying the time segment in RCP8.5 in which a key variable, e.g., CO_2-equivalent, matches the value expected for the selected representative concentration pathway in 2050. Accordingly, we selected the time periods in the RCP8.5 curve when total CO_2-eq concentrations in the atmosphere reached those projected for RCP4.5 in 2050 (see Supplementary Figure 12 in Bell et al. 2021). Based on this method, the equivalent of RCP4.5 in 2050 is reached in 2037 under RCP8.5.

An important assumption of this method is that the dynamical pattern corresponding to a given change of global temperature is independent of the rate of change. This assumption is expected to be met for key features of the tropical Pacific Ocean because the upper ocean generally responds rapidly to changes in atmospheric forcing. However, this assumption is unlikely to hold for tuna population dynamics because interannual variability of tuna biomass is driven by demographic processes (recruitment and mortality), which are in turn influenced by environmental variability. Furthermore, due to the slow nature of demographic processes, the repercussions of environmental variability on tuna population dynamics are time-lagged. For example, there is a time lag of 8 months between the Southern Oscillation Index (SOI) and the biomass of young skipjack tuna (aged from 3-9 months) (Senina et al. 2018), and a time lag of 12 months between SOI and total biomass of skipjack tuna (see Supplementary Figure 13 in Bell et al. 2021). When combined with the effects of stock-recruitment relationships, and different generation times between tuna species, the speed and duration of climate change processes may have a profound effect on tuna biomass. Therefore, due to the rapidly-changing ocean conditions in the RCP8.5 scenario, the population status of a tuna species in the second and third decade cannot be assumed to be equivalent to that under a scenario with lower emissions by mid-century.

To address the complications associated with the population dynamics of tuna in a changing environment, we generated the full 2011-2050 time-series by recycling the years from RCP8.5 simulations. Note that recycling the 'equivalent' years from RCP8.5 simulations to imitate those projected for the RCP4.5 scenario, involves re-using the same years multiple times because of their lower rate of change. To avoid looping the forcings over the same year multiple times, we selected several years around the 'equivalent' RCP8.5 year, while enlarging the temporal window with increasing differences in the rates of GHG change between the two scenarios and ensuring that the mean CO_2-eq within this window was equal to those in the target RCP4.5 scenario. The inverse mapping of the RCP8.5 curve from arrays of CO_2-eq values to the 'equivalent' years in the RCP8.5 simulation (see Supplementary Figure 14 in Bell et al. 2021) provided the selected range of RCP8.5 years to imitate the RCP4.5 scenario. The NEMO-PISCES model variables from those years were then used to compute monthly climatology for each year of the surrogate RCP4.5 forcing to provide smoothed time-series of forcing variables over the complete time range. The temporal evolution of epipelagic ocean temperature is compared for four climate models and the RCP scenarios in Supplementary Figure 14 in Bell et al. (2021).

The biomass changes projected for the three tuna species in 2050 under RCP8.5 and under the moderate, surrogate emissions scenario were then computed for all Pacific Island EEZs (see Supplementary Figure 15 in Bell et al. 2021) following formula (1) (Supplementary Methods in Bell et al. 2021). The biomass changes projected under the RCP4.5 forcing are smaller in magnitude than those for RCP8.5, demonstrating that the effect of climate change is less pronounced in the simulations under this moderate emissions scenario.

Estimating changes in tuna biomass in EEZs and the high seas

For this analysis, reference biomasses were produced for skipjack, yellowfin and bigeye tuna for the period 1979-2010 from quantitative assessment studies using SEAPODYM, which estimates population dynamics, habitats, movements and fisheries parameters with an MLE approach (see Supplementary Note 7 in Bell et al. 2021). The fit between observations and predictions (for catch and catch size-frequencies) was used to validate the optimal solutions of the models within and outside the time window for the model parameter estimates. The fit was analysed spatially by fishery to ensure that there were no regional biases. Once the optimal solution was achieved, a final simulation was made with the same set of parameter estimates but without considering any fishing, to obtain the unfished biomass dynamics during both the historical period and the projection for the 21st Century. The differences in unfished biomass between the historical period (2001-2010) and projections in 2050 (mean of 2046-2050) for each species were used to compute the weighted mean change in total tuna biomass in the EEZs of the nine tuna-dependent Pacific Island countries participating in the GCF Programme for the RCP8.5 and RCP4.5 emission scenarios by 2050 (and for all Pacific Island countries and territories and high-seas areas).

Appendix H. Summary of the vulnerability of the four tuna species to climate-driven changes in ocean variables*

EOV = essential ocean variable for the four tuna species; SKJ = skipjack tuna; YFT = yellowfin tuna; BET = bigeye tuna; SP ALB = South Pacific albacore. PP = primary productivity; IPO = Interdecadal Pacific Oscillation.

EOV	Exposure and sensitivity	Potential impact and adaptive capacity	Vulnerability
Temperature	• SST projected to rise by 0.7-0.8 °C by 2035 relative to 1980-1999; and by 1.0-1.5 °C under low, and 2.5-3.0 °C under high emissions in 2100. • The size of the warm pool is projected to increase by ~ 250% by 2035 and by > 500% under low and 800% under high emission scenarios in 2100. • Observed continuous increase of ocean heat content. • Observed expansion of the mean size of the warm pool at a rate of 4 × 10^5 km^2 per year since 1981. • Increased sensitivity of CMIP6 climate models to climate variability. • Uncertainty due to the cold tongue bias and IPO influence. • Each tuna species has its optimal temperature range and can thermoregulate, diving to colder waters (if sufficient dissolved oxygen concentration available).	• Tunas are highly mobile. Possible changes in spawning location and success. • Electronic tagging data suggest thermoregulation would be of limited value in preventing overheating due to lower oxygen concentration in deeper colder waters, excepted for bigeye tuna (e.g., Humphries et al 2024). • Possibility of phenological adaptation, i.e. arriving earlier on spawning grounds, or use of more subtropical areas for spawning. • Possible change in access to deep forage due to stratification. • Risk of compounding effects with deoxygenation. • Skipjack stock seems currently to benefit of the warm pool expansion.	• **LOW vulnerability** at large scale due to high mobility, allowing movement to preferred temperature ranges, both for spawning and feeding. • **MEDIUM to HIGH** vulnerability at regional level (changing distributions). • **Increased vulnerability** to fishing with enhanced stratification (higher catchability for surface gears).
Dissolved oxygen	• Projected minor decrease at the surface due to reduced solubility of gases in warmer water. Likely higher decrease in subsurface waters, up to 0.2 mL/L where the observed concentrations are now ~ 3 mL/L. • Observed underestimation of deoxygenation by Earth Climate (System ?) Models. • Lack of consensus on mechanisms controlling concentrations, leading to opposite trends for the eastern Pacific in sub-surface waters. • Influence of interdecadal variability on OMZ dynamics. • Dissolved O_2 controls the performance of oceanic fishes, but species dependent: SKJ & ALB (4 ml/L) < YFT (2.5) < BET (1.5). 1 mg/L is an overall minimum threshold for many species.	• Likely greatest effect in the eastern equatorial Pacific that has low oxygen concentrations in sub-surface waters. • YFT & ALB would be affected most by lower O_2 levels in the thermocline, BET has greater tolerance to low concentration. • Uncertainty regarding compound effect of increased temperatures and changes in O_2 concentrations	• **Likely LOW vulnerability** in SKJ inhabiting surface layers and WCPO mostly. • **Likely LOW vulnerability** in YFT & SP ALB in the WCPO, with possible habitat extension further south) but **MODERATE vulnerability** in the EPO. • Vertical contraction of habitat can lead to **higher vulnerability** to fishing gears.
Ocean acidification	• Global mean surface pH has been reduced by 0.1 units since 1750. Decreasing trend of -0.017 unit per decade since 2000. • pH is projected to decline by 0.2 to 0.3 pH units by 2100 in the tropical Pacific Ocean. • Fish tolerate a wide range of dissolved CO_2 and pH but at a physiological cost (acidosis). • Potential strong compound effect of pH and temperature at high metabolic demands. • Possible impact on calcifying zooplankton and sound absorption (-20 to -60% in the upper layer by 2100), with possible impacts in prey-predator relationships.	• Acidosis (process causing increased acidity in the blood and other body tissues) could lead to a narrowing of the optimal thermal performance window of tunas and metabolic rate (growth and egg production). • Lower pH can impact the survival of tuna larvae in some places (Eastern Pacific Ocean), as predicted through laboratory experiments and simulations (Nicol et al. 2022).	• Likely **LOW vulnerability** to projected changes in the WCPO but **large uncertainty** of compound effects. • **MEDIUM vulnerability** in EPO through larval mortality processes.

Ocean currents	• Eddies and upwellings associated to equatorial circulation projected to decline. • Observed multi-decadal strengthening of the ocean boundary current systems. • Oceanic circulation determines spawning and feeding grounds, and dispersal or retention of larvae. • Limited knowledge on the interaction of tuna (spawning and foraging) with their mesoscale environment (eddies, fronts). • Mesoscale features around islands and seamounts can play an important role in the spawning strategies of tunas.	• Projected changes likely to affect spawning grounds of tuna and survival rates of larvae. • Spawning grounds expected to shift to central and eastern equatorial and sub-equatorial regions. • Species-dependent changes. • Adaptative capacity to change vertical behavior is unknown.	• **LOW vulnerability** for SKJ and YFT due to extensive spawning grounds, spawning seasons and high fecundity. • **LOW to MODERATE** for BET and ALB that may have more limited spawning grounds (seasons).
Primary production (PP)	• Increased stratification expected to reduce nutrient inputs from deeper layers, and thus primary production. • Long time series (ALOHA) and satellite ocean color data suggest increasing productivity in tropical waters, but maybe also partly due to IPO. • Higher Inter-model uncertainties in CMIP6 compared to CMIP5. • Evidence of high peaks of skipjack recruitment associated with blooms of PP in warm waters. • Upwellings are poorly simulated by climate models. • Increases in rainfall (5%-20%) would increase the supply of nutrients to archipelagic waters in PNG through greater flows from the Sepik-Ramu River system.	• Any change in PP is cascading to upper trophic levels. • Very high biodiversity in the tropical ocean and possibility of adaptation of phytoplankton species. • Lower PP in WCPO would decrease survival of tuna larvae. • Change in the location of feeding grounds (SKJ; YFT). • More favourable spawning areas are projected toward central and eastern Pacific Ocean.	• At basin scale, **LOW to MODERATE vulnerability** of tuna larvae to change in primary productivity, with **VERY HIGH uncertainty.** • At regional scale, **MEDIUM to HIGH** vulnerability at larval stages. • **LOW vulnerability (high uncertainty**) for adult tuna to reduced area of the nutrient-rich waters.
Zooplankton and micronekton	• Zooplankton biomass in warm pool and adjacent archipelagic waters expected to decrease (range 9-26% in 2100). • Observed long-term increase of zooplankton in ALOHA oceanographic station (north of Hawaii), likely also partly due to interdecadal variability. • Increase in surface temperature and stratification could result in a greater production to biomass (P:B) ratio, and more pronounced differences between epipelagic and mesopelagic micronekton. • Distributions will change in relation to other factors (PP, currents, temperature). • The convergence between the warm pool and the equatorial 'cold tongue' is expected to shift eastward. • Tunas have high energetic requirements.	• Less prey increases the risk of mortality for larvae and juvenile fish. • Tunas are opportunistic and highly mobile predators and can access mesopelagic prey either by diving or due to diel vertical migration. • Access to mesopelagic micronekton by adult tuna could become more difficult due to increased stratification and decreased O_2 concentrations. • Possible higher competition with increased populations of gelatinous organisms or voracious competitors, such as large squid species.	• **LOW to MEDIUM** vulnerability for adult tunas due to: ○ High mobility and opportunistic feeding behaviour ○ High diversity of prey providing resilience to changes ○ Specialized physiology that permits feeding in the deeper layers • **MEDIUM** vulnerability for larvae and juvenile

*Source Lehodey et al. (in press).

Appendix I. Improvements in modelling needed to develop an ‘Advanced Warning System’

Improvements to operational oceanography

Three workstreams are needed to improve operational oceanography to inform SEAPDOYM. Workstream 1 needs to focus on developing and applying an operational framework to mitigate the influence of present-day biases in Earth System Models (ESMs) on future regional ocean physical and biogeochemical projections. Present-day biases in ESMs can significantly compromise the reliability of regional projections. For instance, the strong cold-tongue bias in the IPSL-CM6A-LR model leads to greater warming and chlorophyll decrease in the western equatorial Pacific Ocean compared to the eastern region, whereas bias-corrected simulations show opposite patterns. Current research has focused on applying corrections in the bulk formulae and to flux perturbations (i.e., developing an oceanic counterpart of dynamical atmospheric approaches to mitigate the influence of background atmospheric biases on future atmospheric projections). Operationalising these methods would be a central activity of this workstream. Regionalizing ESMs is an active research area in oceanography and the framework will remain flexible to new and novel approaches to bias correction.

Workstream 2 needs to focus on improvements to the historical environmental forcings used to optimise parameters in the SEAPODYM model. Extending the historical time-series (i.e., to periods before satellite observation) in the atmospheric reanalysis models (e.g., ERA-Interim, ERA5, JRA55) facilitates splitting the historical period into training and validation periods allowing for improved optimisation of the SEAPODYM models. Atmospheric reanalysis models used for optimisation are subject to bias which requires correction before application in SEAPODYM. Operationalizing this bias correction would be an important component of this workstream. Development of historical forcings using ERA6 in a coupled reanalysis, using both atmospheric and ocean observations, is needed. ERA6 has the potential to generate an even more balanced and consistent Earth System climate reconstruction. Historical forcing generated from higher-resolution reanalyses (e.g., GLORYS) would be prepared for downscaled EEZ-scale hindcasts. Environmental forcing for forecasting will need to be developed under this workstream to provide the AWS with this capacity

Workstream 3 needs to focus on inclusion of additional biogeochemical (BGC) models to the environmental forcing ensemble. BGC models provide a framework to integrate chlorophyll-a, nutrients, carbon, and oxygen cycles to estimate lower trophic level structure and function in marine ecosystems. They are the foundation for estimating the distribution and abundance of tuna prey in the SEAPODYM model. PISCES has been the only BGC used in SEAPODYM to date. Workstream 3 needs to add the WOMBAT BGC to the ensemble. It also needs to include validation of BGC outputs and assimilation of observation data with lower- and mid-trophic biomass estimates from SEAPODYM. This later task is necessary for identifying and quantifying uncertainty in prey field estimation.

Improvements to SEAPODYM

Two workstreams are needed to improve the SEAPODYM model:

1. Developing a more realistic model structure to account for variable growth of tuna depending on their feeding conditions. This is essential for accurately representing differences in tuna weight-at-age measurements observed in various oceanic areas with distinct ecosystem traits and productivity.
2. Refining the model resolutions to improve spatial variability and to better estimate tuna abundance at smaller scales, such as EEZs, as well as regionally.

However, these improvements cannot be achieved without first parallelizing the model's computer code. Parallelization experiments indicate that a speedup of 70-90 times from the current sequential processing can be achieved using 76-151 processors, respectively. The implementation of SEAPODYM parallelization and improvements to the numerical solver will need to be done in several stages and will take 1-2 years to complete. After this, it will be possible to proceed to high-resolution simulations. Further development of variable growth (Item 1) will need to be the next priority, focusing on improving reference models and quantitative model applications to tuna populations by integrating available observations from industrial fishing, port sampling, and scientific campaigns.

Development of fleet dynamics and economic models

This workstream will need to establish a fleet dynamics model suitable for evaluating the impacts of climate change on Pacific tuna fisheries. Two complementary approaches will need to be undertaken. The first will focus on econometric (or similar) models that integrate environmental, fleet behavior and cost structures to identify the underlying drivers of fishing decisions. This set of models will also need to facilitate the provision of short-term outlooks to guide application of short-duration adaptive responses to changing fishing activity. The second approach will need to focus on coupling fleet dynamics to the SEAPODYM model to facilitate projection of the dual impact of fishing and climate change on fishery economic performance (at both regional and EEZ scales). The coupled model will facilitate detailed evaluation of current and alternate policies, practices, and adaptations to the impacts of climate change across short-, medium-, and long-term time horizons.

Provision of observational data to validate EEZ-scale outputs

This last component of work will need to provide the necessary observational data to validate outputs from the Advanced Warning System. Three workstream will be needed for this. The first will need to apply modern methods to estimate the absolute abundances of tuna and the population structure of tuna in the Pacific Ocean. Validating abundance is necessary for estimating the realistic impacts of tuna redistribution on the expected economic returns for each participating country and to evaluate the performance of alternate policy and adaptive measures. Quantifying tuna population structure similarly is necessary for establishing the potential impacts of shifting tuna distributions. Methods to quantify each of these needs have been established. The second workstream will need to focus on the collection of market and vessel data necessary to parameterize and validate the fleet dynamics models. The third workstream will need to focus on supporting ocean monitoring data collection by fishing vessels and fisheries observers. Two priority data needs should be the focus: acoustic measurements of tuna prey; and water temperature profiles. Methods for these forms of data collection have been established along with the necessary processes for post-collection data processing and dissemination for use in model validation and assimilation

Adapting tuna dependent Pacific Island communities and economies to climate change:

Options for supplying dietary protein for growing Pacific Island populations.

Report prepared for the SPC

(RFP22-3866: GCF Study 2)

October, 2023

Pacific Community
Communauté du Pacifique

ANCORS
AUSTRALIAN NATIONAL CENTRE FOR OCEAN RESOURCES & SECURITY

UNIVERSITY OF WOLLONGONG AUSTRALIA

This report was prepared for the Pacific Community.

Pacific Community
Communauté du Pacifique

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Suggested citation:

Brewer, T., Kottage, H., Andrew, N. (2023). Options for supplying dietary protein for growing Pacific Island populations Report prepared for the Pacific Community. 94 p.

Acknowledgements

The authors would like to thank Drew Wright, Simon Nicol and Johann Bell for insightful feedback on draft versions of this report. We also acknowledge Australian Centre for International Agriculture Research (ACIAR) project FIS-2018-155 which funded the development of the primary data sources and protein analyses summarized in this report. We also thank partners and collaborators across the Pacific for their input into the development of the databases.

EXECUTIVE SUMMARY

Pacific diets have changed dramatically over the past ~50 years. A transformation from mostly domestic production of fruits and vegetables, including root crops and fish and invertebrates, to dependence on imported cereals, meat and highly processed foods has contributed to significant non-communicable disease challenges across the region. Populations continue to grow and urbanise, particularly in Melanesia, and nearby inshore fish stocks increasingly show signs of localized depletion (Brewer, Cinner et al. 2009, Kronen, Magron et al. 2010, Pratchett, Munday et al. 2011). When the potential effects of climate change, on both domestic production and imports, are also considered there is an urgent need for guiding food system policy and activities towards food security and nutrition through healthy domestic sources. Tuna resources have significant potential to improve nutrition across the region, including to more marginalised populations, and enhance domestic food sovereignty, reducing food security risks associated with global shocks.

Across five chapters, this report summarises the latest data spanning public health, food consumption, food nutrition composition, food pricing, and projected future fish requirements given population growth and dietary protein requirements. This set of analyses is then synthesised in the context of climate change and other plausible drivers of food security and nutrition outcomes across the region.

The report harnesses the most recent and comprehensive datasets on food consumption and food trade for the region, supported by production data, nutrition data, various sources of public health data and human height and body mass index estimates to conduct analysis that have not been possible to date. The data on consumption estimates (Pacific Data Hub – Microdata Library 2023) and food trade (Brewer and Andrew 2023) have been developed in a partnership between the University of Wollongong and the Pacific Community through the Australian Centre for International Agriculture Research (FIS-2018-155). Detailed consumption data allow calculation of both country-level estimates and more detailed estimates, including various population subsets such as 'urban-rural' and analysis by wealth quintile for some countries. These data are invaluable in the context of a general paucity of information ,and substantial heterogeneity among Pacific food systems. Continued improvements to these databases is central to ongoing regional food security activities and policy.

As reported elsewhere (e.g. FAO 2021), and presented in Chapter 1, Pacific Island countries have significant public health challenges including micronutrient deficiency (Table 4), globally high rates of obesity and other non-communicable disease (Table 3). This public health burden, and associated economic cost, is partly attributable to significant dietary shifts that have occurred over the preceding decades (Murray 2001, Andrew, Allison et al. 2022), including changing diets from locally-sourced, seasonally diverse foods towards import dependence including processed foods high in salts, fat and sugars (Legge, Gleeson et al. 2011, Brewer, Andrew et al. 2023). This challenge is not isolated to urban areas (Albert, Bogard et al. 2020) and varies significantly across countries. Improving nutrition outcomes, through targeting vulnerable populations, is essential to tackling the ongoing non-communicable disease challenges facing the region. Understanding which populations are vulnerable is still poorly understood and remains a priority for analyses of the large data sets described above.

Chapter 2 summarises dietary intake of protein across food groups for Pacific Island countries, using 'Global Individual Food Consumption Data Tool' food groupings (Leclercq, Allemand et al. 2019) based on Household Income & Expenditure Surveys as the primary data source. Significant cleaning and standardising of HIES data to conduct the analyses in this chapter provide the best available food consumption estimates for countries in the region. Tuna and other pelagic fish currently represent only a small proportion of protein intake, as does canned fish (Table 6), suggesting opportunity to significantly increase their contribution to future protein requirements. Currently, reef and coastal fish, imported chicken, wheat, and rice contribute a large proportion of dietary protein for most countries. Urban populations tend to consume more tuna and other pelagic fish, while rural populations tend to consume more reef and coastal fish. Assessment of food imports compared to domestic production highlights very high levels of import dependence for non-aquatic sources of protein including chicken, other animal sources foods (e.g., dairy), rice, and wheat. This dependence highlights a potential future risk, depending on the impacts of climate change, and shocks such as possible pandemics and war, on global food production and trade.

There is significant variation in macro- and micronutrient composition across the assessed food groups (Chapter 3, Table 11). Tuna and other pelagic fish are relatively rich in protein and contain Omega 3 fatty acids. Canned fish is high in protein, iron and calcium. Based on nutrient profiles, tuna, fresh or canned, presents a plausible option for enhancing future nutrient intake and ensuring people are consuming adequate calories. Similarly, average prices (Chapter 4) vary significantly across food groups and countries (Table 12). On average fresh tuna and canned fish is more expensive than reef and coastal fish, and comparably priced to chicken, which is now a significant component of Pacific diets, particularly in urban areas. However, the significant variation in prices between food groups across countries prevents confident generalisation.

Chapter 5 presents analysis on future protein requirements for Pacific Island populations. Calculated projections account for recommended protein consumption, given body weight, population projections and the recommendation that 50% of dietary protein is obtained from fish. At an aggregated country level, some countries including Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Palau and Tuvalu currently consume adequate fish to meet dietary protein recommendations, based on consumption estimates from the year of consumption data collection. Cook Islands, Niue, Samoa and Vanuatu are expected to require increased fish availability out to 2050. A number of assumptions were required to conduct the analysis so it should be viewed with caution. For example, the estimates assume consumption of reef and coastal fish at current per capita rates. Additionally, significant variation does exist in the quality and quantity of fish consumed within countries including between rural and urban populations. Initiatives to increase access to affordable fish should incorporate this variation into decision-making processes to ensure that the food and nutrition security benefits of initiatives are maximised.

Chapter 6 considers plausible options for increasing the supply of dietary protein for Pacific Island countries. In doing so, it considers the evidence presented in the first 5 chapters in combination with other attributes of food including nutrition content, affordability and accessibility. This assessment is made within the general framing of anticipated declining reef and coastal fisheries, additional climate impacts on food systems and population growth. It considers various foods which could substitute reef and coastal fisheries, available through either imports, domestic agricultural and aquaculture production or tuna and other pelagic fish. In weighing the evidence, the chapter concludes that increased consumption of tuna through domestic artisanal and commercial fisheries should be central to future food security and nutrition for the region. It does, however, recommend, enhancing domestic agriculture systems to generate greater dietary diversity and resilience in anticipation of the predicted future climatic context.

ACRONYMS

COICOP	Classification of Individual Consumption According to Purpose
BMI	Body Mass Index
FAD	Fish Aggregation Device
FAOSTAT	Food and Agriculture Organisation Statistics
GIFT	Global Individual Food Consumption Data Tool
HIES	Household Income and Expenditure Survey
NCD	Non-communicable Disease
NCD-RisC	Non-communicable disease Risk Factor Collaboration
PFCD	Pacific Food Consumption Database
PFTD	Pacific Food Trade Database
PIC	Pacific Island Country
PNDB	Pacific Nutrient Database
SPC	Pacific Community
USD	United States Dollars
WHO	World Health Organisation

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INTRODUCTION

Pacific diets and malnutrition

Food systems, among communities in the Pacific Islands region, have evolved rapidly over the past 50 years (Andrew, Allison et al. 2022), shifting from agrarian subsistence, cash crops and fishing to significantly elevated dependence on imports of staples and processed foods, particularly in urban areas. These Pacific food systems are highly vulnerable to the effects of climate change and to exogenous events such as COVID-19 and global political and financial events. As Pacific populations have increased, particularly in Melanesia, import dependence to meet caloric needs has escalated (Brewer, Andrew et al. 2023).

Through lifestyle and dietary changes, combined with embedded poverty and other factors, people of the Pacific have globally high rates of malnutrition, and diet-related incidence of non-communicable diseases (NCDs); roughly 3.85 million people in the region live below the international poverty line (FAO 2021). Non-communicable diseases are the leading cause of death in the region (Hou, Anderson et al. 2017). This public health crisis places significant burden on Pacific Island countries, from health departments through to individual households. Improving Pacific diets is a major regional priority, and fisheries resources, including tuna, are expected to be a significant contributor to diminishing NCD prevalence and positive health outcomes.

Importantly, food systems, poverty and malnutrition vary significantly across countries in the Pacific Islands region and in response to social, demographic and economic factors (FAO 2021), so it is essential to avoid generalisation when considering solutions at a regional scale. Instead, it is imperative to apply the best available data to identify countries and populations with the greatest poverty and dietary challenges, and apply locally-appropriate solutions including by improving accessibility to, and use of, the region's rich tuna resource.

Constraints on supply of nutritious food

Climate change is expected to have significant and varied impacts on the Pacific food system. Foremost is a potential change in the distribution of tuna stocks, which is of significant concern for nutritional food security and government revenue (Bell, Senina et al. 2021). Similarly, as coastal habitats including coral reefs degrade, fisheries productivity declines (Kronen, Magron et al. 2010, Hoegh-Guldberg, Andréfouët et al. 2011, Pratchett, Munday et al. 2011) . Crop production is also likely to be adversely affected by climate change, primarily through increased intensity of cyclones, but also due to changing rainfall and temperature, and increases in pests and diseases (Taylor, McGregor et al. 2016). The vast majority of people in the Pacific live within 5 km of the coastline, making them vulnerable to sea-level rise including salt water inundation of crops (Andrew, Bright et al. 2019).

Tuna in Pacific diets

Historically, a significant portion of Pacific diets has been obtained from the ocean, including coastal and pelagic finfish, and harvesting of invertebrates and seaweeds (Charlton, Russell et al. 2016, Farmery, Scott et al. 2020). Atoll nations with limited arable land have historically been particularly reliant on the ocean for dietary requirements. However, the combination of growing populations, habitat degradation and overfishing of coastal resources has increased the price of seafood through increased relative scarcity (T. Brewer, personal observation). In recent decades, with improved mechanisation and technology (e.g., outboard motors, nylon gears and fish aggregation devices (FADs)), pelagic fish in Pacific diets has increased as a proportion of seafood consumption. Domestic commercial fleets, processing facilities in Papua New Guinea, Solomon Islands and Fiji, and transhipment operations have additionally added to the availability of tuna and other pelagic fish in Pacific diets. Canned tuna has enabled greater access to tuna in the region (Bell, Sharp et al. 2019), primarily due to its longer shelf life. Given current malnutrition, projected climate impacts, declining coastal fisheries and projected population growth, it is anticipated that pelagic fisheries will provide an increasingly important role in Pacific diets in the future (Bell, Allain et al. 2015). To fulfill projected shortfalls in fish, based on half of dietary protein requirements to be provided by finfish, one proposed solution is to increase total tuna catch dedicated to domestic consumption in Pacific countries (Bell, Allain et al. 2015).

Fish are an essential source of nutritionally important macro- and micronutrients. Tuna, in particular, are high in protein and omega-3 fatty acids and a good source of iron (Bell, Sharp et al. 2019). Securing adequate dietary protein for Pacific Islands communities is of primary importance, and tuna are a viable option which is available domestically through subsistence and artisanal fisheries, transhipping operations and access to locally-canned tuna. Based on World Health Organisation (WHO) recommendations of ~ 0.7g of protein per kg of body weight to be consumed daily and recommendation of up to 50% of dietary protein to be supplied by finfish (SPC 2008), it is expected that there will be significant shortfalls in the supply of reef fish for many Pacific Island countries in the future (Bell, Allain et al. 2015). This shortfall is anticipated based on a combination of population growth and the limits to fish production from coral reefs and other coastal fish habitats. Increasing tuna consumption to fill the anticipated gap in fish supply of 25% by 2035 will require ~ 6% of the commercial tuna catch from the region to be made available to island populations (Bell, Allain et al. 2015).

Pelagic fisheries have many advantages as a priority source of nutrition in the Pacific Island region to both fill the projected shortfall in dietary protein and to diminish the incidence of diet-related non-communicable diseases. First, there are ample local supplies of tuna and other pelagic fish, which ensure reasonable price stability irrespective of global supply chains. Second, tuna is a good source of protein, essential fatty acids, vitamins and minerals (Bell, Sharp et al. 2019, Hicks, Cohen et al. 2019). Third, tuna and other pelagic fish are already part of the cultural and economic system of the Pacific, with well-established fisheries. However, increasing tuna in Pacific diets of the future will require a supply chain focus (Bell, Allain et al. 2015) (see also Technical Studies 2 and 5), from harvest through to consumption and consideration of affordability, sustainability, and equity of access among other factors.

Figure 1. Tuna for sale at a local market in Auki, Malaita, Solomon Islands. Image from T. Brewer

Alternatives to tuna in Pacific diets

Pelagic fish, and primarily tuna, has the potential to be a major component of the future Pacific diet. However, consideration of alternative foods, with comparable nutrition profiles allows for better understanding of future dietary options. For example, Pacific countries import a significant volume of poultry, pork, and beef. Imports of chicken are increasing exponentially in some countries (e.g. FAO and University of Wollongong 2023). Currently, a meaningful proportion of protein in Pacific diets is derived from imported wheat and rice (Brewer, Andrew et al. 2023). When considering trade-offs between future protein sources it is important to consider factors such as reliability of supply, pricing, specific macro- and micronutrients within specific foods, and impacts on domestic supply chains, health outcomes and the national financial burden associated with malnutrition and high incidence of NCDs.

Forward summary

This study covers a broad set of objectives under the general aim of reviewing options, including tuna, for supplying dietary protein for growing Pacific Island populations. Within the study, we summarise the public health status of member countries of the Pacific Community (SPC), characterise and summarise current Pacific protein across a range of food groups, summarise the nutritional value of each of the summarised food groups, tabulate pricing across food groups, and estimate future protein requirements given projected population growth. We conclude by synthesising this information to identify options for supplying dietary protein, with a focus on tuna.

Specific study deliverables are stated in Appendix 1.

Countries included in analysis are Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands. Niue, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

CHAPTER 1. PUBLIC HEALTH STATUS OF PACIFIC ISLAND MEMBER COUNTRIES

a. Background

Pacific Island countries are experiencing very high rates of non-communicable diseases (NCDs) by global standards. Major drivers include changing lifestyles and diets, high prevalence of tobacco smoking and limited resources available for health interventions. Changing diets have contributed to obesity and diseases such as diabetes and cardiovascular disease (FAO 2021). Some countries are experiencing deficiencies in key macro- and micro-nutrients (FAO 2021). Increased imports of unhealthy foods high in sugar, fats and salts, and declining per capita production of local foods, are driving this dietary change (Brewer, Andrew et al. 2023). Access to affordable protein is of particular concern. Contributing to this is a projected decline in coastal fisheries production, due to a combination of factors including the adverse impacts of climate change, habitat degradation and poor resource management. Meat imports are currently partly filling the animal-sourced protein gap, however, increased dependence on imports in an increasingly volatile trade context (due, for example, to future epidemics and animal disease such as avian influenza, and impacts of climate change on global food production systems) is not desirable.

There is significant variation in public health status among Pacific Island countries, related to various factors including affluence, and the urban or rural settings where people live (Sharp, Troubat et al. in press). Understanding this variation is vital to diet-related health interventions, including evaluating the future role of tuna in contributing to adequate protein consumption across the region. Here, we present key health attributes across the 14 countries to highlight both the range in health status across countries and concerning outliers. We present updated estimates of public health indicators included in Bell, Sharp et al. (2019, appendix 5). Due to the significant number of public health indicators included, this chapter is divided into the following indicator groups: demographics, nutrition status among children < 5 years, lifestyle risk factors and NCDs, micronutrient deficiency, and dietary intake.

b. Demographics

Pacific countries vary across demographic indicators (Table 1). Melanesian high islands with a large land area and fertile soils have the largest populations, while Micronesian and Polynesian atolls with small land areas and infertile soils have very small populations by global standards. Papua New Guinea has by far the largest population, which is significantly greater than all other Pacific Island countries (PICs) combined. Female life expectancy across the region is higher than for males, though lower than in more affluent developed countries. Melanesian countries have high population growth rates through natural increase, whereas some atoll countries are experiencing declining populations, partly caused by emigration to countries including Australia, New Zealand, and the US. Infant mortality per 1000 births varies significantly across countries, reflecting the variation in maternal health care, among other factors. Overall, basic demographics vary significantly across the region and are important to consider in the context of expected impacts of climate change on food security.

Table 1 Demographic attributes of countries including indicator values and year of indicator value.

	Population size (1)		Life expectancy at birth (1)		Births per year (per 1000 population) (1)	Infant mortality (per 1000 live births) (1)
	All	< 5 years	Male	Female		
Cook Islands	15406	1106	72	79	13	9
	2022	*2022*	*2013*	*2013*	*2019*	*2019*
FSM	105987	11632	69	72	24	30
	2022	*2022*	*2010*	*2010*	*2018*	*2013*
Fiji	901603	78157	68	72	23	16
	2022	*2022*	*2017*	*2017*	*2017*	*2017*
Kiribati	122735	14345	58	66	27	41
	2022	*2022*	*2015*	*2015*	*2019*	*2019*
Marshall Islands	54446	6166	71	73	25	23
	2022	*2022*	*2016*	*2016*	*2018*	*2016*
Nauru	11928	1599	58	61	29	25
	2022	*2022*	*2017*	*2017*	*2018*	*2017*
Niue	1532	107	73	75	12	0
	2022	*2022*	*2017*	*2017*	*2018*	*2017*
Palau	17976	1163	68	78	14	12
	2022	*2022*	*2015*	*2015*	*2018*	*2018*
Papua New Guinea	9311874	1298172	63	68	29	33
	2022	*2022*	*2016*	*2016*	*2018*	*2018*
Samoa	200999	25101	74	76	27	14
	2022	*2022*	*2016*	*2016*	*2018*	*2016*
Solomon Islands	744407	102141	61	62	30	19
	2022	*2022*	*2010*	*2010*	*2018*	*2015*
Tonga	99283	11249	69	73	24	17
	2022	*2022*	*2011*	*2011*	*2018*	*2012*
Tuvalu	10778	1326	64	67	25	23
	2022	*2022*	*2014*	*2014*	*2018*	*2016*
Vanuatu	307941	38538	66	69	29	28
	2022	*2022*	*2010*	*2010*	*2018*	*2013*

[1]Latest available data sourced from the Pacific data hub (https://pacificdata.org).

c. Nutrition status among children < 5 years

Although data on child nutrition were not available for all countries, it is evident that the nutrition status among children varies significantly across countries, and between boys and girls within some countries (Table 2). Rates of stunting are extremely high in Papua New Guinea, Solomon Islands, Vanuatu and Marshall Islands, and moderately high in Kiribati and Nauru. The incidence of underweight children is not as high but proportionately similar to stunting across countries with data. Papua New Guinea has relatively high rates of both overweight children and underweight children, suggesting economic inequality. Tonga also has high rates of overweight children. Rates of exclusive breastfeeding in infants is highly variable across countries. These results highlight both marked variation between countries and significant malnutrition among children <5 years old across the Pacific, reflecting a need for improved nutrition which is targeted to populations with the highest malnutrition rates. The absence of data for some countries, and the outdated data for some countries where data are available, reflects a need for greater coverage and frequency of health surveys.

Table 2 Nutrition status among children <5 years of age. Data presented as % of population with diet-related condition.

	Stunting (height for weight <2SD) (2)		**Wasting (weight for height <2SD) (2)**		**Underweight (weight for age <2SD) (2)**		**Overweight (Weight for height > +2 SD) (2)**		**Exclusive breastfeeding (3)**
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Infants <6 months**
Cook Islands	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
FSM	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
Fiji	8.0% *2004*	6.9% *2004*	4.7% *2004*	8.2% *2004*	4.9% *2004*	8.2% *2004*	5.4% *2004*	4.8% *2004*	40.0% *2014-2020*
Kiribati	16.4% *2018*	14.0% *2018*	3.7% *2018*	3.4% *2018*	8.1% *2018*	3.4% *2018*	3.3% *2018*	0.9% *2018*	64.0% *2014-2020*
Marshall Islands	39.3% *2017*	30.0% *2017*	4.6% *2017*	2.4% *2017*	14.1% *2017*	9.5% *2017*	4.9% *2017*	3.2% *2017*	43.0% *2014-2020*
Nauru	22.1% *2007*	25.8% *2007*	2.2% *2007*	0.0% *2007*	6.9% *2007*	2.9% *2007*	4.6% *2007*	1.3% *2007*	67.0% *2014-2020*
Niue	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
Palau	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a
Papua New Guinea	50.9% *2010*	47.9% *2010*	14.4% *2010*	13.7% *2010*	28.9% *2010*	26.6% *2010*	14.3% *2010*	13.1% *2010*	60.0% *2014-2020*
Samoa	7.6% *2019*	6.9% *2019*	2.9% *2019*	3.2% *2019*	3.3% *2019*	3.4% *2019*	9.0% *2019*	8.5% *2019*	70.0% *2014-2020*
Solomon Islands	33.7% *2015*	29.6% *2015*	8.4% *2015*	8.5% *2015*	16.2% *2015*	16.1% *2015*	8.4% *2015*	8.5% *2015*	76.0% *2014-2020*
Tonga	2.5% *2019*	1.8% *2019*	1.2% *2019*	1.0% *2019*	1.0% *2019*	0.5% *2019*	12.2% *2019*	9.9% *2019*	40.0% *2014-2020*
Tuvalu	5.7% *2019*	5.6% *2019*	3.2% *2019*	2.2% *2019*	3.5% *2019*	2.1% *2019*	4.8% *2019*	3.6% *2019*	35.0% *2014-2020*
Vanuatu	33.2% *2013*	24.5% *2013*	5.5% *2013*	4.0% *2013*	13.0% *2013*	10.3% *2013*	5.2% *2013*	4.7% *2013*	73.0% *2014-2020*

[2] https://data.unicef.org/resources/dataset/malnutrition-data/

[3] https://data.unicef.org/resources/dataset/the-state-of-the-worlds-children-2021-statistical-tables/ (Table 9)

d. Lifestyle risk factors and non-communicable diseases

Rates of obesity in adults are extremely high in the Pacific. Reasons include malnutrition, primarily through increased consumption of unhealthy foods, changed lifestyles, and cultural preferences for specific foods (Reeve, Lamichhane et al. 2022). There is, however, significant variation among countries (Table 3). For example, Melanesian countries tend to have lower rates of obesity than Micronesian and Polynesian countries. However, all countries have experienced comparable increases in the proportion of adults that are overweight since the 1970s (FAO 2021). Women have consistently higher rates of obesity, compared to men, across Pacific Island countries (Table 3). Incidence of diabetes in the Pacific is extremely high by global standards, as is raised blood cholesterol. The diets of Pacific populations are causing a significant health burden and high incidence of premature death (FAO 2021). Healthier diets would decrease the prevalence of NCDs and contribute to the regional achievement of Sustainable Development Goals (SDGs) 2 and 3, viz. no hunger and good health and well-being.

Table 3 Lifestyle risk factors and non-communicable diseases.

	Overweight prevalence (% population 18+y with BMI ≥25 kg/m2) (4)		**Obesity prevalence (% population 18+y with BMI ≥30 kg/m2) (5)**		**% with raised blood pressure (SBP ≥140 OR ≥90, age standardised estimate) (6)**		**% with diabetes (fasting plasma glucose levels >=7.0 mmol/L (126 mg/dl); (7)**		**Mean total cholesterol (mmol/L) (Raised total cholesterol (>= 5.0 mmol/L, age-standardized estimate) [#] (8)**		**% with raised blood cholesterol (Raised total cholesterol (>= 5.0 mmol/L, age-standardized estimate) (9)**
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	
Cook Islands	83.7%	85.8%	52.6%	59.2%	24.9%	19.5%	28.3%	26.7%	4.7	4.7	59.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
FSM	72.1%	79.8%	40.1%	51.5%	26.6%	23.2%	20.5%	23.4%	4.1	4.4	48.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Fiji	59.9%	67.7%	25.1%	35.3%	22.4%	20.7%	15.9%	18.9%	4.7	4.7	53.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Kiribati	76.6%	80.9%	41.6%	50.4%	24.0%	19.0%	22.0%	22.6%	4	4.4	36.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Marshall Islands	82.1%	84.9%	48.4%	57.3%	23.8%	18.6%	20.8%	21.5%	4.3	4.5	46.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Nauru	88.3%	88.7%	58.7%	63.3%	23.8%	17.2%	30.1%	28.4%	4.3	4.3	46.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Niue	77.6%	82.5%	44.8%	55.1%	26.1%	22.1%	26.8%	27.3%	4.2	4.4	n.a.
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	
Palau	84.3%	85.9%	51.8%	58.8%	25.7%	20.0%	24.8%	21.6%	4.1	4.4	55.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Papua New Guinea	47.4%	58.1%	16.6%	25.8%	25.1%	25.8%	15.4%	14.3%	4.4	4.5	38.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*
Samoa	73.6%	82.0%	39.9%	55.0%	26.6%	21.0%	22.7%	26.6%	4.3	4.6	35.0%
	2016	*2016*	*2016*	*2016*	*2015*	*2015*	*2014*	*2014*	*2018*	*2018*	*2008*

Solomon Islands	49.6% *2016*	60.5% *2016*	17.9% *2016*	27.1% *2016*	20.4% *2015*	23.6% *2015*	12.6% *2014*	15.1% *2014*	4.3 *2018*	4.6 *2018*	33.0% *2008*
Tonga	74.8% *2016*	82.2% *2016*	41.4% *2016*	54.5% *2016*	25.4% *2015*	21.8% *2015*	21.9% *2014*	26.4% *2014*	4.6 *2018*	4.6 *2018*	50.0% *2008*
Tuvalu	80.0% *2016*	83.8% *2016*	47.0% *2016*	56.2% *2016*	26.1% *2015*	21.2% *2015*	23.2% *2014*	24.3% *2014*	4.2 *2018*	4.4 *2018*	n.a.
Vanuatu	52.2% *2016*	62.0% *2016*	20.2% *2016*	30.1% *2016*	24.2% *2015*	24.1% *2015*	15.7% *2014*	16.0% *2014*	4.4 *2018*	4.5 *2018*	38.0% *2008*

[#] or using insulin or oral hypoglycaemic drugs; or having a history of diagnosis of diabetes; age standardised estimate)

[4] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-overweight-among-adults-bmi-=-25-(age-standardized-estimate)-(-)

[5] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-obesity-among-adults-bmi-=-30-(age-standardized-estimate)-(-)

[6] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/raised-blood-pressure-(sbp-=140-or-dbp-=90)-(age-standardized-estimate)

[7] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/raised-fasting-blood-glucose-(7-0-mmol-l)(age-standardized-estimate)

[8] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/mean-total-cholesterol-(age-standardized-estimate)

[9] https://www.fao.org/3/cb5758en/cb5758en.pdf

e. Micro-nutrient deficiency

Pacific Island countries have high rates of micro-nutrient deficiency by global standards. Iron deficiency anaemia rates among children in PICs range from moderate (≥20%) to severe (≥40%). Anaemia rates among both pregnant and non-pregnant women are moderate, with an average of around 30% (FAO 2021). As expected, pregnant women do have higher rates of anaemia than non-pregnant women (Table 4). Tuna, among other foods, is high in iron, so higher rates of tuna consumption would likely reduce rates of anaemia. Deficiency of Vitamin A among children (6-59 months) ranges from 6%-17% in PICs (Table 4). Vitamin A deficiency is a leading cause of childhood blindness and contributes to morbidity and mortality associated with infection. Fruits and vegetables are a key source of Vitamin A. Comprehensive data on salt consumption are not available for the Pacific. The data on salt consumption (Table 4) are limited to the percentage of households which have salt, and which tested positive for iodine (>0ppm). The available percentages suggest consistent salt consumption, however, determining whether salt consumption levels in PICs is excessive requires better metrics (e.g., volume consumed per capita per day) with better country coverage. Overall, the tabulated indicators suggest micro-nutrient deficiency, as previously published (FAO 2021).

Table 4 Micro-nutrient (Iron and Vitamin A) deficiency and iodised salt consumption among Pacific Island countries.

	% of iron deficiency anaemia (Hb<110g/L) in children aged 6-59 months (< 5 yo) (10)	% iron deficiency anaemia (Hb<120g/L) in non-pregnant women (aged 15-49) (12)	% iron deficiency anaemia (Hb<110g/L) in pregnant women (aged 15 - 49) (12)	Vitamin A deficiency in children 6-59 months (%) (13)	% Iodized salt consumption (>0 ppm) among all tested households with salt (14)
Cook Islands	27% *2019*	27% *2019*	33% *2019*	n.a	n.a
FSM	37% *2019*	24% *2019*	35% *2019*	17% *2013*	n.a
Fiji	40% *2019*	32% *2019*	41% *2019*	11% *2013*	n.a
Kiribati	49% *2019*	32% *2019*	42% *2019*	9% *2013*	96% *2018*
Marshall Islands	40% *2019*	30% *2019*	39% *2019*	13% *2013*	n.a
Nauru	42% *2019*	29% *2019*	36% *2019*	n.a *2015*	n.a
Niue	36% *2019*	27% *2019*	34% *2019*	n.a	n.a
Palau	34% *2019*	28% *2019*	34% *2019*	n.a	n.a
Papua New Guinea	47% *2019*	34% *2019*	44% *2019*	11% *2013*	99% *2005*
Samoa	36% *2019*	26% *2019*	39% *2019*	6% *2013*	98% *2014*
Solomon Islands	38% *2019*	37% *2019*	49% *2019*	8% *2013*	98% *2015*
Tonga	34% *2019*	28% *2019*	37% *2019*	6% *2013*	n.a
Tuvalu	42% *2019*	27% *2019*	34% *2019*	n.a.	n.a
Vanuatu	31% *2019*	29% *2019*	28% *2019*	6% *2013*	68% *2013*

[10] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-anaemia-in-children-under-5-years-(-)

[11] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/anaemia-in-non-pregnant-women-prevalence-(-)

[12] https://www.who.int/data/gho/data/indicators/indicator-details/GHO/prevalence-of-anaemia-in-pregnant-women-(-)

[13] International Food Policy Research Institute country profiles. https://www.ifpri.org/

[14]https://data.unicef.org/resources/data_explorer/unicef_f/?ag=UNICEF&df=NUTRITION&ver=1.0&dq=PLW+NIU+TON+TUV+WSM.NT_IOD_ANY_TH+NT_IOD_ANY_TS..._T._T._T._T&startPeriod=2000&endPeriod=2022

f. Dietary intake

Understanding dietary intake is essential to better decision-making and policy outcomes relating to food production and distribution systems, and to health outcomes including malnutrition. Dietary intake was calculated using consumption estimates from Household Income and Expenditure Surveys (HIES) (Appendix 2, 4) and the Pacific Nutrient Database (PNDB) (FAO and SPC 2020). Food consumption data derived from HIES were thoroughly cleaned (Sharp, unpublished) and integrated with the PNDB to create the Pacific Food Consumption Database (PFCD) (Pacific Data Hub – Microdata Library 2023). The PFCD provides nutrient profiles for each food item acquired, including through subsistence farming and fishing, by households across the Pacific, including information on numerous macro- and micro-nutrients. While this information source is the best available for the region, it should be noted that HIES are generally conducted every 5-10 years so estimates will rarely be current.

To obtain nutrient profiles, the per capita consumption of edible portion, in grams, of each food item (Appendix 4) was multiplied by the corresponding fraction of each nutrient in each food item (grams nutrient/grams of food item) from the PNDB (Statistics for Development Division 2020). Consequently, the PFCD contains valuable nutrient data for each food item, according to the Classification of Individual Consumption According to Purpose (COICOP) code, consumed by each household including information on purchased quantity per capita per day and edible quantity per capita per day across nutrients.

The calculation of the average nutrient intake per capita per day (carbohydrates, fat, and protein) involves several steps:

1. Firstly, the total carbohydrates (or protein or fat) for each household was calculated by summing the carbohydrates in all food items consumed by the household. The estimation is based on per-person per-day because, in PFCD, the consumption per day per person is provided for each food item consumed by the household.
2. Then, the weighted averages across all households were calculated for each country.

The percentage nutrients of the diet in Table 5 are calculated in two steps:

1. The sum of the nutrients and edible quantities of all food items consumed by the population of the country was calculated.
2. The total for each nutrient was then divided by the total edible quantities and multiplied by 100 to obtain the percentage of nutrient in the diet.

The PFCD includes the amounts spent on each food item by each household, as well as the total of all expenditure of each corresponding household. Consequently, the percentages of expenditure on food in Table 5 are calculated using the following steps:

1. The total food expenditure is calculated for each household.
2. Next, the weighted sums of the food expenditure and total expenditure are calculated for each country.
3. Finally, the percentage of total expenditure spent on food is calculated by dividing the country's total food expenditure by the country's total expenditure and multiplying the result by 100.

Primary sources of rich carbohydrates in Pacific diets are root crops and imported rice and wheat (see Chapter 3). From the countries included here, Cook Islands and Niue consume less carbohydrate than other countries. Fat consumption varies from 46 grams per capita per day in Kiribati to 108 grams per capita per day in Samoa and comprises roughly 4-10% of dietary intake across countries. Importantly, these data do not disaggregate fats, including saturated and trans-fats. WHO recommends limiting total fat intake to 30% of total energy intake to reduce the risk of unhealthy weight gain (WHO 2023). Protein consumption will be discussed in Chapter 2 at higher resolution.

At an aggregated national level, the analysis suggests that Pacific populations are obtaining adequate calories. However, significant disparities are likely to exist between populations within countries. For example, wealthier households are likely to consume more calories than poor households (FAO 2021). Expenditure on food and non-alcoholic beverages as a proportion of total expenditure ranges from 25% in Palau to 59% in Kiribati. Considering these estimates, it is important to note the variation in timing of data collection when interpreting the meaning of results. For example, they are the best available, data for Nauru were collected in 2012-13, and data for Kiribati, Marshall Islands and Vanuatu were collected in 2019-2020. These time differences could have significant implications for drawing conclusions concerning trends, given the rapidly-changing diets of Pacific people in recent decades.

Table 5 Dietary intake (average) across countries, including available energy and % of expenditure dedicated to food and non-alcoholic beverages. Data for all except Fiji are derived from the most recent HIES

(Appendix 2). Note, these estimates are specific to the nutrients, rather than whole food quantities containing the nutrients. The estimates exclude food consumed ''away from home" which is a very small fraction of total consumption and can be considered inconsequential.

	Carbohydrate		**Fat**		**Protein**			
	(g)/capita/day	**% of diet**	**(g)/capita/day**	**% of diet**	**(g)/capita/day**	**% of diet**	**Energy (kcal) available/capita/day**	**% of the total Household expenditure on food and non-alcoholic beverages**
Cook Islands	207 2015	16.41 2015	94 2015	7.44 2015	91 2015	7.23 2015	2117 2015	32.02 2015
FSM	404 2013	28.42 2013	77 2013	5.39 2013	105 2013	7.39 2013	2779 2013	34.04 2013
Fiji	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	36.3 (15)
Kiribati	415	36.93	46	4.50	81	7.43	2426	58.69

	2019	2019	2019	2019	2019	2019	2019	2019
Marshall Islands	341 2019	29.65 2019	65 2019	5.78 2019	102 2019	8.65 2019	2398 2019	43.26 2019
Nauru	324 2012	37.18 2012	52 2012	6.01 2012	93 2012	10.67 2012	2162 2012	32.83 2012
Niue	227 2015	16.22 2015	78 2015	5.61 2015	93 2015	6.64 2015	2086 2015	40.36 2015
Palau	345 2013	24.50 2013	92 2013	6.50 2013	119 2013	8.44 2013	2725 2013	25.62 2013
Papua New Guinea	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Samoa	350 2013	26.43 2013	108 2013	8.17 2013	73 2013	5.51 2013	2721 2013	35.54 2013
Solomon Islands	408 2012	26.34 2012	70 2012	4.54 2012	69 2012	4.44 2012	2606 2012	41.82 2012
Tonga	392 2015	24.89 2015	75 2015	4.75 2015	85 2015	5.39 2015	2646 2015	44.74 2015
Tuvalu	415 2015	38.04 2015	97 2015	8.89 2015	84 2015	7.67 2015	2905 2015	44.74 2015
Vanuatu	413 2019	23.63 2019	74 2019	4.30 2019	74 2019	4.33 2019	2686 2019	53.53 2019

[15] 2019/20, https://www.statsfiji.gov.fj/images/documents/HIES_2019-20/2019-20_HIES_Main_Report.pdf, (page 61)

CHAPTER 2. SOURCES AND QUANTITIES OF PROTEIN IN PACIFIC DIETS.

a. Chapter background

This chapter presents an overview of the main sources of protein currently in Pacific diets, which have historically been dominated by fruits and vegetables, including root crops and seafood. Rice and wheat, which is almost entirely import derived, are now a dominant staple in Pacific diets (Brewer, Andrew et al. 2023). Consumption of imported meats, primarily chicken, has increased in recent years, particularly in urban areas. Imports of highly-processed foods, often containing high levels of salts, fats and sugars, now dominates narratives around health and nutrition in the region and are a significant contributor to the high incidence of non-communicable diseases.

Estimating total protein consumption, by food groups, is essential to determining the relative contribution of tuna-based protein in Pacific diets, both now and in the future. Here, we analyse different food groups to better understand their contribution to regional food security and nutrition. Appendix 1 outlines the food group categories analysed, which were adopted for two main reasons. First, definitional constraints within the HIES data, including some fish acquisition records being defined as neither pelagic nor coastal, means that there is a composite fish category. Second, additional categories, including 'all other food' were included to ensure comprehensive analyses and estimation of total protein consumption.

The food groups are aligned with the FAO & WHO GIFT (global individual food consumption data tool) categories (Leclercq, Allemand et al. 2019). The GIFT categorization was developed as a simple nutrition-sensitive approach to grouping foods. The categories developed here are aligned with the GIFT groupings, whilst acknowledging the constraints in HIES data and the focus of the research being on current and future tuna availability for food security and nutrition in the Pacific region in the face of climate change.

The food groups include (1) reef and coastal fish, (2) tuna and pelagic fish, (3) composite fish (not defined as either 1 or 2), (4) canned fish, (5) invertebrates, (6) beef, (7) chicken, (8) pork, (9) processed meat and canned meat, (10) other animal-sourced foods, (11) cereals and their products, (12) vegetables, roots and tubers, (13) pulses, seeds and nuts, (14) composite meals and (15) all other foods (not included in categories 1-14). These categories, including 'all other foods' enables estimation of total protein consumption. Specific foods (by COICOP definition) included in each category are provided in Appendix 3.

Figure 2 Mixed reef fish for sale at Gizo market, Western Province, Solomon Islands. Image supplied by T. Brewer.

This chapter includes 1) an overview of protein consumption by food groups across countries, 2) an assessment of the implications of proximity to the coast for consumption, 3) an analysis of differences in consumption between rural and urban settings, and 4) an analysis of the proportion of consumption derived from domestic or imported sources.

b. Protein consumption across food groups and countries

Background

Fish, including tuna, have historically been the dominant source of protein in Pacific Islands diets. While there has been a shift to increased consumption of meat and imported grains and cereals, seafood still comprises an essential dietary component. As coastal fisheries continue to decline there is expected to be a significant shortfall in fish-derived caloric intake and protein (Bell, Allain et al. 2015). This trend is compounded by growing populations and habitat degradation, among other factors.

Here, we present an overview of total protein consumed per capita in each country, separated into the food groups described above as a baseline for understanding the current status and to project future needs. This analysis summarizes work completed under ACIAR project FIS/2018/155 and prepared for publication as Kottage, Brewer et al. (submitted ms.).

Methods

The information presented in this chapter is primarily derived from HIES conducted across 12 of the 14 PICs. Details of the specific HIES used for each country are presented in Appendix 2. As described in Chapter 1, under 'dietary intake', a cleaning protocol was applied to primary HIES data (Sharp, Troubat et al. in press) to develop the PFCD, from which consumption estimates were derived. Population estimates, including source, are provided in Appendix 4. This method for calculating protein consumption was used for Cook Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Niue, Palau, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The PFCD includes information on protein per capita per day for each food item (COICOP code) consumed by the members of each household. The calculation process involved the following steps:

1. Estimation of total protein consumption (g) per capita per day for each food group within the household.

2. This quantity was then divided by 1000 and multiplied by 365 to obtain the total consumption of protein in kilograms per year for each food group within a particular household.
3. Finally, the weighted average total protein consumption for each food group was calculated for each country.

It should be noted that food consumed away from home may not be included in the calculations due to lack of quantity data. However, food away from home represents a negligible proportion of consumption so discounting it would not meaningfully influence results.

Consumption data were not available for either Papua New Guinea or Fiji. Comparable estimates were derived using FAOSTAT production data (https://www.fao.org/faostat/en/#data) and net import (imports minus exports) data from the Pacific Food Trade Database (Brewer and Andrew 2023). From each database, food and beverage commodities for Fiji and PNG were classed following the groupings used for the other 12 PICs. The commodity definitions do not correlate, precisely, between databases, however, it is assumed that the dominant commodities, in terms of volume, were correctly attributed. For Papua New Guinea and Fiji, the specific foods within each food group are defined in Appendix 5 (FAOSTAT) and Appendix 6 (PFTD).

Net import and production estimates of protein for Papua New Guinea and Fiji were calculated in terms of kilograms per capita per annum. Total per capita protein consumption for each of the food groups for PNG and Fiji was then calculated using the aggregated protein (grams/kilograms) estimate presented in Chapter 3 below.

Importantly, the derived estimates for Papua New Guinea and Fiji are not as robust as estimates for the other countries because edible portion is not controlled for. However, apart from fish and certain cuts of beef and pork, edible portion is likely to comprise the vast majority of the total weight available for consumption. Similarly, domestically processed foods are not included in FAOSTAT production data. The population estimates used for calculating per capita consumption were derived from the Pacific Data Hub (https://pacificdata.org/population-dashboard) using 2018 data and are 8,558,701 for Papua New Guinea and 887,394 for Fiji.

Both FAOSTAT and the PFTD have some data limitations, requiring the use of additional data sources to complete analyses. The PFTD includes all food groups except 'tuna' and 'all other foods'. Tuna is excluded due to complexities of including transhipment and foreign fishing fleet harvest which are not necessarily reported in trade data. Some analysis of tuna imports is presented in the assessment of imports relative to production (section 4 below) but excluded here. Tuna imports, except for those outlined in section 4 of this chapter, are marginal because most tuna consumption is derived from domestic production.

FAOSTAT production data include only beef, chicken, pork, other animal-sourced foods, cereals and their products, vegetables, roots and tubers, and pulses, seeds and nuts (Appendix 5). Given inadequate data on production (harvest) of aquatic foods for Fiji and Papua New Guinea, estimates for the included aquatic food groups (groups 1-5) were taken from Bell, Sharp et al. (2019) and a recent assessment of fish production for the region (Gillett and Fong 2023). Specifically, per capita consumption of reef and coastal fish was calculated from Gillett and Fong (2023) by combining 'coastal commercial', 'coastal subsistence', 'freshwater', and 'aquaculture', harvest estimates from Tables 8-4 and 14-5 and dividing by 2021 Pacific Data Hub population estimates for 2021 (Fiji = 898,402; Papua New Guinea = 9,122,994). Tuna & pelagic fish includes 'offshore local', from the same tables in Gillett and Fong (2023), with the same population estimates used to derive an estimate of per capita availability. 'Offshore local' can include tuna for export which was not possible to differentiate from tuna for consumption. Per capita consumption of canned fish was calculated using the per capita canned fish consumption estimates provided in Table 1 of Bell, Sharp et al. (2019). These per capita estimates for the three aquatic food groups derived from FAOSTAT and the PFTD were then multiplied by the estimated protein fraction (see Table 11 below) to derive a per capita protein consumption estimate.

Figure 3 Tuna entering the local market during transhipment in Honiara, Solomon Islands. Image supplied by T. Brewer.

Results & Discussion

Tuna and other pelagic fish currently contribute a minor portion of total protein consumption across the region (Table 6), however tuna consumption exceeds reef and coastal fish consumption in Cook Islands, Nauru, Papua New Guinea and Tuvalu. These estimates are likely to be lower than previous estimates because they control for edible portion for each specific food (COICOP). Edible portion of fish is around 60% but varies between species. Canned fish similarly provides only a small portion of protein intake across countries. These protein consumption estimates highlight the potential to significantly increase consumption of tuna in the region to compensate for expected shortfalls due to declining coastal productivity and population growth, among other factors. Reef and coastal fish provide significant per capita quantities of protein in some countries including Fiji, Marshall Islands and Palau. Extrapolation of these estimates to future requirements, including total fish quantity, are presented in Chapter 5.

The food group that provides the greatest quantity of protein to Pacific diets is cereals and their products, reflecting the multi-decadal transition to increased rice and wheat consumption (Brewer, Andrew et al. 2023) through imports. Chicken is also a major source of protein across most countries. Based on the data presented here, protein consumption is, on average, sufficient across PICs in the year HIES data were collected (Appendix 2). However, stark disparities among populations within countries in factors such as wealth (FAO and University of Wollongong 2023) show significant variation in access to, and consumption of, particular food types which would influence protein consumption. Additionally, a large portion of the protein is derived from less desirable sources including rice and wheat instead of root crops and from 'all other foods', which includes numerous highly-processed foods containing high levels of salt, fats and sugar.

The supplementary estimates used for both Papua New Guinea and Fiji generally sit within the range of highest to lowest estimates across countries for each of the food groups. However, some estimates for Fiji are higher than expected, including reef and coastal fish, and cereals and their products. Controlling edible portion for reef and coastal fish, assuming 60% recovery, would reduce the estimate from 8.16 to 4.89 kilograms of protein per capita per annum for Fiji, which is better aligned with estimates in other countries. Fiji has a flour mill and is a significant consumer of both wheat and rice, so the estimate of 25.46 kilograms per capita per annum is plausible. The high estimate of pulses, seeds, and grains for Papua New Guinea could be a function of the significant coconut industry, much of which is refined to copra oil for export, rather than eaten (Appendix 5). An additional factor to consider with the supplementary estimates is that they do not control for imports and production for tourism and other non-resident consumption, and so do not reflect local consumption as well as HIES data which uses household surveys. When consumption estimates are derived from both the Papua New Guinea and Fiji HIES data these estimates should be updated so they are standardised with other PICs.

Table 6 National protein consumption (kilograms p.c./year) across food groups for 14 Pacific Island countries (calculated from HIES data excluding food consumed away from home).

Food Group	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Nauru	Niue	Palau	Papua New Guinea	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Reef & coastal fish	0.67	4.91	8.16**	5.56	10.36	2.26	0.24	10.66	1.63**	0.42	3.07	0.18	2.65	2.47
Tuna & other pelagic fish	1.74	2.68	2.80**	3.40	1.28	9.18	0.78	1.47	4.35**	0.16	1.31	0.29	4.07	0.71
Composite fish	2.20	2.23	0.05#	2.36	0.05	0.16	2.11	2.31	0.00#	1.79	3.80	4.07	0.36	0.04
Canned fish	0.54	3.79	1.88*	0.69	1.24	0.31	2.01	1.03	0.40*	1.88	0.83	0.64	0.85	1.34
Invertebrates	0.28	0.46	^	1.10	0.22	0.06	0.48	0.25	^	0.12	1.56	0.95	1.37	0.48
Chicken	9.20	3.26	9.59#	0.85	5.94	3.86	9.08	6.70	0.53#	6.09	0.23	6.86	4.41	1.94
Beef	1.09	0.21	1.81#	0.04	0.54	0.76	1.11	1.37	0.27#	0.35	0.04	0.69	0.01	1.74
Pork	2.51	1.44	1.26#	0.18	0.46	0.11	0.58	1.78	2.31#	0.44	0.11	0.25	1.57	0.77
Processed and canned meat	2.14	2.07	0.08#	1.17	2.12	1.92	4.35	1.25	0.08#	0.68	0.13	1.91	0.90	0.26
Other animal sourced food	2.52	2.14	7.36#	0.48	0.81	3.15	3.41	1.68	7.72#	2.11	0.12	2.89	2.92	0.73
Vegetables, roots and tubers	1.08	0.84	5.71#	0.39	0.17	0.19	1.81	1.17	6.20#	2.38	5.20	3.76	0.20	4.94
Cereals and their products	4.97	10.05	25.46#	11.17	10.67	9.63	4.66	8.56	4.53#	5.00	5.29	5.54	7.16	6.56
Pulses, seeds and grains	1.04	0.65	4.92#	0.51	0.59	0.17	0.30	0.46	22.97#	1.84	2.14	0.55	1.98	1.32
Composite meals	0.75	0.10	n.a.	0.21	0.53	0.34	0.43	0.96	n.a.	0.52	0.41	0.22	0.03	1.46
All other foods	2.48	3.51	n.a.	1.37	2.25	1.83	2.48	3.76	n.a.	2.87	0.90	2.18	2.03	2.41
Total Protein (kilograms p.c./year)	33.23	38.33	n.a.	29.48	37.21	33.93	33.84	43.40	n.a.	26.67	25.14	31.00	30.52	27.19

* Estimates derived from Bell, Sharp et al. (2019).

**Estimates are based on capture, derived from Gillett and Fong (2023), Tables 8-4 and 14-5. For both Fiji and Papua New Guinea 'Reef fish' includes 'coastal commercial', 'coastal subsistence', 'freshwater', and 'aquaculture', and 'Tuna & pelagic fish' includes 'offshore local', from the tables.

Estimates derived from Pacific Food Trade Database and FAOSTAT using approach described above in text.

^ Gillett and Fong (2023) did not include independent estimates of invertebrates harvest so it is assumed all invertebrates are included in 'coastal subsistence'. However, not all invertebrates are harvested for subsistence purposes so there will inevitably some differences in estimates and actual consumption. Bêche-de-mer and trochus, for example, are primarily exported although trochus meat may be consumed locally.

c. Differences in coastal-inland protein per capita consumption per country by food type

Except for Papua New Guinea and Fiji, the vast majority of the population of the Pacific Island countries in this study resides in close proximity to the coast (Figure 4). Therefore, for most countries, the influence of household location relative to the coastline is unlikely to have significant impact on dietary composition. Inland populations of both Papua New Guinea and Fiji, however, are likely to have different dietary profiles to populations living closer to the coast (Figure 4). Georeferenced HIES food acquisition data do not exist for either of these countries, so it is not possible to analyse differences in protein intake between inland and coastal populations. We, assume distance from the coast to be relatively benign in influencing seafood consumption for those countries where data are available. However, it is likely that inland populations in Melanesia consume more terrestrial meat relative to coastal populations.

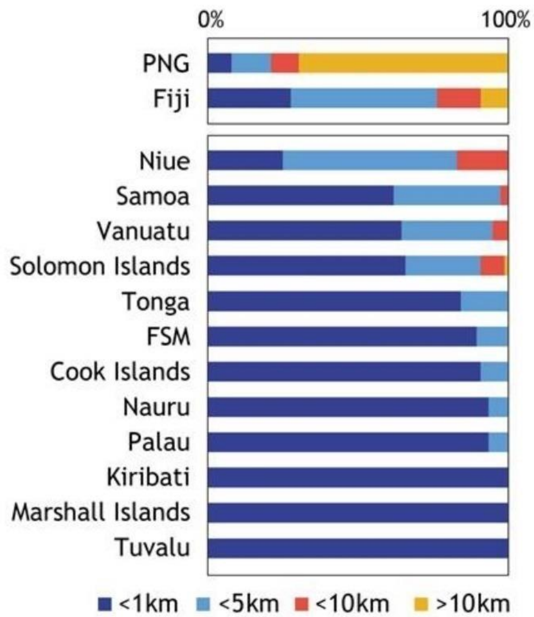

Figure 4 Percentage of PIC populations living within defined distances from the coastline. Adapted from Andrew, Bright et al. (2019).

d. Differences in urban-rural protein consumption per capita per country by food type

Background

The Pacific Island region is extremely heterogenous, both between countries and within countries. It is, therefore, essential to understand intra-country variation when considering food security and nutrition in the context of climate change. Broader variation stems from island geomorphology, with atolls and high islands having different capacities for food production. Similarly, coastal fisheries productivity is highly variable, depending on latitude and extent of coral reefs and other coastal habitats, among other factors.

A rural or urban lifestyle is a significant factor in determining both dietary composition and non-communicable disease outcomes across the region (FAO 2021). While both rural and urban populations in the Pacific experience significant malnutrition, people in rural settings tend to have greater access to domestically-produced agricultural products and aquatic foods, including fish. A major hurdle to ensuring future food security is ensuring affordable, nutritious food, including tuna, is available in urban settings. Here, we compare per capita consumption of protein derived from the food groups used in rural and urban settings across countries by presenting urban consumption, rural consumption, and a comparison of the two.

Methods

HIES data identify whether households are in an urban or rural setting, allowing separation of consumption data into the two categories. However, due to small sample sizes, HIES data do not differentiate between rural and urban populations for two countrie s; Nauru and Niue. As with section 3a, current HIES data are not available within the SPC microdata archive, so these , together with Papua New Guinea and Fiji, are not included here. Following methods used in section 3a, we present protein consumption (kilograms p.c./year) estimates for both rural and urban populations in the other ten countries. We also compare the two different estimates, as the proportion of urban consumption compared to rural consumption, computed by dividing urban consumption by rural consumption.

Results and Discussion

Dominant sources of protein in urban diets vary significantly among countries (Table 7). Tuna and other pelagic fish currently contribute marginally to total protein intake, as does canned fish. Chicken is the dominant source of animal protein in urban areas across the region, except for Kiribati, Palau, and Solomon Islands. Urban populations in FSM, Kiribati and Solomon Islands consume more protein from aquatic foods than all other animal-sourced foods. Cereals and their products (e.g., baked goods, rice, other wheat products) provide more dietary protein to urban populations than any other food group. Populations in rural areas tend to consume more protein from reef and coastal fish than tuna and other pelagic fish (Table 8). Chicken-based protein consumption varies significantly across rural populations (Table 8). Dietary protein from beef and pork is negligible in rural areas in most countries.

The difference in the total is instructive for overall rural/urban disparity in protein consumption. Rural areas tend to obtain more protein from aquatic animal sourced foods than their urban counterparts, while urban populations tend to obtain significantly more protein from non-aquatic animal sourced foods compared to their rural counterparts (Table 9). Urban populations also tend to obtain more protein from cereals and their products and from composite meals. These disparities highlight the importance of aquatic foods to rural populations and the opportunity for increasing consumption of aquatic foods in urban areas relative to other protein-rich dietary options such as imports.

Table 7 Protein consumption (kilograms p.c./year) by urban populations in year of HIES (calculated excluding food consumed away from home).

Food Group	Cook Islands	FSM	Kiribati	Marshall Islands	Palau	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Reef & coastal fish	0.11	4.03	3.29	6.22	12.15	0.39	0.91	0.05	0.85	1.23
Tuna & pelagic fish	0.93	3.19	4.57	1.44	1.62	0.15	0.84	0.35	3.07	1.77

Composite fish	1.03	1.44	1.17	0.01	2.09	0.98	2.15	4.19	0.18	0.01
Canned fish	0.52	3.85	0.77	1.11	0.99	1.58	1.70	0.50	0.92	1.92
Invertebrates	0.27	0.16	0.26	0.10	0.23	0.08	0.44	0.72	0.01	0.20
Chicken	10.46	4.79	1.33	6.90	6.83	6.41	0.71	7.71	5.17	4.75
Beef	1.28	0.40	0.06	0.70	1.40	0.42	0.19	0.83	0.02	2.47
Pork	2.53	1.29	0.25	0.33	2.03	0.34	0.09	0.26	1.03	0.23
Processed and canned meat	2.18	2.77	1.50	2.22	1.31	1.00	0.27	2.08	1.18	0.56
Other animal sourced food	2.66	2.72	0.60	0.91	1.71	3.23	0.13	3.26	2.14	1.55
Vegetables, roots and tubers	0.95	0.63	0.40	0.20	1.20	1.47	2.23	2.80	0.21	3.94
Cereals and their products	4.55	10.71	13.21	10.96	8.37	6.01	9.01	5.44	8.14	8.62
Pulses, seeds and grains	0.37	0.62	0.41	0.45	0.47	0.68	0.91	0.66	0.18	0.72
Composite meals	0.86	0.17	0.29	0.56	1.13	1.02	0.66	0.48	0.03	1.92
All other foods	2.41	3.88	1.43	2.24	4.18	2.60	1.09	2.29	1.50	2.85
Total aquatic foods	2.86	12.67	10.06	8.88	17.09	3.19	6.03	5.81	5.03	5.13
All other animal-sourced foods	19.12	11.98	3.73	11.06	13.27	11.40	1.39	14.14	9.52	9.56
Total	31.12	40.65	29.52	34.35	45.70	26.37	21.32	31.62	24.60	32.74

Table 8 Protein consumption (kilograms p.c./year) by rural populations in year of HIES (calculated excluding food consumed away from home).

Food Group	**Cook Islands**	**FSM**	**Kiribati**	**Marshall Islands**	**Palau**	**Samoa**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Reef & coastal fish	2.01	5.43	8.16	22.77	4.12	0.43	3.56	0.22	4.60	2.91
Tuna & pelagic fish	3.71	2.37	2.05	0.78	0.83	0.16	1.42	0.27	5.16	0.34
Composite fish	5.02	2.70	3.71	0.19	3.30	1.98	4.17	4.04	0.56	0.05
Canned fish	0.59	3.76	0.60	1.64	1.16	1.95	0.64	0.69	0.78	1.13
Invertebrates	0.32	0.64	2.06	0.57	0.29	0.13	1.82	1.02	2.83	0.58
Chicken	6.18	2.36	0.30	3.07	6.11	6.01	0.12	6.61	3.60	0.94
Beef	0.63	0.09	0.02	0.05	1.26	0.34	0.01	0.65	0.00	1.48
Pork	2.45	1.53	0.09	0.86	0.70	0.47	0.11	0.25	2.16	0.96
Processed and canned meat	2.04	1.65	0.80	1.80	0.99	0.61	0.10	1.86	0.61	0.16
Other animal sourced food	2.20	1.80	0.35	0.50	1.55	1.86	0.12	2.78	3.76	0.44
Vegetables, roots and tubers	1.39	0.96	0.38	0.09	1.01	2.59	5.87	4.04	0.18	5.29
Cereals and their products	5.98	9.66	8.85	9.78	9.41	4.77	4.45	5.57	6.10	5.82
Pulses, seeds and grains	2.65	0.67	0.64	1.00	0.43	2.10	2.42	0.52	3.92	1.54
Composite meals	0.49	0.06	0.13	0.42	0.20	0.41	0.35	0.15	0.04	1.30
All other foods	2.66	3.29	1.30	2.30	1.91	2.94	0.85	2.15	2.59	2.26
Total aquatic foods	11.65	14.90	16.59	25.95	9.70	4.65	11.61	6.23	13.94	5.01
All other animal-sourced foods	13.50	7.42	1.56	6.27	10.60	9.28	0.46	12.15	10.13	3.98
Total	38.32	36.96	29.44	45.81	33.26	26.74	26.01	30.82	36.91	25.20

The relative consumption of protein between rural and urban populations for each food type reveals significant disparities (Table 9). Rural populations, except in Palau and Vanuatu, consume more aquatic protein than their urban counterparts. On the other hand, with the exception of Tuvalu, rural populations in all PICs consume less protein from all other animal-sourced foods than their urban counterparts. Rural populations also consume less protein from cereals and their products compared to their urban counterparts. On a per capita basis, consumption of chicken, and canned and processed meat, is consistently higher in urban areas. Relatively less tuna and other pelagic fish is consumed in urban areas in Cook Islands, Samoa, Solomon Islands and Tuvalu. Accessibility and a higher unit price for tuna and other pelagic fish, compared to reef and coastal fish, in urban areas in Cook Islands, Solomon Islands and Tuvalu is a possible explanation for this (see Chapter 4).

Table 9 Urban per capita protein consumption per food group relative to rural per capita consumption. Low scores (<1) represent relative protein poverty in urban areas, whereas high scores (>1) represent relative protein poverty in rural settings. For example, a score of 0.057 (Reef and coastal fish in Cook Islands) means that the per capita urban consumption is 5.7% of the quantity that the rural population consumes.

Food Group	**Cook Islands**	**FSM**	**Kiribati**	**Marshall Islands**	**Palau**	**Samoa**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
Reef & coastal fish	0.06	0.74	0.40	0.27	2.95	0.91	0.26	0.22	0.19	0.42
Tuna & pelagic fish	0.25	1.34	2.23	1.84	1.96	0.94	0.59	1.28	0.59	5.27
Composite fish	0.20	0.53	0.32	0.05	0.63	0.50	0.51	1.04	0.31	0.25
Canned fish	0.87	1.02	1.27	0.68	0.85	0.81	2.67	0.73	1.18	1.69
Invertebrates	0.86	0.26	0.12	0.18	0.81	0.64	0.24	0.71	0.00	0.35
Chicken	1.69	2.03	4.44	2.25	1.12	1.07	6.18	1.17	1.43	5.07
Beef	2.04	4.37	3.10	15.09	1.11	1.25	15.14	1.27	-	1.67
Pork	1.03	0.85	2.65	0.38	2.90	0.73	0.80	1.04	0.47	0.24
Processed and canned meat	1.07	1.67	1.88	1.24	1.32	1.65	2.78	1.12	1.93	3.52
Other animal sourced food	1.21	1.52	1.72	1.81	1.10	1.74	1.10	1.17	0.57	3.52
Vegetables, roots and tubers	0.69	0.66	1.05	2.12	1.19	0.57	0.38	0.69	1.13	0.74
Cereals and their products	0.76	1.11	1.49	1.12	0.89	1.26	2.03	0.97	1.33	1.48
Pulses, seeds and grains	0.14	0.93	0.64	0.45	1.09	0.33	0.37	1.28	0.04	0.47
Composite meals	1.75	2.85	2.24	1.33	5.57	2.51	1.90	3.26	0.75	1.47
All other foods	0.91	1.18	1.10	0.97	2.19	0.89	1.27	1.06	0.58	1.26
Total aquatic foods	0.25	0.85	0.61	0.34	1.76	0.69	0.52	0.93	0.36	1.02
All other animal-sourced foods	1.42	1.61	2.40	1.76	1.25	1.23	3.04	1.16	0.94	2.40
Total	0.81	1.10	1.00	0.75	1.37	0.99	0.82	1.03	0.67	1.30

e. Sources of protein by imports and domestic production per country

Background

Domestic production and imports vary significantly across countries and food types. Processed foods, rice and wheat, and meat are primarily imported, whereas root crops and reef and coastal fish trade is negligible; most domestic production is consumed domestically. For some food groups, it is not possible to ascertain the proportion of total consumption derived from imports primarily due to the absence of production data.

Methods

Standardised and current estimates of production and imports were obtained using 2018 data from FAOSTAT and PFTD (Brewer and Andrew 2023) to calculate the proportion of available chicken, beef, pork, other animal sourced foods, vegetables, roots and tubers, cereals and their products, pulses seeds and nuts that are typically imported. Imported frozen fish and canned tuna are addressed separately. Estimates for canned and other fish are derived from Bell, Sharp et al. (2019) because production estimates are not available in FAOSTAT. Estimates of the amount of available frozen fish imported are derived from the PFTD (Brewer and Andrew 2023).

Caution is required in interpretating these results as there is low confidence in the completeness and accuracy of FAOSTAT production data and the completeness of the PFTD data, particularly for fish. FAOSTAT does not include comprehensive fisheries data, and neither data source is comprehensively linked to the PNDB so total weight is used instead of the protein contribution. Additionally, FAOSTAT does not include data for Federated States of Micronesia and is very limited for Marshall Islands, so both were excluded from analysis. Pacific production data are severely limited and warrant significant investment to facilitate comprehensive analyses. However, the data used here are currently the best available sources for conducting this analysis.

Results and Discussion

With the exception of domestic fisheries and other productio such as fruits, vegetables and root crops, Pacific Island countries and particularly smaller atoll countries, are highly dependent on food imports (Table 10). Beef and chicken are primarily imported, with significant variation between countries, but most pork is domestically produced. Cereals and their products are almost entirely imported, with Fiji being a major regional re-trade hub. Negligible pulses, seeds and grains are imported. 'All other foods' (see Appendix 5 & 6 for specific foods in this food group) should be interpreted with caution due to the differences between commodities in FAOSTAT and the PFTD.

The vast majority of imported frozen fish is tuna or fish 'not elsewhere specified' (Appendix 7). It is difficult to determine whether this fish enters the local food system and is consumed domestically or also comprises tuna that is landed from locally-based fishing operations prior to export. For example, the large quantities recorded as imports for Marshall Islands likely largely comprise fish that is recorded in customs prior to export. Frozen fish imported to Kiribati is, however, likely to be predominantly for local consumption. Therefore, these estimates should be interpreted with caution.

Generally, the estimates presented in Table 10 are likely to be robust for the following food groups: meats, cereals and their products, and pulses, seeds and grains. These groups include limited processing so are more likely to be captured in FAOSTAT data and unambiguously represented in both FAOSTAT data and PFTD data. Aquatic foods including tuna, other animal-sourced foods, and all other foods are less reliable. However, canned fish estimates are likely to be robust due to limited domestic canning operations, except in Fiji, Papua New Guinea and Solomon Islands (Bell, Sharp et al. 2019) and ease of collecting data on canned fish.

While partially informative, this analysis underscores the need for investment in data collection for two reasons. First, improved data on agricultural products and the extent of local processing would greatly improve domestic production estimates, thereby enhancing national assessments for food security and nutrition. Second, improved tuna data, covering the various stages in value chains from harvest through to consumption, would enable clearer guidance on current production for domestic consumption and the potential for increasing this consumption.

Table 10 Percentage of total availability of each food type (domestic production and net imports) comprised of net imports. Negative values are explained by significant export of cash crops, among other food production types. For example, Vanuatu exports beef, and Fiji has a significant food-processing industry and exports products from this industry throughout the region.

Country	Beef	Chicken	Pork	Other animal sourced foods	Vegetables, roots and tubers	Cereals and their products	Pulses, seeds and grains	All other foods	Canned tuna/other fish*	Frozen fish (kg p.c./ yr.)**
Cook Islands	99	99	28	96	38	100	0	79	100/100	1.5
FSM	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	100/100	4.2
Fiji	40	11	12	53	24	97	38	-27	32/54	8.6
Kiribati	100	63	4	85	5	100	0	20	100/100	10.4
Marshall Islands	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	100/100	55.8
Nauru	35	79	7	60	4	71	0	47	100/100	1.8
Niue	100	94	9	87	90	100	0	40	100/100	12.4
Palau	99	98	78	98	33	100	2	90	100/100	2.5
Papua New Guinea	62	69	5	6	1	96	1	-13	61/27	0.9
Samoa	49	98	36	96	11	100	-1	22	100/100	4.8
Solomon Islands	39	96	8	77	1	97	1	-13	9/100	3.9
Tonga	68	98	13	92	-4	100	-1	39	100/100	8.3
Tuvalu	n.d.	92	5	79	16	100	0	56	100/100	6.9
Vanuatu	-4	87	7	70	4	95	0	-11	100/100	0.0

n.d. = no data

*2014 estimates derived from Bell, Sharp et al. (2019). Note that only Fiji, Papua New Guinea, and Solomon Islands have commercial canning operations so values of both canned tuna and other fish are 100% for other PICs.

**Frozen fish imports are 2018 estimates from the Pacific Food Trade Database (Brewer and Andrew 2023). Net imports are not calculated due to the significant export of tuna, which comprises the majority of fish trade. The list of frozen fish, and their tonnage is shown in Appendix 7, noting it is dominated by tuna.

CHAPTER 3. NUTRITIONAL VALUE OF FOOD TYPES

a. Background

The food groups presented in Chapter 2 tend to have greater nutritional similarity within groups compared to between groups. The groups contain a large diversity of specific foods with different nutrient profiles. The resulting nutritional values of the food groups consumed will be dependent on the proportion of each specific food type consumed, which will vary markedly across countries subject to attributes, such as cultural preference, affluence, access.

Information on hormones, antibiotics and other additives in imported foods is poorly documented in the Pacific, with different countries having different requirements. Similarly, additives included during domestic processing are likely to be country-specific. It is therefore beyond the scope of this study to present specific details (see Appendix 1). However, it is worth noting that bulk carbohydrate imports including rice and wheat, are generally fortified.

b. Methods

Here we present the mean nutritional values of all foods within each food group. The numbers are derived from the Pacific Nutrient Database (PNDB) (Statistics for Development Division 2020). The PNDB does not include exhaustive nutrient profiles for all foods. We therefore present commonly measured nutrients that also contained the most complete data within the database. Farmery, Scott et al. (2020) provides a more complete set of nutrients for seafood in Pacific diets. The PNDB includes the nutrient information for 100 g of each food item (COICOP code). The data presented in Table 11 are calculated by taking the average of the nutrients for all the COICOP codes that belong to each specific food group. A complete list of all foods within each food group is shown in Appendix 3.

c. Results and Discussion

Nutrient composition varies significantly across the assessed food groups. Tuna and other pelagic fish are reasonably high in energy (131.4 kcal, Table 11), while tuna alone have 164 kcal of energy per 100 g serve (Farmery, Scott et al. 2020). Meats, other animal-sourced foods, cereals and grains, and pulses nuts and seeds are more energy dense. With respect to protein, tuna and other pelagic fish is the most protein-rich food groups (Table 11). Tuna alone, is estimated at 25 g per 100 g serve for the species commonly consumed in the Pacific (Farmery, Scott et al. 2020). Tuna is low in fats compared to terrestrial meats and high in omega 3 fatty acids. Canned fish is high in energy, has a high protein content, and is a rich source of calcium. Tuna has a similar iron content to other meats and is higher than other finfish. Cereals, pulses and grains are higher in iron, however, heme iron derived from animal-based foods is more bioavailable. Canned fish is both a rich source of iron and vitamin B12.

Both fresh and canned tuna can contain high concentrations of mercury (Kumar 2018). Consumption of foods with high concentrations of methylmercury by pregnant and lactating women can affect the neurological development of children (Choy, Popp et al. 2009). However, increasing consumption of the more commonly consumed tuna species in the Pacific (skipjack and yellowfin) is not expected to cause mercury poisoning because at the size these fish are consumed in the region they have relatively low mercury concentrations. Bell, Allain et al. (2015) estimate that even if the entire fish consumption of 35 kg per person per year recommended by SPC (2008) was comprised only of these species, the limits for mercury ingestion recommended by the United Nations Environment Programme (UN Environment 2019) would not be exceeded.

Table 11 Mean nutritional values per 100 g serve for key macro- and micro-nutrients in Pacific diets across food groups used in this study.

	Energy (kcal)	Protein (g)	Carbohydrates (g)	Fats (g)	Calcium (mg)	Iron (mg)	Vitamin A (RE) (Âµg)	Vitamin B12 (Âµg)
Reef and coastal fish	106.7	21.3	0.2	2.3	15.7	0.7	24.7	1.5
Composite fish	152.0	27.9	0.5	4.3	68.7	1.1	22.7	5.0
Tuna and pelagic fish	131.4	23.2	0.2	4.2	88.1	1.5	46.3	1.8
Invertebrates	95.9	16.8	1.6	2.5	130.4	2.3	30.0	5.2
Canned fish	180.6	20.7	2.0	9.9	132.5	3.6	35.8	5.9
Beef	200.3	23.7	0.1	11.7	6.6	2.3	175.8	2.8
Chicken	204.1	21.2	0.1	13.2	11.5	1.4	304.3	2.1
Pork	187.4	21.8	0.5	10.9	11.3	1.9	87.1	1.3
Processed meat and canned meat	226.8	15.7	3.5	16.5	23.3	1.7	474.5	1.2
Other animal sourced food	255.7	14.3	7.2	18.8	154.9	1.2	89.4	1.4
Vegetables, roots and tubers	60.0	2.2	10.4	0.4	51.8	1.2	183.9	0.0
Cereals and their products	304.2	8.4	55.3	4.5	71.2	3.3	8.2	0.1
Pulses, seeds and grains	338.6	10.9	11.1	26.4	66.7	2.4	4.8	0.0
Composite meals	154.5	8.9	14.4	6.5	39.6	0.9	71.0	0.4
All other foods	208.7	3.7	25.9	8.4	88.0	3.5	113.7	0.1

** See Appendix 3 for specific foods within each group. The mean is the average of all foods within each group.

Âµg = micrograms

CHAPTER 4. COST OF FOOD TYPES

a. Background

Acquisition of food and beverages represents a large portion of total household expenditure across the Pacific (Table 5). Affordability will, therefore, have a significant influence on household consumption patterns. Additionally, limited awareness of the nutritional content of foods and what constitutes a healthy diet, as for example described by the Public Health Division of the Pacific Community (2017), means that some more expensive foods are likely to be avoided despite containing key nutrients for NCD prevention. Similarly, the rise of unhealthy food consumption, including pot noodles, soft drinks and other highly-processed foods offer longer shelf-life, convenience and affordability. Shifting consumption patterns to these mostly imported processed foods are contributing to diet-related NCDs and malnutrition.

If demand for reef fish by growing populations is maintained or increases as supply diminishes, due to unsustainable exploitation and climate impacts, it is expected that the unit price of reef fish will increase relative to other foods where supply is not constrained. There is not yet regionally representative evidence of this, however, there is evidence of significant reef fish price increases during COVID-19 in Solomon Islands (Farrell, Bogard et al. 2023). Imported meat, primarily chicken, has partially filled this gap (Brewer, Andrew et al. 2023), as has the artisanal pelagic fishery and the bycatch available at ports used by commercial fishing fleets. PICs are unable to control supply and pricing of imports, so over-dependence on them will increase food security vulnerability. Increasing consumption of tuna and other pelagic fish as populations grow and supply from coastal fisheries diminishes, is preferable.

b. Methods

The Pacific Food Consumption Database contains information on each food item (COICOP code) consumed by the members of a household, including the quantity of food (in grams) and its corresponding value in the local currency. To determine the amount in USD expended for each food item of each household, the relevant exchange rates for the specific month and year of the household's survey are applied (Appendix 8). Subsequently, the price per gram is calculated by dividing the amount in USD by the quantity. It is important to note that food consumed away from home is excluded from the analysis, as it has been from other sections of this report, due a lack of data.

To provide a more comprehensive view, the weighted average of the price per gram is calculated for each food group in each country and then multiplied by 1000 to obtain the price per kilogram. Here we present pricing ($US/kg) for all countries, except Papua New Guinea and Fiji, across all of the included food groups. As stated previously, cleaned acquisition and consumption data are not yet available for Papua New Guinea or Fiji. It is important to note that comparison between countries should not be made because of the variation in the timing of the HIES (Appendix 2). Instead, relative pricing between food groups is a more robust analytic framing. We also present an estimate of the relative cost of tuna and other pelagic fish in urban areas relative to rural areas where data are available.

c. Results and Discussion

Complete results on unit prices of food groups within PICs are tabulated below (Table 12). Here we focus on a comparison of fresh tuna and canned fish (which is mostly tuna; see Appendix 3) with other aquatic foods and meat. For the nationally aggregated data, tuna and other pelagics are marginally more expensive than reef fish across most countries. However, it is likely that commercial bycatch species including low-grade tuna and other pelagics is cheaper than reef fish in urban markets of countries with commercial fleets such as Papua New Guinea and Solomon Islands. Tuna is comparably priced, or cheaper, than both beef and pork across countries. In Vanuatu, beef is significantly cheaper, which is likely due to the presence of a beef grazing industry. Price differences between chicken and tuna and other pelagic fish are highly variable across countries. Other processed and canned meats are significantly more expensive than tuna and other pelagic fish in all countries except Federated States of Micronesia (FSM). In most countries, tuna and pelagic fish is cheaper in rural areas (Table 12), however, the differences are marginal and could partly be explained by a small sample size, price variation between species and time of survey.

Figure 5 Transhipment of tuna from a purse seine vessel at Honiara, Solomon Islands. Image supplied T. Brewer.

Canned fish is marginally more expensive than fresh tuna and other pelagic fish across the region, although the relative pricing is highly variable across countries. When making this comparison, it is important to note the nutritional differences between these two groups and the long shelf-life of canned fish, which is a major advantage in the Pacific where fish preservation is difficult. Canned fish is similarly priced to other meats and cheaper than processed and canned meats across the countries. Due to the absence of food price data for Papua New Guinea and Fiji, which both have tuna-processing facilities, it is difficult to confidently ascertain whether presence of processing facilities has a significant impact on domestic canned fish prices.

The observed differences in relative pricing of food groups within, and between, countries can be attributed to a number of factors. First, as stated above, there is significant temporal variation in the timing of HIES surveys. Second, domestic production and demand play a significant role in the purchase price of foods. Third, remoteness and associated cost of shipping significantly impacts the price of imports. Fourth, events outside the region, such as the Asian rice crisis and the war in Ukraine can have dramatic impact on wholesale pricing, so if such events occur during HIES years, prices will reflect these events. Finally, the effects of longer-term climate change and continuing climate variability (e.g., El Niño – Southern Oscillation), including impacts on sea surface temperature, air temperature and rainfall, can have dramatic impacts on domestic production including on projected tuna distributions and agricultural productivity (Taylor, McGregor et al. 2016, Bell, Senina et al. 2021). Similarly, weather events such as cyclones, which are expected to become more intense with increased global warming, can have dramatic localised negative impacts on inshore and terrestrial food production systems.

Table 12 Cost of food types ($US/kg) in year of HIES (Appendix 2).

	Reef fish	Composite fish	Tuna and pelagic fish	Invertebrates	Canned fish	Beef	Chicken	Pork	Processed meat and canned meat	Other animal sourced food	Vegetables, roots and tubers	Cereals and their products	Pulses, seeds and grains	Composite meals	Everything else	Tuna and pelagic fish**
Cook Islands	3.41	7.06	6.00	85.92	9.58	9.71	2.79	7.90	11.38	8.99	4.36	6.72	5.91	11.83	10.83	1.15
FSM	2.79	2.19	2.49	2.61	2.14	2.59	3.12	2.54	2.41	2.15	1.77	3.27	2.33	2.87	2.81	0.99
Fiji	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Kiribati	1.63	2.38	2.01	4.49	4.63	9.85	4.90	6.68	6.38	8.29	4.44	2.10	1.75	10.93	83.71	n.d.
Marshall Islands	1.44	10.80	4.32	5.97	8.92	11.22	2.90	5.66	9.99	6.89	6.50	4.19	3.86	13.78	14.22	0.83
Nauru	1.96	6.06	3.83	12.62	9.70	52.94	4.14	14.06	12.10	10.56	5.79	7.32	7.13	11.15	10.07	n.d.
Niue	4.00	15.44	13.30	8.95	7.60	10.48	3.43	21.22	11.01	6.34	6.27	7.24	4.91	25.82	9.89	n.d.
Palau	2.59	4.26	3.57	8.08	7.21	7.61	2.91	4.74	8.11	4.61	3.64	3.97	7.05	10.47	6.96	0.81
Papua New Guinea	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Samoa	4.67	2.49	5.47	6.84	3.13	5.24	1.84	12.37	5.82	5.30	2.03	3.25	1.54	9.79	5.73	1.19
Solomon Islands	1.87	2.20	3.13	1.45	6.20	11.25	7.08	19.71	8.44	9.17	1.09	3.75	6.13	2.00	60.84	1.31
Tonga	12.12	2.92	4.47	8.34	5.10	6.57	2.43	42.47	13.73	6.17	1.72	2.62	5.50	9.07	3.63	4.80
Tuvalu	2.74	5.33	2.54	4.56	8.70	6.77	3.14	4.32	9.21	7.59	2.71	4.23	24.55	6.62	8.53	1.37
Vanuatu	2.64	6.96	4.18	2.83	4.75	3.13	5.48	3.19	9.39	5.71	1.26	2.44	0.87	1.40	17.44	n.d.

** Tuna and pelagic fish price per kg in urban areas relative to rural areas. Values >1 represent higher urban pricing. Value s <1 represent cheaper urban pricing.

CHAPTER 5. FUTURE PROTEIN REQUIREMENTS

a. Chapter background

Most Pacific countries have rapidly-growing populations compared to the global average (https://pacificdata.org/population-dashboard). Over time, carrying capacity of domestic production systems has been exceeded and imports have increased dramatically, including for grains and cereals, meat, and highly-processed foods (Andrew, Allison et al. 2022, Brewer, Andrew et al. 2023). This significant shift has contributed to high incidences of non-communicable disease (NCDs). Looking forward, it is a regional aspiration to improve the nutritional quality of diets. For example, Pacific countries engaged with the 2021 UN Food Systems Summit to develop food systems pathways which articulate national visions aligned with increased food and nutrition security. Overshadowing this aspiration of healthy and resilient food systems is the expected negative effects of climate change on both agriculture and fisheries (Bell, Taylor et al. 2016), including tuna stocks (Bell, Reid et al. 2013). A vital piece of the puzzle in planning for the future aspirations of the Pacific food system is estimating future food requirements given expected population changes.

There are several components to this analysis, including average weight of men, women and children in 2030 and 2050 for each country, the total number of men, women and children in each country in 2030 and 2050 and calculation of future dietary fish requirement based on populations, weights, and estimated protein fraction of fish. This analyses summarizes work completed under ACIAR project FIS/2018/155 and published as Kottage, Brewer et al. (submitted ms.). The structure of this chapter is divided into these three components.

b. Population estimates

Methods

Projected population estimates were obtained from the Pacific Data Hub. Total populations were tabulated initially and then supplemented with data on the proportion of children (<14years old) for both 2030 and 2050. Male and female populations in 2030 and 2050 were calculated as 50% of the proportion not classified as children because projections of the proportions of men and women are not available. We also note that the forecasts to 2050 are >25 years from now, so contain significant assumptions about continuity of current trends in population structures. For countries with small populations, in particular, the actual population and population structure in 2050 could be significantly different to current projections.

Papua New Guinea has a significant inland population, so assuming the entire population should obtain 50% of their dietary protein from fish is not plausible. Instead, we assume that it is the estimate of 21% of the population living within 5 km of the coastline from Andrew, Bright et al. (2019) that will require 50% of their dietary protein from fish. We do, however, assume the same national proportion of men, women, and children within the population sub-set. It is reasonable to assume that relatively less fish would be consumed further from the coast, so the 5 km threshold is relatively arbitrary. For reference, as estimated by Andrew, Bright et al. (2019), 8% of the population live within 1 km of the coast and 30% of the population live within 10 km of the coast. Therefore, the estimated tuna requirement for the coastal population of Papua New Guinea would vary dramatically depending on the chosen distance threshold.

Results and Discussion

Change in total population is predicted to vary significantly across countries (Table 13). Melanesian countries are expected to experience significant population growth through to 2050, and from relatively large current populations relative to historic baselines, compared to other countries in Polynesia and Micronesia. Both Samoa and Kiribati are also expected to experience significant population growth. However, Cook Islands, Marshall Islands, Nauru, Niue, and Tuvalu are predicted to have relatively stable populations to 2050 and Federated States of Micronesia, Palau and Tonga are predicted to experience population declines largely due to immigration. Across most countries, as birth rate diminishes it is expected that the child population will diminish as a proportion of total population. Therefore, even with reduced population growth, protein demand will be heightened because adults have a higher average weight than children.

Table 13 Projected male, female, and child populations across countries in 2030 and 2050. For Papua New Guinea, the estimate is based on the population living within 5 km of the coast, which is estimated at 21% of the total population.

	2030 Population				2050 Population			
Country	Adult male	Adult female	Children (<14 yrs.)	Total	Adult male	Adult female	Children (<14 yrs.)	Total
Cook Islands	6,276	6,276	3,337	15,889	6,393	6,393	2,999	15,786
FSM	37,810	37,810	30,887	106,507	38,480	38,480	21,707	98,667
Fiji	345,368	345,368	230,245	920,980	365,108	365,108	218,117	948,333
Kiribati	47,933	47,933	43,070	138,935	65,465	65,465	50,917	181,848
Marshall Islands	18,354	18,354	17,275	53,983	18,886	18,886	14,689	52,460
Nauru	3,965	3,965	4,658	12,588	4,690	4,690	5,051	14,431
Niue	550	550	293	1,393	526	526	314	1,367
Palau	7,262	7,262	3,407	17,930	6,741	6,741	2,959	16,441
Papua New Guinea	727,413	727,413	818,339	2,273,165	1,077,688	1,077,688	1,014,295	3,169,671
Samoa	68,045	68,045	73,279	209,369	76,378	76,378	78,693	231,449
Solomon Islands	281,009	281,009	330,074	892,093	453,429	453,429	426,756	1,333,614
Tonga	33,554	33,554	30,150	97,257	34,058	34,058	25,194	93,310
Tuvalu	3,769	3,769	3,713	11,250	4,262	4,262	3,315	11,839
Vanuatu	121,672	121,672	119,856	363,200	185,461	185,461	137,191	508,113

c. Average weight of men, women, and children

Methods

We obtained the mean weight of men, women, and children using data from the Non-communicable disease Risk Factor Collaboration (NCD-RisC) database (https://www.ncdrisc.org/data-downloads.html), which holds the most globally-comprehensive data on body mass index and height, among other variables. Body weight data were not available so was calculated as Weight (kg) = Height(m)^2 * BMI. Calculations were done separately for men, women and children. For Papua New Guinea, we assume that BMI and height estimates for the population living within 10 km of the coast are the same as those for the whole population.

Although mean body weights are used, the long-term projection should be viewed with caution, primarily because of how rapidly body weights have increased throughout the region since the mid-1970s (Abarca-Gómez, Abdeen et al. 2017, FAO 2021, Figure 4). Additionally, birth rates, while high in some countries including Papua New Guinea and Solomon Islands, are declining across most of the region. If this trend continues, there will be proportionately less children (compared to adults) in the future compared to current estimates. This has, however, been accounted for in the disaggregated projections derived from modelling by the SPC Statistics for Development Division.

Results and Discussion

Height and BMI estimates were used to calculate weight of men, women, and children across the 14 countries in this study (Table 14). Average weights of men vary significantly across countries, ranging from 67.56 kg in Papua New Guinea to 104.48 kg in Cook Islands. Men in Melanesian countries tend to have lower weights as a function of both smaller heights and lower BMI. While lower, variation in women and children's weights across countries tends to follow a similar pattern. Importantly, both BMI and average weights in both Polynesia and Micronesia are extremely high by global standards (Cassels 2006, Abarca-Gómez, Abdeen et al. 2017). Higher rates of obesity, linked to lifestyle and diet, are a major contributor to non-communicable disease in the region (FAO 2021).

Table 14 Mean height, body mass index (BMI) and weight of men, women and children in the 14 study countries.

	Men			**Women**			**Children (5-18 yrs) ~~average~~**		
	2019 Height (cm)	2016 BMI	Weight (kg)	2019 Height (cm)	2016 BMI	Weight (kg)	2019 Height (cm)	2016 BMI	Weight (kg)
Cook Islands	178.32	32.86	**104.48**	167.31	33.36	**93.39**	149.78	23.71	**53.18**
FSM	169.57	28.34	**81.49**	159.66	31.53	**80.38**	141.99	21.00	**42.34**
Fiji	173.98	26.81	**81.13**	164.28	29.00	**78.28**	146.11	19.34	**41.30**
Kiribati	170.09	29.17	**84.39**	161.04	31.30	**81.18**	144.36	21.73	**45.29**
Marshall Islands	165.26	29.08	**79.42**	154.76	30.67	**73.45**	139.40	20.99	**40.79**
Nauru	169.57	32.28	**92.83**	157.82	32.95	**82.06**	141.54	23.65	**47.38**
Niue	177.19	31.59	**99.18**	167.03	33.51	**93.49**	148.62	23.52	**51.96**
Palau	170.62	29.64	**86.28**	159.52	29.72	**75.62**	144.23	22.83	**47.49**
Papua New Guinea	163.10	25.40	**67.56**	156.89	26.01	**64.02**	139.34	20.69	**40.17**
Samoa	174.42	30.63	**93.18**	163.82	34.34	**92.15**	143.13	22.12	**45.31**
Solomon Islands	163.07	25.81	**68.63**	156.79	27.08	**66.56**	137.80	19.02	**36.12**
Tonga	175.11	30.72	**94.21**	166.08	34.01	**93.80**	148.01	22.63	**49.58**
Tuvalu	171.30	30.23	**88.71**	163.57	31.87	**85.27**	145.91	22.67	**48.25**
Vanuatu	168.29	25.71	**72.82**	160.48	26.97	**69.45**	141.79	20.05	**40.31**

d. Future fish consumption estimation

Methods

To estimate 2030 and 2050 fish consumption requirement based on 50% of dietary protein from fish (50% of 0.7 g per kg of body weight per day) we first calculated the protein requirement using body weight and population data. Total annual protein requirement (tonnes) for men women, and children in each country was calculated as:

$$Protein\ requirement_k = \frac{\left(\frac{1}{2} \times daily\ protein\ requirement\right) \times Mean\ weight_k \times Cohort\ population_k \times 365}{1000000}$$

where $k = males, females, children$

Here, $\frac{1}{2} \times daily\ protein\ requirement = \frac{1}{2} \times 0.7 = 0.35$ and divided by 1,000,000 to convert grams to tonnes.

To convert total protein requirements to be derived from tuna and other pelagic fish in 2030 and 2050 we used the average protein content of these fish (23.2%) from Table 11. The protein value for tuna and other pelagic fish was used, rather than other fish food groups, because it is assumed that tuna and other pelagic fish will comprise an increasing proportion of the fish in diets to 2050 and beyond. This series of calculations provides estimates of total tonnes of fish required in 2030 & 2050 to fulfill 50% of protein intake. We also present current (year of HIES) estimates of total fish consumption per capita for countries as a baseline. It is important to note that when projecting forward, the base tuna consumption varies among countries based on the year the HIES was conducted.

Results and Discussion

Protein required from fish, based on the population estimates (Table 13), body weight estimates (Table 14), and consumption of 0.35 grams (50% of 0.7g) of fish-based protein per kg of body weight per day, are outlined in Table 15. Significant variation between countries is a function of projected population size across men, women and children and estimated differences in the weight of men, women and children among countries. Importantly, this analysis assumes that current average body weight estimates will remain stable through the projected period.

Projections of total fish required by 2050, assuming average protein content of 23.2% for tuna and pelagic fish (Table 11), are tabulated in Table 16. Current (year of HIES consumption and population estimates) total per capita fish consumption estimates and projected per capita fish consumption requirements are outlined in **Table 17**. Some countries are predicted to be consuming adequate quantities of fish out to 2050, assuming current availability is maintained, whereas others are predicted to experience a significant shortfall in fish consumption. Comparison between current and future fish requirements was not possible for Fiji or Papua New Guinea because detailed food consumption data are not available. These estimates assume current total reef and inshore harvests will be the same in the future. It is difficult to project the anticipated declines in this fishery so our calculations of future requirements from tuna is likely to be underestimated.

There are four important points to consider when reviewing these aggregate estimates. First, the threshold of 5 km from the coast used here to estimate the relevant Papua New Guinea population is relatively arbitrary, and using a different threshold would significantly alter estimates. Second, and as mentioned throughout this report, is the significant variation in equity and access within countries, including gender, economic affluence, access to healthy foods, and education. The averages and aggregates presented here, even for countries with surplus fish supply, does not mean that all people are consuming nutritious diets or obtaining adequate protein from fish. Third, this analysis assumes that the current average weight of men, women and children will be the same to 2050 as they are currently. Given the rapid historic increase in BMI across most countries, future average weights are likely to differ significantly from current weights. Plausible scenarios are either a marginal increase in weights if diets and lifestyles do not improve, or a decline in average weights if diets improve and lifestyles are less sedentary. Fourth, and significantly, the current and future consumption estimates (**Table 17**) assume that supply of reef and inshore fish will be sustained in 2030 and 2050. This is unlikely given declining inshore harvests and the expected climate impacts on coral reef and other inshore habitats. While these caveats and considerations suggest that the estimates should be treated with caution, the data used to generate them are the best available.

Table 15 Projected total protein (tonnes) consumption required from fish by 2050 at recommended fish-based protein intake of 0.35 grams of protein per day per kilogram of body weight. Calculations are based on estimates in Table 13 and Table 14.

	2030 fish-based protein requirement				**2050 fish-based protein requirement**			
	Adult male	Adult female	Children (<14 yrs.)	Total	Adult male	Adult female	Children (<14 yrs.)	Total
Cook Islands	84	75	23	181	85	76	20	182
FSM	394	388	167	949	401	395	117	913
Fiji	3,580	3,454	1,215	8,248	3,784	3,651	1,151	8,586
Kiribati	517	497	249	1,263	706	679	295	1,679
Marshall Islands	186	172	90	448	192	177	77	445
Nauru	47	42	28	117	56	49	31	135
Niue	7	7	2	15	7	6	2	15
Palau	80	70	21	171	74	65	18	157
Papua New Guinea	6,278	5,949	4,200	16,428	9,302	8,814	5,205	23,322
Samoa	810	801	424	2,035	909	899	456	2,264
Solomon Islands	2,464	2,389	1,523	6,376	3,976	3,856	1,969	9,800
Tonga	404	402	191	997	410	408	160	978
Tuvalu	43	41	23	107	48	46	20	115
Vanuatu	1,132	1,079	617	2,829	1,725	1,645	707	4,077

Table 16 Projected estimates, in tonnes, of total fish required in 2030 and 2050, for men, women and children to obtain 50% of their protein intake from fish for each of the 14 countries.

	2030 fish-based dietary requirement (tonnes)			2050 fish-based dietary requirement (tonnes)		
	Adult men	Adult women	Children (<14 yrs.)	Adult men	Adult women	Children (<14 yrs.)
Cook Islands	361	323	98	368	329	88
FSM	1697	1674	720	1727	1703	506
Fiji	15430	14886	5236	16312	15737	4960
Kiribati	2227	2143	1074	3042	2926	1270
Marshall Islands	803	742	388	826	764	330
Nauru	203	179	122	240	212	132
Niue	30	28	8	29	27	9
Palau	345	302	89	320	281	77
Papua New Guinea	27062	25644	18103	40094	37993	22437
Samoa	3491	3453	1828	3919	3876	1963
Solomon Islands	10620	10300	6565	17136	16619	8487
Tonga	1741	1733	823	1767	1759	688
Tuvalu	184	177	99	208	200	88
Vanuatu	4879	4653	2661	7437	7092	3045

Table 17 Country estimates of current consumption and future (2030 & 2050) required consumption in both total tonnes per year and kilograms per capita per year. Current consumption estimates include all fish food groups in this study (reef and coastal, tuna and other pelagic, composite and canned). The shading is a coarse indicator of fish shortfall (red) versus adequate supply (green), both currently, and for future needs. Estimates of whole harvest assume total edible portions in 2030 and 2050 are derived from tuna with an estimated edible portion of 60%.

	Current Consumption (Year of HIES)		2030 Consumption Requirements			2050 Consumption Requirements		
	Tonnes/year	Kilograms p.c./year	Tonnes/year (edible portion)	Tonnes/year (whole harvest)	Kilograms p.c./year (edible portion)	Tonnes/ year	Tonnes/year (whole harvest)	Kilograms p.c./year (edible portion)
Cook Islands	543	36	782	1,303	49	784	1,307	50
FSM	9,430	84	4,090	6,817	38	3,936	6,560	40
Fiji	n.a.	n.a.	35,552	59,253	39	37,009	61,681	39
Kiribati	9,971	84	5,444	9,074	39	7,239	12,064	40
Marshall Islands	4,962	91	1,933	3,222	36	1,920	3,199	37
Nauru	1,009	98	503	839	40	583	972	40
Niue	55	34	67	111	48	65	108	47
Palau	1,858	106	736	1,227	41	678	1,131	41
Papua New Guinea	n.a.	n.a.	70,809	118,015	31	100,524	167,540	32
Samoa	6,059	30	8,773	14,621	42	9,758	16,263	42
Solomon Islands	39,303	64	27,484	45,807	31	42,243	70,405	32
Tonga	3,821	38	4,297	7,161	44	4,214	7,023	45
Tuvalu	628	55	460	766	41	496	827	42
Vanuatu	9,210	31	12,192	20,321	34	17,575	29,291	35

-See Appendix 2 for year of HIES data, noting that HIES were conducted over the past decade so do not necessarily reflect current consumption.
-Current estimates are total consumption of reef and coastal fish, tuna and other pelagic fish, composite fish, and canned fish. Importantly, the contribution of reef and coastal fish is expected to diminish with time, both on a total tonnes and per capita basis.
-For some countries the future tonnes of fish per year, in terms of kilos per capita per year is lower than the present consumption, even though populations will be higher in the future because the present-day consumption exceeds the WHO/SPC fish protein intake recommendations, whereas the future consumption requirements are based exactly on those recommendations.

CHAPTER 6. SYNTHESIS

Fish has historically been an essential source of protein in the diets of Pacific Island people and central to cultural identity. Traditionally, the reliability of reef and coastal fish stocks has ensured relative food security when other food sources were scarce and provided an accessible source of financial livelihood. However, overfishing and climate change-driven habitat degradation, among other factors, has reduced, and will continue to reduce, coastal fish stocks across the region (Kronen, Magron et al. 2010, Pratchett, Munday et al. 2011, Bell, Taylor et al. 2016). Furthermore, populations continue to grow, particularly in Melanesia, placing further pressure on coastal food resources (e.g. Brewer, Cinner et al. 2009). In recent decades, imports of staples including rice, wheat flour and meat have increased dramatically to fill the gap in local food production and now form an essential portion of caloric intake (Brewer, Andrew et al. 2023). Additionally, imports of processed foods with adverse health benefits have increased dramatically, leading to a globally high incidence of diet-related, non-communicable disease (Thow, Heywood et al. 2011). This unfolding reality of increased scarcity of domestic protein sources and increased reliance on low nutritional-quality imports increases the vulnerability of Pacific food systems. This is compounded by any global shocks impacting food production among key suppliers. Recent events, including COVID-19, the war in Ukraine and the ban on rice exports from India due to crop failure highlight this vulnerability, which is anticipated to become more acute with increased severity of climate impacts on global food production systems.

Overall, climate change is expected to dramatically influence Pacific food systems. Climate change is projected to cause inshore habitat degradation in the tropics, primarily through degradation of coral reefs caused by increased sea surface temperature and ocean acidification, but also through the effects of sea-level rise and increased intensity of cyclones on all coastal habitats, with flow-on impacts on reef and coastal fisheries production (Technical Study 1). It is also expected to affect agricultural production, including crops and livestock, through saltwater inundation, more intense cyclone events, and more variable and intense dry and wet periods (Taylor, McGregor et al. 2016). Climate change is also anticipated to cause changes to the distribution of tuna stocks in the region, which could have far-reaching consequences for both food security and government revenue (Bell, Senina et al. 2021). Climate change impacts on food systems will not be isolated to the Pacific Island region, so reliance on imports has associated risks. Importantly, high island and atoll systems will be affected differently by climate change.

In this chapter, we compare various options for supplying future nutrition requirements to Pacific Island communities, accounting for the broad drivers of climate change and population growth based on the evidence presented in chapters 1-5. We also consider the dynamic complexity of Pacific food systems, including nutrition composition, reliability of supply and access. Nutrition profiles vary among food groups and among specific foods that are processed and prepared in different ways (Table 11). Prioritising specific foods as future protein sources will inevitably result in trade-offs in various components of nutrition profiles. Access considerations include, but are not limited to, pricing, perishability, and stability of adequate supply. We also consider social, other environmental, and economic impacts and benefits of the various options. The other environmental impacts include land and sea degradation due to runoff and pollution from increased intensive domestic agricultural production and forestry (Taylor, McGregor et al. 2016). Social impacts include potential exclusion from supply chains due to income or cultural reasons or impacts on cultural food practises caused by the increase in access to non-traditional alternatives. Economic impacts include consideration of the level of concentration and diffusion of the benefits of one food type compared to others. For example, there are a multitude of participants in fish and wheat value chains compared to rice value chains. This means that fish and wheat consumption provide greater opportunity for income generation compared to rice.

Fish vary significantly in their macro- and micro-nutrient profiles (Statistics for Development Division 2020), so it is difficult to ascribe specific changes in nutrient availability associated with reduced coastal fish harvest. Additionally, reef and coastal fish species are poorly represented in the PNDB, further reducing confidence in assessment of nutrients derived from coastal fisheries (Farmery, Scott et al. 2020, Statistics for Development Division 2020), particularly for specific micro-nutrients. We therefore focus on reduced fish availability in terms of protein and calories, and do not make assumptions about future availability of other specific nutrients resulting from coastal fishery decline.

Plausible alternative sources of protein and calories to fill the gap in the anticipated shortfall in availability of nutritious food from reduced reef and coastal fish production fall into three broad categories - increased imports, increased domestic agriculture production, or increased consumption of tuna and other pelagic fish. Here, we outline each of these alternatives, including dominant foods available in each category and their advantages and disadvantages in terms of nutrition, reliability of supply and access.

Alternative foods to reef and coastal fish from increased imports are predominantly meat and cereals, both of which currently comprise a large portion of Pacific diets (Brewer, Andrew et al. 2023). Meat imports are largely comprised of beef, pork, and chicken. Chicken imports are increasing rapidly across the Pacific and demand is expected to continue to increase. However, meat imports are highly perishable in the absence of cold supply chains, are relatively expensive, and primarily available in urban areas only. Both rice and wheat are already imported in significant quantities and, except for protein, do not have comparable nutrient profiles to fish, however, some fortification does occur. Both cereal types are comparatively affordable and relatively shelf stable. However, their contribution to broader domestic Pacific economies, including employment, is relatively limited and both are highly vulnerable to global supply shocks so should not be considered as a primary solution to anticipated protein shortfall. While it is inevitable that both meat and cereal imports will remain dominant in Pacific diets, further increasing their role as coastal fisheries decline, would present further food security vulnerability.

Alternative foods to reef and coastal fish from increased domestic agricultural production (crops and Livestock) are more varied and context-dependent compared to opportunities presented by possible imports. Of the plausible locally-produced, animal-sourced food options, chicken production is the most viable due to affordability, ease of scaling, and relatively simple animal husbandry requirements including financial outlay. Chicken farming can also provide eggs, which are rich in protein. Other feasible domestic alternatives include fish farming, primarily small-pond production of tilapia (Pickering, Ponia et al. 2011). Some tilapia farming has been occurring in Melanesia for a significant period of time. Current production estimates are 500-1000 metric tonnes/year (t/yr) in PNG, 300 t/yr in Fiji, 150 t/yr in Solomon Islands and 8 t/yr in Vanuatu (Gillett and Fong 2023). However, it is unlikely that tilapia farming could expand to fill expected national dietary shortfalls in protein to a significant extent. Instead, we assume that it has the potential to provide some increased access to protein in inland areas of Melanesia where it is not practical to develop tuna supply chains. Some increased domestic production of plant-based alternatives such as nuts, vegetables, also offers potential (Farrell, Sharp et al. 2023).

Considering the parameters outlined above, including nutrition, reliability of supply, and cost, overlayed with broader factors that present risks and opportunities, such as global crises that can influence both pricing and reliability of supply, it is apparent that increasing the availability of tuna for domestic consumption will be increasingly important as a significant contributor to national food security. Tuna is good source of protein, omega 3 fatty acids and iron (Table 11), and consumption of tuna up to 50% of recommended protein intake is not expected to exceed safe levels of mercury consumption (Bell, Allain et al. 2015). The vast majority of people live along coastal fringes in all PICs except Papua New Guinea and Fiji so tuna is relatively accessible to artisanal fishers, and consumers through short supply chains. Tuna is also relatively accessible to artisanal fishers, especially where nearshore fish aggregating devices (FADs) have been installed (Technical Study 3). Tuna harvest for domestic consumption is sustainable, and increasing domestic consumption would not significantly impact total commercial harvest (Bell, Allain et al. 2015). Access to tuna is also largely immune to global events such as supply shocks, except in indirect ways such as potential increase in fuel costs. Importantly, even though the spatial distribution of tuna is likely to change due to climate impacts (Bell, Reid et al. 2013, Erauskin-Extramiana, Arrizabalaga et al. 2019), this is not expected to have a significant impact on the availability of tuna for domestic consumption (Bell, Cisneros-Montemayor et al. 2018). In addition, tuna are not vulnerable to other climate-driven impacts, e.g., the effects of more powerful cyclones or rainfall variability on coastal fish habitats due to of increased runoff. Tuna will be important, not only to help meet domestic dietary requirements, but also in expanding domestic livelihood opportunities, and in managing risks associated with import dependence. Increased access to tuna should sit centrally within the general approach of diversifying local diets outlined above. Improving domestic value chains, including increased access to commercial bycatch, canned tuna, and increasing artisanal harvest through FAD deployment activities are pragmatic and feasible vehicles for enabling increased tuna consumption (Bell, Allain et al. 2015).

Although increasing access to tuna has an important role to play in increasing food and nutritional security and food sovereignty in the region, and concurrent reduction in diet-related non-communicable disease, these goals will also be enhanced by increasing domestic production of other nutritious foods that are resilient to the current and anticipated impacts of climate change. A diverse range of context-appropriate livestock, horticultural and aquaculture production systems will be needed for this purpose. Such investments will help to ensure resilience to climatic impacts and unanticipated global events and support healthy balanced diets. Importantly, increasing food diversity is more feasible on fertile high islands than in countries comprised entirely or mainly of coral atolls, which will inevitably be more heavily dependent on imports and aquatic resources into the future. This variability in potential for food production between island types should be considered when prioritising food security and nutrition interventions.

Finally, although our analysis demonstrates that increasing access to tuna represents the best option for diversifying and improving nutrition where population growth and the effects of climate change on reef and coastal fisheries resources significantly reduce recommended per capita availability of fish-based protein, the level at which tuna is needed to fill gaps in protein supply can be expected to vary among countries.

The reason for this is that some countries have small and relatively stable populations, and large areas of coral reef relative to population size. In these countries, the projected effects of climate change on reef and coastal fish production are not likely to reduce protein supply below recommended levels (Table 17) for rural communities simply because the area of coral reef is so large relative to population size. For these countries, even when their reefs are degraded, they will have the potential to supply the quantities of fish required. However, economically-viable distribution of reef and coastal fish from distant reefs to urban populations in such countries is often a problem (Bell, Reid et al. 2011) (Bell, Reid et al. 2011). Expanding the use of FADs (Technical Study 3) within a practical fish-distribution radius of urban centres and improving the distribution of bycatch in such countries where transhipping operations occur (Technical Study 5), will help to ensure equitable national access to recommended levels of protein from fish. Countries in this category include Cook Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Niue, Palau, Tonga and Tuvalu. In some of these countries ciguatera fish poison prevents people consuming reef fish (Pratchett, Munday et al. 2011, Skinner, Brewer et al. 2011) and in others, increasing access to tuna will also be needed to supply fish for tourists, and in creating livelihoods.

In all remaining countries (Fiji, Nauru, Papua New Guinea, Samoa, Solomon Islands and Vanuatu), which collectively comprise X% of the total population of the 14 countries participating in the GCF tuna programme (Andrew, Bright et al. 2019), a significant gap is expected to occur between the amount of reef and coastal fish needed for good nutrition and the quantity of these fish that can be harvested sustainably from coral reefs and other coastal habitats degraded by climate change. In these countries, increasing access to tuna is essential to national plans to provide both rural and urban communities with access to adequate fish protein per capita.

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APPENDICES

Appendix 1. Study tasks and deliverables

Study 2: Options for supplying dietary protein for growing Pacific Island populations

Objectives: The SPC Public Health Division recommends that 50% of the protein needed for good nutrition of Pacific Island people should be derived from fish because of the problems involved in producing nutritious dietary protein in the region due to (often severe) limitations on agriculture and animal husbandry. It has been widely recognised that as the human populations of many Pacific Island countries continue to grow rapidly, and as harvests of coastal fisheries decline due to the degradation of coral reefs and other effects of climate change, more tuna and other oceanic fish species (hereafter grouped as 'tuna') will need to be allocated to domestic food security to ensure that fish provides 50% of dietary protein.
The purpose of this study is to prepare the report entitled 'Options for supplying dietary protein for growing Pacific Island populations' required for the 'options' analysis in the Feasibility Study (see GCF Study 9). This study is needed to make an objective assessment of possible alternatives to tuna (e.g., fish imports, agricultural/meat imports, increased local agricultural/meat production, aquaculture), for filling the gap in dietary protein needed by each of the 14 Pacific Island countries in 2030 and 2050.

The specific tasks to be completed during this Study are described below:

(i) A desk study of the public health status (including, where feasible, nutritional status, e.g., malnourished, obese, incidence of diet-driven non-communicable diseases) in each of the 14 Pacific Island countries participating in the Programme (based on the relevant SPC, WHO and FAO databases).

(ii) An overview of the main sources and quantities (kg per person per year) of protein consumed by coastal and urban communities in the 14 Pacific Island countries participating in the Programme[1]. This information should be derived from the most recent Household Income and Expenditure Surveys (HIES) conducted by programme-targeted countries' national statistics agencies and summarized into the following food types, where available (with gaps and uncertainties identified where it is not):

i • locally available coastal and freshwater fish species from capture fisheries and aquaculture;
ii • locally available tuna (fresh, bycatch, canned),
iii • imported frozen fish;
iv • imported canned fish (including imported canned tuna);
v • chicken (separated into local and imported);
vi • beef (separated into local and imported);
vii • pork (separated into local and imported);
viii • imported canned meat in general;
ix • local root crops and vegetables
x • imported grains and cereals
xi • other sources of protein.

(iii) The nutritional value of each of the sources of dietary protein listed above, in terms of protein, energy, fat, minerals and vitamins, for children (including infants in utero and while breast feeding), women and men.

(iv) The average cost per kg (in USD) of each food type in each of the 14 participating countries. In the case of tuna, this analysis should account for the fact that:

- Some of the tuna consumed by coastal communities will come from subsistence fishing supported by the proposed expansion of National FAD Programmes, and
- Tuna bycatch is available at low cost at several urban centres in the region through transhipping operations, e.g., in Honiara, Solomon Islands.

(v) Analysis of the quantity of dietary protein to be supplied by fish (based on the recommendation that fish provides 50% of dietary protein) in each of the 14 participating countries by 2030 and 2050 based on:

- Expected population sizes in each country in those years.
- Recommendation from WHO that human diets should contain 0.7 g of protein per kg body weight per day.
- Average body weight of children, women and men in each country.

(vi) Synthesis of the above information to compare the advantages and disadvantages, in terms of nutrition, reliability of supply (particularly for imports, which could be affected by changes in global trade arrangements due to pandemics, economic crises and security risks) and cost, of using tuna to ensure that enough fish is available in total to supply 50% of dietary protein in the face of reduced coastal fisheries production and greater human populations, as opposed to substituting tuna with other sources of dietary protein.

Outputs/Deliverables: The main output will be a report that documents:

I. Public health status in each of the 14 countries participating in the Programme. This section of the report should include a table, similar to Supplementary Table 5 in the publication available at: https://doi.org/10.1016/j.marpol.2018.10.034

II. The main sources and quantities of protein consumed in each of the 14 countries, including a table that summarises the per capita consumption of protein derived from each of the sources (food types) listed above (in kg per person per year based on the percentage protein content of each food type, for example, if tuna is 25% protein and 50 kg of tuna is consumed, the quantity of protein derived from tuna would be 12.5 kg). Where relevant, consumption patterns should be shown for both coastal and rural communities.

III. The nutritional value of each of the food types listed above, in terms of average protein, energy, fat, minerals and vitamins. This section of the report should include a table, similar to Supplementary Table 2 in the publication available at: https://doi.org/10.1016/j.marpol.2018.10.034. Information on hormone and antibiotic levels in imported meat products, and heavy metals and persistent organic pollutants in fresh fish products, should also be included if available.

IV. A table summarizing available information on the average cost per kg (converted to USD) of each food type in each of the 14 participating countries.

V. The gap in dietary protein recommended to be filled by fish in each of the 14 participating countries by 2030 and 2050.

VI. Synthesis of the above information to compare the advantages and disadvantages, in terms of nutrition, cost and reliability of supply, of using tuna to fill the gap in recommended protein supply, created by population growth and degradation of coral reefs due to climate change, compared to other sources of locally available or imported dietary protein. This section of the report should evaluate nutritional benefits not only in terms of protein content by also availability of micro-nutrients. It should also briefly identify the risks to continuity of supply of each source of protein.

The report must be a stand-alone document that describes the findings from this study in detail, with an appropriate Executive Summary.

Appendix 2. HIES surveys used for 12 of 14 countries in this study for chapters 1, 2, 3, 4, 5.

Country	HIES year	Data Source
COK	2015-16	"Cook Islands Statistics Office, Household Income and Expenditure Survey 2015-2016 (HIES 2015), Version 01 of the licensed dataset (February 2017), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"
FSM	2013-14	Division of statistics of Federated States of Micronesia, Household Income and Expenditure Survey 2013-2014 (HIES 2013-2014), Version 01 of the licensed datasets (2014), provided by the Pacific Microdata Library. http://pdl.spc.int/index.php/home
KIR	2019-20	"Kiribati National Statistics Office, Household Income and Expenditure Survey 2019 (HIES 2019), Version 01 of the licensed dataset (December 2020), provided by the Pacific Data Hub - Microdata Library. https://microdata.pacificdata.org/index.php/home"
MHL	2019-20	"Economic Policy Planning and Statistics Office of Marshall Islands, Household Income and Expenditure Survey 2019 (HIES 2019), Version 01 of the licensed dataset (March 2021), provided by the Pacific Data Hub - Microdata Library. https://microdata.pacificdata.org/index.php/home"
NRU	2012-13	"Nauru Bureau of Statistics Office, Household Income and Expenditure Survey 2012-2013 (HIES 2012-2013), Version 01 of the licensed datasets (November 2019), provided by the Microdata Library: https://microdata.pacificdata.org/index.php/home"
NIE	2015-16	"Niue National Statistics Office, Household Income and Expenditure Survey 2015-2016 (HIES 2015-2016), Version 01 of the licensed datasets (February 2018), provided by the Pacific Microdata Library. http://pdl.spc.int/index.php/home"
PLW	2013-14	"Office of Planning and Statistics of Palau, Household Income and Expenditure Survey 2013-2014 (HIES 2013), Version 01 of the licensed dataset (January 2005), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"
SLB	2012-13	"Solomon Islands National Statistics Office, Household Income and Expenditure Survey 2012-2013 (HIES 2012), Version 01 of the licensed dataset (January 2020), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"
TON	2015-16	"Tonga Statistics Department, Household Income and Expenditure Survey 2015-2016 (HIES 2015-2016), Version 01 of the licensed datasets (February 2020), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"
TUV	2015-16	"Central Statistics Division of Tuvalu, Household Income and Expenditure Survey 2015-2016 (HIES 2015), Version 01 of the licensed dataset (November 2019), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"
VUT	2019-20	"Vanuatu National Statistics Office, Household Income and Expenditure Survey 2019-2020 (HIES 2019), Version 01 of the licensed dataset (September 2020), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home
WSM	2018	"Samoa Bureau of Statistics, Household Income and Expenditure Survey 2018 (HIES 2018), Version 01 of the licensed dataset (December 2020), provided by the Microdata Library. https://microdata.pacificdata.org/index.php/home"

Appendix 3. Food COICOP codes and nutrient database descriptions of all foods included in chapter 2 analysis for the 12 countries that had consumption estimates derived from HIES data.

Food Group	COICOP code	Pacific Nutrient Database description
1. Reef & Coastal fish	01.1.3.1.9_04	Stingray, raw
	01.1.3.1.9_02	Snapper, flesh, raw
	01.1.3.1.9_98	Fish, reef, composite, raw
2. Tuna & Pelagic fish	01.1.3.1.5_01	Tuna, albacore, flesh, raw
	01.1.3.1.5_02	Tuna, skip jack, flesh, raw
	01.1.3.1.5_03	Tuna, yellow fin, flesh, raw
	01.1.3.1.5_99	Tuna, flesh, composite, raw
	01.1.3.1.6_01	Mackerel, Spanish, "Walu", raw
	01.1.3.1.6_02	Sardine, Australian, whole, raw
	01.1.3.1.6_99	Fish, pelagic/ocean, composite, raw
	01.1.3.1.9_01	Shark, flesh, composite, raw
	11.1.1.1.1_62	Tuna, raw, sashimi style, restaurant style
3. Composite fish	01.1.3.1.9_99	Fish, composite, raw
	01.1.3.2.9_02	Fish, dried, salted
	01.1.3.2.9_03	Fish, smoked, composite, raw
4. Canned fish	01.1.3.2.9_01	Tuna, canned in brine, drained
	01.1.3.3.1_01	Tuna, canned in oil, drained
	01.1.3.3.1_02	Tuna, canned in tomato
	01.1.3.3.1_03	Tuna canned, composite
	01.1.3.3.2_01	Herring, Atlantic, canned in brine, pickled, drained
	01.1.3.3.2_02	Mackerel, canned, composite
	01.1.3.3.2_03	Sardines, canned, composite
	01.1.3.3.9_02	Salmon, canned, unflavoured, drained, composite
	01.1.3.3.9_97	Fish, composite, canned in oil, drained
	01.1.3.3.9_99	Fish, canned, composite, drained
	01.1.3.6.3_01	Mussels, smoked, canned in oil, drained
	01.1.3.6.3_02	Oysters, smoked, canned in oil, drained
5. Invertebrates	01.1.3.4.1_99	Prawn/shrimp, flesh, composite, raw
	01.1.3.4.2_01	Crab, mud, fresh, raw
	01.1.3.4.2_02	Crab, mud, fresh, raw
	01.1.3.4.2_03	Crab, mud, fresh, raw
	01.1.3.4.2_98	Crab, flesh, composite, raw
	01.1.3.4.2_99	Crayfish / lobster, composite, raw
	01.1.3.4.3_01	Mussels, raw
	01.1.3.4.3_02	Octopus, raw
	01.1.3.4.3_03	Scallop, raw
	01.1.3.4.3_04	Sici-shell, meat, raw
	01.1.3.4.3_05	Squid, composite, raw
	01.1.3.4.3_06	Oyster, Pacific, flesh, raw
	01.1.3.4.5_01	Paua, raw
	01.1.3.4.5_02	Sea snail
	01.1.3.4.5_99	Sea-hare, composite, raw

	01.1.3.4.9_01	Sea urchin, raw
	01.1.3.4.9_04	Sea cucumber, edible muscle
	01.1.9.1.2_28	Crab, flesh, purchased steamed or boiled
	01.1.9.1.2_30	Mussels, green, meat, boiled
	01.1.9.1.2_31	Octopus, marinated, baked, grilled, fried or BBQ'd, fat not further defined
	01.1.9.1.2_33	Prawn/shrimp, cooked, composite
	01.1.9.1.2_35	Squid, battered, takeaway outlet, deep fried
	01.1.9.1.2_36	Squid, cooked, composite
	01.1.9.1.2_99	Crab, flesh, cooked, not further specified
	01.1.3.6.2_01	Crab, imitation, surimi
6. Beef	01.1.2.2.1_01	Beef, mince/ground, lean (<5% fat), raw
	01.1.2.2.1_02	Beef, mince/ground, regular fat (5-10% fat), raw
	01.1.2.2.1_03	Beef, lean (fully-trimmed), raw, cuts not specified
	01.1.2.2.1_04	Beef, regular (untrimmed), raw, cut not specified
	01.1.2.2.1_98	Beef, steak, composite, raw
	01.1.2.2.1_99	Beef, composite, raw
	01.1.9.1.2_03	Beef,lean meat and flesh, fried, composite
	01.1.9.1.2_05	Beef, untrimmed, grilled/bbq, composite
	01.1.9.1.2_06	Beef, untrimmed, simmered/stewed, composite
	01.1.9.1.2_91	Beef, cooked, composite
	11.1.1.1.1_41	Beef, rib, shortribs, separable lean and fat, braised
	01.1.2.4.0_95	Beef, offal, composite, raw
7. Chicken	01.1.2.4.0_96	Chicken, offal, composite, raw
	01.1.2.1.4_01	Chicken, purchased live, whole, flesh and skin, raw
	01.1.2.2.4_01	Chicken, breast, flesh, fat and skin, raw
	01.1.2.2.4_02	Chicken, quarters, flesh, fat and skin, raw
	01.1.2.2.4_03	Chicken, thighs, flesh, fat and skin, raw
	01.1.2.2.4_04	Chicken, whole, flesh and skin, raw
	01.1.2.2.4_96	Chicken, composite, raw
	01.1.9.1.2_07	Chicken, light meat, fried
	01.1.9.1.2_09	Chicken, flesh and skin, grilled/bbq, no added fat, composite
	01.1.9.1.2_11	Chicken, lean meat, skin and fat, simmered/stewed, with or without added fat, composite
	01.1.9.1.2_92	Chicken cooked, flesh, skin and fat, no added fat, composite
8. Pork	01.1.2.4.0_99	Pork, offal, composite, raw
	01.1.2.1.2_01	Swine, purchased live, carcass, separable lean and fat, raw
	01.1.2.2.2_01	Pork, lean (fully-trimmed), composite, raw
	01.1.2.2.2_02	Pork, regular (untrimmed), composite, raw
	01.1.2.2.2_99	Pork, composite, raw
	01.1.9.1.2_12	Ham steak, grilled, no added fat
	01.1.9.1.2_17	Pork, fried (puaa vela)
	01.1.9.1.2_94	Pork, cooked, no added fat, composite
9. Processed meat & canned meat	01.1.2.5.2_01	Beef, canned, corned
	01.1.2.5.2_02	Camp pie, canned
	01.1.2.5.2_04	Chicken and vegetable curry, canned
	01.1.2.5.2_05	Duck, stewed in soysauce, canned

	01.1.2.5.2_08	Pork, ham, lean and fat, canned
	01.1.2.5.2_10	Spam, canned
	01.1.2.5.2_96	Beef, canned, composite
	01.1.2.5.2_99	Canned meat, composite
	01.1.2.5.9_02	Luncheon meat, chicken
	01.1.2.3.1_01	Beef, cured, dried
	01.1.2.3.2_01	Salami
	01.1.2.3.2_02	Bacon, composite
	01.1.2.5.1_01	Sausage, beef, fresh, raw
	01.1.2.5.1_02	Sausage, vienna, chicken, beef and pork, canned
	01.1.2.5.1_03	Sausage, chicken, fresh, raw
	01.1.2.5.1_05	Sausage, hot dog, composite
	01.1.2.5.1_06	Sausage, lamb, fresh, raw
	01.1.2.5.1_07	Sausage, pork, fresh, raw
	01.1.2.5.1_99	Sausage, fresh, composite, raw
	01.1.2.5.3_01	Pate, liver, composite
	01.1.2.5.9_01	Devon/fritz, processed luncheon meat, beef and pork
	01.1.9.1.2_08	Chicken, crumbed, fried, composite
	01.1.9.1.2_10	Chicken, nuggets, crumbed, deep fried or baked
	01.1.9.1.2_21	Sausage, beef, grilled, no added fat
10. Other animal sourced foods	01.1.4.8.1_01	Egg, chicken, fresh, whole, raw
	01.1.4.8.1_02	Egg, duck, fresh, whole, raw
	01.1.4.8.2_01	Egg, turtle, fresh, whole, raw
	01.1.9.1.5_01	Egg, chicken, whole, fried, oil not further defined
	01.1.9.1.5_02	Egg, chicken, whole, hardboiled
	01.1.9.1.5_04	Egg, chicken, scrambled
	01.1.9.1.5_05	Omelette, plain, without salt
	01.1.9.1.5_99	Egg, chicken, cooked, composite
	01.1.5.2.1_01	Ghee/clarified butter
	01.1.5.2.1_99	Butter, plain, salted
	01.1.5.9.9_03	Shortening, commercial, composite
	01.1.5.9.1_01	Lard and suet
	01.1.5.9.9_01	Dripping, beef
	01.1.2.2.9_09	Grub, larva, raw
	01.1.2.2.5_01	Rabbit, farmed, whole, raw
	01.1.2.2.6_01	Horse, mule, donkey, camel and the like, raw, composite
	01.1.2.2.9_02	Flying fox, flesh, raw
	01.1.2.2.9_06	Deer, meat, raw
	01.1.2.2.9_07	Dog, meat, raw
	01.1.2.2.9_10	Possum, wild caught, flesh, cooked
	01.1.2.2.9_13	Snake, raw
	01.1.3.4.9_03	Turtle, raw
	01.1.9.1.2_95	Meat, regular, separable fat, cooked, composite
	01.1.9.1.2_96	Meat, bbq/grill/fry cuts, semi-trimmed, cooked, no added fat, composite
	01.1.9.1.2_98	Sausage, grilled, composite
	01.1.2.2.4_06	Turkey, tail, raw
	01.1.2.2.4_07	Turkey, wing, flesh, fat and skin, raw

	01.1.2.2.4_97	Turkey, flesh, without skin, composite, raw
	01.1.2.2.4_98	Goose, flesh and skin, raw
	01.1.2.2.4_99	Duck, flesh, fat and skin, raw
	01.1.2.2.9_04	Bird, all others, composite, raw
	11.1.1.1.1_42	Turkey tail, cooked
	01.1.2.2.3_01	Goat meat, lean, composite, raw
	01.1.2.2.3_02	Lamb and mutton, lean (fully-trimmed), composite, raw
	01.1.2.2.3_03	Lamb and mutton, regular (untrimmed), composite, raw
	01.1.2.2.3_04	Mutton flaps, boneless, separable lean and fat, raw
	01.1.2.2.3_99	Lamb and mutton, composite, raw
	01.1.9.1.2_13	Lamb, lean meat and fat, fried, composite
	01.1.9.1.2_15	Lamb, grilled/bbq, no added fat, composite
	01.1.9.1.2_93	Lamb, cooked, composite
	01.1.4.1.1_01	Milk, cow, fluid, whole
	01.1.4.1.1_02	Milk, cow, fluid, whole, long life, shelf stable (UHT)
	01.1.4.2.0_01	Milk, cow, fluid, lite/low fat, 1.5% fat
	01.1.4.2.0_03	Milk, cow, fluid, skim
	01.1.4.2.0_98	Milk, cow, fluid, long life, shelf stable (UHT), composite
	01.1.4.2.0_99	Milk, fresh, fluid, composite
	01.1.4.3.1_01	Milk, condensed, skim, sweetened, canned
	01.1.4.3.1_02	Milk, condensed, whole, sweetened, canned
	01.1.4.3.1_04	Milk, condensed, whole, sweetened, canned
	01.1.4.3.1_06	Milk, cow, evaporated, whole, canned
	01.1.4.3.1_98	Milk, condensed, sweetened, composite, canned
	01.1.4.3.1_99	Milk, cow, evaporated,composite
	01.1.4.3.2_01	Milk, cow, powdered, full cream
	01.1.4.3.2_02	Milk, cow, powdered, skim
	01.1.4.3.2_99	Milk, cow, powdered, composite
	01.1.4.3.3_04	Cream, sour, regular fat
	01.1.4.3.3_98	Cream, dairy based, composite
	01.1.4.5.0_01	Cheese, block, composite
	01.1.4.5.0_03	Cheese, cheddar, processed, regular fat
	01.1.4.5.0_05	Cheese, spreads, cheddar, regular fat
	01.1.4.5.0_99	Cheese, composite
	01.1.4.6.0_01	Yoghurt, fruit
	01.1.4.6.0_03	Yoghurt, plain/natural
	01.1.4.6.0_04	Yoghurt, composite
	01.1.4.7.0_02	Milk, cow, fluid, flavoured, composite
11. Cereals & their products	01.1.1.1.2_01	Rice, brown, dry, unpolished, raw
	01.1.1.1.2_99	Rice, white, dry, polished, raw
	01.1.1.2.1_01	Flour, wheat, white, plain, unfortified
	01.1.1.2.2_01	Flour, rice, composite (white/brown), dry
	01.1.1.2.6_01	Flour, cornflour/maize, from maize starch
	01.1.1.2.9_99	Flour, wheat, white, plain, unfortified
	01.1.1.3.1_01	Bread, from white flour
	01.1.1.3.1_02	Bread, from wholemeal flour
	01.1.1.3.1_03	Bread, with mixed grains, commercially prepared

	01.1.1.3.1_04	Bread, all others, composite
	01.1.1.3.1_06	Bread, garlic
	01.1.1.3.1_07	Flatbread, naan, commercial
	01.1.1.3.1_08	Flatbread, all others, commercially prepared, composite
	01.1.1.3.1_09	Breadroll, white flour, commercially prepared
	01.1.1.3.1_10	Breadroll, wholemeal flour
	01.1.1.3.1_97	Bread, loaf, from white flour
	01.1.1.3.1_98	Breadroll, from white flour
	01.1.1.4.0_01	Breakfast cereal, flakes of corn, added nuts and/or sugar coated, added minerals and vitamins
	01.1.1.4.0_02	Breakfast cereal, flakes of corn, no sugar added, added minerals and vitamins (iron, vitamins B1, B2 and B3), e.g. corn flakes
	01.1.1.4.0_03	Breakfast cereal, wheat bran flakes, with dried fruits, added minerals and vitamins (iron, zinc, vitamins B1, B2, B3 and B6) e.g. sultana bran/raisin bran
	01.1.1.4.0_04	Breakfast cereal, mixed grain (rice & wheat), flakes, sweetened, added minerals and vitamins (iron, calcium, zinc, vitamins B1, B2, B3 and B6), e.g. special K
	01.1.1.4.0_05	Breakfast cereal, puffed or popped rice, added minerals and vitamins (iron, vitamins B1, B2 and B3), e.g. rice bubbles
	01.1.1.4.0_06	Breakfast cereal, puffed or popped rice, cocoa coating, added minerals and vitamins (iron, vitamins B1, B2 and B3), e.g. coco pops
	01.1.1.4.0_07	Breakfast cereal, whole wheat, biscuit, added mineral and vitamins (iron, B1, B2 and B3), e.g. weetbix, vita-brits
	01.1.1.4.0_08	Oats, porridge, dry, raw
	01.1.1.4.0_98	Muesli, composite
	01.1.1.4.0_99	Breakfast cereal, composite
	01.1.1.5.0_01	Noodles, wheat, instant (Maggi-type), dry, raw
	01.1.1.5.0_03	Pasta, plain, white wheat flour, dry (spaghetti, macaroni etc), raw
	01.1.1.5.0_99	Noodles, dry, raw, composite
	01.1.1.9.0_04	Popcorn, cooked, composite
	01.1.1.9.0_98	quinoa
	01.1.4.4.4_01	Milk, rice, fluid
	01.1.9.1.1_01	Noodles, instant boiled, drained
	01.1.9.1.1_02	Oats, plain, boiled with water
	01.1.9.1.1_04	Rice, white, boiled, no fat or salt added
	01.1.9.1.1_99	Rice, boiled, composite, no fat or salt added
	11.1.1.1.1_09	Bread, white, Maori, fried
12. Vegetables, roots and tubers	01.1.7.5.1_99	Potato, combined cultivars, flesh, raw
	01.1.7.5.2_01	Sweet potato, composite, raw
	01.1.7.5.3_01	Cassava, raw
	01.1.7.5.4_99	Yam, composite, raw
	01.1.7.5.5_01	Taro, common, composite, raw
	01.1.7.5.5_02	Taro, giant, raw
	01.1.7.5.5_99	Taro, composite, raw
	01.1.7.8.0_01	Banana, cooking, raw

01.1.7.9.1_01	Flour, cassava
01.1.9.1.3_02	Banana, cooking, ami, baked, no fat or salt added
01.1.9.1.3_03	Banana, cooking, boiled, no fat or salt added
01.1.9.1.3_26	Cassava, tuber, boiled, no fat or salt added
01.1.9.1.3_68	Potato, pale skin, peeled, baked, no fat or salt added
01.1.9.1.3_69	Potato, white, peeled, boiled, no fat or salt added
01.1.9.1.3_80	Sweet potato, composite, tuber, boiled, no fat or salt added
01.1.9.1.3_84	Taro, common, corm, flesh, baked, no salt or fat added
01.1.9.1.3_85	Taro, common, corm, boiled, no salt or fat added
01.1.9.1.3_86	Taro, giant, baked, no salt or fat added
01.1.9.1.3_87	Taro, giant, boiled, no salt or fat added
01.1.9.1.3_88	Taro, common, corm, flesh, baked, no salt or fat added
01.1.9.1.3_90	Taro, cooked, composite, no salt or fat added
01.1.9.1.3_99	Yam, composite, cooked, no salt or fat added
11.1.1.1.1_58	Takeaway, yam/taro
11.1.1.1.1_60	Tapioca, pearl or seed style, boiled in water, no added fat or salt
11.1.1.1.1_61	Taro, composite, boiled, no salt or fat added
01.1.3.4.9_02	Seaweed, fresh, raw
01.1.7.1.2_01	Cabbage, slippery bush, leaves, raw
01.1.7.1.2_02	Cabbage, Chinese, raw
01.1.7.1.2_03	Cabbage, European, white, raw
01.1.7.1.2_04	Cabbage, fern, leaves, raw
01.1.7.1.2_99	Cabbage, composite, raw
01.1.7.1.3_01	Broccoli, raw
01.1.7.1.4_01	Lettuce, composite, raw
01.1.7.1.5_01	Spinach, water, fresh, raw
01.1.7.1.5_99	Spinach, composite, raw
01.1.7.1.9_01	Oriental radish, peeled, raw
01.1.7.1.9_03	Taro, leaves, raw
01.1.7.1.9_04	Pumpkin, leaves, raw
01.1.7.1.9_05	Leaves, watercress, raw
01.1.7.2.1_01	Chilli, red, flesh, raw
01.1.7.2.2_01	Cucumber, common, unpeeled, raw
01.1.7.2.3_01	Eggplant, flesh, raw
01.1.7.2.4_01	Tomato, common, raw
01.1.7.2.5_01	Pumpkin, raw
01.1.7.2.5_03	Courgette, green, unpeeled, raw
01.1.7.2.6_01	Okra, raw
01.1.7.2.9_01	Choko, peeled, fresh, raw
01.1.7.2.9_99	Capsicum, composite, raw
01.1.7.3.1_01	Beans, green, fresh, raw
01.1.7.3.1_02	Beans, yardlong, in pod, raw
01.1.7.3.1_03	Beans, sprouts, raw
01.1.7.3.3_01	Peas, green, fresh, seed, raw
01.1.7.4.1_01	Carrot, raw
01.1.7.4.2_01	Garlic, peeled, fresh, raw
01.1.7.4.3_01	Onion, mature, peeled, raw
01.1.7.4.3_02	Onion, shallot, fresh, raw

	01.1.7.4.3_03	Onion, spring, fresh, raw
	01.1.7.4.8_01	Corn, cob, fresh or frozen, raw
	01.1.7.4.9_99	Vegetables, composite, raw
	01.1.7.9.2_01	Asparagus, canned in brine, drained
	01.1.7.9.2_02	Beetroot, canned in brine, drained
	01.1.7.9.2_03	Cucumber pickled, dill
	01.1.7.9.2_04	Mushrooms, canned in brine, drained
	01.1.7.9.2_05	Tomato, whole, canned in tomato juice, undrained
	01.1.7.9.2_06	Tomato paste, salted
	01.1.7.9.2_99	Corn, composite, canned in brine, drained
	01.1.7.9.9_07	Kimchee, pickled vegetables, Korean
	01.1.7.9.9_08	Peas, green, canned, drained
	01.1.7.9.9_09	Potato, mashed, powdered, unprepared
	01.1.9.1.3_19	Edible hibiscus, leaves, boiled, no fat or salt added
	01.1.9.1.3_20	Cabbage, Chinese, cooked, no fat or salt added
	01.1.9.1.3_22	Cabbage, composite, boiled, no fat or salt added
	01.1.9.1.3_27	Cauliflower, boiled, no fat or salt added
	01.1.9.1.3_28	Celery, boiled, no fat or salt added
	01.1.9.1.3_32	Corn, cob, baked, no fat or salt added
	01.1.9.1.3_34	Eggplant, boiled, no fat or salt added
	01.1.9.1.3_39	Leaves, choko, boiled, no fat or salt added
	01.1.9.1.3_46	Leaves, okra, boiled, no fat or salt added
	01.1.9.1.3_51	Leaves, taro, boiled, no fat or salt added
	01.1.9.1.3_55	Leaves, wingedbeans, cooked, no fat or salt added
	01.1.9.1.3_56	Leek, boiled, no fat or salt added
	01.1.9.1.3_67	Snow pea, with edible pod, fresh, boiled, drained, no fat or salt added
	01.1.9.1.3_71	Pumpkin, peeled, fresh, boiled, drained, no fat or salt added
	01.1.9.1.3_74	Spinach, frozen, boiled, no fat or salt added
	01.1.9.1.3_76	Spinach, fresh, leaves, baked, no fat or salt added
	01.1.9.1.3_92	Vegetables, mixed, boiled, no fat or salt added
	11.1.1.1.1_33	Salad, garden, made from leafy greens, cucumber & tomato, no added dressing
13. Pulses, seeds and nuts and their products	01.1.4.3.3_02	Cream, coconut, canned/UHT
	01.1.4.3.3_03	Cream, coconut, fresh, no water
	01.1.4.3.3_99	Cream, coconut, composite
	01.1.4.4.2_01	Milk, almond, fluid
	01.1.4.4.3_01	Milk, soya bean, fluid
	01.1.6.1.8_01	Coconut, embryo germinating
	01.1.6.1.8_02	Coconut, green (immature), flesh and water
	01.1.6.1.8_03	Coconut, brown (mature), flesh
	01.1.6.1.8_99	Coconut, flesh, composite, raw
	01.1.6.7.9_02	Coconut, dried
	01.1.6.8.1_01	Almond, composite, raw
	01.1.6.8.3_01	Chestnut, composite, raw
	01.1.6.8.9_01	Betelnut, kernels, dried, raw
	01.1.6.8.9_03	Cutnut, Vanuatu, raw
	01.1.6.8.9_04	Pandanus nuts, kernel

	01.1.6.8.9_05	Peanut, kernel and skin, raw, unsalted
	01.1.6.8.9_08	Pilinut (Ngali/nangai), composite
	01.1.6.8.9_99	Nuts, composite, raw
	01.1.6.9.4_01	Nuts, mixed, salted
	01.1.6.9.4_03	Peanut, kernels, salted, roasted
	01.1.6.9.4_04	Peanut, roasted, unsalted
	01.1.7.6.4_01	Lentils, dry, raw
	01.1.7.9.9_01	Beans, legumes, composite, canned in brine, drained
	01.1.7.9.9_99	Baked beans, canned, composite
	01.1.8.4.0_99	Peanut butter, composite
	01.1.9.1.3_13	Beans, red kidney, dried, boiled, no fat or salt added
	01.1.9.1.3_15	Beans, soya, dried, boiled, drained, no fat or salt added
	01.1.9.1.3_57	Lentils, boiled,drained, no fat or salt added
	01.1.9.4.0_25	Tahini, sesame seed butter
14. Composite meals	01.1.1.5.0_02	Pasta, in tomato and cheese sauce, canned
	01.1.2.4.0_01	Beef, soup, bones and vegetable broth
	01.1.2.5.2_07	Pie, steak and kidney, canned
	01.1.2.5.2_09	Sausage roll
	01.1.2.5.2_11	Stew/Irish stew, canned
	01.1.2.5.2_12	Vegetables and sausages, canned
	01.1.2.5.2_13	Vegetables and steak, canned
	01.1.2.5.2_97	Hamburger patties, rissoles, composite, raw
	01.1.2.5.2_98	Pie, meat, composite
	01.1.3.3.9_03	Fish finger, crumbed, purchased frozen, raw
	01.1.3.3.9_05	Pie, fish, potato top, frozen meal, microwaved
	01.1.9.1.4_01	Quiche, savory, baked, composite
	01.1.9.1.4_02	Pizza, frozen, commercial, composite
	01.1.9.1.6_01	Soup, beef and vegetable, from cafe or restaurant
	01.1.9.1.6_02	Soup, chicken and vegetable, from cafe or restaurant
	01.1.9.1.6_03	Soup, chicken, noodle, dry mix, prepared
	01.1.9.1.6_04	Soup, pumpkin
	01.1.9.1.6_05	Soup, tomato, prepared, canned
	01.1.9.1.6_06	Soup, vegetable, canned
	01.1.9.1.6_08	soup, crab
	01.1.9.1.9_01	Breadfruit, boiled
	11.1.1.1.1_01	Bacon and chicken egg, fried
	11.1.1.1.1_02	Bacon and chicken egg, poached
	11.1.1.1.1_03	Bacon and chicken egg, scrambled, cooked with added fat
	11.1.1.1.1_04	Bacon and chicken egg, composite
	11.1.1.1.1_08	Bun, steamed, savory, pork
	11.1.1.1.1_16	Spring roll, meat & vegetable filling, deep fried, commercial
	11.1.1.1.1_17	Noodle bowl, wheat flour, flavoured, boiled, undrained, Shin Ramyun Noodle Soup Hot & Spicy, Nong Shim
	11.1.1.1.1_18	Noodle bowl, wheat flour, flavoured, boiled, undrained, Shin Ramyun Noodle Soup Hot & Spicy, Nong Shim
	11.1.1.1.1_19	Noodles, Chow Mein, Chinese, takeaway
	11.1.1.1.1_20	Pancake, with syrup, McDonald's
	11.1.1.1.1_21	Pancake, plain, commercial

	11.1.1.1.1_22	Pasta, commercial, cooked, with dairy based sauce
	11.1.1.1.1_25	Poi, paiai (30% solids)
	11.1.1.1.1_27	Potato, pale skin, mashed with cows milk and butter, no salt added
	11.1.1.1.1_28	Ravioli, commercial
	11.1.1.1.1_29	Rice, boiled, with coconut cream
	11.1.1.1.1_30	Rice, boiled with eggs, chicken and vegetables, fried
	11.1.1.1.1_31	Rice, fried, combination, ready to eat. Chinese, takeaway
	11.1.1.1.1_32	Rice and vegetable, stir fry syle, using soy sauce
	11.1.1.1.1_34	Sandwich, filled with chicken
	11.1.1.1.1_35	Sandwich, filled with egg
	11.1.1.1.1_36	Sandwich, filled with ham
	11.1.1.1.1_37	Sandwich, filled with ham and cheese
	11.1.1.1.1_38	Soup, chicken and vegetables from café or restaurant
	11.1.1.1.1_39	Soup, mixed vegetable from café or restaurant
	11.1.1.1.1_40	Sushi,tuna, with seaweed
	11.1.1.1.1_43	Takeaway, noodle, Chinese, chow mein
	11.1.1.1.1_44	Stir-fry, homemade, beef and vegetable, with rice
	11.1.1.1.1_45	Stir-fry, chicken, with rice or noodles, commercial
	11.1.1.1.1_46	Stir-fry, homemade, pork and vegetable, with rice or noodles
	11.1.1.1.1_47	Takeaway, chicken, crumbed, breast, fried, ready to eat, Kentucky Fried Chicken
	11.1.1.1.1_48	Curry, homemade, chicken, with rice
	11.1.1.1.1_49	Fish, white flesh, fried or bbq'd, fat not further defined
	11.1.1.1.1_50	Hamburguer, plain
	11.1.1.1.1_51	Hot dog, bread roll, frankfurt and sauce filling
	11.1.1.1.1_52	Takeaway, pizza, ham and pineapple
	11.1.1.1.1_53	Takeaway, pizza, meat, thin base
	11.1.1.1.1_54	Takeaway, pizza, vegetarian, thick crust
	11.1.1.1.1_55	Takeaway, pizza, composite
	11.1.1.1.1_56	Takeaway, salad, potato, added dressing
	11.1.1.1.1_57	Salad, mixed vegetables (leafy greens, carrot, cucumber and tomato), no added dressing
	11.1.1.1.1_66	Chicken, fried with rice
	11.1.1.1.1_67	Takeaway, fish, battered, deep fried and potato chips
	11.1.1.1.1_70	Fish, baked, with rice, boiled
	11.1.1.1.1_71	Fish, with rice and taro; mixed cooking methods
	11.1.1.1.1_77	Steak, mixed cooking methods with rice, boiled and taro, boiled
	11.1.1.1.1_78	Rice and taiyo (rice with tinned fish)
	11.1.1.1.1_99	Buatoro (Kiribati)
15. All other foods	01.1.8.5.3_01	Cocoa, powder
	01.1.8.5.9_02	Ovaltine, powder
	01.2.1.0.0_01	Coconut toddy, fresh
	01.2.1.0.0_02	Coconut, water only
	01.2.1.0.0_03	Juice, apple, commercial, no added sugar
	01.2.1.0.0_04	Fruit drink, guava, commercial, added sugar
	01.2.1.0.0_05	Fruit drink, lemon, commercial, added sugar

01.2.1.0.0_06	Fruit drink, mango, commercial, added sugar
01.2.1.0.0_07	Juice, orange, commercial
01.2.1.0.0_08	Juice, pineapple, commercial
01.2.1.0.0_09	Juice, tomato, canned, salted
01.2.1.0.0_10	Juice, tropical, commercial
01.2.1.0.0_11	Juice, vegetable, commercial
01.2.1.0.0_99	Juice, fruit, commercial, composite
01.2.2.0.1_01	Coffee, roasted, ground
01.2.2.0.1_02	Coffee, instant, powder (e.g. nescafe), unprepared
01.2.2.0.1_99	Coffee, composite
01.2.2.0.9_01	Coffee, iced, regular fat cows milk
01.2.2.0.9_02	Coffee, mix (e.g. 3in1), unprepared
01.2.3.0.2_01	Tea, black, bag, unprepared
01.2.3.0.3_01	Tea, commerical, ready-to-drink, sweetned, lemon
01.2.3.0.4_01	Tea, chai, instant dry powder, unprepared
01.2.3.0.4_02	Tea, powder, unprepared
01.2.3.0.9_99	Tea, unprepared, composite
01.2.4.0.0_01	Iced chocolate, commercial
01.2.4.0.0_02	Beverage, chocolate flavour, from base (Milo)
01.2.5.0.0_01	Bottled water, still
01.2.5.0.0_02	Mineral water, natural, unflavoured
01.2.6.0.0_01	Cola flavour soft drink, regular
01.2.6.0.0_02	Lemonade, soft drink, regular
01.2.6.0.0_03	Mineral, water, flavored, intense sweetened or diet
01.2.6.0.0_04	Soft drink, diet, intense sweetened
01.2.6.0.0_05	Tonic water
01.2.6.0.0_99	Soft drink, composite
01.2.9.0.0_01	Coconut toddy, boiled
01.2.9.0.0_02	Energy drinks, caffeine added, e.g. red bull, V
01.2.9.0.0_03	Jelly based drinks, e.g. aloevera
01.2.9.0.0_04	Powdered drink/flavouring, dry powder e.g. kool aid/Tang
01.2.9.0.0_05	Sports drinks, dry powder, all flavours
01.2.9.0.0_99	Cordial, concentrated sugar-based syrup, with fruit juice, regular
02.1.1.0.0_02	Gin (29.6% alcohol)
02.1.1.0.0_04	Rum (30.6% alcohol)
02.1.1.0.0_06	Vodka (33.4% alcohol)
02.1.1.0.0_07	Whiskey (20.3% alcohol)
02.1.2.1.0_01	Brandy (29.4% alcohol)
02.1.2.1.0_03	Wine, red (9.5% alcohol)
02.1.2.1.0_04	Wine, sparkling (9.3% alcohol)
02.1.2.1.0_05	Wine, white (10.9% alcohol)
02.1.2.1.0_99	Wine, composite (10.1% alcohol)
02.1.3.0.0_01	Beer, bitter/draught (3.1% alcohol)
02.1.3.0.0_02	Beer, homebrew (2.1% alcohol)
02.1.3.0.0_03	Beer, lager (3.6% alcohol)
02.1.3.0.0_99	Beer, composite (2.4% alcohol)
02.1.9.0.0_01	Tuba (3.8 % alcohol)
11.1.1.1.2_01	Coffee, brewed

11.1.1.1.2_02	Tea, black, brewed, no milk or sugar
11.1.1.1.2_03	Tea, black, brewed, with milk, no added sugar
11.1.1.1.2_05	Tea, green, brewed, no milk or sugar
01.1.5.1.3_01	Oil, olive
01.1.5.1.6_01	Oil, coconut
01.1.5.1.9_01	Oil, vegetable, blend
01.1.5.1.9_02	Oil, vegetable, blend
01.1.5.1.9_99	Oil, composite
01.1.5.3.0_01	Margarine, cooking
01.1.5.3.0_99	Margarine, composite
01.1.4.3.3_01	Creamer, non dairy, powdered
01.1.9.4.0_28	Vanilla extract (34.4% alcohol)
01.1.9.9.0_01	Baking powder
01.1.9.9.0_02	Baking soda
01.1.9.9.0_03	Stock cube
01.1.9.9.0_10	Yeast/baker's yeast, compressed
01.1.9.2.1_01	Infant formula, powder, with iron, not reconstituted
01.1.6.1.1_01	Avocado, flesh, raw
01.1.6.1.2_01	Banana, common varieties, ripe, raw
01.1.6.1.2_02	Banana, raw, composite
01.1.6.1.5_01	Guava, raw
01.1.6.1.5_02	Mango, peeled, composite, raw
01.1.6.1.6_01	Papaya, orange flesh, peeled, raw
01.1.6.1.6_02	Pawpaw, raw
01.1.6.1.7_01	Pineapple, peeled, raw
01.1.6.1.9_01	Breadfruit, pulp, mature, raw
01.1.6.1.9_02	Custard apple, peeled, raw
01.1.6.1.9_05	Jackfruit, peeled, raw
01.1.6.1.9_06	Pandanus, fruit , raw
01.1.6.1.9_07	Passionfruit, raw
01.1.6.1.9_08	Rambutan
01.1.6.1.9_11	Sour sop, raw
01.1.6.1.9_12	Starfruit, raw
01.1.6.1.9_14	Tamarind, pods, fresh, raw
01.1.6.1.9_16	Tava, raw
01.1.6.1.9_17	Wax jambu, raw
01.1.6.1.9_18	Inikori, mangrove fruit (SLB)
01.1.6.2.1_01	Grapefruit, raw
01.1.6.2.1_02	Pomelo, flesh, raw
01.1.6.2.2_01	Lemon, peeled, raw
01.1.6.2.2_02	Lime, peeled, raw
01.1.6.2.3_01	Orange, peeled, raw
01.1.6.2.4_01	Mandarin, peeled, raw
01.1.6.3.1_01	Apple, unpeeled, composite, raw
01.1.6.3.2_01	Pear, packhams, raw
01.1.6.3.5_01	Nectarine, raw
01.1.6.3.5_02	Peach, raw
01.1.6.3.6_01	Plum, red, raw

01.1.6.3.9_01	Chinese apple, "bair", raw
01.1.6.3.9_02	Lychee, peeled, raw
01.1.6.4.5_01	Strawberry, raw
01.1.6.5.1_01	Grapes, raw
01.1.6.5.2_01	Kiwi fruit, flesh and seed, raw
01.1.6.5.3_01	Melon, composite, raw
01.1.6.5.4_01	Watermelon, red pulp, raw
01.1.6.5.9_99	Fruit, composite, raw
01.1.6.7.9_99	Mixed dried fruit, composite
01.1.6.9.2_03	Pear, canned in juice, undrained
01.1.6.9.2_05	Pineapple, canned in juice, no sugar added, undrained
01.1.6.9.2_06	Pineapple, canned in syrup, undrained
01.1.6.9.2_99	Fruit, canned, composite, undrained
01.1.7.9.3_01	Olives, canned in brine, drained
11.1.1.1.1_05	Banana, cooked in small amount of fat
11.1.1.1.1_06	Breadfruit, cooked, composite, no fat or salt added
02.3.1.8.2_01	tobacco/cigarette
02.3.1.8.3_01	Marijuana
02.3.1.8.7_01	Kava
02.3.1.8.9_02	Betel leaves
01.1.1.3.1_12	Crackers/crispbread, plain, composite
01.1.1.3.1_13	Crackers, all others, composite
01.1.1.3.1_99	Crackers, composite
01.1.7.9.9_02	Chips, banana, commercial
01.1.7.9.9_03	Chips, breadfruit, fried in vegetable oil
01.1.7.9.9_05	Chips, potato, plain, salted
01.1.7.9.9_06	Chips, taro, commercial
01.1.7.9.9_10	Savoury snacks, chips, composite
01.1.7.9.9_98	Chips, composite
01.1.9.1.3_29	Chips, banana, deep fried, commercial
01.1.9.1.3_30	Chips, taro, fried
11.1.1.1.1_26	Potato, chips, regular, deep fried, blended oil, salted, independent takeaway outlet
01.1.9.1.9_03	Gravy powder, prepared
01.1.9.3.1_01	Salt, table, iodised
01.1.9.3.1_02	Salt, table, non iodised
01.1.9.3.1_99	Salt, table, composite
01.1.9.3.9_02	Monosodium glutamate seasoning
01.1.9.3.9_03	Chutney or relish, commercial
01.1.9.3.9_04	Dressing, salad, composite
01.1.9.3.9_06	Kimchee, pickled vegetables, Korean
01.1.9.3.9_07	Mayonnaise, commercial, dressing type
01.1.9.3.9_08	Mustard, cream style
01.1.9.3.9_09	Mustard, French style
01.1.9.3.9_10	Chutney or relish, commercial
01.1.9.3.9_11	Salsa, tomato based, commercial
01.1.9.3.9_12	Sauce, BBQ, commercial
01.1.9.3.9_13	Sauce, chilli, bottled

01.1.9.3.9_14	Sauce, soy/shoyu, commercial
01.1.9.3.9_15	Sauce, tomato, for pasta, commercial
01.1.9.3.9_16	Sauce, tomato, ketchup
01.1.9.3.9_17	Sauce, Worcestershire, commercial
01.1.9.3.9_18	Tabasco, sauce
01.1.9.3.9_19	Vinegar
01.1.9.3.9_98	Sauce, composite
01.1.9.3.9_99	Vinegar, composite
01.1.9.4.0_01	Basil, fresh, raw
01.1.9.4.0_02	Bay leaves, dried, crumbled
01.1.9.4.0_04	Chili, dried
01.1.9.4.0_05	Chilli powder
01.1.9.4.0_06	Cinnamon, powder
01.1.9.4.0_07	Cloves
01.1.9.4.0_08	Coriander leaves and stems, fresh, raw
01.1.9.4.0_09	Coriander seeds
01.1.9.4.0_10	Cumin, seeds
01.1.9.4.0_11	Curry powder
01.1.9.4.0_12	Garam masala
01.1.9.4.0_13	Ginger root, fresh, raw
01.1.9.4.0_14	Lemon grass, raw
01.1.9.4.0_15	Mint, fresh, raw
01.1.9.4.0_19	Paprika
01.1.9.4.0_21	Parsley, leaves, fresh, raw
01.1.9.4.0_22	Pepper, ground, black or white
01.1.9.4.0_26	Thyme, dried, ground
01.1.9.4.0_27	Turmeric, powder
01.1.9.4.0_99	Spices, composite
01.1.9.9.0_05	Gravy powder, dried, unprepared
01.1.9.9.0_06	Maggi, seasoning mix
01.1.9.9.0_08	Noodle seasoning, dry powder
01.1.9.9.0_09	Yeast spread, vegemite
01.1.1.3.1_11	Bun, sweetened, with dried fruit
01.1.1.3.1_14	Coconut bread, ring, sprinkled with shredded coconut meat
01.1.1.3.9_01	Biscuits, chocolate
01.1.1.3.9_02	Biscuits, sweet, plain
01.1.1.3.9_03	Biscuits, sweet, all others, composite
01.1.1.3.9_04	Biscuits, cream, wafer
01.1.1.3.9_05	Cake, plain, commercial
01.1.1.3.9_06	Cake, cheesecake, commercial
01.1.1.3.9_07	Cake, chocolate, commercial
01.1.1.3.9_08	Muffin, plain, commercial, uniced
01.1.1.3.9_09	Muffin, chocolate, chocolate chip, commercial, uniced
01.1.1.3.9_10	Croissant, plain
01.1.1.3.9_11	Manihiki bread
01.1.1.3.9_12	Pie, sweet/fruit, all others, composite
01.1.1.3.9_13	Pastry, breakfast, composite
01.1.1.3.9_95	Biscuits, sweet, composite

01.1.1.3.9_96	Cake, composite
01.1.1.3.9_97	Muffin, commercial, composite
01.1.1.3.9_98	Pastry, composite
01.1.1.3.9_99	Doughnut, composite
01.1.1.9.0_01	Cake mix, dry powder, raw, composite
01.1.1.9.0_03	Pancake mix, plain, dry mix, raw
01.1.4.7.0_01	Custard
01.1.4.7.0_03	Pudding (dairy based)
01.1.8.2.0_02	Syrup, sweet pouring, composite
01.1.8.2.0_03	Sugar, brown
01.1.8.2.0_04	Sugar, white
01.1.8.2.0_98	sugar cane
01.1.8.2.0_99	Sugar, composite
01.1.8.3.1_01	Honey
01.1.8.3.9_01	Fruit, prepared, pureed, commercially prepared
01.1.8.3.9_03	Jam, unspecified
01.1.8.3.9_04	Jelly, prepared
01.1.8.3.9_05	Jelly, crystals/powder, unprepared
01.1.8.3.9_06	Marmalade, orange
01.1.8.5.1_02	Chocolate, milk
01.1.8.5.1_03	Chocolate, milk with nuts
01.1.8.5.1_04	Chocolate, white
01.1.8.5.1_99	Chocolate, composite
01.1.8.5.9_01	Chocolate candies, chocolate centre, sugar-coated
01.1.8.5.9_03	Nutella, hazelnut spread, Ferrero
01.1.8.6.0_01	Ice stick, water-based, various flavours
01.1.8.6.0_02	Ice cream, chocolate, standard
01.1.8.6.0_03	Ice cream, with confectionery and waffle cone, chocolate coated, regular fat
01.1.8.6.0_04	Ice cream, fruit based, various flavours, regular fat
01.1.8.6.0_05	Ice cream, vanilla, regular fat
01.1.8.6.0_99	Sorbet, fruit or fruit juice, regular fat
01.1.8.9.9_01	Chewing gum
01.1.8.9.9_03	Sweets, boiled
01.1.8.9.9_04	Sweets, jelly lollies
01.1.9.9.0_04	Custard powder, dry mix, commercial
11.1.1.1.1_14	Milkshake, chocolate or coffee flavour, regular fat cows milk, without ice cream
11.1.1.1.1_15	Milkshake, non-chocolate or coffee flavours, regular fat cows milk, without ice cream
11.1.1.1.1_63	Waffle, plain, frozen, commercial

Appendix 4. Country population estimates, year, and source.

Country	HIES year	Population	Source
COK	2015-16	15,007	Cook Islands: household income and expenditure survey (HIES), report 2015-2016. https://purl.org/spc/digilib/doc/jo4zv
FSM	2013-14	103,382	Federated States of Micronesia 2013-14 HIES report. . Noumea, New Caledonia: Secretariat of the Pacific Community. 108 p. https://purl.org/spc/digilib/doc/dm5j2
KIR	2019-20	118,480	Kiribati 2019–2020 Household Income and Expenditure Survey Report, September 2021. https://purl.org/spc/digilib/doc/kjrto
MHL	2019-20	54,295	Estimated from Pacific Food Consumption Database (PFCD)
NRU	2012-13	10,293	Nauru 2012 2013 HIES Report. . Noumea, New Caledonia: Secretariat of the Pacific Community. 63 p. https://purl.org/spc/digilib/doc/3erjo
NIE	2015-16	1,611	Niue 2015-2016 HIES full Report. . Noumea, New Caledonia: Secretariat of the Pacific Community. 61 p. https://purl.org/spc/digilib/doc/4si9u
PLW	2013-14	17,581	Palau 2014 HIES Report. Noumea, New Caledonia: Secretariat of the Pacific Community. 103 p. https://purl.org/spc/digilib/doc/vsu93
SLB	2012-13	615,804	Solomon Islands 2012-2013 HIES NATIONAL REPORT vol1. Noumea, New Caledonia: Pacific Community. 178 p. https://purl.org/spc/digilib/doc/iux3i
TON	2015-16	99,557	Anon. 2017. Tonga: household income and expenditure, survey 2015-2016. Noumea, New Caledonia: Pacific Community (SPC). 247 p. https://purl.org/spc/digilib/doc/kgyww
TUV	2015-16	11,469	Estimated from Pacific Food Consumption Database) (PFCD)
VUT	2019-20	295,495	Vanuatu HIES 2019-20. Labour Market Monograph. https://www.ilo.org/surveyLib/index.php/catalog/7347/download/45288
WSM	2018	199,331	Estimated from Pacific Food Consumption Database (PFCD)

Appendix 5. FAOSTAT food items, by food group, used in estimating domestic production for Fiji and Papua New Guinea.

Note that the list is not exhaustive as it includes only items with quantities for either Fiji or Papua New Guinea. Raw animal hides were excluded post data acquisition. Note, FAOSTAT production data does not include aquatic foods.

Food group	Foods within food groups
Beef	Edible offal of cattle, fresh, chilled or frozen
	Meat of cattle with the bone, fresh or chilled
Chicken	Meat of chickens, fresh or chilled
Pork	Edible offal of pigs, fresh, chilled or frozen
	Meat of pig with the bone, fresh or chilled
Other animal sourced foods	Butter of cow milk
	Buttermilk, dry
	Cattle fat, unrendered
	Edible offal of goat, fresh, chilled or frozen
	Edible offal of sheep, fresh, chilled or frozen
	Edible offals of horses and other equines, fresh, chilled or frozen
	Eggs from other birds in shell, fresh, n.e.c.
	Fat of pigs
	Game meat, fresh, chilled or frozen
	Goat fat, unrendered
	Hen eggs in shell, fresh
	Horse meat, fresh or chilled
	Meat of ducks, fresh or chilled
	Meat of goat, fresh or chilled
	Meat of sheep, fresh or chilled
	Meat of turkeys, fresh or chilled
	Pig fat, rendered
	Sheep fat, unrendered
	Skim milk of cows
	Tallow
Cereals and their products	Maize (corn)
	Rice
	Sorghum
Vegetables, roots and tubers	Broad beans and horse beans, green
	Cabbages
	Cassava, fresh
	Cauliflowers and broccoli
	Chillies and peppers, green (Capsicum spp. and Pimenta spp.)
	Cucumbers and gherkins
	Edible roots and tubers with high starch or inulin content, n.e.c., fresh
	Eggplants (aubergines)
	Green corn (maize)
	Lettuce and chicory
	Okra
	Onions and shallots, dry (excluding dehydrated)
	Other beans, green
	Other vegetables, fresh n.e.c.
	Plantains and cooking bananas

	Potatoes Pumpkins, squash and gourds Sweet potatoes Taro Tomatoes Yams
Pulses, seeds and nuts	Coconuts, in shell Groundnuts, excluding shelled Other nuts (excluding wild edible nuts and groundnuts), in shell, n.e.c. Other pulses n.e.c.
All other food	Coconut oil Groundnut oil Oil palm fruit Other oil seeds, n.e.c. Palm kernels Palm oil Avocados Bananas Beer of barley, malted Cantaloupes and other melons Chillies and peppers, dry (Capsicum spp., Pimenta spp.), raw Cocoa beans Coffee, green Ginger, raw Lemons and limes Mangoes, guavas and mangosteens Molasses Natural honey Nutmeg, mace, cardamoms, raw Oil of palm kernel Oranges Other berries and fruits of the genus vaccinium n.e.c. Other citrus fruit, n.e.c. Other fruits, n.e.c. Other stimulant, spice and aromatic crops, n.e.c. Other tropical fruits, n.e.c. Papayas Pepper (Piper spp.), raw Pineapples Pomelos and grapefruits Raw cane or beet sugar (centrifugal only) Raw milk of cattle Raw milk of goats Sugar cane Tangerines, mandarins, clementines Tea leaves Vanilla, raw Watermelons

Appendix 6. Pacific Food Trade Database (PFTD) foods included in study 2 analysis for Fiji, PNG, and calculating proportion imports.

Food Group	Commodity Subheading	HS92 Definition
Tuna & Pelagic fish	030231	Fish: albacore or longfinned tunas (thunnus alalunga), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030232	Fish: yellowfin tunas (thunnus albacares), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030233	Fish: skipjack or stripe-bellied bonito, fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030239	Fish: tuna, fresh or chilled, n.e.s. in item no. 0302.3 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030264	Fish: mackerel (scomber scombrus, scomber australasicus, scomber japonicus), fresh of chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030341	Fish: albacore or longfinned tunas (thunnus alalunga), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030342	Fish: yellowfin tunas (thunnus albacares), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030343	Fish: skipjack or stripe-bellied bonito, frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030349	Fish: tuna, frozen, n.e.s. in item no. 0303.4 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
Composite fish	030191	Fish: live, trout (salmo trutta, salmo gairdneri, salmo clarki, salmo aguabonita, salmo gilae)
	030192	Fish: live, eels (anguilla spp.)
	030193	Fish: live, carp
	030199	Fish: live, n.e.s. in heading no. 0301
	030211	Fish: trout (salmo trutta, salmo gairdneri, salmo clarki, salmo aguabonita, salmo gilae), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030212	Fish: Pacific salmon (oncorhynchus spp.), Atlantic salmon (salmo salar), Danube salmon (hucho hucho), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030219	Fish: salmonidae, fresh or chilled, n.e.s. in item no. 0302.1 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030221	Fish: halibut (reinhardtius hippoglossoides, hippoglossus hippoglossus, hippoglossus stenolepis), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030222	Fish: plaice (pleuronectes platessa), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030223	Fish: sole (solea spp.), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030229	Fish: flat fish, fresh or chilled, n.e.s. in item no. 0302.2 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030240	Fish: herrings (clupea harengus, clupea pallasii), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030250	Fish: cod (gadus morhua, gadus ogac, gadus macrocephalus), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030261	Fish: sardines (sardina pilchardus, sardinops spp.), sardinella (sardinella spp.), brisling or sprats (sprattus sprattus), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030262	Fish: haddock (melanogrammus aeglefinus), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
	030263	Fish: coalfish (pollachius virens), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)

030265	Fish: dogfish and other sharks, fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030266	Fish: eels (anguilla spp.), fresh or chilled (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030269	Fish: fresh or chilled, n.e.s. in heading no. 0302 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030270	Fish: livers and roes, fresh or chilled
030310	Fish: Pacific salmon, (oncorhynchus spp.), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030321	Fish: trout (salmo trutta, salmo gairdneri, salmo clarki, salmo aguabonita, salmo gilae), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030322	Fish: Atlantic salmon (salmo salar) and Danube salmon (hucho hucho), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030329	Fish: salmonidae, frozen, n.e.s. in item no. 0302.1 and 0302.2 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030331	Fish: halibut (reinhardtius hippoglossoides, hippoglossus hippoglossus, hippoglossus stenolepis), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030332	Fish: plaice (pleuronectes platessa), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030333	Fish: sole (solea spp.), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030339	Fish: flat fish, frozen, n.e.s. in item no. 0303.3 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030350	Fish: herrings (clupea harengus, clupea pallasii), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030360	Fish: cod (gadus morhua, gadus ogac, gadus macrocephalus), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030375	Fish: dogfish and other sharks, frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030376	Fish: eels (anguilla spp.), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030377	Fish: sea bass (dicentrarchus labrax, dicentrarchus punctatus), frozen, (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030378	Fish: hake (merluccius spp., urophycis spp.), frozen (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030379	Fish: frozen, n.e.s. in heading no. 0303 (excluding fillets, livers, roes and other fish meat of heading no. 0304)
030380	Fish: livers and roes, frozen
030410	Fish: fillets and other fish meat, fresh or chilled (whether or not minced)
030420	Fish: fillets, frozen
030490	Fish: fish meat n.e.s. in heading no. 0304 (whether or not minced), fresh, chilled or frozen
030510	Fish meal: fit for human consumption
030520	Fish: livers and roes, dried, smoked (whether or not cooked before or during the smoking process), salted or in brine
030530	Fish: fillets, dried, salted or in brine, but not smoked
030541	Fish: Pacific salmon (oncorhynchus spp.), Atlantic salmon (salmo salar) and Danube salmon (hucho hucho), including fillets, smoked (whether or not cooked before or during the smoking process)
030542	Fish: herrings (clupea harengus, clupea pallasii), including fillets: smoked (whether or not cooked before or during the smoking process)
030549	Fish: smoked (whether or not cooked before or during the smoking process), n.e.s. in item no. 0305.4 (including fillets)
030551	Fish: cod (gadus morhua, gadus ogac, gadus macrocephalus), dried (whether or not salted but not smoked)
030559	Fish: dried (whether or not salted but not smoked), n.e.s. in item no. 0305.51
030561	Fish: herrings (clupea harengas, clupea pallasii), salted or in brine but not dried or smoked

	030562	Fish: cod (gadus morhua, gadus ogac, gadus macrocephalus), salted or in brine but not dried or smoked
	030563	Fish: anchovies (engraulis spp.), salted or in brine but not dried or smoked
	030569	Fish: salted or in brine, but not dried or smoked, n.e.s. in item no. 0305.6
	160300	Extracts and juices: of meat, fish or crustaceans, molluscs or other aquatic invertebrates
Canned fish	160411	Fish preparations: salmon, prepared or preserved, whole or in pieces (but not minced)
	160412	Fish preparations: herrings, prepared or preserved, whole or in pieces (but not minced)
	160413	Fish preparations: sardines, sardinella and brisling or sprats, prepared or preserved, whole or in pieces (but not minced)
	160414	Fish preparations: tunas, skipjack and Atlantic bonito (sarda spp.), prepared or preserved, whole or in pieces (but not minced)
	160415	Fish preparations: mackerel, prepared or preserved, whole or in pieces (but not minced)
	160416	Fish preparations: anchovies, prepared or preserved, whole or in pieces (but not minced)
	160419	Fish preparations: fish prepared or preserved, whole or in pieces (but not minced), n.e.s. in heading no. 1604
	160420	Fish preparations: fish minced or in forms n.e.s. in heading no. 1604, prepared or preserved
	160430	Fish preparations: caviar and caviar substitutes
	160510	Crustacean preparations: crab, prepared or preserved
	160520	Crustacean preparations: shrimps and prawns, prepared or preserved
	160530	Crustacean preparations: lobster, prepared or preserved
	160540	Crustacean preparations: prepared or preserved crustaceans (excluding crab, shrimps, prawns and lobster)
	160590	Molluscs and other aquatic invertebrates: prepared or preserved (excluding crustaceans)
Invertebrates	030611	Crustaceans: rock lobsters and other sea crawfish (palinurus spp., panulirus spp., jasus spp.), frozen (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030612	Crustaceans: lobsters (homarus spp.), frozen (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030613	Crustaceans: shrimps and prawns, frozen (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030614	Crustaceans: crabs, frozen (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030619	Crustaceans: frozen, n.e.s. in item no. 0306.1 (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030621	Crustaceans: rock lobster and other sea crawfish (palinurus spp., panulirus spp., jasus spp.), not frozen, (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030622	Crustaceans: lobsters (homarus spp.), not frozen, (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030623	Crustaceans: shrimps and prawns, not frozen, (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030624	Crustaceans: crabs, not frozen, (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030629	Crustaceans: not frozen, n.e.s. in heading no. 0306, (whether in shell or not, whether or not cooked by steaming or by boiling in water)
	030710	Molluscs: oysters, live, fresh, chilled, frozen, dried, salted or in brine (whether in shell or not)
	030721	Molluscs: scallops (including queen scallops of the genera pecten, chlamys or placopecten), live, fresh or chilled (whether in shell or not)
	030729	Molluscs: scallops (including queen scallops of the genera pecten, chlamys or placopecten), frozen, dried, salted or in brine (whether in shell or not)
	030731	Molluscs: mussels (mytilus spp., perna spp.), live, fresh or chilled (whether in shell or not)
	030739	Molluscs: mussels (mytilus spp., perna spp.), frozen, dried, salted or in brine (whether in shell or not)
	030741	Molluscs: cuttle fish and squid, live, fresh or chilled (whether in shell or not)
	030751	Molluscs: octopus (octopus spp.), live, fresh or chilled

	030759	Molluscs: octopus (octopus spp.), frozen, dried, salted or in brine
	030760	Molluscs: snails (other than sea snails), live, fresh, chilled, frozen, dried, salted or in brine (whether in shell or not)
	030791	Molluscs and other aquatic invertebrates: live, fresh or chilled (whether in shell or not), n.e.s. in heading no. 0307
	030799	Molluscs and other aquatic invertebrates: frozen, dried, salted or in brine (whether in shell or not), n.e.s. in heading no. 0307
Beef	020110	Meat: of bovine animals, carcasses and half-carcasses, fresh or chilled
	020120	Meat: of bovine animals, cuts with bone in (excluding carcasses and half-carcasses), fresh or chilled
	020130	Meat: of bovine animals, boneless cuts, fresh or chilled
	020210	Meat: of bovine animals, carcasses and half-carcasses, frozen
	020220	Meat: of bovine animals, cuts with bone in (excluding carcasses and half-carcasses), frozen
	020230	Meat: of bovine animals, boneless cuts, frozen
	020610	Offal, edible: of bovine animals, fresh or chilled
	020621	Offal, edible: of bovine animals, tongues, frozen
	020622	Offal, edible: of bovine animals, livers, frozen
	020629	Offal, edible: of bovine animals, (other than tongues and livers), frozen
	021020	Meat, preserved: of bovine animals, salted, in brine, dried or smoked
Chicken	020721	Meat and edible offal: fowls of the species gallus domesticus, not cut in pieces, frozen
	020741	Meat and edible offal: of fowls of the species gallus domesticus, poultry cuts and offal (excluding livers), frozen
Pork	020311	Meat: of swine, carcasses and half-carcasses, fresh or chilled
	020312	Meat: of swine, hams, shoulders and cuts thereof, with bone in, fresh or chilled
	020319	Meat: of swine, n.e.s. in item no. 0203.1, fresh or chilled
	020321	Meat: of swine, carcasses and half-carcasses, frozen
	020322	Meat: of swine, hams, shoulders and cuts thereof, with bone in, frozen
	020329	Meat: of swine, n.e.s. in item no. 0203.2, frozen
	020630	Offal, edible: of swine, fresh or chilled
	020641	Offal, edible: of swine, livers, frozen
	020649	Offal, edible: of swine, (other than livers), frozen
	021011	Meat, preserved: of swine, hams, shoulders and cuts thereof, with bone in, salted, in brine, dried or smoked
	021012	Meat, preserved: of swine, bellies (streaky) and cuts thereof, salted, in brine, dried or smoked
	021019	Meat, preserved: of swine, salted, in brine, dried or smoked, n.e.s. in item no. 0210.1
Processed & canned meat	160100	Meat preparations: sausages and similar products, of meat, meat offal or blood, and food preparations based on these products
	160210	Meat preparations: homogenised preparations of meat, meat offal or blood
	160220	Meat preparations: of the prepared or preserved liver of any animal (excluding homogenised preparations)
	160231	Meat preparations: of turkeys, prepared or preserved meat or meat offal (excluding livers and homogenised preparations)
	160239	Meat preparations: of poultry (excluding turkeys), prepared or preserved meat or meat offal (excluding livers and homogenised preparations)
	160241	Meat preparations: of swine, hams and cuts thereof, prepared or preserved (excluding homogenised preparations)
	160242	Meat preparations: of swine, shoulders and cuts thereof, prepared or preserved (excluding homogenised preparations)
	160249	Meat preparations: of swine, meat or meat offal (including mixtures), prepared or preserved, n.e.s. in heading no. 1602
	160250	Meat preparations: of bovine animals, meat or meat offal, prepared or preserved (excluding livers and homogenised preparations)

	160290	Meat preparations: of meat, meat offal or the blood of any animal, n.e.s. in heading no. 1602
Other animal sourced foods	020410	Meat: of sheep, lamb carcasses and half-carcasses, fresh or chilled
	020421	Meat: of sheep, carcasses and half-carcasses (excluding carcasses and half-carcasses of lamb), fresh or chilled
	020422	Meat: of sheep (including lamb), cuts with bone in (excluding carcasses and half-carcasses), fresh or chilled
	020423	Meat: of sheep (including lamb), boneless cuts, fresh or chilled
	020430	Meat: of sheep, lamb carcasses and half-carcasses, frozen
	020441	Meat: of sheep, carcasses and half-carcasses (excluding carcasses and half-carcasses of lamb), frozen
	020442	Meat: of sheep (including lamb), cuts with bone in (excluding carcasses and half-carcasses), frozen
	020443	Meat: of sheep (including lamb), boneless cuts, frozen
	020450	Meat: of goats, fresh, chilled or frozen
	020500	Meat: of horses, asses, mules or hinnies, fresh, chilled or frozen
	020680	Offal, edible: of sheep, goats, horses, asses, mules or hinnies, fresh or chilled
	020690	Offal, edible: of sheep, goats, horses, asses, mules or hinnies, frozen
	020710	Meat and edible offal: poultry, not cut in pieces, fresh or chilled
	020722	Meat and edible offal: turkeys, not cut in pieces, frozen
	020723	Meat and edible offal: ducks, geese and guinea fowls, not cut in pieces, frozen
	020731	Offal, edible: of geese or ducks, fatty livers, fresh or chilled
	020739	Meat and edible offal: poultry cuts and offal (including livers but excluding the fatty livers of geese or ducks), fresh or chilled
	020742	Meat and edible offal: of turkeys, poultry cuts and offal (excluding livers), frozen
	020743	Meat and edible offal: of ducks, geese or guinea fowls, poultry cuts and offal (excluding livers) frozen
	020750	Offal, edible: of poultry, livers, frozen
	020810	Meat and edible meat offal: of rabbits or hares, fresh, chilled or frozen
	020820	Meat and edible meat offal: frogs' legs, fresh, chilled or frozen
	020890	Meat and edible meat offal: n.e.s. in chapter 2, fresh, chilled or frozen
	020900	Fat: pig fat, free of lean meat, and poultry fat, (not rendered), fresh, chilled, frozen, salted, in brine, dried or smoked
	021090	Meat and edible meat offal, preserved: salted, in brine, dried or smoked, and edible flours and meals of meat or meat offal, n.e.s. in heading no. 0210
	040110	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content not exceeding 1% (by weight)
	040120	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content exceeding 1% but not exceeding 6% (by weight)
	040130	Dairy produce: milk and cream, not concentrated, not containing added sugar or other sweetening matter, of a fat content exceeding 6% (by weight)
	040210	Dairy produce: milk and cream, concentrated or containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content not exceeding 1.5% (by weight)
	040221	Dairy produce: milk and cream, concentrated, not containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content exceeding 1.5% (by weight)
	040229	Dairy produce: milk and cream, containing added sugar or other sweetening matter, in powder, granules or other solid forms, of a fat content exceeding 1.5% (by weight)
	040291	Dairy produce: milk and cream, concentrated, not containing added sugar or other sweetening matter, other than in powder, granules or other solid forms
	040299	Dairy produce: milk and cream, containing added sugar or other sweetening matter, other than in powder, granules or other solid forms
	040310	Dairy produce: yoghurt, whether or not concentrated or containing added sugar or other sweetening matter or flavoured or containing added fruit or cocoa

	040390	Dairy produce: buttermilk, curdled milk or cream, kephir, fermented or acidified milk or cream, whether or not concentrated or containing added sweetening, flavouring, fruit or cocoa (excluding yoghurt)
	040410	Dairy produce: whey, whether or not concentrated or containing added sugar or other sweetening matter
	040490	Dairy produce: natural milk constituents (excluding whey), whether or not containing added sugar or other sweetening matter, n.e.s. in chapter 04
	040500	Dairy produce: butter and other fats and oils derived from milk
	040610	Dairy produce: fresh cheese (including whey cheese), not fermented, and curd
	040620	Dairy produce: cheese of all kinds, grated or powdered
	040630	Dairy produce: cheese, processed (not grated or powdered)
	040640	Dairy produce: cheese, blue-veined (not grated, powdered or processed)
	040690	Dairy produce: cheese (not grated, powdered or processed), n.e.s. in heading no. 0406
	040700	Eggs: birds' eggs, in the shell, fresh, preserved or cooked
	040811	Eggs: birds' eggs, yolks, dried, whether or not containing added sugar or other sweetening matter
	040819	Eggs: birds' eggs, yolks, fresh, cooked by steaming or by boiling in water, moulded, frozen or otherwise preserved, whether or not containing added sugar or other sweetening matter
	040891	Eggs: birds' eggs (not in shell, excluding yolks only), dried, whether or not containing added sugar or other sweetening matter
	040899	Eggs: birds' eggs (not in shell, excluding yolks only), fresh, cooked by steaming or boiling in water, moulded, frozen, otherwise preserved, whether or not containing added sugar or other sweetening matter
	041000	Animal products: edible, n.e.s. in this or other chapters
	150100	Lard: other pig fat and poultry fat, rendered, whether or not pressed or solvent-extracted
	150200	Fats of bovine animals, sheep or goats: raw or rendered, whether or not pressed or solvent-extracted
	150300	Lard stearin, lard oil, oleostearin, oleo-oil and tallow oil: not emulsified or mixed or otherwise prepared
	150430	Fats and oils and their fractions: of marine mammals
	150600	Animal fats and oils and their fractions: whether or not refined, but not chemically modified, n.e.s. in chapter 15
Vegetables, root and tubers	070190	Vegetables: potatoes (other than seed), fresh or chilled
	070200	Vegetables: tomatoes, fresh or chilled
	070310	Vegetables, alliaceous: onions and shallots, fresh or chilled
	070320	Vegetables, alliaceous: garlic, fresh or chilled
	070390	Vegetables, alliaceous: leeks and other kinds n.e.s. in heading no. 0703, fresh or chilled
	070410	Vegetables, brassica: cauliflowers and headed broccoli, fresh or chilled
	070420	Vegetables, brassica: brussel sprouts, fresh or chilled
	070490	Vegetables, brassica: edible, n.e.s. in heading no. 0704, fresh or chilled
	070511	Vegetables: cabbage (head) lettuce (lactuca sativa), fresh or chilled
	070519	Vegetables: lettuce (lactuca sativa), (other than cabbage lettuce), fresh or chilled
	070521	Vegetables: witloff chicory (cichorium intybus var. foliosum), fresh or chilled
	070529	Vegetables: chicory (cichorium spp.), (other than witloof chicory), fresh or chilled
	070610	Vegetables, root: carrots and turnips, fresh or chilled
	070690	Vegetables, root: salad beetroot, salsify, celeric, radishes and similar edible roots, fresh or chilled
	070700	Vegetables: cucumbers and gherkins, fresh or chilled
	070810	Vegetables, leguminous: peas (pisum sativum), shelled or unshelled, fresh or chilled
	070820	Vegetables, leguminous: beans (vigna spp., phaseolus spp.), shelled or unshelled, fresh or chilled
	070890	Vegetables, leguminous: (other than peas and beans), shelled or unshelled, fresh or chilled
	070910	Vegetables: globe artichokes, fresh or chilled

070920	Vegetables: asparagus, fresh or chilled
070930	Vegetables: aubergines, (egg plants), fresh or chilled
070940	Vegetables: celery (other than celeriac), fresh or chilled
070951	Vegetables: mushrooms, fresh or chilled
070952	Vegetables: truffles, fresh or chilled
070960	Vegetables: fruits of the genus capsicum or of the genus pimenta
070970	Vegetables: spinach, New Zealand spinach and orache spinach (garden spinach), fresh or chilled
070990	Vegetables: edible, n.e.s. in chapter 7, fresh or chilled
071010	Vegetables: potatoes, uncooked or cooked by steaming or boiling in water, frozen
071021	Vegetables, leguminous: peas (pisum sativum), shelled or unshelled, uncooked or cooked by steaming or boiling in water, frozen
071022	Vegetables, leguminous: beans (vigna spp., phaseolus spp.), shelled or unshelled, uncooked or cooked by steaming or boiling in water, frozen
071029	Vegetables, leguminous: (other than peas or beans), shelled or unshelled, uncooked or cooked by steaming or boiling in water, frozen
071030	Vegetables: spinach, New Zealand spinach and orache spinach (garden spinach), uncooked or cooked by steaming or boiling in water, frozen
071040	Vegetables: sweetcorn, uncooked or cooked by steaming or boiling in water, frozen
071080	Vegetables: uncooked or cooked by steaming or boiling in water, frozen, n.e.s. in chapter 7
071090	Vegetable mixtures: uncooked or cooked by steaming or boiling in water, frozen
071110	Vegetables: onions, provisionally preserved by sulphur dioxide gas, but unsuitable in that state for immediate consumption
071120	Vegetables: olives, provisionally preserved but unsuitable in that state for immediate consumption
071130	Vegetables: capers, provisionally preserved but unsuitable in that state for immediate consumption
071140	Vegetables: cucumbers and gherkins, provisionally preserved but unsuitable in that state for immediate consumption
071190	Vegetables and mixed vegetables: n.e.s. in heading no. 0711, provisionally preserved but unsuitable in that state for immediate consumption
071210	Vegetables: potatoes, whether or not cut or sliced but not further prepared, dried
071220	Vegetables: onions, whole, cut, sliced, broken or in powder but not further prepared, dried
071230	Vegetables: mushrooms and truffles, whole, cut, sliced, broken or in powder but not further prepared, dried
071290	Vegetables: mixtures of vegetables n.e.s. in heading no. 0712, whole, cut, sliced, broken or in powder but not further prepared, dried
071310	Vegetables, leguminous: peas (pisum sativum), shelled, whether or not skinned or split, dried
071320	Vegetables, leguminous: chickpeas (garbanzos), shelled, whether or not skinned or split, dried
071331	Vegetables, leguminous: beans of the species vigna mungo (l.) hepper or vigna radiata (l.) wilczek, dried, shelled, whether or not skinned or split
071332	Vegetables, leguminous: small red (adzuki) beans (phaseolus or vigna angularis), shelled, dried, whether or not skinned or split
071333	Vegetables, leguminous: kidney beans, including white pea beans (phaseolus vulgaris), dried, shelled, whether or not skinned or split
071339	Vegetables, leguminous: n.e.s. in item no. 0713.30, dried, shelled, whether or not skinned or split
071340	Vegetables, leguminous: lentils, shelled, whether or not skinned or split, dried
071350	Vegetables, leguminous: broad beans (vicia faba var. major) and horse beans (vicia faba var. equina and vicia faba var. minor), dried, shelled, whether or not skinned or split
071390	Vegetables, leguminous: n.e.s. in heading no. 0713, shelled, whether or not skinned or split, dried
071410	Vegetable roots and tubers: manioc (cassava), with high starch or inulin content, whether or not sliced or in the form of pellets, fresh or dried

	071420	Vegetable roots and tubers: sweet potatoes, with high starch or inulin content, whether or not sliced or in the form of pellets, fresh or dried
	071490	Vegetable roots and tubers: arrowroot, salep, Jerusalem artichokes and similar roots and tubers, high starch or inulin content, whether or not sliced or in the form of pellets, fresh or dried: sago pith
	200110	Vegetable preparations: cucumbers and gherkins, prepared or preserved by vinegar or acetic acid
	200120	Vegetable preparations: onions, prepared or preserved by vinegar or acetic acid
	200190	Vegetable preparations: vegetables, fruit, nuts and other edible parts of plants, prepared or preserved by vinegar or acetic acid (excluding cucumbers, gherkins and onions)
	200210	Vegetable preparations: tomatoes, whole or in pieces, prepared or preserved otherwise than by vinegar or acetic acid
	200290	Vegetable preparations: tomatoes, (other than whole or in pieces), prepared or preserved otherwise than by vinegar or acetic acid
	200310	Vegetable preparations: mushrooms, prepared or preserved otherwise than by vinegar or acetic acid
	200320	Vegetable preparations: truffles, prepared or preserved otherwise than by vinegar or acetic acid
	200410	Vegetable preparations: potatoes, prepared or preserved otherwise than by vinegar or acetic acid, frozen
	200490	Vegetable preparations: vegetables and mixtures of vegetables (excluding potatoes), prepared or preserved otherwise than by vinegar or acetic acid, frozen
	200510	Vegetable preparations: homogenised vegetables, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200520	Vegetable preparations: potatoes, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200530	Vegetable preparations: sauerkraut
	200540	Vegetable preparations: peas (pisum sativum), prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200551	Vegetable preparations: beans, shelled, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200559	Vegetable preparations: beans, (not shelled), prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200560	Vegetable preparations: asparagus, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200570	Vegetable preparations: olives, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200580	Vegetable preparations: sweetcorn (zea mays var. saccharata), prepared or preserved otherwise than by vinegar or acetic acid, not frozen
	200590	Vegetable preparations: vegetables and mixtures of vegetables n.e.s. in heading no. 2005, prepared or preserved otherwise than by vinegar or acetic acid, not frozen
Cereals & their products	100110	Cereals: durum wheat
	100190	Cereals: meslin and wheat other than durum
	100200	Cereals: rye
	100300	Cereals: barley
	100400	Cereals: oats
	100590	Cereals: maize (corn), other than seed
	100610	Cereals: rice in the husk (paddy or rough)
	100620	Cereals: husked (brown) rice
	100630	Cereals: rice, semi-milled or wholly milled, whether or not polished or glazed
	100640	Cereals: rice, broken
	100820	Cereals: millet
	100890	Cereals: n.e.s. in chapter 10
	110100	Wheat or meslin flour

110210	Cereal flour: of rye
110220	Cereal flour: of maize (corn)
110230	Cereal flour: of rice
110290	Cereal flours: n.e.s. in heading no. 1102
110311	Cereal groats and meal: of wheat
110312	Cereal groats and meal: of oats
110313	Cereal groats and meal: of maize (corn)
110314	Cereal groats and meal: of rice
110319	Cereal groats and meal: n.e.s. in heading no. 1103
110321	Cereal pellets: of wheat
110329	Cereal pellets: of cereals other than wheat
110411	Cereal grains: rolled or flaked, of barley
110412	Cereal grains: rolled or flaked, of oats
110419	Cereal grains: rolled or flaked, of cereals excluding barley and oats
110421	Cereal grains: worked (eg hulled, pearled, sliced or kibbled) of barley
110422	Cereal grains: worked (eg hulled, pearled, sliced or kibbled) of oats
110423	Cereal grains: worked (eg hulled, pearled, sliced or kibbled) of maize (corn)
110429	Cereal grains: worked (eg hulled, pearled, sliced or kibbled) of cereals n.e.s. in item no. 1104.2, except rice of heading no. 1006
110430	Cereal: germ of cereals, whole, rolled, flaked or ground
110510	Flour and meal: of potatoes
110520	Flakes: of potatoes
110610	Flour and meal: of the dried leguminous vegetables of heading no. 0713
110620	Flour and meal: of sago, roots or tubers of heading no. 0714
110630	Flour, meal and powder: of the products of chapter 8
110710	Malt: not roasted
110720	Malt: roasted
110811	Starch: wheat
110812	Starch: maize (corn) starch
110813	Starch: potato
110814	Starch: manioc (cassava)
110819	Starch: n.e.s. in item no. 1108.11 to 1108.14
110820	Inulin
110900	Wheat gluten: whether or not dried
190110	Food preparations: of flour, meal, starch, malt extract or milk products, for infant use, put up for retail sale
190120	Food preparations: mixes and doughs for the preparation of bread, pastry, cakes, biscuits and other bakers' wares
190190	Food preparations: of flour, meal, starch, malt extract or milk products, for uses n.e.s. in heading no. 1901
190211	Food preparations: pasta, containing eggs, uncooked, not stuffed or otherwise prepared
190219	Food preparations: pasta, uncooked (excluding that containing eggs), not stuffed or otherwise prepared
190220	Food preparations: pasta, stuffed (with meat or other substances), whether or not cooked or otherwise prepared
190230	Food preparations: pasta (excluding stuffed), cooked or otherwise prepared
190240	Food preparations: couscous
190300	Food preparations: tapioca and substitutes thereof, prepared from starch in the form of flakes, grains, pearls, siftings or similar
190410	Food preparations: obtained by the swelling or roasting of cereals or cereal products

	190490	Food preparations: cereal or cereal products (excluding maize), in grain form, pre-cooked or otherwise prepared
	190510	Food preparations: crispbread, whether or not containing cocoa
	190520	Food preparations: gingerbread and the like, whether or not containing cocoa
	190530	Food preparations: sweet biscuits, waffles and wafers, whether or not containing cocoa
	190540	Food preparations: rusks, toasted bread and similar toasted products, whether or not containing cocoa
	190590	Food preparations: bakers' wares n.e.s. in heading no. 1605, whether or not containing cocoa: communion wafers, empty cachets suitable for pharmaceutical use, sealing wafers, rice papers and similar products
Pulses, seeds and nuts and their products	080110	Nuts, edible: coconuts, fresh or dried, whether or not shelled or peeled
	080120	Nuts, edible: Brazil nuts, fresh or dried, whether or not shelled or peeled
	080130	Nuts, edible: cashew nuts, fresh or dried, whether or not shelled or peeled
	080211	Nuts, edible: almonds, fresh or dried, in shell
	080212	Nuts, edible: almonds, fresh or dried, shelled
	080221	Nuts, edible: hazelnuts or filberts (corylus spp.), fresh or dried, in shell
	080222	Nuts, edible: hazelnuts or filberts (corylus spp.), fresh or dried, shelled
	080231	Nuts, edible: walnuts, fresh or dried, in shell
	080232	Nuts, edible: walnuts, fresh or dried, shelled
	080240	Nuts, edible: chestnuts (castanea spp.), fresh or dried, whether or not shelled or peeled
	080250	Nuts, edible: pistachios, fresh or dried, whether or not shelled or peeled
	080290	Nuts, edible: n.e.s. in heading no. 0801 and 0802, fresh or dried, whether or not shelled or peeled
	120100	Soya beans: whether or not broken
	120210	Ground-nuts: in shell, not roasted or otherwise cooked
	120220	Ground-nuts: shelled, not roasted or otherwise cooked, whether or not broken
	120400	Oil seeds: linseed, whether or not broken
	120500	Oil seeds: rape or colza seeds, whether or not broken
	120600	Oil seeds: sunflower seeds, whether or not broken
	120740	Oil seeds: sesamum seeds, whether or not broken
	120750	Oil seeds: mustard seeds, whether or not broken
	120760	Oil seeds: safflower seeds, whether or not broken
	120791	Oil seeds: poppy seeds, whether or not broken
	120799	Oil seeds and oleaginous fruits: n.e.s. in heading no. 1207, whether or not broken
	120810	Flours and meals: of soya beans
	120890	Flours and meals of oil seeds or oleaginous fruits: excluding soya beans and mustard seeds
	121210	Locust beans, including locust bean seeds: of a kind used primarily for human consumption, fresh or dried, whether or not ground
All other foods	040900	Honey: natural
	080300	Fruit, edible: bananas, (including plantains), fresh or dried
	080410	Fruit, edible: dates, fresh or dried
	080420	Fruit, edible: figs, fresh or dried
	080430	Fruit, edible: pineapples, fresh or dried
	080440	Fruit, edible: avocados, fresh or dried
	080450	Fruit, edible: guavas, mangoes and mangosteens, fresh or dried
	080510	Fruit, edible: oranges, fresh or dried
	080520	Fruit, edible: mandarins (including tangerines and satsumas), clementines, wilkings and similar citrus hybrids, fresh or dried
	080530	Fruit, edible: lemons (citrus limon, citrus limonum), limes (citrus aurantifolia)
	080540	Fruit, edible: grapefruit, fresh or dried

080590	Fruit, edible: citrus fruit n.e.s. in heading no. 0805, fresh or dried
080610	Fruit, edible: grapes, fresh
080620	Fruit, edible: grapes, dried
080710	Fruit, edible: melons (including watermelons), fresh
080720	Fruit, edible: papaws (papayas), fresh
080810	Fruit, edible: apples, fresh
080820	Fruit, edible: pears and quinces, fresh
080910	Fruit, edible: apricots, fresh
080920	Fruit, edible: cherries, fresh
080930	Fruit, edible: peaches including nectarines, fresh
080940	Fruit, edible: plums and sloes, fresh
081010	Fruit, edible: strawberries, fresh
081020	Fruit, edible: raspberries, blackberries, mulberries and loganberries, fresh
081030	Fruit, edible: black, white or red currants and gooseberries, fresh
081040	Fruit, edible: cranberries, bilberries and other fruits of the genus vaccinium, fresh
081090	Fruit, edible: fruits n.e.s. in heading no. 0801 to 0810, fresh
081110	Fruit, edible: strawberries, uncooked or cooked by steaming or boiling in water, frozen, whether or not containing added sugar or other sweetening matter
081120	Fruit, edible: raspberries, blackberries, mulberries, loganberries, black, white or red currants and gooseberries, uncooked or cooked, whether or not containing added sugar or other sweetening matter
081190	Fruit, edible: fruit and nuts n.e.s. in heading no. 0811, uncooked or cooked, frozen whether or not containing added sugar or other sweetening matter
081210	Fruit, edible: cherries, provisionally preserved, but unsuitable in that state for immediate consumption
081220	Fruit, edible: strawberries, provisionally preserved, but unsuitable in that state for immediate consumption
081290	Fruit, edible: fruit and nuts n.e.s. in heading no. 0812, provisionally preserved, but unsuitable in that state for immediate consumption
081310	Fruit, edible: apricots, dried
081320	Fruit, edible: prunes, dried
081330	Fruit, edible: apples, dried
081340	Fruit, edible: fruit n.e.s. in heading no. 0812, dried
081350	Nuts, edible: mixtures of nuts or dried fruits of chapter 8
081400	Peel: of citrus fruit or melons (including watermelons), fresh, frozen, dried or provisionally preserved in brine, in sulphur water and other preservative solutions
090111	Coffee: not roasted or decaffeinated
090112	Coffee: decaffeinated, not roasted
090121	Coffee: roasted, not decaffeinated
090122	Coffee: roasted, decaffeinated
090130	Coffee: husks and skins
090140	Coffee: substitutes containing coffee, in any proportion
090210	Tea, green: (not fermented), in immediate packings of a content not exceeding 3kg
090220	Tea, green: (not fermented), in immediate packings of a content exceeding 3kg
090230	Tea, black: (fermented) and partly fermented tea, in immediate packings of a content not exceeding 3kg
090240	Tea, black: (fermented) and partly fermented tea, in immediate packings of a content exceeding 3kg
090300	Mate
090411	Spices: pepper (of the genus piper), neither crushed nor ground
090412	Spices: pepper (of the genus piper), crushed or ground

090420	Spices: fruits of the genus capsicum or pimenta, dried or crushed or ground
090500	Spices: vanilla
090610	Spices: cinnamon and cinnamon-tree flowers, neither crushed nor ground
090620	Spices: cinnamon and cinnamon-tree flowers, crushed or ground
090700	Spices: cloves (whole fruit, cloves and stems)
090810	Spices: nutmeg
090820	Spices: mace
090830	Spices: cardamoms
090910	Spices: anise or badian seeds
090920	Spices: coriander seeds
090930	Spices: cumin seeds
090940	Spices: caraway seeds
090950	Spices: fennel or juniper seeds
091010	Spices: ginger
091020	Spices: saffron
091030	Spices: turmeric (curcuma)
091040	Herbs: thyme, bay leaves
091050	Curry
091091	Spices: mixtures
091099	Spices: mixtures of 2 or more products of the same heading
120300	Copra
121010	Hop cones: neither ground nor powdered nor in the form of pellets
121020	Hop cones: ground, powdered or in the form of pellets: lupulin
121220	Seaweeds and other algae: of a kind used primarily for human consumption, fresh or dried, whether or not ground
121230	Apricot, peach or plum stones and kernels: of a kind used primarily for human consumption
121291	Sugar beet: of a kind used primarily for human consumption, fresh or dried, whether or not ground
121292	Sugar cane: of a kind used primarily for human consumption, fresh or dried, whether or not ground
121299	Vegetable products (including unroasted chicory roots, chicorium intybus sativum variety): n.e.s. in chapter 12, fresh or dried, ground or unground, primarily for human consumption
150410	Oils of fish: fish-liver oils and their fractions, whether or not refined, but not chemically modified
150420	Fats and oils and their fractions: of fish, (excluding liver-oils)
150710	Vegetable oils: soya-bean oil and its fractions, crude, whether or not degummed, not chemically modified
150790	Vegetable oils: soya-bean oil and its fractions, other than crude, whether or not refined, but not chemically modified
150810	Vegetable oils: ground-nut oil and its fractions, crude, not chemically modified
150890	Vegetable oils: ground-nut oil and its fractions, other than crude, whether or not refined, but not chemically modified
150910	Vegetable oils: olive oil and its fractions, virgin, whether or not refined, but not chemically modified
150990	Vegetable oils: olive oil and its fractions, other than virgin, whether or not refined, but not chemically modified
151000	Vegetable oils: oils and their fractions n.e.s. in chapter 15, obtained solely from olives, whether or not refined, but not chemically modified, including blends of these oils or fractions with oils or fractions of heading no. 1509
151110	Vegetable oils: palm oil and its fractions, crude, not chemically modified
151190	Vegetable oils: palm oil and its fractions, other than crude, whether or not refined, but not chemically modified

151211	Vegetable oils: sunflower seed or safflower oil and their fractions, crude, not chemically modified
151219	Vegetable oils: sunflower seed or safflower oil and their fractions, other than crude, whether or not refined, but not chemically modified
151221	Vegetable oils: cotton-seed oil and its fractions: crude, whether or not gossypol has been removed, not chemically modified
151229	Vegetable oils: cotton-seed oil and its fractions, other than crude, whether or not refined, but not chemically modified
151311	Vegetable oils: coconut (copra) oil and its fractions, crude, not chemically modified
151319	Vegetable oils: coconut (copra) oil and its fractions, other than crude, whether or not refined, but not chemically modified
151321	Vegetable oils: palm kernel or babassu oil and their fractions, crude, not chemically modified
151329	Vegetable oils: palm kernel or babassu oil and their fractions, other than crude, whether or not refined, but not chemically modified
151410	Vegetable oils: rape, colza or mustard oil and their fractions, crude, not chemically modified
151490	Vegetable oils: rape, colza or mustard oil and their fractions, other than crude, whether or not refined, but not chemically modified
151511	Vegetable oils: linseed oil and its fractions, crude, not chemically modified
151519	Vegetable oils: linseed oil and its fractions, other than crude, whether or not refined, but not chemically modified
151521	Vegetable oils: maize (corn) oil and its fractions, crude, not chemically modified
151529	Vegetable oils: maize (corn) oil and its fractions, other than crude, whether or not refined, but not chemically modified
151550	Vegetable oils: sesame oil and its fractions, whether or not refined, but not chemically modified
151560	Vegetable oils: jojoba oil and its fractions, whether or not refined, but not chemically modified
151590	Vegetable fats and oils and their fractions: fixed, n.e.s. in heading no. 1515, whether or not refined, but not chemically modified
151610	Animal fats and oils and their fractions: partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, whether or not refined, but not further prepared
151620	Vegetable fats and oils and their fractions: partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, whether or not refined, but not further prepared
151710	Margarine: excluding liquid margarine
151790	Edible mixtures or preparations of animal or vegetable fats or oils or of fractions of different fats or oils of this chapter, other than edible fats or oils of heading no. 1516
170111	Sugars: cane sugar, raw, in solid form, not containing added flavouring or colouring matter
170112	Sugars: beet sugar, raw, in solid form, not containing added flavouring or colouring matter
170191	Sucrose: chemically pure, containing added flavouring or colouring matter, in solid form
170199	Sucrose: chemically pure, not containing added flavouring or colouring matter, in solid form
170210	Sugars: lactose, chemically pure, in solid form: lactose syrup, not containing added flavouring or colouring matter
170220	Sugars: maple sugar chemically pure, in solid form: maple syrup, not containing added flavouring or colouring matter
170230	Sugars: glucose and glucose syrup, not containing fructose or containing in the dry state less than 20% by weight of fructose, the syrup not containing added flavouring or colouring matter
170240	Sugars: glucose and glucose syrup, containing in the dry state at least 20% but less than 50% by weight of fructose, the syrup not containing added flavouring or colouring matter
170250	Sugars: fructose, chemically pure, in solid form
170260	Sugars: fructose (excluding chemically pure fructose), in solid form, containing in the dry state more than 50% by weight of fructose: fructose syrup, not containing added flavouring or colouring matter
170290	Sugars: n.e.s. in heading no. 1702, including invert sugar
170310	Sugars: molasses, from sugar cane, resulting from the extraction or refining of sugar
170390	Sugars: molasses, from sugar beet, resulting from the extraction or refining of sugar

170410	Sugar confectionery: chewing gum, whether or not sugar-coated, not containing cocoa
170490	Sugar confectionery: (excluding chewing gum, including white chocolate), not containing cocoa
180100	Cocoa beans: whole or broken, raw or roasted
180310	Cocoa: paste, not defatted
180320	Cocoa: paste, wholly or partly defatted
180400	Cocoa: butter, fat and oil
180500	Cocoa: powder, not containing added sugar or other sweetening matter
180610	Cocoa: powder, containing added sugar or other sweetening matter
180620	Chocolate & other food preparations containing cocoa: in blocks, slabs or bars weighing more than 2kg or in liquid, paste, powder, granular or other bulk form in containers or immediate packings, content exceeding 2kg
180631	Chocolate and other food preparations containing cocoa: in blocks, slabs or bars, filled, weighing 2kg or less
180632	Chocolate and other food preparations containing cocoa: in blocks, slabs or bars, (not filled), weighing 2kg or less
180690	Chocolate and other food preparations containing cocoa: n.e.s. in chapter 18
200600	Fruit, nuts, fruit-peel and other parts of plants: preserved by sugar (drained, glace or crystallised)
200710	Jams, fruit jellies, marmalades, fruit or nut puree and fruit or nut pastes: homogenised, cooked preparations, whether or not containing added sugar or other sweetening matter
200791	Jams, jellies, marmalades, purees and pastes: of citrus fruit, being cooked preparations (excluding homogenised), whether or not containing added sugar or other sweetening matter
200799	Jams, fruit jellies, marmalades, purees and pastes: of fruit or nuts n.e.s. in heading no. 2007, cooked preparations (excluding homogenised), whether or not containing added sugar or other sweetening matter
200811	Nuts: ground-nuts, whether or not containing added sugar, other sweetening matter or spirit
200819	Nuts and other seeds: whether or not containing added sugar, other sweetening matter or spirit (excluding ground-nuts except in mixtures)
200820	Fruit: pineapples, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200830	Fruit: citrus, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200840	Fruit: pears, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200850	Fruit: apricots, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200860	Fruit: cherries, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200870	Fruit: peaches, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200880	Fruit: strawberries, prepared or preserved in ways n.e.s. in heading no. 2007, whether or not containing added sugar, other sweetening matter or spirit
200891	Palm hearts: prepared or preserved, whether or not containing added sugar, other sweetening matter or spirit
200892	Fruit: mixtures, prepared or preserved, whether or not containing added sugar, other sweetening matter or spirit
200899	Fruit, nuts and other edible parts of plants: prepared or preserved, whether or not containing added sugar, other sweetening matter or spirit, n.e.s. in heading no. 2008
200911	Juice: orange, frozen, unfermented, (not containing added spirit), whether or not containing added sugar or other sweetening matter
200919	Juice: orange, not frozen, unfermented, (not containing added spirit), whether or not containing added sugar or other sweetening matter
200920	Juice: grapefruit, unfermented, (not containing added spirit), whether or not containing added sugar or other sweetening matter

200930	Juice: of single citrus fruit (excluding orange or grapefruit), unfermented, (not containing added spirit), whether or not containing added sugar or other sweetening matter
200940	Juice: pineapple, unfermented, (not containing added spirit), whether or not containing added sugar or other sweetening matter
200950	Juice: tomato, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
200960	Juice: grape (including grape must), unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
200970	Juice: apple, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
200980	Juice: of any single fruit or vegetable n.e.s. in heading no. 2009, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
200990	Juices: mixtures, unfermented, not containing added spirit, whether or not containing added sugar or other sweetening matter
210110	Extracts, essences and concentrates: of coffee and preparations with a basis of these extracts, essences or concentrates or with a basis of coffee
210120	Extracts, essences and concentrates: of tea or mate, and preparations with a basis of these extracts, essences or concentrates or with a basis of tea or mate
210130	Chicory, roasted and other roasted coffee substitutes: extracts, essences and concentrates thereof
210210	Yeasts: active
210220	Yeasts: inactive, other single-cell micro-organisms, dead
210230	Baking powders: prepared
210310	Sauces: soya
210320	Sauces: tomato ketchup and other tomato sauces
210330	Mustard flour and meal and prepared mustard
210390	Sauces and preparations therefor: mixed condiments and mixed seasonings
210410	Soups and broths and preparations therefor
210420	Homogenised composite food preparations
210500	Ice cream and other edible ice: whether or not containing cocoa
210610	Protein: concentrates and textured protein substances
210690	Food preparations: n.e.s. in item no. 2106.10
220110	Waters: mineral and aerated, including natural or artificial, (not containing added sugar or other sweetening matter nor flavoured)
220190	Waters: other than mineral and aerated, (not containing added sugar or other sweetening matter nor flavoured), ice and snow
220210	Waters: including mineral and aerated, containing added sugar or other sweetening matter or flavoured
220290	Non-alcoholic beverages: n.e.s. in item no. 2202.10, not including fruit or vegetable juices of heading no. 2009
220300	Beer: made from malt
220410	Wine: sparkling
220421	Wine: still, in containers holding 2 litres or less
220429	Wine: still, in containers holding more than 2 litres
220430	Grape must: n.e.s. in heading no. 2009, n.e.s. in item no. 2204.2
220510	Vermouth and other wine of fresh grapes, flavoured with plants or aromatic substances, in containers holding 2 litres or less
220590	Vermouth and other wine of fresh grapes, flavoured with plants or aromatic substances, in containers holding more than 2 litres
220600	Beverages, fermented: (eg cider, perry, mead)
220710	Undenatured ethyl alcohol: of an alcoholic strength by volume of 80% vol. or higher
220810	Alcoholic preparations: compound, of a kind used for the manufacture of beverages
220820	Spirits obtained by distilling grape wine or grape marc

220830	Whiskies
220840	Rum and tafia
220850	Gin and geneva
220890	Spirits, liqueurs and other spirituous beverages: n.e.s. in heading no. 2208
220900	Vinegar and substitutes for vinegar: obtained from acetic acid
240110	Tobacco, (not stemmed or stripped)
240120	Tobacco: partly or wholly stemmed or stripped
240130	Tobacco refuse
240210	Cigars, cheroots and cigarillos: containing tobacco including the weight of every band, wrapper or attachment thereto
240220	Cigarettes: containing tobacco
240290	Cigars, cigarillos and cheroots: containing tobacco substitutes including the weight of every band, wrapper or attachment thereto
240310	Tobacco, smoking: whether or not containing tobacco substitutes in any proportion
240391	Tobacco: ""homogenised"" or ""reconstituted""
240399	Tobacco: other than ""homogenised"" or ""reconstituted"" or ""smoking""

Appendix 7. Commodities included in frozen fish import estimates and their associated tonnage for the 14 countries in 2018.

HS92 definition (abridged)	**Tonnes**
Fish: albacore or longfinned tunas (thunnus alalunga), frozen	178,680
Fish: frozen, n.e.s. in heading no. 0303	147,020
Fish: skipjack or stripe-bellied bonito, frozen	72,714
Fish: tuna, frozen, n.e.s. in item no. 0303.4	72,405
Fish: yellowfin tunas (thunnus albacares), frozen	68,536
Fish: fillets, frozen	25,714
Fish: fish meat n.e.s. in heading no. 0304 (whether or not minced), fresh, chilled or frozen	15,255
Fish: herrings (clupea harengus, clupea pallasii), frozen	2,753
Fish: flat fish, frozen, n.e.s. in item no. 0303.3	2,244
Fish: dogfish and other sharks, frozen	1,853
Fish: salmonidae, frozen, n.e.s. in item no. 0302.1 and 0302.2	1,077
Fish: Pacific salmon, (oncorhynchus spp.), frozen	637
Fish: Atlantic salmon (salmo salar) and Danube salmon (hucho hucho), frozen	277
Fish: hake (merluccius spp., urophycis spp.), frozen	176
Fish: livers and roes, frozen	143
Fish: cod (gadus morhua, gadus ogac, gadus macrocephalus), frozen	122
Fish: halibut (reinhardtius hippoglossoides, hippoglossus hippoglossus, hippoglossus stenolepis), frozen	55
Fish: trout (salmo trutta, salmo gairdneri, salmo clarki, salmo aguabonita, salmo gilae), frozen	46
Fish: sole (solea spp.), frozen	30
Fish: plaice (pleuronectes platessa), frozen	27
Fish: sea bass (dicentrarchus labrax, dicentrarchus punctatus), frozen	9
Fish: eels (anguilla spp.), frozen	6

Appendix 8. Local currencies of non-USD Pacific countries and the exchange rates during the time of HIES. The currency of the PICs, Federated States of Micronesia, Marshall Islands, and Palau is USD.

country	Currency	Year	Month	Exchange rate	country	Currency	Year	Month	Exchange rate
Cook Islands	New Zealand dollar	2015	11	0.65667	Tonga	Tongan Pa'anga	2015	10	0.4533
		2015	12	0.67368			2015	11	0.4487
		2016	1	0.65203			2015	12	0.4506
		2016	2	0.66334			2016	1	0.4438
		2016	3	0.67329			2016	2	0.4431
		2016	4	0.68917			2016	3	0.448
		2016	5	0.68034			2016	4	0.4527
		2016	6	0.70336			2016	5	0.4475
		2016	7	0.71231			2016	6	0.45
		2016	8	0.72293			2016	7	0.4547
		2016	9	0.73090			2016	8	0.4561
		2016	10	0.71584			2016	9	0.4589
		2016	11	0.71528			2016	10	0.4576
		2016	12	0.70484	Tuvalu	Australian dollar	2015	11	0.7189
Kiribati	Australian dollar	2019	5	0.6916			2015	12	0.7306
		2019	6	0.7013			2016	1	0.7100
		2019	7	0.6894			2016	2	0.7140
		2019	8	0.6718			2016	3	0.7657
		2019	9	0.6749			2016	4	0.7655
		2019	10	0.6926			2016	5	0.7242
		2019	11	0.6777			2016	6	0.7426
		2019	12	0.7006			2016	7	0.7522

		2020	1	0.6724
		2020	2	0.6524
		2020	3	0.6175
Nauru	Australian dollar	2012	9	1.0464
		2012	10	1.0378
		2012	11	1.0431
		2012	12	1.0384
		2013	1	1.0394
		2013	2	1.0275
		2013	3	1.0426
		2013	4	1.0368
		2013	5	0.9649
		2013	6	0.9275
		2013	7	0.9037
		2013	8	0.8947
		2013	9	0.9309
Niue	New Zealand dollar	2015	11	0.65667
		2015	12	0.67368
		2016	1	0.65203
		2016	2	0.66334
		2016	3	0.67329
		2016	4	0.68917
		2016	5	0.68034
		2016	6	0.70336
		2016	7	0.71231
		2016	8	0.72293
		2016	9	0.73090
		2016	10	0.71584
		2016	11	0.71528

		2016	8	0.7514
		2016	9	0.7630
		2016	10	0.7613
		2016	11	0.7474
		2016	12	0.7236
Vanuatu	Vatu	2019	2	0.0089
		2019	3	0.0088
		2019	4	0.0088
		2019	5	0.0088
		2019	6	0.0087
		2019	7	0.0087
		2019	8	0.0086
		2019	9	0.0086
		2019	10	0.0086
		2019	11	0.0086
		2019	12	0.0087
		2020	1	0.0087
		2020	2	0.0085
		2020	3	0.0082
Samoa	Samoan Tala	2018	3	0.3989
		2018	4	0.3979
		2018	5	0.3907
		2018	6	0.39
		2018	7	0.3863
		2018	8	0.3836
		2018	9	0.3806
		2018	10	0.3785
		2018	11	0.3837

Solomon Islands	Solomon Island dollar	12	10	0.1364
		12	11	0.1361
		12	12	0.1359
		13	1	0.1358
		13	2	0.1368
		13	3	0.137
		13	4	0.1369
		13	5	0.1373
		13	6	0.1372
		13	7	0.1377
		13	8	0.1381
		13	9	0.137
		13	10	0.136

FINAL REPORT

Regional report: Feasibility of scaling-up National Fish Aggregating Device (FAD) Programmes in all 14 participating countries

(RFP22-3866 – Study 3)

Under contract No CS22-4392 with 31 August 2023 amendment for regional component

Prepared by

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October 2023

Contents

Abbreviations

aFAD(s)	Artisanal fish aggregating device(s)
ADB	Asian Development Bank
AUD	Australian dollar
C	Centigrade
CK	Cook Islands
cm	Centimetre
EEZ(s)	Exclusive economic zone(s)
ENSO	El Nino Southern Oscillation
FAD(s)	Fish aggregating device(s)
FAO	Food and Agriculture Organization (of the United Nations)
FAME	Fisheries, Aquaculture and Marine Ecosystems
FFA	Forum Fisheries Agency
FJ	Fiji Islands
FJD	Fijian dollar
FM / FSM	Federated States of Micronesia
FRDP	Framework for Resilient Development in the Pacific (2017-2030)
GCF	Green Climate Fund
GHG	Greenhouse gases
HIES	Household Income and Expenditure Survey
IKM	Information and Knowledge Management
kg	Kilogram
KI	Kiribati
km	Kilometre
km^2	Square kilometres
m	Metre
MH	Marshall Islands
mt	Metric ton (or tonne)
NGO	Non-Government Organisation
nm	Nautical mile
NR	Nauru
NU	Niue
NZD	New Zealand dollar
PG / PNG	Papua New Guinea
PGK	Papua New Guinea Kina
PICs	Pacific Island countries
PICTs	Pacific Island countries and territories
PIFP	Pacific Island Fisheries Professional

PMU	Project Management Unit
PNA	Parties to the Nauru Agreement
PROP	Pacific Islands Regional Oceanscape Programme
PROPER	Phase-2 of PROP programme
PW	Palau
RFP	Request for proposals
RFQ	Request for quotations
SB	Solomon Islands
SBD	Solomon Islands dollar
SPC	Pacific Community
SST	Sea surface temperature
TO	Tonga
TOP	Tongan Pa'anga
TV	Tuvalu
USD	United States dollar
VU	Vanuatu
VUV	Vanuatu Vatu
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WS	Samoa
WST	Samoan Tala

Executive summary

Introduction: The Pacific Community (SPC) advertised a series of studies to support a funding submission to the Green Climate Fund (GCF) titled: Adapting tuna dependent Pacific Island communities and economies to climate change on 19 May 2022 under RFP22-3866. Study 3: "Feasibility of scaling-up National Fish Aggregating Device (FAD) Programmes in all 14 participating countries" was contracted to Lindsay Chapman Consulting Pty Ltd on 8 September 2022 (SPC contract No CS22-4392), with the delivery date of the final report being 30 September 2023. On 31 August 2023 the contract (CS22-4392) was amended to include the regional component of the FAD Project and the delivery date for the final report extended to 31 December 2023. (Para to be deleted once report is accepted).

Purpose: The purpose of this study is to improve the food security of rapidly growing coastal communities in the Pacific Islands region through upscaling the use of nearshore artisanal FADs (aFADs) to increase the supply of tuna and other coastal pelagic species by small scale fishers for local consumption. Increasing the supply of these species will assist in supplementing food security through the provision of additional fish from sources other than reef fisheries. Productivity from reef fisheries is expected to decline in locations close to urban populations due to increasing fishing pressure on these habitats and more broadly throughout coastal areas within the region as a result of coral reef degradation due to ocean warming and acidification.

Strategic Investment: Nearshore (aFADs) have been deployed in all 14 countries in an *ad hoc* approach to create additional fishing opportunities for artisanal fishers over the last 35 years. The lack of formalising aFADs within whole of government policy as infrastructure to support enterprises and livelihoods, achieve food security and contribute to meeting health and wellbeing needs of rural and urban communities has meant that aFAD Programmes have been project-based without ongoing government and community support. Learning from the past, the proposed Programme will be transformative by integrating aFADs into whole of government infrastructure by ensuring that:

- aFAD infrastructure design is consultative across government authorities, stakeholders and communities;
- Legal and policy reform is applied at whole of government culminating in endorsed National aFAD Management Plans that are supported by appropriate legislation and regulations;
- Implementation is local community focused as a collaboration with the fisheries and other agencies agencies;
- Information and Knowledge Management is applied at all levels of participation;
- Capability at all levels of participation is provided;
- Regional support is provided across the sector and across all aspects of aFAD Programmes and is not restricted to aFAD design, deployment and fishing support;
- New data systems are used (TAILS and IKASAVEA applications) for data collection, storage and analysis that are web-based and user friendly; and
- Monitoring of aFAD Programmes transitions from the optimal design and placement of aFADs (to maximise catch per unit effort) to include measurement of the community benefit (e.g., number of additional fish meals provided by locally-sourced pelagic fish; improvement in body mass index, infant/early child health, etc).

Methodology and process for national component: The method for undertaking the study at the national level involved several stages. First a standard questionnaire was developed so an audit of the aFAD Programmes in all 14 participating countries could be undertaken (Annex B). The questionnaire was based on the SPC "matrix for assessing progress towards a sustainable national

FAD Programme"[1]. An additional section was added to the questionnaire to audit the status of national programmes concerned with sea safety for small craft under 12 m in length. Secondly, staff from the fisheries department involved with the aFAD Programme were interviewed during a virtual meeting and the questionnaire completed with each country ranking or scoring themselves against each of the criteria in the questionnaire. Thirdly, an analysis of the completed questionnaire was undertaken to identify any gaps and develop an activity plan and associated budget designed to fill the identified gaps in each country.

Running parallel to the above process was the collection of background information on the aFAD Programme in each country. This included the review of information on the most vulnerable areas to the effects of climate change in each country, plus any climate-change focused risk assessments covering the marine environment and resources that had been developed by country. This information was used to develop a country profile for each of the 14 participating countries. The profiles include the results of the audit, an assessment of the gaps, the vulnerability of candidate project sites to the impacts of climate change, and an activity plan and budget in local currency to address the identified gaps. The country profile, activity plan and budget were agreed with each country. All 14 country profiles are annexed to this report.

Results for climate change projections: National and regional climate change projected impacts on coastal marine resources and habitat[2], and potential responses, are consistent with the findings presented in the accompanying profiles:

- Increase in coral bleaching as a result of both rising air temperature and rising sea surface temperature leading to coral reef ecosystem degradation.
- Higher projected rainfall will increase the amount of erosion in catchments, and turbidity and sedimentation in lagoon areas, resulting in reduced photosynthesis by corals and sea grasses, and smothering of both habitats.
- Increasing ocean acidification will reduce the availability of dissolved carbonate required by many calcifying organisms, including corals, to build their shells or skeletons.
- Increased storm surge which will cause damage to coastal marine environments.
- Stronger although less frequent cyclones causing damage to coral reefs, coastal barrier zones and the marine environment in general.
- Loss of coastal and lagoon fish and invertebrate habitat and nurseries through rising sea surface temperature, sea level rise and increased sedimentation.
- Declines in coastal fisheries productivity and possibly changes in species composition due to both the direct effects of increased sea surface temperature and indirect effects of changes to, and loss of, fish habitats.
- Assessment of adaptation options to improve sustainable access to marine resources indicate that strengthening aFAD Programmes in each of the 14 participating countries so that fishers have access to aFADs to provide fresh fish for home consumption and for sale locally is likely to be necessary.

Results of national aFAD Programme audit gap analysis and areas to be addressed: The results from the audit demonstrate that all countries have gaps that impact the sustainability of their aFAD

[1] Policy Brief 31/2017 – Matrix for assessing progress towards a sustainable national FAD Programme, download from: https://purl.org/spc/digilib/doc/t3ume

[2] Bell, JD., Johnson, JE., and Hobday AJ. 2011: Vulnerability of tropical Pacific fisheries and aquaculture to climate change, Website: https://www.spc.int/DigitalLibrary/Doc/FAME/Reports/Bell_11_Vulnerability_Pacific_Fisheries_to_Climate_Change.pdf

Programme, some more than others. The main points are presented here with the number of countries in brackets that need assistance:

- A lack of staff with the necessary skills for aFAD rigging and deployment (13).
- A lack of suitable equipment for deploying aFADs successfully (13).
- Governance structure lacking around legislation and regulations to support the aFAD Programme (12). Only one country has a comprehensive national aFAD Management Plan that is approved by the government for implementation. Future aFAD Management Plans need to include:
    - Mechanisms for retaining staff with aFAD skills (14);
    - Guidance around aFAD registry and aFAD-related information to be recorded (10);
    - Effective feedback mechanism to strengthen communication between fishers and national fisheries administrations (12);
    - Conflict resolution protocols for aFAD fishers (13); and
    - aFADs being equipped with flags and flagpoles for daytime marker plus light and radar reflector for nighttime marker (14).
- A lack of suitable monitoring and data collection system for aFADs and for aFAD catches (13).
- A need for awareness-raising about aFADs and the national aFAD Programme (12).
- A requirement for a training programme for fishers in FAD-fishing methods (12).
- National funding for aFAD materials and supporting programmes is limited and insufficient to run an effective national aFAD Programme (14).
- A lack of partnerships to allow cost sharing for some aFAD deployments (14).

To address these gaps a 2-phased approach is proposed for each of the 14 participating countries:

- ***Phase I***: Strengthen or develop the governance structure necessary to support a national aFAD Management Plan to address gaps identified in the national aFAD Programme audit. This will be developed with broad stakeholder consultation. The aFAD Management Plan needs to describe the structured or sequenced approach for implementing the aFAD Programme within an appropriate legal framework. The aFAD Management Plan will need endorsement from government and resources to support its implementation.
- ***Phase II***: Implementing the aFAD Management Plan. This includes the purchase of aFAD materials and other required equipment, training and capacity development, and strengthening data collection.

The aFADs will be deployed in all 14 countries over the seven-years of the project. The number of deployments in each country (initial and replacement) range from 18 to 60. The total number of nutritious fish meals to be provided by aFADs installed by the Programme across the region is 6-13 million per year[3]). Deployments depend on the size of the country or, in larger countries, the areas proposed for the GCF Programme to target (refer Table 14 for number of FADs per country and depths for deployment). In addition to the aFADs, lights, radar reflectors and spare floats, shackles and swivels for maintenance work will be provided. The legislation and regulations to support the aFAD Programme will also be reviewed and updated in the 12 countries that require this.

The aFAD designs proposed are based on the SPC recommended Indo-Pacific, subsurface or "lizard" design, but noting that these designs continue to evolve. The eventual designs will be agreed between SPC and each country prior to procurement and shipping of the required materials. Surface

[3] See Annex T: Method for measuring the contribution of strengthened national aFAD Programmes to domestic food security.

aFADs will be assessed for fitting with electronic equipment to provide data on position, currents, water temperature, and wave height to aid the delivery of improved and localised reporting on location, sea safety and meteorological conditions. Sonar buoys will also be trialled for measuring fish biomass aggregated under and around selected surface aFADs by each country to assist fishers with their operational decision-making.

Results of national sea safety audit gap analysis and areas to be addressed: The results from the sea safety audit have identified all countries have gaps that impact the sustainability of their national sea safety programme. The issues arising with the number of countries that need assistance identified in brackets, include:

- Governance structure lacking around sea safety legislation and regulations including certifications or qualifications for small craft (<12 m) operators and the sea safety equipment required to maintain certifications (9).
- Lack of sea safety training facilities and trainers (11).
- Lack of the local availability of some sea safety equipment for purchase (12).
- Lack of legislation and regulations around small craft minimum construction specifications to ensure seaworthiness (12). Many countries considered this to be a low priority because there are no local boat building facilities/services.
- Need to develop and/or strengthen awareness-raising around sea safety (11), including carrying an auxiliary outboard (12) and carrying paddles and/or sail rig (10) when fishing outside the reef.

Sea safety interventions, particularly those regarding awareness-raising are linked to the aFAD interventions. Clear messaging that incorporates a sea safety component into aFAD fishing skills trainings is required with sea safety grab bags provided for training purposes. Seven countries require sea safety legislation and regulations to be reviewed and updated and four countries require the review and update of current small craft minimum construction specifications to ensure seaworthiness.

Funding for national component: Based on the results of the audit of aFAD Programmes and sea safety requirements in each of the 14 participating countries, an activity plan and budget was developed for each country. The budgets were developed in local currency, agreed with each country and then converted to USD (refer to Table 16 for individual country budget amounts) for inclusion in the overall national project budget (refer Table 17). The budgets range from USD $431,542 in the smaller countries up to USD $1,011,167 in larger countries (where activity would be focussed on one or two provinces or states).

Beneficiaries from national interventions: The number of beneficiaries[4] varied from the entire population of a country to a percentage of people living in the states or provinces where the project will be implemented. Overall, the range of people expected to benefit in 2030 was from the full population of Niue (1,393 people) to 20 percent of the population in the two provinces of Papua New Guinea (91,834 people) where the project would be implemented (refer Table 19 for a breakdown by country).

Regional component: The regional component has been designed and will provide support to the 14 participating countries in the implementation of their national aFAD Programmes in a structured 2-phase approach including strengthening sea safety awareness. The regional component includes a

[4] The estimated number of people that will have direct access (catching) or indirect access (receive or purchase) pelagic fish as a result of this intervention.

range of other activities to complement the aFAD work. These include post-harvest activities, economic assessments and data collection, social/gender/human rights assessments, communications and information and knowledge management (IKM), support services, and capacity development through the Pacific Island Fisheries Professionals (PIFP) initiative. Ten (10) staff are required to deliver the regional component. Co-locating all staff in a single location (e.g., an office in Suva Fiji) to form a Project Team, with options for short-term placement of aFAD Specialist in the North Pacific is preferable. The regional component should include eight one-year PIFP capacity development positions over the life of the project.

Implementation of the regional aspect of the project will follow the same 2-phased approach as proposed for the national component. Firstly, the governance structures will be strengthened in each country through the review of legislation and regulations by suitable consultants as outlined in the individual country profiles. Each country will have its specific bespoke requirements in this regard. Developing, revising and/or updating aFAD Management Plans for each country will be a primary activity under the first phase of the work for the Project Coordinator, two aFAD Specialists and consultants. This is a prerequisite for the second phase of the programme. Phase two is the operationalisation of the aFAD Management Plan including the purchase of all equipment and arranging for its shipment to each country. Training and capacity development is a main task under the second phase, together with aFAD deployment, data collection, post-harvest assessment and assistance, economic and social/gender studies and research with communities on the benefits from aFADs and fishing around them, the production of IKM products across the different work areas, among a range of other activities.

An essential early task will be the collection of catch and effort data from at least three aFADs in each country to develop a system for the collection of reliable annual catch data, and to provide the baseline for measuring the benefits of Component A of the GCF Regional Tuna Programme. The project will hire one or two data collectors in each country to undertake the data collection over a two-to-three-year period under the guidance of the Project Economist. This may include the collection and analysis of data from fishing activities associated with aFADs that already exist in some countries.

Annual regional meeting: An annual regional meeting will be held for five-days with three representatives per country attending for two main purposes. Firstly, to serve as a Steering Committee for the Project for two-way information exchange between the national and regional components on activities undertaken and allow planning of activities for the following year. It will also aid in documenting progress in each country for reporting back to the Executing Entity. Secondly, the meeting will allow the countries to learn from each other as they exchange and share information and experiences from the activities being undertaken in their country. This sharing of information at the national level is crucial to allow countries to learn from each other, to encourage ownership and commitment to the Project and assist with supporting efforts to sustain their aFAD Programmes and related activities.

Funding for the regional component: An activity plan and associated budget was developed for the regional component to support the implementation of national aFAD Programmes and sea safety activities. The activity plan and budget include staffing for complementary activities such as post-harvest assistance and economic assessment, as well as for support services. The total budget for the regional component is USD $22,190,831. This includes a five percent contingency and the 15 percent for project management (refer Table 21 for a breakdown of the budget by activity and sub-activity).

Overall budget: The total budget comprising the budget to support national activities in the 14 countries (USD $13,191,050) and the regional budget (USD $22,190,831) (refer Table 22 for a breakdown by activity) is USD $35,381,881 (inclusive of a five percent contingency and the 15 percent for related project management).

Conclusions: Based on the overall assessment undertaken across the 14 participating countries, strengthening the national aFAD Programme seems the most effective approach to support domestic food security in these countries. However, there is a great diversity of needs related to strengthening aFAD Programmes across the 14 participating countries, given differences in their population sizes, previous experiences with aFADs, abundance of tuna in their waters, etc.

It is essential to develop and/or strengthen the governance structure to fully support a national aFAD Programme including legislation and regulations and a comprehensive national aFAD Management Plan that has been developed with all stakeholders. Once the national aFAD Management Plan is approved and endorsed by government, it provides the guidance and approach for implementing the aFAD programme as a collaboration between the fisheries agency, other relevant government departments and all stakeholders.

The aFADs will make a significant contribution to food security in the small countries, both in terms of the number of beneficiaries (Table 19) and the relatively high number of fish meals to be delivered per person per month (see Table 1 in Annex T).

The key benefit for the larger countries should not be measured in terms of the proportion of the total population supplied with more tuna – it is simply not possible for one programme to have a significant impact given the large national population. Rather, the main benefit is that the *ad hoc* nature of previous aFAD deployments will be transformed through establishment of a well-structured national aFAD Programme, following the guidelines in SPC Policy Brief 31/2017. This will lay the foundation for these countries to progressively extend a well-maintained aFAD network to additional provinces or states to enlarge the national infrastructure for food security. This can be done using a combination of national funding and resources available from other donors, e.g., the World Bank PROPER, ADB, etc.

1. Introduction and Background

The Pacific Islands region (Figure 1) is made up of 22 Pacific Island countries and territories (PICTs) that rely heavily on the marine resources within their Exclusive Economic Zone (EEZ) for both food security and for economic development. Of these, 14 are independent Pacific Island countries[5] (PICs) and the focus of the proposed activities presented in this study report.

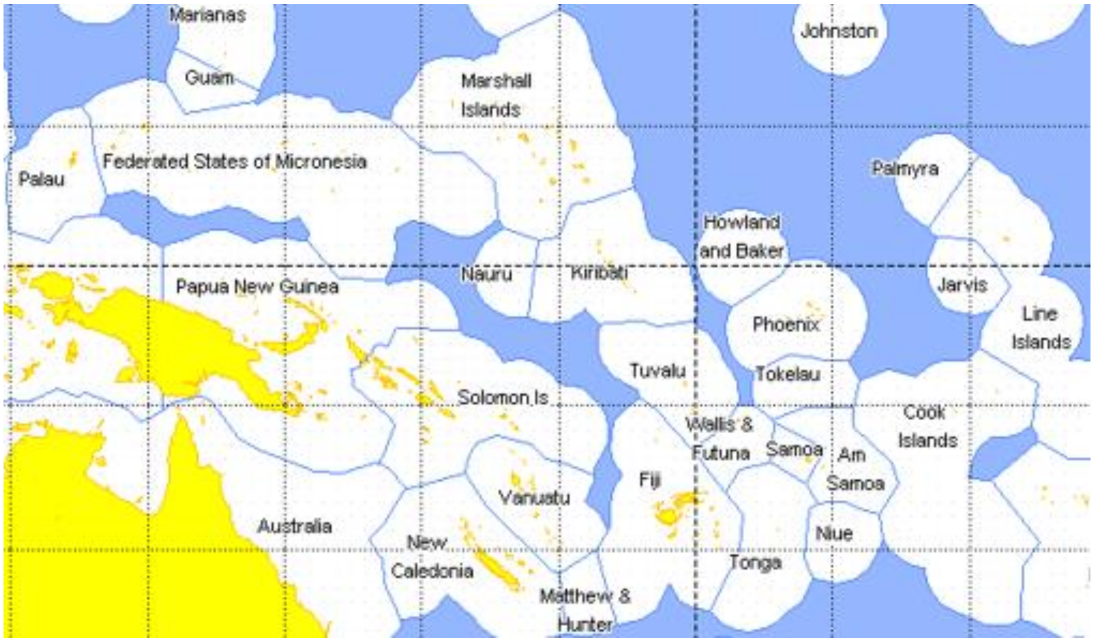

Figure 1: Pacific map showing the 14 participating countries.

The western and central Pacific Ocean (WCPO) has historically been divided into three regions, Melanesia, Micronesia and Polynesia (Table 1), based on the physical nature of the islands and atolls, biogeography, and ethnic and cultural factors[6]. The largest and healthiest tuna resource in the world is located in the WCPO and the Pacific countries rely on this for both food and for economic development. Management of the tuna resource comes under the Western and Central Pacific Fisheries Commission (WCPFC). In 2022 the tuna catch from the WCPFC Convention Area was 2,701,239 mt, which was 54 percent of the global tuna catch[7]. Purse-seining accounted for 70 percent of the catch, with longlining 8.5 percent, pole-and-line 6.2 percent, trolling <1 percent, with other gears contributing 15 percent[7]. The other category includes the catch from artisanal or small-scale tuna fishers in PICs including the catch taken around artisanal fish aggregating devices (aFADs) that are moored to the seafloor in depths from 100-2,500 m.

Table 1 provides a breakdown of the main demographics for the 14 PICs by region that are participating in this Project. The four Melanesian countries support the largest population, land area,

[5] The 14 PICs are: Cook Islands (CK), Federated States of Micronesia (FM or FSM), Fiji Islands (FJ), Kiribati (KI), Marshall Islands (MH), Nauru (NR), Niue (NU), Palau (PW), Papua New Guinea (PG or PNG), Samoa (WS), Solomon Islands (SB), Tonga (TO), Tuvalu (TV), and Vanuatu (VU).

[6] Bell, JD., Johnson, JE., and Hobday AJ. 2011. Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change. Secretariat of the Pacific Community, Noumea, New Caledonia.

[7] Williams, P. and Ruaia, T. 2023. Overview of tuna fisheries in the Western and Central Pacific Ocean including economic conditions – 2022. Western and Central Pacific Fisheries Commission, Scientific Committee, Nineteenth Regular Session, Koror, Palau, 16 –24 August 2023. WCPFC-SC19-2023/GN WP-1. 65 pages.

and coastline length. The five Micronesian countries have the least land area resulting in the entire population living within 5 km of the coast (and most within 1 km of the coast), however, they have the largest Exclusive Economic Zones (EEZs). In addition, the Micronesian and Polynesian countries with their limited land area for agriculture, rely heavily on fishing the coastal and lagoon resources for their daily protein source and the people have some of the highest per capita fish consumption in the world (Table 2). The Pacific region with the many low-lying atolls is particularly vulnerable to the effects of climate change, which is a great concern to the population of the Pacific Island countries.

Table 1: Pacific Island countries by region with population, land area, area of EEZ, coastline length and the percentage of the population living within 1 km and 5 km of the coast.[8]

Country and region	Population (mid-2022 estimate)	Land area (km^2)	EEZ area (km^2)	Coastline length (km)	Percentage of population living within 1 km of coast	Percentage of population living within 5 km of coast
Total	**11,894,867**	**528,047**	**17,628,364**	**24,326**		
Melanesia	**11,265,825**	**521,684**	**4,956,561**	**14,122**		
Fiji Islands	901,603	18,333	1,255,290	1,129	27.2	76.4
Papua New Guinea	9,311,874	462,840	1,558,660	5,152	8.0	21.1
Solomon Islands	744,407	28,230	1,547,600	5,313	65.1	91.4
Vanuatu	307,941	12,281	595,011	2,528	64.1	94.3
Micronesia	**301,044**	**2,158**	**8,906,382**	**9,174**		
Federated States of Micronesia	105,987	701	2,907,950	6,112	88.5	100
Kiribati	122,735	811	3,333,170	1,143	100	
Marshall Islands	42,418	181	1,774,280	370	100	
Nauru	11,928	21	309,044	30	92.6	100
Palau	17,976	444	581,938	1,519	93.5	100
Polynesia	**327,998**	**4,205**	**3,765,421**	**1,030**		
Cook Islands	15,406	237	1,969,960	120	90.7	100
Niue	1,532	259	317,787	64	24.7	83.0
Samoa	200,999	2,934	123,278	403	61.1	97.2
Tonga	99,283	749	628,614	419	84.3	100
Tuvalu	10,778	26	725,782	24	100	

[8] SPC Statistics for Development Division, Website: https://sdd.spc.int/ ; SPC Geoscience, Energy and Maritime Division – Maritime Boundaries Dashboard https://pacificdata.org/dashboard/maritime-boundaries ; and coastline lengths from website: https://www.citypopulation.de/en/world/bymap/coastlines/

Table 2: Per capita fish consumption patterns for Pacific Island countries (showing variation in estimates over time).

Country and region	Per capita fish consumption (kg) 2009[9] National average	Rural average	Urban average	Most recent estimates[10] National average
Melanesia				
Fiji Islands	21	25	15	n.a
Papua New Guinea	20	10	28	n.a.
Solomon Islands	33	31	45	64
Vanuatu	20	21	19	31
Micronesia				
Federated States of Micronesia	69	77	67	91
Kiribati	67	58	67	84
Marshall Islands	39	39	39	91
Nauru	56	56	56	91
Palau	33	43	28	102
Polynesia				
Cook Islands	35	61	25	36
Niue	79	79	79	34
Samoa	87	98	46	30
Tonga	20	20	20	38
Tuvalu	110	147	69	55

Increasing populations and decreasing availability of reef fish and invertebrate resources due to over harvesting and changes to the marine habitat, particularly close to urban centres, is resulting in a gap in domestic fish supply in most PICs[11]. This decline in reef fish resources will be exacerbated by the degradation of coral reefs resulting from increasing sea surface temperatures and ocean acidification. The decline in reef fish availability is also expected to reduce the current per capita consumption levels (Table 2) with low-value fatty imported foods being used as a substitute, leading to potential increases in the prevalence of non-communicable diseases.

Rather than be reliant on imported food to fill the food-security gap, an alternative is increasing the access to, and local consumption of, tuna. To fill the food-security gap, tuna will need to provide 25 percent of all fish required by 2035 across the region. The use of nearshore aFADs is one of the few practical technologies for increasing the availability of tuna for small-scale fishers in most PICs. As a consequence, national governments need to consider nearshore aFADs as basic infrastructure for

[9] Source: Bell, J.D. *et al*. 2009. Planning the use of fish for food security in the Pacific. *Marine Policy* 33, 64-76, which based estimates of national fish consumption mainly on the information in Household Income and Expenditure Surveys (HIES) conducted in the countries between 2001 to 2006.

[10] Derived from Technical Study 2 (Table 17) based on the most recent HIES conducted in the countries between 2012 and 2020; n.a. = not available because HIES were not available from Fiji and Papua New Guinea.

[11] Bell, J.D., Albert, J., Andréfouët, S., Andrew, N.L., Blanc, M., Bright, P., Brogan, D., Campbell, B., Govan, H., Hampton, J. and Hanich, Q. 2015. Optimising the use of nearshore fish aggregating devices for food security in the Pacific Islands. *Marine Policy*, *56*, pp.98-105.

food security, i.e., to support small-scale fishers to catch tuna more efficiently to help fill the gap in domestic fish supply.

The locations of the additional aFADs to be deployed needs careful consideration - in some countries, a significant percentage of the aFADs will need to be close enough to shore to be accessible by fishers in paddling canoes. Other aFADs for use by fishers with power boats, can be placed further offshore where the catch rates of tuna are likely to be higher. The split between the number of aFADs needed for the two types of locations will vary by country and regions within a country, but generally, aFADs should be deployed in depths greater than 150 m to avoid aggregating reef-associated species. Communities and fishers should be consulted for local or traditional knowledge to assist in identifying suitable locations for aFAD deployments. Given the lack of fine resolution bathymetric information for most PICs, it is essential that selected sites are surveyed using GPS for position and echo sounder for depth, so a contour map can be drawn of the surveyed area. This will allow the most appropriate location to be identified within the surveyed area where the ocean floor gradient is not too steep and suitable for the aFAD anchor to secure and hold.

The current approach for implementing national aFAD Programmes is *ad hoc* across the region with little to no governance structure and limited government financial support. In the larger countries some provinces or states have aFADs based on the availability of funding, mainly through donor project funding. The estimated total number of nearshore aFADs across the region in late 2022 (~240) was comprised of varying numbers per country, from two in Niue to 46 in some provinces in Solomon Islands[12]. However, these estimates did not confirm the number of active aFADs in the water, so the actual number is very likely to be lower. Overall, the 333 aFADs to be initially installed and maintained during the Programme (refer Table 14) will significantly increase the supply of tuna and other pelagic fish for domestic food security. By the end of the Programme in 2030, it is estimated that FADs could provide up to an additional 13,320,000 fish meals of 150 g per year for the benefit of ~560,000 people.[13]

The purpose of this study is to support an initiative to improve the food security of rapidly-growing coastal communities in the Pacific Islands region through upscaling the use of nearshore aFADs to increase the supply of tuna and coastal pelagic fish caught by small-scale fishers for local consumption.

Increasing the supply of these species will assist in supplementing food security through the provision of additional fish from sources other than reef fisheries. Productivity from reef fisheries is expected to decline in locations close to urban populations due to increasing fishing pressure on these habitats and more broadly throughout coastal areas within the region as a result of coral reef degradation due to ocean warming and acidification.

The structure of this report follows the requirements of the terms of reference for this study and covers both the national and regional components (Annex A). The introduction and background (section 1) provide demographics for the 14 participating PICs and a snapshot of aFAD deployments in these countries in the early 1980s, 2003 and again in 2022. This also includes some context around the use of nearshore aFADs to increase the catch of tunas and other pelagic species in support of food security given the projected decline in domestic reef fish and invertebrate production. The process (section 2) undertaken for the study is then presented, followed by a

[12] Numbers based on the audit undertaken for this study.

[13] Annex T: Method for measuring the contribution of strengthened national aFAD Programmes to domestic food security.

section (3) covering the projected climate change effects and possible adaptation approaches that can be employed.

The results of the aFAD Programme audit in all 14 PICs are presented (section 4) covering aFAD staff capacity, the management and governance structure including data collection, end-user engagement and partnerships, and funding sources for national aFAD Programmes. This analysis provides the baseline of the aFAD Programme in each country. The audit results for national sea safety support are also provided including governance structure and capacity, training and awareness-raising. A synthesis of the audit results is then presented (section 5). It includes the current gaps with recommendations to fill the identified gaps. This covers the number of aFADs to be deployed to scale-up the national aFAD Programme, national staffing needs and the location or provinces to be targeted. An activity plan with budget is then provided to cover all national aFAD Programme activities to be undertaken by the Project. A risk assessment, a summary of the locations where the intervention will be implemented and estimates of beneficiaries in each country provide the basis for the final part of section 5.

The regional component is then presented (section 6) with an introduction and background for the proposed activities and staffing needs. Activities cover both specific regional activities and linkages to national activities to assist PICs to implement their activities and provides training and other technical support, including the procurement of all materials and equipment for shipping to PICs. An activity plan and budget for the regional component is also presented. The overall activity plan and budget for both national and regional components is then presented (section 7) by activity. Finally, there are a series of annexes including individual country profiles for each of the 14 participating countries (Annexes F to S).

eg1.1 Fish aggregating device (FAD) Programmes in the Pacific Island countries

FADs have been used in the PICTs since the late 1970s/early 1980s. A summary of the deployment situation in the early 1980s is presented in Table 3.[14]

Table 3: Summary by country of FADs deployed, reported or presumed lost, and planned, with estimated average cost/unit from 1979 to March 1983.

COUNTRY	FADs			
	Deployed	Lost	Planned	Approx. Cost/ Unit US$
American Samoa	22	20	4	5000
Australia	10	4	N/A	various
Cook Islands	6	4	20	3000
Fiji	208	182	175	1000–1500
French Polynesia	11	8	19	5500
Guam	10	9	–	4500
Hawaii	59	4	39	4500
Kiribati	5	3	N/A	600
Northern Marianas	5	5	–	N/A
New Caledonia	6	N/A	N/A	N/A
Niue	5	0	N/A	3000
Palau	6	6	6	3600
P.N.G.	76	76	N/A	N/A
Solomon Islands	132	88	20	2000
Tokelau	1	1	N/A	N/A
Tonga	2	2	2	3000
Tuvalu	–	–	2	N/A
Vanuatu	3	–	N/A	N/A
Western Samoa	37	22	Replacement Only	3000
TOTAL	604	434	287	3000

[14] Boy, RL and Smith, BR. (1984). Design improvements to FAD mooring systems in general use in Pacific Island countries and territories. South Pacific Commission (SPC) Handbook No. 24 (1984).

The FAD designs varied across the different countries. A feature of this experience was that there were many losses as indicated in Table 3, with approximately 80 percent of losses occurring within 12 months. The large number of deployments in Fiji, Solomon Islands and PNG (around 70 percent) were associated with industrial tuna fishing activities, primarily pole-and-line operations with some purse seining. In 1980, SPC started to provide assistance to the PICTs with aFAD design using a combination of negatively buoyant nylon rope for the upper mooring, spliced onto positively buoyant polypropylene rope for the lower mooring line, with a catenary curve forming at the connection of the two rope types[14]. SPC also promoted two surface float designs or arrangements, the spar buoy and the SPC modified Indian Ocean aFAD raft (Figure 2).

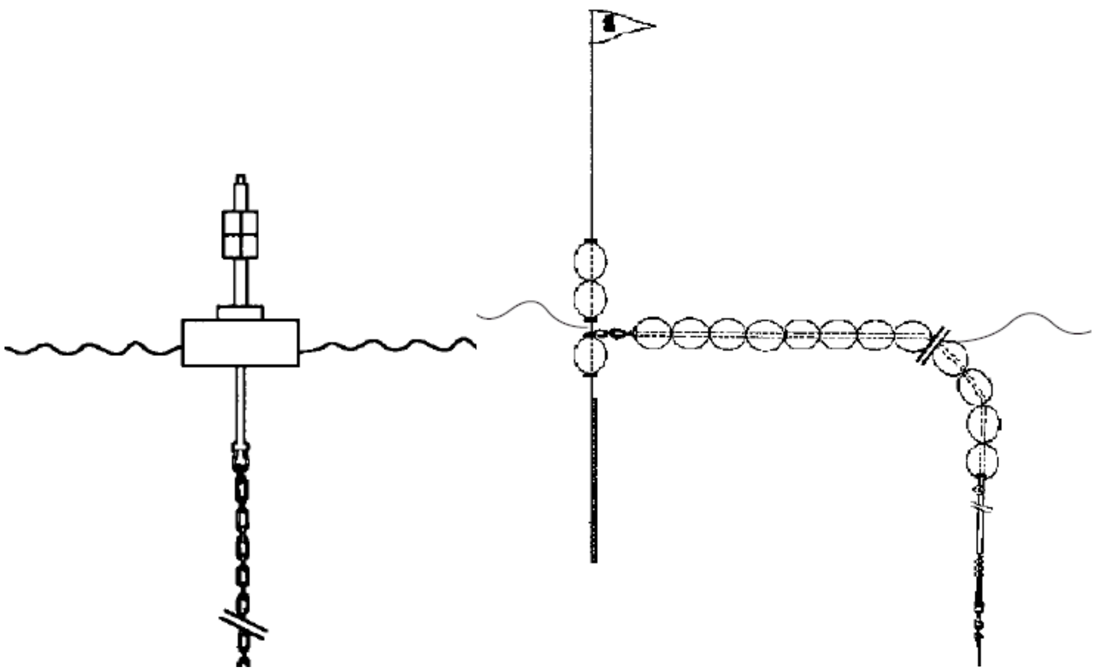

Figure 2: SPC recommended aFAD surface float arrangements with spar buoy (left) and SPC Indian Ocean aFAD raft (right) designs. [15]

PICTs continued with their aFAD activities, with many adopting the SPC recommended mooring and surface float designs. It soon became apparent that the construction of spar buoys was too expensive, so the main buoy system used was the SPC Indian Ocean raft system. Some design faults were corrected in the late 1980s and early 1990s, and by the end of the 1990s, pressure floats were being added to the string of surface floats, alternating with the purse seine floats, and the design evolved into the Indo-Pacific aFAD float system or design. Unfortunately, countries did not keep good records on the designs they used or when they were lost. Also, countries did not collect information on the number of fishers using the aFAD or the catch and effort from the fishers. Some countries continued with aFAD Programmes for their small-scale tuna fishers and others did not.

In 2003/2004, SPC undertook another review of the FAD Programmes across the PICTs and provided a snapshot of the number of FAD Programmes and the number of active FADs in the water in

[15] Gates, P., Cusack, P. and Watt, P. (1996). SPC FAD manual volume II: Rigging deep-water FAD moorings. SPC, Noumea, New Caledonia. 43pp.

September and October 2003.[16] Table 4 summarises the state of FAD Programmes in PICTs in 2003 including planned FAD activities for the next 6-12 months at the time. Of the approximate 882 FAD in the water at the time at least 750 were for industrial fishing operations in PNG and Solomon Islands and not specifically for artisanal fishers.

Table 4: Summary of FAD Programmes and the status of active FADs in the water in September-October 2003 plus planned deployments.

Country/Territory	FAD Programme in place including maintenance.	Number of FADs in the water (at Sept-Oct 2023)	Planned deployments in next 6 months
American Samoa	Ongoing programme	4	1 deep and 7 shallow
Cook Islands	Ongoing programme	17	2 in outer islands + replacements.
Federated States of Micronesia	No active programme	0	2 States with materials and will deploy soon.
Fiji Islands	Ongoing, mainly off Suva	Unspecified	Some deep-water FADs
French Polynesia	Ongoing programme	21	25 planned deployments.
Guam	Ongoing programme	16	Replacement within 2 weeks
Kiribati	Ad hoc/as needs basis	Several	None - no materials
Marshall Islands	No ongoing programme	1	None - no materials
Nauru	Re-activated in 2003 but not maintenance	3	None planned
New Caledonia	Ongoing programme	5	Possibly in early 2004.
Niue	Ongoing programme	14	3 planned + replacements
Northern Mariana Islands	Ongoing programme	3	4 in early 2004
Palau	Separate government and 2 company programmes	24	Companies replace for industrial operations.
Papua New Guinea	No government programme just purse seine companies	600-700	Purse-seine companies maintain FAD numbers
Pitcairn	No programme at all	0	Nothing planned
Samoa	Re-activated in 2002	3	5 in early 2004
Solomon Islands	No government programme just pole-and-line companies	Around 100	Companies replace when needed.
Tokelau	No ongoing programme	0	6 planned for early 2004
Tonga	Re-activated in 2022	18	several planned + replace
Tuvalu	No active programme	0	None - no materials/funding
Vanuatu	Ad hoc programme to change in 2004	2	14 planned with new funding available
Wallis and Futuna	No active programme	1	New funding in 2004
TOTAL	12 active/ongoing	882	69 + replacements

After 2003, SPC continued to refine the aFAD designs to support PICTs with their aFAD Programmes. SPC also undertook some research in Niue and the Cook Islands on different aFAD mooring line systems with some modification made to the SPC recommended designs and published a new aFAD

[16] Chapman, L. 2004. Nearshore domestic fisheries development in Pacific Island countries and territories. Information Paper 8, 4th Heads of Fisheries Meeting, Pacific Community, Noumea, New Caledonia.

manual in support of this.[17] PICTs continued to develop their aFAD Programmes, but this was mainly *ad hoc* when countries had access to donor funding to purchase the necessary materials.

Countries had not implemented a structured approach to their aFAD Programmes at that time. A governance structure and data and information collection systems and processes, as would be described in a formal aFAD Management Plan, were lacking. This resulted in a lack of data on the numbers of aFADs deployed since the 2003 snapshot report and no catch and effort data for artisanal fisheries operating in association with aFADs. This situation was highlighted during the audit of the aFAD Programmes in the 14 PICs completed during this Study (Table 5).[18]

Table 5: The number of active aFADs in PICs, the governance structure or status of aFAD Management Plans or policies, and associated maintenance schedules reported during this Study.

Country	aFAD Programme with Management Plan or policy in place.	Number of aFADs in the water late 2022/early 2023	Planned maintenance
Melanesia			
Fiji Islands	Draft aFAD plan underway, but early stages.	22	No regular maintenance
Papua New Guinea	Starting work on an inshore aFAD policy but early stages.	Around 40	Maintenance is ad hoc with the communities.
Solomon Islands	Have a policy in place but needs review and updating.	46	Do maintenance after 6-months.
Vanuatu	Have draft aFAD Strategy which is being finalised.	25	Monthly maintenance by fisheries officers.
Micronesia			
Federated States of Micronesia	aFAD Programme in Pohnpei but no plan/policy in FSM	2 in Pohnpei and 8 in Chuuk lagoon	1-2 months when there are aFADs.
Kiribati	aFAD Programme with draft plan that needs reviewing.	Around 35	Maintenance 3-monthly where fisheries staff located
Marshall Islands	Have draft aFAD Management Plan that needs updating.	9	Ad hoc with fishers reporting any damage.
Nauru	Draft Nauru National FAD Strategic Development Plan	2	Monthly checking of aFADs
Palau	Internal management plan in place but not formalised.	7	Every 3 months.
Polynesia			
Cook Islands	aFAD Programme with draft policy action plan.	28	1-2 months for maintenance based on location
Niue	Ad hoc, nothing drafted.	10	Every 3 months.
Samoa	Have an aFAD Management Plan but this needs revising.	5	2-3 times per year with limited funds.
Tonga	Have an aFAD Policy and developing an aFAD plan.	17	Monitor and maintain on a quarterly basis.

[17] Chapman, L., Pasisi, B., Bertram, I., Beverly, S., and Sokimi, W. (2005). Manual on FADs: Low-cost moorings and programme management. SPC, Noumea, New Caledonia. 49pp.
[18] Data collected during the audit of FAD Programmes in late 2022 through early 2023 as part of the work being presented in this report.

Tuvalu	Draft plan available and needs finalisation.	5	Once per year.

In 2022, the Food and Agriculture Organisation (FAO) of the United Nations funded an aFAD effectiveness study for some PICTs and the operation of small-scale tuna fishers.[19] There was no climate change focus in this study, however, some of the findings still apply in general to implementing an effective aFAD Programme in a Pacific Island country, especially those that are vulnerable to climate change effects. The relevant findings were:

- ***aFADs***: A general conclusion from many years of experience in fisheries development efforts throughout the Pacific Islands is that aFADs are one of the few innovations that support small-scale fishers to economically take advantage of the region's large tuna resources. Although there is a consensus that aFADs are effective, quantitative evidence of this effectiveness has not been compiled.
- ***Relationship between aFAD Programme institutionalization and aFAD effectiveness*****:** It is now generally accepted that national aFAD activities are most effective where there is a national aFAD Programme that is integrated into the government fisheries agency – rather than a project that comes/goes with the availability of funding, pressure from fishers, or the availability of external aFAD services. In addition, an ongoing aFAD Programme within a fisheries agency allows for greater continuity of aFAD work, in-house training, successful technology transfer to staff, and a mechanism for interaction with stakeholders. By being an established unit inside a fisheries department (rather than a project with no permanent staff), there is likely to be greater stability of funding. Without institutionalization, the process of learning from past aFAD-related mistakes is more difficult.
- ***Stakeholder input***: Several studies[20] indicate that formal input of aFAD users is important for aFAD effectiveness, with the general situation being summed up as "Involving local fishers in the site selection process is important. This local knowledge can also increase the effectiveness of aFAD through deployment at productive fishing grounds. The community engagement process also requires mechanisms to support conflict and dispute resolution."
- ***Institutionalization of aFAD activities***: The important aspects of institutionalization that relate to aFAD effectiveness studies are; a) there may be less need for aFAD effectiveness studies after institutionalization of aFAD activities into a government fishery agency, and b) of the factors that influence aFAD effectiveness, several (greater continuity of aFAD work, more retention of aFAD skills, better skills for teaching aFAD fishing, and a mechanism for interaction with stakeholders) require aFAD institutionalization, or are enhanced with institutionalization.
- ***Other messages***: aFAD fishing skills are important for almost all the dimensions of a FAD effectiveness; and fisher inputs into aFAD Programme design are also important for many dimensions of aFAD effectiveness.

There are no regional policies, plans or strategies that cover artisanal aFAD Programmes for small scale fishers because this is a national issue. SPC provides technical assistance, information and

[19] Gillet, R. 2023. Fish aggregating devices for small-scale fishers - The report of a study of FAD effectiveness in Pacific Islands countries. FAO. Apia.

[20] a) SPC. 2017. Sustainable National Artisanal FAD Programmes: what to aim for. Pacific Community. b) Gillett, R., M, Blanc., I, Cartwright., M, Batty., M, Savins., J, Albert., M, Tanetoa., N, Idechong., T, Emberson., and W, Sokimi. 2018. Forty Years of Small-Scale Tuna Fishery Development in the Pacific Islands: Lessons Learned. Fisheries Newsletter Number 157 (September–December 2018), Pacific Community, pages 60-68. c) Albert, J., and Sokimi, W. 2016. Sharing Pacific Nearshore FAD Expertise. SPC Fisheries Newsletter #150 - May–August 2016, Pacific Community.

training to support national aFAD Programmes and SPC has assisted with the drafting of several national aFAD Management Plans, but most remain in a draft form.

2. Process

The Pacific Community (SPC) advertised a series of Technical Studies to support the preparation of a Funding Proposal for submission to the Green Climate Fund (GCF) titled: Adapting tuna dependent Pacific Island communities and economies to climate change on 19 May 2022 under RFP22-3866. The closing date for bids was 16 June 2022. Study 3: "Feasibility of scaling-up National Fish Aggregating Device (FAD) Programmes in all 14 participating countries" was contracted to Lindsay Chapman Consulting Pty Ltd on 8 September 2022 (SPC contract No CS22-4392), with the delivery date of the final report being 30 September 2023. On 31 August 2023 the contract (CS22-4392) was amended to include the regional component of the FAD Project and the delivery date for the final report was extended to 31 December 2023. The terms of reference for this consultancy are at Annex A.

A workshop was held in Noumea on 27 and 28 September 2022 to bring all lead consultants for the different studies together to outline their work and planned approach. This allowed good discussion around the different studies and how they link together. Under Technical Study 3, a travel budget was agreed to allow up to seven countries to be visited for information gathering and discussion to develop an activity plan and budget for activities that would be incorporated in the GCF Funding Proposal.

Research was then undertaken to identify the climate change risks for each of the 14 participating countries and where aFADs could help communities and governments adapt to the expected climate change effects in terms of increasing access to tuna and other pelagic fish species to improve the food security of rapidly growing coastal communities in the Pacific Island region. The scope of research ranged from entire atoll countries like Tuvalu to provinces or states in the larger countries like PNG and FSM.

Collaboration with SPC staff responsible for aFAD assistance to SPC member countries resulted in a review of the SPC checklist for a sustainable aFAD Programme[21] to include sea safety and related areas. The agreed questionnaire (Annex B) was then used to audit the aFAD Programmes across the 14 participating countries by interviewing key FAD personnel in each country via a virtual Zoom meeting and completing the questionnaire together. At the same time, an audit was completed on sea safety legislation and requirements in each country using a standard questionnaire. A list of people consulted in each country is provided at Annex C.

An analysis of the completed questionnaires identified gaps and areas for improvement to national aFAD and sea safety Programmes in each of the 14 countries. The analysis provided the basis for developing activity plans and associated budget for each of the 14 countries, where implementing or strengthening aFAD Programme and sea safety activities would assist participating communities to adapt to identified climate change risks and vulnerabilities. This information was compiled with background demographics, past aFAD activity information, projected climate change impacts and vulnerabilities, and proposed aFAD designs, into individual country profiles with an accompanying activity plan and budget (Annexes F to S).

[21] Policy Brief 31/2017 – Matrix for assessing progress towards a sustainable national FAD Programme, download from: https://purl.org/spc/digilib/doc/t3ume

In August 2023, the consultancy was expanded to include a regional component. This component will provide the logistical and technical support for the national and in-country work and expand the capacity development activities. Financial support was included to strengthen the data collection and analysis component and allow for aFAD effectiveness studies to be undertaken to support efforts to address some of the long-standing assumptions around relieving fishing pressure on reef fish resources and transferring this fishing effort to small-scale tuna fishing around aFADs.

3. Climate change effects on coastal fish habitats and coastal fish production

The coastal fisheries sector in Pacific Island countries, which has traditionally been a cornerstone of food security across the region[22], is vulnerable to the direct and indirect effects of global warming. Assessments made within the past decade conclude that rising sea surface temperatures (SST) directly threaten the growth, survival, recruitment and distribution of many fish species associated with coastal habitats, particularly coral reefs[23,24,25,26,27]. The various ways in which continued greenhouse gases (GHG) emissions are damaging these coastal habitats (Table 6) is reducing the shelter and food available for many coastal fish species, indirectly reducing their growth, survival and recruitment. The combined direct and indirect effects of climate change on the productivity of coastal fisheries are exacerbating the reduced access to fish for food security occurring in many coastal and urban communities in the region due to rapid population growth, and impeding the steps being taken to combat the high incidence of non-communicable diseases in many Pacific Island countries through the promotion of healthy diets.

Table 6: Summary of the projected effects and impacts of increased greenhouse gas emissions on coastal fish habitats in the Pacific Island region documented by various previous assessments.

Effect	Impact
Increased coral bleaching due to higher sea surface temperatures	Degradation of coral reef ecosystems
Higher rainfall and runoff	Increased turbidity in coastal waters, 'smothering' corals and sea grasses with sediment and limiting/preventing photosynthesis
Increasing ocean acidification	Reduced availability of carbonate required by corals and other calcifying organisms to build skeletons/shells

[22] SPC (2008). Fish and Food Security. SPC Policy Brief 1/2008. https://pacificdata.org/data/dataset/oai-www-spc-int-ced24e95-7e0a-401a-9f0b-d79316c49cb0

[23] Vulnerability of tropical Pacific fisheries and aquaculture to climate change (Chapter 9), Website: https://www.spc.int/DigitalLibrary/Doc/FAME/Reports/Bell_11_Vulnerability_Pacific_Fisheries_to_Climate_Change.pdf

[24] Barange, M. et al. (2018) Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Paper 627. https://www.fao.org/3/i9705en/i9705en.pdf

[25] IPCC (2018) Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf

[26] Website: https://pdf.usaid.gov/pdf_docs/PA00ZK1R.pdf

[27] Website: https://www.dfat.gov.au/sites/default/files/pacific-risk-profile_pacific-region.pdf

Stronger cyclones and increased storm surge	Greater damage to coral reefs and other coastal fish habitats
Sea-level rise	Loss of mangrove habitats where there is no scope for landward migration, and loss of deeper margins of coral and seagrass habitats due to reduced photosynthesis

3.1 Projected climate change risks and effects on coastal fish production across the 14 PICs

The analyses in Technical Study 1[28] also confirm that coastal fish habitats, and coastal fish stocks, across the region are vulnerable to continued greenhouse gas emissions.

The area of coral reef habitat projected to have a high or very high vulnerability to damage from ocean warming and acidification by 2050 under the SSP5-8.5 emissions scenario ranges from 0-80.8 percent. The areas of seagrass and mangrove habitat in the region expected to have a high or very high vulnerability to damage from the same level of global warming by 2050 range from 0-29.5 percent and 0-28 percent, respectively.

The productivity of costal fisheries is projected to decline in all but one country by up to 82.5 percent by 2050 under SSP5-8.5 due to the direct and indirect effects of climate change, with considerable variation among countries. The reduced availability of coastal fish species for local consumption will create a shortfall in the supply of fish needed to provide Pacific Island communities with 50 percent of their daily protein requirement, as recommended by SPC's Public Health Division (Technical Study 2) or maintain the traditionally higher levels of fish consumption in several PICs. The extent of the shortfall in fish supply varies considerably among countries by 2050 under the SSP5-8.5 emissions scenario.

3.2 Adaptation alternatives

Options for filling the gap in fish supply driven by population growth and degradation of coral reefs and other coastal fish habitats due to climate change are limited. Aquaculture has been developed only to a minor extent in the region, and although small-pond tilapia farming promises to be easy for households and small and medium enterprises, it does not have the potential to go anywhere near filling the gap in fish supply for most PICs[29]. The rich tuna resources of the region are the only fisheries resource with potential for meeting the large demand for fish. As a consequence of rapidly-growing national populations alone, it has been estimated that tuna will need to provide 25 percent of the fish required for domestic food security of coastal and urban communities across the Pacific Island region by 2035.[30] Even higher quantities of tuna will be needed as time goes by due to further population growth and climate-driven reduction in coastal fisheries production. There are three main options for increasing access to tuna.

1. Develop domestic tuna longlining and pole-and-line fishing operations. Pole-and-line operations have operated in several Pacific Island countries over the years; however, none are operational in 2023 and this industrial fishing method is not considered viable in the

[28] Results from Study 1: Assessment of the vulnerability of Pacific Island communities and economies to the effects of climate change on fisheries, Tables 1, 2 and 3.
[29] Vulnerability of tropical Pacific fisheries and aquaculture to climate change (Chapter 11), Website: https://www.spc.int/DigitalLibrary/Doc/FAME/Reports/Bell_11_Vulnerability_Pacific_Fisheries_to_Climate_Change.pdf
[30] Bell, J.D. et al. (2015). Diversifying the use for tuna to improve food security and public health in Pacific Island countries and territories. *Marine Policy*, *51, 584-591.*

current context. Longlining to supply fish for domestic consumption has been trialled in some countries but has generally been assessed to be non-profitable given the relatively high cost of constructing and operating longline fishing vessels, and local prices paid for longline-caught tuna and bycatch compared to the prices that can be obtained by exporting the fish.

2. Use of bycatch from purse-seine fishing. This will be a workable solution for at least six of the participating countries where transshipment of tuna occurs regularly. This is the subject of Technical Study 5 and is not considered further here.

3. Scaling-up the use of aFADs to ensure that they become a permanent part of national infrastructure for food security. This will enable small-scale fishers to progressively transfer more of their coastal fishing effort from reef fish to tuna and other pelagic fish. As explained earlier in this report, aFADs are currently being used in all PICs to varying degrees, but the approach to using this cost-effective technology is *ad hoc* at present and needs to be restructured and strengthened.

Considered against the options available, the most appropriate adaptation for increasing access to fresh fish for the food security of coastal communities across the region, and urban communities in the smaller countries, is to strengthen national aFAD Programmes. Such investments will provide increased opportunities for small-scale fishers to catch tuna and other large pelagic fish in nearshore waters and improve the food security of vulnerable communities.

4. National assessments

4.1 The aFAD Programme assessments based on the SPC matrix

Assessments of aFAD Programmes in all 14 participating PICs were undertaken from October 2022 to March 2023, with one assessment undertaken face-to-face and the others conducted virtually via Zoom meetings. The assessment used the SPC "*Matrix for assessing progress towards a sustainable FAD Programme*" in Policy Brief No. 31/2017.[31] The matrix covers four themes; capacity (technical and operational capacity), management (policy, institutional administrative and managerial support), end-user engagement (partnerships, communication and awareness-raising) and funding (government, donor and possible cost-sharing). The score is a self-assessment by national fishery agency personnel engaged in FAD-related activities in each of the 14 countries. The rankings are: 100 percent = fully sustainable (meaning the national aFAD Programme receives on-going institutional and financial support in these areas); 50 to 99 percent = on the way to sustainability (meaning the national fisheries agency is increasing the personnel and financial resources assigned to the national aFAD Programme but that supplementary support is still required from external sources in these areas); and 0 to 49 percent = activities are *ad hoc* (meaning there is no national established, on-going programme of support for the identified aFAD-related activities, and activities generally only occur on an opportunistic basis).

4.1.1 Capacity for aFAD work

Table 7 summarises the assessment for national capacity for undertaking aFAD work in each of the 14 participating PICs. The individual score by country can be found in Annex D. Most countries

[31] Policy Brief No. 31/2017: Sustainable national artisanal FAD Programmes – what to aim for: Website: https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/Anon_17_PolicyBrief31_FAD_Programmes.pdf

assessed themselves as working towards being sustainable in some areas, while others felt the in-country capacity remained *ad hoc*/under-developed.

Table 7: Summary of assessment of national capacity to support national aFAD Programmes across 14 PICs (values in table indicate the number of countries in each category)

Matrix for assessing progress towards a sustainable national aFAD Programme - criteria	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
1. Capacity			
1.a Country-based experts are available to manage the aFAD Programme including the rigging and deployment of aFADs.	1	12	1
1.b The national fisheries agency owns or has easy access to the infrastructure and equipment required to deploy aFADs (e.g., suitable boat with echo-sounder and GPS).	2	11	1
1.c Depending on the size of the country, one or more recurrent positions at the national fisheries agency are fully or partly dedicated to aFAD work and this is reflected in job descriptions.	2	9	3
1.d A succession training plan is in place to ensure that the country does not lose its aFAD technical capacity when the existing aFAD experts move out or retire.	5	9	0

4.1.2 Management to support aFAD work

Table 8 summarises the assessment of management to support national aFAD Programmes in each of the 14 participating PICs. The individual score by country is presented in Annex D. Half of the countries assessed themselves as being sustainable regarding political support for management of the aFAD Programme and having high-level policies and strategies that reflect this. Overall, most countries were progressing towards sustainability across the management criteria, and many have draft aFAD Management Plans or policies that need to be reviewed and updated. The majority of countries also have some legislation in place to support their aFAD Programme, although many thought this needed to be strengthened. Half of the countries only had *ad hoc* arrangements in place for monitoring aFADs and recording catch and effort from around the aFADs, with only one country ranking themselves as sustainable in this area.

Table 8: Summary of assessment of current management support to national aFAD Programmes across 14 PICs (values in table indicate the number of countries in each category)

Matrix for assessing progress towards a sustainable national aFAD Programme - criteria.	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
2. Management			
2.a Political stakeholders understand the contribution of nearshore aFADs to food security and livelihoods.	2	5	7
2.b The national fisheries agency has strategic plans or policies that mention nearshore aFADs and the aFAD Programme.	1	7	6

2.c A registry is used to record aFAD deployments and keep track of lost aFADs that need to be replaced.	1	9	4
2.d Legislation and regulations are in place and enforced to support the national aFAD Programme and to clarify the roles and responsibilities of aFAD users.	4	8	2
2.e The national fisheries agency has a nearshore aFAD Management Plan or policy to guide its aFAD work.	2	12	0
2.f A monitoring framework is in place that captures fishers' use of aFADs and/or catches at representative sites.	7	6	1

4.1.3 End-user engagement

Table 9 summarises the assessment of end-user engagements in the aFAD Programmes in each of the 14 participating PICs. The individual score by country can be found in Annex D. Most countries ranked themselves as on the way to sustainability regarding end-user partnerships, having effective feedback mechanisms in place and awareness-raising and training around aFADs and aFAD fishing skills. Only one country assessed itself as supporting conflict resolution processes including codes of conduct for harmonious use of aFADs by multiple stakeholders that are sustainable.

Table 9: Summary of assessment of end-user engagement in the national aFAD Programmes for 14 PICs (values in table indicate the number of countries in each category).

Matrix for assessing progress towards a sustainable national aFAD Programme - criteria.	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
3. End-user engagement			
3.a Partnerships are developed with end-users (e.g., communities, fishers' associations, sports fishing charters, recreational fishers) for the ownership, co-management and potential cost-sharing of aFADs.	3	8	3
3.b An effective feedback mechanism exists between the national fisheries agency and aFAD end-users.	2	10	2
3.c aFAD awareness-raising and training in sustainable FAD fishing methods and safe aFAD-fishing methods are undertaken in communities that are newly exposed to aFADs.	0	12	2
3.d Conflict resolution protocols are in place and effective.	8	5	1

4.1.4 Funding for national aFAD Programmes

Table 10 summarises the assessment of funding that is in place to support the national FAD Programme in each of the 14 participating PICs. The individual score by country can be found in Annex D. No country considered that it had sustainable funding for the aFAD Programme. Most countries advised that they are making progress towards sustainability but three advised that only *ad hoc* financing arrangements apply. Most countries ranked themselves as on the way to sustainability with donor funding supplementing government funding. Some countries reported that an internal budget is available to support the national aFAD Programme although this was assessed as being inadequate for running a suitable aFAD Programme. Most countries advised that co-financing was *ad hoc* and were interested in exploring co-financing opportunities.

Table 10: Summary of assessment of funding for national aFAD Programmes for 14 PICs (values in table indicate the number of countries in each category).

Matrix for assessing progress towards a sustainable national aFAD Programme - criteria.	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
4. Funding			
4.a The government provides the national fisheries agency with a recurrent annual budget for the implementation of its aFAD Programme.	3	11	0
4.b Donors and/or the government provide occasional funding for aFAD projects.	2	10	2
4.c Partnerships with end-users are in place, which include aFAD cost-sharing.	8	6	0

4.2 Assessment of small craft sea safety based on questionnaire

An assessment of the sea safety requirements for small craft and fishers was undertaken at the same time as the aFAD assessment. This was a complimentary task given fishers are being encouraged to fish outside the reef and offshore around aFADs, which raises potential sea safety concerns. The questionnaire used was developed specifically for this task in collaboration with SPC staff. The score is self-assessed by each country with the rankings being 100 percent equal to fully sustainable, 50 to 99 percent on the way to sustainability and 0 to 49 percent indicating activities are *ad hoc*.

4.2.1 Sea safety requirements

Table 11 summarises the assessment of national sea safety requirements for small craft in each of the 14 participating PICs. The individual score by country can be found in Annex E. Five countries ranked themselves as being sustainable regarding national legislation and regulations relating to qualifications for operating small craft (<12 m length) and sea safety requirements, while four considered that an *ad hoc* approach had been taken to meeting sea safety standards. Most countries were either *ad hoc* or on the way to sustainability when it came to training facilities and trainers for small craft sea safety, i.e., required sea safety equipment was available in-country for purchase, and there were suitable facilities and skilled personnel for maintaining sea safety equipment.

Two countries ranked themselves as sustainable regarding small craft minimum specifications for design and construction while seven advised a status of *ad hoc*, with some of these advising that no national provisions existed in this regard. Most countries reported that they are on the way to sustainability regarding a good working relationship between national fisheries and maritime authorities, with three ranking themselves as sustainable. Eight countries ranked themselves as sustainable with the provision of aFAD locations to maritime authorities for updating maritime charts. Half of the countries ranked themselves as sustainable with sea safety search and rescue vessels and operational plans, with the other seven countries reporting they are on the way to sustainability.

Table 11: Summary of self-assessment of sea safety requirements for small craft across the 14 PICs (values in table indicate the number of countries in each category).

Matrix for assessing the status of national sea safety requirements for small craft (<12 m length) - criteria.	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
5. Sea Safety Requirements			
5.a Country has regulations in place covering qualifications for small craft (3-8 m in length) operators.	4	5	5
5.b Country has regulations on sea safety equipment that needs to be carried when small craft are heading to sea.	4	5	5
5.c Country has suitable training facility and trainers to provide training in qualifications and sea safety equipment use by small-scale fishers.	5	6	3
5.d Required sea safety equipment is available for purchase locally from public or private sector companies.	5	7	2
5.e Country has suitable facilities and skilled personnel for maintaining all sea safety equipment or has arrangements in place to have this done offshore.	7	6	1
5.f Country has required small craft minimum specifications for design and construction to ensure seaworthiness.	7	5	2
5.g Good working relationship and proper information exchange protocols exists between fisheries and maritime authorities around sea safety.	0	11	3
5.h National fisheries agency provide coordinates for anchored aFADs to Maritime for updating navigation charts for merchant vessels.	2	4	8
5.i Country has aFADs marked for easy location day (flagpole with flag) or night (light and radar reflector).	2	12	0
5.j Country has search and rescue vessels and plans in place when a small-scale vessel is reported missing.	0	7	7

4.2.2 Sea safety for fishers

Table 12 summarises the assessment of sea safety for fishers in each of the 14 participating PICs. The individual score by country can be found in Annex E. Three countries ranked themselves as sustainable regarding the promotion of the use of a sea safety checklist for small craft operators, with another nine countries on the way to sustainability and two *ad hoc*. Six countries ranked themselves as *ad hoc* when encouraging fishers to carry a second outboard. This was reported to be principally due to the cost of a second outboard engine which fishers could not afford and where there is no legal requirement in place to do this. Similarly, five countries ranked themselves as *ad hoc* regarding encouraging fishers to carry paddles and/or sail rig when fishing outside the reef, while four countries ranked themselves as sustainable in this regard.

Table 12: Summary of national fisheries agency self-assessment of sea safety support for small craft fishers across the 14 PICs (values in table indicate the number of countries in each category).

Matrix for assessing the status of national sea safety requirements for small craft (<12 m length) - criteria	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)
6. Sea Safety for Fishers			
6.a Fisheries agency uses and promotes the SPC sea safety checklist, or some form of checklist, and has this in local language for small-scale fishers.	2	9	3
6.b Fisheries agency encourages fishers to have a second smaller outboard for safety reasons.	6	6	2
6.c Fisheries agency encourages small-scale fishers to carry paddles and/or sail rig when fishing outside the reef.	5	5	4

5. Planned project activities to fill gaps to optimise potential to establish sustainable aFAD Programmes.

5.1 Country aspirations and aFAD numbers

As summarised in Section 4, all PICs have good to strong political support for a national aFAD Programme. In most countries this is confirmed in national development strategies, fisheries sector policies or other high-level documents. Several countries have support for aFADs included in legislation, although in some cases it is focused on drifting or anchored FADs for the offshore industrial tuna fishery and does not cover inshore aFADs for small-scale artisanal fishers. In other countries, the legislation is outdated and needs to be reviewed and updated. Most countries have commenced drafting an aFAD Management Plan or policy. Others have finalised policies or plans although many require review and updating (13 PICs). Only one PIC has not started the development of a national aFAD Management Plan or policy (Table 5).

Many of the draft aFAD Management Plans or policies do not specifically state the number of aFADs the country wishes to maintain. As a consequence, it is difficult to ascertain the aspiration of each country from these documents as they stand. During the audit of the national aFAD Programme for each PIC, some countries stated the number of aFADs they would like to see deployed and maintained. The range of aFADs desired differed significantly by PIC and the size of the country. PICs were focused on nearshore aFADs anchored at depths of 200 to 500 m, or offshore aFADs at depths of 1,000 to 1,500 m. Several countries have also deployed FADs at depths of 2,000 to 2,500 m.

5.2 Recommended aFAD designs

Much research and trialing has gone into aFAD designs over the last four decades, and SPC has been at the forefront of this work in the Pacific. The result is three main designs recommended for deployment in nearshore and offshore waters: the Indo-Pacific (Figure 3 left), the subsurface (Figure 3 right) and the lizard (Figure 4) designs. These three designs are proposed for use in the GCF Programme, recognizing that participating countries may have a preference for one or two of these designs.

The Indo-Pacific design incorporates a string of surface floats attached to negatively buoyant (sinking) nylon multistrand rope connected (spliced) into positively buoyant (floating) polypropylene multistrand rope which is attached to the anchor system. The length of rope used is around 25 percent longer than the depth of water the aFAD will be deployed in, with supplementary buoyancy added to the lower mooring line when aFADs are deployed in less than 1,500 m. A full description of the aFAD design and materials used has been published by SPC.[32]

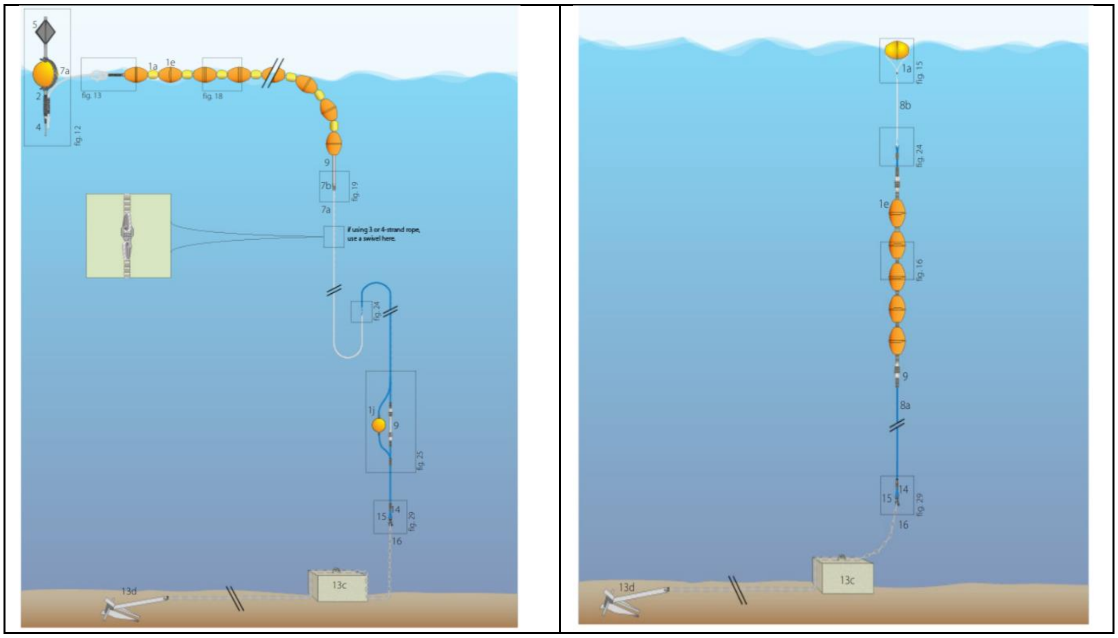

Figure 3: Indo-Pacific aFAD mooring design showing the upper floatation system used in offshore areas (left) and subsurface aFAD mooring design showing the temporary surface marker to aid fishers to locate the aFAD initially (right).[32]

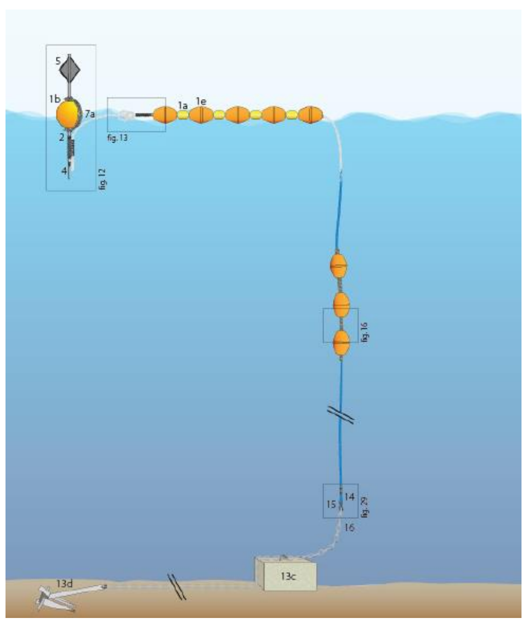

Figure 4: "Lizard" mooring design aFAD that combines features from both the surface Indo-Pacific design and subsurface design.[32]

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[32] Sokimi, W., M, Blanc., B, Colas., I, Bertram and J, Albert. 2020. Manual on anchored fish aggregating devices (FADs): An update on FAD gear technology, designs and deployment methods for the Pacific Island region. Pacific Community.

This subsurface design has the string of floats attached to polypropylene rope that is shorter than the depth of water the aFAD is being deployed in and is attached to the bottom by an anchor system. A small surface float is also attached with light nylon rope so that fishers are able to locate the aFAD initially and formulate their own landmarks for locating the aFAD when the surface float is removed.[32]

The lizard design incorporates a string of surface floats on negatively buoyant (sinking) nylon multistrand rope connected (spliced) into positively buoyant (floating) polypropylene multistrand rope which is attached to the anchor system. In addition, several pressure floats are attached to the upper end of the polypropylene rope the same as in the subsurface design. Therefore, if the surface float system is lost, the aFAD continues to operate as a subsurface design.[32]

The three aFAD designs continue to evolve with small changes or refinements to increase their lifespan, to use more environmentally friendly materials and to reduce the costs of materials wherever possible. Therefore, the actual design or designs to be used in each country will be decided between SPC and each country prior to the procurement of materials.

5.3 Addressing the gaps across the participating countries

This section describes a programme to address the gaps identified during the audit of the national aFAD Programmes in all 14 PICs undertaken from October 2022 to March 2023. Any area that was not ranked or scored as “sustainable” (100 percent) is considered a gap to be filled. The lower the ranking or score, the larger the gap to be filled. The 2-phased approach planned for each of the 14 participating countries is:

- ***Phase I***: Establish the institutional means to develop, implement and sustain a national aFAD Programme in a way that is applicable equally to countries which already have a national aFAD Programme, or countries with aspirations to establish one, and engaging broadly with stakeholders. This Phase includes the review and strengthening of relevant supporting national legislation and regulations, institutional resources and capacity, and general governance arrangements. A principal output will be a detailed description of the institutional and governance arrangements for a National aFAD Programme that provides for the development, or strengthening, of an aFAD Management Plan that will require endorsement from government prior its implementation.
- ***Phase II***: Operationalising the national FAD Programme, including implementation of the aFAD Management Plan to address all gaps identified in the 2022/23 audit of the national aFAD Programme. This includes the purchase of FAD materials and required equipment, training and capacity development, support for deployment and strengthening, or establishing new, monitoring/data collection systems.

5.4 Addressing aFAD Programme gaps

Table 13 presents the criteria for effective national aFAD Programmes and the number of countries that scored lower than sustainable (0 to 99 percent) for each area for their aFAD Programme covering capacity, management, end-user engagement and funding following the audits undertaken from October 2022 to March 2023. Suggestions on how to address the gaps, some of which will require financial support, are included. These are covered in the budget section (Table 17) of the report.

Table 13: Criteria for national aFAD Programmes and number of PICs scored at lower than sustainable (0 to 99 percent), with suggestions for addressing the identified gaps in the aFAD Programmes of the 14 PICs.

Criteria	Number of countries ranked at 0 to 99 percent	How to address
Capacity		
1.a Country-based experts are available to manage the aFAD Programme including the rigging and deployment of aFADs.	13	Support needed to strengthen the aFAD rigging and deployment expertise and budget needed.
1.b The national fisheries agency owns or has easy access to the infrastructure and equipment required to deploy aFADs (e.g., suitable boat with echo-sounder and GPS).	13	Need a budget for the purchase of suitable equipment including a deployment barge for some countries, GPS and echo sounder(s).
1.c Depending on the size of the country, one or more recurrent positions at the national fisheries agency are fully or partly dedicated to aFAD work and this is reflected in job descriptions.	11	Review staff job descriptions and ensure aFAD work is included for the appropriate staff. Internal process undertaken by government and no funding required.
1.d A succession training plan is in place to ensure that the country does not lose its aFAD technical capacity when the existing aFAD experts move on or retire.	14	Training programme to ensure aFAD expertise is passed on to other staff. Can also be written into the aFAD Management Plan. Budget needed.
Management		
2.a Political stakeholders understand the contribution of nearshore aFADs to food security and livelihoods.	7	Continue briefing political stakeholders on the importance of aFADs. Internal process.
2.b The national fisheries agency has strategic plans or policies that mention (and support) nearshore aFADs and the aFAD Programme.	8	Review and update strategic plans and policies as and if needed. Internal process.
2.c A registry is used to record aFAD deployments and keep track of lost aFADs that need to be replaced.	10	Review current aFAD registry and strengthen where appropriate. This may include some countries that scored 'sustainable' and will be covered in the national aFAD Management Plan budget.
2.d Legislation and regulations are in place and enforced to support the national aFAD Programme and to clarify the roles and responsibilities of aFAD users.	12	Review legislation and regulations and strengthen where appropriate in support of aFAD Programme. Strengthen enforcement capacity. Budget needed.
2.e The national fisheries agency has a nearshore aFAD Management Plan or policy to guide its aFAD work.	14	Strengthen, review and update current draft aFAD Management Plan or strategy and develop into a full aFAD Management Plan to guide the implementation of the aFAD Programme. Budget needed.
2.f A monitoring framework is in place that captures fishers' use of aFADs and/or catches at representative sites.	13	Work with SPC to strengthen or implement a suitable monitoring framework using SPC's new TAILS and IKASAVEA applications and approaches. Budget needed.
End-user engagement		

3.a Partnerships are developed with end-users (e.g., communities, fishers' associations, sports fishing charters, recreational fishers) for the ownership, co-management and potential cost-sharing of aFADs.	11	Incorporate in the aFAD Management Plan through an aFAD Advisory Committee so stakeholders are consulted and kept informed, so included in aFAD Programme budget.
3.b An effective feedback mechanism exists between the national fisheries agency and aFAD end users.	12	Incorporate in the aFAD Management Plan, including the process for feedback. Part of aFAD Management Plan budget.
3.c aFAD awareness-raising and training in sustainable aFAD fishing methods and safe aFAD-fishing methods for communities that are newly exposed to aFADs.	12	Establish or strengthen a training programme for both aFAD rigging and deployment including maintenance and aFAD fishing skills. Budget needed.
3.d Conflict resolution protocols are in place and effective	13	Incorporate in the aFAD Management Plan, including supporting processes. Part of aFAD Management Plan budget.
Funding		
4.a The government provides the national fisheries agency with a recurrent annual budget for the implementation of its aFAD Programme.	14	Support the sustainable financing mechanisms and assist with supplementary funding support in the short-term. Budget needed.
4.b Donors and/or the government provide occasional funding for aFAD projects.	12	Continue seeking donor support to supplement the sustainable financing mechanism for the national aFAD Programme in the short-term. Internal process.
4.c Partnerships with end users are in place, which include aFAD cost-sharing.	14	Incorporate in the national aFAD Management Plan. Part of the aFAD Management Plan review budget.

5.4.1 Number of aFADs for each country and targets for optimising the potential to establish sustainable aFAD Programmes by end of the Project

The size of the proposed aFAD Programme by country across the 14 PICs will vary. In the smaller countries, it will cover the whole country whereas in the larger countries it will be focused on one or two provinces or states. Where a province or state is to be chosen, discussions were held with the fisheries staff to identify the area's most vulnerable to climate change effects, acknowledging that in most cases the whole country is vulnerable. During national consultations associated with the audit of existing aFAD activities, countries identified the optimal number of aFADs and deployment preferences (such as locations and depths) under a future national aFAD Programme.

Table 14 summarises this information by country. A total of 528 aFADs are proposed for deployment across the 14 PICs. This comprised 333 aFADs for initial deployment, with an additional 195 replacement aFADs over the life of the Programme to maintain the overall addition of 333 aFADs. The deployment depths fell into three ranges; 200-500 m, 800-1,400 m and 1,500-2,500 m.

All countries will also receive additional floats, shackles and swivels for maintaining the aFADs. In addition, 40 aFADs will be stored in cyclone-proof storage, half in Suva, Fiji (15 for 200-500 m and 5 for 800-1,400 m) and the other half in Port Vila, Vanuatu (20 for 800-1,400 m), for use as part of rapid response following a cyclone in those countries. These provisions were incorporated into the budget for each country as part of the country profiles (Annexes F to S). It is also presented in the overall national budget for the Programme in the budget section of this report (Refer Table 17, Activity 2.6).

Table 14: The proposed locations and number of aFADs for the initial deployment and replacements, with the depth range to be deployed. Note: this does not include the 40 aFADs reserved for cyclone storage.

Region and country	Location for Project aFADs	Number of aFADs to be deployed			Number of aFADs by depth		
		Initial deployment	Replacement aFADs	Total	200-500 m	800-1,400 m	1,500-2,500m
Melanesia							
Fiji (Annex F)	Southern Central and Eastern Divisions	40	20	60	43	17	
Papua New Guinea (Annex G)	Manus and AROB (Bougainville) provinces	36	18	54	45	9	
Solomon Islands (Annex H)	Temotu Province and north coast of Guadalcanal	20	13	33	24	9	
Vanuatu (Annex I)	Shefa and Tafea provinces including Port Vila	34	17	51		51	
Micronesia							
Federated States of Micronesia (Annex J)	Pohnpei and Yap States	24	16	40	24	16	
Kiribati (Annex K)	Gilbert Islands Group	38	19	57	27	30	
Marshall Islands (Annex L)	All Marshall Islands except 3 atolls with populations <100.	27	13	40		40	
Nauru (Annex M)	All country	12	6	18	12		6
Palau (Annex N)	All Palau except Sonsorol, and Hatohobei	16	16	32		16	16
Polynesia							
Cook Islands (Annex O)	Southern Cook Islands Group	20	14	34	15	19	
Niue (Annex P)	All country	14	6	20	13	7	
Samoa (Annex Q)	All country	18	15	33		15	18
Tonga (Annex R)	Tongatapu, Eua and Ha'apai Group	20	14	34	17	17	
Tuvalu (Annex S)	All country	14	8	22	16	6	
TOTAL		**333**	**195**	**528**	**236**	**252**	**40**

In addition, to make optimum use of the network of aFADs in each country, different electronic equipment will be attached for positioning, measuring current, water temperature, and wave height to provide additional data for climate change modelling and local meteorological services in the future. Sonar buoys will also be trialled for measuring fish biomass aggregated under and around the aFAD. These trials will be undertaken in collaboration with SPC and will inform decisions by fishers regarding potential harvests of individual aFADs. The costings for the necessary electronic equipment and the aFAD materials are incorporated in the national budget section (Table 17).

5.4.2 Minimising the environmental impact of aFADs

It is important to minimise the environmental impact of aFADs including any interactions with marine life, such as marine mammals, turtles and sea birds. The aFADs will be deployed in locations away from any known whale migratory paths to minimise any chance of interaction. The FADs will also be deployed in depths over 150 m to ensure they attract tuna and other nearshore pelagic species and do not attract any reef-associated fish species.

The aFAD mooring line, consisting of a single rope from the anchor to the floats, will also minimise the chance of interaction or encounters by whales and other marine life. Nothing will be attached to the mooring line that would entangle marine life or sea birds.

Plastics or netting will not be used or attached to the aFADs to act as an aggregator. Instead, local natural materials such as bamboo or coconut fronds that are biodegradable will be used as aggregators attached under the float system, and this will be decided with each country at the time of implementing the Programme.

A survey of the bottom topography using echo sounder and GPS will be undertaken for all sites identified as possible locations for installing an aFAD. Some sites will not be suitable due to the slope being too steep for the anchor blocks to settle and hold. Choosing suitable sites with gentle slope or that are relatively flat will allow the anchor to settle and hold, increasing the lifespan of the aFADs and reducing the chance of premature loss.

Some of the surface aFADs will have electronic meteorological equipment and/or sonar buoys for measuring the biomass of tuna around the aFAD attached to the float system. This equipment has GPS for location, and in the event that the aFAD breaks free, it can be retrieved reducing the risk of the FAD washing ashore or onto the reef. The materials recovered can be reused as part of another aFAD.

5.5 Analysis of the small craft sea safety requirements

Table 15 presents the different criteria for small craft sea safety requirement and the number of countries that scored lower than sustainable (0 to 99 percent) regarding current gaps in sea safety requirements following the audit undertaken from October 2022 to March 2023. Suggestions on how to address the gaps, some of which will require financial support, are included. These are incorporated into the budget section (Table 17) of the report.

Table 15: Criteria for small craft sea safety and number of PICs scored at lower than sustainable (0 to 99 percent), with suggestions for addressing the identified gaps in the current sea safety requirements in the 14 PICs.

Criteria	Number of countries ranked at 0 to 99 percent	How to address
Sea safety requirements		
5.a Country has regulations in place covering qualifications for small craft (3-8 m in length) operators.	9	Review current legislation and regulations and strengthen as appropriate for small craft operators including compliance monitoring. Will need to raise the awareness through a campaign. Budget needed.
5.b Country has regulations on sea safety equipment that needs to be carried when small craft are heading to sea.	9	Review current legislation and regulations and strengthen as appropriate for sea safety requirements and equipment for small craft including compliance monitoring. Will need to raise awareness through a campaign. Budget needed.
5.c Country has suitable training facility and trainers to provide training in qualifications and sea safety equipment use by small-scale fishers	11	Explore options to provide sea safety training and include in aFAD trainings.
5.d Required sea safety equipment is available for purchase locally from public or private sector companies	12	Explore what sea safety equipment items are hard to get and provide sea safety grab bags for training purposes.
5.e Country has suitable facilities and skilled personnel for maintaining all sea safety equipment or has arrangements in place to have this done offshore.	13	Explore options for maintaining sea safety equipment or having this done offshore. Internal process.
5.f Country has required small craft minimum specifications for design and construction to ensure seaworthiness	12	Consultancy to assess current situation and recommend a way forward, and link to other Project activities and the results from Study 12. Some countries do not see this as a priority as no boatbuilding done locally. Budget needed.
5.g Good working relationship and proper information exchange protocols exists between fisheries and maritime authorities around sea safety	11	Review current processes to see where the working relationship can be strengthened. Internal process.
5.h Fisheries provide coordinates for anchored aFADs to Maritime for updating navigation charts for merchant vessels	6	Review the current process where coordinates of aFADs are not provided to marine department and strengthen to ensure this happens. Internal process.
5.i Country has aFADs marked for easy location day (flagpole with flag) or night (light and radar reflector).	14	Cover in aFAD Management Plan and assist with lights etc as part of aFAD Programme budget.
5.j Country has search and rescue vessels and plan in place when a small-scale vessel is reported missing.	7	No action needed as this is a national responsibility and internal process.
Sea safety for fishers		

6.a Fisheries agency uses and promotes the SPC sea safety checklist, or some form of checklist, and has this in local language for small-scale fishers	11	Strengthen awareness-raising around sea safety. Budget needed.
6.b Fisheries agency encourages fishers to have a second smaller outboard for safety reasons.	12	Include in strengthened awareness-raising around sea safety.
6.c Fisheries agency encourages small-scale fishers to carry paddles and/or sail rig when fishing outside the reef.	10	Include in strengthened awareness-raising around sea safety.

As described in the country profiles, the range of services and technical assistance will vary between countries. The types of activities will include consultancies, where needed, for the review of legislation and regulations around marine qualifications and sea safety requirements or equipment, and minimum standards for vessel design etc. Where these are identified as lacking, assistance will be provided to draft appropriate legislation and regulations. Sea safety training will also be incorporated into the aFAD training activities, and a joint awareness-raising campaign developed or strengthened around aFADs, the aFAD Programme and sea safety for small craft in general. Awareness-raising materials for different media platforms will also be developed and disseminated widely and regularly in each country.

5.6 National budgets including activity plan

The budget for each country was developed in the local currency. The cost estimate of activities was based on information provided by each country on the costs for running workshops (venue and catering), indicative staff salary for an aFAD technician or data collector, internal travel costs by air and sea and government daily subsistence allowance rates etc. A standard rate was used for consultancies and for the purchase of equipment such as the echo sounders, GPS units, computers and tablets and containers of aFAD materials including the cost of the container and freight to each country.

Once the draft activity plan and budget was developed for each country, based on the gaps identified during the audit of their aFAD Programme, it was discussed, refined as considered appropriate, and agreed with national officials. The agreed activity plan and budget was converted into USD for inclusion in the master budget for activities across all countries. The local currency budget and activity plan was then incorporated into the country profile for the country and sent for final comment and approval. Table 16 presents the budget amount for each country in both the original local currency amount and the approximate USD equivalent. The overall budget for the national activities is USD $10,924,265 spread across the seven years of the GCF regional programme implementation. Note the contingency and management fee is not included in this Table.

Table 16: Budgets for each national aFAD Programme in local currency and in USD.

Region and country	USD budget amount	Budget in local currency	
		Currency	Budget amount
Melanesia			
Fiji Islands – Annex F	950,351	FJD	2,111,900
Papua New Guinea – Annex G	818,955	PGK	2,729,750
Solomon Islands – Annex H	720,572	SBD	5,542,860
Vanuatu – Annex I	1,011,167	VUV	112,352,350

Micronesia			
Federated States of Micronesia – Annex J	869,700	USD	869,700
Kiribati – Annex K	843,412	AUD	1,204,875
Marshall Islands – Annex L	925,240	USD	925,240
Nauru – Annex M	522,416	AUD	746,310
Palau – Annex N	916,020	USD	916,020
Polynesia			
Cook Islands – Annex O	790,013	NZD	1,215,400
Niue – Annex P	431,542	NZD	663,910
Samoa – Annex Q	717,383	WST	1,938,880
Tonga – Annex R	697,562	TOP	1,550,130
Tuvalu – Annex S	709,932	AUD	1,014,210
TOTAL	**10,924,265**		

Table 17 provides a breakdown of the 2-phased approach for implementing the aFAD and sea safety work across the 14 PICs. Year 1 of the Project will be a half year due to Project setup and the recruiting of staff/consultants. Year 6 of the Project is also budgeted for 9-months and year 7 has no funding allocation and can be used for implementing budgeted activities that may have been delayed during implementation of the activity plan. Table 17 provides the consolidated amount with detailed breakdown by activity including a five percent contingency and 15 percent for project management. The total budget is USD $13,191,050.

Phase I will focus on strengthening the governance structure with legislation to support the national aFAD Programme as well as a reviewed and updated aFAD Management Plan. One or two staff/consultant will be employed to implement much of the work with staff from the fisheries department in each country and other partners. The staff/consultant will transition in years 3 and 4 to be paid half from the Project and half by the respective fisheries department with the fisheries department covering the full staff costs from year 5. Sea safety legislation and regulations for small craft and minimum specifications and designs for small craft will also be reviewed and developed to further strengthen the governance structure in some countries. As the national aFAD Management Plan is developed through stakeholder consultations in each county, procurement of materials and equipment will take place for shipment to each country in year two of the Project.

Phase II focuses on operationalising the national aFAD Management Plan, including using the equipment purchased and shipped to each country. Train-the-trainer workshops involving fisheries agency staff will be undertaken in the areas of aFAD rigging, deployment and undertaking site surveys, and in aFAD-fishing skills including sea safety. Staff from each fisheries agency will then be able to undertake the training of small-scale fishers and communities in these areas, focusing on communities close to where aFADs are or will be deployed. Awareness-raising will also be undertaken around the aFAD Programme and its importance and purpose, and around the need to strengthen sea safety in each country. A range of platforms (print, radio social media etc) will be used to disseminate the awareness-raising information widely. Data collection and analysis using the SPC TAILS and IKASAVEA applications will be a critical component of the Project. It will be important to document aFAD utilisation, aFAD maintenance demands and catch and effort data, including that needed to estimate the total annual catch from representative aFADs (Annex T). Not only will these data inform the Monitoring and Evaluation components of the Project, they will also support future management decisions relating to the national aFAD Programme in each country.

Table 17: Combined activity plan and budget to strengthen national aFAD Programmes and sea safety to minimise projected climate change vulnerability across the 14 participating countries.

Overall national activity plan for in-country work	Overall national budget for in-country work - USD							
Activity	**Year 1 (6-months)**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6 (9-months)**	**Year 7 for additional time if needed**	**Total**
Total including contingency and project management fee	**265,323**	**5,506,499**	**2,675,274**	**3,361,661**	**1,002,867**	**379,425**	**0**	**13,191,050**
Phase I: Activities to strengthen national governance structure for aFAD Programme and small craft sea safety	**172,225**	**961,104**	**250,416**	**144,250**	**75,053**	**3,866**	**0**	**1,606,914**
Activity 1.1: Recruitment of local staff/consultants for implementing all areas of the national component including data collection and imbedded within the fisheries department. Note for staff, project covers full salary for years 1 and 2, 50% salary years 3 and 4 and government the other half, and government pays full salary year 5 and beyond.	**172,225**	**280,855**	**213,657**	**144,250**	**75,053**	**3,866**	**0**	**889,906**
Recruitment costs for in-country staff/consultants	22,185	0	0	0	0	0	0	22,185
First National staff/consultant - salary and allowances	98,725	197,450	148,837	99,225	49,613	0	0	593,850
Second National staff/consultant - salary and allowances	39,150	78,300	59,475	39,650	19,825	0	0	236,400
Stationary, internet and expendable office supplies.	12,165	5,105	5,345	5,375	5,615	3,866	0	37,471
Activity 1.2: Development or review of aFAD Management Plan or policy for the country in collaboration with the national fisheries agency and SPC.	**0**	**177,771**	**36,759**	**0**	**0**	**0**	**0**	**214,530**
First workshops for stakeholder consultations, venue and catering.	0	41,057	0	0	0	0	0	41,057
Venue costs for first workshop.	0	12,947	0	0	0	0	0	12,947
Catering costs for first workshop.	0	28,110	0	0	0	0	0	28,110
Travel for people to attend the workshops (airfare/boat fare, DSA and incidentals)	0	42,631	0	0	0	0	0	42,631

Transport cost for some participants attending first workshop.	0	22,133	0	0	0	0	0	22,133
DSA for some participants attending first workshop.	0	20,498	0	0	0	0	0	20,498
Second workshops for stakeholder consultations, venue and catering	0	41,057	0	0	0	0	0	41,057
Venue costs for second workshop.	0	12,947	0	0	0	0	0	12,947
Catering costs for second workshop.	0	28,110	0	0	0	0	0	28,110
Travel for people to attend the workshops (airfare/boat fare, DSA and incidentals)	0	42,646	0	0	0	0	0	42,646
Transport cost for some participants attending second workshop.	0	22,138	0	0	0	0	0	22,138
DSA for some participants attending second workshop.	0	20,508	0	0	0	0	0	20,508
Third workshops for stakeholder consultations, venue and catering	0	0	6,852	0	0	0	0	6,852
Venue costs for third workshop.	0	0	3,387	0	0	0	0	3,387
Catering costs for third workshop.	0	0	3,465	0	0	0	0	3,465
Travel for people to attend the workshops (airfare/boat fare, DSA and incidentals)	0	0	6,277	0	0	0	0	6,277
Transport cost for some participants attending third workshop.	0	0	787	0	0	0	0	787
DSA for some participants attending third workshop.	0	0	5,490	0	0	0	0	5,490
Finalisation of the aFAD Management Plan or policy including taking this through internal process for government approval and gazetting, printing and distribution costs.	0	10,380	23,630	0	0	0	0	34,010
Activity 1.3: Arranging international consultants to undertake specific activities, reviews in consultation with the national fisheries agency, other appropriate government departments, and where appropriate, SPC, FFA or FAO.	**0**	**502,478**	**0**	**0**	**0**	**0**	**0**	**502,478**
a) Consultant to review national legislation and regulations for the national aFAD Programme with recommendations for improving these with draft text.	0	273,576	0	0	0	0	0	273,576
Consultancy fee for (a)	0	182,080	0	0	0	0	0	182,080
Travel and DSA for consultant (a) to country for consultations.	0	77,142	0	0	0	0	0	77,142

Workshop for stakeholder consultations, venue and catering.	0	14,354	0	0	0	0	0	14,354
b) Consultant to review national legislation and regulations for small craft (less than 12 m) covering qualifications for operators and sea safety requirements using the FAO-developed draft regulations or template and through national consultation develop specific legislation and regulation text for each country.	0	145,336	0	0	0	0	0	145,336
Consultancy fee for (b)	0	98,040	0	0	0	0	0	98,040
Travel and DSA for consultant (b) to country for consultations.	0	39,982	0	0	0	0	0	39,982
Workshop for stakeholder consultations, venue and catering.	0	7,314	0	0	0	0	0	7,314
c) Consultant to develop or review national legislation and regulations for minimum specifications and design for small craft (less than 12 m) to ensure seaworthiness with recommendations for improving these with draft text.	0	83,566	0	0	0	0	0	83,566
Consultancy fee for (c)	0	56,080	0	0	0	0	0	56,080
Travel and DSA for consultant (c) to country for consultations.	0	22,986	0	0	0	0	0	22,986
Workshop for stakeholder consultations, venue and catering.	0	4,500	0	0	0	0	0	4,500
Phase II: Implementing the aFAD Management Plan and addressing all gaps identified in the audit of the aFAD Programme and small craft sea safety.	**47,504**	**3,599,144**	**1,965,132**	**2,639,734**	**755,479**	**310,358**	**0**	**9,317,351**
Activity 2.1: Procurement of all materials for the aFAD and sea safety component of the project in all 14 countries through a centralised competitive tender process.	**47,504**	**2,814,454**	**512,450**	**1,404,576**	**90,900**	**0**	**0**	**4,869,884**
Purchase of aFAD materials including freight and container costs	0	1,627,800	90,000	992,900	90,900	0	0	2,801,600
Purchase of deep-water echo sounder(s) including freight	0	320,010	0	0	0	0	0	320,010
Purchase of GPS/plotter(s) including freight	0	24,022	0	0	0	0	0	24,022
Purchase of VHF handheld radios for sea safety.	0	17,970	0	0	0	0	0	17,970
Purchase of deployment barges to be made for project including freight.	0	200,000	0	0	0	0	0	200,000
Purchase of weather monitoring electronic equipment (wave buoy, acoustic doppler current profiler, GPS tracker etc) to be installed on some surface aFADs.	0	144,000	12,000	78,000	0	0	0	234,000

Purchase of GPS echo sounder buoys for monitoring aggregated fish biomass under the aFAD (info sent by satellite to fisheries department and SPC).	0	142,142	10,000	128,142	0	0	0	280,284
Purchase of vessel tracking systems for small craft for trailing.	0	6,000	0	0	0	0	0	6,000
Purchase of fishing gear for use and distribution during aFAD fishing skills workshops with fishers and communities.	0	0	127,970	103,000	0	0	0	230,970
Purchase of laptop computers for in-country staff/consultants.	47,504	0	0	42,504	0	0	0	90,008
Purchase of computer tablets for data collection (aFADs and catch and effort) based on the SPC TAILS or IKASAVEA applications.	0	130,060	70,030	60,030	0	0	0	260,120
Purchase of sea safety grab bags for training purposes.	0	202,450	202,450	0	0	0	0	404,900
Activity 2.2: Implementing recommendations or findings from the different consultancies to strengthen the aFAD Programme and sea safety at the national level.	**0**	**0**	**24,158**	**20,053**	**11,799**	**0**	**0**	**56,010**
a) Implement the findings of the national legislation and regulations review for the national aFAD Programme with the fisheries department.	0	0	14,354	14,354	7,544	0	0	36,252
Workshop for stakeholder engagement and awareness, venue and catering.	0	0	14,354	14,354	7,544	0	0	36,252
b) Implement the findings of the national legislation and regulations for small craft (less than 12 m) covering qualifications for operator and sea safety equipment requirements with the fisheries department and maritime department.	0	0	6,279	4,724	4,255	0	0	15,258
Workshop for stakeholder engagement and awareness, venue and catering.	0	0	6,279	4,724	4,255	0	0	15,258
c) Implement the findings of the national legislation and regulations for minimum specifications and design for small craft (less than 12 m) to ensure seaworthiness with the fisheries department and maritime department.	0	0	3,525	975	0	0	0	4,500
Workshop for stakeholder engagement and awareness, venue and catering.	0	0	3,525	975	0	0	0	4,500

Activity 2.3: Implement and operationalise the aFAD Management Plan in the locations identified in each of the 14 countries with the fisheries department staff and local staff/consultants hired under the project once the aFAD materials have arrived in-country.	**0**	**772,105**	**799,043**	**537,292**	**316,804**	**41,988**	**0**	**2,467,232**
Local purchase of materials to make plywood moulds for constructing steel reenforced concrete blocks for aFAD anchors including making the moulds.	0	34,694	4,800	19,230	0	0	0	58,724
Local purchase of steel reenforcing rod, cement, sand and gravel for making concrete anchor blocks in the moulds, including making the blocks.	0	137,436	114,408	100,008	6,000	0	0	357,852
Train the trainer national workshop for building local capacity in rigging and deploying aFADs including undertaking site surveys of areas for aFAD deployment plus sea safety, fuel, venue and catering.	0	71,538	0	0	0	0	0	71,538
Deployment costs where boats need to be hired to undertake the actual deployment of aFADs in different locations.	0	244,295	180,755	154,750	115,285	0	0	695,085
Fuel costs for fisheries deployment vessel.	0	34,220	25,590	20,640	14,215	0	0	94,665
Communications costs for satellite communication for the GPS echo sounder buoys and other electronic equipment attached to aFADs.	0	15,901	31,802	31,802	31,802	22,840	0	134,147
Travel for people to attend the train the trainer workshop (airfare/boat fare, DSA and incidentals).	0	119,261	0	0	0	0	0	119,261
In-country freight costs to get aFAD materials and possibly fuel to the locations identified for aFAD deployments.	0	52,770	55,650	15,620	43,755	1,280	0	169,075
Fuel for quarterly aFAD maintenance trips.	0	5,956	23,824	23,824	23,824	17,868	0	95,296
Community trainings and awareness-raising in aFAD site surveys, rigging, deploying and maintenance, and sea safety in communities where aFADs are being deployed plus fuel, venue and catering.	0	33,232	74,055	49,000	7,937	0	0	164,224
Travel for trainers to community areas (airfares/boat fares, DSA, Incidentals etc).	0	11,869	33,716	20,812	3,700	0	0	70,097
Train the trainer national workshop for building local capacity in aFAD fishing skills and sea safety including practical sessions on participants boats plus fuel, venue and catering.	0	0	78,029	0	0	0	0	78,029

Travel for people to attend the train the trainer workshop (airfare/boat fare, DSA and incidentals).	0	0	119,321	0	0	0	0	119,321
Community trainings and awareness-raising in aFAD fishing skills and sea safety in communities where aFADs have been deployed plus fuel, venue and catering.	0	8,853	41,508	73,238	49,458	0	0	173,057
Travel for trainers to community areas (airfares/boat fares, DSA, Incidentals etc).	0	2,080	15,585	28,368	20,828	0	0	66,861
Activity 2.4: Strengthening national data collection on aFADs and their maintenance as well as catch and effort information from aFAD fishing activities based on using the SPC TAILS or IKASAVEA applications.	**0**	**0**	**128,644**	**35,728**	**27,838**	**11,234**	**0**	**203,444**
Train the trainer workshop for building local capacity in data collection on aFADs and catch and effort from aFAD fishing activities using tablets and the SPC TAILS or IKASAVEA applications, venue and catering.	0	0	40,725	0	0	0	0	40,725
Travel for people to attend the train the trainer workshop (airfare/boat fare, DSA and incidentals).	0	0	67,414	0	0	0	0	67,414
Community/fisher group training in the use of SPC TAILS or IKASAVEA.	0	0	10,980	21,830	15,250	6,830	0	54,890
Travel for trainer to community/fisher group areas (airfares/boat fares, DSA, Incidentals etc).	0	0	9,525	13,898	12,588	4,404	0	40,415
Activity 2.5: Developing and/or strengthening awareness-raising around aFADs, the aFAD Programme, sea safety and predicted climate change effects on the marine environment and resources at the national level through a structured campaign using different media platforms and approaches.	**0**	**12,585**	**500,837**	**497,085**	**308,138**	**257,136**	**0**	**1,575,781**
Development of the national awareness-raising campaign strategy including stakeholders and other government departments as a collaboration for consistent and accurate messaging across the countries.	0	12,585	12,587	12,585	12,588	12,586	0	62,931
Development of awareness-raising materials for different media platforms including social media	0	0	193,350	193,350	193,350	158,350	0	738,400

Development of educational materials for trialling in schools at different levels as part of their curriculum.	0	0	192,700	188,950	0	0	0	381,650
Dissemination of awareness-raising materials through the identified media platforms on a regular basis.	0	0	102,200	102,200	102,200	86,200	0	392,800
Activity 2.6: Trialling cyclone-proof storage areas in Vanuatu and Fiji, one location per country plus materials for 20 aFADs in each storage unit.	**0**	**0**	**0**	**145,000**	**0**	**0**	**0**	**145,000**
Construction of cyclone-proof storage area in identified locations including all materials and local labour.	0	0	0	145,000	0	0	0	145,000
Stock each storage area with materials for 20 aFADs which are purchased as part of the aFAD procurement process.	0	0	0	0	0	0	0	0
Subtotal for combined national budgets	**219,729**	**4,560,248**	**2,215,548**	**2,783,984**	**830,532**	**314,224**	**0**	**10,924,265**
5 percent contingency funding	**10,986**	**228,012**	**110,777**	**139,199**	**41,527**	**15,711**	**0**	**546,213**
Subtotal for national budget and contingency	**230,715**	**4,788,260**	**2,326,325**	**2,923,183**	**872,059**	**329,935**	**0**	**11,470,478**
Project management fee of 15 percent	**34,607**	**718,239**	**348,949**	**438,477**	**130,809**	**49,490**	**0**	**1,720,572**
Overall total	**265,323**	**5,506,499**	**2,675,274**	**3,361,661**	**1,002,867**	**379,425**	**0**	**13,191,050**

5.7 Potential risks that the investments do not fill the gaps effectively with recommendations to reduce the identified risks.

The implementation of 14 national aFAD Programmes in a diverse range of geographic, social and economic settings will be accompanied by some significant risks. Some of these risks, and potential responses to them, are presented in Table 18.

Table 18: Potential risks the intervention will not fill gaps and recommendations to reduce the risks in the 14 participating countries.

Potential risk	Recommendations to reduce risk
Government struggles to implement the sustainable financing mechanism identified for their country.	• Provide evidence that the sustainable finance approach is viable and the benefits to government. • Work with fishers and stakeholders to support the implementation of the sustainable finance mechanism.
Fishers reluctant to fish around the aFADs due to increasing fuel prices.	• Work with government to assess options for reducing fuel usage, possibly through the introduction and promotion of 4-stroke outboard engines and consider the introduction of a subsidy to assist fishers with the purchase price of the more fuel efficient 4-stroke engine. • Share the data on fish biomass under the aFADs in real time so fishers are more assured they are likely to achieve a good catch.
aFADs are lost as a result of vandalism.	• Awareness campaign on the benefits of aFADs and their importance for food security and livelihoods. • Enforce penalties for proven incidences of vandalism. • aFAD Management Plan to include a section on vandalism and the penalties that apply as a possible deterrent. • Switch design of aFADs to subsurface and/or the lizard design to reduce the chance of vandalism.
Good catches of tuna from aFADs at times drives the selling price down.	• Promote post-harvest processes to produce alternative products from the tuna that have a longer shelf life and support initiatives to diversify markets. • Promote fishers to possibly form associations or cooperatives so they work together and not compete for markets.
Government does not provide adequate support for resourcing of the national aFAD Programme.	• Consider the inclusion of some staff time and costs as part of the sustainable financing mechanism. • Nurture strong stakeholder support for the aFAD Programme and its importance to encourage stakeholder advocacy.
Sea safety incidents increase, and the lives of fishers are at risk.	• Awareness-raising campaign on sea safety issues, the carrying of sea safety equipment (including trials of new equipment), and regulations and requirements implemented and enforced. • Where sea safety legislation and regulations are inadequate for small-scale fishing craft, strengthen these and include in the sea safety awareness campaign.
Fisheries agency staff and fishers resist or are complacent around collecting and documenting aFAD data and/or providing data on their catches.	• Awareness-raising campaign to highlight the benefits that the provision of data can provide to strengthen the overall aFAD Programme. • Review the method of data collection using SPC systems to better suit the needs of fishers and provide training to fishers to raise awareness. • Provide regular analysis of the data back to fishers so they understand the purpose of the collection of data and the benefits generated for them.

5.8 Number of people expected to benefit from the intervention across the 14 PICs

The beneficiaries of this intervention, both direct and indirect, will vary among the 14 participating countries. In some of the smaller countries, such as Niue, Nauru and Tuvalu, it is anticipated that a relatively large proportion if not all of the national population will benefit. In the larger countries, such as PNG, Solomon Islands and Vanuatu, the proportion of the population benefitting from increased access to fish caught in association with aFADs will be less (as a consequence of practical realities associated with the distribution of aFAD-caught fish to potential markets significant distances from the point of capture). Table 19 provides a breakdown of the number of beneficiaries (Total estimated to be 558,890) by country or area within each country that will have access to the aFADs for fishing, or to the fish landed as a result of fishing around aFADs. The fate of fish harvested in association with aFADs includes home consumption, bartering and/or sale to the general public.

Table 19: Forecast number of beneficiaries by country, or area within each country, that will benefit from fishing aFADs or the catch landed from FAD fishing in 2030.

Region and country	Number of Beneficiaries (men, women and children)	Calculation of beneficiaries
Melanesia		
Fiji (Annex F)	72,483	30% of the population in Rewa, Serua and Namosi districts and 80% of the population in Kadavu, Lau and Lomaiviti districts.
Papua New Guinea (Annex G)	91,834	20% of the population of Manua and Bougainville provinces.
Solomon Islands (Annex H)	62,752	90% of the population of the Temotu Province and 20% of the population of Guadalcanal Province.
Vanuatu (Annex I)	66,850	50% the population of Shefa and Tafea provinces and 20% of the population of Port Vila.
Micronesia		
Federated States of Micronesia (Annex J)	38,588	80% of the population in Pohnpei State and 80% of the population in Yap State.
Kiribati (Annex K)	81,778	40% of the population of South Tarawa and all of the population in the other 16 inhabited Gilbert Islands Group islands.
Marshall Islands (Annex L)	26,993	50% of the population of the Marshall Islands.
Nauru (Annex M)	12,539	100% of the population of Nauru.
Palau (Annex N)	8,815	50% of the population for 14 States.
Polynesia		
Cook Islands (Annex O)	8,792	50% of the population of Rarotonga and 100% of the population of 5 inhabited islands in southern Cook Islands.
Niue (Annex P)	1,393	100% of the population of Niue.
Samoa (Annex Q)	41,874	20% of the population for Samoa.

Tonga (Annex R)	32,950	. 40% of the population for Tongatapu, Eua and Ha'apai.
Tuvalu (Annex S)	11,250	100% of the population of Tuvalu.
TOTAL	**558,890**	

6. Regional assessment and proposed activities

6.1 Introduction and Background

During the 1970s, the SPC's coastal fisheries development work focused on developing the deep-water snapper fishery with fishing in depths of 200-400 m for these species. Fishing trials in the different PICTs were undertaken with training programmes to introduce the new fishing methods. The SPC had two master fishers employed to undertake this work. The 1980s saw a move away from deep-water snapper fishing as catch rates for the deep-water snappers remained constant or started to decline, indicating this to be a fragile resource that could only sustain limited fishing pressure.

The SPC master fishers changed their focus to small-scale tuna fishing activities and the introduction of aFADs to many of the PICTs. The use of FADs was increasing in the Pacific, both in the industrial tuna fishery and the small-scale sector. SPC master fishers began by experimenting with aFAD designs that had been used in other locations. On the basis of that experience, in 1984 SPC produced a report on FADs 'An improved FAD mooring line design for general use in Pacific Island countries: a report of the SPC design study on fish aggregation devices.[33] This increased the information available to SPC member countries to support national aFAD activities. Coupled with this was the trialling of different mid-water fishing methods to target the larger, deeper-swimming tunas that aggregated around aFADs. These methods were primarily developed to reduce the fishing costs because, until that time, trolling was the favoured fishing method and it required significant fuel.[34]

In the 1990s, SPC supported three master fishers. Their work moved away from deep-water snapper fishing and focussed on the design, rigging and deployment of aFADs, and small-scale tuna fishing around aFADs. As a result of this work, several manuals were produced in the 1990s: Vertical longlining and other methods of fishing around FADs – a manual for fishermen[35]; Planning FAD Programmes[36]; Rigging deep water FAD moorings[37]; and Deploying and maintaining FAD systems[38].

[33] Boy, RL and Smith, BR. (1984). Design improvements to FAD mooring systems in general use in Pacific Island countries and territories. South Pacific Commission (SPC) Handbook No. 24 (1984).

[34] Chapman L. 2016. The history of SPC's involvement in fisheries development in the Pacific - Part 1: the 20th century. SPC Fisheries Newsletter 150:52-60. https://purl.org/spc/digilib/doc/hizys

[35] Preston, G., Chapman, L., Watt, P. 1998. Vertical longlining and other methods of fishing around fish aggregating devices (FADs): a manual for fishermen. Noumea: SPC. Secretariat of the Pacific Community. Coastal Fisheries Programme. Capture Section. v, 64 p. https://purl.org/spc/digilib/doc/8d3op

[36] Anderson J., Gates P.D. 1996. South Pacific Commission fish aggregating device (FAD). Volume I: Planning FAD Programmes. Noumea, New Caledonia: South Pacific Commission. vii, 46 p. https://purl.org/spc/digilib/doc/rcyaz

[37] Gates, P.D., Cusack, P., Watt, P. 1996. South Pacific Commission fish aggregating device (FAD). Volume II: Rigging deep water FAD moorings. Noumea: SPC Coastal Fisheries Programme. Capture Section. Fish aggregating device (FAD) manual, vii, 46 p. https://purl.org/spc/digilib/doc/7pof2

[38] Gates, P.D., Preston G., Chapman, L. 1998. South Pacific Commission fish aggregating device (FAD). Volume III: Deploying and maintaining FAD systems. Noumea: SPC Coastal Fisheries Programme. Capture Section. Fish aggregating device (FAD) manual, vii, 46 p. https://purl.org/spc/digilib/doc/y9aip

During the early 2000s, the main focus of many SPC members remained on providing technical assistance with the development of domestic tuna longline operations. A series of studies was undertaken in collaboration with the Forum Fisheries Agency (FFA) to assess development options and constraints, including training needs and infrastructure requirements, within the tuna fishing industry and support services in 10 countries, with a focus on domestic development of longlining and small-scale fishing around aFADs.[39]

The aFADs and aFAD-fishing skills continued to be a focal area for assistance provided by the SPC master fishers. Research continued on aFADs, and a study was undertaken in Niue, and in Rarotonga and Aitutaki in the Cook Islands from late 2001 to mid-2004, to trial different mooring designs with the objective of achieving a minimum two-year lifespan for moored aFADs. Additionally, a data collection system was implemented so a cost-benefit analysis could be undertaken on the effectiveness of the aFADs and the catch taken from around them, as opposed to trolling on free schools or around the reef.[38] Good results were obtained, and a aFAD manual covering low-cost moorings and programme management was developed.[40]

The cost-benefit analysis was based on a comparison of the costs of the aFAD materials and deployments against the value of the catch recorded by fishers and entered in the data collection system. Over 3,000 logsheets were completed, and these showed a marked season for wahoo trolling in open water along the reef (August to October), while catches from aFADs were spread more evenly throughout the year. The main fishing methods were trolling around aFADs, open water trolling and midwater fishing around the aFADs.[39] The catch recorded from aFADs in Niue was 27,468 kg of fish over the 3-year project, with a value of NZD $153,988. The recorded open water trolling catch for Niue equalled 25,714 kg with a value of NZD $169,359. The catch recorded from aFADs in Rarotonga (39,188 kg) during the 3-year project was higher than Niue's and had a value of NZD $230,302. In contrast, the recorded catch from open water trolling in Rarotonga was much lower than in Niue (15,609 kg, with a value of NZD $99,035). Due to the low levels of data collection coverage of fishing activities, the reported catch figures were estimated to be around one-third of the actual catch; increasing the value of the aFAD-related catch to around NZD $491,964 in Niue and NZD $690,906 in Rarotonga.[41]

The cost of all aFAD materials provided to Niue equalled NZD $91,007 and covered 14 aFADs of which 11 were deployed (8 original and 3 replacements) with materials for three remaining at the end of the project. The cost of the materials for Rarotonga aFADs equalled NZD 90,480. In the case of Rarotonga, four aFADs were deployed initially, with one replacement and materials remained for another three aFADs. In addition, three aFADs were initially deployed off Aitutaki with one replacement.[38] The value of the catch far exceeded the cost of the materials in both Niue and Rarotonga (3 to 7 times), especially as there were still materials on hand for three replacement aFADs at each location and some of the deployed aFADs from the project remained active. In terms of the overall catch, aFADs were a major contributor to the success of small-scale fishing operations in both locations. These deployments also provide important social benefits for local communities, with many subsistence and recreational fishers using the aFADs to catch fish for their families or for sport or pleasure.[39]

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[39] Chapman L. 2017. The history of SPC's involvement in fisheries development in the Pacific – Part 2: The 21st century. SPC Fisheries Newsletter 151:27–34. https://purl.org/spc/digilib/doc/anokc

[40] Chapman, L., Pasisi, B., Bertram, I., Beverly, S., Sokimi W. 2005. Manual on fish aggregating devices (FADs): Lower-cost moorings and programme management. Noumea, New Caledonia: SPC, Secretariat of the Pacific Community. Handbook, vi, 47 p. https://purl.org/spc/digilib/doc/xe3qt

[41] Chapman, L., Bertram, I., and Pasisi, B. 2005. FAD research project: Final results from community surveys, gender assessment, and catch and effort data analysis. SPC Fisheries Newsletter #113 April/June 2005. Pp 27-47.

The aFAD assistance work of SPC continued through the 2000s and 2010s, although the number of master fishers or fisheries development officers was reduced to one. However, the demand for technical assistance around aFADs has continued and was supported by SPC members at the Fifteenth Heads of Fisheries Meeting in 2023.[42]

SPC's advice to PICTs with technical assistance and capacity development in all aspects of aFAD work, from rigging, deploying and maintaining the aFADs to aFAD fishing skills, small boat operations and sea safety, has continued as the staffing in national fisheries agencies in SPC members change and skills are lost. This has been an ongoing challenge, resulting in many national aFAD Programmes being impacted by disruptions, only operating when funding is available from donors to purchase aFAD materials. Trials to improve aFAD designs have continued, the results of which have been published in a new SPC aFAD manual produced in 2020, ''An update on FAD gear technology, design and deployment methods in the Pacific Islands region''.[43]

The key lessons from SPC's long experience in supporting the deployment of aFADs in the region, and which the GCF Programme will benefit from, and build upon, are:

- The need for an approach that is inclusive to bring government and stakeholders together to develop and maintain an ongoing National aFAD Programme, with adequate resourcing to ensure continuity over time.
- The need for national fisheries agencies to order aFAD materials for several years at one time to fill a container (or two) to minimize the cost per aFAD and freight and maximize the availability of aFAD materials in-country for rigging and deploying when needed. When there are only materials left for several aFADs, a new order should be placed so the materials arrive before those in-country are fully used.
- The need for a sound governance structure to support an ongoing national aFAD Programme, guided by an aFAD Management Plan that is endorsed by the national government for implementation and supported by appropriate legislation and regulations.
- The need for national fisheries agencies to monitor and enforce the legislation and regulations, especially where the vandalism of aFADs leading to premature loss is an issue.
- The need to include stakeholders (community, fishers etc.) at all stages of developing the aFAD Management Plan and its implementation to draw on their experience, expertise and traditional knowledge.
- The need for national fisheries agencies to reach agreement with communities and fishers on the roles and responsibilities of each stakeholder prior to aFAD deployments.
- The need to undertake site surveys using GPS for position and echo sounder for depth to develop a contour map for all identified areas for aFAD deployments to ensure their suitability, and to identify the actual deployment location. If the bottom topography is not suitable for an aFAD anchor (e.g., the slope is too steep), then another area should be surveyed.
- The need for the national fisheries agencies to have a coordinated approach with

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[42] Outcomes from the 15th Heads of Fisheries Meeting 2023: website https://spccfpstore1.blob.core.windows.net/digitallibrary-docs/files/2e/2e576f5387e32c47c33e4865bc2f78b3.pdf?sv=2015-12-11&sr=b&sig=yCP4l6RZlLIqML3jW3%2BreXoU54pkmYf1JrdjLNWO8RA%3D&se=2024-03-11T01%3A08%3A43Z&sp=r&rscc=public%2C%20max-age%3D864000%2C%20max-stale%3D86400&rsct=application%2Fpdf&rscd=inline%3B%20filename%3D%22HoF15_Outcomes.pdf%22

[43] Sokimi W., Blanc M., Colas B., Bertram I. and Albert J. 2020. Manual on anchored fish aggregating devices (FADs): an update on FAD gear technology, designs and deployment methods for the Pacific Island region. Noumea, New Caledonia: Pacific Community. 56 p. https://purl.org/spc/digilib/doc/xrz3p

stakeholders to maintain and service deployed aFADs to increase in-country capacity in this area and to maximize the lifespan of deployed aFADs.

- The need to greatly improve data collection at the national level covering both the aFADs themselves (positions, depth, materials used, when deployed and lost etc.), and catch and effort data on the fishing activity including species caught and fishing methods used. SPC has developed and supports the TAILS and IKASAVEA applications to assist national governments to collect these data.
- The need to improve communication on aFADs and national aFAD Programmes between fisheries agencies, stakeholders and the general community through awareness-raising using different media platforms to maximize dissemination.
- The need for ongoing research into the design of aFADs to increase their lifespan, use of more environmentally friendly materials as these are identified, and to reduce costs for materials where possible.
- The need to strengthen sea safety requirements and awareness to ensure fishers take responsibility for their safety when fishing outside the reef around aFADs.
- The need to assess deployment vessel options at the national level, especially because some countries struggle with deploying aFADs due to the availability of a suitable vessel locally and the costs involved in chartering vessels for undertaking deployments.

6.2 Regional component

A regional component is needed for coordinating the implementation of the Project to ensure consistency in delivery of activities across the participating countries. The regional component will allow the transfer of information across the countries while documenting the results from in-country activities. Countries are lacking local capacity with appropriate skills to implement many coastal fisheries activities. Therefore, having a pool of centralised expertise within the regional component will allow countries to request technical assistance when needed to support their aFAD Programme and related activities in support of national food security and small-scale livelihoods.

Data collection through a centralised approach is essential for the success of the Project. The regional component will support countries in their data collection, storage and analysis to ensure consistency for documenting the outcomes from different national activities. These outcomes can then be shared with other countries and more widely where applicable. Information sharing and capacity development across the 14 countries will be covered by the regional component to ensure consistent messaging and a standardised approach. The regional component will also be responsible for all reporting on Project activities under Component A to the Project Management Unit (PMU).

6.3 Proposed activities for regional component

The regional component will provide support to the 14 participating PICs in the implementation of their national aFAD Programmes in a structured manner while strengthening sea safety awareness. The regional component includes a range of related activities to complement the aFAD work. These include post-harvest activities, economic assessments and data collection, social/gender/human rights assessments, communications and information and knowledge management (IKM), technical and logistical support services, and capacity development.

Implementation of the regional component will complement and support the 2-phased approach proposed for the national component in two ways. Firstly, relevant governance structures will be strengthened in each country through legislation and regulations as outlined in the individual country profiles. Developing, revising and/or updating aFAD Management Plans for each country will be a primary activity under the first phase of the work – it will lay the foundation for the second phase. Phase two is the operationalisation of the aFAD Management Plan, including the purchase of all equipment and arranging for its shipment to each country. Training and capacity development is a key task under the second phase, as is data collection and a range of other activities. The experience and skills of staff to be employed under the regional component of the Project to support the delivery of these tasks is detailed below (Sections 6.3.1 to 6.3.8). The specific activity plan with operational budget for all positions is provided in Section 6.4, as well as the engagement period for all positions presented in Table 20.

6.3.1 Project oversight and coordination

The Project Coordinator will have oversight of the Project activities and be the main focal point to coordinate activities. The Coordinator will have a background in fisheries development, preferably in small-scale fisheries in the Pacific Islands region. They will be responsible for the coordination of all Project-related activities with the Project staff. Providing technical assistance in the development of aFAD Management Plans or policies will be a primary task for the Coordinator who will work closely with both Project and SPC staff in this endeavour.

Working with the PMU, Letters of Agreement or equivalent will be developed with each of the 14 participating countries to support the disbursement of agreed funding to each country to support the implementation of national activities. Oversight of the procurement of all materials for both the regional and national components will be an important role for the position to ensure that equipment starts flowing to countries in year two of the Project. With assistance from Project staff and Fisheries Monitoring, Evaluation and Learning Office, the Coordinator will also be responsible for narrative and financial reporting. The Coordinator will also represent the Project at national, subregional and regional meetings as required.

An annual regional meeting/workshop of five days with three representatives per country will be arranged by the Coordinator for two main purposes. Firstly, this will act as a Steering Committee for the Project. It will support two-way information exchange between the national and Project staff on activities undertaken and allow planning of activities for the following year. It will also aid in documenting progress in each country for reporting back to the GCF. Secondly, the meeting will allow the countries to learn from each other as they exchange and share information and experiences from the aFAD-related activities being undertaken in their country. Such opportunities to share information and exchange views on all aspects of aFAD Programme implementation, management and initiatives to support sustainability have proven invaluable to the region over many years.

6.3.2 aFAD technical support

Two aFAD Specialist positions, one for the life of the project, and a second for a 3-year term from mid-year two to mid-year five will deliver technical and logistical support. The aFAD Specialists will initially work with the Project Coordinator to assist efforts to strengthen national governance arrangements. Their main focus will be on the aFAD Management Plan, policy development and/or updating. It is anticipated that some countries will undertake this process faster than others which will permit activities to be staggered across the participating countries.

The aFAD Specialists will also assist with the procurement of aFAD materials. The number of aFADs and the depth range for the aFADs has already been determined as outlined in the individual country profiles. However, the actual design of the aFADs to be used in each country requires further consultation as aFAD designs continue to evolve. The aFAD Specialists will consult with each country to determine the most appropriate design of aFADs for each country situation. These consultations will provide the basis for the preparation of a list of materials and equipment including lights, radar reflectors and spare floats, shackles and swivels (for maintenance work). A competitive procurement process will then be supervised by the Project's Procurement Specialist.

Once the aFAD materials have arrived in each country the main work of the aFAD Specialists commences. Firstly, a 2-week in-country train-the-trainer workshop dedicated to rigging, deploying and maintaining aFADs, and undertaking site surveys of potential deployment locations, will be undertaken in each of the 14 PICs. It is expected that two or three aFADs will be deployed during the workshop. This will promote the development of the skills required for the deployment of aFADs nationally. Participants will primarily be staff from the national fisheries agency but representatives of fishers and/or community groups will also be encouraged to participate in the trainings.

Once some aFADs have been deployed (6-9 months after the first workshop), a second train-the-trainer 2-week workshop will be held on aFAD-fishing skills, small boat operations and sea safety in each country. This workshop will include at-sea fishing trials around aFADs that have been deployed. The purpose of the second training session will be to strengthen the skills of fisheries staff so they can deliver the same training around the country with fishers and community groups.

The two aFAD Specialists will provide ongoing technical and logistical advice and assistance to the countries on an as-needs basis. They will support the annual regional meeting facilitating discussions related to aFADs and aFAD work at the national level. They will also be involved in promoting data collection and monitoring aFAD Programmes to strengthen this in partnership with the Project Economist. Awareness-raising for the Project, support for national aFAD Programmes and sea safety will be an ongoing activity working in collaboration with the Project's Communications and IKM Specialist and national counterparts.

6.3.3 Post-harvest activities

A Post-Harvest Specialist will be employed to provide a range of services to the participating countries. Firstly, the Specialist will undertake an analysis of small-scale post-harvest activities previously undertaken in the 14 PICs to draw out any lessons that have been identified, challenges that were faced, and success stories regarding ongoing small-scale post-harvest activities. The results of this analysis will then be applied to develop a workplan for small-scale post-harvest activities to be implemented during the GCF programme. There is funding in the regional budget for the purchase of post-harvest equipment and expendable items to be used in-country as part of trainings and trialling value-adding activities. The Post-Harvest Specialist will be required to liaise with the Procurement Specialist and provide the specifications for any equipment to be purchased.

The post-harvest activities will mainly be with fishers or community members, with a focus on the participation of women and youth. Post-harvest activities will focus on different small-scale processing and packaging operations using the tuna that has been caught from the aFADs to add value, improve the shelf life of fish, diversify processing options, and generally endeavour to increase the return to fishers and communities. There may also be a need to improve the onboard handling of the tuna during capture to ensure good quality tuna are available for the post-harvest activities. The Project Economist and Social/Gender Specialist will work closely with the Post-Harvest Specialist to gather social and economic information that can be used for analysing the success or otherwise of post-harvest interventions. After the first few interventions have been completed, an assessment of adjustments required before working in other countries or with other communities on similar initiatives will be undertaken.

The Post-Harvest Specialist will also be involved in the annual regional meeting, where they will report to countries on activities undertaken and facilitate discussions around post-harvest activities supported under the Programme. Awareness-raising and development of post-harvest IKM products will also be a part of the role of this position in collaboration with the Communications and IKM Specialist and national counterparts. Economic and social aspects of the activities that have been undertaken will be featured in reporting and awareness-raising efforts.

6.3.4 Economics and social/gender/human rights activities

The Fisheries Economist will focus on data collection and analysis from the aFAD component, coordinating activities with the SPC Coastal Fisheries and Aquaculture Economist and the SPC Coastal Fisheries Information and Database Manager. This will include data concerning the deployment and maintenance of aFADs and catch and effort data required to document the productivity of aFADs. One-week training on the SPC TAILS and IKASAVEA applications will be undertaken by the Fisheries Economist in each of the 14 countries. The Fisheries Economist will work closely with the SPC Fisheries and Aquaculture Economist and SPC Information and Database Manager to ensure all data collection aligns with SPC protocols and are collected and stored in the SPC systems. The Fisheries Economist will lead targeted data collection efforts from a subset of aFADs in each country over a 2–3-year period using local data collectors to estimate the annual catch rate from aFADs in each country, as described in Annex T. This important task, which is needed to establish the baseline to measure the success of Component A of the GCF regional tuna programme, will also support in-country efforts to establish systems and processes to sustain data collection activities in the longer term.

The Fisheries Economist will work closely with the Social/Gender/Human Rights Specialist to collect and analyse economic and social data from the Project's aFAD and post-harvest activities, documenting lessons learned and benefits to communities. The Fisheries Economist and/or Gender/Social/Human Rights Specialists will undertake targeted research and studies to better understand the flow-on effects from Project activities within communities. The results will assist in refining strategies and activities to increase the potential for success as implementation of the programme progresses.

Like other Project staff, the Fisheries Economist and Social/Gender/Human Rights Specialist will be involved in the annual regional meeting. They will report on in-country activities and future plans, provide analysis of data and facilitate discussions with national counterparts on these topics. Awareness-raising at the national and regional levels and the development of IKM products around the economic and social/gender/human rights work will also be undertaken in collaboration with the Communications and IKM Specialist to ensure the results of their work are widely circulated.

6.3.5 Pacific Island Fisheries Professional capacity development activities

One of the important capacity development activities the Project will undertake is the hiring of eight Pacific Island Fisheries Professionals (PIFP), each on a one-year, non-renewable contract over the life of the Project. The aim of the PIFP activity is to recruit fisheries department staff from the participating PICs on a temporary arrangement that does not require them to resign their current position with their national fisheries agency while on attachment with SPC. The PIFPs will work alongside the SPC and Project staff to gain experience on-the-job and assist with Project implementation at the country level. They will accompany Project staff to assist with a range of fieldwork activities, engage in research and reporting and participate in the annual meeting. At the end on their one-year term with the Project, they will return to their national employer where the experience and skills acquired during their attachment will be applied for national benefit.

6.3.6 Communications, information and knowledge management activities

The Communications and IKM Specialist will work with the Project team to strengthen the flow of information and communication of results at both national and regional scales. The appointee will work closely with national staff on the design and implementation of national communications and awareness-raising activities using appropriate communications and social media platforms locally available. Activities will include the development of generic material that is suitable for region-wide distribution and use.

The Communications and IKM Specialist will also promote the work of the regional component supporting the dissemination of the results of Project activities. The appointee will work closely with the Project Coordinator to assist with format and layout of donor reports and the development of audio-visuals for presentations and reports. The appointee will also support the annual regional meeting where awareness-raising, public relation and social marketing initiatives will be promoted.

6.3.7 Consultants

Consultants will be used for specific activities where the Project Staff do not have the required expertise. Some areas include reviews of aFAD legislation and regulations, sea safety legislation and regulations and minimum specifications and designs for small craft to ensure seaworthiness, and the drafting of amendments where needed. There is scope for *ad hoc* consultancies in the areas identified as the Project is implemented.

6.3.8 Project administration, finances and procurement activities

An integral part of the Project will be administration, finance and procurement with one person hired for each activity given the project's large budget, the number of staff that will be regionally engaged and the volume of procurement to be undertaken. The Project Administrator will be responsible for arranging travel for all staff and for participants attending the annual regional meeting and other activities. The appointee will also arrange the logistics (catering and venue) for the annual regional meeting plus any other workshops convened by the Project and provide general administrative support to the Project Coordinator and Project staff.

The Finance Officer will be responsible for making payments and accurately recording expenditure from the Project following approval of expenditure by the Project Coordinator. The Finance Officer will also work with the fisheries departments of each country to acquit any funds advanced under their Letter of Agreement or other formal engagement mechanism and arrange progress payments once the acquittal is approved. Some virtual training with national fisheries finance staff may be needed to ensure they are familiar with Project financial reporting requirements and can provide the required supporting documentation as part of the acquittal process. The Finance Officer will work closely with the Procurement Specialist on budget matters relating to procurement and the Project Coordinator on expenditure reports for the GCF.

The Procurement Specialist will be responsible for sourcing the equipment and materials required for the national and regional components of the Project. The Procurement Specialist will work closely with all Project Staff to ensure the specifications and requirements of all items to be procured are clearly described so that when a request for quotation (RFQ) or request for proposals (RFP) is prepared it accurately reflects requirements. The Procurement Specialist will also establish procurement assessment teams to review RFQs so successful bidders can be selected, and contracts awarded. The SPC procurement process will be followed at all times and the Procurement Specialist will work closely with the SPC procurement team.

Note: The above administration, finance and procurement positions form a "FAD Support Unit" necessary for implementing Component A of the GCF programme. A Project Management Unit is also being considered for the entire Project; however, this is in the discussion stage. The Project Management Unit may have administrative and finance staff and possibly staff to support communications and outreach, monitoring, evaluation and learning etc. There is a need to discuss or consider the relationship between these units.

6.4 Regional component activity plan and budget

The regional component will be implemented to align and complement national activities and timelines across the participating countries. Table 20 lists the staff to be engaged under the regional component and the duration of engagement. Table 21 provides a breakdown of the 2-phased approach for implementing the regional component across the 14 PICs. Year 1 of the Project will be a half year due to project setup and the recruiting of staff/consultants. Year 7 of the Project is also budgeted for 9-months as the Project winds down for completion. The total budget for the regional component including a contingency and project management fee is USD $22,190,831.

Phase I of the regional component will commence with the recruitment of staff at SPC for Project implementation. Staff will be recruited on standard 3-year contracts. Following the execution of Letters of Agreement or a similar formal mechanism to support national-level activities, the recruited regional staff will initially focus on assisting countries review and strengthen the national governance structure to support a national aFAD Programme. This will include the review of national legislation and the review and updating, as appropriate, of aFAD Management Plans across the 14 PICs. The Project staff will facilitate country-driven processes to recruit one or two national staff/consultant(s) to take responsibility for much of the national-level Project work with staff from the fisheries department in each country and other partners. Where required, Project staff will recruit consultants to review and/or develop sea safety legislation and regulations for small craft to further strengthen national level administration and regulation of FAD-associated activities.

As the aFAD Management Plan is developed through stakeholder consultations in each county, the Project will undertake the procurement process for all materials and equipment so that these are shipped to each country in year 2 of the Project. Other Project Staff will commence their work with undertaking a review of past post-harvest activities, the current state of data collected on aFADs and aFAD catches, economic and social/gender studies around community involvement and engagement with aFAD or post-harvest activities, and a review of awareness-raising campaigns and the platforms being used for disseminating information in each country. The results of the reviews will feed into the overall Activity Plan (Table 21) and allow Annual Work Plans to be developed for Project Implementation.

Arrangements will be established for the collection of catch data from at least three aFADs in each country during Phase 1 to develop a reliable annual catch rate per aFAD for each country (Annex T). The SPC TAILS and/or IKASAVEA applications will be used for data collection and storage. The Project will hire one or two data collectors in each country to undertake data collection over a two-to-three-year period under the guidance of the Fisheries Economist. As data for this purpose are required as early as possible, the catch monitoring may target fishing activities associated with aFADs of a similar design to those to be installed that already exist in some countries.

The first 5-day annual regional meeting will be arranged to bring the countries together for two-way information exchange and the first Steering Committee meeting. At the first meeting, Project staff will present the planned activities, work plans and timelines for finalisation with national representatives. Countries will be requested to provide an update on the current status of their aFAD activities and sea safety programmes to reconfirm the baseline that will be used to measure progress over the life of the Project in each country.

Phase II is dedicated to supporting countries to operationalise their aFAD Management Plan including deploying the equipment purchased and shipped to each country. Project staff will undertake train-the-trainer workshops in the areas of aFAD rigging, deployment and undertaking site surveys, and in aFAD fishing skills including sea safety in each country. Staff from the fisheries department will then be able to undertake trainings in these areas with local fishers and at the community level, focusing on communities close to where aFADs are or will be deployed. Project staff will be available to provide technical advice and assistance when requested. Results from the different governance consultancies, including legislation and regulations for aFAD Programmes, sea safety and minimum standards for the construction of small craft will also be implemented in-country. Assistance for these activities will also be available from Project staff or consultants hired by the Project.

The Project Coordinator will continue working with countries to finalise their aFAD Management Plans and work with the administration, finance and procurement team to progress procurement and ensure that disbursements to participating countries comply with the provisions of the Letters of Agreement. The annual regional meeting will be arranged for years three to seven to provide countries with opportunities to exchange knowledge and share experiences. The meeting will also serve an oversight role, providing strategic input to the activities of the Project through the Steering Committee discussions. The Project Coordinator will draw on the outcomes of the meeting to compile information to inform reporting to the GCF. The Project Finance Officer will be responsible for acquittals of the national expenditure in accordance with SPC and GCF protocols.

Post-harvest, economic and social/gender/human rights activities will commence with countries based on the assessments undertaken during Phase-I of the Project. The activities will vary from country to country to align with national priorities and needs. Research and case studies will be undertaken to focus on benefits to fishers and communities from having access to an aFAD. Communities with a surplus of aFAD-sourced tuna will be targeted for post-harvest training.

Data collection and analysis will be a critical component of the work for the Fisheries Economist. This will include documentation of analysis of data relating to aFAD deployment and maintenance, catch and effort data analysis, including estimation of average annual catch rates per aFAD, and analysis of social and economic information to support future management decisions, illustrate lessons learned and support assessments of benefits and costs.

Project staff will also work with countries to either develop or strengthen awareness-raising around the national aFAD Programme and sea safety. Drawing on the expertise of Project staff, a range of platforms will be utilised to disseminate Project-related information and IKM products widely. Awareness-raising materials will include the presentation of information concerning the effects of climate change on the marine environment, the supply of reef fish, and related topics for each country. The Communications and IKM Specialist will assist with the development of educational materials for trialling in schools. This will include materials dedicated to climate change, aFADs, aFAD fishing, the contribution of fish to healthy diets, and sea safety.

Year seven will focus on the winding down of the Project. Financial reports, acquittals, audits and narrative reports will be finalised. A final annual regional meeting and Steering Committee meeting for participating countries and partners will be convened to help provide a final assessment of the activities of the Project over its 7-year life, and document the impact of the Project and lessons learned throughout its implementation.

Table 20: Staff to be engaged under the regional component and the duration of engagement

Position	Year 1 - quarters				Year 2 - quarters				Year 3 - quarters				Year 4 - quarters				Year 5 - quarters				Year 6 - quarters				Year 7 - quarters			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Project Coordinator																												
Full-time aFAD Specialis																												
Short-term aFAD Specialist																												
Post-Harvest Specialist																												
Fisheries Economist																												
Social/Gender/Human Rights Specialist																												
Communications and IKM Secialist																												
Procurement Specialist																												
Finance Officer																												
Project Administrator																												
Consultants																												
Pacific Island Fisheries Professional (PIFP) - 1																												
PIFP - 2																												
PIFP - 3																												
PIFP - 4																												
PIFP - 5																												
PIFP - 6																												
PIFP - 7																												
PIFP - 8																												

Table 21: Activity plan and budget for the regional component to support the 14 PICs with conducting their national activities.

Regional support for in-country work through SPC	USD							
Activity	Year 1 (6-months)	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7 (9-months)	Total
Total including contingency and project management fee	**833,175**	**3,536,164**	**4,394,696**	**4,304,134**	**3,766,193**	**3,265,080**	**2,091,390**	**22,190,831**
Phase I: Activities to strengthen national governance structure for aFAD Programme and small craft sea safety, including recruitment of national and regional staff.	**684,000**	**1,552,500**	**1,632,500**	**1,548,500**	**1,501,000**	**1,436,000**	**1,069,000**	**9,423,500**
Activity 1.1: Recruitment of local staff/consultants and SPC staff for implementing all areas of the regional and national component.	**670,000**	**1,439,500**	**1,522,500**	**1,548,500**	**1,501,000**	**1,436,000**	**1,069,000**	**9,186,500**
Suva-based position: Project Coordinator for Component A. Band 13 - managerial/policy position with some fisheries and climate change experience.	80,000	162,500	165,500	169,000	172,500	176,000	135,000	**1,060,500**
Suva-based position: Full-time aFAD Specialist. Band 11 - Technical position on aFAD work including development of aFAD Management Plans.	65,500	133,500	136,500	139,000	142,000	145,000	112,500	**874,000**
Pohnpei Regional Office-based position: Short-term aFAD Specialist. Band 10 - 3-year aFAD position starting in middle of year 2.		60,000	121,500	124,500	64,000			**370,000**
Suva-based position: Fisheries Economist. Band 11 - Fisheries and conservation economist to establish and oversee data collection and analysis including aFAD effectiveness in collaboration with Social/Gender Specialist.	65,500	133,500	136,500	139,000	142,000	145,000	112,500	**874,000**
Suva-based position: Social/Gender/Human Rights Specialist. Band 11 - Position to assess social impacts of aFADs in a climate change context and the effectiveness of aFADs to contribute to national food security in collaboration with the Fisheries Economist.	65,500	133,500	136,500	139,000	142,000	145,000	112,500	**874,000**

Suva-based position: Post-Harvest Specialist. Band 10 - Position for value adding and product development at the community level including marketing. Links in with work of the Fisheries Economist and Social/Gender Specialist.	0	60,000	121,500	124,500	127,000	130,000	99,000	**662,000**
Suva-based position: Project Administrator. Band 7 - Administration and travel logistics for Component A Project staff and in-country activities.	12,500	25,500	26,000	26,500	27,000	28,000	21,500	**167,000**
Suva-based position: Finance Officer. Band 10 - Maintain the finances for Component A covering both SPC regional component and in-country activities and disbursement of funds.	58,000	120,000	121,500	124,500	127,000	130,000	99,000	**780,000**
Suva-based position: Procurement Specialist. Band 10 - undertake all procurement activities for Component A for both SPC regional activities and in-country activities. Will need to work closely with SPC procurement team.	0	120,000	121,500	124,500	127,000	130,000	99,000	**722,000**
Suva-based position: Communications, Information and Knowledge Management (IKM) Specialist. Band 11 - assist countries with awareness-raising activities and the development of knowledge products for different media platforms.		67,000	136,500	139,000	142,000	145,000	112,500	**742,000**
SPC charges								
Onboarding cost at USD $25,000 per person (10 staff)	150,000	100,000						**250,000**
Onboarding cost at USD $25,000 per person - 8 Pacific Island Fisheries Professionals on 1-year contracts each.		25,000	50,000	50,000	50,000	25,000		**200,000**
SPC Facilities charge at USD $2,000/person/year in Suva	6,000	22,000	24,000	24,000	24,000	22,000	13,500	**135,500**
ICT charge of USD $7,000/person/year.	21,000	77,000	84,000	84,000	80,500	77,000	47,500	**471,000**
SPC cost recovery								
15% of SPC Deputy Director FAME (coastal fisheries)	10,000	30,000	31,000	32,000	33,000	34,000	27,000	**197,000**
15% of SPC FAME CFAP Economist	8,000	23,000	24,000	25,000	26,000	27,000	21,000	**154,000**
20% of SPC FAME MEL Officer	11,000	25,000	26,000	27,000	28,000	29,000	22,000	**168,000**
25% of SPC Coastal Fisheries Information and Database Manager	20,000	40,000	41,000	42,000	43,000	44,000	33,000	**263,000**
Equipment for Office								

Office tables and chairs	25,000	15,000						**40,000**
Printer for the office	10,000			10,000				**20,000**
Photocopier for the office including maintenance	25,000	2,000	2,000	2,000	2,000	2,000	1,500	**36,500**
Office consumables including printer cartridges	5,000	5,000	3,000	3,000	2,000	2,000		**20,000**
National activities								
Assist countries with the recruitment of suitable aFAD technicians and/or data collectors. Note: the funding for the positions is in the national budget allocation.	4,000	4,000						8,000
Develop a Letter of Agreement or Service Agreement with each of the 14 countries to support the transfer of funds for national staff in each country to implement activities. Travel for SPC Project Coordinator to each country at $7,000 per 1-week trip and 14 countries.	28,000	56,000	14,000					98,000
Activity 1.2: Development or review of national aFAD Management Plan or policy in collaboration with the national fisheries agency and SPC.	**14,000**	**77,000**	**77,000**	**0**	**0**	**0**	**0**	**168,000**
Provide technical support and guidance in the development of the aFAD Management Plan though stakeholder consultations. SPC Project staff travel costs for first consultation. 10 countries with average estimate of USD $7,000/ 1-week trip	14,000	42,000	14,000					70,000
Provide technical support and guidance in the development of the aFAD Management Plan though stakeholder consultations. SPC Project staff travel costs for second consultation. 10 countries with average estimate of USD $7,000/ 1-week trip.		35,000	35,000					70,000
Provide technical support and guidance in the development of the aFAD Management Plan though stakeholder consultations. SPC Project staff travel costs for third consultation. 4 countries with average estimate of USD $7,000/ 1-week trip.			28,000					28,000

Activity 1.3: Arranging international consultants to undertake specific activities, reviews in consultation with the national fisheries agency, other appropriate government departments, and where appropriate, SPC, FFA or FAO.	**0**	**36000**	**33000**	**0**	**0**	**0**	**0**	**69,000**
a) Consultant to review national legislation and regulations for the national aFAD Programme with recommendations for improving these with draft text. SPC Project staff to assist with arranging the consultancy, but funding for consultant in national budget allocations. Advertising and selection of consultants at $3,000/consultancy and 12 countries.		18,000	18,000					36,000
b) Consultant to review national legislation and regulations for small craft (less than 12 m) covering qualifications for operators and sea safety requirements using the FAO-developed draft regulations or template and through national consultation develop specific legislation and regulation text for each country. SPC Project staff to assist with arranging the consultancy, but funding for consultant in national budget allocations. Advertising and selection of consultants at $3,000/consultancy and 7 countries.		12,000	9,000					21,000
c) Consultant to develop or review national legislation and regulations for minimum specifications and design for small craft (less than 12 m) to ensure seaworthiness with recommendations for improving these with draft text. SPC Project staff to assist with arranging the consultancy, but funding for consultant in national budget allocations. Advertising and selection of consultants at $3,000/consultancy and 4 countries.		6,000	6,000					12,000
Phase II: Implementing the aFAD Management Plan and addressing all gaps identified in the audit of the aFAD Programme and small craft sea safety, including SPC assistance and activities.	**6,000**	**1,376,000**	**2,007,000**	**2,016,000**	**1,618,000**	**1,268,000**	**663,000**	**8,954,000**

Activity 2.1: Procurement of all materials for the aFAD and sea safety component of the Project in all 14 countries and regional materials through a centralised competitive tender process at SPC.	**6,000**	**323,000**	**418,000**	**335,000**	**205000**	**105000**	**0**	**1,392,000**
Procurement Officer and Finance Officer to undertake the procurement of all materials for in-all country activities on behalf of the countries and have goods shipped to each country. Funding for procured items in the national budget for each country. Advertising and selection of service provider at $6,000/country and 14 countries.	6,000	60,000	18,000					84,000
Purchase of deep-water echo sounder(s) including freight (I deep-water echo sounder at $25,000 with transducers (3KW) for SPC Project Staff to use where needed.		25,000						25,000
Purchase of GPS or GPS/plotter(s) including freight 2 units at $1,500 each for SPC Project staff use with countries.		3,000						3,000
Purchase of FAD materials for research trials on new and/or improved FAD designs including freight to Fiji where the Project will be based.		50,000	25,000	25,000				100,000
Purchase of fishing equipment for SPC Project aFAD Specialists for training purposes at $5,000 each/year for 4 years.		10,000	10,000	10,000	5,000	5,000		40,000
Purchase of post-harvest equipment for community level activities including solar freezers, smokers, fish dryers and processing equipment.		100,000	300,000	300,000	200,000	100,000		1,000,000
Purchase of vessel tracking systems for small craft for trailing. Purchase 50 units at $300 each for trialling in several countries.			15,000					15,000
Purchase of 100 computer tablets at $500 each for data collection and training (aFADs and catch and effort), economic and social and gender information based on the SPC TAILS or IKASAVEA applications.		25,000	25,000					50,000
Purchase of sea safety grab bags (50 bags at $1,500 each) for training purposes.		50,000	25,000					75,000
								0
Activity 2.2: Implementing recommendations or findings from the different consultancies to strengthen the aFAD Programme, sea safety and other identified areas at the national level.	**0**	**24,000**	**126,000**	**90,000**	**42,000**	**20,000**	**10,000**	**312,000**

a) Implement the findings and recommendations of the national legislation and regulations review for the national aFAD Programme with the fisheries department. Using SPC Project consultancy funding to assist 8 countries with implementing review findings to strengthen legislation and regulations in support of the artisanal FAD Programme at $12,000 for fees and travel/country.		12,000	36,000	36,000	12,000			96,000
b) Implement the findings and recommendations of the national legislation and regulations for small craft (less than 12 m) covering qualifications for operator and sea safety equipment requirements with the fisheries department and maritime department. Using SPC Project consultancy funding to assist 5 countries with implementing review findings to strengthen sea safety legislation and regulations at the national level at $12,000 for fees and travel/country.		12,000	36,000	12,000				60,000
c) Implement the findings and recommendations of the national legislation and regulations for minimum specifications and design for small craft (less than 12 m) to ensure seaworthiness with the fisheries department and maritime department. Using SPC Project consultancy funding to assist 3 countries with implementing review findings to strengthen minimum specification and design for small craft legislation and regulations at $12,000 for fees and travel/country.			24,000	12,000				36,000
Implement other *ad hoc* consultancies as identified during the project to assist countries with implementing their aFAD Programme, sea safety programme or post-harvest activities.			30,000	30,000	30,000	20,000	10,000	120,000
Activity 2.3: Implement and operationalise the aFAD Management Plan in the locations identified in each of the 14 countries as well as post-harvest, economic and social/gender activities with the fisheries department staff, SPC Project and local staff/consultants hired under the Project once the aFAD materials have arrived in-country.	**0**	**732,000**	**953,000**	**1,014,000**	**985,000**	**812,000**	**551,000**	**5,047,000**

Train the trainer national workshop with SPC building local capacity in rigging and deploying aFADs including undertaking site surveys of areas for aFAD deployment plus sea safety. Travel cost for SPC Project aFAD Specialists at $9,000 for each 2-week training and 12 countries. Workshop costs covered in national budgets.		36,000	36,000	36,000				108,000
Train the trainer national workshop with SPC building local capacity in aFAD fishing skills and sea safety including practical sessions on participants boats. Travel for SPC Project aFAD Specialists at $9,000 for each 2-week training in 12 countries. Workshop costs included in national budgets.		18,000	36,000	36,000	18,000			108,000
Travel for responding to *ad hoc* country requests for technical assistance in all areas covered by the Project, with 4 ad hoc requests per year with travel at $9,000 per 2-week assignment over 4 years.			18,000	36,000	36,000	36,000	18,000	144,000
Increase local capacity by implementing a training programme for 8 x 1-year Pacific Island Fisheries Professionals (PIFP) positions at SPC for the PIFP's to be trained and work alongside SPC Project staff to expand their skill set to take back to their country at the end of their 1-year attachment to SPC.		100,000	200,000	200,000	200,000	100,000		800,000
Travel costs for the PIFP staff to undertake 5 by 2-week trainings in country under SPC Project staff guidance at $9,000 travel costs per training.		45,000	90,000	90,000	90,000	45,000		360,000
Annual regional workshop and steering committee meeting to bring the 14 countries together for discussions on all Component A activities as well as all aspects of data collection including catch and effort, social/gender data, economic data and the analysis of the data to better inform all countries. Annual 5-day meeting for 6 years at $500,000/meeting for travel of 3 representatives per country plus all meeting and travel logistics.		500,000	500,000	500,000	500,000	500,000	500,000	3,000,000
Trainings in post-harvest techniques at the community level processing the tuna caught from aFAD fishing to make a range of post-harvest and value-added products. Six trainings per year for 4.5 years at $9,000 per 2-week		33,000	33,000	66,000	66,000	66,000	33,000	297,000

training for travel and $2,000 per training for consumables.								
Production of post-harvest training materials and manuals for in-country use and capacity development.			15,000	25,000	25,000	15,000		80,000
Post-harvest product development including packaging and marketing trials in 6 countries			25,000	25,000	50,000	50,000		150,000
								0
Activity 2.4: Strengthening national data collection on aFADs and their maintenance as well as catch and effort and other economic and social information from aFAD fishing activities based on using the SPC TAILS or IKASAVEA applications.	**0**	**248,000**	**347,000**	**405,000**	**214,000**	**173,000**	**58,000**	**1,445,000**
Train the trainer workshop with SPC building local capacity in data collection and database support on aFADs and catch and effort from aFAD fishing activities using tablets and the SPC TAILS or IKASAVEA applications. SPC and Project Fisheries Economist to provide 5 trainings per year over 3 years at $7,000 for travel for each 1-week training.		21,000	35,000	35,000	14,000			105,000
Country monitoring targeting data collection from 2-3 aFADs per country using in-country data collectors to develop a reliable annual catch rate for each country from aFADs over a 2–3-year period. This data collection will transfer to national fisheries agencies as part of the overall data collection initiative under the Project.		200,000	200,000	200,000				600,000
Training in the collection of social/gender and economic data to understand the social impacts of aFADs on communities. SPC Project Social/Gender Specialist to provide 6 trainings per year for 4 years at $9,000 for travel per 2-week training.		27,000	54,000	54,000	54,000	27,000		216,000
Training in data collection for economic and environmental data to better understand the effectiveness of aFADs and look at whether their use does reduce fishing pressure on reef fish resources. SPC Project Fisheries Economist to provide 4 trainings per year for 4 years at $9,000 for travel for each 2-week training.			18,000	36,000	36,000	36,000	18,000	144,000

Specific research activities around social, gender and economic activities at the community level in 10 communities to pilot the benefits from aFADs to these communities with $30,000 per community including travel.			30,000	60,000	90,000	90,000	30,000	300,000
Production of data analysis reports for awareness-raising across the Pacific in support of promoting the aFAD Programme in each Pacific Island country.			10,000	20,000	20,000	20,000	10,000	80,000
Activity 2.5: Developing and/or strengthening awareness-raising around aFADs, the aFAD Programme, sea safety and predicted climate change effects on the marine environment and resources at the national and regional level with SPC assistance through a structured campaign using different media platforms and approaches.	**0**	**28,000**	**142,000**	**172,000**	**172,000**	**158,000**	**44,000**	**716,000**
Assist countries with developing their awareness programmes around aFADs, aFAD Programme, sea safety and climate change effects on the marine environment, to ensure consistent messaging across the countries. Travel for SPC Project Communications and IKM Specialist to all 14 countries over 5 years with 2 by 1-week travel per country at $7,000/travel.		28,000	42,000	42,000	42,000	28,000	14,000	196,000
Assist countries to develop awareness-raising materials for different media platforms including social media. Development of different print materials, short videos and short messages with photos for social media. Estimate of 60,000/year for 4 years to complement national budgets.			50,000	60,000	60,000	60,000	10,000	240,000
Assist countries to develop educational materials for trialling in schools at different levels as part of their curriculum. Specific education materials developed around climate change, aFADs, aFAD fishing and sea safety for curriculum at $40,000/year for 4 years to complement national budgets.			30,000	40,000	40,000	40,000	10,000	160,000

Assist countries in their dissemination of awareness-raising materials through the identified media platforms on a regular basis and disseminate regional messaging to complement the national work. Estimated $30,000/year for dissemination over 4 years to complement national budgets.			20,000	30,000	30,000	30,000	10,000	120,000
Activity 2.6: Trialling cyclone-proof storage areas in Vanuatu and Fiji, one location per country plus aFAD materials for 20 aFADs in each storage unit with SPC assistance.	**0**	**21000**	**21000**	**0**	**0**	**0**	**0**	**42,000**
Oversee the construction of a cyclone-proof storage area in identified location in Fiji and Vanuatu with materials and labour covered in national budget. Travel for 3 by 1-week trips to each country at $7,000/trip.		21,000	21,000					42,000
Stock each storage area with materials for 20 aFADs which are purchased as part of the aFAD procurement process.								0
Subtotal for regional budgets[44]	**690,000**	**2,928,500**	**3,639,500**	**3,564,500**	**3,119,000**	**2,704,000**	**1,732,000**	**18,377,500**
5 percent contingency funding	**34,500**	**146,425**	**181,975**	**178,225**	**155,950**	**135,200**	**86,600**	**918,875**
Subtotal for regional budget and contingency	**724,500**	**3,074,925**	**3,821,475**	**3,742,725**	**3,274,950**	**2,839,200**	**1,818,600**	**19,296,375**
SPC project management fee of 15 percent	**108,675**	**461,239**	**573,221**	**561,409**	**491,243**	**425,880**	**272,790**	**2,894,456**
Overall total	**833,175**	**3,536,164**	**4,394,696**	**4,304,134**	**3,766,193**	**3,265,080**	**2,091,390**	**22,190,831**

[44] Given the project will not start until 2025/2026 the budget estimates include projections of an early 2026 start date and staff costs with a 2% increase annually. Equipment costs are based current costs plus 5%. Travel costs are best estimates.

7. Overall activity plan and budget

As the PMU will be responsible for all reporting and acquitting of expenditure to the GCF, it will have oversight of Project activities and implementation at both regional and national levels. National activity plans and budgets provide for nationally-implemented activities. In addition, there is provision within the regional component, such as procurement and the hiring of consultants, that will be done in consultation with each country. Most countries expressed support for the Project to be responsible for the procurement process for all materials, as this has been problematic for many countries in the past. Table 22 presents the budget for both national and regional components by activity, plus the overall total including a five percent contingency and the 15 percent project management fee, with the total amount being USD $35,381,881.

Table 22: Combined activity plans and budgets for the national and regional components.

Combined regional and national activities	Combined regional and national budget		
Activity	National	Regional	Total
Total including contingency and project management fee	**13,191,050**	**22,190,831**	**35,381,881**
Phase I: Activities to strengthen national governance structure for aFAD Programme and small craft sea safety including recruitment of national and regional staff.	**1,606,914**	**9,423,500**	**11,030,414**
Activity 1.1: Recruitment of local staff/consultants and Project staff for implementing all areas of the regional and national component.	889,906	9,186,500	10,076,406
Activity 1.2: Development or review of national aFAD Management Plan or policy in collaboration with the national fisheries agency and SPC.	214,530	168,000	382,530
Activity 1.3: Arranging international consultants to undertake specific activities, reviews in consultation with the national fisheries agency, other appropriate government departments, and where appropriate, SPC, FFA or FAO.	502,478	69,000	571,478
Phase II: Implementing the aFAD Management Plan and addressing all gaps identified in the audit of the aFAD Programme and small craft sea safety including SPC assistance and activities.	**9,317,351**	**8,954,000**	**18,271,351**
Activity 2.1: Procurement of all materials for the aFAD and sea safety component of the Project in all 14 countries and regional materials through a centralised competitive tender process.	4,869,884	1,392,000	6,261,884
Activity 2.2: Implementing recommendations or findings from the different consultancies to strengthen the aFAD Programme, sea safety and other identified areas at the national level.	56,010	312,000	368,010

Activity 2.3: Implement and operationalise the aFAD Management Plan in the locations identified in each of the 14 countries as well as post-harvest, economic and social/gender activities with the fisheries department staff, SPC Project and local staff/consultants hired under the Project once the aFAD materials have arrived in-country.	2,467,232	5,047,000	7,514,232
Activity 2.4: Strengthening national data collection on aFADs and their maintenance as well as catch and effort and other economic and social information from aFAD fishing activities based on using the SPC TAILS or IKASAVEA applications.	203,444	1,445,000	1,648,444
Activity 2.5: Developing and/or strengthening awareness-raising around aFADs, the aFAD Programme, sea safety and predicted climate change effects on the marine environment and resources at the national and regional level with SPC assistance through a structured campaign using different media platforms and approaches.	1,575,781	716,000	2,291,781
Activity 2.6: Trialling cyclone-proof storage areas in Vanuatu and Fiji, one location per country plus aFAD materials for 20 aFADs in each storage unit with SPC assistance.	145,000	42,000	187,000
Subtotal for combined budget	**10,924,265**	**18,377,500**	**29,301,765**
5 percent contingency funding	**546,213**	**918,875**	**1,465,088**
Subtotal for combined budget and contingency	**11,470,478**	**19,296,375**	**30,766,853**
Project management fee of 15 percent	**1,720,572**	**2,894,456**	**4,615,028**
Overall total	**13,191,050**	**22,190,831**	**35,381,881**

SPC will be responsible for narrative and financial reporting that complies with GCF procedures and policies. In addition to quarterly narrative and financial reports, an Annual Progress Report, an Annual Financial Report, and an Annual Audit will be provided to the GCF. The annual regional meeting will be scheduled to occur a month before the annual progress reporting deadline to allow information and updates from the countries to be included in the Annual Progress Report. The GCF Secretariat and other key partners, such as Conservation International and Minderoo Foundation, will be invited to observe the annual regional meeting and associated steering committee.

7.1 Conclusions

Based on the overall assessment undertaken across the 14 participating countries, strengthening the national aFAD Programme seems the most effective approach to support domestic food security in these countries. However, there is a great diversity of needs related to strengthening aFAD Programmes across the 14 participating countries, given differences in their population sizes, previous experiences with aFADs, abundance of tuna in their waters, etc.

It is essential to develop and/or strengthen the governance structure to fully support a national aFAD Programme including legislation and regulations and a comprehensive national aFAD

Management Plan that has been developed with all stakeholders. Once the national aFAD Management Plan is approved and endorsed by government, it provides the guidance and approach for implementing the aFAD programme as a collaboration between the fisheries agency, other relevant government departments and all stakeholders.

The aFADs will make a significant contribution to food security in the small countries, both in terms of the number of beneficiaries (Table 19) and the relatively high number of fish meals to be delivered per person per month (see Table 1 in Annex T).

The key benefit for the larger countries should not be measured in terms of the proportion of the total population supplied with more tuna – it is simply not possible for one programme to have a significant impact given the large national population. Rather, the main benefit is that the *ad hoc* nature of previous aFAD deployments will be transformed through establishment of a well-structured national aFAD Programme, following the guidelines in SPC Policy Brief 31/2017. This will lay the foundation for these countries to progressively extend a well-maintained aFAD network to additional provinces or states to enlarge the national infrastructure for food security. This can be done using a combination of national funding and resources available from other donors, e.g., the World Bank PROPER, ADB, etc.

Annexes

Annex A

A. Terms of reference for consultancy

Project Title: Studies and analyses to support the Green Climate Fund proposal: Adapting tuna dependent Pacific Island communities and economies to climate change.

Project Description

Background

Climate change is adversely affecting the Western and Central Pacific Ocean large marine ecosystem, degrading its coral reefs and changing the distribution of tuna. The impacts on coral reefs are reducing the supply of reef fishing and threatening the food security of more than four million people that live along the coasts of the programme's targeted 14 Pacific Island countries. In parallel to the threat to the food security of highly vulnerable populations, the redistribution of tuna will have profound implications for national economies that derive as much as 70% of their (non-aid) government revenue from tuna fishing, thereby dramatically reducing basic social services that are essential to the resilience of Pacific Island people.

Recognising this impending threat, the governments of the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Niue, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu have instructed the Pacific Community (SPC) to collaborate with Conservation International (as an Accredited Entity and Executing Entity for the Green Climate Fund) to prepare an application to the Green Climate Fund to support a programme that will:

1) Increase supply of tuna for domestic consumption as an adaption to degradation of coral reefs and the resulting food insecurity for vulnerable populations; and
2) Usher in the reforms needed to minimise the risks for citizens of countries with economies that are vulnerable to climate-driven redistribution of tuna.

The concept note for the proposal has been endorsed by the Green Climate Fund and the Pacific Community and Conservation International are currently designing the regional programme of work and preparing associated documentation for the Green Climate Fund. Ten independent feasibility studies will be commissioned to assist this process. These are outlined under the scope of work below. Potential consultants are invited to submit proposal for one or more of these studies or for tasks within each study.

Scope of Work

- This RFP aims at identifying entities interested in providing consultancy services in one or more of the studies detailed further below.
- Service Providers are expected to provide technical services and capabilities within one or more of the following studies (e.g.: 1 or 2; or 1 and 2; or 3, 7, and 10, etc)
- The Objectives, Expected Outputs, indicative Timeframe for Completion for each study are specified below:

B.3 GCF Study 3: Feasibility of scaling-up National FAD Programmes in all 14 participating countries

Objectives: Nearshore Fish Aggregating Devices (FADs) are now widely recognised as an effective way of increasing access to tuna and other oceanic fish species (hereafter grouped as 'tuna') to improve the food security of rapidly-growing coastal communities in the Pacific Island region (see Chapter 13 in https://www.spc.int/cces/climate-book/spc-publications-on-climate-change#tab-682-2 and https://www.sciencedirect.com/science/arti:cle/abs/pii/S0308597X1400267X). Most Pacific Island countries have been deploying nearshore FADs for several years, often with the assistance of SPC, however, the number of FADs has yet to be scaled-up to the level where FADs are a significant part of the national infrastructure for food security.

SPC has provided a blueprint for sustaining and strengthening National FAD Programmes so that this simple technology can be used to meet the increasing demand for tuna driven by human population growth and the decline in reef fisheries caused by over-harvesting and poor management of coastal fish habitats in several locations, and by the degradation of coral reefs due to ocean warming and acidification across the region. This blueprint is available at https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/Anon_17_PolicyBrief31_FAD_Programmes.html

Component A of the GCF regional tuna programme is designed to strengthen National FAD Programmes in all 14 participating countries.

The purpose of this study is to document the existing needs and capacity of each country to maximise the benefits of investments by GCF in all activities related to strengthening National FAD Programmes.

The specific tasks to be completed during this study are described below.

(i) An analysis of the capacity of the national fisheries agency in each country to deploy the number of FADs needed to significantly increase the supply of tuna for domestic food security by the end of the Programme in 2030. The numbers of FADs required for this purpose are expected to vary widely among countries due to population size and the distribution of the population. In the smaller countries, the expectation is that the majority of FADs needed to fill the gap in fish supply would be installed. However, in the large countries, such as PNG, Fiji and Solomon Islands, an assessment will need to be made of the capacity to install sufficient FADs to significantly increase the supply of tuna in those coastal communities that have the greatest needs for an increased supply of fish. The important decisions about the number of FADs to be deployed in each country will be made during the consultations with the national fisheries agencies about the priorities for strengthening their National FAD Programmes during development of the Funding Proposal and guided by the information provided in the publication by CI and SPC on optimising the use of FADs for food security in the Pacific Islands http://dx.doi.org/10.1016/j.marpol.2015.02.010

(ii) In support of (i) above, analyse the current capacity in each of the 14 participating countries to:

- Implement the necessary increases in the deployment and management of nearshore anchored FADs, taking into consideration allocation of existing staff and shore-based facilities for the construction, installation and maintenance of FADs; development of protocols for procurement and storage of FAD materials; availability of suitable vessels for deploying FADs; and establishment/strengthening of fishers' associations as vehicles to help deliver all aspects of National FAD Programmes.

- Develop codes of conduct for harmonious use of FADs by multiple stakeholders (including, for example, a measure of how each country is implementing community-based fisheries management and resource sharing).
- Modify the design of FADs to further reduce any potential impacts on marine mammals, turtles and seabirds.
- Train small-scale fishers in safe and effective FAD-fishing methods.
- Improve the use of boating safety equipment by small-scale FAD fishers so that they can make the transition to fishing further offshore with confidence and safety.
- Monitor the performance of FADs to determine how to continually improve the effectiveness of the infrastructure and its use by small-scale fishers.
- Train coastal communities in remote locations without refrigeration in simple post-harvest methods (e.g., drying and smoking, home canning) to maximise use and storage life of tuna caught around FADs.

(iii) Synthesise the information in (i) to (iii) above to:

- Identify the gaps in capacity that need to be addressed to scale-up National FAD Programmes in each of the 14 countries;
- Recommend the priority areas and extent of investments (in USD) needed to achieve the GCF Programme objectives for nearshore FADs in each country; and
- Document the status of National FAD Programmes in each country to establish a baseline for measuring the achievements of the Programme.

Outputs/Deliverables: The main output from this study will be a report that documents:

I. The number, size and distribution of coastal communities in each participating country.

II. The optimum locations and numbers of FADs needed to maximise access to tuna for coastal communities and the (country-agreed) target and priorities for FAD deployment given the funding available for Component A of the GCF Programme for each country.

III. The status of National FAD Programmes in each country at the start of the GCF regional tuna programme, including a table summarizing the extent to which the various activities needed to implement a scaled-up National FAD Programme listed above are already in place (in percentage terms).

IV. The gaps in capacity needed to implement a National FAD Programme at the appropriate scale in each country, including a table summarizing the nature and cost of investments that will need to be made for each of the activities listed above to complete all FAD-related activities at the appropriate level before the end of the Programme.

V. An assessment of the risk that the proposed investments do not fill all the gaps in capacity effectively, and recommended measures for reducing any such risks.

VI. The total number of people expected to benefit from scaled-up National FAD Programmes in each participating country.

The report must be a stand-alone document that describes the findings from this study in detail, with an appropriate Executive Summary.

B. Questionnaire for assessing progress towards a sustainable national aFAD Programme including sea safety and other related areas

Part I: Assessing progress towards a sustainable national aFAD Programme

	Ad hoc (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)	Comments
1. Capacity				
1.a Country-based experts are available to manage the aFAD Programme including the rigging and deployment of aFADs.				
1.b The national fisheries agency owns or has easy access to the infrastructure and equipment required to deploy aFADs (e.g. suitable boat with echo-sounder and GPS).				
1.c Depending on the size of the country, one or more recurrent positions at the national fisheries agency are fully or partly dedicated to aFAD work and this is reflected in job descriptions.				
1.d A succession training plan is in place to ensure that the country does not lose its aFAD technical capacity when the existing aFAD experts move out or retire.				
2. Management				
2.a Political stakeholders understand the contribution of nearshore aFADs to food security and livelihoods.				
2.b The national fisheries agency has strategic plans or policies that mention nearshore aFADs and the aFAD Programme.				
2.c A registry is used to record aFAD deployments and keep track of lost aFADs that need to be replaced.				
2.d Legislation and regulations are in place and enforced to support the national aFAD Programme and to clarify the roles and responsibilities of aFAD users.				
2.e The national fisheries agency has a nearshore FAD management plan or policy to guide its aFAD work.				
2.f A monitoring framework is in place that captures fishers' use of aFADs and/or catches at representative sites.				
3. End-user engagement				
3.a Partnerships are developed with end-users (e.g. communities, fishers' associations, sports fishing charters, recreational fishers) for the ownership, co-management and potential cost-sharing of aFADs.				
3.b An effective feedback mechanism exists between the national fisheries agency and aFAD end users.				
3.c FAD awareness-raising and training in sustainable FAD fishing methods and safe aFAD fishing methods are undertaken in communities that are newly exposed to aFADs.				

3.d Conflict resolution protocols are in place and effective				
4. Funding				
4.a The government agency provides the national fisheries agency with a recurrent annual budget for the implementation of its aFAD Programme.				
4.b Donors and/or the government agency provide occasional funding for aFAD projects.				
4.c Partnerships with end users are in place, which include aFAD cost-sharing.				

Part 2: Assessing complementary activities such as sea safety in support of a sustainable National aFAD Programme.

May be a mix of Fisheries Department and Maritime Department jurisdiction for sea safety.	*Ad hoc* (0-49%)	On the way to sustainability (50-99%)	Sustainable (100%)	Comments
5. Sea Safety Requirements				
5.a Country has regulations in place covering qualifications for small craft (3-8m in length) operators.				
5.b Country has regulations on sea safety equipment that needs to be carried when small craft are heading to sea.				
5.c Country has suitable training facility and trainers to provide training in qualifications and sea safety equipment use by small-scale fishers				
5.d Required sea safety equipment is available for purchase locally from public or private sector companies				
5.e Country has suitable facilities and skilled personnel for maintaining all sea safety equipment or has arrangements in place to have this done offshore.				
5.f Country has required small craft minimum specifications for design and construction to ensure seaworthiness				
5.g Good working relationship and proper information exchange protocols exists between fisheries and maritime authorities around sea safety				
5.h Fisheries provide coordinates for anchored aFADs to Maritime for updating navigation charts for merchant vessels				
5.i Country has aFADs marked for easy location day (flagpole with flag) or night (light and radar reflector).				
5.j Country has search and rescue vessels and plan in place when a small-scale vessel is reported missing.				
6. Sea Safety for Fishers				
6.a Fisheries agency uses and promotes the SPC sea safety checklist, or some form of checklist, and has this in local language for small-scale fishers				
6.b Fisheries agency encourages fishers to have a second smaller outboard for safety reasons				
6.c Fisheries agency encourages small-scale fishers to carry paddles and/or sail rig when fishing outside the reef.				

7. Fishing and processing				
7.a Fisheries agency is promoting fisher associations and/or cooperatives to encourage fishers to work together				
7.b Country has adequate ice making facilities providing ice at affordable prices for fishers to use				
7.c Fisheries agency is promoting post-harvest value-adding to tuna to develop new products and markets.				
7.d Fisheries agency is promoting and training fishers to troll around aFADs				
7.e Fisheries agency is promoting and training fishers in mid-water handlining and drift line methods around aFADs				
8. General information				
8.a What is the current price fishers pay for outboard fuel?				
8.b What is the current price fishers pay for ice?				
8.c What price do fishers sell their tuna for off the boat – per kg whole fish				
8.d What price do fishers sell their reef fish for off the boat – per kg whole fish				
8.e How much time do fishers spend fishing?				
8.f What other income earning activities do fishers engage in? Full-time fishers? Part-time fishers?				
8.g Where do fishers sell their catch? Roadside? Direct to buyers? Fish stalls? Other?				

C. List of all those consulted by country and region

Region and country	Name	Title	Organisation
Melanesia			
Fiji Islands	Ms Neomai Ravitu	Director	Ministry of Fisheries (MoF)
	Mr Navneel Singh	Principal Fisheries Officer (PFO), Inshore Fisheries Management Division	MoF
	Mr Saimoni Tauvoli	Senior Fisheries Officer (SFO), Fisheries Central Division	MoF
	Mr Kolinio Naivalu	SFO, Fisheries Northern Division	MoF
	Mr Aporosa Rabo	SFO, Fisheries Eastern Division	MoF
	Mr Anare Luvunakoro	Fisheries Officer Northern Division	MoF
	Mr Katagateman Tokabwebwe	SFO, Fisheries Western Division	MoF
	Mr Epeli Tawake	Fisheries Officer Western Division	MoF
	Mr Shalendra Singh	PFO Central Division	MoF
	Ms Mere Namudu	Regional Manager Eastern Division	MoF
Papua New Guinea	Mr Thomas Usu	Manager Tuna Fishery and Acting Executive Manager	Papua New Guinea (PNG) National Fisheries Authority (NFA)
	Ms Lorel Dandava	Manager, Inshore Fishery	PNG NFA
	Ms Rachel Rabi	Fisheries Management Officer - Sedentary	PNG NFA
	Mr Aisi Anas	Executive Manager, Fisheries Management	PNG NFA
	Mr Bredlee Murray	Inshore Fisheries Officer	PNG, NFA
	Mr Jonathan Manieva	Team Leader	Raun Wara Business Solutions
Solomon Islands	Ms Rosalie Masu	Deputy Secretary Technical – Inshore Fisheries Division	Ministry of Fisheries and Marine Resources (MFMR)
	Mr Bennie Buga	Deputy Director, Provincial Fisheries Division	MFMR
	Mr Aldrin Pezabule	Principal Fisheries Officer, FAD and Training section	MFMR
	Mr John Maefasimaoma	Chief Fisheries Officer Provincial Fisheries Division	MFMR
	Mr Ivory Akao	Deputy Director Inshore	MFMR

	Mr Jimmy Eroamae	Fisheries Officer Inshore	MFMR
Vanuatu	Mr Sompert Gereva	Deputy Director, Coastal / Acting Director	Vanuatu Fisheries Department (VFD)
	Mr George Amos	Manager, Development and Capture Section	VFD
	Mr Ajay Arudere	Fisheries Officer	VFD
Micronesia			
Federated States of Micronesia	Mr Bradley Phillip	Assistant Director, Fisheries Science Division	National Oceanic Resource Management Authority (NORMA)
	Mr Jamel James	Assistant Biologist	NORMA
	Ms Vanessa Fread	Assistant Secretary	Division of Marine Resources (DMR), FSM Department of Resources & Development (FSM R&D)
	Mr Dave Mathias	Fisheries Officer	DMR, FSM R&D
	Mr. Dahker Abraham (Kyo)	Administrator	Office of Fisheries and Aquaculture (OFA), Pohnpei State Government (PSG)
	Mr. Clay Hedson	Fisheries Specialist and FAD program coordinator	Coastal Fisheries Division, OFA, PSG
	Mr. Bruno D. Ned	Administrator	Division of Fisheries and Marine Resources, Department of Resources and Economic Affairs - Kosrae State Government (KSG)
	Mr. Kirisos Victus	Director	Department of Resources and Development (DRD) – Chuuk State Government (CSG)
	Mr Binaso Ruben	Deputy Director	DRD, CSG
	Mr. Enjoy Rain	Chief of Marine	DRD, CSG
	Mr. Anthony Yalon	Chief	Marine Resources Management Division – Department of Resources and Management – Yap State Government
Kiribati	Ms Tooreka Temari	Director, Coastal Fisheries Division (CFD)	Ministry of Fisheries and Marine Resources Development (MFMRD)
	Mr Karibanang Tamuera	Principal Fisheries Officer, CFD	MFMRD
	Mr Mike Savins	Managing Director and consultant with FAO on FAD (FishFAD) work	Kiricraft Central Pacific (boat builder) and FAO consultant
	Ms Rebeka Abaiota	National Project Assistant	FAO FAD project (FishFAD) in Kiribati

Marshall Islands	Ms Florence Edwards	Deputy Director	Marshall Islands Marine Resources Authority (MIMRA)
	Mr Glen Joseph	Director	MIMRA
	Mr Benedict Yamamura	Chief, Coastal Fisheries Division	MIMRA
	Mr Beven Wakefield	Programme Officer working on FAD Programme	FAO (FishFAD) and MIMRA
	Mr Junior Lanwi	Technician working on FAD Programme	MIMRA
Nauru	Mr Monte Depaune	Coastal Fisheries Manager	Nauru Fisheries and Marine Resources Authority (NFMRA)
	Ms Jasmina Jones	Fisheries Policy and Legal Manager	NFMRA
	Mr Being Yeeting	Fisheries Adviser	NFMRA
	Mr Giovanni Gioura	Senior Coastal Fisheries Officer	NFMRA
	Ms Breeze Grundler	Coastal Extension Officer	NFMRA
	Mr Elko-Joe Agir	Coastal Extension Officer	NFMRA
	Mr Micah Jeremiah	Coastal Fisheries Officer	NFMRA
Palau	Ms Kathy Sisior	Acting Director	Bureau of Fisheries (BOF), Ministry of Agriculture, Fisheries and the Environment (MAFE)
	Mr Fabio Siksei	Fisheries Specialist II/Acting Chief Division of Coastal Fisheries	BOF, MAFE
	Mr Erbai Yukiwo	Fisheries Extension Officer (and FAD person)	BOF, MAFE
	Mr Roman Mongami	Fisheries Extension Officer (and FAD person)	BOF, MAFE
	Mr Keobel Sakuma	Director of Conservation Policy (and FAD person), Micronesia and Polynesia Chapter	The Nature Conservancy (TNC)
Polynesia			
Cook Islands	Ms Pamela Maru	Secretary	Ministry of Marine Resources (MMR)
	Mr Koroa Raumea	Director: Inshore and Aquaculture Fisheries Division	MMR
	Mr Peter Graham	New FAD Programme Manager	MMR
	Mr Richard Story	Senior Fisheries Officer – Station Manager and FAD technician	MMR

	Mr Paul Upokokeu	Fisheries Extension Officer and assists with FAD work	MMR
Niue	Ms Josie Tamate	Director General	Ministry of Natural Resources
	Mr Poi Okesene	Director	Department of Agriculture, Forestry and Fisheries (DAFF)
	Mr Launoa Gataua	Fisheries Officer	DAFF
Samoa	Ms Moli Iakopo	Principal Fisheries Officer, Oceanic Fisheries and Compliance	Ministry of Agriculture and Fisheries (MAF)
	Mr Lorian Finau Groves	Senior Fisheries Officer, Fisheries Control and Development	MAF
	Mr Autalavou Tauaefa	Principal Fisheries Officer, Advisory	MAF
	Ms Serafina Ah Fook	Senior Fisheries Officer - Offshore	MAF
	Mr Roseti Imo	Assistant Chief Executive Officer	MAF
Tonga	Mr Poasi Ngaluafe	Deputy CEO, Head of Fisheries Science and Extension Division	Ministry of Fisheries (MOF)
	Mr Sione Mailau	FAD technician	MOF
	Mr Viliami Fatongiatau	??	MOF
Tuvalu	Mr Mike Batty	Fisheries Adviser to the TFD.	Tuvalu Fisheries Department (TFD), Ministry of Fisheries and Trade (MFT).
	Mr Nelly Seniola	FAD Technician and Training Officer	TFD of MFT
	Mr Viliamu Petaia	Fisheries Training and Development Officer	TFD, MFT
SPC Staff	Mr Ian Bertram	Principal Fisheries Adviser (Management and Livelihoods)	Division of Fisheries, Aquaculture and Marine Ecosystems (FAME), SPC
	Mr William Sokimi	Fisheries Development Officer (Fishing Technology)	FAME, SPC
	Mr Ludwig Kumoru	Technical focal point at SPC for the GCF fisheries proposal.	FAME, SPC
	Mr Phil Bright	Manager, Statistics Infrastructure and dissemination	Division of Statistics for Development, SPC

	Dr Andrew Smith	Deputy Director FAME (Coastal Fisheries and Aquaculture).	FAME, SPC
	Mr Franck Magron	Coastal Fisheries Information and Database Manager	FAME, SPC
	Dr Simon Nicol	Principal Fisheries Scientist (Fisheries and Ecosystems Monitoring and Analysis	FAME, SPC
	Mr Lui Bell	Fisheries Technician with SPC	SPC, FAME and based with MAF in Samoa
	Mr Andrew Wright	SPC staff to support writing the GCF funding proposal	SPC FAME
	Ms Mia Rimon	Regional Director - Melanesia.	SPC Melanesia Regional Office in Vanautu.
Conservation international staff	Dr Johann Bell	Senior Director Tuna Fisheries	Conservation International
	Ms Kara Miller	Technical Adviser, Pacific Tuna	Conservation International, Centre for oceans
Others that have been consulted	Mr Robert Jimmy	Deputy Chief of Party/Senior Regional Fisheries Adviser	USAID funded OurFish OurFuture project
	Mr Garry Preston	Fisheries consultant based in Vanuatu	Gillett, Preston and Associates (GPA)

D. Matrix for assessing progress towards a sustainable national aFAD Programme by region and country.

Matrix for assessing progress towards a sustainable national aFAD Programme.	Melanesia				Micronesia					Polynesia				
	FJ	PG	SB	VU	FM	KI	MH	NR	PW	CK	NU	WS	TO	TV
1. Capacity														
1.a Country-based experts are available to manage the aFAD Programme including the rigging and deployment of aFADs.	40	50	55	100	55	85	50	60	90	70	75	60	60	80
1.b The national fisheries agency owns or has easy access to the infrastructure and equipment required to deploy aFADs (e.g. suitable boat with echo-sounder and GPS).	60	90	50	80	43	60	60	75	55	80	75	20	60	100
1.c Depending on the size of the country, one or more recurrent positions at the national fisheries agency are fully or partly dedicated to aFAD work and this is reflected in job descriptions.	60	50	45	100	28	100	70	75	85	75	75	100	50	75
1.d A succession training plan is in place to ensure that the country does not lose its aFAD technical capacity when the existing aFAD experts move out or retire.	35	40	50	90	39	80	40	60	35	50	75	60	50	80
2. Management														
2.a Political stakeholders understand the contribution of nearshore aFADs to food security and livelihoods.	100	30	100	100	43	100	99	90	80	100	100	80	100	50
2.b The national fisheries agency has strategic plans or policies that mention nearshore aFADs and the aFAD Programme.	100	80	80	90	35	100	95	80	100	70	100	80	100	100
2.c A registry is used to record aFAD deployments and keep track of lost aFADs that need to be replaced.	60	60	65	100	53	45	80	80	90	75	100	100	100	75
2.d Legislation and regulations are in place and enforced to support the national aFAD Programme and to clarify the roles and responsibilities of aFAD users.	35	50	60	100	39	55	35	25	50	50	100	80	50	75

2.e The national fisheries agency has a nearshore aFAD Management Plan or policy to guide its aFAD work.	75	50	75	90		15	70	50	65	70		70	45	60	50	85
2.f A monitoring framework is in place that captures fishers' use of aFADs and/or catches at representative sites.	25	30	30	90		20	40	45	75	50		80	65	100	30	50
3. End-user engagement																
3.a Partnerships are developed with end-users (e.g., communities, fishers' associations, sports fishing charters, recreational fishers) for the ownership, co-management and potential cost-sharing of aFADs.	60	20	70	90		61	40	75	100	75		80	100	100	40	75
3.b An effective feedback mechanism exists between the national fisheries agency and aFAD end users.	55	50	45	90		40	85	50	65	70		80	100	100	70	80
3.c FAD awareness-raising and training in sustainable FAD fishing methods and safe aFAD fishing methods are undertaken in communities that are newly exposed to aFADs.	80	50	55	100		61	90	70	85	70		70	65	100	60	80
3.d Conflict resolution protocols are in place and effective.	25	30	55	100		43	40	49	85	40		20	45	80	80	95
4. Funding																
4.a The government agency provides the national fisheries agency with a recurrent annual budget for the implementation of its FAD Programme.	75	90	70	85		35	80	80	65	30		60	60	30	65	50
4.b Donors and/or the government agency provide occasional funding for FAD projects.	80	40	70	60		40	80	75	60	70		100	75	70	100	80
4.c Partnerships with end users are in place, which include aFAD cost-sharing.	70	20	80	60		23	30	60	0	40		50	75	10	35	0

E. Matrix for assessing the status of national sea safety requirements for small craft (<12m length) by region and country.

Matrix for assessing the status of national sea safety requirements for small craft (>12m length)	Melanesia				Micronesia					Polynesia				
	FJ	PG	SB	VU	FM	KI	MH	NR	PW	CK	NU	WS	TO	TV
5. Sea Safety Requirements														
5.a Country has regulations in place covering qualifications for small craft (3-8m in length) operators.	100	80	45	100	34	65	100	N/A	100	60	100	80	50	0
5.b Country has regulations on sea safety equipment that needs to be carried when small craft are heading to sea.	100	50	45	60	35	65	100	30	100	60	100	100	50	0
5.c Country has suitable training facility and trainers to provide training in qualifications and sea safety equipment use by small-scale fishers.	100	85	100	100	39	65	97	20	30	40	60	80	30	90
5.d Required sea safety equipment is available for purchase locally from public or private sector companies.	100	40	70	100	43	65	60	25	75	65	75	20	30	75
5.e Country has suitable facilities and skilled personnel for maintaining all sea safety equipment or has arrangements in place to have this done offshore.	100	50	80	80	29	45	30	20	65	40	60	20	10	50
5.f Country has required small craft minimum specifications for design and construction to ensure seaworthiness.	100	50	50	90	5	75	70	25	40	20	N/A	100	10	0
5.g Good working relationship and proper information exchange protocols exists between fisheries and maritime authorities around sea safety.	100	50	70	90	53	60	95	50	70	90	100	100	80	50
5.h Fisheries provide coordinates for anchored aFADs to Maritime for updating navigation charts for merchant vessels.	100	40	60	100	38	60	100	100	100	100	100	100	80	50
5.i Country has aFADs marked for easy location day (flagpole with flag) or night (light and radar reflector).	50	50	50	90	61	45	50	70	30	70	60	50	60	50

5.j Country has search and rescue vessels and plan in place when a small-scale vessel is reported missing.	100	70	60	100		56	90	100	60	100		70	90	100	100	100
6. Sea Safety for Fishers																
6.a Fisheries agency uses and promotes the SPC sea safety checklist, or some form of checklist, and has this in local language for small-scale fishers.	80	40	80	100		41	90	100	90	85		60	100	60	80	80
6.b Fisheries agency encourages fishers to have a second smaller outboard for safety reasons.	80	35	55	90		40	80	90	20	80		30	100	100	40	25
6.c Fisheries agency encourages small-scale fishers to carry paddles and/or sail rig when fishing outside the reef.	100	50	45	100		49	100	80	50	80		75	100	20	40	35

Melanesia

Micronesia

Polynesia

T. Method for measuring the contribution of strengthened national aFAD Programmes to domestic food security

The effectiveness of strengthening aFAD Programmes to increase access to tuna to improve domestic food security will be estimated in each country by: a) measuring the average annual catch of tuna and other pelagic fish from a range of aFADs, and b) combining this information with the number of additional aFADs installed in the country to calculate the total amount of additional tuna produced from the aFADs deployed by the Programme.

This increased tuna catch from the aFADs deployed by the Programme will then be converted into the number of fish meals provided by these aFADs. For the reasons explained below, the number of fish meals can be based on portions of 150 g and the typical ~60% recovery of fish flesh per kg from tuna and other large pelagic fish.

A fish meal of 150 g, although smaller than the fish meals eaten in many Pacific Island countries, is of important nutritional value for the following reason. The World Health Organisation (WHO) recommends that daily protein intake for good nutrition should be 0.7 g of protein per kg of body weight per day, derived from a variety of sources to prevent micronutrient deficiencies. Accordingly, the SPC Public Health Division has recommended that fish should be used to provide 50% of this dietary protein[45]. A tuna meal of 150 g will provide more than the recommended level of fish consumption per day for the average Pacific Island man and woman, and will meet the needs of two average Pacific Island children per day. These calculations are based on the average weights of Pacific Island men (85 kg), women (81 kg) and children of 5-18 years (45 kg) (Appendix 1), and the fact that tuna is ~23% protein (see Technical Study 2). Thus, a 150 g portion of tuna will provide ~35 g of protein, which is $\geq$50% of the protein intake recommended by WHO for someone with a body weight of up to 100 kg, and >50% of the dietary protein needed for two children of 45 kg.

A weakness in this approach, however, is that data on the average annual catches per aFAD are limited – they were collected irregularly 10¬20 years ago and are available for only five of the 14 countries[46]. This weakness can be overcome by a) monitoring catches around a representative subset (n = 3) of aFADs in each country over an ~2-year period as early as practical during Phase 1 of the aFAD Management Plan; and b) hindcasting the estimate of average annual catch (taking account of any other factors that may have influenced the use of tuna associated with aFADs) to create the baseline against which to measure the additional quantity of fish meals of 150 g made available per person resulting from the increased number of aFADs deployed under strengthened national FAD programmes.

To understand the general scope for increasing the quantity of fish meals available for local food security in each country through strengthening the national aFAD Programme, estimated catches from an aFAD in the range of 5¬10 tonnes per year have been used. This range is based on a more recent, albeit limited,

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[45] SPC (2008). Fish and food security. Policy Brief 1/2008. Secretariat of the Pacific Community, Noumea.

[46] Bell, J.D., Albert, J., Andréfouët, S., Andrew, N.L., Blanc, M., Bright, P., Brogan, D., Campbell, B., Govan, H., Hampton, J. and Hanich, Q. 2015. Optimising the use of nearshore fish aggregating devices for food security in the Pacific Islands. *Marine Policy*, *56*, pp.98-105 (see Supplementary Table 3).

amount of unpublished data available from some SPC member countries and is somewhat higher than the range from the older data mentioned above. Use of the higher range of catches is thought to be appropriate because of the greater number of people now living (and fishing) in coastal areas and the efforts that have been made to disseminate information on effective aFAD-fishing methods. Even so, considerable variation is expected in annual catches from an aFAD both within and among countries. For example, 'inshore' aFADs placed relatively close to the coast (at a depth of 200 – 500 m) to provide access to tuna and other large pelagic fish for fishers in paddling canoes are not expected to be as productive as 'offshore' aFADs placed several km out to sea (at depths ranging from 800 – 2500 m) used by fishers who have motor boats. In countries where it is evident that there will be large differences in potential catches between inshore and offshore aFADs, it will be necessary to monitor catches from three representative aFADs from each type of location.

Based on the use of average annual catches from aFADs in this range, and the number of aFADs to be deployed in each country during the 7-year programme, strengthening national aFAD Programmes could deliver up to an additional 13 million fish meals across the region per year by 2030 (Table 1).

Importantly, for five of the smaller Pacific Island countries (Cook Islands, Nauru, Niue, Palau and Tuvalu), strengthening the national aFAD Programme could deliver up to 3¬8 additional fish meals per person per month (and 6¬16 meals for children) for the entire population or a target population that represents a significant proportion of the total population (Table 1) (and a much higher number of meals per month for Niue given the low number of people living there).

For the larger countries (PNG, Fiji, Solomon Islands and Vanuatu), Component A of the GCF regional tuna programme needs to be managed at the provincial level because it is simply not possible to scale-up the number of aFADs throughout all areas of the country to meet the needs of coastal communities nationwide. Given the relatively large population at the provincial level in these Melanesian countries, strengthening national aFAD Programmes is estimated to provide an average of only up to 1¬2 tuna meals per person per month for the target populations in these countries (Table 1). This is also the case for the remaining countries (FSM, Kiribati, Marshall Islands, Samoa and Tonga), where it is not possible to target the majority of the national population in some cases.

There are, however, good prospects for increasing the number of fish meals per person per month in several countries by harmonising the proposed aFAD-related activities in the GCF Programme with the plans that the World Bank's Pacific Islands Regional Oceanscape Program (PROP) also has to strengthen national aFAD Programmes. The second phase of PROP (known as PROPER) is now underway and involves many of the 14 countries participating in the GCF Programme. PROPER is expected to be active throughout much of the implementation phase of the GCF Programme and preliminary talks with the World Bank PROPER team on a collaborative approach have been promising. A collaboration between the two programmes to promote synergies and avoid duplication will enable more provinces in the larger countries to receive aFADs, and the number of aFADs for some provinces proposed under the GCF Programme to be increased where this is a national priority.

Table 1. Preliminary analysis of the number of fish meals per person provided in 2030 by strengthening national FAD programmes (assuming that annual catches from a FAD are in the range of 5 to 10 tonnes).

Country	No. of people expected to benefit in 2030	No. of FADs	No. of fish meals $year^{-1}$*		No. fish meals $person^{-1}$ $year^{-1}$		No. fish meals $person^{-1}$ $month^{-1}$	
			@5 mt per FAD $year^{-1}$	@10 mt per FAD $year^{-1}$	@5 mt per FAD $year^{-1}$	@10 mt per FAD $year^{-1}$	@5 mt per FAD $year^{-1}$	@10 mt per FAD $year^{-1}$
Melanesia								
Fiji	72,483[a]	40	800,000	1,600,000	11.0	22.1	0.9	1.8
PNG	91,834[b]	36	720,000	1,440,000	7.8	15.7	0.7	1.3
Solomon Is	62,752[c]	20	400,000	800,000	6.4	12.7	0.5	1.1
Vanuatu	66,850 [d]	34	680,000	1,360,000	10.2	20.3	0.8	1.7
Micronesia								
FSM	38,588[e]	24	480,000	960,000	12.4	24.9	1.0	2.1
Kiribati	81,778[f]	38	760,000	1,520,000	9.3	18.6	0.8	1.5
Marshall Is	26,993[g]	27	540,000	1,080,000	20.0	40.0	1.7	3.3
Nauru	12,539[h]	12	240,000	480,000	19.1	38.3	1.6	3.2
Palau	8,815[i]	16	320,000	640,000	36.3	72.6	3.0	6.1
Polynesia								
Cook Is	8,792[j]	20	400,000	800,000	45.5	91.0	3.8	7.6
Niue	1,393[k]	14	280,000	560,000	201.0	402.0	16.8	33.5
Samoa	41,874[l]	18	360,000	720,000	8.6	17.2	0.7	1.4
Tonga	32,950[m]	20	400,000	800,000	12.1	24.3	1.0	2.0
Tuvalu	11,250[n]	14	280,000	560,000	24.9	49.8	2.1	4.1
TOTAL	**558,890**	**333**	**6,660,000**	**13,320,000**	**11.9**	**23.8**	**1.0**	**2.0**

*Based on four fish meals of 150 g per kg of fish, based on a recovery rate of fish flesh of ~60%.

a. 30% of the population in Rewa, Serua and Namosi districts and 80% of the population in Kadavu, Lau and Lomaiviti districts; b. 20% of the population of Manua and Bougainville provinces; c. 90% of the population of the Temotu Province and 20% of the population of Guadalcanal Province; d. 50% the population of Shefa and Tafea provinces and 20% of the population of Port Vila; e. 80% of the population in Pohnpei State and 80% of the population in Yap State; f. 40% of the population of South Tarawa and all of the population in the other 16 inhabited Gilbert Islands Group islands; g. 50% of the population of the Marshall Islands; h. 100% of the population of Nauru; i. 50% of the population for 14 States; j. 50% of the population of Rarotonga and the full population of the other five inhabited islands in southern Cook Islands; k. 100% of the population of Niue; l. 20% of the population for Samoa; m. 40% of the population for Tongatapu, Eua and Ha'apai; n. 100% of the population for Tuvalu.

Appendix 1. Mean height, body mass index (BMI) and weight of men, women and children in the 14 participating countries (source Technical Study 2).

Country	Men			Women			Children (5-18 yrs) average		
	2019 Height (cm)	2016 BMI	Weight (kg)	2019 Height (cm)	2016 BMI	Weight (kg)	2019 Height (cm)	2016 BMI	Weight (kg)
Cook Is	178	33	104	167	33	93	150	24	53
Fiji	174	27	81	164	29	78	146	19	41
Kiribati	170	29	84	161	31	81	144	22	45
Marshall Is	165	29	79	155	31	73	139	21	41
FSM	170	28	81	160	32	80	142	21	42
Nauru	170	32	93	158	33	82	142	24	47
Niue	177	32	99	167	34	93	149	24	52
Palau	171	30	86	160	30	76	144	23	47
PNG	163	25	68	157	26	64	139	21	40
Samoa	174	31	93	164	34	92	143	22	45
Solomon Is	163	26	69	157	27	67	138	19	36
Tonga	175	31	94	166	34	94	148	23	50
Tuvalu	171	30	89	164	32	85	146	23	48
Vanuatu	168	26	73	160	27	69	142	20	40
Average	**171**	**29**	**85**	**161**	**31**	**81**	**144**	**22**	**45**

Disaster Risk Reduction in Fisheries in the Pacific Islands

Study 4 – Review of the capacity of national administrations to manage the risks posed by natural disasters to small-scale fishers.

By Jessica Sanders

Fisher surveys conducted by Neelam Bhan, Viliami Fatongiatau, Nimilote Halatoafa, Georgina Kaising, Janet Saeni-Oeta, Maria Sapatu, Laitailiu Seono and Tooreka Temari

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Acronyms

DRM	Disaster risk management
DRR	Disaster risk reduction
EWS	Early Warning Systems
FADs	Fish Aggregating Devices
FAO	Food and Agriculture Organization of the United Nations
FRDP	Framework for Resilient Development in the Pacific
ICSF	International Collective in Support of Fishworkers
NHMSs	National Hydrological and Meteorological Services
PDNA	Post disaster needs assessments
PIMS	Pacific Islands Meteorology Strategy
rPFSC	Regional Pacific Food Security Cluster
SIDS	Small Island Developing States
SPC	The Pacific Community
UNDRR	United Nations Office for Disaster Risk Reduction
WMO	World Meteorological Organization

Executive Summary

As climate change continues to impact the Pacific Islands and their fisheries in a myriad of ways, building adaptation strategies and improving reliance within the fisheries sector and coastal communities is essential. Natural hazards such as extreme weather events already have a large impact on the Pacific with 41% of all declared disasters over the last decade in the region being meteorological. However, the fisheries sector is often not adequately considered or integrated into disaster risk management. Small-scale fisheries and associated communities are on the frontline of metrological events and resulting declared disasters leaving communities and the essential food and nutrient source of coastal fisheries in peril. Improved integration and fisheries specific plans for disaster risk reduction as well as anticipatory actions can reduce, or even mitigate the impact of natural hazards.

This study was conducted through desk-based research, a national survey of fisheries administrations and National Disaster Management Offices (using a google survey) and a fisher survey (using KoboToolbox) administered by Neelam Bhan, Viliami Fatongiatau, Nimilote Halatoafa, Georgina Kaising, Janet Saeni-Oeta, Maria Sapatu, Laitailiu Seono and Tooreka Temari. The latter inputs are summarized in this report and were used to design the proposed activities for the GCF project, "Adapting tuna-dependent Pacific Island communities and economies to climate change," on the topic of disaster risk manage the risks posed by natural disasters to small-scale fishers.

1. Introduction

1.1. Disaster risk reduction and fisheries

Throughout the tropical Pacific, coastal aquatic systems deliver many of the benefits from fisheries that directly affect coastal communities, such as food security, nutrition and family income. Yet, according to a study from the Food and Agriculture Organization of the United Nations (Barange et al. 2018) , Pacific Island countries will be among the most affected by climate change impacts on fisheries and aquaculture. Climate change impacts are not only expected to affect fish reproduction, replenishment and distribution, they are also linked to changes in global weather patterns, sea levels, and the frequency, intensity, geographic distribution and timing of extreme events. The World Meteorological Organization reported that from 1970 to 2019, weather, climate and water hazards accounted for 50% of all disasters, 45% of all reported deaths and 74% of all reported economic losses worldwide (WMO 2021).

The fisheries and aquaculture sector has a particularly high exposure to weather-related hazards and faces substantial threats from extreme events, which can lead to short- and long-term displacement of human populations, safety and health hazards caused by flooding, as well as severe loss and damage to infrastructure, such as wharves, markets, access roads, and fishing boats and gear.

Although the impacts of climate change may originate as an external shock, the interplay of vulnerability, exposure and the severity of a natural hazard combine to create disasters. Reducing disaster risk is critical to alleviating poverty, meeting sustainable development goals and improving resilience, particularly in exposed and vulnerable countries such as many Pacific small island developing states. In the latest risk assessment profile from IFHV and Bündnis Entwicklung Hilft (2023), Melanesian countries score high on vulnerability and exposure to disaster risk, with Papua New Guinea and Solomon Islands rating as the most vulnerable within the subregion. In addition, fisherfolk and their communities are often particularly exposed to natural hazards, a situation that is compounded by typically low incomes and few alternative livelihoods for small-scale fishing communities. Thus, integrating fisheries into disaster risk reduction is crucial for building resilience in the Pacific Islands.

Disaster risk reduction (DRR) guides policy and actions to reduce existing risk to natural hazards, such as flooding, drought and storms, as well as strengthen resilience. Whereas disaster risk management (DRM) refers to the entire process from reducing risk to response and recovery after a disaster has struck. These concepts are defined and brought to the forefront of policy through the internationally agreed Sendai Framework for Disaster Risk Reduction (2015 to 2030).

Unfortunately, the fisheries sector in many countries is not adequately integrated into DRR and DRM frameworks or strategies. To illustrate the disconnect, in a 2021 FAO study, out of 71 post disaster needs assessments (PDNA) reviewed, only a few mentioned the fisheries sector (FAO 2021). This lack of inclusion of the sector holds true for Pacific Islands nations as well, at both regional and national levels. For this reason, there is an urgent need to expand DRR and DRM systems for the fisheries and aquaculture sector in order to anticipate, prevent, prepare for, and reduce the impact of extreme events and disasters, as well as protect and build resilient fisheries-based livelihoods and support production systems.

1.1. The Pacific, fisheries and natural hazards

Globally, over the last three decades, there has been a rising trend in the occurrence of disasters and related economic damage. This is particularly noteworthy in relation to climatological events such as droughts, hydrological events like floods and meteorological events such as storms.

1.2. The Pacific, fisheries and natural hazards

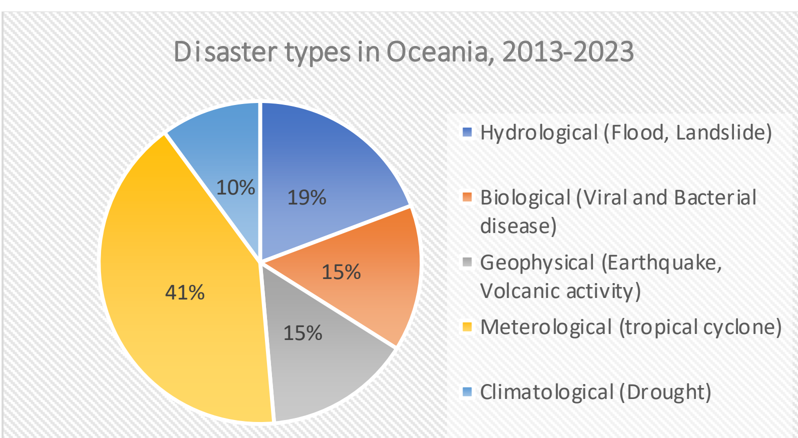
Globally, over the last three decades, there has been a rising trend in the occurrence of disasters and related economic damage. This is particularly noteworthy in relation to climatological events such as droughts, hydrological events like floods and meteorological events such as storms.

Despite the paucity of attention to fisheries in the wake of disaster, the fisheries sector is in a unique position to assist in recovery to re-establish food security. Fisheries provide a high-quality, protein and nutrient-rich food source (see Technical Study 2) which is usually immediately accessible after a disaster, depending on the impact on fish habitats and fishing assets. This contrasts with agricultural consumables, which may take many months to replant, recover, and provide viable food and income sources. Relatively small inputs to small-scale fisheries may enable the sector to restart food production activities quickly, as described for small-scale fisheries targeting tuna in the Pacific Island region (Bell et al. 2018). Additionally, quickly re-starting these crucial fisheries activities after a disaster can help local communities generate cash and assist with restarting the local economy.

Despite this, FAO (2021) reports that the fisheries sector is often an absent or a newly adopted partner in many parts of the world. Sector-specific disaster risk reduction plans and strategies, as well as improved integration of fisheries, into overall disaster risk management is a missing piece of improving recovery options and resilience for affected communities.

The fisheries subsector is most affected by tsunamis and storms, such as hurricanes and cyclones, which is particularly evident in small island developing states, such as in the Pacific Islands, where a large percentage of declared disasters (41%) according to the Centre for Research on the Epidemiology of Disasters in the last decade have been meteorological, including storms and cyclones (Figure 1). Thus, the Pacific Island region stands to benefit substantially from the integration and consideration of the fisheries sector in disaster risk reduction and management.

Figure 1 – Cumulative declared disasters in Oceania from 2013 to August 2023, excluding Australia and New Zealand.
Source: EM-DAT, CRED / UCLouvain, Brussels, Belgium. Accessed August 4, 2023.



1.2. Terms of reference and methodology

This study is one of the series of Technical Studies commissioned to inform the development of the Funding Proposal for the GCF regional tuna programme[1]. The main purpose of this study is to assess the capacity of national administrations to manage the risks posed by natural disasters to small-scale fishers, and identify gaps to be filled. A complementary focus on accessibility and utilization of existing systems to support disaster risk reduction in fishing or coastal communities has been included.

To accomplish this, a desktop study was conducted as well as online surveys of national administrations and an in-person survey of fisherfolk. Results from a complementary study on early warning systems in the Pacific Islands completed by the International Collective in Support of Fishworkers (ICSF) has been drawn (Naidu et al. *In preparation*). The fisher-focused survey has informed the majority of the outputs and was designed to glean insights into the mechanisms and channels through which small-scale tuna fishers and their communities receive critical information regarding severe weather warnings and disaster recovery information. The survey was intended to provide a snapshot of the current situation at the local level, which served to inform the development of specific DRR and DRM activities in the regional tuna programme, rather than a comprehensive analysis.

The fisher survey was undertaken in the eight countries which responded to the request by a combination of fisheries staff and independent national consultants supported by national fisheries staff. These surveys were conducted at fish markets, fish landing sites, and dockside locations. Enumerators in each country sought out small-scale fishers who were likely to be engaged in fishing using nearshore, artisanal fish aggregating devices (aFADs) or targeting tuna and other large pelagic fish species (hereafter 'tuna'). The survey was administered using the KoboToolbox platform.

In total, 329 individuals were interviewed, comprising 89% male and 11% female participants. Most respondents had extensive fishing experience, with 62% having engaged in fishing for over a decade, and only 11% with less than five years of experience. Over half of the respondents were over 40 years old, 45% between 25 to 40 years old and only 2% were under 25 years old.

Table 1 – Total number of respondents to fisher survey by country

Country	Total	Male	Female
Tonga	71	62	9
Solomon Islands	75	73	2
Fiji	87	73	14
Samoa	24	19	5
Cook Islands	6	6	0
Kiribati	15	9	6
Vanuatu	35	35	0
Tuvalu	16	16	0

[1] https://www.greenclimate.fund/document/ppf-adapting-tuna-dependent-pacific-island-communities-and-economies-climate-change

3. Policy framework

The Pacific region has developed and implemented many relevant policies outlining strategies and frameworks from the disaster risk reduction, meteorology and fisheries perspective. All of the frameworks outlined below are supporting structures for disaster risk reduction in the fisheries sector, but do not provide explicit advice, steps or tools to inform how to forecast disasters, turn forecasts into products and communication materials to support timely and tailored preventive actions by small-scale fishers or train small-scale fishers in how to use the information from forecasts referred to in the terms of reference for this study (see Appendix 5).

The frameworks listed below are important elements of national plans, providing guidance on disaster risk reduction, advancing early warning systems and improving meteorological information for small-scale fishers. In addition, these frameworks and associated agreements lay out commitments made by the Pacific Small Island Developing States including the 14 GCF participating countries at the regional level on reducing impacts of disasters and improving the lives and livelihoods of small-scale fishers.

Policies and Strategies	**Related global frameworks**
The Framework for Resilient Development in the Pacific (FRDP)	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
Pacific Islands Meteorology Strategy (PIMS)	the Small Islands Developing States Accelerated Modalities of Action (S.A.M.O.A) Pathway
The Noumea strategy: A new song for coastal fisheries – pathways to change	United Nations Framework Convention on Climate Change (UNFCCC)
Asia-Pacific Action Plan 2021-2024 for the Implementation of the Sendai Framework	Sustainable Development Goals (SDGs)
2050 Strategy for the Blue Pacific Continent	Sendai Framework for Disaster Risk Reduction, 2015–2030

The Framework for Resilient Development in the Pacific (FRDP), 2017 – 2030

The Framework for Resilient Development in the Pacific (FRDP), 2017 – 20302 combines the two previous separate regional strategies on disaster risk reduction and climate change to combine expertise and reduce overlaps.[3] The FRDP provides high level guidance useful to the fisheries sector, but as a high-level document does not provide specific guidance on training or tools. It does set out strong policy basis for empowering communities, including fisheries communities to develop skills and access resources to be able to respond to disasters and climate change.

Pacific Islands Meteorology Strategy (PIMS), 2017-2026

The Pacific Islands Meteorology Strategy (PIMS), 2017-2026 outlines the aspirations of the national meteorological and hydrological services (NMHS) of the Pacific Islands. This strategy guides the national services and provides a framework for capacity development and resourcing. The strategy is updated every five years

[2] Framework for Resilient Development in the Pacific: An Integrated Approach to Address Climate Change and Disaster Risk Management (FRDP) 2017-2030. Voluntary Guidelines for the Pacific Islands Region
[3] The Pacific Islands Framework for Action on Climate Change (PIFACC) and the Pacific Disaster Risk Reduction and Disaster Management Framework for Action (RFA)

and supported by the Pacific Meteorological Council (PMC) and the Pacific Meteorology Desk Partnership (World Meteorological Organization (WMO) and the Secretariat for the Regional Environment Programme (SPREP)).

Priority 1 is of particular relevance to the development of DRR activities needed to support the GCF regional tuna programme because it includes the objective to achieve "Improved marine weather services and establishment of ocean services''. The policy notes that although many "meteorological services are often well developed in the region, communication to communities and other user groups requires strengthening." In addition, Priority 2 highlights disaster risk reduction and notes "Strengthened National Hydrological and Meteorological Services capacity to implement Multi-Hazard early Warning Systems" as a priority.

While not directly relevant as a high-level policy to the capacity development or training for small-scale fisheries, the policy is crucial in bringing together NMHS' of the Pacific to work toward improved marine weather services, strengthening of early warning systems and a focus on inclusion and access for vulnerable groups for weather information. There is a disconnect from the fisheries sector which would benefit from collaborative discussions on practical improvements for marine weather services and more accessible weather information.

Asia-Pacific Action Plan 2021-2024 for the Implementation of the Sendai Framework

This Regional Action Plan meets the need for regional action plans and strategies under the Sendai Framework for Disaster Risk Reduction 2015-2030 and builds on the 2018-2020 Plan[4] for the region. The Plan notes that when the impact of disasters is viewed through the lens of the percentage of a population impacted, the Pacific Islands region has experienced some of the worst disasters. As examples, Cyclone Gita in 2018 affected 86% of Tonga's population and Cyclone Tino in 2020 which affected 50% of Tuvalu's population. This new Action Plan aims to accelerate the Asia-Pacific's transformation to risk-informed development, by treating DRR as a cross-cutting theme and by increasing investment in prevention, risk reduction, climate change adaptation and anticipatory approaches to enhance resilience.

At the national level, the Plan outlines the importance of mainstreaming DRR across sectors and strengthening linkages between NDMOs, metrological and relevant agencies, including agricultural (and fisheries) agencies, as well as advancing innovative low-cost technologies for DRR.

At the local level, the Plan calls for ensuring early warning and disaster impact information is available in formats that are understood by everyone in the community, as well as addressing misinformation.

2050 Strategy for the Blue Pacific Continent

Recognizing the deep connection of the Pacific Islands to the Pacific Ocean, a long-term strategy for resilience and opportunities to harness the power of the blue Pacific continent was developed with ten commitments and seven thematic areas.[5] This Strategy builds on the values as well as challenges that Pacific region may face with increasing impacts from climate change and seeks to bring resilience to the region through the shared stewardship of the "Blue Pacific Continent." It maps various pathways toward resilience, including regional cooperation and collaboration to build capacity and resilience of communities to address the impacts of climate

[4] The Action Plan 2018-2020 of the Asia Regional Plan for Implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030

[5] 2050 Strategy for the Blue Pacific Continent

change and disasters. One of the thematic areas of the Strategy is "Climate Change and Disasters" which aims to ensure that "all Pacific peoples remain resilient to the impacts of climate change and disasters and are able to lead safe, secure, and prosperous lives."

This Strategy builds on several related regional strategies, including the Framework for Pacific Regionalism (2014), the Regional Roadmap for Sustainable Fisheries (2015) and The Blue Pacific Narrative (2017).

The Noumea strategy: A new song for coastal fisheries – pathways to change.

The *New Song for Coastal Fisheries – pathways to change: The Noumea strategy* was developed and approved by SPC Heads of Fisheries and the Forum Fisheries Committee in 2015. The Strategy recognizes the importance and value of coastal fisheries and provides a platform to measure, elevate and work toward actions to improve the small-scale fisheries in the region. Of relevance to disaster risk reduction are goals related to fisheries agencies working toward integrating and coordinating on small-scale fisheries management activities; ensuring coastal fisheries are included in development; cross sectoral advice is provided; and that there is equitable access to benefits and resources.

A Regional Roadmap for Sustainable Pacific Fisheries

In 2010, Pacific Islands Forum Leaders were presented with the outcomes of a forward-looking study on the Future of Fisheries, which identified very broad focal areas to achieve a best-case scenario for the region over the following 25 years. Five years later, in an effort to address missed opportunities, and the importance of coastal fisheries for food security and livelihoods, that are under threat from growing populations and, in the longer term, from the impacts of climate change, SPC and FFA also adopted a Regional Roadmap with broad aims to improve the management of coastal fisheries and provide alternative livelihoods and protein sources which can prevent a decline in fish supplies and further degradation of the coastal environment.

Key goals that are specific importance to small-scale fisheries and disaster risk reduction include the below goals under both the Tuna Fisheries and Coastal Fisheries sections.[6] The relevant goal under the section on Tuna Fisheries is Goal 4 on Food Security which aims to increase the "supply of tuna for domestic consumption in the region by 40,000 tonnes per year by 2024". Increasing the amount of tuna available domestically will ensure a continuous supply of a crucial healthy and nutrient dense food source as well as reduce pressure on coastal fisheries. The Roadmap envisions that this goal could include the contribution of small-scale tuna fisheries.

The section on Coastal Fisheries includes a goal on Empowerment (Goal 1). The goal seeks to ensure that communities are involved and have a say in the management of coastal resources which facilities disaster risk reduction. Communities need access to information, knowledge and resources from fisheries agencies, disaster risk management offices and National Hydrological and Meteorological Services to protect their families, assets and businesses from the impacts of disasters. In addition, goal 2 which is focused on resilience is relevant to the topic of disaster risk reduction. Resilience of coastal ecosystems to threats from outside of the fisheries sector supports disaster risk management goals for the fisheries sector and coastal communities. Developing DRR and DRM systems to protect communities from the increasing impacts of climate change will include healthy coastal ecosystems that provide services and protection to communities from natural hazards.

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[6] A Regional Roadmap for Sustainable Pacific Fisheries.
https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/FFA_SPC_2015_Roadmap.pdf

Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication

While global in nature, the SSF guidelines are a valuable reference as the main link between small-scale fisheries and disaster risk reduction and response. They specifically discuss policy elements of disasters and climate change and include the following as guiding principles.

- The importance of integrated and cross-sectoral collaboration to address disaster risks.
- Acknowledgment of the specific impacts that a disaster may have on the fisheries sector including the post-harvest and trade areas.
- At the national level, an understanding of how emergency response and preparedness address or include small-scale fisheries is essential.
- Emergency response should include a view toward long-term development and building resilience when working with the small-scale fisheries sector.

Table 2 – Global policy and strategy linkages to regional frameworks on disaster risk reduction, meteorology and small-scale fisheries

	Global linkages				
Regional frameworks	**SAMOA Pathway**	**Sendai Frwrk**	**UNFCCC**	**SDGs**	**VG - SSF**
The Noumea strategy: A new song for coastal fisheries – pathways to change. 2015					
The Framework for Resilient Development in the Pacific (FRDP)					
Asia-Pacific Action Plan 2021-2024 for the Implementation of the Sendai Framework					
A Regional Roadmap for Sustainable Pacific Fisheries					
2050 Strategy for the Blue Pacific Continent					
ASEAN Framework on Anticipatory Action in DM					
Pacific Islands Meteorology Strategy (PIMS) 2017-2026					

4. Weather warnings and meteorological information in small-scale fisheries

4.1. Weather warnings and early warning systems

Accessing weather information and being informed in advance of severe weather is an important component of resilience and allows small-scale fishers to make appropriate decisions to reduce their exposure to dangerous sea conditions, protect their assets and themselves. Full, transparent and accessible weather warnings and information links to regional goals such as empowering communities (Noumea Strategy), ensuring that practical on-the-ground actions are embedded across all sectors (FRDP), and Priority 2 of the *Pacific Islands Meteorology Strategy (PIMS)* which highlights disaster risk reduction and notes that strengthened NHMSs capacity to implement multi-hazard early warning systems is an imperative.

The world of development and humanitarian aid is continually developing to improve outcomes and increase responsiveness as well as work toward locally owned solutions to support resilient communities. One key aspect of reducing impacts and supporting particularly vulnerable populations is the use of early warning systems (EWS). Such systems save lives by allowing people to act before a natural hazard becomes a disaster. EWS have such importance in the global dialogue that the UN Secretary-General launched, in March 2022, the Early

Warnings for All initiative which called for every person on Earth to be protected by early warning systems by 2027.[7]

The four main components of an early warning system as identified by the Sendai Framework (chapter G) include; (i) Disaster risk knowledge, (ii) Observations, monitoring and forecasting systems, (iii) warning dissemination mechanisms, and (iv) preparedness and response capability. A recent report on the global status of early warning systems notes the importance of such systems in saving lives but also the paucity of functional EWS in many small island developing States (SIDS) (UNDRR and WMO 2022).[8] This is also true in the Pacific Island region where governments, and regional and international agencies, have placed importance on EWS but often struggle to achieve long-term functional, effective EWS systems. Important initiatives, such as the policy frameworks outlined above and regional funding initiatives such as Strengthening Hydro-Meteorological and Early Warning Services in the Pacific (CREWS Pacific SIDS 2.0; WMO) and the Community Based Early Warning Systems (World Bank, WMO and UNDRR), have moved EWS forward. However, most countries do not yet have fully functional, timely, accurate and accessible EWS (see Annex 1).

Another crucial component to reducing impacts on vulnerable populations lies in the recent work to develop anticipatory actions. This can comprise actions to reduce impacts to both slow-onset or quick-onset disasters, such as cyclones, and can include concepts such as cash advances to assist communities in protecting assets or infrastructure. A number of pilot activities involving anticipatory actions for fishing or coastal communities within Pacific Island countries are underway.[9]

Both effective and accessible early warning systems, and clearly communicated effective anticipatory actions, will be a tremendous improvement for the small-scale fisheries sector in preparing for and responding to natural disasters. This can be seen in the comments from fisheries personnel from the various countries who responded to the survey requesting timely and accurate early warnings as well as options for useful and cost-effective anticipatory actions.

Information voluntarily reported by governments on the targets of the Sendai Frameworks show that progress is being made (Table 3).

[7] WMO and the Early Warnings for All Initiative. https://wmo.int/site/wmo-and-early-warnings-all-initiative

[8] UNDRR and WMO (2022) "Global status of multi-hazard early warning systems: Target G", United Nations Office for Disaster Risk Reduction

[9] Current pilot activities include anticipatory action pathways for coastal communities in Fiji including assistance to act to protect assets through early warning systems. The works is being undertaken by the Anticipatory Action group in the FAO Asia Pacific Office (RAP). Further information on FAO work in the Pacific on Anticipatory Action can be found here: Davila, F. Jones, C. Jenkinson, K. Talakai, M. 2022. Pathways towards anticipatory action in Pacific Island Countries: Phase One Summary – Regional Analysis. Food and Agriculture Organization of the United Nations and University of Technology Sydney. Bangkok/Sydney.

Table 3– Data reported against Target G-3 - Number of people per 100,000 that are covered by early warning information through local governments or through national dissemination mechanisms.
Source: https://sendaimonitor.undrr.org/analytics/country-global-target/18/8?indicator=35&countries=9

	Vanuatu	Fiji	Sol Is	Marshall Is	Samoa	PNG	Kiribati	Palau	Nauru	Tuvalu	FSM	Tonga
2022	-	0.8	-	1	.35*	-		-	0.98	-	-	-
2021	0.7	0.8					1	0.8	0.66	0.45	0.48	
2020	0.88	0.8	0.5	0.8			0.7		0.66	0.45	0.47	
2019		0.7	0.5	0.8								

* It is mostly urban areas that has warning systems in place and have access to the internet, including Upolu (Fagalii to Vaitele, Vailima, Magiagi & Aleisa) and Savaii (Salelologa & Faasaleleaga 1-5) urban areas. The other two islands of Apolima and Manono Tai have poor coverage of internet with no warning system in place and therefore, heavily rely on information from main island of Upolu.

** The Cook Islands and Niue were not included in the database.

Despite the progress reported in global monitoring frameworks, country-level interviews and on-the-ground validation show that the systems do not necessarily reach or serve coastal communities and small-scale fishers as many fishers and members of coastal communities report not receiving or have access to warnings. In some cases, fishers may not be aware of, or have access to, early warning systems and in other situations they do have access but do not consider the weather warnings provided to be frequent, timely or reliable.

Voices of Pacific fishers

"Weather warnings reporting timing is always late. Bad weather comes first and weather warnings came later" Fisher from Malaita, Solomon Islands

"We need more awareness on preparation for natural disasters as not always we are able to get weather updates. For instance, if there is a cyclone, we get power cut and reception is also down so we are unaware of the track of cyclone." Fisher from Macuata Province, Fiji

The overview of early warning systems in the Pacific Islands in Annex 1 undertaken in 2022 provides a snapshot of significant improvements in recent years and identifies accessible current opportunities to improve existing systems and reach for early warnings. However, it is clear that much remains to be done to ensure that robust early warning systems provide timely, actionable information to fishers and coastal communities. Outer islands and remote communities, in particular, often have little or no access to such information and are extremely vulnerable to the impacts of natural hazards.

4.2. Small-scale fishers – availability, access and timeliness of weather information and warnings

The majority of fishers consulted during this Study advised that they do check the weather forecast before heading to sea, largely on the local radio but also with many fishers checking various mobile applications (Table 4). The proliferation of cell phones and access to mobile data is rapidly changing the options for warning systems and improving safety-at-sea even in remote areas. However, despite a large number of respondents advising that they utilize a mobile phone for weather information, many identified the need to improve cell phone reception to improve warning systems. In addition, many fishers identified SMS emergency warnings as an area requiring improvement in relation to awareness, access and accuracy of updates where such a system already exists.

Table 4 – Response to the question: Where do fishers check the weather before leaving for a fishing trip? Percentages based on total number of respondents to the fisher survey by country.
Source: Fisher survey

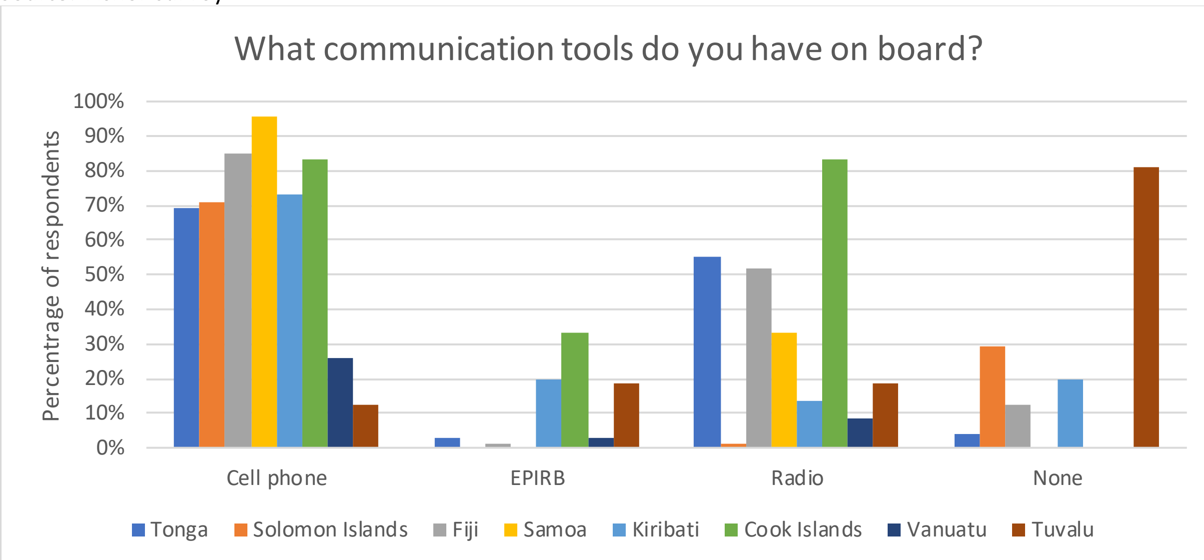
	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu
Radio (local station)	97%	48%	87%	54%	60%	33%	97%	75%
Marine radio / VHF	15%	41%	1%	0%	7%	0%	3%	6%
Smart phone	13%	39%	80%	46%	33%	67%	97%	31%
Internet	11%	33%	8%	33%	0%	33%	6%	31%
Check with community or family member	6%	33%	71%	4%	20%	0%	89%	100%
N/A don't check in advance	1%	0%	0%	0%	20%	17%	3%	0%
Other	0%	0%	41%	17%	0%	17%	3%	0%

However, once fishers go to sea their communication channels and avenues for warning systems change drastically. Most appear to take their cell phones to sea with them and while reception varies by country and island, many use their cell phones to call family when close enough to shore to check in and receive weather updates (Figure 2). Overall, an average of 56% of respondents reported having some kind of mechanism to check weather while at sea with the notable exceptions of Solomon Islands and Kiribati, where fishers largely did not have any access to weather information while at sea (Table 5). The Cook Islands respondents reported having no weather access at sea but did carry emergency communication devices onboard their vessels.

Table 5 – Response to the question: Do fisherfolk receive weather information and warnings while at sea? Percentages based on total number of respondents to the fisher survey by country.
Source: Fisher survey

Do you receive weather while at sea	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cooks	Vanuatu	Tuvalu
Yes	58%	24%	78%	88%	27%	0%	83%	31%
No	42%	76%	22%	13%	73%	50%	17%	69%

Figure 2 – Small-scale fisher communication tools carried onboard fishing vessels by country. Percentages based on total number of respondents to the fisher survey by country.
Source: Fisher survey



Now that cell phones are the primary tool used to check weather before going to sea as well as carried onboard fishing vessels, a deeper dive into the websites and mobile applications was warranted. Fishers in some countries are using real-time weather applications such as Windy TY in Fiji, whereas others are frequent users of national MET Facebook pages, including in Vanuatu, Samoa, Fiji and Tonga. Fishers in Solomon Islands were unusual in that they use cell phones to communicate with family, friends and other fishers to access weather information (Table 6).

Table 6 – Response to the question: Which mobile app, internet site or phone function do you use for weather information? Percentages based on total number of respondents to the fisher survey by country. The total percentage is the overall percentage of respondents using this site / tool from all countries.
Source: Fisher survey

	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu	Total
Windy	6%	0%	75%	0%	13%	17%	0%	25%	20.1%
Nadraki		0%	10%	0%	0%	0%	0%	0%	2.4%
local Met service	24%	0%	0%	0%	7%	0%	0%	81%	1.5%
Facebook (local MET office)	41%	4%	53%	58%	0%	0%	43%	0%	26.4%
Use phone to call and ask about weather	0%	33%	0%	0%	0%	0%	0%	0%	65.5%
Use SMS for weather update	0%	6%	0%	0%	0%	0%	3%	0%	1.2%
Local news site	0%	0%	8%	0%	0%	0%	0%	0%	1,8%
Google weather	0%	0%	8%	5%	13%	17%	51%	0%	8.5%
Weather radar	0%	0%	9%	0%	0%	0%	0%	0%	2.1%
Flowx	0%	0%	0%	0%	0%	17%	0%	0%	0.3%

Windfinder	0%	0%	0%	0%	0%	17%	0%	0%	0.3%
Wind Guru	0%	0%	0%	0%	0%	17%	0%	0%	0.3%
Fiji MET service	0%	0%	0%	0%	0%	17%	0%	0%	0.3%

4.1. Small-scale fishers' perception of weather warning quality and recommendations

Many fishers in the countries surveyed do feel that they receive advance warnings of adverse weather conditions (Table 7). In Tonga, Solomon Islands, Samoa and Cook Islands fishers also felt the weather forecasts received were very reliable. However, it is clear from the individual recommendations from fishers that there is a disconnect between the reported frequency and reliability of weather information received and the recommendations for early warnings (which seem to not be in place for many respondents based on recommendations).

Table 7 – Do fisherfolk receive advance warnings about extreme weather events (adverse weather conditions), e.g. cyclones, king tides, storms, etc. Percentages based on total number of respondents to the fisher survey by country.
Source: Fisher survey

	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu
Yes	99%	64%	94%	71%	53%	83%	94%	50%
Occasionally	0%	31%	6%	29%	33%	0%	6%	50%
No	0%	5%	0%	0%	13%	17%	0%	0%

Table 8 – Reporting on reliability of weather forecasts by fisherfolk. Percentages based on total number of respondents to the fisher survey by country.
Source: Fisher survey

	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu
Very reliable	83%	79%	8%	67%	40%	67%	23%	25%
Somewhat reliable	17%	20%	90%	29%	47%	17%	77%	75%
Not reliable	0%	0%	0%	4%	0%	0%	0%	0%
Other	1%	1%	2%	0%	13%	17%	0%	0%

Of the options presented to interviewees, a large number considered improvements, such as more local signage and better communication in more languages as priority needs (Figure 3). Country-by-country responses allow for a more comprehensive picture of recommendations, with Tonga and Cook Islands reporting that existing systems are largely functional. Solomon Islands, Fiji, Samoa, Kiribati, Vanuatu and Tuvalu had a number of recommended improvements, with many respondents detailing their suggestions under the ''other'' category (Figure 3).

Figure 3 – Recommendations for improved weather warnings from small-scale fishers. Percentages based on total number of respondents to the fisher survey.

Source: Fisher survey

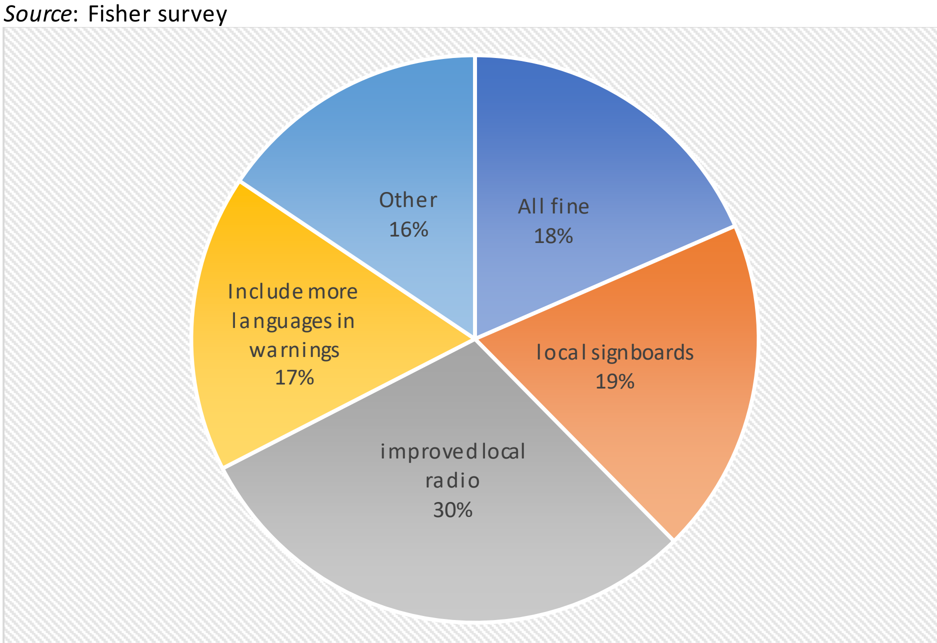


Table 9 – Recommendations for improved weather warnings from fisherfolk. Percentages based on total number of respondents to the fisher survey by country.

Source: Fisher survey

	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu
All fine	85%	32%	2%	54%	33%	83%	0%	0%
Local signboards	10%	7%	69%	8%	33%	0%	97%	0%
Improved local radio	6%	49%	94%	46%	40%	17%	100%	69%
Include more languages in warnings	8%	8%	61%	4%	53%	0%	74%	69%
Other	7%	59%	37%	17%	33%	33%	0%	100%

Fishers had many practical suggestions on how to improve access to weather information and early warnings (Table 9). The full list is included in Annex 2. Recommendations have been listed by country and grouped around the major topics raised including awareness, preparedness, or anticipatory actions; more frequent, accessible and accurate weather warnings; alternative communication options; and extension of radio or cell phone access.

Voices of Pacific Fishers

"We would like SMS text for early warning as everyone is now with a cell phone" Fisher in South Tarawa, Kiribati

"Use language that local fishers can understand - not words like longitude, latitudes, degrees etc" Fisher in Guadalcanal, Solomon Islands

Some of the suggestions raised by fishers are relatively easy improvements that can be done at the provincial level. These include displays of weather information in fish markets. More extensive changes relate to the need for improved access to cell phone networks in outer islands. In some cases, there is an inconsistency between the recommendations of fishers and early warning systems that are reported to be in place already. Thus, connecting fishers and fishing communities to national meteorological agencies and national disaster management organizations may serve to increase access to information from early warning systems, or weather information services, that are already in place. The fishers' suggestions and, where appropriate, existing programs can be included for discussion in the national workshops integrated into the priority activities in Section 6.

5. Mainstreaming the fisheries sector into disaster risk reduction

5.1. National disaster risk strategies and guidelines relevant to fisheries sector

Many countries have begun to update their disaster risk reduction and management strategies and plans with some now considering sector-specific roles and mainstreaming across the various agencies. Very few countries have fisheries-specific strategies or guidance for disaster risk management, with the notable exception of Tuvalu as well as Fiji, Solomon Islands and Vanuatu, which are in the process of preparing standard operating procedures for Disaster Preparedness, Response and Recovery in Fisheries. A few countries have made significant progress with training for the fisheries sector on disaster response and the sector is highlighted in national disaster response strategies, e.g., in Samoa and Tonga. However, there remains a significant gap for most countries, and opportunities for countries at various stages of progress in mainstreaming fisheries into national disaster strategies to share experiences, successes, and challenges (Table 10).

Table 10 – Overview of DRM and DRR contexts in each country as well as specific integration of the fisheries sector. *Source*: Compilation of survey data from national fisheries administrations, desk-based research and Naidu et al (*In Preparation*).

National Context			
Country	**Relevant Offices**	**DRR legislation / plans**	**Fisheries sector inclusive**
Cook Islands	Emergency Management Cook Islands (EMCI) Cook Islands Meteorological Service (CIMS)	National Disaster Risk Management Policy 2005 Emergency and Disaster Risk Management Plan 2019 Climate and Disaster Compatible Development Policy 2013-2016	Reported that fisheries inclusive strategy is in progress.
Federated States of Micronesia	National Disaster Committee FSM National Weather Service Office Pacific Region of the National Weather Service	National Disaster Response Plan 2016 Disaster Risk Management and Climate Change Policy (Yap, Kosrae 2015; Pohpei 2016; Chuuk 2017)	No specific strategy. The fisheries unit is included under the Livelihood working group under the National Disaster Management Response Structure
Fiji	National Disaster Management Office (NDMO)	National Disaster Management Act 1998 Standard Operating Procedures (SOPs) for Disaster	SOPs for Disaster Preparedness, Response and Recovery in Fisheries [Final version being approved by MOF November 2023]

	Fiji Meteorological Services	Preparedness and response for the Ministry of Fisheries and Forestry are under preparation (FAO CanAdapt Project)	
Kiribati	Kiribati Meteorological Service National Disaster Management Office	Kiribati Climate Change Policy Kiribati Joint Implementation Plan for Climate Change and Disaster Risk 2019-2028 Kiribati Meteorological Service Strategic Plan	Fisheries is recognized as key sector for food security. No specific DRR/M role for fisheries sector.
Marshall Islands	Marshall Islands Weather Service Office National Disaster Management Office (NDMO) The National Disaster Committee (NDC)	The NDMO Strategic Plan 2020-2023 The Pacific Islands Meteorology Strategy 2017-2026 Standard Hazard Mitigation Plan	The role of fisheries in the country context is highlighted but there is no fisheries specific action plan or strategy for DRR/M.
Nauru	Nauru Disaster Risk Management (NDRM) Office National Emergency Service	National Disaster Risk Management Act (2016, amended 2020) National Disaster Risk Management Plan Nauru Framework for Climate Change Adaptation and Disaster Risk Reduction (RONAdapt)	The importance of fisheries in the country is recognized but no specific role is elaborated.
Niue	Climate Change Section of the Department of Meteorology National Climate Change and DRM Committee	National Climate Change Policy 2009 Joint National Action Plan for Disaster Risk Management and Climate Change Adaptation 2012	The importance of fisheries in the country is recognized but no specific role is elaborated.
Palau	Disaster Executive Council (DEC) National Emergency Committee (NEC) National Emergency Management Office (NEMO) Palau National Weather Office	National Disaster Risk Management Framework 2016	The importance of fisheries in the country is recognized but no specific role is elaborated.

Papua New Guinea	National Disaster Centre (NDC) to be replaced by National Environment and Disaster Mitigation Authority PNG National Weather Service (PNGNWS)	National Disaster Risk Reduction Framework (NDRRF) 2017-2030 Disaster Management Act (DM Act) 1984 (revised 1987)	The importance of fisheries in the country is recognized but no specific role is elaborated.
Samoa	Ministry of Natural Resources and Environment (MNRE) Disaster Management Office	Disaster and Emergency Management Act 2007 National Disaster Management Plan (NDMP) 2017-2020 Samoa's National Action Plan for Disaster Risk Management (NAP for DRM) 2017-2021	In 2016, the NAP indicated that Agriculture and Fisheries had advanced plans to integrate DRR. DRR is also integrated into the Agriculture and Fisheries Sector Plan 2022-2026. However, it is unclear how implementation has progressed.
Solomon Islands	Solomon Islands Meteorological Services National Disaster Management Office	National Disaster Council Act 1989 National Disaster Risk Management Plan 2010 Standard Operating Procedures (SOPs) for Disaster Preparedness and response for the Ministry of Fisheries and Marine Resources are under preparation (FAO CanAdapt Project)	SOPs for Disaster Preparedness, Response and Recovery in Fisheries [1st draft complete - stakeholder validation to take place in Honiara, December 2023]
Tonga	National Emergency Management Office (NEMO) Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC) Tonga Meteorological Services (TMS)	Tonga's National Strategic Development Framework (TSDF, 2015-2025), National Emergency Management Act 2021 National Emergency Management Plan (2009) Joint National Action Plans on Climate Change Adaptation and Disaster Risk Management (JNAP 2018-2028)	The ministry of Fisheries is a co-lead on the national Food Security and Livelihoods cluster and has fisheries specific surveys for disaster response.
Tuvalu	Tuvalu Meteorological Service Tuvalu Disaster Management Office	National Disaster Management Act National Climate change policy Tuvalu Fisheries Sector DRR Plan	Yes, fisheries specific DRR plan in place. Information on the implementation of fisheries plan and associated recommendations is not available.

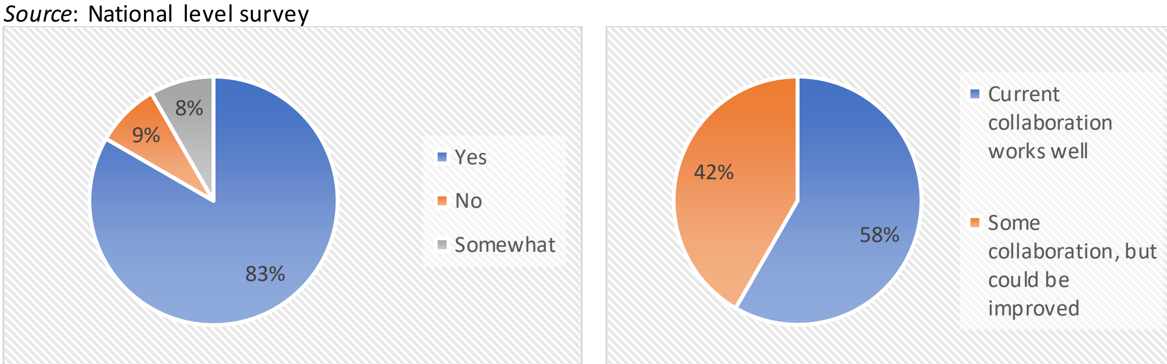
Vanuatu	Vanuatu Meteorology and Geo Hazard Department National Disaster Management Office	Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 International Disaster Response Laws, Rules and Principles (IDRL) in Vanuatu Standard Operating Procedures (SOPs) for Disaster Preparedness and response for the Fisheries Department are under preparation (FAO CanAdapt Project)	SOPs for Disaster Preparedness, Response and Recovery in Fisheries [Final version validated at stakeholder meeting November, 2023, now awaiting sign off by Director Fisheries]

5.2. Collaboration between national fisheries agencies and meteorological agencies and/or national disaster risk management offices

Fisheries departments and ministries report a significant level of existing collaboration with national meteorological agencies and national disaster management offices. However, the level of collaboration and specificity of work directly relevant to the fisheries sector is unclear. While most respondents (83%) to the national level survey indicate that there is collaboration, 42% report that the quality of collaboration could be improved (Figure 4).

Figure 4– Cumulative responses from Pacific Islands Fisheries Administrations to question a (left): Is the Fisheries Ministry or Department's collaboration with the national meteorological (MET) agency or national disaster management office (NDMO) sufficient? And question b (right): Does the current collaboration between the Fisheries Ministry or Department and the MET agency or NDMO work well?

Source: National level survey



Recommendations by fisheries departments and ministries to improve collaboration and the way that the fisheries departments handle disaster response and management included:

- Include DRR in fisheries sector plans;
- Improve capacity of fisheries departments and ministries on Disaster Risk Management;
- Allow for DRR in the structure of ministry of fisheries or institutionalize DRR within fisheries;
- Improve collaboration of responsible agencies to reduce community impacts and improve resilience;

- National-level agencies or organizations could offer a grant to communities and fishers for preparedness and response to disasters, and governments should offer repair or replacement of equipment after cyclones or disasters for the benefits of local people, as well as food security and income; and
- Governments, through the relevant ministries, should be more responsive to fisherfolk and fishing industries in the post-disaster period. There should be better direction of funding support for fisherfolk and industries affected by disasters.

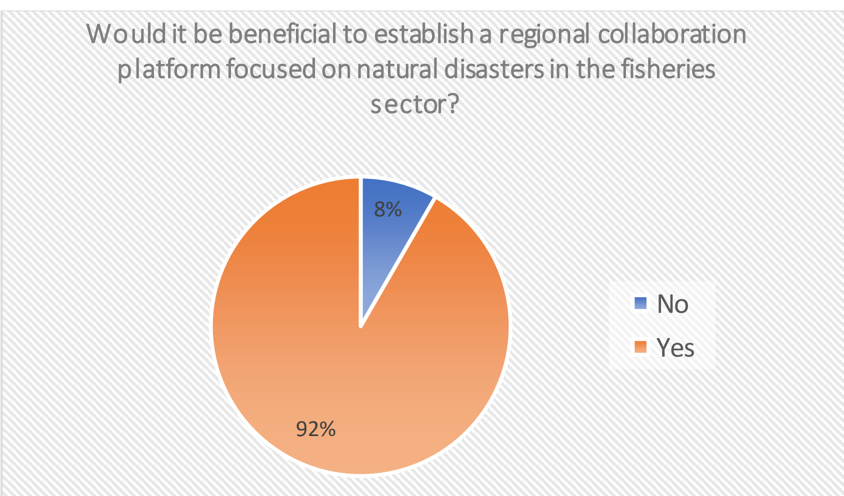
5.3. Regional collaborative platform for the fisheries sector

Despite the various platforms in the Pacific Island region for collaboration on fisheries matters, such as the Heads of Fisheries Meeting, the Regional Technical Meeting on Costal Fisheries and Aquaculture (RTMCFA) or the Marine Sector Working Group, and those for humanitarian response such as the Pacific Food Security Cluster, a fisheries specific platform or mechanism to collaborate on and discuss disaster risk reduction as well as recovery and response does not exist. The possibility for establishing such a group has been discussed over the years with an idea to create a sub-group to the Regional Pacific Food Security Cluster (rPFSC). However, although the fisheries and aquaculture sector is in theory included in both the rPFSC as well as at the national level Food Security Cluster when cluster systems are in use, the fisheries sector reportedly rarely participates. In some countries, this is beginning to change as the fisheries sector becomes more active in DRR and DRM. Examples include Fiji and Tonga, where a representative from fisheries co-chairs the national food security cluster when active.

The rPFSC functions at the regional level to support national governments, country-level actors, and regional stakeholders on topics such as resilience building and emergency preparedness and response. Given the transboundary nature of many disasters in the Pacific Island region, and the wealth of new information on DRR and DRM programs in fisheries, there is much to be gained from such a group.

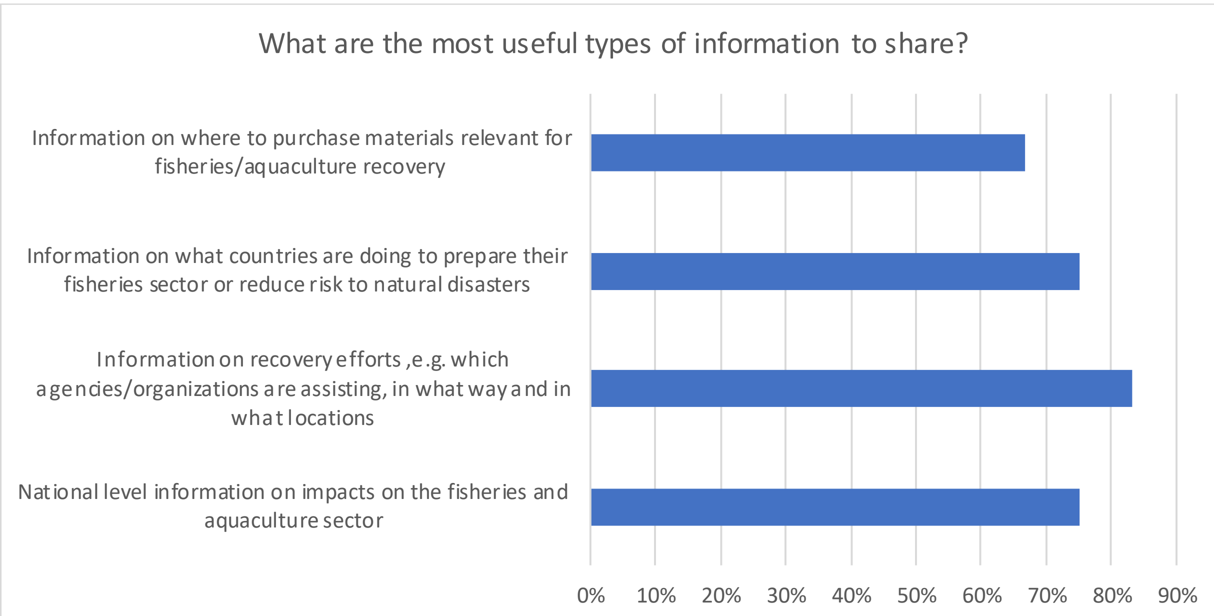
The majority of respondents from fisheries ministries or departments agreed that the establishment of this group is a good idea and so warrants further discussion (see Figure 5).

Figure 5 – Response to the below question from fisheries departments and ministries.
Source: National level survey



A number of focal areas were proposed to respondents to the survey for potential inclusion in a fisheries working group under the rPFSC. Respondents clearly valued collaboration on recovery efforts after a disaster as a priority, but the majority would like to include information on where to purchase materials for fisheries and aquaculture for recovery, country-level preparation to reduce risk, and national-level information on impacts on the sector (Figure 6).

Figure 6 - Cumulative responses from Pacific Islands Fisheries Administrations to the below question from fisheries departments and ministries on the most useful information to share through a potential regional platform on disaster risk management and the fisheries sector.
Source: National level survey

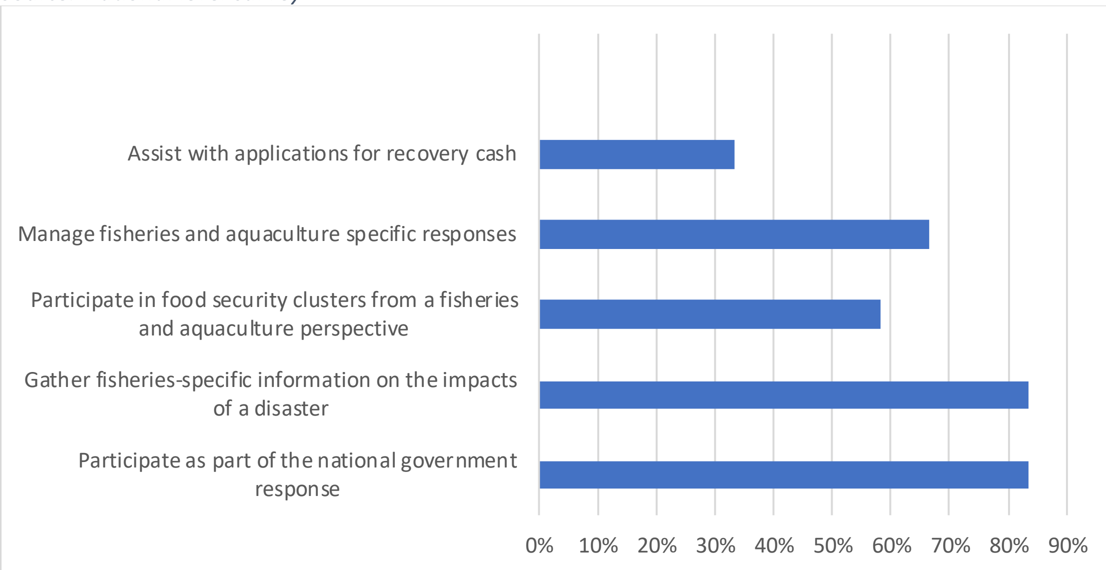


6. Disaster response and recovery

6.1. Participation of the fisheries sector in disaster response

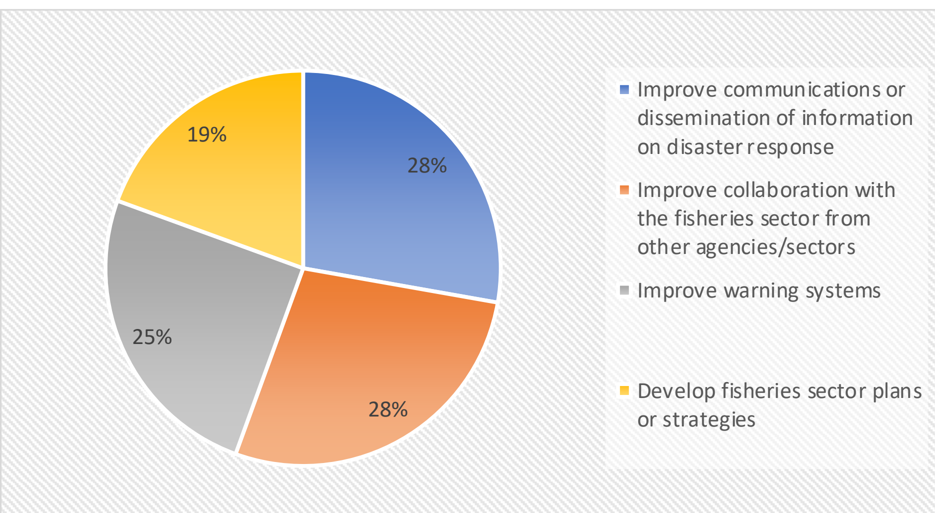
Although many countries do not have a fisheries-specific role in national disaster management planning or strategies, most still play important roles in recovery. Over 80% of fisheries departments and ministries reported that they assist with gathering of fisheries data on the impacts of a disaster, and participate in general in the national response. Some countries reported that the fisheries agency managed the fisheries and aquaculture response (67%) as well as participating in the food security cluster (58%) when activated.

Figure 7- Cumulative responses from Pacific Islands Fisheries Administrations to the question - How does the Fisheries Ministry or Department respond to disasters at the national level?
Source: National level survey



When asked how disaster response in the fisheries sector could be improved, many respondents from national fisheries agencies recommended improved communication and collaboration (28%), as well as better warning systems (25%). Those that reported that no fisheries-specific strategy existed, or was being prepared, recommended the preparation and implementation of such a strategy (Figure 8).

Figure 8 – Cumulative responses from Pacific Islands Fisheries Administrations to the question - How could disaster response in the fisheries sector be improved?
Source: National level survey



6.3. Small-scale fishers - disaster response and resilience

In many countries fishers do not necessarily have a chance to report damages or receive assistance after damages and losses are reported (Table 11). Fishers voiced concerns about disaster recovery, including issues such as lack of response when damages were reported, a desire to have been trained to prepare for a disaster to reduce impacts, and a concern that traditional knowledge of weather systems is being lost.

Voices of Pacific Fishers

"Maybe media platforms could be used to announce it. Fishermen should have a chat group for an update of the weather when one of the fishermen received any information. Also family members should also advice when the receive any weather forecast before departing for fishing." Fisher in Funafuti, Tuvalu

"We should continue with what our ancestors have taught us about weather and integrate that with modern weather science. Our traditional knowledge, like watching how certain birds fly, how the sky color changes, it helps us know more about how the weather acts close to us and when seasons change." Fisher in Fiji

Table 11 – Who do fishers report damage to after an extreme weather event or disaster?
Source: Fisher survey (percentages indicate total number of respondents by country)

	Tonga	Solomon Islands	Fiji	Samoa	Kiribati	Cook Islands	Vanuatu	Tuvalu
Local Gov	59%	16%	40%	25%	47%	67%	83%	0%
Fisheries Authority	35%	4%	10%	50%	0%	0%	86%	0%
Town leader	68%	0%	0%	0%	0%	0%	74%	0%
Cooperative / Association	1%	1%	0%	33%	7%	0%	0%	0%
No one	20%	65%	16%	58%	67%	17%	6%	100%
Other	1%	28%	49%	4%	7%	33%	6%	0%

Building resilience to reduce risk to natural disasters that is not tied to external support or the physical presence of central government officials is challenging in many Pacific Island nations, particularly in remote islands far from central administrations. Options that support coastal communities in areas near and far from central government should be explored, together with the many valuable ideas conveyed by the fisherfolk and national government staff surveyed in this study.

Social protection schemes can be an important part of resilience and stability for coastal communities. According to the 2022 review of social protection systems (Naidu *In preparation*), a variety of formal systems exist in much of Polynesia and Micronesia, but such support is often new or informal in much of Melanesia. Fiji is an exception, with a broader range of social support mechanisms.

Notwithstanding the availability of some social protection schemes, other tools that provide direct support and reduce the need for recovery assistance are vital. Insurance is not a frequently used tool in small-scale fisheries, but new products and concepts are becoming available that may be of use to the sector. Access to low-cost, high-quality options for what - insurance? can improve resilience and bring stability. Pilot projects have started in the region, including in Fiji, where the government has launched an anticipatory action pilot insurance scheme to support farmers to prepare for cyclones. Other regional options have emerged, including through the Pacific Catastrophe Risk Insurance Company (PCRIC). This emerging sector has not yet been considered in national and regional fisheries fora and warrants dedicated discussion, particularly as the results of pilot schemes become known.

7. Priority activities

The program and activities proposed below draw on the information summarized in the above sections. The fisheries administrations in the region are either in the initial or nascent stage of developing specific DRR and DRM policies and actions for the sector. A platform for integrating DRR and DRM will provide the necessary platform for sharing of ideas, harmonizing work plans and exploring new concepts for both regional and national benefit. At the national level, there is a clear opportunity to bring together the main DRM actors with fisheries administrations to share ideas and link the fisheries sector to broader national planning and policy. In addition, it is evident that, despite the progress and systems currently in place for DRR and early warning systems, fisherfolk and their communities are not necessarily aware of these systems and how to access them. Thus, the proposed activities are designed to address the recommendations and concerns for national governments as well as fisherfolk drawn from the surveys and information summarized in this paper.

The proposed activities are described below and should be read in conjunction with Annex 3 (Activities-based budget). Information on the implementation timeline and full budget to address priority areas of need in relation to strengthening DRR and DRM fisheries considerations is presented in annexes 4 and 6, respectively. The activities are designed to be across 5 years with year one primarily being hiring and starting up for activities and year 5 being a wrap down year for evaluation and finalizing any remaining activities. Supporting staff and consultants are listed below to assist with clarity of roles in the activities.

Table 12 - Staff and consultants to be hired to conduct the proposed activities

Title	Role
Project Coordinator	To support and coordinate activities (to be based in and from a country in the Pacific region)
Early Warning System (EWS) Expert	Develop EWS triggering concept for regional workshop
Fisheries Working Group (WG) Facilitator	Drive and facilitate the Fisheries WG
MET / Safety-at-sea Expert	Prepare training materials to be integrated into safety-at-sea materials for the region
Engineer	Review mobile coverage for small-scale fishers and provide recommendations for improvements
EWS / DRR National Experts	National DRR / EWS experts to provide national overviews for workshops
Gender Expert	To provide gender strategy and gender equity guidance
Monitoring and Evaluation Specialist	To provide monitoring plan and monitor outcomes of activities

7.1. Output 1: Enable regional collaborative platform on disaster risk reduction in the fisheries sector

Activity 1.1 – Enable the Regional Pacific Food Security Cluster (rPFSC) working group on fisheries and aquaculture. Create and enable a Working Group (WG) on fisheries and aquaculture through the rPFSC. This WG is intended to include countries, civil society, regional agencies, donors and NGOs. Set up tasks include developing systems and forms for partners (e.g., governments, NGOs, donors, etc.) on emergency responses as well as facilitating discussions, seminars, collaborative events.

Implementation Notes: The activity will be led by the WG Facilitator (funded through this project) and includes funding for 2 travels per year as well as editing or graphic design for two informational pieces related to the WG (e.g. document prepared for the WG under below activities, formalization of forms for the WG, etc). The WG facilitator will prepare documents and online forms including the 5W Food Security Cluster form (Who does What, Where, When and for Whom) tailored for fisheries and aquaculture (ready for a potential disaster), facilitate the platform and associated regional meetings, link the WG to national FSC systems and the rPFSC as well as other associated regional platforms (e.g. Pacific MET Council, Pacific Resilience Council, etc.). The platform should assist with coordination during disaster response, but also host discussions and working groups for the region on disaster risk reduction and management in the fisheries sector. The other activities listed in this output are intended to be hosted and deliberated by participants in the WG through this platform.

The Project coordinator in collaboration with WG facilitator will develop a sustainability plan and eventually handoff to a regional agency or agencies as appropriate.

Activity 1.2 – Advancing early warning systems and disaster risk reduction in the fisheries sector. Enhance national and regional Early Warning Systems (EWS) as well as options for anticipatory actions by developing concepts for a triggering system or leveraging existing systems in specific countries. The Early Warning System Expert (EWS expert) will be hired to conduct a retrospective analysis of past cyclone-related (to be eventually expanded to other hazards such as storm surge, coastal flooding, oil spill, tsunami) damage to the fisheries sector and examine the relationship between the impact and the forecasted event's intensity. A preliminary set of responses to meteorological hazards will be developed to facilitate options for anticipatory actions and early warning systems to reduce impacts on small-scale fishers and their communities. The analysis prepared by the EWS expert will be reviewed by countries, regional experts and organizations at the regional workshop on advancing EWS and DRR facilitated by the rPFSC Working Group on Fisheries and Aquaculture. The preliminary suggested responses will provide guidance on recommended anticipatory actions for local fishers, communities and governments, tailored to an event's severity, to proactively mitigate its impact.

Implementation Notes: This activity should be carried out by the EWS Expert and guided by the Project Coordinator working in close collaboration with the WG Facilitator and with countries. It should also be cross sectoral in nature - Fisheries, MET and NDMO - to develop and assess appropriate trigger points that are realistic and responsive to small-scale fishers. The activity should assess the potential to build on the work that is currently under development with FAO CERF's Anticipatory Action (AA) program in Fiji. Funding for a regional meeting which could be conducted through a Letter of Agreement with a relevant organization is included to present the analysis and collect feedback. The regional meeting could also include presentations from countries on the current state of early warning systems for fisheries, possible incorporation of triggers into national early warning systems and review of suggested preventative or mitigative actions governments and communities can take.

Activity 1.3 – Initiate a repository for best practices on preparedness. Build and populate a regional repository for preparedness and anticipatory actions based on best practice. These can be both community-based actions as well as those funded by the government/partners (no-cost or costed actions). The repository should be presented, reviewed and further populated during the workshop mentioned in activity 1.2. The output and repository (a working document) will be linked to the rPFSC Working Group (e.g. hosting the repository and supporting resource materials).

Implementation Notes: The work will be carried out through a letter of agreement or contract and will be guided by Project Coordinator in collaboration with the WG Facilitator. Support and examples from other regions can be requested from the FAO RAP Anticipatory Action group.

Activity 1.4 – Integrate early warning systems into safety-at-sea guidance and training. Review options for linking existing early warning systems, guidance on what is available at the regional level and training on understanding meteorologic information into safety-at-sea trainings and materials provided to fishers/fishing communities within the region. Regionally relevant materials and guidance will be developed and reviewed through a small expert workshop with SPC/FAO to develop and agree on integration of EWS and meteorological training into safety-at-sea material.

Implementation Notes: A review of gaps in understanding of meteorological information and regional EWS systems should be done by Meteorological Expert prior to the small workshop. The new materials and guidance will then be reviewed within a small expert group facilitated by FAO and SPC. Note that SPC is working on a larger safety at sea component within this project. This meeting could be linked to an existing regional meeting such as the Regional Technical Meeting on Coastal Fisheries and Aquaculture for cost savings and integration into regional mechanisms.

7.2. Output 2: Improved access and awareness of emergency preparation, response and recovery systems for fishers and fishing communities at the national level

Activity 2.1 – Review DRR plans and EWS relevant for the fisheries sector for each country. In preparation for the below national workshops, a short overview of each country's disaster risk reduction/management policies or procedures related to the maritime and fisheries sector will be prepared. This should include how and when the fisheries sector is involved in disaster preparedness and response, identification of early warning systems in place or being developed (including how to access and utilize them), and future plans for DRR or DRM specifically tailored for the fisheries sector. Gaps and recommendations should be included for discussion in the national workshops.

Implementation Notes: The review will be presented to each country at the national workshops described below. It may be useful to look for an organization or agency which can undertake the above review and organize the workshop in a single Letter of Agreement or contract.

Activity 2.2 – National workshops to build awareness on EWS and develop action plans for improving preparedness and anticipatory actions in the fisheries sector. National workshops on emergency response, preparedness, anticipatory action and early warning systems (access and awareness) in the fisheries sector are funded for each country. These workshops should focus on building awareness and access to existing systems as well as looking to the future for recommendations and next steps (i.e., an action plan to improve DRR). Workshop participants should include fisheries agencies, national disaster management offices, meteorology offices, fisherfolk and other civil society groups working in the sector.

As a step toward anticipatory action, the workshops may collate and discuss what procedures are in place to trigger early warning activation, what the experience has been in terms of timing, and any recommendations to improve or advance these triggers.

Implementation Notes: Funding for the national workshops is provide through a Letter of Agreement. An LoA could be organized with either the individual countries or an organization with relevant experience in each country.

Activity 2.3 – Share best practices on emergency response, preparedness, anticipatory action and EWS from the fisheries sector. A regional workshop will be held to share lessons learned and outcomes from national experiences with preparedness and response in the fisheries sector (e.g., implementation of Standard Operating Procedures (SOPs) /DRR strategies or plans in DRR in the fisheries sector) utilizing the outputs from the above national workshops. Lessons learned from implementation of early warning systems, anticipatory actions and fisheries-specific DRR plans or operating procedures could be shared at the workshop to develop recommendations and further this work throughout the region.

Implementation Notes: Development of this workshop should be led by the Project Coordinator and could be held within the context of the WG under the rPFSC. The workshop is designed to be carried out through a Letter of Agreement or contract with relevant organization.

7.3. Output 3 – Developing and expanding early warning systems and risk reduction options for fishers and fishing communities.

Activity 3.1 – Using mobile phone applications to expand early warning systems. Identify mobile phone applications and other types of communication channels (e.g. FM/AM radio, VHF, AIS) that have been successful for small-scale fishers within the Pacific Island region and in other jurisdictions to improve safety and EWS, e.g., receive warnings, connect to disaster preparation and recovery information as well as improve skills on information, communications and technology (ICT). Fund study and regional workshop to review/present options. This review could be presented to the rPFSC, reviewed and discussed for promising opportunities. While this project does not have the funding for the development and trialing of an mobile application, opportunities for future funding opportunities could be explored through the rPFSC and donor community.

Activity 3.2 – Extending coverage of mobile phones to improve access to warnings, preparedness and recovery. Identify options and work with mobile phone companies to extend coverage of radio, mobile phone at sea in 2-3 Pacific Island countries. This work will include identifying countries where mobile phone providers and other groups (e.g., WASH in the Food Security cluster) may be interested in collaborating to determine mobile phone coverage at sea where this is unknown and reviewing low-cost options for improvements (e.g., reduce signal errors, change orientation, etc.). It may also be useful to include an overview of where other types of communication tools, e.g., VHF, etc., would be a better option and link to other components of this project (or other national projects) to potentially trial / fund options to improve safety-at-sea.

Activity 3.4 – Exploring insurance and assistance options for small-scale fishers. A workshop will be held to discuss existing options for insurance products and social protection schemes relevant for small-scale fishers in the Pacific Island region as well as information on successes and challenges from other regions (e.g., COAST in the Caribbean). The workshop will bring together select insurers, fisheries authorities, relevant civil society organizations and fisherfolk representatives to discuss insurance options and present successful schemes from elsewhere in a small 2-day workshop (possibly back-to-back with the RTMCFA or other regional meeting) on options to increase resilience to disasters.

7.1. Output 4 – Project management

Activity 4.1 – staffing and project set up. This will include staffing of the project, as well as initial project set up tasks such as the development of a monitoring and evaluation plan and a gender strategy. A project manager from the region will be hired to lead activities.

Activity 4.2 – Project support. This activity includes funding for FAO support costs such as time and travel for the lead technical officer, project evaluation and reporting.

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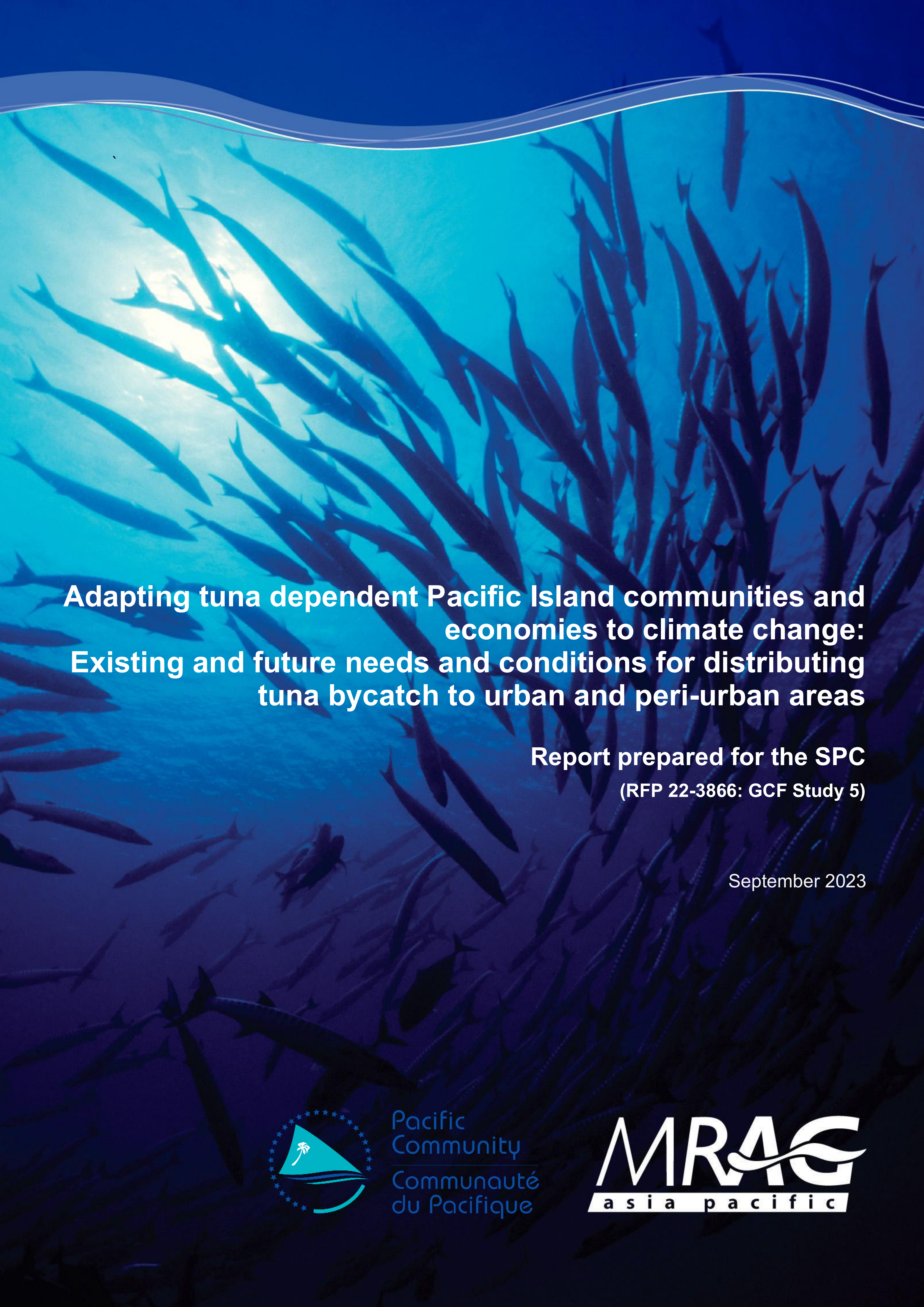

Adapting tuna dependent Pacific Island communities and economies to climate change: Existing and future needs and conditions for distributing tuna bycatch to urban and peri-urban areas

Report prepared for the SPC

(RFP 22-3866: GCF Study 5)

September 2023

Pacific Community
Communauté du Pacifique

MRAG asia pacific

About MRAG Asia Pacific

MRAG Asia Pacific is an independent fisheries and aquatic resource consulting company dedicated to the sustainable use of natural resources through sound, integrated management practices and policies. We are part of the global MRAG group with sister companies in Europe, North America and the Asia Pacific.

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This report was prepared by M. Skirtun and D. Souter on behalf of MRAG Asia Pacific. The views in the report represent those of the authors and do not necessarily represent the views of the above organisations.

Suggested citation:

MRAG Asia Pacific (2023). Existing and future needs and conditions for distributing bycatch to urban and peri-urban areas. Report prepared for the Pacific Community. 49 p.

Acknowledgements

Undertaking a study of this type requires the collection of information and insights from a wide range of people and organisations. Particular thanks go staff at national fisheries administrations from participating countries, industry members, and technical experts who gave generously of their time and knowledge during interviews. Very special thanks go to the secretariat staff at SPC for reviewing the report and providing feedback.

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Acronyms and abbreviations

BOQ	Bill of Quantities
CMM	Conservation Management Measure
CPPL	Central Pacific Producers Limited (Kiribati)
EEZ	Economic Exclusive Zone
ENSO	El Niño Southern Oscillation
EPO	Eastern Pacific Ocean
FCF	FCF Co, Ltd.
FFA	Forum Fisheries Agency
FFIA	Fiji Fishing Industry Association
FOFA	Fishermen of Funafuti Association
FSM	Federated States of Micronesia
GHG	Greenhouse gas
HIES	Household income and expenditure surveys
IPCC	Intergovernmental Panel on Climate Change
KFL	Kiribati Fisheries Limited
KMI	Kendall Micronesia Inc. (RMI)
KFAT	Korean Fisheries Association for Tuna
KPA	Kiribati Ports Authority
MFMR	Ministry of Fisheries and Marine Resources (Solomon Isl.)
MIMRA	Marshall Islands Marine Resources Authority
MT	Metric tons
NAFICOT	National Fishing Corporation of Tuvalu
NFA	National Fisheries Authority (PNG)
NFD	National Fisheries Developments (Solomon Isl.)
NORMA	National Oceanic Resource Management Authority (FSM)
PIC	Pacific Island Country
PNA	Parties to the Nauru Agreement
PNG	Papua New Guinea
PPF	Pan Pacific Foods (RMI)
RCP	Representative Concentration Pathway
RMI	Republic of the Marshall Islands
SPC	The Pacific Community
SSTC	South Seas Tuna Corporation (PNG)
TACL	Te Atinimarawa Company Limited (Kiribati)
TFD	Tuvalu Fisheries Department
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean

Executive Summary

Background and approach

Urbanisation and the impact of climate change on fish distribution have been identified as key challenges to food security for Pacific Island nations. Tuna bycatch from industrial purse-seine fishing fleets has the potential to make a substantial contribution to the fish protein required for good nutrition of rapidly-growing urban populations, particularly in countries which serve as transhipment hubs. In that context, SPC engaged MRAG Asia Pacific to examine the future infrastructure needs and other conditions required to optimise the availability of tuna bycatch to urban populations.

The two main objectives of the study were: a) to assess the nature of present-day supply chains delivering tuna bycatch to urban centres, and b) identify where improvements to market infrastructure are needed to efficiently deliver bycatch to urban centres in the future.

Current conditions for bycatch delivery

For the majority of purse-seine transhipment/landing ports covered in the study, the nature of present-day supply chains in delivering tuna bycatch to urban centres are mostly informal. This is based on the fact that there is very little coordination in the collection, sale and/or distribution of bycatch beyond the individual level. The only exceptions are Tarawa, Kiribati and Noro, Solomon Islands. For Tarawa, the government-owned enterprise CPPL is responsible for the collection and sale of tuna bycatch through their two fish markets in Bikenibeu and Bairiki. In Noro, all bycatch (including non-target species) is retained and sold to the local market, in accordance with internal policies of the domestically-based fishing company NFD. The main difference between the traders who purchase fish from NFD and individuals purchasing at compounds of processing companies in Lae, Madang and Wewak in PNG is that the traders located in Noro are known to be established and well-organised, with extensive networks to distribute the fish to the final destination, Honiara. In general, the most common means in which bycatch enters the local market across ports in the Pacific Island region is through individuals in small boats paddling out to transhipping vessels with goods to trade or barter in exchange for fish rejected for processing (canning). The goods offered by locals to crew aboard transhipping vessels include fresh produce (e.g., vegetables, bananas, coconuts, etc.), cigarettes and phone cards. The brined bycatch reject fish is usually then sold raw at local markets or by the side of the road on open display without refrigeration or ice. In some cases, the fish is cooked or smoked first before sale, or used in fish and chips by small food bars.

Improvements to infrastructure and supply chain

Four key areas for infrastructure improvements were identified. These were: 1) development of efficient collection systems – having large, reliable vessels to go between the shore and transhipping vessels; 2) ensuring transportation networks on both land and sea provide support for the distribution of bycatch between the point of landing and sale; 3) establishing basic facilities at ports and markets for preparation, sale or storage of the fish, e.g., concrete spaces with access to water and waste disposal; and 4) providing support for private investment along the supply by improving access to finance and financial literacy, training in post-harvest handling as well as reducing tax burdens for SMEs.

Recommendations

One of the most important messages that came out of the consultations with industry and other experts was that bycatch is a low-value product with very little margin to justify large investments in its delivery. The best use of government resources would be to focus on facilitating a conducive environment to do business rather than direct intervention in the supply chain. That being said, the environment

to do business for SMEs can be compromised by volatility and infrequency in access to tuna and bycatch associated with fluctuating ENSO conditions. Whilst operating cold storages for the purpose of storing bycatch is not economically attractive, other government policies could offer opportunities to reduce supply volatility. These policies include requiring a minimum frequency of transhipments by vessels that fish regularly inside a country's EEZ; creating value in fish landing through educational campaigns that aim to boost demand for (higher-quality) tuna; and/or invest in post-harvest facilities that can be used across sectors to help even-out seasonal fluctuations in availability of fish and other agricultural products.

1 Introduction

Urbanisation is rapidly increasing in Pacific Island countries (PICs), with rate of urban population growth in nearly every country in the region outstripping the national growth rate (Campbell 2019). Tuna and other pelagic fish species are not only culturally significant to many PICs, with traditional fishing techniques passed down from generation to generation, but is an important source of protein across the region. However, strengthening national FAD programmes is expected to make only limited contribution to the supply of tuna and other oceanic fish species, hereafter grouped as 'tuna', to urban centres. In many PICs, tuna bycatch – undersized or damaged tuna and other pelagic species, such as rainbow runner, mahi mahi and triggerfish – from industrial fishing fleets has the biggest potential to provide the majority of fish protein required for good nutrition of these rapidly-growing urban populations.

In that context, SPC engaged MRAG Asia Pacific to examine the future infrastructure needs and other conditions required to optimise the availability of tuna bycatch to urban populations. The purpose of this study was two-fold: 1) to assess the nature of present-day supply chains delivering tuna bycatch to urban centres; and 2) identify where improvements to market infrastructure are needed to efficiently deliver bycatch to urban centres in the future, where catch from small-scale tuna fisheries will not meet the fish demand of growing populations[1].

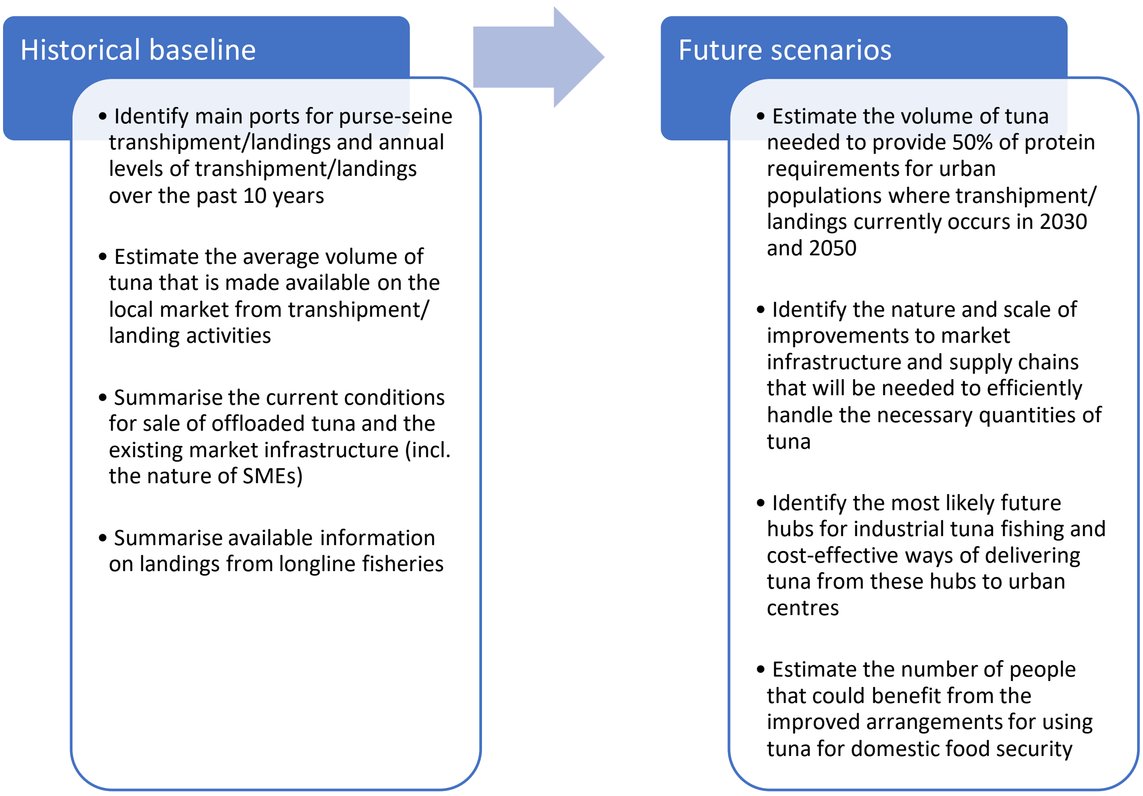

Figure 1: Deliverables from the proposed approach.

This study primarily used existing data and literature on tuna bycatch available through transhipment and landing operations in the region, as well as consultations with national stakeholders and industry experts (refer to Annex 2 for list of stakeholders consulted). The study was carried out across two phases, with the first phase focused on reviewing the historical baseline of transhipment and landing operations in both the purse-seine and longline sectors, and the current

[1] For the full terms of reference for the study, please see Annex 1.

arrangements to supply of tuna to urban and peri-urban areas (Figure 1). The second phase examined future bycatch and infrastructure needs, taking into consideration projected changes in population, climate and associated effects on the distribution and nature of Pacific tuna fisheries.

The report is set out as follows. Section 2 presents an overview of transhipment and landing data by key ports in the region. Section 3 documents the proportion of catch from transhipment/landing operations that is made available to the local market, while section 4 discusses the future bycatch and infrastructure needs to deliver the necessary quantities of fish to urban and peri-urban populations from key transhipment hubs. Finally, section 5 concludes the study with a summary of the findings.

2 Historical transhipment and landing in the Pacific

In 2021, an estimated 2,493,571 metric tons (MT) of tuna was caught in the waters of the Western and Central Pacific Fisheries Commission (WCPFC) statistical area, accounting for 56% of the global tuna catch (Williams and Ruaia 2022). Of this amount, 70% or 1,740,370 MT was caught in the purse-seine fishery, with around 2/3rd of the purse-seine catch transhipped or landed in PIC ports[2]. While the longline fishery accounted for 8% of the total catch (191,666 MT), only 18% of the longline catch was unloaded in PIC ports.

The Pacific Community (SPC) holds data on the volume and number of purse-seine and longline unloading/transhipments derived from vessel logbooks. However, the data only specify the return port for vessels, and the distinction between transhipment and landing is not always made. Further, data coverage on vessel unloadings – to canneries or for export via air or reefer containers – is biased and incomplete. As such, care must be taken when interpreting and using the data to inform policy decisions. For the purpose of the study, reported purse-seine unloadings are treated as transhipments, with the exceptions of a small number of ports mentioned in the note to Table 1. No distinction is made for longline unloadings to PIC ports.

2.1 Purse-seine transhipment and landing

Transhipment-at-sea for purse-seine vessels operating in Western and Central Pacific Ocean (WCPO) is generally not permitted under Article 29 (5) of the WCPFC Convention[3]. Consequently, transhipping in PIC ports is an attractive option for vessel operators because it allows them to continue fishing in the region without needing to return to their home port. Using data from SPC and the PNG National Fisheries Authority (NFA), Table 1 summarises the average volume of fish transhipped or landed, along with the average number of port visits, by purse-seine vessels to key PIC ports for the 10-year period from 2012 to 2021. For detailed annual data on purse-seine landing and transhipments, refer to Table 10 and Table 11 in Annex 2.

Purse-seine transhipments in the Pacific take place predominantly in port(s) of countries that are Parties to the Nauru Agreement (PNA). The bulk of purse-seine fishing occurs inside the waters of PNA countries and, as such, transhipping in the ports of PNA countries minimises the travel time needed to and from fishing grounds. Nevertheless, small volumes of purse-seine catch are occasionally transhipped and/or landed into reefer containers in Suva, Fiji, owing to the

[2] As per the Convention text, "transhipment" means the unloading of all or any of the fish on board a fishing vessel to another fishing vessel either at sea or in port. Transhipment differs from landing, where catch is offloaded either for local consumption or processing prior to further export (Tolvanen et al. 2021).

[3] With the exception of exemptions made under paragraph 25 of CMM 2009-06. The Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean is available online at https://www.wcpfc.int/doc/convention-conservation-and-management-highly-migratory-fish-stocks-western-and-central-pacific, and CMM 2009-06 can be found at https://www.wcpfc.int/doc/cmm-2009-06/conservation-and-management-measure-regulation-transhipment-0

infrastructure, supply and services available there, as well as Pago Pago (American Samoa) which is a key transhipment port for the US purse-seine fleet.

Table 1: Purse seine landing and transhipments by key PIC ports, 2012 to 2021 (based on SPC and NFA data)*

Port	Country	Average volume per year (MT)	Average number of visits per year
Pohnpei	FSM	157,797	234
Kosrae		14,478	17
Kiritimati	Kiribati	50,472	53
Tarawa		196,468	229
Majuro	Marshall Isl.	317,640	424
Lae	PNG	27,975	89
Madang		35,583	82
Rabaul		156,269	284
Wewak		27,211	53
Honiara	Solomon Isl.	50,473	69
Noro		28,043	81
Funafuti	Tuvalu	97,550	106
Annual average across listed ports		1,113,711	1,545

* For majority of the ports listed, transhipment is the only activity that takes place. The exceptions are Noro, Lae, Madang, and Wewak. In Noro, up until recently, all purse-seine vessel visits were associated with unloading to the Soltuna processing plant. From early 2019, with the operation of the Star Loader system (which unloads catch from purse seiners directly into Maersk reefer containers), containerisation is also accommodated. The distinction between volume transhipped and landed is not made here. In PNG, the only purse-seine vessels visiting Madang and Wewak are tied to the respective cannery in each location, and as such, land fish to service the canneries – whether the fish is processed or exported whole. There are 4 canneries located in Lae, and while the majority of vessel visits are dedicated to landing fish to the canneries, the lack of port infrastructure can result in purse-seine vessels transhipping to carriers during peak fishing periods when there is insufficient wharf space to accommodate all boats. This amount (i.e., fish transhipped to carriers in Lae) is very small compared to that landed and the coverage is incomplete. As such, it is not included in this table.

Over the last decade, transhipment volumes in the region have been highest in Majuro (27%), followed by Tarawa (17%), Pohnpei (14%) and Rabaul (13%) – see Figure 2[4]. However, the choice of transhipping port in any given period tends to vary with the prevailing El Niño Southern Oscillation (ENSO) conditions, given its influence on the distribution of fishing effort[5]. El Niño conditions are associated with a higher concentration of fishing in the eastern WCPO, and industry preference for transhipment in the Marshall Islands and Kiribati (Tolvanen et al. 2021). In La Nina years, fishing effort tends to be highest in the western WCPO, with increased transhipment activity in Papua New Guinea (PNG), Federated States of Micronesia (FSM) and Solomon Islands.

[4] The share of transhipment by port is measured by the volume of fish transhipped.
[5] Based on consultations with industry, other factors influencing the choice of transhipment port include: administrative efficiency; level of compliance/regulation; frequency of flights for crew changeovers; availability of supplies; infrastructure; and entertainment services and amenities (e.g., hotels, bars and restaurants).

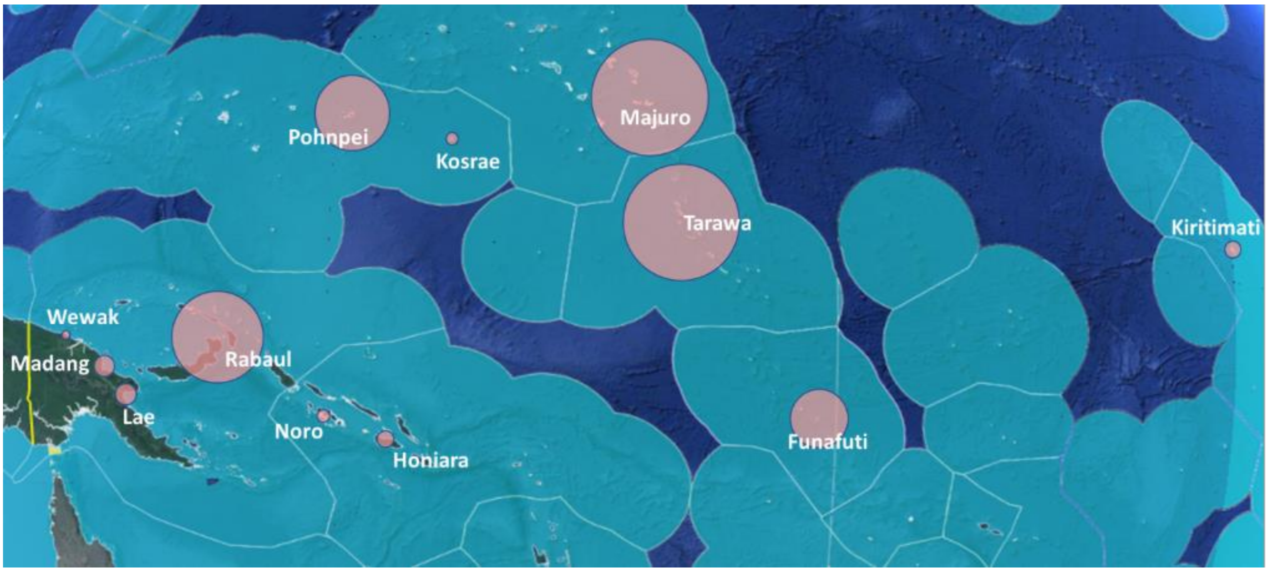

Figure 2: Map of key PIC ports for tuna transhipment and landing in the region (the size of the circles reflects the average volume of tuna transhipped or landed per year for the period from 2017 to 2021, refer to Table 10).

The ports of Tarawa, Funafuti, Rabaul, Lae, Madang and Kosrae have experienced considerable growth in transhipment/landing volumes and vessel visits over the second half of the last decade. The volume of transhipments in many ports in the region were impacted by port restrictions during the COVID pandemic, with Majuro, Honiara and Pohnpei some of the most impacted (Table 10 and Table 11). Compared to other countries in the region, vessel movements in PNG were not as restricted during 2020 and 2021. Together with the prevailing La Nina conditions in these years, this led to an increase in transhipments in Rabaul (PNG's main port for purse seiner to carrier transhipments). As vessel visits reported for Lae and Madang are based on those supplying the canneries, the increase in volume landed reflects the increase in production by the canneries in the respective ports under PNG's Rebate Scheme that came into effect in 2018 to incentivise local processing. In FSM, COVID restrictions are implemented at the State level which allowed transhipment and landing activities to grow in Kosrae despite declines in Pohnpei. With the opening of the new cold storage facility and yellowfin loining plant by Da Yang Seafood in Kosrae in late 2019[6], it is expected that landing and transhipments will continue to increase.

2.2 Longline transhipment and landing

While transhipment at sea for longline vessels is generally prohibited by FFA countries within EEZs, transhipment at sea is allowed for longliners on the high seas subject to flag State authorisation. On that basis, a smaller proportion of the overall WCPFC longline catch is landed at PIC ports. Table 2 below presents an overview of the average volume unloaded, along with the average number of port visits, by longline vessels to key PIC ports for the 6-year period from 2016 to 2021. For detailed annual data on longline landing and transhipments, refer to Table 12 and Table 13 in Annex 2.

The information provided in Table 2 is based on raw data collected from logbooks and unloading reports. As such, some discrepancies between volume caught and volume unloaded (or number of trips and number of unloads) can be expected due to incomplete coverage of logsheet data. For example, there are several instances where a value of greater than 100% is observed in Table 2. These errors are likely to be due to incomplete coverage of the denominator (i.e., logged catch or trip) as opposed to the volume unloaded or number of unloads exceeding the total volume of catch or number of trips. However, it is also important to note that logbook recordings are based on visual

[6] The new cold storage facility was established alongside other on-shore developments to handle containerisation of catch. While the processing facility opened in 2019, loining production did not begin until late 2022 (pers. comm. NORMA).

estimations of catch while data on unloadings uses weighed catch, which could also contribute to a lower estimated catch compared to the volumed unloaded.

Table 2: Longline unloadings by key PIC ports, for the period from 2016 to 2021 (based on SPC data)

Port	Country	Average volume unloaded per year (MT)	Average % volume unloaded against catch log*	Average number of unloads	Average % unloads per trips logged*
Suva	Fiji	25,720	86%	957	91%
Pohnpei	FSM	1,717	61%	53	49%
Malakal	Palau	1,238	82%	421	107%
Majuro	RMI	2,138	61%	387	64%
Apia	Samoa	6,427	75%	141	51%
Honiara	Solomon Is.	1,741	33%	59	51%
Noro	Solomon Is.	1,022	30%	25	38%
Nuku'Alofa	Tonga	2,538	103%	180	101%

* Average % volume unloaded against catch log refers to the recorded volume of tuna unloaded in port divided by the total volume of tuna caught by longline vessels reported in the logbooks of all flags visiting a specific PIC port for the period from 2016 to 2021. Similarly, average % unloads per trips logged is the number of unloadings divided by the number of trips recorded on the logbooks for longline vessels of all flags visiting a specific PIC port for the period from 2016 to 2021.

The largest port of unloading longline catch in the WCPO has always been Suva, due to the availability of vessel support services and onshore facilities/amenities. However, the volume of longline-caught tuna unloaded in Suva has gone through a period of decline since 2018, when the fish levy for unprocessed fish leaving Fiji was increased to FJ$450/mt from FJ$350/mt. Anecdotal accounts from industry suggest that the number of foreign vessels using Suva as a base (and unloading) reduced by more than half. Between 2017 and 2021, the volume of tuna unloaded in Suva from the longline fishery fell by 23,004 MT or 62% (Table 12), albeit that some of the decline is likely to be related to restrictions brought in during the pandemic. The fish levy has since been abolished and there are signs of vessels returning to Suva.

3 Local consumption from purse-seine transhipment and landings

The contribution of in-port tuna transhipment and landings to food security in the Pacific Island region has been subject to limited research to date, particularly for fish entering the local market through unofficial means. The most recent study on leakage of tuna bycatch from purse-seine transhipments in PIC ports was carried out by Tolvanen et al. (2021). The authors defined leakage from transhipment as '*fish landed for local use via unofficial channels – for example, crew, observers, visiting officials, agents and other port personnel that take the fish ashore for personal use, as well as unofficial bartering and trades made with ships outside formal trading arrangements and customs entry requirements*'. The study also provided estimates of tuna/bycatch entering the local market from transhipment and landing operations through official means, i.e., commercial trade.

Prior to this, the topic of food security from tuna transhipments was only briefly covered by McCoy (2012), who looked at opportunities for increasing benefits from tuna transhipments in PICs. That report included a section on trade in discards and non-target tuna species, usually between locals offering vegetables, other produce and items such as cigarettes and phone cards to the crew onboard transhipping vessels.

Estimates of leakage and discharge from purse-seine transhipments from the two reports are presented in Table 3 below.

Table 3: Previous estimates of leakage and discharge from purse-seine transhipment and landing entering the local market.

Port	Value and volume (McCoy 2012)	Volume in MT (Tolvanen et al. 2021)	Percent of total transhipped (Tolvanen et al. 2021)
FSM	Very little leakage occurs due to a lack of market for low quality fish	For 2016: 100 MT from transhipment	Leakage ~0.07% of transhipment
Kiribati	200 MT generating a value between AU$50,000 to AU$100,000	For 2018*: 254 MT	Sales ~0.15% of transhipment in Tarawa Leakage is negligible
Marshall Is.	Similar situation to FSM	For 2016: 111 MT	Leakage ~0.03% of transhipment Commercial trading is negligible
PNG	Fish obtained from transhipment is usually first smoked or cooked in traditional earth ovens and distributed to villages distant from the commercial centre.	For 2020: 2,080 to 3,190 MT	Rabaul: leakage ~1% of transhipment Madang: canteen ~1% of landing Lae: sales and leakage ~0.35% of landing Wewak: sales and leakage ~0.6% of landing
Solomon Is.	During peak transhipment periods in Honiara (Nov-Feb), leakage trade could reach between US$15,000 to $30,000 per month in value. For other periods, trade is valued from US$3,000 to $8,000 per month.	For 2016: 953 MT from transhipment For 2019: 956 MT from sale of purse-seine landed fish	Leakage ~1% of transhipment NFD sales ~2% of landing
Tuvalu	Was not a major port for transhipment in 2012.	Negligible	0%

* Estimates for volume entering the local market in Kiribati for 2018 is based on volume reported by CPPL and KFL in Tolvanen et al. (2021) and leakage estimate from gifting to officers and stevedores for 1 in 4 of the 189 purse-seine transhipments, i.e., 47 events

3.1 Volume of tuna bycatch entering the local market

Using purse-seine landing and transhipment data from SPC and NFA, the average volume of tuna bycatch entering the local market is estimated by applying the most recent and relevant leakage and discharge percentage calculations from Tolvanen et al. (2021) in Table 3. Where available, the estimates are supplemented/updated by information provided during stakeholder consultations. The estimated volumes of tuna bycatch entering local markets from commercial landings and transhipments are summarised in Table 4.

In this study, transhipment and landing are considered together as potential sources of tuna bycatch from the purse-seine fishery because the average proportion of bycatch available is likely to be similar irrespective of the destination for the catch. This is the current situation in Noro, Madang and Lae[7].

Table 4: Estimated volumes of tuna bycatch entering local markets from commercial landings and transhipments, 2017 to 2021

Country	Average volume transhipped/landed per year (MT)	Estimated volume of tuna bycatch entering the local market per year (MT)	Percent of total volume (%)	Reliability of estimates
FSM	192,673	135	0.07%	Med confidence
Kiribati	298,210	386	0.15%	High confidence
Marshall Is.	257,126	77	0.03%	Med confidence
PNG^	310,076	2,739	0.88%	Med confidence
Solomon Is.^	72,204	1,036	1.43%	High confidence
Tuvalu	130,832	4.4	Negligible	Low confidence
Total	**1,261,320**	**4,378**		

^ Estimated volume of tuna bycatch entering the local market is calculated by multiplying the volume transhipped or landed in each of the 4 ports of PNG with the respective percentage of sales/leakage in Table 3. The percent of total volume in column 3 is then the weighted average from the 4 ports (i.e., estimated volume of bycatch entering the local market divided by the total volume transhipped or landed). The same method was used for Solomon Islands for the ports of Noro and Honiara.

It should be noted that the average volume transhipped or landed reported in Table 4 refers to the 5-year average from 2017 to 2021, based on data obtained from SPC and NFA. The 5-year average, rather than the 10-year average from Table 1, has been used to better reflect current trends in bycatch volumes entering the local market whilst accommodating fluctuations associated with changes in ENSO conditions.

For Tuvalu, Tolvanen et al. (2021) did not report any leakage from transhipment aside from donations made by agents of fishing companies for occasional special events, which was estimated at under 0.5 MT per year. However, consultations with fisheries officers and agents in Tuvalu confirmed leakage in the form of employment perks to stevedores do take place and are around 10 kg bag of fish per person working on transhipping vessels, prior to COVID restrictions[8]. Working on the assumption that only half of the vessels transhipping provide this perk to stevedores employed and an average of 5-6 stevedores support each purse-seine transhipment – this equates to 3.9 MT from an average of 70 events over the period from 2017 to 2021 in addition to the gifts estimated by Tolvanen et al. (2021). Leakage in the form of bartering was also confirmed during stakeholder consultations. However, as most of the bartering is done by local fishermen in exchange for fish for bait use, this amount was not considered in the calculations.

3.2 Current conditions of sale for offloaded tuna bycatch

The conditions and agents involved in the sale of offloaded tuna bycatch varies across the region, depending on the size of the population, transportation and infrastructure available, as well as demand for reject fish from purse-seine vessels. The latter is often a reflection of consumer

[7] For the PNG ports of Lae and Madang, the bulk/if not all of purse-seine vessel visits are dedicated to landing tuna for the canneries located in the respective cities. The wharves used to receive tuna are privately owned by Frabelle and RD. Nevertheless, locals (mostly women) line up at the gate to the private compounds to buy reject fish at low cost. Similarly in Noro, where the majority of fish is landed to the Soltuna plant, an estimated 2% of bycatch is made available for local consumption by organised sales through the staff credit union (Tolvanen et al. 2021).

[8] During the period from April 2020 and March 2022, transhipment activities in Tuvalu were moved from Funafuti lagoon to an area offshore southeast of Funafuti: Tuvalu Fisheries Department – 2020 Annual Report, available from https://tuvalufisheries.tv/library/

preference as well as other forms of proteins available and their relative affordability. The information presented in this section is primarily drawn from stakeholder consultations, supplemented by available literature. It should be noted that the 'current' conditions of sale described in this section are primarily based on the operating environment pre- and post-COVID restrictions.

Federated States of Micronesia

The majority of purse-seine vessel visits in FSM are related to transhipment, with most of the visits taking place in Pohnpei. However, since the opening of the new loining plant and cold storage facility in Kosrae, transhipment and landing activities have steadily increased there. In Pohnpei, the sale of catch (incl. tuna bycatch) by both foreign and domestically-flagged commercial fishing vessels is prohibited to protect the livelihoods of small-scale tuna fishers who supply skipjack and yellowfin tuna to the local market, even though supply does not always satisfy demand. To reduce the scope for corruption, it is also illegal for government officers to ask for gifts from those whose actions they regulate. However, Tolvanen et al. (2021) reported that a limited amount of high-level 'patronage' gifting – mainly for special official/community functions – is practiced from time to time under the approval of the NORMA Executive Director or the company CEO in the case of FSM flagged vessels. Similarly, for any locally based-processing plant wishing to process fish by vessels other than their own, approval from the NORMA Executive Director must be granted before fish can be landed.

Despite the official regulations, some informal trade still occurs beyond surveillance undertaken by the Pohnpei Port Authority (e.g., after sunset or in outer anchorage areas). This mostly involves six local fish traders and miscellaneous fishers (Tolvanen et al. 2021). Four of the fish traders were registered produce and fish mongers in town and two were individual traders located in rural areas. The traders generally use one or two large ice chests to carry fish which restricts the weight of fish handled to about 114kg per transaction (Tolvanen et al. 2021). Public spaces for vessels to land fish are limited, which has also been a constraint to larger volumes of tuna being traded or illegally sold and supplied through the rural areas outside of the main port area. While not intended to support an increase in the supply of bycatch from purse-seine transhipments, needs assessments are underway for all four ports in FSM to identify necessary infrastructure upgrades, e.g., extensions to port frontages, alternative wharf spaces and so on.

There were plans to utilise reject fish from purse-seine transhipments for pig feed production by the katsuobushi plant set up under the joint venture enterprise Taiyo Micronesia Corp (TMC) in 2018, which aimed to replace the feed imports at the time, of around 1,000 MT per year (Havice 2019). However, the katsuobushi plant has since shut down due to the difficulties in sourcing enough fish from other vessels to meet the production needs.

In general, the demand for bycatch and damaged tunas from transhipments in FSM is relatively low. The preference is for reef fish and imported foods. Nevertheless, fresh tuna is regularly consumed and available at many restaurants, fish stores/stalls and supermarkets in the state capital, Pohnpei.

Kiribati

Unlike other purse-seine transhipment hubs, there is a formal process for selling tuna bycatch from purse-seine transhipment activities for local consumption in Tarawa through the government owned/joint-venture company – Central Pacific Producers Limited (CPPL). The company operates two fish markets on Tarawa atoll, located at Bikenibeu and Bairiki. The markets are used to sell various seafood products, including bycatch offloaded from purse-seine vessels. In 2019, CPPL also opened a new restaurant in Betio. However, it's unclear whether tuna bycatch is served at the restaurant.

CPPL is the only authorised agent for the collection, transportation, and distribution of tuna bycatch from purse-seine vessels transhipping in Tarawa. They are supported by licenced stevedores who transport the bycatch from the transhipping vessels to shore. The supply of bycatch is secured through licencing conditions for purse-seine vessels fishing in Kiribati waters, which requires that transhipments take place in Tarawa and allows local landings from transhipments to occur. However, the requirements are not set in stone but rather negotiated on a case-by-case basis.

Currently, bycatch available for local consumption is less constrained by the supply of fish from transhipping vessels and more by infrastructure limitations. It was highlighted in the survey response from CPPL that they do not possess any large collection boats to transport bycatch from purse-seine vessels to shore, and the wharf space operated by the Kiribati Ports Authority (KPA) is also limited. This is consistent with Tolvanen et al. (2021), who noted that the collection process is dependent on having small collector boats operational, which is not always the case with CPPL boats sometimes not functioning. For the six months from September 2022 to February 2023, CPPL reported only 107 MT of bycatch sold through its fish markets.

As a result of the constraints in the official supply chain, private individuals are still actively involved in the collection and distribution of tuna bycatch from purse seine transhipments despite the regulations against it. Anecdotal accounts suggest that the CPPL markets are closed more often than they are open, with a large portion of tuna bycatch entering Tarawa's local economy as 'leakage' – i.e., informal and unmonitored collection of fish from purse-seine vessels by private individuals in small skiffs/canoes and selling the fish at pop-up stands by the side of the road (pers. comm. Francisco Blaha).

Figure 3: Local private individuals/entrepreneurs gutting and cleaning small skipjacks obtained from purse-seine vessels transhipping in Tarawa. Photo credit: Francisco Blaha

Reject fish collected by CPPL staff onboard transhipping vessels is transported from the wharf to their shop fronts or cold storage facility (i.e., reefer container) via a truck with the capacity of holding up to ~2 MT. Once the fish is distributed to the two retail fronts in Bikenibeu and Bairiki, it is sold whole and unprocessed. The fish is normally sold quite quickly owing to the competitive price charged – AU$2.20/kg in 2023, or half the market price of fresh fish. On the odd occasion where there is more discard tuna than the market can absorb, due to limited cold storage capacity, the discard is sold as animal feed, equating to around 1 MT per year since 2016 (Tolvanen et al. 2021).

Currently, CPPL is selling bycatch from transhipment activities only to the public in Tarawa. The company does not supply reject fish to any public institutions (e.g., schools, hospitals etc.) and is not planning to distribute fish to outer islands as the bycatch is intended to support food security needs for people in the capital.

Marshall Islands

To date, all transhipment activities in the Republic of the Marshall Islands (RMI) take place in the Port of Majuro. Despite the large volumes of purse-seine caught tuna transhipped through Majuro and the absence of regulations restricting individuals trading or bartering for tuna bycatch from transhipping vessels[9], only a very small amount of bycatch or reject fish is locally consumed. This is primarily due to the low demand for frozen-in-brine tuna. Similar to FSM, consumer preference is for reef fish and imported foods, with preference in tuna geared towards fresh tuna more than frozen.

When trade or bartering does occur, it usually takes place at the beginning of transhipments with locals paddling out to fishing vessels with bananas and other fresh produce in exchange for the fish caught in the last set. For purse seiners, the last set is usually made closer to the port of transhipment and sits on top of the brine wells, making it fresher and less damaged. The fish obtained is usually consumed privately or used as bait.

Stevedores and boarding parties are also sometimes gifted fish from transhipping vessels, although the fish is not necessarily bycatch. On rare occasions, purse-seine vessels might donate fish to local institutions, such as hospitals. One key factor impacting the local consumption of bycatch from purse-seine vessels is the ready availability of fresh tuna offcuts from the longline-supplied processing plant operated by Luen Thai. These are sold by the side of the road by local plant workers for US$5 per 3 kg bag. However, the practice is not encouraged by the company due to the limited capacity to monitor how the fish is handled after it leaves the plant.

In the formal market, there are two main actors that handle bycatch from purse-seine vessels in RMI – Pan Pacific Foods (PPF) and Kendall Micronesia Inc. (KMI). PPF is a Chinese-owned fishing company operating 5 RMI-flagged purse-seine vessels that supply tuna and bycatch to their cooked loin processing facility in Majuro. Bycatch, along with tuna scraps from loin production, are used in the production of fish meal. However, all fish meal produced from bycatch fish is fully exported. It should also be noted that production at PPF was halted from mid-2020, in part due to COVID restrictions and staff shortages. Production of cooked loins and fishmeal has resumed since February 2023.

KMI, on the other hand, is a Marshallese-owned and operated shipping agent for purse-seine vessels transhipping in Majuro. As such, they have access to bycatch aboard the transhipping vessels which they can obtain for free or in exchange for fruits and vegetables. In recent years, the company has begun utilising waste fish in the production of pellets for aquaculture, which is then used in the country's milkfish farming sector (*Figure* 4, MRAG Asia Pacific 2022).

[9] Although the commercial resale of bycatch from purse-seine transhipments is prohibited.

Figure 4: Fish meal production facility of Kendall Micronesia Inc., in Majuro. Photo credit: Maurice Brownjohn.

Both PPF and KMI utilise the public port and wharf available, with PPF collecting the bycatch as part of the unloading process and KMI transporting reject fish from transhipping vessels using their own skiffs. The public port is shared with container ships bringing goods and supplies to Majuro, which take priority over fishing vessels. This is the only bottleneck identified by officers from Marshall Islands Marine Resources Authority (MIMRA) with regard to any fish landed from purse-seine vessels to local processors.

Papua New Guinea

There are a number of ports in which purse-seine transhipments and landings take place in PNG. The busiest of these is the Port of Rabaul, thanks to the large and well-sheltered Simpson Harbour. As there are no processing facilities in Rabaul, the majority of vessel visits are dedicated to transhipment between purse seiners and fish carriers. In contrast, vessel visits to the other 3 key ports (i.e., Lae, Madang and Wewak) are primarily associated with the landing of tuna into processing plants located in the respective centres. This is also one of the main reasons behind the consistency of tuna volume recorded through the three ports, compared to larger fluctuations in volumes transhipped in Rabaul as a result of ENSO cycles.

The process in which bycatch, and damaged or small tunas, enter the local market varies by port. For Rabaul and Wewak, tuna are transhipped between anchored purse-seine vessels and carriers, or, in the case of Wewak, are landed onto barges that transfer fish from the fishing vessel to the wharf. Bartering for tuna/bycatch with fruit and vegetables primarily occurs through locals approaching anchored vessels in canoes and dinghies, although the practice has declined in Wewak in recent years as more fish is arriving pre-sorted via carrier from Rabaul (*Figure 8*, Tolvanen et al. 2021).

Figure 5: Satellite map of Frabelle Wharf in Lae. Source: Google

In Lae and Madang, tuna landed for processing/exporting is done through private wharves operated by Frabelle and RD Tuna, respectively (Figure 5 and Figure 6). The compounds are fenced and guarded with trading taking place at the gate to the private wharfs instead of locals directly approaching the fishing vessels. On days of unloading, it is common to see locals (mostly women) lining up outside the compounds, waiting to purchase bycatch at very low cost. In the case of RD Tuna in Madang, the sales outlet is set up with a local landowner group at the compound gate, with revenue from fish sales shared with the fishing crew (Tolvanen et al. 2021).

For a number of processing plants, including RD, Frabelle and South Seas Tuna Corporation (SSTC), a considerable portion of bycatch is also used in the canteens for the consumption of workers at the plants.

The volume of bycatch available for local consumption in the PNG ports where tuna is landed to processing plants is heavily dependent on the offloading capacity of the respective wharves. Despite the growing volumes landed in the three ports, there are several constraints and limitations persisting. At this time, the Frabelle Wharf is the main point of off-loading for all four processing plants based in Lae and is frequently subject to congestion and disruptions caused by weather (i.e., southerly/monsoonal winds). In addition, not all of the 230 m wharf frontage can be used for large-draft vessels due to depth restrictions at both ends, limiting the number of carriers that can berth to two to three. For the volume of tuna landed in Lae to significantly increase from current levels, additional fish-dedicated wharfage is needed.

Figure 6: Satellite map of RD Wharf in Madang. Source: Google

Similarly, the main wharf in Wewak, which is operated by Wewak Port Authority, can accommodate only one vessel at a time (Figure 7). Moreover, general freight (e.g., food, construction materials, fuel and other cargo) are given preference over vessels supplying fish. If a fish carrier is unloading when a cargo vessel is inbound, the carrier is required to vacate the wharf space. As such, SSTC constructed a landing craft barge which carries two insulated trucks to fish carriers anchored offshore. However, the unloading rate to the trucks/landing craft is constrained to less than 200 MT per 24-hour period, which means that SSTC often must unload 7 days a week to obtain the required supply of raw materials for 5 days of production. As such, there are limited opportunities to increase the supply of tuna to SSTC and, in turn, bycatch available for local consumption.

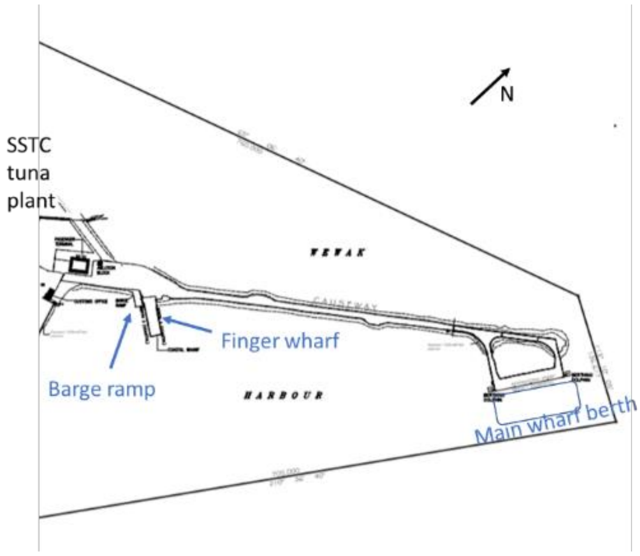

Figure 7: Wewak Port layout

Unlike the other three ports, Simpson Harbour in Rabaul enjoys an expansive sheltered area in which numerous purse-seine vessels and fish carriers can be accommodated for transhipment. During 2021, when La Nina conditions dominated, the volume transhipped peaked at over 327,000 MT across 639 visits (Table 10 and Table 11). While fluctuations in ENSO conditions will affect the amount of bycatch available for local consumption, the main constraint to the delivery of bycatch is likely to come from an inefficient informal supply chain with virtually no cold chain for wide and timely distribution of a perishable product (Tolvanen et al. 2021). Earth oven-smoking techniques used to dry and preserve tuna/bycatch landed in Rabaul for distribution to villages distant from the commercial centre offers one way to extend the shelf life of fish (McCoy 2012), but it only goes so far during periods of high transhipment volume.

Figure 8: Lady bartering for fish in Simpson Harbour, Rabaul. Photo credit: Francisco Blaha

As a result of the cold chain constraints, as well as the large distances between transhipment ports, bycatch that is made available for domestic consumption is very much a localised commodity. There are no reports of tuna bycatch making its way to Port Moresby or into the Highlands.

Solomon Islands

Until recently all vessel visits to Noro were associated with unloading fish to the Soltuna processing plant by the domestically-flagged National Fisheries Developments (NFD) fleet. In March 2019, the Star Loader facility, which unloads catch from purse seiners directly into Maersk refer containers for shipment, commenced operation and began accommodating containerisation activities for domestic and foreign purse-seine vessels alike[10]. Tolvanen et al. (2021) suggests that unloading and containerisation activities in Noro constitute a relatively small proportion of total number of visits but growth is expected, particularly during La Nina years. In general, total volumes landed/containerised in Noro are considerably less than that through Honiara at the current time. However, vessel visits are far more stable due to the association with the cannery for the bulk of the visits, which reduces the impact of ENSO conditions on transhipment/landing activities compared to the country's capital.

Similar to Lae and Madang, fish unloaded in Noro takes place within NFD's security gated compound. However, unlike elsewhere in the Pacific, all bycatch is retained as part of NFD's company policy – including non-target species such as rainbow runner and mahi mahi. The policy extends beyond the retention of small and reject target tunas mandated under the WCPFC's Conservation and Management Measure (CMM) 2021-01[11] and what is widely practiced across the region. Since the introduction of the company policy and the establishment of the sales outlet at the NFD compound in 2013/14, revenue generated from the sale of bycatch and reject tuna has grown considerably, with bycatch sales now considered as an official revenue stream for the fishing fleet. With the growth in NFD bycatch sales also came the commercialisation of the value chain.

Figure 9: Reject fish from purse-seine vessels at the Central Market, Honiara. Photo credit: Johann Bell

The bycatch supply chain in Noro begins with the vessels unloading their catch at the NFD facility. The fish is then sorted and weighed before it is stored in the company's cold storage unit. Bycatch sales to the local community are regulated by NFD, and follow the Hazard Analysis and Critical Control Points (HACCP) process including keeping the fish properly stored until the point of sale. The point of sale takes place at the NFD fish outlet where traders, mostly women, line up with 300 L insulated cool boxes (see blue containers in *Figure* 9) to purchase their desired volume of bycatch by

[10] https://trimarinegroup.com/2019/03/08/nfd-new-si-star-loader-services/

[11] CMM 2021-01 - Conservation and Management Measure for Bigeye, Yellowfin and Skipjack Tuna in the Western and Central Pacific Ocean is available online at https://cmm.wcpfc.int/measure/cmm-2021-01

species[12]. After the financial transaction is complete, the traders then go to a designated area to collect the fish and pack their cool boxes. Casual stevedores are usually engaged at this point, and they continue to assist throughout the whole process until the fish is onboard the overnight passenger and cargo vessels to Honiara – which is the final market for the majority of the bycatch landed in Noro. More specifically, the stevedores will help pack the fish into the cool boxes at the NFD compound, help load the cool boxes onto hired trucks equipped with a lifting crane, and unload the fish onto the transport vessels to Honiara.

The traders in Noro are well connected with buyers in Honiara and have an organised distribution chain, supplying bycatch to fish and chips outlets, Kai bars (small food bars) and other retailers who then sell the fish at the central market or various roadside locations (*Figure* 9). Some traders are not only wholesalers but also retailers with several locations that they service. The volumes moved by the traders is of commercial significance, with purchases from NFD made in MTs, i.e., multiple 300 L cool boxes. On the day(s) prior to scheduled overnight passenger and cargo vessel trips to Honiara, as much as 15 MT or ~60 x 300 L cool boxes could be sold through the NFD outlet. While Honiara is the final destination for the bulk of the bycatch sold at NFD, small amounts of fish are also consumed locally in Noro and/or make their way to Gizo. In Noro, bycatch often undergo some preparation before sale, e.g., sold as fish and chips. When good-quality bycatch is available, some local shops also sell raw fish from a freezer.

Figure 10: Satellite map of main market locations in Honiara.

Aside from the formal avenue of bycatch sale and distribution from NFD, there are other means by which reject fish from purse-seine vessels enter the local economy. For instance, foreign vessels that unload to Soltuna or make use of the Star Loader facility are not bound by NFD policies, and therefore deal with the bartering and sale of bycatch to locals who approach the vessels as they see fit. Bycatch is also distributed to the local community through a donations system – where church groups/fundraisers, the hospital (~once a month), or villages where there's been a death come to NFD and ask for fish. These are ad hoc requests made to NFD, and fish is provided on a case-by-case basis. Finally, crew working on NFD vessels are entitled to 2 bags of fish per trip for personal consumption which is shared among family and relatives.

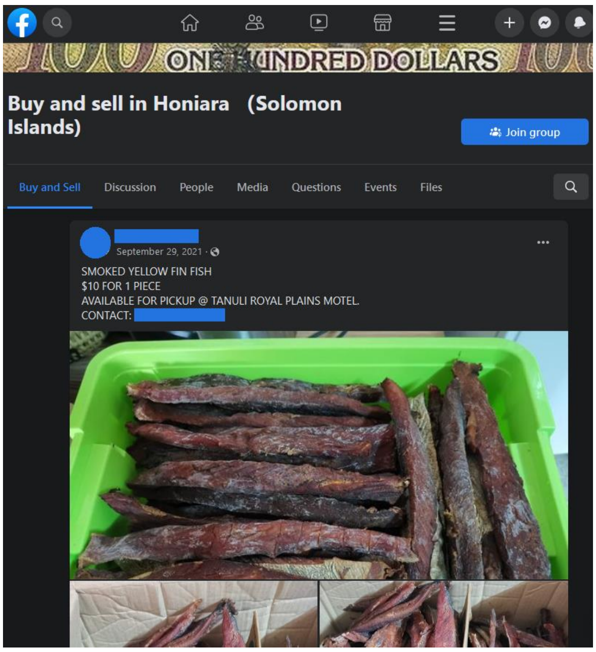

Figure 11: Smoked fish sold online in Honiara.

[12] The price of bycatch sold by NFD varies with species and size. Normally undersized reject skipjack and island bonito sells for SBD$5/kg, although it can go up or down by $1/kg depending on the season and volume of bycatch landed. For larger and more sought-after species like bigeye, the price is around SBD$9/kg.

All transhipment activity in Honiara involves transferring fish from purse seiners to carriers. Given there are no regulations governing the sale of fish from transhipments, bycatch and reject tuna enter the market through more informal means. Similar to Rabaul, bycatch and reject tuna are usually bartered by locals approaching transhipping vessels in smaller canoes or banana boats offering fruits and vegetables in exchange. Casual security guards privately hired by purse-seine vessels and/or carriers have also become key traders in this informal industry, thanks to having direct access to sorted fish on deck which are often bagged and transported back to shore by their family members (Tolvanen et al. 2021). 'Wantoks' or extended family members of locals engaged in obtaining fish from transhipping vessels, which are usually women, then sell the fish at one of many markets across the capital, e.g., Central Market, Kukum/Fishermen's village market, White River market. (Figure 9 and *Figure 10*).

As with the case for Noro, some of the reject fish obtained from transhipping vessels also undergo preparations before sale, mostly cooked and sold as fish and chips or smoked/dried fish. There has been an increase in the sale of smoked fish in recent years, especially via online platforms such as Facebook. However, it is not clear whether the fish is obtained from transhipping purse-seine vessels in Honiara, transported from Noro or caught locally by artisanal fishers (*Figure 11*).

Figure 12: Fresh reef fish in an 'iced' cool box, for sale at the Central Market in Honiara. Photo credit: Johann Bell

One of the key challenges to the distribution of fish in Honiara, both fresh and 'saltfish' (i.e., from transhipments in Honiara or fish that makes its way from Noro) is the lack of cold storage available. Fish sold across the key markets in Honiara are displayed unrefrigerated/not iced for long periods of time prior sale (Figure 9). For more expensive seafood (e.g., lobsters, squid, larger fresh-caught reef fish or yellowfin tuna), large cool boxes are used usually with some amount of ice (*Figure 12*). However, cheaper fish like that from transhipments do not justify the cost of cold storage during the day. At the Central Market, there is the option for vendors to store their saltfish in an icebox overnight for a small fee (Tolvanen et al. 2021).

Another problem that exists with the saltfish trade is the exchange of personal services by young women in return for fish, which is not prohibited or regulated, but rather disapproved of (Tolvanen et al. 2021). This is a social problem that also has implications on personal health and the spread of diseases.

Tuvalu

Funafuti has only become a major purse-seine transhipment hub in recent years. Since 2015, the level of transhipment activity in Funafuti has rivalled that of major hubs in the region, such as Tarawa and Rabaul (depending on ENSO conditions), due to its sheltered lagoon. There are currently no formal or legal regulations in place around the handling of bycatch from transhipment in Tuvalu. As such, most of the reject fish enters the local community through informal means – a combination of free fish given to workers (e.g., stevedores), officials visiting the vessels, vessel agents on an opportunistic basis, as well as those bartered with locals, who paddle out to transhipping vessels, for coconuts, bananas, breadfruit etc. Large blast-frozen yellowfin (Purse Seine Special) are sometimes requested, through the vessel agents, for funerals or similar special events.

Consultations with Tuvalu Fisheries Department (TFD) and agents in Funafuti suggest that most fish received from transhipping vessels are not sold on the local market, but rather used for personal consumption among family members or as bait in artisanal fishing. The requirement of a licence to sell fish, and the close network of fishers supplying the local market, are likely reasons preventing fish from transhipment being commercially traded in the community. Moreover, reject fish from purse-seine transhipments are normally used for salting and drying with waste used for pig food. Brined, frozen fish is not popular for normal cooked fish dishes in Tuvalu.

In terms of infrastructure, there is a small boat landing area at the main wharf available for public use with a TFD jetty scheduled for construction in 2024/25. However, most small boats land on the beach by the village near to their owners' houses. There are 30-40 small open boats (5-7m) with outboards that are active in Funafuti that can collect fish from transhipping vessels. There are also two larger TFD vessels (17 m and 19 m) that could be engaged for larger quantities should the collection of bycatch be formalised.

Currently, there are two fish markets on Funafuti in operation – by The Fishermen of Funafuti Association (FOFA) and the National Fishing Corporation of Tuvalu (NAFICOT). Each market is equipped with half a dozen chest freezers, and the NAFICOT market also has a 1 MT/day ice machine. A 25 cubic meter freezer room at the NAFICOT market will have new refrigeration machinery fitted in the second half of 2023. However, as mentioned earlier, bycatch is not openly sold at present. Only fresh fish is sold at the fish markets and roadside stalls.

Discussions to formalise the handling of bycatch and reject tuna from transhipment through NAFICOT or FOFA took place prior to the COVID-19 pandemic. Both NAFICOT and FOFA make processed fish products – mainly sun-dried and smoked fish. NAFICOT had began ramping up its capacity in 2019, with the installation of new fin bins, freezers, drying/smoking machine donated by Korea, as well as training around 20 locals in processing techniques. However, due to limited transhipment activities since early 2020, plans to process bycatch have been temporarily placed on hold. Nevertheless, NAFICOT is actively processing fish bought from local fishers, making salted-dried and smoked product which constitutes around 90% of the company's sales.

While there is inter-island shipping available, TFD advised there is likely to be limited demand for brine frozen fish or products in the outer islands. Any fish trade would tend to be the other way around, i.e., fresh fish from outer islands transported to Funafuti for sale.

4 Future tuna bycatch and infrastructure needs

The combined urban populations for the key purse-seine transhipment port countries examined in this study are projected to increase from 1.5 million in 2022 to ~1.7 million in 2030, and to ~2.4 million in 2050 (Table 5). The increases in urban populations are expected to put pressure on food and other resources, particularly for countries where climate change will also impact on the productivity of marine and terrestrial environments.

4.1 Future tuna bycatch needs

The quantities of fish needed by urban populations in countries where transhipping occurs in 2030 and 2050 are summarised in Table 5. These estimates are based on: i) the estimated percentages of men, women and children in these urban populations, ii) the average body weights of men, women and children in each country, iii) the recommendation by the World Health Organisation (WHO) that people should consume 0.7 g of protein per kg of body weight per day, and iv) the recommendation from the Public Health Division of the Pacific Community (SPC) that Pacific Island people should obtain 50% of their dietary protein from fish. The port countries most in need of the fish for domestic food security are PNG, Solomon Islands and Kiribati (Table 5).

Table 5 also shows that the average annual quantity of bycatch currently offloaded in each country will only make a modest contribution to the amount of fish needed to meet the recommended protein requirements of urban populations in port countries in 2030 and 2050. However, given that there are several other sources of fish available to urban populations (e.g., a wide range of coastal fish species and canned tuna), key questions centre around the size of any gap in fish supply, and the extent to which bycatch can be used to fill the gap. Such considerations are best assessed in terms of how many fish meals per month are needed to meet the dietary requirements of urban populations, how many are provided by other sources of fish and how many could be available from bycatch and from tuna caught by purse-seine if needs be. Table 5 provides this information. Although it was not possible to identify how many meals per month will be supplied by other sources of fish, it is unlikely that they will fill the gap. Other analyses being done to inform the Feasibility Study for the Funding Proposal for the GCF regional tuna programme will identify the size of the gap to be filled. Preliminary indications are that it will be significant in several countries. It will also grow wider with urban population growth and the continuing decline in coastal fisheries production due to the effects of ocean warming and acidification on coral reef fish production. Therefore, the scope for increasing the offloading of bycatch and tuna to fill more of the gap in supply needs to be determined.

Table 5: Estimated tonnes of fish needed to meet the recommended protein requirements of urban or peri-urban populations in key port countries in 2030 and 2050. See Annex 4 for details of how these estimates were made.

Country	Estimated population in urban and peri-urban areas*	Fish needed for protein requirements (MT)	Current landings of bycatch (MT)**	% of fish requirements supplied by bycatch	Gap in fish supply (MT)
2030					
FSM	23,000	1,476	135	9.1	1,341
Kiribati	74,000	4,855	386	8.0	4,469
Marshall Is.	40,000	2,399	77	3.2	2,322
PNG	1,407,000	73,773	2,739	3.7	71,034
Solomon Is.	169,000	8,786	1,036	11.8	7,750
Tuvalu	7,000	480	4.4	0.9	476
Total	**1,720,000**	**91,771**	**4,378**	**4.8**	**87,394**
2050					
FSM	22,000	1,467	135	9.2	1,332
Kiribati	96,000	6,399	386	6.0	6,013
Marshall Is.	39,000	2,390	77	3.2	2,313
PNG	1,962,000	104,763	2,739	2.6	102,024
Solomon Is.	253,000	13,528	1,036	7.7	12,492
Tuvalu	7,000	493	4.4	0.9	489
Total	**2,372,000**	**129,039**	**4,378**	**3.4**	**124,662**

* Source for the degree of urbanisation for population projections is extracted from Pacific Data Hub (SPC), available from: https://stats.pacificdata.org/, last updated 26 October 2022.
** From Table 4.

However, an important consideration is that the potential volume of tuna bycatch may decline due to the projected effects of ocean warming on the distribution of tuna. Table 6 presents a simple projection of transhipment volume for the key port countries based on forecasted changes in catch within the countries' Economic Exclusive Zones (EEZs). It does not take into consideration vessel licencing and/or political arrangements (incl. its influences on the Flag States of vessels) that could see changes in catch transhipped and fish caught within the countries' respective EEZs. In addition, it could be the case that some fish caught on the high seas, including in the Eastern Pacific Ocean (EPO), will still be transhipped in a PIC port in the WCPO and this is also not accounted for in the simple projection. In such a situation, the PIC ports that are most likely to be utilised for transhipment will be those located in the eastern WCPO, where the need for bycatch is much lower than in PNG and Solomon Islands.

Overall, however, and assuming that the potential volume of bycatch which can be recovered from purse-seine transhipments remains around the average industry estimate of 1%, tuna bycatch available from transhipment operations is unlikely to come close to filling large gaps in the supply of fish recommended for protein requirements (Table 5, Table 6). In addition, changes in fishing technology (incl. selectivity) as well as regulatory changes, such as area closures or introduction of marine parks, may impact on (i.e., reduce) the volume of bycatch available from purse-seine transhipment activities in the future.

Table 6: Projected volume of purse seine transhipment and potential tuna bycatch available in key port countries in 2050

Country	Declines in tuna catch within EEZ from Bell et al. (2021) (%)	Simple projection of transhipment volume under RCP8.5 (MT)[13]	Potential bycatch available based on 1% of transhipment	Projected urban population growth in 2050 compared to 2022*
FSM	-13.0%	167,625	1,676	-6%
Kiribati	-8.21%	273,727	2,737	48%
Marshall Isl.	-0.7%	255,326	2,553	-3%
PNG	-33.1%	207,441	**2,074**	62%
Solomon Isl.	-26.1%	53,507	**535**	79%
Tuvalu	-23.40%	100,217	1,002	3%
Total	-20.3%	1,057,842	10,578	46%

* Source for the degree of urbanisation for population projections is the Pacific Data Hub (SPC), available from: https://stats.pacificdata.org/, last updated 26 October 2022

These factors highlight for the need for a multi-sector approach to increasing the availability of fisheries (and aquaculture) products for consumption in urban centres of PICs with a high population growth under changing climate conditions. More specifically, governments in countries with fast-growing urban populations could consider the introduction of policies for i) mandating the landing of bycatch during transhipping operations, and the landing of some the tuna caught by purse-seine (normally destined for canning) at the going market rate (ca. USD1.50 – 2.00 per kg), and ii) generally supporting other fisheries and aquaculture production, to improve the supply of fish for the food security of urban populations. The latter could involve, for example, increasing availability of nearshore FADs, providing financial support or training to artisanal fishers and aquaculture farmers, engaging with industrial fishing companies for assistance in deploying and maintaining FADs and/or promoting domestication of commercial fishing operations (MRAG Asia Pacific 2022).

It should be noted that if bycatch landing requirements are not consistently implemented across all PNA countries, countries with such requirements may be disadvantaged by fleets preferring to fish in countries without such policies. However, transhipment policies (including fees and charges) have to date been country specific and there are no precedents for PNA members to act collectively on these matters. It is also not certain that a bycatch landing mandate would be attractive to all PNA members given that some countries have a ban or restrictions on commercial landing at the current time as a means to protect its local/artisanal fishing sector. An alternative policy that could be considered may be to require vessels that fish regularly inside the EEZ of a country to undertake a minimum frequency of transhipment in port, irrespective of fishing patterns that can vary across years as a result of the prevailing ENSO conditions. The policy could make it easier for port countries to encourage purse-seine operators to land bycatch as needed.

[13] Simple projection of transhipment volume under RCP 8.5 is based on percentage declines in catch forecasted in Bell et al. (2021) applied to the average volume transhipped in the 5-year period from 2017 to 2021 in Table 4.

4.2 Nature and scale of improvements to infrastructure

To harness the full benefits of policies aimed at increasing the delivery of bycatch to bolster domestic fish supply in key purse-seine port countries, upgrades to existing market infrastructure and supply chain networks are required. For the most part, the upgrades identified are likely to be necessary to support more efficient distribution of all fisheries products to meet the SPC Health Division's recommended protein intake under the urban population projections. The information presented in this section is primarily drawn from stakeholder consultations and available literature as well as basic economic concepts, such as economies of scale[14]. For detailed descriptions of existing conditions of sale for offloaded tuna bycatch from purse-seine transhipment operations, refer to section 3.2.

Federated States of Micronesia

FSM is one of the few countries where the urban population is projected to decrease in 2050, by 6% from 23,317 in 2022. This suggests that the scope for increased tuna bycatch consumption is likely to be limited. Given that the demand for brine-frozen fish is already considerably lower compared to other PICs, owing to consumer preferences for other seafood and protein sources, there is unlikely to be sufficient justification for significant infrastructure improvements needed for handling bycatch. That said, infrastructure upgrades may still be necessary to support artisanal fishers in supplying the local market with fresh fish as bottlenecks have been identified at port facilities. To this end, there are four needs assessment studies currently underway for each of the States in FSM that have been commissioned by NORMA.

On a more general note, an important condition in promoting the establishment or growth of any Small or Medium Enterprise (SME) in the fisheries sector that has been noted throughout all stakeholder consultations is an environment conducive for doing business and incentives for companies to unload or process bycatch onshore. The same was highlighted during the talks with NORMA, with the view that fisheries administrations should look at improving the business operating environment beyond just the tuna value chain. For example, tying onshore development to access agreements with fishing companies to provide onshore developments that can improve the overall business environment such as establishing solar farms, operating inter-island (passenger) transport, provide commercial air freight services and so on, offer potential.

If restrictions to the sale of tuna and bycatch from purse-seine transhipments are eased in the future, it was also suggested during consultations that the sales should be coordinated through women's groups or fishermen associations in order to minimise the impact on artisanal fishers and/or promote inclusive employment or livelihood opportunities. In particular, direct control over bycatch supply by local fishermen associations could see the fish utilised more appropriately, e.g., to supplement artisanal catch during periods of bad weather. However, it should be noted that there have been plans to allow fish from purse-seine transhipments to enter the domestic market in the past but were rejected as result of pressures from local fishermen.

Kiribati

The Kiribati government has plans to develop transhipment hubs in Betio, Tarawa and in Kiritimati by 2027 and 2036, respectively (Kiribati 20 Year Vision[15]). However, there are a number of issues facing Kiribati under future climate change scenarios. The current elevation in Tarawa is 3.05 m above sea level, while the projected global mean sea level rise under business-as-usual emissions is 0.20 – 0.29 m by 2050 and 0.63 – 1.01 m by 2100(IPCC 2014, 2023). As such, the general

[14] Economies of scale are cost advantages companies experience when production increases, as total cost can be shared over larger volumes of output produced. Smaller or emerging companies often struggle to compete with those established due to a higher average cost from producing low volumes.
[15] Kiribati 20 Year Vision 2016-2036. Available from: https://www.fao.org/faolex/results/details/en/c/LEX-FAOC193353/

infrastructure landscape is likely to be very different in 2050 to what it is now. President Taneti Maamau has the ambition of raising the islands in Kiribati as part of the fight against climate change (Pala, 2020[16]). If the plan of dredging fill materials from the lagoon to raise Tarawa goes ahead, this could lead to a re-design of the current urban planning.

In the more immediate future, a number of improvements could be carried out to address the infrastructure limitations outlined in section 3.2. More specifically, investing in larger collection boats so that CPPL that can transport up to 3 MT of bycatch will help minimise disruptions to the supply of fish to the local market, as well as expanding on cold storage available. Work is currently underway to sublease land from the Ministry of Land for space next to Te Atinimarawa Company Limited (TACL) for the construction of a small wharf that will reduce travel time to the transhipment zone to 30 minutes. This will not only bring about more efficiency in the transportation and distribution processes, but also improve food safety as the cold chain can be better maintained.

A point of contention for artisanal fishers has been the competition brought on by the availability of cheap fish. On this note, CPPL has advocated for infrastructure investment in a simple processing facility to promote local employment and reduce competition with artisanal fishers. The view is supported by some of the artisanal fishers who believe that processed fish (i.e., dried, smoked or canned fish) is sought by a different market and does not compete with fresh fish sold. The facility and machinery may not need to be very advanced but rather in line with the transportation capacity of vessels, which might see six to nine MT of tuna bycatch received per day[17].

Consultations with industry and technical experts have consistently highlighted the need to improve the business operating environment in PICs by reducing regulations that inhibit entrepreneurship and promoting private initiatives. In Tarawa, CPPL is seen by some as a barrier to SMEs by prohibiting the sale and distribution of bycatch from purse-seine vessels by private individuals who can operate more efficiently. While the suggested infrastructure improvements still stand, moving towards a free-market approach is likely to see greater competition in the supply of bycatch, and with it, increased efficiency in meeting food security needs under the projected population and climate conditions.

Marshall Islands

Similar to FSM, the projected urban population in 2050 is lower than that in 2022 – a fall of 1,290 persons or 3%. The country's strong affiliation with the United States[18] provides various immigration opportunities to Marshallese citizens. This, and the fact that the elevation of Majuro, similar to that of Tarawa (i.e. 3m above sea level), are likely to play a role in influencing population growth and migration patterns.

Given the lack of food insecurity, and the various alternative seafood options available in Majuro, the focus for bycatch from purse-seine transhipment operations would be better directed at supporting nutrition security and livelihoods of small-scale producers/fishers. For example, utilising bycatch in animal feed and agriculture (i.e., as fertiliser) to increase the production and diversity of other proteins for local consumption. Another infrastructure or distribution improvement that was highlighted during the stakeholder consultations is the possibility of supporting the transportation of tuna bycatch to outer islands to use as bait by local fishermen. At the current time, to meet the high demand of reef fish in urban areas, MIMRA organises the collection of reef fish from outer islands for distribution and sale in Majuro and Kwajalein Atoll (MRAG Asia Pacific, 2022). This transportation

[16] https://www.theguardian.com/world/2020/aug/10/kiribatis-presidents-plans-to-raise-islands-in-fight-against-sea-level-rise

[17] Calculation is based on both the number of trips a 3 MT collection boat could realistically make on average per day and the volume of bycatch available – assumed at 1% of the average transhipped volume in the period from 2017 to 2021.

[18] Under the Compact of Free Association with the United States in 1983 – https://mh.usembassy.gov/our-relationship/policy-history/

system could be better utilised by loading the vessels with tuna bycatch in Majuro for the trip over to the outer islands, providing fishermen on the islands with ample bait.

The last infrastructure improvement for Majuro, which was already touched upon in section 3.2, is potentially increasing the public wharf space available. This will minimise disruptions to purse-seine vessels (and skiffs) unloading tuna and bycatch to the local processing facilities when container ships come into port.

Papua New Guinea

PNG has the highest projected increase in urban population out of all major transhipment port countries in the region. However, urban and peri-urban areas in PNG are spread far and wide – for instance, the distance between Lae and the Mount Hagen in the Western Highlands is 453km or ~8 hours' drive. There is no road connection between the largest urban centre, Port Moresby, and the closest purse seine landing/transhipment port Lae. Travel between the two urban centres can take 3-4 days by boat. The vast distances between key ports and urban centres make it difficult to distribute tuna bycatch obtained from purse seine vessels beyond the local region. On the other hand, urban areas in PNG are more widespread compared to most other PICs in the region and there is already substantial benefit that can be realised from the potential volume of bycatch available in port cities – for instance Lae, Madang, Wewak and Kokopo (capital of East New Britain Province where Rabaul is situated) are among the top 10 most populous urban centres in PNG[19]. Moreover, there is road connection between Madang, Lae and Mt Hagen via the Highlands Highway and Ramu Highway that could see processed bycatch distributed to the populous Western and Southern Highlands Provinces.

However, the supply chains for bycatch in PNG ports are not as commercially organised as that in Noro, Solomon Islands. For large volumes of bycatch to be efficiently distributed beyond the initial port of landing, some degree of commercialisation would be required. To that end, the business environment for SMEs needs to be conducive for commercial interests – including access to cold storage (e.g., cool boxes, ice), micro-processing equipment (e.g., cookers and smokers), finance, as well as good transport networks and well-maintained roads. However, it may be worth addressing the infrastructure constraints to the tuna bycatch supply chains within port centres first before looking to improvements to support wider distribution which might generate linked benefits for other sectors.

As discussed in section 3.2, the volume of bycatch available for local consumption in the Lae, Madang and Wewak is heavily dependent on the offloading capacity of the respective wharves. The Frabelle Wharf in Lae, which handles off-loading for all four processing plants based there, is frequently subject to congestion and disruptions caused by weather (i.e., southerly/monsoonal winds). Similarly, the main wharf in Wewak can accommodate only one vessel at any one time, necessitating the local processing plant to construct its own landing craft barge to overcome the congestion problems. Extensions and upgrades to wharf areas in key processing ports are needed to not only support the processing plants in increasing their production capacity but also the volume of bycatch available for local consumption. Funding of the upgrades required would be substantial and should be coordinated with the commercial stakeholders, especially in the case of privately owned/operated wharves.

In the informal tuna bycatch supply chain, one of the biggest constraints identified by NFA officers is the lack of cold storage facilities. Of the four main transhipment ports, only Lae has an ice making facility large enough to cater to the local market. In addition, none of the markets in Lae, Madang or Wewak has any overnight facilities in which vendors could store their produce in a chilled manner. While some reject fish from purse-seine transhipments obtained from Rabaul are sold at the larger

[19] There is limited up-to-date statistics available. The observation is based on the latest census data (for 2011 – https://www.nso.gov.pg/statistics/population/) and anecdotal estimates.

market in Kokopo, there is no organised water transport system that supports the collective distribution of bycatch bartered by individual operators. As a result, the majority of bycatch is sold on the road side or at the smaller market in Rabaul. Infrastructure improvements in terms of markets themselves could also offer increased efficiency in distribution. Refer to the Bill of Quantities presented in Table 7 of this section (4.2) under Solomon Islands.

Although not strictly an infrastructure improvement, greater awareness in better fish handling is another area that needs to be considered if higher volumes of bycatch are to be supplied to the local market. At the current time, most of the bycatch and reject fish obtained from purse-seine operations are sold without appropriate handling, e.g., without ice or cooling. The fish that is cooked or dried first before being sold at the market may have slightly lower health risks, but there is also very little official guidance on shelf life of preserved or prepared fish products. Educational campaigns that provide the public with guidance on fish handling, how to identify unsafe fish for consumption, as well as promote awareness of the benefits of eating fish will be needed if tuna bycatch is to make a more substantial contribution to the protein needs of urban populations in PNG by 2050. This recommendation also has regional application.

Solomon Islands

Urban population growth in Solomon Islands is projected to increase by the highest percentage across the key purse-seine transhipment ports examined by 2050 – an increase of 111,563 persons compared to 2022 or 79%. While the urban population is concentrated in Honiara, populations in the greater Guadalcanal, Malaita (capital Auki) and Western (capital Gizo) Provinces are also considerable[20]. Under the current infrastructure available, bycatch landed in Noro can be transported to Honiara and Gizo with some level of efficiency. Nevertheless, a number of constraints remain. As is the case with private wharfs of processing facilities in PNG, the NFD compound can get quite busy. As a result, forklifts needed to pick up bycatch from cold storage tend to be prioritised for unloading operations. After the fish is sold to traders at the NFD outlet, there is then a shortage of transport that can move the 300L cool boxes packed with fish. Buyers usually wait some time before they can transport the fish to the wharf where the overnight passenger and cargo vessel to Honiara is docked. The frequency of the passenger and cargo vessel to Honiara is also a constraint, with only one vessel scheduled per week at the present time.

Given that the current system already attracts a number of costs (e.g., fish cost, storage equipment, hired casual labour, transportation, port entry cost, freight etc.), for any additional private investment to be economically viable, the returns must outweigh the investment costs. Tuna bycatch is not a high-value product, so investment strategies would need to rely on either increasing economies of scale (i.e., large volumes) or value-adding to the product itself. For instance, transport trucks fitted with lifting mechanisms/cranes would be a welcome investment in the bycatch supply chain from Noro. However, as reject fish is not an everyday cargo, investments made to the transport system or other infrastructure would need to be multi-use and cross-sectoral (e.g., can be used for agricultural and other sectors) for the returns to justify the investment. Similarly, if further processing or value-adding were to occur from tuna bycatch through an organised facility for micro-canning, drying or similar[21], the facility will again need to be shared across industries and sectors. This may include canning or drying of fruits and vegetables – such as pineapples, bananas, mangos, casava and so on. Even so, industry experts consulted did not see investments in shared micro-canning facilities as becoming a commercially viable venture because canned tuna is already available to the public at a low cost (i.e., dark meat tuna) and any micro-canning processing is only

[20] Based on population projections from the Solomon Islands National Statistics Office – available at https://www.statistics.gov.sb/statistics/social-statistics/population

[21] An organised facility for individuals or SMEs to bring produce for additional preservation or processing is seen as necessary due to the risks associated with poorly home canned or jarred products, which, in the case of botulism, can cause death – MRAG Asia Pacific (2022).

likely to work for artisanal-caught fish as it would command a higher price. Instead, investments would be better directed to basic and low-cost facilities, such as a sheltered and concreted packing area with access to water for fish cleaning.

In Honiara, where the majority of the tuna bycatch landed from purse-seine operations is sold in Solomon Islands, infrastructure upgrades have been previously looked into by FFA. Table 7 below summarises the bill of quantities (BOQ) for a generic 1,500 m^2 produce market with boat access. It should be noted that BOQ does not include measures for cold room installation and market fit-out (including benches or precast tables to display the produce sold).

Table 7: Bill of quantities for construction of a simple fish market with a base area of 1,500m^2 (i.e. 50m x 30m)[†]

Description	Unit	Measure
(a) Excavation, earth works, to construct a wharf frontage for longboats to offload catch.		
*Based on a 30 m frontage and 4 fingers for the boats	1	Item
(b) Foundation and flooring;		
* Foundation and flooring (incl. beams etc. at 10m)	430	m
* Slab area incl. concrete slab	1,500	m^2
(c) Structural metal works, roof and roofing structure; painting and finishing;		
* Columns allowance	1,500	m^2
* Roof framing and sheet (i.e. floor area + 10%)	1,650	m^2
* Roof – rainwater gutters and downpipes + drainage to tanks	192	m
* Roof – cappings and flashings	200	m
* Tanks for water collection for bathrooms and hose-outs	4	No.
* Pump and associated works	1	Item
(d) Sanitary facilities and toilets;		
* Mains connections / fees and associated costs	1	Item
* Bathrooms	90	m^2
* Sanitary plumbing & drainage to 100m^2 spaces	12	No.
(e) Electrical installation;		
* Mains connections / fees and associated costs	1	Item
* Bathrooms	90	m^2
* Open areas	1,410	m^2
* External lighting to perimeter	160	m
* Mechanical extraction to main roof	1	Item
* Mechanical extraction to toilets	1	Item
(f) Floor, wall and ceiling finishes and painting;		
* Bathrooms	90	m^2
* Covered areas with ceilings (enclosed rooms for icemakers etc.)	90	m^2
* Floor finishes to balance of slab (epoxy)	1,320	m^2

Description	Unit	Measure
(g) Water, drainage and sewage works;		
* General allowance to bathrooms and showers (2 x 45m^2)	90	m^2
* General Allowance to enclosed rooms	90	m^2
* Sub surface catchment for hose-out with arrestor	750	m^2
* Arrestor for all fish waste and product	1	Item
(h) Fencing.		
* Allowance for fencing (70 x 50) – 10m around structure	240	m
* Allowance for gates and entry statement / access	1	Item

† The bill of quantities (BOQ) is for a generic 1,500m^2 land-based market and does not consider any major over-water infrastructure, such as a pontoon wharf which could include additional work, i.e., piling, land reclamation and some form of breakwater to protect from storm impacts, etc. Moreover, no measure of cold rooms or market fit-out with precast display tables were included in the BOQ. Costs were redacted due to large changes in material costs since the document was produced in early 2019, prior to COVID and supply chain shocks. Source: pers. communication with FFA.

In 2019, when the BOQ was estimated, there were three or more fresh produce markets already in operation in Honiara (not necessarily all to 1,500m^2) that supported the distribution of tuna bycatch in the urban centre – the Central Market, Kukum Market, White River Market and roadside fish stalls set up in between, including the small fish market across from Panatina. Under the projected population in 2050, the number of produce markets needed could extend to five or six[22].

The other key urban areas in Solomon Islands are Auki in the Malaita Province and Gizo in the Western Province. While some of the tuna bycatch in Noro makes its way to Gizo, there is little transportation of fish from purse-seine vessels to Auki. That being said, work is underway to prepare for the construction of a second tuna processing plant at Bina Harbour in Malaita that could provide a supply of reject fish for local consumption in the Province. Similar infrastructure arrangements to that in Noro and Honiara are likely to be needed to facilitate an efficient distribution chain for the fish.

Tuvalu

The demand for frozen fish from transhipment is more limited in Tuvalu than other transhipment hubs in the region given the smaller population size and the fact that reject brine frozen fish from purse-seine operations is not locally popular for cooked fish dishes. Nevertheless, there is an opportunity to supply to the hospital (notwithstanding the preference for other fish types) as well as the Government-run passenger vessels – which supplies a lot of meals to passengers which currently do not include fish. The distribution of tuna bycatch to these institutions could be managed through NAFICOT, with infrastructure improvements including increased cold storage and an efficient logistics chain to cater for the required volumes to meet the orders from the public institutions, needed.

For the smoked and dried fish market, much of the product purchased by Tuvaluans is actually taken overseas and gifted to families and friends living abroad. These products are produced from artisanal catch at the current time so it's difficult to assess whether brine frozen fish would achieve the same quality and taste that would meet the needs of the specific market – i.e. gifting family and friends. For this market, processing and packaging quality is also potentially an area that requires improvement as new airline baggage restrictions as well as overseas biosecurity regulations is making it more difficult to take smoked or dried food products out of Tuvalu.

[22] Based on a linear extrapolation of 1 large produce market to ~30,000 people and a uniform population growth of 79% (refer to Table 6).

There are plans to formalise the bycatch supply chain with organised collection by the two TFP vessels for delivery to NAFICOT where the fish will be processed before sale[23] (section 3.2). This would require increased cold storage and additional processing staff compared to that available at present, and the question on the level of demand still remains. As NAFICOT is positioned to handle all bycatch collected from transhipping purse seiners, the increase in cold storage capacity could be used in both supplying frozen/cooked products to public institutions mentioned above as well as storing raw materials for processing. If NAFICOT is able to improve its production processes to meet export requirements (i.e., through designation as a Competent Authority), there may be opportunities to distribute tuna bycatch products to the greater Pacific region.

Interests have also been expressed by the TFD and stakeholders in creating opportunities for SMEs to use the relatively large volumes of bycatch now available in Funafuti to produce pig and chicken feed as well as fertilisers. Given the high pH and alkalinity levels affecting soil condition in Tuvalu, the availability and application of fertilisers may help boost agricultural production and food security indirectly.

4.3 Future fishing hubs and possible arrangements for delivering bycatch

Consistent with previous studies by McCoy (2012) and MRAG Asia Pacific (2019), consultations with industry stakeholders indicated the biggest driver behind the choice of transhipment port is proximity to fishing location, pre- and post-transhipment. All other things being equal (which they are not always[24]), vessels will tranship at the closest possible transhipment port to maximise fishing time and minimise travel costs. Therefore, the concentration of purse-seine transhipment (i.e., hubs) in the future will likely to be a reflection of projected fish movements under climate conditions.

Four pathway scenarios under greenhouse gas (GHG) emissions and atmospheric concentrations, air pollutant emissions and land-use were originally set out by the Intergovernmental Panel on Climate Change (IPCC) in their Fifth Assessment Report (AR5). They include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0), and the 'business as usual' scenario with high GHG emissions (RCP8.5). More recently, the IPCC released their Sixth Assessment Report (AR6) in March 2023, which updated and expanded the pathway scenarios to cover five Shared Socio-economic Pathways (SSPs) based on peer-reviewed scientific, technical, and socio-economic literature since the publication of AR5 in 2014 (IPCC, 2023).

[23] To minimise potential impacts to artisanal fishers, the plan for formalising the bycatch supply chain is focused only the sale of processed products.

[24] Other important features of a 'good' transhipment port indicated by industry include vessel safety (i.e. from weather and rough seas), administrative efficiency, ease of compliance, accessibility in terms of flights for crew changes, availability of supplies and infrastructure as well as entertainment services and amenities.

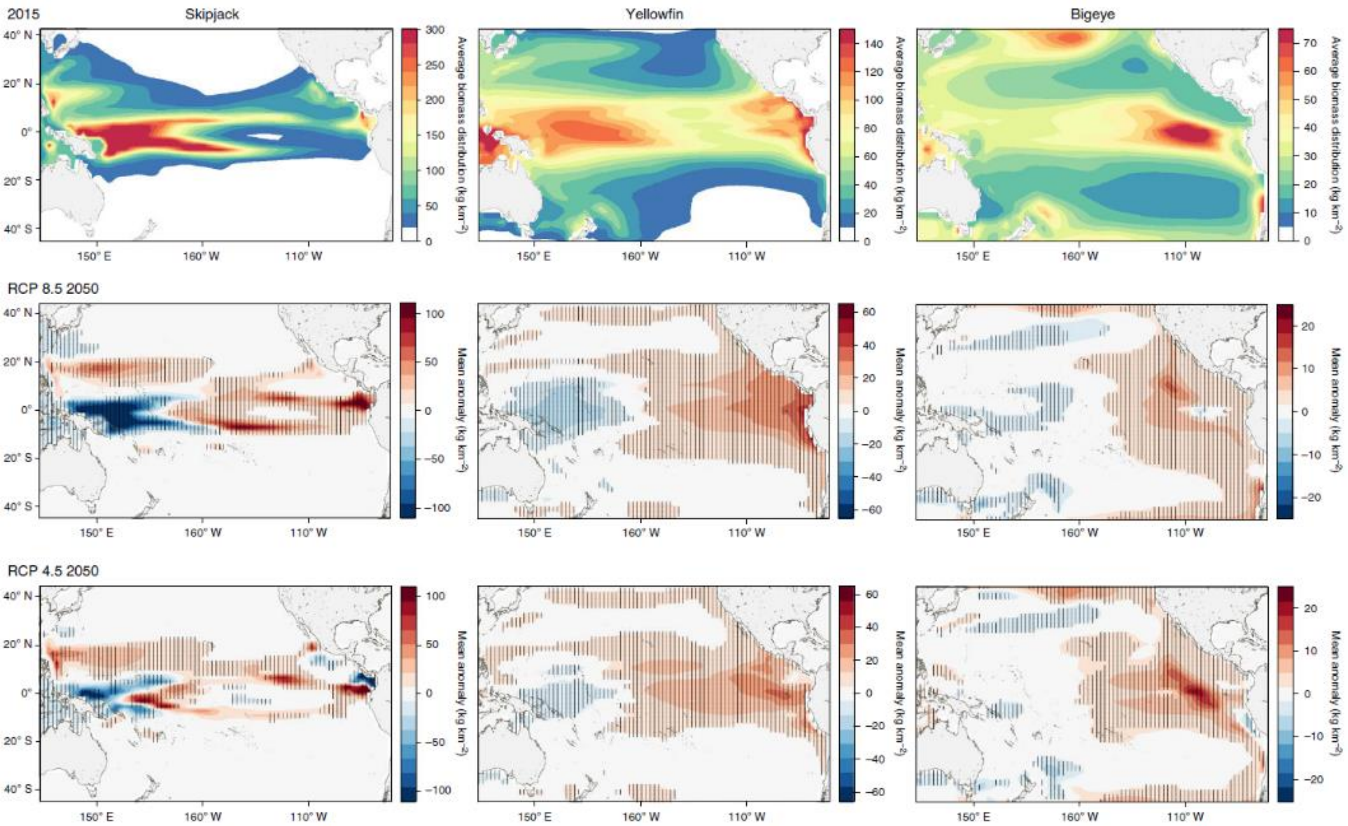

Figure 13: Projected effects of climate change on the distributions of the three tuna species caught by purse-seine fishing in the Pacific Ocean. Source: Bell et al. (2021)
Average biomass distributions (kg km–2) of skipjack, yellowfin and bigeye tuna in the Pacific Ocean basin for 2015 (2011–2020) (top row) and mean anomalies (kg km–2) from the average 2015 biomass distribution of each tuna species projected to occur by 2050 (2044–2053) under two emissions scenarios, RCP 8.5 (middle row) and RCP 4.5 (bottom row).

However, the latest research on responses of tuna biomass in the WCPO to climate pathways is still based on the original RCP 8.5 and RCP 4.5 emission, modelled by Bell et al. (2021) for 2050. While the new SSPs cover a broader range of greenhouse gas and air pollutant futures compared to the RCPs, and therefore are not identical to the RCPs referenced in AR5, they are somewhat similar (IPCC, 2023). Noting that the overall effective radiative forcing tends to be slightly higher for SSPs compared to RCPs. In the absence of literature on tuna responses in the WPCO at present, the information contained in this section is based on the research outputs referencing RCPs. Figure 13 shows the projected effects of climate change on the distributions of the three tuna species caught by the purse-seine fishery in 2050. The shifts in biomass for these species translate to considerable reductions in the average volume of purse-seine catch for PNG, Solomon Islands and the Gilbert Islands of Kiribati under RCP 8.5 (Bell et al. 2021)[25]. The only EEZ expected to experience an increase in catch is the Line Islands of Kiribati – mostly skipjack. Under the mitigation scenario RCP 4.5, catches of the three tuna species for the purse-seine fishery are still projected to decline in PNG and Solomon Islands, albeit less than under the business as usual scenario (Bell et al. 2021)[26]. In contrast, the Gilbert Islands of Kiribati is projected to have an increase in skipjack catch with the Line Islands performing less well under RCP4.5 compared to RCP8.5.

On the basis of biomass shifts and catch volumes projected, the most likely transhipment hubs for purse-seine fishing in 2050 will remain those located in FSM, Kiribati, PNG, Solomon Islands and

[25] Projected average changes in catches of skipjack, yellowfin and bigeye tuna under RCP 8.5 can be found in Supplementary Table 11a of Bell et al. (2021).
[26] Projected average changes in catches of skipjack, yellowfin and bigeye tuna under RCP 4.5 can be found in Supplementary Table 13a of Bell et al. (2021).

Tuvalu. This is because despite declines in catch projections under RCP4.5 and RCP8.5, these EEZs still account for the highest catches. In addition, it is projected that catches of EPO-C and EPO-N [27] will increase considerably under both RCP4.5 and RCP8.5 pathways, which could see more purse-seine catch transhipped through eastern PIC ports in the WCPO or otherwise, elsewhere.

The other key consideration for future purse-seine transhipment hubs is the physical characteristics of the port. For instance, despite the considerable catch projected in the EEZ of Nauru in 2050 – which declines under RCP8.5 but increased under RCP4.5 – it has not been considered a likely transhipment hub owning to limited access to a safe location for transhipping. The lack of a lagoon or sheltered area for transhipment means that vessels would be subjected to tranship on open waters unless they are able to secure suitable wharf space. Construction of the new wharf commenced in September 2022. Under the current design, the quay face for the wharf has a length of only 158 m – which would limit the number of purse-seiners unloading to a maximum of two if no container vessel requires use of the wharf. In addition, there will need to be sufficient economies of scale for the shipment of containerised tuna by reefer vessels to their final destinations for such transhipping operations to be financially viable. The limited number of purse-seine vessels that can use the wharf could be a problem in this regard. At this time, containerisation is not the preferred method of tuna shipment in countries with greater capacity.

In terms of physical characteristics of ports, elevation of the land is another important factor. A number of the purse-seine transhipment hub countries at present are atoll countries with low lying land. The global mean rise in sea level is projected to be anywhere between 0.15m to 0.29m by 2050 under (Figure 14, IPCC 2023). For port cities like Majuro (average 3 m above sea level) and Tarawa (average 3.05 m above sea level), the projected rise constitutes a considerable percentage of the current elevation. This may impact the facilities, goods and services available onshore that influences the attractiveness of the port for transhipping (e.g., space for net-repair yards, entertainment facilities, and growing vegetables and fruits that are often used to barter or re-stock fishing vessels). With that said, although preferred, most services and facilities are secondary to the port location/proximity to fishing grounds and the safety offered to vessels by sheltered lagoons.

[27] EPO-C: Area east of Americas, as far as 150°W, bound by 10°N and 20°S and EPO-N: Area east of Americas, as far as 150°W, above EPO-C and below 40°N.

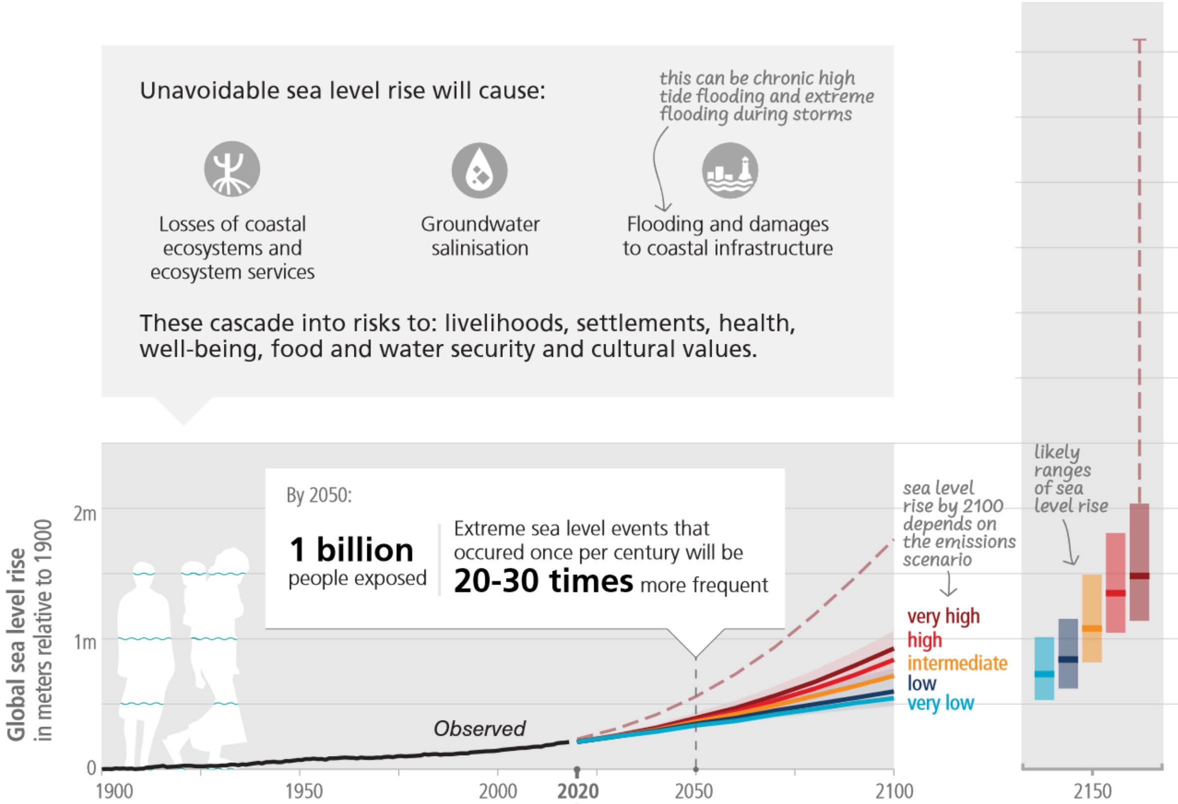

Figure 14: Projected sea-level rise in accordance with 5 SSPs set out by the IPCC. Source: IPCC (2023), Figure 3.4.

All things considered, the future transhipment hubs for tuna purse-seine operations will likely be similar to that in Table 1, with increased activities expected in the eastern WCPO ports under projected changes in fishing conditions. In addition, if the planned processing facility at Bina Harbour, Solomon Islands, is to be constructed and operate as envisioned, a considerable volume of tuna and bycatch can be expected to be landed at the Malaita port. Despite the likelihood of ports in PNG and Solomon Islands remaining key transhipment hubs in the region, an undersupply of tuna bycatch to the urban areas as outline in Table 5 and Table 6, remains likely. This is also the case for catch and transhipment projections under RCP 4.5.

The mismatch between supply and demand for tuna bycatch in the two populous Melanesian countries will come irrespective of any internal movements of fish (e.g., from Noro to Gizo and Honiara, or from Lae/Madang to the Western Highlands in PNG). Industry and industry experts consulted indicated that transferring frozen bycatch between transhipment hubs to meet demand (e.g., from Pohnpei to ports in PNG or Funafuti to ports in Solomon Islands) was not likely to be practical, or economically viable, given the low value of the product. As discussed in section 3.2, with the exception of NFD boats who are required to retain all bycatch caught according to company policy, most purse-seine vessels fishing in the WCPO operate by the minimum requirements set out in CMM 2021-01 with 'bycatch' retained constituting predominantly small or reject tunas. Prior to the adoption of the WCPFC catch retention requirement for target species, most undersized fish were discarded to prioritise space for the portion of the catch with higher value. This example shows that without appropriate economic incentives or specific legal requirements to retain bycatch, fishing or carrier vessels will not willingly deliver bycatch or reject fish to specific urban centres across the Pacific where there is a need for more bycatch.

The idea of transporting processed bycatch or reject fish from a transhipment hub in one country to urban centres in another also did not receive support from industry and industry experts, on similar economic grounds. Namely that, if it was profitable to do so, then it would already be done by industrial processors, whereas this only occurs at the current time to a very limited degree. Instead, it was suggested for transhipment hub countries to better focus on maximising returns from transhipment activities (i.e., with fees charged according to volume transhipped) and utilising the returns to invest in increasing food security/resilience to climate change.

What is possible or could be improved is the efficiency with which bycatch enters the local market in transhipment hub countries. There are several areas of improvement to the bycatch supply chain that were repeatedly highlighted during industry stakeholder consultation across all ports included in this appraisal. They included:

1) The need for an efficient system for collection of bycatch (including large, reliable collection vessels) because bycatch is not financially rewarding for most purse-seine operators. As such, it would be unlikely for vessel operators to dedicate crew or time to gather and deliver reject fish to shore. A practical arrangement would be for governments or local businesses (e.g., fishing associations, shipping agents, etc.) to coordinate the collection of bycatch during transhipment operations. Efficient collection of fish will also reduce the time reject fish spend on the boat deck, maintaining the cold chain and minimising health risks.
2) Providing a good transport system for entrepreneurs or SMEs to move the fish. This can include improving the frequency of cargo ferries, or improving roads and road networks, between ports and urban areas, as well as supporting access to finance for private investments in transport vehicles, e.g., trucks and cranes (see point 4).
3) Investing in safe and clean facilities at ports or markets to prepare, sell or store the fish. Concreted areas with access to fresh water and waste disposal at ports and markets would make a considerable difference to local entrepreneurs engaged in the fisheries sector (including participants in the bycatch supply chain), as well as to other sectors such as agriculture. While the provision of blast freezers may not be financially feasible, access to affordable ice and a cool place to store fish overnight would improve the cold chain for a number of produce markets in urban centres.
4) Supporting business investments along the bycatch supply chain. Privatisation and liberalisation are commonly accepted in economics as means of achieving efficient markets – thanks to competition generated by businesses seeking to capture more profit and market share, which results in reduced costs to consumers and better service. Similar views were shared by industry and industry experts consulted. This is not to say there is no role for governments – reform of regulations and financial instruments (e.g., taxes) can have important impacts on decisions made by small business holders. Improving access to finance and strengthening financial literacy, as well as reducing tax burdens to SMEs, can foster greater private investment and growth in the tuna bycatch industry. The latter can stimulate higher economies of scale, further reducing the price of fish and increasing consumer surplus (i.e., benefits to consumers). While private investments are important for the sector, they cannot replace public investments in shared facilities and infrastructure discussed in point 4.

Based on the above, ideal arrangements to delivering bycatch could involve local SMEs or associations gaining official access to transhipping vessels under government arrangements with suitable local collection boats. In a business-conducive environment with good access to finance, the SMEs and participants in the bycatch supply chain could justify investments in collection boats and road transport trucks for the distribution of fish to the market or other retailers, including food shop owners and small processors involved in simple preservation techniques such as drying or smoking. Provided economic returns for products that undergo simple processing justify it, distribution to other peri-urban and other urban centres connected by well-maintained roads could see contributions to food and nutrition security from bycatch products increased. Additional preservation or processing will also help to differentiate the product from fresh fish sold by artisanal fishers in PICs.

4.4 Benefits and costs of future arrangements for delivering bycatch

Any benefits derived from future arrangements in delivering bycatch would be dependent on the gap in supply and demand of all fisheries products to urban populations. In countries where other seafood alternatives are available, limited or negative population growth and consumer preferences against brine-frozen fish in countries – such as FSM, Marshall Islands and Tuvalu, the benefits from improving arrangements for delivering bycatch in terms of food security are likely to be negligible. That is not to say there will not be any benefits as reject fish from purse-seine transhipments could bring additional income security to the locals in urban areas from processing bycatch into fish meal, animal feed or other products. For countries where there is demand for tuna bycatch from purse-seine operations, improvements in the supply and cold chain can help increase both food and nutrition security to the populations in urban and peri-urban areas.

Table 8: Estimated additional number of people able to benefit from improved arrangements for delivering bycatch in 2050

Country	Estimated population in urban and peri-urban areas ('000)*		Estimated volume of tuna bycatch currently entering the local market		Estimated additional number of people able to benefit from improved delivery of bycatch in 2050 ('000)	
	2022	2050	MT/year	As a % of recommended protein needed from fish in 2022	With potential bycatch available	With bycatch meeting protein requirements
FSM	23	22	135	9%	0	0
Kiribati	65	96	386	9%	35	90
Marshall Isl.	40	39	77	3%	0	0
PNG	1,211	1,962	2,739	4%	-13	1,910
Solomon Isl.	141	253	1,036	14%	-10	233
Tuvalu	7	7	4.4	1%	0	0
Total	**1,992**	**2,910**	**4,377**	**6%**	**12**	**2,233**

Table 8 presents an estimate for the additional number of people that would benefit from improved delivery of bycatch arrangements in 2050 in relation to food security. For countries with limited demand for brine-frozen fish (i.e. FSM, Marshall Islands and Tuvalu), the proportion of urban residents expected to benefit from increased supply of bycatch is capped at the ratio of reject fish entering the market at present to the current population. For instance, if the current volume of bycatch entering the market constitutes only 3% of the recommended protein intake, or only 3% of the urban population is making use of the bycatch available as a result of personal preference – then it is assumed that even if more bycatch becomes available, only 3% of the urban population will utilise the bycatch available. This is a reasonable assumption especially in cases where there are no constraints (i.e. regulations) against obtaining bycatch.

For countries where there is a demand for brine-frozen fish from purse-seine operations, the additional number of people expected to benefit from improved arrangements for delivering bycatch is estimated to be the difference between the percentage of the urban population that is already consuming the recommended amount of protein from bycatch and the total population in urban areas in 2050. However, for Kiribati, Solomon Islands and PNG where the bycatch available from transhipment (estimated at 1% of the projected transhipment volume) is expected to be less than the volume needed to meet the recommended protein intake from fish, the additional number of people to benefit from improved delivery arrangements is split into two scenarios (Table 5, Table 6 and Table 8). The first is based on the potential volume of bycatch available from transhipment (i.e. 1% of total transhipped volume) and the second, if bycatch available from purse-seine transhipments could meet the all the recommended protein requirements from fish – for example, through bilateral agreements with fishing companies or countries.

The results presented in Table 8 suggests a no major change in the number of people benefiting from increased availability of tuna bycatch for FSM, Marshall Islands and Tuvalu, owing to the lack of demand for brined tuna. This rests on the argument that despite the fact that the volumes of tuna bycatch available from transhipment to these three island states are almost, if not completely sufficient, to cover all protein needs from fish for the local populations in 2022, only around 5% of protein consumed is from the bycatch available. Elsewhere, increased access to reject fish from purse-seine transhipment could be expected to benefit an additional 12,034 people. For PNG, if the amount of tuna bycatch falls from the current 5-year average of 2,739MT to 2,074MT then 13,388 people could be worse off compared to the present situation in terms of accessing purse-seine caught bycatch. However, if the attractiveness of PNG ports for purse-seine transhipments is improved, or the number of tuna processing plants in PNG increased (and in turn the volume of tuna bycatch landed increased), then more than 1.9 million additional people could potentially benefit from access to greater volumes of bycatch.

Aside from the benefits derived from improving food security, an efficient bycatch delivery arrangement could offer employment and income opportunities to entrepreneurs and SMEs throughout the whole supply chain. This includes collection boat operators, casual or full-time stevedores, truck owners and drivers, retail/market stall operators, people earning an income from preparing, cooking, drying and/or smoking fish. As many of the actors involved in the supply chain are women, increased income security can generate other flow-on benefits. For example, Gibson et al. (2020) also showed that women with greater control of income are more likely to spend money on food and nutritional needs of the family. Similarly, other studies have found that money earned by women in the Pacific is more likely to be spent on food and school fees for the children although the linkage between financial independence and domestic violence is less clear (Do No Harm series by Eves et al. 2018).

For countries without high demand for reject fish from purse-seine transhipments, bycatch could still be utilised to improve farming and aquaculture (i.e., use to produce animal feed), and agriculture (i.e., fertiliser). These sectors offer alternative sources of protein for a healthy diet for populations in urban and peri-urban areas.

Improving arrangements for delivering bycatch is not something that can be achieved without cost. As underscored during consultations with industry stakeholders, for the supply chain to be as efficient as possible supply chain initiatives should be market driven. Therefore, the cost for better bycatch delivery arrangements would need to come from both the public (i.e., government) and private sectors. For the private sector, costs needed to improve the supply chain will likely be investment related, for the purchase of capital and equipment – such as collection boats, delivery trucks, 300L cool boxes, ice making machines and so on (depending on the size of the SME). In some instances, governments could have a role in supporting major capital investment by SMEs as many have done in the past. For example, a number of Pacific Island governments have trialled some form of capital support scheme offering artisanal fishers opportunities to purchase boats on credit or at a subsidised price (MRAG Asia Pacific 2022).

Nevertheless, the key cost area from a government perspective in improving future arrangements for delivering bycatch should be focused on providing an environment conducive to doing business. This could include providing the right infrastructure and facilities to support the supply/cold chain for tuna bycatch from transhipment activities (e.g., wharf upgrades, safe and clean market to sell fish, concreted areas to clean and prepare fish, well maintained roads to transport fish, etc.) through to improving access to finance. The latter may be done through grants, free education on financial literacy and regulations that reduces the burden on small business holders to apply for loans, all of which can go a long way in supporting local SMEs and entrepreneurs.

In certain cases, hidden costs such as forgone income or opportunity costs, may need to be considered. For example, concessions provided to processing plants or locally-flagged or based vessels to operate out of the country and land tuna (incl. bycatch) at domestic ports/plants. While arrangements such as these are unlikely to be implemented for the purpose of increasing the accessibility to bycatch alone, it is important to assess the benefits and costs in negotiations with plant or vessel operators. As highlighted during the consultations with industry experts, it may be more beneficial to focus on maximising revenue from transhipments in port and utilising that revenue to improve food security.

From the perspective of the commercial fishing industry, additional compliance measures (e.g., bycatch landing mandates) are usually seen as deterrents to operate within an EEZ because they are at additional cost to companies with little to no benefits. For tuna and bycatch landing to be attractive to industry, there must be value in doing so. This could be in the form of higher demand (and price) received for bycatch or reducing the price gap for higher-quality tuna transhipped to overseas canneries. Whether governments could support education campaigns aimed at boosting demand for tuna products or have the necessary funds to subsidise tuna consumption from transhipment revenue would be case and situation specific.

5 Summary and recommendations

With the exception of Tarawa and Noro, the nature of existing supply chains delivering tuna bycatch to urban centres for the major purse-seine transhipment ports around the Pacific are mostly informal. Very little coordination occurs in the collection, sale and/or distribution of bycatch beyond the individual level. The biggest drawback of an informal bycatch market is that small actors in the supply chain cannot make the same gains from economies of scale as more commercially organised traders, and the limited returns they achieve from selling the fish are often insufficient to justify additional investments needed to improve their operating efficiency.

That is not to say that coordinated supply chains don't come without their challenges. A lack of large, reliable collection boats is a common constraint in collecting unwanted fish from transhipping vessels, even in the case of Kiribati's government owned enterprise CPPL. Consultations with industry members highlighted that the lack of adequate collection vessels to offload reject fish from transhipping vessels in a timely manner compromises the cold chain. This can pose potential health risks given reject fish can be left lying in the sun on the deck for extended periods before being bartered or given away.

For bycatch unloaded from purse-seine vessels to processing facilities onshore, the most frequently cited constraint is the capacity of the commercial operators to distribute unwanted fish to buyers outside the compound. Bycatch is not the main source of income for vessel owners or processing facilities, and as such is not prioritised when it comes to use of space or machinery, e.g., forklifts. In the case of Noro, despite individual bycatch traders being commercially more organised than at other ports, the level of private investment still fails to facilitate efficient delivery of bycatch to urban markets. The bottlenecks in this case come from an undersupply of trucks with lifting mechanisms to transport the packed fish to the wharf for shipment, and the infrequency of sea transport to the main markets.

Synthesising the key barriers and lessons learned for the tuna bycatch supply chain in the Pacific, the following recommendations are expected to improve the efficiency in delivering bycatch to urban centres in the future (refer to section 4.3 for more detail):

1) Providing an efficient system for fish collection (including large reliable collection vessels). This could be a service that is either provided by the fisheries administration if there is capacity, or promoted through private investment – see point 4.
2) Providing a good transport system to support the distribution/movement of fish. For example, improving roads and road networks, increasing frequency of over water transport or supporting access to finance for private investments in transport vehicles.

3) Investing in safe and clean facilities at ports or markets to prepare, sell or store the fish, such as concreted areas with access to fresh water and waste disposal and cool places to store fish overnight.
4) Supporting business investments along the bycatch supply chain, in the form of improving financial literacy and access to finance (which can include capital support programs); providing practical training in post-harvest preservation and/or byproduct production (e.g., animal feed, fertilisers); as well as reducing tax burdens for SMEs.

The key message from industry and industry experts interviewed is that it's not the most efficient use of government resources to dictate the market. Bycatch is not a product that has a lot of value or value potential (i.e., through processing or distribution to other markets). If there is value or demand for the product, some level of commercialisation or privatisation would already be happening. Rather than focusing resources on directly intervening in the delivery or utilisation of bycatch from purse-seine transhipment, more benefits (and flow-on benefits) could be generated if the environment to do business is improved for individuals, SMEs and commercial fishing companies alike. That being said, the environment to do business for SMEs can be compromised by volatility and infrequency in access to tuna and bycatch associated with fluctuating ENSO conditions. Whilst operating cold storages for the purpose of storing bycatch is not economically attractive, other government policies could offer opportunities to reduce supply volatility. For instance, governments could require a minimum frequency of transhipments by vessels that fish regularly inside its EEZs; create value in fish landing through educational campaigns that aim to boost demand for (higher-quality) tuna; and/or invest in post-harvest facilities that can be used across sectors to help even-out seasonal availability of fish and other agricultural products.

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Annex 1: Terms of Reference

GCF Study 5: Description of existing and future needs and conditions for distributing bycatch to urban and peri-urban areas

A. Objectives

Although the majority of the population in many of the participating countries lives in rural areas, data from SPC's Statistics for Development Division (SDD) show that the rate of population growth in urban areas is greater than in rural areas. Strengthening National FAD Programmes is expected to make only limited contributions to the supply of tuna and other oceanic fish species (hereafter grouped as 'tuna') to urban centres. In many of the participating countries, tuna bycatch (undersized/damaged tuna and other species, such as rainbow runner, mahi mahi and triggerfish) from industrial fishing fleets will need to provide the majority of fish protein required for good nutrition of these rapidly-growing urban populations.

The purpose of this study is to identify the nature of present-day and future supply chains for delivery of tuna bycatch to urban centres in all participating countries where the catch from small-scale tuna fisheries will not meet demand as described in GCF Study 2. This information will be used to establish the baseline for two of the food security activities in the Funding Proposal. These activities are described briefly in the Concept Note under Activity A2 (Develop pathways to minimise climate-driven disruptions to the supply of tuna and bycatch for the food security of urban communities from industrial fishing fleets) and Activity A3 (Improve the market and supply-chain facilities needed to encourage participation of small and medium enterprises in distribution of tuna from transhipping operations to urban communities). This study will also inform the framing of these two food security activities during development of the Funding Proposal.

The specific tasks to be done during this study are described below. Some of these tasks will be done in consultation with FFA.

1) Identify the main ports where transhipping of purse-seine catches occurs in the region, and summarise the average annual level of transhipping (in terms of purse-seine vessels involved and total tonnes of fish transhipped) in each of the ports in the past 10 years.
2) Estimate the average quantities (tonnes) of tuna bycatch (undersized/damaged tuna and other species, such as rainbow runner, mahi mahi and triggerfish) that come ashore each year for local consumption at each port.
3) Summarise available information on the existing conditions for sale of offloaded tuna bycatch in each transhipping port, including market infrastructure and the nature of small-medium enterprises (SME) distributing tuna to urban and peri-urban areas.
4) Estimate the amount of tuna bycatch (and additional tuna if necessary) that will be needed to provide the protein requirements for the urban populations where transhipping currently occurs in 2030 and 2050, based on: the advice from SPC's Public Health Division that fish should provide 50% of recommended protein consumption of 0.7 g per kg of body weight per day; the future predicted sizes of the urban populations in 2030 and 2050; and average body weight (where available from SPC SSD). (Note that this information will be informed by the broader analysis to be done under GCF Study 2.
5) Specify the nature and scale of improvements to market infrastructure and supply chains in general terms that will be needed to efficiently handle the necessary quantities of tuna bycatch (or higher-quality tuna if there is insufficient bycatch) for good nutrition of the urban populations by 2030 and 2050, noting that FFA will undertake an in-depth analysis of market infrastructure and supply chain needs for Honiara under the TOR for another study under PPF Activity 1, entitled 'Improving market infrastructure for sale of tuna bycatch'.

6) Identify the most likely future hubs for industrial tuna fishing and cost-effective ways of delivering tuna bycatch/tuna from these hubs to urban centres as the frequency of transhipping at ports in the west declines due to progressive climate-driven redistribution of tuna.
7) Summarise available information on landings from longline fisheries, and the potential for bycatch discards to contribute to local fish supply, for each participating country.
8) Estimate the number of people that could benefit from improved arrangements for using bycatch from industrial tuna fishing for domestic food security.

B. Outputs/Deliverables

The main output from this study will be a report that:

1) Documents where transhipping of purse-seine catches occurs in the region, and the average level of transhipping in each of the ports in the past 10 years. This information should also be summarized on a map of the region.
2) Summarises estimates of the average quantities (tonnes) of bycatch from transhipping operations that come ashore each year in participating countries for local consumption, summarized in a table with comments on the reliability of the estimates.
3) Describes the conditions for sale of offloaded tuna bycatch in each transhipping port, including market infrastructure and the nature of SME distributing tuna to urban and peri-urban areas. This description should provide a suitable baseline against which the impact of the GCF investment can be measured.
4) Estimates the amount of bycatch/tuna that will be needed to provide 50% of the protein requirements for the urban populations where transhipping occurs in 2030 and 2050. This information should be summarized in a table which also includes the inputs described under task (ii) above.
5) Describes the general nature and scale of improvements to market infrastructure and supply chains needed to handle the necessary quantities of bycatch/tuna for good nutrition of urban populations in 2030 and 2050.
6) Identifies the most likely future hubs for industrial tuna fishing, practical arrangement for delivering tuna bycatch/tuna to urban centres, and the risks that climate-driven redistribution of tuna is likely to impose on the capacity to implement these arrangements.
7) Summarises available information on longline caught bycatch discards and landings by Pacific Island port/facility/harbour.
8) Estimates the number of people that could benefit from improved arrangements for using bycatch from industrial tuna fishing for domestic food security.

The report must be a stand-alone document that describes the findings from this study in detail, with an appropriate Executive Summary.

C. Indicative Timeframe

Within 9 months from commencement of contract.

Annex 2: Stakeholders who participated in the study

Table 9: List of stakeholders that participated in the study

Name	Position	Organisation	Country	Sector
Mr Gerry Katai	Fisheries Manager	NFA	PNG	Fisheries Administration
Mr Benthly Sabub	Fisheries Manager	NFA	PNG	Fisheries Administration
Ms Berry Muller	Deputy Director for Oceanic	MIMRA	RMI	Fisheries Administration
Mr Beau Bigler	Chief Fisheries Officer (Oceanic)	MIMRA	RMI	Fisheries Administration
Ms Angie Tretnoff	Senior Fisheries Economist	NORMA	FSM	Fisheries Administration
Mr Michael Batty	Fisheries Adviser	TFD	Tuvalu	Fisheries Administration
Mr Tala Simeti	Fisheries Economist	TFD	Tuvalu	Fisheries Administration
Ms Jan Oli Pitu	CFO - Offshore Fisheries	MFMR	Solomon Isl.	Fisheries Administration
Mr Tony Sullivan	Development Advisor	FFA	Solomon Isl.	Regional secretariat
Dr Peter Williams	Principal Fisheries Scientist	SPC	New Calendonia	Regional secretariat
Emmanuel Schneiter	Regional Fisheries Data Manager	SPC	New Calendonia	Regional secretariat
Dr Michael Sharp	Manager Statistical Collections	SPC	New Calendonia	Regional secretariat
Mr Phil Roberts	Managing Director	TriMarine	Singapore	Industry
Mr Fong Lee	Project Manager	FCF	PNG	Industry
Various participants	Representatives from purse seine fishing companies	KFAT	Korea	Industry
Mr Anare Raiwalui	Executive Officer	FFIA	Fiji	Industry
Mr XueJun Du	Managing Director	Golden Ocean	Fiji	Industry
Ms Radika Kumar	General Manager	Solander	Fiji	Industry
Taamwaa Batoromaio	Ag Marketing Manager	CPPL	Kiribati	Industry
Ms Cynthia Wickham	Ex-NFD Manager	Freelance	Solomon Isl.	Technical expert
Mr Francisco Blaha	Independent Fisheries Adviser	Freelance	Pacific wide	Technical expert
Mr Maurice Brownjohn	Ex-PNAO Commercial Manager	Freelance	RMI	Technical expert

Annex 3: Supplementary data on transhipment and landing

Annual breakdown of data on the volume transhipped or landed is provided in the tables below. Calculations are based on SPC data on port of return, which is used to assume transhipment or landing from purse seine and longline activities.

Data for PNG ports for the period from 2018 to 2021 was sourced from NFA directly, because SPC data is incomplete for the period and NFA data collection for landing had been ramped up under the Rebate Scheme for fish landed and processed into PNG canneries.

Table 10: Volume of purse seine landing and transhipments (in MT) in the Pacific by key ports, for the period from 2012 to 2021, based on SPC and NFA data.

Port	Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Pohnpei	FSM	170,158	256,052	120,697	65,891	144,141	171,148	274,712	152,904	144,115	78,154
Kosrae	FSM	0	0	0	0	2,449	3,999	10,833	12,323	38,346	76,829
Kiritimati	Kiribati	29,182	37,078	45,024	175,369	13,974	12,651	44,255	105,390	39,323	2,475
Tarawa	Kiribati	147,220	98,041	244,501	73,550	114,415	131,986	166,751	387,070	270,510	330,638
Lae	PNG	18,690	10,726	15,841	15,709	7,402	24,778	28,370	47,356	54,574	56,306
Madang	PNG	41,862	38,271	21,234	20,426	25,332	48,615	37,628	42,267	43,492	36,703
Rabaul	PNG	147,299	192,021	60,215	65,081	76,077	104,507	124,693	157,645	308,056	327,099
Wewak	PNG	86,236	26,526	24,840	15,264	10,955	13,537	28,699	21,317	19,641	25,097
Majuro	Marshall Isl.	320,594	282,171	498,911	391,364	397,736	294,218	296,910	353,382	133,042	208,077
Honiara	Solomon Isl.	35,175	107,685	21,576	38,901	95,327	88,769	43,917	15,240	56,463	1,680
Noro	Solomon Isl.	29,375	25,573	24,156	24,226	21,147	27,109	28,332	33,624	27,606	39,282
Funafuti	Tuvalu	27,943	3,770	33,492	140,106	116,026	150,118	176,542	125,857	139,039	62,604

For majority of the ports listed, transhipment is the only activity that takes place. The exceptions are Noro, Lae, Madang, and Wewak. In Noro, up until recently, all purse seine vessel visits were associated with unloading to the Soltuna processing plant. From early 2019, with the operation of the Star Loader system (which unloads catch from purse seiners directly into Maersk refer containers), transhipment activities are also accommodated. The distinction between volume transhipped and landed is not made here. In PNG, the only purse seine vessels visiting Madang and Wewak are tied to the respective cannery in each location, and as such, land fish to service the canneries – whether the fish is processed or exported whole. There are 4 canneries located in

Lae, and while the majority of vessel visits are dedicated to landing fish to the canneries, the lack of port infrastructure can result in purse seine vessels transhipping to carriers during peak fishing periods when there is insufficient wharf space to accommodate all boats. This amount (i.e. fish transhipped to carriers in Lae) is very small compared to that landed and the coverage is incomplete. As such, it is not included in the table above.

Table 11: Number of purse seine landing and transhipments in the Pacific by key ports, for the period from 2012 to 2021

Port	Country	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Kosrae	FSM	0	0	0	1	6	6	15	17	43	84
Pohnpei	FSM	271	404	214	113	208	255	370	215	180	112
Kiritimati	Kiribati	26	31	49	181	18	15	53	114	44	2
Tarawa	Kiribati	192	108	297	95	125	165	189	440	317	366
Lae	PNG	23	30	39	39	13	47	95	212	184	208
Madang	PNG	110	119	90	69	39	72	80	60	79	105
Rabaul	PNG	220	278	103	105	117	167	303	271	638	639
Wewak	PNG	124	58	61	36	9	24	65	47	61	41
Majuro	Marshall Isl.	401	364	637	554	545	429	401	452	175	284
Honiara	Solomon Isl.	58	155	35	55	122	112	55	23	69	2
Noro	Solomon Isl.	86	74	74	79	68	81	85	91	77	97
Funafuti	Tuvalu	33	4	37	161	131	166	192	131	144	65

Table 12: Volume of longline unloadings against vessel catch log (in MT) in the Pacific by key ports, for the period from 2016 to 2021.

Port	Country	2016		2017		2018		2019		2020		2021	
		Unloaded	***Catch log***	***Unloaded***	***Catch log***	***Unloaded***	***Catch log***	***Unloaded***	***Catch log***	***Unloaded***	***Catch log***	***Unloaded***	***Catch log***
Suva	Fiji	29,249	33,955	36,966	39,526	27,306	31,448	25,219	30,652	21,616	25,922	13,962	16,944
Pohnpei	FSM	1,044	406	1,884	2,283	1,934	4,756	4,320	5,100	390	2,207	731	2,141
Malakal	Palau	1,829	2,009	2,061	2,518	1,923	2,487	1,551	1,962	22	46	39	43
Majuro	RMI	1,405	3,297	285	3,553	2,702	3,908	3,402	4,304	2,497	3,007	2,538	2,990
Apia	Samoa	9,156	10,872	9,552	9,914	6,055	7,988	7,916	12,068	4,150	7,160	1,736	3,627
Honiara	Solomon Is.	977	4,273	438	4,668	3,209	7,700	793	6,296	2,667	4,511	2,361	4,375
Noro	Solomon Is.	0	4,075	0	3,157	1,395	2,711	1,693	4,824	2,074	3,106	970	2,245
Nuku'Alofa	Tonga	3,187	2,694	3,404	2,965	1,322	1,424	3,062	3,358	2,155	2,174	2,099	2,215

Table 13: Number of longline unloadings against vessel trip log in the Pacific by key ports, for the period from 2016 to 2021.

Port	Country	2016		2017		2018		2019		2020		2021	
		Unloads	***Trips***	***Unloads***	***Trips***	***Unloads***	***Trips***	***Unloads***	***Trips***	***Unloads***	***Trips***	***Unloads***	***Trips***
Suva	Fiji	1,124	1,228	1,249	1,324	1,154	1,231	975	1,191	788	812	454	532
Pohnpei	FSM	29	10	44	64	40	126	138	180	44	169	20	91
Malakal	Palau	642	569	682	647	622	608	534	490	23	27	24	23
Majuro	RMI	226	581	54	749	463	648	524	539	587	602	467	517
Apia	Samoa	210	415	164	335	137	254	136	290	139	233	60	129
Honiara	Solomon Is.	20	90	9	86	101	167	28	146	108	116	89	95
Noro	Solomon Is.	0	92	0	51	34	59	52	107	44	57	20	34
Nuku'Alofa	Tonga	216	207	252	240	150	149	179	182	146	145	134	141

Annex 4: Calculation of fish needed to meet dietary protein requirements

*Table 14. Fish needed (MT) in **2030** to meet the recommended protein requirements of urban populations in Pacific Island countries actively involved in transhipping operations for the purse-seine fishery.*

Country	Urban population [1]	% men [2]	% women [2]	% child [2]	No. men in urban popn.	No. women in urban popn.	No. children in urban popn.	Mean weight men (kg) [3]	Mean weight women (kg) [3]	Mean weight child (kg) [3]	Total weight urban popn. (kg)	Protein needed (g) by urban popn. per day @ 0.7 g per kg [4]	Protein needed (g) from fish per day @ 50% [5]	Fish needed (kg) per day @ 23% protein [6]	Gross weight of fish (kg) needed per day @ 60% recovery [7]	Fish needed (MT) per year
FSM	23,000	36	36	29	8,165	8,165	6,670	81	80	42	1,594,705	1,116,294	558,147	2,427	4,045	1,476
Kiribati	74,000	35	35	31	25,530	25,530	22,940	84	81	45	5,244,791	3,671,354	1,835,677	7,981	13,302	4,855
Marshall Is.	40,000	34	34	32	13,600	13,600	12,800	79	73	41	2,591,989	1,814,392	907,196	3,944	6,574	2,399
PNG	1,407,000	32	32	36	450,240	450,240	506,520	68	64	40	79,692,487	55,784,741	27,892,370	121,271	202,119	73,773
Solomon Is.	169,000	31	31	37	53,235	53,235	62,530	69	67	36	9,491,030	6,643,721	3,321,860	14,443	24,071	8,786
Tuvalu	7,000	34	34	33	2,345	2,345	2,310	89	85	48	518,952	363,266	181,633	790	1,316	480
Total	**1,720,000**				**553,115**	**553,115**	**613,771**				**99,133,953**	**69,393,767**	**34,696,884**	**150,856**	**251,427**	**91,771**

1. Source: https://stats.pacificdata.org/
2. From Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong, and makes the assumption that the percentages in urban area are the same as the national percentages.
3. Source: NCD RisC database (https://www.ncdrisc.org/data-downloads.html). Body weight data were not available so this was calculated as Weight (kg) = Height(m)^2 * BMI. This approach to estimating average body weight has been used to be consistent with Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong.
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6. From Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong
7. Based on the average percentage recovery of edible fish flesh per kg from a broad range of reef fish and tuna.

*Table 15. Fish needed (MT) in **2050** to meet the recommended protein requirements of urban populations in Pacific Island countries actively involved in transhipping operations for the purse-seine fishery.*

Country	Urban populatio n [1]	% men [2]	% women [2]	% child [2]	No. men in urban popn.	No. women in urban popn.	No. children in urban popn.	Mean weight men (kg) [3]	Mean weight women (kg) [3]	Mean weight child (kg) [3]	Total weight urban popn. (kg)	Protein needed (g) by urban popn. per day @ 0.7 g per kg [4]	Protein needed (g) from fish per day @ 50% [5]	Fish needed (kg) per day @ 23% protein [6]	Gross weight of fish (kg) needed per day @ 60% recovery [7]	Fish needed (MT) per year
FSM	22,000	39	39	22	8,580	8,580	4,840	81	80	42	1,584,658	1,109,260	554,630	2,411	4,019	1,467
Kiribati	96,000	36	36	28	34,560	34,560	26,880	84	81	45	6,911,965	4,838,376	2,419,188	10,518	17,530	6,399
Marshall Is.	39,000	36	36	28	14,040	14,040	10,920	79	73	41	2,581,851	1,807,296	903,648	3,929	6,548	2,390
PNG	1,962,000	34	34	32	667,080	667,080	627,840	68	64	40	113,168,152	79,217,706	39,608,853	172,212	287,021	104,763
Solomon Is.	253,000	34	34	32	86,020	86,020	80,960	69	67	36	14,613,283	10,229,298	5,114,649	22,238	37,063	13,528
Tuvalu	7,000	36	36	28	2,520	2,520	1,960	89	85	48	532,558	372,791	186,395	810	1,351	493
Total	**2,372,000**				**812,800**	**812,800**	**753,400**				**139,392,467**	**97,574,727**	**48,787,363**	**212,119**	**353,532**	**129,039**

1. Source: https://stats.pacificdata.org/
2. From Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong, and makes the assumption that the percentages in urban area are the same as the national percentages.
3. Source: NCD RisC database (https://www.ncdrisc.org/data-downloads.html). Body weight data were not available so this was calculated as Weight (kg) = Height(m)^2 * BMI. This approach to estimating average body weight has been used to be consistent with Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong.
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6. From Technical Study 2 for the GCF Regional Tuna Programme by T. Brewer et al., University of Wollongong.
7. Based on the average percentage recovery of edible fish flesh per kg from a broad range of reef fish and tuna.

Green Climate Fund Study 6 Report

Mechanisms to produce behavioural change in fishing and consumption of tuna and other pelagic fish species by Pacific Island coastal communities

RFP22-3866 – Study 6
Contract no. (CS23-4998)

Prepared by

cChange

January 2024

Contents

Suggested citation:

Edwards N.J and Radway S. in press. Mechanisms to produce behavioural change in fishing and consumption of tuna and other pelagic fish species by Pacific Island coastal communities. Technical Study 6 prepared for the Pacific Community as a contribution to a Funding Proposal being prepared for submission to the Green Climate Fund (GCF). January 2024. cChange4Good, Brisbane, Australia. https://www.cchange4good.org/. 45 p.

Executive summary

cChange was contracted by the Pacific Community (SPC) to conduct a technical study that provides recommendations to develop a behavioural change program(s) as part of the GCF Regional Tuna Programme (RTP) titled: *Adapting tuna-dependent Pacific Island communities and economies to climate change*, under RFP22-3866 – Study 6. This Report presents the findings of this study.

The study specifically targeted identifying practical ways, in Pacific Island contexts, to raise awareness about the benefits of diversifying reef fish diets to increase consumption of tuna and other pelagic fish species (hereinafter as tuna), and support scaling-up nearshore fish aggregating device (FAD) programs to increase access to tuna in rural communities and the formalisation of tuna landings by commercial tuna fishing vessels to increase supply in markets for urban communities.[1] In this Report, "practical ways" are defined as methods that are culturally appropriate, support inclusive local dialogues, and access information is cost-effective to reach and engage target audiences. This criterion is critical regionally to increase the likelihood of adoption and sustained long-term commitments for implementation through limited national budgets.

As outlined in the Terms of Reference, the initial task called for in the study was to categorise the 14 countries participating in the RTP. Countries were categorised into Category A: direct need to increase consumption of tuna or Category B: tuna already integrated into diets. The purpose of this task was to identify priority countries, where there is the greatest need to adapt diets to integrate more tuna. This task identified 7 countries for Category A to prioritise for targeted behavioural change interventions coordinated at the national level.

However, during inception of the RTP, it is recommended to consult national governments to assess interest and capacity to support these behavioural change approaches. Identifying early adopters could also provide motivation for additional countries to participate over time and reduce inefficient use of resources where priorities are not aligned. This additional assessment should consider all 14 countries.

Building on the initial task, this Report provides a strategic framework for the adoption of behavioural change approaches that targets actions to increase tuna consumption in Category A countries. This section of the Report builds a case to invest in context-appropriate interventions, which primarily will require additional consultation with Category A countries. However, the additional contextual background provided will assist all country national planning processes.

To support further consultations, this Report presents high-level barriers to action, interventions for behavioural change, planning guides and targets for monitoring and evaluation. Estimated reach for target beneficiaries is also presented.

[1] Although not specifically requested in the Terms of Reference, much of the context, needs assessment and response options could equally apply to sourcing tuna and bycatch transhipped or unloaded by commercial tuna fishing vessels for processing and distribution to urban and peri-urban communities to contribute to efforts to address concerns about national food security.

Based on discussions with RTP advisors, it is apparent that there is a need to also incorporate behavioural change approaches into RTP subsidiary initiatives. The framework presented in this Report can provide a starting point for this approach. Further, integrating recommendations presented in this report Programme-wide also intends to improve budget constraints for behavioural change program(s) in all jurisdictions.

While not part of the Terms of Reference, guidance on costs associated with behavioural change programs in the Pacific Islands was requested. An indicative budget is included to guide future RTP investment decisions. These budget estimates are likely beyond current allocations. However, the indicative budgets are valuable to illustrate the cost for fully developed behavioural change programs in Category A countries. Further work is needed to refine budget details for the activities targeted in each country, which will be dependent on interest and capacity. In addition, it is recommended that in year one a regional planning process is established to assess and prioritise components to integrate behavioural change approaches within the wider RTP communications and visibility strategy, and subsidiary initiatives. This can potentially lower overall costs.

Finally, implementation risks are presented to further guide decision making during implementation.

Throughout the Report, recommendations are informed by background research, which involved a review of available research and reports and interviews with identified coastal fisheries practitioners and subject-matter experts (see Appendix 1). Tuna consumption analyses and climate change vulnerability assessments were also reviewed to assess country-level resource needs.

The approach taken throughout the study was to ensure recommendations are practical. As a result, resource and capacity gaps and needs prevalent within fisheries ministries in the participating countries are accommodated to the extent practicable.

It is also important to note that this Report focuses on only the behavioural change aspects that the RTP seeks to achieve: increasing tuna consumption in daily diets as a result of behavioural change interventions in coordination with other subsidiary initiatives. This approach, as recommended, moves beyond raising awareness and requires more substantial funding than a traditional awareness campaign.

This work should also not be confused with Programme-level communications and visibility, which is a funder requirement, and should not replace the need for audience focused communications. It is highly recommended for the RTP to have a standalone Communications and Visibility Plan and allocate a separate core budget for such communications and visibility activities.

About cChange

Established in 2013, cChange is a non-profit organisation with offices in Brisbane, Australia, and Suva, Fiji, working to improve lives of Pacific Island communities through strategic communications and behavioural change initiatives.

cChange believes that solutions to society's challenges, big and small, lie in changing the behaviour of individuals. When people understand the personal relevance of society's issues, when they are motivated by their own values and desire the solutions, when barriers to action are meaningfully addressed and they are adequately resourced, only then will they change their behaviour in ways that will lead to the transformational outcomes needed.

As part of its approach, cChange has through years of work in the region refined behavioural change methodologies for the Pacific Island region, including adapting for the unique cultures and the limited capacity and resources and underdeveloped infrastructure throughout the region. This report is informed by cChange's experience in the region advancing behavioural change strategies.

Terms of reference

This report presents the outputs/deliverables as outlined in the Terms of Reference published with the Request for Proposal.

(i) The relative proportions of reef fish and tuna in the diets of coastal communities in all 14 countries, based on the information available in the latest household income and expenditure survey (HIES) available for each country.

(ii) The Pacific Island countries where coastal communities consume relatively small proportions of tuna relative to reef fish (i.e., countries in Category A), and those countries where coastal communities have already integrated tuna well into their diet (Category B countries).

(iii) Practical methods for raising awareness of coastal communities in all countries in 'Category A' about the decreasing supply of reef fish per capita, and the need to progressively substitute tuna for reef fish. These methods should include a monitoring and evaluation component so that staff from national fisheries agencies can gauge whether the desired awareness is improved and whether the transition from consumption of reef fish to tuna is occurring.

(iv) An implementation plan for applying these methods in coastal communities in all countries in Category A' during the life of the Programme. The focus of this plan should be communities located in areas selected for installation of FADs.

(v) An estimate the total number of people to be reached by the proposed mechanisms to increase awareness of the need to eat more tuna in 'Category A' countries.

Prioritising countries behavioural change interventions

Climate change impacts on the productivity of coastal fisheries, continuing population growth and ongoing unsustainable fishing in nearshore areas are contributing to increasing vulnerability to food insecurity for coastal communities in the Pacific. [2,3,4,5] Vulnerability assessments of coastal fisheries confirm that rural coastal communities cannot depend solely on their customary fishing grounds for future protein needs[6,7]. The RTP is being designed on the basis of a need to increase the consumption of tuna as a necessary adaptation to fill per capita protein deficiency gaps expected to occur in many of the 14 participating countries as a consequence of climate-related impacts on the fisheries productivity of reef ecosystems.

There are also high risks of food insecurity in urban areas with declining availability of affordable reef fish (see GCF Study 2). Such modelling shows that by 2030 coastal fisheries are unlikely to meet the demand for fish at sub-national levels in at least 8 of the 14 participating countries. High risk of food insecurity continues to increase by 2050 even if favourable climate change emission scenarios are achieved[5] (also see GCF Study 1 & 2). These risks compound the problems associated with addressing existing food and nutrition security, particularly the burden of non-communicable diseases (NCDs).[8] Such increasing vulnerability demands practical and urgent interventions to support efforts that aim to diversify diets that are currently dependent to reef fish. Through the proposed RTP, increasing the consumption of tuna is presented as a suitable adaptation to increase food security among countries where protein deficiencies are likely.[9]

To support the prioritisation of behavioural change interventions that aim to diversify diets through increasing the daily consumption of tuna, the 14 participating countries of the RTP were assessed on the basis of several key factors, including:

1. The current level of tuna consumption compared to reef fish consumption.
2. Projected protein deficiencies/need for alternative non-reef fish protein sources.

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[2] Bell, J.D., Allain, V., Allison, E.H., Andréfouët, S., Andrew, N.L., Batty, M.J., Hanich, Q. 2015. Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories, *Marine Policy,* Vol 55, pp: 584-59.
[3] Johnson, J., Bell, J., Gupta, A. S. (2016) *Pacific islands ocean acidification vulnerability assessment.* Apia, Samoa : SPREP.
[4] Barnett, J. (2011) Dangerous climate change in the Pacific Islands: food production and food security, Reg Environ Change, Vol 11 (Suppl 1), pp: S229–S237.
[5] Weng, K. C., Glazier, E., Nicol, S. J., Hobday, A. J. (2015) Fishery management, development and food security in the Western and Central Pacific in the context of climate change, Deep-Sea Research II Vol 113, pp: 301–311.
[6] Bell, J. D., Johnson, J. E., Hobday, A. J. (2011) *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change,* Secretariat of the Pacific Community, Noumea, New Caledonia.
[7] Bell, J. D., Reid, C., Batty, M., J Lehodey , P., Rodwell, L., Hobday, A. J., Johnson , J. E., Demmke, A. (2013) Effects of climate change on oceanic fisheries in the tropical Pacific: implications for economic development and food security, Climatic Change, Vol 119, pp: 199–212.
[8] Savage, A., McIver, L., Schubert, L. (2020) Review: the nexus of climate change, food and nutrition security and diet-related non-communicable diseases in Pacific Island Countries and Territories*, Climate and Development*, Vol 12(2), pp: 120-133.
[9] Pilling, G. M., Shelton, H. J., Nicol, S., Williams, P., Hampton, J. (2015) Can the tropical Western and Central Pacific tuna purse seine fishery contribute to Pacific Island population food security? *Food Security*, Vol 7, pp: 67–81.

This assessment included reviewing complimentary studies commissioned for the RTP, particularly Study 1, 2, 3 and 5 (climate vulnerability, protein dependencies and national FAD program assessments and landing assessments) and additional relevant literature. Due to the lack of literature to provide subject-specific context, the assessment additionally conducted key informant interviews to add depth to the assessment and further test assumptions (see Appendix 1). Email engagement with subject-matter experts further clarified insights to complete an assessment that adequately supported the behavioural change recommendation's decision points.

Central to the behavioural change intervention prioritisation assessment involved calculating current consumption trends for reef fish and tuna. This comparative analysis focused on only finfish (tuna and reef fish), as outlined in the Terms of Reference. However, this approach does not intend to signal the dismissal of other critical seafood protein sources particularly reef-associated invertebrates.

To estimate trends between reef fish and tuna, total protein consumption data for reef fish and tuna were extrapolated from GCF Study 2 to calculate the percentage of tuna per kilogram consumed compared to reef fish, as:

$$\frac{Total\ reef\ and\ coastal\ fish \,\&\, tuna\ and\ other\ pelagic\ fish\ consumed\ per\ country, per\ year}{tuna\ and\ other\ pelagic\ fish\ consumed\ per\ country, per\ year\ X\ 100}$$

In addition, the assessment reviewed current and projected consumption trends also outlined in GCF Study 2 and overarching qualitative insights regarding climate vulnerability in GCF Study 1. Together, these studies helped identify protein needs, or more specifically, protein deficiencies for all finfish food groups to meet national population needs due to climate change impacts on the productivity of coastal fisheries. As highlighted in the summary analysis (Table 1), high risk means countries will not be able to meet protein needs without significant intervention, while medium risk acknowledges increasing risks though there is capacity to adapt diets over time[5] (also see GCF Study 1). These insights guided decision-making for recommendations when prioritising countries for the focus of this behavioural change program.

It must be noted that GCF Study 2 states that much of the Household Income Expenditure Surveys (HIES) data are at least a decade old, which this study also used. Some countries also have incomplete or unpublished HIES data, such as Papua New Guinea and Fiji, which could potentially create unexpected high relative proportions of tuna consumption compared to reef fish.

Finally, countries were further assessed based on the sub-national areas identified in GCF Study 3. GCF Study 3 has further details regarding the selection of sub-national areas which target the deployment of artisanal FADs in nearshore areas to provide additional opportunities for coastal communities to access tuna.

Based on these insights, countries were categorised into two categories:

1. Category A countries: Target coastal communities consume relatively small proportions of tuna and there are expected to be increasing protein deficiencies due to declining reef fish availability.
2. Category B countries: Target coastal communities that already have means to increase consumption of tuna or declines in per capita availability of reef fish are not forecast to occur.

Table 1: Country categories and target areas

Country	Target District/Province*	Current relative proportion of reef fish vs tuna consumption (per country, per year)	Protein deficiency shortfalls	Country Categories (A or B)
Melanesia				
Fiji Islands	Rewa, Serua, Namosi, Kadavu, Lau	25.55%	High risk	A
Papua New Guinea	Manus, AR Bougainville	72.74%**	High risk	A
Solomon Islands	Temotu, Guadalcanal	29.91%	High risk	A
Vanuatu	Shefa, Tafea	22.33%	High risk	A
Micronesia				
Federated States of Micronesia	Pohnpei, Yap	35.31%	Medium risk	A
Kiribati	South Tarawa, Gillbert Island group island	37.95%	Medium risk	A
Republic of the Marshall Islands	Marshall Islands	11.00%***	Medium risk	B
Nauru	Nauru	80.24%	Medium risk	B
Republic of Palau	Palau - 14 states	12.12%***	Medium risk	B
Polynesia				
Cook Islands	Rarotonga, southern Cook Islands	72.2%	Medium risk	B
Niue	Niue	76.47%	Medium risk	B
Samoa	Samoa	27.59%	High risk	A
Tonga	Tongatapu, Eua, Ha'apai	61.70%	Medium risk	B
Tuvalu	Tuvalu	60.57%	Medium risk	B

**Target areas outlined in Study 3*

***Unexpected high relative proportion potentially due to incomplete data.*

**** Percentage of tuna consumed is low because there is an abundance of reef fish*[5.]

To inform a strategic framework for a behavioural change program and recommendations to support decision points for the RTP, 7 countries were identified as Category A countries, as summarised in Table 1. The countries include Fiji, Papua New Guinea, Solomon Islands, Vanuatu, Federated States of Micronesia, Kiribati, and Samoa. The districts or provinces identified in GCF Study 3 are also included in Table 1.

Understanding behavioural change to design context-appropriate interventions

Behavioural change approaches are increasingly promoted as critical for creating sustainable outcomes across a host of societal challenges. However, behavioural change approaches are commonly viewed as simply smart communications or smart design rather than robust methodologies to understand behaviours, barriers and motivations to empower actions. This section introduces the strategic framework to adopt behavioural change approaches across the RTP, particularly at the national level. Contextual information will assist implementation planners and managers to best apply behavioural change approaches across the RTP.

First, it is important to highlight key foundational aspects of behavioural change approaches and discuss the limits and complexities for context.

The four areas of discussion presented below are:

A. Behaviour change is a process of changing mindsets and not only raising awareness.
B. Barriers must be addressed for people to change their behaviour, which is demonstrated through taking targeted actions.
C. Interventions must consider contexts, particularly in terms of resources and capacity limitations.
D. The complexity and variance across the Pacific and participating RTP countries warrant additional national and sub-national planning considerations, particularly for Category A countries.

A. Behavioural change is a process

Behavioural change should aim to move beyond awareness and create specific interventions that are locally appropriate. This recommendation is informed by understanding that behavioural change is a process, which requires designing interventions for several key stages of change for sustained success: from awareness to building urgency for action to supporting taking action to assessing impact and learning and adapting. Progress from awareness to action often requires first creating a level of urgency among targeted audiences so that they prioritise target issues/actions, and providing support for target audiences to overcome barriers through information, organisation, training, or equipment.

To help design approaches that target action, rather than just "awareness", the behavioural change model illustrated in Figure 1 is recommended. This model applies a theory of change-based approach, a proven theoretical framework for behavioural change initiatives in both the health[10] and fisheries[11] sectors in the Pacific. As illustrated in Figure 1, the staged approach can help inform required information interventions to influence behavioural change, as further described in Table 2. At each stage, interventions should be designed to support people to increase their knowledge of the problem and appropriate actions they can take to resolve "the problem".

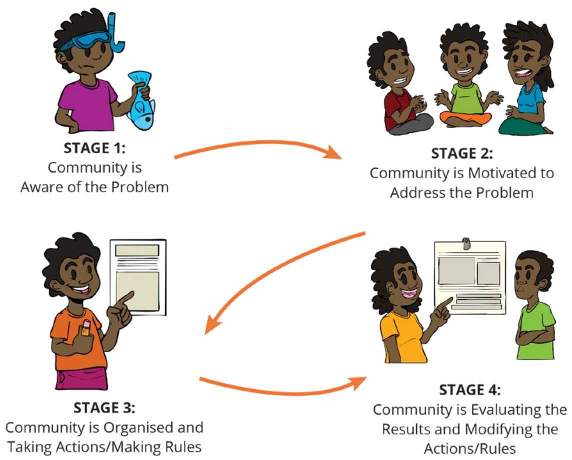

Figure 1: Example of the theory of change-based approach to behavioural change, illustration credit: cChange

Table 2: A schematic representing each stage in the recommended behavioural change model. Additional explanation is provided in the following table.

Stage	Summary of stage
Stage 1: Raising awareness	Involves building urgency for action through raising awareness about a problem. Most programs that seek to create behavioural change usually fail during this stage as target audiences have not made the connection between the problem and how it impacts them. It is critical during this stage that target audiences have appropriate information to identify the problem and support, on the basis of their lived experience, for raising awareness to be more effective. This approach presents information that reflect the values and priorities of the target audience rather than presenting facts of the problem. It is critical to screen information to be made available for Gender Equity and Social Inclusion (GESI) and Human Rights (HR).
Stage 2: Building motivation	Involves supporting communities to organise in preparation for making decisions ideally through existing structures or where needed create new ones. Inclusivity during this stage is critical to ensure solutions which may be

[10] Ryan, S. T., Kariippanon, K. E., Okely, A. O., Stanley, R. M. (2021) Social marketing benchmark criteria use in health behaviour change interventions in pacific islands populations: a systematic review, *Journal of Social Marketing*, Vol. 12 (2), pp: 124-153.
[11] Prince, J., Lalavanua, W., Tamanitoakula, J., Tamata, L., Green, S., Radway, S., … Mangubhai, S. (2020). Spawning potential surveys in Fiji: A new song of change for small-scale fisheries in the Pacific. *Conservation Science Practice*, Vol 3, pp: 1–13.

	intended to help address the problem do not create new issues or unequally distribute benefits. It is critical to screen information for GESI and HR.
Stage 3: Getting organised	When target audiences are part of taking action – evidence of behavioural change.
Stage 4: Evaluation & Adaptation	Involves the monitoring and evaluation of solutions. Sharing feedback among target audiences during this stage can help build wider support and sustain dialogue to adapt and improve solutions.

B. Barriers to increasing fishing and consumption of tuna

A goal of the RTP is to increase effective, small-scale tuna fishing through more FAD deployments for coastal communities to increase access to tuna as an alternative protein source to reef fish in the face of declining coastal fisheries resources. Without understanding local contexts, particularly barriers to action, activities targeted will likely fail to produce real impact.

To identify potential key barriers to action, this study reviewed literature and applied targeted questioning during the informant interviews (see Appendix 1). While this study alone cannot identify all barriers in each country or at sub-national levels, insights presented below can provide useful context for additional consultations prior to implementation through the behavioural change program or subsidiary initiatives of the RTP. For instance, it is advised for key stakeholders for Category A countries to review and discuss barriers to action as part of Year 1 planning processes.

Firstly, it is critical to understand common barriers to behaviour change, which can be categorised as being (1) attitudinal-driven, (2) capability-driven and (3) environment and cognitive-driven:

1. **Attitudinal barriers** include the perceived limited need for change or lack of understanding of the opportunities. These social barriers can be based on fear, ignorance, or reinforcement of stereotypes.

2. **Capability** is based on skills and knowledge, which is also a social barrier.

3. **Environment and cognitive** include the physical environmental constraints which are usually time and resource-related but can also include policy-driven constraints such as regulation and enforcement. These barriers refer to structural elements that can prevent change.

Broadly speaking, to change mindsets, the behavioural change program and its interventions need to address both social and structural barriers. Without addressing these barriers, any behavioural change strategy is unlikely to succeed.

In summary, this study identified three core barriers to tuna consumption as summarised below and further categorised in Table 3:

1. **Preference:** Common perception that tuna is not a preferred fish to eat compared to reef fish due to cultural values that preference reef fish.

2. **Availability:** Structural and economic barriers which impact people's access to tuna; in rural areas, limited access to nearshore/artisanal FADs and suitable gear for fishing around FADs, also preference in households to sell their catch for income rather than consume it for food; in urban areas, inconsistency of supply and quality of produce at markets impacts consumer purchasing trends.

3. **Affordability:** In rural areas, the cost of fuel and gears for fishing further from the coast around FADs; in urban areas, the perception that tuna is more expensive than reef fish.[12]

Table 3: Summary of key barriers to tuna consumption from key information interviews.

Barrier theme	Core barrier	Examples
Attitudinal	Preference	- Tuna is not culturally important - Diet & taste preference for reef fish - Perception that bigger fish are used for feasts and not daily consumption
Capacity	Accessibility & availability	- Cost of fishing offshore – gear, boats, fuel - Sea safety and seasonal sea conditions - FADs constructed using non-local materials - Limited/lack of appropriate cold storage - Access to deeper waters within customary fishing grounds
Environment & cognitive	Affordability	- Cost of fishing offshore – gear, boats, fuel - Perception of high price for tuna sold at markets

Some of the barriers, such as fuel costs and the perception of high prices at markets, as outlined in Table 3, will likely require actions beyond the remit of behavioural change interventions. However, these barriers should be further assessed for the broader work of

[12] There is a broad perception that fresh tuna is perceived to be more expensive since they are generally larger than reef fish. Even though the price may be lower per kilogram for tuna than reef fish, individual fish cost more.

the RTP so that minimum conditions that address social and structural barriers for behavioural change can be reached.

For example, a minimum requirement may involve the implementation of a national FAD program to increase the accessibility to tuna in rural areas. In urban areas, this might relate to the formalisation of tuna landings from commercial tuna fishing vessels to increase availability in market settings. Therefore, any outcomes of the behavioural change interventions will be dependent on minimum structural interventions.

A key recommendation from this study is to create a process at the national levels to further assess barriers to action so any subsidiary initiative of the RTP responds to the real challenges on the ground. This process can be robust, or it can be also done through inexpensive focus groups. But it is a critical foundational component for any behavioural change invention to succeed.

C. Interventions must consider the limitations in PICs

Before interventions are presented, it is important to highlight how common limitations across PICs can impact implementation.

Broad limitations for behavioural change initiatives in the fisheries sector include the limited resources and capacity to support this discipline within fisheries ministries. Common constraints include limited knowledge, skills and appropriate training, lack of funding, access to locally-appropriate information, and outreach materials. In addition, many countries face vast geographic distances to disseminate information and reach rural and maritime communities with undeveloped or limited infrastructure or means of communication.

In acknowledgement of these internal and external challenges, it is recommended for any behavioural change program, regionally or nationally, to implement the following key strategic actions to help address cost-effectiveness, limited resources and gaps in knowledge, and the provision of appropriate information for local audiences.

1. **Identify and invest in cost-effective outreach opportunities**, such as the development of a regional-level toolkit that can be localised and implemented through various activities (e.g., consistent messaging through radio and social media to reach a large proportion of target audiences, and digital and printed information products targeted for widespread dissemination to reach all targeted coastal communities).

2. **Support the localisation of information,** e.g., fishing with FADs, to help communities to take locally-led actions.

3. Where possible, **work through Provincial/District Fisheries Extension Officers** to design locally-appropriate, cost-effective distribution and dissemination strategies.

4. **Identify local partners**, such as faith-based organisations, NGOs, and grassroots networks, to support outreach to communities.

5. **Identify local champions** who are trusted messengers among target audiences.

To help illustrate these strategic approaches in practice, intervention levels for information and communications activities are categorised into the four activity categories below (see also Table 4).

Activity Categories:

1. **Broadcast:** Radio, news media and social media to reach a large proportion of target audiences with information about the problem and solutions. Information is framed through locally informed messaging backed up with local stories that communicate the benefits, such as champion stories that share positive outcomes. This intervention is the least resource intensive and has the highest reach.

2. **Targeted engagement:** Frequent, low-cost opportunities to engage target audiences, e.g., fishers, fish buyers and sellers, and vendors through fisher forums, markets, and fisher association meetings. This intervention-level engagement should utilise key champions to reach target audiences. Similar approaches can be applied to engage women councils and youth groups consistent with GESI and HR guidelines. Activities should aim to be low costs with the goal of engaging target audiences more frequently.

3. **Widespread dissemination:** Informed by a National/Provincial/District-level distribution plan that identifies appropriate pathways for widespread dissemination of an information toolkit, inclusive of digital and printed products. Such information toolkits provide critical information to guide target audiences, specifically coastal communities, why and how to diversify diets to include more tuna. Pathways should aim to be simple and cost-effective such as training videos shared through Facebook groups, WhatsApp groups or information to be picked up at fisheries centres, markets, government offices. Production of the information toolkit can incur initial higher costs, however, through a distribution plan widespread dissemination can reach 100 percent of targeted coastal communities, which will increase cost-effectiveness.

4. **Direct Engagement:** Working through national agencies, local partners, and champions, are engaged to coordinate trainings in National/Provincial/ District

centres and demonstration sites in villages (e.g., Look and Learn/Community Exchanges). This intervention is the most resource intensive, and the target audience is limited.

Table 4 also includes the stages of change as outlined in Figure 1 to help guide how an integrated activity approach aims to create sustained change. Additionally, see Appendix 2: Spreadsheet for the breakdown of engagement tactics that could be employed at the country-level.

Table 4: Summary of example recommended interventions to be implemented in each country (i.e., prioritising Category A countries).

Activity Category	Channels	Frequency	Information interventions	Stages of Change (refer Table 2)
Broadcast	Talkback radio shows News media Social media Messaging Apps	1 x month 2-4 per year 5 per week As needed	Information on the problem – declining reef fish Information on the solution – fishing using FADs, role of markets, preparing tuna, cooking with tuna Messaging Apps to broadcast information	Stage 1 Stage 2
Targeted engagement	Local Fisher Forums Women Council/Fisher Meetings/ Small-Medium Enterprise Networks Fishing Forecasts Messaging Apps	2 per year 1 per year 1 per year As needed As needed	Short, frequent meetings with fishers and fisher associations Short, frequent meetings with women's & mother's groups and enterprise networks Frequent forecast updates from echo-sounder buoys attached to FADs (Study 3) Messaging Apps to reach target audiences	Stage 1, 2, 3 Stage 1, 2, 3 Stage 2, 3, 4 Stage 2, 3, 4
Widespread distribution	Short videos Posters Market billboards Information toolkit	4 videos per year One-off posters & billboards One-off (adapted as needed)	Information on the problem – declining reef fish Information on the solution – fishing using FADs, role of markets, preparing tuna, cooking with tuna Localise SPC technical information (e.g., translate Fishing with FADs into the local dialect), have printed	Stage 1, 2, 3

			and digital toolkits available for target audiences.	
	High-volume Events	At least once a month	Host events/stalls during high-volume events, national/provincial days (demonstration on cooking with tuna)	
	School education package	On-e-off (adapted as needed)	Align SPC information with education curriculums, with activities that target youth	
Direct engagement	Workshops & Trainings & Site visits	Annually (once a year)	Host national/provincial/district-level workshops to maximise engagement with target audiences.	Stage 1, 2, 3, 4
			Host annual Look & Learn / Community Exchanges for fishers to learn from each other	Stage 4

D. Addressing complexities across PICs and in individual PICs

It is important to acknowledge that geographical contexts among other development needs can greatly impact the cost and complexity for behaviour change programs in the Pacific. For example, the need to increase tuna consumption in Papua New Guinea and Pohnpei may be the same, however, the complexity to implement behavioural change interventions, even to reach targeted audiences, is expected to be vastly different. In addition, it is anticipated that some countries might have variance at the sub-national level.

To help address complexities, this study, through desktop and informant interview analyses, identified the following strategic recommendations to be considered when designing interventions to change behaviours:

- **Localise messaging so information reflects local values and priorities** to engage target audiences and build ownership for interventions to sustain change. Regional draft messaging and tools, such as SPC technical information, can be used to help guide national and sub-national discussions, but messaging must be targeted for each jurisdiction.
- **Messages should communicate the audience benefits** so information is relatable and translates how targeted actions will improve people’s lives. This again needs to be achieved at a national level in each country.
- **Market test messaging** to ensure assumptions are known and understood is ideal. This can be done with inexpensive focus groups at minimum.

- **Utilise existing information channels** to reach target audiences and undertake monitoring and evaluation. In addition, utilisation or building on current national programs and activities, and existing staff capacity, should be considered to achieve cost savings.
- **Build institutional capacity** to enable extension officers to assist with delivering the behavioural change program.
- **Engage across ministries and sectors,** particularly health and climate change ministries given the RTP's cross-cutting focus.

Given the substantial barriers and complexities that need to be addressed to shift both fishing practices and consumption patterns, it is recommended for the RTP allocate resources to support participatory planning processes during the inception phase (Year 1). This planning should be targeted at the national level, and where needed, at provincial levels, to review and refine recommendations, particularly to confirm appropriate solutions. An additional objective of this process should aim to create local buy-in, particularly among influential gatekeepers such as political and cultural leaders.

Recommended steps for implementation and application of behavioural change approaches to promote increased consumption of tuna

The following section outlines steps to:

(1) Develop/endorse a regional strategy/framework to advance national behavioural change approaches to promote tuna consumption; and
(2) Using the regional framework, develop national programs and/or activities that apply the behavioural change approaches in country.

Please note the study calls for focusing on the Category A counties, but it is recommended that all countries are further screened for readiness and buy-in from national governments to advance specific programs targeted at increasing tuna consumption. Lessons learned during implementation in Category A countries will be invaluable if similar behavioural change interventions are proposed for other participating countries.

Following this section, additional guidance is provided for further RTP planning:

(1) Draft regional framework to guide the development of national program(s);
(2) Indicative budget; and
(3) Draft monitoring and evaluation plan.

This, combined with the suggested activities in the previous section, provides the needed direction for the support of behavioural change interventions for the RTP.

Recommended steps for implementation

The following section presents a guideline for RTP planning at regional and national levels, including key outputs and expected activity targets and timelines.

Regional-level planning

Year(s)	Key Outputs
Year 1	**Activity 1: Develop A Regional Framework for Behavioural Change** Building upon this study, conduct consultations including workshop(s), background research, additional interviews with identified stakeholders and subject-matter expert to confirm framework. This consultation process should aim to review and confirm: ○ High-level, regional objectives and targeted outputs, and a range of M&E indicators. ○ Identify target audiences and partners (regional and national level). ○ Assess budget availability for information interventions targeted countries. ○ Identify information needs/gaps, including assess existing tools for FAD use and tuna consumption. ○ Develop regional workplan for Years 1-7 ○ Identification of activities that need resourcing. **Deliverable:** An Endorsed Regional Framework for Creating Behavioural Change for the RTP. Notes: This process can and should be implemented in coordination with the wider RTP and its broader strategic communications plan. Ideally, a consultant can support facilitating this process. However, this report provides key information to inform this process through existing program staff.
Year 1	**Activity 2: Project Management Framework** ○ Develop workplan to manage identified deliverables ○ Hire a full-time regional coordinator to support national-level behavioural change initiatives **Deliverable:** Develop Project Management Tools

	Notes: Ideally the regional coordinator is hired and a participant in Activity 1.
Year 1	**Activity 3: Develop monitoring and evaluation framework** ○ Develop monitoring and evaluation framework with practical templates and tools to be adapted at each national-level. **Deliverable:** Develop M&E Framework and Tools for adaptation at national level.
Year 1 – 2	**Activity 4: Design & develop draft regional information toolkit** ○ Develop draft messaging and tools package to support national-level interventions. ○ Communications and Visibility Plan guidelines, to support key information interventions. ○ Guideline for education/school curriculum. This task may be supported through sub-contracts. **Deliverable:** Draft Information Toolkit for national partners to localise through national level processes in each target country
Year 1 – 7	**Activity 5: Coordination support for national-level program(s), assessing barriers to actions, developing annual workplans using activities categories (Table 4) and localising information tools for target audiences in target countries.** **Activity 6: Annual face-to-face engagement with country-level national coordinators and facilitate national/provincial/district learning events.** **Activity 7: Reporting (6-monthly progress and annual reporting). Reports include progress for learning objectives and include recommendations to strategically target program resourcing.** **Activity 8: Annual regional workplan**

National-level coordination planning for target countries

Year(s)	Key Outputs
Year 1 - 2	**Activity 1: Program design consultation** Applying endorsed framework, host inception workshop per country* with key national and provincial/district-level stakeholders to localise recommendations. This workshop and subsequent planning should cover at a minimum: ○ Review objectives and targeted outputs ○ Identify target audiences and partners ○ Review barriers to action ○ Review information interventions and target beneficiaries ○ Localise messaging and branding and identify trusted messengers (e.g., champions) ○ National/provincial/district-level distribution plan (information distribution plan targeting key areas identified in GCF Study 3) ○ Minimum M&E targets** ○ Screen for GESI and HR implications and opportunities ○ Prepare workplan for Years 2 – 7 ○ Identification of activities that need resourcing, including practical workplan. [Review budget. Each country will have variations in costing, and some countries might select a more focused program based on, for example, smaller target audiences, or on easier-to-engage audiences, which may reduce costs]. * Potentially host 1 x workshop for each province in Papua New Guinea (Manus and AR Bougainville) ** M&E supported by regional program coordination - at minimum provide templates to support reporting on activities being implemented. **Deliverable:** Country endorsed behavioural change strategies and workplans – "behaviour change program" Notes: It is recommended that a national level coordinator is hired to advance behavioural change initiatives. Alternatively, the program can be built into existing national government staff work plans, if funding is not available for a dedicated position. In addition, this process can be streamlined in the wider RTP. However, it is critical that the core elements of the behavioural change approaches be applied, such as local messages, barrier identification and targeting cost-effective dissemination.
Year 1 - 2	**Activity 2:** Establish partnership agreements (e.g., media partnership and provincial-level government) ○ Engage key partners who can assist with delivering program activities (e.g., media partnership and provincial-level government partnership agreements)

	Deliverable: Partnership Agreements
Year 1 - 2	**Activity 3:** Localise Information Interventions ○ Prepare key messages* for awareness-raising activities ○ Translate selected technical information and print necessary quantities ○ Produce digital information package for identified targeted activities (videos, social media tiles, photos, e-information) ○ Other branded information products to share at events *Engage local or regionally-based information specialists to assist with localising key messages. **Deliverable:** Endorsed Information Toolkit (by Year 2)
Year 1 - 2	**Activity 4: Project Management Framework** ○ Develop national level project management framework to manage deliverables outlines in workplan. **Deliverable:** Develop Project Management Tools
Year 1 - 2	**Activity 5: Adapt Monitoring and Evaluation Framework** ○ Adapt monitoring and evaluation framework and templates and tools to be used at the national-level. **Deliverable:** Develop national M&E Tools.
Year 2	**Activity 6: Launch "Behavioural Change Program"** ○ Coordinate the launching of the behavioural change program(s) in each target country. Recommended to build-in flexibility over the year to allow regional coordinator to fully support each jurisdiction appropriately. **Deliverable:** Behavioural change program implementation
Year 2 – 7	**Activity 7: Coordination support to deliver workplan.**

	Activity 8: Facilitate national/provincial/district event(s). **Activity 9: Deliver 6-monthly progress and annual report. Reports include progress towards learning objectives and include recommendations to strategically target program resourcing.** **Activity 10: Annual workplan**

As noted above, it is recommended that a full-time coordinator be hired at the regional level, and a full-time coordinator be hired at each national level. To assist in assessing needs, and the feasibility and value of these positions, the following outlines key responsibilities of each position.

Regional coordination responsibilities

- Endorsed Regional Behavioural Change Framework, informed by this study.
- Expand SPC's technical information on fishing using FADs (digital and printed products) to target messaging that communicates program benefits.
- Digital and printed information toolkit templates targeted for fish markets.
- Messaging guides for key activities (e.g., radio show guides, fisher forums, tuna cooking and preservation demonstrations).
- Stakeholder engagement guides (e.g., fisher forum agenda, private sector outreach, strategies to engage faith-based organisations and women and youth audiences).
- Guideline(s) to align key messages with education curriculums.
- Support the development of agendas for annual country-level program workshop(s) and training(s).
- Communications training and mentorship opportunities to increase behavioural change expertise among RTP staff and connect other RTP support (e.g., technical expertise).
- Regional monitoring and evaluation toolkit.
- Coordinate regional lessons learning through sustainable, low-cost mechanisms.

National coordination responsibilities (Category A countries only)

- Endorsed National Behavioural Change Program Plan(s), targeted for each Category A country.
- Localise SPC's technical information on fishing using FADs (digital and printed products).
- Local information toolkit for markets in digital and printed formats.
- Localise messaging guides for various activities (e.g., broadcast, and targeted engagement activities).
- Localise stakeholder engagement guides (e.g., fisher forum agenda templates, private sector outreach, engaging faith-based organisations and women and youth audiences).
- Mechanism to implement regional guidelines to align information with education curriculums at minimum cost.
- Integrate annual program workshops and trainings with existing ministry workplans.
- Integrate communications training and mentorship opportunities to increase behavioural change expertise among ministry extension officers.
- Localise regional monitoring and evaluation toolkit.

Strategic behavioural change framework summary

To assist the development of a regional framework for advancing behavioural change for the RTP, a strategic behavioural change framework summary is presented in Table 5. The purpose is to illustrate expected change among Category A countries as a result of the RTP investing in context-appropriate behavioural change interventions. This framework provides a starting point for further regional and national discussions.

There are three (3) simple and measurables objectives that aim to focus the behaviour change initiatives to achieve outcomes and therefore produce evidence of sustained change.

Given the barriers and complexities outlined above, the **first objective** focuses on ensuring target audiences are aware of declining reef fish and the benefits of fishing for and consuming tuna. Key outputs include ensuring information interventions reach target audiences in both rural and urban areas and build capacity among key partners and stakeholders to increase effective communications and engagement and ownership of the national-level behaviour change program(s). Measurable outcomes include audiences understanding of the issues and solutions to protect food security and livelihoods through fishing for and consuming tuna, and an increase in tuna consumption among rural and urban areas. It is recommended that messaging includes not only increased FAD fishing, but promotes increased access to tuna through tuna and bycatch transhipped or unloaded by commercial longline tuna fishing vessels for processing and distribution in urban and peri-urban areas.

The **second objective** focuses on supporting national FAD program(s) through targeted engagement within communities located in areas selected for the installation of FADs, particularly fisher groups and associations. Key outcomes include increased use of FADs for fishing and consuming FAD-caught tuna at the household level within coastal communities.

The **third objective** seeks to assess and improve project and activity delivery and therefore produce sustained change. It will be critical for the RTP to adapt project delivery to improve effectiveness and efficiencies as behavioural change interventions are delivered and integrate learnings from the field and other RTP subsidiary initiatives.

As advised throughout this report, it is recommended to undertake additional critical inquiry targeted at the national-level and where possible provincial and district level to understand known and unknown assumptions. This work should be carried out during Year 1 planning processes as part of the delivery of national behavioural change program plans.

Through efficient and effective coordination with other RTP subsidiary initiatives, there is great potential for this behavioural change program to increase food security in the Pacific.

Table 5: Summary of overall strategic behavioural change framework.

Objectives	Outcomes (Overall Change)	Outcome Indicators	Key Outputs	Assumptions
Objective 1: Target audiences are aware about declining reef fish and the benefits of fishing for and consuming tuna.	Increased understanding among target audiences about the issues and solutions to protect food security and livelihoods through fishing for and eating tuna. Increased consumption of tuna in both rural and urban areas.	Communities report that they have received locally-informed information and there is evidence of hosting dialogues themselves and organising in preparation of taking action (e.g., Expression of Interest to participate in national FAD programs). Fishers demonstrate understanding of the benefits of fishing using FADs through increased positive engagement in program activities and taking broader ownership of FAD programs. Urban areas have access to information on where and when to buy tuna, and comparable price trends between reef fish and tuna.	Localised information toolkit, at minimum an information toolkit produced for regional-outreach. Widespread dissemination of information and regular, low-cost engagement opportunities to create and sustain dialogues. Tuna pricing and availability information targeted for urban areas at markets (online and physical locations).	Locally-informed and market tested messaging communicated regularly through multiple activities and channels. Identified trusted messengers, such as local champions, are engaged and continually support the dissemination of information. There is a formal landing program to enable markets to provide consumer confidence with consistent value of money price trends for tuna.
Objective 1 continued.	Increased communications capacity among extension officers and key partners to communicate the impacts of declining reef fish effectively and convincingly for coastal communities to understand the benefits of fishing for tuna to protect food security and livelihoods.	All project stakeholders can effectively communicate the benefits of fishing for and consuming tuna. Key ministry staff and extension officers show ownership of the behavioural change program through taking initiative in hosting dialogues with target audiences, participating in media opportunities, providing leads	Key extension officers and partners participate in targeted communications training. Key extension officers contribute to localising information interventions and workplan meetings.	Extension officers received adequate training and resources to deliver effective community engagement and stakeholder engagement. Extension officers are engaged and committed to

		for champion stories, and supporting the documentation of outputs for reporting, evaluation, and learning.	Key extension officers have access to suitable mechanisms to share feedback from the field.	the behavioural change program. Extension officers are acknowledged for their contributions, boosting morale and commitment.
Objective 2: Reach all targeted coastal communities with appropriate information on the benefits of diversifying diets through fishing using FADs and consuming tuna at household levels.	Increased understanding of projected declines in reef fish and the benefits of diversifying diets through fishing for and consuming tuna using FADs. Increased fishing using FADs, including a reduction in the vandalism of FADs. Increased fishing for tuna targeted for household consumption.	Communities in targeted provinces/districts demonstrate increased understanding through the participation of building and deploying FADs, and ongoing ownership through the monitoring and maintenance of FADs. Households report increase access to tuna for household consumption and/or evidence of increasing tuna consumption at household level.	Localised information toolkit, at minimum an information toolkit produced for regional-outreach. Widespread dissemination of information and regular, low-cost engagement opportunities to create and sustain dialogues. Create and sustain opportunities for communities to participate in the building and deployment of FADs, including access to materials. Targeted and regular information for fishers to plan fishing trips with the aim of reducing costs (e.g., biomass forecasts).	**Assumptions outlined for Objective 1 AND:** National FAD programs developed and implemented so that communities and/or ministries have access to appropriate building materials to construct FADs, AND access to resources to monitor and maintain FADs. Fishers have access to appropriate boats and gears to fish using FADs, or at minimum understand sea safety to access FADs safely. Fishers receive regular information on biomass trends to reduce fishing costs and increase trip efficiency. Communities have access to appropriate cold storage

				or other means to preserve tuna.
Objective 3: Provide recommendations to improve the effectiveness of project and activity delivery, therefore produce sustained change.	Improved delivery of program (i.e., projects and activities) that targets behavioural change objectives (1 & 2).	Evidence-based recommendations to guide decision-making, including the adaptation or development of new information interventions, and program resourcing investment that targets behavioural change objectives (1 & 2).	Practical monitoring and evaluation (M&E) framework that utilises existing information channels or where needed create suitable feedback mechanisms. Regional M&E toolkit, including templates, that can be adapted and utilised by national-level program(s).	Committed by extension officers or at least available capacity at provincial/district level to report on activities. M&E is well resourced to capture at minimum annual evaluation of activities to strategically target resources that aim to address barriers that may be limiting outcomes for behavioural change objectives (1 & 2).

Monitoring and evaluation framework

The monitoring and evaluation (M&E) framework presented in Table 6 is to be used as a guideline to monitor and evaluate key outputs outlined in the strategic behavioural change framework presented in the previous section. The purpose of the M&E framework is to provide regular feedback to inform RTP investment throughout the life of the Programme to ensure resourcing is invested in areas that will create sustained change – increase the consumption of tuna in daily diets to protect food security in the Pacific.

It is recommended to design and develop M&E activities that can adapted and implemented by national partners (i.e., national coordinators as discussed in following section). For example, develop M&E tools at the regional level that can be adapted for national-level program delivery within Category A countries.

By taking this approach, the M&E framework is designed around learning objectives. Broadly, learning objectives aim to measure progress towards overarching objectives with the intention of promoting adaptation, investing resources strategically, and sharing lessons to improve sustainability of initiatives.

Therefore, it is recommended that the M&E learning objectives target:

1. Monitor progress in reaching all target audiences with information and evaluate the effectiveness of this information, with a particular focus on the communities located in areas selected for installation of FADs.

2. Monitor progress in meeting the RTP's GESI & HR objectives, focusing on how women and youth and people with disability benefit from information interventions.

3. Share learnings to inform RTP investment, ensuring decisions are based on technical analysis and continuous learning. This learning objective should also target peer-to-peer exchanges to support capacity building among key stakeholders and partners.

It is recommended to integrate M&E activities from the outset to ensure learnings are captured to support ongoing problem solving to adapt and improve program implementation. See Table 6 on the following page.

Table 6: Monitoring and evaluation framework, including outcome indicators and methods.

Outcomes (Overall Change)	Outcome indicators	Measurement indicators	Methods
Increased understanding among target audiences about the issues and solutions to protect food security and livelihoods through fishing for and eating tuna.	Communities report that they have received locally-informed information and there is evidence of hosting dialogues themselves and organising in preparation of taking action (e.g., Expression of Interest to participate in national FAD programs).	Who receives information, and where, when, and how to track demographics and locations (e.g., ensure interventions meet objectives). Records of meetings hosted by communities. Government FADs EOI tracking.	○ Annual Intercept audience surveys ○ Activity reports ○ Distribution tracking tool updated quarterly ○ Analytics tracking ○ EOIs received ○ Photos and videos of actions taken once information is received
Increased consumption of tuna in both rural and urban areas.	Target audiences in rural* and urban areas report increasing consumption of tuna. * Households in targeted areas for FAD deployment report increase access to tuna for household consumption and/or there is evidence of increasing tuna consumption at household level.	Who, where, when, and how to track demographics and locations and ways people access tuna for consumption (e.g., how program interventions contributed to changes in consumption trends).	○ Intercept surveys (prior*, during and post program interventions) ○ Periodic online polls ○ Activity reports ○ Focus groups ○ HIES/Census
Increased communications capacity among extension officers and key partners to communicate the impacts of declining reef fish effectively and convincingly for coastal communities to understand the benefits of fishing for tuna to protect food security and livelihoods.	All project stakeholders can effectively communicate the benefits of fishing for and consuming tuna. Key ministry staff and extension officers show ownership of the behavioural change program through taking initiative in hosting dialogues with target audiences, participating in media opportunities, providing leads for	Document partner demographics and associations who participate in program workshops and trainings. Document outcomes post-workshops and trainings to identify if capacity building contributed to increasing communications capacity.	○ Activity reports ○ Focus groups

	champion stories, and supporting the documentation of outputs for reporting, evaluation, and learning.		
Increased understanding of projected declines in reef fish and the benefits of diversifying diets through fishing for and consuming tuna using FADs. **Increased fishing practice using FADs, including a reduction in the vandalism of FADs.** **Increased fishing for tuna targeted for household consumption.**	Communities in targeted provinces/districts demonstrate increased understanding through the participation of building and deploying FADs, and ongoing ownership through the monitoring and maintenance of FADs.	Who receives information, and where, when, and how to track demographics and locations (e.g., ensure interventions meet objectives). Records of meetings hosted by communities. Government FADs EOI tracking	○ Annual Intercept audience surveys ○ Activity reports ○ Distribution tracking tool updated quarterly ○ Analytics tracking ○ EOIs received ○ Photos and videos of actions taken once information is received ○ Activity reports ○ Focus groups
Improved delivery of program that targets behavioural change objectives (1 & 2).	Evidence-based recommendations to guide decision-making, including the adaptation or development of new information interventions, and program resourcing investment that targets behavioural change objectives (1 & 2).	6-monthly and annual report document progress towards objectives	Program interventions are documented systematically through existing information channels or where needed create suitable feedback mechanisms. Program M&E dashboard (activity tracking spreadsheets)

**Prior program assessments to be captured through intercept survey methods. Household level consumption surveys would require substantial investment, unless integrated into other RTP subsidiary initiatives.*

Indicative budget

Costings displayed in Tables 7-12 have been estimated based on cChange's experience delivering behavioural change programs in the Pacific. Costings are indicative and it is recommended for the RTP to review the budget(s) during additional participatory consultation processes. Considerable cost savings can be achieved through the development partnerships and aligning outputs with other complimentary RTP subsidiary initiatives.

At the Programme level, it is also understood that there will be 1 x Project Manager to oversee the Information and Knowledge Management component for this RTP. It is advised to recruit at minimum an additional Communications & Media Officer who would be positioned to support and coordinate country-level information activities and requests (e.g., this post could also potentially support the information requests from Category B countries). Engaging behavioural change information and educational specialists, designers, videographers, and media practitioners and journalists to support regional and/or national-level planning and implementation could improve efficiencies and reduce overall costs. Specific tasks could be contracted via deliverable-based contracts.

A practical solution to overcome budget limitations could involve providing targeted capacity building support for media officers within fisheries agencies to build in-country ownership through the life of the Programme. Media officers are already well-placed within fisheries agencies, and through engaging them directly they can further support extension officers engaged in RTP activities beyond the behavioural change program(s).

In addition, there could be beneficial outcomes through establishing networks with provincial/district-level government media officers and provincial-based journalists.

Cost savings could be achieved through the development of regional-level information and communications outputs for ongoing activities such as radio and champion story guides, awareness materials, event ideas and short videos or animations.

Please note that Programme costings do not include staff hours or international travel, or additional workshops and trainings.

See Appendix 2: Spreadsheet for detailed costings.

Table 7: Indicative activity budget per Category A country per year. Excludes salary/contractor rates/international travel.

Category	Activities	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Broadcast	Talkback radio shows		$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00
	News media		$3,000.00	$3,000.00	$3,000.00	$3,000.00	$3,000.00	$3,000.00
	Social media		$500.00	$500.00	$500.00	$500.00	$500.00	$500.00
	Messaging Apps							
Targeted Engagement	Fisher Forums		$4,000.00	$4,000.00	$4,000.00	$4,000.00	$4,000.00	$4,000.00
	Women Council/ Small-Medium Enterprise Networks/Faith-based groups		$2,000.00	$2,000.00	$2,000.00	$2,000.00	$2,000.00	
	FAD Fishing Forecasts & Messaging Apps		$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00	$1,000.00
Widespread Distribution	Champion stories		$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00
	Information Toolkit (printed products)	$30,000.00		$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00
	Information Toolkit (digital products)	$30,000.00		$5,000.00	$5,000.00	$5,000.00	$5,000.00	$5,000.00
	Train the Trainers (capacity building)			$15,000.00	$15,000.00	$15,000.00	$15,000.00	$15,000.00
Direct Engagement	Provincial-level workshop* (including Host National Annual Look & Learn / Community Exchanges)			$20,000.00	$20,000.00	$20,000.00	$20,000.00	$20,000.00
Estimated Annual Activity Costings		**$60,000.00**	**$25,500.00**	**$70,500.00**	**$70,500.00**	**$70,500.00**	**$70,500.00**	**$68,500.00**

Table 8: Indicative Administration and Equipment Budget per Category A country per year.

Key Budget Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Office expenses: printing, data, software subscriptions	$ 5,000.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	$ 2,500.00	
Media set up kit: laptop, camera, voice recorder, phone (Once off, with top up in Year 3/4)	$ 10,000.00			$ 3,000.00			
EST. Total Budget	**$28,500.00**						

Table 9: Indicative Budget for Program Consultations per Category A country per year.

Key Budget Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
2-day Inception Workshop	$5,000.00						
2-day Mid-Program Workshop (Year 3/4)			$5,000.00				
2-day End-of-Program Workshop							$5,000.00
EST. Total Budget*	**$15,000.00**						

*Excludes International Travel for Program Staff or Consultants. Additional costs might be needed for local participants depending on travel in country.

Table 10: Indicative Budget for M&E Activities per Category A country per year.

Key Budget Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Baseline Survey Support**	$10,000.00						
Annual Audience Survey**		$2,000.00	$2,000.00	$2,000.00	$2,000.00		
End-of-Program Review**							$10,000.00
EST. Total Budget							$28,000.00

**Additional funds might be needed for analysis, dependent on skill set for program manager.

Table 11: Indicative Annual Budget inclusive of Activities, Administration and Equipment, Program Consultations and M&E Activities.

EST. Total Budget Per Year for Category A countries	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
	$90,000.00	$30,000.00	$80,000.00	$78,000.00	$75,000.00	$73,000.00	$83,500.00

Table 12: Summary budgets for life of RTP *(7 years) per Category A countries and total investment needs for the behavioural change program.*

EST. SUMMARY BREAKDOWN	Total Budget Summary (USD)
EST. Total Budget Per Country (Activities Only)	$436,000.00
EST. Admin & Equipment	$30,500.00

EST. Additional budget for Category A country planning Years	$15,000.00
EST. M&E Activities	$28,000.00
EST. Total Budget Per Category A country for life of RTP	**$509,500.00**
EST. Total Budget for 7 x Category A countries for life of RTP	**$3,566,500.00**

Target beneficiaries

Through recommended interventions it is estimated that 100% of targeted beneficiaries identified in Study 3 will be reached and receive benefits as a result of RTP investment in the behavioural change interventions recommended in this Report. It is recommended to clarify and confirm targets in coastal communities during Programme planning consultation as this will inform strategic methods to reach all coastal communities targeted in Study 3, and provide information on cost-effective ways to reach urban populations.

Table 13: Estimated beneficiaries expected to receive benefits as a result of the RTP investment in the behavioural change program targeting Category A countries.

Category A Countries	Target Population Description	Est. Pop targeted in 2030 (Study 3)
Fiji	30 percent of the population in Rewa (108,074), Serua (20,010) and Namosi (7,885) districts in the central division and 80 percent of the population in Kadavu (10,869), Lau (9,539) and Lomaiviti (15,657) districts in the eastern division, based on Fiji 2017 census.	72,483
PNG	20 percent of the 2022 population estimate of Manus and A.R. Bougainville provinces (395,000), based on 2022 population estimate.	91,834
Solomon Islands	90 percent of the population of the Temotu Province (22,132) and 20 percent of the population of Guadalcanal Province (154,150), based on the provisional 2019 census.	62,752
Vanuatu	Half the population of Shefa (54,953) and Tafea (45,714) provinces and 20 percent of the population of Port Vila (49,034) based on the 2020 census.	66,850
Samoa	20 percent the 2021 census population for Samoa (205,557).	41,874
Federated States of Micronesia	80 percent of the population in Pohnpei State (36,500) and 80 percent of the population in Yap State (11,500) in the FSM based on the mid-2022 population estimates.	38,588
Kiribati	40 percent the population of South Tarawa (63,072) and all population in other 16 inhabited Gilbert Islands Group islands (45,073) from the 2020 census.	81,778
Total Estimated Summary		**456,159**

Implementation Risks

There are broader, and at times conflicting, challenges that could impact implementation of the behavioural change interventions. There are additional implementation risks not exclusive of project management, national elections, geography, development which are summarised below:

- ***Embedding the behaviour change initiatives into existing initiatives***

As outlined in GCF Study 3, it is suggested to seek avenues to integrate the behavioural change interventions into existing initiatives wherever possible. For example, fisheries agencies community-based fisheries management programs, which are targeting to reach

100 percent of communities as part of the region's adoption of scaling-up. Establishing a stand-alone program, outside these community-targeted programs could be viewed as being in competition, or conflicting with existing awareness programs, and this could impede progress.

- ***Build capacity for behavioural change***

The RTP will require at a minimum some behavioural change readiness within fisheries ministries; meaning, an open mindset to consider new approaches to community engagement.

The RTP should consider developing a mechanism to provide ongoing mentoring in behaviour change to build capacity from start to finish for the behavioural change agenda that the Programme seeks to achieve. This approach could involve creating a community of practice within the RTP, where people can learn by doing and sharing as a way to inform and improve their practice.

Given one of the RTP's core focus is behavioural change, it will be critical for all other Programme streams to understand what this means, and the strategies and resources required to truly change behaviour. This approach goes beyond workshops and trainings and seeks to embed sharing and learning to improve daily practice in the delivery of the RTP.

- ***Design with GESI and HR***

Gender equity and social inclusion (GESI) and human rights (HR) is a necessary design principle to ensure activities are well thought through. There has been substantial work in recent years to understand best practices for designing support for GESI and HR elements within the inshore and offshore fisheries sectors. It is recommended to engage a GESI specialist, as it has been already identified, to advise on behavourial change interventions (e.g., review country-level plans and information outputs).

- ***Information, Communications and Technology challenges***

Access to internet is increasingly more accessible and affordable in the region but not everyone has equal access. Most countries have national information, technology, and communications strategies. Consider the objectives of these strategies and design with foresight, particularly taking advantage of the rapid uptake of smart phones. But also, how information can be further broadcast at a village-level where there is no coverage or where data costs are prohibitive.

- ***Technical advisory committee & local advisors***

Engage and create a regional/national technical advisory committee or working group, whichever is more appropriate in the wider RTP, to advise on the appropriateness for targeted information and activities (including content for rural communities). Members must understand local contexts and should bring key technical experience, e.g., fisheries management, fisheries science, information and communications, GESI & HR, and working with coastal communities in the Pacific. See Appendix 3 for an example terms of reference for such support.

- ***Conditions for successful implementation***

Minimum social and structural barriers will need to be addressed for information interventions to create sustained change. For example, the implementation of a national FAD program to increase accessibility in rural areas and the formalisation of tuna landings from commercial fishing vessels to increase accessibility in urban areas are key minimum conditions, to be delivered through other RTP streams, for information interventions to be successful.

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Appendix 1

Informant Interviews

Eight (8) semi-structured interviews were conducted by the project lead researcher to address the paucity of literature that examines social and broader barriers that may limit tuna consumption among coastal communities in the Pacific.

Participants were identified in consultation with the SPC GCF Project Manager and were selected based on their experience working within government ministries and/or with fishers, and coastal communities in inshore and offshore fisheries management across the Pacific. One additional interview was completed via snow-ball sampling, where a participant recommended a colleague given their direct experience working with fishers and communities in this topic. There was also consideration to ensure participants could provide insights at a country-level, and if possible, at the regional level. Gender was also considered, though only two (2) out of eight (8) interviews were women. All but one participant had some direct involvement in community-based FAD programs. See Table A for participant list and background.

Table A: Informant interview participant list

Participant	Gender	Country background	Background
1	Male	Pohnpei	Inshore & offshore fisheries management
2	Male	Pohnpei	National FAD management, Inshore & Offshore fisheries
3	Male	Fiji	Government ministry & Offshore fisheries management
4	Female	PNG, FSM	e-Monitoring & e-Reporting in Offshore fisheries
5	Male	Regional	Research, policy, implementation
6	Male	Samoa	Government Fisheries role
7	Female	Tonga / regional	Socio-economic researcher, implementation specialist
8	Male	Tonga	CEO of fisheries ministry

A semi-structured interview schedule was prepared to guide the questioning for each interview. Questioning focused on the barriers that may limit consumption and what conditions may enable or have enabled increased consumption. Questioning also inquired about the benefits of increasing consumption, including fishing for and value-adding for livelihoods. The researcher encouraged participants to share specific insights on information interventions that have worked as a way to capture success stories to inform potential behavioural change interventions.

Each interview went for 45min to 1hr in length and a transcript of each interview was prepared and cleaned in preparation for analysis. A thematic analysis was manually carried out, which involving reviewing transcripts and developing codes to identify themes. Due to the minimal sample size, it was not necessary to carry out a context analysis using additional software as previously discussed with the project team.

Appendix 2

Estimated Operations Budget Per Category A country

**excluding salary/contractor rates/international travel*

Category	Activities	Frequency	Annual outputs	Estimated Annual Budget (USD)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
Broadcast	Talkback radio shows	1 x per month	10 per year	$5 000,00		$5 000,00	$5 000,00	$5 000,00	$5 000,00	$5 000,00	$5 000,00	
	News media	2-4 x story collection trips per year	2 per year	$3 000,00		$3 000,00	$3 000,00	$3 000,00	$3 000,00	$3 000,00	$3 000,00	
	Social media	3 – 5 posts per week	Approx., 150 per year	$500,00		$500,00	$500,00	$500,00	$500,00	$500,00	$500,00	
	Messaging Apps	Weekly updates	Dependent on members									
Targeted Engagement	Fisher Forums	2 per year	2 x per year in target provinces	$4 000,00		$4 000,00	$4 000,00	$4 000,00	$4 000,00	$4 000,00	$4 000,00	
	Women Council/ Small-Medium Enterprise Networks/Faith-based groups	Target minimum 2 forums/meetings per year	2 x per year in target provinces	$2 000,00		$2 000,00	$2 000,00	$2 000,00	$2 000,00	$2 000,00		
	FAD Fishing Forecasts & Messaging Apps	Once a week	40 posts per year where smart biomass buoys are being launched - may need funds for data	$1 000,00		$1 000,00	$1 000,00	$1 000,00	$1 000,00	$1 000,00	$1 000,00	
Widespread Distribution	Champion stories	1 x per month	10 per year	$10 000,00		$10 000,00	$10 000,00	$10 000,00	$10 000,00	$10 000,00	$10 000,00	
	Information Toolkit (printed products)	Once off deliverable, reach 50% of target in Study 3.	Distribution to target areas in Study 3.	$10,000-$55,000	$30 000,00		$5 000,00	$5 000,00	$5 000,00	$5 000,00	$5 000,00	
	Information Toolkit (digital products)	Once off deliverable, reach 50% of target in Study 3.	Distribution to target areas in Study 3.	$10,000-$55,000	$30 000,00		$5 000,00	$5 000,00	$5 000,00	$5 000,00	$5 000,00	
	Train the Trainers	Top-up capacity building (Year 3 - 5 only)		$15 000,00			$15 000,00	$15 000,00	$15 000,00	$15 000,00	$15 000,00	
Direct Engagement	Provincial-level workshop*	Annual (Year 3-5 only)	1 x per year	$20 000,00			$20 000,00	$20 000,00	$20 000,00	$20 000,00	$20 000,00	
	Host National Annual Look & Learn / Community Exchanges	Annual (Year 3-5 only)	1 x per year (part of workshop)									
Estimated Annual Activity Costings					$60 000,00	$25 500,00	$70 500,00	$70 500,00	$70 500,00	$70 500,00	$68 500,00	**$436 000,00**

				Estimated Annual Budget (USD)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
Admin & Equipment												
Office expenses: printing, data, software subscriptio				$ 5 000,00	$ 5 000,00	$ 2 500,00	$ 2 500,00	$ 2 500,00	$ 2 500,00	$ 2 500,00		**$ 17 500,00**
Media set up kit: laptop, (		Once off, with top up in Y		$ 3 000,00	$ 10 000,00			$ 3 000,00				**$ 13 000,00**
Additional budget for Inception & M&E					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
Project Consultation	2-day Inception Workshop				$5 000,00							$5 000,00
	2 day Mid-Program Workshop (Year 3/4)						$5 000,00					$5 000,00
	2 day End-of-Program Workshop										$5 000,00	$5 000,00
												$15 000,00
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
M&E	Baseline Survey Support**				$10 000,00							$10 000,00
	Annual Audience Survey**					$2 000,00	$2 000,00	$2 000,00	$2 000,00			$8 000,00
	End-of-Program Review**										$10 000,00	$10 000,00
												$28 000,00

*Excludes International Travel for Program Staff or Consultants. Additional costs might be needed for local participants depending on travel in country.

**Additional funds might be needed for analysis, dependent on skill set for program manager

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	
Total estimated operational costings per Category A Country per y	$90 000,00	$30 000,00	$80 000,00	$78 000,00	$75 000,00	$73 000,00	$83 500,00	**$509 500,00**

EST. Total Budget Per Country (Activities Only)	$436 000,00
Admin & Equipment	$30 500,00
Additional budget for Category A country planning	$15 000,00
M&E Activities	$28 000,00
EST. Total Budget Per Category A country	$509 500,00

EST. Total Budget for 7 x Category A countries	$3 566 500,00

Appendix 3

Technical Advisory Committee (TAC) terms of reference

Purpose:

It is recommended to establish a regional, and if possible, national technical advisory committee(s) to inform and review information, ensuring all information is technically accurate and can support practical local actions that can reasonably provide tangible benefits to communities. All information should also be socially inclusive and be culturally appropriate and follow best practices to meet GESI and HR guidelines. The committee(s) should be exclusively focused on technical areas.

Membership:

Membership should be voluntary and cover range of technical disciplines including:

- Coastal fisheries, specifically FADs.
- Nearshore fishing practices
- Coastal and marine resource management
- Community-based fisheries management expert
- A gender inclusivity expert, if not included in the above expertise
- Media, information and/or communications expert

The advisory committee should be asked to apply a strict criteria to ensure best advice goes to communities, i.e., based on best available science/knowledge and demonstrated to be effective for communities in achieving food security and livelihood aims, including the equitable sharing of benefits.

As part of the review, information must also be vetted to ensure it is practical and appropriate for communities.

The committee will be mindful of the various gender and human rights elements of the RTP, including relevant policies and strategies of the governments information is developed for.

Funding:

The TACs should be unfunded. The costs of any member participating in committee activities will be responsibility of the member. However, meetings will be on an as needs basis, and conducted virtually. Ideally most reviews can be conducted via group emails and shared documents. Members must be able to operate well through email communications and meet reasonable turnaround times for content/key messages.

Governance Structure:

The Committee Chair shall be a technical advisor from the RTP or a government representative. The regional project manager for the behavioral change program should be the Secretary to guide the review process, including sharing all content concepts and related products with members and schedule meetings as necessary.

All advisory committee members will be given the opportunity to provide feedback on the content/tools developed for the behavioural change program(s).

Should a member be no longer able to serve on the committee, a replacement will be sought.

Should a member be unresponsive or not provide feedback in a timely and reasonable manner, a replacement may be sought.

Review Process:

As information and content is developed, there will ideally be a series of emails and discussions to develop core messaging and materials over weeks. This period will allow for each member to provide thoughtful feedback. With each review step, a specific timeline will be provided. If no feedback is received in that period, the non-communication will be viewed as approval.

However, there will be issues that emerge and circumstances that will require immediate review. For emergencies and minor developments, each member will be given two days to provide feedback. If no feedback is received in that period, the non-communication will be viewed as approval. These expectations will be stated in these circumstances.

GCF Study 7: Scope for data collection by industrial fishing vessels to inform climate/weather/fisheries models

Jose A. Fernandes-Salvador, Ivan Manso, Guillermo Boyra, Asier Anabitarte, Josu Santiago

Project: Studies and analysis to support the Green Climate Fund proposal: Adapting tuna dependent Pacific Island communities and economies to climate change

Final report

Sukarrieta (Spain), 29th September 2023

OVERALL INDEX

1. Executive summary

The report starts by highlighting the need of robust environmental and taxonomic data for development of earth system, ecosystem and fisheries models. Some of this data can be gathered by fishing vessels during their usual operations. Sections 3 focus on the taxonomic data gathering from acoustics installed on vessels and buoys, and/or from catches identification using image analysis. Section 4 focus on environmental data with validated examples. Section 5 revises the principles needed for data to be assimilated and revises GEOSS structure and functioning as main channel to this assimilation for scientific and public use. The Section 6 assess the cost of a pilot project based on recent digitalization projects. Finally, section 7 provides on stakeholder engagement and participation as well as potential barriers and incentives.

In relation to biological data, acoustics can be used for biomass estimation or even further classified by species. This acoustic data can be from the echosounder of the vessel or from FADs buoys. Further biological information (taxa and sizes) can be cost-effectively obtained with image analysis using machine learning and artificial intelligence applied to electronic monitoring of catches. In terms of environmental data three main devices considered: anemometer, buoys, and an acoustic doppler current profiler (ADCP). An anemometer measures wind data, bouys are used to infer surface currents and ADCPs often include a thermometer. All thee have been positively validated. However, the ADCP requires additional evaluation in relation to providing data in absolute terms and in relation to vessels position. This evaluation is required for already installed ADCPs or in the selection of new ADCPs.

To make data accessible, interoperable and reusable it is important to ensure that the data is useful and manageable. Therefore, a set of principles for scientific data management have been created: the Findable, Accessible, Interoperable, and Reusable (FAIR) principles. FAIR focuses on data that are easy to identify and find, well-described, interoperable with other data and has more than one use. The Collective Benefit, Authority to Control, Responsibility, Ethics (CARE) principle seeks to ensure that the data respects data producers, and that themselves can use the data and benefit from it. TRUST[1] focuses on making the data repositories trustworthy. For this, among other things, users must be clear about the conditions of use, data and metadata must comply with norms and standards and repositories must be constantly updated. The future of the repository must be guaranteed to ensure on-going access to the data.

Global Earth Observation System of Systems (GEOSS) facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations. GEOSS is divided into regional aggrupation. The Pacific region is served by organisations and affiliations such as PI-GOOS, SEAGOOS and IMOS. Regional organizations like SPREP, SPC, PEC, ESCAP and UNEP are key candidates to coordinate environmental data ingestion from vessels of opportunity (e.g. fishing vessels) into GEOSS community. However, regional capacities, data governance arrangements and protocols need to be further developed.

The purpose of this report was to assess the scope for enlisting the assistance of industrial fishing fleets to collect:

- additional data on sea surface temperature and ocean current velocity across much of the Western and Central Pacific Ocean (WCPO) to inform CMIP6 Earth System Models and, in turn, the SEAPODYM model used to assess the effects of climate change on the distribution of tuna; and

[1] Transparency, Responsibility, User focus, Sustainability and Technology:

- acoustic data on tuna prey (micronekton) in the water column to assess the response of these organisms to climate change, thereby also improving the skill of the SEAPODYM model.

The scope for collecting species data and environmental data is assessed. Data management and the role and responsibilities of stakeholders (from fishers to global data aggregators used by earth systems modellers) provides the basis for mapping a digitalization pilot project based on experience in the Indian Ocean with the SusTunTech project.[2]

There are uncertainties associated with designing such an initiative for the WCPO. The availability of vessels and technicians and price fluctuations for equipment and flights and other expenses allow the preparation of only an approximate budget for a pilot project. It is estimated that installation of at least one vessel would be over US$1,000,000, but cost would reduce by vessel if more vessels were digitalized (at least two suggested).

Four groups of key stakeholders are critical to the project: 1) fleet or vessels owners; 2) technological providers; 3) national agencies; and 4) international agencies. The main identified limitations are: lack of technological skills and trust, cost of technology, legal and bureaucratic uncertainty, lack of stablished or known standards and competition. Incentives include a significant contribution to improving public image, ??communication for workers??, improved forecasting models and, subsequently, improved information available for resource management decision-making.

[2] https://www.sustuntech.eu/

2. Background

Coarse resolution models that couple tuna population dynamics with climate have been used to project tuna abundances in the Pacific Ocean (Bell et al. 2021; Erauskin-Extramiana et al., 2023). These projections show a redistribution of tuna biomass with reduced biomass and reduction of fish sizes. The extent of this redistribution of biomass is dependent upon the magnitude of continued greenhouse gas emissions. To assist Pacific Island administrations with developing and evaluating options for adaptation to this potential redistribution an Advanced Warning System has been proposed for development under a Green Climate Fund regional project (Adapting tuna-dependent Pacific Island communities and economies to climate change). This AWS intends to provide administrations of the participating Pacific Island Countries with capacity for short-term forecasting and long-term projection on the distribution and abundance of tuna for which their food systems and economies are dependent.

SEAPODYM (Senina et al. 2020) is expected to be used for the foundations of the AWS for making projections (i.e. to describe the average or statistical properties of the system over a future time window). SEAPODYM couples physical, bio-geochemical, lower and mid trophic prey fields with tuna population dynamics (Lehodey et al, 2010). While the Earth System Models that provide the physical and bio-geo-chemical forcings assimilate observational data, as does the tuna population dynamics component (through catch, length and tagging data), the estimation of lower and mid trophic prey fields is derived from physics. Moreover, data to externally validate the estimates of lower and mid trophic biomass is sparse in the Pacific Ocean. An increase in observational data on micronekton distribution and abundance is needed to test the robustness of the projections made using SEAPODYM and to reduce model uncertainty.

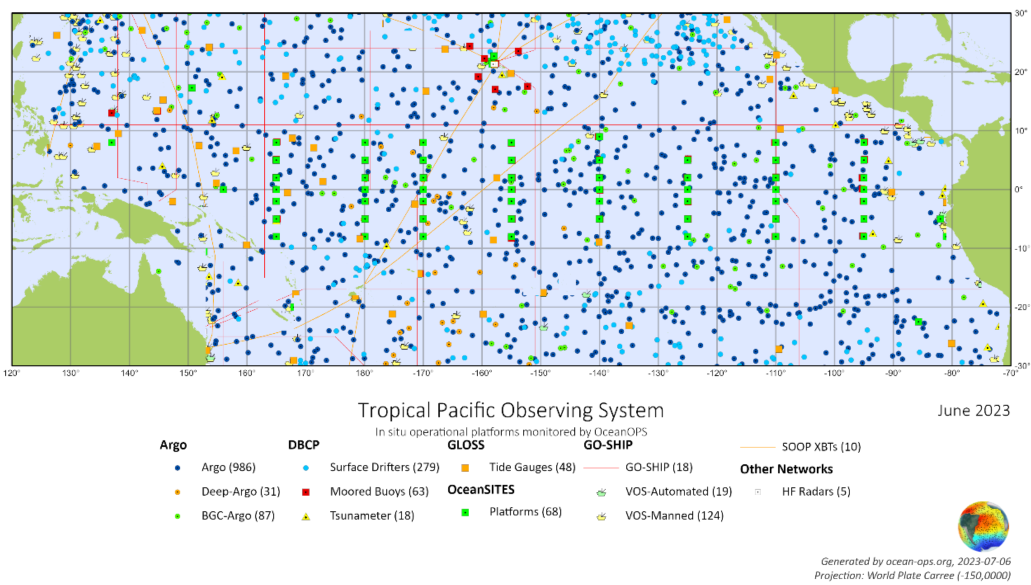

Figure 1. *Coverage of the tropical Pacific Observation System composed by multiple platforms monitored by OceanOPS.*

Similarly, the capacity to provide shorter-term forecasts of tuna availability and ocean conditions is dependent on knowing current environmental conditions. As a forecast (or prediction) is intended to describe the actual state of the ocean at a particular point in the future, the skill of the models used are dependent on their starting conditions being as similar as possible to the actual ocean. While satellite-based observation has provided near-continuous monitoring of ocean surface conditions, sub-surface measurements of ocean properties are limited both spatially and temporally (e.g. on average Argo floats are more than 2 degrees of longitude and/or latitude apart and generally only report every 10 days in the Pacific – see Fig. 1). In contrast fishing buoys can report currents data at least once per day within current uses and this data quality has been verified.

Freight, passenger and fishing vessels (i.e.. Voluntary Observing Ships (VOS)) fitted with appropriate instrumentation are one tool for filling some of the current observational gaps (Uranga et al., 2017). Typically, such vessels are instrumented to measure, record and transmit marine meteorological and oceanographic observations as they go about their day-to-day business at sea. Ship-based observations can provide: parameters that satellites cannot observe (e.g., atmospheric pressure, subsurface measurements); data from regions with gaps in satellite coverage; and validation data that are relevant to forecast operations. Ships fitted with calibrated acoustic sounders have also provided a source of data on micronekton distribution and abundance. Beyond their use in numerical weather prediction, data from ships has also been used operationally in the preparation of forecasts and warnings, and to support the routing of ships to avoid adverse weather and efficiently transport cargo (International Maritime Organization [IMO], 2018).

The VOS is coordinated by the World Meteorological Organization (WMO) and involves approximately 2000 vessels participating and acting globally as remote weather stations (although the majority of data comes from <500 vessels). The value of these data is recognised in Regulation 5, "Meteorological Forecasts and Warnings," of the Safety of Life at Sea Convention (International Maritime Organization [IMO], 2002), which encourages contracting governments to arrange for a selection of ships to be equipped with tested marine meteorological instruments and to take, record, and transmit meteorological observations at the standard times for surface synoptic observations. Contracting governments are instructed to encourage other ships to make, record, and transmit observations particularly in areas with sparse data. The near-surface observations taken include atmospheric pressure, wind speed and direction, air temperature, relative humidity, and sea surface temperature (SST), as well as wave height, direction, and period. The WMO requires that the data collected and derived products are exchanged without charge and with no conditions on use.

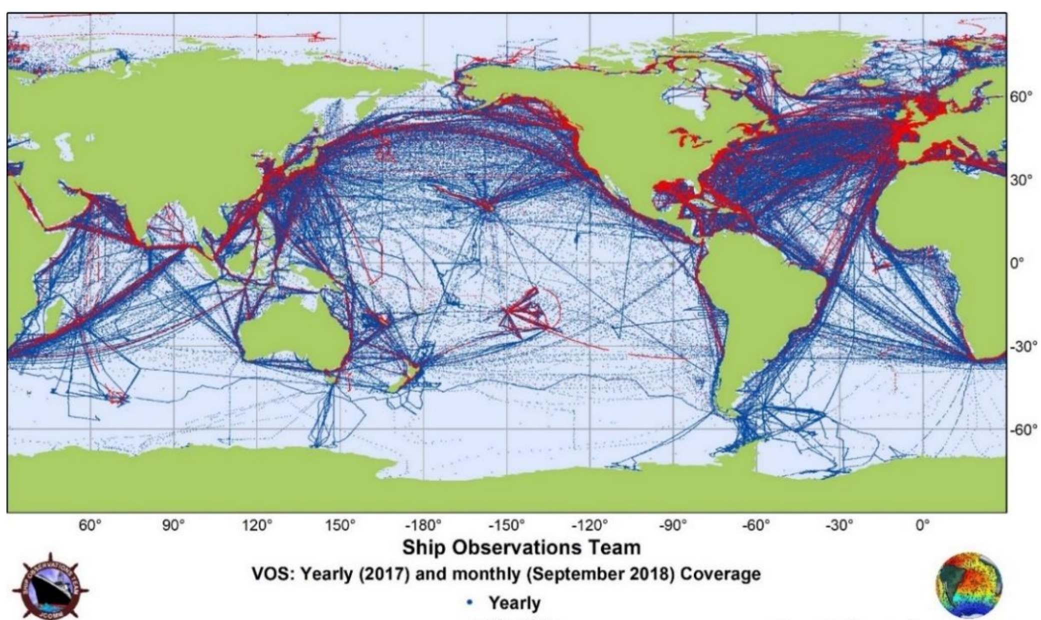

Figure 2. *Integration of data from Voluntary Observing Ships (VoS) integrated by OceanOPS.*

Atmospheric and oceanographic observational data from VOS in the equatorial Pacific is sparse (Fig. 2), with most coverage reflective of the shipping routes between major economies and populations. Although cargo is more prevalent outside of the equatorial Pacific there are opportunities for fishing vessels to make a significant contribution towards filling the gaps in this region (Fig. 3).

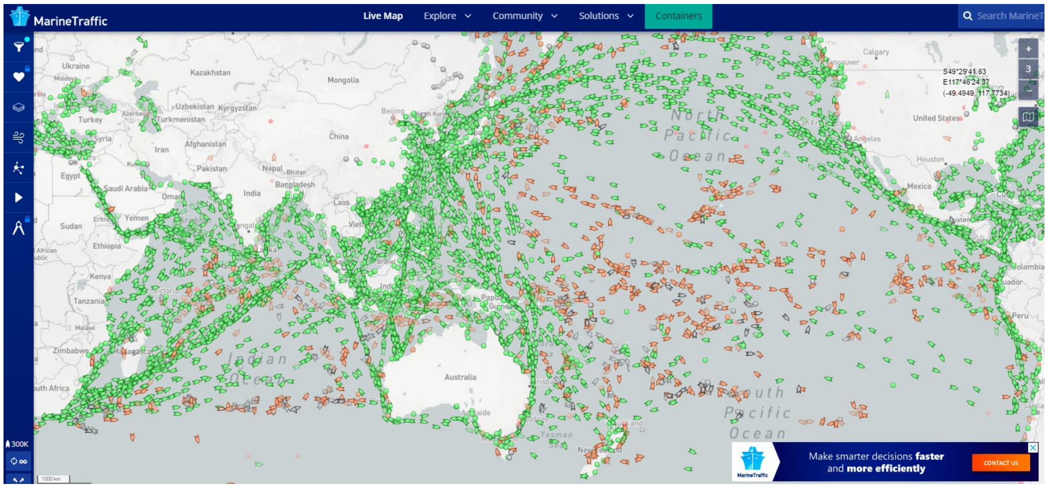

Figure 3. *Map of vessels traffic based on AIS data available from MarineTraffic website over what period?.*

In this context, the purpose of this report is to assess the scope for enlisting the assistance of industrial fishing fleets to collect:

- additional data on sea surface temperature and ocean current velocity across much of the Western and Central Pacific Ocean (WCPO) to inform CMIP6 Earth System Models and, in turn, the SEAPODYM model used to assess the effects of climate change on the distribution of tuna; and
- acoustic data on tuna prey (micronekton) in the water column to assess the response of these organisms to climate change, thereby also improving the skill of the SEAPODYM model.

The specific deliverables of the ToR were documentation of:

(i) The quality of water temperature data, current velocity data and acoustic data presently collected by industrial purse-seine vessels, and from the drifting fish aggregation devices (FADs) that they routinely deploy, and the scope for these data to be used to improve the continued development of CMIP6 Earth System Models and SEAPODYM.

(ii) The potential for improving the calibre of water temperature data, current velocity data and acoustic data collected by purse-seine fishing vessels and, if sufficient potential exists, the approximate costs of installing the necessary equipment on a typical purse-seine vessel and electronic transmission of the data to the appropriate user groups.

(iii) If warranted, the design of a pilot project to be implemented with a selected industrial fishing company to:
- assess the costs involved in installing the equipment on vessels and on drifting FADs and the logistical challenges of doing so;
- trial the use of equipment capable of collecting higher-quality data;
- verify the quality of the data collected; and
- evaluate any associated additional operational measures involved in transmitting the data to the appropriate user groups.

(iv) A summary of the regional and national fisheries management agencies and stakeholders that would need to be involved in assessing the cost-benefit of improved data collection across the WCPO to tuna-dependent Pacific Island countries, fishing fleets and the broader global climate-change science community.

The first two ToRs are addressed in chapter 2 and 3, first addressing the species data and later the environmental data. The last two ToRs are addressed in chapters 4 and 5, first addressing the needs for appropriate data flow across stakeholders (from fishers to global data aggregators used by earth systems modellers) and later with the design of a digitalization project. These are based on the example of SusTunTech project due to the similarity of vessels (tuna purse seiners) used in the WCPO with vessels used in the SusTunTech Project.. The main goal of the SusTunTech project was to develop methods and tools to ''facilitate a more efficient and sustainable tuna fishery'' using weather forecast data combined with species distribution and fuel consumption data. To achieve this goal, the project combines in situ data with marine environmental and biological data obtained from the Copernicus Marine Environment Monitoring Service (CMEMS). The installations required for this in situ data collection are described. The project also provides in situ data to the Copernicus framework, helping it to validate and improve its products.

3. The potential for collecting species data by purse-seine vessels suitable for models

This chapter reviews the literature concerning biomass estimations, disaggregated by species, utilising acoustic and image data on board vessels and from drifting buoys.

3.1. Collection of acoustic data by fishing vessels

The skippers on purse seiners targeting tropical tuna extensively use sophisticated acoustic sensors, including echosounders and multibeam sonars, to detect and monitor fish aggregations (Moreno et al., 2019). Long-range multibeam sonars are typically used to search for fish schools, whereas medium- to short-range models aid in the manoeuvring of purse seine fishing vessels and for estimating fish abundance found both in free-swimming schools and those associated with dFADs (Gerlotto et al., 2004; Korneliussen et al., 2009). Fishing vessel use of multibeam sonar is not suitable to monitor tuna prey, because its signal is focussed on the first layers of the water column to detect and measure tuna biomass.

Vertically oriented mono-beam echosounders are widely used on fishing vessels to estimate the acoustic abundance of fish species (e.g., ICES, 2007; Doray et al., 2021) or other ecosystem organisms (Korneliussen et al., 2018). This equipment is normally non-scientific (e.g., single beam rather than split-beam transducers), uncalibrated and the settings that may not be appropriate for measurement of lower and mid-trophic organisms. However, depending on the model of echosounder installed on the vessel, it is possible for georeferenced and calibrated acoustic backscattering coefficient s_v values to be recorded (Haris et al., 2021). Backscatter represents a linear sum of acoustically detectable individual organisms within the sampling volume (typically to 1000m depth). The acoustic estimation of biomass however is usually complicated by a lack of taxonomic information about insonified organisms, complex size distribution of scattering organisms, unknown species composition, and frequency-specific selectivity of echosounder measurements (Haris et al., 2021).

There are also additional difficulties in collecting acoustic data from commercial fishing vessels that must be addressed. Fishing vessels have noisier propellers than research vessels, which can result in reduced operational range of acoustic data due to noise interference. Acoustic equipment onboard fishing vessels is normally not synchronized, causing cross-talking and interference between sensors that operate simultaneously. Cruising speed of fishing vessels is often higher than recommendable speeds for optimal acoustic quality because it produces aerated bow waves under the hull that attenuates acoustic signal. Multi-frequency transducers provide a means to overcome some of the taxonomic issues by providing data which allows improved segregation of dominant scattering groups.

Despite these difficulties, acoustic data has been collected from commercial fishing vessels to fulfil a wide variety of research objectives successfully (ICES, 2007). For example, Haris et al., (2021) describes the successful establishment of a Ships of Opportunity (SOOP) Bioacoustics sub-Facility as part of Australia's Integrated Marine Observing System (IMOS). Twenty-two vessels (13 fishing vessels) are part of the program. The majority of archived data in the IMOS Bioacoustics sub-Facility are single-frequency 38 kHz echosounder observations, but also include growing coverage of multi-frequency 18 kHz, 70 kHz, and 120 kHz data. Data processing routines have been developed to manage/correct for the sub-optimal operating condition for the collection of acoustic data on fishing vessels (Haris et al., 2021). To the best of our knowledge, acoustics data from VOS have not yet been integrated into Earth System or ecosystem model products. Acoustic data has been used to independently verify biomass estimates in the lower and mid trophic component of SEAPODYM (i.e.. a comparison between SEAPODYM estimates and the observation).

3.2. Collection of acoustic data by echosounders on FADs buoys

Drifting Fish Aggregating Devices (dFADs) are man-made floating objects designed to attract tunas and improve catches of the fleet. In the last decades, they have become common in tropical tuna purse seine fisheries (Fonteneau et al., 2013; Scott and Lopez, 2014). They take advantage of a behavioural pattern shared by various pelagic species that compel them to gather around floating items. Currently, all dFADs are equipped with satellite-linked GPS and are thus able to provide remote information on their position and velocity. They also have installed low-cost echosounders of [[??several acoustic characteristics??] that allow them to estimate fish abundance below the FAD (Dagorn et al., 2013; Lopez et al., 2014 Moreno et al., 2019). This capability has resulted in a significant increase in the fishing efficiency of purse seine vessels (Fonteneau et al., 2013; Lopez et al., 2014).

Echosounder bearing dFADs could represent an observatory of marine communities (Brehmer et al., 2018; Moreno et al., 2016; Uranga et al., 2017). They represent a cost-effective way of collecting information about the marine ecosystem, owing to their large number, broad distribution through the three oceans and maintenance by the fishers. They can be used to provide information about ocean dynamics (Imzilen et al., 2019), fish behaviour and spatial distribution (Lopez et al., 2017; Orue et al., 2019a; Baidai et al., 2020a), provide quantitative information about abundance of different tuna species (Santiago et al., 2016; Santiago et al., 2020) or help reducing bycatch for the tropical tuna purse-seiner fleet (Mannocci et al., 2021). Currently there are various manufacturers building and providing dFAD buoys to the fleet, each providing different hardware and software characteristics and data format (Moreno et al., 2019). In recent years, some processing protocols have been proposed to standardize the collection of data from instrumented dFADs (Maufroy et al., 2015; Orue et al., 2019a; Baidai et al. 2022).

However, the use of dFAD buoys to study pelagic species is not free from limitations. First, the acoustic equipment is typically low-cost, uncalibrated and small sized, hence with limited acoustic performance. In addition, the need to broadcast the data through satellite link, requires drastic reduction of data resolution that limits the utility of the data for proper discrimination of species. Moreover, as the echosounders are specifically designed to detect tuna, they are not able to provide good quality information about micronekton and other species yielding comparatively lower intensity acoustic responses.

3.3. Comparative species composition data from electronic monitoring and machine learning based species identification

Image analysis programs enhanced with automatic species identification (Lekunberri et al., 2021) are of growing interest for industry and managers. EM is a proven technology for fisheries monitoring that has been widely tested and continues to grow, primarily in industrial fleets but with potential applications in smaller vessels. It provides a good example of development that could be useful for AI systems good practice development. An effective EM system should meet several requirements (i.e., Minimum Standards) to guarantee quality and consistency across vendors. All tuna RFMOs have engaged in recent years in the definition and implementation of these minimum standards, with different progress among RFMOs. In the Pacific (WCPFC and IATTC) draft standards have been prepared for the longline and purse seine fisheries, while in the Atlantic (ICCAT) and Indian (IOTC) oceans, minimum standards for the purse seine fishery have been preliminary adopted by the Commission (Ruiz et al., 2016; Ruiz et al., 2017; Román et al., 2020). However, species composition monitoring programs remain very costly due to the need for skilled human observers who are not exempt from errors (Duparc et al., 2019; Ruiz et al., 2015; Gilman et al., 2019).

Machine learning (ML) and image analysis approaches to catches for species identification have been under development for some time (Strachan et al., 1990; Storbeck & Daan, 2001; White et al., 2006). These have continued with a recent trend to increase the application of electronic monitoring (EM) (Wang et al., 2018) and capitalizing on neural networks and image analysis methodological development. The utilization of deep learning (DL) has also increased recently on species identification of catches (French et al., 2020; Tseng & Kuo, 2020; Yu et al., 2020; Lekunberri et al., 2021; Qiao et al., 2021; Palmer et al., 2022). However, most of these publications are simply a proof-of-concept in controlled environments. Recently Lekunberri et al. (2022) have approached the problem of identifying tuna species on vessels using current commercial digitalisation systems already installed on board. Some recent research work has focused on fish size estimation without differentiating species (Monkman et al., 2019; Álvarez-Ellacuría et al., 2020; Yu et al., 2020; Garcia et al., 2020). Species identification was also the objective behind using genomic datasets and ML algorithms (Sylvester et al., 2018; Brophy et al., 2020). Fish species identification and counting with underwater in situ devices has used classification with supervised ML and DL which can be used in biodiversity studies or to improve fishing selectivity (Salman et al., 2016; Marini et al., 2018; Villion et al., 2018; Labao & Naval, 2019). Supervised classification has also been used on genetic data in other species for ecological quality status assessment (Cordier et al., 2017) despite current limitations with genetic data (Hanse et al., 2018). DL as also been employed for underwater detection of sea life and debris floating on the ocean surface using satellite data (Watanabe et al., 2019).

Several EM practices are in place in New Zealand, where invasion of privacy is one of the main concerns raised by fishers. These concerns are addressed by conducting monitoring in vessel areas where only fishing-related activities take place. EM footage is recorded electronically and automatically encrypted. Therefore, only authorised staff can access the footage. This footage allows dolphin interactions with vessels and gears to be identified. A sample of this footage is also reviewed to verify species fish catch composition. The information collected is then compared to fishers' reports. The MPI conducts an impact assessment to identify risks to privacy. Owners and skippers are involved in the process of installation to guarantee full transparency in decisions about location of cameras to ensure that the video footage concerns only fishing activities. The MPI aims to install cameras in more than 300 vessels by 2024, which represents around 85% of the catches starting in late 2022.

In 2011, a 100% monitoring at sea was implemented in the Pacific ground fisheries. In 2015, EM arose as an alternative to full observer coverage. It was deployed in the pelagic longline fishery to monitor bluefin tuna bycatch. EM is currently in place in at least 113 fishing vessels (EDF, 2020). The use of EM was expanded to US tuna longliners under the purview of ICCAT to evaluate whether the shortfin mako shark was released alive. It is expected that EM could provide evidence to reopen fisheries currently closed due to conservation issues.

Video review and storage is carried out by National Fisheries Marine Service (NFMS). The system introduces the 'third-party scheme' which consists in the certification of the providers of hardware, software, installations, etc. These providers have to submit a plan to NFMS to describe how they will provide NFMS with the information necessary for fisheries management. Similarly, to the observer program, the industry will be required to outsource the services through private certified providers. In turn, fishers must prepare a plan for the use of the EM system onboard and obtain certification and guarantee complete identification of catch, continuous vessel location monitoring, recording of any haul, set, or discard event, prevention of radio frequency interference, etc. Consultation continues and the program is expected to be fully operative by January 2024 (NOAA, 2021).

Within the EU level, the European Fisheries Control Agency published in 2019 guidelines and specifications for the implementation of remote EM in EU fisheries (EFCA, 2019). Meant as a guidance document for Member States, it describes minimum technical requirements and standards for EM systems which could be used as a tool to monitor and document compliance with the Common Fisheries Policy (CFP), and specifically compliance with the ??LO??. Similarly, in 2021 spell out UNE, the Spanish standardization body at the national level, published the UNE 195007:2021. This standard establishes the requirements and technical conditions that must be meet when implementing an EM system on any fishing vessels greater than 12 m. This standard includes the characteristics that the equipment should meet, as well as the requirements for all the operators involved in the electronic observation (fishing vessel owners, technology companies that manufacture onboard equipment and data analysis entities).

4. Processing environmental data from vessels

This chapter reviews the potential to acquire environmental data (temperature, winds and currents) onboard purse seine fishing vessels and from buoys. It is mainly based on using sample data from vessels operating in the Indian Ocean.

4.1. Measurement of Currents from FADs and ADCP

4.1.1. Currents from tracking of FADs

Buoys are attached to structures typically made of a bamboo raft, equipped with floats to ensure buoyancy and a subsurface structure built of non-entangling material (e.g., ropes or panels) that attract tuna and increase fishery productivity. This submerged structure ranges from a few meters (2-3 m) to 80 m depth and might have different forms depending on the area/season and the ocean. The buoys transmit, among other variables, position and date data ranging from every 15 minutes to once a day. From position and time data, current velocities can be inferred. As a result, they become a new invaluable source of information of near surface currents. The information from the buoy is sent to the servers of the buoy provider by GPS, and is then relayed to the vessels. Each vessel belongs to a fleet or company which owns the data provided by the buoy. Each vessel is responsible for its corresponding buoys. They attach ??the structures to the buoys, deploy, recover and bring them back to port.

Table I. *Filters applied for QC raw position data. They are applied sequentially.*

FILTER	Description
F1. Duplicated	Adjacent points with the same date and position for the same buoys are clearly erroneous. When these points are found, the first datum is kept, and the following ones are removed.
F2. Ubiquitous	Multiple positions for the same date and buoys are also erroneous. In this case, the first point is kept if the second one is further than 1 km (as in Ruiz et al., 2019). If not, they are all removed.
F3. Single location	Trajectories of one point are removed since they do not provide any information of the ocean drift.
F4. Isolated	Points with aberrant velocities (>18 m/s, as in Baidai et al. (2017)) with respect to adjacent points are removed.
F5. Land	Buoys with continental positions are removed using the NOAA - Global Self-consistent, Hierarchical, High-resolution Shoreline (Wessel and Smith, 1996), with a buffering of 0,05 arc degrees around the shoreline (as in the ??RECOLAPE project?what's this project?).
F6. Bathymetry	Positions with depths shallower than -50 m are removed since the structure attached to the buoy usually reaches 40-60 m depth and therefore the trajectory would be affected by the drag against the sea floor.

F7. Zero velocity	Adjacent points with the same date are supposed to be removed before this step; thus, points with zero velocity corresponds to adjacent points in time of zero distance, which is not realistic. Thus, these points are removed.
F8. On board	Buoys are regularly retrieved and re-deployed in a new location. These paths clearly do not represent the drift of the buoy in the ocean; therefore, 'on-board' points must be removed. For this purpose, a classification system based on velocities and acceleration values estimated between adjacent points is used. Essentially: • First, the points with velocity > 3m/s are flagged as 'on-board' since ocean currents in the Indian Ocean are below this threshold value. • The rest of the points (≤3 m/s), if the velocities during the previous 3 days have also been ≤3 m/s, are classified as 'at-sea' since typically buoys are at sea for at least 3 days. The remaining points are flagged as 'on-board' or 'at-sea' by comparing their acceleration with the distributions of accelerations estimated for constant (sea-sea or on board-on board) and transition (on board-sea and vice versa) sequences. These comparisons are made using the t-test at a confidence level of 0.95. Once the sequence of the points are known the state ('on-board' or 'at-sea') of each point can be deduced from the initially known states. For additional details see Baidai et al. (2017,2022)
F9. Velocity	Finally, a velocity filter is applied to remove the remaining spurious data. The method used was proposed by Hansen and Poulain (1996) and has been used to process several drifter datasets (e.g., AOML and CMEMS drifters). The filter is applied to each trajectory: • The velocity between adjacent points is first measured and a velocity threshold is set to determine if a point is legitimate or not. A point is considered spurious when its velocity exceeds this threshold. This threshold is set as the mean·4·std of the velocity (as in CMEMS drifter datasets) of each trajectory. • When a spurious point is detected, the velocity is calculated with respect the next point… and so on until a velocity (which does not exceed the fixed threshold) is found. • Then, this process is repeated backwards in time (within the trajectory). • If a point is acceptable/not-acceptable for both forward and backward directions in time, it is flagged as good/bad. • For the points which are good/bad for only one direction the direction that has more good points is accepted as the reference. Points with bad data are removed.

Experience with the utulisation of bouy generated data in the IO from 2010 to 2020 serves as the basis for the implementation of a comparable initiative in the WCPO. In the IO, positions were obtained by GPS usually every 24 hours, 99.3 % of the time-gaps between consecutive positions was of 72 hours or less. Once the raw data of the positions were obtained, spurious data (duplicate data, data on land, data on-board etc.) was removed. To that end, data quality control (QC) filters were applied (Table 1). Then, positions were regularly interpolated by the Kriging technique at 6 hourly intervals (Hansen and Herman, 1989; Hansen and Poulain, 1996); and finally, velocities were derived from finite differences of their position fixes using a 12-hour centred scheme.

This process resulted in the removal of 12.68% of the raw data. Trajectories with on-board sequences (which were removed) were split. Also, trajectories with gaps bigger than 3 days were split for avoiding interpolating data between two points which are far from each other (gaps equal or smaller than 3 days account for 99.3% of the data). The interpolation was carried out for obtaining position data every 6 hours. This was achieved by the Kriging technique, which is based on the optimally weighting of the nearby observations of the point to be interpolated (Hansen and Herman, 1989; Hansen and Poulain, 1996). Latitude and longitude data were separately interpolated in time considering the data of the previous and next 5 dates as in Hansen and Poulain (1996). Once the positions were interpolated, the velocities were estimated using a 12-hours centred scheme and then decomposed into zonal and meridional components. A few positions (0.04% of the data) still provided velocities higher than 3 m/s for one of the current components (peak speeds of 2.6 m/s were observed in the Agulhas current (Lutjeharms, 2006)); which were unrealistic and thus, those positions were removed.

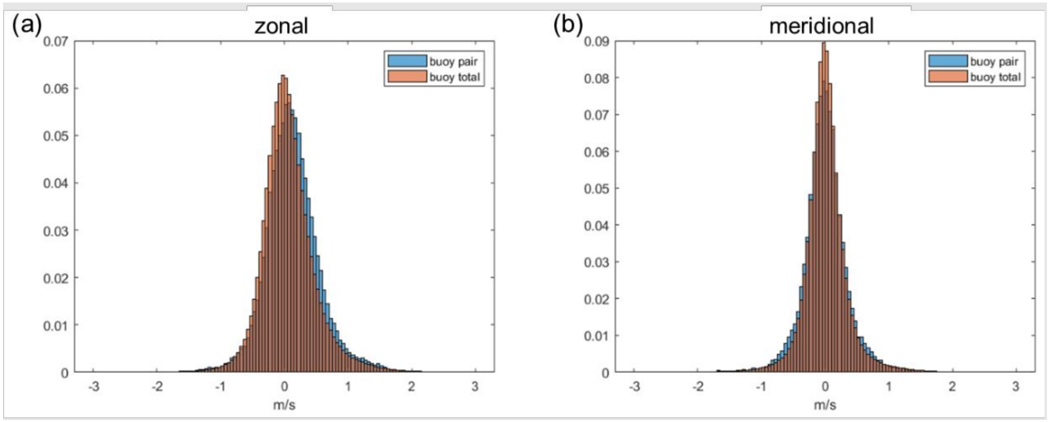

Figure 4. *Normalized histograms of the buoy data considered for the comparison against the total buoy data, compared to the total buoy dataset for zonal (a) and meridional (b) current components.*

The velocity data obtained were compared against drifter data. In a previous study, buoy-derived and drogue (at -15 m) drifter-derived velocities showed quite a good agreement in the Indian Ocean (Imzilen et al., 2019). A similar comparison was carried out for our dataset.

The drifter dataset used was the Global Drifter Program -15 m drogue data[3], which were processed following Hansen and Poulain (1996). The period covered by the drifter dataset is the same as reported by our buoy datasets. To compare buoy-derived against drifter-derived velocities ??the same date and a maximum distance of 10 nm (as in Imzilen et al., 2019) were found and compared. Before carrying out these comparisons, the representativity of the buoy data considered within those pairs was analysed. To this end, the normalized histograms of the total buoy data and the buoy data considered within the pairs were compared for each current component (Fig. 4), showing the percentage of the number of data (Y-axis) corresponding to each velocity value (X-axis). These comparisons provide an idea of the similarity of the data distribution for each dataset and showed a high degree of similarity with a higher percentage of negative (small) values for buoy zonal (meridional) velocities. After concluding that the buoy data used for the comparisons could represent the entire buoy dataset, drifter and buoy datasets were compared. The normalized histograms of each dataset show almost the same distributions of the velocities for each current component (Fig. 5a and b). This agreement is also observable in the time series as shown by a subsample of the series shown in Figure 5c and d. In addition to the good agreement, the results show a low bias between drifter and buoy velocities.

[3] https://www.aoml.noaa.gov/phod/gdp/interpolated/data/all.php

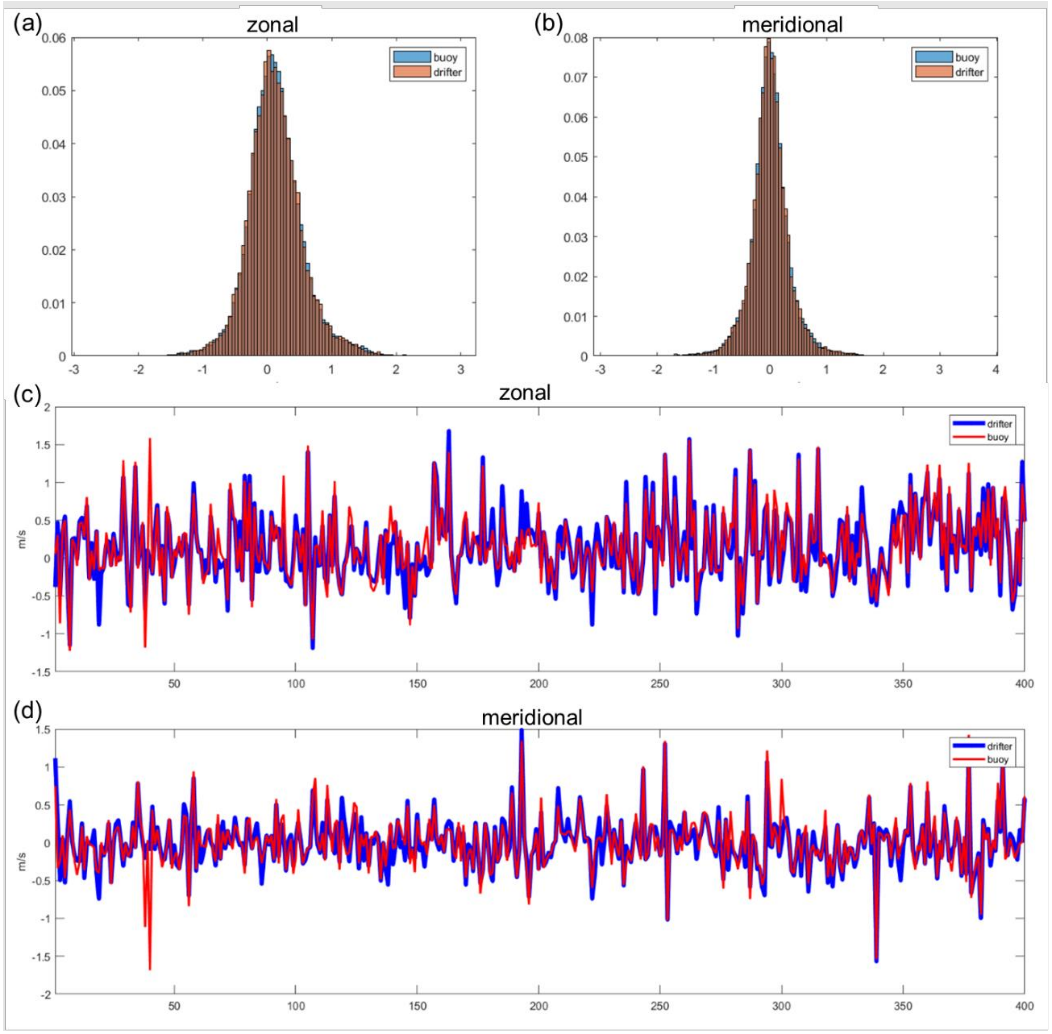

Figure 5. *Normalized histograms of the buoy and drifter data considered for the comparison for zonal (a) and meridional (b) current components. Subsamples of 400 points of the data series of zonal (d) and meridional (d) components of the drifter (blue) and buoy (red)-derived velocities (in m/s).*

The scatterplots of the time series (Fig. 6) show that the clouds of points are relatively well adjusted to the 1:1 isolines of each current component, which represents the perfect agreement between drifter and buoy-derived velocities. In fact, the linear adjustments of the clouds have slope values close to 1 (which corresponds to the above-mentioned ideal isoline), again showing similar distributions and strong linear relationships between both datasets. The correlations between the data pairs are of 90% and 89% for the zonal and meridional components, respectively, once again showing a high agreement. A slight overestimation of the buoy-derived velocities is observed compared to drifter-derived velocities.

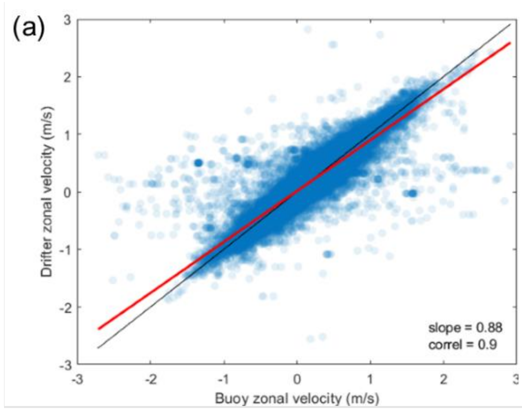

Figure 6. *Velocity comparisons between the buoy and drifter pairs for the meridional (left) and zonal (right) components. The red line indicates the major axis regression model, and the black line indicates the 1:1 isoline.*

Concerning the performance evaluation (Table II), the mean of the absolute value of the difference between both datasets is around 10 cm/s and the root mean square difference (RMSD) values of around 18 cm/s. All these comparisons were made with data pairs that did not correspond to the same position (maximum distance of 10 nm). This means that these error ranges would be lower for pairs that were closer to each other and consequently for values at the same position, than would be the case of a perfect comparison strategy (which is not realistic since it is extremely unlikely to have the same position in the ocean). The RMSD relative (RRMSD) to the root mean square (RMS) of the drifter dataset ranges between 0.42 and 0.48.

Table II. *The mean of the absolute value of the difference between buoy and drifter-derived velocities and its standard deviation (STD), RMSD between both datasets, the RMSD relative RRMSD to the RMS of the drifter dataset and the slope and correlation values shown in figure A2.5 for zonal (U) and meridional (V) current components.*

	<|drifter-buoy|> (STD) (cm/s)	RMSD (cm/s)	RRMSD (=RMSD/RMS_drifter)	Correlation	Slope
U	10.37 (15.64)	18.76	0.42	0.90	0.88
V	9.22 (13.74)	16.55	0.48	0.89	0.86

The depth of the structure attached to the buoys ranges from 3 to 80 meters. In the Indian Ocean the structure is normally shallower than 50 m depth; (Murua et al., 2016). Therefore, the velocities derived from buoy positions are representative of different depths. Nevertheless, given the good agreement between the drifter-derived and buoy-derived currents, the buoy dataset can be considered a robust dataset and the velocities contained in this dataset are considered representative of the same depth as the drifters', that is -15 m.

4.1.2. Currents from ADCP onboard vessels

Acoustic Doppler Current Profilers (ADCPs) installed on vessels enable the measurement of subsurface currents over wide areas. The available dataset in the Indian Ocean contains subsurface current data collected onboard vessels during 2022 (over 20,000,000 observations) at around 7 m depth. Data were collected by Furuno CI-68 ADCPs.

These ADCPs have a triple-beam emission system for providing accurate measurements reducing the effects of the vessel's roll, pitch and heave motions. In deep waters, where ground reference is not available acoustically, the CI-68 can provide current information by receiving position and speed data from a GPS and heading data from a gyrocompass. Therefore, the effect of the motion of the vessel can be corrected. The ADCP system uses the Furuno CIF protocol for data output, but this protocol is proprietary and the specifications are not available. The NMEA-0183 protocol was used instead, which is the de facto standard for the exchange of information between ships' navigation instruments. In this way, the ADCP data are transferred via a serial cable to an Ethernet converter. This dataset contains 1Hz data of current speed and direction at three different depths (-30 m, -75 m, and -120 m). The measurement accuracy of the instruments is: ± 2% of vessels speed + 0.2 kt.

Once the measured currents were corrected for the motion of the vessel, the spurious data were removed. Current speed and direction data are provided and used for quality control (QC). Quality control of ADCP data can also consider other variables such as the echo intensity, the correlation between bins, etc. as suggested by García-Górriz et al. (1997). Since current speed and direction data were available for different positions, the data were QC as fixed vertical profiles based on the QARTOD manual of the Integrated Ocean Observing System (https://repository.oceanbestpractices.org/handle/11329/1004). The QC filters used are listed in Table III and were applied in a sequential way.

***Table III**. Filters applied for QC raw data. They are applied sequentially. Some parameters are generic since they still need to be defined as well as certain filters.*

FILTER	Description
F1. Time	Check that the dates are realistic and increasing in time. Remove the dates which are not realistic and sort the data if they do not increase in time. If dates are duplicated the first one is removed.
F2. Location	Check for realistic locations. Latitudes (longitudes) above or below 90º (180º) and -90º (-180º), respectively, are removed.
F3. Realistic values	Check for current speed values that are not realistic: values above 3 m/s are removed (peak speeds of 2.6 m/s were observed in the Agulhas current (Lutjeharms, 2006)).
F4. Flat line	When some sensors fail, the result can be a continuously repeated observation of the same value. Therefore, when an observation has the same value (or almost the same value within a range of A m/s) as the previous N observations it is removed. If an observation has the same value as the previous N-1 ones, it is flagged as suspicious. The values of N and A must be adjusted depending on the dataset. This test is performed for the zonal and meridional components of the currents.
F5. Spikes	Once the flat line effects are removed the spike test is performed. Outliers are found for values exceeding the mean+C*standard_deviation values estimated for a window of M points cantered at the point at issue. The values of C and M have to be adjusted depending on the dataset. This test is performed for the zonal and meridional components of the currents. Outliers are flagged.

F6. Rate of change	Check that the difference of an observation with respect to the previous one does not exceed a certain threshold. This threshold can be fixed or estimated based on recent variability. This test is performed for the zonal and meridional components of the currents by flagging the points that exceed the threshold.
F7. Current gradient	Check for excessive speed changes of the zonal and meridional components along the water column. When an excessive vertical shear is found all the depths involved are flagged.
F8. Visual inspection	Visual inspection comparing the data series with data flagged, removed and not removed is finally performed. Suspicious flags need to be checked as well as any other uncommon patterns detected.

Once the spurious data were removed, the remaining observations were validated against 6-hourly drifter-derived velocity data at –15 m obtained from the Global Drifter Program (GDP). Although this dataset does not provide temporal high-resolution current data (compared to the 1 Hz data measured by the vessel), the comparisons enable an assessment of the quality of the data in general terms.

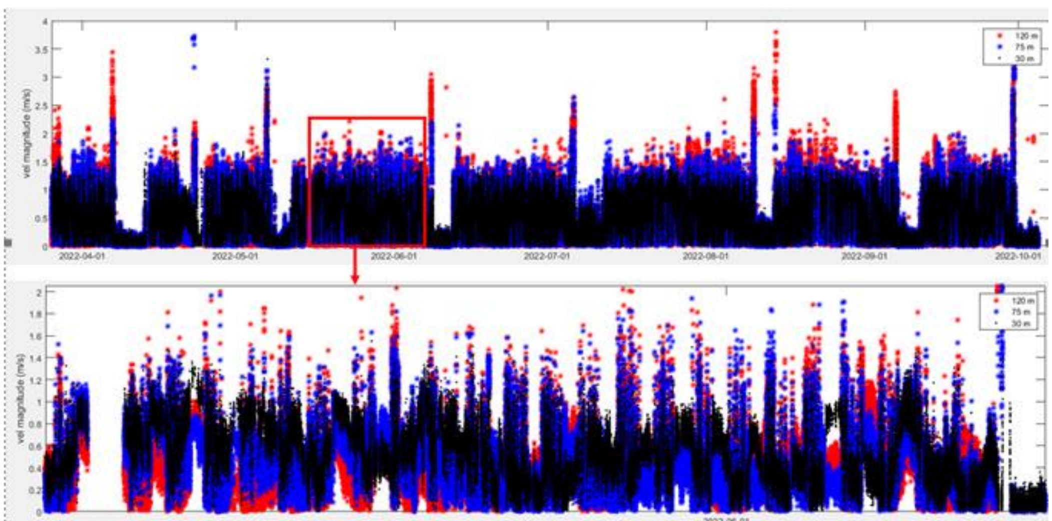

Figure 7. ADCP data time-series examples.

ADCP data were adapted to the GDP product by 6-hourly averaging current and position values to homogenise the data. Then ADCP and drifter-derived velocity data pairs of the same date and a maximum distance of 10 nm (as in Imzilen et al., 2019) were found and compared by estimating the correlations, root mean square differences and scatterplots. Analysis of data collected over a one-year period suggested that the velocities at -120 m were systematically higher and with higher variability than for the other layers. In fact, at greater depths the higher the velocity. We could expect this kind of behavior for some periods but not across one year. After several tests and checking we concluded that the currents were measured with respect to a subsurface reference layer and that the measurements must be corrected to get total currents referenced to a fixed reference system (for making them shareable). To this end, we used the data obtained from the vessel (vessel total speed and direction, vessel speed over water etc.). We extracted the velocity of the reference subsurface layer from the difference between the total speed (and direction) of the vessel and the speed over water. Then we corrected the ADCP measurements since we knew the velocity of the layer they were referenced at (Fig. 7). However, there remained low confidence in the high systematic velocities and variability observed at -120m.

4.2. Other environmental data from devices on vessels

4.2.1. Temperature from ADCP

Data were obtained from external temperature sensors (i.e. thermometers) installed on vessels and connected to acoustic current Doppler profilers (ADCP) which are mainly used for calculating current velocities. The sensors were located at the vessel's hulls at around 7 m depth, thus providing temperature data almost at the surface. Temperature data were quality controlled based on the QARTOD manual of the Integrated Ocean Observing System (IOOS, https://ioos.noaa.gov/ioos-in-action/temperature-salinity/) selecting the filters that best suited the data and adapting them. The QC filters used are listed in Table 1 and were applied in a sequential way. Around 20% of the data were removed mainly due to NaN values (Filter F1 in Table 1).

***Table IV**. Filters applied for QC raw data. They were applied sequentially.*

FILTER	Description
F1. Bad values	Data with no temperature (i.e. not-a-number (NaN)) value were removed.
F2. Time	Check that the dates were realistic and increasing in time. The dates which were not realistic were removed and they were sorted if they did not increase in time. If dates were duplicated the first one was removed.
F3. Location	Check for realistic locations: Latitudes (longitudes) above or below 90° (180°) and -90° (-180°), respectively, were removed.
F4. Realistic values	Check for values that were not realistic: Temperature values below or above 0°C and 40°C were removed.
F5. Spikes	Check for outliers found for values higher or lower than 0.15°C than the previous observation. Outliers were removed.
F6. Visual inspection	Visual inspection of the data series for ensuring that outliers were removed. Uncommon patterns that might remain in the data series were also checked.

This data were compared with SST_GLO_SST_L4_REP_OBSERVATIONS_010_011 product from Copernicus Marine Environment Monitoring Service (CMEMS). This product provides daily reprocessed Level 4 sea surface temperature (SST) data measured from satellites on a 0.05° grid produced by ??Met Office?? using the Operational SST and Ice Analysis (OSTIA) system (Donlon et al., 2012).

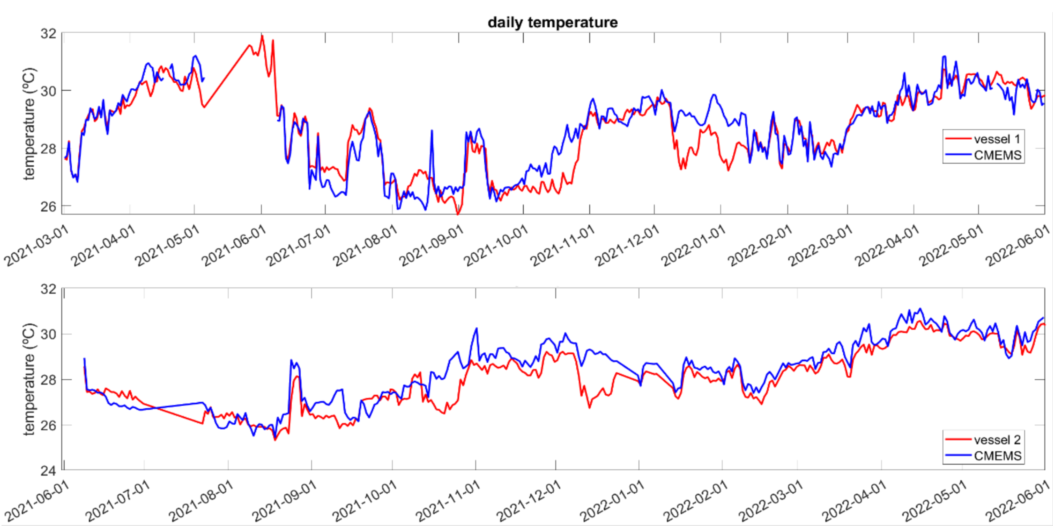

***Figure 8.** Daily temperature (in °C) time series of vessels (red) and CMEMS (blue) for vessel 1 (top panel) and vessel 2 (bottom panel).*

Vessel data were daily averaged for comparison with CMEMS data. Then CMEMS data were interpolated to the vessel positions and correlations, root mean square differences and scatterplots were computed. Note that the periods of the comparisons ranged from the beginning of the series of each vessel until 31 May 2022, which is the latest date when CMEMS data are available. The data series (Fig. 8) show a good agreement between the CMEMS and vessels' data. The main seasonal patterns are detected in both. The scatterplots of the time series (Fig. 9) show that the clouds of points and the linear adjustments of the clouds are relatively well adjusted to the 1:1 isolines, thus representing the good agreement between CMEMS and vessel data. The slight overestimation of the temperature of CMEMS data is also noticeable. Moreover, the correlations show a good agreement (over 91 %) and the root mean square differences are not higher than 0.7 °C (Table V). The slopes of the linear adjustment in Figure 9 are also very close to 1.

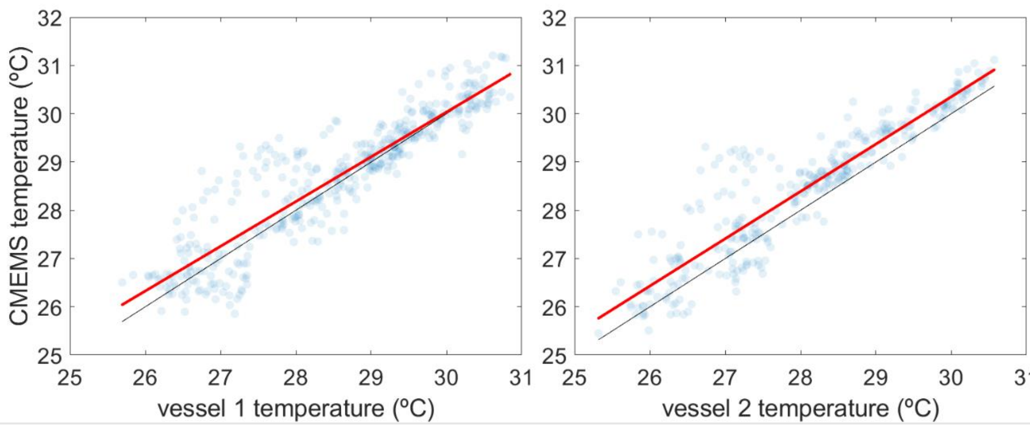

Figure 9. *Temperature comparisons between the vessel and CMEMS. For vessel 1 (left panel) and vessel 2 (right panel). The red line indicates the major axis regression model, and the black line indicates the 1:1 isoline.*

One possible source of discrepancy between CMEMS and vessel data could be that the former corresponds to the surface whereas the latter to the near-surface (at around 7 m depth), thus obtaining slightly higher temperatures for the CMEMS data. Another possible source is that the CMEMS data is an L4 product that has interpolated values when there were gaps in the SST satellite observations. In any case, the agreement is good and the veracity of the vessel temperature data is demonstrated. It must be also considered that CMEMS data has its own error since it is the result of satellite data analysis and modelling. Since the temperature sensors are located at around 7 m under the water, this is the depth that is going to be considered for the datasets. For the final products, temperature measurements were hourly averaged to provide 1-hour temporal resolution datasets.

Table V. *Correlation, root mean square difference (rmsd) and slope of the linear regression (shown in Figure 2) values of the comparisons between the temperatures of vessels 1 and 2 vs CMEMS.*

	Ves. 1 vs CMEMS	**Ves.2 vs CMEMS**
correlation (%)	91.01	91.94
rmsd (°C)	0.57	0.67
slope	0.93	0.98

4.2.2. Winds from anemometer

The wind data come from anemometers, placed on vessels, that measure the speed and direction of the wind relative to the vessel. Therefore, to establish the true wind speed and direction (relative to the true North), it is necessary to compensate for the vessels' speed and heading. Anemometers were positioned on the foreside of the bow pole as far as possible from the vessel structure and at around 7.5 m from the deck to reduce disturbances. Then the possible effects of the pole or other structures near the anemometer in the measurements were analysed and measurements were adapted when necessary, as explained in the following section. The true speed and direction data were quality controlled (QC) based on the QARTOD manual of the Integrated Ocean Observing System (IOOS, https://doi.org/10.7289/V5FX77NH) selecting the QC filters that best suited the data and adapting them if needed (Table VI).

***Table VI**. Filters applied for QC raw data. They were applied sequentially.*

FILTER	Description
F1. Time	Check that the dates were realistic and increasing in time. The dates which were not realistic were removed and they were sorted if they did not increase in time. If dates were duplicated the first one was removed.
F2. Location	Check for realistic locations: Latitudes (longitudes) above or below 90° (180°) and -90° (-180°), respectively, were removed.
F3. Realistic values	Check for direction and speed values that were not realistic. Direction values below or above 0 rad and 2π rad were removed, while speed values higher than 100 m/s were removed as well.
F4. Flat line	When some anemometers fail, the result can be a continuously repeated observation of the same value. Therefore, when an observation had the same value or almost the same value (within a range of 0.001 m/s and 0.001 rad for speed and direction respectively) as the previous 1 and/or 2 observations it was removed.
F5. Spikes	Check for outliers found for values higher or lower 8 times the standard deviation from the mean within a moving window of 200 observations for each observation. Outliers were removed. This filter was applied to speed data and not for the direction due to the gap from 0 and 2π radians.
F6. Visual inspection	Visual inspection of the data series for ensuring that flat lines and outliers were removed.

After the QC, approx. 4% of the data were removed. Once the observations were QC, the effects of the pole or any other structure on the wind measurements were analysed. To this end, marked changes in the intensity of the average wind speed when the wind blew from specific directions in the reference system of the vessel (i.e. apparent wind) were analysed. Then, dates corresponding to problematical apparent wind direction data were removed. In Figure 2 the average true wind speed with respect to the direction in the reference system of the vessels shows a decrease in the intensity when the wind blows from the bow and stern of the vessel. Given the dimensions of the pole and the distance of the anemometer to it, the measurements of the winds blowing from the stern and within a range of 25° (i.e. 180° ± 25°) should be affected by the pole as observed in the Figure. In addition, a decrease in the wind intensity was observed for winds blowing from the bow probably due to the perturbations caused by the structures located nearby in that direction even if they are located at a different height than the anemometer. Thus, based on the intensities observed in Figure 10, winds coming from the bow within a range of 35° (i.e. 0° ± 35°) were also removed. All these removals caused the elimination of 15.72 % and 22.83 % of the remaining data for vessels 1 and 2 respectively.

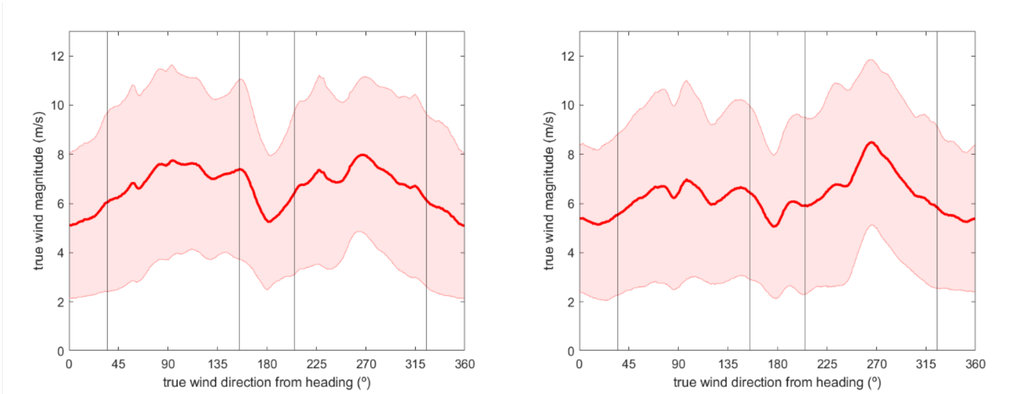

Figure 10. *Average true wind (Y-axis) relative to each wind direction with respect to the vessel heading (i.e. in the system of reference of the vessel; X-axis) for vessels 1 (left) and 2 (right). The shaded areas show the standard deviation of the averages. The vertical black lines show the angle thresholds used for the removal of measurements affected by the structures of the vessel.*

Anemometer data were compared against the WIND_GLO_PHY_L4_NRT_012_004 product from Copernicus Marine Environment Monitoring Service (CMEMS). This product provides hourly Level 4 information with a resolution of 0.125°. The product is a result of a combination of numerical models and satellite observations. In addition, ERA5 hourly data provided a second source. This product is the fifth generation ECMWF reanalysis for the global climate and weather and combines model data with observations from across the world with a resolution of 0.25°.

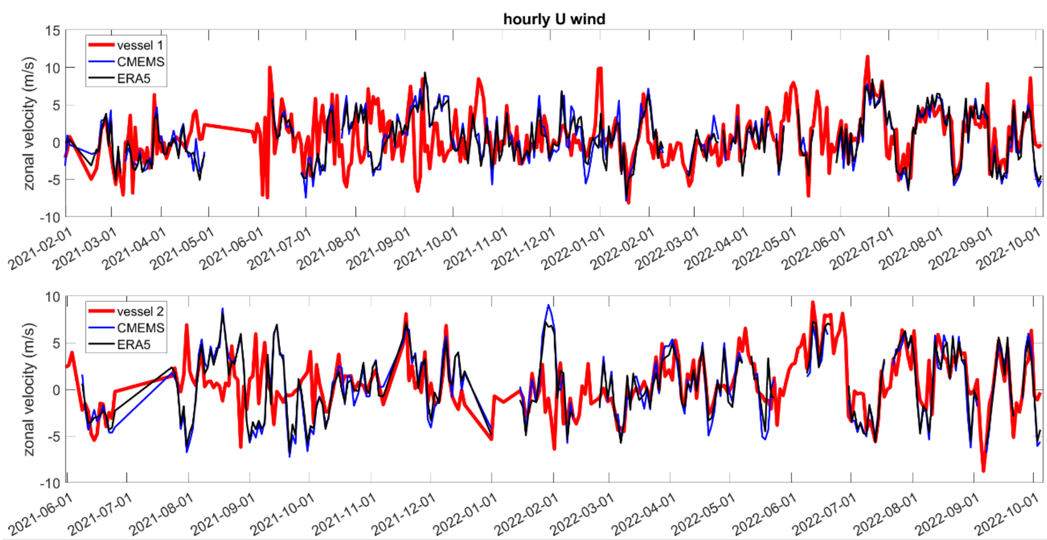

Figure 11. *Hourly zonal (top panel) and meridional (bottom panel) wind speed (in m/s) time series of vessel 1 (red), CMEMS (blue) and ERA5 (black).*

In order to make the datasets comparable, anemometer data were adapted by hourly averaging wind and position values and decomposing speed and direction into zonal (U) and meridional (V) components. Then CMEMS and ERA5 data were interpolated to the anemometer positions and correlations and root mean square differences were computed. The anemometer data were additionally smoothed to remove excessive variability. Note that the anemometer data used for the comparisons ranged from the beginning of the series of each vessel until 4 October 2022 (using more than one year of data in both cases). The data series (Figures 11 and 12) of both wind components show a fair agreement between anemometers and CMEMS/ERA5 data. The main seasonal patterns are detected in the three datasets.

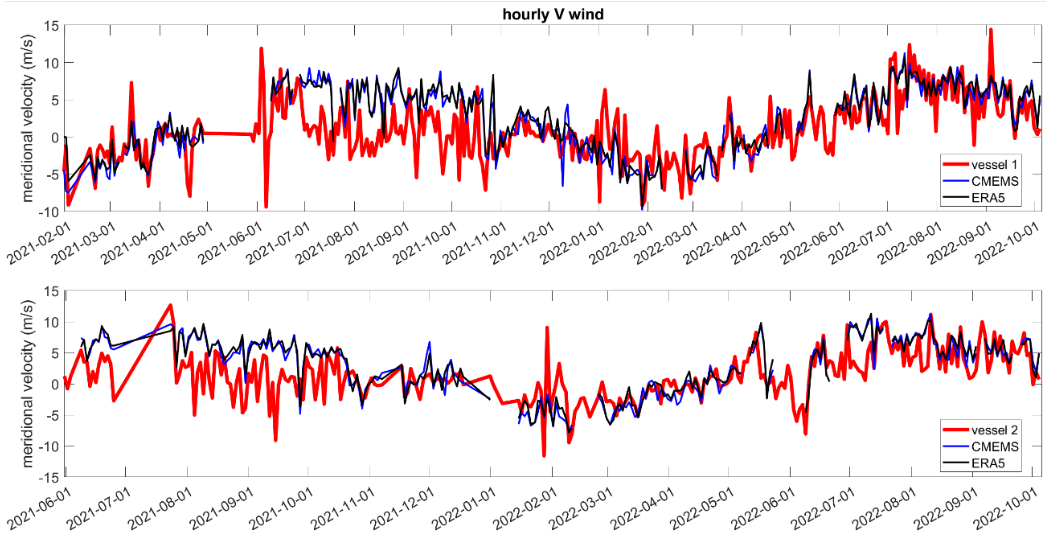

Figure 12. *Hourly zonal (top panel) and meridional (bottom panel) wind speed (in m/s) time series of vessel 2 (red), CMEMS (blue) and ERA5 (black).*

The correlations also show a relatively good agreement (between 47 and 65%) and the root mean square differences are not higher than 4 m/s (Table VII). Higher agreements are unlikely since the CMEMS/ERA5 data is the output of models and not direct observations.

Table VII. *Correlation and root mean square difference (rmsd) values of the comparisons between anemometer of vessels 1 and 2 vs CMEMS and ERA5 for zonal (U) and meridional (V) wind components.*

	correlation (%)				**rmsd (m/s)**			
	Ves. 1 vs CMEMS	**Ves. 1 vs ERA5**	**Ves.2 vs CMEMS**	**Ves. 2 vs ERA5**	**Ves. 1 vs CMEMS**	**Ves. 1 vs ERA5**	**Ves.2 vs CMEMS**	**Ves. 2 vs ERA5**
U	47.14	50.29	51.79	55.26	3.42	3.25	3.32	3.10
V	63.08	63.51	64.08	64.95	3.90	3.88	3.81	3.75

5. Data assimilation and accessibility

The two previous chapters have shown the capacity and suitability of data collection (species and environmental) by purse seine fishing vessels as vessels of opportunity. However, for this data to be useful and available, it is needed that certain principle are followed (FAIR, CARE, TRUST) in section 5.1, and that the data is appropriately assimilated in global data initiatives as described in the rest of sections.

5.1. FAIR, CARE and TRUST data principles

To make data accessible, interoperable and reusable for both humans and computers, it is important to ensure that the data is useful and manageable (Huber, 2021). A set of principles for scientific data management and stewardship have been created with the aim of making the data accessible to anyone with a minimum of easiness: the Findable, Accessible, Interoperable, and Reusable (FAIR) principles which were the first to be created with the aim of improving data accessibility and reuse (Wilkinson, 2016). Data uploaded to aggregators or repositories ensure data availability for the final users. However, unless data is correctly documented its use may be limited. FAIR principles (Fig. 13) aim to ensure a continuum of increasing reusability of rigorously evaluated data (e.g., Wilkinson et al., 2016; Sagarminaga et al., 2017). These guidelines were defined to give support to the Open Science movement, adopted by the European Council (Mons et al., 2017). Our recommendation is to follow the FAIR data principles using the recommendations provided in the OceanObs19 white paper (Tanhua et al., 2019).

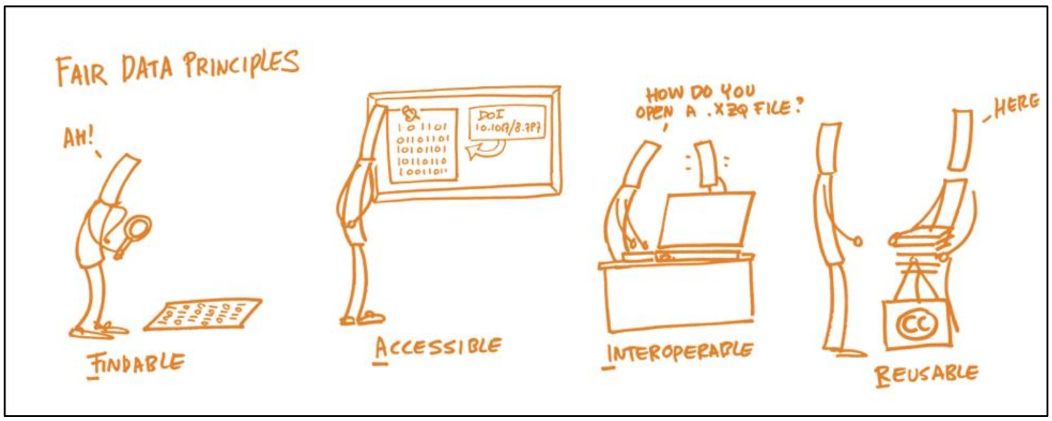

Figure 13. *Sketch of the different components of the FAIR principles (https://book.fosteropenscience.eu/).*

Each letter of FAIR refers to a group of principles that, in total, make 15 principles. If the data comply with the four fundamental principles, the data in question can be reused by other computers:

- Findable: Digital resources must be easy to find on both humans and computers. Metadata must be extensive for computers to identify relevant datasets and services.
- Accessibility: Protocols for retrieving digital assets should be explicit, including well-defined mechanisms for obtaining authorization to access protected data.
- Interoperability: When two or more digital resources are related, information can be merged. When processing data, the computer should be able to detect the conformity of the data, and for this, the semantics of each resource is important.

- Reusability: If the digital resources are sufficiently well described, the authorizing officer should know what task to use them for, whether they can be reused and under what conditions and to whom the use can be credited.

For each fundamental principle to be fulfilled, each must fulfil different principles. In total there are 15 principles that describe how the data must be to follow the FAIR principles (Jacobsen et al., 2020).

Within the fundamental FINDABLE principle, there are four principles:
F1: Data and metadata must have a unique and persistent identifier. For example, a DOI.
F2: The data should have well-described metadata to facilitate search and filtering.
F3: The metadata must contain the identifier of the data it describes.
F4: Data and metadata must be registered or indexed in a searchable repository.

In turn, the fundamental principle of ACCESIBILITY has four principles.
A1: Data and metadata must be retrieved via their identifiers using a standardized communication protocol.
A1.1: The protocol must be open, free and universally applicable.
A1.2: The protocol allows for authentication and authorization if necessary.
A2: The metadata must be accessible even if data are not available.

The fundamental principle of INTEROPERABLE is based on three principles:
I1: Data and metadata should use formal, accessible, common, and widely applicable language to represent knowledge.
I2: Data and metadata should use vocabulary that follows FAIR principles. For example, the "Web Ontology Language".
I3: Data and metadata must include references to other data and metadata.

The fundamental principle of REUSABILITY combines four principles.
R1: Data and metadata must be described in detail with a plurality of accurate and relevant attributes.
R1.1: Data and metadata must be published with a clear and accessible licence.
R1.2: Data and metadata must be associated with detailed provenance.
R1.3: Data and metadata should comply with relevant industry standards.

The TRUST principle (Lin, D. 2020) aims to create trusted data repositories based on five principles. These five principles focus on the trustworthiness of the data repositories. TRUST comprises the following principles, which, in turn, make up the word that gives them their name: Transparency, Responsibility, User focus, Sustainability, and Technology.

TRANSPARENCY discusses making a data repository as appropriate as possible by ensuring that the mission and scope of the repository are clearly stated. In addition, they should be transparent in the following respects:
T1: Conditions for use of both the repository and data.
T2: Minimum period of digital data preservation.
T3: Any relevant additional features or services, for example, the ability to manage sensitive data responsibly.

RESPONSABILITY stresses that repositories must take responsibility for managing the data and serving the community. Repository users must trust that data depositors are encouraged to provide metadata and comply with community standards. To this end:

R1: Metadata must conform to standards and standards preservation, furthermore along with data should be required technical validation, documentation, quality control, authenticity protection and long-term persistence.
R2: Manage the intellectual property rights of data producers, the protection of sensitive information resources, and the security of the system and its contents.

USER FOCUS. The use and reuse of research data is an important part of the scientific process; therefore, TRUSTworthy repositories should make it easier to find, explore and understand data.
Repositories should encourage the provision of as much information as possible regarding the data at the time of deposit to facilitate data understanding and interoperability. It is essential for repositories to follow norms and standards in metadata, file formats, vocabularies, ontologies and other semantics. This facilitates the interoperability. TRUSTworthy repository should
U1: Implement data metrics and make them available to the users.
U2: Provide community catalogues to facilitate data discovery.
U3: Monitoring and identifying evolving community expectations and meeting changing needs.

SUSTAINABILITY. To ensure uninterrupted access to a repository, it is important that the repository is sustainable. To this end, it must comply with the following criteria:
S1: Plan well for risk mitigation, business continuity, disaster recovery and succession.
S2: Secure funding to enable continued use and to maintain desirable data properties.
S3: Provide the necessary governance for long-term data preservation so that the data can remain accessible.

TECHNOLOGY. Repositories are maintained through software, hardware, and technical services. A repository should have the following technological capabilities.
T1: Implement relevant standards, tools and technologies for data management and preservation.
T2: Plans and mechanisms in place to prevent, detect and respond to cyber and physical security threats.

To summarize the above principles, FAIR focuses more on data that are easy to identify and find, well-described, interoperable with other data and able to have more than one use. The CARE principle seeks to ensure that the data respects, in this case, Indigenous Peoples and that, in turn, Indigenous Peoples themselves can use the data and benefit from it. This principle provides a more social vision of the data and reminds us that data are not just numbers. TRUST focuses on making the data repositories trustworthy. For this, among other things, they must be clear about the conditions of use, data and metadata must comply with norms and standards and repositories must be constantly updated. The future of the repository must be guaranteed to ensure access to the data.

Wide differences in interpreting FAIR principles lead to misapplications, which minimize their interoperability and reusability. Partly because of this, representatives of the digital repository community developed the TRUST principles with the aim of demonstrating the reliability of repositories (Kinkade, D. 2021; Lin, D. 2020). A dataset may adhere to the FAIR principles, but be suspect in terms of its quality or integrity status to allow reuse in research (Kinkade, 2021). The goal of FAIR and TRUST is to enable computers to identify and handle the data of interest and to be able to perform data analysis on that data. In this way, we can minimize time and cost and be more sustainable by using a dataset for different uses. From the planning stages of a research project, researchers should consider the types of data to be produced and inform themselves of the vocabularies available in the community, file formats, unit conventions and specific existing repositories (Kinkade, 2021).

In terms of accessibility and trust of oceanographic data, tools or practices aimed at data interoperability are now available (Argo Programme, Environmental Research Division Data Access Programme (ERDDAP), Ocean Data View (ODV), Thematic Real-time Environmental Distributed Data Services (THREDDS), etc.). However, this underlines the need for data management planning and the adoption of FAIR principles, which will be implemented in the next decade according to the authors (Tanhua, 2019). Many of today's data repositories follow FAIR principles, although the vast majority do not meet all the requirements in terms of data handling, formatting, and compliance (Schmidt, 2020). However, according to Schoening (2022), marine imagery data is a problem because it is difficult to homogenize and create norms and standards for metadata as it is made up of many variables that are highly changeable compared to other data that may be simpler. According to Schoening (2022), the Planetary Data System (PDS4) standard is the best fit for these data, although it is not used because it does not cover all the requirements of marine science. The authors propose the image FAIR Digital Objects (iFDOs) standard for homogenization and compliance with FAIR principles.

In short, marine and oceanographic data have already started the process of meeting the principles of being accessible, interoperable, and trustworthy, although there is still a long way to go. There are also institutionally led repositories containing marine and oceanographic data that are within the World Data System and/or CoreTrustSeal, which ensures that the data meet a minimum of the above-mentioned principles. In addition, the WDS has developed a prototype data portal with the aim of bringing together data from WDS members' catalogues, which was hosted by Pangaea. Registries such as FAIRsharing and Re3data, which have 743 identified geoscience repositories, can help locate suitable repositories to share their data. However, selecting the correct repository is not always easy (Enabling the FAIR Data Community et al., 2018). Kinkade et al. (2021) stress the importance of creating specialised domain repositories, in this way, repositories bring expertise to the process of data management, because they can bring together scientific knowledge and information management. Therefore, TRUST principles are also of vital importance.

5.2. GEOSS global organization

The Global Earth Observation System of Systems (GEOSS)[4] is a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations within GEOSS. Further, GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services. Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making: it provides access to data, information and knowledge to a wide variety of users. Within GEOSS, oceans are covered by **Global Ocean Observing System** of the Intergovernmental Oceanographic Commission of UNESCO (IOC GOOS) in coordination with the United Nations World Meteorological Organization (WMO). The GOOS currently subdivides in the following regional alliances covering worldwide oceans and seas (Fig. 14):

- Black Sea GOOS[5] integrates by institutions from 6 Black Sea countries: Bulgaria, Georgia, Romania, Russian Federation, Turkey, Ukraine.
- EuroGOOS[6] adhere 44 Members from 18 European countries.
- GOOS Africa[7] adhere by 36 African Member States.
- GRASP[8] coordinates 12 Institutions from 4 countries.
- IOCARIBE-GOOS[9] is composed by 30 American Member States.
- IOGOOS[10] has 29 organizations from 17 countries in the Indian Ocean.
- MONGOOS[11] coordinates 48 Partners from 14 countries around the Mediterranean Sea.
- NEAR-GOOS[12] networks 8 organizations across China, Japan, Korea, and Russia.
- OCEATLAN[13] assembles 15 Institutions in 3 countries: Argentina, Brazil & Uruguay.
- U.S. IOOS[14] agglutinate 17 U.S. Federal agencies and 11 U.S. IOOS Regional Associations.
- SOOS[15] includes SC members, representatives, data committee members, and national representatives worldwide with interest on Southern Ocean.
- SAON[16] collaborates closely with its partners and other prominent Arctic and international organizations as well as with the Arctic Council Permanent worldwide.
- **PI-GOOS**[17] groups 21 Pacific Island Countries and Territories & 5 Metropolitan Members (Australia, France, New-Zealand, United Kingdom & Unites States).

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[4] https://www.earthobservations.org/geoss.php
[5] https://goosocean.org/index.php?option=com_content&view=article&id=38&Itemid=425
[6] https://goosocean.org/index.php?option=com_content&view=article&id=31&Itemid=425
[7] https://goosocean.org/index.php?option=com_content&view=article&id=43&Itemid=425
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[14] https://goosocean.org/index.php?option=com_content&view=article&id=44&Itemid=425
[15] https://www.soos.aq/
[16] https://www.arcticobserving.org/
[17] https://goosocean.org/index.php?option=com_content&view=article&id=40&Itemid=139

- **SEAGOOS**[18] has 21 Member States of the IOC Sub-Commission for the Western Pacific**.**
- **IMOS**[19] is formed by 8 institutions within Australian National Innovation System.

[18] https://goosocean.org/index.php?option=com_content&view=article&id=45&Itemid=425
[19] https://goosocean.org/index.php?option=com_content&view=article&id=48&Itemid=425

5.3. Data assimilation and accessibility within GEOSS in Pacific Islands

The main regional alliances of interest for this project are PI-GOOS, which is focussed on PICs, SEAGOOS and IMOS. Responsibility for the functioning of PI-GOOS was with the Secretariat of the Pacific Regional Environmental Programme (SPREP) from 1998-2023. This responsibility has recently been transferred to the Pacific Community (SPC)..

The potential for improving the calibre of VOS collected data is determined by the infrastructure and systems that are in place within PI-GOOS, SEAGOOS and IMOS to assimilate the data generated and make it available to the scientific community and other potential uses (e.g. companies generating services or policy makers) through GOOS/WMO. The ingestion process should be based on the different types of variables using the best expertise and systems already in place (cost effective and faster). Given that the broader membership of SPC includes, Australia, France, New Zealand, United Kingdom and United States of America there is opportunity to utilise existing expertise and systems, such as data centres, in these countries.

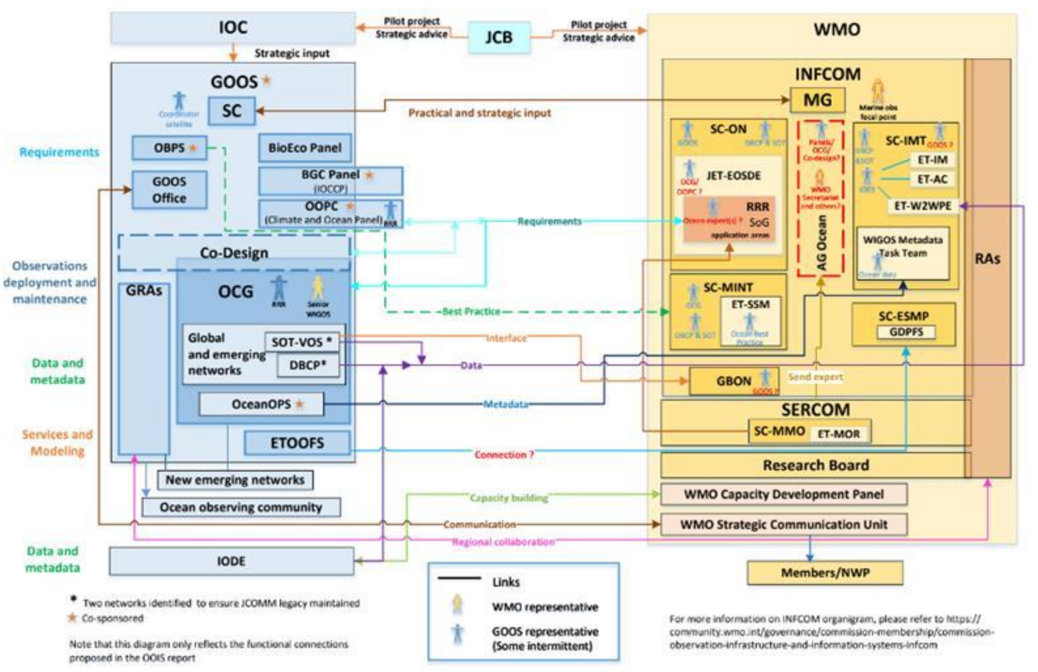


Figure 15. *LEGOS salinity data assimilation within IOC/GOOS/WMO.*

Several existing data centers or systems that can be used include PacIOOS[20] in the North West Pacific wichwhich has significant expertise in relation to waves, currents, temperature and salinity data. In terms of expertise on ocean currents measured by Shipboard Acoustic Doppler Current Profilers (SADCP) from global oceans as part of the Joint Archive (JASADCP) since 1985 the NOAA[21] are a reference. The Sea Surface Salinity Observation Service from Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS)[22] in France has expertise in salinity from VOS (Fig. 15). TPOS is a collaborative international project that represents the collective recommendations of a group of scientists and stakeholders which members linked to GOOS, Mercator-Ocean, European Space Agency (ESA) and National weather agencies worldwide also have useful infrastructure and expertise. Since 2006, the Integrated Marine Observing System (IMOS) has been routinely operating a wide range of observing equipment throughout Australia's coastal and open oceans including VOS[23], making all of its data accessible to the marine and climate science community, other stakeholders and users, and international collaborators. IMOS is one of the national research infrastructure capabilities currently supported under the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS).

5.4. Synergies with EuroGEOSS

EuroGEOSS, launched in 2017, is Europe's part of the Global Earth Observation System of Systems (GEOSS). It brings together all the Earth observation resources available in Europe. One of the key European contributors in GEOSS is **Copernicus** managed by the European Commission which is one of the organizations within WMO. EuroGEOSS uses the Copernicus program which develops **information services** based on data from space satellites and other sources. Another key organization for ocean observation and member is **EuroGOOS**, the European component of the **Global Ocean Observing System** of the Intergovernmental Oceanographic Commission of UNESCO (IOC GOOS). EuroGOOS identifies priorities, enhances cooperation and promotes the benefits of operational oceanography to ensure sustained observations are made in Europe’s seas underpinning a suite of fit-for-purpose products and services for marine and maritime end-users. EuroGOOS **DATAMEQ working group** supports harmonization and integration of European marine data. DATAMEQ WG works with the main European aggregators of marine data (Copernicus Marine Service, SeaDataNet and EMODnet) and with the **EuroGOOS Task Teams** which develop specific Ocean Best Practices for each observing platform.

The Copernicus Marine Service relies on a network of European marine data producers that provide state-of-the-art scientific knowledge to build a portfolio of ocean data products. The CMEMS producers are categorized into two types: 1) **Thematic Data Assembly Centers (TAC)** process data acquired from satellite ground segments and *in situ* observations into real-time (today) and reprocessed (20 years historic) products; and, 2) **Monitoring and Forecasting Centers (MFC)** run ocean numerical models assimilating the above TAC data to reanalyse (20 years in the past), analyse (today) and 10-day forecasts of the ocean. For physical variables, we work mainly with two CMEMS producers: The **In Situ Thematic Centre (INSTAC)** for studying the integration of new observations and the **Global Monitoring and Forecasting Center (GLO MFC)** for evaluating the impact of these inputs for the products at global level. The mission of

[20] https://www.pacioos.hawaii.edu/
[21] https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:NCEI-UH-JASADCP
[22] http://www.legos.obs-mip.fr/observations/sss/
[23] https://imos.org.au/facilities/shipsofopportunity

INSTAC is to provide integrated in situ products built from in situ observations acquired from outside Copernicus Marine Service data providers to fit the needs of Copernicus Marine Service internal and external users. The mission of **GLO MFC** is to provide marine data (waves, currents, temperature, salinity, sea level and biogeochemistry) for the world's oceans, including the Atlantic, Indian, Pacific, Arctic and Antarctic oceans as well as the European seas. GLO MFC uses information from both satellite and in situ observations, combined with ocean models established within operational production and service environments, to provide state-of-the-art reanalysis, analysis and forecasts. The integration of new ocean data through **INSTAC** produce impacts on the other main European aggregators of marine data: **EMODnet** (European Marine Observation and Data Network) and **SeaDataNet** (pan-European infrastructure for archiving historical data). The pilot project will have to identify clearly the Pacific equivalent to task teams and INSTAC (Fig. 16).

Figure 16. *Diagram of GEOSS organization in Europe.*

6. Pilot project of digitalizing a typical purse-seine vessel and data transmission of the data to user groups

The project design and estimated costs are based on real costs of recent vessels installations and digitalization (e.g. DataBio and SusTunTech projects in the Indian Ocean, hoppers in all oceans, engines in Bay of Biscay) and acoustic scientific campaigns needed to calibrate acoustic data processing algorithms.

6.1. Overall architecture

This section provides an overview of the installation of the main monitoring system components onboard based on a tuna vessel installation in Indian Ocean from SusTunTech project is presented since to the best of our knowledge this is the most complete and similar to this project needs. This approach takes advantage of the use of already VSAT connection to communicate with FADs (in this example Marine Instruments company as buoys and technological provider). Other approaches focus data recording using WIFI connection when vessels approach the port, but these do not have to deal with vessels needing buoys data in real-time. The example of SusTunTech has been used in previous sections and here due to the similarity of vessels (tuna purse seiners) and our access to this project data. The main goal of the SusTunTech project is to develop methods and tools to facilitate a more efficient and sustainable tuna fishery. To achieve this goal, the project aims to combine in situ data with marine environmental and biological data obtained from the Copernicus Marine Environment Monitoring Service (CMEMS). Based on these data sources, tools will be developed to help tuna fishing companies optimize their operations and contribute with in situ measurements to CMEMS (Fig. 17).

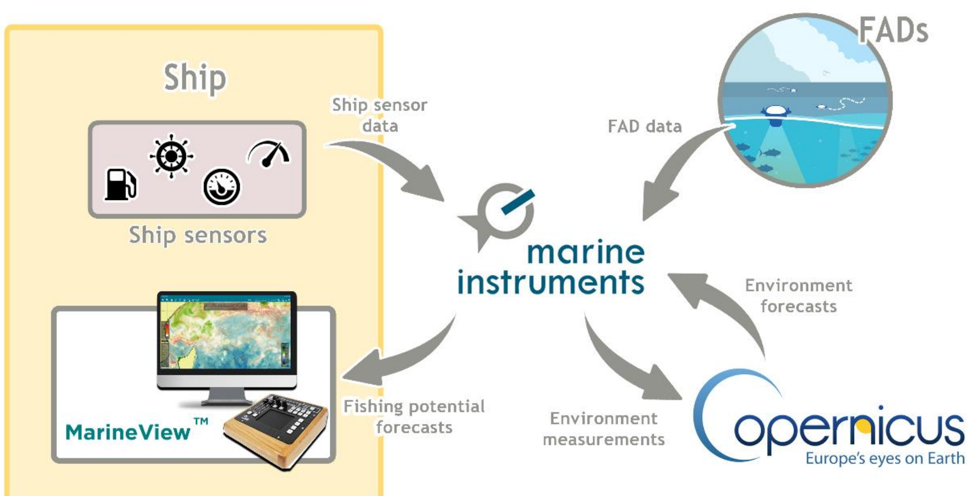


Figure 17. *A global overview of the SusTunTech System to collect environmental data from vessels and return decision Support information.*

6.2. Installation and operation costs

Fishing vessels are notoriously heterogeneous with respect to onboard installed sensors, data protocols and network topology. This is a major obstacle for both collecting data from vessels, but also for local data exchange on board vessels. Non-harmonised data collection and recording requires tailor-made ad hoc integration against individual sensors, instead of interfacing a central hub which again integrates against the individual sensors and onboard systems. In effect, this makes it difficult to achieve the otherwise usual large-scale synergies found in other kinds of industrial processes. Here we use the example of a vessel digitalized in SusTunTech project. SusTunTech aims to collect information valuable for improving oceanographic forecasts, as well as information for analysing how ship energy consumption is affected by oceanographic conditions (Fig. 15). To achieve this, information must be measured within time frame and geographical position records. Furthermore, the commercial products must integrate to vessels with different configurations and sensor equipment. An important aspect of SusTunTech is therefore to develop the tools and methods facilitating such integration. As many of the necessary sensors, wiring and other components are already installed in many fishing vessels, transference of project results to other fishing vessels should therefore be possible with a minimum development cost. This should increase the marketability of the final product. In addition, it is a cost-effective way of capturing data for improving Earth Observation services. The installations (Fig. 18) are in the engine room (ER), the engine control room (ECR) and the wheelhouse (W/H). A dedicated Ethernet network is mainly used for data communication between the different locations and onboard vessel systems. The onboard data exchange network is formed by two interconnected switches, one in the wheelhouse and another in the engine control room. Some components are connected directly to this network, such as the Ratatosk server, while many sensors are connected through converters. The Ratatosk server is also connected to a managed switch of the ship's own network to use the ship's VSAT system for data transmission and systems maintenance.

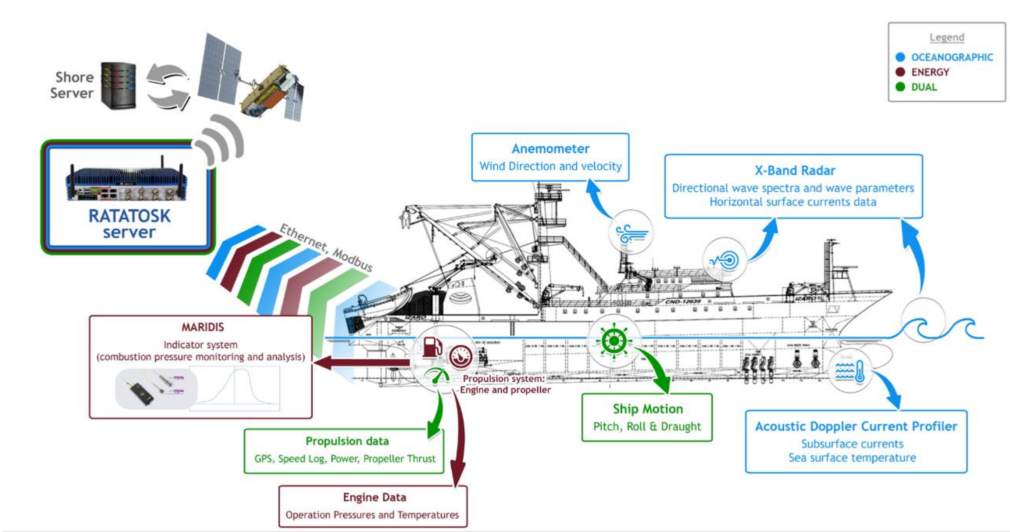


***Figure 18**. Data acquisition and monitoring system scheme. Components measuring oceanographic data in blue, components measuring energy consumption in red, and in green dual components needed for data synchronization or to consider when using oceanographic and energy data measurements.*

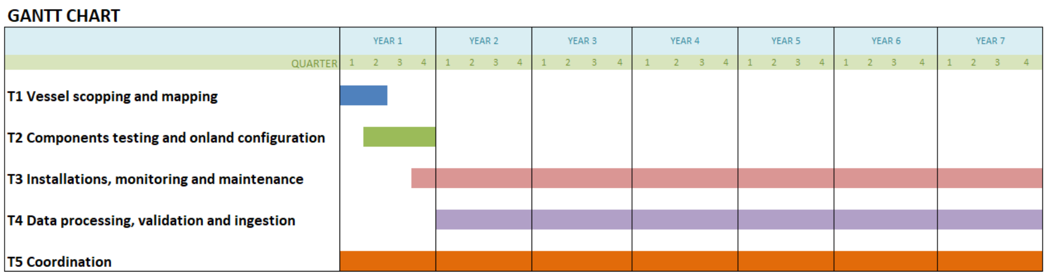
The installation and operational costs assume that participating vessels do not have existing systems that can be used. The budgeting assume that full installations will be required. The budget is described on a per vessel basis considering a 7 years project. Person months are budgeted at $17 000 considered an average from a range of junior to senior staff considering a long-term project of 7 years.

	Unit	USD
Purchase of EK80 is a high-precision scientific echo sounder	Per sounder	$200,000
Purchase of ADCP system	Per vessel	$15,000
Installation of EK80 mad ADCP installations	Per vessel	$50,000
Purchase of Anemometer	Per vessel	$2,000
Purchase of Ratatosk (data aggregator and backup, hardware and license)	Per vessel	$10,000
Installation of vessel instrumentation and networking	Per vessel	$25,000
Onshore data storage and processing capacity (computing cluster, 2 modules)	Per vessel	$40,000
Purchase and installation of electronic monitoring system with species identification	Per vessel	$15,000
Buoys (50 per year for 6 years, i.e. 300 buoys and $1200 per buoy)	Per vessel or fleet	$360,000
Equipment calibration	Three months per vessel	$51,000
Equipment maintenance and repair	Per vessel (6 years)	$60,000
VSAT connection	Per vessel (7 years)	$42,000
Coordination	One month per vessel and year (7 month for 7 years)	$119,000
Data post-processing, validation and ingestion into appropriate platforms	Four months per vessel and year (24 months for 6 years)	$408,000
Total per vessel for 7 years project		$1,397,000

This is a broad estimation considering that there are high uncertainties in cost of equipment, the availability of technicians and installation and maintenance costs. This budget is per vessel, but the number of vessels is large enough the prices can be negotiated, and multiple vessels installed on single technician trips. Some maintenance costs might be reduced if there are observers' programs that can help to reduce technicians' interventions or crew skilled enough to learn basic systems maintenance or interventions. Calibration time per vessel might be highly reduced depending on the similarities and differences among vessels. Similarly with coordination, data post-processing and validation, the more vessels the less time per vessel due to shared resources and automatization. The use of a limited number of ports for installation and maintenance would also reduce costs. Our recommendation would be to install at least two vessels in case there are failures with one of the vessels considering that it is likely that considering shared costs would be likely around 1,000,000 per vessel.

6.3. Pilot project timeline (Gantt chart)

The Gant Chart below shows the timeline of tasks. The first year would be the most intense in terms of number of tasks and timing since concentrates all related with the setup and installations. From year two, the main tasks are maintenance and monitoring of systems and data (T3), and the FAIR data processing, validation and ingestion by the scientific platforms.



Stage 1 (Year 1)

During the first half of the project the vessels should be visited to take measurements, see the different spaces and any devices installed. This will be used to design where each system will be installed and the needs for data network within the vessel. This includes connectivity of all devices with Ratatosk and its connection with VSAT connection. Afterwards (or meanly if possible) the system will be built and configured on land for testing and setup which reduces effort later in installation and maintenance (Fig. 19). Hopefully, the main installation on the vessel is likely to be made within this year. But, it is strongly dependant on vessel and technicians availability. The aim is to disturb as little the vessel fishing operations which is key for good collaboration with the crew. The travelling for vessels scoping can be used also to better scope the capacities of current GOOS agreements of organizations in the Pacific (i.e. PMC) for data ingestion and current data protocols identification.

***Figure 19**. Land installation including an engine simulator to test devices and to perform preliminary configuration within SusTunTech project.*

Stage 2 (Year 2)

Highly likely this year activities will start with vessel final installation and/or initial monitoring set up. Our recommendation is regular monitoring of the data flows to detect downtimes and an early validation of data (e.g. after one month) to ensure that data capture is at the right scales and quality (see previous sections on data validation and issues with ADCP). GRAFANA visualization package can be used since it permits an easy visualization of all the monitored variables, which is especially helpful for monitoring the status of the monitoring system and ensuring that reliable data is collected (Fig. 20). GRAFANA is used for visualization, not for actual data analysis. By grouping dashboards into monitoring subsystems, it is easier to check the performance of the system. Once there is at least one month of data, validation of the data can start to identify issues and start working on the process for its ingestion in scientific data platforms (GOOS).

Figure 20. *Dashboards configured for the easy monitoring of data flows in real-time used in SusTunTech project.*

Stage 3 (from Year 3 to Year 7)

It is expected that in reaction to data downtimes or hardware failures actions in the vessels (or through the crew) will be needed. However, this period will focus on data processing, validation and ingestion. This likely will require to setup a ERDAP server (Fig. 21) according to FAIR data principles which will facilitate the link with GOOS facilities and makes the data available also to the wider scientific community. The protocols for data ingestion will be studied. In our experience certain variables (e.g. temperature) will have protocols stablished in terms of name and format of variables with regular ingestion periods (e.g. twice per year). But, there can be variables where these protocols might need to be stablished in collaboration with GOOS ingestion authorities. This can be done in collaboration with EMODNET which is the ingestion organization in Europe and it seems there are already in place agreements to collaborate between Europe and Pacific.

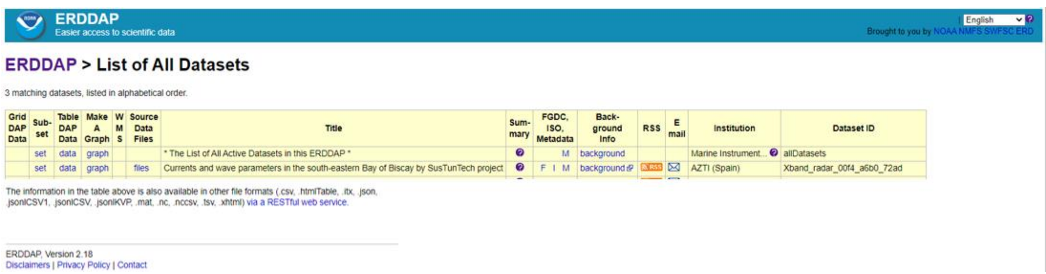


Figure 21. *Main page of the SunTunTech ERDDAP during early stages of its development.*

7. A summary of the relevant agencies and stakeholders

The main identified stakeholders in assessing the cost-benefit of improved data collection across the WCPO to tuna-dependent Pacific Island countries, fishing fleets and the broader global climate-change science community stakeholders' summary are:

1) The participating countries to the GCF project Cook Islands, Fiji, Federal States of Micronesia, Kiribati, Nauru, Niue, Palau, Papua New Guinea, Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu
2) Fleets and/or vessels owners: they need to understand and agree on the vessel's installations. Early meetings once there is a preliminary design are very helpful to engage them and ensure their participation that is crucial not only for the installation, but also for the maintenance (solving issues with lower intervention of technicians).
3) Technological providers: mapping what technological/technical providers are already present in main operation ports and if the vessels are already using them would facilitate installations and maintenance interventions. Some companies might only accept interventions by providers they know and that have deep knowledge of their vessels.
4) National agencies and/or port facilities managers: they can be facilitators to reach the two previous groups. In same cases, they might want to co-finance somehow the installations and/or maintenance (monetary or in-kind contributions such us premises or their own staff time).
5) International agencies as coordinators and data aggregators: the raw data and the final quality check data for scientific work needs to be in a centralized or distributed storage and this needs to have proper protocols for its storage, processing, and public disclosure. The first chapter has identified potential participants, but it is unclear their operational capacity.

Finally, this section presents a summary of stakeholders' opportunities and barriers identified in recent vessels installation and digitalization projects worldwide. Based on these projects' experiences and on recent literature (Bradley et al., 2019: Fernandes-Salvador et al., 2022).

- Potential limitations/barriers:
  - Lack of trust in technology. For example, often technological companies provide products that are not enough tested. Other times the users trust more their experience that external helps.
  - Lack of technological skills. Use, understanding and maintenance of many systems require multidisciplinary knowledge about computing and electronics that often is not available.
  - Cost of technology. Many systems are expensive to install and require maintenance that adds time and monetary cost.
  - Legal and bureaucratic uncertainty, as well as lack of stablished/known standards. Novel systems are often ahead of legal and management measures that might require their revision in the future.
  - Competition between vessels/fleets/companies. Often use of technology and data gathering is seen as a way of competitors to get access to their knowledge and a lack of competition capacity.

- Potential opportunities/incentives:
  - Improve communications. The modernization and many of the benefits of digitalization (higher social, environmental and economic sustainability) have been used as marketing tools for promotion of fisheries products.
  - Improve ecosystem approach management. Higher digitalization allows to prove that the good management is enforced by the industry helping in getting certifications, their public image and revalorization of products.
  - Improve public image of the industry. In general, modernization and sustainability is perceived by consumers as positive therefore opening some markets with higher willingness to pay prices.
  - Forecast of hot spots of key species. The digitalization and data can improve ecosystem models for real-time advice to deal with shifts of distribution of fishing grounds due to climate change and variability, optimize routes (reduce time at sea and fuel consumption), avoid bycatch and discards.

8. ACKNOWLEDGEMENTS

It is appreciated the advice and input provided by Jerome Aucan (jeromea@spc.int).

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AUSTRALIA

Preliminary Framework for Joint Management of Redistributed Tuna Stocks by WCPFC and IATTC

GCF Study 8

Report prepared for the Pacific Community

ANCORS, August 2023

AUSTRALIAN NATIONAL CENTRE FOR
OCEAN RESOURCES & SECURITY

The **Australian National Centre for Ocean Resources and Security (ANCORS**), University of Wollongong, is Australia's only multidisciplinary university-based centre dedicated to research, education and training on ocean law, maritime security and natural marine resource management providing policy development advice and other support services to government agencies in Australia and the wider Asia-Pacific region, as well as to regional and international organizations and ocean-related industry.

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Citation:

Goodman, C., Azmi, K., Davis, R., Haas, B., and Hanich, Q., Preliminary framework for joint management of redistributed tuna stocks by WCPFC and IATTC. Report prepared for the Pacific Community by the Australian National Centre for Ocean Resources and Security, Wollongong, Australia, 2023.

Acknowledgments:

This report is based on and developed from a paper prepared by the authors together with a number of co-authors, published as: Camille Goodman, Ruth Davis, Kamal Azmi, Johann Bell, Grantly R. Galland, Eric Gilman , Bianca Haas, Quentin Hanich, Patrick Lehodey, Lara Manarangi-Trott , Simon Nicol, Pablo Obregon, Graham Pilling, Inna Senina, Katherine Seto and Martin Tsameny (2022). Enhancing cooperative responses by regional fisheries management organizations to climate-driven redistribution of tropical Pacific tuna stocks. Front. Mar Sci. 9, 1046018. doi: 10.3389/fmars.2022.1046018.

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List of Abbreviations

AWS	Advanced Warning System
CAOF Agreement	Central Arctic Ocean Fisheries Agreement
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CMM	conservation and management measure
EEZ	exclusive economic zone
EPO	Eastern Pacific Ocean
EPO-C	Central Eastern Pacific Ocean
EU	European Union
FAO	United Nations Food and Agriculture Organization
FFA	Pacific Islands Forum Fisheries Agency
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IOTC	Indian Ocean Tuna Commission
ISC	International Scientific Committee
IUU fishing	illegal, unreported and unregulated fishing
JNSFC	Joint Norwegian-Soviet Fisheries Commission
Joint Working Group	IATTC-NC Joint Working Group on Pacific Bluefin Tuna Management
MCS	monitoring, control and surveillance
MSY	maximum sustainable yield
NAFO	North Atlantic Fisheries Organization
NC	WCPFC Northern Committee
NEAFC	North East Atlantic Fisheries Commission
PICES	North Pacific Marine Science Organization
PNA	Parties to the Nauru Agreement
RCP	representative concentration pathway
RFMO	regional fisheries management organization
SC	WCPFC Scientific Committee
SEAPODYM	Spatial Ecosystem And Population Dynamics Model
SIDS	small island developing States
SPC-OFP	Oceanic Fisheries Programme of the Pacific Community

SPRFMO	South Pacific Regional Fisheries Management Organization
TCC	WCPFC Technical and Compliance Committee
UN	United Nations
UNCLOS	1982 United Nations Convention on the Law of the Sea
UNFCCC	1992 United Nations Framework Convention on Climate Change
UNFSA	1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
VDS	Vessel Day Scheme
VMS	vessel monitoring system
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean

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Executive Summary

Climate change is predicted to alter the distributions of tropical tuna stocks in the Pacific Ocean. Recent modelling projects future shifts in tuna biomass from west to east, and, to a lesser degree, in polar directions, resulting in decreases in national jurisdictions in the Western Pacific and increases in high seas areas. The extent of this redistribution of biomass is dependent upon the magnitude of continued greenhouse gas emissions. Under high emission scenarios, the resulting redistribution of tuna may present new challenges for the regional fisheries management organizations (RFMOs) responsible for the conservation and management of tropical tuna stocks in Convention Areas spanning areas of both high seas and national jurisdiction: in the Western and Central Pacific Ocean (WCPO), the Western and Central Pacific Fisheries Commission (WCPFC), and in the Eastern Pacific Ocean (EPO), the Inter-American Tropical Tuna Commission (IATTC). This report provides a horizon scan to identify issues that will need to be considered by both RFMOs as the impacts of climate change on Pacific Ocean tuna populations continue to emerge. The report summarises the mandates and existing legal frameworks governing the operation of each RFMO at both the global and regional levels, summarises the issues likely to increase in prominence if redistribution of tuna biomasses due to climate change is substantive, and discusses options for both RFMOs to enhance cooperation and prepare for such change.

Shifting biomass distribution induced by climate change is likely to result in disproportionate burdens and affect small island developing States (SIDS) and developing economies in ways that challenge existing processes (including current rights-based principles) and invoke rights and responsibilities under the global legal frameworks for the law of the sea, international fisheries law, and international climate law (including important principles of inter- and intra-generational equity). Pursuant to these international law frameworks as well as the specific regional conventions by which they were established, WCPFC and IATTC have the ability and the obligation to cooperatively prepare for any climate-driven redistribution of tuna stocks between their Convention Areas. While there are already examples of cooperation between the WCPFC and IATTC, the report concludes that some of the projected shifts in the distribution of tropical tuna stocks in the Pacific Ocean Basin suggest that a more strategic approach to the form and substance of such cooperation will be needed in the future in order to ensure fisheries for Pacific tuna stocks are managed so they remain resilient to the impacts of climate change.

A more precise understanding of the likely extent of tuna biomass redistribution in the Pacific Ocean will be needed to help guide the degree of cooperation and climate adaptation that will be needed by both RFMOs. In this respect, harmonising (to the extent practical) fisheries and ecosystem monitoring activities undertaken by each RFMO will assist with future interoperability of data and cooperation in areas such as data analysis and modelling. Increasing the existing scientific dialogue and cooperation between both RFMOs would be a simple way to achieve this outcome. Participation of both RFMOs in the development and

implementation of the GCF-supported 'Pacific Islands Advanced Warning System' (PI-AWS) will also help improve the precision of the models currently used to project future tuna biomass distributions, provide validated scalars of biomass, and improve stock structure definition.

Shifting distributions of biomass are also expected to necessitate a need for harvest strategies, evaluations of conservation and management measures and stock assessments to be climate aware. Strengthening scientific cooperation to support this technical work will assist with integrating climate awareness into the technical processes. Including climate change as a standing agenda item in all RFMO bodies that consider these processes would also help ensure that climate awareness is included in the technical work undertaken.

Increased availability of tuna biomass in high seas areas because of climate-induced redistribution is likely to necessitate greater cooperation on monitoring, control and surveillance (MCS) measures and other enforcement tools. WCPFC and IATTC have already established arrangements for cross-endorsement of at sea observers, sharing of data, and responses to vessels deemed to be engaging in illegal, unreported and unregulated (IUU) fishing. Enforcement in high seas areas is typically more challenging due to the remoteness of these regions and the reliance on flag State responsibility. Establishing arrangements that facilitate enhanced MCS and enforcement activities now will allow both RFMOs to be prepared for greater MCS and enforcement in the high seas, particularly in the central Pacific where the potential for more joint activity could be expected given the jurisdictional boundary and overlap area.

More broadly, formalising consultation between the two RFMOs on a more regular basis would assist the preparedness of both organisations. The IATTC was a participant in the negotiations to establish the WCPFC, and the Executive Secretaries of both organisations met annually until 2008, leading to the formal adoption of a Memorandum of Understanding relating to cooperation. Over time, however, this formal cooperation has diminished. Re-establishing (or re-invigorating) formal consultations between the two RFMOs would facilitate early dialogue on the options available for managing what potentially will become a more shared resource. Moreover, some international markets are moving towards 'jurisdictional' or 'seascape' approaches to seafood supply, and the development of principles for jointly managing the impacts of climate change on fisheries resources are likely to assist the Pacific to demonstrate its broader social and environmental responsibilities. This in turn would assist with growing the Pacific presence within these markets.

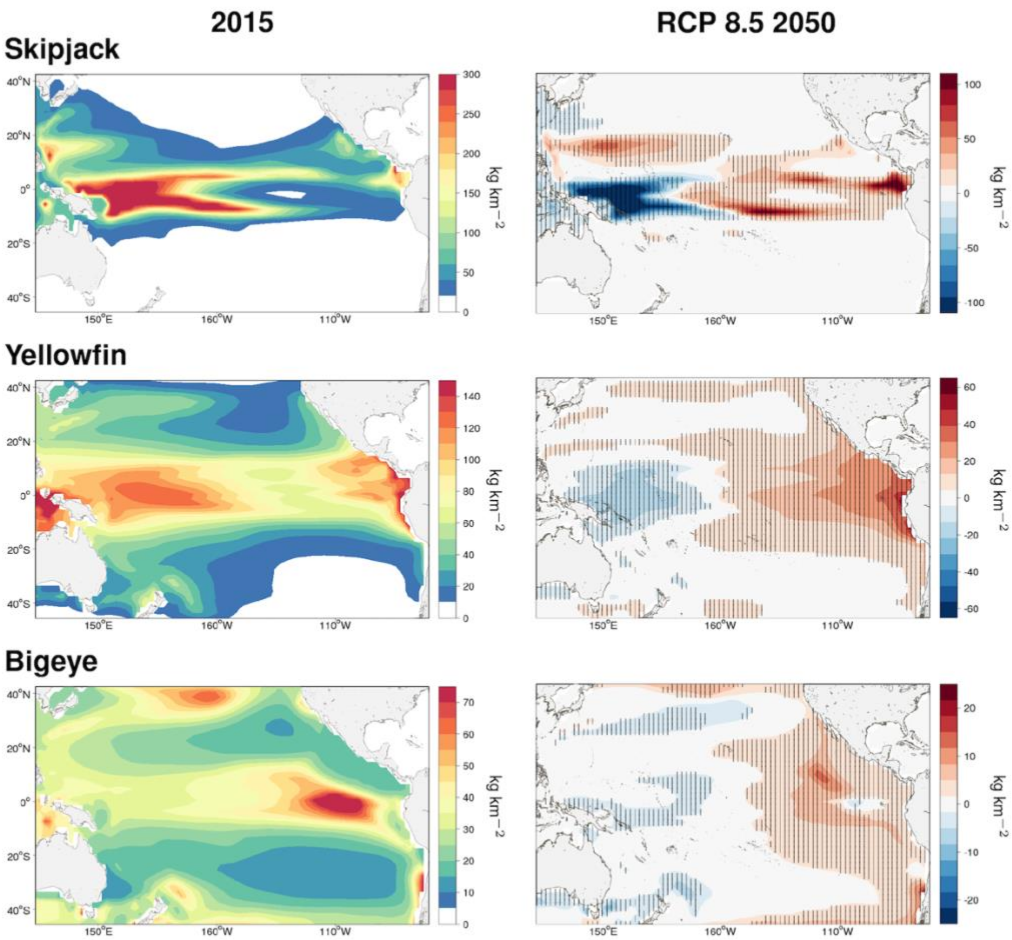
In addition to providing a horizon scan on emerging and developing issues for the two RFMOs about climate-induced redistribution of tuna biomass, this report serves as a basis for identifying potential priority investment for the GCF Pacific Tuna Proposal. Based on our review and evaluation of emerging issues, we recommend consideration be given to the following investments:

1. Designing the GCF Programme to include activities that engage both WCPFC and IATTC in the development of the PI-AWS and its supporting fisheries and ecosystem monitoring activities.
2. Strengthening processes to facilitate practical measures of cooperation between WCPFC and IATTC, including with respect to: enhanced dialogue on MCS and enforcement; harvest strategy development; the evaluation of conservation and management measures; data sharing and data compatibility; and stock assessment.
3. Including resources to re-establish or re-invigorate formal dialogue between WCPFC and IATTC with a purpose of, *inter alia,* preparing both RFMOs for adapting to the impacts of climate change and the consequent changes to international responsibilities and markets.

1. Introduction

It is predicted that climate change will alter the distribution of tropical tuna stocks in the Pacific Ocean. Recent modelling shows that continued high greenhouse gas emissions are expected to cause substantial changes in the distribution of skipjack, yellowfin and bigeye tuna within the Pacific Ocean Basin over a relatively short time frame (several decades), with predicted shifts in stock biomass from the Western and Central Pacific Ocean (WCPO) to the Eastern Pacific Ocean (EPO) and (to a lesser extent) in polar directions, resulting in decreases in areas under national jurisdiction in the Western Pacific and increases in high seas areas (Bell et al. 2021) **(Figure 1).** This is likely to present new challenges for the regional fisheries management organizations (RFMOs) responsible for the conservation and management of tropical tuna stocks in Convention Areas spanning both high seas and national jurisdiction: in the WCPO, the Western and Central Pacific Fisheries Commission (WCPFC), and in the EPO, the Inter-American Tropical Tuna Commission (IATTC).

Figure 1. Average biomass distributions (kg km–2) of skipjack, yellowfin and bigeye tuna in the Pacific Ocean basin for 2015 (2011−2020) (left), and mean anomalies (kg km–2) from the average 2015 biomass distribution of each tuna species projected to occur by 2050 (2044−2053) under the RCP 8.5 greenhouse gas emissions scenario (right). Shading indicates areas where projections from four Earth System Models agree in the sign of change. Source: Bell et al. (2021).



This report examines issues that will need to be considered in order to prepare both RFMOs for enhanced cooperative management of shared tropical tuna stocks into the future.

Section 2 summarises the existing legal framework for cooperation between the WCPFC and IATTC at both the global and regional levels and summarises the mandates of each RFMO and the core principles under which they operate **(output (i)),** as well as the extent and rationale for the existing overlap in their Convention Areas **(output (ii))**. This background is important in order to establish the principles and processes that may be invoked to support discussion on the sort of cooperation that could be undertaken in response to the redistribution of tropical tuna stocks in the Pacific Ocean. Section 3 provides an overview of the existing form and extent of cooperation between the two organizations to establish the benchmark from which future cooperation should be considered. With the existing forms of cooperation in mind, Section 4 identifies challenges and complexities that are likely to arise in sustainably managing shared tuna stocks occurring largely in high seas areas across the Convention Areas of the WCPFC and IATTC, **(output (iii)).** Section 5 concludes the report by outlining options that could be used to revise existing management arrangements for tuna stocks that are shared by the two tuna RFMOs, and the ways in which these mechanisms could be adapted to the continuing redistribution of these stocks due to climate change **(output (iv))**. To assist States in evaluating the likely effectiveness, applicability and attractiveness of these options, Section 5 also examines how similar issues have been addressed in other regions and highlights some potential incentives.

2. The legal framework for cooperation between WCPFC and IATTC

In order to evaluate the options for cooperation between WCPFC and IATTC, it is important to understand the legal framework which governs the activities of these RFMOs. Accordingly, this section of the report asks: to what extent are WCPFC and IATTC empowered or obliged under the existing international law framework to cooperate in response to the climate-driven redistribution of Pacific tuna stocks?

To answer this question, we must consider the requirements of the international fisheries law framework and of the specific agreements governing the WCPFC and IATTC, to clarify whether and how they may—or must—cooperate in the management of tuna stocks that are shared between areas under their jurisdiction. We can also draw on other areas of international law and policy that affect the exercise of rights and obligations under the fisheries regime, including international climate law, the sustainable development framework and the new implementing agreement on biodiversity beyond national jurisdiction.

2.1 International Fisheries Law

The international fisheries law framework provides limited guidance on cooperation between RFMOs on measures to manage climate-driven changes to the abundance and distribution of fish stocks. The global framework for international fisheries is focused primarily on the rights and obligations of individual States. While individual flag and coastal States have a general duty to cooperate in the management of shared fish stocks (including within the context of an individual RFMO), and RFMOs themselves generally have the legal capacity to engage in cooperative activities with other RFMOs, the global framework provides little guidance on cooperation between RFMOs.

2.1.1 United Nations Convention on the Law of the Sea

The global legal framework for international fisheries management is based on the 1982 *United Nations Convention on the Law of the Sea* (UNCLOS). UNCLOS assigns responsibility for fisheries management based on a regime of maritime zones, with coastal States accorded primary responsibility for stocks within their 200 nautical mile exclusive economic zones (EEZs), and flag States responsible primarily for their vessels fishing on the high seas. Within the EEZ, the coastal State has sovereign rights over fishery resources, and must determine the total allowable catch (TAC) and establish the conservation and management measures that would support maximum sustainable yield (MSY) (Articles 56(1)(a) and 61, UNCLOS). On the high seas, all States *prima facie* have equal rights of access pursuant to the freedom of fishing (Article 116), subject to a general duty to conserve living resources and to 'cooperate with each other in the conservation and management of living resources in the area of the high seas' (Article 118). On the high seas, it is up to the fishing (flag) States to determine the allowable catch and other conservation measures in a way designed to produce MSY (Article 119).

In both cases, conservation and management measures must be based upon the best scientific advice available and the determination of MSY must be qualified by relevant environmental and economic factors (Articles 61, 119, UNCLOS). The special requirements of developing States are specifically identified as one of the 'economic' factors that must qualify any determination of MSY (Articles 61 and 119, UNCLOS). Although not specifically contemplated by UNCLOS, climate change must now be regarded as a 'relevant environmental factor' in determining MSY.

Fish which migrate between zones present a particular problem for international regulation. UNCLOS recognises different categories of fish stocks in this situation: 'straddling' stocks (whose range straddles the EEZ of two or more countries, or straddles areas of both EEZ and high seas) (Article 63, UNCLOS), and 'highly migratory' species (identified in Annex I and including the major commercial tuna species) (Article 64, UNCLOS). For straddling stocks and highly migratory species, as well as for high seas stocks, conservation and management must be coordinated between all relevant States. In these situations, the duty to cooperate is key.

UNCLOS lacks detail as to how this cooperation should proceed. In relation to highly migratory species, States whose nationals are fishing on the high seas and coastal States whose waters fall within the range of a highly migratory species must cooperate with a view to 'ensuring conservation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the exclusive economic zone' (Article 64, UNCLOS). The relevant States have a duty to cooperate either directly or through the appropriate international organization (i.e. an RFMO). In regions where no appropriate RFMO exists, the duty to cooperate extends to the establishment of such an organization and participation in its work (Article 64, UNCLOS).

The duty to cooperate has been recognised to exist not only under UNCLOS but also under general international law. In the *MOX Plant Case* (ITLOS, 2001) the International Tribunal for the Law of the Sea (ITLOS) stated that 'the duty to cooperate is a fundamental principle in the prevention of pollution of the marine environment under Part XII of the Convention and general international law' (par 82). In its *Sub-Regional Fisheries Commission Advisory Opinion* (2015), ITLOS recognised that the principle extended beyond the protection and preservation of the marine environment to fisheries conservation and management (in that case, dealing with illegal, unreported and unregulated (IUU) fishing). While the cases provide little guidance as to the level and form of cooperation required, ITLOS has been willing to identify a failure to cooperate and to make orders to cooperate in a specific way (*Land Reclamation in and around the Straits of Johor (Malaysia v. Singapore)*, Provisional Measures, Order of 8 October 2003, ITLOS Reports 2003, par 97).

2.1.2 United Nations Fish Stocks Agreement

UNCLOS is supplemented by the 1995 *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks*

(UNFSA). The UNFSA provides more detail on how States must fulfil the duty to cooperate in relation to straddling and highly migratory stocks. The UNFSA also sets out principles relating to the long-term conservation and sustainable use of these fish stocks, which are relevant to the question of how best to respond to the management challenges posed by climate-driven stock redistribution.

The UNFSA requires States to 'adopt measures to ensure long-term sustainability' of fish stocks and 'promote the objective of their optimum utilization' (Article 5, UNFSA). In doing so, they must 'assess the impacts of fishing, other human activities and environmental factors', and 'apply the precautionary approach in accordance with Article 6' (Article 5, UNFSA). In applying the precautionary approach, States must take into account, inter alia, the impact of uncertainties relating to existing and predicted oceanic and environmental conditions (Article 6, UNFSA). The impact of climate variability and change must therefore be considered as part of the conservation and management process (Rayfuse, 2019).

Part III of the UNFSA focuses on mechanisms for international cooperation and requires States to participate in the relevant RFMO (Article 8, UNFSA). The UNFSA provides an extensive list of matters to be agreed upon or implemented by States through an RFMO to fulfil the duty to cooperate, including appropriate conservation and management measures, participatory rights, and the conduct of scientific stock assessments (Article 10, UNFSA). The UNFSA requires States to cooperate in establishing compatible conservation and management measures for the high seas and areas under national jurisdiction (Article 7, UNFSA).

The UNFSA does not directly address the issue posed by stocks that shift beyond their known geographical distribution in the area under the competence of one RFMO to an area under the management of another RFMO. Nor does it establish any specific standards or procedures for cooperation between RFMOs. In particular, although Article 7 addresses the compatibility of conservation and management measures adopted for areas under the jurisdiction of coastal States with measures adopted for the high seas, the UNFSA does not consider how to ensure compatibility *between RFMOs* in relation to highly migratory species in adjacent areas of the high seas.

Despite these limitations, many features of the UNFSA framework support enhanced cooperation between RFMOs in the context of climate-driven redistribution of highly migratory fish stocks. These include requirements for open and informed decision-making (Article 12, UNFSA), requirements for cooperation to strengthen RFMO performance through regular performance reviews (Article 13, UNFSA) and a requirement to cooperate in scientific research (Article 14, UNFSA). These requirements support sharing of information between RFMOs as well as the ongoing assessment of the management performance of each organization in light of current stock conditions.

2.2 RFMO Mandates

WCPFC and IATTC share a very similar objective—the long-term conservation and sustainable use of highly migratory stocks in their respective Convention Areas—and both RFMOs have the power to adopt binding conservation and management measures for their members in order to achieve this. In addition, the constituent treaties of both RFMOs do specifically recognise the need to cooperate with other RFMOs in order to achieve their objectives, including in situations where two Convention Areas overlap, or where fish stocks also occur in or migrate through the Convention Area of another RFMO. However they differ significantly in some fundamental characteristics—they have different histories, geographical configurations, and membership.

The WCPFC manages the world's most valuable tuna fishery (McKinney et al, 2020) and provides approximately 52 per cent of the global tuna catch (Williams and Ruaia, 2021; ISSF, 2022). It is distinguished from other tuna RFMOs by the size and productivity of the EEZs in its Convention Area . In contrast to WCPFC, the IATTC Convention Area primarily covers high seas rather than EEZs, and the IATTC tuna fisheries are significantly less productive, producing around 13 percent of the global tuna catch (ISSF, 2022). The relevant features of both RFMOs, including key provisions, characteristics and measures, are summarized in **Table 1**.

2.2.1 WCPFC

The WCPFC was established in 2004 under the *Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean* (WCPFC Convention). The objective of the Convention is 'to ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the western and central Pacific Ocean'. The WCPFC Convention Area extends from the Western and Northern limits of the Pacific Ocean to 60 degrees south and eastward to 130°W (WCPFC, 2004).

The WCPFC comprises 26 members, 7 participating Pacific Island territories and eight cooperating non-members. The members include major flag States such as Japan, China, Korea, the US and the EU, and more than half the members of WCPFC are coastal States in the Convention Area. None of the key target species (bigeye tuna, yellowfin tuna, albacore tuna and skipjack tuna) are overfished, nor is overfishing occurring (Hare et.al., 2021; ISSF, 2022). In 2021, the total catch of albacore, bigeye, skipjack and yellowfin tuna in the WCPFC Statistical Area was 2,635,291 metric tons. This catch was taken by vessels flagged to 31 different States, territories and fishing entities, with 77% of the overall catch coming from eight States with the highest catches.

The fisheries management framework under the WCPFC Convention strongly reflects the UNFSA. It incorporates the UNFSA conservation and management principles (Article 5), guidance on application of the precautionary approach (Article 6 and Annex II), and rules for ensuring compatibility between measures adopted for the high seas and for areas under national jurisdiction (Article 7) (WCPFC, 2004). The work of the WCPFC is directed and overseen by a Commission (Articles 9 and 10), supported by subsidiary bodies including the Scientific Committee (SC), Technical and Compliance Committee (TCC), and a Northern Committee (NC) (Article 11) (WCPFC, 2004). The WCPFC Convention specifically recognises the importance of adequate scientific information (Article 5(b)) and authorises the Commission to engage the services of scientific experts to provide the necessary information and advice (Article 13) (WCPFC, 2004). Scientific and data management services in relation to tropical and southern tuna fisheries in the Convention Area are provided by the Oceanic Fisheries Programme of the Pacific Community (SPC-OFP). The International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) provides similar scientific services in relation to northern stocks.

Importantly, Article 22(2) requires the Commission to make suitable arrangements for consultation, cooperation and collaboration with other organizations, including the IATTC. Article 22(3) notes that where the WCPFC Convention Area overlaps with an area under regulation by another RFMO, the WCPFC shall cooperate with that organization in order to avoid duplication of measures in respect of species that are regulated by both organizations. Even more specifically, Article 22(4) requires the WCPFC to initiate consultation with the IATTC with a view to reaching agreement on a consistent set of conservation and management measures for fish stocks that occur in the Convention Areas of both organizations. In addition, Article 12(4) specifies that representatives of the IATTC shall be invited to participate in the work of the WCPFC Scientific Committee.

Currently, ten members of WCPFC are also members or cooperating non-members of IATTC (refer to **Table 1**).

2.2.2 IATTC

The 2003 *Convention for the strengthening of the Inter-American Tropical Tuna Commission established by the 1949 Convention between the United States of America and the Republic of Costa Rica* (Antigua Convention) entered into force in 2010 and updates a 1949 agreement focused largely upon scientific research. Pursuant to the Antigua Convention, the IATTC manages fishing primarily for 'tuna and tuna-like species' in a Convention Area located between 50N and 50S, bounded by the coastline of North, Central and South America in the east, and extending to 150W in the west . The IATTC has 21 members and 5 cooperating non-members. Some of the IATTC members are major flag States, but more than half are coastal States in the Convention Area. In 2021, the total retained catch of tunas and bonitas caught by purse-seine vessels in the EPO was 651,163 metric tons. This catch was taken by vessels flagged to ten States, of which three States with the highest catches combined took 74.9% of the total (Ecuador, Mexico and Panama).

The provisions of the Antigua Convention reflect the fact that—like the WCPFC Convention—it was negotiated after the UNFSA, but it does not hew as closely to the UNFSA as the WCPFC Convention. For example, the Antigua Convention does not include the general principles for conservation and management established in Article 5 of the UNFSA, nor the specific provisions on the requirements of developing States contained in Article 24 of the UNFSA (although it does envisage financial and technical cooperation to assist developing members of the Commission (Article XXIII)). And while it does provide for the application of the precautionary approach (Article IV) and the establishment of compatible measures for the high seas and areas under national jurisdiction (Article V), these provisions are less detailed than those in the UNFSA.

The work of the IATTC is directed and overseen by a Commission (Articles VI and VII), supported by a Committee for the Review of Implementation of Measures Adopted by the Commission (Article X) and a Scientific Advisory Committee (Article XI) (IATTC, 2003). The Commission is specifically required to promote, carry out and coordinate scientific research on the stocks and species covered by the Antigua Convention—including 'the effects of natural factors and human activities on the populations of these stocks and species'—and adopt measures based on the best scientific evidence available (Article VII). In this respect, and reflecting its original focus on scientific research, the IATTC has its own Scientific Staff to provide information, advice and recommendations to the Scientific Advisory Committee and the Commission (Article XIII), as well as field offices in a number of countries and its own research laboratory, based in Panama.

Like the WCPFC Convention, the Antigua Convention provides for cooperation with other RFMOs. Article XXIV(1) calls on the Commission to establish relevant institutional arrangements (such as consultative committees) with other RFMOs in order to achieve the objectives of the Convention, obtain the best available scientific information, and avoid duplication. Article XXIV(3) addresses the situation of overlapping Convention Areas and—without referring specifically to the WCPFC—provides that in such a situation, the IATTC shall cooperate with the other RFMO, and strive to agree on the relevant measures to be taken, such as ensuring harmonization and compatibility of the conservation and management measures adopted, or deciding that one RFMO avoid taking measures in respect of species regulated by the other RFMO. Finally, and of particular relevance to this report, Article XXIV(4) provides that this cooperation shall also apply in the situation where fish stocks migrate through areas under the purview of the IATTC and another RFMO.

Currently, eleven members of IATTC are members or cooperating non-members of WCPFC (refer to **Table 1**).

2.2.3 Overlap area

There is an 'overlap' area between the Convention Areas of the WCPFC and the IATTC, which falls between the western boundary of the IATTC at 150°W, and the eastern boundary of the WCPFC at 130°W . The history of this overlap is briefly explored in discussion papers prepared by the Executive Directors of the IATTC and the WCPFC, which note that IATTC scientists and managers began to use 150°W as the western boundary of the IATTC as early as 1972, and that the Pacific Community also used 150°W as the eastern boundary of the central-western Pacific Ocean in preparing reports and assessments on yellowfin tuna in the 1990s (IATTC, 2011; WCPFC, 2011a). This approach was followed in setting the northern segment of the WCPFC's eastern boundary (north of 4°S) at 150°W, but during the negotiation of the WCPFC Convention the southern part of the eastern boundary (between 60°S and 4°S) was placed at 130°W.

The decision seems to have been informed primarily by the desire to ensure that the entirety of French Polynesia's EEZ (much of which lies between 150°W and 130°W) was included in the WCPFC Convention Area (WCPFC, 1999), rather than by scientific advice about the likely structure or location of Pacific Ocean tuna stocks, or patterns of historic fishing practice. However, the States participating in the negotiation of the WCPFC and the members of the IATTC were both cognisant of the creation of this overlap, and this is reflected in the inclusion of specific provisions on cooperation in each Convention, as described above.

Table 1. Key features, provisions and measures of WCPFC and IATTC. Adapted from Goodman et al, 2022.

WCPFC **(Articles refer to the WCPFC Convention)**	**IATTC** **(Articles refer to the Antigua Convention)**
Convention Area	
The WCPFC Convention Area comprises all waters of the Pacific Ocean extending south from the Australian continent along 141°E to the southern boundary at 60°S, then north at 130°W to 4°S, and thence north along 150W. It does not have a defined boundary in the north or north-east (see Figure 2).	The IATTC Convention Area is located between 50°N and 50°S, bounded by the coastline of North, Central and South America in the east, and extending to 150°W in the west (see Figure 2).
Catch	
The WCPFC Convention Area contains the world's most valuable tuna fishery, which provides approximately 52% of the global tuna catch (McKinney et al, 2020; Williams and Ruaia, 2021; ISSF, 2022). In 2021, the total catch of tuna taken in the WCPFC Statistical Area by all gear types was 2,635,291 metric tons. This was caught by vessels flagged to 31 States.	The tuna fisheries in the IATTC Convention Area are significantly less productive than those managed by the WCPFC, producing around just 13% of the global tuna catch (ISSF, 2022). In 2021, the total retained catch of tunas and bonitas caught by purse-seine vessels in the EPO was 651,163 metric ton. This was caught by vessels flagged to 10 States. The 3 States with the highest catches combined took 74.9% of the total (Ecuador, Mexico and Panama).

Members and Cooperating Non-Members (CNMs) *Small Island Developing States (SIDS) indicated in *italics*		
WCPFC Member only	**WCPFC and IATTC Member**	**IATTC Member only**
Australia, *Cook Islands*, *Federated States of Micronesia*, *Fiji*, *Marshall Islands*, *Nauru*, New Zealand, *Niue*, *Palau*, *Papa New Guinea*, Philippines, *Samoa*, *Solomon Islands*, *Tonga*, *Tuvalu*	Canada, China, European Union, France, Japan, *Kiribati*, Korea, United States, *Vanuatu* **IATTC Member and WCPFC CNM** Ecuador, El Salvador, Nicaragua, Panama	*Belize*, Colombia, Costa Rica, Guatemala, Mexico, Peru, Venezuela
WCPFC CNM only	**WCPFC and IATTC CNM**	**IATTC CNM only**
Curacao, Thailand, Vietnam	Liberia	Bolivia

Structure of the RFMO	
The work of the WCPFC is directed and overseen by a Commission (Articles 9 and 10), supported by subsidiary bodies including: • the Scientific Committee (SC) (Article 12)	The work of the IATTC is directed and overseen by a Commission (Articles VI and VII), supported by: • a Committee for the Review of Implementation of Measures Adopted by the Commission (Article X) • a Scientific Advisory Committee (Article XI), and

• the Technical and Compliance Committee (TCC) Article 14) • the Northern Committee (NC), which makes recommendations in relation to stocks which occur in the area north of 20°N (Article 11(6)), and • the Finance and Administration Committee (Article 11(6)). A Secretariat, overseen by the Executive Director, supports the work of the Commission (Article 15). The work of the Commission and its subsidiary bodies may be supported, from time to time, by ad hoc or more long-term inter-sessional working groups.	• a Committee on Finance and Administration (Article VII(1)(u)). A Secretariat, overseen by the Director, supports the work of the Commission (Article XII). The work of the Commission and its subsidiary bodies may be supported from time to time by ad hoc or more long-term working groups. The IATTC also provides Secretariat services for the Agreement on the International Dolphin Conservation Program (AIDCP), which covers the Eastern Pacific Ocean.
Scientific Advice	
The WCPFC Convention specifically recognizes the importance of adequate scientific information (Article 5(b)) and provides for the Commission to engage the services of scientific experts to provide the necessary information and advice (Article 13). Scientific and data management services are provided by the Oceanic Fisheries Programme of the Pacific Community (SPC-OFP). Additional advice in relation to northern stocks is provided by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).	The Commission is specifically required to promote, carry out and coordinate scientific research on the stocks and species covered by the Antigua Convention—including 'the effects of natural factors and human activities on the populations of these stocks and species'—and adopt measures based on the best scientific evidence available (Article VII). The IATTC has internal scientific staff to provide information, advice and recommendations to the Scientific Advisory Committee and the Commission (Article XIII), as well as field offices in a number of countries and its own research laboratory, based in Panama. Additional advice in relation to northern stocks is provided by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC).
Conservation and Management Principles	
Reflecting the developments incorporated in the UNFSA, the WCPFC Convention incorporates an expanded range of conservation and management principles (Article 5), specific guidance on the application of the precautionary approach (Article 6 and Annex II), and rules for ensuring compatibility between measures adopted for the high seas and for areas under national jurisdiction (Article 7).	The Antigua Convention does not incorporate the general principles for conservation and management established in Article 5 of the UNFSA. It does provide for the application of the precautionary approach (Article IV) and the establishment of compatible measures for the high seas and areas under national jurisdiction (Article V), but these provisions are less detailed than those in the UNFSA.
Special Requirements of Developing States	
Article 30 of the WCPFC Convention addresses the special requirements of developing States, and in particular small island developing States. It provides that the Commission shall take these into account in giving effect to the duty to cooperate through the adoption of conservation and management measures and notes the vulnerability of developing States which are dependent on the exploitation of living marine resources.	The Antigua Convention does not include the specific provisions on the requirements of developing States contained in Article 24 of the UNFSA, although it does envisage financial and technical cooperation to assist developing members of the Commission (Article XXIII).

Measures to Address Climate Change	
In 2019, the WCPFC adopted a non-binding resolution on climate change, which commits the Commission to considering the impact of, and options for addressing, climate change on the WCPFC's tuna stocks (WCPFC 2019a). In 2022, the WCPFC agreed to recommendations from the Scientific Committee relating to the inclusion of climate change in the Committee's work, and also agreed to include climate change as a standing agenda item for the Commission, and to prioritize discussion of how to best incorporate climate change information and analysis in its work, as well as the work of the TCC and NC (WCPFC, 2022a). The WCPFC has supported the continuation of large-scale tagging experiment work led by the Oceanic Fisheries Programme of the Pacific Community (SPC-OFP) (the scientific services provider for the WCPFC), recognizing that it is necessary to inform stock assessments of tropical tunas in the WCPO (Hare et.al., 2021). The WCPFC's Regional Observer Programme, which uses existing national and subregional observer programmes of WCPFC members, collects biological samples and data and provides information concerning the catch composition of the main WCPO tuna fisheries (Hare et.al., 2021). The WCPFC has also been using the Spatial Ecosystem And Population Dynamics Model (SEAPODYM) (Lehodey et al. 2014) framework to investigate how climate change could affect the distribution and abundance of tropical tunas and albacore tunas.	In 2023, the IATTC adopted a resolution providing for climate change to be included as an agenda item on the annual meetings of the Commission, the Scientific Advisory Committee and the Working Group on Ecosystem and Bycatch, in order to consider what amendments or new measures may be needed to address climate change impacts on fisheries in the Convention Area. The IATTC Strategic Science Program incorporates some projects on climate change, including Project N.2.a on developing models of the effects of climate change on pre-recruit life stages of tropical tunas and Project N.2.b on supporting climate-ready and sustainable fisheries using satellite data to conserve and manage life in the ocean and support sustainable fisheries under climate change. The IATTC's Observer Programme uses a combination of national and IATTC Secretariat placements, and similarly collects biological samples and provides information concerning the catch composition of the main EPO tuna fisheries.
Current Conservation and Management Measures Giving Effect to Cooperation with the other RFMO	
WCPFC CMM 2021-02 on Conservation and Management Measure for Pacific Bluefin Tuna provides that the WCPFC Executive Director must communicate the measure to the IATTC Secretariat and its Parties who fish for Pacific bluefin tuna in the EPO, with a request that they take equivalent measures. WCPFC members are also 'encouraged to communicate with and, if appropriate, work with the concerned IATTC contracting parties bilaterally' (WCPFC, 2021b). WCPFC CMM 2009-03 on Conservation and Management for Swordfish recognizes 'the need for both WCPFC and IATTC to adopt conservation and measures to provide for the sustainable management of swordfish stocks across the Pacific Ocean',	Resolution C-21-05 Measures for the Conservation and Management of Pacific Bluefin Tuna in the Eastern Pacific Ocean recognizes that the stock of Pacific bluefin tuna is caught in both the WCPO and the EPO, and that conservation and management measures by WCPFC and IATTC should be considered 'in cooperation between the two RFMOs taking into account historical and future projected proportional fishery impacts on spawning stock biomass (SSB) between fisheries in the EPO and fisheries in the WCPO'. Assessments prepared by the IATTC shall take into account conservation and management measures adopted by the WCPFC, and that in revising management measures for Pacific bluefin tuna, the Commission must consider outcomes of the Joint Working Group (IATTC, 2021b).

although in practice swordfish is essentially unmanaged by IATTC (WCPFC, 2009b). WCPFC CMM 2019-03 on North Pacific Albacore goes further, tasking the WCPFC Executive Director to communicate the WCPFC measure to the IATTC with a request that the two Commissions engage in consultations with a view to adopting uniform conservation and management measures and agreement on any reporting or other measures needed to ensure compliance (WCPFC, 2019b).	IATTC Resolution C-22-04 states that the Commission 'shall promote compatibility, starting with the definition of "reference points", between the harvest strategy adopted through this Resolution, and any future harvest strategy adopted in the WCPFC with respect to North Pacific albacore' and tasks the Director to communicate this Resolution to the WCPFC Secretariat (IATTC, 2022c).

2.3 Broader International law and policy considerations

Global rules and principles in the fields of marine environmental protection, climate change and sustainable development operate alongside the more specific rules governing international fisheries under each RFMO. The requirement for cooperative management must be viewed in the context of international obligations to mitigate climate change impacts and to ensure equity both in the allocation of marine resources and in the distribution of conservation burdens. This section of the report outlines some of the key areas of international law and policy which frame international fisheries management.

2.3.1 International climate law

International obligations to respond to climate-driven redistribution of fish stocks can be derived from international climate law. The *United Nations Framework Convention on Climate Change* (UN, 1992a) (Climate Change Convention) seeks to stabilise the atmospheric concentration of greenhouse gases 'at a level that would prevent dangerous anthropogenic interference with the climate system', and to do so in a time frame that allows ecosystems to naturally adapt to climate change, to permit sustainable development and to ensure that food production is not threatened. That level was set in the 2015 *Paris Agreement* (UN, 2015a) at 'well below 2 degrees Celsius above pre-industrial levels', and preferably no more than 1.5 degrees Celsius above pre-industrial levels.

The Climate Change Convention includes a long list of specific commitments, but these can be summarised under the general principle that Parties must 'take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects.' They are to do so in order to 'protect the climate system for the benefit of present and future generations … on the basis of equity and in accordance with [the parties'] common but differentiated responsibilities' (Article 3.1). The Convention requires Parties to give full consideration to the special needs of developing country parties, especially those that are particularly vulnerable to the adverse effects of climate change, and those that would have to bear a disproportionate burden (Article 3.2). The Paris Agreement further seeks 'to strengthen the global response to the threat of climate change … including by … increasing the ability to adapt to the adverse impacts of climate change' (Article 2(1)(b)), and states that it 'will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances' (Article 2(2)).

The climate law framework can therefore be drawn upon to highlight the obligations of developed State parties to take measures to mitigate the impact of climate change on developing countries, based upon principles of equity and common but differentiated responsibilities. Ensuring that developing country parties to the WCPFC and IATTC are not unduly disadvantaged through the redistribution of fish stocks could be viewed as one way of meeting this obligation to mitigate climate change impacts.

Questions about the responsibilities of States with respect to climate change also underpin the Resolution adopted by the UN General Assembly on 23 March 2023 on the *Request for an advisory opinion of the International Court of Justice on the obligations of States in respect of climate change* (UN Doc A/77/L.58), as well as the *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law* submitted to ITLOS in December 2022, which seeks clarification of the legal consequences of the failure of States to avoid causing significant harm, in particular to small island developing States. The outcome of these requests may also be relevant to the way in which the international climate law framework can be drawn upon in considering responses to the climate-driven redistribution of fish stocks.

2.3.2 Sustainable development framework

These arguments are strengthened when considered alongside the 2030 *Agenda for Sustainable Development* and the UN Sustainable Development Goals (UN, 2015b). While all 17 goals are interconnected, a number are particularly important to the challenge of climate induced redistribution of tuna stocks. SDG 13, *Climate Action,* urges States to take 'urgent action to combat climate change and its impacts'. SDG 14, *Life below water*, requires States to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. In particular, SDG 14 targets 'increased economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including the sustainable management of fisheries' (target 14.7).

2.3.3 The BBNJ Agreement

The recently negotiated *Draft Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction of 4 March 2023* (draft BBNJ Agreement) (UN, 2023) reinforces these important principles. The preamble to the draft BBNJ Agreement recognises the need to address climate change-induced degradation of marine ecosystems and biodiversity loss 'in a coherent and cooperative manner', whilst 'contributing to the realization of a just and equitable international economic order which takes into account … the special interests and needs of developing States'. More concretely, the draft BBNJ Agreement provides a mechanism for the establishment of area-based management tools, including marine protected areas, in areas beyond national jurisdiction (Part III). There is clearly the potential for such measures to overlap with the management area of an existing RFMO. While the draft BBNJ Agreement requires that decisions regarding area-based measures 'respect the competences of, and not undermine, relevant legal instruments and frameworks and relevant [regional bodies]', it also contains significant obligations to regularly consult, and to enhance international cooperation and coordination amongst relevant bodies (Article 19). Whilst it remains to be seen exactly how the draft BBNJ Agreement is implemented once it enters into force, the strength of obligations regarding international cooperation and coordination in this context support a strong reading of existing obligations under international fisheries law.

2.4 Summary

This section has examined the extent to which existing international agreements and arrangements address cooperation between RFMOs in the sustainable use of living marine resources, including with respect to impacts arising from climate change, and the needs of SIDS and developing States.[1] While none of these instruments specifically contemplate the action to be taken by RFMOs to address the climate-driven redistribution of tuna stocks, a strong legal basis for cooperative action can nonetheless be found in the relevant legal frameworks. The global framework for the law of the sea and international fisheries, as set out in UNCLOS and UNFSA, generally requires States to cooperate in the management of highly migratory species such as tuna and to take into account the special requirements of developing States as they do so. In addition, there are international obligations in other legal frameworks—including international climate law, the sustainable development framework and the draft BBNJ Agreement—which can be drawn upon to invoke important principles of inter- and intra-generational equity that are directly challenged by the impact that climate change is projected to have on the distribution of tuna stocks and, consequentially, the livelihoods, nutrition and food security of Pacific Small Island Developing States.

As shown in **Table 2** below, not all of the legal instruments discussed in this report are legally binding on all the members of WCPFC and IATTC—whether because they are by nature 'non-binding' (the SDGs), because they have not yet opened for signature and ratification (the BBNJ Agreement), or because not all States are Party to them (UNCLOS and UNFSA). However, the WCPFC and the IATTC Conventions *are* binding on all the members of each RFMO, and all the CNMs have agreed to apply them as a condition of their co-operating non-membership. This is important, because the constituent instruments of the WCPFC and the IATTC provide a more expansive and detailed framework for cooperation than UNCLOS or the UNFSA. In particular, they recognise the necessity of cooperation in relation to shared stocks, and contain the necessary principles and powers for the members of these organizations to take the decisions that are likely to be required to manage the climate-driven redistribution of

[1] While there are other binding and non-binding instruments addressing important aspects of fisheries law and policy (including the 1993 Compliance Agreement, the Code of Conduct for Responsible Fisheries and the Port State Measures Agreement), these do not address the issues under examination in this report.

tuna stocks. So while the broad obligations of UNCLOS and the UNFSA may not apply directly to all Parties, the more specific cooperation obligations in the WCPFC and IATTC Conventions do.

Table 2. Participation in international agreements and instruments by WCPFC and IATTC members and CNMs

Agreement or Arrangement	WCPFC/IATTC Members who are not Party	WCPFC/IATTC CNMs who are not Party
UNCLOS	United States, Peru, Venezuela	All are Party
UNFSA	China (signatory), Colombia, El Salvador, Guatemala, Mexico, Nicaragua, Peru, Venezuela	Bolivia
UNFCCC	All are Party	All are Party
Paris	All are Party	All are Party
SDGs	Non-binding, apply to all as a political commitment	Non-binding, apply to all as a political commitment
BBNJ	Not yet open for signature	Not yet open for signature

It is also worth noting that the duty under international law to take measures for the conservation and management of stocks on the high seas—or to cooperate with other States in the taking of such measures—is not dependent upon or confined to the existence of RFMOs with suitably defined areas of competence. The duty to cooperate in relation to the living resources of the high seas ultimately rests with individual States fishing for those resources, as does the duty to cooperate with regard to highly migratory stocks. It is the duty of a coastal State to adopt the conservation and management measures necessary to ensure the living resources of its EEZ, and the duty of a flag State to ensure that vessels flying its flag do not fish illegally in the waters of a coastal State. Each of these duties points to the ultimate responsibility of the relevant States themselves. Accordingly, it is up to the relevant coastal and fishing States to make the amendments necessary to the structure and operation of the RFMOs to which they are members, if there are blockages or difficulties that prevent or limit cooperation.

3. The current state of cooperation between WCPFC and IATTC

Cooperation between WCPFC and IATTC has been underway in a range of guises for many years. Between 1996 and 2000, the IATTC Executive Director participated as an observer at all seven sessions of the Multilateral High Level Conference that led to the adoption of the WCPFC Convention and made interventions reflecting on the need for—and potential options for—future cooperation between the WCPFC and the IATTC on 'both of the issues in which cooperation is necessary—overlapping areas and cross-boundary migrations' (WCPFC, 2000). During the preparatory conference for the entry into force of the WCPFC Convention, the Secretariats of the two organizations collaborated to produce a paper on how to give effect to cooperation between them, which included recommendations about cooperation on stock assessments for bigeye tuna, a Pacific-wide tagging program for tropical tunas, procedures for sharing information on scientific and management issues, and the creation of a permanent working group to enhance cooperation through information sharing and dialogue (WCPFC, 2002; IATTC, 2005). This Section provides a stock-take of the extent to which practical measures have so far eventuated, by considering four areas of cooperation:

- governance and institutional issues;
- scientific research;
- conservation and management; and
- compliance and enforcement.

3.1 Governance and institutional issues

To date, cooperation between WCPFC and IATTC at the institutional level has consisted primarily of: (i) formal Memoranda of Understanding addressing specific issues; (ii) meetings between the two Secretariats; and (iii) attendance by members of one Secretariat at the meetings of some bodies of the other RFMO.

The two organizations have developed three formal instruments on cooperation:

- a 2006 Memorandum of Understanding (2006 MOU), in which they agree to consult and cooperate in respect of matters of common interest including the exchange of data and information, research on stocks and species of mutual interest (including Pacific-wide stock assessments), and conservation and management measures for stocks of mutual interest (WCPFC, 2006a);
- a 2009 Memorandum of Cooperation on the Exchange and Release of Data (MOC on Data), which underpins cooperation on Pacific-wide stock assessments for tunas and sharks and an annual exchange of data and information between the IATTC and SPC-OFP (WCPFC, 2009a); and
- a 2011 Memorandum of Cooperation on the Cross-Endorsement of Observers (MOC on Observers), which provides for approved observers who meet the necessary training requirements to be cross-endorsed to operate on vessels that fish on the high seas in both Convention Areas and the overlap area (WCPFC, 2011b).

A meeting between the Secretariats was also established to facilitate cooperation between the two RFMOs (the 'WCPFC-IATTC Consultative Meeting'), which met on four occasions in 2007 and 2008. While there have not been any further meetings of the WCPFC-IATTC Consultative Meeting since 2008, in 2011 the Executive Directors of both RFMOs met to discuss measures for managing fishing in the overlap area. This discussion produced five options for consideration by WCPFC and IATTC (IATTC, 2012a):

1. management of the overlap area assigned to one RFMO only, through an MOU;
2. management of the overlap area assigned by gear type, with IATTC managing the purse-seine fishery, and WCPFC managing longlining;
3. establishment of a 'special management area', where an agreed set of management measures would be applied;
4. application of measures by both Commissions, with vessels from the WCPFC Register fishing under WCPFC rules, vessels from the IATTC Register fishing under IATTC rules, and vessels registered with both RFMOs selecting and advising under which Commission's rules they wished to fish; and
5. establishment of a working group to consider longer-term options for management of tuna in the Pacific Ocean basin.

The RFMOs agreed that option 4 was the most practical in the short term, but that a longer-term process should be established to explore avenues for managing tuna stocks in the entire Pacific Ocean, as proposed in option 5 (IATTC, 2012b; WCPFC, 2013). The first (short term) part of this decision is reflected in the conservation and management measures of both organizations (as discussed below), but no progress appears to have been made on the second (long term) proposed avenue for cooperation.

Although the two Secretariats have not held a WCPFC-IATTC Consultative Meeting since 2008, a member of the Secretariat of each RFMO generally attends the Commission meetings and the Scientific Committee meetings of the other RFMO, although only as an observer. However, this does not currently extend to attendance at meetings of all other subsidiary bodies, such as the WCPFC Technical and Compliance Committee or the meeting of the IATTC Committee for the Review of Implementation of Measures Adopted by the Commission.

3.2 Scientific research

Scientific research is currently the area of closest cooperation between the RFMOs. Until recently, scientific collaboration between the two RFMOs has tended to focus on coordination of tagging initiatives, tuna biology, ecosystem modelling, bycatch vulnerability analyses and northern stocks. Cooperation in regard to northern stocks has been conducted principally through the WCPFC Northern Committee (which makes recommendations to WCPFC in relation to stocks which occur mostly in the WCPFC Convention Area north of 20°N) and the

ISC (which provides scientific advice to both the WCPFC and IATTC for northern stocks).[2] The ISC comprises seven full Members,[3] four non-voting Members[4] (including the WCPFC and SPC)[5] and one cooperating non-Member (the IATTC). All Members of the ISC are also Members of the IATTC and, with the exception of Mexico, are Members of the WCPFC. The ISC has facilitated scientific collaboration on Pacific-wide stock assessments for Pacific bluefin tunas, billfishes and sharks, many of which have a shared distribution between the IATTC and the WCPFC Convention Areas. The ISC also has four species working groups (for Pacific bluefin tuna, North Pacific albacore, billfish and sharks) through which Members and non-voting Members collaborate on scientific research and technical matters. A Statistical Working Group focuses on the collection and exchange of scientific and monitoring data.

In contrast to SPC's Commission-wide role as Scientific Services Provider to the WCPFC, the ISC and the Northern Committee effectively quarantine their work on northern stocks from the rest of the WCPFC, despite the fact that non-ISC Members harvest species for which the ISC and Northern Committee provide advice.[6] The IATTC's Strategic Science Plan indicates that the IATTC will collaborate with ISC on stock assessments conducted by the latter, and on management strategy evaluations (MSEs) for North Pacific albacore and Pacific bluefin tuna (IATTC, 2018).

The IATTC and WCPFC also collaborate on scientific assessments by attending each other's Scientific Committee meetings and exchanging data and assessments as required under the MOU. Both organizations take account of stock distributions in the WCPO and EPO, and the IATTC takes account of the ISC's stock assessments and recommendations on harvest strategies. Both organisations also assist each other with periodic and independent peer-review of their stock assessments.

3.3 Conservation and management

In 2015, the WCPFC Northern Committee requested WCPFC to arrange a joint meeting with IATTC on the management of Pacific bluefin tuna. This led to the establishment of the IATTC-

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[2] This distinction is reflected in the different way in which stock assessments for South Pacific and North Pacific albacore have been conducted: while the ISC has conducted the North Pacific albacore assessment (covering the entire North Pacific, including the waters of the IATTC), SPC has conducted the South Pacific albacore assessment (covering the WCPFC Convention Area only). However, this distinction may be starting to diminish, with a Pacific-wide stock assessment for south Pacific albacore conducted jointly by the SPC and IATTC for the first time in 2021, utilizing data from both Convention Areas.

[3] Canada, Japan, Republic of Korea, Mexico, People's Republic of China, the United States of America.

[4] Food and Agriculture Organization of the United Nations (FAO), North Pacific Marine Science Organization (PICES), Secretariat of the Pacific Community (SPC), and the WCPFC.

[5] While SPC is a member of ISC, it rarely participates.

[6] For example, the 2020 stock assessment for North Pacific albacore noted that Vanuatu caught 4% of total catches from 2014-2018.

Northern Committee Joint Working Group on Pacific Bluefin Tuna Management (Joint Working Group), which has convened annually since 2016, and makes recommendations and drafts proposals for each RFMO on the basis that there will be few or no alterations when the proposals are put forward for final adoption at each Commission. The annual meetings of the Joint Working Group include all participants in Pacific bluefin tuna fisheries, who receive the scientific advice and stock assessment updates from the ISC and develop harmonized draft proposals for conservation and management measures and harvest strategies. At the Joint Working Group's second meeting in 2017, a rebuilding plan was negotiated for the depleted, single population of Pacific bluefin tuna (Madigan et al., 2017). In 2018, the Joint Working Group also established a Technical Working Group to progress the development of a draft Catch Documentation Scheme for Pacific Bluefin tuna, which has so far met three times.

The practical extent of cooperation between WCPFC and IATTC through the Joint Working Group can be considered by reference to the conservation and management measures adopted for relevant stocks, such as Pacific Bluefin tuna. For the WCPFC, CMM 2021-02 requires the WCPFC Executive Director to communicate the measure to the IATTC Secretariat and its Parties who fish for Pacific bluefin tuna in the Eastern Pacific Ocean, with a request that they take equivalent measures (WCPFC 2021a). WCPFC members are also 'encouraged to communicate with, and if appropriate, work with the concerned IATTC contracting parties bilaterally'. The IATTC measure for Pacific Bluefin Tuna (Resolution C-21-05) is more comprehensive. It specifically recognises that the stock of Pacific bluefin tuna is caught in both the WCPO and the EPO, and that conservation and management measures by WCPFC and IATTC should be considered 'in cooperation between the two RFMOs taking into account historical and future projected proportional fishery impacts on SSB between fisheries in the EPO and fisheries in the WCPO' (IATTC 2021b). It also specifies that assessments prepared by the IATTC Scientific Staff shall take into account conservation and management measures adopted by WCPFC, and that in revising management measures for Pacific bluefin tuna, the Commission must consider outcomes of the IATTC-NC Joint Working Group. The success of the cooperation in conservation and management through the Joint Working Group is reflected in the adoption of the rebuilding plan for Pacific bluefin tuna, the resulting improvement in stock status (ISC, 2022), and the negotiation of new management activities by both RFMOs in 2021 (IATTC, 2021a; WCPFC, 2021a).

Cooperation between the two organizations is also specifically addressed in individual conservation and management measures for other species. For example, WCPFC CMM 2009-03 on Conservation and Management for Swordfish recognises 'the need for both WCPFC and IATTC to adopt conservation and measures to provide for the sustainable management of swordfish stocks across the Pacific Ocean'. WCPFC CMM 2019-03 on North Pacific Albacore, tasks the WCPFC Executive Director to communicate the WCPFC measure to the IATTC with a request that the two Commissions engage in consultations with a view to adopting uniform conservation and management measures and agreement on any reporting or other measures needed to ensure compliance. Similar sentiments are reflected in IATTC Resolution C-18-03, which states that the Commission 'shall continue efforts to promote compatibility between the conservation and management measures adopted by the IATTC and the WCPFC with respect to North Pacific Albacore', and tasks the Director to communicate this Resolution to the WCPFC Secretariat.

Cooperation between the two RFMOs in conservation and management also arose for consideration at the most recent (2022) WCPFC Commission meeting, in relation to South Pacific albacore, for which the WCPFC is seeking to develop a management procedure. While no substantive decisions were made at this meeting, a number of WCPFC members (including Pacific Island Countries, New Caledonia and French Polynesia) urged the WCPFC to work with IATTC to secure compatible management of South Pacific albacore in the EPO.

3.4 Compliance and enforcement

As part of their obligation to cooperate through RFMOs, members of the WCPFC and the IATTC are responsible for ensuring the establishment of 'appropriate cooperative mechanisms for effective monitoring, control, surveillance and enforcement' (MCS) of the stocks and areas under their jurisdiction (Article 10(h), UNFSA). In addition, the constituent instruments of both RFMOs contain general obligations to cooperate with other organizations—and Article 22(4) of the WCPFC Convention specifically requires the WCPFC Commission to consult with the IATTC on measures relating to MCS for stocks that occur in the Convention Areas of both organizations (WCPFC, 2004). The MOC on Observers has provided a foundation for cooperation in compliance and enforcement duties undertaken by the observer programmes operating in each jurisdiction. Each RFMO has adopted measures to give effect to their agreement that approved observers from both observer programs who meet the necessary training requirements can be cross-endorsed to operate on vessels that fish on the high seas in both Convention Areas and the overlap area (WCPFC, 2011b).

Both RFMOs have also independently established many of the key MCS tools needed to ensure compliance and enforcement with their conservation and management measures, from a record of fishing vessels and a regional observer programme to a vessel monitoring system and a procedure for establishing a list of vessels engaged in IUU fishing. Beyond these, neither of the two RFMOs' constituent instruments specifically provide for cooperation with other RFMOs in relation to compliance or enforcement issues.

3.5 Summary

The legal frameworks of both organizations envisage, enable and encourage cooperation between the WCPFC and the IATTC on relevant issues, and some steps have been taken to put meaningful measures into place—in particular, the 2006 MOU, the MOC on Data, the MOC on Observers, the decision regarding vessels operating in the overlap area, and the Joint Working Group on Pacific Bluefin Tuna. While the decisions that will be needed to effectively manage shifting stocks cannot be taken in advance, WCPFC and IATTC can act now to identify the relevant challenges, in order to develop a framework that will support informed and effective cooperation in the management of shared tropical tuna stocks when the time comes.

4. Emerging needs, challenges and potential complexities arising from the redistribution of tuna stocks

Building on the existing forms of cooperation as well as the issues, gaps and obstacles identified across the areas of RFMO activity discussed above, a number of future needs and emerging challenges can be identified:

- collaborating in further scientific research
- clarifying the extent of each RFMO's jurisdiction
- developing governance or institutional mechanisms or processes for cooperation
- addressing questions of membership
- inter-operability and compatibility of conservation and management measures
- implications for participatory rights, and
- enhancing cooperation in compliance and enforcement.

4.1 Collaborating in scientific research

The need for cooperative management approaches to the climate-driven redistribution of tuna resources will depend on the extent to which stocks become or remain transboundary. As such, it will be imperative to develop a clearer understanding of the spatial distribution and connectivity within and between tuna stocks within the Pacific Ocean. For example, if further scientific research confirms that stock structures of tropical tuna species are panmictic, Pacific-wide processes would need to be considered for stock assessments, but little to no change may be required to current management practices. Conversely, if research reveals more complex population structuring and the presence of multiple stocks, more complicated and spatially explicit assessment frameworks will be required.

Cooperation will also be needed to improve the modelling for how each identified tuna stock is likely to respond to climate change. WCPFC has been using the Spatial Ecosystem And Population Dynamics (SEAPODYM) modelling framework (Lehodey et al., 2014) to investigate how climate change could affect the distribution and abundance of tropical tunas and albacore tunas. SEAPODYM is particularly well suited for simulating the effects of climate-driven changes to the physical, chemical and biological features of the Pacific Ocean on the distribution of tuna (Lehodey et al., 2008; Senina et al., 2008; Senina et al., 2020a). However, further improvements over past and recent SEAPODYM simulations and analyses (Lehodey et al., 2011; Lehodey et al., 2013; Lehodey et al., 2015; Bell et al., 2021) are needed to reduce uncertainty and improve the resolution of current models from basin-wide to more regional or sub-regional application. The two RFMOs can also play a role in reducing uncertainty in ecosystem and tuna modelling through enlisting the assistance of industrial fishing vessels operating within their jurisdictions to collect additional data and information needed to verify and inform the modelling.

Most Pacific tuna stock assessments to date have generally been RFMO-specific, although Pacific-wide assessments have been performed to test the 'sensitivity' of assessed stock status to the RFMO-specific stock assumption (Hampton and Maunder, 2005; McKechnie et al., 2015) or to meet managers' specific requests (Castillo Jordán et al., 2021). In these cases, the spatial structure of pan-Pacific assessments was developed so that RFMO boundaries were maintained, and RFMO-specific results could be provided. These results to date have proved to be relatively robust to the regional/Pacific-wide assumption (Hampton and Maunder, 2005; McKechnie et al., 2015). However, adjustments may need to be made to incorporate the improved understanding of stock structure and the projected responses of stocks to climate change.

Cooperation in monitoring of biological parameters such as growth and reproductive biology is also likely to be needed. These parameters can vary from the west to the east Pacific (Hampton, 2017), and are likely to shift with changing environmental conditions caused by climate change. Close monitoring of these parameters will be necessary given the sensitivity of the stock assessment models to shifts in the shape and value of these parameters.

It will also be useful to integrate information from climate modelling into the harvest strategies being developed for tuna stocks by WCPFC and IATTC (see, e.g., Merino et al., 2019). While harvest strategies are likely to be reviewed at timescales shorter than those currently projected for the substantial impacts of climate change on Pacific tuna, ongoing improvements to modelling about how climate change may alter stock distribution, and fish movement and biology, will allow these uncertainties to be re-examined as harvest strategies evolve. In turn, monitoring the actual impacts of climate change on the stock and fishery over time will signal an 'exceptional circumstance' where those changes fall outside the ranges of uncertainty against which a harvest strategy was tested, and hence whether that strategy needs to be revisited (de Moor et al., 2022). It will also allow review of the ability of selected management procedures to continue to achieve the objectives of stakeholders in the face of regional climate impacts (Merino et al., 2019). In short, using climate modelling to inform harvest strategies would provide both RFMOs with a better framework to adjust overall catch and effort limits to ensure sustainable management within their jurisdiction, and to adjust these limits if fish are progressively re-distributed into other jurisdictions so that shared stocks can be managed sustainably.

4.2 Clarifying the extent of jurisdiction

In the WCPFC Convention and the Antigua Convention, jurisdiction is defined both spatially (in terms of the Convention Area within which each RFMO has competence), as well as biologically (in terms of the species and stocks that are the focus of their management). These jurisdictional requirements are cumulative; that is, neither Convention contemplates the organization having management of a particular stock once it travels outside the relevant Convention Area.

This limitation reflects both the essential strength and fundamental weakness of the UNCLOS framework of maritime zones: the clear demarcation lines of each Convention Area provide certainty in terms of the exercise of rights and responsibilities by each RFMO, but do not reflect biological limits. Accordingly, it will be important for the two RFMOs to identify the stocks that are likely to be impacted by climate-driven redistribution, and then—reflecting the commitments to inter-RFMO cooperation already contained in each RFMO agreement—agree on the best institutional arrangements for the cooperative management of these stocks.

4.3 Developing governance or institutional mechanisms for cooperation

A starting point for this should be to add climate change to the agenda of RFMO meetings, both in terms of individual RFMO activity, and as a priority area for cooperation. While the meeting agendas of Commissions and subsidiary bodies are already crowded and contested, the issue of climate change and the importance of cooperation will increase in importance over time as climate-driven stock redistribution occurs. Developing a practice of substantive and open discussion within and across the RFMOs will be a critical basis for responding to change. At an individual level, both RFMOs have made some progress with respect to integrating climate change into their work agenda and discussions.

For example, at its 2022 meeting, the WCPFC agreed that climate change be included in the Scientific Committee's work, and also agreed to include climate change as a standing agenda item for the Commission, and to prioritize discussion of how to best incorporate climate change information and analysis in the work of the Commission as well as the work of the Technical and Compliance Committee and the Northern Committee (WCPFC, 2022a). However, no formal progress has yet been made with the IATTC on any cooperation needed for managing the effects of climate change.

4.4 Addressing questions of membership

As shown in **Table 1**, there is already a substantial overlap in participation between WCPFC and IATTC. However, as stocks re-distribute, States which are not currently members of one or other of these RFMOs might be motivated to pursue membership of that RFMO in order to ensure access to the fishery, and to participate in decision-making. The possibility of additional States seeking to join these RFMOs highlights the importance of effective mechanisms for institutional cooperation, but also raises complex questions about the application of the rules in each organization regarding whether—and how—to accommodate new members. In this event, the provisions of the Antigua Convention and the WCPFC Convention on accession to the treaty will become particularly important.

In respect of the IATTC, aside from Parties to the 1949 Convention which originally established the IATTC, and Parties with a coastline bordering the Convention Area, accession to the Antigua Convention is generally open to new members only if their vessels fish for stocks covered by the Convention (following consultations with the existing Parties), or if they are otherwise invited to become members on the basis of a decision by the existing Parties (Articles XXVII and XXX, Antigua Convention). The situation is similar in the WCPFC, since Article 35 of the WCPFC Convention provides that, beyond the States which participated in the negotiation of the Convention, other States may only become party by a consensus decision of all Parties. This regime gives considerable control to the existing members in determining whether or not to allow new members—although it may be difficult to reconcile with Article 8 of UNFSA, which provides that 'States having a real interest in the fisheries concerned may become members of such organization', and further, that 'the terms of participation in such organization or arrangement shall not preclude such States from membership or participation; nor shall they be applied in a manner which discriminates against any State or group of States having a real interest in the fisheries concerned'. In this context, questions might also arise about the existing approach that these organizations take to new membership. To date, for example, consensus to admit new members to the WCPFC has not been forthcoming, despite explicit requests to join from co-operating non-members including Belize, Ecuador, El Salvador, Mexico, Panama and Vietnam (WCPFC, 2017a). There is also the possibility of additional States seeking co-operating non-membership of these RFMOs.

In addition to resolving processes for membership, the complex issues of access to participatory rights and/or the allocation of such rights to new members or co-operating non-members will need to be resolved.

4.5 Inter-operability and compatibility across RFMO conservation and management measures

As described in their constituent instruments, the central objective of both the WCPFC and the IATTC is to ensure the long-term conservation and sustainable use of highly migratory stocks in the Pacific Ocean through the adoption of appropriate conservation and management measures (WCPFC, 2004; IATTC, 2010). This necessarily includes setting appropriate limits on fishing. Where stocks are overfished or where overfishing is occurring—or where there is a risk of exceeding target and limit thresholds—effective conservation and management of fish stocks should include a limit in some form, whether defined as catch volume, effort or capacity. Limits should be applied across the entire range of the stock or sub-stock (Article 7(2), UNFSA), guided by harvest strategies based on the best scientific evidence available and applying a precautionary approach. Importantly, limits for highly migratory stocks must be compatible across jurisdictional boundaries—not only between EEZs and high seas, as established in Article 7 of the UNFSA, but also between the Convention Areas of different RFMOs.

In this respect, a critical challenge for the WCPFC and the IATTC will be to consider how to define limits adopted by the two organizations in a way that ensures they are compatible. This will be particularly important if the ranges of principal market tuna stocks increasingly straddle the two Convention Areas. At present, the WCPFC manages its key tropical tuna stocks through a combination of catch and effort limits, whereas the IATTC primarily relies on closures and capacity limits. If limits cannot be defined using the same metrics, they should at least be translatable between RFMOs to ensure that they are directed toward achieving a shared objective for the stock. An increasing priority towards Pacific basin evaluations of

CMMs may be necessary as connectivity within and between stocks becomes better understood.

If basin-scale CMM evaluations suggest that differences between the measures of the two RFMOs generate counter-productive outcomes, the two RFMOs will need to come to some form of agreement that enables the adoption of equivalent CMMs. This could include the adoption of harvest strategies for all shared stocks, or stocks that are likely to shift across RFMO boundaries over time. The WCPFC and the IATTC may therefore need to consider the role of harvest strategy development in providing a tool to assist in managing potential future shifts in tuna biomass. Although they are at different stages in the process, both RFMOs have already decided to develop harvest strategies for one or more of the stocks under their jurisdiction. Thus, there should be scope for aligning some aspects of these strategies—whether in relation to the management objectives or the actions to be taken in the face of specified situations—to help ensure that foreseeable levels of change can be managed as consistently, predictably and as transparently as possible within the scope of each RFMO's management framework.

4.6 Implications for participatory rights

Allocation is a complex and often divisive task, and the level of difficulty will only be increased by the climate-driven redistribution of stocks. The failure to equitably allocate resources has been recognized as one of the greatest threats to the stability of fisheries management regimes (Lodge et al., 2007), and significant cooperation will be needed to ensure that fishing opportunities continue to be allocated equitably in light of climate-driven stock redistributions, not only between parties to one RFMO or the other, but across both RFMOs.

Options for transferability of rights between RFMOs will need to be developed and considered by each RFMO if the magnitude of climate-induced biomass redistribution results in significant losses and damages to SIDS and developing economies who have existing participatory rights. The development of options should give meaningful effect to principles of intra-generational and inter-generational equity. In addition to the 'special requirements' and 'special circumstances' provisions in Articles 24 and 25 of the UNFSA, the principle of common but differentiated responsibilities which is laid out in the 1992 *Rio Declaration on Environment and Development* (UN, 1992a) and embodied in the *United Nations Framework Convention on Climate Change* (UNFCCC) (UN, 1992b) will also be relevant. A key objective of cooperation between the RFMOs in this context should be to find a way to preserve the rights and interests of all States as they were prior to the climate-driven changes that are coming.

This idea is not without precedent. At the 2019 WCPFC Commission Meeting, Korea noted anecdotal evidence that tropical tunas were aggregating in the high seas more frequently compared to past years, and expressed concern that its industry would suffer if Korea was unable to access sufficient fishing opportunities in the high seas. In this context, Korea suggested that the WCPFC explore the possibility of allowing States to use 'vessel days purchased under bilateral fishing arrangements in the high seas, while making sure that such a system does not negatively affect the sovereign rights or aspirations of SIDS' (WCPFC, 2019c; Hanich et al, 2021).

For example, providing coastal States that are expected to lose biomass in their EEZ due to climate change with a permanent, transferable allocation would enable them to hold valuable rights that could be exercised wherever the fish are—even if they no longer occur in the EEZ of the coastal State in the same numbers. This would retain some level of equity for both current and future generations by providing a permanent income stream regardless of biomass redistribution. In this respect, some examples of transferable rights have already been developed in the WCPO, where they have been operating successfully between the PNA members (and the flag States who fish in their waters) for many years under the Vessel Day Scheme. A significant additional complexity in a climate change scenario will be to consider transferability not only among EEZs, or between EEZs and the high seas, but potentially between RFMOs.

How rights in such schemes are allocated between coastal and flag states will also need consideration, particularly given the jurisdictional differences between the RFMOs (one of which is dominated by EEZs and one by the high seas). Making allocations to coastal States based on past fishing in their EEZs would be consistent with international law (Davis et al., 2022) and would assist in mitigating the economic impacts of stock losses incurred by coastal States—and particularly by Pacific SIDS—as a result of climate change. Flag States would continue to have the opportunity to fish in coastal States' EEZs by negotiating access for their vessels, consistent with the established practice.

4.7 Enhancing cooperation in compliance and enforcement

A final challenge for cooperation will relate to compliance and enforcement. In this respect, both RFMOs have already established many of the key MCS tools needed to monitor and enforce compliance with their conservation and management measures. However, the IATTC compliance and enforcement regime is not as developed as that of WCPFC. For example, while the WCPFC has established its own high seas boarding and inspection regime (WCPFC, 2006b), which has now been in operation for more than 15 years, IATTC has not—although the high seas boarding and inspection procedure established in Articles 21 and 22 of the UNFSA does apply between UNFSA parties in any area covered by an RFMO, including the IATTC Convention Area. In addition, although members of IATTC are required to ensure that all commercial fishing vessels longer than 24 meters carry and operate a satellite-based VMS, this is not a centralized system which reports directly to the Commission in the same way as the WCPFC VMS. This means that, unlike WCPFC member States, coastal State members of IATTC cannot get access to centralized VMS data for IATTC-registered vessels operating in their EEZs (as provided for in Article 24(8) of the WCPFC Convention), nor can they receive real-time VMS data for these vessels in areas of high seas adjacent to their EEZs for the conduct of compliance and enforcement operations (as established in paragraph 22 of Rules and Procedures for Access to High Seas Non-Public Domain Data) (WCPFC, 2009c). However, at its 2022 Commission meeting, IATTC did commit to improving its compliance review process (IATTC, 2022b).

With the strengths and weaknesses of the current arrangements in mind, there are some gaps where enhanced cooperation and collaboration may be required. The first, and most obvious, is in the overlap area. WCPFC and IATTC already have some basic measures in place for cooperation in compliance and enforcement in the overlap area—in particular, the MOC on Observers, which provides that approved observers from both observer programs who meet the necessary training requirements can be cross-endorsed to operate on vessels that fish on the high seas in both Convention Areas and the overlap area (WCPFC, 2011b).

However, given the overlapping jurisdiction in this area, a sensible next step might be to consider the extent to which the existing arrangements are fit for purpose—both currently, and in anticipation of future changes in the distribution of fish stocks due to climate change. In particular, further scientific modelling might be needed to understand whether the overlap area is expected to be more productive or less productive, and whether and how the existing compliance and enforcement arrangements might need to be enhanced.

Second, although each RFMO will continue to oversee compliance and enforcement with respect to fishing for highly migratory stocks in the high seas of its own Convention Area, there are also opportunities for greater cooperation—and this might be particularly important in the high seas of the EPO, where the biomass of tropical tuna is expected to increase significantly. To date, the majority of tuna in the Pacific Ocean basin have been caught in the EEZs of WCPFC coastal State members, where compliance and enforcement can be carried out by coastal States in an exercise of their sovereign rights. However, if Pacific tuna biomass shift progressively east and into the high seas of the EPO, where there are fewer oceanic islands to generate coastal State jurisdiction, this will become more difficult, because the primacy of flag State jurisdiction on the high seas will limit the jurisdiction of other States for compliance and enforcement activities. Further modelling of the likely climate-driven redistribution of each stock to these high seas areas will once again be important, this time in revealing the areas with the greatest potential for increased risk of illegal fishing, and concomitant need for closer cooperation.

For example, it might be necessary to cooperate to expand the operation and coverage of the WCPFC and IATTC VMS systems, so that vessels authorized to operate under the rules of either RFMO are required to transmit VMS data at all times when fishing in, transhipping catches in or transiting both Convention Areas. In this case, the MOC on Data might need to be amended to ensure that relevant data and information are available to both RFMOs. In relation to electronic monitoring, which is in its infancy in terms of implementation across both organisations, the cooperative model established in the MOC for Observers, which allows vessels operating in the high seas of either Convention Area to use authorized observers from either RFMO to meet their observer coverage obligations, could be considered as a starting point.

Finally, a review could be undertaken in cooperation with both RFMOs to see whether any best practice or innovative approaches developed and applied in one organization might be able to be adapted and applied in the other, in order to enhance the overall high seas compliance and enforcement capacity of both organizations. A candidate for evaluation is the agreement in the WCPFC that coastal States can access near real-time VMS data for the high seas in areas up to 100 nautical miles adjacent to their EEZs, for the purpose of conducting MCS activities (WCPFC, 2009c).

4.8 Summary

As biomass shifts and new scientific information emerges, the management frameworks for affected stocks will need to be flexible—particularly in relation to stocks that are shared between RFMOs. WCPFC and IATTC will need to identify appropriate and adaptive governance frameworks and management tools to address new challenges, and effectively manage new or emerging fisheries. Consideration will also need to be given to enhancing and expanding existing modes of cooperation—and to developing new forms of cooperation. Much of this will be breaking new ground for RFMOs and will require the development of new institutional and management arrangements.

5. Opportunities for enhancing cooperation between WCPFC and IATTC

At the heart of the challenge explored in this report are two key questions:

- the first relates to **governance**: what institutional mechanisms are needed to enable WCPFC and IATTC to cooperate effectively in the management of tuna stocks affected by climate-driven redistribution in a way that takes into account the needs and interests of all relevant States and entities?
- the second relates to **management**: how can WCPFC and IATTC set fishing limits and allocate fishing opportunities for tuna stocks affected by climate-driven redistribution in a way that ensures the sustainable management of the stock and takes into account the needs and interests of all relevant States and entities?

Potential options for addressing these questions can be identified, ranging from minimal change to much greater change, with a variety of potential costs and benefits. To aid in the consideration of these options, we start by outlining the range of options potentially available to revise existing arrangements and facilitate adaptation to continuing change, and then explore examples of the sort of approaches that have been taken in other regions, and highlight some of the limitations, challenges and incentives that may be relevant in evaluating and applying them in the Pacific context.

5.1 Options for revising existing institutional mechanisms

At the 'minimal' end of the scale, there are a wide range of ways in which WCPFC and IATTC can simply **enhance the existing arrangements for cooperation**. This might include (but is not limited to):

- re-instituting the annual meetings between the Executive Directors of both RFMOs;
- establishing procedures for a senior representative of one RFMO to routinely attend each meeting of the other RFMO (not just the Commission meeting and the Scientific Committee);
- adding a standing agenda item on cooperation to each meeting of both RFMOs, to formalise and facilitate meaningful information sharing and cooperative approaches to the issues under discussion;
- ensuring that representatives from one RFMO attending a meeting of the other RFMO have access to all relevant papers and are invited to speak on relevant measures and attend key discussions (such as Heads of Delegation discussions on management and allocation issues); and
- formalising consideration of 'the effects of climate change and cooperative responses to address them' as a standing requirement in the development, adoption or amendment of all conservation and management measures.

These options would enhance the existing arrangements for cooperation by providing more formalised opportunities for information-sharing between the RFMOs, highlighting the need for consideration of climate-driven impacts on fisheries, and normalising cooperation on these issues as a routine consideration in the discussion and decision-making of each RFMO.

Further along the scale of cooperation, the two RFMOs could **create a new mechanism for cooperation**. There are a number of ways in which such a mechanism could be set up, and some existing examples from which inspiration might be drawn. For example, consideration could be given to re-enlivening the WCPFC-IATTC Consultative Meeting, which was held four times between 2007 and 2008 in the margins of the annual WCPFC and IATTC meetings. This Meeting was focused on reviewing three areas for collaboration: data and information, scientific research, and conservation. There were some useful outcomes from this Meeting, including the 2006 MOU, the MOU on Data, the exchange of information on IUU lists, and ongoing informal cooperation between the Secretariats on relevant issues. This Meeting primarily involved discussion between the Secretariats of the two RFMOs (although it was also attended by IATTC and WCPFC members participating in the main Commission meeting),and has not been convened since 2008. However, it could be re-instituted, the agenda revised to address contemporary areas in which cooperation is needed to address the effects of climate change, and the focus shifted to attendance of and discussion between IATTC and WCPFC members. There are a range of issues that WCPFC and IATTC members would need to work through in setting up such a mechanism, from administrative issues such as chairing, duration and administrative support to substantive questions of scope and objective, procedures for decision-making and the participation of observers.

Noting the importance of discussions between RFMO members themselves, a new mechanism for cooperation between WCPFC and IATTC could be modelled loosely on the Joint Tuna RFMOs Meeting, commonly known as the Kobe Process. The Kobe Process met three times between 2008 and 2011 to bring together the members of the five tuna RFMOs with the objective of improving coordination across the whole range of RFMO policy. In this context, participants discussed and adopted recommendations on a range of issues, including scientific research, ecosystem considerations, capacity, allocation, and support for developing countries, for consideration and implementation by each tuna RFMO. Many of these recommendations were subsequently considered and adopted by WCPFC and IATTC.

Drawing on these examples, arrangements for a new mechanism for cooperation between WCPFC and IATTC might include (but are not limited to):

- participation by the member States of each RFMO (rather than Secretariats);
- regular scheduling, possibly in conjunction with the Commission meeting of one or other RFMO (perhaps alternating each year);
- an objective of improving coordination between the two RFMOs in relation to issues on which substantive cooperation is required to address the impacts of climate change, reflected in a standing agenda;
- an option to establish working groups or thematic groups on topics for which additional discussion is needed; and

- a process for adopting recommendations to be considered, adopted and implemented by each RFMO individually (not directly binding on each RFMO).

A joint meeting of this sort would provide a basis for discussion and cooperation on more substantive issues and allow the two RFMOs to elaborate joint approaches and make recommendations on issues of shared interest—from scientific research agendas to draft conservation and management measures—but would still leave each RFMO to discuss, adopt and implement them pursuant to decisions of its own membership, under its own legal framework.

At the far end of the scale, the members of the two RFMOs could decide to **revise or amend existing institutional arrangements to enhance cooperation**. For example, one option would be to establish an over-arching Pacific-wide organization to sit above WCPFC and IATTC, underneath which WCPFC and IATTC could serve as regional sub-committees, responsible for making recommendations to the over-arching organization for adoption (along the lines of the Eastern and Western Sub-Regional Management Committees established in the South Pacific Regional Fisheries Management Organization (SPRFMO)). Another option would be to merge the two RFMOs together into one Pacific-wide organization with responsibility for highly migratory stocks across the whole ocean basin, in a similar way to the Inter-American Commission for the Conservation of Atlantic Tunas (ICCAT).

5.2 Options for revising existing arrangements for allocation

Regardless of what institutional arrangements are adopted, the two RFMOs will still need to consider how to define and allocate fishing rights. In this respect, the simplest option might be for **management of a particular stock or species (including the setting of catch limits) to be assigned to one RFMO only, on the proviso that a portion of the quota be set aside for the other RFMO**. This sort of approach is followed in the North Atlantic to address the redistribution of the oceanic redfish stock (discussed in Section 5.2 below), whereby the North East Atlantic Fisheries Commission (NEAFC) reserves a portion of the stock for NAFO, which is then able to allocate that amongst its members.

Applied in the context of climate-driven redistribution of a particular tuna stock from the WCPFC Convention Area to the IATTC Convention Area, this might entail WCPFC setting the limit for fishing of that stock (however defined), and then reserving a portion of the quota for that stock for the IATTC, which would then be able to allocate it amongst its own members. There are a number of ways in which this option could be implemented within the existing legal framework (provided agreement was reached between both RFMOs), and it could be adopted together with the various options for institutional cooperation noted in Section 5.1. If this approach were adopted, there would be no need to reach agreement on how the limits are defined, since the management and catch limit of each stock would be the responsibility of one RFMO alone—the only requirement would be for the other RFMO to allocate its reserved portion of the ~~quote~~ amongst its own members in compatible terms. However, it may be challenging to secure agreement on which RFMO is to manage the stock—let alone the difficult question of how much should be set aside for the other RFMO, or how to reflect the inequities that are likely to be produced by climate-driven redistribution of tuna stocks. In this respect, as noted in Section 4.6 above, the allocation between RFMOs would need to take into account the characteristics of their respective membership and reaching agreement on management strategies that currently apply catch- or effort-based systems.

Another option would be for the two RFMOs to adapt their fisheries management regimes to **permit fishing rights to be transferred from the Convention Area of one RFMO to the other**, or to **permit pooling of fishing rights to allow them to be exercised in multiple jurisdictional zones**. The objective of such an arrangement would be to achieve an equitable outcome by maintaining allocations at a level that is more reflective of the 'pre-climate change' distribution of fish stocks. This approach would enable fishing rights to 'follow the fish', rather than limit their exercise to the jurisdiction in which they were originally allocated. This sort of approach has been a feature of Pacific tuna fisheries for some time, in the context of adaptations required to reflect the El Nino-La Nina southern oscillation.

For example, allocations of fishing opportunities (or participatory rights) could be made in each RFMO, to coastal State members with respect to their EEZs and the high seas, and to fishing State members for the high seas only. Once allocated, States could then transfer rights to another coastal State or fishing State member of either RFMO, to be exercised in the transferee coastal State's EEZ or on the high seas in the Convention Area of either RFMO. These sorts of transfers between coastal States already occur between the Parties to the Nauru Agreement (PNA), a subset of WCPFC Members, pursuant to the Palau Arrangement.

Alternatively, a form of pooling could be employed. This might entail a coastal State member of an RFMO (in particular, the WCPFC) being able to assign a portion of its allocation to a particular vessel, with conditions that permit that vessel to exercise the right not only in the coastal State's EEZ, but in other EEZs or in a portion of the high seas in the Convention Area of either RFMO. Once again, this sort of mechanism already operates between some coastal States in the WCPO, pursuant to the Federated States of Micronesia Arrangement, which allows a Party to assign rights that the Party has been allocated under an overall cap to vessels to fish in the EEZ of any Party to the Arrangement.

Once again, these options will require cooperation to be made in relation to a range of institutional prerequisites. These include:

- a process for jointly conducting scientific assessments and setting limits on fishing opportunities for shared stocks, for example, through a single harvest strategy for each stock;
- a sustainable Pacific-wide limit on fishing opportunities, or compatible limits in each RFMO Convention Area;
- allocation of a Pacific-wide cap to each RFMO, to be assigned by that RFMO to each coastal State and fishing State Member of the RFMO;
- consistent definitions of fishing opportunities to enable transfers to occur between jurisdictions on a like-for-like basis;

- strong monitoring, particularly in relation to the high seas, to ensure that vessels exercising rights are doing so in compliance with relevant RFMO measures and their authorisations;
- clear rules about where transferred or pooled rights may and may not be exercised;
- a single joint register of rights allocated to RFMO Members, including transfers;
- a public register of vessel authorisations, including where any authorisations (rights) are able to exercised; and
- agreement between the two RFMOs on the arrangements to permit transfers or pooling.

Importantly, these options would be adaptive, in that they would not attempt to centrally predict where stocks are and assign rights accordingly. Instead, they would allow the actors—RFMO members and vessels flagged to those members—to make decisions about where to fish. Coastal States who transfer rights out of the EEZ would still receive a return on their allocation through the sale of fishing rights to vessels, compensating for the physical loss of stocks from their waters, and the anticipated revenues lost under various climate change scenarios (Bell et al, 2021).

5.3 Examples from other regions

The effects of climate change on the distribution of fish stocks will not be limited to the WCPFC and the IATTC, or to the Pacific Ocean. Climate change is also predicted to lead to other distributional shifts in fish stocks, and in particular, a poleward distribution of fish species (Pecl et al., 2017)—and in some places, geographic shifts in species distribution have been underway for a long time. These changes are likely to alter the adequacy of the coverage and effectiveness of existing management regimes and require enhanced cooperation between States and between RFMOs. Although most RFMOs now have MOUs in place with neighbouring RFMOs, these MOUs predominantly relate to information sharing and awareness programmes, and the sharing of or cooperation in scientific research (Haas et al., 2021).

While none of these MOUs specifically address climate change or climate-driven redistribution of fish stocks (Haas et al., 2021), there are nonetheless some useful examples of cooperation between RFMOs (and even just between States) regarding the management of and access to shared stocks, from which some lessons could be drawn for the WCPFC and the IATTC. This section gives a brief overview of the following examples:

- the approach to cooperation between NEAFC and NAFO following a shift in the distribution of Oceanic redfish in the North Atlantic Ocean;
- the ongoing tensions between NEAFC members regarding the northward movement of Northeast Atlantic mackerel;
- the long-standing cooperation between Norway and Russia in relation to shared fish stocks in the Barents Sea;

- the adoption of a precautionary approach by the parties to the *Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean* (CAOF Agreement) in light of the potential that climate change will increase accessibility to the Central Arctic Ocean; and
- the idea that one RFMO may have a 'regulatory priority' and be best-placed to address stock shifts, focusing on the example of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) and the Indian Ocean Tuna Commission (IOTC).

The impact of climate change is highly apparent in the North Atlantic Ocean, where cooperation has been required to address shifts in the distribution of the commercially exploited Oceanic redfish (Caddell, 2021) from the waters of NEAFC into the neighbouring NAFO Convention. Although Oceanic redfish had been under the exclusive jurisdiction of NEAFC since 1982, by the late 1990s, warming waters had displaced a sizeable portion of the stock into the NAFO Convention Area (Caddell, 2021). Despite a lack of clarity about the longevity of this shift, the two RFMOs agreed on a system of joint management pursuant to which NEAFC would continue to set the TAC for redfish, of which a portion would be allocated to NAFO, which would then distribute it among its members (Caddell, 2021). As Caddell notes, this approach ensured that 'the parties to two RFMOs with broadly similar memberships and conservation obligations were able to broker a pragmatic solution to a then-unprecedented issue, which has subsequently facilitated further collaboration on common operational matters' (Caddell, 2022). Due to the overfished status of redfish in the Irminger Sea and adjacent waters, NEAFC adopted a ban on fishing for this stock from 2011 to 2019, which was also implemented by NAFO members (NEAFC, 2011; NAFO, 2011). NAFO and NEAFC do not have an MoU in place that formalises their relationship but conduct yearly informal negotiations (Koubrak & VanderZwaag, 2020). They have also established a joint advisory group to streamline data management and reporting procedures (Stokke, 2019).

Shifts in the distribution of North Atlantic species have also produced tension among the members of NEAFC, due to the northward movement of the Northeast Atlantic mackerel, which is one of the most profitable fish stocks in the region. Since NEAFC only has jurisdiction in waters beyond 200 nautical miles, coastal State agreement is first reached on EEZ quotas before NEAFC starts negotiations on management measures for the high seas (Osthagen et al., 2022), and for many years the Northeast Atlantic mackerel quota was allocated predominantly among the European Union (EU), Norway, and the Faroe Islands (Osthagen et al., 2022). Starting in 2006, however (in parallel with a rise in sea temperatures in the North Sea), the stock shifted northwards into Icelandic waters, and by 2009 Iceland's catches increased from virtually nothing to 737,969 tonnes. Since agreement could not be reached between NEAFC members on the quota to be attributed on the basis of 'zonal attachment', and the other coastal States were unwilling to reduce their quota, Iceland set its quota unilaterally—and as the stock continued to shift westwards, Greenland also sought a quota (Osthagen et al., 2022). Due to the failure of the NEAFC member States to agree on a TAC, the stock is now overfished (ICES, 2022) and has lost its MSC certification (MSC, 2019). This example demonstrates not only the pitfalls that can arise from a lack of clarity about the drivers and longevity of shifts in distribution, but the particular challenge of negotiating disagreements regarding the calculation of ‘zonal attachment’ (Osthagen et al., 2022). As Jorgensen observes, this cautionary example is a situation in which the task of negotiating a ‘climate-resilient’ allocation mechanism has thus far proven ‘beyond the abilities of the coastal States in the region’ (Jorgensen, 2022).

A more constructive example is the Norwegian-Russian fisheries management regime in the Barents Sea, where there has long been a link between ocean temperature and the spatial distribution of fish stocks. In warm periods, the stocks tend to grow and expand toward the north and east, whereas in colder periods they tend to decrease and shrink back to their core areas in the south and west (Matishov and Zhichkin 2013; Zhichkin 2014). As early as the 1970s, Norway and Russia established the Joint Norwegian-Soviet Fisheries Commission (JNSFC), which sets the TAC and other regulations for stocks shared between the two States in the Barents Sea. There is also a supplementary agreement, which grants each party the right to fish in the other’s waters. Even prior to the establishment of the JNFSC, agreement was reached on ‘allocation keys’, pursuant to which cod and haddock stocks are split 50:50 and capelin 60:40 (in favour of Norway). Although this regime has experienced a range of challenges and fluctuations in effectiveness, it is generally considered successful—and despite stock-shifts up to four times faster than the global average, the allocation keys have remained ‘an unalterable feature of the regime itself’ (Jorgensen, 2022).[7] While this example involves only two States and a regime that has been in place for 50 years, two of its features may be worth considering in the Pacific context: first, the stability produced by the agreement on allocation keys; and second, the flexibility that is produced by a multi-stock governance system, which provide more room for trade-offs and quota swapping (Jorgensen, 2022).

Another example is found even further north, where the coastal States of the Central Arctic Ocean (CAO),[8] along with other States with an interest in the region,[9] have sought to address the potential for future shifts in fish stocks and the management of associated commercial fisheries, should receding ice coverage make such activities feasible. This is reflected in the 2018 *Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean* (CAOF Agreement), which recognises that climate change justifies precautionary consideration of the current and potential future fish stocks in the region, and seeks to ‘prevent unregulated fishing in the high seas portion of the central Arctic Ocean through the application of precautionary conservation and management measures’ (Article 2, CAOF Agreement). The CAOF applies in the waters of the Arctic beyond the fisheries jurisdiction of coastal States with

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[7] However, this stability is not equally evident for other stocks (such as Saith, halibut and redfish), in relation to which Russia has sought to increase its quotas in light of eastward shifts (Jorgensen, 2022).

[8] Canada, Denmark, Norway, Russia and the United States.

[9] China, the EU, Iceland, Japan and South Korea.

respect to all fish other than sedentary species (Article 1, CAOF Agreement), and imposes a moratorium on all commercial fishing activities pending the adoption of applicable measures by an RFMO, although there are exceptions for exploratory and research fishing (Article 3, CAOF Agreement). Caddell suggests that the regulation of such fishing will likely mirror the experience of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in regard to new and exploratory fisheries, but notes that the CAOF Agreement 'represents a unique approach to managing changing ecosystems by elaborating pre-emptive controls and imposing a precautionary ethos *ab initio'* (Caddell, 2021). While this example is very different to the situation in the Pacific, it does involve a number of the same fishing States and may be drawn on for inspiration regarding the practical application of a precautionary approach in a situation of climate-driven changes in stock distribution.

Finally, it has been suggested that the position of the IOTC in respect of the measures established by the CCSBT for southern bluefin tuna illustrates that there can be 'acquiescence of a regulatory priority for the organization within which the bulk of a tuna stock occurred' (NAFO, 2001). CCSBT provides the clearest example of this approach, because its constituent treaty provides for jurisdiction over the entire migratory range of a single species, rather than to multiple species within a specified geographic area, and other tuna RFMOs (including IOTC and WCPFC) have recognised its 'prime responsibility' over any stocks of that species located within their areas of operation (Caddell, 2022). For example, the MOU between WCPFC and CCSBT notes that CCSBT 'is the appropriate body to develop and implement southern bluefin tuna conservation and management measures' (WCPFC, 2009d). These arrangements have been more challenging to negotiate in relation to non-tuna RFMOs, in particular CCAMLR, which initially insisted on recognition of its own measures (particularly with respect to by-catch mitigation) (Caddell, 2022). CCAMLR has now agreed to a more collaborative approach, involving the exchange of data on fishing effort and practices for species of relevance to each organisation, and cooperation to 'harmonise measures in areas of mutual interest and concern' but has not ceded jurisdiction over southern bluefin tuna to CCSBT in the same way as WCPFC (CCAMLR, 2019). Nevertheless, the concept of a 'regulatory priority' or 'prime responsibility' for particular stocks may provide some inspiration for dealing with shifting stocks in the Pacific Ocean.

These examples from other regions highlight the importance of pro-actively dealing with climate change-driven redistribution. They demonstrate that having an MOU in place is an important step in cooperation (although cooperation can also take place in other ways), but that this will likely only be effective to the extent that it addresses climate-driven redistribution. They also suggest that RFMOs should take a precautionary approach to addressing climate change-induced changes, and they provide some blueprints for action that involve some key flag States which are also members of WCPFC and IATTC. But while they provide valuable inspiration for potential approaches to cooperative management, they also show what can happen if management fails—in particular, the cautionary tale of northeast Atlantic mackerel, which is now overfished, and for which overfishing is continuing.

5.4 Incentives for cooperation

The members of WCPFC and IATTC have **legal obligations to cooperate** in the management of highly migratory species such as tuna. This duty to cooperate falls on individual States engaged in fishing for such stocks, regardless of their membership of RFMOs, so each member of WCPFC and IATTC has an independent duty to act even if the RFMOs fail to do so—and the UNFSA contains a range of principles and standards by which the fulfilment of the duty can be assessed. In addition, the constituent instruments of both WCPFC and IATTC recognise the necessity of cooperation in relation to shared stocks, and contain the principles and powers necessary for their members to take the decisions required to manage the climate-driven redistribution of tuna stocks.

In the specific context of the Pacific—where the climate driven-redistribution of tropical tuna stocks will disproportionately affect the small island developing States of the WCPO, including by significantly impacting their national economies—it is relevant to note that both UNCLOS and the UNFSA require their Parties to give consideration to the special requirements of developing States and to relevant environmental factors (which would include the impact of climate change). The UNFSA in particular contains specific instructions that the duty to cooperate in the establishment of conservation and management measures for highly migratory fish stocks must take into account 'the vulnerability of developing States which are dependent on the exploitation of living marine resources' and 'the need to ensure that such measures do not result in transferring, directly or indirectly, a disproportionate burden of conservation action onto developing States' (Article 24, UNFSA). In addition, the UNFSA specifically requires all States to cooperate, either directly or through RFMOs, 'to assist developing States, in particular the least-developed among them and small island developing States to enable them to participate in high seas fisheries for such stocks', including with respect to the allocation of participatory rights to new members in an RFMO (Article 25, UNFSA).

Beyond the law of the sea and international fisheries law, support can also be drawn from international obligations in other legal frameworks—including international climate law, the sustainable development framework and the draft BBNJ Agreement. These frameworks also invoke important principles of inter- and intra-generational equity which will be directly challenged by the impact that climate change is projected to have on the distribution of tuna stocks and thereby on the livelihoods, nutrition and food security of Pacific Small Island Developing States.

From both a **diplomatic and security perspective**, all members of WCPFC and IATTC should support effective cooperation to address climate-driven redistribution of Pacific Ocean tuna stocks. Without framing this issue through a 'deficit narrative', it is relevant to note that the projected redistribution of tropical tuna could have severe economic impacts for Pacific Small Island Developing States (Bell et al., 2021). This could have a negative effect on the regional security situation—not only in terms of food security and economic security, but political security—which would be contrary to the interests of most WCPFC and IATTC members.

Framing the issue through a positive lens, it is also clear that the Pacific Island States are extremely adept at advancing important law of the sea and climate-related issues through multilateral forums—from the Pacific-led UNGA resolutions banning high seas driftnet fishing and regulating fishing on vulnerable marine ecosystems, to their effective advocacy in the BBNJ negotiations, Vanuatu's successful instigation of a UNGA request for an ICJ advisory opinion on climate change, and a similar request to ITLOS from the Commission of Small Island States. A wide range of diplomatic efforts could be contemplated in response to any failure of cooperation between WCPFC and IATTC.

A third category of arguments relates to issues of **economic imperative and social licence**, particularly in relation to market-based incentives and certification schemes. For example, a failure of cooperation between IATTC and WCPFC might lead to the loss of MSC certification for key fish stocks. This was the case in NEAFC, where the failure of cooperation between NEAFC members led to the loss of the MSC certification of mackerel. A similar situation in the Pacific might have severe economic consequences for all WCPFC and IATTC members, as retailers in the EU and USA are increasingly paying attention to what happens in tuna management, and commonly prioritize fish from MSC-certified fisheries. For example, the dire status of yellowfin tuna in the Indian Ocean prompted some retailers to boycott yellowfin tuna sourced from there. If WCPFC and IATTC are unable to agree on a management solution for shared stocks, retailers might boycott relevant fish, regardless of its status.

On a positive note, effective cooperation between WCPFC and IATTC would anticipate advocacy efforts by private-sector market partners, who are increasingly recognizing the need to support 'jurisdictional' or 'seascape' approaches to seafood (Murphy et al., 2021a). 'Jurisdictional' approaches integrate market-based and governance incentives at relevant ecological and political scales to drive fisheries sustainability and value creation across entire seafood production geographies, while 'seascape' approaches seek to integrate market-incentives and ecosystem-based management at relevant ecological and political scales to drive fisheries sustainability and value creation across entire seafood production geographies (Kittinger et al., 2021; Murphy et al., 2021b). The UK-based super-market chain, TESCO, for instance recently announced a 'seascape sourcing approach' for tuna, and has developed a roadmap to transition to sourcing tuna from fisheries with an ecosystem-based management approach by 2030 (Holland, 2021; Tesco, 2021). The member States of the PNA are already applying these principles in the WCPO to manage fishing effort through their Vessel Day Scheme under the Palau Arrangement and associated marketing initiatives (Aqorau, 2020). Enhanced cooperation in the Pacific Ocean Basin, including through application of jurisdictional approaches spanning WCPFC and IATTC Convention Areas where appropriate, could therefore competitively position Pacific tuna as managed under a climate-resilient ecosystem approach, and further strengthen market partner interest in preferentially sourcing sustainable tuna from the region.

A fourth reason to cooperate relates to the **continued uncertainty about the long-term effects of climate change**, and other potential causes of redistribution. While current projections are that climate change will cause biomass of some of the key tropical tuna stocks to redistribute from the WCPO to the EPO, there is still a great deal of research to be done—and a range of other drivers, stocks and living marine resources to consider. In a situation of such uncertainty, rather than seeking to secure new advantages from shifting stocks or benefit from the climate-driven losses of other States or RFMOs, there is a strong argument to be made for both WCPFC and IATTC—and their member States—to take an active, constructive, precautionary and equitable approach to cooperation.

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Adapting tuna-dependent Pacific Island communities and economies to climate change

Study 9: Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by GCF

Part 1: Finance mechanisms and supporting policies to sustain national FAD programs

Sari Tolvanen
Marine Change

Final report

22 January 2024

Executive summary

Component B of the Green Climate Fund (GCF) Regional Tuna Programme (RTP) titled: Adapting tuna-dependent Pacific Island communities and economies to climate change, under RFP22-3866 addresses the need to manage the challenges associated with national food security. One of the priorities for the RTP is to increase the supply of tuna to coastal communities through strengthening the use of anchored fish aggregating devices (FADs) by artisanal fishers. This priority is driven by the projected degradation of coral reefs and production of associated fish species due to ocean warming and acidification, and the need to fill the expected gap in fish supply.[1]

The purpose of this study, as stated in the SPC RFP[2], is to assess the scope and need for the Governments of all 14 participating countries to sustain strengthened national FAD Programs to increase access to tuna for the food security of coastal communities by:[3]

1. Classifying FADs as part of the permanent national infrastructure for food security and incorporating National FAD Programs within ongoing National Development Plans and recurring budgets;
2. Creating legislation to prosecute willful actions that result in destroyed or damaged FADs, or violate community- based FAD rules;
3. Promoting models for community and industry engagement and ownership of FADs;
4. Promoting transfer of fishing effort by small-scale fishers in coastal communities from coral reefs to tuna;
5. Including the importance of tuna consumption for improved nutrition in national programs to combat non-communicable diseases in rural areas; and
6. Analysis of the long-term costs of maintaining FAD programs and the suitable sources of finance and mechanisms to maintain their ongoing costs.

Although the use of anchored FADs[4] is well embedded in coastal artisanal fishing practices, the history of the region's experience with the deployment of FADs for coastal fisheries can be characterised as *ad hoc*. FAD deployment initiatives for coastal fisheries have generally not been supported by formal national policy, few national fisheries agencies have embedded support for coastal FADs in their recurrent work program and funding has largely been dependent on a range of sources of bilateral development assistance on an opportunistic basis. In addition, the deployment and maintenance of FADs several kilometers offshore raises issues associated with sea safety. Anchored FADs have a limited life span and may last less than a year unless they are a) properly built and anchored in the correct locations, b)

[1] Bell, J.D., Allain, V., Gupta, A.S., Johnson, J.E., Hampton, J., Hobday, A.J., Lehodey, P., Lenton, A., Moore, B.R., Pratchett, M.S. and Senina, I. 2018. Climate change impacts, vulnerabilities and adaptations: Western and Central Pacific Ocean marine fisheries. *Impacts of climate change on fisheries and aquaculture*, p.305.

[2] SPC 2022, *Request for proposals*. Accessed July 2023. https://www.spc.int/sites/default/files/tenderfiles/2022-05/RFP22-3866%20-%20FAME%20-%20Studies%20to%20support%20GCF%20proposal.pdf

[3] SPC 2022, *Request for proposals*. Accessed July 2023. https://www.spc.int/sites/default/files/tenderfiles/2022-05/RFP22-3866%20-%20FAME%20-%20Studies%20to%20support%20GCF%20proposal.pdf

[4] Fish aggregating device (FAD) is a generic term that applies to a range of floating objects that aggregate fish. The industrial tuna surface fishery (purse seine and pole and line vessels) takes advantage of fish aggregations beneath naturally occurring floating objects such as logs that are disgorged from rivers. The industrial purse seine fishery also deploys floating rafts that drift with the currents to aggregate tuna. Anchored FADs are also used by the industrial fleets. Coastal artisanal and commercial fishers almost always use anchored FADs to aggregate tunas and other neritic species. The subject of discussion here is anchored FADs used by artisanal fishers.

protected from vandalism, and c) monitored and maintained.[5] Furthermore, severe weather such as cyclones, which are common in much of the region, can damage FADs beyond repair or result in them simply being lost. As populations increase in Pacific Island countries (PICs) and the capacity of reef ecosystems to contribute to per capita national dietary protein is increasingly constrained, the implementation of a national network of FADs to increase access to tuna and associated pelagic fish requires a long-term strategic approach that enshrines on-going support for FADs as a national priority.

Technical Study 3[6] provides a detailed assessment of the current capacity of the 14 participating governments to manage FAD programs and recommends a two phased approach for the RTP: a) Strengthen or develop the governance structure necessary to support national FAD Management Plans for coastal fisheries to address gaps identified in the national FAD Program audits, and b) Implementing FAD Management Plans. This includes the purchase of FAD materials and other required equipment, training and capacity development, and strengthening data collection. This study identifies the additional steps required to consolidate the policy landscape using long-term financial mechanisms to sustain national FAD programs.

A situation analysis of the FAD programs and current financial models of the 14 participating countries was conducted (Appendix 2) and based on this, a list of key policy recommendations made that will be essential precursors for the long-term sustainability and finance of these programs. These include the need to elevate the priority of the FAD programs as nationally significant infrastructure, as well as complete and update comprehensive FAD management plans that will both help de-risk financial approaches to FAD fisheries as well as collect the necessary data to further structure investments on the fisheries and their long-term maintenance. Other measures to help de-risk and ensure the financial performance of the fisheries such as eradication of vandalism and better placement of FADs to withstand severe weather and improve catch rates are also recommended across the countries.

Different supporting financial mechanisms are assessed. These include on-going support from national recurrent budgets, bilateral and multilateral development assistance, loss and damage funds, public-private partnership (PPP) approaches, community cost share model, climate insurance, development of national funding sources such as local lending by banks or local bonds, as well as impact investment options. Their likelihood of success, timelines, associated risks and required expertise for each are assessed.

Annual maintenance budgets for national FAD programs are estimated to be in the range of USD 100,000-300,000. It is recommended that all the countries be supported to prepare a detailed FAD finance model that draws on a diversity of potential funding opportunities to provide on-going, sustainable support.

[5]Gillett, R. and McCoy, M. 2019. A Survey of Fish Aggregation Devices and Fisher Associations in Selected Pacific Island Countries. FAO and SPC. 75 pages.

[6] SPC 2023, *Technical studies*. Accessed in November 2023. https://fame.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

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Suggested citation:

Tolvanen, S. in press. Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by the GCF: Part 1: Finance mechanisms and supporting policies to sustain national FAD programs. Technical Study 9 prepared for the Pacific Community as a contribution to a Funding Proposal being prepared for submission to the Green Climate Fund (GCF). January 2024. 43 pages plus annexes.

This is an advanced copy and is not the final version of this Report. The Report is still undergoing editorial review and formatting. As with all Technical Reports commissioned to support the preparation of the Funding Proposal to the Green Climate Funding advice and recommendations regarding programmes of future work and strategies proposed in the Report will be subject to review by the 14 participating countries, SPC as the Executing Entity and subject matter experts during finalization of the Proposal and at Programme inception.

List of acronyms and abbreviations

AUD	Australian dollar
BPM	Blue Prosperity Micronesia
BOF	Bureau of Fisheries
CDF	Commodity Development Framework
COP	Conference of Parties
EEZ(s)	Exclusive economic zone(s)
ENSO	El Nino Southern Oscillation
FAD(s)	Fish aggregating device(s)
FAO	Food and Agriculture Organization (of the United Nations)
FAME	Fisheries, Aquaculture and Marine Ecosystems
FFA	Forum Fisheries Agency
FJD	Fijian dollar
FSM	Federated States of Micronesia
GCF	Green Climate Fund
IDF	International Development Finance
Kg	Kilogram
KI	Kiribati
Km	Kilometre
km^2	Square kilometres
M	Metre
MAF	Ministry of Agriculture and Fisheries
MIMRA	Marshall Islands Marine Resource Authority
MH	Marshall Islands
Mt	Metric ton (or tonne)
NCD	Non communicable disease
NFA	National Fisheries Authority
NFMRA	National Fisheries and Marine Resource Authority
NGO	Non-Government Organisation
Nm	Nautical mile
NZD	New Zealand dollar
PNG	Papua New Guinea
PGK	Papua New Guinea Kina
PICs	Pacific Island countries
PICTs	Pacific Island countries and territories

PNA	Parties to the Nauru Agreement
PNMS	Palau National Marine Sanctuary
RMI	Republic of Marshal Islands
RFP	Request for proposals
SMA	Spatial Management Area
SI	Solomon Islands
SBD	Solomon Islands dollar
SDG	Sustainable Development Goals
SPC	Pacific Community
SST	Sea surface temperature
TFD	Tuvalu Fisheries Department
TNC	The Nature Conservancy
TOP	Tongan Pa'anga
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VFD	Vanautu Fisheries Department
VGTA	Vava'u Game Fishing Association
VUV	Vanuatu Vatu
WB	World Bank
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WHO	World Health Organization
WST	Samoan Tala

1. Introduction

Climate change is adversely affecting the Western and Central Pacific Ocean (WCPO) large marine ecosystem, degrading its coral reefs and changing the distribution of tuna.[7] The impacts on coral reefs are reducing the supply of reef fish and threatening the food security of more than four million people that live along the coasts of the 14 RTP PICs.[8] The redistribution of tuna will have profound implications for national economies that derive as much as 70% of their (non-aid) government revenue from tuna fishing, thereby dramatically reducing basic social services that are essential to the resilience of Pacific Island people. The proposed RTP will 1) increase supply of tuna for domestic consumption as an adaption to degradation of coral reefs and the resulting food insecurity for vulnerable populations; and 2) usher in the reforms needed to minimise the risks for citizens of countries with economies that are vulnerable to climate-driven redistribution of tuna.

One of the two priority areas of focus for the RTP is the increased supply of tuna from coastal tuna fisheries to Pacific Island populations. This will be a priority food security related aspect of the RTP as predictions show that reef fish supplies will decline as climate impacts progress and the climate-related redistribution of tuna stocks may negatively impact current industrial fisheries based incomes and the supplies of tuna from existing domestic fleets.[9] In addition data indicates that urban populations in particular will be growing as the coastal reef fishery declines towards 2050.[10] This leaves the region with increasing seafood demand and a widening gap in fish supplies. Hence there is an acute need to improve the productivity of the nearshore coastal and off-shore fisheries targeting tuna for the purpose of addressing national food security needs. [11]

Although the use of FADs is well embedded in coastal artisanal fishing practices,[12] the history of the region's experience with FADs can be characterised as *ad hoc*. FAD deployment initiatives have generally not been supported by formal national policy, few national fisheries agencies have embedded support for coastal FADs in their recurrent work program and funding has largely been dependent on a range of sources of bilateral or multilateral development assistance on an opportunistic basis.

In addition, the deployment and maintenance of FADs several kilometers offshore raise issues associated with sea safety. Anchored FADs have a limited life span and may last less than a year unless they are a) properly built and anchored in the correct locations, b) protected from vandalism, and c) monitored and

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[7] Bell, J.D., Allain, V., Gupta, A.S., Johnson, J.E., Hampton, J., Hobday, A.J., Lehodey, P., Lenton, A., Moore, B.R., Pratchett, M.S. and Senina, I. 2018. Climate change impacts, vulnerabilities and adaptations: Western and Central Pacific Ocean marine fisheries. *Impacts of climate change on fisheries and aquaculture*, p.305.

[8] Throughout ''Programme'' refers to the GCF Regional Tuna Programme. ''Project'' and/or ''activities'' are used to describe initiatives and actions within the Programme.

[9] Bell, J.D., Senina, I., Adams, T. *et al.* Pathways to sustaining tuna-dependent Pacific Island economies during climate change. *Nat Sustain* **4**, 900–910 (2021). https://doi.org/10.1038/s41893-021-00745-z

[10] Kiddle, KL 2017. Unpacking the Urban Agenda: Resilience Challenges and Opportunities. *Sustainability* 2017, *9*(10), 1878; https://doi.org/10.3390/su9101878

[11] Here we consider ''coastal'' fisheries to be generally small-scale artisanal and subsistence fisheries that take place in small vessels using low-technology fishing methods relatively close to shore. ''Offshore" fisheries generally occur in oceanic waters often using sophisticated fishing technology and relatively large-scale vessels.

[12] Gillett, R. and McCoy, M. 2019. A Survey of Fish Aggregation Devices and Fisher Associationsin Selected Pacific Island Countries. FAO and SPC. 75 pages.

maintained.[13] Furthermore, severe weather such as cyclones, which are common in much of the region, can damage FADs beyond repair or result in them being lost. As PICs populations increase and the capacity of reef ecosystems to contribute to per capita national dietary protein is increasingly constrained, the implementation of a national network of FADs to increase access to tuna and associated pelagic fish requires a long-term strategic approach that enshrines on-going support for FADs as a national priority.

FAD maintenance requires funding, management and implementation capacity, infrastructure such as support vessels, rafts and equipment for maintenance and public education and information campaigns. Ideally FAD programs should include a means to assess FAD utilisation, costs and benefits including catch monitoring and analysis to evaluate socio-economic and ecological impacts. All these tasks require both initial budgets for capacity building and infrastructure as well as recurring budgets for maintenance, program implementation and replacement infrastructure.[14]

The RTP proposes a comprehensive suite of strategic interventions directed at coastal FADs for the region to build on the lessons learned, progress made to date and to expand sufficiently to ensure adequate long-term term food security for the PIC populations. As opposed to previous FAD-related initiatives it will promote a more formalised, strategic, approach the design and implementation of national FAD programs on the basis that FADs have the potential to make a significant contribution to securing the protein requirements of increasing populations of PIC communities as climate-induced changes impact the productivity of nearshore reef-associated ecosystems on which these communities have traditionally relied.

Study 3 of the GCF proposal consultancies has made a detailed assessment of the current capacity of the 14 participating PIC governments to manage FAD programs, the gaps in the current implementation and an assessment on the number and types of FADs needed to meet the increasing food security needs. The report includes a detailed 7-year implementation program and budget, including personnel requirements and timelines. This Study discusses additional steps required to consolidate the policy landscape in support of long-term financial mechanisms to secure the sustainability of those programs.
The purpose of this Study, as stated in the SPC RFP[15]is to assess the scope and need for the Governments of all 14 participating PICs to sustain strengthened national FAD Programs to increase access to tuna for the food security of coastal communities by:[16]

- Classifying FADs as part of the permanent national infrastructure for food security and incorporating National FAD Programs within ongoing National Development Plans and recurring budgets;
- Creating legislation to prosecute willful actions that result in destroyed or damaged FADs, or violate community- based FAD rules;
- Promoting models for community and industry engagement and ownership of FADs;
- Promoting transfer of fishing effort by small-scale fishers in coastal communities from coral reefs to tuna;

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[13] Gillett, R. and McCoy, M. 2019. A Survey of Fish Aggregation Devices and Fisher Associations in Selected Pacific Island Countries. FAO and SPC. 75 pages.

[14] Gillet, R. 2023. Fish aggregating devices for small-scale fishers - The report of a study of FAD effectiveness in Pacific Islands countries. FAO. Apia.

[15] SPC 2022. *Call for proposals*. Accessed in August 2023. https://www.spc.int/sites/default/files/tenderfiles/2022-05/RFP22-3866%20-%20FAME%20-%20Studies%20to%20support%20GCF%20proposal.pdf

[16] SPC 2022. *Call for proposals*. Accessed in August 2023. https://www.spc.int/sites/default/files/tenderfiles/2022-05/RFP22-3866%20-%20FAME%20-%20Studies%20to%20support%20GCF%20proposal.pdf

- Including the importance of tuna consumption for improved nutrition in national programs to combat non-communicable diseases (NDCs) in rural areas, and
- Analysing the long-term costs of maintaining FAD programs and suitable sources of finance and mechanisms to sustain their ongoing costs.

A country-by-country summary of previous and current FAD-related programs is presented at Appendix 1. Section 2 presents a national FAD policy analysis that addresses the above first five points.[17] It builds on existing studies, the recent (early 2023) country consultations that were supported as part of the early national engagement with countries on the design of the RTP together with material assimilated during national consultations related to Study 3.[18] Section 3 presents the budgets required for the maintenance of the FAD programs and discusses different funding mechanism options to finance the sustain the programs in the long term.

2. FAD Policy Analysis

With the long but *ad hoc* history of FAD programs in the region, PICs have active but limited fisheries around coastal FADs. Many studies and reviews have been conducted over the years to assess FAD fisheries performance and propose improvements to FAD programs including ecological impacts.[19]

It is now generally accepted that national FAD activities are most effective where there is a national FAD program that is integrated into the government fisheries agency as opposed to a project that comes/goes with the availability of funding, pressure from fishers, or the availability of external FAD-related services. In addition, an ongoing FAD program within a fisheries agency allows for greater continuity of FAD work, in-house capacity building, successful technology transfer to staff and a formal mechanism for interaction with stakeholders. This can be supported directly through either government or non-government activities. With an established unit inside a national fisheries department, rather than a project with no permanent staff, there is potential for greater stability of funding.[20]

As demonstrated in the country summaries (Appendix 1), the status of permanent national FAD programs, as opposed to projects varies widely between countries as does the state of their implementation. Study 3 conducted an in-depth analysis of the implementation status of the national FAD management plans using the SPC "matrix for assessing progress towards a sustainable national FAD program". Study 3 used that analysis to design detailed country specific activity plans to support those programs under the RTP. In order not to replicate this very thorough report, this analysis focuses on the main policy actions that need to be taken to maximise the potential for the sustainability of the FAD programs at the conclusion of RTP support.

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[17] As a more detailed country profiles were provided in Study 3, this section only focuses on the key points above.
[18] Additional information was kindly provided by Franscisco Blaha and Robert Gillett.
[19] Gillett, R. and McCoy, M. 2019. A Survey of Fish Aggregation Devices and Fisher Associations in Selected Pacific Island Countries. FAO and SPC. 75 pages.
[20] Gillet, R. 2023. Fish aggregating devices for small-scale fishers - The report of a study of FAD effectiveness in Pacific Islands countries. FAO. Apia.

For the benefit of this broader policy analysis and recommendations a summary of the main operational issues facing FAD program implementation across all the countries and detailed in Appendix 1 were as follows:

1. Incomplete national FAD management plans and programs;
2. Lack of regular budgets and finance models to ensure materials are available to quickly replace lost and damaged FADs (materials often program funded);
3. Lack of suitable vessels for FAD deployment and regular monitoring;
4. Lack of cyclone proof shelter for materials;
5. Vandalism, accidental damage, and community conflicts around FADs;
6. Lack of technology for improved deployment and monitoring of FAD effectiveness.

In terms of the policy improvements needed to ensure the longevity of the expanded FAD programs after RTP implementation, the above actions will need to be supported with priority policy and financial interventions. This will require the completion and revision as needed of the national FAD management plans together with the resourcing of those plans and a gradual transfer of the program responsibility from the RTP to the national administrations towards the end of the 7-year period.

At present national FAD Management plans or programs fall under the responsibility of the fisheries administrations although their legal requirement is determined country by country. Generally, national fisheries agency recurrent budgets only support labour and deployment costs of FADs. The bigger expense, the material costs of FADs are commonly provided for by short-term projects which leaves frequent budget shortages for timely replacement of lost FADs. In addition, this potentially leave a shortage of funding for other essential activities such as community socialisation and improved FAD deployment methods using electronic equipment. This can result in partial implementation of FAD programs, with higher rates of FAD loss and vandalism, as well as a general lack of data relating to their effectiveness and to provide information that can be used to improve deployment practices, usability and reduced ecological impacts.

In Vanuatu, Nauru and PNG the central government provides a recurrent annual budget allocation for the national FAD program. It is not unusual for this to be supplemented by occasional support provided by bi- or multi-lateral donor agencies. Vandalism is a major cause for lost and damage to FADs in many countries although experience demonstrates that where community education has been prioritised vandalism had been reduced significantly.[21] Together with the consistent application of penalties for vandalism, continuous community engagement is a critical determinant for the success of national FAD programs.

To ensure long-term financing of the FAD infrastructure, all 14 RTP PICs should be encouraged to formally recognise the importance of the FAD infrastructure as a key component of national efforts to address food security needs. National FAD management plans need to be completed/revised and elevated to the same level as other critical infrastructure strategies and policies such as roads, sanitation and hospitals. Formal government acknowledgement will be critical in securing the long term recurrent budgetary allocations required and to attract supplementary finance. It is also key in securing inter-government agency collaboration, which is a priority in terms of supporting national food security. Inter-agency collaboration could include the navy, coast guard and ports in relation to emergency maintenance and the use of port infrastructure in support of the FAD program, as well as provide a framework for the engagement of private sector and international donors in the national program. Embedding national FAD program support in the recurrent work program of national fisheries administrations will also provide a valuable

[21] See Appendix 1 country consultations.

platform for broader engagement with the international donor community for complementary support (see below chapter 3).

The climate adaptation strategy for FADs in moving fishing effort from coral reefs was not widely discussed in the in-country consultations. Some countries noted that strategic FAD positioning together with the necessary training and equipment will help encourage fishers to move offshore. The possibility of allocating FADs to communities adjacent to threatened reef systems would provide compound benefits for both food security as well as overall reef resilience. There are many marine conservation programs active in the 14 countries that could be consulted early in the RTP to identify such locations in collaboration with community stakeholders. The safety, technology and training needs highlighted in the in-country consultations and detailed in Study 3 are essential components of the program when introducing 'new' fishers to more challenging offshore fishing conditions. The detailed safety requirements of the program are detailed in Study 12.[22]

In terms of non-communicable diseases (NCDs) which are prevalent across the entire region and the impacts of which were severely exacerbated in the region during the COVID-19 pandemic, the availability of fresh seafood from FAD programs will play a positive role towards addressing the NDC epidemic. Health Ministries should be made aware of the increased supply of fish from FADs as a potentially significant contribution to efforts to improve dietary health and address threats to national food security. With their support, national planning authorities can help to elevate the expansion and maintenance of national FAD programs to increase nutrition and strengthen the suite of policies designed to address the prevalence of NCDs.

A summary of the status of key elements supporting a sustainable national FAD program in each of the RTP PICs based on the analysis presented in Appendix 1 is provided in Table 1.

[22] SPC 2023, *Technical studies*. Accessed in November 2023. https://fame.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

Table 1: Summary of key FAD program gaps identified for each of the RTP PICs.

Country	Status of national FAD management plan / program	FADs classified as part of national infrastructure	All FAD costs including materials covered by national annual budgets	Routine monitoring and maintenance of FADs by government	FAD awareness training to minimise vandalism and community engagement
Cook Islands	FAD program with draft policy action plan	No	No, some donor funding for materials	1-2 months for maintenance based on location	No
Fiji	Draft FAD plan underway, but early stages.	No	No, some donor funding for materials	No regular maintenance	No
FSM	FAD program in Pohnpei but no overarching national plan	No	No, some donor funding for materials	1-2 months when there are FADs in the water	No
Kiribati	FAD program with draft plan that needs reviewing	No	No, some donor funding for materials	Maintenance 3-monthly where fisheries staff located, otherwise very infrequent	No
Nauru	Draft Nauru National FAD Strategic Development Plan	No	Yes	Monthly checking of FADs	No
Niue	Ad hoc, nothing drafted	No	No, donor funding for materials	Every 3 months	no (but no vandalism reported)
Palau	Internal management plan in place but not formalised	No	No, donor funding for materials	Every 3 months	No
Papua New Guinea	Starting work on an inshore FAD policy but early stages.	No	Yes	Ad hoc by government and also local community	No

Country	Status of national FAD management plan / program	FADs classified as part of national infrastructure	All FAD costs including materials covered by national annual budgets	Routine monitoring and maintenance of FADs by government	FAD awareness training to minimise vandalism and community engagement
				monitoring and fixing of broken FADs	
RMI	Have draft FAD management plan that needs updating.	No	No, donor funding for materials	Ad hoc with fishers reporting any damage	No
Samoa	Have a FAD management plan but this needs revising	No	No, donor funding for materials	2-3 times per year with limited funds.	No
Solomon Islands	Have a policy in place but needs review and updating	No	No, donor funding for materials	Do maintenance every 6 months	Yes, has had some impact (See Appendix 1) but more needed
Tonga	Have a FAD Policy and developing a FAD plan	No	No, donor funding for materials	Monitor and maintain on a quarterly basis	Yes, has had a good impact (See Appendix 1) but more needed
Tuvalu	Draft plan available and needs finalisation	No	No, mix of donor and national fishery agency	Once a year	No
Vanuatu	Has management plan	Yes to an extent as FADs have priority beyond fisheries department.	Yes, but some project funding components as well	Monthly maintenance by fisheries officers	Yes, has had a good impact (See Appendix 1) but more needed

2.1 Policy interventions to ensure investment readiness of FAD programs

The policy interventions described in Table 1 are prerequisites to securing sustainable long-term finance options for the program as explained in more detail in section 3 below. A well-regulated sustainable management environment within which the small-scale tuna FAD fishery takes place nationally will be an important prerequisite for any investment.

The lack of national FAD management plans and policies and evidence of capacities to efficiently implement them would make it difficult to meet many investment standards, whether it is public or private. For private investment, the actual financial details of the FAD fishing businesses and proof of business management capacities of FAD-related fishing enterprises will be the most important determining factors. However, the underlying financial viability of the fishing business will be supported by the policies outlined above in Table 1. The financial baseline will be impacted by factors such as vandalism and loss of FADs. Fishing rates, and financial performance, will also be impacted if damaged or lost FADs are not replaced in a timely basis. Hence policy interventions are a pre-requisite to the effective establishment of a national FAD program. In addition to technical support for deployment and maintenance, data collection functions are also critical to support assessments of the costs and benefits of the program and in supporting finance models and projections associated with seeking finance.

High government priority for the maintenance of coastal FAD programs with active monitoring of the use and status of FADs, a well resourced FAD maintenance and replacement program and capacity building support for the communities will further help to de-risk investments in FAD fisheries and can count as co-finance for the private sector.

A clear strategic government policy supporting FADs, supported by legislation and integrated to the program of work of national fisheries administrations will be critical to securing on-going allocations from recurrent government budgets. Clear government commitment demonstrated in this manner, which is the expected outcome of the RTP , will be critical to securing additional public and development sector support, including in terms of supplemental funding. Although not as necessary as the good economic performance of the fishery, this will also further help de-risk the investment for the private sector.

3. Financial analysis of the FAD program post GCF

3.1 Financial forecast of the costs associated sustaining national FAD programs

Study 3 complied comprehensive budgets for the RTP FAD program for each participating country. Based on the findings of Study 3, an indicative recurrent budget has been prepared for each country (Appendix 2). These budgets will need to be revised during the early stages of the RTP based on:

a) improvements made in FAD designs and programs impacting the longevity of FADs and associated impacts on recurrent budgets;
b) re-estimates of the scale of the FAD programs needed based on more accurate/timely climate impact forecasting;
c) dates on shared costs between fisheries departments and other involved government entities;
d) partnerships or cost sharing arrangements with industry and/or communities, and
e) inflation.

Table 2 presents the estimated annual recurrent costs of national FAD programs at the end of the RTP. [23] Annual costs vary between USD100.000-300,000 annually. In order to prepare more detailed business and financial models as described in Section 3.2 below, an update of detailed cost/benefit data including

[24] This kind of on site and fishery specific financial modeling was out of scope of this study

market price information and current operational costs will be required for each RTP PIC early in the program.in the [24]

Despite many previous studies detailing FAD fishing practices[25], management[26] and investment needs,[27] this level of up to date financial and operational detail needs to be collected in each of the fishery locations with input from a business analyst who can develop detailed financial models at the start of the RTP. The numerous previous studies conducted in the region can provide useful historical catch and effort data, seasonal information and other details that are crucial in developing credible finance models. Section 3.2 below describes potential long-term financial assistance mechanisms.

Table 2. Cost estimate of the maintenance of the FAD program per country post GCF.

	Annual recurrent budget estimate (USD)	**Annual estimate without cyclone proof housing upgrade (USD)**
Cook Islands	198,889	153,889
Fiji	272,004	227,004
FSM	217,725	172,725
Kiribati	268,800	223,800
Nauru	171,216	126,216
Niue	172,140	127,140
Palau	236,100	191,100
PNG	271,680	226,680
RMI	210,100	165,100
Samoa	183,554	138,554
Solomons	247,428	202,428
Tonga	178,139	133,139
Tuvalu	198,495	153,495
Vanuatu	272,419	227,419

[24] This kind of on site and fishery specific financial modeling was out of scope of this study
[25] Sharp, M. (2011). The benefits of fish aggregating devices in the Pacific. SPC Fisheries. Newsletter, 135, 28-36. 53.
[26] Gillett, R. and McCoy, M. (2019). A Survey of Fish Aggregation Devices and Fisher Associationsin Selected Pacific Island Countries. FAO and SPC. 75 pages.
[27] Bell JD, Allain A, Allison EH, Andréfouët S, Andrew NL, Batty MJ, Blanc M et al. (2015) Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories. *Marine Policy 51:584–591*.

3.2 Detailed description of potential financial mechanisms

3.2.1 Financing FAD programs as part of national infrastructure

If FAD programs are prioritised as part of national infrastructure needs as discussed in the policy section 2.1 above, their long-term maintenance and operational costs will be budgeted in the domestic budget in a similar manner to roads, ports, wharfs, hospitals and schools. Given the RTP will provide significant support over a period of 7 years, governments will need to plan and ensure the necessary means to sustain these programs in a highly competitive environment for limited government funds. There is currently no assurance that a national FAD program will receive the ongoing support required to continue to make a significant contribution to addressing national food security in the long term.

For the PNA countries, where significant income is generated through the Vessel Day Scheme (VDS) for purse seine fisheries, earmarking some of this income for the national near shore FAD programs would be a strategic investment. For countries where there is no VDS based income another way to safeguard necessary budgets is to earmark allocations within government budgets dedicated to FADs that are to be supported through international development finance. PICs are some of the most vulnerable countries to climate impacts in the world and are already faced with increasing annual costs as a result of the increased frequency and intensity of climate-induced extreme natural events. These impacts incur a significant cost to already vulnerable economies of PICs and the region will need serious ongoing international support to cope with these challenges. Future support should include dedicated attention to addressing national food security needs including through national FAD programs.

A summary of selected international development and climate finance options which offer potential for such support is presented in the following sections.

3.2.2 Loss and damage fund

There is increasing international recognition that the current ambitions for climate adaptation and mitigation may not be effective for managing the consequences of climate change and that developing countries, in particular, may suffer huge damage and losses due to increased climate impacts.

The Warsaw International Mechanism for Loss and Damage associated with climate change impacts (WIM) was established at the COP19 in 2013. The Paris Agreement further underlined the importance of this issue. All Parties are requested to develop and implement concrete and effective climate risk management instruments and measures to avert, minimise, or when the limits of adaptation are reached, effectively address residual loss and damage caused by climate-related extreme events and slow onset changes. The loss and damage discussions under the United Nation Framework Convention on Climate Change (UNFCCC) have been somewhat controversial and became the main focus of the negotiations at the COP27 in 2022 in Egypt where developed nations pledged an additional USD 230 million for the adaptation fund. However, this is still seen as widely insufficient.[28] At the COP28 in 2023 negotiations started towards a new fund for loss and damage and additional pledges were made towards it.[29]

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[28] UNFCCC 2023. *COP27 reaches breakthrough agreement on loss and damage*. Accessed January 2024. https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries

[29] WRI 2023. *COP28 opening day operationalize loss and damage fund*. Accessed in January 2024. https://www.wri.org/news/statement-cop28-opening-day-negotiators-operationalize-loss-and-damage-fund

Given the already severe impacts of climate change being felt in the Pacific region, PICs and SIDSs in particular, are likely to be leading many of the negotiations on loss and damage and compensation processes to do with slow onset events and extreme weather events. Loss and damage to Pacific tuna and reef fisheries is likely to fall into the category of slow onset events, unless marine heat waves or other extreme events cause large, widespread and sudden damage. According to the UNFCCC loss and damage guidelines[30] there is a need for Parties to pursue ocean and fisheries-based mitigation and adaptation strategies as a first step, as the loss and damage fund is for unavoidable damage.

Funding support for FAD programs could fall under the slow onset events provision given reef fisheries are predicted to decline due to habitat changes caused by warming ocean temperatures and ocean acidification and national FAD programs are being put into place as an adaptation measure. When FADs and related infrastructure are damaged by extreme weather events compensation could be sought under the extreme weather events provisions. However, current processes are extremely protracted and are not responsive to the immediate needs associated with repairing damaged FADs and associated support infrastructure.

3.2.3 Development finance

International Development Finance (IDF) typically provide either grants or loans and the usual lenders in the region are the World Bank (WB), the Asian Development Bank (ADB) and other regional development banks and as well as many bilateral financiers. The IDFs usually have long-term programs in the countries and regions they support and the investment needs are evaluated within those programs. IDF investments are required to align with the UN Sustainable Development Goals (SDGs) as well as climate-related adaptation and mitigation targets as mandated by the Paris Agreement.

Roads, ports, renewable energy projects and cold chain infrastructure all fall within the usual scope of this kind of finance and can include national debt finance, grant components and blended finance. The RTP should engage ‘the Banks’ in considering the broader climate adaptation and food security needs in the region and how the proposed FAD infrastructure could be supported within these programs. Combining sectors and generic country needs (wharves, roads) could also help reach sufficient scale in terms of the financial amounts needed for this kind of finance, providing benefits that go beyond FAD infrastructure (or by-catch distribution) and assist with the capacity building needed for to secure the longevity of these projects and investments.

Although international development finance is not usually considered as a sustainable finance model, in this case if it can ensure regular budgets for FAD programs through dedicated budget allocations, then it is a long-term finance model.

3.2.4 Industry cost share, public private partnership (PPP) and SMEs

Although the RTP targets small-scale fishing and community-based food security needs, as opposed to providing facilities for corporations to expand their operations, there are opportunities for collaboration that have the potential to generate mutual benefits including by engaging industry to assist in the technical implementation of FAD programs.

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[30] UNFCCC 2018. *Loss and damage guide*. Accessed in July 2023.
https://unfccc.int/sites/default/files/resource/Online_guide_on_loss_and_damage-May_2018.pdf

The Solomon Islands provides an example of successful PPP collaboration where a commercial fishing company uses its purse seine vessels to help deploy FADs for small-scale fishers.[31] Given purse seiners manage large numbers of FADs on a regular basis, and that many fisheries administrations and communities lack suitable vessels for FAD deployment, making use of existing vessels active in the local area can provide significant cost savings.

Locally-based vessels or vessels visiting for transshipments should be encouraged to support national FAD programs as part of their corporate social responsibility (CSR) programs. As well as including this as a licensing condition, incentives for collaboration could include reduction in port fees, license fees or taxes. Companies active in the fishery in each participating country should be engaged to provide support with FAD deployments and assist, as required, in the event of emergencies associated with climate-induced extreme events. Countries are encouraged to consider including such obligations in national licensing arrangements for fishing vessels.

Sharing of FADs between small-scale local fishers with industrial scale vessels might be possible in some countries like Palau or the Solomon Islands where pole and line vessels or large handline boats are active. However, this may cause user conflicts on the FADs with commercial scale operations having the potential to adversely impact the catch rates and economic performance for small scale fishers. An alternative may be to assess the potential for introducing a 'levy' or fee for industry that would be used to support the on-going running costs of the national FAD program that is added to the licensing conditions and administered as part of the overall fishery access fee.

In addition, the role of SMEs in the FAD fishery should be assessed country-by-country as capable SME players maybe be able to expand their operations to benefit community-based fisheries or support local food security. SMEs are also more likely to attract private investment for scaling and often provide a more sustainable long term financial model than community-based approaches (see 3.2.7).

There are also possible opportunities for mutual benefits for small-scale coastal fisheries, SMEs and industrial-scale tuna fishing operations relating to cold storage and on-shore infrastructure. Future plans should examine the costs and benefits of infrastructure assets being shared across different users.[32]

This approach does not require new capacity to develop and can be implemented nationally as part of the regular dialogue, licensing arrangements and cooperation with the private sector members.

3.2.5 Private FADs, community cost share and ownership model

In some other parts of the world, such as Indonesia, it is common that a private entity may own FADs and fishers who fish on these pay a user fee. This is usually done on a catch share basis. For example, 10% of the catch may be paid to the FAD owner. This means that each FAD is for private use and not all fishers automatically have access rights. A draw back from this practice in Indonesia is that it has led to a proliferation of FADs that are largely uneconomic. In the Pacific this approach might be difficult to implement as traditional ownership and shared resources and access within/between communities remains strong.[33] There is a risk that this approach could quicky lead to conflict and vandalism.

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[32] See also study 9, Part 2. Transshipment study

[33] Personal communication: Johann Bell 2021

Another approach could be a cost recovery/payment scheme for FADs which is based on a community ownership model. This model would involve a community or a local fishing association fully or partially owning FADs. They would pay for the FAD materials and either all or partial deployment costs, depending on the logistics and equipment required and the level of government support available. A user fee system, based on a fishing trip/catch share, administered by the association/or a community officer, could then be applied to cover the construction and deployment costs.

The government FAD program would then coordinate with the association or community officer in areas such as program maintenance and data collection to monitor both FAD utilisation and assessment of appropriate user fees.

Such an arrangement could still benefit and qualify for government or third-party support particularly if the association or community group was able to demonstrate that the FAD was a valued resource for local fishers. In situations where FAD fishing provides a positive income and is well socialised within the community with well quantified and communicated benefits, a shared ownership model warrants consideration.

The community/association share model has not been tested in the region to date, despite many countries voicing their intention to move towards 'cost recovery approaches' in the RTP national consultations. Some co-funding approaches were tried in Fiji where the 2000 Commodity Development Framework (CDF) FAD program was designed to subsidize fishers with new boats that could access FADs. Fishers funded 1/3 of the cost and Fiji Government funded the balance.[34] This program however ended up increasing the fishing pressure on the inshore areas because the fishers preferred to spear fish as opposed to use the FADs with the boats provided.[35] Such outcomes underscore the need for clear commitments from participating communities to the objectives of the FAD program and obligations that are associated with government or donor agency support for that program.

Implementation of the FAD component of the RTP will require early elaboration of the various financial obligations and commitments required of stakeholders. This will include consideration of long-term sustainable financing arrangements and FAD management responsibilities and obligations. A culturally appropriate stakeholder participation mechanism will be required to support this engagement.

This financing model does not require additional capacity by the RTP as it can be assessed and set up as part of national FAD program activities. It does not require complicated data beyond regular fisheries monitoring data and support for capacity-building locally.

3.2.6 Climate insurance

Parametric insurance is an agreement to make a payment upon the occurrence of a triggering event, and as such is detached from an underlying physical asset or piece of infrastructure. Parametric insurance development for the small-scale fishing sector is a rapidly developing subject area as coastal communities prepare for climate adaptation in the face of increasing risks. Parametric or index-based insurance products support transparent and fast claims payment and the ability to offer a payout without actual

[34] We were not able to obtain further details beyond what was mentioned in the country consultations.

[35] Gillet, R. 2023. Fish aggregating devices for small-scale fishers - The report of a study of FAD effectiveness in Pacific Islands countries. FAO. Apia.

physical damage to an asset. Parametric or index-based solutions are often considered when assessing hard to insure risks.[36] A parametric solution always consists of the following:

a. A triggering event

The insurance cover is triggered if pre-defined event parameters are met or exceeded, measured by an objective parameter or index that is related to a particular exposure to the insured party. In practice, this event could be an earthquake, tropical cyclone, or flood where the parameter or index is the magnitude, wind speed or precipitation respectively. Whilst Natural Catastrophes (Nat Cats) or weather events are the most prominent triggers, there are many other applications. The key criteria for an insurable trigger is that:

(i) it is fortuitous, and
(ii) it can be modelled.

b. A pay-out mechanism

A pre-agreed pay-out occurs if the parameter or index threshold is reached or exceeded, regardless of actual physical loss sustained. For example, USD 30 million if a Category 5 tropical cyclone occurs in a defined area, or USD 50,000 for every millimeter of cumulative rainfall above a certain threshold. The threshold is usually set in such a way that aligns with a client's own continuity plan, risk tolerance and capacity to pay the necessary premiums.

Any parameter or index that is used as the basis for a parametric solution must be objective (i.e. independently verifiable), transparent, and consistent. Generally, indices that are easily measurable and can be reported upon quickly and effectively are selected in order to ensure prompt pay out. It is important that neither the risk taker or the insured are able to influence the event or its reporting. This is why indices around weather and "Acts of God" are common in parametric insurance.
Some examples of agencies that monitor trigger events and respective parameters or indices:

- Hong Kong Observatory (HKO) typhoon warning signals
- Japan Meteorological Agency (JMA) seismic intensity
- US Geological Survey (USGS) earthquake magnitude
- Australian Bureau of Meteorology (BoM) tropical cyclone category

Parametric insurance products for the fishing sector include insurance products bought by the fishers themselves, fishing associations or others such the fish buyers or even the local government. The insurance payments themselves are triggered by climate events such as wave height, wind speed, and other weather phenomena and monitored by agencies such as those identified above that confirms that fishers are suffering climate and weather related losses (e.g. loss of fishing days due to rough sea conditions).[37] In the case of Pacific based FAD programs, certain triggers can be chosen that would confirm damage to FADs by tropical cyclones that would then trigger payments allowing for a quick replacement of FADs to minimise loss of fishing days for the fishers. So far there are no existing examples on FAD based

[36] SWISSRE. What is parametric insurance? Accessed in July 2023.
https://corporatesolutions.swissre.com/insights/knowledge/what_is_parametric_insurance.html
[37] ORRAA 2022. Pramaetric insurance for small-scale fisheries. Accessed in July 2023.
https://oceanriskalliance.org/project/weather-index-based-parametric-insurance-for-small-scale-fishers/

climate insurance but given other small-scale fisheries approaches are being developed this should be explored.

Given the ownership of FADs in the Pacific often sits with the government authorities, any parametric model needs to consider who the ultimate client is, and how possible insurance premiums are either collected from the fishers (possibly as part of the community ownership/cost recovery model) or paid by the government itself. The insurance design and data collection process will need to determine in detail how the premiums are calculated and reviewed as well as detailing payout mechanisms.

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) is an example of regional parametric insurance product that is designed to offer earthquake, tropical cyclone and excess rainfall policies to Caribbean and Central American governments. CCRIF helps to mitigate the short-term cash flow problems small developing economies suffer after major natural disasters. CCRIF's parametric insurance mechanism allows it to provide rapid payouts to help members finance their initial disaster response and maintain basic government functions after a catastrophic event.[38] This kind of more generic climate risk and disaster related insurance mechanism could also be developed for the Pacific and include aspects of FAD post cyclone repairs and replacement budgets.

Climate insurance is a new and experimental area of work and it will require dedicated people with relevant insurance experience to develop. FAD fisheries already provide much data and relevant information but some additional data collection and modelling may need to be conducted as well. All require time, budget and expertise. This would take at least a few years to complete within the RTP and a minimum of USD200,000 of budget for data collection, modelling and necessary consultations and it would cost much more if separate insurance products are developed per country.

3.2.7 Innovative and impact focused finance mechanisms

As opposed to traditional investments that seek to maximise financial returns, impact investments are made with the intention of generating positive, measurable social and environmental impact alongside a financial return. Impact investments can be made in both emerging and developed markets and target a range of returns depending on investors strategic goals and priorities.

Although the blue economy concept has been explored at length by policy makers and investors, in practise only in recent years have actual deals and specific investors started to emerge that are actively structuring marine and ocean investments that contribute positive impacts to areas such as sustainable fisheries, technology transfer, marine protected area finance and eco-tourism. Investments supporting marine infrastructure, aquaculture, fisheries and waste management have been around for longer, but have not been addressing the hard issues around progressing actual marine conservation. Small-scale fisheries investments are also far and few between to date and have mainly focused on processing or technology.

Impact investments are generally in the range of USD1-10 million. In the context of PICs tuna fisheries climate adaptation needs, and FAD programs specifically, several smaller investments may need to be bundled into one larger investment to be viable. One such generic investment was made in Fiji to Matanaki Ltd, which received USD75 million for a program to invest in coral reefs and the Blue Economy, under

[38]CCRIF. 2023. *Company overview*. Accessed in November 2023. https://www.ccrif.org/about-us?language_content_entity=en

which several small enterprises receive investment support.[39]

There is significant scope for impact investment in climate mitigation, adaptation and marine conservation initiatives in the Pacific. An entrepreneurial approach with appropriate technical support from conservation and financial experts who assist with structuring these deals around desired conservation and social impacts contribute to the success of securing such investment. There will also be a need to develop de-risking measures through co-investments depending on the scale and complexity of the investments (from multilateral banks and others). In terms of FAD program financing, if for example, a suitable private sector partner to maintain and deploy FADs is identified, the approach could be incorporated in a bigger impact investment for the partner (processing, fishing vessels, wharves and associated infrastructure).

If the community payments model also works well, and can be proven to provide a sustainable income, it may be possible for a fishing association to form a company and receive impact investment for its FAD program. This would require evidence of good financial management, leadership and potentially, for some lenders, a blended finance approach to help de-risk the investment. As the broader Blue Economy initiative is developed in the Pacific to pay for ocean ecosystem services and support sustainable economies around it, a coastal community food security and FAD program should be kept under consideration. One such program has recently been announced by the GCF and focuses on the Blue Economy development of the Cook Islands, Fiji, PNG, Palau and FSM[40] and includes coastal livelihoods that could include FAD fisheries. Again, the precursor will be the financial cost and benefit information relating to FAD businesses, as well as the proper detailed definition of the specific fisheries on their social and economic contribution to community livelihoods and national food security.

There are numerous marine and blue economy focussed impact investment funds. One such fund offering significant potential for RTP PICs is the Global Fund for Coral Reefs (GFCR).[41] The GCF contributes to the GFCR and the regional tuna Programme's FAD program is well aligned with the GFCR's objective to mobilise blended finance to protect and restore coral reefs. This is consistent with a co-benefit that will be generated under the RTP in moving fishing pressure from coral reefs to offshore.

Another fund that has recently made investments in sustainable tuna fisheries, MPAs, the blue economy as well as biodiversity conservation is Mirova,[42] although their investment size is usually above USD 5 million, there could be interesting opportunities in tuna fisheries investments that could include FAD finance. In recent years, Mirova has invested USD 10 million into small-scale tuna fisheries processing improvements in Indonesia.

The Conservation International Venture Fund[43] is another conservation and blue economy focused fund that may be able to provide debt-based funding or advice. This program targets small enterprises and provides readiness finance (USD 200,000 - 500,000) which may appeal to some SME's as they prepare to scale and receive larger investments.

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[39] Matanaki 2022. *About us*. Accessed in July 2023. https://matanataki.com/portfollio/
[40] Blue Co (document povided by GCF)
[41] GFCR 2022. *Global Fund for Coral reefs intro*. Accessed in July 2023. https://globalfundcoralreefs.org/
[42] Mirova 2023. *About us*. Accessed in July 2023. https://www.mirova.com/en/about-us
[43] Conservation International 2023. *CI Venture Fund LLC*. Accessed in July 2023.
https://www.conservation.org/projects/conservation-international-ventures-llc

To date there have not been many impact investments into small-scale fishery FADs due to small investment size and/or the lack of investable companies globally. It will be a challenge to identify suitable SMEs or cooperatives that can provide the necessary scale and can handle this kind of investment. Especially in the PIC context, the opportunities may be few and far between and this opportunity should be approached perhaps as part of larger related investments into other supply chains and related infrastructure (perhaps transshipment by-catch related investments). The impact investment approach will require dedicated capacity in identifying and structuring the deals as well as ensuring the impact of these investments is meeting the required outcomes.

3.2.8 Mobilising local private investors

Local financial innovation is important and will bring a range of benefits for the region beyond the RTP and consideration should be given to building the awareness and capacity of local private institutions in ”blue lending” and local bond issuance to attract local private investors. Private investors in PICs are risk-averse and not familiar with ocean finance.[44] One option for some countries would be to raise a local bond to cover a range of food security, health and sustainable livelihoods components. The recent Fiji green bond provides an example.[45] Most PICs have sovereign wealth funds that could be interested in investing in food security and fisheries provided it is supported by government legislation and guarantees and possibly insurance. The RTP should map the local lenders and assess their ability and interest to contribute to FAD program finance and long-term needs early during implementation. Expert support may be needed to help familiarise PICs with the blue economy lending needs and opportunities in providing new finance vehicles for this sector.

3.3. Summary finance recommendations

It is not practical to make country by country financial model recommendations, as all the countries need to prepare a detailed FAD finance model that will ideally consist of several different finance mechanisms. This is necessary to ensure the ultimate success in securing sustainable finance and the ability to respond to changing conditions and account for currently unseen risks and failures.

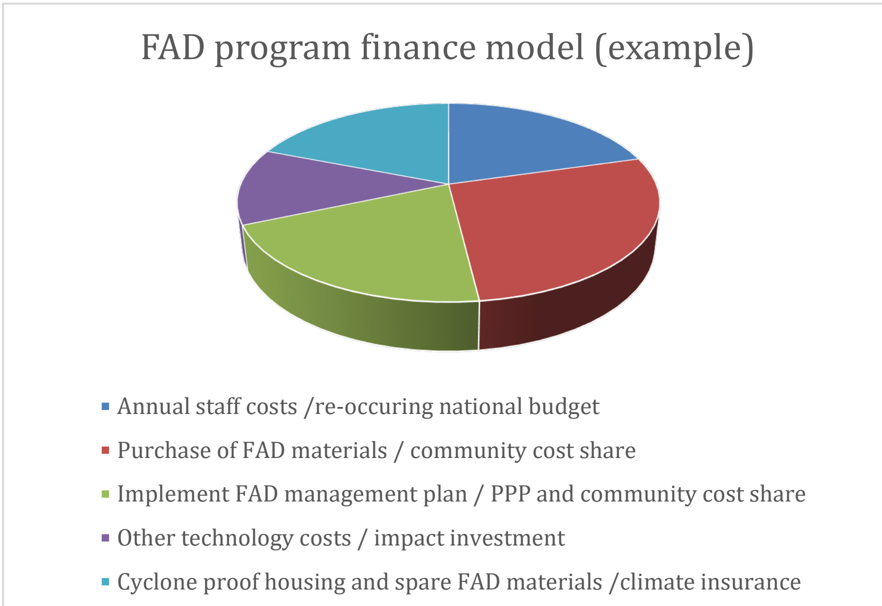
For example, it would be appropriate to begin planning for all potential sources of finance in most of the participating countries, with the view that there will be different mechanisms sharing the cost of the overall budget (see example Figure 1). Given the technicalities and skills required in the planning and implementation, regional coordination and support will need to be provided to avoid duplication of efforts. There is already some regional and national experience with mechanisms such as loss and damage finance, and international development finance so that FAD program long-term needs could be incorporated into those opportunities early during the implementation of the RTP.

PPP approaches and community-based fee/cost recovery models and their design supported by the right government policy and regulatory environment (as outlined in chapter 2) should be taken up as a priority in every country at the start of the RTP to review their suitability in more detail. In countries/fisheries

[44] UNDP 2022. *Demystifying green and blue bonds in the Pacific*. Accesed November 2023. https://www.undp.org/pacific/publications/demystifying-green-and-blue-bonds-pacific-region

[45] World Bank 2017. *Fiji Issues First Developing Country Green Bond*, Raising $50 Million for Climate Resilience. Accessed in July 2023. https://www.worldbank.org/en/news/press-release/2017/10/17/fiji-issues-first-developing-country-green-bond-raising-50-million-for-climate-resilience

where these approaches provide potential, early engagement will ensure they are reasonably well established before the program ends. A focus on the development and capacity building of fishing associations as partners in the FAD programs is especially important.[46] These approaches will need the least amount of capacity building and new technical expertise and have high likelihood of success within the RTP time frame.



Climate insurance and blue economy focused innovative approaches should also be taken up with the regional agencies that can support the development of the additional skills and expertise required. Some regional agencies already provide support to their member countries in this field. It will take several years to research and structure this kind of mechanism as well as sufficiently pilot them to be able to support them regionally. These innovative finance options are also the riskiest endeavors due to their experimental nature, the need to develop investment opportunities and the large scale usually required for these instruments. They are not always successful and can have unforeseen consequences, that need to be prepared and mitigated for. As a result, it is prudent to develop these initiatives in parallel with other less risky approaches.

The RTP should also review the local lending sector and their knowledge and ability to invest in the blue economy. Depending on the assessment and the needs and opportunities arising, the RTP can provide specific knowledge-sharing and capacity-building activities to help forge new local finance mechanisms that can help support FAD programs and other regional development needs including the transshipment infrastructure needs.

A rapid assessment of the financial options is presented in Table 3. They are subjectively ranked according to the likelihood of success, a timeline of implementation, innovation/risk involved and additional capacity needs for the approach. The analysis shows that the PPP approach as well as national budgets supported

[46] Gillett, R. and McCoy, M. (2019). A Survey of Fish Aggregation Devices and Fisher Associations in Selected Pacific Island Countries. FAO and SPC. 75 pages.

by international development finance are the most likely to succeed in the short to medium term. Other mechanisms may have potential also but are riskier and require additional expertise and longer timelines of implementation.

Table 3: Comparative analysis of the different finance mechanisms

Investment mechanism	**Likelihood of success**	**Timeline of implementation**	**Innovation and associated risk**	**Additional expertise requirement**
Re-occuring national budget/development finance	high	medium	low	low
Loss and damage funds	low	long	low	medium
Community cost share	medium	medium	low	low
Public private partnership approach	high	short	low	low
Climate insurance	medium	long	high	high
Impact investment	medium	medium	high	high
Mobilising local investors	medium	medium	medium	medium

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Appendix 1: Summary of the current coastal FAD situation by country

Cook Islands

Current FAD program

The Cook Islands has an extensive FAD program with 28 FADs active. Of these 12 are in deep water (1,200m) and 16 in shallow water (250-300m). Three islands do not currently have FADs. The lifespan of the FADs is 1-3 years with an average of 1.5 years. FADs deployed in shallow water were reported to last as long as FADs set in deeper water. The Ministry of Marine Resources (MMR) endeavors to inspect/maintain the FADs once a month in Rarotonga and Aitutaki and on outer islands every 1-2 months. Coral growth on ropes after a month is the main issue that requires attention during maintenance. If the FAD is lost/damaged it can be replaced within a month if materials are available in Rarotonga and Aitutaki. On the outer islands the replacement takes longer as the materials need to be transported there. FADs are sometimes damaged by fishers with gear tangled on the mooring lines, some vandalism also occurs and it is suspected that shark bites can also sometime damage FADs.

Current supporting policies

Cook island has a national FAD program however it does not at the current time have a comprehensive national FAD policy. There is a need to endorse and implement a FAD policy or regulation to manage FAD fishing activities and to address conflicts relating to FAD use. In addition to the need to establish a policy there are needs around equipment for storage and deployment of FADs as well as regular supply of materials, improved FAD location design through technology and improved community engagement for FAD monitoring and data collection.

Current costs

The costs of the FADs vary between deep water FAD; NZD $7,200 and shallow NZD $5,800 in Rarotonga and Aitutaki. Plus $1,000 for PVC pipe (150m long) for new FADs. For the Southern group the prices are $9,900 and Northern group $14,800 due to higher material and transport costs. The prices include travel costs for a FAD technician to oversee installation.

Current financial models

FAD deployment and maintenance costs are currently shared between funding provided by various donors and from the national budget. The port authority tug boat is used for deployment and includes covering fuel costs. There is a need to invest in a barge in the future to support deployments and maintenance. There are no private FADs although a private donor did fund one FAD once, no other financial models or cost sharing arrangements are currently in place. It was mentioned in the consultations that cost sharing between the islands could be considered in the future.

Other

In--country consultation indicated that the local fishing communities are keen and willing to transfer fishing effort from reefs to off-shore as part of the FAD implementation program. This will need to take account of safety and technical support as well as consideration of fishers and communities traditional fishing knowledge.

No information on the national plans to promote tuna consumption to combat non communicable diseases (NCD) was obtained in the consultations. There is an ongoing action plan 2021-2025 on the prevention of non-communicable diseases[47] and it should be investigated how to integrate the tuna consumption issue into the program as part of the FAD fishery expansion andRTP activities.

Fiji

Current FAD program

Fiji has 22 active FADs as follows: four in the East, two in Kadavu, two in Lau, one in Rotuma, one in central, seven in Northen and five in Western part of Fiji. Most are in around 50m depth, Kadavu has one deeper at 180m. There has been many more FADs deployed but most were lost to cyclones and not yet replaced. The average life span of a FAD is 1-2 years (Eastern). The Ministry of Fisheries (MoF) carries out limited FAD monitoring with no regular maintenance. There is some vandalism with floats taken and some boats tie up to the FADs to fish, which can also cause damage.

Current supporting policies

The MoF began their FAD work in the 1980s to support the pole and line fishery and small industrial purse seine sector. In 2001, the FAD program was revived through the Commodity Development Framework (CDF) and scaled up across Fiji. While consultations, data sharing, and collaboration with other pertinent Ministries such as the Fiji Navy and the Maritime Authority of Fiji need to be strengthened, as well as operationalizing a centralized FAD management unit and FAD management plan, there are also strengths and ambitious plans to add value to ongoing activities including scaling up the FAD network and prioritizing locations most vulnerable to climate change. The MoF has identified four key priority areas necessary to accomplish this work: monitoring and maintenance, impact analysis for fishers around FADs, operationalizing a FAD Management Unit and finalizing a FAD Management Plan.

Current costs and financial models

The FADs cost FJD $2-5,000 depending on depth and quality of materials with deep FADs costing up to $10,000. The Fiji Government funds the FAD program but materials are funded by different projects, which means they are not replaced until there are new project budgets available for materials. In the East there are also NGO budgets for some FAD programs. The earlier CDF FAD program was designed to subsidize fishers, with fishers funding 1/3 of cost and Fiji Government funding the rest.

There are annual investments towards the National FAD program but the amounts vary from year to year and there has not been an accurate costs and needs assessment to ensure the budgets are properly justified as well as adequate. No other financial models were reported as part of the consultations.

Other

The focus of the previous CDF program was around encouraging fishers to fish around FADs for tuna to reduce fishing pressure on reef and lagoon resources. Consultations did not cover information on current programs to encourage fishers to move offshore from reef fisheries. There needs to be a more detailed assessment on the key reef areas vulnerable to climate impacts and coordination with the expanded FAD program so that it will help remove fishing pressure from these priority areas building on the lessons and success of the CDF program.

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47 Cook Islands NCD plan

The consultations did not touch on the NCDs programs and tuna. However, the issue of NCDs is severe in Fiji and this was exacerbated by the Covid-19 pandemic.[48] Preventing disease is a major focus on Fiji health services and early engagement with them during the GCF program should ensure FAD program integration.

Federated States of Micronesia

Current FAD program

The Federated States of Micronesia (FSM) coastal FAD programs are organised by the States and not by the Federal Government.

The Pohnpei State currently has two FADs, one in 500m and one in 1,000m. Both were deployed in 2020. They also have nine smaller lagoon FADs in 50m for attracting scads and bait fish. The FADs were reported to last up to seven years. Maintenance is conducted two times per month when the coconut leaf aggregators are replaced. Currently the state has materials in storage to replace lost or damaged FADs quickly. Vandalism was an issue before but better collaboration with communities has mitigated this.

Kosrae State currently has no FADs and the last deployment was in 2017 (four FADs) and the FADs lasted only a few months before fishers cut them off. The costs were similar to Pohnpei State and they were maintained every other month but there has been no budget or materials to deploy more since they were lost.

Chuuk State deployed 17 FADs between 2015-2017 and all were deployed within the lagoon of Chuuk and some outer islands. They were shallow in 30-70m depths and mainly subsurface. Eight of these FADs are still in place, the rest were damaged by typhoons and not replaced as the materials were provided by SPC as one-off donation. As these are lagoon FADs, no tuna is currently caught, only rainbow runner and other inshore pelagics. The markers flags were cut off after a couple of days due to vandalism. There is no real maintenance as the FADs are subsurface.

Yap has no active FADs at the moment. The last 3 FADs were deployed in 2018 around 4 miles off the coast in around 1,000m and lasted 1-2 years. Maintenance was conducted every couple of months in the past. Mainly replacing flags and aggregators. It is not clear why the FADs were lost, vandalism or natural wear and tear. Can only replace them when there is specific project funding again.

Current supporting policies

There is a FAD program in Pohnpei, but nothing comprehensive in place nationally. Small-scale fisheries projects within 12-24 miles need to go through National Oceanic Resource Authority (NORMA) for permitting although the FAD projects are at the state level.

Current costs and financial models

For Phonpei state FADs cost USD 7000 for materials and anchors and a charter vessel for deployment is USD 10,000 a day. Material costs are from donors and national government and some NGOs cover the deployment costs. NGOs are also purchasing materials for communities that they use for the lagoon FADs.

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48 Fiji NCD plan link

For the other three states there are only project-based materials funding and state based deployment funding but these are not regular budgets. The current costs are also not clear but likely similar to Phonpei costs.

Other

Consultations in FSM did not cover information on current programs to encourage fishers to move off shore from reef fisheries. A more detailed assessment is needed on the key reef areas vulnerable to climate impacts and coordination with the expanded FAD program so that it will help remove fishing pressure from these priority areas. There are several parallel programs that may provide a framework for this such as the Blue Prosperity Micronesia (BPM) multi-year program to strengthen nationwide efforts towards conservation and management of fisheries resources as well as the ongoing National Government led program with the overarching goal to protect 30% of FSM's EEZ by 2030.

FSM has a national strategy on the prevention of NCDs that includes actions on food such as ensuring affordable fresh food items and subsidies to farming to allow for wider up take of healthy food.[49] It should be possible to collaborate with the health authorities in promoting FAD caught tuna as part of the activities under healthy food. A comparison of imported seafood and locally caught fish prices may need to be made to ensure the FAD caught tuna price is not prohibitive.

Kiribati

Current FAD program

There are currently four FADs around South Tarawa, eight FADs in Southern Islands and around 35 in in the Gilbert Islands. There are none in the Line Islands. Most FADs are deployed in around 300m depth and generally have a short lifespan with most are lost within eighteen months. The coral atolls have strong currents, steep slopes and a concentration of sharks in a small area that all take their toll on the FADs. The Ministry of Fisheries and Marine Resource Development (MFMRD) has a FAD monitoring plan and the FADs are checked every three months on the islands where there are fisheries officers, on other islands there is no maintenance nor monitoring. Fishers in the Southern Islands monitor the FADs when fishing around them. Lost FADs are replaced close to Tarawa in 2-3 months but on islands further away it can take 3-4 months and on the Line islands this can take up to 1-2 years. Some vandalism has been reported near Tarawa as fishers have taken the floats. Very little vandalism in the outer islands.

Current supporting policies

Kiribati has an active FAD program but a comprehensive FAD management plan is still in development and review phase. Consultations mentioned that community engagement requires more focus so that they can better monitor their own FADs on the outer islands without fishery officers. Communities can also engage on all aspects of the fabrication, deployment and maintenance of FADs. In addition to community education, the MCS team monitoring and enforcing the existing regulations around FAD vandalism need strengthening and overall FAD program monitoring requires improvement to include catch and effort related data.

Current costs and financial models

The FAD cost is around USD 3,500 for FAD materials and anchor plus deployment costs. Deployments costs are very expensive, especially in the outer islands. A container of materials for 15 FADs costs AUD 40,000. Current funding is based on project finance and some government budgets with the FAD materials

[49] FSM NCD national strategy

mainly donor funded. Some Islands also have more long-term project finance for FADs. There are no private FADs or other finance models in use, all are government owned and free access to all fishers.

Other

*A*lthough no ongoing programs to replace reef fisheries with off-shore FAD fishing were mentioned in consultations, it was highlighted that inshore FAD made of local materials were piloted just outside an MPA to support communities and compensate them for the loss in their fishing grounds. This was trialed in one the islands and the MFMRD is seeking to clarify the success of this inshore FAD and how this could support communities. There should be opportunities for the RFP program to collaborate the FAD program implementation with these efforts to support community and MPA implementation.

NCD programs were not discussed in the consultations but Kiribati does face a severe NCD health burden. International organisations such as Doctor's Without Borders are active in the country and assists the government in planning and implementation of remote island work.[50] The RTP should engage with the health authorities to coordinate the FAD program with the outreach to communities at risk.

Nauru

Current FAD program

Currently Nauru has two offshore FADs at 2,400m of water. Previously they also had seven inshore FADs in 300m but they have all been lost now. The FADs last four years on average with some lasting up to 10 years. There is monthly checking and maintenance and the replacement of lost or damaged FADs depends on available materials. In general it can take six to 12 months for replacements. Some vandalism takes place mainly by breaking the flag and flagpole when fishers tie on the FAD and the added weight of having boats tied to the FAD has caused FADs to come loose and lost.

Current supporting policies

Nauru has a draft National FAD management plan that needs finalising. There are challenges in maintaining a stockpile of FAD materials for replacement. There is also a need to provide The Nauru Marine Resources and Fisheries Authority (NFMRA) with access to a suitable vessel for deploying FADs, together with FAD designs that are easier to deploy from small boats. It was also mentioned that monitoring of catch rates around FADs to improve the locations selected for FAD deployment and FAD design over time is needed. In addition, there are technology needs to equip FADs with acoustics to assess the number of fish underneath with information conveyed to fishers using mobile phone application.

Current costs and financial models

It costs between AUD $5,000 to $7,000 for inshore FADs and $7,000 to $15,000 for offshore depending on deployment depth. The cost for deployment is additional AUD $5,000 per FAD. NFMRA budget covers all costs and sometimes there is some one-off donor funding of materials. There are no privately owned FADs around Nauru or other finance mechanisms to cover costs.

Other

Consultations in Nauru did not directly discuss programs to move fishing pressure from reefs to offshore but a number of actions were highlighted as required to encourage the use of FADs by community. These

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50 News Article Kiribati NCD plan

include workshops, training and ongoing dialogue with NMRFA and fishers to educate, train and continuously improve fishers use of the FADs. The revival of the local fishing association was also mentioned as a key to success of the FAD program and the uptake of FAD fishing.

In terms of NCDs Nauru has an active health program to grow fresh food[51] and up
to 2020 there was an active WHO supported national strategy. The RTP should engage with the health ministry to understand current strategic efforts and overlaps with the FAD program.

Niue

Current FAD program
Currently Niue has four offshore FADs (800-1000m), six inshore FADs (300-400m) and six shallow FADs for baitfish (15-30m). The life span of the FADs relates to cyclone frequency but os generally 4-5 years on average. There is no reported vandalism and it was reported that only whale entanglement and cyclones impact FADs.

On average FADs are maintained every three months. During the routine inspection the top part of the mooring is checked, coral growing on ropes removed and coconut fronds for aggregators replaced. If a FAD is lost it can take 6 months or more to replace depending on the availability of materials and access to the government boat and lifting gear to get the concrete blocks on board for deployment.

Current supporting policies
Niue's Ministry of Natural Resources (MNR) has national FAD program but no comprehensive management plan has been drafted. There is a need to have improved arrangements for the use of a suitable vessels to deploy and maintain FADs at short notice to ensure the FADs are always operating as a basis for food security. There is also a need to have a regular supply of materials for quick replacements and repairs, as well as higher quality depth sounders for accurate FAD site surveys for mooring deployment resulting in extended FAD working life. There is also a need to improve catch and effort monitoring and associated technology. In addition, the wider community is keen to be more involved in site selection, monitoring and FAD program design. A concern to solve problems with marine mammal entanglement before the program expands was also noted.

Current costs and financial models
Inshore FAD costs around NZD $5,000 and offshore around NZD$10,000 each including deployment costs. The costs are covered with a mix of core government and donor funding and in-kind contribution with use of the government boat for deployment and inspections. There are no private FADs or finance models in place.

Other
Active programs to move fishing away from reefs were not discussed in the country consultation but there were suggestions to encourage community use of offshore FADs. These included placement of FADs close to the coast to so that they can be accessed with non-motorised 'vakas' as well as designating some FADs for spearfishing. It was also suggested that each community should have a off-shore FAD as well as a suitable boat for accessing it.

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[51] Nauru NCS news article

In terms of NCDs, no information on current active programs in Niue were found, but the GCF program should engage with the health ministry as a priority to incorporate the FAD program design with the best approaches on NCD prevention.

Current FAD program

In Palau the Bureau of Fisheries (BOF) deploys and maintains coastal FADs. Currently there are two on East, and five on the West side in depths ranging from 1500 - 2600m which is between three to seven miles off the reef. The FADs are inspected every three months and repairs made if materials are available. Lost and damaged FADs are regularly replaced. The lifespan of a FAD is usually 3-5 years, aside from weather related wear and tear . FAD vandalism and damage from boats mooring to FADs is a concern.. The Palau Sports Fishing Association also deploys coastal FADs with assistance from BOF.

Current supporting policies

The BoF has a FAD Strategic Plan (2020-2023) which is due to be updated and can take account of the priority activities expected to be supported by the RTP. The following items were highlighted as items for the updated plan:

- Establish data collection on catch and market data;
- Institutionalize a monitoring process to support the National FAD program;
- Prioritize more reliable data collection on FAD catch and effort, location and the reasons for FAD disappearance;
- Establish a FAD central database;
- Establish/update rules and regulations for FADs: regulate access and/or effort;
- Institutionalize fishery-independent monitoring;
- Install sat link buoys on all deployed FADs;
- Enhance catch/effort and market data collection;
- Create a national framework to define the program and establish sustainable financing mechanisms to ensure the program continuity;
- Deploy 10 FADs in selected sites;
- Stock up on FADs replacement materials;
- Invest in updated design for large scale FADs (Japan design, up to 10 year lifespan, little to no maintenance required);
- Scale up FAD fishing training for fishers in priority communities;
- Continue to provide safety gear to fishers as incentives for BoF data collection;

In addition, community consultation in Palau highlighted that The Nature Conservancy (TNC) is supporting BoF to trial utilization of an Eco Buoy with satellite links to monitor the biomass around a FAD in the North. The data collected will be used to inform fishers on fish biomass around the FAD and will help detect any movement or changes in FAD location. There was also suggestion to refine the laws and regulations regarding protection of FADs from vandalism and to provide more incentives for fishers to to participate in data sharing and collection.

Current costs and financial models

The deep water FADs cost upwards of USD $10,000 depending on material prices with deployment costs by a a tug boat or barge comprising around USD $4000-6000. The smaller shallow water FADs are cheaper at between USD $4000-5000 including deployment by aBoF vessel. FAD construction and maintenance costs are funded by both program and BoF core funds. The Palau Sports Fishing Association does not directly charge for the use of their FADs but has an association fee.

Other

In Palau there are active programs engaged in supporting the Palau National Marine Sanctuary (PNMS) which includes efforts to protect reefs and encourage fishing offshore. Discussions on a detailed FAD program between national authorities, communities and PNMS representatives are required.

Consultations did not cover recent NCD actions and the RTP should engage with the health ministry as a priority to incorporate FAD program design with the best approach on NCD prevention.

Papua New Guinea

Current FAD program

Since 2021, Papua New Guinea (PNG) has deployed 15 FADs in each of the five provinces with 75 in total. The current number of active FADs as of February 2023 was uncertain as some have been vandalised or lost. All the FADs are deployed in 200-400m last at least 2 years if not vandalised. Vandalism is usually the result of community conflicts over FAD access. FADs are rigged with communities who also carry out monitoring and maintenance on ad hoc basis. The National Fisheries Authority (NFA) provides FAD maintenance materials and orders enough materials for 75 FADs per year for distribution to the provinces. Some communities also deploy their own FADs using local materials.

Current supporting policies

The NFA has a national FAD program and is interested in expanding and strengthening it to a comprehensive FAD management plan. Consultations highlighted the need to strengthen the community programs and education to reduce vandalism, as well as improve the deployment, design, technology and FAD monitoring to improve longevity and productivity. There are also ecosystem interactions that need attention and change in design/locations. The lack of cold chain in landing locations is acute in PNG and community solar ice makers and stores were highlighted as necessary with expanded FAD program.

Current costs and financial models

FAD materials cost around PNG Kina 8,000-10,000 per FAD with shipping to the provinces costing PNG Kina 60,000-70,000 for 15 FADs. Deployment costs, hire of boats, staff travel costs and accommodation add to costs as the deployment trips can take a month in some provinces. The NFA is currently fully funding the program with an annual budget of PNG Kina 1.5-2.2 million. Some provinces provide some cost sharing by providing fuel for deployments and some communities put out their own FADs with funding assistance from their local member of parliament. In addition, some NGOs are assisting one or two communities with FADs. There was a suggestion that user conflicts could also be managed by introducing a FAD user ‘levy’.

Other

There are were no other activities focused on reducing fishing effort on reefs discussed but community consultations mentioned that this is a key strategy in ensuring long-term food security. Once the RTP commences environmental programs focusing on reef health and MPAs should be consulted to ensure strategic placement of FADs to account for reef health and conservation. Community consultations also mentioned the importance of fresh fish from a health perspective and relevant NCD educational and health promotion programs should be consulted early in the RTP to identify synergies and overlaps.

Marshall Islands

Current FAD program

Currently the Republic of Marshall Islands (RMI) has nine active FADs out of 18 deployed in recent years. These are in depths ranging from 1,200 to 1,400m and are 1-2 mile off the coast with one in deeper water around 4-5 miles off coast. The average life span of a FAD in RMI is one to two years with several lasting longer if a good location is found for anchoring. Fishers are asked to check FADs when fishing around them and replace coconut fronds. The Marshall Islands Marine Resource Authority (MIMRA) does some maintenance on an ad hoc basis. There is no current program to replace FADs on the outer islands but near Majuro some replacements have been done every two years with SPC assistance. There are some reports of vandalism but no proof and it is possible some FADs are cut off by boats that accidentally run over them. There are also reports of some shark bite like damage but no proof this has had an impact.

Current supporting policies

The Marshall Islands has a FAD management plan but it needs updating.

Current costs and financial models

Materials cost around USD $3,000 for one FAD including the anchor. Deployment costs near Majuro are around USD $600 and for outer islands around USD $5,800. MIMRA funds deployment costs with donor support covering materials. No privately owned FADs or payment mechanisms in place but this has been discussed as possible in the future.

Other

Consultations in RMI did not discuss other programs and initiatives to move fishing effort from reefs. The RTP should engage the government and marine conservation programs to obtain further information and to identify overlaps and opportunities.

RMI is currently planning a new NCD strategy for 2025 onwards and SPC is leading this strategy development which should provide good opportunities for identifying synergies and opportunities between the programs.[52]

Samoa

Current FAD program

Samoa has five active FADs and all are in 500-1000m of water. The FADs last three to four years on average and are inspected 2-3 times per year. There are limitations on funding for maintenance. If a FAD is lost or damaged, replacement will depend on the availability of materials and funds to support replacements. If materials available this will take around six months, possibly even a year and if no materials are on-hand and budget needs to be found. Some vandalism issues were reported, especially the flag and flagpole getting taken and boats tying up to FADs and adding stress to the mooring.

Current supporting policies

The FAD management program is one of the key priorities of the Fisheries Division of the Ministry of Agriculture and Fisheries (MAF). The program requires updating and consultations identified matters such as cyclone proof materials storage, catch and effort monitoring and community engagement and education.

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52 RMI NCD program

Current costs and financial models

FADs are designed according to FAO principles and cost NZD $10,000 to 15,000 each. Materials are funded by projects/donors and deployment costs funded MAF. The FAO FishFad project, the Pilot Program for Climate Resilience (PPCR) and another small-scale fisheries project have helped support and maintain the Samoa FAD Program. In addition, the Samoan International Fishing Association deploy FADs for fishing competitions that are self-funded. The development of a cost recovery mechanism was mentioned as a potential source of sustainable finance.

Other

During consultations the importance of village-based fisheries management committee's involvement in FAD programs was highlighted and also the need to coordinate strategies to help transfer fishing pressure from reefs.

In terms of NCDs there is an ongoing WHO and World Bank (WB) program to deliver better NCD information and care at the community level[53] and the RTP should seek early engagement with authorities and programs to promote fresh fish protein in NCD prevention.

Solomon Islands

Current FAD program

The Solomon Islands (SI) has 46 active FADs all around the country, at 100-500m depths with an average life span of 3-4 years. FADs are monitored for maintenance every 6 months and if damaged or lost replacement depends on the availability of budget and materials and funding for this was included in the 2023 budget. FAD sabotage is a problem and is usually due to issues associated with community ownership and fishing boundaries relating to traditional marine tenure system. The Ministry of Fisheries and Marine Resources (MFMR) has undertaken mitigating community education and there have been trials to use subsurface FADs to avoid vandalism.

Current supporting policies

The MFMR has a National FAD program and a FAD management plan that is due to be updated. The current plan covers installation and maintenance of FADs. All communities with local area FADs have a FAD Committee. Consultations noted the need for additional FAD materials and access to suitable deployment vessels with better echo sounders and bathymetric information for deployment. Improved data collection and monitoring to optimise FAD locations, designs and overall program management was noted as well as a new FAD design to reduce any potential impacts on mammals, turtles and birds. The development of strengthened the policies and education to mitigate vandalism is also a consideration.

Current costs and financial models

The FADs cost SBD $80,000 each including deployment costs with half for materials and the other half for deployment which includes freight, travel costs and boat hire at the deployment location. FAD material costs are donor funded and MFMR also provides core funding. There are also NGO deployed FADs using local materials for the buoy system. The National Fisheries Developments (NFD) has an active program deploying both industrial and coastal artisinal FADs as part of their corporate, social responsibility (CSR)

[53] Samoa NCD program

and the government would like to see this expanded. The need to ensure recurrent MFMR budget to cater for increased community FAD demand was also noted.

Other

Consultations noted the need for the Community-Based Resource Management (CBRM) Section within MFMR to raise awareness of the decline in coral reef fish resources and the need to promote tuna consumption for good nutrition.

There is a national strategy to address the NCD burden that includes healthy nutrition and education[54] the RTP should seek early engagement with this program to identify synergies in approaches.

Tonga

Current FAD program

Tonga currently has 17 active FADs with5in Tongatapu, 4 in Eua, and 8 in Vava'u. FADs are moored in a range from 200 - 1,000m in depth and last 2-5 years on average with several examples of a 5-7 year FAD life. The Ministry of Fisheries (MoF) undertakes quarterly and post-cyclone monitoring and maintenance. Replacement is subject to the availability of materials but usually within six months. Aside from cyclone and current related loss s there has historically been some vandalism but this has diminished as communities understand the importance of FADs, especially in special management areas (SMAs).

Current supporting policies

The MoF has a FAD policy and a National FAD management plan is in development. Consultations noted needs for technology upgrades to allow for real-time monitoring and site surveys and better fisher catch and effort data collection as well as a need for cyclone proof housing to store materials and access suitable boats for deployment.

Current costs and financial models

FADs cost Pa'anga $5,000 for shallow water and Pa'anga $30,000 for deep water (700-1200m). The MoF funds FAD monitoring with donor funding covering materials and deployments and theVava'u game fishing association (VGFA) have their own self-funded FADs.

Other

Consultations in Tonga did not discuss opportunities and program overlaps for reducing fishing effort from reef areas vulnerable to climate change and the RTP should seek early engagement with the relevant environmental programs and authorities to identify program synergies.

There are active NCD focused programs involving healthy food and education and these programs should also be engaged early in the RTP to identify overlaps and synergies with the FAD program.[55]

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54 Solomon Islands NCD program
55 Tonga NCD national plans

Tuvalu

Current FAD program

Tuvalu currently has 5 FADs with one in each of the island groups. The deeper ones are at 1,200m and shallow ones at 400m with most in shallow water. The average life span is around two years but some last longer. Inspection is undertake annually and

there are challenges in replacing lost FADs. The target is to maintain one FAD per outer island and three in Funafuti but this hass not been achieved since 2019 with only two deployed in 2022. There is some vandalism with at least two cut off deliberately and the inter-island cargo vessel has also run over and accidently cut off FADs.

Current supporting policies

Tuvalu Fisheries Department (TFD) has a national FAD program with a management plan which is in need of finalisation. Challenges in implementation include the need for a larger and more stable vessel for deployment such as a barge fitted with a small crane that can be towed to FAD sites anywhere in the country and improved better echo location is needed for accurate bathymetric information in the selection of deployment sites.

Current costs and financial models

The ten deep water FADs deployed in 2019, cost AUD $51,000 plus the concrete anchors and deployment costs, with the cement and sand imported to make blocks. Boat cost are AUD $1,200/day plus diesel with materials and some deployment costs donor funded and the balance covered by government.

Other

Consultations in Tuvalu did not discuss opportunities and program overlaps for removing fishing effort from the reef areas most vulnerable to climate change and the RTP should seek early engagement with the relevant environmental programs and authorities to identify program synergies.

Tuvalu has a national strategy addressing NCDs and this includes healthy diet. Again, the RTP should seek early engagement with the health department to further identify synergies in programs and the opportunity of the FAD program to address healthy diet in vulnerable communities.[56]

Vanuatu

Current FAD program

There are currently 25 FADs in the water around the country. They are deployed in 700-1200m of water and the average lifespan is two to three years with one known to be in the water for 15 years. The Vanuatu Fisheries Department (VFD) of the Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity undertakes monthly maintenance as well as daily routine checks by fishers who report any damage to fisheries officers. FADs are usually replaced within one month after being reported missing and vandalism hasn't been a problem in recent years and since 2021 the FAD program has included community awareness which has helped mitigation..

Current supporting policies

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56 Tuvalu NCD program

Since 2020 the National FAD Management Plan and implementation of the FAD program has been a VFD priority activity.

Current costs and financial models

FADs cost vatu-ika 450,000 plus vatu 100,000 for deployment with total cost around vatu 550,000 per FAD. Materials procurement and deployment costs are covered through VFD with government budget and some materials are also funded by projects. FADs are also deployed and owned by the game fishing club with membership fees used to cover costs.

Other

Consultations mentioned the need to have both offshore and nearshore FADs to allow access for smaller boats and less experienced fishers. Early RTP FAD program engagement is needed to ensure synergies with other environmental programs to identify priority reef areas that are most vulnerable for climate impacts. n support.

Vanuatu has a national strategy addressing NCDs and this includes a healthy diet.[57] The RTP should engage with the health department to further identify synergies in programs and the opportunity of the FAD program to address healthy diet in vulnerable communities.

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[57] Vanuatu NCD national strategy

Appendix 2: Annual FAD maintenance budget

Corresponding master budget code	Annual contingency budgets	Comment	Palau (USD)	Tuvalu (usd)	Tonga (USD)	PNG (USD)	Kiribati (USD)	Cook Islands (USD)	Samoa (USD)	Fiji (USD)	Solomons (USD)	FSM (USD)	Nauru (USD)	Niue (USD)	RMI (USD)	Vanuatu (USD)
1.3	First National staff salary and allowances	Based on year two of GCF budget	27,000	11,200	8,100	15,000	11,200	16,900	12,950	10,800	6,500	10,000	14,000	15,600	22,000	16,200
1.3	Second National staff salary and allowances	Based on year two of GCF budget	21,000	12,600		15,000	9,800			9,900		10,000				
1.3	expendable office supplies.	Based on year two of GCF budget	500	350	225	240	350	195	370	360	130	800	350	195	500	540
2.1	Purchase of FAD materials including freight and container costs (plus extra buoys, shackles and swivels for maintenance per container).	Based on half of the budget of the year two of the CGF budget, may not be annual cost depending on the life-span of the FADs	45,000	45,000	45,000	90,000	90,000	45,000	45,000	90,000	90,000	45,000	45,000	45,000	45,000	90,000
2.1	equipment for FAD deployments (GPS/plotter and sounders	Based on budget estimate by Lindsay Chapman	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
2.1	Electronic monitoring equipment for fish biomass and for metereological equipment for CC	This cost will only occur if the data is seen usefull durin the pilot. Based on budget estimate by Lindsay Chapman	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
2.1	Purchase of tablets for recording catch and effort data	Based on budget estimate by Lindsay Chapman	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
2.3	operationalise the FAD management plan in the	implementation budget for year 4 of the	48,200	37,160	28,934	35,640	38,775	41,832	32,622	38,189	36,759	61,800	19,740	19,357	52,200	46,084
2.3	Local purchase of steel reenforcing rod, cement, sand and gravel for making concrete anchor blocks in the molds, including making the	Estimate only, actual amount will depend on yearly number of FADs deployed. Based on year 4 of the master budget.	6,400	4,000	8,000	10,800	11,400	5,980	4,800	16,000	6,578	3,000	3,990	4,030	3,000	12,030
2.3	national workshop with SPC building local capacity in rigging and deploying FADs including undertaking site surveys of areas for FAD deployment plus sea safety, fuel, venue	Estimated to be done every two years to keep up capacity Annual budget based on 50% of the year 4 of master budget.	3,000	3,185	2,880	0	2,275	3,982	2,812	1,755	2,461	2,125	3,136	2,958	2,400	2,565
2.4	Strengthening national data collection on FADs and their maintenance as well as catch and effort information from FAD fishing activities	Based on budget estimate by Lindsay Chapman	10,000	10,000	10,000	20,000	20,000	10,000	10,000	20,000	20,000	10,000	10,000	10,000	10,000	20,000
2.5	Developing and/or strengthening awareness raising around FADs, the FAD programme, sea safety and predicted climate change effects on the marine environment	Based on budget estimate by Lindsay Chapman	10,000	10,000	10,000	20,000	20,000	10,000	10,000	20,000	20,000	10,000	10,000	10,000	10,000	20,000
2.6	at two locations per country plus FAD	depedning on country needs based on Fiji	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
	Country total annual estimate		236,100	198,495	178,139	271,680	268,800	198,889	183,554	272,004	247,428	217,725	171,216	172,140	210,100	272,419
	Without cyclone proof storage costs		191,100	153,495	133,139	226,680	223,800	153,889	138,554	227,004	202,428	172,725	126,216	127,140	165,100	227,419

Adapting tuna-dependent Pacific Island communities and economies to climate change

Study 9: Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by GCF

Part 2. Assess the scope for governments of participating countries with hubs for the transshipment of purse-seine catches to regulate these operations and capitalize on these activities in new ways to sustain access to tuna for the food security of urban communities.

Sari Tolvanen
Marine Change

Final report
22 January 2024

Executive summary

Component B of the Green Climate Fund (GCF) Regional Tuna Programme (RTP) titled: Adapting tuna-dependent Pacific Island communities and economies to climate change, under RFP22-3866 addresses the need to manage the challenges associated with national food security.

Traditionally, much of the fish consumed in the Pacific Island region has come from coastal fisheries, which are based mainly on coral reefs. Climate change is adversely affecting the Western and Central Pacific Ocean large marine ecosystem, degrading its coral reefs and changing the distribution of tuna. The impacts on coral reefs are reducing the supply of reef fish and threatening the food security of more than four million people that live along the coasts of the 14 Pacific Island Countries (PICs) targeted in the RTP. In parallel to the threat to the food security of highly vulnerable populations, the redistribution of tuna will have profound implications for national economies that derive as much as 70% of their (non-aid) government revenue from tuna fishing, thereby dramatically reducing basic social services that are essential to the resilience of Pacific Island people.

With abundant off-shore tuna resources, there is an opportunity to increase the availability of good quality and affordable tuna to Pacific Island populations through increased utilisation of landings of by-catch and small/damaged tuna (hereafter referred to as by-catch) from purse seine transshipment operations. Increasing by-catch from transshipment does, however, come with several caveats. Planning for the year-on-year variability in transshipment volume caused by the El Nino Southern Oscillation (ENSO) conditions and operational decisions by industry, and the potential for such landings to adversely affect local fishers if pricing and sales are not managed requires careful consideration. Additionally, there are practical challenges that need to be overcome to ensure any such landings can be brought ashore, stored, and marketed according to established food safety standards.[1] In addition, strong consumer preference for reef fish over pelagic fish in some countries can cause low demand for by-catch and tuna sourced from commercial operations meaning investment and distribution options stimulate low interest as alternative food sources or to support livelihoods and enterprise.

Technical Studies 2 and 5 of the RTP have quantified future seafood protein needs and reviewed logistical, infrastructure and distribution, considerations associated with transshipment hubs in relation to current and future needs of PICs. This Study builds on these findings by reviewing country-by-country approaches and suggesting supporting policies that will enable the delivery of by-catch and support the infrastructure investments in the RTP Participating PICs where transshipments take place to improve the availability of by-catch to assist in addressing threats to national food security. This Study also introduces options for finance mechanisms and supporting capacity building needs that provide the potential for funding these investments beyond the RTP.

The Western and Central Pacific Fisheries Commission (WCPFC) regulates by-catch on the high seas in the Convention Area by prohibiting dumping of by-catch at sea under CMM 2022-01 but does not explicitly

[1] Green Climate Fund 2021, Pacific Concept Note. Accessed in August 2023. https://www.greenclimate.fund/document/adapting-tuna-dependent-pacific-island-communities-and-economies-climate-change

mention non-tuna by-catch. In addition, the PIC Coastal States have varied policy approaches to by-catch landing ranging from compulsory requirements, to an optional undertaking to full prohibition.

Given that some of the required infrastructure needs often take a long-time to materialize and might well fall outside the capacity of the RTP to implement (roads, wharves) more immediate decisions will be required to secure short to medium-term benefits of increased access to, and utilization of, tuna and by-catch transshipped from industrial-scale fishing to contribute to national food security. The use of by-catch for local micro canning and methods to provide products that extend shelf life and do not compete with local fishers has been trialed with mixed results.[2] If this is not a feasible option and where the delivery of by-catch to urban populations is not possible, or the demand for direct by-catch use is low, there is an option to maximize the benefit of by-catch for other purposes such as fish meal, poultry or other animal feeds. Policy gaps to improve the local utilisation of by-catch will need addressing together with the development of national strategies for promoting the use of by-catch either as a primary source of direct food or prioritizing its secondary uses for fish and animal feed.

Investment in the required by-catch collection, storage and distribution infrastructure is difficult to attract and will require a country-specific approach based on the local demand and other factors. Based on future discussions with the RTP participating countries and their willingness to make the necessary policy changes as well as consider the potential development of a 'protein hierarchy' strategy, the detailed assessment of the infrastructure needs and costs will be based on the strategy chosen. The investment needs will depend on whether the transshipped tuna and by-catch is prioritized for direct consumption or other uses such as fish meal for local agriculture and aquaculture depending on supply/demand and the need to protect local fishers and their livelihoods. Given the low level of demand in some of the high-volume locations, the secondary uses of by-catch are an important consideration for the overall increased use of tuna resources to ensure no by-catch is wasted and that it can contribute to increased food security.

A combination of port infrastructure and a long-term supporting regulatory and policy environment will potentially be required to incentivize by-catch offloading in PIC ports. This may include attracting international investment in the required infrastructure and possible national and SMEs investment in distribution, storage and processing. Governments may need to consider prioritizing the use of tuna bycatch as an important source of food security and potential for local economic opportunities especially if direct human consumption in urban centers is going to be logistically and economically possible. Proven finance models for the sector and required investments are largely lacking and will require policy-driven direction. It will be important to co-invest in infrastructure that will benefit other sectors as well and provide broader food security-based benefits for the country. The secondary uses of by-catch, such as fish or animal meal, are likely going to be easier to put into place and attract SME involvement in the short-term in the countries where there is also limited demand of by-catch for human consumption. The secondary uses are also more likely to attract private investment if existing business models of fish meal and other products already exist locally and the upfront costs are less than those needed for direct human use of by-catch.

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[2] FFA. 2019. *Small-scale tuna canning in Plau starts next week*. Accessed in September 2023, https://tunapacific.ffa.int/2019/09/20/small-scale-tuna-canning-training-in-palau-starts-next-week/

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Suggested citation:

Tolvanen, S. in press. Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by the GCF. Part 2: Assess the scope for governments of participating countries with hubs for the transshipment of purse-seine catches to regulate these operations and capitalize on these activities in new ways to sustain access to tuna for the food security of urban communities. Technical Study 9 prepared for the Pacific Community as a contribution to a Funding Proposal being prepared for submission to the Green Climate Fund (GCF). January 2024. 43 p. + annexes.

This is an advanced copy and is not the final version of this Report. The Report is still undergoing editorial review and formatting. As with all Technical Reports commissioned to support the preparation of the Funding Proposal to the Green Climate Funding advice and recommendations regarding programmes of future work and strategies proposed in the Report will be subject to review by the 14 participating countries, SPC as the Executing Entity and subject matter experts during finalization of the Proposal and at Programme inception.

List of acronyms and abbreviations

AUD	Australian dollar
AWS	Advance Warning System
COP	Conference of Parties
CPPL	Central Pacific Producers Limited
EEZ(s)	Exclusive economic zone(s)
ENSO	El Nino Southern Oscillation
FAD(s)	Fish aggregating device(s)
FAO	Food and Agriculture Organization (of the United Nations)
FAME	Fisheries, Aquaculture and Marine Ecosystems
FFA	Forum Fisheries Agency
FJD	Fijian dollar
FSM	Federated States of Micronesia
FOFA	The Fishermen of Funafuti Association
GCF	Green Climate Fund
IDF	International Development Finance
kg	Kilogram
KFL	Kiribati Fisheries Limited
KI	Kiribati
KMI	Kendal Micronesia Inc.
km	Kilometre
km^2	Square kilometres
KPA	Kiribati Port Authority
LCD	Least Developed Countries
m	Metre
MAF	Ministry of Agriculture and Fisheries
MIMRA	Marshall Islands Marine Resource Authority
MH	Marshall Islands
mt	Metric ton (or tonne)
NAFICOT	National Fishing Corporation of Tuvalu
NCD	Non communicable disease
NFA	National Fisheries Authority
NFMRA	National Fisheries and Marine Resource Authority
NGO	Non-Government Organisation
NORMA	National Oceanic Resource Management Authority
nm	Nautical mile
NZD	New Zealand dollar
PNG	Papua New Guinea
PGK	Papua New Guinea Kina
PICs	Pacific Island countries
PICTs	Pacific Island countries and territories
PNA	Parties to the Nauru Agreement
PNMS	Palau National Marine Sanctuary
PPF	Pan Pacific Foods
RMI	Republic of Marshal Islands
RFP	Request for proposals
SI	Solomon Islands

SIDS	Small Island Developing States
SBD	Solomon Islands dollar
SDG	Sustainable Development Goals
SPC	Pacific Community
SME	Small medium enterprise
SST	Sea surface temperature
TFD	Tuvalu Fisheries Department
TNC	The Nature Conservancy
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States dollar
VDS	Vessel Day Scheme
WB	World Bank
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WHO	World Health Organisation

1. Introduction

Traditionally, much of the fish consumed in the Pacific Island region has come from coastal fisheries, which are based mainly on coral reefs. With a decline in reef fish catches and population growth a larger volume of national requirements are sourced from imported and processed foods. These processed foods are contributing to the health crisis of non-communicable diseases in the region and there is an urgent need to address the gap in the supply of fresh fish (see Study 2). Climate change is also further predicted to adversely impact the productivity of coral reef ecosystems and their capacity to contribute to national food security.[3] With abundant offshore tuna resources, there is an opportunity to increase the availability of good quality and affordable tuna to Pacific Island populations to address the gap between protein demands of growing populations and the capacity of alternative sources of protein, particularly coral reefs, to fill it. However, there is a common perception[4] that the current foreign export-focused fisheries, whilst increasingly economically beneficial to the region, do not currently contribute sufficiently to local food security.

One of the three priority areas of work of the proposed RTP is to increase the availability of tuna and by-catch from industrial purse seine tuna fishing[5] and associated transshipment operations to local populations. This builds on the Pacific Island Forum (PIF) Fisheries Ministers 'Regional Roadmap for Sustainable Pacific Fisheries,' which sets ambitious 10 year targets and includes increasing the supply of tuna for domestic consumption by 40,000 metric tonnes (mt) across the region by 2024.[6] This RTP will: 1) increase the supply of tuna for domestic consumption as an adaption to the degradation of coral reefs and the resulting food insecurity for vulnerable populations; and 2) usher in the reforms needed to minimize the risks for citizens of countries with economies that are vulnerable to climate-driven redistribution of tuna.

However, increasing by-catch and small/damaged tuna (hereafter referred to as by-catch) landings from transshipment comes with several caveats. Planning for the year-on-year variability in transshipment volume caused by the El Nino Southern Oscillation (ENSO) conditions and operational decisions by industry, and the potential for such landings to adversely affect local fishers if pricing and sales are not managed requires careful consideration. Additionally, there are practical challenges that need to be overcome to ensure any such landings can be brought ashore, stored, and marketed according to established food safety standards.[7] In addition, strong consumer preference for reef fish over pelagic fish

[3] Toth, L.T., Aronson, R.B., Vollmer, S.V., Hobbs, J.W., Urrego, D.H., Cheng, H., Enochs, I.C., Combosch, D.J., Van Woesik, R. and Macintyre, I.G. 2012. ENSO drove 2500-year collapse of eastern Pacific coral reefs. *Science*, *337*(6090), pp.81-84.

[4] Pacific Forum Sec 2016. Forum Communique. https://www.forumsec.org/wp-content/uploads/2016/09/2016-Forum-Communique_-Pohnpei_-FSM_-8-10-Sept.pdf

[5] Although this study is focussed on purse seine transshipments the ports in many FFA member countries support unloading by longliners which also offer opportunities for non-premium grade export quality fish to make a contribution to addressing national food security concerns. Tonga is an example where there is a formal requirement for a proportion of a vessel's catch to be made available to local markets on unloading at Nuku álofa.

[6] SPC. 2015. Regional roadmap for sustainable fisheries. https://www.spc.int/DigitalLibrary/Doc/FAME/Brochures/FFA_SPC_2015_Roadmap.pdf

[7] Green Climate Fund 2021, Pacific Concept Note. Accessed in August 2023. https://www.greenclimate.fund/document/adapting-tuna-dependent-pacific-island-communities-and-economies-climate-change

in some countries can cause low demand for by-catch and tuna sourced from commercial operations meaning investment and distribution options stimulate low interest.

Given the predicted changes and availability of reef fish in many parts of the Pacific, it is timely to review how policy changes and supporting investments can both create a better reputation and acceptance of transshipped by-catch as a protein source and minimize unwanted consequences such as competition with local fishers. It is important to avoid uneconomical or time-consuming policy and regulatory requirements on industry to help ensure the region is ready to adapt to changing fishing and transshipment patterns and distribution of fish to address threats to national food security.

There have been several previous studies in the region that have looked at the options over the years for coastal States to benefit from transshipments,[8] the distribution and leakage of tuna from transshipments[9] as well as the policy options available for countries to increase tuna available for food security.[10] However, little to no progress has been made in terms of policy changes that support increased food security benefits and no major investments have taken place to facilitate the distribution of by-catch, indicating the low priority status of this matter within the region to date. This is despite the commitments made to improve food security by PIF Ministers and the 2024 target of 40,000 mt of tuna being made available for domestic consumption in PICs.

Study 2 and Study 5 of the RTP have quantified future seafood protein needs and reviewed logistical, infrastructure and distribution considerations associated with transshipment hubs in relation to current and future needs for domestic protein requirements. This study builds on these findings by suggesting supporting policies that will enable the delivery of by-catch and support infrastructure investments in the RTP PICs where transshipments take place. This study also introduces options for finance mechanisms that provide the potential for funding these investments beyond the RTP.

2. Supporting policies for transshipments programs to increase tuna available locally

2.1. Analysis of incentives for (or mandating) purse-seine vessels operating in the exclusive economic zones to offload bycatch in coastal State ports

The Western and Central Pacific Fisheries Convention mandates that purse seine transshipments will take place within territorial waters consistent with applicable national laws, aside from special exemptions granted by the Commission.[11] The WCPFC CMM 2022-01 para 29, states: *to create an incentive to reduce the non-intentional capture of juvenile fish, to discourage waste and to encourage efficient utilization of fishery resources, CCMs shall require their purse seine vessels fishing in EEZs and on the high seas within the area bounded by 20oN and 20oS to retain on board and then land or tranship at port all bigeye, skipjack, and yellowfin tuna.*[12] The Parties to the Nauru Agreement (PNA) 3rd Implementing Agreement

[8]McCoy, M. (2012) *A Survey of Tuna Transshipment in Pacific Island Countries: Opportunities for Increasing Benefits and Improving Monitoring*. FFA Report, July 2012.

[9]Tolvanen, S., Thomas, K. and Lewis, T. (2021), *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[10] MRAG Asia Pacific (2022), *Policy Options to Increase the Contribution of Tuna Fisheries to National Food Security Across FFA Members*. Report prepared for the Forum Fisheries Agency. 75 p.

[11] WCPFC transhipment regulation

[12] CMM 2021-01

(3IA) only refers to the retention of tuna species caught by purse seine vessels but does not specify transshipment, landing or other requirements for by-catch.[13] The regional agreements therefore currently do not mandate the landing of non-tuna by-catch species leaving a gap in regulations and a need to update the CMM 2021-01 to specifically include by-catch in the CMM as a means to address regional food security needs and encourage the full utilization of catch.

Aside from vessels that operate 'domestically', landing catch for local processing and/or markets, transshipment locations are in general decided by proximity to the fishing ground. Other considerations include fees and regulatory stipulations that affect the ease of doing business. Secondary considerations include the availability and diversity of vessel port services such as supplies, net making, engineering and entertainment options. Ease of doing business and the onshore facilities are the main incentives to encourage visits and potentially mean that all other things being equal, some hubs such as Majuro are more popular than alternatives with less developed facilities.[14]

There are some examples where PNA counties are encouraging local landings via Vessel Day Scheme (VDS) discount rates to support 'domestication policies' meant to provide the raw material for onshore processing. PNG, for example, has offered a discount on VDS days. The discount amounted to 111 million USD in one year and was designed to ensure that 100% of the fish caught within the Exclusive Economic Zone (EEZ) was landed locally for onshore processing. However, the landed amount was only 20% of the total EEZ catch for that year resulting in some vessels benefitting from the discount which then created a secondary market for VDS days by some companies (profiting the local company given a discounted rate). [15]This underlines the need for effective compliance monitoring of any incentive scheme designed to stimulate use of local ports and ancillary services.

VDS discounting to encourage transshipment requires detailed economic and cost-benefit analysis. For countries with no processing or immediate need for by-catch for food security, there is likely to be little economic basis to offer such discounts, especially if the purpose is solely to increase by-catch landing as the value of the product is low.

Based on reports from studies 2 and 5 countries with immediate food security needs as a basis to encourage transshipment and the landing of by-catch caught in their EEZs can be determined. According to the current assessments Solomon Islands, Papua New Guinea and Kiribati have the largest need to ensure increased by-catch delivery locally.[16] There is adequate rationale for offering small VDS discounts in these countries as an incentive for local landings of tuna and bycatch. The greater national benefit would be secured by following the example of Kiribati and requiring by-catch to be landed locally as a condition of licensing conditions. Such provisions need to be accompanied by the necessary collection and distribution investments (see study 5) and capacity to enforce compliance to ensure its implementation.

Despite WCPFC CMM 2022-01, in practice if local laws prohibit landing or if no local collection takes place, by-catch and small tuna that is not economical to transship are dumped overboard according to industry informants. There are minimal apparent implications for transshipment operations themselves if there is a requirement to separate tuna and by-catch for local distribution. Appropriate incentives should lead to an increase in the availability and utilization of tuna and by-catch to local communities during

[13] PNA 3IA.
[14] Personal Communication M Brownjohn (July 2023)
[15] Interview with a PNA member (July 2023)
[16] Ref: Study 5

transshipment. It is critical to ensure that such requirements do not take time from the crew conducting the transshipment and that the removal of the by-catch is facilitated promptly. Supply of provisions such as fruit and vegetables and other provisions or small services may well cover the gratuity needed as the product is of low economic value and otherwise wasted.[17]

Current forecasts and projections suggest that climate-induced redistribution of tuna will have different implications for different countries.[18] To secure long-term economic benefits, including in relation to food security and livelihoods, RTP PICs should assess the potential for a regional approach to managing transshipment activity to optimize the availability of tuna and by-catch for increasingly vulnerable communities. It is within the collective capability of the PNA to mandate offloading requirements of licensed commercial vessels to contribute to national food security needs in a way that no individual PNA member is disadvantaged. Precedents for this include the PNA's conditions of access being linked to an undertaking by licensed vessels not to tranship on the high seas.

2.2 Analysis on the potential for the prohibition of discards of bycatch species caught by purse-seine fishing and monitoring compliance with such requirements

The WCPFC Convention as well as the PNA 3IA mandate that vessels are not allowed to discard small or undersized skipjack, yellowfin or bigeye tuna at sea and that both small and undersized fish have to be retained (apart from the last haul of the trip and fish unfit for human consumption).[19] The regulations do not currently cover non-tuna by-catch and will need updating in this regard (see 2.1). However in practice, if the port does not allow for the by-catch to be landed, as well as actively facilitate its offloading, vessels are reported to dump the fish at sea as there is no other alternative.[20] The lack of adequate economic incentives, and the cost associated with disposing of fish unloaded for dumping in port, whether that be undertaken by government agencies or the private sector, is a significant impost that does not currently generate a national benefit.

The approach taken to landing by-catch from transshipment vessels varies greatly between Pacific countries. Regulation of the practice ranges from banning landings, with varying degrees of adherence (FSM and RMI) to mandating them under vessels' license conditions (Kiribati) (see 2.3 for individual country summaries). In some cases, there are no regulations for landings from transshipment under fisheries legislation (Solomon Islands, Papua New Guinea) but it is practiced unofficially and mainly unaccounted for despite the large dependency of the urban population on the by-catch as a contribution to food security.

In practical terms, until all the countries have found a way to; a) allow by-catch landing and sales in their territory in a way that does not impact local prices and fisher livelihoods, b) have established facilities to

[17]Tolvanen, S., Thomas, K. and Lewis, T. (2021), *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[18] Bell, J.D., Senina, I., Adams, T. *et al.* (2021), Pathways to sustaining tuna-dependent Pacific Island economies during climate change. *Nature Sustainability*, **4**, 900–910.

[19] CMM 2021-01

[20]Tolvanen, S., Thomas, K. and Lewis, T. 2021. *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

ensure hygienic handling and distribution of by-catch, and c) have attracted SME to operate processing, distribution and sales, the discard prohibition, even if enshrined in regional and national regulations, cannot be adequately enforced.

Once the regulatory requirements are in place, together with the required infrastructure needs and SME distributors, the compliance with regulations and requirements for increased landings from the commercial vessels for domestic consumption will need to be routinely monitored and reported against. To effectively achieve this additional resourcing will be required to support the extension of services provided by fisheries observers, transshipment monitoring staff, port inspectors and data reporting and analysis.

The policy changes to prohibit discards and allow by-catch landing in all of the participating countries should follow a detailed strategy development as explained in 2.2.1 below.

2.2.1 Alternative policy options to support local landing of by-catch

Below is a summary of some examples where governments have regulated the access of commodities to the market with a view to a) ensuring affordable local commodity access, and b) mitigating harm to local producers that can be drawn from considering appropriate courses of action available to PICs in respect of transshipped fish intended for local consumption.

One such policy is the Western Australian Domestic gas policy which requires exporters to release 15% of the gas they produce to the domestic market at a certain price.[21] Many Asian countries also regulate domestic rice prices and exports in this manner to ensure domestic food security.[22] Similarly in Tonga, it is a requirement for locally based tuna fleets (longline) to land 30% of their catch to the local market.[23] If governments kept account of their protein production and consumption, they could establish similar policies to ensure an adequate supply of by-catch, or fresh tuna from locally based fleets, for their needs and require the landing of by-catch/tuna in their national policy and licensing conditions for the use in direct human consumption when needed and desired, or for the production of secondary protein in animal and fish feed.

The governments with transshipment hubs or domestic tuna industry should consider a more detailed strategy on the full use of the by-catch. For countries with high demand such as the Solomon Islands, PNG and Kiribati, all by-catch can be prioritized for direct human consumption. For other countries with less demand such FSM, RMI and others, authorities should monitor fish prices and availability (and promote tuna and by-catch consumption as per Technical Study 2) and at times of high demand for by-catch, allow transshipped by-catch for sale in the local markets. At other times, governments could prioritize by-catch for fish and animal feed production to support the secondary protein sources domestically, maximize food security benefits and ensure by-catch is not wasted.

In this 'protein hierarchy' fresh fish/by-catch, be it from locally based fleets or transshipment by-catch, would, as a priority, be distributed to local populations when other protein access is low and there is

[21] Western Australian Government 2023. *Western Australia Domestic gas policy*. Accessed November 2023. https://www.wa.gov.au/government/publications/wa-domestic-gas-policy

[22] Bishwajit, G., Sarker, S., Kpoghomou, MA. *et al.* 2013. Self-sufficiency in rice and food security: a South Asian perspective. *Agric & Food Secur* **2**, 10 (2013)

[23] Tolvanen, S., Thomas, K., Lewis, T. and McCoy, M. 2019. *Assessing the contribution of landings from locally based commercial tuna fishing vessels to food security*, FFA Report.

demand and at other times utilized for the fish/animal feeds. In this way harm to local fisher livelihoods is minimized but the populations are still as priority provided fresh food over processed imports. This would require the infrastructure and resources to store and distribute the fish as well as capable SMEs and investments into the fish meal plants that will allow for secondary uses of the by-catch and potential development of the domestic fish farming and poultry industry as alternative proteins (see Study 5).

2.3 Analysis of current policies in place

The accompanying summary of the status of tuna purse seine transshipment activity [24] in each of the Participating Countries is based on previous 2021 research.[25] Information was collated from responses to questionnaires sent to the participating countries, additional information from recent country consultations, Study 5, as well as information directly sought from experts (see Appendix 1).

2.3.1 Federated States of Micronesia

Current policy

Federated States of Micronesia (FSM) law (Title 24 FSM Code) prohibits licensed tuna fishing vessels, both foreign and domestic flagged, from selling any of their catch to local markets. This also includes the so-called bartering and trading. The prohibition on local sales by commercial tuna vessels was adopted to protect the livelihoods of local tuna fishermen who engage in trolling for skipjack and yellowfin tuna and deep handline fishing for yellowfin tuna within the 12 nm fishing zone. Both national and state laws and regulations prohibit government officers from asking for gifts from those whose actions they regulate, to reduce the scope for corruption. FSM law also prohibits persons from offering gifts to regulators that might be construed as a bribe.[26]

While it is illegal for boats to gift catch to officials, a limited amount of high-level 'patronage' gifting has been practiced under the approval of the NORMA Executive Director or company CEO in the case of FSM flag vessels. These have been primarily for special official and community functions and are limited.

Future policy considerations

Whilst not necessarily focused on by-catch, needs assessments are currently underway for all four ports in FSM to identify possible infrastructure upgrades such as extensions to port and wharf frontages and cold storage facilities. [27]

The recent consultation with NORMA as part of the RTP visits indicated that there is interest to revisit the ban on the sale of tuna and by-catch transshipped from commercial vessels but there needs to be a mechanism to ensure that this does not have a negative impact on local food prices and fisher livelihoods. There was a suggestion to support women's associations as a vehicle for distribution. This would require appropriate infrastructure including collection vessels and cold storage to accommodate large volumes of fish.

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[24] Note Fiji was removed from the review due to infrequent purse seine transshipments and small historical volumes.

[25] Tolvanen, S., Thomas, K. and Lewis, T. 2021. *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[26] The government staff encompassed by these constraints include fisheries managers, transhipment observers, port officials, boarding officers and fishery observers.

[27] Ref: Study 5

In addition, the recent tuna value addition study in the region made a strong recommendation to consider the animal and fish feed industry in FSM for the use of by-catch in a way that would contribute to increased food security but be sensitive to local livelihood concerns and the general population's preference for other types of fish.[28]

FSM opportunity summary

Issue	Status	Recommendation
Current policy on by-catch landings	Prohibited	Review this policy based on alternative use of by-catch for animal and fish feed
Future protein needs[29]	Not increasing, population predicted to decline	Demand for by-catch likely not going to increase in the short term, no economic basis for direct investments.
Seafood preference	Reef species and fresh fish[30]	As above
Concerns for local fisher livelihoods	High concern, local fishers have rejected past proposals to allow by-catch landing	Local fishers role in supplying non-reef based protein should be prioritised (i.e. through a FAD program and shore based infrastructure).
Infrastructure needs for by-catch distribution	Not in place	Due to lack of demand there is currently no basis for large investments. , If aqua/animal feed opportunity is more defined, investments for transport vessels, cold storage and facilities could be made together with investment in small-scale fisher infrastructure (cold storge, landing sites).
Alternative use of by-catch to support food security	Potential for animal and fish feed processing	The local demand for these products should be evaluated in more detail and a business case/incentives provided for

[28] Personal communication F. Blaha (July 2023).
[29] Ref: Study 5 and Study 2
[30] Tolvanen, S., Thomas, K. and Lewis, T. 2021. *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

		SME involvement in the use of by-catch.

2.3.2 Kiribati

Unlike some countries where tuna and/or tuna bycatch informally enter the local market from transshipment operations, this source of fish is part of Kiribati's formal local tuna supply. The practice of landing bycatch and rejected tuna from vessels transshipping in Kiribati dates back at least to the 1990's.[31] Kiribati regulations [32] require that landings from transshipment occur via the government-owned Central Pacific Producers Limited (CPPL) and the government joint-venture company Kiribati Fisheries Limited (KFL).

Purse seine fishing licenses issued by Kiribati require local landings from transshipments occurring in Tarawa. However, in reality this practice is negotiable and managed on a case-by-case basis. Through locally-based and foreign purse seiners license conditions transshipping vessels supply CPPL with damaged and/or small tunas, mainly skipjack, as well as bycatch, for sale on the local market in Tarawa.

Reject fish collected by CPPL staff onboard transshipping vessels are transported from the wharf to their shop fronts or cold storage facility (i.e. reefer container) via a truck with the capacity of holding up to ~2 mt. Once the fish is distributed to the two retail fronts in Bikenibeu and Bairiki, it is sold whole and unprocessed. The fish is normally sold quite quickly owing to the competitive price charged – AU$2.20/kg in 2023, or half the market price of fresh fish.[33] When there is more discarded tuna than the market can absorb (for example after transshipments by the large Korean vessels) the excess is sold for animal feed, as CPPL has limited cold storage capacity. This excess amounted to 3 mt in 2016 reducing to around 1 mt in subsequent years and is used for pig feed.[34, 35]

Currently bycatch available for local consumption is less constrained by the supply of fish from transshipping vessels and more by infrastructure limitations. It was highlighted by CPPL that in addition to limited cold storage, they do not possess any large collection boats to transport bycatch from purse seine vessels to shore, and the wharf space operated by the Kiribati Ports Authority (KPA) is also limited. For the six months from September 2022 to February 2023, CPPL reported 107 mt of bycatch sold through its fish markets.

As a result of the constraints in the official supply chain, private individuals are still actively involved in the collection and distribution of tuna bycatch from purse seine transshipments despite the regulations against it. Anecdotal accounts suggest that the CPPL markets are closed more often than they are open, with the large portion of tuna bycatch entering Tarawa's local economy as 'leakage' – i.e. informal and unmonitored collection of fish from purse seine vessels by private individuals in small skiffs/canoes and selling the fish at pop-up stands by the side of the road.[36]

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[31] Fisheries Division, Kiribati (undated, 1990s) Report on Foreign Fishing Vessels Transhipments in Kiribati.
[32] Fisheries Division, Kiribati (undated, 1990s) Report on Foreign Fishing Vessels Transhipments in Kiribati.
[33] Ref: study 5
[34] Meeting with CPPL, March 2019
[35] The study found no information if the by-catch is processed or used as it is for animal feed.
[36] Ref: Study 5

Future policy considerations

The in-country consultations indicated that in order to more efficiently distribute by-catch volumes when available there is interest in scaling up the CPPL markets from the current two locations – Bairiki and Bikenibeu.. In addition, logistical problems associated with the lack of reliable collection boats, wharf space and cold storage need addressing. There is good demand in Tarawa for the fish when it is available but the large one-off volumes and lack of cold storage mean some of it is used as pig feed when too spoiled for human consumption. A policy decision could be made to prioritize the direct food security need and appropriate infrastructure gaps addressed.

Kiribati opportunity summary

Issue	Status	Recommendation
Current policy on by-catch landings	License requirement to land by-catch in Tarawa	Strengthen capacity to monitor compliance.
Future protein needs[37]	Increasing, urban population growth predicted to increase by 48% by 2050.	Likely severe future protein deficiency unless by-catch volumes and distribution are addressed adequately.
Seafood preference	Mixed	There appears to be a strong demand for economically priced transhipped tuna and by-catch landings.
Concerns for local fisher livelihoods	Medium concern	Given high market demand there appears to be limited competition with local fishers, this should be monitored if by-catch volumes available locally are increased.
Infrastructure needs for by-catch distribution	Landing volumes are limited by lack of appropriate infrastructure	There appears to be a strong need for both transportation vessel(s), additional cold storge as well as additional shop/market capacity.
Alternative use of by-catch to support food security	By-catch currently being used as pig feed when volumes exceed local capacity to store/sell fish	Given high demand by urban populations direct use of by-catch for food security should be prioritised and invested in, not animal feed.

[37] Ref: Study 5

	and it spoils, estimated to be only 1 mt in 2021.[38]	

2.3.3 Nauru

Nauru has not been a transshipment hub to date due to a lack of port facilities and the related services required to facilitate transshipment and re-supply operations. It also does not have current regulations in regard to transshipment and landing of by-catch. There is a major port upgrade currently underway in Nauru which was planned to be completed in 2020. The current estimated date for completion was September 2023.[39] Once the port is operational Nauru is likely to start attracting purse seine transshipments, especially from vessels active in its EEZ. There is a need to clarify the national regulations in regard to permitting/prohibiting landing. It is likely that given the small local population and the large potential volumes of by-catch at this time, local fisher livelihoods may be impacted and will require considerations as the national strategy is developed. Alternative uses of by-catch as described in chapter 2 may be a necessary consideration for Nauru to balance the need to fully utilize by-catch and the local livelihoods.

2.3.4 Papua New Guinea

The amended National Tuna Fishery Management and Development Plan of 2014[40] provides the authority to regulate the unloading, transshipment and marketing of all catch including by-catch. Currently there are no other provisions to do so other than the regulation of the use of motherships for at-sea transshipment. In-port transshipment in designated ports is required consistent with the WCPFC ban on at-sea transshipment for purse seine vessels.

There are several ports in which purse seine transshipments and landings take place in PNG. The busiest of these is the Port of Rabaul. As there are no processing facilities in Rabaul, the majority of vessel visits are dedicated to transshipment between purse seiners and fish carriers. In contrast, vessel visits to the other three key ports; Lae, Madang and Wewak are primarily associated with the landing of tuna into the local processing plants.[41]

Limited information is available on current trading practices of by-catch in PNG ports but bartering primarily of fruit and vegetables from small vessels (dinghies and canoes) predominates, especially in Rabaul and Wewak. In Lae and Madang, where private wharves service the tuna fleets, minimal leakage reportedly occurs and trading is more regulated under processing company control. Commercial trading of small or damaged tuna and bycatch is regulated in Madang, and partly controlled in two others (Lae and Wewak). In Rabaul there are varying degrees of sorting and leakage but there is no organized commercial trading.

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[38] Tolvanen, S., Thomas, K. and Lewis, T. (2021), *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[39] Green Climate Fund 2017, *Sustainability and climate resilience* for Nauru. Accessed November 2023. https://www.greenclimate.fund/project/fp052

[40] Papua New Guinea Government. 2014. National Tuna Fishery Management and Development Plan

[41] Ref: Study 5

In Madang the catch is sorted and graded during unloading at the wharf, with damaged or small tuna and non-tuna bycatch species separated, and temporarily parked in the cold storage. Disposal then occurs via canteen utilization in both RD tuna operating locations (Vidar port and Nagada plant) and there are relatively low volume sales through an outlet set up with a local landowner group selling at the compound gate.

Whilst there is local demand at the cannery locations it seems likely that a large proportion of the available tuna and bycatch is discarded in Rabaul during periods of high-volume transshipments.[42] There are no reports of by-catch reaching Port Moresby or other urban centers.

Future policy considerations

With high priority on tuna fishery domestication and value adding in PNG, the use of by-catch has not received priority attention. Given the high volumes of transshipped and landed purse-seine catch in PNG a key question remains as to how to ensure the by-catch is efficiently collected and processed. In Rabaul and Wewak where cannery operations do not handle by-catch, there is an opportunity to increase access to by-catch. The main constraint relates to an inefficient informal supply chain with virtually no cold chain for the effective distribution of a perishable product. As highlighted in study 5, a multisector infrastructure approach is required to secure appropriate investments as by-catch alone is currently low value and available in limited in volumes such that large investments in distribution infrastructure cannot be justified.

Papua New Guinea opportunity summary

Issue	Status	Recommendation
Current policy on by-catch landings	Transshipments in port required but policy does not include provisions for by-catch landings	Policy revision should be prioritised to mandate by-catch landing by licensed vessels similar to Kiribati.
Future protein needs[43]	Increasing, urban population growth predicted to increase by 62% by 2050.	Likely severe future protein deficiency unless by-catch volumes and distribution is increased.
Seafood preference	Mixed	Given the population trends and low economic status of urban populations there is likely demand for well-priced by-catch.
Concerns for local fisher livelihoods	Low concern	Given high market demand there appears to be limited competition with local fishers.

[42] Tolvanen, S., Thomas, K. and Lewis, T. (2021), *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[43] Ref: Study 5

		This should be monitored if by-catch volumes available locally are increased.
Infrastructure needs for by-catch distribution	Distribution of by-catch currently limited by the lack of cold storage and adequate supply chain to urban centres.	There is a need for additional cold storge and cold supply chain as well as logistical solutions (road or freezer container transport) to Port Moresby. This is likely to require major government led investments. In addition, wharf space is limited at the current processing sites and will require expansion if landed volumes are to be increased.
Alternative use of by-catch to support food security	No information on current use of by-catch for animal feed but it is usual practise for canneries to produce fish meal from fish waste and potentially also from the unused by-catch.	Until logistical issues are solved, and distribution to local populations is improved, the by-catch should be processed into animal feed. However, given high demand by urban populations direct use of by-catch for food security should be prioritised. As part of the policy revision for by-catch landing, the canneries should be consulted to understand what additional role they can play in ensuring local distribution of by-catch and cold chain support (consider the Noro example in Solomon Islands).

2.3.5 Republic of Marshall Islands

Landing tuna or bycatch from transshipping purse seiners for local sale is officially prohibited in the Republic of Marshall Islands (RMI) under local fisher law.[44] Unlike in FSM, where landing is prohibited and gifting to officials is prohibited, in RMI the gifting practice for personal use is not specifically regulated. Government officials visiting the ships include fisheries managers, port officials, boarding officers and fisheries observers are all known to receive gifts of tuna and by-catch.

[44]This was confirmed by MIMRA in 2020 but no regulation was ever produced/shown

The local market demand is for reef fish, and local fresh tuna catch is preferred over transshipped frozen and brined fish. Hence, there is no evidence of leaked damaged tuna or large quantities of bycatch at the local market.[45] As a result of the local ban on commercial trade, and low demand, such fish is usually dumped at sea or utilized by one of the two local fish meal companies, Pan Pacific Foods (PPF) and Kendall Micronesia Inc (KMI). In the case of KMI, which is an agent for purse seine vessels, by-catch is received free or in exchange of fruit and supplies. The fish is processed into fish meal for local milkfish farms. In addition, it is common practice for local fishermen to barter goods for bait fish with the purse seiners.

Future policy considerations

Given the population trends, local fish preferences and local fisher livelihood concerns there is currently no case for immediate policy change or additional investments to facilitate by-catch access for the local population. The use of by-catch for animal and aquaculture feed is already serviced by the local SMEs. Both PPF and KMI utilize the public port and wharf, with PPF collecting the by-catch as part of the unloading process and KMI transporting reject fish from transshipping vessels using their skiffs. The public port is shared with merchant ships delivering goods and supplies to Majuro. These vessels have priority access to the wharf over fishing vessels. This is the only bottleneck identified by officers from the Marshall Islands Marine Resources Authority (MIMRA) regarding fish landed from purse seine vessels to local processors and could be considered for inclusion as part of a planned generic port upgrade in Majuro.[46]

Marshall Islands opportunity summary

Issue	Status	Recommendation
Current policy on by-catch landings	By-catch landings for human consumption are prohibited but individual bartering and gifting is not actively regulated.	It does not appear necessary to revise the regulation at the current time.
Future protein needs[47]	There is a small (-3%) decline predicted in Majuro's population by 2050. Projected declines in reef fish availability (due to overfishing and habitat loss) means protein needs will have to be met from other sources.	Local food security needs should be monitored and policy changes considered if and when the conditions change.
Seafood preference	Reef fish and fresh tuna	Demand for by-catch is likely not going to increase in the short term. There is currently

[45] Tolvanen, S., Thomas, K. and Lewis, T. (2021), *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

[46] Ref: Study 5

[47] Ref: Study 5

		no economic justification for direct investments.
Concerns for local fisher livelihoods	High concern	Local fishers' role in supplying non-reef sourced protein should be prioritised (i.e. through a FAD program and shore-based infrastructure).
Infrastructure needs for by-catch distribution	Wharf space to allow for by-catch collection for aquaculture and animal feed is currently limited.	Consider PPP approach for additional wharf investment that can facilitate by-catch offloading and distribution.
Alternative use of by-catch to support food security	Already active SME sector utilising by-catch for secondary products that support food security.	See above discussion in relation to additional wharf space to support increased use of by-catch.

2.3.6 Solomon Islands

Whilst there are currently no regulations covering transshipment and unloading in the existing Fisheries Management Act (2015), the Tuna Fisheries Management and Development Plan was recently reviewed as part of the Solomon Islands Ministry of Fisheries and Marine Resources (MFMR) Corporate Plan and Strategy 2019 – 2023 and the Solomon Islands National Fisheries Policy 2019-2029. These policy documents aim to ensure the long-term management, conservation, development and sustainable use of Solomon Islands fisheries resources and may contain regulations applying to transshipment and unloading but we were not able to verify the status as part of this study.

There are two main avenues of by-catch sales in the Solomon Islands. Firstly, the Soltuna processing facilities in Noro requires all small and reject tuna and by-catch to be landed at their facility. Study 5 describes the landings, storage and distribution chain in detail. It should be noted that the majority of by-catch is transported overnight to Honiara for sale at to restaurants and through the fish market.

There is also more unofficial trading and bartering of rejected brined and frozen fish set aside during transshipment by industrial purse seiners in Honiara port (locally called saltfish). The saltfish is available for trade and is generally regarded as leakage, as it remains largely outside regulated commercial supply chains. No statistics are available despite the importance of the trade and details remain poorly known. Aspects of the trade in Honiara have attracted attention at various times. This includes concerns relating to possible health risks from poor hygiene - the fish may remain unrefrigerated/not iced for long periods on the vessel and on land, before sale in the markets. Saltfish is usually displayed and sold on ice box tops in a dedicated area in Honiara Central Market and can be stored overnight in Market-maintained ice boxes for a small fee. Vendors report quality checks by Government officials are rare, but they monitor fish quality themselves and reject fish that has been unsold for several days and is exhibiting a strong deterioration in quality. Despite these quality issues, salt fish trade is important for food security particularly among lower socio-economic components of the Honiara community.[48]

Solomon Islands opportunity summary

Issue	Status	Recommendation
Current policy on by-catch landings	Not specifically regulated	Policies should be put in place to mandate all licensed vessels to land all by-catch as well as seek other agreements to keep transshipment volumes high for food security considerations.
Future protein needs[49]	The urban populations are expected to grow by 79% by 2050 with severe food security implications.	There is a need to both increase by-catch volumes as well as ensure hygienic distribution.
Seafood preference	Mixed	There is high demand for by-catch from the lower income sector especially around Honiara.[50]
Concerns for local fisher livelihoods	Low	In the urban markets there is high demand for all fish.
Infrastructure needs for by-catch distribution	Cold storage and distribution needs to enable hygienic local distribution operations.	The current local distribution channels in Honiara are unofficial and would be difficult to channel private investment to. There is a need for government to provide facilities or attract private sector investments.
Alternative use of by-catch to support food security	No information	Given high demand, direct human use of by-catch should be prioritised over secondary products.

[48]Tolvanen, S., Thomas, K. and Lewis, T. 2021. *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report

[49] Ref: Study 5

[50] Tolvanen, S., Thomas, K. and Lewis, T. 2021. *Assessing the contribution of landings from in-port transshipment to food security in the Pacific*, FFA Report.

2.3.7 Tuvalu

There is no specific legislation relating to local landings from transshipping vessels (either requiring or prohibiting it) however any such landings could potentially not be compliant with customs and agricultural quarantine regulations. Consultations with Tuvalu Fisheries Department (TFD) and agents in Funafuti suggest that most fish received from transshipping vessels are not sold on the local market but are rather used for personal consumption among family members or as bait for artisanal fishing. The requirement for a license to sell fish and the close network of fishers supplying the local market are likely reasons preventing fish from transshipment being commercially traded in the community.[51]

There is a policy plan to increase the use of bycatch from transshipments to support local food security (not small /reject tuna) needs which is yet to be actioned. Currently, there are two fish markets in Funafuti in operation, the Fishermen of Funafuti Association (FOFA) market and the National Fishing Corporation of Tuvalu (NAFICOT). Discussions to formalize the handling of by-catch and reject tuna from transshipment through NAFICOT or FOFA took place before the COVID-19 pandemic. Both NAFICOT and FOFA offer processed fish products, mainly sun-dried and smoked fish. NAFICOT escalated its capacity in 2019, with the installation of new fin bins, freezers and a drying/smoking machine donated by Korea, as well as training for approximately 20 locals in processing techniques. However, due to limited transshipment activities since early 2020, plans to process bycatch have been temporarily placed on hold.[52]

Tuvalu opportunity summary

Issue	**Status**	**Recommendation**
Current policy on by-catch landings	Not specifically regulated	Policy changes should be considered to mandate the landing of by-catch.
Future protein needs[53]	Small 3% population increase expected by 2050	Given potential climate induced changes to transshipment volumes and reef fish availability the food security situation on Funafuti needs to be monitored.
Seafood preference	Fresh fish	There is more demand for processed bycatch products than brined fish sales.
Concerns for local fisher livelihoods	Moderate	Local fishers role in supplying non-reef based protein should be prioritised (i.e. through a FAD program and provision of shore-based infrastructure).

[51] Ref: Study 5
[52] Ref: Study 5
[53] Ref: Study 5

Infrastructure needs for by-catch distribution	Some infrastructure in place but if volumes increased additional investments to support storge and distribution might be needed.	Local SMEs have potential to receive investment or enter into PPPs.[54]
Alternative use of by-catch to support food security	Fish waste is currently used as pig feed	Given by-catch volumes are at times high and can exceed local capacity the production of aquaculture or animal feed should be considered as a secondary product.

Table 1. Summary of priority policy recommendations per country

Country	Revise licensing condition to mandate by-catch landing	Update domestic regulations to allow by-catch landing	Prohibit at sea discards of all species in licensing conditions	Other
FSM	Consider	Consider for secondary products as a start	Consider	Policy changes need to be implemented in line with investments to secondary products or a strategy not to harm local fishers.
Kiribati	Already in place	Already in place	Priority action	Enforcement of existing regulations
Nauru	Consider	Consider	Consider	Nauru's new port needs more information on the volumes transshipped and

[54] A Public-Private Partnership (PPP) is a partnership between the public sector and the private sector for the purpose of delivering a project or a service traditionally provided by the public sector.

Country	Revise licensing condition to mandate by-catch landing	Update domestic regulations to allow by-catch landing	Prohibit at sea discards of all species in licensing conditions	Other
				potential food security benefits as it becomes operational
Papua New Guinea	Priority action	Issue needs clear policy guidance	Priority action	Policy changes need to be accompanied by high level action plans to provide cross sector infrastructure support for distribution to Port Moresby.
RMI	Consider	Consider	Consider	Policy changes need to be implemented in-line with investments to support processing of secondary products or a strategy not to harm local fishers.
Solomon Islands	Priority action	Issue needs clear policy guidance	Priority action	SI needs to consider more overarching mechanisms to secure consistent and increasing supply of by-catch under the different climate scenarios given the predicted gap in protein supply. The viability of a PNA collective

Country	Revise licensing condition to mandate by-catch landing	Update domestic regulations to allow by-catch landing	Prohibit at sea discards of all species in licensing conditions	Other
				agreement to ensure transshipment volumes are maintained should be assessed.
Tuvalu	Consider	Issue needs clear policy guidance	Consider	n/a

3. Financial mechanisms recommended to support transshipments programs to increase the local availability of tuna

3.1 Recommendations from study 5

Study 5 identified four key areas for infrastructure improvements to ensure efficient delivery of by-catch from transshipment:

1. development of efficient collection systems – underpinned by large reliable vessels to go between the shore and transshipping vessels;
2. ensuring transportation networks on both land and sea provide support for the distribution of bycatch between the point of landing and sale;
3. establishing basic facilities at ports and markets for preparation, sale or storage of the fish – e.g. concrete spaces with access to water and waste disposal; and
4. providing support for private investment along the supply chain by improving access to finance and financial literacy, as well as reducing tax burdens to SMEs.

One of the most important messages that came out of the consultations with industry and other experts in study 5 was that bycatch is a low-value product with very little margin to justify large investments in its delivery or value-added processing. The best use of government resources would be to focus on facilitating a conducive environment to conduct business rather than direct intervention in the supply chain. The study also concluded that any public investments made in infrastructure should be for facilities that can be used and shared across sectors such as roads for general access, wharf facilities for multiple uses, cold storage and others. The following section discusses different investment mechanisms that can support the required infrastructure.

3.2 Estimating the costs associated with optimizing the availability of fish from transshipping operations for domestic food security

Local operators currently involved in by-catch distribution were approached for views on costs for different infrastructure needs. Unfortunately, any information obtained was inadequate to make a meaningful assessment. Even previous estimates made for investments such as the Honiara fish market were not seen as accurate given the recent global inflation and changes in prices. As a result, it was not possible to prepare a detailed financial model for the required infrastructure (refer to Study 11).

Also, given that some of these infrastructure needs often take a long-time to materialize and might well fall outside the capacity of the RTP to implement (roads, wharves) more immediate decisions will be required to secure short to medium-term benefits of increased access to, and utilization of, tuna and by-catch transshipped from industrial-scale fishing to contribute to national food security. The use of by-catch for local micro canning, provide products that extend shelf life and do not compete with local fishers has been trialed with mixed results.[55] If this is not a feasible option and where the delivery of by-catch to urban populations is not possible, or the demand for direct by-catch use is low, there is a need to maximize the benefit of by-catch for other purposes such as fish meal, poultry or other animal feeds as explained in 2.2.1.

Future discussions with the participating countries in the RTP on their willingness to make the necessary policy changes as well as consider the potential diversification of the use of by-catch to fish and animal feeds and other products that support food security will be required. A detailed assessment of the infrastructure needs and costs will be based on the approach chosen. The investment needs will depend on whether the transshipped tuna and by-catch are prioritized for direct consumption, for fish/animal feed or other products depending on demand.

Following consideration of the above policy decisions, it is recommended that the RTP conduct a more detailed feasibility study of the infrastructure requirements to support sourcing tuna and by-catch from transshipment operations to contribute to addressing national food security needs . This assessment needs to be based on detailed information relating to:

a. current infrastructure and its useability;
b. volume projections and national protein needs;
c. based on the above determine the size of collection vessels, size of fish markets, cold storage and solar capacity requirements, and/or
d. the capacity needs of appropriately scaled fish processing facilities to produce fish and animal meal;
e. SME landscape analysis and appropriate training and support to potential SMEs;

Engineering and fishery operations experts are also needed to assess the potential locations. Other external needs such as legal and rental requirements and specific construction requirements accounting for a range of potential climate change impacts will also be required. Following on from this and taking account of the findings, reflective tender documentation will need to be prepared for construction firms active in the region who can give up-to-date reliable estimates of the costs based on the exact parameters of the construction, the location and other operational details. Study 11 is preparing this for the Honiara fish market and could serve as a pilot for other countries/locations within the RTP.

As discussed earlier (3.1), many of the above investments are difficult for private investment in a traditional sense, given the low-value product, the high cost of infrastructure needs and the lack of replicable models of private sector leadership on the issue. However, there are still viable options for Public Private sector Partnership (PPP) approaches in engaging existing SMEs to be involved in the sector

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[55] FFA 2019. *Small scale tuna canning in Palau strats next week*. Accessed in January 2024. https://tunapacific.ffa.int/2019/09/20/small-scale-tuna-canning-training-in-palau-starts-next-week/

as well as options to encourage larger SMEs roles in the operations. The financing options for the different infrastructures are highlighted in more detail in 3.3. below.

3.3. Most practical and reliable sources of funding to optimise the domestic food security and sustainable livelihoods benefits from transshipping operation

Given the lack of detailed cost information on the required infrastructure needs this section provides an overall assessment of the types of investments the RTP can help facilitate. The options presented below involve long-term financial arrangements that will support infrastructure that will be utilized well beyond the life of the RTP.

Table 2. Summary of potential investment models per infrastructure need for by-catch distribution

Infrastructure requirement	Domestic public finance / international development finance	Development grant / blended finance	Traditional bank / private investment	Incentives to encourage SME involvement
Road	x			
Wharf and port infrastructure	x	x		
Collection vessel		x	x	x
Fish market with waste management and water	x	x		
Cold storage	x	x	x	x
Ice factory	x	x	x	x
Renewable energy	x	x	x	
Fish meal and other processing facilities		x	x	x
Trucks, ice boxes etc.		x	x	x

Infrastructure requirement	Domestic public finance / international development finance	Development grant / blended finance	Traditional bank / private investment	Incentives to encourage SME involvement
Waste Management	x	x	x	

3.3.1 Domestic public finance and/or international development finance

This finance stream can include national infrastructure budgets that are either financed from the regular national budget or through International Development Finance (IDF). IDF typically provides either grants or concessional loans and the usual lenders in the region are the World Bank (WB), Asian (or other regional) Development Banks as well as many bilateral financiers. The IDFs usually have long-term programs in the countries and regions they support and the investment needs are evaluated within those programs. IDF investments are required align with the UN Sustainable Development Goals (SDGs) as well as climate-related adaptation and mitigation targets as mandated by the Paris Agreement.

Roads, ports, renewable energy projects as well as cold chain infrastructure all fall within the usual scope of this kind of finance and can include national debt finance, grant components and blended finance (see below). Green electricity, climate-friendly cooling and cold chain investments are a priority for many of the IDFs, especially as the Covid-19 pandemic highlighted the global inequities in vaccine distribution due to the lack of sufficient cold chains to store and distribute vaccines in many parts of the world, including in the Pacific.[56]

It is well within the scope of the RTP to engage the Development Banks in considering the broader climate adaptation and food security needs in the region and how the proposed infrastructure falls within these programs and the overall green/climate resilient infrastructure for the region. Combining sectors and generic country needs (wharves, roads) would also help reach the scale required for this kind of finance, provide benefits that go beyond the by-catch issues and assist with the necessary policy and regulatory environment and capacity building needed to support the longevity of these projects and investments.

3.3.2 Development grants or blended finance

As well as 'the banks' above there are many national and multilateral players involved in the development finance space with grant-based funding. Developed nations have committed to spending at least 1% of their GDP in assisting the least developed countries and these commitments are on the increase to cover the recent commitments to climate change-related loss and damage.[57]

International development programs such as USAID, AUSAID, the EU and others are regular funders of different programs in the region that include long-term capacity building as well as infrastructure needs.

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[56] UN FAO 2022. *Sustainable food cold chains*. Accessed November 2023. https://www.fao.org/3/cc0923en/cc0923en.pdf

[57] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

Again, early engagement of these programs by the RTP on the investment needs for transshipment by-catch distribution is needed to ensure sufficient time to include these aspects in their long-term programs. Also, other climate-specific funders and food security funds such as the UN International Fund for Agricultural Development (IFAD) may be able to consider contributing to the work of the RTP with additional grants or blended finance options.

Blended finance combines the power of development finance and private capital to reduce risks and increase opportunities for private investors and PPPs or bonds are the usual vehicle for this kind of investment. Development finance can include grant or non-grant components such as debt, equity or guarantees to attract additional private investments to the projects. Most of the proposed investments for by-catch landing and distribution infrastructure can fall within this type of finance, especially for SIDS where environmental and social outcomes are often focus areas of blended finance.[58]

PPPs have had a bad reputation due to widespread criticism of the intrinsic weaknesses of the PPP model. This includes a lack of accountability of private companies to the people, leading to cost overruns that impose a burden on future generations. PPPs have also been used as a financial mechanism that hides expenditures off the public balance sheet. In the last decade there has been more effort to implement standards to ensure better performance of PPPs so that, among other objectives, they remain one of the key pathways for achieving the SDGs as part of the 2030 agenda. Some considerations for successful PPP approaches include:[59]

a. Careful consideration given to the structure and use of blended finance instruments;
b. Sharing risks and rewards fairly;
c. Meeting social and environmental standards;
d. Ensuring "sustainable, accessible, affordable and resilient quality infrastructure";
e. Ensuring accountability mechanisms and transparency, including in public procurement frameworks and contracts ;
f. Ensuring the participation of communities in decisions that will affect them;
g. Ensuring effective management, accounting, and budgeting for contingent liabilities, and debt sustainability, and
h. Alignment with national priorities and relevant principles of effective development cooperation.

In initiatives aimed at improving national food security, cold storage is often prioritized by governments as it has broad utility across a range of perishable foods beyond fisheries. In the case of many PICs, facilities could be shared with several operations including local small-scale fishers, farmers and SMEs interested in food processing. Innovative PPP approaches can help cover their upfront as well as ongoing costs. Electricity costs in many PICs are extremely high and solar or other renewable and affordable electricity investments need to be considered as part of the initial investments to ensure long-term operational efficiency. This kind of essential national infrastructure need is often financed by development banks

[58] GEF 2023. *Call for proposals*. Accessed in August 2023. https://www.thegef.org/documents/second-call-proposals-gef-8-blended-finance-global-program
[59] World Bank 2022. *A short history of PPPs*. Accessed in August 2023. https://blogs.worldbank.org/ppps/short-history-ppps-development-good-bad-and-hopeful

provided sufficient scale can be reached. Recently there has been a focus on cold storage infrastructure in PNG, which was funded by the World Bank for example.[60]

3.3.3 Traditional bank or private investment

There is a wide consensus within the industry that it is challenging to attract private investment for low value by-catch storage, processing and distribution initiatives. Given the projected large expenses involved in most of the infrastructure needs and the lack of proven finance models, it is unlikely that a local bank or a private investment fund, even an impact fund that prioritize environmental and social outcomes as well as economic returns, would involve in a project without additional de-risking or approaches such as those explained above.

If investments such as renewable energy, cold storage and associated infrastructure are treated as more generic investments, within a broader finance model that goes beyond by-catch, the potential for this type of finance will be improved. A proven private sector operator, with sufficient track record of financial management, who can manage the investment and the operations would improve the prospects for success of such an initiative. Some of the smaller investments such as skiffs, ice boxes and working capital might also be possible to finance through local banks or impact-facing funds (either private or public) if a capable SME is involved.

As with the recommendations for the FAD part of this study, there is a need to support local financial innovation. The RTP should consider building the awareness and capacity of local private institutions in "blue lending" and local bond issuance to attract local private investors. Private investors in PICs are risk-averse and not familiar with ocean finance.[61] An option for some countries would be to raise a local bond to cover a range of food security, health and sustainable livelihoods components. The recent Fiji green bond provides an example.[62] Most PICs have sovereign wealth funds that could be interested in investing in food security and fisheries, provided there is or would be government legislation, guarantees and possibly insurance. Early on in RTP, mapping of local lending frameworks should be undertaken to assess their ability and interest to contribute to transshipment by-catch program finance and long-term needs. Expert support may need to be put this in place to help familiarise the parties with the blue economy lending needs and opportunities in providing new finance vehicles for this sector.

3.4 Incentive options for small and medium enterprises (SME) and PPP to distribute tuna from transshipping operations to urban and peri-urban communities.

The definition of an SME varies between countries and is generally more linked to the economic and business environment of the specific country, rather than a strictly defined parameter (such as revenue or number of employees).[63] Hence an SME in Tuvalu and Australia might look quite different. In the

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[60] World Bank 2019. Recovery amid uncertainty. Accesed August 2023. https://documents1.worldbank.org/curated/en/534921562647834569/pdf/Papua-New-Guinea-Economic-Update-Recovery-Amid-Uncertainty.pdf

[61] UNDP 2022. Demytyfuing green bonds in the Pacific. Accessed November 2023. https://www.undp.org/pacific/publications/demystifying-green-and-blue-bonds-pacific-region

[62] World Bank 2017. *Fiji Issues First Developing Country Green Bond, Raising $50 Million for Climate Resilience.* Accessed in Augut 2023. https://www.worldbank.org/en/news/press-release/2017/10/17/fiji-issues-first-developing-country-green-bond-raising-50-million-for-climate-resilienc

[63] UNESCAP, SMEs in the Asia Pacific. Accessed in August 2023. https://www.unescap.org/sites/default/files/7%20-%201.%20SMEs%20IN%20ASIA%20AND%20THE%20PACIFIC.pdf

context of the by-catch collection and distribution in the transshipment hubs, an SME can be a small business operation that is either involved in a part of the supply chain for the by-catch such as delivery and distribution to the market or is responsible for the full supply chain from the pick-up of by-catch to processing and distribution. At present many of the unofficial players involved in the distribution of by-catch are micro-operators of just a few people, often from the same family unit, collaborating, rather than an official registered business that would be labelled as an SME.

SME development is an important area for many emerging and developing economies due to the important role they play in employment and economic activities. Although not specific to the SME sector, the WB's annual Doing Business rankings comprise perhaps the most comprehensive survey of the differing business conditions globally in 190 countries. Briefly, the Doing Business exercise seeks to quantify and rate the ease of doing business in a country based on 10 components, comprising: (a) starting a business; (b) dealing with construction permits; (c) employing workers; (d) registering property; (e) getting credit; (f) protecting investors; (g) paying taxes; (h) trading across borders; (i) enforcing contracts; and (j) closing a business. The highest-ranking PIC in 2019 was Fiji at 102 (out of 190 countries assessed), followed by PNG (120) Solomon Islands (136), RMI (153), FSM (158) and Kiribati (164). Tuvalu was not assessed.[64] Together with the acknowledged high costs of operations, such an index confirms the region as a challenging place to start and successfully operate a business.

Locally-based support is also available through initiatives such as the Pacific Private Sector Development Initiative (PSDI).[65] PSDI is a regional technical assistance program undertaken in partnership with the Government of Australia, the Government of New Zealand, and the Asian Development Bank. Since 2007, PSDI has worked to alleviate poverty and promote economic growth in the Pacific region through reforms that reduce the constraints to doing business and promote inclusive growth, entrepreneurship, and new business models.

Smaller investment needs to support engagement in by-catch supply chains, such as skiffs, ice bins, ice machines and associated small-scale equipment are generally within the investment capability of SMEs. Some larger companies might also be able to receive investment for cold storage and transport vessels, if they have diversified income streams. Given the facilitation that large and potentially unpredictable volumes of by-catch might require such as large additional cold storage, this type of investment need may fall outside of the capacity of most local SMEs and finance available for them, unless they are already involved in other activities that provide them income complimentary to the by-catch. Another option to finance the cold storage use is to rent it out for other users during times when by-catch volumes are low.

A business decision by an existing SME to get involved in by-catch collection and distribution will require additional risks associated with expanding their traditional operations and core business. Examples include RMI where two companies made the necessary investments to process fish meal. In Tuvalu, development aid was successfully applied to support the diversification of market vendors to utilize by-catch as an additional activity to their established fish processing and selling operations. Specialised SME platforms such as the ADB Blueimpact and the EU BlueInvest[66] provide training and facilitate the

[64] World Bank 2019, Ease of doing business rankings. Accessed August 2023. https://archive.doingbusiness.org/en/rankings

[65] PSDI 2017, *Financing growth*, Accessed January 2024. https://www.pacificpsdi.org/what-we-do/financing-growth/

[66]European Comission 2019. Blue Invest. Accessed Novemver 2023. https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/blueinvest_en

aggregation of small projects into a pipeline of investable projects at scale able to attract investors interested in aligning their investment with global goals.

In countries where unofficial collection and distribution of by-catch is common, distributors often lack adequate cold chain facilities. This leads to hygiene issues and spoilage particularly during periods of high volume underscoring the need to develop models of operations that are safe, hygienic and able to operate at sufficient scale. Additional support is required for these SMEs or micro-enterprises in areas such as hygiene training, financial literacy and other capacities in order to attract investment by banks or other local lenders. This is likely to require a government intervention and a support program that will identify and bring these players up to the required level.

Aside from government-operated collection and distribution in Kiribati and the Solomon Islands, this Study has not revealed any companies or SMEs that are commercially active in by-catch utilization/distribution. The only examples in the region are the local companies in RMI that expanded their operations to fishmeal processing and the seafood market vendors in Tuvalu. There are likely some additional players in PNG but their operations have not been adequately documented.

Given the well-documented challenges of business (and capacity) development in the region, it would be preferable to try and engage established local SMEs with a track record of good financial management and operational and managerial capacity to expand their operations to include by-catch collection, distribution and sale. Incentives that could be considered to support such involvement include tax exemptions, donated equipment to expand businesses as well as other grants and partially subsidized development programs. It is recommended that a review of the SME sector in each participating country be conducted early in the RTP to begin assessing gaps and mapping opportunities.

In some countries where domestic fleets already operate and land their catch in local ports and facilities that are in the vicinity of transshipment locations, incentives could be explored also to see how these companies could expand their operations to handle by-catch from the foreign purse seine fleet. This would take advantage of existing skills, potential markets and distribution chains and established infrastructure that could be shared and expanded upon. The incentives to engage such established operators could involve discounts for port and licensing fees, tax breaks and preferential access.

Aside from providing direct grants for equipment and working capital, SMEs may also be influenced by policies that help to de-risk their operations, especially in new ventures where viability and long-term finance plans need to be proven while markets are developed. Fixed-term tax breaks or discounts can be attractive. These however may not be sufficient, especially if the operation is evolving and requires support to grow. A commitment from governments or other development partners and financiers to the long-term capacity building of SME’s and their success is equally important. Early attention should be given to how the SME can be supported in this regard. The PPP model offers potential in this respect particularly if the private sector partner is well established and demonstrates the required competencies to improve the potential success of the venture.

There are many different SME and start-up support ecosystems around the world[67]and it is a priority for many governments to foster such support through technology, regulations, capacity building, innovation and finance. As a remote region the Pacific, with a small business environment, lags in offering these kinds

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[67] ADB 2021. *Blue Sea Finance Hub*, Accessed in November 2023. https://www.adb.org/what-we-do/themes/environment/bluesea

of support. Learning and capacity building initiatives that provide opportunities for young entrepreneurs or principals of established businesses to study relevant programs and initiatives in other countries to gain experience and network offer potential benefits. There are ongoing calls for accelerators and innovation support for SMEs and start-ups. For example, the latest UN call is specifically focused on businesses based in the SIDs and LDCs.[68] There are also other programs that support struggling businesses such as the Australian Business Volunteers which sends experienced professionals (business management, financial management, accounting, manufacturing, supply chain development, advertising and sales), often retired on overseas volunteer postings.

3.5 Evaluation of the potential for the private sector to benefit from the investments made by GCF to adapt transshipping operations to increase access to bycatch for urban communities.

Due to the lack of accurate cost information which is necessary to develop detailed finance and investment models, it is not possible to evaluate in detail the potential benefit of the GCF investment made. This will need to be modeled in more detail during the GCF Programme implementation once the steps suggested in Section 3.2 are actioned accurate cost and financing options have been assessed and the extent of the impact created can be measured.

Table 3 below summarises the potential long-term benefits for the private sector per investment category and the likelihood of cost-sharing possibilities.

Table 3: Summary of potential benefit for industry from infrastructure investments

Infrastructure requirement	**Potential for industry to benefit**	**Potential cost sharing arrangement**
Road	Can benefit industries across different sectors	Unlikely, as road infrastructure is seen as government responsibility
Wharves and port infrastructure	Can benefit industries across different sectors	Unlikely, as port infrastructure is seen as government responsibility or limited to specific equipment related to their special operations.
Collection vessel	Can benefit other seafood companies if a joint operation or expansion of an existing fishing related SME	Potential
Fish market with waste	Can provide market for	Unlikely unless part of a large

[68] UNFCCC 2018, *Loss and Damage – online guide*. Accessed August 2023. https://unfccc.int/sites/default/files/resource/Online_guide_on_loss_and_damage-May_2018.pdf

Infrastructure requirement	Potential for industry to benefit	Potential cost sharing arrangement
management and water	small-scale fishers and value added products by local micro enterprises	corporate CSR
Cold storage	Can benefit industries across different sectors	Potential
Ice factory	Can benefit industries across different sectors	Potential
Renewable energy	Can benefit industries across different sectors	Unlikely, as energy infrastructure is seen as government responsibility
Fish meal processing facility	Can benefit local processors that may also have fish waste	Potential
Trucks, ice boxes etc.	Can benefit other seafood companies if a joint operation or expansion of an existing fishing related SME	Potential
Waste management	Can benefit industries across sectors	Potential

3.6 Summary recommendations for supporting financial mechanisms

Investment in the required by-catch collection, storage and distribution infrastructure is difficult to attract and will require country-specific approaches based on the local demand and other factors as explained in 3.2. Each RTP country will consider the appropriate strategy to pursue based on policy decisions and changes around the potential development of a 'protein hierarchy' strategy and the associated detailed assessment of the infrastructure needs and costs. The investment needs will depend on whether the transshipped tuna and by-catch is prioritized for direct consumption or other uses such as fish meal for local agriculture and aquaculture depending on supply/demand and the need to protect local fishers and their livelihoods. Given the low level of demand in some of the high-volume locations, the secondary uses of by-catch are an important consideration for the overall increased use of tuna resources to ensure no by-catch is wasted and that it can contribute to increased food security.

A combination of port infrastructure and a long-term supporting regulatory and policy environment will need to be created (summarised in Table 1) to incentivize by-catch offloading in PIC ports, attract international investment in the required infrastructure and facilitate local investment and SMEs in distribution, storage and processing. Governments need to consider prioritizing the use of tuna by-catch as an important source of food security and potential for local economic opportunities especially if direct human consumption in urban centers is going to be logistically and economically possible. Proven finance models for the sector and required investments are largely lacking and will require policy-driven direction. It will be important to co-invest in infrastructure that will benefit other sectors as well and provide broader food security-based benefits for the country. The secondary uses of by-catch, such as fish or poultry meal, are likely going to be easier to put into place and attract SME involvement in the short-term in the countries where there is also limited demand. The secondary uses are also more likely to attract private investment as existing business models exist and the upfront costs are less than those needed for direct human use of by-catch.

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Appendix 1. List of people consulted on this study

Name	Title
Maurice Brownjohn	Independent consultant
Francisco Blaha	Independent consultant
Marcelo Hidalgo	PNG national fishing association
Robert Lee	Independent consultant
Maggie Skritum	MRAG Asia Pacific
Tuna industry players who did not want to be referenced	

Adapting tuna-dependent Pacific Island communities and economies to climate change

Study 9: Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by GCF

Part 3: Finance mechanisms, supporting policies and institutional arrangements to support the Advance Warning System (AWS)

Sari Tolvanen
Marine Change

22 January 2022

Executive summary

Component B of the Green Climate Fund (GCF) Regional Tuna Programme (RTP) titled: Adapting tuna-dependent Pacific Island communities and economies to climate change, under RFP22-3866 addresses the need to manage the risks to national economies, and the vulnerable populations who depend on public spending associated with tuna populations by providing reliable information on the extent and timing of climate-driven redistribution of tuna. This will be achieved through the development of an 'advance warning system' (AWS) for tuna-dependent economies to predict nearer-term changes in the distribution of tuna across the tropical Pacific Ocean, including robust forecasts in 1−10-year timeframes and at spatial scales relevant for national and regional level adaptation This report describes the institutional framework and capacity to support the AWS beyond the lifetime of the GCF-funded program as well as the current policy framework and future needs that will support its implementation. The financial and capacity needs that will be required after the initial 7 years to ensure the financial sustainability of the program are assessed.

Development of the AWS will be facilitated by the Pacific Community (SPC) under its Oceanic Fisheries Program (OFP). The OFP currently provides technical support to the participating Pacific Island countries for tuna fisheries research, fishery monitoring, stock assessment and data management. The OFP is also the contracted Science Service and Data Management Provider to the Western and Central Pacific Fisheries Commission (WCPFC) which is responsible for the overall management of the highly migratory tuna stocks in the Western and Central Pacific Ocean (WCPO).

The program of work for SPC's Division of Fisheries, Aquaculture and Marine Ecosystems (FAME), under which the OFP operates, includes climate and marine ecosystems-related assessments, advice and capacity building.[1] This institutional framework will ensure that AWS related activity is integrated to the broader program of work of SPC and that AWS initiatives will be sustained within SPC beyond the life of the GCF project.

The Pacific Islands Forum Fisheries Agency (FFA) is an advisory body providing expertise, technical assistance and resource management advisory support to its members who make sovereign decisions about their tuna resources and participate in regional decision-making on tuna management through agencies such as the WCPFC. The capacities of the FFA also include economic analysis and sustainable investment advice as well as the provision of climate advice and support to its members engaged in international negotiations.[2] The RTP will support these efforts and FFA is well-equipped to continue this role beyond the lifetime of the RTP.

[1] SPC 2011*, Modelling the impacts of climate change on tropical tuna*, accessed June 2023. https://oceanfish.spc.int/en/major-projects/climate-change

[2] FFA interview 2023

The Parties to the Nauru Agreement (PNA) is an important regional grouping of tuna dependent economies[3] that supply 95% of the region's purse seine tuna resources under its vessel day scheme (VDS). The AWS will provide both management and economical advice and forecasting critical for the objective of the PNA.

Given this strong institutional context the AWS will be operated and linked to no additional supporting policies were identified regionally or nationally to support its implementation beyond the operational framework needed to revise and adjust priorities. There are also the necessary agreements already in place between the WCPFC and Inter American Tropical Tuna Commission (IATTC) to accommodate the scientific cooperation needs of the AWS in relation to tuna resources that are shared with the Eastern Pacific Ocean (EPO).

The AWS also supports the implementation of the WCPFC Resolution 2019-01 on climate change[4], especially its points 1-4 and provides the membership with means of meeting these climate ambitions.

In terms of long-term sustainable finance and capacity needs the operating costs after the 7-year setup period under the RTP is under USD1 million annually (increasing to just over USD1 million annually 5 years after the RTP . This is just 0.01-0.02% of the current annual value of tuna fisheries of USD5 billion.[5] Given the moderate cost and the potential for benefits for the industry such as cost savings in terms of fuel, more efficient planning and operations and others, to be adequately quantified during the RTP, it is potentially a key cost recovery mechanisms under the PNA VDS, the WCPFC or directly with industry can be implemented to provide at least part of the long-term finance requirements of the AWS.

In addition, existing regional capacity such as the Regional Observer Program (ROP) can help sustain the data collection needs of the AWS.

In the event that cost recovery mechanisms prove difficult, or do not cover the full costs, other financial mechanisms are also discussed. Options include finance under the United Nations Framework Convention on Climate Change (UNFCCC) Loss and Damage Fund. Given that the AWS will be a key in quantifying any further potential loss occurring for the PICs AWS operational costs could fall under the finance provided by the Fund. Alternatively, more innovative finance mechanisms are discussed that if developed in the region could include AWS costs as part of the approach/investments made. One such example is climate insurance which also could use AWS data and hence provide finance towards it maintenance. Innovative debt instruments and Blue Economy approaches, including impact investments, are also discussed. The different policy and finance options are ranked in terms of relative accessibility on the basis of the likely timeline of

[3] Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Tuvalu plus Tokelau.

[4] WCPFC climate resolution

[5] The Pacific Forum Fisheries Agency (2022). Economic and development indicators and statistics: Tuna fisheries if the Western and Central Pacific Ocean 2022.

implementation, additional capacity needed to deliver as well as the level of innovation/risk involved.

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Suggested citation.

Tolvanen, S. in press. Identification of financing mechanisms, supporting policies and capacity needs to sustain the benefits achieved through investment by the GCF: Finance mechanisms, supporting policies and institutional arrangements to support the Advance Warning System (AWS). Technical Study 9 prepared for the Pacific Community as a contribution to a Funding Proposal being prepared for submission to the Green Climate Fund (GCF). January 2024. 39 pages plus annexes.

This is an advanced copy and is not the final version of this Report. The Report is still undergoing editorial review and formatting. As with all Technical Reports commissioned to support the preparation of the Funding Proposal to the Green Climate Funding advice and recommendations regarding programmes of future work and strategies proposed in the Report will be subject to review by the 14 participating countries, SPC as the Executing Entity and subject matter experts during finalization of the Proposal and at Programme inception.

List of Acronyms and abbreviations

AWS	Advance Warning System
COP	Conference of Parties
EEZ(s)	Exclusive economic zone(s)
ENSO	El Nino Southern Oscillation
FAD(s)	Fish aggregating device(s)
FAO	Food and Agriculture Organization (of the United Nations)
FAME	Fisheries, Aquaculture and Marine Ecosystems
FFA	Forum Fisheries Agency
FJD	Fijian dollar
FSM	Federated States of Micronesia
GCF	Green Climate Fund
IDF	International Development Finance
KI	Kiribati
LCD	Least Developed Countries
nm	Nautical mile
PNG	Papua New Guinea
PICs	Pacific Island countries
PICTs	Pacific Island countries and territories
PNA	Parties to the Nauru Agreement
RMI	Republic of Marshal Islands
RFP	Request for proposals
SI	Solomon Islands
SIDS	Small Island Developing States
SDG	Sustainable Development Goals
SPC	Pacific Community
SME	Small medium enterprise
SST	Sea surface temperature
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States dollar
VDS	Vessel Day Scheme
WB	World Bank
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean
WHO	World Health Organisation

1. Objectives and main tasks of AWS

Climate change is adversely affecting the Western and Central Pacific Ocean (WCPO) large marine ecosystem, degrading its coral reefs and changing the distribution of important fisheries species. The impacts on coral reefs are reducing the supply of reef fish and threatening the food security of more than four million people that live along the coasts of the RTP's targeted 14 Pacific Island countries.[6] The redistribution of tuna will have profound implications for national economies that derive as much as 70% of their (non-aid) government revenue from tuna fishing, thereby dramatically reducing basic social services that are essential to the resilience of Pacific Island people. The RTP will 1) increase supply of tuna for domestic consumption as an adaption to degradation of coral reefs and the resulting food insecurity for vulnerable populations; and 2) usher in the reforms needed to minimise the risks for citizens of countries with economies that are vulnerable to climate-driven redistribution of tuna.

The RTP comprises two components. Component A[7] is being designed to support adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change. This component addresses the need to improve food security of vulnerable communities by increasing access to tuna through empowering small-scale fishers to progressively transfer their fishing effort from coral reefs to tuna as well as and securing better access to tuna for rapidly-growing urban communities from industrial fishing operations. Importantly, these interventions will also ensure that coastal communities are equipped with the training and technology needed to fish around FADs safely and effectively. They will build the capacity of national fisheries administrations and coastal communities to prepare for and respond to climate-related natural disasters, and support fishers and communities to access local markets and add value to catches. Sustainable financing and supporting policy considerations associated with this Component are addressed in separate reports.

Component B[8] addresses the need to manage the risks to national economies, and the vulnerable populations who depend on public spending, associated with shifting tuna populations by providing reliable information on the extent and timing of climate-driven redistribution of tuna. This will be achieved through the development of an 'advance warning system' (AWS) for tuna-dependent economies to predict nearer-term changes in the distribution of tuna across the tropical Pacific Ocean, including robust forecasts in 1−10-year timeframes, in addition to longer-term projections in the 30−50-year range.

Development of the AWS centres around a new paradigm for reducing uncertainty in assessing the likely effects of ocean warming on tuna by integrating climate impacts into models of tuna populations (stocks) used to understand the impact of fishing on stock dynamics (ie; for the first time assess the combined impacts of fishing and climate change). By scaling to spatial resolutions of 1 degree or higher and applying a full ensemble approach the AWS will allow Pacific Island

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[6] Bell, J.D., Senina, I., Adams, T., Aumont, O., Calmettes, B., Clark, S., Dessert, M., Gehlen, M., Gorgues, T., Hampton, J. and Hanich, Q. 2021. Pathways to sustaining tuna-dependent Pacific Island economies during climate change. *Nature sustainability*, *4*(10), pp.900-910.

[7] Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change.

[8] Adaptations to reduce risks to Pacific Island economies from climate-driven tuna redistribution.

Countries (PICs) participating in the program to identify adaptations that capitalise on any projected changes in abundance of tuna in their waters with greater confidence.

The Pacific Community (SPC), which is the science provider to the Western and Central Pacific Fisheries Commission (WCPFC), is best suited to be the main implementing agency of the AWS as it currently has the research infrastructure, technical capability and access to confidential fisheries information necessary for development of the AWS. SPC will need to further develop its scientific capability to support improved climate modelling and predictions, drawing from a range of inter-related initiatives that will include:

(i) Collection of tissue samples from tuna across the Western and Central Pacific Ocean (WCPO) and Eastern Pacific Ocean (EPO), in collaboration with industrial fishing companies, for use in genetic population analyses to benchmark the population size and connectivity of all skipjack, yellowfin, bigeye and albacore populations of tuna in the Pacific Ocean tuna;

(ii) Analysis of genetic samples to produce resource maps showing the number and distribution of all stocks comprising each species of tuna within their range in the tropical and subtropical Pacific Ocean;

(iii) Tuna tagging programmes to verify the distribution, size and behaviour of all identified tuna stocks (in collaboration with the Inter-American Tropical Tuna Commission, IATTC);

(iv) Launching the AWS by integrating the projected effects of climate change on each tuna stock to produce robust assessments of the recommended sustainable catch from the WCPO expected to be caught in the Exclusive Economic Zones (EEZs) of Pacific Island countries, and in high seas areas, on a regular basis in the decades ahead; and

(v) Collaborations with industrial fishing companies operating in the WCPO to collect data on sea surface temperatures and ocean current velocities to inform and validate global climate models. Acoustic data will also need to be collected to assess responses of tuna prey to climate change to improve models predicting the responses of tuna species to ocean warming. These collaborations will identify appropriate protocols for use of these data.

The AWS will also need participation by the Pacific Islands Forum Fisheries Agency (FFA) to build fleet dynamics models that project future fishing effort to conduct improved economic impact analysis based on the climate model's projections of tuna movements and availability in the EEZ of the PICs and the high seas. This information will support PICs in negotiating tuna management measures both regionally and internationally, with the goal of retaining income in line with historical catches of tuna taken in their waters.

This analysis describes the institutional framework and capacity to support the AWS beyond the lifetime of the GCF-funded program as well as the current policy framework and future needs that will support its implementation. The financial and capacity needs that are required after the initial 7 years to ensure the financial sustainability of the program are assessed. Recommendations relating to candidate finance mechanisms and arrangements to support the program financially into the future are included.

A full description of the institutions and the arrangements between them relevant to the AWS is included in Appendix 1.

2. Analysis of the WCPFC climate resolution and AWS

2.1 Background to the WCPFC climate Resolution

The WCPFC 2019 Resolution[9] on climate change (see Appendix 2; hereafter Resolution 2019-01) is the first declaration of its kind to address the inter-related issues of climate change and WCPO fisheries. It is one of the few agreed to date by RFMOs.[10]

The WCPFC Resolution was prompted by a delegation proposal from the FFA members to the regular WCPFC session in December 2019. The FFA's paper brought to the Commission's attention a Pacific Islands Forum Leaders' declaration from August 2019 declaring the need for urgent climate action.[11] The issues put forward by FFA members are all broadly reflected in the five points of the WCPFC Resolution, although it did not become a binding Conservation and Management Measure (CMM). FFA's proposal to reduce the carbon footprint of fishing activities was worded in diplomatically acceptable terms in the final WCPFC Resolution (point 4).

2.2 Analysis of the AWS in implementing the WCPFC climate resolution

The WCPFC climate change Resolution has not, to date, been implemented through a clear action plan. However, at the 2022 WCPFC meeting it was agreed that annual updates on the climate Resolution will be a standing item on the Commission's agenda. It will also be considered in the meetings of WCPFC subsidiary bodies. The AWS will support the practical application of Resolution 2019-01, as set out below:

Resolution point 1:

Consider the potential impacts of climate change on highly migratory fish stocks in the Convention Area and any related impacts on the economies of CCMs and food security and livelihoods of their people, in particular Small Islands Developing States and Participating Territories.

The AWS will provide an important platform to contribute to on-going initiatives to understand the short- and medium-term impacts of climate change on Pacific tuna stocks. Together with the economic modelling conducted by the FFA, this will support PICs to optimise the benefits associated with the use of those resources that are not compromised as a consequence of re-distribution of tuna biomass. The AWS will support PICs in the negotiations in WCPFC for the allocation of fishing rights on the high seas areas and via other relevant international fora such as UNFSA and UNFCCC, as required.

The capacity building component of the AWS programme will promote regional solidarity and enhance negotiating skills to secure long-term benefits from the contribution of tuna to their national economies that are not less than historical contributions.

The AWS will also guide other adaptations relevant to SIDS livelihoods and food security. For example, adaptations to capitalise on any opportunities arising from redistribution of tuna into the EEZs of subtropical PICs. Opportunities may include investments in infrastructure to ensure

[9] WCPFC climate resolution

[10] At its annual session in 2022, ICCAT adopted the ''Resolution by ICCAT on Climate Change'' and at its 101st Meeting in August 2023, IATTC adopted a climate resolution (C-23-10).

[11] Kainaki II Declaration 2019.

food security and distribution of bycatch from industrial operations in an efficient manner as per other parts of this proposal (see Technical Study 5 relating to transhipment by-catch study).[12]

Resolution point 2:

Support further development of science on the relationship between climate change and target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks, as well as interrelationships with other factors that affect these stocks and species and estimates of the associated uncertainties.

SPC as the science services provider to WCPFC and the principal partner in the AWS initiative, will be the primary source of information and advice for this component of the Resolution through current and improved ocean modelling and tuna stock assessment activities. SPC's science work has supported the development of the SEAPODYM model to assess the ocean-basin-scale effects of climate change on the distribution and abundance of tuna. The proposed additional inputs for this model within the AWS include protocols to transition current fisheries and ocean monitoring activities to include approaches that facilitate assessment at the EEZ and higher resolution (e.g. molecular approaches) to verify the absolute abundance and connectivity of stocks and stock assessment models that can be used to develop indicators for climate-driven redistribution of tuna. The existing modelling expertise, and additional data to be collected, lay a firm foundation for building an AWS based on information that is robust for applying improved versions of the SEAPODYM model to each stock at finer spatial resolution for projection and forecasting purposes. The data collection and models produced by SEAPODYM will also feed into international climate models and improve the accuracy of global efforts related to understanding climate-induced impacts on fish stocks and their ocean ecosystems.

Resolution point 3:

Take into account in its deliberations, including in the development of conservation and management measures, scientific information available from the Scientific Committee on the potential impacts of climate change on target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks.

The AWS contributes to this point of Resolution 2019-01 by strengthening the scientific information and modelling that will be available to the WCPFC Scientific Committee to advise the Commission on the impacts of climate change of the WCPO ecosystem.

Resolution point 4:

Consider how climate change and fishing activities may be related and address any potential impacts in a manner consistent with the Convention.

The improved ability to monitor and respond to changes in the distribution of tuna at the regional level with information from the AWS will enable countries to plan to secure the essential economic benefits they receive from the region's most valuable natural resource. The forecasts and projections that will be available through the AWS will also assist PICs and other WCPFC members to develop more efficient fishing operations and, in so doing, minimise greenhouse gas emissions.

Resolution point 5:

[12] SPC 2023, *SPC fame technical studies*. Accessed November 2023. https://fame.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

Consider options to reduce the environmental impacts of the Commission related to headquarters operation and meetings of the Commission and its subsidiary bodies.

This is not relevant to the AWS, but rather to standard operating practices of the Commission and the subsidiary bodies.

3. Supporting policies required for the AWS

The AWS will become an important tool for the region to support the development of adaptive fisheries management policies and approaches. However, there are some supporting frameworks and policies that should be further analysed and, if necessary, strengthened to ensure effective and collaborative operation of the AWS.

3.1 Collaboration between the WCPFC and IATTC

The WCPFC and IATTC are two overlapping management bodies that effectively share the management of the same large-scale ecosystem. There is already an official overlap area, which the Commissions jointly manage. In addition, there is an MOU of collaboration that covers other aspects of both Commissions' work, such as joint research activities, data sharing, proactive information sharing about their respective work and collaboration on management measures.[13] For the purposes of the AWS and collection of oceanographic, tagging and genetic samples, this MOU already covers these needs and no further policies are needed at this time.

For the purposes of adaptive regional management within the WCPFC and IATTC and retaining the economic benefits of tuna for the PICs as the fish redistribute eastwards (including redistribution into the high seas of the IATTC jurisdiction), more comprehensive collaboration and policy reforms may be needed (refer to Study 8).[14]

3.2 Supporting policies for data collection

The WCPFC climate Resolution already mandates that the membership of WCPFC support scientific data collection and other efforts to achieve increased and more accurate scientific understanding of climate change impacts on the sustainability and management of tuna stocks. As the AWS data collection will require long-term collaboration with industrial tuna fishing fleets for the collection of oceanographic and acoustic data and tuna tissue samples, it may be necessary to arrange for more specific obligations under the climate Resolution that require fleets to collaborate adequately. Oceanographic data collected from industrial tuna vessels can also be used to reduce their energy consumption and carbon footprint by 25%.[15] Mandating vessel instrumentation and application in data collection obligations would also contribute to meeting Resolution 2019-01 point 4 on mitigation.

Obligations for data collection can also be mandated under national licensing and through the organisations that oversee and/or negotiate sub-regional access arrangements. Historically, this has also been an influential pathway for WCPFC CMM adoption. A number of important WCPFC CMMs have been based on arrangements implemented by the PNA for their collective EEZs as part of their licensing requirements, before they were adopted by the WCPFC for all fleets operating throughout the Convention Area.

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[13] WCPFC – IATTC MOU

[14] SPC 2023, *SPC fame technical studies*. Accessed November 2023. https://fame.spc.int/technical-studies-support-funding-proposal-green-climate-fund-regional-tuna-programme

[15] SusTunTech 2023. *Sustainable tuna fisheries through earth observation technologies*, Accessed June 2023. https://www.sustuntech.eu/

The WCPFC manages a Regional Observer Programme (ROP)[16] and the PICs National Observer Programs contribute to this. WCPFC CMM's currently required 100% observer coverage on purse seine vessels operating in the WCPFC and a minimum of 5% for longline vessels. Data collection needs for the AWS are not currently specified in the "minimum data fields" of the ROP. An assessment should be undertaken to access whether additional data fields and/or activities need to be mandated under the ROP to support the AWS.

3.3. National level supporting policies

National consultations conducted in support of this Study (February-April 2023) did not identify any major requirements in terms of supporting policies needed to operationalise the AWS in the region. Issues raised mainly concerned governance arrangements between SPC and the RTP member countries, as well as the preferred balance of activities between gaining new knowledge, projections (>15 years), forecasting (<10 years) and capacity building for enhanced negotiating power. An agreed governance arrangement will need to be developed to ensure the AWS meets the expectations of the GCF project member countries as their priorities change over time.

There is also the need to socialise the modelling results at all levels of national administrations to ensure they are properly understood and utilised. The contribution of FFA to the economic aspect of the modelling is considered to be essential, given the significance of the economic impacts predicted, and the PICs need for informed financial forecasting.

Although not a supporting policy as such, the long-term success of the AWS in the region will also require capacity building and integration into national data collection activities. There are already many national level initiatives that can assist the long-term data needs of the AWS and vice versa. Some of the relevant points bought up at the consultations in regard to harnessing opportunities to build national capacity to contribute to the AWS were:[17]

(i) Foster collaboration between local research institutions and AWS developers;
(ii) Capacity building for staff and fishers on the AWS;
(iii) Short-term accredited courses (stock assessment, harvest strategy, climate change and resilience, biological sampling/genetic sampling, fish economic workshops);
(iv) Training of fisheries data collection staff and national observers in the collection of data that goes into the AWS;
(v) Assist in the review of current oceanic fisheries structure to accommodate national implementation of project activities;
(vi) Assist in data gap analysis for oceanic fisheries;
(vii) Inconsistent data monitoring (artisanal)
(viii) Strengthening existing data system
(ix) Weather buoy tracking
(x) E-reporting (ER)

4. Analysis of institutional roles and capacities

4.1 SPC and capacity needs

The largest long-term capacity needs in maintaining the AWS into the future lies with the SPC as the scientific services provider for the 14 participating countries as well as the WCPFC. The

[16] WCPFC Regional Observer Programme
[17] The below list is a direct copy paste from the summary consultation notes.

responsibility to maintain the AWS system beyond the GCF project period is expected to remain with SPC while it fulfils the role of scientific services provider.

The implementation of Component B of the RFP will develop additional data collection, analysis, and modelling capability as well as capacity to interpret results and develop practical management advice and predictions. These increased responsibilities bring with them increased demand for management and administrative oversight. In addition, there will be a need for further outreach and communication to effectively communicate the results of the AWS with project partners and PICs.

The long-term roles that will need to be maintained beyond the lifetime of the GCF project are a priority and are identified in the budget post project funding (Table 1). These include additional analytical capacity for specimen sampling, data collection and analysis.

4.2 FFA and capacity needs

FFA has recently added in-house climate change expertise to its permanent fisheries advisory and policy outreach roles supporting the August 2023 adoption of their Climate Change Strategy. These roles will provide national-level advice and capacity building for the PICs as well as using the results of the AWS in international fora, such as the UNFCCC. These roles are currently funded through the regular financing channels of the FFA with additional support falling under the GCF at the start of the programme.[18]

FFA will require additional fisheries advisory and climate policy outreach capacity within its existing economic analysis team to conduct the necessary economic modelling to support implementation of the AWS. Any additional short-term needs arising from the AWS could be outsourced to contractors on an as-need basis.

4.3 PNA Office and capacity needs

No additional staff needs are identified for the PNA Office (PNAO) and their role in providing regular fisheries management advice can simply take information from the AWS into consideration during decision making. The FFA will additionally be providing economic advice that will cover the interests and needs of the PNA membership. It is envisaged that any ad hoc needs by PNA and its membership that may arise from the AWS can be outsourced to contractors on an as-need basis. .[19]

4.4 IATTC and capacity needs

Unlike the WCPFC, which has outsourced its scientific tasks for the SPC, the IATTC has an in-house science unit. The scientific work of the IATTC is funded through its member contributions, as per Resolution C-15-05. Their main collaborative components that are aligned with the AWS are their tuna-tagging program and their Regional Observer Programme. These tagging cruises are not fully funded through the core funding of the IATTC, requiring additional grants to cover costs. At present, 30% of the tuna tagging budget of the IATTC is covered by the annual membership contributions. To cover the entire budget of the tagging programme, 70% of the funds come from programme specific funding (currently provider through a grant from the EU). Although there are regular staff who manage and execute the tagging, the tag return collection, data management

[18] As per discussions with Chris Reed and Simon Nicol during consultations

This matter has yet to be discussed in detail with the PNAO.[20] The Pacific Forum Fisheries Agency (2022). Economic and development indicators and statistics: Tuna fisheries if the Western and Central Pacific Ocean 2022.

and some of the analysis, the additional grant budget includes funds for a quantitative modeller. According to the IATTC, these budgets will also be available in the future given the importance of the tagging programme for the scientific work of the Commission.

The same observer coverage requirements are mandated for the IATTC Regional Observer Programme as those for the WCPFC ROP. Similarly to WCPFC, although IATTC observers routinely collect specimen samples and oceanographic information while undertaking their duties these tasks are not mandated as a minimum data requirement.

Ongoing tuna tagging, data sharing and analysis from the Eastern Pacific Ocean will be required for the AWS. However, there are no additional needs for the IATTC over and above its core operations and funding (including existing grant requirements for the tagging cruises). It is also estimated that the IATTC's long-term capacity needs will remain approximately the same despite the development of the AWS.

Other areas of scientific collaboration between WCPFC and IATTC based on AWS-related activities include joint assessments for stocks such as South Pacific albacore and biological investigations, particularly in relation to bigeye and yellowfin tuna.

4.5 The WCPFC and capacity needs

The scientific advisory role of the WCPFC is performed by its Scientific Committee with SPC serving as its scientific services provider. WCPFC provides its Scientific Committee with an annual budget to support data collection and curation, stock assessment and tuna-related research and analytics. These activities will support the AWS. Depending on the ultimate design and execution of the AWS, the WCPFC may need to support policy work around the industrial vessel sampling protocols and associated industry liaison. The responsibilities for this could be assigned to the WCPFC Secretariat (coordination, legal etc.) and are not envisaged to necessitate additional resources to support the AWS.

5. Financial analysis and needs

The full financial analysis, including the draft budget for the 7-year RTP, supported program, external contributions from the regular donors to the various agencies to the AWS as well as the post-RTP budget including the predicted funding gap post RTP investment (= total budget – expected external support) is provided as Appendix A.

Due to the many ongoing funded supportive roles by the regional agencies that will contribute to the AWS activities (explained in Chapter 4), the long-term funding gap beyond the RTP is not expected to be large. At current exchange rates, the funding gap for the first year following the RTP is expected to be USD925,000, increasing to USD1,041,000 by year 5 after the program (Table 1) and USD1,207,000 for year 10.

The largest annual financial needs will lie with the FFA Secretariat's climate-related staff costs that will be around USD580,000 in the first year after the RTP. Staff costs for SPC will be USD295,000 in the first year, with an additional USD50,000 in staff time needed per year for the tagging programme (Table 1).

Table 1: Annual funding gap to continue to develop and operate the AWS following the RTP, based on current projections and an estimated 3% annual increase in costs.

Budget item	Year 7 GCF	Year 7 external	Funding gap at the end of RTPme	Funding need year 2 post GCF	Funding need Year 3 post GCF	Funding need Year 4 post GCF	Funding need year 5 post GCF
SPC staff costs							
SEAPODYM modelling[5]	700,000	215,000	235,000	242,050	249,312	256,791	264,495
Management /model launch[6]			-	-	-	-	-
Oceanographic data collection (WCPO/EPO)[3]	200,000		-	-	-	-	-
Pacific Tuna Tagging Programme staff cost (WCPFC)[2]		450,000	50,000	51,500	53,045	54,636	56,275
Tuna tissue sampling (Pacific Marine Specimen Bank)[1]	275,000	380,000	30,000	30,900	31,827	32,782	33,765
Genetic and connectivity analysis[4]	1,100,00 0	380,000	30,000	30,900	31,827	32,782	33,765
FFA staff costs							
FFA economic analysis	190,000		190,000	195,700	201,571	207,618	213,847
FFA International negotiations (IATTC/UNFCCC)	200,000		200,000	206,000	212,180	218,545	225,102
FFA Fisheries management advice integration	190,000		190,000	195,700	201,571	207,618	213,847
Activities and assets							

Pacific Tuna Tagging Programme (WCPFC)		950,000	-	-	-	-	-
Pacific Marine Specimen Bank (WCPFC)		340,000	-	-	-	-	-
Tuna Tagging Programme (IATTC)		1,330,737	-	-	-	-	-
Total:	**2,855,000**	**4,045,737**	**925,000**	**952,750**	**981,333**	**1,010,772**	**1,041,096**

1=SPC programme resources supporting PMSB staff (supervisor and technician)
2=SPC programme and other project resources (supporting supervising scientist, data manager & technician)
3=likely PCCOS external contribution (but $ amount to be determined)
4=SPC programme support for molecular scientist and technician
5=SPC programme support for 1 modeller
6=WCPFC and SPC support for MSE team

6. Recommendations for finance mechanisms and policies to support the AWS and relevant technology

The long-term maintenance costs of the AWS after the initial 7-year period are not large overall, at approximately USD925,000 annually. The current annual value of tuna fisheries to the region is 5 billion USD.[20] The predicted cost of the AWS is just 0.01-0.02% annually of this value at current rates and therefore there is a strong case to be made for the region's administrations (including WCPFC) being able to cover this cost as part of their annual budgets. This is especially true as the AWS will try to understand the scale and speed of the climate threat to the economic value of the fishery. There is good justification for the Fisheries and Finance Ministries of the PICs, as well as the national/international fishing industry, to invest in R&D as part of their annual budgets that supports AWS. As a comparison, large enterprises annually spend at least 3% of their income on R&D.

Options for funding this include adding the additional roles and resources to the standard operating budgets (donors of SPC and FFA) or existing co-financing arrangements, or incorporating them within the cost recovery mechanism and budgets of the RMFOs themselves.

Resolution 2019-01 provides a good basis for the additional costs arising from the AWS to be included in the Commission's operational budget supported by the WCPFC membership through annual contributions. The case for this payment model is especially strong given that the AWS will also generate benefits for the industrial fishing sector by providing information that industry can use to make long-term investment and operational decisions.

There is evidence from other regions suggesting that improved use of scientific instrumentation and forecasting will allow for fuel cost savings of up to 25%.[21] It is important that these benefits are quantified and conveyed as justification for long-term financial and data provision support from industry during the RTP. FFA and SPC can include the range of likely benefits for the industry and assess industry's capacity to contribute to the AWS, under the different climate scenarios, through their collective bioeconomic modelling work for the duraction of the RTP. The funding could be done indirectly, through the Commission, or directly with industry through a cost recovery mechanism (see recommendations for more details).

Similarly, for the IATTC the justification for member support for critical scientific advice that impacts the short, medium and long-term investment and operations landscape provides strong justification for financial support from IATTC to the AWS, particularly as climate impacts and predictions for the IATTC/WCPFC overlap area will be included in AWS assessments.

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[20] The Pacific Forum Fisheries Agency (2022). Economic and development indicators and statistics: Tuna fisheries if the Western and Central Pacific Ocean 2022.

[21] SusTunTech 2023. *Sustainable tuna fisheries through earth observation technologies*, Accessed June 2023. https://www.sustuntech.eu/

A summary of additional long-term finance possibilities for the AWS is presented below. These funding mechanisms might provide additional financial support for Component B of the RTP, especially if unforeseen circumstances impact regular grant and donor-based funding sources or the cost recovery and other existing finance mechanisms as outlined above do not materialise.

6.1. Potential innovative finance mechanisms

In addition to cost recovery options and other traditional bilateral and multilateral funding[22] there are a number of new innovative finance mechanisms being developed that can support ocean-related climate adaptation and mitigation. These usually involve the private sector and new methods of gauging the assessment of climate impacts and/or offsets.

Given the cost recovery mechanisms are most likely to deliver immediate finance at the end of year 7 (or earlier) these should be prioritised during the RTP. Other potential finance mechanisms assessed are included in Appendix E. The finance mechanisms described in Appendix E are long-term aspirational and innovative mechanisms that, in most cases, are being developed ‘’outside of the AWS immediate needs” that do not directly relate to but offer potential for synergies. Data generated by the AWS will be valuable in developing some of these finance mechanisms.

6.2 Loss and damage

There is increasing international recognition that the current ambitions for climate adaptation and mitigation may not be effective for managing the consequences of climate change and that developing countries, in particular may suffer huge damage and losses due to increased climate impacts. The Warsaw International Mechanism for Loss and Damage associated with climate change impacts (WIM) was established at the COP19 in 2013. The Paris Agreement further underlined the importance of this issue. All Parties are requested to develop and implement concrete and effective climate risk management instruments and measures to avert, minimise, or – when the limits of adaptation are reached – effectively address residual loss and damage caused by climate-related extreme events and slow onset changes. The loss and damage discussions under the UNFCCC have been somewhat controversial and became the main focus of the negotiations at the COP27 in 2022 in Egypt, where developed nations pledged an additional USD 230 million for the adaptation fund, although this is still seen as widely insufficient.[23]

Given the already severe impacts of climate change being felt in the Pacific region, PICs and SIDSs

[22] There are a number of global initiatives which are dedicated to ocean including the World Bank Problue, and The ADB Ocean health programme[22] which are important donors for fisheries management in the region.

[23] United Nations Climate Change 2022, COP27 reaches breakthrough on new loss and damage fund for vulnerable countries. Accessed June 2023. https://unfccc.int/news/cop27-reaches-breakthrough-agreement-on-new-loss-and-damage-fund-for-vulnerable-countries.

in general are likely to be leading many of the negotiations on loss and damage and compensation processes to do with slow onset events and extreme weather events. Loss and damage to Pacific tuna and reef fisheries is likely to fall into the category of slow onset events, unless marine heat waves or other extreme events cause large, widespread and sudden damage. According to the UNFCCC loss and damage guidelines[24] there is a need for Parties to pursue ocean and fisheries-based mitigation and adaptation strategies as a first step, as the loss and damage fund is for unavoidable damage.

Should the WCPFC/IATTC negotiation pathway fail in agreeing to share the tuna resources in a way that does not disadvantage the PICs, or be too slow to implement, then the loss and damage option becomes a reality for tuna fisheries compensation, and the AWS can play a key role in quantifying the scale, speed and severity of the loss and damage. There is of course nothing stopping the region from pursuing these strategies in parallel and using the loss and damage pathway as leverage to drive progress in the RFMO negotiations. Funding for the AWS could be sought to support loss and damage negotiations given the key role it will play in quantifying the loss and damage suffered, however given the likely speed of these negotiations it should not be relied upon as a primary source of funding for the AWS.

Given the PICs are already very active in the UNFCCC loss and damage discussions, this finance avenue does not require extra capacity, the negotiators simply need to be informed of the AWS, its role, importance and cost considerations. The timelines with this finance are however unpredictable and as such it should not be depended upon as a sole source of finance for the AWS.

7. Next steps to realise the long-term financial and policy sustainability of the AWS

Based on the likelihood of success and ease of implementation it is recommended that industry contributions and cost recovery options are explored in the first instance as sources of long-term finance for the AWS (see Table 2). The basic steps needed to explore industry contribution and cost recovery options under the GCF grant are outlined below.

- ***Ensure the finance ministries of the PICs are investing part of their annual fishery related income to R&D activities that contribute to the AWS.*** This will help provide a long-term financing basis for AWS activities.
- ***Explore the willingness of the fishing industry to provide sampling support for the AWS***. If it is difficult to obtain necessary scale through voluntary participation, explore the opportunity to introduce a CMM at the WCPFC under Resolution 2019-01 that mandates vessel owners to contribute to the AWS to gain better understanding of climate impacts on the WCPO tuna stocks.

[24] United Nations Climate Change 2018, *Annual Report*, Accessed june 2023. https://unfccc.int/sites/default/files/resource/UN-Climate-Change-Annual-Report-2018.pdf

- Alternatively, or in addition to the above, ***explore the possibility of the PNA including sampling support to the AWS as a requirement under the vessel licensing conditions of the VDS***.
- As the AWS is implemented and the total number of vessels, different data collection instruments and other parameters are defined and operationalised, it will become possible to measure fuel efficiency and other benefits to industry in detail. For example, improved Internet connection will support the distribution of AWS outputs to assist more efficient fishing operations by more accurate and timely forecasting of tuna movements which can improve fishing efficiency. Once these benefits have been quantified, it will be possible to ***conduct a detailed cost benefit analysis and based on that propose a long-term industry contribution model***.
- Once the details of the onboard instrumentation, data collection tasks and time requirements are more defined, it will be possible to ***properly evaluate the role of fishery observers in the AWS related data collection***. Depending on their ability to contribute, and the extent of the tasks, there may be relevant policy changes to the existing observer regulations and protocols to enable them to collect the required information.
- Depending on the feasibility and successful implementation of the industry (and observer program) support model, or in parallel, explore the cost recovery options of the WCPFC to maintain the AWS. Once the program is designed and the cost benefit thoroughly assessed, the role of the Commission in providing on-going support for the AWS should be considered. The functions of the AWS to support WCPFC Resolution 2019-01 and its implementation should be considered as core business of the WCPFC and be covered by the long-term contributions from its Members.
- Once the cost benefit analyses are clearer, ***relevant fishing industry bodies can also be approached for cost share contributions to AWS related costs***, given they also receive direct benefit. As an alternative to fees through PNA licensing conditions (see above), the national purse seine associations of the fishing nations could be approached for cost recovery payments based agreements and contributions.

Other more innovative finance options that can also be explored simultaneously. Such possibilities are summarised below (more detail in Appendix E).

1) ***Parametric climate insurance:*** National FAD programs and other small-scale fishery operations impacted by climate change in the region can potentially to benefit from parametric climate insurance. To promote this, an insurance broker is required to undertake a feasibility assessment and design exercise. There are on-going projects in the region in parametric insurance design for

small-scale fisheries already where some lessons can be learned and replicated.[25] [26] If the data requirements for insurance can utilise data from the AWS, there is potential that some of the long-term costs of the AWS can be included in the insurance financial model.

2) ***Blue economy and impact investment***: As climate adaptation and mitigation actions in the region intensify and finance is sought for new or renovated infrastructure and other assets, the potential for incorporating AWS-related components in these new investments should be explored. Depending on the objectives of the instruments there may also be scope for the AWS to provide monitoring data that supports the impact evaluation of these investments.

3) ***Debt instruments and debt swaps:*** As debt instruments and debt swaps are explored in the Pacific, either nationally or as part of regional initiatives, there is a possibility that area, ecosystem and/or species-based conservation outcomes may be required as a pre-condition for funding support. These are often geared towards meeting SDG, Paris Agreement and general sustainability and climate related objectives. AWS-derived outcomes can be applied to monitor the impacts of such agreements and provide data for both the development and maintenance of these instruments.

4) ***Loss and damage:*** The AWS will provide critical data to support the negotiation process through various fora (WCPFC, UNFCCC, IATTC and related regional and international forums) for equitable outcomes for PICs to secure the income from tuna based on historical catches in their EEZs. The AWS has the potential to play a key role in quantifying the scale, speed and severity of the loss and damage. As part of the loss and damage process adequate funding to support the AWS should be negotiated given the key role of AWS-derived data and modelling in quantifying the spatial and temporal loss and damage.

A rapid assessment of the policy support options as well as the two main financial approaches that are most likely to succeed in the PIC context given the limited implementation window of the RTP 1) industry support, 2) cost recovery finance mechanisms available to cover the AWS long-term finance needs are presented in Table 2. In addition, a table assessing the ease of implementation of the innovative finance mechanisms introduced above in in Appendix D. These mechanisms should be pursued parallel to the other more likely cost recovery mechanisms and not relied upon alone. They are subjectively ranked from easy to difficult according to ease of implementation and likelihood of success. It is anticipated that a ranking of ‘’easy’’ could be implemented within a year or two, ‘’moderate’’ 2+ years and ‘’difficult’’ 3+ years of design and

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[25] WWF Pacific 2021. Safeguarding Melanesian fishing communities against climate threats. Accessed June 2023. https://www.wwfpacific.org/?369375/Safeguarding-Melanesian-fishing-communities-against-Climate-threats

[26] WWF Pacific 2021. Safeguarding Melanesian fishing communities against climate threats. Accessed June 2023. https://www.wwfpacific.org/?369375/Safeguarding-Melanesian-fishing-communities-against-Climate-threats

negotiations. Other criteria used are additional expertise required (low, moderate, and high levels) and the level of innovation/risk (low, moderate and high levels).

In addition, other mechanisms that could also be explored include national sovereign wealth funds and trust funds such as the Niue New Ocean Commitment Trust Fund.[27] However, given the amount of funding support required is relatively modest, these alternative sources would only need to be explored if all other efforts were unsuccessful.

Table 2: Ranking on the ease of implementation of the supporting policy and finance mechanisms.

Intervention	**Ease of implementation**		
Supporting Policy	**Likely time line**	**Additional expertise required**	**Innovation/risk**
WCPFC CMM requiring industry sampling support for AWS	**moderate**	**low**	**low**
PNA licensing requirement for industry sampling support	**easy**	**low**	**low**
WCPFC and IATTC collaboration on scientific data collection and sharing	**easy**	**low**	**low**
WCPFC ROP to support AWS sampling efforts	**easy**	**low**	**low**
Long-term integration of AWS activities to PIC national science and innovation initiatives	**moderate**	**moderate**	**low**
Finance mechanism			
National R&D budgets	**easy**	**Low**	**low**
Cost recovery through WCPFC/IATCC membership fees	**moderate**	**low**	**low**
Cost recovery through direct	**easy**	**low**	**low**

27 See study 9: Part 1. FAD report.

industry financial contributions			
UNFCCC loss and damage payments	**difficult**	**High**	**moderate**

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Appendix A. Institutional arrangements to support the AWS

The WCPFC

The WCPFC is the responsible fisheries management and conservation body for highly migratory fish stocks in the West and Central Pacific Ocean (WCPO). It was established by the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention), which entered into force on 19 June 2004.

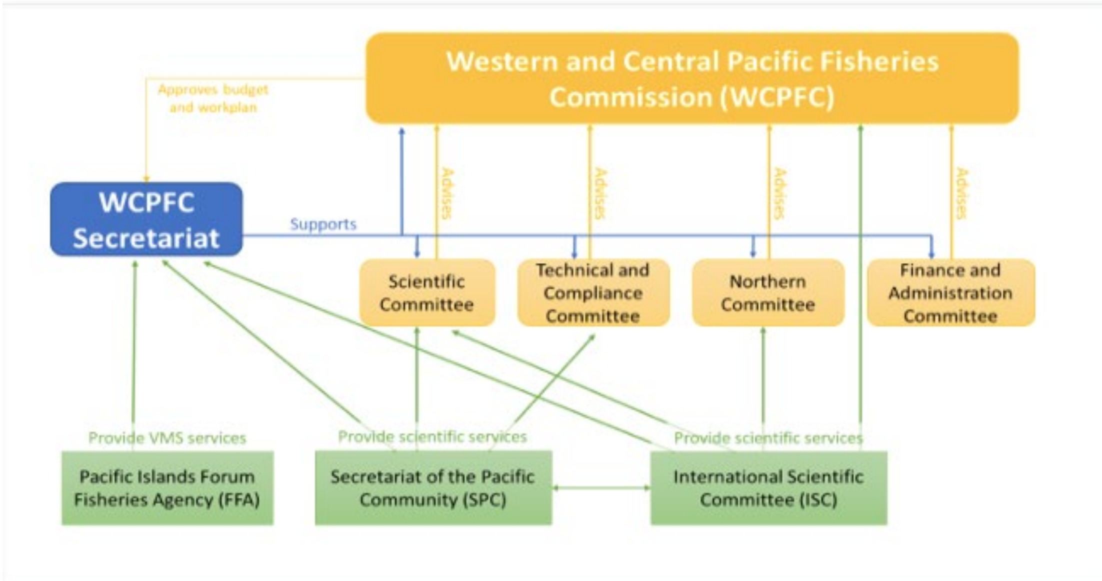
The WCPF Convention draws on many of the provisions of the UN Fish Stocks Agreement (UNFSA) while, at the same time, reflecting the unique political, socio-economic, cultural, geographical and environmental characteristics of the WCPO region. The Convention incorporates social as well as fisheries management objectives. In particular, it recognises the ecological and geographical vulnerability of the many Small Island Developing States (SIDS) within the Convention Area, the economic and social dependence they have on migratory fish stocks, as well as their need for special scientific, and technological assistance.[28]

The WCPFC Convention Area differs from other RFMOs in that much of the tuna under its jurisdiction migrates across the EEZs of the PICs. Particularly prominent among the management principles of the Convention is the principle of compatibility, which provides that the decisions of the Commission for the high seas and the measures adopted by Coastal States for areas under national jurisdiction shall be compatible in order to ensure conservation and management of highly migratory stocks in their entirety.[29]

The Commission supports three technical subsidiary bodies, the Scientific Committee, the Technical and Compliance Committee and the the Northern Committee, which each meet annually. The subsidiary body meetings are followed by a full session of the Commission in December each year. The work of the Commission is assisted by a Finance and Administration Committee[30] and numerous ad hoc working groups convened to address specific technical issues before the Commission. The Scientific Committee requires ocean modelling and stock assessments and the AWS will contribute to its work through SPC as further explained below.

The below diagram illustrates the relationship between the Commission, its subsidiary bodies, its Secretariat and three other regional institutions, of which two, the Pacific Community (SPC) and the Pacific Islands Forum Fisheries Agency (FFA), are key partners in the proposed AWS.

[28] WCPFC institutional review
[29] WCPFC instiutional review
[30] WCPFC



(Image from WCPFC 2022)

The Pacific Islands Forum Fisheries Agency

While the WCPFC is tasked with the management of the high seas in the Convention Area there are other bodies that coordinate the PICs management approaches and ensure the compatibility requirement of Article 5 of the Convention is met. The FFA was established in 1979 with the mission to facilitate regional cooperation so that all Pacific countries benefit from the sustainable use of tuna. The FFA supports its member countries to sustainably manage the fishery resources that fall within their 200-nautical mile EEZs. The FFA is an advisory body providing expertise, technical assistance and other support to its members who make sovereign decisions about their tuna resources and participate in regional decision-making on tuna management through agencies such as the WCPFC. The capacities of the FFA also include fisheries management, fisheries development and economic analysis and sustainable investment advice to its members as well as the provision of climate advice and support to its members engaged in international negotiations.[31] Compliance monitoring and support for the engagement of FFA members in WCPFC are important components of FFA's work programme.

The Pacific Community

The Pacific Community (SPC) is an international development organisation that operates regionally with 22 member countries and territories. SPC's vision for the region is a secure and prosperous Pacific Community whose people are educated and healthy and manage their resources in a sustainable way. The SPC Oceanic Fisheries Program (OFP) was established in 1980 and is the regional centre for tuna fisheries research, fishery monitoring, stock assessment and

[31] FFA interview 2023

data management. The OFP is the contracted Science Service and Data Management Provider to WCPFC.

The programme of work for SPC's Division of Fisheries, Aquaculture and Marine Ecosystems (FAME), under which the OFP operates, includes climate and marine ecosystems-related assessments, advice and capacity building.[32] This institutional framework will ensure that AWS-related activity is integrated to the broader programme of work of SPC and that AWS initiatives will be sustained within SPC beyond the life of the GCF project.

Parties to the Nauru Agreement

The Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest, or The Nauru Agreement, is an Oceania subregional agreement between FSM, Kiribati, RMI, Nauru, Palau, PNG, Solomon Islands and Tuvalu.

Historically, the Nauru Agreement and other joint fishery management arrangements made by the Parties to the Nauru Agreement (usually referred to as PNA) have been concerned mainly with the management of the tuna purse seine fishing in the tropical western Pacific.

The PNA Vessel Day Scheme (VDS) supplies 95% of tuna caught in the region.[33] The PNA membership overlaps with that of the FFA, and there is a high-level alignment between the management advice and approaches that maximises the economic benefits of the PNA members and helps meet the sustainability requirements of the WCPFC. Improved ocean modelling provided by the AWS will assist PNA in meeting its objective of sustained economic benefit from the sustainably managed tuna resources for its membership.

Other relevant parties and declarations

As seen from the above institutional arrangements, the AWS will be well institutionalised within SPC which sits within the WCPFC framework to support the long-term work of the Commission in sustainably and fairly managing the highly migratory fish stock in the high seas, and in support of the WCPFC climate resolution (see section 2). In addition, the AWS will build resilience to climate change by supporting the following important management frameworks, strategies and resolutions for the fisheries sector and the region more broadly:

- The Pacific Island Forum Leaders declarations and initiatives, including the recently adopted Blue Pacific Continent 2050 strategy[34] that includes actions associated with climate change and resilience as well as economic development and fisheries goals.
- The *Regional Roadmap for Sustainable Pacific Fisheries,*[35] designed *in 2015* to improve sustainability of tuna resources, add value to tuna catches, increase employment, and provide better access to tuna for food security, as well as building resilience of coastal

[32] SPC Oceanic Fisheries

[33] PNA

[34] 2050 strategy

[35] FFA roadmap

habitats (by progressively shifting fishing effort from coral reefs to tuna); the roadmap will be reviewed and renewed in the coming years.

- *A New Song for Coastal Fisheries – Pathways for Change*,[36] provides an innovative regional approach to maintain the benefits of small-scale fisheries in the face of declining coastal ecosystems and associated fish stocks.
- FFA Climate Strategy adopted by the Forum Fisheries Committee in August 2023.

In addition, the AWS will contribute towards the PICs implementation of their Nationally Determined Contributions (NDCs) under the Paris Agreement. Ten of the 14 participating countries in the RTP have included a need for support for adaptations to the effects of climate change on the ocean and coastal marine habitats in their NDCs.[37]

The Noumea Strategy

[37]Gallo, N., Victor, G. and Levin, L. 2017. Ocean Commitments under Paris Agreement. Nature Climate Change, 7.
https://www.researchgate.net/publication/320721251_Ocean_commitments_under_the_Paris_Agreement

Appendix B.: WCPFC Climate resolution

COMMISSION SIXTEENTH REGULAR SESSION
Port Moresby, Papua New Guinea
5 –11 December 2019

RESOLUTION ON CLIMATE CHANGE AS IT RELATES TO
THE WESTERN AND CENTRAL PACIFIC FISHERIES COMMISSION

Resolution 2019-01

The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean,

RECOGNISING international initiatives to address the impacts of climate change including through the United Nations Framework Convention on Climate Change; NOTING the work of the Intergovernmental Panel on Climate Change;

MINDFUL of the work of the Scientific Services Provider to the Commission in assessing the impacts of climate change on target stocks and non-target species, and species belonging to the same ecosystem or dependent or associated with the target stocks in the Convention Area;

NOTING that Pacific Islands Forum Leaders reaffirmed at their meeting in August 2019 that climate change is the single greatest threat to the livelihoods, security and wellbeing of the peoples of the Pacific and their commitment to progress the implementation of the Paris Agreement;

FURTHER NOTING the Kainaki II Declaration for Urgent Climate Change Action Now made by Pacific Islands Forum Leaders in August 2019;

NOTING the importance of addressing the potential impacts of climate change and other environmental degradation on target stocks, non-target species, and species belonging to the same ecosystem or dependent or associated with the target stocks in the Convention Area;

NOTING the objective of the Convention to ensure, through effective management, the long term conservation and sustainable use of highly migratory fish stocks in the Western and Central Pacific Ocean in accordance with the 1982 Convention and the 1995 United Nations Fish Stocks Agreement;

Resolves to:

1. Consider the potential impacts of climate change on highly migratory fish stocks in the Convention Area and any related impacts on the economies of CCMs and food security and livelihoods of their people, in particular Small Islands Developing States and Participating Territories.

2. Support further development of science on the relationship between climate change and target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks, as well as interrelationships with other factors that affect these stocks and species, and estimates of the associated uncertainties.

3. Take into account in its deliberations, including in the development of conservation and management measures, scientific information available from the Scientific Committee on the potential impacts of climate change on target stocks, non-target species, and species belonging to the same ecosystem or dependent on or associated with the target stocks.

4. Consider how climate change and fishing activities may be related and address any potential impacts in a manner consistent with the Convention.

5. Consider options to reduce the environmental impacts of the Commission related to headquarters operation and meetings of the Commission and its subsidiary

Appendix C. People consulted as part of this study

Name	Institution
Simon Nicol	SPC
Ludwig Kumorou	SPC
Chris Reid	FFA
Jale Samuwai	FFA
Daniel Fuller	IATTC
Alexander Aires-de-silva	IATTC
Camille Goodman	Wollongong University
Josean Fernandez	AZTI

Appendix D. Table assessing the ease of implementation of the different finance mechanisms

Intervention	Ease of implementation		
Finance mechanism	**Likely timeline**	**Additional expertise required**	**Innovation/risk**
National R&D budgets	**easy**	**Low**	**low**
Cost recovery through WCPFC/IATCC membership fees	**moderate**	**low**	**low**
Cost recovery through direct industry financial contributions	**easy**	**low**	**low**
Climate insurance as part of long-term finance model	**moderate**	**high**	**high**
Impact investment based finance mechanism	**moderate**	**high**	**moderate**
Innovative debt instruments as part of finance mechanism	**difficult**	**high**	**high**
UNFCCC Loss and damage payments	**difficult**	**High**	**moderate**

Appendix E. Innovative finance mechanisms assessed

Climate insurance mechanisms

There are various climate insurance products and approaches under development to meet the needs of increasing climate-related perils. As mentioned in the FAD finance mechanisms and supporting policies report, parametric insurance products are becoming popular for areas that are otherwise difficult to insure. This type of insurance provides for payments based on a set of pre-agreed, independently verified, metrics such as wind speed, rainfall, wave height and other weather-related phenomena. c. With appropriate policies in place, payments are triggered when a threshold pre-agreed metrics are met or exceeded' rather than needing evidence of damage. An example of this mechanism is the Caribbean Catastrophic Risk Insurance Facility funded by the World Bank, the EU and others donors as well as member countries fees, operating in the Caribbeans to insure governments against natural disasters. The availability of insurance is also used in debt-based transactions to reduce risks to private investors in addition to other risk reductions measures such as bank guarantees.

The AWS has the potential to provide a source of independent data for various oceanographic metrics. If this was successfully established long-term data collection and analysis costs associated with the AWS could be included in the insurance product.

Climate insurance is a new and experimental area of work and should this approach be developed as part of funding other climate adaptation measures (the FAD programs) it will require dedicated people with relevant insurance experience to develop. The FAD fisheries already include much data and relevant information but some additional data collection and modelling exercises may need to be conducted as well that require time, budget and expertise. This may take several years to complete within the RTP and a minimum of 200,000 USD of budget and much more if separate insurance products are developed per country.

The Blue Economy and impact investment

As opposed to traditional investments that seek to maximise financial returns, impact investments are made with the intention of generating positive, measurable social and environmental impact in addition to a financial return. Impact investments are possible in both emerging and developed markets and target a range of returns depending on investors' strategic goals and priorities.

Increasingly, blue economy investments are emerging in marine and ocean sectors that contribute positive impacts to areas such as sustainable fisheries, technology, marine protected area finance and eco-tourism.

Impact investments often require a sufficient scale of at least USD 1 million although scales of at least 5-10 million USD are preferable. Therefore, developing suitable investment targets requires some work and in the context of PIC's tuna fisheries climate adaptation needs and many smaller investments may need to be aggregated into one larger investment pipeline for feasibility. One such investment has been recently made in Fiji by Matanataki Ltd, a development and finance partnerships, which connects local entrepreneurs and projects in coral reefs conservation and blue economy with impact investors using blended finance. The partnership raised USD 75 million in investments[38] under which several small enterprises receive investment.

There is broard scope for impact investment in climate mitigation, adaptation and marine conservation initiatives in the Pacific. It will require the right kind of entrepreneurial approach and likely at least some expert support from conservation and financial experts to identify and structure these deals and their desired conservation and social impacts. This is also noted under the FAD section of the report.

The blue economy is defined as the sustainable and equitable development of the ocean[39] and whilst it is a large is a collection of investments and instruments to do with investing in the ocean and related sustainable economies, there is significant potential for sustainable finance that could contribute to the support of the AWS and the broader programme of climate adaptation and mitigation initiatives associated with tuna fisheries in the region. The FFA Secretariat has expertise in innovative finance capacity which could be applied to identify and develop suitable impact investment opportunities.

As an example, with respect to the AWS, a green port upgrade strategy to meet sustainability, environmental and climate requirement could include investment in the storage and laboratory facilities required for tissue sample analysis. Instrumentation on board the vessels collecting AWS-related data could measure the CO_2 efficiency and mitigation targets of industrial fishing vessels. Such provisions could be a pre-condition for impact investment finance.

The impact investment approach will require dedicated capacity in identifying and structuring the deals as well as ensuring the impact of these investments is meeting the required outcomes. It may also take some work to identify not just the investment need but a capable private sector actor able to receive the investment. These may be large multinational operations in case of the investments related to the AWS. Early in the RTP, a dedicated team or at least some persons that leverage other regional programs working on this issue if impact investments are going to support the long-term finance options.

Innovative debt mechanisms

Blue Bonds are tradable fixed income financial instruments that are designed to support the protection and sustainable use of oceans including fisheries projects. The World Bank defines Blue Bonds as *"a debt instrument issued by governments, development banks or others to raise capital*

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[38] Matanaki

[39] High Level Panel for Sustainable Ocean Economy 2022, Ocean Finance, Accessed November 2023. https://oceanpanel.org/publication/ocean-finance-financing-the-transition-to-a-sustainable-ocean-economy/

from impact investors to finance marine and ocean-based projects that have positive environmental, economic and climate benefits".[40]

Seychelles was the first country to issue a sovereign Blue Bond in 2018 with support from a WB guarantee and a GEF concessional loan. The initiative raised USD 15 million from three impact investors. The Proceeds from the Blue Bond were disbursed as grants (3 million) and loans (12 million) and were used to support the design and management of sustainable use marine protected areas under the Seychelles MSP, and a transitioning to sustainable artisanal fisheries, complementing the WB Third South West Indian Ocean Fisheries Governance and Shared Growth Programme (SWIOFISH 3) and contributing to the Seychelles blue economy.[41]

The Nordic Investment Bank (NIB) launched a 5-year SEK 2 billion Nordic–Baltic Blue Bond to support banks that are lending to selected water management and protection projects in the Baltic Sea.[42] In addition, to draw attention to plastic waste pollution in oceans, the World Bank launched a Blue Bond in April 2019. This scalable step-up fixed rate bond, which was targeted at both institutional and individual investors, raised USD 10 million. The Bank of China issued Blue Bonds in November 2020. The dual-currency bond raised the equivalent of USD 942 million towards investments in initiatives to protect the oceans.[43] This was the first Blue Bond from the private sector, the first from a commercial bank and the first from Asia.

The Nature Conservancy (TNC), a US based NGO has been engaging with countries on the conservation of marine ecosystems using debt-for-nature swaps. In 2015, with the support of TNC, the Government of Seychelles negotiated a 21.6 million debt-for-nature swap with the club of Paris for ocean conservation. The Government of Seychelles established the Conservation and Climate Adaptation Trust (SeyCCAT) to administer debt repayments and the proceeds of the debt swap, including the designation of 30% of its EEZ as MPAs and the development of Seychelle MSP. Annual small grant finance has been disbursed for fisheries, conservation and marine research projects. A more recent SIDS debt conversion example is from 2021 in Belize 'Blue Bonds' where the government of Belize purchased part of it debt at a favourable discount rate with the support if TNC and credit Suisse.

Although PICs will undoubtedly consider Blue & Green Bonds and debt-for-nature-swaps in the coming years, the question remains how to best leverage these funds to support fisheries, oceans and climate adaptation and mitigation and if debt based approaches that are adding burden to

[40] Nasdag 2021, *What are blue bonds?* Accessed June 2023. https://www.nasdaq.com/articles/what-are-blue-bonds-2021-08-04

[41] World Bank 2018, Seychelles lunches world's fisrt sovereign blue bond. Accessed June 2023.https://www.worldbank.org/en/news/press-release/2018/10/29/seychelles-launches-worlds-first-sovereign-blue-bond

[42] Nasdag 2021, *What are blue bonds?* Accessed June 2023. https://www.nasdaq.com/articles/what-are-blue-bonds-2021-08-04

[43] Bank of China 2020, attestation report on he issuance of blue bonds. Accessed June 2023. https://pic.bankofchina.com/bocappd/report/202104/P020210430614087906599.pdf

already indebted nations is the right long-term approach and will require caution.[44] Good standards of governance, transparency with wide stakeholder consultations for the processes will be required as the lack of them has caused issues in previous debt-for-nature-swaps.[45] Close cooperation will be required between countries and agencies across the Pacific region to develop these mechanisms and to assess the possibility of including programmes like the AWS in the support offered/broader investments made.

These investment structures are large and take a long time to develop, structure and find suitable investment targets. This is a huge amount of work by different actors ranging from governments, the investors themselves and other players such as NGOs who find and develop suitable investment opportunities. The RTP should work closely with the Pacific Island's Forum (PIF), leading the assessments on the suitability of these instruments for the PICs in general and keeping the financial needs and outcomes of the AWS in the frame.

[44] Abeta R (2021) The Blue Pacific Ocean Report https://www.academia.edu/49332201/Blue_Pacific_Ocean_Report_2021

[45] CFFA 2023. Gabon's odious dept-for-ocean swapt. The implications for ocean governance. Accessed November 2023. https://www.cffacape.org/publications-blog/gabon-debt-ocean-swap-tnc?rq=Gabon

GCF REGIONAL TUNA PROGRAMME

"Adapting tuna-dependent Pacific Island communities and economies to climate change"

Study 12

Structure of vessel design Needs Analysis
for small-scale fishers operating around FADs

Programme Activity Title:	Design and arrangements for utilization of safer vessels for fishing around coastal fish aggregating devices (FADs)
Recipient Countries:	Cook Islands, Federated States of Micronesia, Fiji, Kiribati*, Marshall Islands. Niue, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands*, Tonga, Tuvalu*, Vanuatu (* = least developed country)
Designated Counterparts	**Cook Islands** (Climate Change, Cook Islands Division of the Office of the Prime Minister); (Ministry of Marine Resources (MMR)
	Federated States of Micronesia (Department of Finance and Administration); (FSM National Government Department of Resources and Development)
	Fiji (Ministry of Economy); (Ministry of Fisheries)
	Kiribati (Ministry of Finance and Economic Development); (Ministry of Fisheries and Marine Resources Development (MFMRD))
	Marshall Islands (Office of Environmental Planning and Policy Coordination); (Marshall Islands Marine Resources Authority (MIMRA)
	Nauru (Department of Foreign Affairs and Trade); (Ministry of Fisheries)
	Niue (Ministry of Finance); (Department of Agriculture, Forestry and Fisheries (DAFF))
	Palau (Office of the President); (Ministry of Agriculture, Fisheries, and the Environment)
	Papua New Guinea (Climate Change and Development Authority); (Papua New Guinea National Fisheries Authority)
	Samoa (Ministry of Finance); (Ministry of Agriculture and Fisheries (MAF)
	Solomon Islands (Ministry of Environment, Climate Change, Disaster Management and Meteorology); (Ministry of Fisheries and Marine Resources (MFMR))
	Tonga (Ministry for Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications); (Ministry of Agriculture, Food, Forests and Fisheries (MAFF))
	Tuvalu (Government of Tuvalu); (Ministry of Fisheries and Trade)
	Vanuatu (Ministry of Climate Change, Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management; (Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB))
Expected EOD (Starting Date):	On signing of Funding Agreement between the Program Executing Entity and FAO
Expected Activity Duration	4 years after signing agreement
Total Estimated Budget:	USD 2.2 million (to be finalised in line with funding proposal budget development)

FAO Strategic Framework and the Global Sustainable Development Goals
2030 Agenda and the SDGs are at the centre of the FAO's Strategic Framework 2022 - 2031[1]
Linkages to:

- The framework is anchored in four Aspirations namely better production, better nutrition, a better environment, and a better life.
- FAO is the custodian or contributing Agency contributing to the following SDGs. SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Production and Consumption), SDG 14 (Life under Water), and SDG 15 (Life on Land).
- This activity explicitly contributes to achieving the sustainable development goals **No. 12 Responsible Consumption and Production, No 13. Climate Action and No. 14 Life Below Water** by supporting investing in transformative and innovative fisheries management, transforming and upgrading fish value chains, and making fish an indispensable component of food security and nutrition strategies.
- This activity addresses climate change and intensification of natural hazards by making agri-food systems more resilient to shocks and climate hazards by reducing the fishing effort on near shore fish resources and on reef ecosystems and by securing longer term food security to hunger, eliminate all forms of malnutrition and maintain these results in the long run.

FAO Programme Priority specifically related to this activity are:

Priority Area	SDG Targets
BP 2 Blue transformation	2.1, 2.2, 14.2, 14.4, 14.6, 14.7, 14.b, 14.c
BP 4 Small-scale producers' equitable access to resources	1.4, 2.3, 2.4, 9.3
BE1: Climate change mitigating and adapted agri-food systems	2.4, 13.1, 13.2, 13.b, 14.3
BE2: Bioeconomy for sustainable food and agriculture	12.2, 12.4, 12.5
BE3: Biodiversity and ecosystem services for food and agriculture	2.5, 14.4

The Green Climate Fund, Conservation International, the Program Executing Entity(ies) and the FAO (Program Implementing Partner) all uniquely contribute to achieving the SGDs. By Joining forces within the framework of the GCF REGIONAL TUNA PROGRAMME the agencies create synergies much greater than their combined individual efforts.

[1] FAO Conference 42nd. Session Strategic Framework 2022 - 2031
https://www.fao.org/3/ne577en/ne577en.pdf

1. Executive Summary

This programme Activity "Design and arrangements for utilization of safer vessels for fishing around coastal fish aggregating devices (FADs)" is an Activity of the larger Green Climate Fund Regional Tuna Programme (GCPRTP). The Activity has a duration of 4 years and an estimated cost of USD 2 200 000 USD.

The main beneficiaries of this activity will be firstly the fishers, fish sellers, their families and communities and governments of Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

The expected overall Programme Impact is 'Increased food security in Pacific Small Island Developing States'. The Activity Outcome that contributes to Programme Impact, in addition to the other activities of the GCFRTP, is that 'Fishers that fish on anchored FADs (a-FAD) will have access to safe, proven, economically viable and appropriate vessel designs which allow them to fish further offshore and in safer ways'.

In the design of this activity, stakeholder engagement was secured through surveys that were sent to all fourteen countries through SPC and discussions with fishers, fisheries authorities and boat builders in various Pacific SIDS. The key experts on fisheries development in the Pacific were consulted[2]. The results of this study show that to develop safe, economically viable designs for fourteen widely diverse countries, in terms of the variation in their macro-, medium-, and micro-economies, population sizes and geographical isolation, different fishing vessel sizes and characteristics are required to satisfy their specific requirements. No one size fits all.

Based on expert consultations and 6 surveys received from Cook Islands, Federated States of Micronesia, Samoa, Tuvalu, Papua New Guinea and Solomon Islands, this study identified the following critical elements of the Needs Assessment to be undertaken to develop new vessel designs.

- **Suitability of existing designs:** Thorough assessment of the suitability of existing vessels for FAD fishing will need be conducted and the scope for introducing modifications to improve these vessels will need to be evaluated to identify the requirements for new, safer vessels that meet better the FAD fishing operational requirements.
- **Financial viability of vessel operations**: New vessels with different operational capacities may cost more than those currently in use. Although there is a need to design new vessels that perform better further offshore, costs will need to be kept to a minimum given the average earnings of local fishers and the cost-benefit of the new designs will need to be tested thoroughly. In addition, it will be important to understand and make recommendations on different financial tools and instruments (including insurance) to the governments on how fishers can access financial services to purchase the recommended new vessels. Assessment of available finance

[2] See Stakeholder consultation report related to Study 12.

instruments and banking and financing requirements, as well as past present and future government incentives for purchasing safer and more efficient equipment, will also be needed.

- **Technical capacity of boat builders and fishers:** The technical capacity of local boat builders to construct new designs needs to be improved and increased with access to the necessary tools, better materials and better construction methods. For multi-day fishing vessels, the technical capacity of local fishers in sea safety and mechanics will need to be strengthened more than for vessels used for day trips. A capacity needs analysis and development plan will be required.
- **Onshore Infrastructure:** Increased local fish production (and additional landings from purse seiners), will require a better understanding of the operations and aspirations of existing processing and market infrastructure operators. A value-chain approach is needed to ensure that the fish caught from FADs further offshore brings economic benefits to both fisher and buyer. In addition, the availability of mechanics and mechanical workshops and access to spare parts needs to be considered.
- **Safety of fishing operations:** Weather conditions greatly affect safe fishing operations, and climate change adaptation in fishing requires safety improvements in fishing vessels. In several of the participating countries there are no specific regulations for the design, construction and equipment for fishing boats. Safety in fishing operations is an important factor and safety regulations and their implementation needs to be reviewed and/or updated.
- **Fishing operations:** To better understand how improved designs for vessels fishing around FADs will bring safety benefits the operators, it is important to understand how vessels are used presently. In some countries, fishing vessels may have multi-purpose uses such as transport of goods and passengers. The frequency of multi-purpose usage and the carrying capacities has implications for the financial viability and safety of the vessel. In addition, vessels may switch between fishing methods in times when other species are more seasonally available before going back to FADs. A good understanding of the fishing operations, seasonality, and usage must be considered in vessel design. Environmental factors such as the proximity to sea mounts, exposure to high winds and seas are essential considerations in the Needs Analysis.
- **Vessel Size:** The survey results showed a large variation in vessel size preferences among the Pacific Island countries that responded. Further analysis of the vessel usage needs and related dimensions is required in the Needs Analysis to determine the optimal vessel characteristics for fishing operations on offshore FADs.

This document details the design of the Needs Analysis and how the Programme Activity will be implemented.

The overall approach towards new vessel designs is based on the reality that there is no single design likely to fulfill the requirements of all countries. Therefore, a range of vessel designs, which together correspond to the <u>most important and common attributes</u> required by fishers, will be at the center of the theory of change to be considered. In view of this, the key features of the approach to be used for the Activity are:

- To modify traditional vessels used for day trips into slightly larger vessels, which have greater carrying capacity, stability, freeboard, and installed buoyancy and are faster so that they can get offshore and back quickly. Where there is no obvious benefit for modification no changes to vessel design will be proposed.

and

- To develop new fishing vessel designs for multi-day trips, which will be a fully decked boat with fixed fish and ice storage holds to supply urban populations with tuna where small-scale fishers making day trips and the use of bycatch from industrial tuna fishing are not able to meet demand.

To accomplish the above, the naval architect and the fisheries economist will conduct a thorough needs analysis in each country. They will be assisted by national consultants that will be hired to conduct surveys. The results of analysis will provide the most common attributes and specifications of vessels and the country requirements which will be needed to develop new and to modify existing designs. The Needs Analysis will include an assessment of the suitability of the existing vessels used in each country for fishing around FADs. This assessment will include an analysis of technical, socio economic and environmental factors of FAD fishing fleet in each of the countries.

Technical Assessment will include boat building capacity, availability of building materials, engines, tools, repair and haul out facilities, cold chain and ice making and storage.

Socio Economic Assessment will include fisher technical capacity and training opportunities, marketing systems, market volumes, selling prices, outer island transport, roles of island councils and the banking sector in the fishery, overall economic potential of the FAD fishery, fisheries development plans, roles, and involvement of women in FAD fishing.

Environmental Assessment will include oceanographic (currents) and hydrographic and climactic features (seamounts, sea conditions <winds and waves>, SST, seasonality of different fisheries, fisheries management planning and aspirations of the government.

The experts will analyze and integrate the results of the different assessments and synthesize these into a comprehensive overview to determine with a view to determine whether there is a need modification of existing vessels, or larger multi day vessels will be better suited.

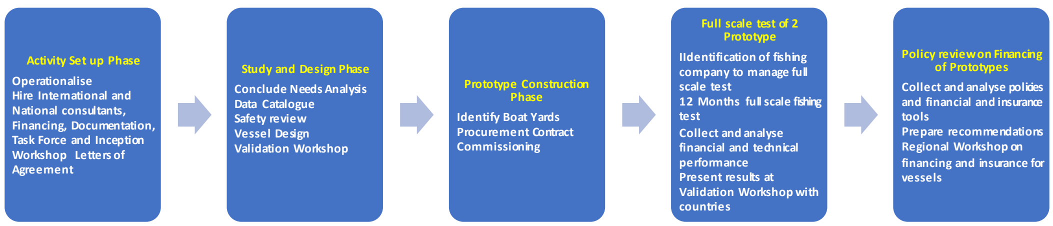
Please refer to Annex 1 for more technical details on the assessments.

The objectives of the analyses will be to develop:

- One vessel design layout for daily fishing trips in 3 different lengths
- One vessel design layout for multi day-fishing trips in 3 different lengths

In this way, the countries and fishers would be able to choose between six different vessels sizes to meet their needs. However, to provide designs without proof of concept along with financial viability tests will be insufficient. The implementation strategy is therefore to develop the designs described above, construct two prototype vessels (one for day trips and the other for multi-day trips), and then to conduct full-scale tests of these vessels over 12 months under commercial conditions. The lengths of the two prototypes and the locations of the full-scale tests will be determined through stakeholder workshops and meetings during the implementation of the activity once the thorough needs analysis described above has been completed.

The Activity will be implemented in five phases as summarised below. The details of each phase, together with the expected outcomes, outputs and sub-activities can be found in the work plan and logical framework described in the document.



The Programme Activity is structured so that each phase has a distinct Activity Output. However, these are phased and liked into each other contributing to the overall Activity Outcome. The Expected Activity Outputs are listed below:

- Cost effective Activity setup and management.
- Two designs of prototype fishing vessels, each with three different lengths, presented to and accepted by national Fisheries Departments, fishers and boat owners.
- Two prototype fishing vessels constructed in line with international construction and safety standards and guidelines.
- Two new fishing vessel prototypes successfully tested in commercial fishing operations.
- Enabling policy, legislative and financing frameworks for the construction and operations of safe, energy efficient and economically viable fishing vessels for the Pacific Island countries.

Thirty seven distinct sub-activities will be undertaken to achieve the above-mentioned Activity Outputs. These sub-activities range from conducting studies and consultations with fishers and governments, preparation of six vessel designs and testing of the models in a towing tank, construction of two prototypes based on the designs, as well as training of boat builders.

Cost-benefit analyses for each of the two prototype vessels wil be prepared and recommendations related to the development and implementation of innovative financial and insurance instruments to assist governments and their fishers to finance the production of vessels based on the prototypes will be made. The cost benefit analyses will be be undertaken by a financial expert, who consults with local banks and government ministries, and will culminate in a regional workshop to present the findings and recommendations on how the appropriate vessels can best be financed by the fishers.

This activity will be implemented by the Food and Agriculture Organization of the United Nations (FAO) on behalf of Conservation International as the Accredited Entity and the Pacific Community (SPC) as the Executing Entity under Component A of the overall Green Climate Fund Regional Tuna Programme.
https://www.greenclimate.fund/document/adapting-tuna-dependent-pacific-island-communities-and-economies-climate-change.

This activity is aligned strategically, technically and synergistically with the development objectives, policies and plans of the 14 participating Pacific Island countries. The activity supports the development and climate adaptation goals of the United Nations Sustainable Development Goals (SDGs), and those of the Green Climate Fund.

TABLE OF CONTENTS

ACRONYMS

Acronym	Meaning
%	Percentage
CI	Conservation International
EEZ	Exclusive Economic Zone
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
GCF	Green Climate Fund
GCFRTP	GCF Regional Tuna Program
GCP	Government Cooperative Programme (FAO)
GDP	Gross Domestic Product
GHG	Green House Gas
ILO	International Labour Organization
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
KM^2	Square Kilometres
LTO	Lead Technical Officer (FAO)
a-FADs	Anchored Fish Aggregating Devices
MCS	Monitoring Control and Surveillance
NFI	FAO Fisheries and Aquaculture Division
NFIFO	FAO Fishing technology and operations team (FAO)
PEFC	Programme for the Endorsement of Forest Certification
PIC	Pacific Island Countries
RFB	Regional Fisheries Body
RFMO	Regional Fisheries Management Organization
rPFSC	regional Pacific Food Security Cluster
SAP	Sub Regional Office for the Pacific (FAO)
SDG	Sustainable development goals
SIDS	Small Island Developing States
SPC	South Pacific Community
STCW-F	Standards of Training, Certification, and Watchkeeping Convention - Fishing
TCP	Technical Cooperation Programme (FAO)
UNOCHA	United Nations Office for Humanitarian Affairs
UNOCHA	United Nations
USD	United States Dollar
WCPO	West Central Pacific Ocean

2. General Context

This Programme Activity is one of the components that will be implemented under the framework of the GCF Regional Tuna Program (GCFRTP). The overall objective of the GCFRTP is to provide, knowledge and tools, and support activities and policies for "Adapting tuna-dependent Pacific Island communities and economies to climate change".

This Activity "Structure of vessel design needs analysis for small-scale fishers operating around anchored FADs'" will be implemented by the Food and Agriculture Organization of the United Nations (FAO) during Program implementation and will contribute synergistically to the overall objective and expected results of the GCFRTP.

The GCFTP will be implemented for the benefit of 14 Pacific small island developing states (SIDS). The participating countries are distinct from each other in terms of population size and economies. However, there are communalities such as their small land masses compared to the sizes of their Exclusive Economic Zones (EEZs), their dependence on fisheries and particularly tuna for food security, and the earnings from the sale of industrial fishing access rights.

Table 1 Characteristics of the participating countries, , listed in order of total area of their Exclusive Economic Zones (EEZs).

Country	Population 2022/ % annual growth	Land (Km^2)	EEZ (Km^2)	Coastline (Km)	Per capita GDP USD 2022[2]
Kiribati	122,735 / +1.65	811	3,441,810	1,143	1,632
Micronesia Fed. States	105,987 / +0.22	701	2,996,419	6,112	3,830
Papua New Guinea	9,311,874 / +2.07	462,840	2,400,000	5,152	2915
Marshall Islands	54,446 / -0.13	181	2,131,000	370.4	4,714
Cook Islands	15,406 / +0.42	236	1,977,000	120	14,909
Solomon Islands	744,407 / +2.25	28,230	1,589,477	5,313	2,001
Fiji	901,603 / +0.36	18,333	1,290,000	1,129	5,111

Country	Population 2022/ % annual growth	Land (Km^2)	EEZ (Km^2)	Coastline (Km)	Per capita GDP USD 2022[2]
Tuvalu	10,778 / +0.93	26	719,714	24	5,083
Vanuatu	307,941 / +2.21%	12,281	680,000	2,528	3,223
Tonga	99,283 / -0.25	749	659,558	419	4,952
Nauru	11,928 / +0.81	21	431,000	30	10,020
Niue	1,532 / -1.1	259	390,000	64	19,464
Samoa	200,999 / +0.57	2,834	129,000	403	3,967
Palau	17,976 / +0.11	444	603.987	1,529	13,230

The GCFRTP will be implemented in the Western Central Pacific (Major Fishing Area 71) and has two major components working in tandem as follows:

Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change and

Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.

This Programme Activity contributes directly to Component A.

3. Rationale

The national small-scale fishing fleets of Pacific SIDS consist mainly of small outboard-powered skiffs engaging in daily fishing trips. These fleets provide the bulk of the fish and fishery products for national consumption (often from coral reef habitats. As coral reefs continue to decline due to the impacts of climate change, increasing the existing gap in fish supply in many Pacific Island countries due to rapidly-growing populations, small-scale fishers will need to catch more tuna to fill the gap.

Very aware of these impacts and looking into the future, many Pacific SIDS have been making efforts to increase the access of small-scale fishers to tuna and other large pelagic fish by expanding the use of anchored Fish Aggregating Devices (a-FADs) in coastal waters. This adaptation also has the advantage of moving fishing effort away from threatened coral reefs.

It should be noted that these anchored FADs differ significantly from the drifting FADs used by industrial purse-seine vessels operating in the exclusive economic zones of Pacific Island countries (Figure 1).

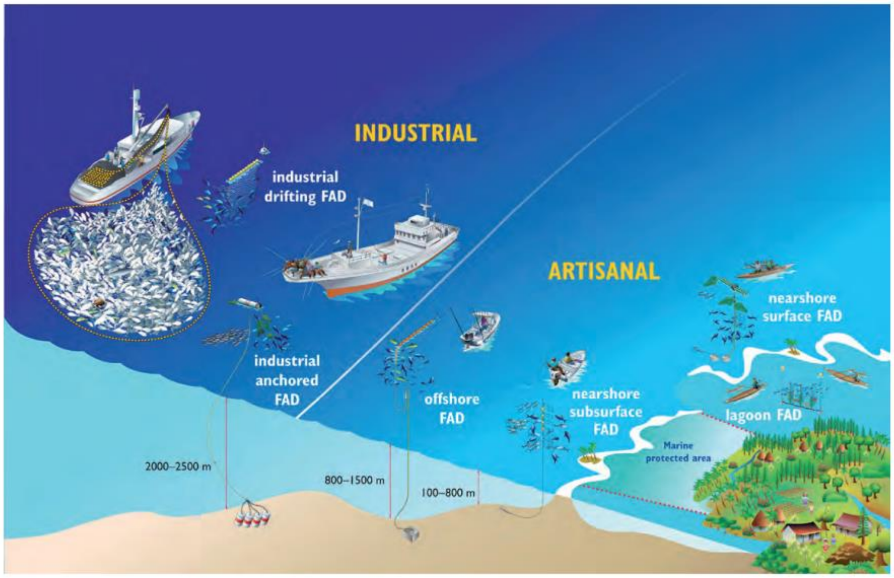


Figure 1 The differences in FADs used by small-scale fishers and by industrial fleets. Source: SPC (2014). Fish aggregating devices. SPC Policy Brief 19/2014

To ensure that existing small-scale fishers already targeting tuna and fishers making the transition from catching fish associated with coral reefs to fishing further offshore for tuna can do so safely, the suitability and safety of the boats currently in use for coastal fishing, typically up to 7 m in length, needs to be fully assessed. These assessments should also evaluate the need for improvements to the design of these boats.

The weather prognosis in the Pacific is for tropical cyclones and weather events to become more frequent and/or more intense due to increased sea surface temperature over the next decades. Fishing around FADs, particularly those that are somewhat distant from shore is expected to become more dangerous (e.g., higher waves, larger swells, more intense storms), increasing the risks of accidents and loss of life at sea. Adapting fishing vessels to the changing ocean conditions will improve safety-at-sea for small-scale fishers as they travel further offshore to catch tuna around FADs. The safety of fishing is discussed in more detail in section 0 Safety of fishing operations.

This activity will contribute to climate change adaptation in the fisheries sector by developing new, safer designs for small fishing vessels suitable for fishing around nearshore and in some cases offshore FADs expected to be placed up to 10 km offshore, preserving the fish that they catch in good condition, and transporting fish caught around outer islands to the urban centres in a manner that is economically viable. It is expected that the introduction and use of these more adequate vessel designs will increase food security and help reduce fishing pressure on over-exploited coral reef fish. Moreover, the vessels will be designed so that they can be built, outfitted, maintained and repaired locally, thereby contributing to employment and self-reliance of Pacific Island communities.

4. FAO Comparative Advantage

This activity will be implemented by the Food and Agriculture organization of the United nations. This Programme Activity contributes to FAO's Strategic Framework 2021-2031 of

- Better Production by preparing and designing fishing vessels that are more stable, safe, suitable for fishing further offshore and which can preserve the catches better.
- Better Nutrition by landing high quality fresh protein to replace imported canned fish and low-quality proteins. Fish has micronutrients which cannot be found in other foods in addition to Omega 3 fatty acids.
- Better Environment by moving fishing effort away from fragile coral reefs which are being degraded by global warming. This will contribute to reef rehabilitation and maintenance of fish biodiversity around the islands.
- Better Life by promoting policies and recommendations related to innovations in safety, finance and insurance instruments to protect investments.

The activity is also in support of FAO's work in adaptation to climate change.

The Fisheries and Aquaculture Division of the Food and Agriculture Organization (FAO) is in the Agency's headquarters on Rome. The FAO has a Sub Regional Office for the Pacific islands (SAP), which was inaugurated in Apia Samoa on 13 May 1996. The SAP office has been responsible for the implementation and coordination of FAO's Program of Work for the last 26 years in the Pacific Region. During this period FAO has worked closely with the Fisheries departments and Ministries responsible for fisheries in the exact same countries where the GCFRTP will be implemented.

Since 2005, the FAO Fisheries and Aquaculture Division (NFI) has been working on fishing vessel design, construction, and equipment with the International Labour Organization (ILO) and the International Maritime Organization (IMO). The three organizations have prepared and published a range of safety and construction Codes, Protocols, Guidelines and Requirements for fishing vessel design, construction, and equipment for various vessel sizes.

FAO has also assisted countries to implement and improve their vessel and safety regulations, with an emphasis on small- and medium sized vessels. In 2012, FAO jointly published Safety Recommendations for Decked Fishing Vessels of Less than 12 meters in Length and Undecked Fishing Vessels [3] (FAO/ILO/IMO). FAO also prepared and published with IMO and ILO, the Code of Safety for Fishermen and Fishing Vessels 2005; both these guidelines are pertinent to this activity as many of the vessels in the Pacific SIDS fall into the categories covered in these publications.

The FAO Fisheries and Aquaculture Division works with the Pacific SIDS on Disaster Risk Reduction and Management, Fisheries Management, Gender Mainstreaming in fisheries, Fish Processing and Marketing, and Safety at Sea. FAO is also implementing the project for "Enhancing livelihoods and food security through nearshore fish aggregating device fisheries in the Pacific" (FishFAD project), which is financed by the Japanese Government in 7 of the

[3] https://www.fao.org/documents/card/en/c/3d78177f-bfeb-5566-ae97-a4cb55984b4f/

GCFRTP participating countries[4]. This FAO activity is assisting the governments to develop their FAD fisheries. FAO brings experience, technically competent personnel, ongoing programs and synergy to the GCFRTP. In addition, FAO Development Law Service (LEGN) is assisting SIDS with fishing safety legislation.

Table 2 FAO Synergy activities in Pacific SIDS 2022

Country	Activity Name	Outputs
Fiji, Kiribati, Marshall Islands, Palau, Samoa, Tuvalu, Vanuatu	Enhancing livelihoods and food security through nearshore fish aggregating device fisheries in the Pacific GCP/SAP/002/JPN	Strengthening and developing community nearshore FAD programmes to provide improved access to high value species; Structuring and strengthening of fishers' associations and cooperatives; Developing livelihood opportunities and revenue generating activities and products; and Improving safety at sea for fishers of nearshore fish aggregation devices
Fiji Solomon Islands Vanuatu	Strengthening Small-scale fisheries in the Pacific GCP/SAP/003/CAN	Strengthened national and local management capacity in small-scale fisheries for climate change adaptation through a gender-sensitive approach. National and local actors are better prepared for natural disasters and climate change impacts, resulting in reduced vulnerability. Resilient fisheries value chains developed that reduce vulnerability of fishers and women in coastal communities to climate related changes, extreme events and other economic, social and environmental shocks
Fiji Federates States of Micronesia Niue Palau Solomon Islands	Reducing COVID-19 Related Food Insecurity in the Pacific Region GCP /SAP/004/CAN	Enhanced COVID-19 impact analysis, including rapid gender analysis to identify gender gaps, to inform gender-sensitive national and regional response plans, strategies, policies and actions. The rapid gender analysis will build on existing FAO country gender assessments in participating countries.

[4] Fiji, Kiribati, Marshall Islands, Palau, Samoa, Tuvalu, Vanuatu.

		Strengthened household gender-sensitive agriculture production and resources management for more resilient to disasters in the selected countries. Strengthened national and regional coordination on gender-sensitive food security and agriculture in the Pacific.
Fiji	Building resilience in Fiji's fisheries sector through improved DRR and DRM TCP/FIJ/3801	Fisheries focused disaster risk reduction (DRR) and Management Plan Drafted/Prepared Relevant government staff and selected fishers acquire new skills in boat repair, engine maintenance and participate in improving local boat design. Prepare a Disaster Risk Reduction and Management Plan Develop adaptive fisheries and aquaculture management plan. Safer, more stable, and fuel-efficient boat design with greater carrying capacity prepared and presented to Ministry of Fisheries
PACIFIC SIDS	Pacific Regional Food Security Cluster	Support Pacific SIDS in disaster risk reduction (DRR) and disaster risk management (DRM) Support to National Food Security Clusters, Response to crises, mobilise funding in disasters, humanitarian coordination between UN-OCHA, World Food Programme (WFP) and FAO.
Vanuatu	Building resilience in Vanuatu`s small-scale fisheries sector through improved vessel designs TCP/VAN/3901	To enhance the capacity of Vanuatu's small-scale fisheries with safer and more productive small-scale fishing vessels.
Fiji Samoa Tonga	Seafood risk management and awareness raising on	To strengthen national capacities to identify and address the risk of ciguatera poisoning

	practices to minimize risk of ciguatera poisoning. TCP/SAP/3807	
Cook Islands Fiji Marshall Islands Micronesia, Federated States of Palau Samoa Solomon Islands Tuvalu Vanuatu	Mapping and characterization of Fishers and Fisher Workers Organizations in selected PICs, Phase II of TCP/SAP/3710 TCP/SAP/3901	To map fisherfolk organizations and understand their level of functionality and support needs
Marshall Islands	Intra-ACP Blue Growth program for Sustainable Fisheries and Aquaculture Value Chains Productivity and Competitiveness (FISH4ACP)" GCP/GLO/028/EC	The overall objective of the activity is to contribute to poverty reduction, jobs creation, food and nutrition security by improving the economic, social and environmental sustainability of fisheries and aquaculture value chains in ACP countries.

FAO together with World Food Program are the lead agencies in the regional Pacific Food Security Cluster (rPFSC). Since this activity has implications for food security, the rPFSC will support the programme activity through information and knowledge sharing and training. It will also assist with strengthening the national food security clusters.

In summary, the comparative advantages of FAO for executing this activity include its authority and status as a global intergovernmental organization, the FAO membership of the Pacific region countries and network with regional partners, the unparalleled information source and institutional memory FAO has on the subject of fishing vessel design, the decentralized office with its professional staff in fisheries supported by a multidisciplinary team, its ongoing technical programme supporting fisheries in the region, and its capacity to respond to unforeseen needs of member countries in the Pacific. Moreover, as an UN agency, FAO applies responsible financial and administrative management.

5. Needs analysis requirements

In this section we discuss the needs analysis and the implications that must be addressed to introduce new vessels designs to ensure that small scale a-FAD fishers will have safer, more reliable and productive fishing operations that are environmentally sustainable and financially viable.

The successful introduction and use of safer and financially viable new vessels are dependent on a suite of enabling policies, regulations, and financing mechanisms. Furthermore, it requires not just documentation but strong commitments to implement the policies and new regulations and financing particularly for larger vessels. Improvements are needed in fisheries management to register and monitor the impact of the new designs, financial tools and insurance policies will be important for the private sector to acquire boats; crews and boat builders will have to upgrade their skills; and infrastructure in cold chain will be required to prevent spoilage and waste.

Not all the problems in this analysis will be addressed by the activity. Many of the requirements will have to be addressed by the governments of the participating countries once the policies have been geared to introduction of the new designs. However, the activity will carry out studies that can support better and more informed decision making on fisheries and fishing fleet development. For example the activity will study various innovative financing mechanism for fishers to acquire/finance vessels but the activity will not provide vessels for fishers. The activity will, however, build two prototypes and test these as proof of concept and carryout the financial viability studies under commercial conditions.

5.1 Financial viability

New vessel designs that enable fishers to operate further away from shore and most possibly for longer periods will inevitably cost more. This is because it makes little sense to build a bigger boat that can fish further but it fishes the same number of days as a smaller boat.

To cover the investment and financing costs (boat, engine, and gear) of a larger boat, it will be necessary to catch more fish, sell the fish at a higher price or both. However, given the limited spending power of the populations, increasing prices is probably not the best strategy. **To better understand the financial viability of fishing operations over several days with boats of larger capacity there will be need for cost-benefit and techno-economic fleet performance studies, and full-scale testing of prototype vessels. These prototypes should be developed after preliminary cost benefit analyses have been completed.**

Commercial banks have been quite averse to giving loans to fishers and if they do, the costs for down payments, guarantors and collateral to cover the loan are usually beyond the scope of many small-scale fishers. This leaves the options, that future fishing boats are financed by private businessmen, or that special policies and mechanisms related to financing are put in place to facilitate small- scale fishers obtaining these boats. **There will therefore be a need to provide targeted assistance to develop a financial and insurance services for fishers.**

5.2 Training and capacity building

Fishers in many of the participating countries are adept in daily fishing operations of small plywood skiffs powered by outboard engines. However, the operation of vessels capable of fishing further offshore and on multi day trips will require upgrading local fisher skills in navigation, seamanship/boat handling meteorology, safety at sea, marine engineering, fishing methods, planning and organization, preservation of fish, legal aspects, and financial management. Without these enhanced skills, the operation of new vessel designs, particularly multi day designs will be inefficient and could lead to low or negative financial viability. The use of new multi day designs of vessels will have to be accompanied by proper training and capacity building accompanied by regulations related to certification of Masters, Engineers, and Deck personnel**.** There are 11 maritime training schools in the 14 participating countries, which could facilitate such training and certification.

Boat builders in many of the countries are constrained by the lack of tools and boat building materials which all must all be imported. The quality of these materials and tools is often of low and supplies are infrequent. In addition, boat building skills are varied from very good to poor and methods from cheap to expensive. **The activity will develop and implement a training plan for boat builders. The number of boat builders and type of training will have to be determined once the preliminary studies are completed to identify the skill requirements. ~~A lumpsum amount will be budgeted to start the process.~~**

5.3 Infrastructure

5.3.1 Volume of fish, cold-chain, and transport

Presently fish that is landed daily by small vessels is sold almost immediately. For large catches, the fish is stored in insulated fish boxes in ice. When vessels stay out to sea for multiday voyages, the catches will be larger in volume. Fish that is not sold on the day that it is landed will have to be stored in ice, possibly for several days and in some cases the catch will have to be transported to a fish storage facility. This presents a challenge in terms of costs of electricity to produce ice and cold chain as well as transport costs (insulated trucks or vans). Depending on the market absorption capacity, investments in cold chain will be required. **Investments in infrastructure will be required based on the studies about the aspirations and market fish absorption capacity in each country. Relevant studies will have to be carried out. Opportunities to sell fish to established exporters, if there is over production may be relevant in some countries where processing plants and mechanisms to export are already taking place. These countries include Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu.**

5.3.2 Haul out, workshop, repair facilities

- Presently boats are hauled onto the beach for repair and maintenance. Haul out is easily done on small vessels. However, larger vessels would require, boat ramps, trailers, vehicles to haul the vessels up ramps or may require slipways or cranes. These facilities come at a cost and are only economically viable once there are sufficient vessels that warrant such investments. It will therefore be necessary to carefully consider the number, types and sizes of vessels and the market in each country. **Investments in infrastructure will be required based on the studies about the aspirations and market fish absorption capacity in each country.**
- All vessels require maintenance and repairs. Proper repairs on engines and boats require, workshops, tools, boat hardware and spare parts. It will be necessary to improve workshops, tooling and mechanisms to acquire spare parts. **The size and investment in workshops will be proportional to the type and number of vessels targeted by the government's policies. Many countries already have mechanics and workshops. Most likely there will be need for upgrading of some of these facilities. This programme activity will not be upgrading infrastructure facilities. However, the activity will identify the details needs and requirement by country where necessary.**

5.4 Fisheries and Fleet Management

At present the management of small-scale fishing is done through fisheries laws and regulations which are focused on biological conservation of the marine ecosystems. The introduction of new vessels capable of fishing further offshore introduces a new paradigm. Some of the SIDS have little or no experience managing these types and sizes of vessels. The strengths of the fisheries departments of Pacific SIDS are in the management of high seas vessels, licensing, inspections and application of international and regional frameworks and agreements mainly through the WCPFC.

The introduction of new designs or vessels will require additional layers of Monitoring, Control and Surveillance (MCS) as well as pertinent regulations and inspection protocols related to safety for the type, design, construction, equipment and autonomy of vessels, fisheries regulations specific to FADs and offshore fishing, and development planning for the future of the fleet. **The fisheries and safety regulations for each country will have to be reviewed and updated to address the greater number of small-scale fishers targeting tuna and the need for these fishers to use new, safer vessel designs. It should be noted that regulations without related awareness-raising and support for implementation are usually ineffective. Already, the FAO's Development Law Service is currently assisting countries in updating their safety regulations.**

Due to the diverse nature of the countries participating in this activity, it is envisaged that most of the above issues raised in the needs analysis will have to be tackled at the country level and not at the regional level. **The needs analysis points out that the introduction of new vessel designs will require accompanying measures in terms of investments, policies, studies, and regulations to successfully support m-FAD fisheries development.**

6. Technical analysis of present vessels

The following is an analysis of the vessels presently being used in Pacific SIDS. During the preparation of this document, the main stakeholders were requested to complete a survey designed to provide technical information on the vessels that exist, discover gaps in information, and to design a future looking adaptation activity based on existing and past technical information.

6.1 Demography, economics, location, and designs

The great diversity and differences between the participating countries in terms of populations size, Gross Domestic Product (GDP), location of markets, EEZ area is evident from Table 1. These factors influence the size of the economy and the market, which in turn dictates the number of vessels and fishers required to supply tuna for domestic consumption, the supporting policies and the fisheries annual budgets needed by the fisheries agencies. To cover the wide range of social, cultural and market conditions across the region, several vessel designs are likely to be needed to meet the diverse needs of the participating countries.

6.2 Summary of survey results

The following is a summary of the survey results (See Annex VIII). The survey showed the following:

- The countries that reported all have more than 20 FADs installed.
- Except Samoa, boatbuilders did not receive any training in building techniques,
- The average vessel length and breadth of a-FAD fishing boats is 8 meters and 2 meters respectively.
- All boats use Yamaha outboard engines between 15 and 60 HP.
- Most respondents though that the optimum size of vessel was between 8-10 meters except Samoa who proposed 12-14 meters this is because of the widespread use of the Alia and longlines as a main gear.
- Except for FSM which imports all boats, all reporting countries built their own boats out of plywood or planks.
- Four of the six countries that responded had boat building companies and individual boat builders. One country did not have any boatbuilders as all boats were imported and another had individual boat builders only .
- At Programme activity start up, the survey will be updated, and the remaining countries' inputs will be solicited.

7. Technical, social, and economic considerations related to the construction of new FAD fishing vessel designs

Given the diversity of contexts in which small-scale fishing for tuna occurs across the region, and the wide range of existing small vessels, an in-depth 'needs analysis' for improving the design and availability of safer vessels for small-scale tuna fishing is needed. This analysis will examine options for modifying existing vessels to improve their safety where needed and where practical to do so. It may well be that in some countries there is little or no need for improved vessel design because the boats currently in use are fit for purpose, e.g., where well-designed aluminium or fiberglass boats are imported from overseas. However, it is anticipated that improved designs, or modifications to existing designs are likely to be needed in the majority of the 14 participating countries. In countries where it is determined that new vessel designs are needed, the analysis will not only investigate the technical aspects of vessel design but also the social, marketing, and financial arrangements needed to support the introduction and adoption of new vessel designs. The various aspects to be considered related to construction of new vessel designs are summarized below (see also Annex I for detailed technical guidance).

7.1 *Boat construction materials*

7.1.1 Quality of material

All participating countries will import some or all their boat construction materials. These will include but are not limited to wooden planks, plywood, nails, screws, bolts, nuts, washers, paints, glues, resins, and epoxies. These materials are widely available at varying prices and quality. It is important not to sacrifice quality for price as this affects the longevity and frequency of repairs. All timber should meet local and global certification for sustainability (PEFC, FSC, etc.)

7.1.2 Material dimensions (scantlings)

Incorrect scantlings make the boats, weak, requiring frequent repairs or make the boat too heavy with excessive fuel consumption and too heavy to be manually hauled out of the water necessitating a slip way (Annex I). It is essential to have the correct scantlings to achieve load paths, no hard spots, continuity and alignment of structural elements.

7.1 3 Construction methods

In addition to the quality of the materials, the correct techniques for cutting, shaping, curing, clamping, laminating, drying, fastening, painting, launching are important and application of incorrect processes and methods will make the vessel weak even though the materials are of good quality and the scantlings correct.

Decisions will have to be made related to the choice between fiberglass and wooden plank and plywood and fibreglass covered wood and aluminium. Skills to work with new materials need to be developed and sheds and storage facilities may be needed depending on the construction.

7.2 Weather and Sea State

Fishing vessel should be constructed to withstand the weather and sea states in the sea areas accessed by fishers. Length, breadth, draught, hull form adequate freeboard, stability, and scantlings are the most important parameters to integrate into the design. It is important to establish the wave heights, wind speeds, ocean currents and the seasons when the largest waves and winds are most prevalent[5].

The warming climate is affecting the sea state and the prognosis is that in the Pacific is that cyclones with higher intensities can be expected in the future.

The consequence of fishing further offshore with larger waves and risks of more intense weather is that the construction of fishing vessels will have to compensate for adverse weather by increasing the length, breadth, draught, buoyancy and robustness.

7.3 Safety of fishing operations

Fishing is one of the most hazardous occupations and, globally many fishers are injured or die at work. Estimating fatalities in fisheries is challenging for many reasons. Estimates made by FAO and ILO (24,000 fatalities annually), ILO, 80 deaths per 100,000 on fishing vessels over 24

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[5] FAO will enter into an agreement with the European Space Agency (ESA) in 2023 under which FAO will obtain for free satellite data on ocean currents, surface water temperature and wave height. This may be useful for weather index/parametric insurance of fisheries, as well as for trip/voyage planning.

meters, in a recent paper published in "Triggering Death[6]" in November 2022 by FISH Safety Foundation estimated find fatalities among fishing communities worldwide surpass 100,000 annually. The estimations are illusive because of different methodologies used, differences in reporting requirements and legal obligations.

A study[7] on deaths at sea in Pacific Islands from the Asia Pacific Sustainable Development Journal (Vol 26, No. 2 Page 107). The study found that *"The quality of death registration data in Pacific island countries and territories remains suboptimal. Data on deaths occurring at sea are especially limited"*. The study did three case studies on deaths at sea in Fiji, Kiribati, Tuvalu. The data analysed by the study covered the period 2008 -2017. The researchers found that *"between 2008 and 2017, 58 deaths at sea in Fiji, 81 deaths at sea in Kiribati, and seven deaths at sea in Tuvalu were identified from the data sources collated (table 3). The numbers fluctuated annually, reflecting variations in the frequency and severity of sea accidents. Based on these numbers, the average unadjusted mortality over the 2008-2017 period was 7.5 deaths per 100,000 in Kiribati and 17.6 per 100,000 in Tuvalu and 0.8 per 100,000 population in Fiji*. *The researchers concluded that "Data on deaths at sea in the three study countries are fragmented among multiple sources. The majority of reported deaths include no information on age. Data on small vessels involvement is also limited. These factors hamper measurement of the true burden of all at-sea mortality and limit inferences about risk groups".* A following table shows a summary of the data deaths in the case studies.

[6]Triggering Death FISH Safety Foundation November 2022 Internet:

https://go.fishsafety.org/downloads/White%20Paper%20-%20Triggering%20Death%20-%20November%202022.pdf

[7] DEATHS AT SEA IN THE PACIFIC ISLANDS: CHALLENGES AND OPPORTUNITIES FOR CIVIL REGISTRATION AND VITAL STATISTICS SYSTEMS. Carah Figueroa, Gloria Mathenge, Christine Linhart and Philip A.S. James* https://www.unescap.org/sites/default/files/Paper%205.pdf

Table 3. Reported deaths at sea in study countries, by age, sex, and source, 2008-2017

Variable	Fiji	Kiribati	Tuvalu
Age (years)[a]			
<10	5	18	..
10-29	5	5	..
30-49	7	4	..
>50	6	3	..
Unknown	35	51	..
Sex			
Men	24	34	7
Women	6	11	—
Unknown	28	36	—
Source[b]			
Police	50	14	..
News media	36	17	..
Health	..	35	7
Civil registry	..	17	7
Total	**58**	**81**	**7**

Notes: [a] Only six reported deaths in Tuvalu had data on age. Due to small numbers, age disaggregated data are not provided.

[b] Based on news sources, 13 reported deaths at sea in Fiji were related to small vessel activities. News sources also indicated five deaths at sea in Fiji being reported to the health facility. Information linking small-vessel activity to the deaths could not be ascertained from the other sources in all study countries. Data from the Ministry of Health and Civil Registration Office in Fiji were not available at the time of the study.

Most small scale fishers in Pacific SIDS are usually poor and food insecure due to seasonality of fishing, lack of fish preservation equipment, fluctuation market conditions and purchasing power of the populations. The loss of life of a fisher deals a heavy blow to the income, livelihoods food security of the family.

Not only are deaths devastating but, accidents at sea and natural disasters which cause loss of assets (boat, engine and equipment) and injuries causing loss of limb or handicap also weigh heavy on the fisher families' livelihoods and their futures.

The fourteen countries participating in this activity have varying levels, from none to comprehensive, of safety regulations related to design, construction and equipment of small scale fishing vessels. For example, in built buoyancy to ensure that boats will not sink if flooded is not a common requirement. Vessels are constructed according to traditional methods and in many cases inspections are not required or not carried out systematically during construction to ensure buoyancy and strength of the vessels to withstand the expected sea conditions.

Safety inspections for life saving equipment may be carried out consistently, randomly or not at all. Similarly, the carriage of safety equipment on board, as well as operator qualifications may or may not be required by different countries. Usually, the requirements are assessed by the countries based on how fishing operations evolve over time. One such case happened during expansion of the 'alia' small boat fishery in Samoa, when the fishermen ventured far offshore to fish for albacore with longlines, rather than for the deep-water snapper for which the original alia design was intended. The change in the use of the boats resulted accidents and loss of life. Several of these accidents are thought to have been due to modifications to the original alia design, reducing the seaworthiness and stability of the vessels when loaded in rough sea conditions[8]. Samoa has now changed its regulations and all crew must undergo safety at sea training before embarking.

Over the last 20 years or more, SPC, FAO and Pacific Island Governments have provided training in safety at sea and more recently grab bags with survival equipment to fishers. FAD fishers have benefitted from these interventions. However, safety culture still needs significant work to improve safe working conditions on board fishing vessels. Many of the countries have accident reporting systems, however, only a percentage of losses are reported and particularly when there are deaths or missing for days or weeks or mobilization of search and rescue operations. Many incidents such as capsize, swamping, engine breakdown and rescue by other fishers are not reported to the authorities, making statistical analysis difficult. In addition, accident reporting terminology is not standardized across the region. Understanding the causes of accidents is the first steps in mitigating them. Lack of accident data is an obstacle to understanding.

Many SIDS use sea transport to move people, goods and fish between outer islands and main urban centres. However, appropriate vessels are frequently not available or inadequate for the tasks of transporting and maintaining the cold chain from outer islands to urban centres. Consideration also needs to be given to assessing national needs for vessels suitable for multi-day trips to deliver tuna caught around a-FADs installed at outer islands to urban centres, and to people transport requirements (as necessary).

A programme activity Study 3 related to development of FAD fisheries will conduct training in safety at sea and provision of equipment under the GCFRTP.

[8] https://coastfish.spc.int/News/Fish_News/84/Fish_News_84.pdf

(see pages 24 and 25)

This activity will work in synergy with the Study 3 and conduct a complete review of the national legal frameworks for safety of fishing vessels and provide recommendations for governments to implement to ensure the safety of the fishers and their investments.

To ensure that fishing operations are safe and less people are injured or die its essential that the authorities responsible for maritime safety have at their disposal, and enforce, rules and regulations. It is also imperative that fishers are knowledgeable and competent in seamanship and certified if possible. Owners and operators should know the laws and regulations and should comply.

FAO/ILO and IMO have developed the Safety Recommendations for decked vessels and less than 12 meters in length and undecked fishing vessels. In Pacific SIDS where no rules and regulations exist, the FAO/ILO/IMO Safety recommendations should be applied until such time as a country develops its own rules and regulations. In the implementation of this activity the FAO/ILO/IMO safety recommendations will be applied to the design, construction and equipment of vessels built under this activity. Naval Architect Daniel Davy contributed to this document and his report relating to Safety at Sea including the draft catalogue can be found in Annex I.

Appropriate formulation and application of national safety regulations will increase safety, protect fishers, reduce accidents, lower loss of property, increase confidence of financial and insurance institutions to provide loans and coverage and professionalize the small-scale fisheries for tuna. On the other hand, owners may well incur additional costs in complying with regulations, in terms of acquiring and servicing of safety and communications equipment, inspections, training for crews, and maintenance and repairs. However, regulations without implementation are not worthwhile.

7.4 Competence of crews

The quality and efficient operation of fishing boats are linked to the competence of the crew. The best equipped boat will not catch fish, navigate safely and be free of break downs without a competent crew. Many SIDS have competent day fishers that operate skiffs with outboard engines, however, crews taking boats to sea on multiday trips or operating a considerable distance offshore will require additional training and certification. Crews whether going to sea on daily or multi day trips should receive training in safety and seamanship. The International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), was adopted by IMO in 1995, sets certification and minimum training requirements for crews of seagoing fishing vessels with the aim to promote the safety of life at sea and the protection of the marine environment, considering the unique nature of the fishing industry and the working environment on fishing vessels.

There are maritime training schools in Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. However, the courses offered are those required under the IMO STCW Convention (1978), which mainly target training of seamen for the merchant marine. These existing schools will have a part to play in providing training for fishing skippers and engineers and can do so relatively easily by adding the basic STCW-F courses to their curriculum and/or alternatively use training package on fishing safety subjects developed by FAO . The latter is highly suitable for small-scale fishers and can easily be integrated into vocational school training programs for fishers.

7.5 Boatyards and workshops

7.5.1 Boat Yard

Larger vessels built to withstand larger seas will have to be hauled out of the water every 12 to 18 months for cleaning the hull and inspecting, repairing or replacing underwater gear (rudder, propeller, skeg, struts, anodes, shaft bearings and thru-hull fittings). Since it is not possible to have a boat yard in every landing site, the harbour where there are the largest number of boats is usually the location of the boat yard.

Smaller boats are usually hauled up the beach on wooden rollers manually or by a mechanical winch or hauled out of the water by a trailer on a concrete ramp. The method depends on the number of persons that live at the site and the size of the boats.

7.5.2 Workshops

All boats, no matter what size, require a covered boat shed and mechanical and woodworking workshop with appropriate tools, spare parts, and materials to carry out repairs to the hulls and engines. Finally, well trained boat builders and mechanics are essential to keep the fleet afloat and fishing.

As boats move further offshore to fish there will be a need for haul out and workshop facilities. These will be investments that will have to be made but will only be viable if there are a certain number of boats that can keep the boat yard and workshops financially viable.

7.6 Electrification of boats

As boats fish further offshore it would become necessary to stay out to sea longer at night. This will require lights for safety and for working on the deck and even attracting bait fish. Boats that fish on daily operations do not need lights except for an emergency torch light in case they come back late.

Both outboard and inboard engines can generate electricity to charge DC batteries which in turn provide electricity for navigation and deck lights and communications and electronic navigation GPS and sounders for finding FADs and fish. Solar panels will keep batteries charged without the need for running the engines. A combination of engine and solar generated electricity to charge batteries will be important for vessels that fish further offshore.

7.7 Daily vs. Multi-day fishing

The space requirements on board a fishing boat increases dramatically when comparing daily to multi-day fishing. With multi day fishing there is greater need for space for fuel, water, oil and lubricants, spare fishing gear, bait storage, fish and ice storage, boat equipment, safety and communications equipment, bunks for resting, storage for food and space for cooking and toilet facilities as well as tools and engine and deck equipment spare parts. For daily fishing trips, these needs for space are greatly reduced or not required. The size of the boat increases exponentially when changing from daily to multi-day fishing. The 2007 ILO Work in

Fishing Convention (C188) is the key international legal instrument establishing minimum standards for working and living conditions on board fishing vessels. It entered into force in 2017 and is gaining importance internationally. It would be important that multi-day fishing boats are designed to meet the minimum standards of this convention.

7.7.1 Fish carrying capacity

The vessel design should start with a calculation of the optimum fish hold capacity. The optimum size of the fish hold is the volume of space needed to carry the quantity of fish and ice, that, when the fish is sold will be able to pay all the fixed and variable costs and provide a profit for the owner. The net profit margins of fishing vessel operations by the new fishing vessels should be higher than 10 percent and the return on fixed tangible assets (ROFTA) and the return on investment (ROI) should also be above 10 percent to make sure that investment in the new vessels will be attractive. The fish hold capacity is determined after a cost benefit analysis and techno-economic performance review of the current fishing vessel operations.

7.7.2 Optimum fit for purpose

- The decision between multi-day and daily fishing will depend on the following factors:
- Distance to the offshore a-FADs and reliable access to fish within range of operation of vessel.
- Sea state in the offshore operating area and the amount of time that there are adverse conditions.
- Volume of the market and buying power of the population.
- Onshore storage and fish preservation facilities.
- Cultural acceptance to leave families and go to sea for multi-day fishing and whether the financial compensation is sufficient to encourage shifting from daily to multi-day.
- The difference in income between daily and multi-day offshore fishing.
- Using boats designed for daily fishing without modification to fish offshore exponentially increases safety risks.

7.7.3 Fishing gear and deck equipment

During the development of this document exchanges of emails and meetings were held with William Sokimi (SPC Master Fisherman), Ian Bertrand (SPC Coastal Fisheries Expert) and Michael Savins (FAO Chief Technical Adviser for the FishFAD activity). These discussions centred around fishing strategies of Pacific fishermen i.e. how do they cope with seasonality and adjust their fishing gears and operations to make the most of their fishing efforts. It was agreed by all that due to variability of tunas in their waters and the distribution and numbers of FADs that fishers will have to diversify their gears. FAD fishing is only one of the fishing methods that fishers use in their strategies to cope with seasonality, therefore, to maximise the profitability and diversity, new vessel designs should consider the following technical recommendations.

- Fishing strategies include seasonality, weather conditions, market considerations, target species, and access to fishing grounds.

- Fishers take into consideration many different methods and the activity needs to consider adapting the different methods according to seasonal changes, weather conditions and marketing.
- The design of any boat should consider incorporating the following gears to be used in addition to fishing around FADs.
    - Vertical longlines
    - Chumming / Palu Ahi
    - Trolling
    - Light fishing for small pelagic which can be used as bait
    - Deep water reels for deep bottom and midwater fishing.
    - Squid fishing jigging for diamond back and loligo squid
    - Live bait fishing
    - Pole & line / Dangler fishing
    - Not mentioned in the discussion
- "trap fishing" for deep demersal snapper, shrimps, and lobsters
- Very shallow light weight long lines
- Flying fish fishing using lights and scoop nets or gillnets as used in Tuvalu and Kiribati
- To accomplish the above, the multi-day boats need to have:
    - Available electrical or hydraulic power for reels, and other hauling equipment
    - Electrical power for running air pumps to keep bait alive.
    - Water pump capability for pole and line or dangler spray system
    - Power for lights to attract bait and other pelagic fish.
    - Hydraulic power for more powerful applications
    - Use of solar panels to charge batteries for communications, lighting, and safety.
    - Outrigger for trolling
- In addition, where applicable for boats less than 9 m in length, boats need to have emergency sail mechanisms to get to shore in case of engine failure. The sail and mast should be light and not an encumbrance, there is need for steering and leeboard.
- Installing twin inboard diesel engines for boats > 9 m should be considered. In case of engine problems, the second engine can bring the boat home. Also, one of the engines can be used to power fishing accessories such as hydraulic and water pumps.

7.8 Financial viability of vessels

Not only must fishing vessels be built of good quality materials using proper methods, appropriately sized for the weather conditions, have sufficient carrying capacity, count on good shore-based infrastructure, have navigation and safety equipment and operated by competent crews, but they must also be financially viable, covering all variable and fixed costs and turn a profit. The FAO has developed a methodology to assess the techno-economic performance of fishing vessels worldwide, which is being applied by many countries. The methodology has been discussed at an expert meeting held in India in 2019 (see report), validated in 2020 by FAO, (see technical paper). The methodology includes an analysis of costs and earnings structures, capital investments, technological state, and uses a range of financial and economic performance indicators. The methodology will be applied also in this activity, to assess scope for performance improvement.

Fishing trials with prototypes for small-scale fishing have been carried out in the Pacific previously. In Kiribati trials were carried out on a monohull, a catamaran and a trimaran to conduct longline fishing. In Western Samoa, the 12-meter Super Alia was tested with promising results. Unfortunately, none of these designs and their full-scale tests were continued after the trial period and none were scaled-up.

In Kiribati, a workshop and analytical report of a consultancy carried out by Master Fisherman David Itano and Economist Ray Greer recommended a modified skiff and a 15-meter monohull as possible designs to overcome the shortcomings in the designs tested in Kiribati. No construction of any 12-meter Super Alia took place after the trials carried out by William Sokimi; this was because the operators of Alias surmised that the Super Alia investment costs were too high for the fishery. This activity will apply and build on the lessons learnt from the Kiribati and Samoa experiences and will come up with six different options from which operators may choose to suit their financial situation and experiences.

7.9 Summary of technical, social, and economic considerations and recommendations

1. To provide the fish needed for domestic food security of growing Pacific Island populations in the face of continued degradation of coral reefs due to climate change, it will be necessary to fish further offshore around anchored FADs. A thorough assessment is needed of the suitability of existing vessels for this purpose, the scope for modifying the existing vessels to improve their suitability, and the need for new safer and more economically efficient vessels.
2. Based on preliminary analyses and expert knowledge of the region, it is evident that new designs are likely to be needed in several countries. , Two options for new vessel designs are proposed as follows:
    - Modify the designs of fishing vessel used for day trips into slightly larger vessels, which have greater carrying capacity, stability, freeboard, and installed buoyancy and are faster so that they can get offshore and back quickly and,
    - Develop new fishing vessel designs for multi-day trips, which will be a fully decked boat with fixed fish and ice storage holds to supply urban populations with tuna where small-scale fishers and the use of bycatch from industrial tuna fishing are not able to meet demand.

Due to the great diversity in the demographics, economies, and cultures of the participating countries, there is no single design is likely to fulfill the requirements of all countries. Instead, a range of vessel designs is needed which together correspond to the most important and common attributes required by Pacific SIDS fishers.

To overcome the challenges of economic viability, distance to fishing grounds, culture needs, economies of scale and access to finance, the following are proposed:

- One vessel design layout for daily trips in 3 different lengths
- One vessel design layout for multi day fishing trips in 3 different lengths

In this way, the countries and fishers would be able to choose between six different vessels sizes to meet their needs.

A key objective of this activity is to provide governments with the designs of safer vessels and cost / maintenance information so that they can seek bilateral support to provide the vessels needed to fish around nearshore and offshore FADs.

The lengths of the two prototypes and the locations of the full-scale tests will be determined during the implementation of the activity once the range of studies described above have been completed.

8. Feasibility

This section details the feasibility of implementing the activity from a technical and administrative point of view. It delves into the risk analysis and the management arrangements envisaged to achieve the results, considering stakeholder engagement, staffing, budget, and Terms of Reference.

8.1 Implementation Arrangements

8.1.1. Institutional Framework and Coordination

Conservation International (CI) is an Accredited Entity has prepared the Funding Proposal for the GCF regional tuna programme “Adapting tuna-dependent Pacific Island communities and economies to climate change”. This activity is a sub-activity of the overall GCFRTP. CI is responsible for the oversight of implementation of the GCFRTP and its sub-components. The management of the Programme will be the responsibility of the Executing Entity(ies).

FAO has been chosen as a partner to implement the vessel design activity, because of its long history and competence in fishing vessel design. The governments of the 14 participating countries in this activity are key partners and will provide overall governance and guidance, during implementation of the activity and sub activities.

The FAO Lead Technical Officer (LTO), SAP Fisheries and Aquaculture Officer, the CI Program Coordinator, SPC delegate to the GCFRTP and the GCF representative will meet on a regular basis, at least every 6 months, or *Ad Hoc* (as needed) to discuss progress on activity implementation.

The FAO through the activity Lead Consultant will organize regular coordination, information and guidance meetings and workshops with participating country focal points. The focal points will transmit the information and meeting documents to update their respective Ministers and Ministries.

The FAO as the main implementing partner for this activity will closely coordinate with CI and SPC, and participate in high level meetings, such as the SPC Heads of Fisheries Meetings, the Forum Fisheries Agency and WCPFC or other meetings, as appropriate where the progress and results of the activity is required to be presented to a wide high level regional audience. In most of these forums, FAO already has observer status, and is invited frequently, which also facilitates the coordination with the organizers of the meetings.

The FAO, in close coordination with CI and SPC will organize formal decision-making and guidance meetings and workshops to validate designs and adjust activity implementation timelines as required, and if necessary. FAO will also participate in CI hosted annual GCFRTP meetings.

8.1.2 Government Inputs

The activity participating governments have already assigned fisheries officers as focal points to the GCFRTP. These officers would be responsible for coordinating and implementing the sub activities in their countries.

Participating Governments will provide up-to-date information and data on their a-FAD fisheries as well as local access and transport to ports, landing sites and infrastructure to FAO international and national consultants. Where feasible, Governments can provide a working space for the staff and consultants of the FAO.

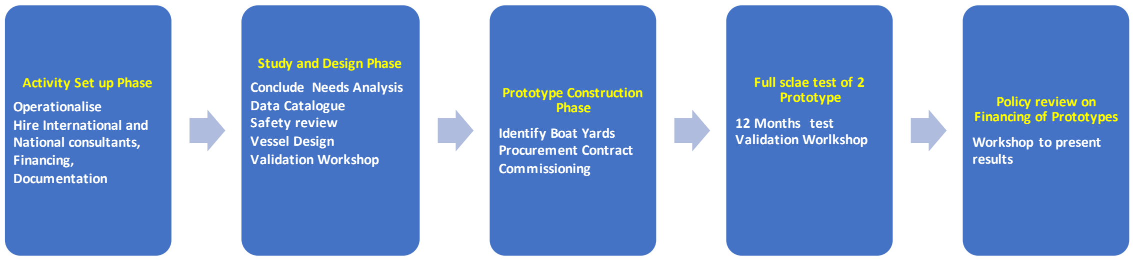
8.1.3 Activity Implementation Strategy

Five international technical consultants and 14 national consultants will be hired to implement the activity. Their Terms of Reference along with their terms of tenure are in Section 11 of this document. The consultants envisaged are as follows:
1 Lead Consultant/Economist
1 Fisheries Finance/Insurance Expert
1 Naval Architect
1 Master Fishermen
1 Maritime Lawyer/Safety Specialist
14 National consultants

FAO will also support the activity with in-house technical, operational and administrative assistance, which will be provided by the Subregional Office for the Pacific (SAP) and FAO headquarters. A part-time operations assistant will be hired by SAP to support the activity implementation, with a focus on arranging contracts and assisting with procurement matters.

Overall, the activity is set to be implemented in different phases with each subsequent phase building on the results of the preceding phase. A list of the contracts that will be signed is in Annex VI.

- The phases are as follows:



8.1.3.1 Phase 1 Implementation - Set Up

Upon signing the agreement with Executing Entity for the implementation of this activity, FAO will immediately set the activity in the FAO systems and begin the recruitment of the Lead Consultant/Economist, subsequently national consultants and key international consultants will also be hired. (See ToRs in Annex IX) Simultaneously, FAO will set up an internal taskforce to guide and monitor the activity progress to ensure adequate coordination and technical oversight. The first taskforce meeting will be held during this phase. FAO will also set up the operating base for the activity at its sub-regional office in Apia and prepare Letters of Agreement with each participating country to implement and facilitate wide participation in virtual meetings as well as physical attendance to two regional meetings planned during the activity lifespan. An inception workshop will also be held to plan the activities in accordance with the final approved budget.

8.1.3.2 Phase 2 Implementation - Study and design

This phase of the activity is focused on conducting detailed studies related to the development of two new boat designs - one for a multi-day boat and the other for a day boat. The designs will be prepared by a naval architect, models of the boats will be tested in a towing tank to establish correct stability, seakeeping behaviour, power needs and other criteria revealed during the study phase. Once these parameters have been optimised, the naval architect will prepare three different vessel lengths for each of the two designs. Making six designs overall. A regional workshop will be organized to present the designs and, if needed, integrate any modifications requested by the countries into the design specifications. It is anticipated that about 30 fishers, government and private sector representatives, and the banking sector will participate in this virtual regional meeting to comment on and validate the designs.

8.1.3.3 Phase 3 Implementation - Prototype construction

Phase 3 will be directed to the construction of one of the multi-day fishing boats, and one of the day fishing boats. These boats will be built by established boat-building companies in the region. The naval architect and one regional master fisherman will inspect the vessels during their construction to ensure that they will are built according to the specifications. To facilitate training of boat builders from participating countries, the activity will pay the costs to send up to 14 boat builders (1 from each country) to participate in construction of the vessels in the country of construction for a period of 30 days. This will allow boat builders from Pacific SIDS to exchange ideas, learn from each other, and garner new techniques.

It is envisaged that the boats will be constructed in the same country. The selection of the country will be based on the technical capacity, boat building experience and pricing of the construction, as well as the logistics involved. Preferably, the full-scale tests of the boat will take place in the same country to avoid the shipping costs to other countries. Once the vessels have been built, they will undergo sea trials before acceptance of delivery. A step-by-step guide and video will be prepared to record the construction process and technical details.

8.1.3.4 Phase 4 Implementation – Full scale test of 2 prototype vessels

Activities in Phase 4 will start during the implementation of Phase 3. This is needed to prepare all the equipment and contracting for the full-scale testing before the vessels are completed. It is anticipated that fishing companies based in the Pacific will manage and implement the full-scale trial of the two boats. The boats will not be given to individual fishermen. A "lease" type contract agreement will be made whereby the vessels are commercially fished and all the financial data and fish catches are recorded and a full report written, like the work done by SPC on the full-scale tests of the Super Alia in Samoa. Except that the test period will be 12 months. The Master Fisherman hired by the activity will monitor the trials and go to sea with the vessel as per the work plan. At the end of the trial, the catch data and vessel technical performance data will be prepared, analysed and presented to the countries at a virtual regional workshop.

8.1.3.5 Phase 5 Implementation

This phase will start during Phase 4 and focuses on financial, insurance tools and policies for financing and acquisition of new vessel designs as well as safety at sea improvements. This phase is crucial without the enabling instruments the new designs may not be easily acquired. Therefore, the activity will conduct a supply/demand assessment for financial and insurance services, and review the available tools and financing instruments, terms and conditions of loans, government plans, past and ongoing loan schemes and overall study of financial and insurance services provision to the fisheries sectors in most activity countries.

National consultants will be hired to collect the information (10 days each country). A finance and Insurance expert will analyse the information obtained from national consultants and prepare a report and presentation of the findings with recommendations including potential innovations to existing credit schemes and insurance products that have worked in other countries. The activity will organize a regional fisheries finance, investment and insurance workshop with Pacific SIDS to present and discuss the findings of the various studies. A key result will be a policy statement that Fisheries Departments may use to promote an enabling environment for finance and insurance products appropriate to Pacific SIDS. Finance service providers and insurers will be invited to participate in the information collection, analysis and workshop.

A maritime safety lawyer will be contracted to carry out a thorough review of existing (fishing) vessel safety regulations and prepare draft generic safety regulations for small fishing vessels that fish offshore on a-FADs. Participating countries can modify the generic regulations according to their requirements.

The details of activities of each phase can be found in the Logical Framework Annex II, Beneficiary Analysis Annex III, Activity Work Plan in Annex IV, and the proposed budget in Annex V.

During the implementation of the activity, there will be meetings and workshops to present the results of the designs, construction process, full-scale sea trials and policy discussions. As it is very expensive to organize face to face meeting with focal points and other stakeholders, it is envisaged that most meetings will be held virtually or in hybrid mode. At least two regional meetings will be held in person. Letters of Agreement will be prepared with each country for organizing the participation of local stakeholders and for organizing their travels to the regional meetings.

8.1.4 Activity oversight and responsibility during implementation

The overall responsibility for the successful implementation of this activity under the GCFRTP is The FAO Sub Regional Representative (SRR) who represents the Director General of FAO in the Pacific. FAO's Sub Regional Office (SAP) is in Apia, Samoa. The SRR is the budget holder of this activity and has full mandate to oversee and manage FAO's programme in the Pacific.

The Lead Technical Officer (LTO) of this activity will be provided by the Fishing Technology and Operations Team (NFIFO) in FAO Headquarters in Rome, Italy. The LTO will be technically supported by the sub-regional fisheries and aquaculture officer at the SAP office, as well as fisheries legislation officer of FAO's Development Law Service (LEGN), and a fisheries safety officer of NFIFO.

The SAP fisheries and aquaculture officer, who is responsible for management and development of FAO's fisheries programme in the Pacific, will ensure consistency of the activity with the programme and linkages with other ongoing and planned projects of FAO and partner organizations in the region. The LTO provides the overall technical oversight of the activity, consultants and ensures that the activity results are technically sound and meet international and FAO quality standards.

The NFIFO LTO and fishing safety officer will provide technical expertise on safety at sea, vessel design, equipment, construction, liaison with IMO and ILO on safety of fishing vessels, techno-economic performance review of fishing vessels, as well as fisheries finance and insurance support services. The LTO will also be responsible for the quality of the publications produced under this activity by consultants, as per normal course of his/her duties.

8.1 5 Management, Support and Operational Arrangements

The SRR is supported by program, procurement, human resources, program, operational and administrative staff at the SAP office in Apia. The activity introduces additional workload on the SAP staff and it is anticipated that funding will be required for an operations officer on a 10% basis to support the activity. This is included in the activity budget.

The activity will be Direct Implementation by FAO. All recruitments and procurements will be in accordance with FAO Manual Sections, rules and procedures, which are consistent with UN-wide established practices.

8.1.6 Risk Management

It is well recognized that there are wide geographical, demographic, social and cultural diversities in all the participating countries. The activity will share experiences and contribute to knowledge generation and management.

This activity aspires to develop 2 vessel designs and to build 2 only small vessels and conduct the full-scale fishing trials. The vessels will be designed and constructed under supervision of FAO technical staff, they will be safe, stable, and culturally acceptable and built under the safety recommendations developed by the FAO/ILO/IMO. They will be equipped with safety equipment and gears and operated by skilled and experienced skippers and crew during the 12-month trials. Given that commercial fishing is among the most dangerous occupations, and many accidents and fatalities happen in fishing operations, the strict adherence to safety recommendations and standards will be ensured. As needed, safety training will be provided for by the activity. Vessel and crew insurance services will be arranged for by FAO for the duration of the fishing trials.

Moreover, during vessel construction safety standards will be applied and safety gears will be used (e.g., protective clothing, glasses, gloves) to reduce chances of accidents. The boat yard contracted for the construction will be obliged to have adequate accident insurance cover.

In terms of environmental impact of the activity on fisheries resources, the vessels would fish for a period of 12 months and the volume of fish caught by the two vessels will not have any significant impact on the overall fish resources in the region. On the contrary, once the vessel designs are made available to the governments and other stakeholders and several boats are built in a country, a reduction of pressure on coral reef fish resources is expected, together with safer fishing operations. Small-scale fishers will increase the food security of their communities, adapt to climate change and contribute to mitigating climate change impacts.

The following risks have been identified with the scaling up of new vessel prototypes for fishing offshore:

Non or only partial technical acceptance of the new designs by governments and fishers due to wide financial, cultural, demographic, social and geographic diversity amongst participating countries. Low uptake of designs by the fishers.
Lack of trained qualified personnel for multi day vessels
Multi day designs not culturally acceptable
Reluctance to finance new designs as these were not tested in every in a particular country
Insufficient a-FADS installed in deep waters
Natural disasters or human error destroy prototypes and or interrupt fishing trials
Resurgence of COVID-19 or other Pandemics
Weak stakeholder engagement by some governments and fishers

The risk matrix in Annex VII proposes several mitigations from each of the above-mentioned risks. In addition, the mitigation owners are identified in the Matrix. There are some risks out of control of the activity such as the resurgence of a pandemic, some mitigations have been inserted as well.

9. ANNEXES

ANNEX I Report of Naval Architect for the development of Study 12, 'Structure of vessel design Needs Analysis for small-scale fishers operating around FADs'

Daniel Davy – Consultant Naval Architect
20 March 2023

Consultants Deliverables:

A. Preparation of the draft design format of catalogue of the motorised vessels currently used by small-scale FAD and other tuna fisheries in each of the participating countries.

B. Elements related to comprehensive technical assessments of the suitability of vessels used by small-scale fishers in each country.

C. Elements related to laws and regulations related to safety in the design, construction, and equipment of small fishing vessels.

D. Elements related to electrification of small vessels.

E. Elements related to IT tools for review of safety aspects to be included in the databases.

Introduction:

This report supports the preparation of the Study 12 document and provides inputs regarding the technical elements which relate to vessel design, operation and safety.

There are a wide variety of small-scale fishing vessels across the 14 Pacific Small Island Developing States (SIDS). The design and operation of these vessels varies according to location but there are technical elements which are common across all vessel types and designs. This report identifies these elements and describes their function and importance.
Future small-scale vessels will be required to operate safely and effectively around a-FADs, which may be a significant distance from shore. Many current designs are unlikely to be suitable for such operation regarding vessel and crew safety.
In order to understand current vessel designs and their suitability for extended fishing operations vessel surveys will need to be undertaken in each location. A draft format for a catalogue of information for motorised vessels used by small-scale FAD is included here.

Part A

Draft design format for catalogue of the motorised vessels

The elements of the catalogue are drawn from the consultant's experience in the study and design of small fishing vessels, typically under 12m in length. The sections itemised are based on the typical breakdown of the specification of a fishing vessel, and in particular the type of vessel under consideration in this study.
The draft catalogue is presented in Appendix A.

Part B

<u>Elements related to technical assessment of suitability of vessels.</u>

B1. General considerations

Fishing vessels operate in a wide range of sea areas and weather conditions and it is imperative that vessels are designed and built to operate safely in the worst conditions anticipated. In some cases the area of operation permitted by the Competent Authority is limited by the vessel's design, equipment and safety features. For example: "vessels working further than 12 nm from shore should carry a spare outboard motor…"

B2. Materials and strength

Fishing vessel should be constructed to suit weather and sea states in the sea areas – categories as defined by marine authorities – accessed by fishers. The construction should be by a proven method and make use of materials suitable for the marine environment. The dimensions of the material components (the scantlings) should be sized according to proven experience and/or regulatory requirements. Factors to consider include: vessel operating speed, type of engine and its horsepower, vessel weight, the weather, sea state and loads imposed on the hull and deck.

For strength and longevity the details of construction are important. This includes the scantlings, such as thickness and dimensions of components that make up the boat and the correct arrangement of the connections and fastenings that hold the materials together.
The weight of construction plays a part in the strength of the vessel but a heavy vessel may be difficult to haul out of the water. The availability of shipyard/workshop facilities will be important depending on the size and weight of the boat.

B3. Freeboard and stability

These factors are vital in the vessel's ability to withstand the actions of wind and waves at sea. Freeboard is the distance from waterline to the deck edge or gunwale if undecked. Low freeboard reduces the vessel's ability to keep water off the deck or out of the boat, this increases the possibility of swamping or capsize. Regulations often set limits on the minimum freeboard required, these vary but are generally in the region of 200 to 400 mm.

Stability is the ability of a vessel to withstand the heeling forces which arise from loads on board or the action of wind and sea. In addition, the location of the loads affects stability and in particular the heights of loads onboard, for example, heavy nets or fish boxes on the deck. Knowledge of the centre of gravity (C of G) of each load is very important.

During a fishing trip the stability and freeboard of the vessel change according to the loads on board and their position and it is important to be aware of how stability could change and anticipate the worst-case scenario. Typical load cases include: depart port with full fuel and stores, no fish; at fishing ground with full catch of fish; depart fishing ground with full catch and low fuel & stores.

Meeting stability requirements is complex and requires computer analysis, however, this is often not required for vessels under 12m in length. The situation will vary across different national marine authorities. Simplified stability assessment methods, suitable for <12m vessels, are available in various documents. The most basic are a rolling test and a heeling test, these are easy to conduct alongside a quay.

To improve stability various actions can be taken such as keeping loads low in the hull, including fuel tanks, fish/ice holds and taking care how fishing gear is loaded.

An additional factor related to stability is seaworthiness, this is the vessels response to wind and waves in terms of motions, this is important for crew safety whilst working. In many cases this capacity is achieved by vessel evolution over time and the experience of builders. New vessel designs should reflect good practice in this area. Testing of vessels to improve seakeeping can be achieved by model scale tests or using specialist software, then comparisons between old designs to new could be made.

In all discussions about the safety of the vessel's hull, watertight integrity must be considered. This is the ability of a vessel to keep water out of the hull, this is different for decked and un-decked designs. Decked vessels need a watertight deck and hatches and openings which are protected from water ingress. Un-decked designs need to have flotation or buoyancy spaces, these need to be either air/watertight or spaces filled with buoyant materials. All small vessels should be able to remain afloat when swamped, in this way they become a kind of life raft.

B4. Machinery

For most fishing vessels a motor or engine is the primary means of propulsion, using petrol or diesel fuel. This machinery fulfils the obvious task of moving the vessel in all anticipated sea states but also plays a significant role in safety – it can position the vessel for fishing operations, resist waves and get the vessel out of trouble, for example, on a lee shore.

Machinery should be installed correctly and fixed to adequately strong structural elements. Throughout the machinery's life it will need frequent maintenance and repair, this is ideally carried out at port but the fishers should anticipate that work and repairs may be needed at sea. Tools and spares should be carried on board.

Where vessels using outboard motors are undertaking longer trips or multi-day trips vessels should carry a spare or second motor which is well maintained and in good condition. This may be a smaller 'get-you-home motor' or a second motor of the same power as the main motor. With some maritime authorities taking a second motor to sea is required where the trip planned is over a certain distance, for example 20 nm from shore.

B5. Crew protection

Working on the deck can be dangerous and suitable safety features should be included to reduce the occurrence of injury or accidents to the crew. Features to be incorporated may include: bulwarks and/or railings of a sufficient height; handrails and grips; protection around moving parts and ropes and cables (although these are inevitably part of the vessels equipment).

In addition, various items of safety equipment for crews should be onboard according to distance offshore, including:

- Life raft
- Buoyant apparatus
- Lifejackets
- Lifebuoys
- Distress signals: 4 parachute rockets
- Distress signals: 2 handheld flares
- Capsize rope Whistle, mirror, and torch.

B6. Fishing operations

As discussed above fishing is dangerous and working on deck is full of hazards. Safe fishing operations rely on several factors, including: adequate training for crews; the skill and experience of crews; the layout of the deck and the safety features of the gear used. Familiarity with the vessel is important as this assists avoiding hazards. An example might be accidentally stepping inside a loop of warp which will endanger the crew. Overall, the layout and gear should be neat, logical and as crew friendly as possible.

B7. Navigation and communications

Vessels departing on fishing trips should have the ability to know their location and to be able to communicate with other vessels or a shore station.
Traditionally, fishers know their location by long experience and by sight of known features. However, where trips are made beyond known features and sight, then a better method is required, generally a GPS.

Communication methods are also necessary where longer trips are made. The simplest form is making a mobile phone call; however, this can be limited by range of signal and battery charging. When relying on the use of a mobile phone for communication, a method of charging the phone or carrying spare batteries is essential. For greater coverage, a VHF radio should be carried, again there are some difficulties relating to signal range and charging/batteries. In some States there may be a system of radio base stations on shore, with signal repeaters, which can increase transmission range. If not, vessels may be able to form a chain of communications to request assistance.

The range of a VHF radio is limited and perhaps no more than line of sight. The height of the transmitting and receiving aerials is significant - the higher the better. Range may be extended by a chain of vessel-to-vessel communications and where available land-based repeater stations.

B8. Crew accommodation

A vessel which is at sea for multi day trips will need to have suitable accommodation for the crew including cooking, sleeping and toilet facilities. On smaller vessels with limited space this can be difficult to achieve, however, consideration must be given to these items.

Part C

Elements related to laws and regulations related to safety of vessels.

C1. General

Fishing is considered one of the most hazardous occupations and many fishers are injured or die at sea because they work, many of these work on small vessels and can face dangerous conditions. To ensure that fishers work in a safe environment and operate vessels in safe manner it is essential that there are national rules and regulations which address the risks, and that these are enforced.

"Safety First" should be the ethos for all persons working on fishing vessels. In all events, safety must be given top priority. Most important: The vessel should remain afloat in all conditions or carry a buoyant apparatus. The vessel should have a means of emergency propulsion. And there should be some means of communication on the vessel. Proper safety measures will save lives, protect vessels from damage, prevent serious accidents and injuries, protect the environment, and contribute to profitable fisheries.

C2. Regulatory requirements

To make these regulations effective a registry of vessels and licences should be in operation. Vessels may be categorised to ensure regulations are applicable, categories include length, tonnage, engine power and other methods. Such categories may limit the area of operation for a vessel, including distance from safe haven, seasonal weather and other factors. A vessel category may also link to the required equipment to be carried, such as life jackets, buoyant apparatus, lifebuoy, flares, communications, navigation, radio, spare parts etc.

Before a new vessel is built it is useful to have a process for approval of the design and review of the drawings, in particular the construction. When the vessel is complete and equipped, a final inspection may be conducted by a competent authority before the vessel is approved to go to sea. It is important that the vessel is also registered and in some circumstances insurance could also be important.

To maintain the safety regime there is generally regular surveys covering the vessels integrity and the gear and equipment required. These surveys should cover the care, repair and maintenance of the vessel structure, and awareness of worn and damaged parts of the vessel. Checks of the presence onboard of required equipment are also undertaken including safety items and their function, such as pumps, radios etc. This work should be carried out by the relevant competent authority.

It may be that the hardest part of the regulation of fishing activities is building understanding and cooperation with the boatbuilders, operators and owners, and working together with them to implement the regulatory requirements. (There is no point in having a set of regulations which remains on the shelf!)

C3. Crew experience and training

For safe operation, documentation of the crews' training, experience and formal qualifications should be in place. In some cases, such qualifications affect the allowable vessel size which can operate and the areas of fishing permitted. Some marine authorities offer or encourage access to training courses to increase skills in the fishing fleet.

Part of the crews' work should be the care and repair of all parts the vessel and its equipment, this should be done regularly. This may require materials and spare parts which will need to be carried on board. A major component of a safe vessel is a well-maintained means of propulsion, generally an inboard or outboard motor. If a motor fails to function the crew and the vessel could be in a dangerous situation. Crews may also need training regarding fire safety and emergency procedures including managing a damaged, swamped or capsized vessel. Training on the IMO Colregs[9] will also be required in some countries, to know the rules of the road at sea.[10]

Training for crews of larger (>24m) fishing vessels may result from the International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F)[11]. Such trainees may find work on large or small vessels and in some cases training for small vessel crews may also be available.

Subjects covered could include:

- Understanding stability
- Fire safety, use of appliances
- Crew protection
- Lifesaving appliances
- Emergency procedures
- Radio communications, use of equipment
- Navigational equipment, use of equipment

Part D

<u>Elements related to electrification of small vessels</u>

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[9] https://www.imo.org/en/About/Conventions/Pages/COLREG.aspx

[10] The FAO eLearning course on the rules of the road at sea for small-scale fishers is available here in various languages: https://elearning.fao.org/course/view.php?id=704

[11] https://www.imo.org/en/ourwork/humanelement/pages/stcw-f-convention.aspx

D1. General

The availability of stored electricity and, if possible, a means of its generation onboard is essential for both working on deck and for safety at sea. The key elements are communication, navigation and lights. These elements are part of the safety equipment and will save lives.

D2. Electric energy, generation and storage

Most electrical equipment on small vessels is DC (direct current) and not AC (alternating current) so this will be the requirement. How is the electrical energy generated? This can be achieved in several ways generally: alternators, solar panels, wind turbines or generators (fixed or portable), or a combination of sources.

Any engine which has an electric start is likely to have the capacity to generate electricity via stator or alternator (which includes a voltage regulator rectifier). Many outboard motors are fitted with an alternator which does not require a rectifier.
Solar panels are becoming cheaper and easier to install where facilities are off grid. These systems are small scale and found on small homes, vans, schools etc. For example, a 1.6m^2, solar panel could produce around 0.37 kWp** which can charge two 12V, 110Ah batteries. Navigation lights on a small boat might draw around 30W and a VHF radio could also be used for emergencies.

(Note** kWp stands for kilowatt 'peak' power output of a system)
The energy generated needs to be stored in batteries with sufficient capacity so that consumers can be powered when generating is not occurring. Often, service batteries and engine starting batteries are separate units.

D3. Use of electric energy

Communication on board is essential on longer trips. This allows contact with other vessels whereby information about sea state, weather and fishing can be shared. And in case of an emergency at sea, effective communication can improve safety allowing messages to be passed regarding the position of the affected vessel and the nature of the problem. Ultimately a rescue may be possible.

In addition, the position of the vessel needs to be known, many seafarers use local knowledge or dead reckoning to do this, but increasingly using GPS.

Lighting on board is also essential on longer trips. International regulations (IMO Colregs) require the use of fixed navigation lights on the vessel. For safe working on deck at night, the vessel will need sufficient lights to illuminate the working areas. Lighting reliant on burning oil or gas should not be used.

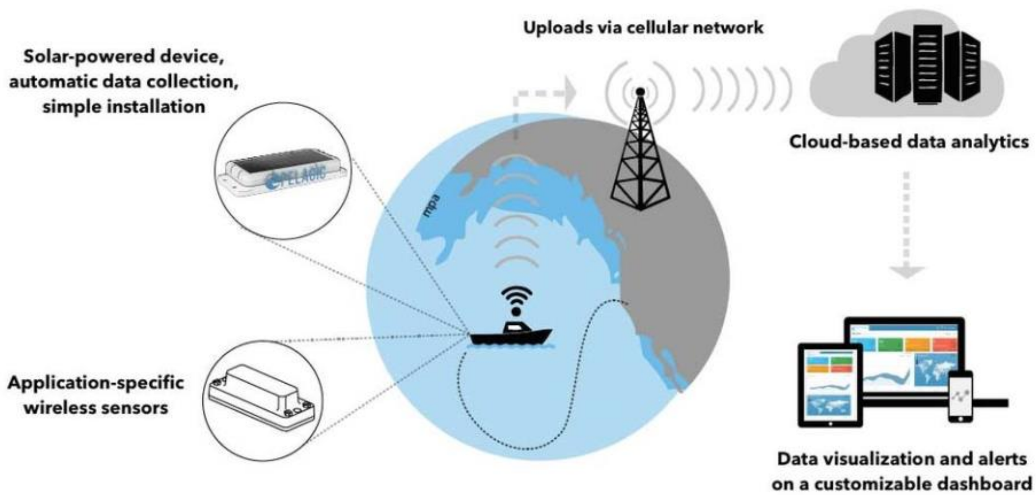
Emergency lights including search lights and torches should be supported by charging onboard. As should the charging of mobile phones and other devices. See next section.

Part E

<u>Elements related to IT tools for safety</u>

Information technology and digital systems can contribute to safety at sea as well as enhancing and monitoring fishing activities. Even small vessels can be fitted with tracking/vessel monitoring systems (VMS) to transmit the location of vessels. Electronic catch reporting tools could be valuable to both authorities and other stakeholders. The basic components for some systems are illustrated below:

Ruggedized AIS transceivers with specialist VMS functionality for all vessel types and sizes

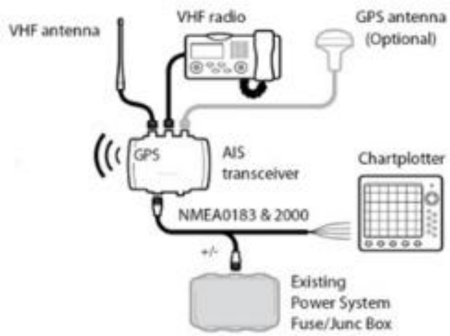


Such systems are compact, easy to install in small vessels and can be solar powered. They can make use of cellular data networks and provide records and positions frequently, perhaps hourly.

To achieve this, the vessel would need to have a reliable power source, a tracking device (AIS), a GPS and a mobile phone or VHF. A tablet or similar device would be needed for data entry, note that some AIS units can, with WiFi & Bluetooth connectivity, stream AIS data to smartphones and tablets onboard.

Fisheries authorities could record the movement of fishing vessels and establish databases for future monitoring and potentially control access to certain areas (marine conservation zones etc). Recording the species caught can assist fishers to better locate valuable fishing resources, evaluate fishing effort, and enhance safety at sea.

An AIS system like the illustration below can provide the tracking requirements but also enhance safety of the crew and vessel. For example, impending bad weather, calling for assistance in case of accident or loss of power and man overboard locating etc.



Such systems could be relatively inexpensive, perhaps $200 to $500.

Appendix A

Draft format catalogue of information for motorised vessels used by small-scale FAD and other tuna fisheries in each of the participating countries.

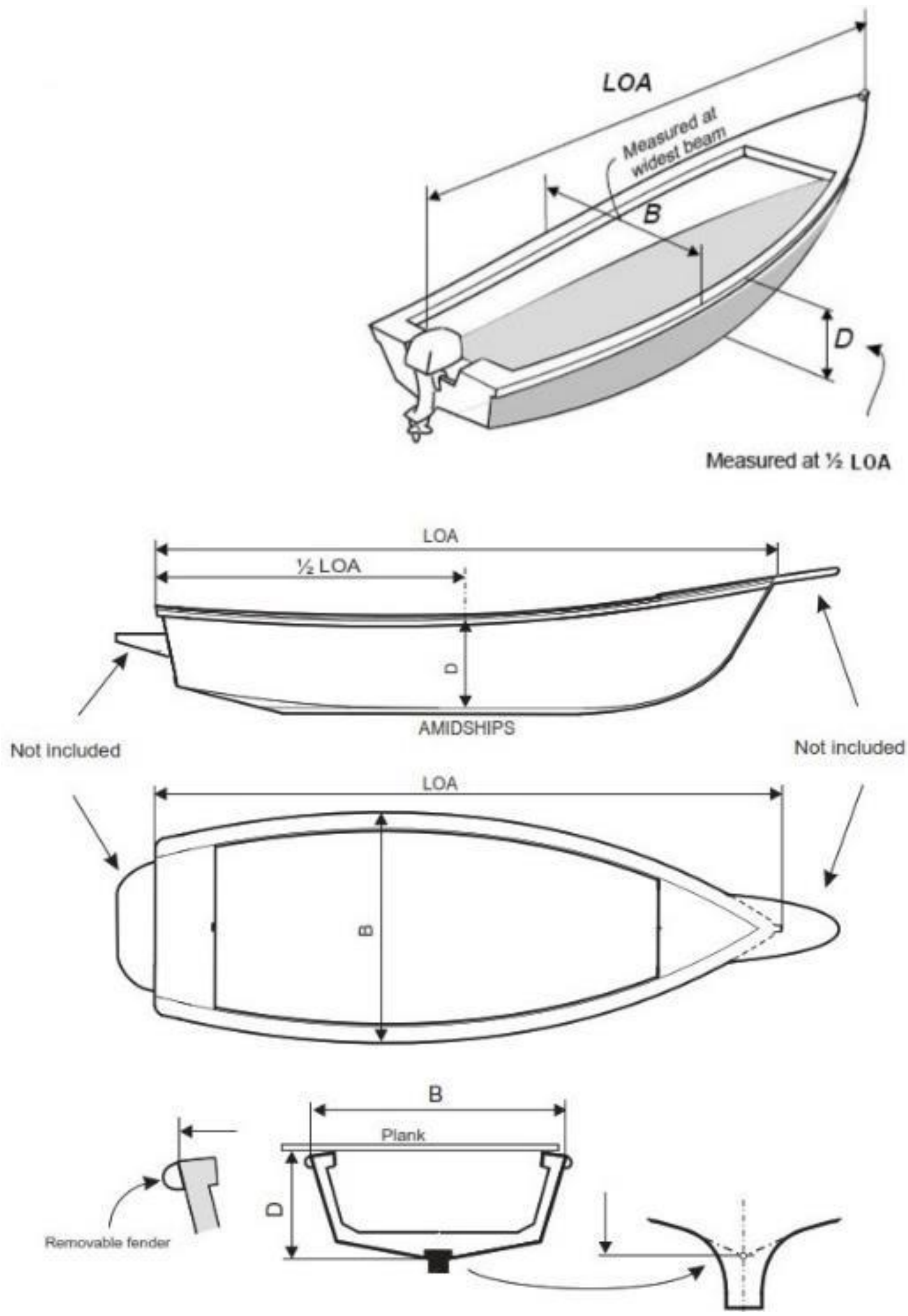
Section 1 – General	
Country	
Local Region	
Vessel type	
Vessel local name/ type	

Photograph 1		
Photograph 2		

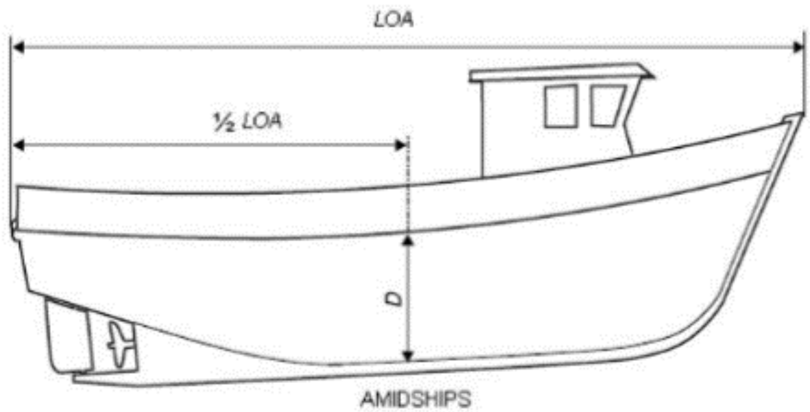
Section 2 – Vessel type		
TYPE	ANSWER & COMMENTS	NOTES
Mono hull		
Catamaran		
Proa/ Outrigger		
Trimaran		
Other		
V bottom hull		
Flat bottom hull		
Round bottom hull		
Buoyancy provided		To ensure vessel unsinkable
Foam material		
Closed airtight spaces		
Other material		Plastic bottles, floats
Open (no deck)		
Partial deck		
Fully decked		
Normal duration of fishing trip. Hours or days		
Number of crew		
Shelter or small cabin		Less than standing height
Full cabin		Sufficient standing height
Cooking arrangements		
Sleeping arrangements		
Washing and toilet arrangements		

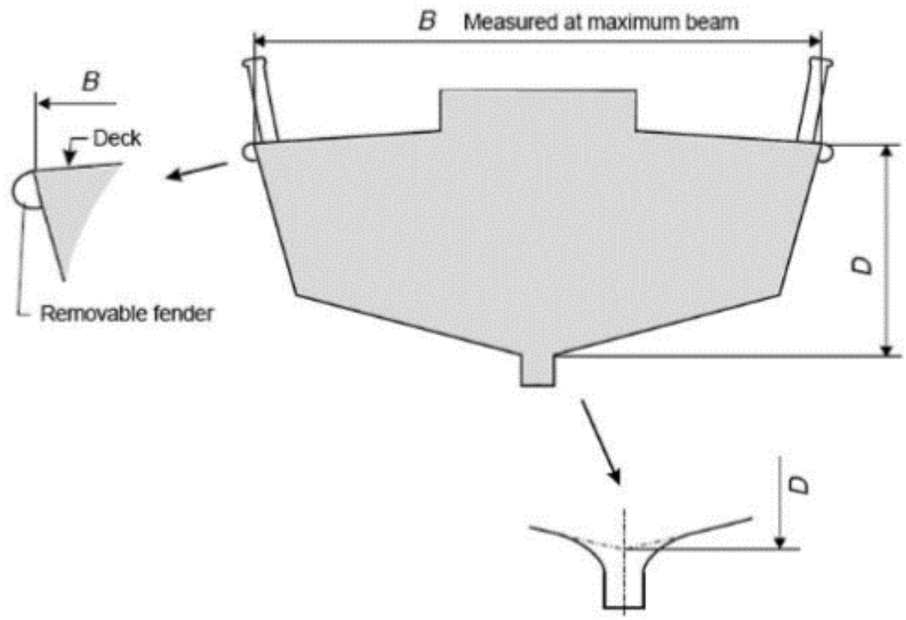
Section 3 – Vessel dimensions		
ITEM	ANSWER & COMMENTS	NOTES
Length, max, m		See section 4
Length, on waterline, m		
Beam, max, m		As above
Depth, m		Keel to edge of deck at middle of boat
CUBIC number		See section 6
Ice box fitted		
Ice box capacity		Weight or volume
Fish box/ storage fitted		Dimensions
Insulation used		

Section 4 – Measure open vessels

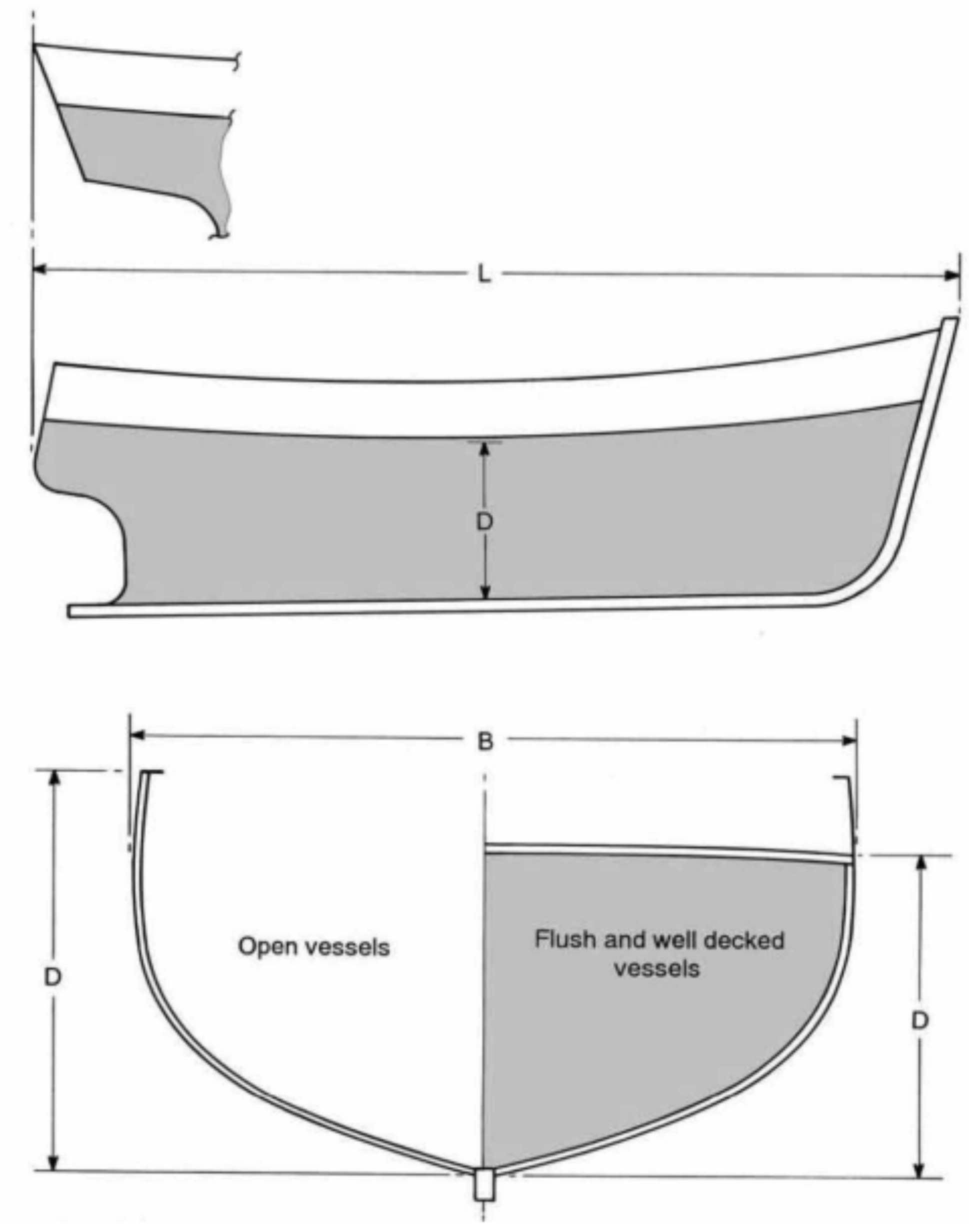


Section 5 – Measure decked vessels





Section 6 – Calculate cubic number



LOA x *B* x *D* = Cubic numeral (CuNo)

Section 7 – Vessel condition, use and ownership		
CONDITION	ANSWER & COMMENTS	NOTES
Year vessel built		
Good working condition		
Poor working condition		
Under repair		
Broken in need of repair		
Broken end of life		
In use frequently		
In use occasionally		
Not in use		
Vessel certified for use		Maritime authority approval
Vessel registered, yes/no		
Vessel has markings and identification		Record markings and identification
Vessel owner operated		
Vessel fisher operated, not owned		
Vessel hired by operator		
Other operational arrangements		

Section 8 – Vessel construction		
CONSTRUCTION	ANSWER & COMMENTS	NOTES
Solid wood		Type of Wood
Solid wood & plywood		Type of wood Type of plywood
Plywood		Type of plywood
Dugout		Tree species
Other wood construction		
Fastened with screws		
Fastened with nails		
Fastening material		Steel, bronze, galvanised etc
GRP		
GRP & wood		Type of wood
GRP & plywood		Type of plywood
Aluminium		
Steel		

Other materials		

Section 9 – Vessel propulsion		
EQUIPMENT	ANSWER & COMMENTS	NOTES
Outboard motor single		2 stroke or 4 stroke
Power, hp or kW		
Outboard motor twin		2 stroke or 4 stroke
Power, hp or kW		
Inboard motor		Gasoline or diesel
Power, hp or kW		
Normal fuel load, litres		
Normal operating range, nm		
Batteries fitted		Navigation lights and radios Number/capacity & Voltage
Solar Panels		Watts
Engine alternator		Amps and voltage
Other propulsion method e.g. Sail		
Paddles or Oars carried		
(Emergency) Sail carried		Size of sail m2
Tools carried		For motor and other equipment onboard

Section 10 – Vessel fishing gear[12]		
ITEM	ANSWER & COMMENTS	NOTES
Longline	Hydraulic or Engine powered	
Longline, hand hauled		
Length of mainline, m or km		
Number of hooks		
Hooks and Lines		
Handlines		
Mechanised lines		
Vertical lines		
Trolling lines		
Nets		
Gillnets		

[12] Please see for gear types and characteristics: https://www.fao.org/documents/card/en/c/cb4966en

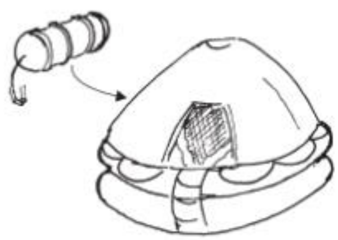
Squid Jigging		
Traps and Pots		
Surrounding nets		
Diving		

Section 11 – Safety equipment		
ITEM	ANSWER & COMMENTS	NOTES
Approved safety grab bag carried on vessel		
Lifejackets carries, number		
Life raft or Buoyant apparatus, number		
Lifebuoys with line, number		
Capsize rope		
Torch		
Emergency flares		
Mirror & whistle		
Paddles		
Fire extinguisher, number		
Marine compass		
First aid kit		
Bailer		
Drinking water carried, litres		
Radar reflector		

All boats should carry life jackets for every crew member, and should be stored in an accessible place. Small boats without possibility for storage of life jackets should satisfy the requirement for flotation in a flooded condition.

LIFE BUOY

One per boat, stored on the port or starboard side of the deckhouse.



INFLATABLE LIFE RAFT

Unfortunately, expensive.
Must be checked every year.

BUOYANT APPARATUS (LIFE FLOAT) WITH MARKING

Can be made locally, but does not offer the crew much protection.

Section 12 – Electronic communications		
ITEM	ANSWER & COMMENTS	NOTES
VHF radio, fixed		
VHF radio, handheld		
GPS		
Mobile phone		State normal Range
Navigation lights		
Fish finder		
EPIRB		

Section 13 – Deck equipment		
ITEM	ANSWER & COMMENTS	NOTES
Anchor and		Weight
Chain or rope		Length
(Bilge) Pumps fitted		Type and number
Railings and hand holds fitted		To ensure safe working
Hydraulic line drum/winch		

Section 14 – Definitions	
Colregs	Collision Regulations
Cubic Numeral (CUNO)	A measurement of the volume and size of the vessel, see section 6 for details.
EPIRB	***Emergency Position Indicating Radio Beacon***
GRP	Glass reinforced plastic, usually made from polyester resin and glass fibres
GPS	Global position system
Capsize rope	Fitted to the vessel to allow persons to hold on to the vessel in the event of a capsize
VMS	Vessel monitoring system

GCF REGIONAL TUNA PROGRAMME

"Adapting tuna-dependent Pacific Island communities and economies to climate change".

Study 12

TECHNICAL REPORT TO SUPPORT STUDY 12

Daniel Davy – Consultant Naval Architect – Revision B - 12 May 2023

<u>Consultants Deliverable #2:</u>

Short report related to Inputs into the 2nd and 3rd Progress report in matters related to the design phase, and vessel prototype construction and testing phase

A. Requirements for technically appropriate vessel design, including the technical specifications details that the project will require.

B. Requirements needed for professional technical assessments of existing motorised FAD fishing vessels and recommendations for improvements and modifications to basic safety, fuel-efficiency, emissions, and storage criteria.

C. List of requirements to be considered for the construction and full-scale testing of the most appropriate vessel designs agreed to after consultations with national fisheries agencies.

Part A

<u>Requirements for appropriate vessel design and specifications</u>

The designs for new vessels will need to address a number of factors in order to fulfil the essential requirements. The first is to prepare a design specification which sets out the required functions of the vessel and main parameters – dimensions, areas, volumes and capacities. This will not necessarily define a vessel design but will define an overview of what is required.

A fundamental parameter to consider is the vessel's capacity and volume, this represents the space available for the storage of fish, ice, gears, crew, machinery, fuel and water. Capacity and volume defines the ability of a vessel to land fish and to ensure economic success. The hull form (design) will need to specify capacity and volume, as well as achieving sufficient safety, stability and freeboard, and the performance and range needed to access the fishing grounds envisaged. The operating speed and range are linked to vessel capacity because sufficient fuel must be carried to complete a fishing trip to preferred fishing grounds. This is balanced against the power and fuel consumption of the motors and thus the vessel's overall weight.

The material used for construction of the vessel must be decided at an early stage and this choice will also have a significant effect on the weight of the vessel. The choice of material will be based on a number of factors, including: cost, availability, strength, longevity and the experience of builders in the region.

In terms of developing vessel design specifications, the key items to include are:

- Dimensions and capacity – ice, fish, fuel, water and stores
- Hull form and type – single, catamaran, multi-hull
- Materials and construction method – GRP, ply, timber, aluminium
- Machinery type and power – inboard, outboard
- Systems – fuel, water, pumping, electrical and communications
- Deck area, gear and storage
- Mooring, towing, and anchoring features
- Crew accommodation and facilities (vessel for multi-day trips only)
- Safety features and equipment – lifesaving, flares, lighting, etc.

Part B

Technical assessments of existing fishing vessels and recommendations for improvements

The approach for a technical assessment of the suitability of existing fishing vessels for fishing safely around FADs can be based around the specification for a newbuild vessel. The key elements of a technical assessment are shown in Part A above but should also consider the catalogued information provided in Annex A of the report submitted as Deliverable 1. The technical assessments of existing vessels should therefore focus on three linked areas:

1) The design, form, shape and suitability of the vessel for the fishing activities undertaken. Critical factors are appropriate stability, freeboard, buoyancy and capacity.

2) The condition and integrity of the structural elements of the vessel – the hull, deck and equipment. Assessing damage to the structures and the repairs made over the vessel's life will require special attention.

3) The safety features and safety equipment carried onboard and, importantly, the condition and functionality of these items. There may well be vessels where some required items are not onboard.

In all areas, there will be opportunities to improve the vessel's function and safety and whilst the hull form is largely fixed it is highly likely that there will be aspects of the existing vessel designs where improvements can be made. These could include:

1) The incorporation of insulated fish/ice boxes to improve fish quality (the catch will spoil rapidly if not iced properly). Storage of the catch is also important because it can dictate the value of the fish at landing.

2) The structure of fishing vessels is prone to damage caused by gear handling, berthing alongside wharves and other vessels, and general wear and tear. The damaged parts can be repaired and, in some cases, the repairs may improve the original construction.

3) Installation of navigation lights to improve safety at night and, if available, the energy needed can be provided by low-cost solar panels.

4) If the vessel's stability is not in line with requirements it may be possible to improve this by reducing/ removing weights added during the vessel's life. Where freeboard is insufficient it may be possible to add a cockpit coaming at the sides, and at the transom were swamping of a motor or water ingress can be serious. Ref: https://www.fao.org/3/i3108e/i3108e00.htm

5) Ensuring or improving the condition and quantity of buoyancy spaces (or foam) to ensure that, when swamped, the vessel remains afloat and level with crew onboard.

6) Ensure that sufficient tools and spare parts – especially for the motor – are onboard and in good condition.

7) Ensure that the required safety items are carried, to include at least lifejackets, flares, pump/bailer.

8) In many vessels used for Multi-day trips, the crew's accommodation is not adequate and some modifications can be made to improve cooking facilities and sleeping arrangements.

Part C

Requirements for the construction and testing of the vessel designs

Depending on the location of construction, the procurement of materials and tools needs to be carefully considered given that many of these items may have to be imported/shipped. This can be an expensive and time-consuming process and will need planning. In the same way, procurement and delivery of large items, such as motors, gearboxes and pumps, etc., can have a long lead time and need to be planned in a timely manner.

The availability of a workshop is essential for most types of vessel construction because it enables activities to be carried out under a fixed roof and preferably in an enclosed space. A dry environment and cleanliness in the workshop are important for the health of workers, and to prevent the contamination of materials. Materials should also be stored in the appropriate way. Timber and plywood need to be stored in a dry environment. Other building materials, such as resins, need to be stored carefully in closed containers and at the correct temperatures away from heat ignition sources and sunlight. The workshop will preferably have electrical power by grid or generator to allow the use of power tools, which improves building accuracy and speed. In addition, suitable hand tools will also be required.

The process of building a fishing vessel requires inputs from skilled boatbuilders with experience and training in working with the chosen construction material. Alternatively, where the desired skills are not available, training and supervision will be required to construct a strong and seaworthy vessel.

Testing of the vessels on completion is important especially where a new design (first of class) is being launched. Best practice would be to write a 'trials document' before launching, this ensures that all important aspects of construction are tested. The trial should include the following key test and procedures:

- Before launching, check that all items are correctly installed and secured.
- At launch, test all the auxiliary systems, for example, pumps and electrical items (alongside a wharf or jetty).
- Also, alongside a wharf, check that the engine(s) start and run correctly at an initially low rpm.
- Starting low, run the vessel at progressively increasing speeds. Observe any vibrations, noises, and any other unexpected events. Generally, this should be done with a light load and with a full load.
- Check the operation of the vessel, including steering and maneuvering, in a moderate sea state. Observe any unexpected events and any unsatisfactory performance.

- Where required or simply as good practice, a measure of the freeboard and stability of the vessels should be established. Methods for this may be found in various documents including: https://www.fao.org/3/i3108e/i3108e00.htm
- A 'swamp test' should be carried out in accordance with a recognized (approved) method.
- Photography of all aspects of the trial for record keeping.

ANNEX II Logical Framework

IMPACT	Food security in Pacific SIDS has increased			
OUTCOME	**Activity Outcome** fishers that fish on anchored FADs (a-FAD) will have access to safe, proven, economically viable and appropriate vessel designs which allow them to fish further offshore and in safer ways			
Indicator	**Baseline**	**Target**	**Means of Verification**	**Assumptions**
Activity implementation arrangements have been created	0	1	Inception Report Steering Committee report	Activity starts on time
By end of 2nd Quarter after project start up Needs assessment of suitability of existing small vessels for fishing around FADs (based on criteria listed in Annex 1) 2 vessel designs of 6 length categories of prototype fishing vessels capable of fishing safely on near and offshore a-FADs are provided to Pacific SIDS	0	2 designs 3 length categories / design	Needs Assessment Report of national consultants, Naval Architects and Economist Vessel General Arrangement Plans, lines plans, towing and seakeeping test results Model vessels (scale 1:6 or 1:7) tested in towing tanks Vessel Specifications Activity reports	Fisheries Departments and stakeholders cooperate and provide logistical and administrative support to the activity Fish resources remain stable
By end of 3rd quarter of second year after project start up 2 (1 x open daily and 1 x multi-day) fishing vessels are	0	2	Contract with a boat builder in one of the activity countries. 2 prototype fishing vessels	Boat builder can source the materials required for the prototype vessels

built and tested in operation for one year			built up to international standards Master Fisherman report Activity report Country Report published by FAO/CI and SPC	Competent Master fishermen recruited to conduct sea trials
By end of 4th quarter of third year after project start up Cost benefit analyses and technoeconomic performance reviews of the prototype vessels and traditional vessels are made available to activity countries	0	2	Cost benefit analysis report Techno-economic performance report, comparing current vessel performances with those of the prototype vessels	Fishers and fishing vessel owners contribute to the data collection efforts. Competent master fisherman and good record keeping by the department where the tests are conducted.
By 2nd Quarter of fourth year after project start up. Participating countries have draft enabling policy, legislative and financing frameworks for the construction and operations of safe, energy efficient and economically viable fishing vessels for the Pacific SIDS	0	At least 3 countries	Draft vessel safety regulations Draft vessel construction guidelines Draft finance and insurance policies and strategies for fisheries	During full scale tests the prototype vessels prove to be safer and economically viable

OUTPUT 1	*Cost effective activity management*	*Responsibility*
SUB-ACTIVITIES for achieving output 1		
Number	**Description**	
1.1	Recruitment of lead consultant/coordinator	FAO LTO
1.2	Recruitment of technical expertise and contracting of service providers/ companies, using UN procurement and recruitment processes	FAO LTO FAO Budget Holder Consultant/Coordinator
1.3	Review and update work plan, Virtual workshop with GCFRTP focal points	Consultant/Coordinator
1.4	1st. meeting of activity Task force / Steering Committee	GCFRTP CI / FAO Consultant/Coordinator
1.5	Preparation of activity inception meeting	Consultant/Coordinator
1.6	Inception report with updated work plan	Consultant/Coordinator
1.7	Activity management office established at the Sub regional for office for the Pacific islands in Samoa (SAP). A PMU will be established and an internal task force will monitor implementation	FAO LTO FAO Budget Holder Consultant/Coordinator
1.8	Establish an FAO activity task force to monitor activity implementation	FAO Budget Holder
1.9	Semi-annual progress reports preparation	Consultant/Coordinator FAO LTO
1.10	Mid-term external review and final activity evaluation	FAO Budget Holder/FAO LTO/ review consultants
1.11	Financial and technical closure of activity	FAO LTO/ FAO Budget Holder

OUTPUT 2	***2 designs of prototype fishing vessels with 6 different lengths have been prepared and accepted by the Fisheries Departments, fishers and boat owners***	***Responsibility***
SUB-ACTIVITIES for achieving output 2		
Number	**Description**	
2.1	Conduct detailed country technical, socio economic and environmental needs analysis[13] studies to update survey and consult with stakeholders to verify their needs to best determine common attributes of importance to be included in the designs. Prepare a catalogue of existing vessel designs in participating	Consultant/coordinator Naval Architect Master Fisherman 14 National Consultants

[13] See overview description on page

OUTPUT 2	***2 designs of prototype fishing vessels with 6 different lengths have been prepared and accepted by the Fisheries Departments, fishers and boat owners***	***Responsibility***
SUB-ACTIVITIES for achieving output 2		
Number	**Description**	
	countries. The template for the catalogue is in Annex IX.	
2.2	Naval Architect prepares 2 designs with 6 different lengths (3 per design)	Naval Architect
2.3	Validation workshop to present designs, receive feedback and decision taken as to best place to undertake trials.	Consultant/coordinator Naval Architect Master Fisherman
2.4	Build models of the selected designs and arrange for tow tank and seakeeping tests	FAO LTO/Naval architect and tow tank facility
2.5	Prepare Boat Builder and fisheries infrastructure data base	Consultant/coordinator

OUTPUT 3	***Two prototype fishing vessels constructed- in line with international construction and safety standards and guidelines***	***Responsibility***
SUB-ACTIVITIES for achieving output 3		
Number	**Description**	
3.1	Finalise identification of Boat Building Companies. Finalise technical specifications Prepare tender documents and organize the procurement	Consultant/Coordinator Naval Architect & Master Fisherman FAO LTO & FAO procurement
3.2	Contracting of Boat Building Company to build prototypes (only one company to build the three boats) 1 Multi day a d 2 Day fishing	FAO LTO FAO Procurement
3.3	Training of boat builders from each country at the contracted shipyard	Consultant/Coordinator FAO LTO FAO Procurement Country focal points to ID Builders
3.4	Supervision of construction and ensure safety requirement meet best practice standards Supervision reports	Naval Architect & Master Fisherman
3.5	Prepare a step-by-step video and written guidelines for the construction process to build the prototypes	Naval Architect and Videographer company FAO procurement

OUTPUT 3	***Two prototype fishing vessels constructed- in line with international construction and safety standards and guidelines***	***Responsibility***
SUB-ACTIVITIES for achieving output 3		
Number	**Description**	
3.6	Preparation of specifications of fishing gears, engines, outfitting, navigation and safety equipment	Master Fisherman, FAO LTO & FAO Procurement
3.7	Conduct sea trials, handover of the boats to FAO and demonstrate effectiveness of safety equipment and compliance with regulations in place.	Naval Architect Master Fisherman
3.8	Organize a regional workshop to present the designs, step by step video about the construction, construction guidelines and the constructed prototype vessels	Naval Architect Master Fisherman FAO LTO

OUTPUT 4	***Two new fishing vessel prototypes successfully tested in commercial fishing operations***	***Responsibility***
SUB-ACTIVITIES for achieving output 4		
Number	**Description**	
4.1	Identify and select experienced professional fishers/boat owners for the (one-year) trails of the prototype vessels	Consultant/Coordinator (with inputs from Fisheries Departments)
4.2	Develop the methodology for the techno-economic performance assessment study of Pacific islands fishing vessel types.	Consultant/coordinator FAO LTO
4.3	Carry out a techno-economic performance assessment study of at least 6 Pacific Island fishing vessel types	Consultant/coordinator National consultants FAO LTO
4.4	Prepare and conclude lease contracts with commercial fishers/boat owners for the two prototype vessels (including arrangements for maintenance, repair, insurance, sea trial days and data collection and reporting)	FAO LTO Consultant/Coordinator
4.5	Prepare Letters of Agreement with two Departments of Fisheries for supervision of the sea trials and related reporting.	LTO and Consultant/Coordinator
4.6	Participate in sea trials of Multi day and daily fishing vessels, provide fishing	Master Fisherman

OUTPUT 4	***Two new fishing vessel prototypes successfully tested in commercial fishing operations***	***Responsibility***
SUB-ACTIVITIES for achieving output 4		
Number	**Description**	
	gear/technology/operational advice and demonstrate effectiveness of safety equipment, monitor compliance with regulations in place, and report on the trials.	
4.7	Arrange for continuation of protype vessel lease contracts, transfer to other fishers/owners for data collection/trails, or hand over to Fisheries Departments.	LTO and Consultant/Coordinator
4.8	Organize a regional workshop to present the results of the full-scale trials and the techno-economic performance assessment study,	LTO and Consultant/Coordinator Master Fisherman

OUTPUT 5	**Enabling policy, legislative and financing frameworks for the construction and operations of safe, energy efficient and economically viable fishing vessels for the Pacific SIDS**	***Responsibility***
SUB-ACTIVITIES for achieving output 5		
Number	**Description**	
5.1	Conduct a review of fisheries and maritime policies, legislation and management measures in activity countries relevant and RFBs/RFMOs that affect fishing vessel design, construction and operations	Maritime/fisheries legal expert FAO LEGN
5.2	Review of safety at sea legal aspects and prepare draft fishing safety regulations for various types of fishing vessels, for incorporation in national legislation of Pacific SIDS	Maritime/fisheries legal expert FAO LEGN
5.3	Desk review of financial policies and legislation and their effects on fishing fleet development in the activity countries	Finance/ insurance expert FAO LTO
5.4	Conduct a supply/demand assessment for financial and insurance services, and review available tools and financing instruments, terms and conditions of loans, government plans, past and	FAO LTO Consultant/coordinator Financial/insurance services expert National Consultants

OUTPUT 5	**Enabling policy, legislative and financing frameworks for the construction and operations of safe, energy efficient and economically viable fishing vessels for the Pacific SIDS**	***Responsibility***
SUB-ACTIVITIES for achieving output 5		
Number	**Description**	
	ongoing loan schemes and overall study of financial and insurance services provision to the fisheries sectors in most activity countries.	
5.5	Organize a regional fisheries finance and insurance workshop with Pacific SIDS to discuss the findings of the various studies and prepare policy recommendations and strategies.	FAO LTO Financial/insurance services expert Consultant/Coordinator GCFRTP/SPC

ANNEX III Beneficiary analysis

Beneficiary Analysis

The following is a preliminary SWOC analysis of the various beneficiaries that have be identified. On activity inception one of the first tasks will be to review, update and expand this stakeholder. The objective of this preliminary stakeholder analysis is to reveal the connectivity between different stakeholders. This analysis also facilitates the activity design and shows the way to increase strengths, decrease weaknesses and mitigate challenges within the activity framework.

SWOC Stakeholder Analysis

Stakeholder	Strengths	Weaknesses	Opportunities	Challenges
Fishers	• Competent handling of small boats • Professionalism and dedicated to catch Fish	Generally Low education No skills on larger boats Weak safety culture Lack of knowledge on safety Lack of safety equipment Economic dependence on vessel owners	Training and certification of fishers Build skills Professionalize the sector	The education levels of some small-scale fishers are insufficient to pass the training requirements for multi day vessels leading to reduced numbers of fishers qualifying to operate multi day boats Requires long term strategy Training given is focused on merchant ships
Boat Owners	Business management Have financial stake Fishing Knowledgeable	May not be interested to invest more money	Increase investment if right policies implemented Banking system gains confidence to provide loans	Lack of enabling policy, management and regulatory environment to support new designs. Commercial banks have bad

Stakeholder	Strengths	Weaknesses	Opportunities	Challenges
			Access to vessel insurance increases availability of credit/loans	experiences with repayment of loans in sector and continued reluctance to finance boats
Boat Builders	Build traditional boats Skilled and experienced	Lack of skills in modern boat building Lack of tools Lack of material for boat construction	Training in boat building Integrate boat building into maritime school curriculums Provision of tools Improve safety standards of boats	No enabling environment to finance boats Competition from imported boats Training in boat building needs long term financing commitments to be sustainable albeit an opportunity
Fisheries Departments	Committed to improvement of the fisheries sector Power to legislate Policy implementation Funding opportunities available through bilateral and multilateral activitys Most countries have maritime training schools	No budget for boat building Lack of boat building technical personnel Difficulty in effectively implementing safety regs Low staffing rates. Weak safety and MCS regulations for new designs Financial constraints	Formulate policies and regulations on MCS and (vessel) Safety Improve national food security Provide budget/loan guarantees or subsidies to kick start vessel construction Make fishing vessel/third-party insurance mandatory through legislation	No or few policies that support investment in fisheries to increase access to finance and insurance for local fishers

Stakeholder	Strengths	Weaknesses	Opportunities	Challenges
		lead to poor construction methods and materials	Establish or strengthen national fishing vessel records and registries	
GCFRTP/FAO	Budget Technical Competence Long term planning	Bureaucracy (e.g., activity agreements to be signed by all activity countries) Large area with many countries complicates logistics and increases costs	Good activity design and proper planning Increase implementation skills Provide policy guidance	Slow implementation by activity partners due to many activities and lack of personnel Not enough budget to support construction of demonstration vessels in each activity country
Local Tuna Value Chain	Dynamic Private sector in a few larger populated countries	Mainly subsistence in some smaller countries Lack of tools and equipment and infrastructure Low spending power of populations	Integrate small scale fish into export markets where possible Improve distribution and cold chain storage using solar and renewable energy Improve fish transport from outer island islands and remote areas to urban centres. Increase food security and reduce spoilage and waste	Lack of policies and support for marketing and commercialization of fish through credits. Fragmented markets Fixed fish prices in some countries which may compromises the financial viability of new designs or make them inviable

Stakeholder	Strengths	Weaknesses	Opportunities	Challenges
			Develop local products with longer shelf life	

ANNEX IV Workplan

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	
1.0	***Output 1. Cost effective activity management***																	
1.1	Recruit Lead Consultant Fisheries/Economist																	FAO LTO
1.2	Recruitment of technical assistance expertise and contracting of service providers/ companies, using UN procurement and recruitment processes.																	FAO LTO FAO Budget Holder Consultant/ Coordinator
1.3	Review and update work plan, Virtual workshop with GCFRTP focal points																	Consultant/ Coordinator
1.4	1st. meeting of activity Task Force/Steering Committee																	GCFRTP CI / FAO Consultant/ Coordinator
1.5	Preparation of activity inception meeting																	Consultant/ Coordinator
1.6	Inception report with updated work plan																	Consultant/ Coordinator
1.7	FAO make provisions for the activity coordinator office at SAP																	FAO LTO FAO Budget Holder Consultant/ Coordinator
1.8	Establish an FAO activity task force to monitor activity implementation																	FAO Budget Holder

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	
1.9	Semi-annual progress reports preparation																	Consultant/ Coordinator FAO LTO
1.10	Mid-term external review and final activity evaluation																	FAO Budget Holder/FAO LTO/ Mid Term Review consultants
1.11	Financial and technical closure of activity																	FAO LTO/ FAO Budget Holder
2.0	***Output 2. Two designs of prototype fishing vessels with 6 different lengths have been prepared and accepted by the Fisheries Departments, fishers and boat owners***																	
2.1	Conduct detailed country needs analysis studies to update survey and consultation with beneficiaries and stakeholders to verify their needs and physical needs to best determine common attributes of importance to be included in the designs																	Consultant/ Coordinator Naval Architect countries Master Fisherman countries
2.2	Naval Architect prepares 2 designs with 6 different lengths (3 per design)																	Naval Architect
2.3	Validation workshop to present designs, receive feedback and decision taken as to the best place to undertake trials.																	Consultant/ Coordinator Naval Architect & Master Fisherman
2.4	Build models of the selected designs and arrange for tow																	FAO LTO/Naval architect

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	
	tank and seakeeping tests																	and tow tank facility
2.5	Prepare national boat builder and fisheries infrastructure data base																	Consultant/ Coordinator
3.0	***Output 3. Two prototype fishing vessels constructed- in line with international construction and safety standards and guidelines***																	
3.1	Finalise identification of Boat Building Companies. Finalise technical specifications Prepare tender documents and organize the procurement																	Consultant/ Coordinator Naval Architect & Master Fisherman (Technical content) FAO LTO & FAO procurement
3.2	Contracting and Boat Building to build prototypes (only one company to build the two boats)																	FAO LTO FAO Procurement
3.3	Training of boat builders from each country																	Consultant/Coordinator FAO LTO FAO Procurement Country focal points to ID Builders
3.4	Supervision of construction and ensure safety requirement meet best practice standards Supervision reports																	Naval Architect & Master Fisherman

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	
3.5	Prepare a step-by-step video and written guidelines for the construction process to build the prototypes																	Naval Architect and Videographer company FAO procurement
3.6	Procurement of fishing gears, engines, outfitting, navigation and safety equipment																	Master Fisherman, FAO LTO & FAO Procurement
3.7	Conduct sea trials, handover of the boats to FAO and demonstrate effectiveness of safety equipment and compliance with regulations in place.																	Naval Architect Master Fisherman
3.8	Organize a regional workshop to present the designs, step by step video about the construction, construction guidelines and the constructed prototype vessels																	Naval Architect Master Fisherman FAO LTO
4.0	***Output 4. Two new fishing vessel prototypes successfully tested in commercial fishing operations***																	
4.1	Identify and select experienced professional fishers/boat owners for the (one-year) trails of the prototype vessels																	Consultant/ Coordinator (Inputs from Fisheries Departments)

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
4.2	Develop the methodology for the techno-economic performance assessment study of Pacific islands fishing vessel types.																	Consultant/ coordinator FAO LTO
4.3	Carry out a techno-economic performance assessment study of at least 6 Pacific Island fishing vessel types																	Consultant/ coordinator FAO LTO
4.4	Prepare and conclude lease contracts with commercial fishers/boat owners for the two prototype vessels (including arrangements for maintenance, repair, insurance, sea trial days and data collection and reporting)																	FAO LTO Consultant/ Coordinator
4.5	Prepare Letters of Agreement with two Departments of Fisheries for supervision of the sea trials and related reporting.																	LTO and Consultant/ Coordinator
4.6	Participate in sea trials of Multi day and daily fishing vessels, provide fishing gear/technology/ operational advice and																	Master Fisherman

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	
	demonstrate effectiveness of safety equipment, monitor compliance with regulations in place, and report on the trials																	
4.7	Arrange for continuation of protype vessel lease contracts, transfer to other fishers/owners for data collection/trails, or hand over to Fisheries Departments.																	LTO and Consultant/ Coordinator
4.8	Organize a regional workshop to present the results of the full-scale trials and the techno-economic performance assessment study,																	LTO and Consultant/ Coordinator Master Fisherman
5.0	**Output 5. Policy review on financing of prototypes**																	
5.1	Conduct a review of fisheries and maritime policies, legislation and management measures in activity countries relevant and RFBs/RFMOs that affect fishing vessel design, construction and operations																	Maritime/fisheries legal expert FAO LEGN FAO NFIFO Fishing Safety Officer

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	
5.2	Review of safety at sea legal aspects and prepare Draft fishing vessel safety regulations for various types/sizes of fishing vessels, for incorporation in national legislation of the Pacific SIDS																	FAO LEGN Maritime/fisheries legal expert FAO NFIFO Fishing Safety officer
5.3	Desk review of financial policies and legislation and their effects on fishing fleet development																	Finance/insurance services expert FAO LTO
5.4	Conduct a survey of financing supply/demand for financial and insurance services, and review the available tools and financing instruments, terms and conditions of loans, government plans, past and ongoing loan schemes and overall study of financial and insurance services provision to the fisheries sectors in most 14 activity countries.																	FAO LTO Consultant/coordinator Financial/insurance services expert National Consultants
5.5	Organize a regional fisheries																	

#	Description of Activities to Achieve Outputs	Year 1				Year 2				Year 3				year 4				Responsible
		Q 1	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	*Q 1*	*Q 2*	*Q 3*	*Q 4*	
	finance and insurance workshop with Pacific SIDS to present and discuss the findings of the various studies and prepare policy recommendations and strategies.																	

ANNEX V Budget

(USD)

Description		Account		2025	2026	2027	2028	Total
Consultants		5570						
	International		5,542	133,300	142,100	150,150	53,100	478,650
	National		5,543	84,000	84,000	84,000	84,000	336,000
			5556 - DSC	6,112	6,473	6,473	2,863	21,921
Contracts		5650						
			5,650	375,000	65,000	225,000	0	665,000
			5586 - DSC	3,520	300	1,500	0	5,320
Travel		5900						
			5,900	57,000	59,000	59,000	46,000	221,000
			5906 - DSC	528	616	616	528	2,288
Training		5920						
			5,920	0	50,000	0	10,000	60,000
			5906 - DSC	0	132	0	44	176
Equipment								
	Expendable	6000	5,024	6,800	7,800	9,300	6,800	30,700
			5956 - DSC	132	176	220	132	660
	Non-expendable		5,025	5,000	0	0	0	5,000
		6100	6056 - DSC	88	0	0	0	88
Technical Support Services		6120		24,240	24,240	42,742	29,718	120,940
Report costs		6111		0	0	0	6,550	6,550
Evaluation costs		6116		0	0	0	25,000	25,000
General Operating Expenses		6300						
	Security (Headquarters base		6216 - DSC	155	155	349	349	1,008
	Office Occupancy Costs (Hea		6280 - DSC	265	265	596	596	1,723
	Security (Field based persor		6216 - DSC	3,688	3,688	1,918	1,918	11,210
	Miscellaneous, insurance, vi		6,152	2,500	9,200	7,548	4,000	23,248
	General Operating Expenses		5956 - DSC	132	220	264	176	792
General Operating Expenses		5050						
	IT Services		6420 - DSC	2,688	2,856	2,856	1,176	9,576
	Envirinmental and social safe		DSC	625	625	625	625	2,500
	Financial Services		6421 - DSC	26,726	0	0	0	26,726
Indirect Support Costs (7%)		6130		51,275	31,979	41,521	19,150	143,925
Total Budget				783,773	488,825	634,677	292,725	2,200,000

Note: DSC= direct support costs

ANNEX VI List of contracts

Contract Name	Contractor Type	Summary of Details	Amount (USD)
Test boat design/ models in a tow tank	Maritime Research Institute	Construction of models according to design Test in tow tank Prepare report	30 000
Boat Building**	Boat building company/Boat yard	Construction of 1 multi day boat Construction of 1 x Day boat Delivery and sea trials	165 000
Step by Step Guide to construction of boats	Video and Graphic Art company	Preparation of video and test	15 000
Lease contract for sea trials	Commercial fishing company	Sea trials of new vessels	10 000
Training of Boat Builders	Boat Yard	Upgrading boat building skills for nationals of participating countries	40 000
Letters of Agreement**	Departments of Fisheries	Participating in national meetings and regional workshops	420 000

** These contracts will be split between different institutions

ANNEX VII Risk Matrix

Table 3Risk Management Table

Risk	Impact	Probability	Mitigation
Non or only partial technical acceptance of the new designs by governments and fishers due to wide financial, cultural, demographic, social and geographic diversity amongst participating countries. Low uptake of designs by fishers.	High	Medium	At activity start up an updated survey of existing fishing vessel, demographics, financials, social and geographical will be carried out to provide the most common essential requirements for each country. (FAO) Based on the most common essentials the naval architect prepares 1 multi day and 1 day fishing design. (FAO) Designs validated by stakeholders at workshop and ongoing engagement with stakeholders. (Governments) Each design will have 3 different lengths overall with corresponding CUNOs (Cubic Number). (FAO)
Lack of trained qualified personnel for multi day vessels	High Fishing further offshore for multi-day boats requires more training of captains and engineers	Medium	The legal safety review of identify Gaps in the laws and regulations related to design, construction, equipment and qualifications for the vessels. (FAO) Governments will need to finance phased

Risk	Impact	Probability	Mitigation
			training programs for small scale fishers to use multi day vessels. These should hand in hand with donor and multi-lateral financing and or ODA (Governments) There are already existing maritime training schools in 11 of the participating countries[14] (Governments) Only countries requiring multi day boats will require additional training (Governments)
Multi day fishing vessel designs are not culturally acceptable	Innovation is always more difficult to accept over traditional designs Culturally fishers may not want to change from daily fishing to multi day fishing trips	Medium	Fishers open to try but require proof that the multi-day fishing vessels are profitable Prototypes of multi day fishing vessel design will be tested over 1 year fishing and results shared. (FAO) Multi day fishing vessels are not essential for all countries. There will be 6 different size options for multi-day and day fishing vessels.
Reluctance to finance new designs as these were not tested in	High There will be limited uptake as only 1	High Mainly due to the conservative and	The results of the full-scale tests will be made available including their financial viability at a

[14] Maritime schools exist in Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu.

Risk	Impact	Probability	Mitigation
a particular country	multiday and 1 day fishing design will be tested in one country as it is not possible to test both designs and sizes in all countries	risk averse nature of governments and fishers.	regional stakeholder workshop, along with policy options. (Governments) Activity will engage with governments and financing institutions and policy makers to create incentives to finance fishing fleet improvements. (FAO) There will be 6 different vessel lengths to suit various fishing operations and financing options. (FAO)
Insufficient a-FADS installed in deep waters	High Vessels fit for offshore will fish inshore with possible limited viability	Low	The GCPRTP has a Activity component to assist countries to develop offshore a-FADs
Natural disasters or human error destroy prototypes, cause ship builders or crew accidents and or interrupt fishing trials	High Slow activity implementation if prototypes must be rebuilt Lack of funds to rebuild prototypes	Medium Natural disasters are increasing in intensity and frequency in the Pacific. Accidents in fisheries happen more frequently than in most other occupations.	Prototypes will be built in bona fide shipyards that have for accidents (fire, theft, human error) and natural disasters. Prototypes will be insured during the trials (FAO) Safety standards and safety gears will be applied and inspected throughout construction and trails (FAO).
Resurgence of COVID-19 or other Pandemics	High	Low to Medium	Use as many local human resources as possible. (FAO)

Risk	Impact	Probability	Mitigation
			Respect vaccine and travel norms. Monitor early warnings. (FAO)
Weak stakeholder engagement by some governments and fishers	High The government, fishers and their organizations are important to the success of the activity and for scaling up. It is important that they are actively involved in the analysis, choices and technical inputs to overcome the many challenges	Medium Due to the disperse nature of the Pacific island states and expensive travel costs some participating countries may not always join in regional events Stakeholders may easily feel left out if there is no activity in their country or engagement on a regular basis Due to the indicative funding of this activity, there is insufficient funding to have a full-time activity coordinator for the entire activity duration	A consultant coordinator will be engaged to coordinate and tasked to follow-up with the countries. (FAO) There are other studies that will be taking place and it is important that other activities being implemented in the countries are kept up to date and engaged. (FAO SAP, SPC and CI) There should be regular team meetings between the consultant/coordinator and SPC/CI and other persons intervening on behalf of the GCFRTP. (FAO) The SAP Fisheries and aquaculture Officer based in Samoa will play an important role in filling in for the consultant coordinator.

ANNEX VIII Results of a preliminary vessel and fishing operations survey among participating countries

Technical Specification of Vessels used in FAD fishing

Country **Spec**	**Cook Islands**	**FSM**	**Fiji**	**Kiribati**	**Marshall Islands**	**Niue**	**Nauru**	**Palau**	**PNG**	**Samoa**	**Solomon Islands**	**Tonga**	**Tuvalu**	**Vanuatu**
# FADs	>20	>20							10-20	>20	>20		>20	
Boat Type	Alu Skiff	FRP							Plank + FRP	FRP	FRP		Wood Skiff	
Material	AL/Plank	FRP							P + Dugout	FRP	Plank		Plywood	
Avg. LoA	8-10M	6-8 m							<4+4-6	8-10	8-10		6-8 m	
Avg. Beam	1.8m	1.5 m							1.8?	2+	1.5		+2 m	
Max/Min HP	100/60	40/15							40/15	75/40	60/15		60/15	
Type Ice Box	Portable	Portable							Portable	Portable	Portable		Portable	
Sport FAD fishers	Yes	Yes							No	Yes	No		None	
Distance to sea mounts	22	20 nm							6 nm	None	3		60 nm	

CONSERVATION INTERNATIONAL

GREEN CLIMATE FUND

Boat Building

Country / Spec	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Niue	Nauru	Palau	PNG	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Registration of Boat Builders	Yes	No							Yes	Yes	No		No	
Individual / Companies	Both	None							Both	Both	Both		Individual	
Legislation on Construction	No	None							Some provinces	Yes	No		No	
Training of builders	No	None							No	Yes	No		No	
Slipway /LoA	No	None							No	No/13m	No/NA		Yes	
Majority Imported Boats	No	Yes							No	No	No		No	
Availability of Tools	No	Yes							No	Yes	Yes		No	
Optimum LoA	6-8 m	6 – 8 m							8-10 m	12-14 m	8-10 m		8 -10 m	

Safety at Sea

Country / Spec	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Niue	Nauru	Palau	PNG	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Safety regulations	Yes	Yes							Some Province	Yes	No		No	
Status of Regulations	Done	Pending							Pending	Pending	No		No	
Life jackets /Grab Bags	Yes	No/No							Yes/no	Yes	No		Yes	
Inspection of boats	Yes	No							No	Yes	No		No	
Communications / Coverage	Mobile Limited	Mobile Limited							Mobile wide	Mobile Wide	Mobile Wide		Mobile V. Limited	
# Fishers drifted away in the last 5 years	0	12							Many	0	N/A		0	
GPS for sale	No	Yes							Yes	Yes	Yes		No	
# SAR 5 years	1	8							Yes	0	N/A		6	
Accident Reporting	Yes	Yes							Yes	No Reply	Yes		Yes	

Fishing Seasons

COUNTRY	SEASON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Cook Islands	GOOD	X	X	X	X							X	X
	POOR					X	X	X	X	X	X		
FSM	GOOD			X	X	X	X	X	X	X	X		
	POOR	X	X									X	X
Fiji	GOOD												
	POOR												
Kiribati	GOOD												
	POOR												
Marshall Islands	GOOD												
	POOR												
Niue	GOOD												
	POOR												
Nauru	GOOD												
	POOR												
Palau	GOOD												
	POOR												
PNG	GOOD	**Variable depending on area**											
	POOR	**Variable depending on area**											
Samoa	GOOD					X	X	X	X	X	X		
	POOR	X	X	X	X							X	X
Solomon Islands	GOOD			X	X	X	X	X	X	X			

COUNTRY	SEASON	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	POOR	X	X								X	X	X
Tonga	GOOD												
	POOR												
Tuvalu	GOOD	X	X	X	X	X	X	X	X	X	X	X	X
	POOR	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanuatu	GOOD												
	POOR												

Training and capacity building of fishers organized in the last 2 years (2021-2022)

Country / Spec	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Niue	Nauru	Palau	PNG	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Safety	Yes	Yes							No	Yes	No		Yes	
Fishing methods	Yes	Yes							No	Yes	Yes		Yes	
Engine operation	No	Yes							No	No	No		Yes	
Fisheries Management	No	No							No	No	No		Yes	
Environmental protection	Yes	No							No	Yes	No		No	
Fish Handling	Yes	No							No	Yes	Yes		Yes	
Seamanship	No	No							No	No	No		Yes	
Business Planning	No	No							No	No	No		No	

Institutional Arrangements

Country	Cook Islands	FSM	Fiji	Kiribati	Marshall Islands	Niue	Nauru	Palau	PNG	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
How many officers	10	?							5	6	10		1	
Boat Builders on staff	No	No							No	No	No		No	
Planned boat building	No	No							Yes	No	No		Yes	
Min. Operate a boat yard	No	No							No	Yes	No		No	
Adequate storage space	No	?							Yes	No	No		No	
Are you Building a boat now	No	No							No	Yes	No		Yes	
Program to assist boat acquisition	No	?							Yes	Yes	No		Yes	
Loan		N/A							Yes	No	N/A		Yes	
Grant		N/A							Yes	Yes	N/A		No	
Subsidiz. Loan		N/A							Yes	Yes	N/A		No	
Commercial Bank		No							Yes	No	N/A		Yes	
Government		No							Yes	No	N/A		No	
Project		No							No	Yes			No	
Past Loan Program	No	No							Yes	No	Yes		No	
If yes what year		No							10 years	N/A	2009		N/A	
What are Interest rates	10.25-17.25%	N/A							4%	?	15%		?	

ANNEX IX. Terms of reference for consultants

منظمة الأغذية والزراعة للأمم المتحدة | 联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Alimentación y la Agricultura

Food and Agriculture organization of the United Nations
Terms of Reference for Consultant Category A *

Name:	TBA			
Job Title:	Consultant/Coordinator Fisheries economist			
Division/Department:	FAO SAP			
Programme/Activity Number:				
Duty Station:	Home Based with travel to Pacific countries			
Expected Start Date of Assignment:	ASAP	Duration:	32 months within 48 months activity implementation	
Reports to:	*Name:*	Lead Technical Officer SAP Sub-regional representative	NFIFO, Rome SAP, Apia	
General Description of task(s) and objectives to be achieved				

Supervision:
The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund regional tuna programme.

Background and General Context:
This activity is one of the components that will be implemented under the framework of the GCF regional tuna programme. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for a-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[15] (SIDS).

Tasks and Services:

[15] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit: • Prepare and modify as required Terms of Reference for consultants and coordinate their inputs. • Coordinate with the LTO and SAP fisheries and aquaculture officer, data collection and studies to be prepared by national consultants. • Coordinate with the FAO LTO and SAP fisheries and aquaculture officer the work planning and activities in the activity work plan; • Organize, coordinate and plan activity meetings and workshops in coordination with the FAO Team and Task force and the CI Coordinator and SPC including: the activity inception meeting, presentation of the vessel designs, vessel construction and vessel full scale trials. • Prepare reports and documents in accordance with the activity work plan and with the meetings and workshops including but not limited to Letters of Agreement and drafting of contracts. • Work with National Consultants to collect technical and economic and financial data on the fisheries and prepare reports leading to the preparation of a fishing vessel catalogue of FAD fishing vessels being used in the participating countries. • Undertake cost and benefit analyses and activities for prototype vessels. • Organize surveys with national consultants and international finance and insurance experts leading to the preparation of recommendations, policies and guidance related to appropriate and innovative financing and insurance instruments. • Organize in close collaboration with the FAO, CI, participating countries a regional fisheries finance and insurance workshop with Pacific SIDS to present and discuss the findings of the various studies. • Any other duties that may be required by the FAO LTO officer and/or SAP Fisheries and aquaculture officer.
KEY QUALIFICATIONS
The Candidate should have the following knowledge and qualifications. • Advanced university degree in Fisheries economics and financing Economics or another relevant field. • 5 - 7 years working experience in the fisheries sector • Experience in coordination and activity management • Experience in preparing cost and earnings evaluation of fishing vessels. • Ability to prepare concise reports according to United Nations standards and donor requirements. • Excellent oral and written skills in English. • Availability to travel frequently to the activity countries. • Excellent knowledge of English. • Experience working with FAO systems would be an asset.

Key performance indicators	
Expected Outputs:	Required Completion Date:
Inception report including detailed workplan for consultancy 6 monthly progress reports Cost Benefit Analyses/techno-economic performance review of fishing vessels Mission/travel reports Workshop reports (as required) End of assignment Report	TBA

Name:	TBA				
Job Title:	Naval Architect				
Division/Department:	FAO SAP				
Programme/Activity Number:					
Duty Station:	Home Based with travel to Pacific countries				
Expected Start Date of Assignment:	ASAP	Duration:	7 months (when actually employed) within 48 months		
Reports to:	Name:	Lead Technical Officer	NFIFO, Rome		

General Description of task(s) and objectives to be achieved

Supervision:

The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund regional tuna programme..

Background and General Context:

This activity is one of the components that will be implemented under the framework of the GCF regional tuna programme. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for a-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[16] (SIDS).

Tasks and Services:

The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit:

- Coordinate with the Activity LTO, Coordinator / Economist, Activity Task Force, CI Coordinator and SPC all the work and activities and update them on progress as needed/requested.
- Coordinate, technical surveys of existing FAD fishing vessels and assist in the identification of common attributes and technical specification s that can be used to develop the most appropriate FAD fishing vessel designs.
- Participate in the workshops and meetings where the designs, construction, full scale test of the vessels and financing options will be presented to participating countries, banks and development partners.
- Contribute to various workshops and meetings during the lifespan of the activity.

[16] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

- Travel to most of the participating countries, conduct consultations with stakeholders, update information and understand the needs of the fishers in participating countries.
- Prepare 2 main vessel designs (1 for a multi-day fishing vessel and 1 for a day fishing vessel) with 3 different size lengths for each of the designs.
- Coordinate with a towing tank facility to ensure that the designs are fully stable sea going and that the power requirements will be adequate for all the conditions that the designs are likely to encounter in the participating countries.
- Prepare the complete technical specifications for each of the 6 models. The specifications should be ready for tender to a boat building company to construct 2 vessels 1 multi day vessel and 1 day-fishing vessel. The exact sizes of the day vessels will be determined based on the survey carried out in each country and at a meeting when the designs will be presented.
- Assist the LTO in the preparation of the construction contracts.
- Inspect vessels during their construction to ensure compliance with the safety and specifications.
- Participate in the sea trials and hand over the boats from the boat construction company to FAO (as needed)
- Provide technical advice on an ongoing basis to the construction, full scale testing and policy discussions at the end of the activity.
- Any other duties that may be required by the FAO LTO officer

KEY QUALIFICATIONS

The Candidate should have the following knowledge and qualifications.

- A Degree in naval architecture
- Over 10 years continuous experience in the design of small-scale Fishing Vessels less than 18 metres.
- Experience in the Pacific SIDS in matters related to designs and testing of fishing vessels
- Excellent oral and written skills in English.
- Availability to travel frequently to the activity countries.
- Excellent knowledge of English.
- Experience working with FAO systems would be an asset.

Key performance indicators

Expected Outputs:	Required Completion Date:
Report on the common attributes for 2 vessel designs in 3 different size lengths Full technical drawings and specifications for construction of 2 vessels Travel/mission reports Inspection reports Sea trial report End of assignment report	TBA

Name:	TBA				
Job Title:	Maritime Lawyer				
Division/Department:	FAO SAP				
Programme/Activity Number:					
Duty Station:	Home Based with travel to Pacific countries				
Expected Start Date of Assignment:		Duration:	1.5 months (When actually employed)		
Reports to:	*Name:*	Lead Technical Officer Chief LEGN	NFIFO, Rome LEGN, Rome		
General Description of task(s) and objectives to be achieved					

Supervision:
The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and the Chief Development Law Service (LEGN) in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund regional tuna programme.

Background and General Context:
This activity is one of the components that will be implemented under the framework of the GCF regional tuna programme. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for a-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[17] (SIDS).

Tasks and Services:
The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit:

- Coordinate with the Activity LTO, Coordinator / Economist, Activity Task Force, CI Coordinator and SPC all the work and activities and update them on progress as needed/requested.
- Conduct a desk review of the legislation in most participating countries in relation to safety of small-scale fishing vessel including vessels that will navigate on multiday fishing trips.
- Prepare a GAP analysis.
- Working in close collaboration with the FAO Development Law Service (LEGN) and FAO NFIFO Fishing Safety Officer, prepare draft fishing vessel safety regulations and

[17] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

accompanying explanatory notes for various types/sizes of fishing vessels, for incorporation in national level legislation of the Pacific SIDS. • Prepare a final report. • Any other duties that may be required by the FAO LTO officer	
KEY QUALIFICATIONS	
The Candidate should have the following knowledge and qualifications. • A Law Degree with specialisation in maritime or fisheries issues • Over 5 years-experience in maritime/fisheries laws • Experience in safety of fishing operations will be an asset particularly if it included safety of fishing vessels or smaller sea going vessels. • Experience in drafting fisheries and safety regulations. • Experience in the Pacific SIDS in matters related to fisheries laws • Excellent oral and written skills in English. • Availability to travel frequently to the activity countries. • Excellent knowledge of English. • Experience working with FAO systems would be an asset.	
Key performance indicators	
Expected Outputs:	Required Completion Date:
GAP analysis of safety regulation for smaller fishing vessels Generic Safety Regulations for small fishing vessels Travel/mission reports End of assignment report	TBA

Name:	TBA				
Job Title:	National Consultant on data collection and coordination				
Division/Department:	FAO SAP				
Programme/Activity Number:					
Duty Station:	Home Based with travel to Pacific countries				
Expected Start Date of Assignment:			Duration:	1 month per year (4 months in total – when actually employed- within 48 months)	
Reports to:	*Name:*	Lead Technical Officer SAP Subregional representative	NFIFO, Rome SAP, Apia		

General Description of task(s) and objectives to be achieved
Supervision: The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund Regional Tuna Programme.. **Background and General Context:** This activity is one of the components that will be implemented under the framework of the GCF regional tuna programme. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for a-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[18] (SIDS). **Tasks and Services:** The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit: • Coordinate with the Coordinator Economist, FAO LTO, Naval Architect and SPC focal points to collect data on the technical attributes of vessels in country and economic and financial data from banks, insurance companies and funding of fishing vessels your country • Prepare the data collected according to the format required by the activity • Any other duties that may be required by the FAO LTO officer
KEY QUALIFICATIONS
The Candidate should have the following knowledge and qualifications

[18] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

• University degree at bachelor's level. • Minimum of 2 years' working experience in the fisheries sector or as economist • Experience in conducting surveys and research • Ability to prepare concise reports according to United Nations standards. • Excellent oral and written skills in English. • Availability to travel frequently within the national country. • Excellent knowledge of English. • Experience working with FAO systems would be an asset.

Key performance indicators	
Expected Outputs:	Required Completion Date:
Inception report including detailed workplan for the consultancy. Short monthly reports Cost Benefit Analyses of selected national fishing vessels Workshop reports (as required) End of assignment report	TBA

Name:	TBA				
Job Title:	Master Fisherman				
Division/Department:	FAO SAP				
Programme/Activity Number:					
Duty Station:	Home Based with travel to Pacific countries				
Expected Start Date of Assignment:			Duration:	9 months (when actually employed)	
Reports to:	*Name:*	Lead Technical Officer SAP Fishery and aquaculture officer	NFIFO, Rome SAP, Apia		

General Description of task(s) and objectives to be achieved

Supervision:

The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund Regional Tuna Programme.

Background and General Context:

This activity is one of the components that will be implemented under the framework of the GCF regional tuna Programme. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for a-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[19] (SIDS).

Tasks and Services:

The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit:

- Participate in planning workshops and meetings and prepare presentation related to the technical attributes of FAD fishing vessels.
- Contribute and review the survey carried out by national consultants.
- Contribute to the preparation of the specifications on fishing vessels designs for multi day and day boats.
- Inspect vessels during their construction.
- Coordinate with the FAO LTO and Coordinator/Economist and Naval Architect in matter related to coordination with the Departments of Fisheries, Boatyard, other consultants and fishers and the company that will conduct the full-scale trials of the prototype vessel.

[19] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

• Participate in fishing for tuna around FADs during the full-scale testing of the vessels. • Prepare reports, presentations and analyses as required. • Any other duties that may be required by the FAO LTO officer
KEY QUALIFICATIONS
The Candidate should have the following knowledge and qualifications. • Fishing Skipper License • Ability to prepare concise reports according to United Nations standards and donor requirements. • Excellent oral and written skills in English. • Availability to travel frequently to the activity countries. • Excellent knowledge of English. • Experience working with FAO systems would be an asset.

Key performance indicators	
Expected Outputs:	Required Completion Date:
Quarterly reports Inspection reports Fishing Trial reports End of assignment report	TBA

Name:	TBA				
Job Title:	Financial / Insurance Services Expert				
Division/Department:	FAO SAP				
Programme/Activity Number:					
Duty Station:	Home Based with travel to Pacific countries				
Expected Start Date of Assignment:			Duration:	1.5 months (when actually employed)	
Reports to:	*Name:*	Lead Technical Officer	NFIFO, Rome		

General Description of task(s) and objectives to be achieved

Supervision:
The Consultant will work under the overall supervision of the FAO Sub-Regional Representative for the Pacific (SRC), the technical supervision of the Lead Technical Officer (LTO) and in close collaboration with the SAP Fisheries and Aquaculture Officer, and in collaboration and liaison with the Conservation International Coordinator and the Manager of the SPC Activity Management Unit of the Green Climate Fund regional tuna programme.

Background and General Context:
This activity is one of the components that will be implemented under the framework of the GCF regional tuna program. The program is funded by the Green Climate Fund (GCF) and The Implementing Agency is Conservation International (CI), which is responsible for the overall implementation of the GCFRTP. The GCFRTP will be implemented in the West Central Pacific Ocean (WCPO) and has two major components working in tandem as follows: *Component A. Adaptations to harness tuna for food security of Pacific Island communities as coral reefs are degraded by climate change* and *Component B. Adaptations to reduce risks to Pacific Island economies of climate-driven redistribution of tuna.* The overall objective of the GCFRTP is to provide, knowledge, tools, policies, and actions for "Adapting tuna-dependent Pacific Island communities and economies to climate change". This activity "Design of energy saving fishing vessels for A-FADs fisheries" is set under Component A. and will be executed by The Food and Agriculture Organization of the United Nations (FAO) and will contribute synergistically to the overall objective and expected results of the GCFRTP. The GCFTP will be implemented for the benefit of 14 Pacific Small Island Developing States[20] (SIDS).

Tasks and Services:
The consultant will undertake the following tasks and services in close coordination and cooperation and support from the FAO LTO, CI Coordinator, SPC Activity Management Unit:

- Desk review of activity and other documents and studies related to the financial sector in Pacific SIDS
- Prepare surveys to gather information on financial and insurance services in Pacific SIDS. The information will be gathered by national consultants.
- Analyse the survey results and make recommendations related to innovative financial and insurance instruments adaptable to the context of Pacific SIDS.
- Participate in the organization and planning of workshops and meetings and prepare presentations.
- Contribute to the preparation of the workshop report on financing and insurance. The workshop will be a face to face not virtual meeting.
- Any other duties that may be required by the FAO LTO officer

[20] Cook Islands, Federated Stated of Micronesia, Fiji, Kiribati, Marshall Islands, Nieu, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

KEY QUALIFICATIONS	
The Candidate should have the following knowledge and qualifications. • Advanced Degree in finance /economics • 10 years' experience in rural finance and insurance internationally • Experience in developing innovative financial and insurance instruments. • Proven track record in finance • Experience in Pacific SIDS will be an asset. • Ability to prepare concise reports according to United Nations standards and donor requirements. • Excellent oral and written skills in English. • Availability to travel attend meetings and workshop. • Excellent knowledge of English. • Experience working with FAO systems would be an asset.	
Key performance indicators	
Expected Outputs:	Required Completion Date:
Survey methodology and contents Survey Analysis report Presentation on innovative financial and insurance instruments End of assignment report	TBA