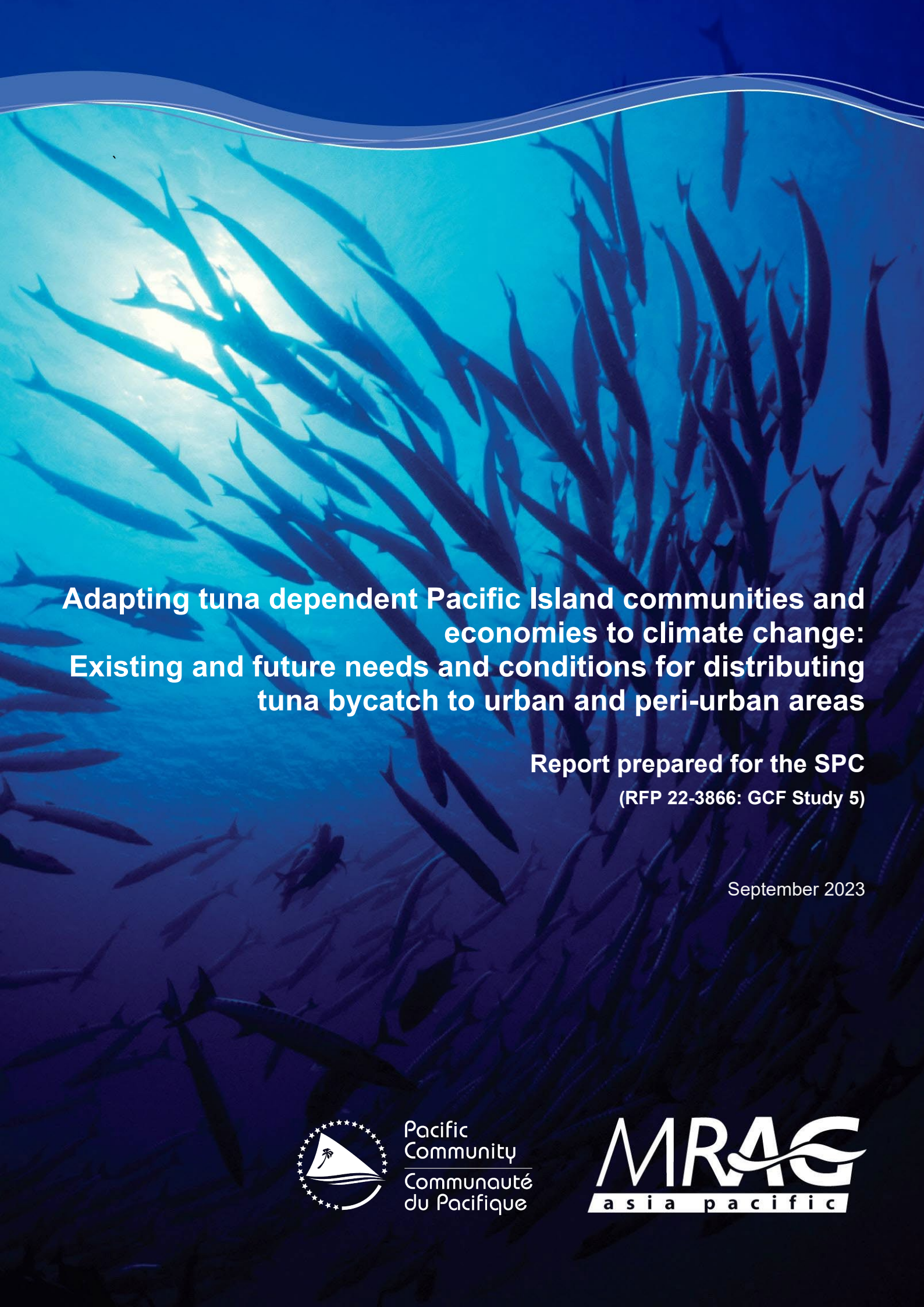

Adapting tuna dependent Pacific Island communities and economies to climate change: Existing and future needs and conditions for distributing tuna bycatch to urban and peri-urban areas

Report prepared for the SPC

(RFP 22-3866: GCF Study 5)

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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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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].

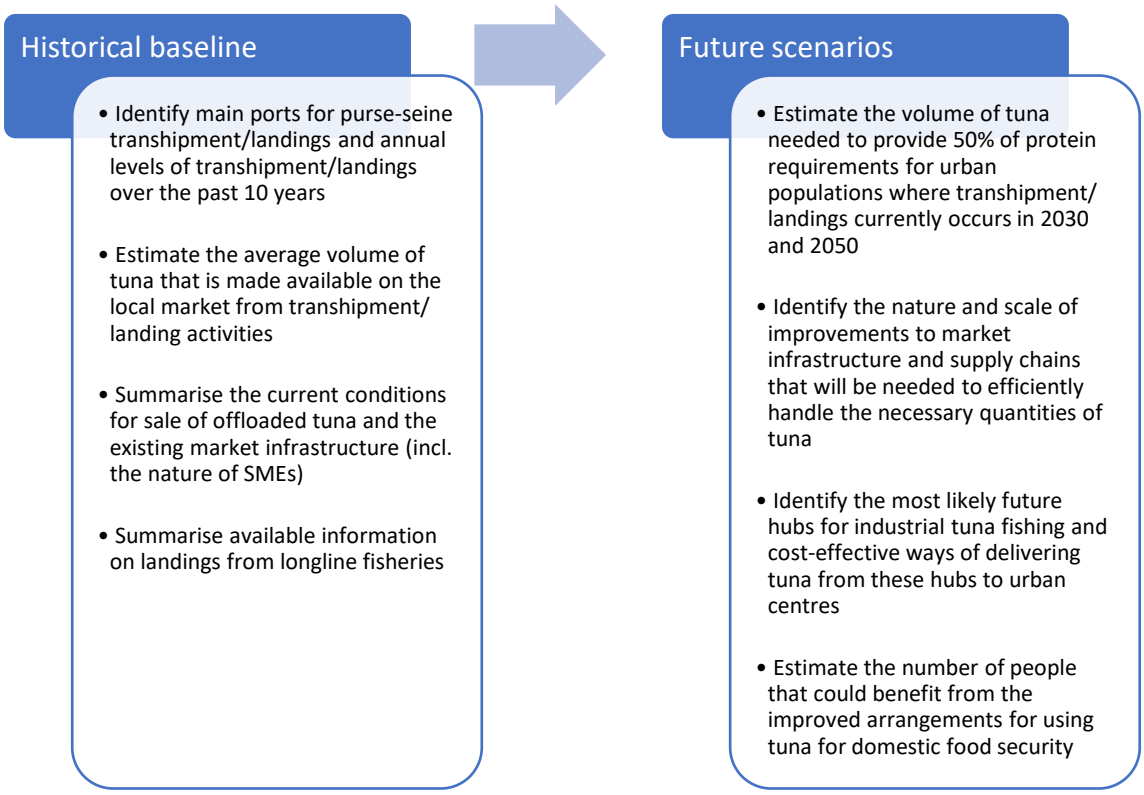

Figure 1: Deliverables from the proposed approach.

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 11 and Table 12 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).

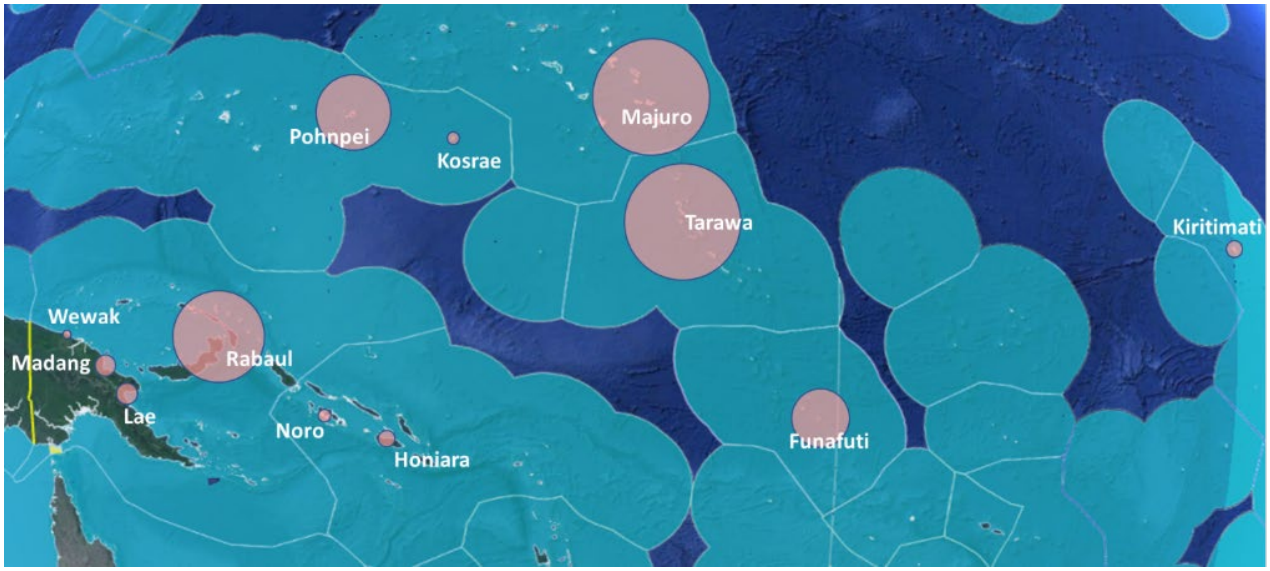

Figure 2: Map of key PIC ports for tuna transhipment and landing in the region (the size of the circles reflects the average volume of tuna transhipped or landed per year for the period from 2017 to 2021, refer to Table 11).

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 11 and Table 12). 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 13 and Table 14 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 13), 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 (excl. Taiwan and Chinese flags as the crew of these vessels usually undertake transhipment tasks), 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 Earth

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.

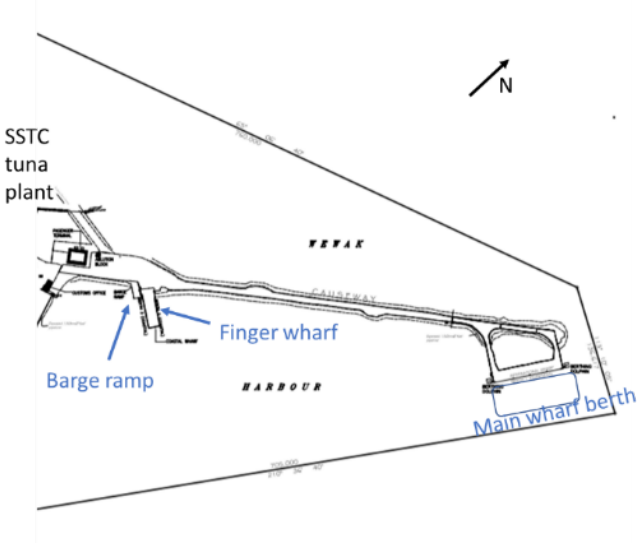

Figure 7: Wewak Port layout

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 11 and Table 12). 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.

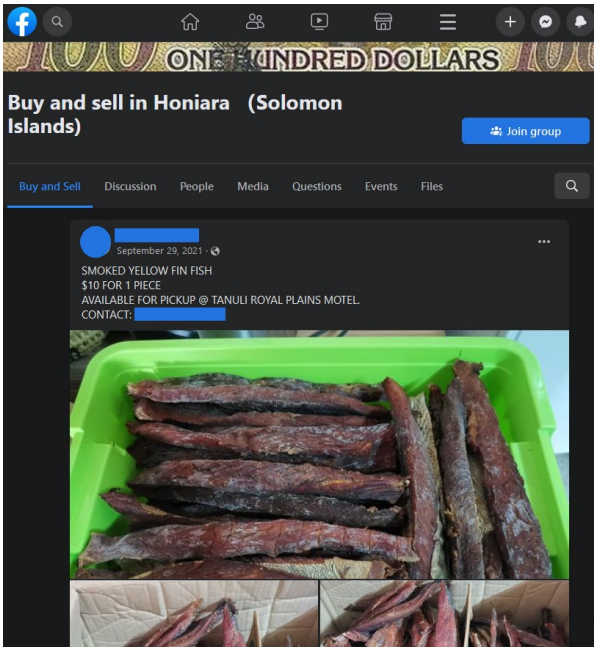

Figure 11: Smoked fish sold online in Honiara.

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.

[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.

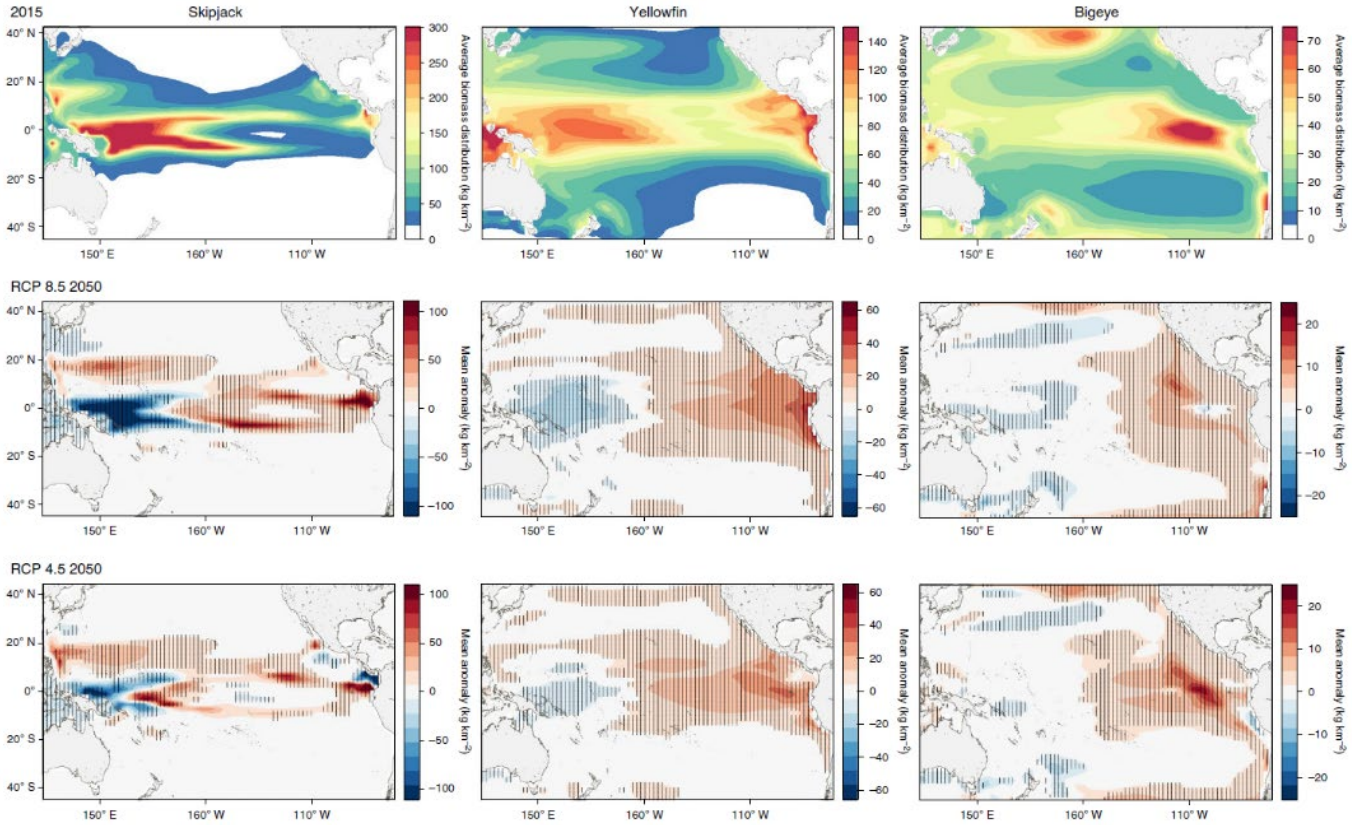

Figure 13: Projected effects of climate change on the distributions of the three tuna species caught by purse-seine fishing in the Pacific Ocean. Source: Bell et al. (2021)

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.

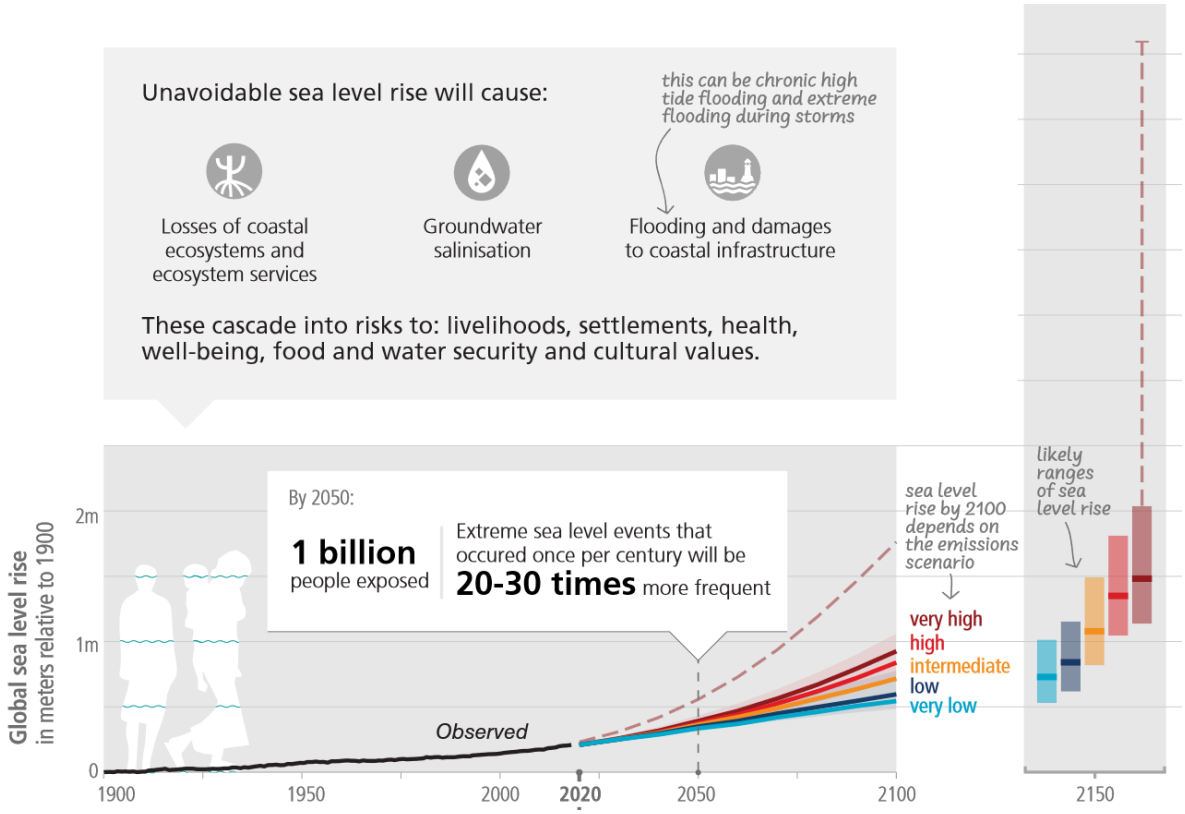

Figure 14: Projected sea-level rise in accordance with 5 SSPs set out by the IPCC. Source: IPCC (2023), Figure 3.4.

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.
4. FAO/WHO/UN. Energy and protein requirements. Report of the joint FAO/ WHO/UNU Expert Consultation. WHO Technical Report Series 724, 1985. /http://www.fao.org/DOCREP/003/AA040E/AA040E00.HTMS.
5. 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
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 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	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.
4. FAO/WHO/UN. Energy and protein requirements. Report of the joint FAO/ WHO/UNU Expert Consultation. WHO Technical Report Series 724, 1985. /http://www.fao.org/DOCREP/003/AA040E/AA040E00.HTMS.
5. 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
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.