Tuna Fisheries

PACIFIC POSSIBLE BACKGROUND PAPER NO.3.

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Pacific Island countries face unique development challenges. They are far away from major markets, often with small populations spread across many islands and vast distances, and are at the forefront of climate change and its impacts. Because of this, much research has focused on the challenges and constraints faced by Pacific Island countries, and finding ways to respond to these.

This paper is one part of the Pacific Possible series, which takes a positive focus, looking at genuinely transformative opportunities that exist for Pacific Island countries over the next 25 years and identifies the region's biggest challenges that require urgent action.

Realizing these opportunities will often require collaboration not only between Pacific Island Governments, but also with neighbouring countries on the Pacific Rim. The findings presented in Pacific Possible will provide governments and policy-makers with specific insights into what each area could mean for the economy, for employment, for government income and spending.

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1818 H Street, NW
Washington, DC 20433
Telephone: +1 202-473-1000
Internet: www.worldbank.org

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Abbreviations and Acronyms

AIS	Automatic Identification System
IMF	International Monetary Fund
EEZ	Exclusive Economic Zone
ENSO	El Nino-Southern Oscillation
EPO	Eastern Pacific Ocean
GDP	Gross Domestic Product
EU	European Union
EUMOFA	European Market Observatory for Fisheries and Aquaculture
F	Fishing Mortality
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FFA	Forum Fisheries Agency
FPO	Framework for a Pacific Oceanscape
FSM	Federated States of Micronesia
FSMA	Federated States of Micronesia Arrangement
GCM	Global Climate Model
GHG	Greenhouse Gas
GPS	Global Positioning System
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
IOTC	Indian Ocean Tuna Commission
IW	International Waters
MEA	Millennium Ecosystem Assessment
MSY	Maximum Sustainable Yield
PAE	Party Allowable Effort
PIC	Pacific Island Country
PIPA	Phoenix Islands Protected Area
PIROP	Pacific Islands Regional Ocean Policy
PNA	Parties to the Nauru Agreement
PNAO	Parties to the Nauru Agreement Office
PNG	Papua New Guinea
RFMO	Regional Fisheries Management Organization
RMI	Republic of Marshall Islands
SB	Spawning Biomass
SPC	Secretariat of the Pacific Community
SRES	Special Report on Emissions Scenarios
SST	Sea Surface Temperature
TAE	Total Allowable Effort
USDA	United States Department of Agriculture
VDS	Vessel Day Scheme
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean

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Summary for Policy-Makers

Pacific Island countries are endowed with valuable tuna resources. The stocks of four tuna species in the Western and Central Pacific Ocean (WCPO) – a region that includes the Pacific Island countries (PICs) and extends south below New Zealand and north to the Bering Sea to cover some 8 percent of the global ocean - collectively form the basis of one of the world's largest and most valuable fisheries. This fishery supplies roughly 60 percent of the world's tuna from what are some of the last healthy tuna stocks. PIC waters alone cover half of the WCPO region and supply some 34 percent of the world's tuna catch each year, with an estimated delivered value to processors on the order of US$3.4 billion in recent years. From this endowment PICs received net economic benefits on the order of US$500 million in 2013, the majority of which came from the purse seine fishery in the waters of countries near the equator. While not distributed evenly, these benefits have been significant for some PICs, for example with public revenues estimated to be equivalent to 36 percent of GDP in Tuvalu, 32 percent in Kiribati, and 10 percent in FSM, and constituting a much higher proportion of the total public budget (e.g. 63 percent in Kiribati in 2012).

These resources will need to make bigger economic contributions to help avoid a 'low-growth future' in the region. Despite this tremendous natural endowment, the rate of economic growth in many (though not all) PICs has generally been low over the last decade, and if this trend were to continue over the next 25 years, with only Fiji and Palau's gross domestic product GDP per capita growing at a rate higher than two percent annually, many PICs will fall significantly behind other countries, with per capita GDP levels only moderately higher than at present. One of the few opportunities to avoid this 'low-growth future' is utilization of the region's tuna resources.

This report describes a scenario for the year 2040 where this might plausibly happen. The report aims to look forward over the next 25 years, to suggest some viable answers to the questions: in a plausible best case scenario, how much more could the WCPO tuna resources sustainably contribute to Pacific Island countries' economies by the year 2040, and what policy decisions would be required from the countries? In complement, what would be the impacts and benefits in terms of employment and food security of these policy decisions? Building upon the *2010 Future of Fisheries report* and subsequent *Regional Roadmap for Sustainable Pacific Fisheries* endorsed by Forum Leaders in 2015, the report develops a best-case scenario for the tuna fisheries in the year 2040, identifying the potential additional economic contributions to PICs, and proposing further detail on likely policy decisions that would need to be taken. The report does not aim to provide predictions or forecasts of the future, but rather a plausible story based on recent trends and expected future directions that can communicate risks and opportunities to inform policy-making – and thereby provide a better understanding of the policy choices in the upcoming decades and highlight present-day developments.

As a starting point, some of the recent trends in the fisheries have been summarized, including:

- *The purse seine fishing 'revolution' and the explosion in these fishing vessels and their catch*. Purse seine fishing to produce canned tuna has grown exponentially in the WCPO since 1980, with 34 vessels catching roughly 100,000 metric tons of tuna that year, increasing to a steady state of some 180 to 220 vessels operating from 1990 to 2006, to 344 vessels catching over 2 million tons in 2014. Fifty-two new purse seine vessels have been built since 2010 and registered to fish in the WCPO. This fleet has grown more efficient over time (notably in the technology used for fish aggregating devices) and its composition has changed. While always largely a foreign fleet, the number of Pacific Island-based vessels is growing (notably in Papua New Guinea), combined catches by Indonesian and the Philippines vessels more than doubled between 1997 and 2014, over half of all purse seine vessels operating in the region that have been built since 2010 are from China, and during this same time catches by vessels from Japan, Korea, the United States and China, Taiwan have been relatively constant.

- *Stagnation and possibly senescence in the longline fisheries*. Productivity and profitability in the southern albacore longline fishery has declined, even as fishing increased sharply in 2008 with the rise of the PIC albacore fleet, which caught as much as 50 to 60 percent of albacore in 2014, and more recently the rise of the Chinese fleet. Catch rates have decreased steadily since 2009, hitting a low in 2011 for the period since 2002, with only marginal improvements since, even as new (and reportedly subsidized) vessels enter the fishery. Similarly, the trend in catches from the tropical longline fishery (much of which occurs in waters outside the jurisdiction of PICs) supplying sashimi markets has been flat. Over the period from 2003 – 2013, the catch rates for bigeye peaked in 2008 and have generally declined since (i.e. kg caught per hundred hooks on a longline), while yellowfin catch rates consistently declined from 2010 to 2013. In general, these two fisheries have provided relatively little economic benefits for PICs, which have typically captured an estimated 3 percent of the value of the catch delivered to processors, largely via access fees (though locally-based longline vessels have provided higher benefits to PICs such as Fiji, Samoa, etc.).

- *Establishment of a regional management body for the tuna fisheries*. The Western and Central Pacific Fisheries Commission was established in 2004 to promote the conservation and management of WCPO tuna stocks, and includes both PICs and foreign fishing nations, generally taking decisions based on consensus. However, given the diversity of actors in the Commission, consensus has been elusive in many cases – particularly on issues surrounding the distribution among members of the costs that would be imposed by proposed fish stock conservation measures, and some PIC representatives have expressed frustration when key decisions on conservation and management measures have not been taken. PIC representatives have cited the pace of decision-making at the Commission as a rationale for pursuing sub-regional agreements and governance arrangements, such as the vessel day scheme implemented under the Palau Arrangement, and the recent Tokelau Arrangement.

- *A new model of cooperation by a sub-regional coalition of PICs to manage purse seine fishing access*. The eight Parties to the Nauru Agreement (PNA) and Tokelau established a 'vessel day scheme' (VDS) to limit purse seine fishing access to their waters and allow transferability and greater flexibility in access terms; Tokelau joined the VDS in 2013. As a result, access fees are estimated to have increased by at least a multiple of four between 2009 and 2015. An estimated 13 percent of the delivered value of the total purse seine catch was captured by PICs via access fees in 2014. While these countries have generally held the limit on purse seine access through the VDS, throughout the WCPO catch and effort continue to grow. Current information suggests that fishing effort and catch have grown more in the waters outside of the PNA countries, notably in the waters of Indonesia and the Philippines as well as some high seas pockets in 2014. Following the model of the purse seine vessel day scheme, similar arrangements have been introduced for the longline fisheries. In 2015 the same countries began a VDS for the tropical longline fishery, and in late 2014 ten countries signed the Tokelau Arrangement to implement a similar scheme for access to the southern albacore long-line fishery in their waters.

- *Failures of state-led efforts to capture more of the tuna value chains in the Pacific Islands*. Most of the Government-led enterprises created in the 1980s or 1990s are no longer operating, but a number of private-led companies are currently processing catch in PNG, the Solomon Islands, Fiji and to a lesser extent RMI. In total the WCPO tuna fisheries value chains likely employ less than 0.5 percent of the region's current labor force. Less than 10 percent of the WCPO purse seine catch is processed locally, and Bangkok remains the world's largest tuna canner (despite increasing labor costs and several PICs' trade preference with the EU market).

- *Overall, a relatively steady global market for tuna products*. In terms of canned tuna supplied by the purse seine fishery and southern longline fishery, the three main markets in the European Union, U.S. and Japan are considered as 'mature' with relatively flat growth trends. The price of skipjack

in Bangkok has declined significantly in recent years, attributed to the growth (or 'glut') in supply – largely from increasing catch volumes in the WCPO. The sashimi market supplied by the tropical longline fishery was pioneered by Japan but has since become global with the remainder destined for the U.S., Korea, China, the European Union and Taiwan, China.

- *Decline of the WCPO bigeye tuna stock, while fishing on other stocks approaches limits recommended by scientists*. The size of the region's bigeye stock has shown a steady decline since the 1970s, reaching overfished status in the last five years. At the same time, the growth of purse seining has taken a larger share of the bigeye catch, accounting for 41 percent of the WCPO bigeye catch in 2014. The other three WCPO tuna stocks: albacore, skipjack and yellowfin, remain relatively healthy but approaching limits. While these stocks are not currently considered overfished, they are not likely to continue to support the growth in fishing effort and catch seen in the past, according to current scientific assessments.

Against the backdrop of these trends, a number of key external forces are expected to drive the performance of WCPO tuna fisheries over the next 25 years, including climate change, markets and the economy, science and technology, demographic changes and external governance. Expected changes include:

- *Climate change*. Modeling conducted to date by the Secretariat of the Pacific Community (SPC) on two of the region's four tuna stocks, skipjack and bigeye, suggest that in twenty years the sizes of the stocks will not be affected by climate change, but the distribution of the stocks may begin to shift towards the central and eastern Pacific, changing the catch rates in the waters of many PICs with potentially significant implications for purse seine by-catch rates of bigeye. The potential re-distribution of tuna stocks throughout the WCPO (and beyond) due to climate change will reinforce the need for flexible management systems that can cope with spatial shifts in fishing activity, e.g. to avoid the need for eastern countries to continually purchase purse seine vessel days from countries in the west, and the importance of maintaining healthy and resilient tuna stock sizes.
- *Markets and the economy*. Globally, the supply of tuna is approaching natural limits with little further increase expected, and likely to remain highly dependent on the WCPO region. In aggregate, demand for tuna may see a modest increase given flat supply and population growth, though with little change for canned tuna where declining mature markets may be balanced by emerging new ones. A slow increase in price for both canned and fresh tuna may be expected, but the same may also be said for fishing costs as crude oil prices are projected to double in real terms by 2040.
- *Science and technology*. Fishing technology is expected to continue to change in order to enhance efficiency (this is already ongoing in the purse seine fleet, and eventually would be in the longline fleet with the return of economic incentives), as well as product quality. Fisheries monitoring and surveillance technology can be expected to advance to significantly reduce enforcement costs, including expanded satellite tracking of vessels, use of unmanned aircraft systems for patrols and electronic fishing catch and effort monitoring.
- *Demographic change*. The overall population of the Pacific Island countries is expected to grow by some 50 percent over the next twenty years, together with rapid urbanization. In 2040 coastal fisheries production would be expected to remain largely stagnant (as it likely has since at least 2005), with concerns from SPC that a food fish gap could open in some PICs.
- *External governance*. The trade preferences that several PICs currently enjoy with the European Union can be expected to erode in comparison to other producers, further reducing the ability of regional tuna processors to compete in the global marketplace. At the same time, foreign fishing subsidies for tuna fleets can be expected to continue in some form in a number of cases. The Western and Central Pacific Fisheries Commission can be expected to slowly take regulatory measures to conserve bigeye stocks, which would affect PICs.

Taking into account past trends and expected external drivers of performance, the following potential scenario can be described for the region's tuna fisheries in 2040, dependent upon implementation of the policy decisions outlined in the *Regional Roadmap for Sustainable Pacific Fisheries*: By 2040, sub-regional coalitions of PICs are entrenched around the three tuna fisheries – purse seine, tropical longline and southern longline, with norms of transparency and trust established, as well as flexible formulas to distribute the returns on access in order to accommodate spatial shifts in the stocks as impacts from climate change are felt. Countries continue to see greater benefits from cooperation to manage the tuna stocks as shared natural capital assets, and many count upon their annual returns for stability funds and public investment. Working together, these coalitions set targets for maintaining minimum sizes of the four tuna stocks as a basis for firm and sustainable catch limits from the waters under their jurisdiction, based on regular assessments from the world's top tuna biologists at SPC. The coalition of countries around the equator - comprised largely of PNA members - operates a well-functioning organization governed by a permanent board of global experts from within the region, with a secretariat of professional staff from strong education and training programs within the region, built over recent years with public revenues from the fisheries. Similarly, the Tokelau Arrangement's successor is governed by a permanent board with a well-staffed secretariat. Staff in both organizations are highly skilled and focus on managing registries of tuna catch quota, monitoring trends in use and synthesizing key biological, ecological and economic research for the board, as well as managing quota auctions. The Pacific Islands Forum Fisheries Agency (FFA) provides monitoring and surveillance support, among other services, to the coalitions, and is recognized as a world leader in cutting-edge surveillance technology.

Seeing a future constraint on returns and potential external influence from the WCPFC, PNA members moved quickly in 2017 - 2018 to invest in research and development for by-catch reduction, and to implement an innovative fish aggregating device (FAD) licensing scheme to spur industry investment – particularly given projected eastward shifts in distribution of the stock. The combination of technology advances and some initially painful catch reductions, coordinated with similar action through the longline VDS, placed the bigeye stock on a slow recovery path, with biomass eventually and steadily increasing towards 40 percent of unfished levels. Albacore, skipjack and yellowfin stocks continue to remain healthy in 2040, with a slightly stricter target reference point to provide some reserve should climate change make it necessary. These stocks provide the world's last healthy tuna stocks and have become an even more international fishery system, as global demand for tuna products has remained steady with Asian and Middle Eastern markets becoming more mature.

Inclusion of Indonesia in the purse seine and tropical longline arrangements, and the Philippines in the former, enhanced the total allowable catch limits for both and placed most of the world's skipjack under robust management. Strong restrictions for fishing on the high seas, linked to access to national waters, was recognized in 2020 by the WCPFC together with robust management and monitoring, and even with shifting stocks, high seas fishing is minimal. Some three quarters of the southern albacore longline fishery operates on rules set through successors to the Tokelau Arrangement, with profitability on an upward trend.

As an example, gradually over the years PNA members enhanced the flexibility of fishing vessel day trading among them while increasing durability of allocations – with some countries moving slowly in order to give domestic fleets time to adjust and improve efficiency (and thereby maintain contributions to local value added). Vessel days with longer duration were progressively issued to companies for higher returns (e.g. for a five-year duration instead of one year), or in some cases in consideration of local investment. Continued trials in pooling with successful results, as well as improved auction designs, led to an agreement whereby the PNA members directed the secretariat to pool all access rights, allocated via auctions, with revenues distributed to parties via the agreed formula. Several parties opt to continue to invest access revenues in processing clusters, reducing the total fishing effort allowed and their distribution accordingly. After years of investment in effort adjustments at the individual vessel level, the parties made sufficient preparations for a transition of rules towards a quota-system. Secondary markets for quota developed,

regulated by the parties and enhancing overall fleet efficiency. Increased efficiency of fishing operations, together with the enhanced visibility and reduced risk for firms, led to significant investment in technology for higher quality products, generating value throughout the supply chain. As a result of healthy fish stocks and a well-functioning access market, revenues are between 50 percent higher and double 2015 levels in real terms (after management costs and concessions for domestic processing are subtracted).

Building off of healthy stocks and efficiently-regulated access, the PNA countries (plus Indonesia and the Philippines) have created a trading company that controls much of supply to processors and in some cases direct to retailers, supported by freezing/storage facilities in key hubs throughout the region. A number of PICs have well-developed vessel support systems that provide services to the fleets. Utilizing the pooled access regime, several countries exchange revenue distributions for allocations to secure access for coastal tuna fisheries developed through nearshore FAD networks to help ensure sufficient flow of food fish. This process began in the 2020s in advance of continued stagnation in coastal fisheries. Some countries have established dedicated coastal community funds with tuna revenues, to invest in reef restoration and key infrastructure and social goods. Additionally, countries with relatively large populations near ports or transshipment hubs, e.g. PNG and Solomon Islands, trial measures to support greater retention and local sale of purse seine by-catch (not including bigeye).

As a result of the policy strategies and decisions pursued under the *Regional Roadmap for Sustainable Pacific Fisheries*, sustainable public revenues are some US$177 to 345 million per year higher for PICs in real terms, after concessions for onshore investment and investments in administration, monitoring and surveillance are subtracted. A number of countries have increased local value added by a combined US$88 million per year in real terms, due to processing clusters and vessel service hubs (though many processing facilities operate under capacity and at a loss given erosion of European trade preferences). These efforts have created some 7,500 to 15,000 additional jobs in the region for processing, without including the additional employment from service hubs. Over time an Oceanic Tuna Export Company (OTEC) could develop and generate significant profits shared, as well as employment at storage facilities throughout the region.

The policy strategies leading to this potential scenario in 2040 can be summarized as:

1. Regional cooperation around a shared resource, eventually expanded to include key resource owners like Indonesia and the Philippines,
2. Hard fishing effort and catch limits that maintain the tuna stocks as valuable natural capital assets in the water that are used sustainably (and help constrain supply and hence increase price), with proactive efforts and up-front investments to rebuild the bigeye stock before further declines,
3. Flexible access and eventually output rights for fleets, that enhance the value of the fisheries without increasing production, and provide a tool for interested PICs to lever greater foreign investment in processing,
4. Significant investment in skills and capacity to develop the world's top tuna managers as well as to monitor compliance with catch limits and access rights and thereby prevent illegal fishing, and
5. Inclusion of coastal communities in the fisheries where feasible, through dedicated access and inshore FAD networks, as well as targeted investments maintain food security with coastal fish supplies stagnating and growing populations.

A key point of emphasis in these strategies is continued and expanded investment in **policy delivery capacity**, notably in terms of regional agencies that support the information base for setting fishing limits and the monitoring of compliance, the secretariats of sub-regional coalitions setting fishing limits, and the national agencies developing and implementing policy within countries' waters. Expanded staffing, training and partnerships with regional and international organizations could help ensure the delivery capacity is in place, together with dedicated regional programs and activities towards this end.

I. Introduction and Objectives of the Report

1.1 Introduction: The importance of tuna resources to economic growth in the Pacific Islands

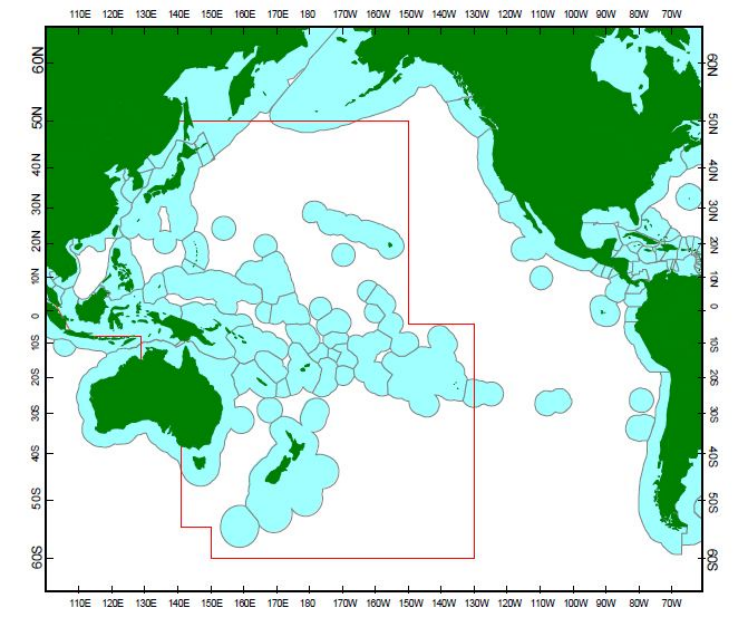
Pacific Island Countries' economic growth aspirations are not on track to be achieved. One of the principal objectives shared between the eleven Pacific Island member countries of the World Bank (including Papua New Guinea)[1] is economic growth that is inclusive and equitable, as articulated in the Framework for Pacific Regionalism (the region's overarching policy framework for collective action) (Pacific Islands Forum, 2014). However, the rate of growth in many of these countries has generally been low over the last decade, and if this trend were to continue over the next 25 years, with only Fiji and Palau's gross domestic product (GDP) per capita growing at a rate higher than two percent annually, many Pacific Island countries (PICs) will fall significantly behind other countries, with per capita GDP levels only moderately higher than at present.

One of the few opportunities to avoid this 'low-growth future' is utilization of the region's tuna resources. Potential drivers of economic growth are limited in the Pacific due largely to the geography and the constraints of isolation. PICs' resource endowments such as the tuna stocks and the economic activities they support, may be some of the most economically viable growth areas for the region.

The Pacific is endowed with some of the world's largest tuna stocks. As units of analysis, the entire Pacific Ocean is divided into either (i) the Western and Central Pacific Ocean (WCPO) - covering over 8 percent of the global ocean, or (ii) the Eastern Pacific Ocean (EPO), where each contains separate stocks[2] of tuna whose interactions are relatively limited (see Box 1 and Figure 1) (Hampton et al., 1999). Tuna is a general term referring to several species of fish, and scientists often categorize some 61 species as 'tuna and tuna-like fish', 14 of which are considered 'true tuna' (SPC, 2015).

Box 1: The Western & Central Pacific Ocean (WCPO) region

The WCPO region is defined by the wide range of the Pacific Ocean covered under the Convention on the Conservation and Management of High Migratory Fish Stocks in the Western and Central Pacific Ocean, and includes both the national waters of a number of countries as well as areas beyond national jurisdiction (WCPFC, 2010). Although the western boundary notionally extends to the East Asian seaboard, it is understood that the Convention Area does not include the South China Sea. In the east, the Convention Area adjoins, or overlaps, the area of competence of the Inter-American Tropical Tuna Commission. The southern boundary extends to 60 degrees south and the northern boundary extends to Alaska and the Bering Sea (WCPFC, 2010).



Western and Central Pacific Ocean (area of the Western and Central Pacific Fisheries Commission (WCPFC) inside the red lines. Source: Harley et al, 2011.

[1] Federated States of Micronesia (FSM), Fiji, Kiribati, Palau, Papua New Guinea, Republic of the Marshall Islands (RMI), Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. See: http://www.worldbank.org/en/country/pacificislands/overview accessed on August 10, 2015.

[2] A 'fish stock' is an operational rather than biological term, defined by FAO as the living resources in the community or population from which catches are taken in a given fishery (where the fish stock may be one or several species of fish, and also includes commercial invertebrates and plants) (FAO Fisheries Glossary).

The WCPO region contains stocks of four tuna species that are commercially harvested:

- albacore (*Thunnus alalunga*), separated into two discrete stocks by the equatorial area (where they are rare): a northern and a southern component, long-lived and often caught between 1.5 and 10 years old at a length of 45 to 50 cm, generally in deeper waters with longlines;

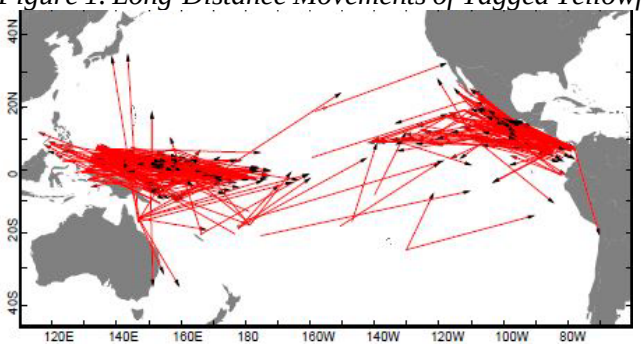
- bigeye (*Thunnus obesus*), long-lived and among the largest of the world's tuna species, bigeye are broadly distributed in the WCPO both horizontally and vertically in the water column, typically caught either as juveniles (3 months to 1.7 years old) at a length between 20 to 75 cm or between 100 and 180 cm (2 to 10 years old) the latter by longline;

- skipjack (*Katsuwonus pelamis*), fast-growing and short-lived species (few live longer than three to four years), surface-schooling species distributed year-round in warmer, tropical waters, with seasonal expansion into northern and southern sub-tropical waters, typically caught at a length between 40 to 70 cm; and

- yellowfin (*Thunnus albacares*), fast-growing species distributed throughout WCPO tropical and sub-equatorial waters, typically spending most of their time in warmer mixed surface waters and caught either as juveniles (3 months to 1.5 years old) at a length between 20 to 70 cm or between 90 to 160 cm (1.5 and 6 – 7 years old) (SPC).

These WCPO tuna resources collectively form the basis of one of the world's largest and most valuable fisheries. Their movements cover a massive area of the WCPO, and the fleets that hunt them travel thousands of kilometers to do so (see for example Figure 1). The movement of the four tuna stocks within the WCPO occurs in large part within the waters under the jurisdiction of Pacific Island countries. In particular, the 11 Pacific Island country members of the World Bank (including Papua New Guinea) control over 55 percent of this WCPO area[3] and indeed almost 5 percent of the global ocean (see Table 1 below). From these waters alone, 34 percent of world's global tuna catch[4] is supplied each year, with an estimated delivered value[5] of over US$3.4 billion annually (FFA, 2014).

Figure 1. Long-Distance Movements of Tagged Yellowfin Tuna



Source: Secretariat of the Pacific Community, in Gillett (2014)

[3] WCPO convention surface area estimated at 30 million square kilometers, from https://portals.iucn.org/library/efiles/html/EPLP-072/section11.html#fn1

[4] Global tuna catch defined as the global catch of the 4 main species (albacore, bigeye, skipjack and yellowfin), totaling 4.61 million metric tons in 2013.

[5] The term 'delivered value' is defined here in terms of the price paid by processors in Thailand for supply of tuna. This differs from the synonymous terms of 'first-sale value', 'ex-vessel value' and 'landed value' which refer to the price paid to the harvester for the tuna, often by a trading company who will transship the catch to the processor.

Table 1: Pacific Ocean under the Jurisdiction of World Bank member countries as Exclusive Economic Zones

Country	Land Area (sq. km.)*	EEZ (sq. km.)**
Federated States of Micronesia	702	2,992,597
Fiji	18,274	1,281,122
Kiribati	811	3,437,345
Palau	459	604,289
Papua New Guinea	462,840	2,396,575
Republic of the Marshall Islands	181	1,992,232
Samoa	2,821	131,812
Solomon Islands	27,986	1,597,492
Tonga	717	664,853
Tuvalu	26	751,797
Vanuatu	12,189	827,891
TOTAL	527,006	16,678,005

* CIA World Factbook; ** Claus et al, 2014; via www.seaaroundus.org

1.2 Objectives of the Report

The objective of this report is to suggest some viable answers to the questions: in a plausible best case scenario, how much could these tuna resources contribute to Pacific Island countries' economies by the year 2040, and what policy decisions would be required from the countries? In complement, what would be the impacts and benefits in terms of employment and food security of these policy decisions? To answer these questions, the remainder of the report is organized as follows:

(i) *Methodology*: defining the key drivers of performance for the use of these resources;
(ii) *Baseline*: in terms of the current economic contributions from the resources and past trends in the key drivers of performance;
(iii) *Key Drivers of Change*: describing expected changes in the direction of indicators of key external drivers of the fisheries' performance, and potential key policy strategies or decisions that might be taken by PICs in this context; and
(iv) *Opportunity Scenario in 2040*: describing a plausible best-case scenario in 2040 based on potential policy strategies and expected changes in given the key drivers.

The building blocks for this report are the *2010 Future of Fisheries report* and subsequent *Regional Roadmap for Sustainable Pacific Fisheries* endorsed by Forum Leaders in 2015. In 2010 the Pacific Islands Forum Fisheries Agency (FFA) and the Secretariat of the Pacific Community (SPC) prepared a report identifying broad focal areas to achieve a best-case scenario for the development of the region's fisheries over a 25-year period from 2010 to 2035 (Gillett and Cartwright, 2010). With the aim of informing long-term strategic approaches to the region's fisheries, the report led to a 'status check' on progress in 2015, and the development of a Regional Roadmap for Sustainable Pacific Fisheries with strategies and measurable targets to help achieve the best-base scenario described in 2015, within the context of the Framework for Pacific Regionalism (FFA and SPC, 2015). This Roadmap was endorsed by the leaders of the member countries of the Pacific Islands Forum, during the 46th Forum meeting in Port Moresby during September of 2015 (Pacific Islands Forum Secretariat, 2015).

This study aims to build upon the Future of Fisheries report and subsequent Roadmap, by building upon the best-case scenario for the tuna fisheries to the year 2040, identifying the potential economic contributions to the region from achieving this best-case scenario by building upon the 10-year targets in the Roadmap, and proposing further detail on likely policy decisions that would need to be taken by Pacific Island countries within the context of implementing the Roadmap in order to achieve the best-case scenario.

II. Methodology

In developing a best-case scenario for the economic contribution of WCPO tuna fisheries to the economies of Pacific Island countries, the following methodology describes:

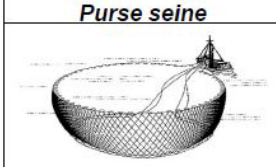
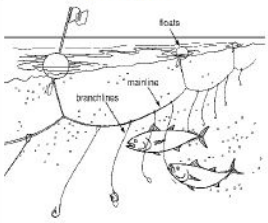
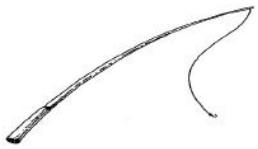
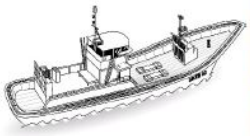
- The units of analysis for WCPO tuna fisheries,
- Measurement of the economic contribution of these fisheries, and
- Construction of the best-case scenario for 2040.

2.1 Defining the Units of Analysis within Western and Central Pacific Ocean Tuna Fisheries

Throughout the WCPO and particularly the waters of Pacific Island Countries, these four stocks of tuna move widely and are hunted by industrial fishing vessels with sophisticated technology, collectively forming one of the world's largest fisheries by any measure – value, volume and range. This collective WCPO tuna fishery is actually a diverse range of fisheries[6] and accompanying supply chains, which are often defined by the method of fishing used and include:

- *Small-scale artisanal operations* in the coastal waters of Pacific Island countries;
- *Industrial purse-seine operations* capturing multiple species but largely targeting skipjack (70 – 85 percent of total catch) and yellowfin (15 – 30 percent), where a fishing vessel sets a net in a circle around a school of tuna by first releasing one end attached to a buoy or skiff, and then releasing more of the net as the vessel moves around in a large circle until the two ends are brought together and retrieved, and the purse seine wire that runs through the rings around the lower weighted edge of the net is hauled to cinch the bottom closed;
- *Industrial longline operations* comprised of a number of different discrete fleet segments and operations whereby vessels pull longlines (comprising a mainline to which branch lines with baited hooks are attached at intervals) along the surface of the water behind it, and which can be grouped as (i) tropical longline fisheries largely targeting yellowfin and bigeye (including 'offshore' sashimi longliners from Taiwan, China and from mainland China, and domestic fleets from Indonesia, Philippines, PNG, the Solomon Islands, FSM, RMI and Vietnam; and 'distant-water' vessels from Japan, Taiwan, China and mainland China, and Vanuatu, operating primarily in the eastern tropical waters of the WCPO), and (ii) southern longline fisheries largely targeting albacore (including Pacific Island

Figure 2. The Main Tuna Fishing Methods in the Pacific

Gear Type	Catch	Typical vessel
Purse seine		
	Mainly skipjack and small yellowfin are caught by purse seine gear. Most catch is for canning.	
Longline		
	Most tuna caught are large size yellowfin, bigeye, and albacore. The prime yellowfin and bigeye often are exported fresh to overseas markets. Most of the albacore is for canning.	
Pole-and-line		
	Mainly skipjack and small yellowfin are caught by pole-and-line gear. Most catch is for canning or producing a dried product.	

Source: Gillett, 2014

[6] The United Nations Food and Agriculture Organization (FAO) defines a fishery as a geographical place, activity, or unit that is involved in raising and/or harvesting fish. As a unit of analysis, a fishery is typically defined in terms of some or all of the following, people involved, species or type of fish, area of water or seabed, method of fishing, class of boats and purpose of the activities (FAO Fisheries Glossary).

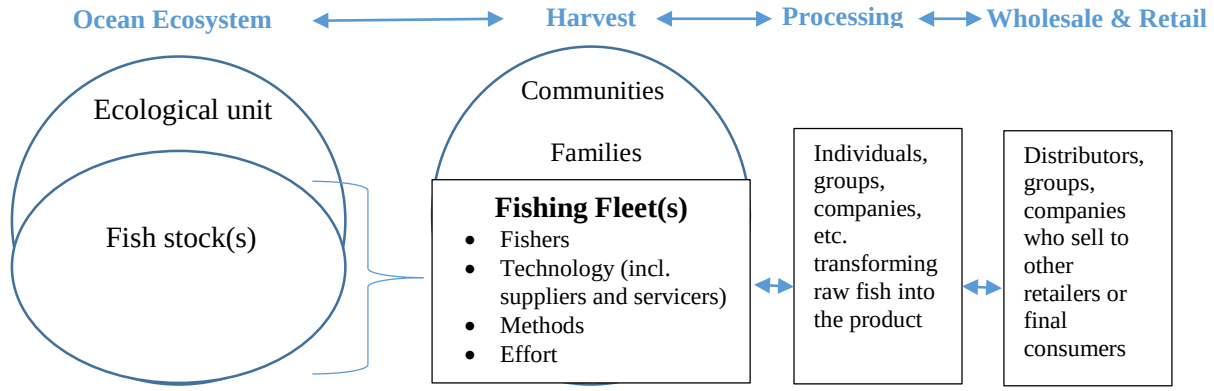
fleets and 'distant-water' fleets from Taiwan, China and mainland China operating in sub-tropical waters in the southern area of the WCPO); and

- *Industrial pole-and-line operations*[7] by domestic fleets from Indonesia, Solomon Islands, French Polynesia and the distant water fleet from Japan, targeting skipjack year-round, as well as seasonal sub-tropical skipjack fisheries in the national waters of Australia, Japan (extending eastwards to include albacore also) and the United States (i.e. Hawaii) (King, 2007; Gillett, 2014; SPC, 2015).

In terms of both the volume and value, the two largest of these fisheries are the purse seine fishery and the longline fishery – both tropical and southern albacore (Williams and Terawasi, 2015), which will be the two units of analysis for this report. Although roughly 10 percent of the WCPO tuna catch was taken by the pole and line fishery in 2014 for consumption in Japan in various forms or canning in the Solomon Islands, this fishery has been less productive than the purse seine fishery, and the 120 vessels based in the region 30 years ago have dwindled to 5 (Gillett, 2014). As such, this report does not focus on the pole and line fishery, though certainly market preferences and operating conditions may change in the future that make this fishery more attractive in the region.

The WCPO purse seine and longline tuna fisheries support global supply chains, which in aggregate form complex and multi-layered systems. Fish is one of the world's most traded agricultural commodities (World Bank and FAO, 2009; FAO, 2014), and WCPO purse seine and tropical longline tuna fishery supply chains are no exception. These often originate in Pacific Island waters and end with consumers in Europe, Japan or North America (Gillett, 2014). As such, for purposes of analyzing the economic benefits they provide, these fisheries should be considered as dynamic systems that include all of the components of the supply chains, beginning with the finite natural resource stock, which produces a flow of benefits to users along the chain – illustrated as a generic and simple value chain in Figure 3 (Ostrom, 1990; Hilborn and Walters, 1992; Charles, 1995; Lackey, 2005; Garcia and Charles, 2007).

Figure 3. Generic components of a simple commercial fisheries value chain



Source: Adapted from Charles (2001), drawing from Orbach (1980)

While simple, predictable, mechanistic systems were referred to as 'clockworks' by Boulding (1956), given the interaction of biophysical variables in a given ocean ecosystem that determines the size and abundance of a fish stock(s) that is targeted by a group of fishers and their methods, fishery systems are complex, imperfectly predictable, dissipative structures that could be referred to as 'soft watches' based on Salvador Dali's allegory in a 1931 painting to indicate that things may not be as rigid as usually assumed (Garcia and Charles, 2007). In fact, a given fishery system is actually a plexus of subsystems, while also part of broader natural and human systems and is affected by the global environment, economy, and society within which

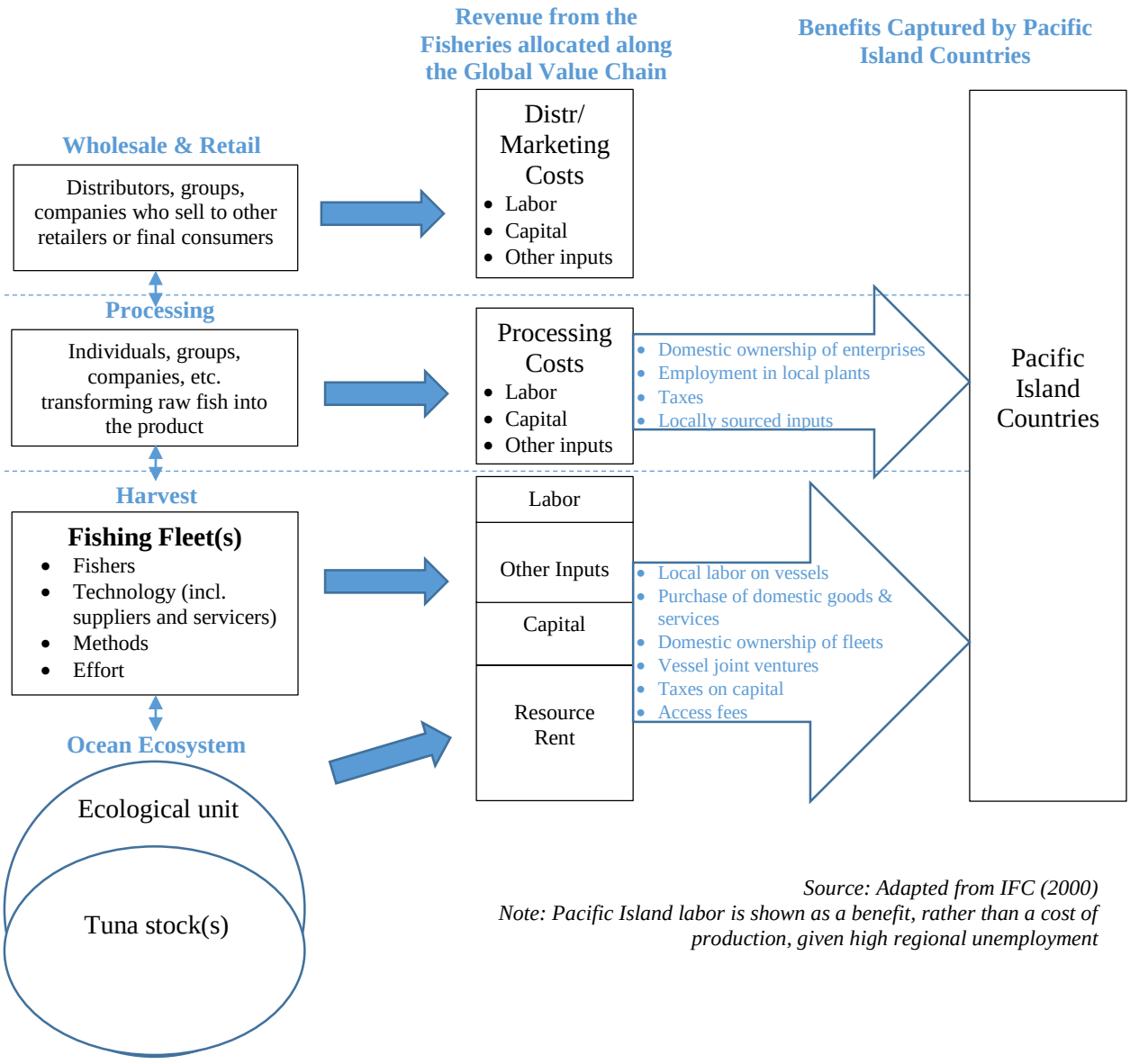
[7] The method of pole and line fishing refers here to vessels fishing with barbless, un-baited hooks on short lines attached to poles to catch tunas (King, 2007).

it exists (Garcia and Charles, 2007). For this reason, the units of analysis in this report will be the WCPO purse seine tuna fishery, the tropical longline tuna fishery and the southern albacore longline fishery value chains.

2.2 Measuring the Current and Future Economic Contribution from these Fisheries

Given that the WCPO tuna fisheries support global value chains, the current economic contributions to Pacific Island countries can be measured at each component of the chain, as follows:

Figure 4. Current Economic Benefits to Pacific Island Countries from WCPO Tuna Fisheries



Source: Adapted from IFC (2000)
Note: Pacific Island labor is shown as a benefit, rather than a cost of production, given high regional unemployment

As shown above, the economic contributions from fishery value chains are often measured by their annual contributions to a country or group of countries' economy, typically in terms of GDP. However, annual measures such as GDP indicate a growth in contributions from one year to the next, but do not indicate whether such growth is sustainable, or alternatively if it has been achieved at the expense of future benefits (for example through capital and other input expansion in the harvesting sector at the expense of resource rent in Figure 4 above) (World Bank, 2012). For this reason, many countries have adopted wealth accounting principles to supplement GDP (though not yet in Pacific Island countries), by measuring

changes in the size of the underlying assets[8] that support human well-being – such as the tuna stocks illustrated in Figure 4 above (World Bank, 2012). A country's total wealth is comprised of three classes of assets: (i) natural capital such as tuna stocks in the ocean, (ii) produced capital (machinery and structures, urban land), and (iii) intangible capital (skills, expertise, etc. with which labor is applied) (World Bank, 2006). With this in mind, GDP is considered as essentially the annual economic returns to a country from its assets (World Bank, 2006). When countries fail to account for their assets such as natural capital and rely solely on GDP, "it's like grading a corporation based on one day's cash flow and forgetting to depreciate assets and other costs," according to Joseph Stiglitz, winner of the Nobel Prize for Economics (World Bank, 2012).

Box 2. Measuring the Ocean's Natural Capital

Recent efforts have been undertaken to measure the ocean's natural capital on a global scale. In 2015, WWF estimated the asset value – i.e. the value of the services provided – of fisheries, mangroves, coral reefs and seagrasses, at some US$6.9 trillion, with an annual return on all ocean 'assets' (a 'gross marine product') of some US$2.5 trillion.

Source: Hoegh-Guldberg et al (2015)

Renewable natural assets such as the WCPO's tuna stocks are considered as a true gift of nature, or endowment, because they can potentially supply a sustainable stream of benefits that can be reinvested to grow the value of the country's capital and therefore wealth (World Bank and FAO, 2009). Because the value of an asset is both the current and future benefits it can provide in an assumed lifetime, taking a greater amount of benefits from a renewable natural asset now than it can sustain will reduce the future stream of benefits from that asset, and thus its present value. Essentially, one is robbing the future to pay the present. The value of renewable natural assets such as tuna stocks is therefore linked to their environmental well-being, where increases in stock size lead to higher values and conversely a reduction in asset value may reflect resource degradation. More specifically, the asset value is measured as the present value of the future consumption (i.e. value of consuming current and future benefits from all economic items, in this case given as the economic profits[9] generated along the fishery value chains).

Economic growth is an engine of poverty reduction (World Bank, 2015). Taking natural capital accounting into consideration, efforts to increase shared economic growth and hence poverty reduction from the region's tuna fisheries are linked to sustainably increasing the present value of these assets, i.e. the sustainable benefits they can produce, rather than just their annual contribution to GDP (World Bank and FAO, 2009). Essentially, the economic returns from the fisheries and the contribution they can make to poverty reduction are tied to the abundance of fish in the ocean. For this reason, to the extent possible, this report will refer to both:

(i) the annual contribution of the WCPO purse seine and longline tuna fishery value chains to Pacific Island countries' GDP, and
(ii) the value of the region's underlying natural capital asset (i.e. the present value of the stream of profits generated along the tuna fishery value chains).

In addition, given the transaction costs in translating national gains in economic growth into gains for the bottom forty percent of a country's income distribution (World Bank, 2015), the report will include information on the current and potential direct contribution of the fishery value chains to Pacific Island employment and food security.

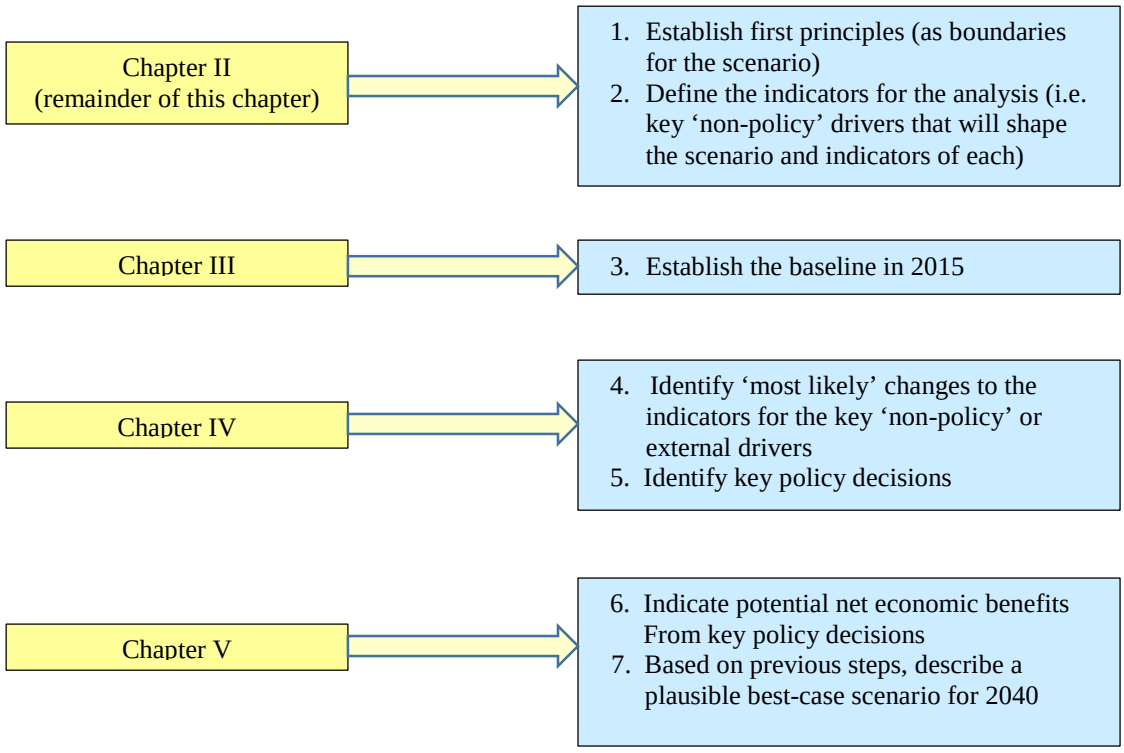
[8] An asset is defined as an item of economic value or able to produce a flow of benefits such as income (World Bank, 2006).
[9] Economic profits refers here to the profits generated by the fishery, as a very broad proxy for the more specific concept of resource rent which is generated through fishing activities and captured along the value chain, based on Ricardo's theory of land rents whereby a natural resource is in fixed supply and thus the owner can charge a rent for its use (World Bank and FAO, 2009). Figure 4 above shows resource rent captured at the harvesting segment by Pacific Island countries, largely through access fees.

2.3 Developing a Plausible Scenario for Change to 2040 to this Economic Contribution

To construct a plausible best-case scenario for the contribution of WCPO tuna fishery resources to Pacific Island countries' economies in 2040, the report draws upon the relatively recent field of scenario development, together with secondary data collected from WCPFC and SPC databases and published reports, supplemented by literature review and consultations with experts (see Annex I for an overview of the field of scenario analysis). Scenarios tell compelling stories that capture the imagination and communicate future risks or opportunities, often for policy decisions (Swart et al., 2004). They are neither predictions nor forecasts, but rather should be thought of as coherent and plausible stories, told in words and numbers, about the possible co-evolutionary pathways of combined human and environmental systems (Nakicenovic et al., 2000; Swart et al., 2004; Carpenter et al., 2005). Each scenario is one plausible alternative image of how the future might unfold under particular assumptions, and a set of such scenarios can support understanding of possible future developments in complex systems and policy making (Nakicenovic et al., 2000; Carpenter et al., 2005). In this way, they assist policy-makers to understand the upcoming choices that need to be made and highlight developments in the present (Carpenter et al., 2005).

Specific methodology for construction of a scenario for Pacific Island tuna fisheries in 2040. Building off of the experiences to date, the report will develop an 'opportunity' scenario, whereby a plausible and desirable vision of the future will be prescribed, based on expected future directions of the fisheries and given key policy decisions. As such, the study will: (i) begin with the baseline or current contributions and trends based on data available as of 2015, and (ii) articulate the description of a plausible, best-case scenario for the contribution of tuna fisheries to Pacific Island economies in 2040, given key policy decisions that would need to be taken by Pacific Island countries and the expected changes to other key drivers of performance in these fisheries. While robust scenarios of alternative future pathways for WCPO tuna fisheries could take years to build, the scenario developed here will rather suggest an initial narrative in order to highlight possible opportunity and the key policy decisions that would arise over the next 25 years, which would require more detailed scenarios and modeling to better understand. The methodology includes the following steps, described in the remaining sections and chapters of the report:

Figure 5. Methodology for Developing the 2040 Opportunity Scenario for Pacific Tuna Fisheries



These steps are described in more detail below:

1. *Step One: Establish first principles (as boundaries for the scenario)*: Any discussion of potential scenarios and policy decisions concerning regional resources such as the WCPO tuna stocks, takes place in the context of the shared values, goals and policies of the Pacific, most recently articulated in the Framework for Pacific Regionalism (Pacific Islands Forum Secretariat, 2014). The Framework states the following *Pacific regional values* that will guide policy-making:
    - We value and depend upon the integrity of our vast ocean and our island resources.
    - We treasure the diversity and heritage of the Pacific and seek an inclusive future in which cultures, traditions and religious beliefs are valued, honored and developed.
    - We embrace good governance, the full observance of democratic values, the rule of law, the defense and promotion of all human rights, gender equality, and commitment to just societies.
    - We seek peaceful, safe, and stable communities and countries, ensuring full security and wellbeing for the peoples of the Pacific.
    - We support full inclusivity, equity and equality for all people of the Pacific.
    - We strive for effective, open and honest relationships and inclusive and enduring partnerships—based on mutual accountability and respect—with each other, within our sub-regions, within our region, and beyond.

    The Framework elaborates the following *principal objectives*:
    - Sustainable development that combines economic, social, and cultural development in ways that improve livelihoods and well-being and use the environment sustainably;
    - Economic growth that is inclusive and equitable;
    - Strengthened governance, legal, financial, and administrative systems; and
    - Security that ensures stable and safe human, environmental and political conditions for all.

    These values and objectives provide a set of first principles for development of the scenario for Pacific tuna fisheries in 2040. As such, the scenario developed will be consistent with these principles, and bounded by them. For example, a scenario that significantly enhances economic growth at the expense of social development or environmental sustainability would not be an option.

2. *Step Two: Define the indicators for the analysis*: Key indicators for the scenario analysis include (i) the indicator variable for success in 2040 (i.e. the dependent variable), (ii) the key policy decisions that will determine success (i.e. the independent variable), and (iii) the most likely values for the indicator variables of other key drivers of success (i.e. controlled variables). Each of these three types of indicators are further defined below:

    i. *The dependent variable (i.e. 'the opportunity')* is defined as the contribution of the purse seine and longline tuna fisheries to Pacific Island countries' economies in 2040. As mentioned previously, the indicator most commonly used is the contribution to GDP, which reflects essentially an annual return on the country or countries' assets, including natural capital assets such as tuna stocks. For this reason, the report uses contribution to GDP as the indicator variable for the opportunity the fisheries could provide in 2040, but also to the extent data permits, references the underlying status and value of the natural capital asset, as measured by the present value of the stream of benefits generated along the tuna fishery value chains. As such, the biological status of the fish stocks is incorporated into this dependent variable. Additionally, although not the dependent variable, the report also indicates the impact of this opportunity on Pacific Island employment as well.

ii. *The independent variable (i.e. 'the policy decisions needed' or key policy drivers)* is defined as the fisheries governance reforms under the control of Pacific Island decision-makers – notably to maintain an abundance of the resource to support optimal harvests and the wider ecological support functions needed - that would be required to achieve the target for the dependent variable in 2040. This variable is considered endogenous to the decision-makers in Pacific Island countries, and will be described fully in terms of the dependent variable. These governance reforms will be discussed in terms of policy decisions to be taken, institutional changes and organizational capacity to deliver the reforms.

iii. *The controlled variables (i.e. 'the key non-policy or external drivers')* are defined as the main 'non-policy' or external drivers that will shape future events for the tuna fishery systems under analysis (i.e. in addition to the governance driver in step ii above). Previous scenario analyses have identified a number of key direct and indirect external drivers that affect the performance of systems such as Pacific Island tuna fisheries. For example, in supporting the development of business strategies, Porter (1979, 2008) categorized five major forces generally affecting industries. Subsequently, Doyle and Windheim (2014) adapted this approach to examine the societal forces shaping environmental quality. The four forces or key drivers they identified as affecting environmental quality (and the value chains dependent upon it) include: (i) governance (policy, law, regulation, regulatory environment); (ii) science and technology (technology methods and innovations, innovation ecosystem, intellectual property); (iii) markets and economy (market size, profitability, micro and macro-economic trends, investment); and (iv) behavior (consumer and industry perceptions and response, non-compulsory actions and choices). Building upon this approach, as well as the range of drivers identified in the 2010 Future of Fisheries report (Gillett and Cartwright, 2010), the following three key direct and two key indirect external drivers have been selected, together with the most important or priority indicator variables for each, in order to help articulate a technically and economically plausible scenario for the best-case economic contribution of WCPO tuna fisheries to Pacific Islands in 2040, while drawing upon relevant experiences from other countries and considering global and regional trends that could shape the opportunity:

Direct Drivers[10]

1. Climate change:
    - Change in the abundance and distribution of tuna stocks

2. Markets and the economy:
    - Global price for various tuna products, reflected changes as well as trends in global supply from other oceans, including consumer preferences
    - Fixed and operating costs along the Pacific tuna fishery value chains (notably harvesting costs, particularly fuel, but also processing and distribution costs such as labor, utilities, etc.)

3. Science and technology:
    - Harvesting technology (fishing vessels, gear, methods, storage)
    - Fishery monitoring and enforcement technology

[10] Both direct and indirect drivers are not listed in order of any priority or impact.

Indirect Drivers

4. Demographic change:
    - Changes to Pacific Island population size, and subsequently change in Pacific Island demand for animal protein, notably the change in fish demanded by the population (kg/year), as a driver of local demand for the region's tuna resources

5. External Governance:
    - Trade barriers (tariffs and standards) and preferences
    - Foreign fishing subsidies and fleet capacity policies
    - Western and Central Pacific Fisheries Commission policies

The above variables for each of the key external drivers are considered exogenous (based on their temporal and spatial scale), over which Pacific Island decision-makers (largely) do not have any control. This reflects basic bio-economic functions that show the profitability of fish harvesting operations as a function of product price, the harvesting technology employed, the fixed costs of harvesting, the operating costs of harvesting, the fishing effort expended and the abundance of the resource targeted (Anderson and Seijo, 2010). The fishing effort that vessels expend in Pacific Island waters, and indirectly the abundance of the tuna resources targeted, are considered endogenous to regional decision-makers and subject to governance, while the remaining variables (e.g. price, the harvesting technology employed, fixed and operating costs for harvesting inputs and regulations of foreign market access) are subject to factors beyond the spatial and/or temporal control of Pacific decision-makers.

3. *Step Three: Establish the baseline from data available in 2015*: The evolution of the region's tuna fisheries value chains since the 1950s will be described, together with their current economic contributions, as the starting point for the scenario. Data and information used will be based on the latest available as of 2015, which generally reflects catch data and economic indicators as of the end of 2013 or where possible end of 2014.

4. *Step Four: Identify 'most-likely' changes to the priority variables of the key 'non-policy' or external drivers of tuna fisheries' economic contribution to Pacific Islands*: The most likely future changes to the priority variables for each of the key 'non-policy' drivers (drawing as needed upon any additional variables upon which the priority variables are dependent) will be described, essentially as 'mini-scenarios'. Each mini-scenario would state past trends, current measures, and assumptions about the step-wise changes in the values of the variables (or the direction of the change in values), including assumptions about the relationships between changes in the variables over time (indicating any specific linkages and interactions between the key 'non-policy' drivers).

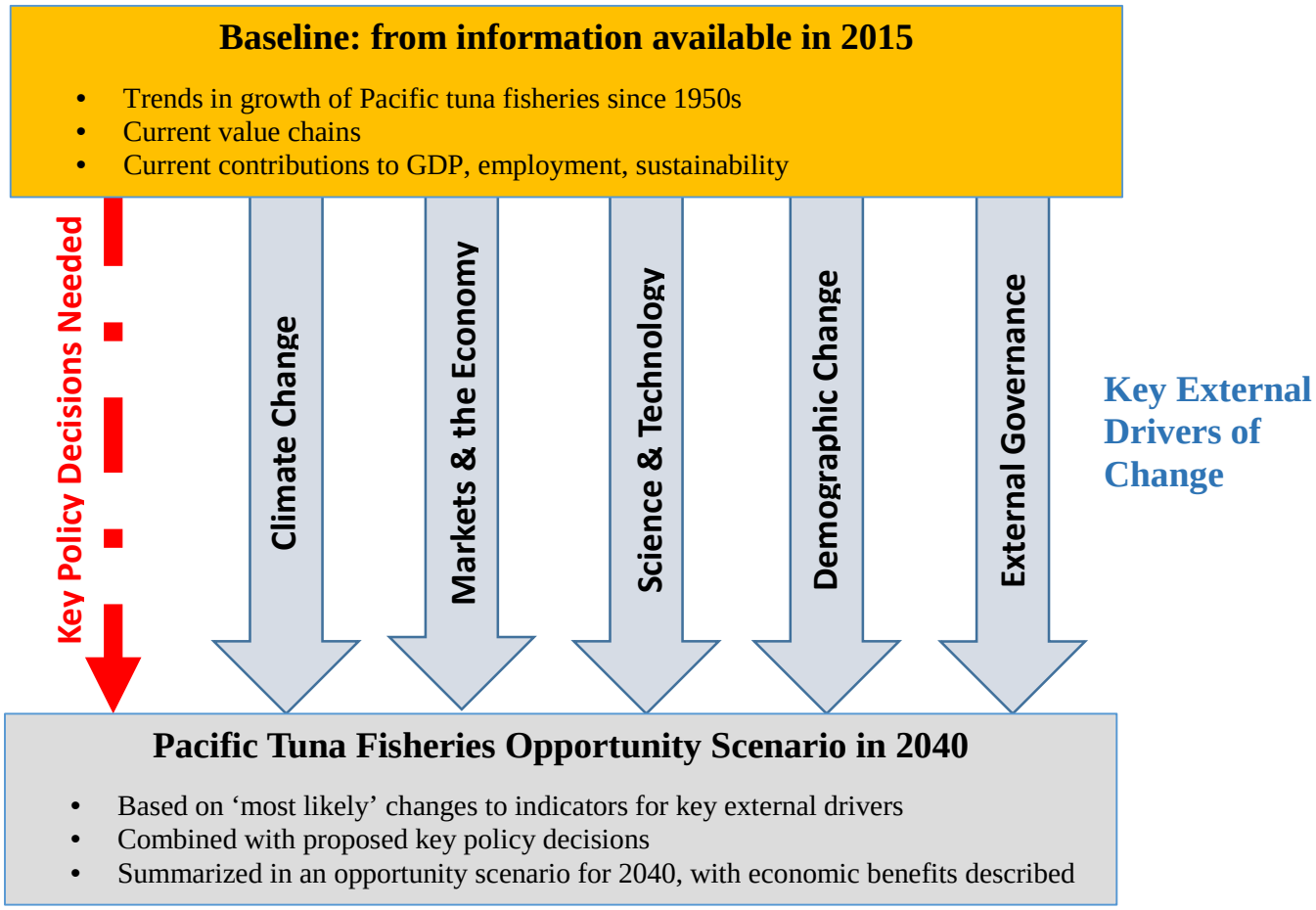
5. *Step Five: Identify the key policy decisions PICs would need to take in order to attain the opportunity scenario (i.e. prescribed vision of the future) in 2040, given the 'most likely' changes to key 'non-policy' or external drivers*. Given the expected changes to key external drivers, the key governance reforms (i.e. policy decisions) PICs would need to take in order to attain a best-case or opportunity scenario in 2040 will be proposed.

6. *Step Six: Describe the opportunity scenario in 2040*: Starting from the baseline, the 'mini-scenarios' for the most likely changes in the priority variables of key external 'non-policy' drivers and the proposed key policy decisions will be combined into a narrative storyline that describes the resulting and plausible best-case scenario for the economic contributions of the purse seine and tropical longline tuna value chains to Pacific Island countries in 2040. This scenario will

incorporate the 'best-case' scenario from the *Future of Fisheries* report, and 10-year targets from the *Regional Roadmap for Sustainable Pacific Fisheries* as milestones.

7. *Step Seven: Summarize the impact of achieving the opportunity scenario*. Available measures for the dependent variable will be summarized (including the status and value of the underlying natural capital asset), i.e. the economic contribution of the tuna fishery value chains to Pacific Island countries under the opportunity scenario, as well as measures of livelihoods.

Figure 6. Summary of Conceptual Framework for Developing the 2040 Opportunity Scenario



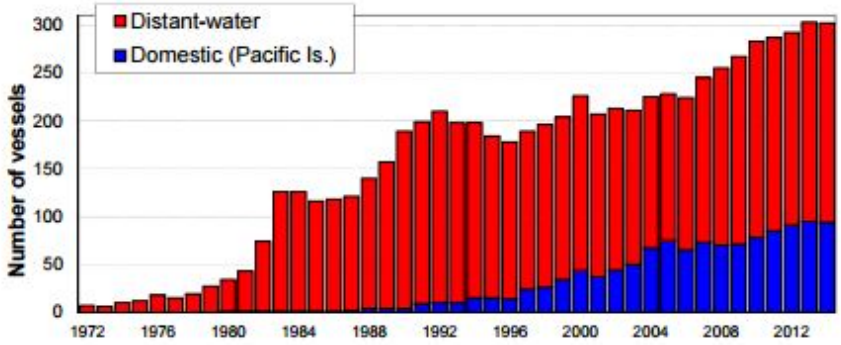
III. Baseline

3.1 Historical Development of Tuna Fisheries Value Chains in the Western and Central Pacific Ocean

Any discussion of the starting point is enriched by a brief understanding of the historical context. Tuna have provided an important source of food for Pacific Island populations for centuries, and now collectively support one of the world's largest and most valuable fisheries (SPC, 2015). While traditional tuna fisheries have existed for centuries, the region's modern tuna fisheries date back to the Treaty of Versailles in 1919, when Japan gained control of many German colonial territories in the region (including what is now Palau, FSM, RMI and the Northern Mariana Islands) and began to invest in food production systems (Gillett, 2007). By the 1930s industrial tuna fishing accelerated with 116 pole-and-line vessels based in Japanese territories in the region, and increasingly Japanese longline vessels fishing in the area (Barclay, 2010). After a pause during World War Two, this activity recommenced in 1952 with Japanese public investment in both distant-water pole-and-line and longline fleets to enhance food production, generally in Fiji, American Samoa, Vanuatu, New Caledonia and French Polynesia (Barclay, 2010). The longline vessels mostly caught albacore for export to canneries in Hawaii and the U.S. mainland during this period, while technology continued to develop rapidly (Gillett, 2007). Similarly, the U.S. followed suit with canneries first established in Pago Pago in 1953 (Barclay, 2010). As Japanese pole-and-line operations were limited by the distance achievable from a shore base with live bait, by the 1970s based had been established in PNG (1970), the Solomon Islands (1971), and Fiji (1976) – many in local joint ventures (Barclay, 2010). Total production from the pole-and-line fishery would eventually peak in the mid-1980s, just after the onset of the biggest development in industrial tuna fishing: purse seining.

Purse seining was a 'revolution' in tuna fishing in the WCPO. This development began when the California pole-and-line fishery started to re-orient towards purse seine fishing in the 1950s, in response to competition from Japanese fleets (Barclay, 2010). Fueled by public support, new technology and innovation allowed purse seining to be adapted to tropical waters, and by the 1970s efforts were increasing to encourage U.S. purse seining in the region in order to supply the canneries in Pago Pago (Barclay, 2010). However, in the early 1980s a confluence of factors drew more U.S. purse seine vessels to the region, including early successes, difficulties in Mexico and Costa Rica, a new agreement with U.S. trust territories in the region, a strong El Nino event in 1982-83 that reduced catch in the Eastern Pacific, and a public outcry against by-catch of marine mammals in tuna harvests in the Eastern Pacific, among others (Barclay, 2010). At the same time, Japanese fleets began to transition from pole-and-line to purse seine methods, which could generate much greater volumes (Barclay, 2010). The results have been dramatic: purse seine fishing caught some 100,000 metric tons in the WCPO in 1980, growing to over 1.8 million metric tons per year in 2013 and now an estimated 2 million metric tons in 2014 (SPC, 2015; Williams and Terawasi, 2015).

Figure 7. Increasing Number of Purse Seine Vessels Operating in the WCPO

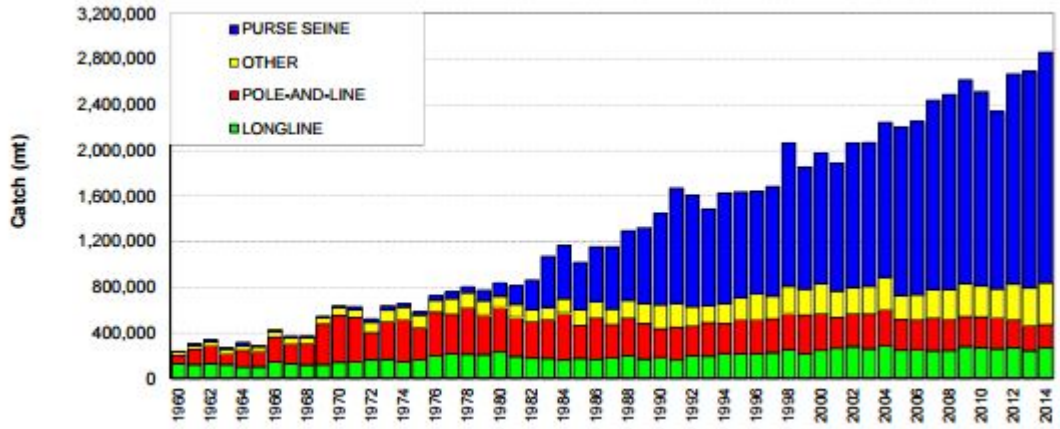


Source: Williams and Terawasi, 2015 (Note: does not include coastal Japan purse seine fleet, nor domestic Indonesia, Philippines and Vietnam purse seine fleets.)

As the purse seine fleet has grown, so too has the technology deployed, particularly with drifting fish aggregating devices (FADs) that may be located electronically and in some cases transmit information on the size of tuna aggregations underneath them (Hampton, 2006). While some 40 to 60 percent of the sets of purse seine nets in the water for tuna have generally been associated with FADs over the years, the technology around FADs has developed rapidly in the last ten to fifteen years, contributing to a greater catch of bigeye tuna by purse seine vessels (WPRFMC, 2015).

Collectively, the various harvesting units in the WCPO produced a record yield of an estimated 2.86 million metric tons (mt) of tuna in 2014 (see Figure 8 below), constituting roughly 60 percent of the world's tuna catch and approximately 8 times the harvest of all coastal fish stocks of the region combined (Williams and Terawasi, 2015; Gillett, 2014). In many cases, these represent some of the last tuna stocks still healthy enough (i.e. with sufficient abundance as measured by biomass) to support the estimated annual maximum sustainable yield, roughly equivalent to the total annual tuna catch from all other major tuna fishing areas of the world combined – i.e. in the Eastern Pacific Ocean, the Indian Ocean and the Atlantic Ocean (WCPFC, 2013; Gillett, 2014).

Figure 8. Total WCPO Tuna Catch in 2014



Source: Williams and Terawasi, 2015

Per the above, the provisional estimates for the break-down of the 2014 WCPO tuna catch by fishery are as follows:

- *Purse seine catch*: 2.02 million metric tons, comprised of approximately 1.60 million metric tons of skipjack, 0.36 million metric tons of yellowfin, and 0.07 million metric tons of bigeye (differences due to rounding);
- *Longline catch*: 268,795 metric tons;
- *Pole and line catch:* 203,736 metric tons; and
- *Troll and other small-scale gear catch*: 367,469 metric tons (mostly in eastern Indonesia and the Philippines) (Williams and Terawasi, 2015).

In terms of the specific break-down of the 2014 WCPO tuna catch by species are as follows:

- Skipjack: 1.96 million metric tons;
- Yellowfin: 608,807 metric tons;
- Bigeye: 161,299 metric tons; and
- Albacore: 132,849 metric tons (Williams and Terawasi, 2015).

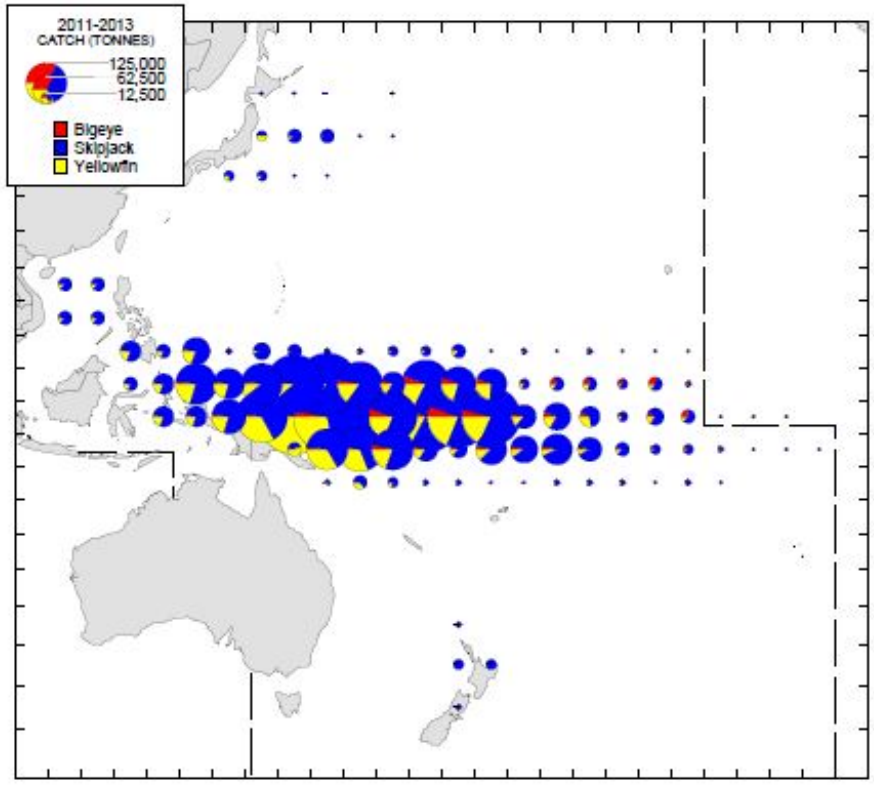
Given that the benefits generated from fish stocks occur throughout the system, measuring the economic benefits of WCPO tuna fisheries requires assessing the contributions along the entire value chain. The following sections provide the baseline or current economic contributions to Pacific Island countries from

the purse seine tuna fishery and the tropical longline tuna fishery. While these fisheries form complex, global value chains, the best available information for each is summarized along three general segments of the chain: (i) resource owners and harvesting; (ii) processing (including distribution); and (iii) retailing. In terms of products, globally some 72 percent of tuna catch is canned, another 14 percent is used as sashimi, and the remaining 14 percent provides a range of other products (e.g. fresh steaks, etc.) (Conservation International, 2015).

3.2 Measuring the Economic Benefits to Pacific Island Countries from the Purse Seine Tuna Fishery

Resource owners (i.e. jurisdiction). As mentioned above, the purse seine fishery value chain produced an estimated 2.02 million metric tons in 2014 (79 percent of which was skipjack, 18 percent yellowfin and 3 percent bigeye), caught almost entirely in the tropical waters of the equatorial band, with the highest catches in the zone between 5 degrees N and 10 degrees S, as shown in Figure 9 below (Williams and Terawasi, 2015). The provisional data behind these totals are available from FFA, and indicate that in 2014, some 77 percent of the total WCPO purse seine catch was taken in the waters of the 8 Parties to the Nauru Agreement (PNA): Federated States of Micronesia (FSM), Kiribati, Nauru, Palau, Papua New Guinea, Republic of Marshall Islands (RMI), Solomon Islands and Tuvalu; plus Tokelau – and almost 50 percent of the total was taken in the waters of Kiribati and PNG (FFA, 2015). An additional 16 percent was caught in the national waters of other countries in the WCPO such as Indonesia and the Philippines, and the remaining 7 percent was caught in international waters – i.e. the 'high seas' which in some cases resemble 'doughnut holes' between the estimated national boundaries of Pacific Island countries (FFA, 2015).

Figure 9. Distribution of Purse Seine Tuna Catch in the WCPO from 2011 - 2013



Source: WCPFC, 2014

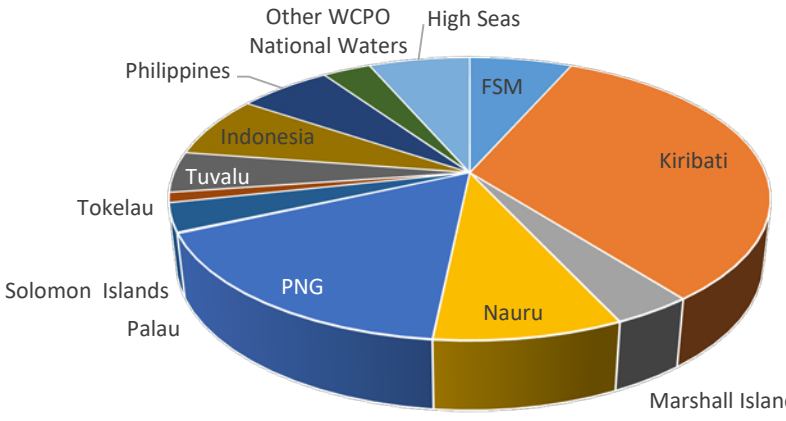
As mentioned previously, FFA provides data available on the location of the purse seine tuna catch, allowing for a picture of where the harvests have taken place and the resource owners or jurisdictions, as follows:

Table 2. Break-Down of WCPO Purse Seine Tuna Catch by Water in 2013 and 2014 (metric tons)

Waters where harvest took place	2013		2014	
	Purse Seine Catch	% of Total	Purse Seine Catch	% of Total
FSM	210,453	10.9	135,871	6.6
Kiribati	282,466	14.6	679,294	32.9
Nauru	161,795	8.4	177,049	8.6
Palau	310	0	2,825	0.1
PNG	591,252	30.5	342,981	16.6
RMI	39,635	2.0	74,803	3.6
Solomon Islands	107,629	5.6	66,595	3.2
Tokelau	15,856	0.8	23,748	1.1
Tuvalu	52,892	2.7	96,040	4.6
Sub-Total PNA + Tokelau	1,462,289	75	1,599,207	77
American Samoa	497	0	1,763	0.1
Cook Islands	8,338	0.4	12,765	0.6
Indonesia	215,651	11.1	145,017	7.0
Japan	14,441	0.7	6,218	0.3
Korea	234	0	44	0
New Zealand	12,754	0.7	10,158	0.5
Philippines	101,711	5.3	123,655	6.0
Samoa	32	0	288	0
Taiwan, China	4,510	0.2	4,510	0.2
U.S. + territories (except American Samoa)	4,501	0.2	5,592	0.3
Vietnam	22,484	1.2	22,483	1.1
Wallis and Futuna	0	0	162	0
Sub-Total Other National Waters	385,316	20	332,653	16
International waters	69,831	5	134,547	7
TOTAL	**1,937,236**	**100**	**2,066,047***	**100**

**Total of FFA 2014 data differs by 2 percent from Williams and Terawasi (2015) total of 2,020,000 submitted to WCPFC scientific committee*
Source: FFA (2015) http://www.ffa.int/node/425

Figure 10. Breakdown of 2014 WCPO Purse Seine Tuna Catch by Location

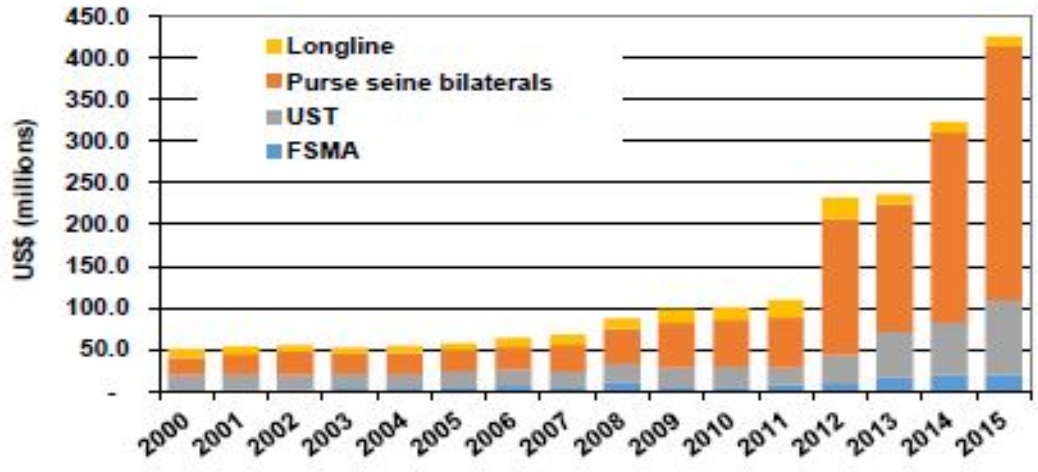


Source: FFA (2015)

As shown above, some 77 percent of the WCPO purse seine tuna was caught in the waters of Pacific Island countries in 2014, and almost 50 percent in the waters of Kiribati and PNG alone. As resource owners, i.e.

having jurisdiction over tuna harvests within these waters, Pacific Island countries can charge harvesters a rent for access to the fish stocks, essentially applying the theory of land rents to accessing fishing grounds under nations' control (World Bank and FAO, 2009). The greater the profitability of fishing, the higher the rent is that the harvesters can afford to pay to the resource owners, i.e. the Pacific Island countries with jurisdiction over access to the waters where the tuna are often found. The returns to Pacific Island countries as resource owners, via payment of access fees by harvesters, has grown steadily in the five years since the introduction of the vessel day scheme (VDS) by the PNA member countries and Tokelau (see Figure 11 below) (FFA, 2014).

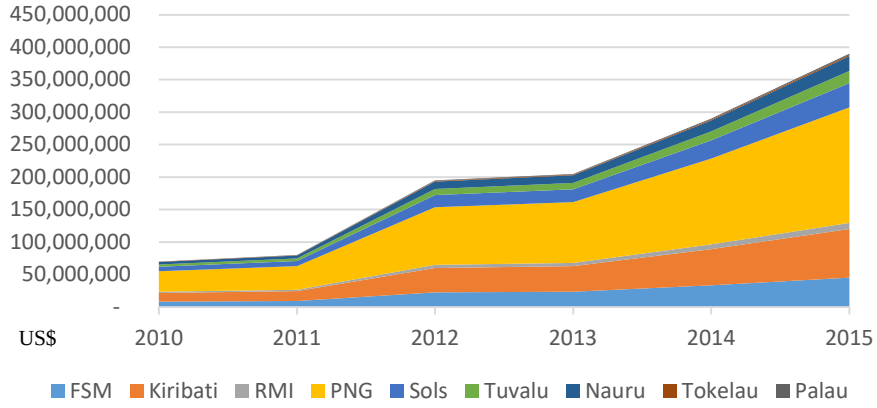
Figure 11. Estimated Tuna Access Fees Received by Pacific Island Countries



Source: FFA, 2014

The VDS sets a collective cap on purse seine fishing effort in PNA waters, translates that cap into a common currency (a fishing day by a vessel – i.e. vessel days), agrees on a minimum 'benchmark' price that countries will charge harvesting units for vessel days (though countries may charge more, in some cases testing auctions), and allocates the cap of vessel days to the countries according to an agreed formula (Havice, 2013). While the agreed price of vessel days is publicly available, i.e. the minimum 'benchmark' price, the distribution among the member countries often is not easily accessible. Thus calculating the distribution of the fees in Figure 11 is difficult (even more so given that some vessels receive concessional access fees if licensed as local fleets, including vessels licensed under the Federated States of Micronesia Arrangement). According to the Palau Arrangement establishing the VDS, the distribution of vessel days is based on formulas that rely at least in part on the 7-year moving average of the distribution of purse seine effort in the waters of member countries (PNA, 2015). For indicative purposes only, the 2007 – 2009 moving average of the distribution of the purse seine catch among member countries available from SPC has been applied to the total purse seine foreign access fees (including revenues from the U.S. Treaty but excluding concessionary access fees received under the Federated States of Micronesia Arrangement) shown in Figure 11 above, as follows:

Figure 12. Indicative Growth in Purse Seine Foreign Access Fees Received by PICs

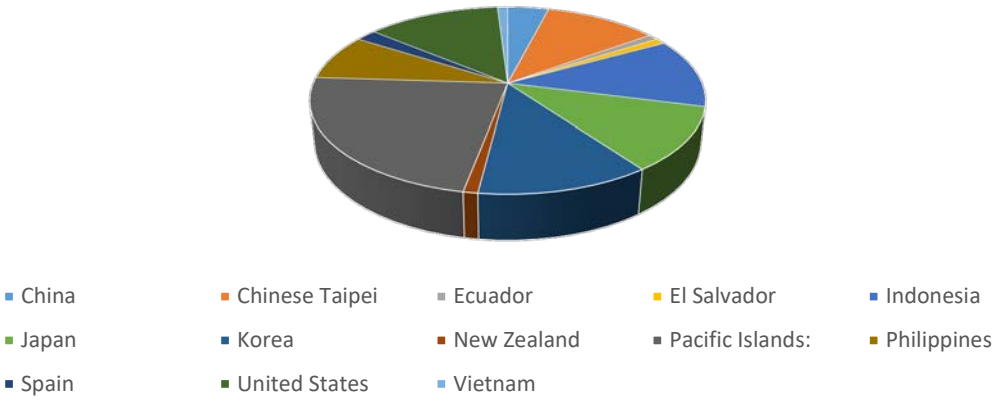


Note: Does not include fees received from domestic vessels, including vessels operating under the Federated States of Micronesia Arrangement (FSMA) for Regional Access

The above fees again are indicative only of the break-down between Pacific Island countries, using the 2007 – 2009 distribution of catch among countries' waters as a proxy. The actual distributions and fees received in each country differ from Figure 12, based on the specific allocations of days and the price of sales in each country. Nonetheless, the use of the 2007 – 2009 distribution provides a consistent and useful proxy or indicator of the magnitude of fees received by Pacific Island countries for access by foreign purse seine tuna vessels. Of note, this would only represent gross benefits to the countries as resource owners, rather than net benefits, as Pacific Island countries' (as well as donors') expenditures on fisheries management have not been subtracted. While data on Pacific Island country public expenditures for fisheries management are scarce, the best available information provides an annual expenditure on the tuna fisheries combined of some US$50 million (Govan, 2015). However, this should be interpreted with some caution, as significant transaction costs in negotiating access arrangements or managing resources may be borne by other public agencies and departments not included in the study (of note, significant tuna fisheries management costs in the Pacific are borne by regional agencies and often via donor funding sources).

Harvesting Units (including tuna trading companies working with harvesters). Within WCPO waters, a number of mobile fleets follow the tuna stocks as they move across both national boundaries and the high seas, including four main distant water fleets from Taiwan, China; Japan; Korea and the United States; collectively responsible for some 47 percent of the catch in 2013, as well as a growing Pacific Islands fleet (23 percent of the catch) and (largely) domestic fleets operating in Indonesia and the Philippines (20 percent of the catch) (WCPFC, 2014; Terawasi and Williams, 2015). In total, although some 76 percent of the WCPO purse seine catch volume in 2013 was taken in Pacific Island country waters, approximately 77 percent of the WCPO purse seine catch was taken by fleets foreign to the Pacific Islands (see Figure 13 below).

Figure 13 Distribution of Purse Seine Catch by Fleet



Source: WCPFC Data Catalogue

Table 3. Catch levels and description of WCPO purse seine fleet segments

Four largest distant-water purse seine fleets: 47 percent of WCPO purse seine catch in 2013
Taiwan, China (212,480 metric tons caught in 2013, 11 percent of the total purse seine catch): This fleet has operated in WCPO for some time, with 34 vessels active at the end of 2014, remaining relatively constant over the years (due to limits imposed by the Government on fleet size to 34 vessels after a rapid expansion in the 1980s and 1990s), as the number was 33 in 2011. Imports of used vessels were traditionally prohibited by the Government, encouraging the development of a domestic ship-building industry. Some 90 to 95 percent of the fleet's catch has historically been transshipped from Pacific Island ports to Bangkok canneries via one of the major trading companies, with the remaining 5 to 10 percent sold to Japan for Katsuobushi[11]. Despite the self-imposed cap on the fleet size, the domestic ship-building industry has been developing increasingly more efficient vessels, in some cases pre-fabricating materials for construction in other countries for their fleets.
Japan (206,999 metric tons caught in 2013, 11 percent of the total purse seine catch): With 40 vessels active in the WCPO in 2014, the fleet has historically been one of the largest in the region, typically equipped with 'ultra-low' temperature (<60 degrees C) freezers on board for storing a portion of the purse seine catch (usually yellowfin or bigeye) for sale in lower-quality segments of the Japanese Sashimi market. Fishing only in Japanese coastal waters from May to October, these vessels have typically fished in the WCPO throughout the year, in both national waters and the high seas, but particularly in PNG, the Solomon Islands and FSM. These vessels were traditionally required to offload in Japan rather than transship from Pacific Island ports, so incurred higher costs, however in recent years new and larger purse seine vessels have been constructed, equipped with helicopters to reduce fuel time searching for fish (which Korean, Taiwan, China and U.S. fleets have used for some time).
Korea (225,632 metric tons caught in 2013, 12 percent of the total purse seine catch): The fleet included 28 vessels in 2014, exactly the same number as active in 2010 and owned by three large companies, Dongwon Industries, Sajo/Oyang and Silla Co. Ltd. These fleets have typically been extremely efficient, catching 10,000 metric tons per vessel annually in 2009, and utilizing both national waters of all PNA members and the high seas, though the exact distribution is not available. The fleet has traditionally transshipped in a number of Pacific Island ports including Pohnpei, Majuro, Honiara and Tarawa, with carriers transporting fish for processing either domestically in Korea or in Bangkok.
United States (254,342 metric tons caught in 2013, 13 percent of the total purse seine catch): The fleet included 40 vessels in 2014, an increase from 35 vessels in 2009 (18 of which were older vessels from

[11] Japanese name for dried, fermented and smoked skipjack tuna.

the 1980s and 1990s and 17 of which were newer vessels built in Taiwan, China). The older segment of the fleet traditionally landed catch at Pago Pago for processing for the U.S. market, but most of the newer fleet operated similarly to the Asian fleets and transshipped to Bangkok or Latin America, often through Pohnpei or Majuro. Part of the cost of access for U.S. fleets has been traditionally borne by the U.S. Government through treaty with Pacific Islands, essentially as a subsidy.

Other distant water fleets: 10 percent of the WCPO purse seine catch in 2013

China (81,871 metric tons caught in 2013, 4 percent of the total purse seine catch): State-owned enterprises in China have traditionally maintained a number of purse seine vessels operating worldwide, utilizing a Government policy providing tax incentives to shipyards that export vessels (Hamilton et al., 2011). According to the Western and Central Pacific Fisheries Commission (WCPFC) registry, the fleet operating in the WCPO has grown from 16 vessels in 2009 (Hamilton et al., 2011) to 69 in 2015, 49 of which were built in 2010 or after (constituting over half of all the purse seine vessels operating in the WCPO built since 2010) (WCPFC, 2015b). However the current purse seine fleet that is actually operational in the region is likely to be much smaller. In 2009, some 81 percent of the fleet's catch was transshipped in either Pohnpei or Majuro to Bangkok for processing via a trading company, with the remaining 19 percent likely sent to China for processing (Hamilton et al., 2011).

- Ecuador (21,453 metric tons caught in 2013, 1 percent of the total purse seine catch)
- El Salvador (13,276 metric tons caught in 2013, 1 percent of the total purse seine catch)
- New Zealand (24,430 metric tons caught in 2013, 1 percent of the total purse seine catch)
- Spain (45,010 metric tons caught in 2013, 2 percent of the total purse seine catch)
- Vietnam (22,484 metric tons caught in 2013, 1 percent of the total purse seine catch)

Indonesian and Philippines fleets: 20 percent of the WCPO purse seine catch in 2013

Indonesia (215,582 metric tons caught in 2013, 12 percent of the total purse seine catch): Data is not readily available on the fleet size nor final markets of catch, though much of it has traditionally been landed and processed in Indonesia (with some consumed locally, and some exported to Bangkok).

Philippines (148,552 metric tons caught in 2013 - 63,719 of which were domestic, 8 percent of the total purse seine catch): This fleet grew rapidly in the 1970s and eventually expanded out of Philippines' waters and into PNG, and then broader WCPO waters. In 2009 the fleet included 40 vessels (excluding domestic vessels), half of which fished in PNG under an access agreement, and the majority of the rest were included in PNG's fleet through charter arrangements. These vessels were older and typically less efficient than many of the other fleets in the WCPO. Additionally, a number of vessels from the Philippines have fished in the high seas pockets. Most of the catch from the Philippines fleet has been landed and processed in PNG, with some 15 percent exported to Bangkok and also a significant percentage exported to the Philippines. The catch by domestic purse seiners is landed locally and processed in 7 canneries in the country, many of which are based at General Santos in southern Mindanao.

Pacific Islands fleets: 23 percent of the WCPO purse seine catch in 2013

PNG (192,967 metric tons caught in 2013): In 2014 some 51 vessels were flagged to PNG and registered for the WCPO, including chartered vessels (e.g. from the Philippines). This is relatively stable since 2010, consisting then of: (i) PNG-flagged fleet of 8 to 9 vessels fishing in the country's waters, one quarter of which are considered archipelagic waters, and landing locally for processing in PNG canneries; (ii) a number of foreign-flagged vessels based locally or chartered in order to supply PNG canneries with at least a portion of their catch (17 – 18 vessels); and (iii) PNG-based foreign-flagged vessels fishing in the waters of other Pacific Island countries (19 vessels). About 20 percent of PNG canned tuna production is consumed in PNG and the rest is exported to the EU.

Solomon Islands (24,769 metric tons caught in 2013): In 2014 the fleet included 5 vessels.
FSM (24,193 metric tons caught in 2013): In 2014 the fleet included some 10 vessels, up from 7 in 2009.
RMI (77,634 metric tons caught in 2013): In 2014 the fleet included some 10 vessels, most of which have traditionally fished in other Pacific Island country waters. By contrast, most of the fish caught in RMI's waters have been transshipped to Bangkok, with a small volume (on the order of 5,000 tons in 2009) processed at a loining facility in Majuro.
Kiribati (72,241 metric tons caught in 2013): The fleet included 14 vessels in 2014, with most of the catch in the country's waters taken by foreign vessels, largely destined for processing in Bangkok.
Vanuatu (22,484 metric tons caught in 2013): Vanuatu's fleet included 3 vessels in 2014, all fishing in foreign waters (as no purse seining taking place in the country's waters), almost all of which has been transshipped to Bangkok.
Tuvalu (10,866 metric tons caught in 2013): The fleet included 1 vessel in 2014.

Sources: WCPFC Data Catalogue for 2013 catch levels and distribution; Terawasi and Williams, 2015 for 2014 fleet levels, and Hamilton et al., 2011 for 2009 fleet comparison and detailed description of fleets.

The WCPFC registry reflects a shifting composition of the WCPO purse seine fleet, with significant numbers of new vessels constructed since 2010 (WCPFC, 2015b). Not all of these vessels would be considered 'large-scale' (i.e. a fish-hold volume of greater than 335 cubic meters), though throughout the WCPO some 52 large-scale vessels have been built since 2010 and operating in the region (Restrepo, 2015). The capacity (i.e. ability to catch fish) of the fleet has continued to grow since the fleet began roughly in 1980, via innovation and improved efficiency as catch per vessel increased from 3,750 tons annually in 1986 to 7,100 tons in 2007 (Hamilton et al., 2011). The number of purse seine vessels has increased from a range of 180 to 220 between 1990 to 2006, to 344 vessels in 2014 (WCPFC). This indirectly points to the profitability of the fishery, as the estimated capital cost of new purse seine vessels is on the order of US$10 million per vessel (Hamilton et al., 2011).

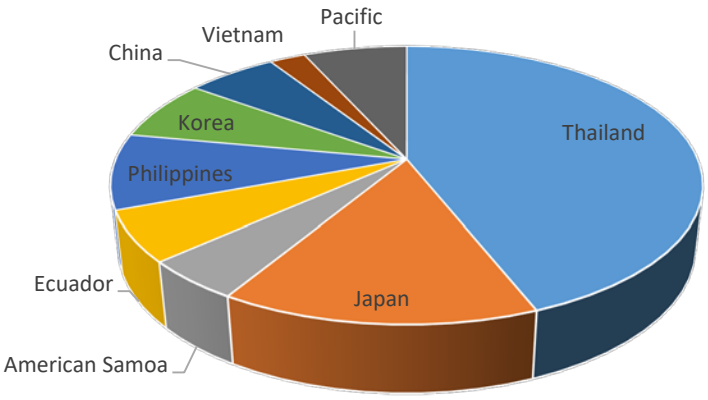
Of note, several large companies provide services to the fleets in the WCPO and buy their catch (rather than taking a commission on a trade), with guaranteed delivery to processors and often with exclusive relationships with vessel owners and fleets (and in some cases vertical integration) (Hamilton et al., 2011). With thin margins and high volumes, trading companies will provide a guarantee of raw material to processers with advance (e.g. 1 to 2 months) purchase contracts, generally in support of the needs of Bangkok processors dependent upon foreign fleets and fishing grounds (Hamilton et al., 2011). As of 2010, three main trading companies purchased over half of the WCPO purse seine catch for processors (as well as additional catch from other areas) and provided some 90 percent of the supply to Bangkok: Trimarine, Itochu and FCF Fishery Co. Ltd (Hamilton et al., 2011). Given this level of control over the supply to Bangkok, these three traders are in a position to exert significant influence over the purse seine value chain.

The net economic benefits from the Pacific Island harvesting fleets (calculated as the intermediate costs, e.g. fuel, bait, provisions and maintenance, subtracted from the landed value of the catch) to Pacific Island countries are not disaggregated in publicly available data from the benefits of domestic processing in the countries. According to FFA estimates (2014), the value added to Pacific Island countries from these two segments combined was some US$291 million in 2013.

Processing Segment (i.e. canning and loining). The purse seine catch is targeted largely for canning and subsequently a range of markets for consumption, notably the European and North American markets, as part of an increasingly globalized supply chain (Hamilton et al., 2011; Gillett, 2014). A number of countries have developed processing clusters to capture economies of scale (together with high labor productivity

and in some cases tariff preferences), and as of 2010 Thailand was the world's leading tuna canner, followed by Japan, Ecuador and the Philippines (Hamilton et al., 2011). Many of the larger companies in these clusters source tuna from around the world (with WCPO providing the largest proportion), but have suffered from overcapacity in the past, utilizing some 80 to 85 percent of processing capacity in 2010 for example (Hamilton et al., 2010). Although the balance between different channels for processing is constantly shifting due to market conditions, fishing areas, processing facility requirements, etc. (Gillett, 2014), the break-down from the WCPO's tuna catch in 2010 is indicative:

Figure 14 Distribution of Processing of WCPO Purse Seine Catch in 2010



Source: Hamilton et al., 2011

Thailand is far and away the world's leading tuna processor, although not the only processor, as a number of other significant processing clusters exist as destinations for WCPO tuna. The major processors for WCPO tuna include:

- *Thailand*: As of 2010 Thailand processed about a quarter of the world's canned tuna products, typically processing volume on the order of 750,000 metric tons of catch annually (Hamilton et al., 2011). The country became the world leader in the early 1980s, benefiting from a well-established food processing industry in general and excellent shipping logistics, as well as being strategically positioned to source supply from both the Pacific and Indian oceans (Hamilton et al., 2010). Although the number of processors has typically been on the order of 30, the industry has been dominated by two companies: Thai Union (the world's largest vertically-integrated canned tuna company) and Sea Value, both of whom source almost all of their tuna supply through tuna trading companies (Thailand does not have a significant domestic purse seine fleet) – with these purchasing contracts essentially setting the global price for tuna (Hamilton et al., 2010). In the past Thai processors have sourced some 90 percent of their tuna from the WCPO (on the order of 700,000 tons in 2010), with almost half of all canned tuna products exported to the United States (23 percent), the EU (15 percent) and the Middle East (12 percent - with Egypt as the biggest destination in the region), and with Australia (6 percent), Canada (6 percent) and Japan (5 percent) also serving as important markets – many of whom Thailand has negotiated free trade agreements (Hamilton et al., 2011). Additional major processors include:
- *Japan*: includes canneries generally producing for the domestic market;
- *Philippines*: in 2009 seven canneries processed 220,000 metric tons of tuna, estimated to be sourced one third from domestic waters and two thirds from elsewhere in the WCPO, with almost all products exported (some 60 percent to Europe and another ten percent to the U.S.);

- *Korea*: had 5 major canneries in 2009 processing some 110,000 to 130,000 metric tons of tuna, entirely for domestic consumption;
- *Pacific islands*: PNG dominates the processing sector in the Pacific islands with five large plants in operation, mostly clustered in Lae, with another 4 large plants under construction (see Table 4 below). Estimated volume of tuna processed in the country was on the order of 100,000 metric tons in 2013 (FFA, 2014). The growth of the PNG processing sector has been driven by a Government policy of providing concessional access to its major tuna resource in return for onshore investment in processing plants, and aided by duty free access for processed product to EU markets. Despite this growth, PNG processing plants have typically operated below capacity and, in common with other plants in the region, are known to have considerably higher operating costs than their counterparts in Thailand, Philippines and Vietnam. Elsewhere there is a large canning/loining operation at Noro in Solomon Islands - with total volume processed in the country in 2013 of 15,200 metric tons (FFA, 2014), a large canning/loining operation at Levuka in Fiji, and a medium scale plant at Majuro in the Marshall Islands – with total volume of 10,000 metric tons processed in 2013 (FFA, 2014), all of which typically operate below capacity and struggle for profitability. The constraints to viable processing in the region include high energy and shipping costs, and relatively low labor productivity. Despite these constraints several other PICs, particularly those with access to large tuna resources such as Kiribati, are seeking to attract similar investments. Smaller plants in Fiji, Solomon Islands and elsewhere are mostly involved in processing longline catch, producing fresh/ frozen whole fish or fresh and/ or cooked loins.

Table 4. Tuna Processing Plants in Pacific Island Countries

Country	Plant	Location	Plant size	Product form	Current capacity MT/ yr	No. of direct jobs (fishing & processing)
Papua New Guinea	Frabelle	Lae	L	Canned	20,000	1,868
Papua New Guinea	Majestic	Lae	L	Canned	10,000	6,900
Papua New Guinea	IFC	Lae	L	Canned	5,000	1,000
Papua New Guinea	RD Tuna	Madang	L	Canned	25,000	3,500
Papua New Guinea	SST	Wewak	L	Loins	20,000	1,200
Papua New Guinea	Nambawan	Under construction in Lae (6,900 direct jobs estimated)				
Papua New Guinea	Sapmer	Under construction in Lae (2,500 direct jobs estimated)				
Papua New Guinea	Dongwong	Under construction (4,600 direct jobs estimated)				
Papua New Guinea	Hailisheng	Under construction (4,200 direct jobs estimated)				
Solomon Islands	SolTuna	Noro	L	Canned/ cooked loins	24,000	1,669
Solomon Islands	SSI	Honiara	S	Fresh/ frozen	2,000	60
Fiji	PAFCO	Levuka	L	Canned/ cooked loins	11,000	812
Fiji	Golden Ocean	Suva	M	Fresh/ frozen	3,000	647
Fiji	Viti Foods	Suva	S	Canned	10,000	230
Fiji	Sealand Fish	Suva	S	Fresh/ frozen	n/a	30
Fiji	Blue Ocean	Suva	S	Fresh/ frozen	n/a	10
Fiji	TriPacific	Suva	S	Fresh/ frozen	n/a	108
Fiji	Tosa Busan	Suva	S	Fresh/ frozen	n/a	38
Kiribati	Kiribati Fish	Tarawa	S	Fresh/ frozen	160	58
Marshall Islands	Pan Pacific	Majuro	M	Loins	2,000	170
Marshall Islands	MIFV	Majuro	M	Fresh-frozen	1,500	168
				Totals:	**133,660**	**12,867**

Source: Data gathered by IFC from industry sources

- *Ecuador*: imported some 70,000 tons of tuna caught by purse seine vessels in the WCPO in 2009, with most of the product destined for the European market, and to a much lesser extent the U.S. and a small portion to Latin America;
- *Vietnam*: had 3 major tuna canneries in 2009, importing some 35,000 metric tons of tuna from the WCPO, with final products destined for the U.S. and Europe; and
- *Indonesia*: had a number of canneries supplied almost entirely from local vessels fishing in domestic waters, and then exporting to Europe, the U.S. and Middle East among others (Hamilton et al., 2011).

In terms of the net economic benefits from this segment of the value chain to Pacific Island countries, as mentioned previously the estimates are combined with those of the Pacific Island harvesting fleets (reported as an aggregate US$291 million in value added in 2013).

Retailing Segment. Canned tuna developed in the 1950s as a low-cost protein alternative to canned salmon, and has since become a global commodity (i.e. high volume, low price, low profit margins) (Hamilton et al., 2011). In 2008, global canned tuna consumption was equivalent to over 3.1 million metric tons of tuna, or some 250 million cases of canned tuna (with one ton of tuna catch, i.e. whole round tuna, equivalent to roughly 80 cases of canned tuna), valued at approximately US$7.5 billion:

*Table 5. Total global canned tuna consumption by region in 2008**

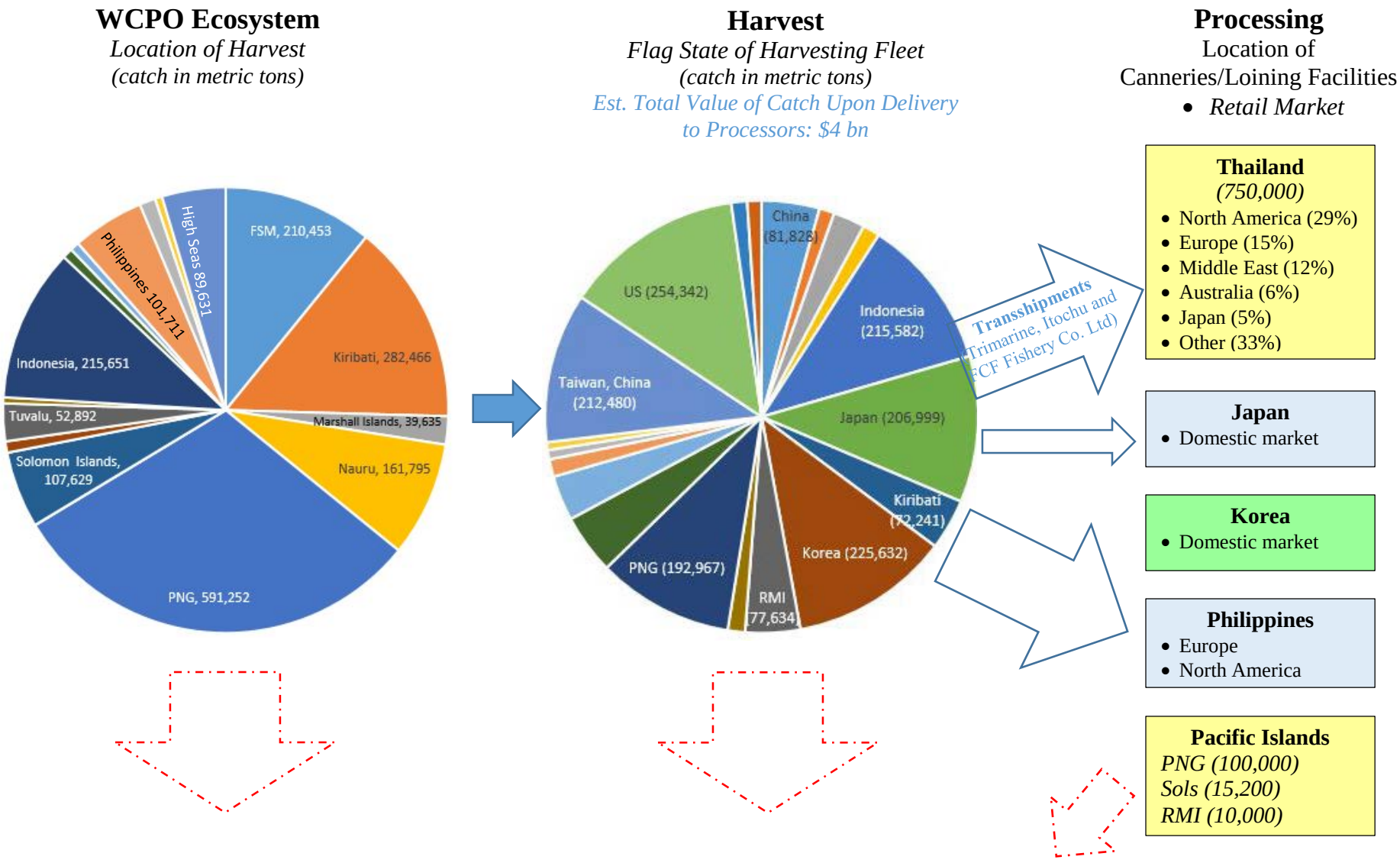
Market	Cases (no. millions)	Whole round weight equiv. (mt)
EU	76	950,000
US	48	600,000
Asia	38	475,000
Latin America	35	437,500
Middle East	16	200,000
Australia/New Zealand	8	100,000
Africa	7	87,500
Eastern Europe	4	50,000
Others	19	237,500
Total	251	3,137,500

*Source: Hamilton et al., 2011; *Although from 2008, no more recent global assessment is available, and the above markets and their proportions continue to be representative even if the specific volumes differ*

While certainly older, these data give an indication of the markets for tuna products from the purse seine fishery, and likely global distribution of final products from the harvests in Pacific Island waters.

Overview of the WCPO Purse Seine Tuna Fishery Value Chain. Putting these various segments together is useful for visualizing the magnitude of this global value chain originating in WCPO waters, and the distribution of economic benefits generated at various stages. Figure 15 provides a crude attempt to depict this flow of benefits and distribution in one given year (2013), across more than 20 countries and 5 continents around the world. This is a snap shot, and of course will change from year to year.

Figure 15. Illustration of the WCPO Purse Seine Tuna Fishery Value Chain in 2013 & Net Economic Benefits to Pacific Island Countries



Total Est. Net Economic Benefits in 2013: US$ 446 million

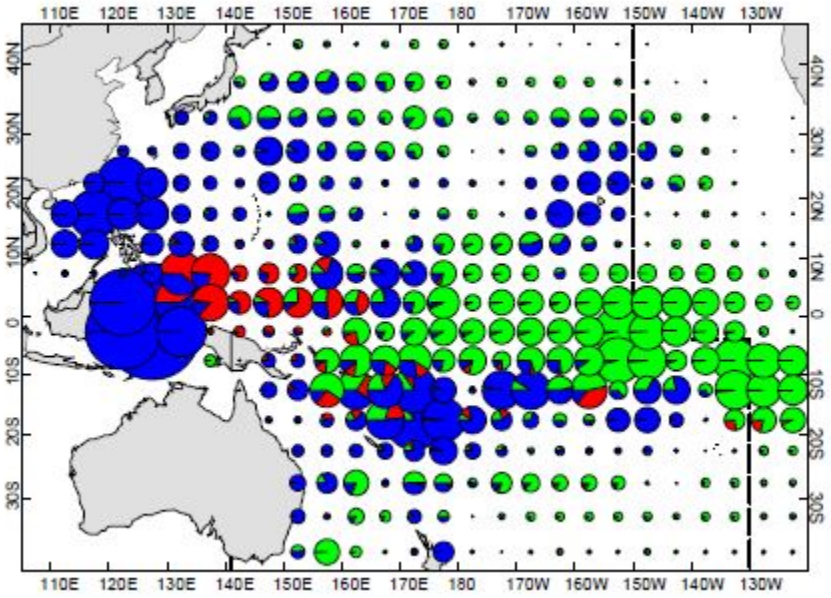
Source: Drakou and Virdin, 2016
** Net benefits of foreign access = fees - est. management costs*

3.3 Measuring the Economic Benefits to Pacific Island Countries from the Longline Tuna Fishery

Resource Owners (i.e. jurisdiction). As mentioned above, the longline fishery value chains produced an estimated 0.27 million metric tons in 2014 (34 percent of which was albacore, 27 percent bigeye and 38 percent yellowfin), caught over a wide range throughout the WCPO, with clusters in tropical waters along the equatorial belt, and sub-tropical waters in the South Pacific (largely targeting albacore) (Williams and Terawasi, 2015). In 2014 some 37 percent caught on the high seas, another 20 percent was caught in the waters of five Pacific Island countries (Cook Islands, Fiji, Kiribati, Solomon Islands and Vanuatu), 11 percent in Japan, 10 percent in Indonesia and the remaining 21 percent distributed throughout the waters of 18 different WCPO countries or territories (see Table 5 below: FFA, 2015). More specifically:

- for the '*southern longline fishery*', some two-thirds of the albacore was caught in the waters of the Cook Islands, Fiji, the Solomon Islands and Vanuatu in 2014; and
- for the '*tropical longline fishery*', some 27 percent of the bigeye and yellowfin was caught in the waters of FSM, Kiribati, RMI, Palau and the Solomon Islands in 2014; another 26 percent in the waters of Indonesia and Japan, and 27 percent on the high seas (FFA, 2015).

Figure 16. Distribution of Longline Tuna Fishing Effort in the WCPO for Distant Water Fleets (Green), Foreign Offshore Fleets (Red), and Domestic Fleets (Blue) for the period 2000 – 2014



Source: Williams and Terawasi, 2015

Based on the provisional data available from FFA (2015), the break-down of the origin of catch by location is as follows:

Table 6. Break-Down of WCPO Longline Tuna Catch by Water in 2013 & 2014 (in metric tons)

Waters where harvest took place	**2013**		**2014**	
	Longline Catch	**% of Total**	**Longline Catch**	**% of Total**
American Samoa	2,383.6	1.0	1,922.6	0.7
Australia	2,086.9	0.9	2,351.4	0.9
Cook Islands	8,053.5	3.3	7,771.4	2.9
Federated States of Micronesia	2,984.2	1.2	6,178.6	2.3
Fiji	5,823.3	2.4	5,825.8	2.2
French Polynesia	4,927.4	2.0	5,545.2	2.1
Kiribati	6,712.1	2.8	17,918.4	6.7

Nauru	163.2	0.1	265.9	0.1
New Caledonia	2,289.9	0.9	2,421.5	0.9
New Zealand	413.0	0.2	436.0	0.2
Niue	458.8	0.2	421.3	0.2
PNG	1,324.1	0.5	1,979.2	0.7
Palau	2,333.6	1.0	2,102.8	0.8
RMI	3,012.7	1.2	3,471.4	1.3
Samoa	2,019.8	0.8	1,091.0	0.4
Solomon Islands	18,697.6	7.7	40,754.3	15.1
Tokelau	0	0	413.4	0.2
Tonga	4,300	1.8	1,678.9	0.6
Tuvalu	2,434.0	1.0	1,653.7	0.6
Vanuatu	10,153.0	4.2	8,853.9	3.3
International waters	88,826.0	36.6	71,803.3	26.7
Indonesia	23,805.6	9.8	35,700.9	13.3
Japan	27,419.8	11.3	27,734.8	10.3
Philippines	1,002.0	0.4	786.3	0.3
Taiwan, China	2,668.5	1.1	1,554.0	0.6
US + Territories	2,160.6	0.9	2,125.7	0.8
Vietnam	16,428.0	6.8	16,428.0	6.1
TOTAL	242,881.2	100	269,189.8	100

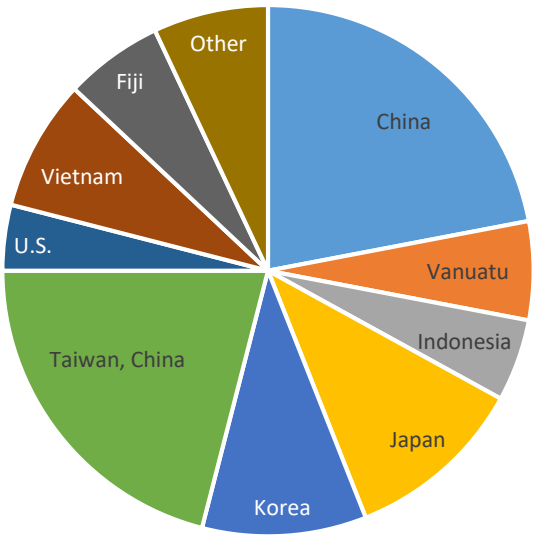
Source: FFA (2015) http://www.ffa.int/node/425

Although Pacific Island countries function as resource owners for a relatively smaller proportion of the resource base for the WCPO longline fishery, it generates far more valuable products on a unit-basis than the purse seine fishery, as the latter generates a global commodity with a relatively low price (canned tuna), whereas the longline fishery provides either albacore for higher-priced canned tuna, or yellowfin and bigeye for the valuable sashimi market (Hamilton et al., 2011). In 2013, the delivered value of the total WCPO longline catch was on the order of US$1.3 billion for a total of just over 200,000 tons, compared to the delivered value of the WCPO purse seine catch of roughly US$4 billion for over 1.8 million tons (FFA, 2014). Essentially the broad unit values indicate a longline fishery three times as valuable on a per unit basis as the purse seine fishery – acknowledging that there are differences in products and prices within each of the two fisheries. Thus, although Pacific Island countries have jurisdiction over a far smaller proportion of the longline fishery than the purse seine fishery, the former is much more valuable on a per unit basis, and therefore still provides significant rent opportunities.

To date, the rents received by Pacific Island countries as access fees for the longline fishery have been relatively small – on the order of some US$10 to 15 million per year – compared to the estimated delivered value of some US$300 million of the fish caught in the countries' waters (FFA, 2014). In sum, Pacific Island resource owners have typically received access fees on the order of 3 to 5 percent of the delivered value of the tuna caught via long-lining in their waters, whereas in 2013 the countries received access fees equivalent to an estimated 7 percent of the delivered value of the tuna caught in their waters via purse-seining, and 2015 this number is estimated to rise to 13 percent (FFA, 2014).

Harvesting Units (including tuna trading companies working with harvesters). A number of mobile fleets follow the tuna stocks as they move across both national boundaries and the high seas within the WCPO, including large distant water fleets from China; Japan; Korea; and Taiwan, China; as well as fleets from the U.S., Vietnam, Indonesia, Fiji and Vanuatu (WCPFC Data Catalogue). In addition, a number of other fleets, many from the Pacific Islands, harvested relatively small amounts of tuna via long-lining (see Figure 17 below and Table 6).

Figure 17. Distribution of 2013 WCPO Long-Line Catch by Fleet



Source: WCPFC Data Catalogue

Table 7. Distribution of 2013 WCPO tuna longline catch by fleet (in tons)

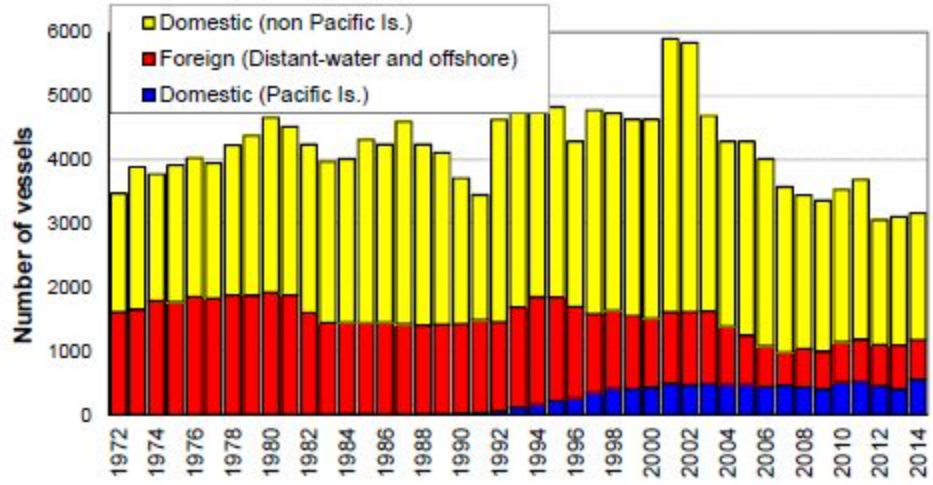
	Albacore	Bigeye	Yellowfin	Total	% of Total
Cook Islands	1,354	208	346	1,908	0.8
Fiji	9,561	1,018	2,203	12,782	5.3
FSM	750	1,270	850	2,870	1.2
Kiribati	186	582	175	943	0.4
Marshall Islands	7	80	47	134	0.1
New Zealand	302	109	1	412	0.2
PNG	261	32	1,041	1,334	0.6
Samoa	1,642	36	330	2,008	0.8
Tonga	13	7	126	146	0.1
Tuvalu	92	76	41	209	0.1
Vanuatu	10,446	1,989	1,626	14,061	5.8
American Samoa	2,113	359	412	2,884	1.2
Australia	647	425	1,139	2,211	0.9
Belize	14	217	21	252	0.1

China	24,162	10,671	4,638	39,471	16.3
French Polynesia	3,512	787	615	4,914	2.0
Indonesia	-	4,513	19,207	23,720	9.8
Japan	24,940	11,723	7,778	44,441	18.4
Korea	1,155	12,818	5,716	19,689	8.2
New Caledonia	1,732	51	531	2,314	1.0
Philippines	-	167	27	194	0.1
Portugal	67	106	2	175	0.1
Spain	3	23	2	28	0
Taiwan, China	17,403	10,600	14,999	43,002	17.8
US + territories (ex Am Sam)	295	4,113	638	5,046	2.1
Vietnam	251	2,260	13,917	16,428	6.8
TOTAL	100,908	64,240	76,428	241,577	100

Source: FFA (2015)

The WCPFC vessel registry currently lists some 3,085 tuna longline vessels eligible to fish in the WCPO (though registration does not equate to operation), generally consisting of two broad categories: (i) large (longer than 24 meters), distant-water freezer vessels that undertake long voyages to various parts of the region to target both the yellowfin and bigeye tuna in the tropical area as well as albacore in the southern Pacific (supplying frozen sashimi-grade tuna), and (ii) smaller (shorter than 24 meters), offshore vessels that are usually domestically-based and take trips of one month or less, serving the fresh or air-freight sashimi markets or albacore for canneries (Hamilton et al., 2011; Williams and Terawasi, 2015), and increasingly equipped with freezer capacity.

Figure 18. Longline Tuna Vessels Operating in the WCPO



Source: Williams and Terawasi, 2015

As Figure 18 indicates, longline fleets have declined significantly in recent years, as have catch rates and profitability (reflecting increased operating costs and a smaller resource base) (Hamilton et al., 2011; Gillett, 2014). From within the large fleet scattered throughout the WCPO, two major segments can be distinguished: (i) fleets targeting yellowfin and bigeye in tropical waters for the sashimi market, and (ii) fleets targeting albacore largely in the sub-tropical waters of the south Pacific for canning (Gillett, 2014). Both are described briefly in Table 7 below.

Table 8. Description of WCPO Tuna Longline Fleet Segments

Longline tuna fleets targeting yellowfin and bigeye in tropical waters for the sashimi market
These fleets operate widely throughout WCPO central (more predominantly yellowfin) and eastern tropical waters (focused more on bigeye), notably in the high seas, Kiribati, RMI and Solomon Islands, as well as in Japan, Indonesia and the Philippines among others. Some of the major fleets supplying the sashimi market include: • *Taiwan, China* (25,599 metric tons of yellowfin and bigeye in 2013) has large, distant water freezer vessels that transship frozen tuna to Japan as well as a smaller, offshore fleet that has been increasing as a share of the total fleet (particularly as the number of distant-water vessels has declined). In 2009, the fleet included 75 distant water vessels operating in the WCPO, and some 1,200 smaller scale vessels (Hamilton et al., 2011; FFA, 2015). • *Japan* (19,501 metric tons of yellowfin and bigeye in 2013) operates distant-water freezer fleets as well as smaller offshore vessels throughout the WCPO, most of which are small, family-owned companies. The catch is typically taken straight to Japan or offloaded in WCPO ports and air-freighted to Japan. In 2009 Japan operated some 268 distant water vessels (not exclusively in the WCPO) and 326 smaller, offshore vessels (Hamilton et al, 2011; FFA, 2015). • *Korea* (18,534 metric tons of yellowfin and bigeye in 2013) operates a fleet consisting mostly of larger, distant-water vessels working throughout the WCPO. In 2010 the fleet included 105 longline vessels operating in a number of WCPO countries' waters, but also extensively on the high seas (Hamilton et al, 2010; FFA, 2015). • *China* (15,309 metric tons of yellowfin and bigeye in 2013) operated a fleet of some 99 distant-water vessels in the WCPO in 2009, many of which utilized Suva to re-supply as needed (Hamilton et al., 2011; FFA, 2015). • *Indonesia* (23,720 metric tons of yellowfin and bigeye in 2013) has operated a fleet supplying low-grade sashimi to U.S. market (Hamilton et al., 2011; FFA, 2015).
Longline tuna fleets targeting albacore largely in south Pacific waters for canning
Long-lining principally for albacore for canning takes place year-round largely in the temperate, sub-tropical waters of the south Pacific, between the 10 degree S and 30 degree S parallels, as well as temperate waters in the north of the WCPO. The fleets include both large, distant-water vessels and smaller, offshore vessels, with many of the latter being Pacific fleets from American Samoa, the Cook Islands, Fiji, French Polynesia, Kiribati, New Caledonia, Samoa, the Solomon Islands, Tonga and Vanuatu, among others (Williams and Terawasi, 2015). Some of the major fleets supplying albacore to canneries include: • *China* (24,162 metric tons of albacore in 2013) has maintained a fleet of vessels based in Suva, with some 80 vessels operating in 2009, fishing largely in the high seas west of Fiji, and in the national waters of Fiji, the Solomon Islands and Vanuatu (Hamilton et al., 2011; FFA, 2015). • *Taiwan, China* (17,403 metric tons of albacore in 2013) operated some 38 distant-water vessels and some 60 -80 smaller-scale vessels targeting albacore in the WCPO in 2009, usually sold to trading companies for canning in Pago Pago (Hamilton et al, 2011; FFA, 2015). • *Fiji* (9,561 metric tons of albacore in 2013) operated some 97 longliners in 2009, catching about half albacore for canning in Pago Pago, and the other half bigeye and yellowfin for air-freight to Japan and U.S. as sashimi (Hamilton et al, 2011; FFA, 2015). • *Vanuatu, the U.S. and Japan* all catch smaller but significant amounts of albacore as well.

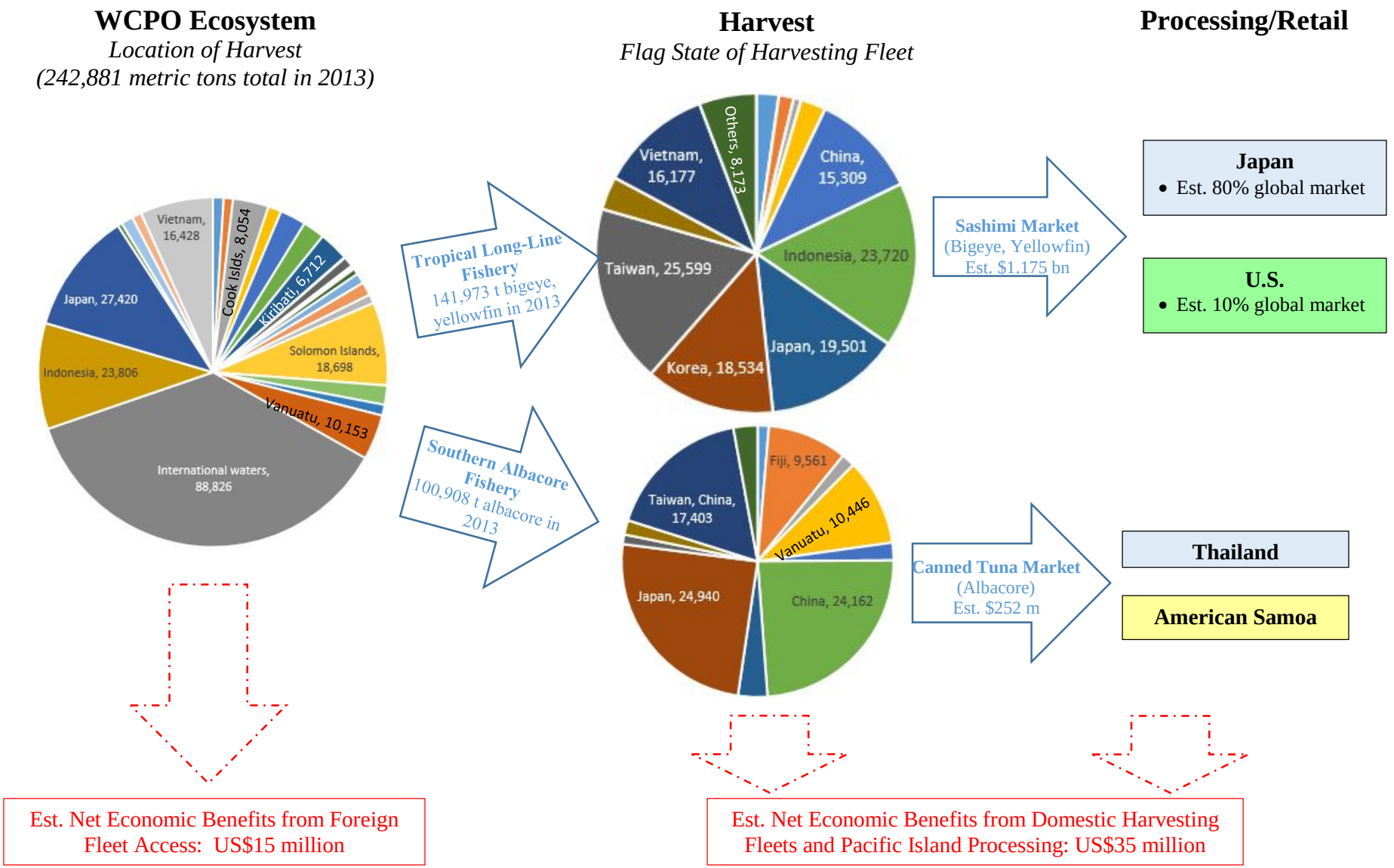
The net economic benefits from the Pacific Island harvesting fleets (calculated as the intermediate costs subtracted from the landed value of the catch) to Pacific Island countries have not recently been disaggregated in publicly available data from the benefits of domestic processing in the countries. According to FFA estimates (2014), the value added to Pacific Island countries from these two segments combined was some US$35 million in 2013.

Processing/Retailing Segment. The tropical longline fishery supplies tuna to Japan, which pioneered the now-global sashimi[12] market and consumes some 80 percent (with the remainder destined for the U.S., Korea, China, the European Union and Taiwan, China) (Hamilton et al., 2011). Sashimi requires minimal processing (though there may be some preparation of fish for shipment), and essentially catch is taken directly to the retailing destination in Japan, where some 300,000 to 400,000 metric tons is estimated by the Government to be consumed annually (World Fishing & Aquaculture, 2014). The sashimi market is generally supplied by bluefin tuna (the most valuable species), bigeye, yellowfin and albacore, mostly via long-lining (Hamilton et al., 2011), with yellowfin providing some 61 percent of sashimi in Japan in 2013 (Conservation International, 2015). For the albacore caught by longline vessels in the WCPO, the majority is canned in American Samoa and Bangkok (Hamilton et al., 2011).

The WCPO Longline Tuna Fishery Value Chains. The following diagram aims to depict for indicative purposes only, the flow of resource and product along the longline fishery value chains, assuming that all bigeye and yellowfin are targeted for sashimi, and albacore for canning.

[12] In Japan the term 'sashimi' refers to fresh raw seafood sliced into bite-sized pieces.

Figure 19. Illustration of WCPO Long-Line Tuna Fishery Value Chains in 2013 and Estimated Net Economic Benefits to Pacific Island Countries



Total Est. Net Economic Benefits in 2013: US$50 million

3.4 Summary of the Economic Contributions of WCPO Tuna Fisheries

The current estimates described in previous sections, which should be treated with great caution given the scattered and limited nature of the data, indicates a 'delivered' value of the tuna caught in WCPO waters in 2013 of some US$5.7 billion. Of this, the tuna caught in the waters of Pacific Island countries had an estimated delivered value of some US$3.4 billion in 2013, which provided an estimated net economic benefits on the order of almost $500 million to Pacific Island countries (15 percent), as shown in Table 8 below.

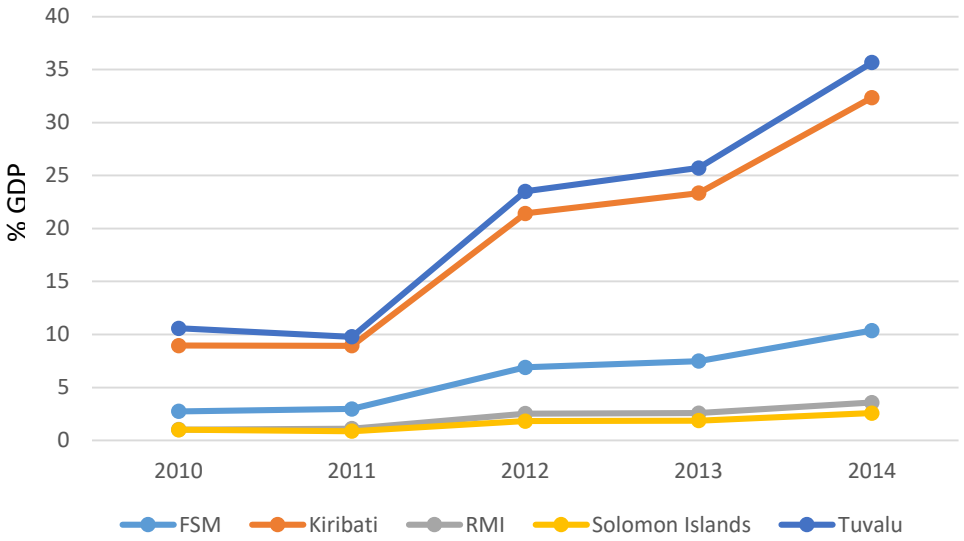
Table 9. Estimated Contribution of WCPO Tuna Fisheries to Pacific Island Countries' Economies in 2013

WCPO Tuna Fishery Value Chain	Value Chain Segment	Est. Net Economic Benefits (US$ M)	Est. Delivered Value of Catch in PIC waters (US$ M)	Est. Net Economic Benefits as % of Delivered Value
Purse Seine Fishery	Foreign fleet access	155	3,100	14%
	Domestic harvesting fleets & Pacific Island processing	291		
Longline Fishery	Foreign fleet access	15	300	17%
	Domestic harvesting fleets & Pacific Island processing	35		
Total Est. Net Economic Benefits		**US$496 million**	**US$3.4 bn**	**17%**

Provisional estimates for 2014 indicate a number of trends in the economic contribution of WCPO tuna fisheries:

- The delivered value of the WCPO purse seine catch decreased significantly to US$3.2 billion even as catch volume increased to a record high, reflecting a decline in the price in Bangkok for canned tuna supply;
- The delivered value of the WCPO longline catch increased to US$1.7 billion, reflecting an increase in catch volume even as both prices for supply in Japan and profitability of the fleets decreased; and
- Even as the value of the purse seine harvest decreased, the portion of that value collected by PNA members (plus Tokelau) as access fees increased significantly, from an estimated US$205 million in 2013 to an estimated US$290 million in 2014 – and now projected to reach some US$390 million by the end of 2015 – though this may be further revised (FFA, 2014; Williams and Terawasi; 2015).

Figure 20. WCPO tuna access fees from foreign fleets as a % of GDP for selected countries

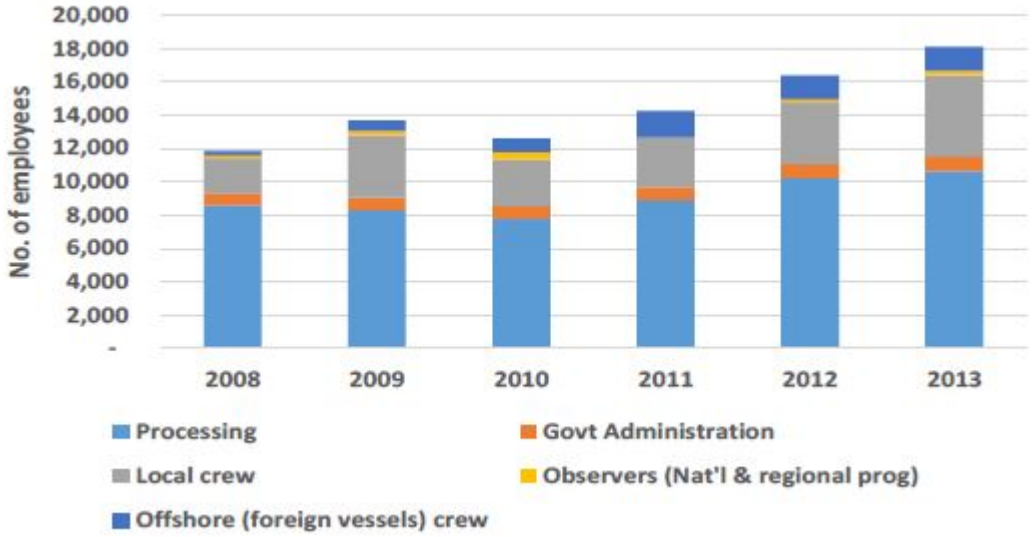


Note: Access Fees estimated based on Distribution of Total Revenues according to 2007 – 2009 distribution of moving average of purse seine catch; 2014 GDP figures are an estimate, taking 2013 values and adding 2 percent.
Sources: GDP at purchaser's price in current US dollars, from http://data.worldbank.org/indicator/NY.GDP.MKTP.CD

The returns from the region's tuna assets are not distributed evenly, but rather reflect higher endowments in the waters of some countries compared others. Additionally, the dependence of Pacific Island countries upon these returns varies. Figure 20 above highlights the magnitude of the growing contribution of foreign fleet access fees from the purse seine fishery as public revenues to the economies of five Pacific Island countries, notably Tuvalu (equivalent to 36 percent of GDP in 2014), Kiribati (32 percent), FSM (10 percent), RMI (4 percent) and the Solomon Islands (3 percent). Collectively, these revenues would be equivalent in 2014 to 8 percent of the aggregated GDP of these five countries. These fees constitute an even higher proportion of the public revenues and budget in many cases, estimated for example to provide 63 percent of public revenues in Kiribati in 2012 for example (Bell et al., 2015). By contrast, foreign fleet access fees to Pacific Island countries from the longline fishery have remained a relatively small US$10 to 15 million (Williams and Terawasi, 2015).

In terms of the contribution of WCPO tuna fishery value chains to employment in Pacific Island countries, the proportion is far smaller. In 2013 the tuna fisheries overall were estimated by FFA to provide just over 16,000 livelihoods in harvesting and processing through Pacific Island countries and territories (see Figure 21 below), over 10,000 of which were in PNG, and another approximately 1,600 were in the Solomon Islands (showing a doubling of processing jobs since 2009) (FFA, 2014). In total, the WCPO tuna fisheries value chains likely employ less than 0.5 percent of the region's current labor force (World Bank[13]). However it should be noted that livelihoods in processing in PNG have increased significantly, currently to roughly 14,500, with another estimated 18,000 to result from plants currently under construction or proposed (see Table 4).

*Figure 21. Estimated Employment in FFA Member Countries related to WCPO Tuna Fishery Value Chains**



**Includes employment in resource management: 'Govt. Administration, Observers'; Source: FFA (2014)*

A particular constraint is the lack of gender-disaggregated data for employment in the region's tuna fisheries, which is essential for understanding how women and men participate in the various segments of the value chains (Weeratunge et al, 2013). More broadly, gender analysis has yet to be integrated into planning processes, resulting in a knowledge gap about gendered retail and consumption patterns and the differing constraints on women and men to more effective participation in tuna value chains and markets (Barclay et al., 2015).

[13] http://data.worldbank.org/indicator

3.5 Summary of the Status of the WCPO Tuna Resource Base

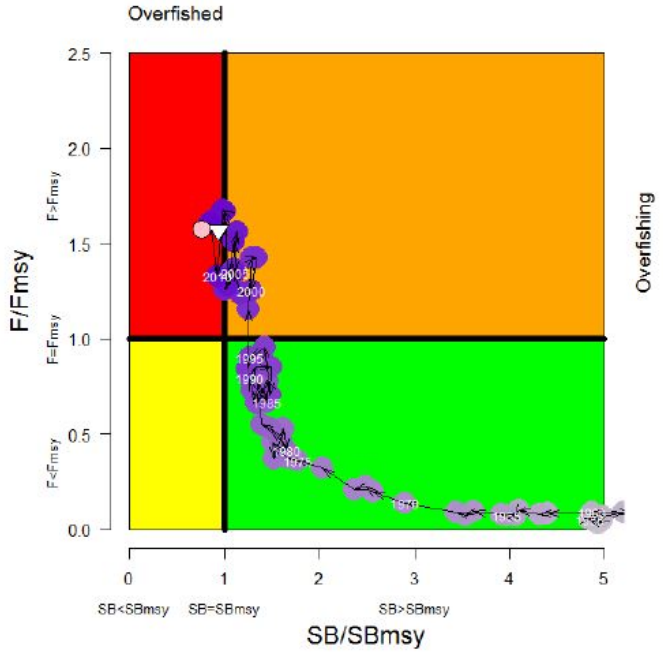
The WCPO purse seine and longline tuna fishery value chains depend on the region's four main species of tuna and the ecosystems that support them: (i) albacore, (ii) bigeye, (iii) yellowfin and (iv) skipjack. As the tuna 'science provider' to the region, the assessments conducted by the Secretariat of the Pacific Community (SPC) serve as the basis for resource management in the region. Simply put, counting fish in the water is inherently challenging, hence there will always be uncertainties associated with fish stock assessments. That said, SPC's tuna assessments are based on models whose predictions have been compared to observations in order to examine model fit to the data, and critically examined by fishery scientists outside the organization, e.g. at the annual meeting of the Scientific Committee of the Western and Central Pacific Fishery Commission, via independent evaluations and through peer-reviewed publication (Gillett and Bromhead, 2008). SPC's most recent assessments indicate the following:

Albacore. Assessments divide the albacore stock into two units: (i) the south Pacific albacore stock (south of the equator) and (ii) the north Pacific albacore stock (essentially north of the equator). According to the most recent assessment in 2014, the north Pacific albacore stock is not experiencing overfishing (though it had in the past, and is currently healthy (Albacore Working Group, 2014). In terms of the south Pacific stock, an assessment was just conducted in 2015 based on data from 1960 to 2013, indicating that fishing mortality has generally been increasing over time, but concluded that overfishing is not occurring and the stock is not in an overfished state (Harley et al., 2015). The assessment concluded that increasing fishing mortality to levels that would provide the maximum sustainable yield would require a significant increase in fishing effort but likely yield only very small (if any) increases in long-term catch (Harley et al., 2015). The assessment reiterated the recommendations of the scientific community in 2014, noting that any declines in the biomass of the stock would render it vulnerable to overfishing, and recommended that longline catches of albacore in the south Pacific be reduced (WCPFC, 2014).

Bigeye. Based on the most recent stock assessment carried out in 2014, the stock is considered overfished and requiring a 36 percent reduction in fishing mortality[14] from the 2008 – 2011 average (notably a reduction in catch of juveniles): fishing mortality is estimated to be 1.57 times the level associated with a stock that could support the maximum sustainable yield, and the spawning biomass[15] has been reduced to 16 percent of the unfished spawning biomass (see Figures 22 and 23 below) (WCPFC, 2014).

[14] Fishing mortality (F) = a mathematical expression of the part of the total rate of deaths of fish due to fishing. Fishing mortality is often expressed as a rate that indicates the percentage of the population caught in a year (Restrepo, 1999).
[15] Spawning stock biomass (SSB) = the total biomass of fish of reproductive age during the breeding season of a stock (Cooke, 1984).

Figure 22. 'Kobe plot' of the trend in bigeye stock status from 1950 to 2011



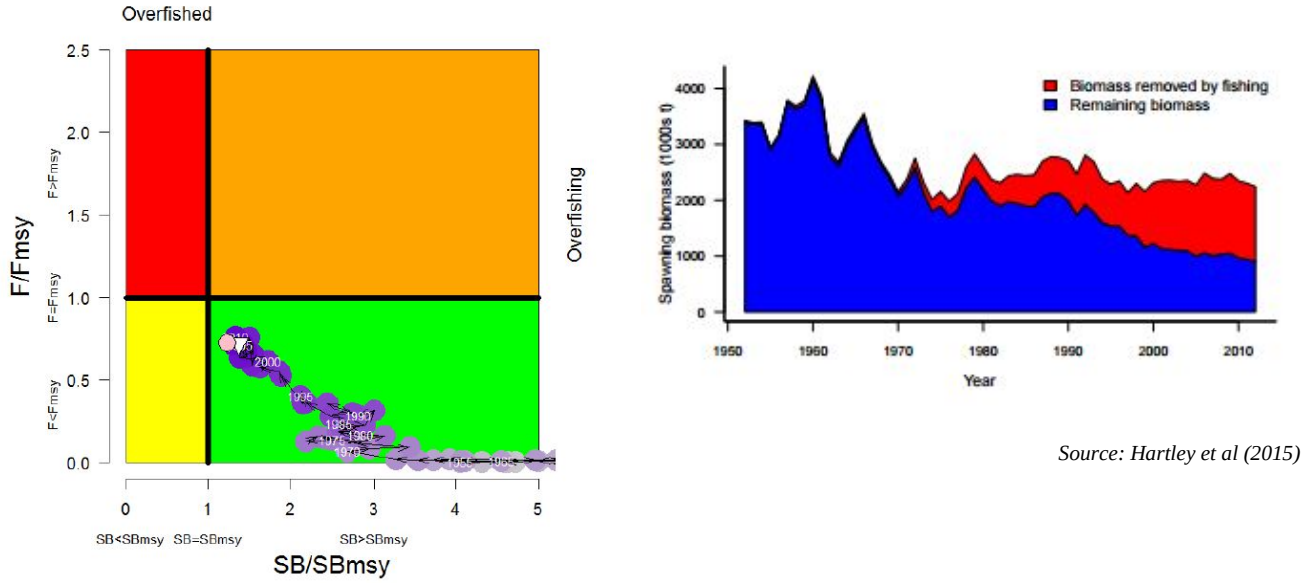
Note: X-axis is the ratio of current spawning biomass (SB) of bigeye stock to the spawning biomass that would support the maximum sustainable yield (Sbmsy); Y-axis is the ratio of current fishing mortality (F) to the fishing mortality that would be associated with a stock size that would support the maximum sustainable yield (Fmsy). The color of the points is graduated from mauve to dark purple through time, and points are labelled at 5-year intervals. The white triangle represents the average for the current period and the pink circle represents the latest period.
Source: Harley et al., 2014

Figure 23. Bigeye stock: ratio of exploited to unexploited potential over time

Notes: Grey line indicates the limit at which the stock is considered overfished
Source: Harley et al., 2014

Yellowfin. Based on the most recent stock assessment carried out in 2014, the stock is not considered overfished, though fishing mortality has generally been increasing through time and is currently estimated to be 0.72 times the rate that will support the maximum sustainable yield (WCPFC, 2014). However, most recent catch levels are close to or have exceeded the estimated maximum sustainable yield by up to 13 percent, and the scientific community recommends that annual catches should not be increased from 2012 levels (WCPFC, 2014).

Figure 24. 'Kobe plot' of the trend in yellowfin stock status & estimated spawning biomass: 1950 to 2011

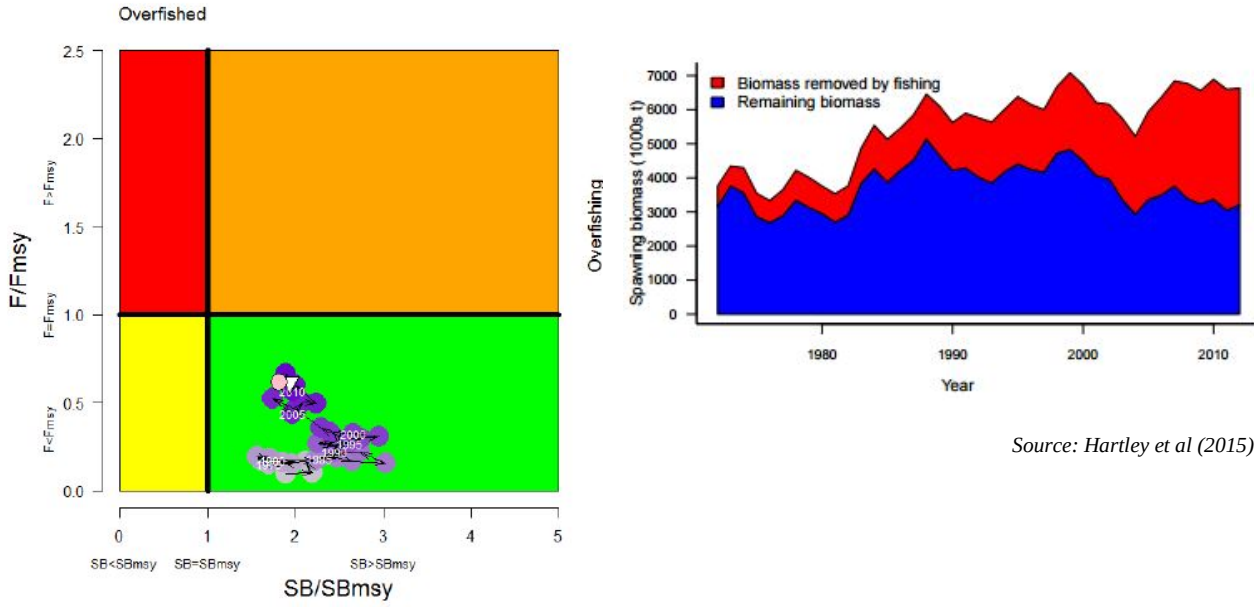


Source: Hartley et al (2015)

Note: For 'Kobe plot', X-axis is the ratio of current spawning biomass (SB) of bigeye stock to the spawning biomass that would support the maximum sustainable yield (Sbmsy); Y-axis is the ratio of current fishing mortality (F) to the fishing mortality that would be associated with a stock size that would support the maximum sustainable yield (Fmsy). The color of the points is graduated from mauve to dark purple through time, and points are labelled at 5-year intervals. The white triangle represents the average for the current period and the pink circle represents the latest period.
Source: Harley et al., 2014b

Skipjack. Based on the most recent stock assessment carried out in 2014, the stock is not considered overfished, though fishing mortality has generally been increasing through time and is currently estimated to be 0.62 times the rate that will support the maximum sustainable yield (WCPFC, 2014). However, most recent catch levels are slightly above the estimated maximum sustainable yield, and the current scientific consensus recognizes that fishing mortality is increasing and stock size declining (to about 52 percent of the level predicted in the absence of fishing), potentially resulting in a contraction of the geographic range of the stock and a reduction in availability in higher latitudes (WCPFC, 2014). According to the assessments, additional purse seine fishing effort in the WCPO will yield only modest gains in long-term skipjack catches and may result in a corresponding increase in fishing mortality for bigeye and yellowfin (WCPFC, 2014. As a result, the recommendation of the scientific community is that fishing mortality should not be increased in order to keep the skipjack stock at approximately current levels (WCPFC, 2014).

Figure 25. 'Kobe plot' of the trend in skipjack stock status & estimated spawning biomass: 1950 to 2011

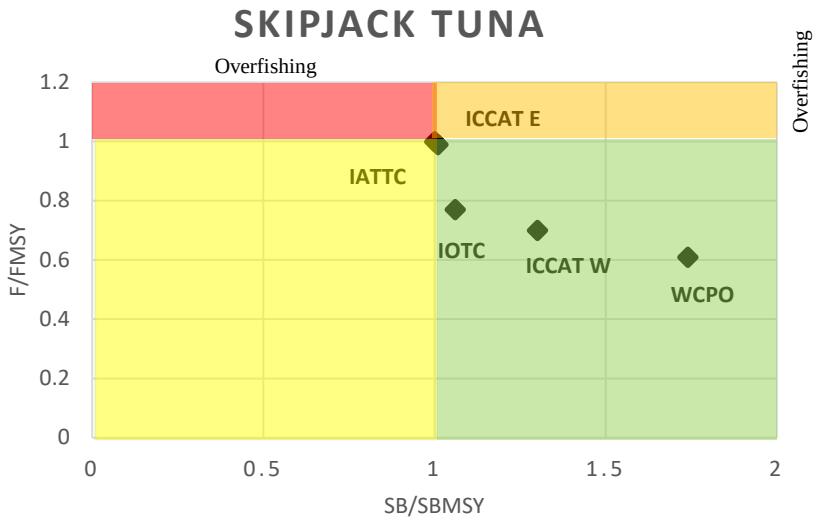


Source: Hartley et al (2015)

Note: X-axis is the ratio of current spawning biomass (SB) of bigeye stock to the spawning biomass that would support the maximum sustainable yield (Sbmsy); Y-axis is the ratio of current fishing mortality (F) to the fishing mortality that would be associated with a stock size that would support the maximum sustainable yield (Fmsy). The color of the points is graduated from mauve to dark purple through time, and points are labelled at 5-year intervals. The white triangle represents the average for the current period and the pink circle represents the latest period.
Source: Rice et al., 2014

In comparing the status of the WCPO resource base to other tuna stocks around the world, the region's skipjack and yellowfin stocks show signs of greater health, as per below:

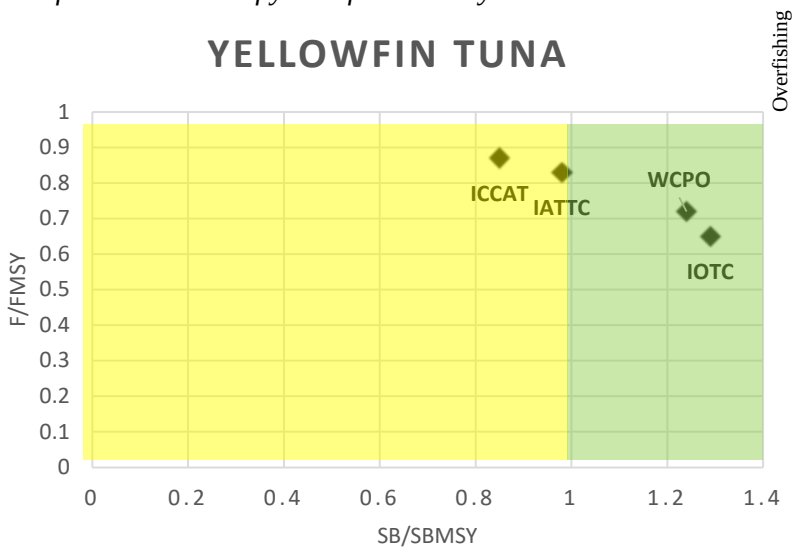
Figure 26. 'Kobe Plot' of current status of skipjack tuna stocks by convention area



Note: ICCAT = International Commission for the Conservation of Atlantic Tunas (East Atlantic & West Atlantic stocks)
IATTC = Inter-American Tropical Tuna Commission
IOTC = Indian Ocean Tuna Commission
Sources: ISSF (2015), ICCAT (2015), IOTC (2015), Rice et al (2014b)[16]

[16] ISSF: http://iss-foundation.org/wp-content/uploads/downloads/2015/03/ISSF-2015-03-Status-of-the-Stocks-Feb-2015.pdf; ICCAT: https://www.iccat.int/Documents/SCRS/ExecSum/SKJ_EN.pdf; IOTC: http://www.iotc.org/documents;

Figure 27. 'Kobe Plot' of current status of yellowfin stocks by convention area



Note: *ICCAT = International Commission for the Conservation of Atlantic Tunas (East Atlantic & West Atlantic stocks)*
IATTC = Inter-American Tropical Tuna Commission
IOTC = Indian Ocean Tuna Commission
Sources: ISSF (2015), ICCAT (2015), IOTC (2015), Harley et al., 2014b [17]

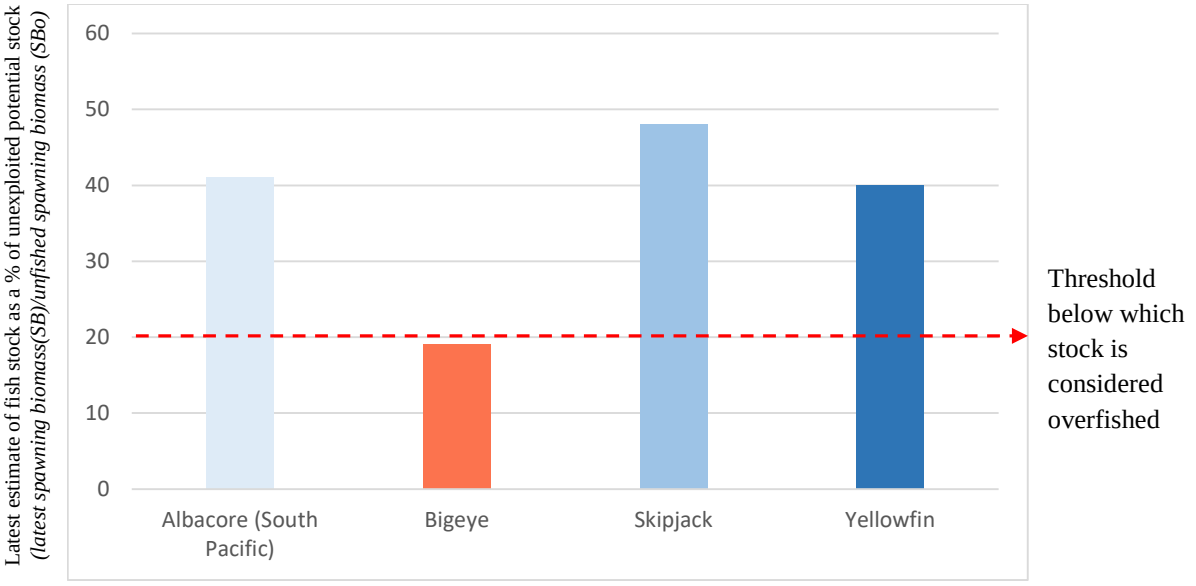
Additionally, though indicative only of the order of magnitude given the age of the data, the most recent assessment of by-catch levels (i.e. catches, whether discarded or not, of species other than the principal target tuna species of skipjack, yellowfin and bigeye, e.g. other finfishes, billfishes, sharks and rays, etc.) suggested total levels from the WCPO purse seine fishery on the order of roughly 20,700 mt per year (Lewis, 2014). These by-catches were linked largely to the use of fish aggregating devices (FADs), and as a percentage of the targeted catch were lower in the WCPO than any other major tuna fishery (Lewis, 2014).

3.6 Characterization of Current Status of the WCPO Tuna Asset

As mentioned previously, natural resources are special economic goods because they are not produced. As a consequence, natural resources will yield economic profits – rents – if properly managed. Living resources such as fish stocks are unique because unlike minerals for example, they are a potentially sustainable source of rents if well managed. Such stocks can be considered as natural capital assets of a country, contributing to its development. The optimal stock size is a complex question, but would in theory be such that it maximizes the present value of the future stream of benefits. If this optimal stock size and that present value can be estimated, then the difference between the present value of the future stream of benefits generated by the optimal size and the present value associated with the current size, is essentially depletion or 'borrowing from the future' – i.e. the asset's potential compared to its current value (World Bank, 2006). Figure 28 below provides a snapshot of the rate that WCPO's current portfolio of tuna stocks is being drawn down at the moment, in terms of the latest assessment of spawning stock biomass compared to the potential biomass that would be expected in the absence of fishing.

[17] ISSF: http://iss-foundation.org/wp-content/uploads/downloads/2015/03/ISSF-2015-03-Status-of-the-Stocks-Feb-2015.pdf; ICCAT: https://www.iccat.int/Documents/SCRS/ExecSum/YFT_EN.pdf; IOTC: http://www.iotc.org/documents;

Figure 28. WCPO 'Tuna Bank': Fish Stocks in the Water



Sources: Albacore working group (2014); Harley et al. (2014); Harley et al. (2014b); Rice et al. (2014b)

The above figure depicts assessments of the current status of the natural resource stocks, but does not indicate if this status is sustainable under current rates of fishing pressure, or if they will increase or decrease in the future if current rates of fishing pressure are maintained. Nonetheless, it provides a useful snapshot of the current status, and the resource management challenge for tuna fisheries governance in the region – to regulate fishing pressure to levels that will grow or maintain the stocks such that they can provide optimal returns for Pacific Island countries' economic growth aspirations.

3.7 Summary of Key Trends in WCPO Tuna Fisheries Policy

Building upon the key trends identified in WCPO tuna fisheries by Gillett and Cartwright (2010), the following have been noted in terms of trends in policy at a number of different levels within the WCPO (see Annex 1 for more detail):

WCPO level. In the early to mid-1990s there was a growing awareness of the need for a tuna management agency that would cover an area larger than that encompassed by Pacific Island countries and which would include foreign nations with vessels fishing in the WCPO (Gillett, 2014). After six years of complex negotiations between the PICs and distant-water fishing nations, a treaty for the creation of a Western and Central Pacific Fisheries Commission (WCPFC) was opened for signature in September 2000 and the Secretariat established in Pohnpei in 2004 (WCPFC, 2015). The WCPFC currently includes 26 member countries, 7 participating territories and 7 cooperating non-members, meeting annually with decisions generally taken on the basis of consensus towards the objective of ensuring the long-term conservation and sustainable use of the highly migratory fish stocks in the WCPO (WCPFC, 2015). The decisions of the Commission, known as 'conservation and management measures', are binding upon members, and have included the requirement for example that all members' vessels are authorized to fish in the WCPO and registered with the Secretariat, as well as transfer information on vessels' fishing activities in order to support management (see Annex 1). The Oceanic Fisheries Program of the Secretariat of the Pacific Community (SPC) is the agreed science service provider to the WCPFC, collecting and analyzing tuna catch and effort data, observer reports and other relevant information, and providing stock assessments to the Commission (Gillett, 2014).

Pacific Islands region. Leaders from Pacific Island nations have articulated a number of policy statements of principle and objective for the region's use of WCPO tuna resources, consistently focused on increasing

conservation of the resources and domestic benefits from their sustainable use, and enhanced regional cooperation towards that end. These policy statements include (among others):

- *Pacific Islands Regional Ocean Policy (2002)*: Endorsed by leaders of the Pacific Islands Forum[18] leaders recommended the development of a regional policy statement in 1999, and endorsed the Pacific Islands Regional Ocean Policy (PIROP) in 2002 (Gillett, 2014). The PIROP articulates a vision for a healthy Pacific Ocean that sustains the livelihoods and aspirations of the region's communities, under guiding principles of improved understanding of the ocean, sustainable development and management of ocean resource use, maintained ocean health, promotion of peaceful ocean uses and the creation of partnerships and promotion of cooperation (Gillett, 2014).

- *Pacific Islands Regional Ocean Framework for Integrated Strategic Action (2005)*: Developed as a guide for implementation of the PIROP, the Framework provides a regional consensus on priority actions for improved ocean governance and sustainable resource use, a framework for regional coordination of action and guidance to development partners on priorities (Gillett, 2014).

- *Vava'u Declaration on Pacific Fisheries Resources (2007)*: Annual meetings of Forum leaders have generated a number of statements of policy objectives for tuna resources, but the 2007 meeting is perhaps the most comprehensive in articulating a number of specific objectives, including: promotion of domestic fisheries and particularly the development of national tuna industries, maintaining Pacific Island solidarity in managing WCPO tuna stocks, full implementation of conservation and management measures agreed at the WCPFC and promotion of additional conservation measures for bigeye and yellowfin, enhancing effectiveness and transparency in national licensing and cooperation with FFA on monitoring and surveillance of fishing activity (Gillett, 2014).

- *Framework for a Pacific Oceanscape (2009)*: The Framework for a Pacific Oceanscape (FPO) was proposed at a meeting of Forum leaders by the Republic of Kiribati, as a vision for a secure future for PICs based on ocean conservation and management. A document was subsequently developed based on regional consultation entitled "Our Sea of Islands, Our Livelihoods, Our Oceania - Framework for a Pacific Oceanscape: a catalyst for implementation of ocean policy" (Pratt and Govan 2010) and was endorsed by the Pacific Island leaders in that same year (Gillett, 2014). Since that time, a number of PICs and territories have established large marine protected areas under the FPO, including Kiribati's Phoenix Islands Protected Area (PIPA), large marine protected areas in the Cook Islands and French Polynesia, and a proposed tuna fishing reserve in Palau.

[18] Pacific Islands Forum member countries are: Australia, Cook Islands, FSM, Fiji, Kiribati, Nauru, New Zealand, Niue, Palau, PNG, RMI, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. Tokelau, French Polynesia and New Caledonia are associate members.

- *Framework for Pacific Regionalism (2014):* The Framework replaced the 2005 Pacific Plan as the overarching strategy for regional integration and coordination between PICs, by establishing a process through which regional priorities for collaboration and pooling of resources would be identified and implemented (Pacific Islands Forum, 2014). Based on the process established by the Framework for Pacific Regionalism, in 2015 Forum leaders identified the region's fisheries as one of five issues that met the test for regionalism in the new framework and endorsed the Regional Roadmap for Sustainable Pacific Fisheries (Pacific Islands Forum Secretariat, 2015). The Roadmap sets 4 targets for benefits to PICs from WCPO tuna fisheries over the next 10 years, with indicators of success and implementation strategies, and a commitment for Fisheries Ministers to provide an annual 'fishery report card' of progress to the Forum leaders meeting (see Box 4) (FFA, 2015). In their endorsement of the Roadmap, Forum leaders called for the economic targets to be achieved within 5 years, and directed a joint taskforce of FFA, PNA and the Forum Secretariat to develop a program towards that end, including examination of a quota management system for purse seine tuna fishery and an evaluation by 2016 of the region's fisheries monitoring and surveillance system (Pacific Islands Forum Secretariat, 2015).

Box 3. 2015 Regional Roadmap for Sustainable Pacific Fisheries

Four Targets:

- *Enhance sustainability of the resource as a prerequisite for greater benefits*, including agree on objectives (i.e. 'target reference points') for minimum stock sizes (biomass) for all four tuna species as a basis for access limits, that would result in clear progress towards growth/maintenance of stocks sizes towards these objectives within 10 years – particularly for rebuilding the bigeye stock.
- *Enhance the economic value of the tuna fisheries without increasing production*, by reducing harvests and oversupply to the markets, increasing productivity and profitability in the fisheries (and therefore the value access) and targeting higher value products and markets, resulting in a doubling of the value of the region's tuna catch in 10 years.
- *Increase Pacific Island employment in WCPO tuna fisheries,* through additional processing in Melanesia, as well as increased Pacific Island crew for fishing vessels, resulting in 18,000 new jobs over the next 10 years.
- *Enhance Pacific Islands food security,* through increased small-scale catch of tuna, local processing and supply, and utilization of incidental catch (i.e. 'by-catch') of non-targeted species, resulting in 40,000 tons of additional tuna supplied for Pacific Island consumption by 10 years.

Six Strategies to Achieve Targets:

1. *Effective management of tuna fishing in PICs' waters (zones)*, based on assertion of national rights to access the stocks within a framework for cooperation and binding limits towards resource objectives (i.e. target reference points), which within 10 years would be based on quotas of catch rather than effort (fishing days);
2. *Continued efforts to reduce illegal fishing*, through investments in cooperative monitoring and surveillance programs through the Niue Treaty, utilizing technology advances such as enhanced investment in satellite and electronic surveillance, at-sea boardings and inspections, cooperation in aerial surveillance and strengthened port controls;
3. *Progressive restriction of fishing on the high seas by non-PIC vessels*, through continued conditions of access to PIC waters as well as efforts through the WCPFC and promotion of consumer preferences for tuna caught in national waters;
4. *Prioritize supply of raw material to Pacific Island processors,* through requirements to offload a portion of catch locally and coordinated increases in transshipment fees;
5. *Establish high standards for employment in harvesting and processing*, through uniform minimum standards and a renewed emphasis on training; and
6. *Establish regional processing hubs in two or three PICs*, where fish caught in other PIC waters can be received and processed.

Specific policy instruments for shared management of tuna resources in Forum members' waters begin with the *South Pacific Forum Fisheries Agency Convention of 1979*. This treaty arose from the perception of PICs in the late 1970s that many distant water fishing nations negotiated access agreements bi-laterally in

a strategy of 'divide and conquer' (Gillett, 2014). This treaty aimed to drive regional cooperation for the sustainable use and management of Forum members' shared tuna resources, and created the Forum Fisheries Agency (FFA) in support of this objective (FFA, 2015b). Governed by a Forum Fisheries Committee of member countries that meet annually and take decisions based on consensus, the FFA Secretariat serves as an advisory body that provides expertise, technical assistance other support to inform members' decisions about the use of tuna resources in their waters and participation in the WCPFC (FFA, 2015b). Focused almost entirely on tuna, FFA supports development of regional and national policies, provides national and regional tuna fisheries management services (such as maintaining a tuna fishing vessel registry and a satellite-based tuna fishing vessel monitoring system) and providing information, analysis and training for industry development along the value chain (FFA, 2015b). Under the 1979 Convention, the Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region was agreed in 1992 and amended with a subsidiary agreement in 2012. This treaty promotes cooperation among FFA members on: (i) enforcement of national tuna fishing laws and regulations, (ii) regional surveillance procedures and patrols, and (iii) establishment of harmonized minimum terms and conditions of foreign fishing vessel access to PIC waters, among others (FFA, 2015b). FFA has also helped facilitate agreement between members and the United States on a Multilateral Fishing Treaty since 1987, for common conditions and fees for access to PIC waters by the U.S. tuna fleet, together with targeted bi-lateral aid from the U.S. (U.S. State Department, 2015).

Pacific Islands Sub-Region: Equatorial Belt. Building from the context of the 1979 FFA Convention, PICs in the equatorial belt where the heaviest concentration of purse seine fishing takes place began to discuss more specific cooperation around the tuna fisheries in their waters. In 1982 seven countries (and subsequently an eighth, Tuvalu) signed the *Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest*, with aim of coordinating and harmonizing management of the common fish stocks shared across the zones of the Parties to the Agreement (PNA, 2010). The Parties to the Nauru Agreement (PNA) agreed to work together to set uniform terms and conditions of access to tuna in their waters, including licensing, reporting, identification, etc. Following a period in the 1980s of policy focus in the sub-region (and beyond) on public investment in local fleets and canneries, which by the mid-1990s were generally judged to have been unsuccessful, some countries began to focus on increasing benefits from access fees (Gillett, 2014). In 2000 a study by FFA suggested shifting the strategy of PNA efforts to manage the purse seine fishery in their waters, from a cap on vessel numbers (and licenses), to a strategy based on limits on purse seine fishing days (Gillett, 2014).

The transition was actually made seven years later (Gillett, 2014), and the Parties subsequently amended the *Palau Arrangement for the Management of the Western Pacific Purse Seine Fishery* (most recently in 2015) to create a vessel day scheme (VDS) to manage access to Parties' waters for purse seine tuna fishing vessels, by setting a total collective limit on fishing days in those waters by licensed purse seine vessels each year (total allowable effort or TAE), and allocating that TAE among the Parties (Party allowable effort or PAE). All Parties agree to limit fishing effort in their water to the respective PAEs, using standard criteria for reporting fishing days. Parties may transfer unused days within their PAEs, or agree on arrangements to pool them for sale. Effort expended under the FSMA and US Treaty is included in the calculations for TAE and PAEs, and Parties must allocate a portion of their PAEs to account for any days fished by their national fleets in other Parties' waters. To combat 'effort creep' (increasing fish catch per the same measure of fishing effort, i.e. increasing catch per fishing day), the following conversion factors are used: (i) every fishing day by a purse seine vessel with a length overall of less than 50 meters shall equate to a deduction of one half of a fishing day; (ii) every fishing day by a purse seine vessel with a length overall of between 50 meters and 80 meters shall equate to a deduction of one fishing day; and (iii) every fishing day by a purse seine vessel with a length overall in excess of 80 meters shall equate to a deduction of one and one half fishing days. The VDS is implemented as part of a Conservation and Management Measure agreed at the WCPFC, together with the Third Implementing Arrangement in 2009 that closes a number of high seas areas to foreign vessels wishing to obtain/maintain a license to fish in Party waters (PNAO, 2015). Originally FFA provided secretariat services to the PNA, but in 2010 the Parties amended

the Agreement to establish an office (PNAO) in Majuro. A number of instruments have been introduced by the PNA, notably the Federated States of Micronesia Arrangement (FSMA) of 1995 to provide a mechanism for Parties' domestic vessels to access other non-home Parties' waters at reduced fee rates, in order to support domestic industry (though countries are reviewing and in some cases revising these rates).

Additionally, the Palau Arrangement has been amended in 2014 to include a VDS for the longline fishing effort in PNA waters, under similar terms as the purse seine VDS, except that the conversion factors are as follows: (i) every fishing day by a longline vessel with a length overall of less than or equal to 40 meters shall equate to a deduction of 0.8 of a fishing day; (ii) every fishing day by a longline vessel with a length overall greater than 40 meters shall equate to a deduction of 1.6 fishing days; and (iii) artisanal vessels are exempt. For both the purse seine and longline VDS, the PNAO conducts administration and maintains a registry of purse seine vessels (with registration on the FFA register as a pre-requisite).

Pacific Islands Sub-Region: Southern region. In November 2014, ten countries signed the Tokelau Arrangement to introduce fishing catch limits by zone (i.e. EEZ), following loosely on the model of the VDS whereby limits on access for the southern albacore longline fishery will be introduced via national measures in each of the participating countries (Havice et al, 2014). The agreement was signed by Australia, the Cook Islands, Fiji, New Zealand, Niue, Samoa, the Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu, with provision for the states to meet once annually to take decisions by consensus, with FFA acting as secretariat.

Pacific Island Countries. Access and regulation of tuna fishing within the waters of PICs is regulated at the national level, according to the various regional agreements made. Towards this end, almost all PICs have prepared national Tuna Fishery Development and Management Plans or the equivalent (World Bank, 2012), with varying degrees of implementation to date.

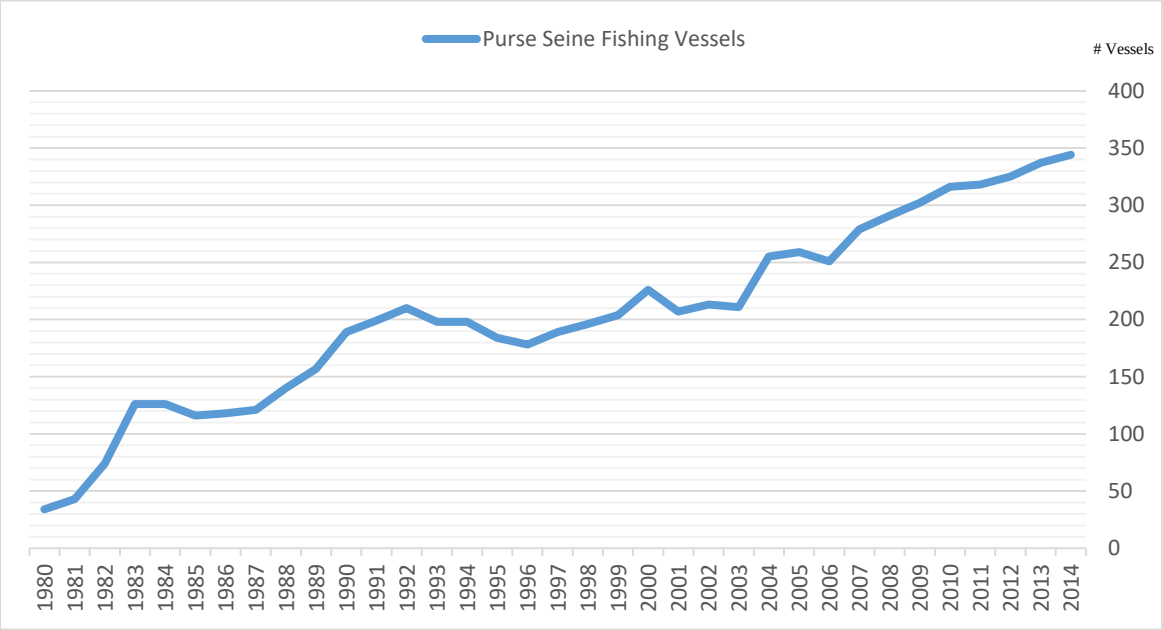
A key caveat on the above policies is the difference between articulation/endorsement of policy statements and instruments, and their implementation at various levels. Assessments of fisheries governance in the region have noted in the past a disconnect in some cases between regional policy statements (e.g. declarations) and the day-to-day activities of the agencies required to give them effect (Gillett and Cartwright, 2010).

3.8 Summary of Key Trends in WCPO Tuna Fisheries Outcomes

This section carries forward the previous discussion on key trends in policy at various levels within the WCPO, to highlight trends in outcomes from the tuna fishery for Pacific Island countries, again building upon the work of Gillett and Cartwright (2010).

Trends in the status of the resource base. One of the defining trends in the WCPO tuna fisheries since the late 1970s and early 1980s, has been the growth of purse seine fishing. As mentioned previously, the skipjack stock contributing around 79% of the purse seine catch remains healthy, and PNA and the WCPFC have recently adopted a target reference point to maintain the skipjack stock at around current levels, largely for economic reasons. The WCPFC Scientific Committee has recommended that the yellowfin catch level is not further increased.

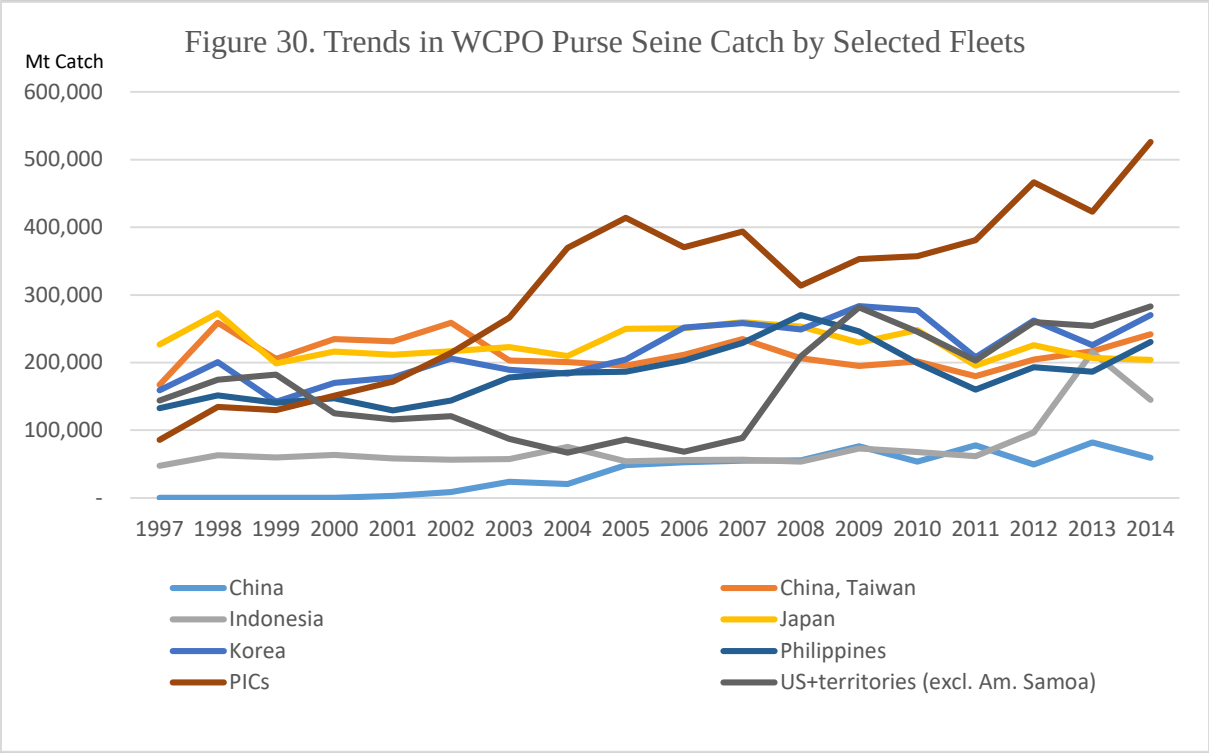
Figure 29. Trends in WCPO Purse Seine Capacity



Source: WCPFC Tuna Fishery Yearbook 2014

As shown above, the number of large scale purse seine vessels fishing in the WCPO (i.e., excluding smaller purse seine vessels) has increased by a multiple of 10 over the last 35 years, from 34 in 1980 to 344 vessels in 2014 (WCPFC, 2015). Over the same period, the aggregate purse seine catch, including by the smaller coastal vessels, increased to an estimated 2,036,968 tons in 2014. Within the aggregate purse seine fleet, a number of specific trends stand out, as shown in Figure 30 below (FFA, 2015 unless otherwise noted):

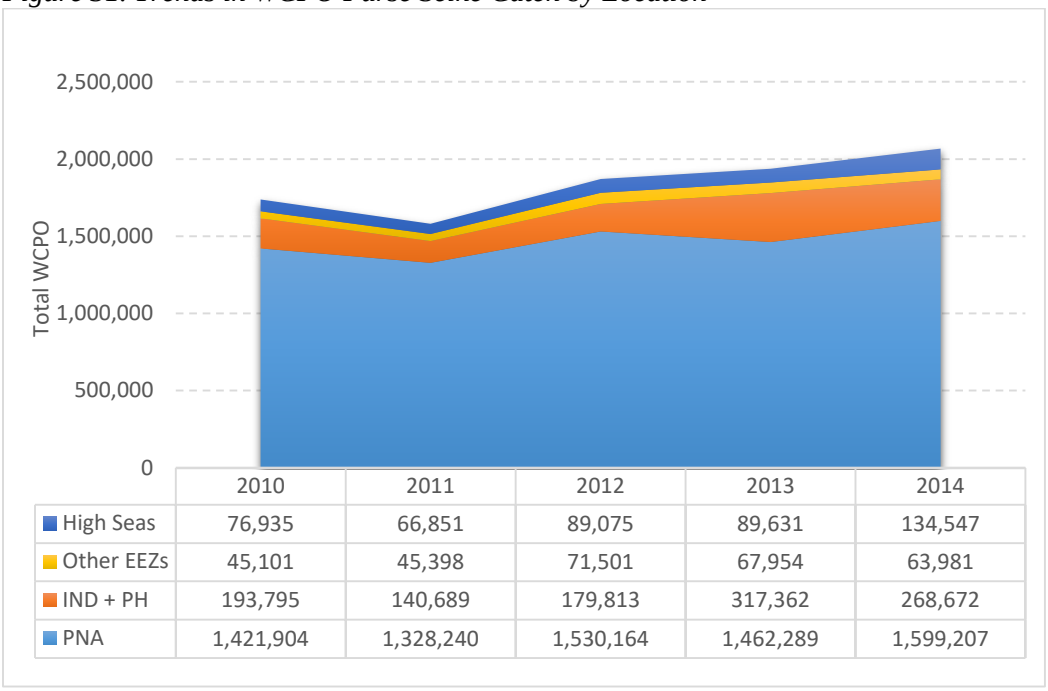
- *Declining*: catches by the Japanese fleet have been declining since 2007;
- *Relatively constant*: catches by fleets from China, Taiwan as well as Korea have been relatively constant since 1997 (though both China, Taiwan and Korea's catches increased somewhat in 2014), and similarly although the U.S. fleet (including all territories except American Samoa) increased its catch from 144,082 metric tons in 1997 to 283,230 metric tons in 2014, catches have been on a relatively flat trend since 2009;
- *Increasing from the edges*: catches by the fleets from Indonesia and the Philippines have increased from a combined 180,160 metric tons in 1997 to 268,672 metric tons in 2014;
- *A new fleet*: catches by the purse seine fleet from China are a relatively new factor in the WCPO, increasing from 0 in 1997 to 59,407 metric tons in 2014 (WCPFC, 2015b); and
- *Exponential growth*: catches by the PIC fleets have increased from 85,657 metric tons in 1997 to 526,067 metric tons in 2014, while the number of vessels has increased from 40 in 2002 to 95 in 2014, over half of which are flagged to PNG (Williams and Terawasi, 2015), in many cases foreign-owned but securing access partly in exchange for landing catch locally.



Source: FFA (2015)

The aggregate purse seine fleet and catch have grown significantly over the years, but the distribution of fishing effort has not been uniform. The question arises, since the introduction of the VDS in the waters of the PNA countries plus Tokelau, where most purse seining takes place, as well as the associated closure of the high seas pockets, has fishing capacity and catch increased? Has the VDS truly capped fishing pressure?

Figure 31. Trends in WCPO Purse Seine Catch by Location



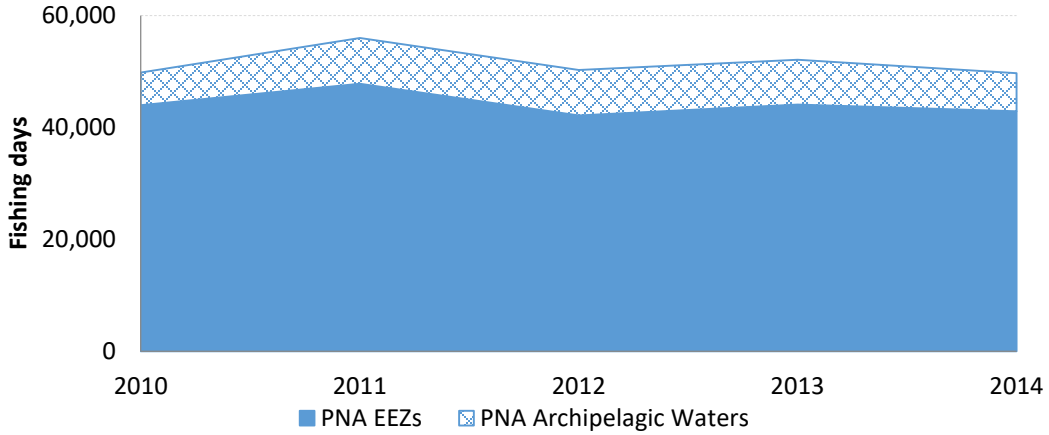
	2010	2011	2012	2013	2014
High Seas	76,935	66,851	89,075	89,631	134,547
Other EEZs	45,101	45,398	71,501	67,954	63,981
IND + PH	193,795	140,689	179,813	317,362	268,672
PNA	1,421,904	1,328,240	1,530,164	1,462,289	1,599,207

Source: Williams and Terawasi (2015)

Purse seine catches in PNA waters have been relatively stable from 2010 to 2013. Catches increased in 2014, which according to SPC, *"could be due to a strong year-class in conjunction with environmental conditions resulting in a prolonged period where skipjack tuna were more available to the gear"*. Over the same period, catches outside PNA waters have increased by around 48%, with increases in the high seas (75%), Indonesia and Philippines (39%) and other EEZs (42%) (Williams and Terawasi, 2015). Increased reporting may also have played a role in some instances.

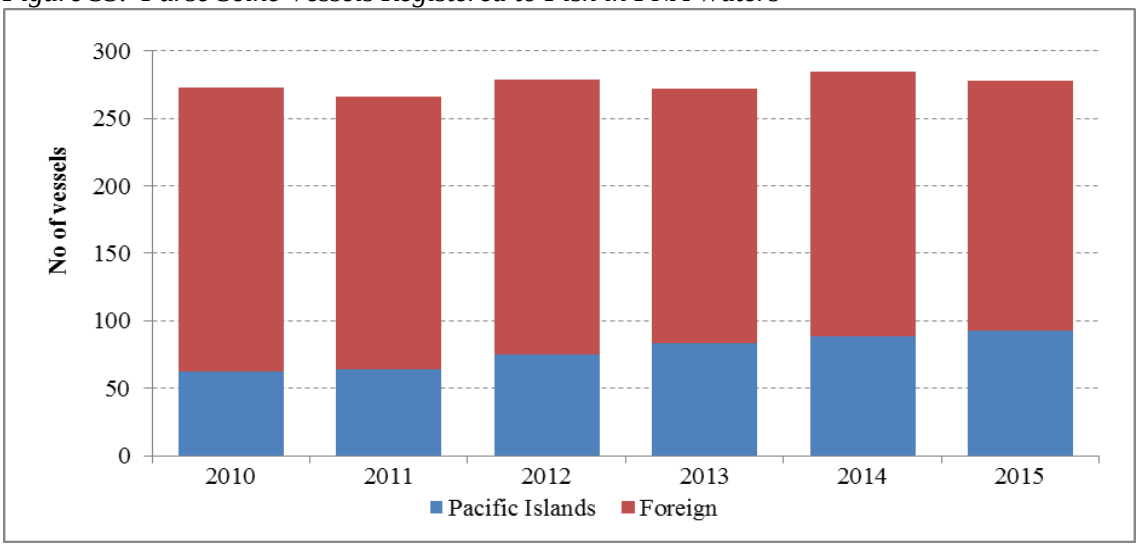
The relative stability of catches in PNA waters reflects the implementation of the VDS. Before 2012, the VDS was only partially applied, excluding the US fleet and domestic vessels operating under the FSMA. An overall hard limit at the 2010 level was applied to the fishing days available under the VDS from 2012. As shown below, the application of this limit reduced effort from the high level reached in 2011 and has, since then, maintained effort in PNA EEZs at below the 2010 level.

Figure 32. Purse Seine Effort in PNA Waters



As illustrated in the graph below, implementation of the VDS has also held the total number of purse seine vessels registered to fish in PNA waters at roughly the same as in 2010 (Clark, 2015).

Figure 33. Purse Seine Vessels Registered to Fish in PNA Waters



Source: Clark (2015)

However, at the same time, fishing effort (as measured in days fished) has increased substantially in waters outside of the PNA since the introduction of the VDS. In response to the question, based on the data available, it appears that purse seine fishing catch and effort have been relatively stable under the VDS in PNA waters until 2013, with an increase in the catch in 2014, which could be largely due to favorable fishing conditions. By comparison, purse seine effort and catch, outside PNA waters, though relatively smaller than the PNA catch and effort, have grown rapidly from 2010 to 2014. (Clark, 2015).

Throughout the entire WCPO, a total of 57,138 vessel days were fished in 2014 (excluding national waters in Indonesia and the Philippines), which could be translated into the number of vessels that would be estimated to operate full time at that level. A preliminary analysis estimated this as equivalent to a total of 229 vessels – below the current levels registered, suggesting that many of these vessels may be operating less than full time (Pilling and Hardy, 2015). Additionally, Pilling and Hardy (2015) estimated that 281 to 289 vessels could operate full time within the total limit of 65,867 fishing days per year currently agreed at the WCPFC, including: 51,879 for PNA countries and Tokelau (including archipelagic waters), 7,047 days for other countries' waters in the WCPO, and 6,941 for the high seas, but excluding the waters of Indonesia and the Philippines (Pilling and Hardy, 2015). However, Pilling and Hardy (2015) note that the number of vessels operating full-time would be significantly less if the WCPO wants to maintain the skipjack tuna stock at a target biomass of 50 – 60% of unfished levels: in the range of 142 to 220 vessels – i.e. below current levels. Additionally, Tidd et al. (2015) recently found that the 'catching capability' of purse seine vessels in the WCPO steadily increased between 2005 and 2011 at a rate of 3 – 5% per year, as younger and bigger vessels in the fleet tended to be more efficient (i.e. catching more fish per day than previous vessels). At this rate, a day of fishing was 19 – 34% more effective in 2011 than 2005, again reflecting not just the growing fleet size and catch, but the growing efficiency of the WCPO purse seine fleet (Tidd et al., 2015). However, this trend had reversed in the early years of the introduction of the VDS, with vessel efficiency estimated as declining overall from 2009-2011, especially in the FAD fisheries. This is contrary to expectations that effort limits would create incentives to increase vessel efficiency, though may reflect 'closures' of FAD fishing for several months annually that were in effect during this period.

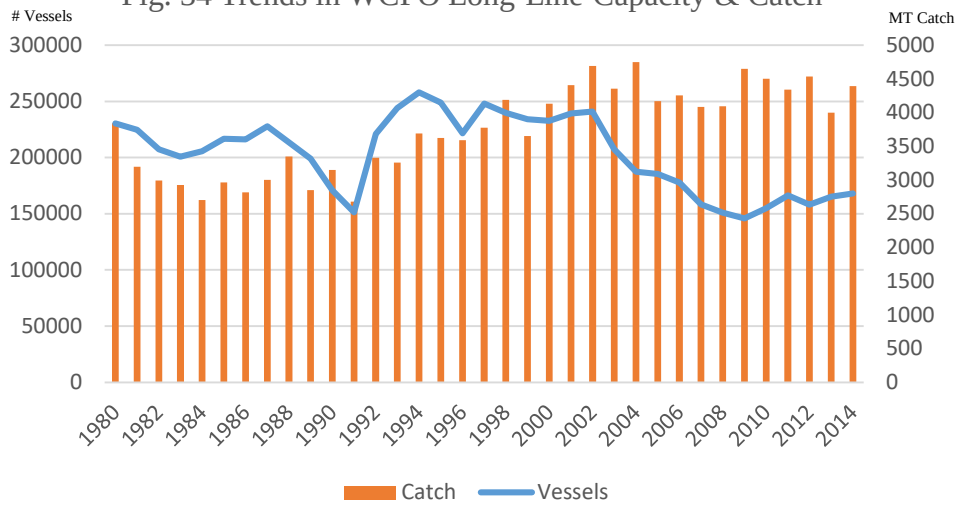
It remains to be seen whether the decline in vessel efficiency in the early years of the VDS is a short term effect and accelerated increases in vessel efficiency develop, or continues as a result of features in the VDS including the effects of the price of vessel days in removing economic rents and of PNA members using the VDS to replace larger roaming vessels with smaller, more locally-based vessels.

In summary, a few conclusions may be drawn based on current information available:

1. Purse seine fishing capacity and catch have continued to grow throughout the WCPO. The fleet registered to PICs has grown exponentially in the last decade, as has its catch, while most other fleets have remained stable.
2. Fishing effort and catch appear to have grown much more in the waters outside of the PNA since 2010, by around 50% from 2010 to 2014, though catch did increase in PNA waters as well (some 9% from 2013 to 2014). This growth outside PNA waters has been highlighted as a concern by Parties, as it may to be due to efforts to operate outside the VDS and evade its controls as well as illustrating the challenges of regulating fishing on the high seas. Fishing effort and catch increased significantly in some high seas pockets in 2014 for the first time since 2010, and have steadily increased in the waters of Indonesia and the Philippines.
3. It is not clear what the effect of the VDS has been on vessel efficiency and whether the VDS has overall created incentives to increase fishing power and catch/day. This will be a critical factor to monitor in the future development of the VDS.
4. The VDS appears to have effectively controlled fishing pressure in the purse seine fishery in PNA waters in terms of the number of vessels and fishing effort involved. It remains to be seen whether the catch increase in 2014 is a one-off increase due to oceanographic conditions, or indicates the emergence of systematic increases in fishing power in the fleet (or potentially fishing effort reported as 'non-fishing days' within the VDS in some instances).

In terms of capacity in the WCPO longline fisheries, Figure 34 below shows that the fleet has declined from previous peaks, even as catch levels have remained relatively constant.

Fig. 34 Trends in WCPO Long-Line Capacity & Catch



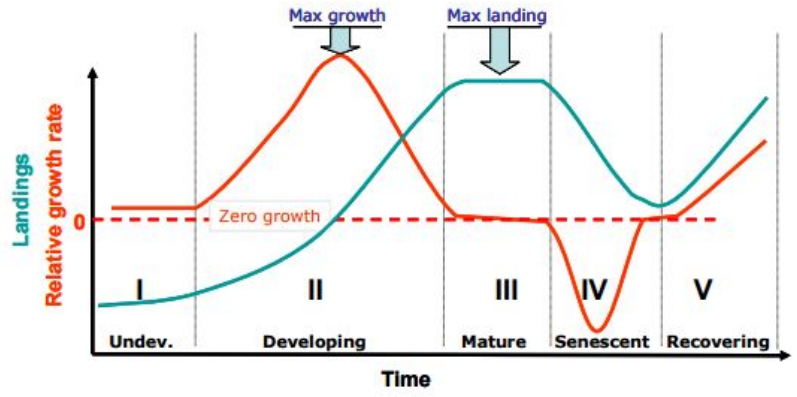
Source: WCPFC Tuna Fishery Yearbook 2014

As mentioned previously, the longline fishery in the southern part of the WCPO (i.e. south of the 10 degree south parallel) has shown decreased productivity since 2009, with catch-per-unit of effort (i.e. kilograms of tuna per one hundred hooks on a longline) hitting a low in 2011 for the period since 2002, with only marginal improvements since that time (Gillett, 2014; FFA, 2014). This drop coincides with a sharp increase in fishing effort in this part of the WCPO longline fishery in 2008 (Gillett, 2014), reflecting the rise of the PIC albacore fleet in recent years (consisting of smaller, offshore vessels, many of which are chartered), which caught as much as 50 to 60% of albacore in 2014 (Williams and Terawasi, 2015). Even more recently, a fleet of smaller vessels from China has been operating in the fishery, which are reported to be subsidized (Ilakini, 2013; Havice et al., 2014). The sustained reduction in vessel productivity since 2011 led FFA to express some concern with regard to the economic health of the fishery in late 2014 – notably as low catch rates have reduced profits (Gillett, 2014; FFA, 2014). Distant-water vessels in particular have seen a decline in productivity and overall numbers, though the trend has been common throughout all fleets (Gillett, 2014). Gillett (2014) writes that "[Pacific Island] fleets participating in the South Pacific longline albacore fishery are struggling, blaming fierce competition from the burgeoning subsidized Chinese longline fleet and depressed prices due to the over-supply of albacore. Many longline vessels are not operating, awaiting conditions to improve." Similarly, Campling et al. (2014) wrote that many of the Fiji-based vessels are struggling for profitability. In 2015 the Deputy Director of FFA stated that some 400 new longline vessels from China were operating in the southern Albacore fishery, and that catch rates were declining to unprofitable levels for all other fleets (Matangi Tonga Online, 2015). Much of the increase in catch of albacore in WCPO is attributed to vessels from China and also China, Taiwan (Harley et al., 2015). In its 2015 assessment of the southern Pacific albacore stock, SPC also noted the strong declining trend in the economic conditions experienced by many PIC fleets, and cited a decline in the size of the stock as a key driver (Harley et al., 2015).

The longline fishery targeting fresh fish for the sashimi markets operates largely in tropical waters near the equator, targeting bigeye and yellowfin. Over the period from 2003 – 2013, the catch rates for bigeye peaked in 2008 and have generally declined since (i.e. kilograms caught per hundred hooks on a longline), while yellowfin catch rates consistently declined from 2010 to 2013 (FFA, 2014). The flat trend in the growth in catches in the longline fisheries bears some resemblance to the global analysis that Garcia (2009) conducted of long-term trends in fish landing statistics. On the basis of trends in the growth of landings,

Garcia (2009) classified five stages in the development of ocean fishery systems: (i) undeveloped, (ii) developing, (iii) mature, (iv) senescent and (v) recovering, and classified a majority of the world's ocean fishery systems as 'senescent' based on declining rates of growth in landings (see Figure 35 below). Essentially, a drop in the growth rate of landings presages a drop in the actual fish landed, in a trend towards what Garcia (2009) classifies as 'senescence'.

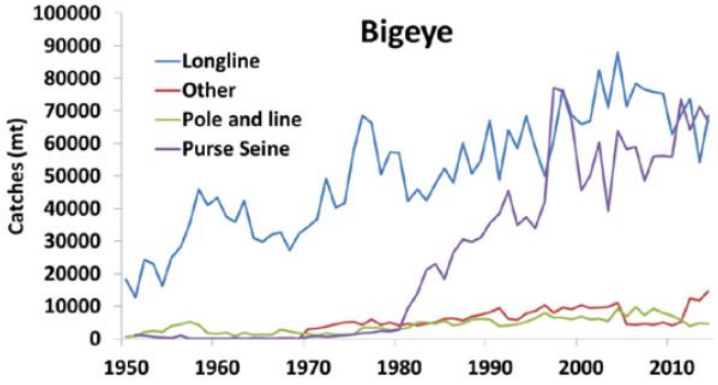
Figure 35. Classification of stages of development of ocean fishery systems based on analysis of landings



Source: Garcia (2009)

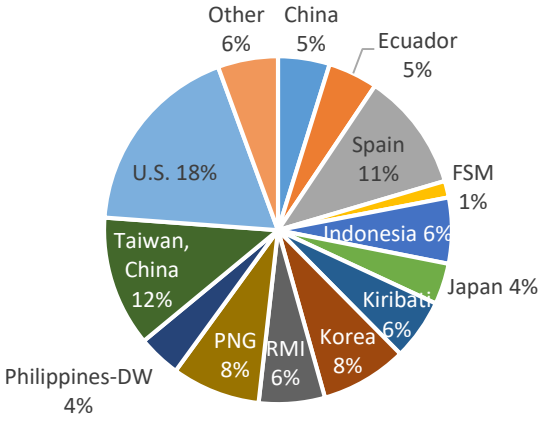
In both the tropical longline fishery and the purse seine fishery, the declining stock of bigeye has become a key trend in the resources. The longline gear explicitly targets the large and valuable bigeye for the sashimi market, but smaller, juvenile bigeye are caught incidentally in purse seine nets that are set on fish aggregating devices (FADs), as they associate with skipjack schooling under floating objects (Gillett, 2014). In 2014, 41 percent of bigeye catch in the WCPO was taken as incidental 'by-catch' by purse seine vessels, while the remainder taken by longline vessels was the lowest in the last 10 years (WCPFC, 2014). Bigeye mortality has been the highest in the tropical areas, also where purse seining is the highest (WCPFC, 2014).

Figure 36. Trends in WCPO Bigeye Catch by Fishing Gear



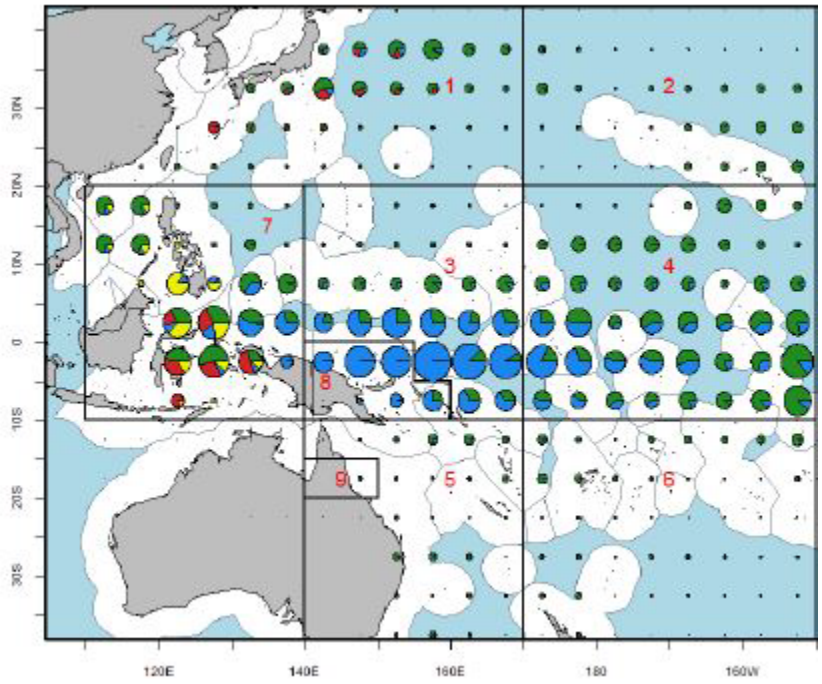
Source: ISSF (2015)

Figure 37. Distribution of 2013 WCPO Bigeye Purse Seine Catch by Fleet



Source: WCPFC Data Catalogue

Figure 38. Distribution of WCPO Bigeye Catch by Location and Fishing Method (2003 – 2012)



Source:https://www.wcpfc.int/system/files/SC10-SA-WP-01%20%5BBET%20Assessment%5D_rev1_25July.pdf

In summary, some key trends in WCPO tuna resources are as follows:

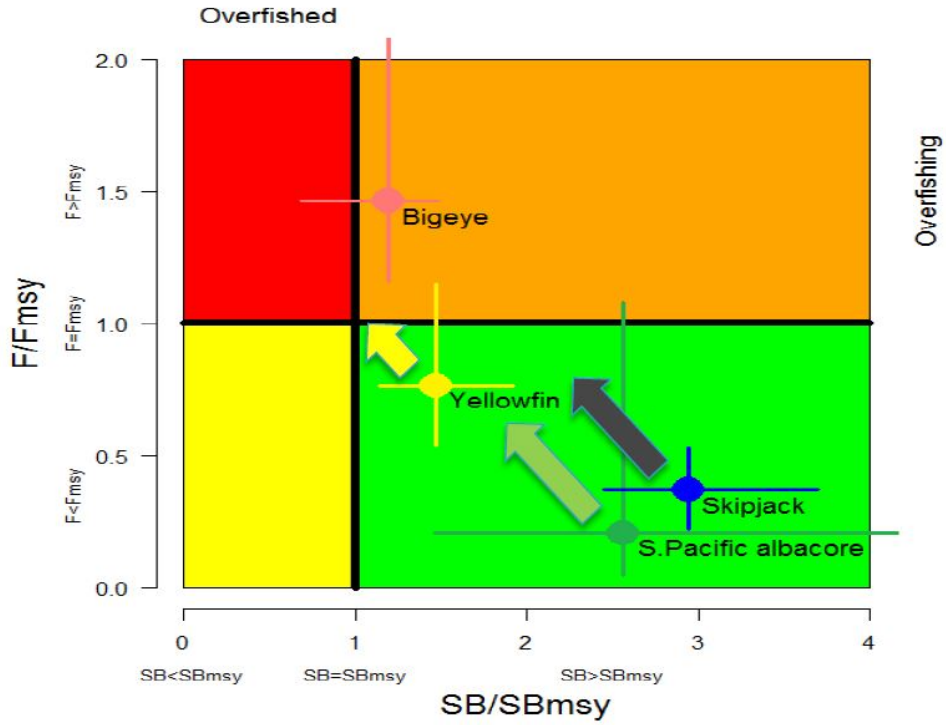
- *The exponential growth of purse seine fishing*: The purse seine fleet has grown in number of vessels steadily and exponentially since 1980, even as the composition has changed, with some individual fleets staying constant while others have grown drastically in recent years (e.g. PIC fleets). During this time the efficiency and catching capacity of the average vessel has grown steadily – notably the increased technology of FADs. The introduction of the VDS and subsequent fixed caps on fishing days have slowed this growth somewhat in PNA waters, together with enclosure of the high

seas activity. Purse seine effort outside of the PNA waters appears to have grown unabated, all resulting in a record high purse seine catch in 2014.

- *Stagnation in the longline fisheries:* After an increase in fishing effort in 2008, the southern albacore longline fishery saw a low point in catch rates in 2011 and has only marginally improved since. In the tropical longline fishery, catch rates for bigeye peaked in 2008 and have generally declined since, while yellowfin catch rates consistently declined from 2010 to 2013, even as new vessels reportedly enter the fishery. Even with declining catch rates, the 2014 catch of yellowfin was a record high, while bigeye catches have been stagnant or declining.
- *Bigeye stock overfished and declining*: the biomass of the bigeye stock has shown a steady decline since the 1970s, reaching overfished status in the last five years. At the same time, the growth of purse seining has taken a larger share of the bigeye catch, representing 41% of the WCPO bigeye catch in 2014.
- *Albacore, skipjack and yellowfin stocks relatively healthy but at the limit*: these stocks are not currently considered overfished, but they are approaching limits and cannot continue to support the growth in fishing effort and catch seen in the past, according to current scientific assessments.

In summary, although more recent assessments have been conducted, Figure 39 provides a useful illustration of trends in the status of the resource base, indicating clearly that future directions are unlikely to continue past trends:

Figure 39. 2012 WCPO Tuna Stock Assessments Showing Trends in Status



Source: Hurry (2014), at: http://devpolicy.org/presentations/2014-Pacific-Update/Day-2/Glenn-Hurry.pdf accessed on December 4, 2015.

Similarly, the International Seafood Sustainability Foundation's global tuna scorecard provides another means to visualize the status of the stocks (with the exception of albacore given less recent assessments), as shown in Figure 40:

Figure 40. WCPO Tuna Stock Status Scorecard from ISSF

	Bigeye	Skipjack	Yellowfin
Stock Abundance*			
Fishing Mortality**			

** Green: Spawing biomass (SB) is greater than levels needed to support the maximum sustainable yield (MSY); yellow: SB is less than levels needed to support MSY, but stable or increasing; orange: SB is less than levels needed to support MSY, and has not been stable or increasing.*
*** Green: Fishing mortality (F) is lower than levels that would support the MSY; yellow: F is greater than levels needed to support MSY, but adequate measures are in place and expected to end overfishing; orange: F is greater than levels needed to support MSY, and no adequate measure are in place, or those in place are insufficient.*
Source: ISSF (2015)

Trends in the economic benefits to PICs from the WCPO tuna resources. The harvesting component of the WCPO tuna fisheries value chains has provided benefits to Pacific Island countries over the years largely in the form of: (i) access fees from foreign vessels, (ii) ownership of harvesting enterprises and (iii) employment on vessels. In terms of access fees, the return to PICs had been relatively stable over the years, until the recent introduction of the VDS for the purse seine fishery. Total access fees to PICs from the tuna fisheries was US$66 million in 1996 (IFC, 2000), and according to Figure 12 somewhat lower in 2000, and staying at these levels essentially until 2009 when the VDS was introduced. Since that time the access fees to PICs have increased exponentially, to an all-time high of an estimated US$400 million in 2015 (see Figure 12). In terms of ownership of harvesting enterprises, Gillett (2014) notes that previous Government investments in fishing companies throughout the region showed little success, and their decline has been one of the constant trends in the region. At the same time, the growth in Pacific Island fishing fleets has been one of the central trends in recent years, many of which are joint ventures. In terms of employment on vessels, the number of Pacific Islanders working as crew on regional or foreign fleets has grown in recent years, to some 6,000 persons in 2013 (see Figure 22), up from just under 3,000 in 2002 (Bell et al., 2011).

The processing component of the WCPO tuna fisheries value chains has provided mixed results for the region. Most of the Government-led processing enterprises created in the 1980s or 1990s are no longer operating, but a number of private-led companies are currently working in PNG, the Solomon Islands, Fiji and to a lesser extent RMI. Much of this industry has developed as a result of the countries using access to the tuna resources to leverage companies to base locally (Gillett, 2014). Given the canneries and loining factories operating in these countries, processing employment has fluctuated over the years in the region but stayed relatively flat, at an estimated 10,000 jobs in 2000 (IFC, 2000), 5,555 in 2002 and up to 11,000 in 2006 due to increase in PNG (Bell et al., 2011), and roughly 11,000 in 2013 (FFA, 2014). Although data is difficult to obtain on full processing volumes, it is likely that less than 10 percent of the tuna caught in the WCPO is processed in PICs. As mentioned previously, in total the WCPO tuna fisheries value chains likely employ less than 0.5 percent of the region's current labor force (World Bank[19]), though in some cases it constitutes a much higher percentage of formal employment for women.

[19] http://data.worldbank.org/indicator

Summary of Key Trends in WCPO Tuna Fisheries over Recent Decades

In describing the baseline situation of the WCPO tuna fisheries, collectively one of the world's largest and most valuable fisheries, the following key trends can be extracted:

The purse seine fishing 'revolution'

- *Explosion in purse seine vessels and catch*. Purse seine fishing to produce canned tuna has grown exponentially in the WCPO since 1980, with 34 vessels catching roughly 100,000 metric tons of tuna that year, increasing to a steady state of some 180 to 220 vessels operating from 1990 to 2006, to 344 vessels catching over 2 million tons in 2014. Fifty-two new purse seine vessels have been built since 2010 and registered to fish in the WCPO. Purse seine harvesting technology has increased as well, notably for FADs.
- *Changing composition of the fleet*. The purse seine fleet has always been a largely foreign fleet, but the composition is changing, and the number of vessels based in PICs is growing – notably in PNG:
    - *Relatively constant*: Since 1997 catches by fleets from China, Taiwan as well as Japan and Korea have been relatively constant, and catches by the U.S. fleet have been on a relatively flat trend since 2009;
    - *Increasing on the edges*: combined catches by the fleets from Indonesia and the Philippines more than doubled between 1997 and 2014;
    - *A new fleet*: catches by the Chinese fleet increased from 0 in 1997 to 59,407 metric tons in 2014; and
    - *Pacific Island fleet growth*: catches by the PIC fleets increased by a multiple of over 6 between 1997 and 2014, with the fleet flagged in PNG accounting for over half of all vessels - in many cases foreign-owned but securing access in exchange for landing catch locally.
- *A more efficient fleet*. The purse seine fleet in the WCPO has grown more efficient over time, increasing catches per day of fishing at a rate of 3 percent per year between 2005 and 2011.

Stagnation and possibly senescence in the long-line fisheries

- *Declining productivity and profitability in the southern albacore long-line fishery, even as fishing has increased*. Fishing increased sharply in 2008 with the rise of the PIC albacore fleet, which caught as much as 50 to 60 percent of albacore in 2014, and more recently the rise of the Chinese fleet. Catch rates have decreased steadily since 2009, hitting a low in 2011 for the period since 2002, with only marginal improvements since, even as new (and reportedly subsidized) vessels enter the fishery. While the stock is not considered overfished, a decline in the size of the stock is cited by SPC as a key driver in the declining economic conditions.
- *Flat trend in catches from the tropical long-line fishery supplying sashimi markets.* Over the period from 2003 – 2013, the catch rates for bigeye peaked in 2008 and have generally declined since (i.e. kg caught per hundred hooks on a long-line), while yellowfin catch rates consistently declined from 2010 to 2013.
- *Overall, little benefits for PICs.* PICs capture an estimated 3 percent of the delivered value of the long-line fisheries.

Establishment of a regional management body for the tuna fisheries

- *Western and Central Pacific Fisheries Commission met for the first time in 2004*. Established as the body recognized under international law to promote the conservation and management of WCPO tuna stocks, and includes both PICs and foreign fishing nations, generally taking decisions based on consensus.
- *PICs have expressed frustrations with the pace of decision-making*. Given the diversity of actors in the Commission, consensus has been elusive in many cases, and some PIC representatives have expressed frustration when decisions have not been taken (Gillett, 2014). PIC representatives have cited the pace of decision-making at the Commission as a rationale for pursuing sub-regional agreements and governance arrangements, such as the Palau Arrangement and the Tokelau Arrangement (Campling et al, 2015).

A new model of cooperation by a sub-regional grouping of Pacific Island countries to manage purse seine fishing access

- *The Parties to the Nauru Agreement and the purse seine vessel day scheme*. The establishment of a cooperative scheme by 9 PICs to limit purse seine fishing access to their waters and allow transferability and greater flexibility in access terms, has significantly enhanced their ability to charge and capture resource rents in the form of access fees.
- *Access fees have increased by at least a multiple of four since 2009*. An estimated 13 percent of the delivered value of the purse seine catch was captured in rent via access fees in 2014.
- *The countries have held the limit on purse seine access, but throughout the WCPO catch and effort continue to grow*. Fishing effort and catch appear to have grown much more in the waters outside of the PNA countries, notably in the waters of Indonesia and the Philippines as well as some high seas pockets in 2014, though catch did increase in PNA waters as well between 2013 and 2014.
- *Following the model of the purse seine vessel day scheme, similar arrangements have been introduced for the long-line fisheries*. In 2015 the PNA countries have begun a vessel day scheme for the tropical long-line fishery, and in late 2014 ten countries signed the Tokelau Arrangement to implement a similar scheme for access to the southern albacore long-line fishery in their waters. Given the order-of-magnitude higher number of long-line vessels than purse seine vessels, monitoring such arrangements and including observers on vessels will be an operational challenge.

Failures of state-led efforts to capture more of the value chains in the Pacific Islands

- *State fishing and processing companies have generally not succeeded*. Most of the Government-led processing enterprises created in the 1980s or 1990s are no longer operating, but a number of private-led companies are currently working in PNG, the Solomon Islands, Fiji and to a lesser extent RMI. In total the WCPO tuna fisheries value chains likely employ less than 0.5 percent of the region's current labor force.
- *Pre-eminence of trading companies in the canned tuna supply chain*. As of 2010, three main trading companies purchased over half of the WCPO purse seine catch for processors (as well as additional catch from other areas) and provided some 90 percent of the supply to Bangkok: Trimarine, Itochu and FCF Fishery Co. Ltd. Given this level of control over the supply to Bangkok, these three traders are in a position to exert significant influence over the purse seine value chain.
- *Continued dominance of Bangkok canning cluster, despite a lack of trade preferences*. Less than 10 percent of the WCPO purse seine catch is processed locally, and Bangkok remains the world's largest tuna canner (despite higher labor costs and PNG and Solomon Island trade preference for the EU market).

Relatively steady global market for tuna products

- *Canned tuna relatively flat*. The three main markets for canned tuna, the EU, US and Japan, are considered as 'mature' with relatively flat growth trends. The price of skipjack in Bangkok has declined significantly in recent years, attributed to the growth (or 'glut') in supply – largely from increasing catch volumes in the WCPO, especially outside PIC waters.
- *Japan pioneered the sashimi market, which has become global*. In 2010 Japan consumed some 80 percent of sashimi in the world, but the global market has grown, with the remainder destined for the U.S., Korea, China, the European Union and Taiwan, China.

Decline of the bigeye stock, while fishing on other stocks approaches limits recommended by scientists

- *Bigeye stock overfished and declining*. The biomass of the bigeye stock has shown a steady decline since the 1970s, reaching overfished status in the last five years. At the same time, the growth of purse seining and particularly FAD technology has taken a larger share of the bigeye catch, representing 41 percent of the WCPO bigeye catch in 2014.
- *Albacore, Skipjack and Yellowfin stocks relatively healthy but at the limit*. These stocks are not currently considered overfished, but they are approaching limits and cannot continue to support the growth in fishing effort and catch seen in the past, according to current scientific assessments. Scientists have recommended a reduction in the long-line catches of southern albacore.
- *Overall, the WCPO tuna fisheries is 'tilting towards the need to reduce catch and rebuild stocks'* according to scientists (Campling et al, 2015).

IV. Key Drivers of Future Change in the Western & Central Pacific Tuna Fisheries

4.1 Evolution of Key Non-Policy or External Drivers of WCPO Tuna Fisheries' Economic Contribution to Pacific Island Countries

Direct Driver #1: Climate Change

This section is based on the work of Bell et al. (2011), who used global climate models to simulate projected changes to the atmospheric climate in the region and the main features of the tropical Pacific Ocean, under two scenarios of future greenhouse gas emissions: (i) low emissions (B1) leading to atmospheric concentrations of 500 – 600 ppm of carbon dioxide in 2100; and (ii) high emissions (A2) leading to atmospheric concentrations of 750 - 800 ppm of carbon dioxide in 2100. On this basis, the authors modelled the impacts on the abundance and distribution of the WCPO skipjack and bigeye stocks (noting that the biology and ecology of yellowfin can be considered to lie somewhere between the two) (Bell et al., 2011). The models gave very similar results for 2035 under both scenarios, but diverged significantly for the results by 2100 (Bell et al., 2011). The oceanographic features that influence the distribution and abundance of tuna stocks in the WCPO (see Box 5) are expected to change in the future, notably with an increase in 'El-Nino-like' conditions, which will likely affect where tuna spawn, the survival and growth of juveniles, and where adults feed (Bell et al., 2011).

Box 4. The impact of oceanographic conditions on abundance and distribution of WCPO tuna stocks

The features of the tropical Pacific Ocean that influence distribution and abundance of tuna stocks are the currents, water temperature, dissolved oxygen and nutrient supply. The El Nino-Southern Oscillation (ENSO) refers to an oscillation between a warm (El Nino) and a cold (La Nina) state every 2 – 7 years in the tropical Pacific Ocean. The ENSO has a very strong influence on distribution and abundance of tuna in the equatorial waters, resulting in large-scale, east-west displacements of skipjack correlated with ENSO events, as the fish prefer warmer waters that extend farther to the east during El Nino episodes (resulting in higher purse seine catches in the central Pacific, e.g. Kiribati near the Line Islands). Several months after the completion of an El Nino episode, the productivity shifts and the habitat contracts, and higher skipjack catch rates may occur in PNG and the Solomon Islands, particularly if a La Nina episode follows an El Nino. Additionally, long-line catch rates of yellowfin and bigeye seem to increase in regions of increased sea surface temperatures.
Source: Bell et al. (2011)

Changes to the distribution and abundance of tuna. The preliminary modeling conducted by Bell et al. (2011) suggests an overall eastward re-distribution of the WCPO skipjack and bigeye stocks over time, however much uncertainty remains (notably the possible impacts of ocean acidification on juvenile and adult tuna are not well understood). Skipjack in the WCPO is projected to have almost no change in abundance by 2035, but by 2100 the stock's biomass is expected to have decreased 32 percent compared to 2000 under the high emissions scenario (A2) if average fishing effort from 1980 to 2000 were to continue, and increase by 50 percent in the Eastern Pacific Ocean outside of WCPO (Bell et al., 2011). At the same time, projected changes in skipjack catch relative to the 20-year average for 1980 to 2000, suggest a likely increase across the WCPO by 2035, with greater increases expected in the eastern than in western Pacific, notably in Kiribati, Tokelau, Nauru and Tuvalu (see Table 9 below). By 2100 under the low emissions (B1) scenario, catches for the western Pacific are projected to decrease and return to average levels for 1980 to 2000, although catches in Solomon Islands and PNG are projected to decrease by 5 and 10 percent respectively. In contrast, catches in the eastern Pacific are projected to increase on average by over 40 percent. Under the high emissions (A2) scenario, in 2100 catches of skipjack for the western Pacific are estimated to decline further, by an average of over 20 percent and by as much as 30 percent for PNG. Under this scenario catches in the eastern Pacific are expected to remain greater than the baseline, but decrease relative to B1 scenario. Across the WCPO, catch is projected to decrease by 7.5% by 2100 under the A2 scenario. A subsequent study projects a slight increase in WCPO skipjack catch and biomass under simple

fishing effort scenarios until 2050, and then biomass stabilizes and starts to decrease after 2060, with feeding and spawning habitat becoming progressively more favorable in the eastern Pacific Ocean and extending to higher latitudes (Lehodey et al., 2012).

For adult bigeye, there is no obvious difference in abundance and distribution projected by 2035, however small decreases in catch (less than 5%) are projected to occur in 17 of 22 PICs and territories by 2035. The magnitude of the reduced catches is projected to increase to 5 – 10 percent in most PICs and territories under the low emissions (B1) scenario by 2100, and 10 – 30 percent for many PICs and territories under the high emissions (A2) scenario. Impacts on yellowfin should be similar to those described for skipjack and bigeye. Initial modeling suggests a potential positive impact for abundance of albacore, although some poleward displacement of distribution of stocks is possible.

Additionally, a recent study has modelled the impacts of the high emissions (A2) scenario on the south Pacific albacore stock, and projected that under a scenario of average fishing effort based on recent years, by 2035 the population would decrease by roughly a third from 2006 levels, with the trend reversing after 2080 when a new spawning ground emerged in the north Tasman Sea (Lehodey et al., 2015). Of note, a test simulation highlighted the sensitivity of the model results to projected dissolved oxygen concentration for which there is large uncertainty in the tropical region, and a second test simulation showed factors where the spawning ground does not emerge and hence the trend does not reverse after 2080 (Lehodey et al., 2015).

In summary, there is the eventual possibility of reduced overall abundance of skipjack, yellowfin and bigeye in the WCPO by 2100, but less likely by 2035 – while south Pacific albacore abundance may be reduced by this time period. Distribution of skipjack and bigeye (and by extension yellowfin) are likely to shift progressively towards the central and eastern Pacific during the 21st century. Within this larger trend, sub-regional concentrations may be maintained or increased, for example increased rainfall and nutrient flow into the Bismarck Sea may retain concentrations of tuna in the Indonesia-PNG archipelagos. On balance, projected changes in skipjack catch from preliminary modeling indicate that there could be more advantages than disadvantages for the region, notably with potential increased access fees captured by Kiribati, Nauru, Tokelau and Tuvalu.

*Table 10. Projected % changes in catches of skipjack and bigeye tuna, relative to the 20-year average for 1980 to 2000, under low (B1) and high (A2) greenhouse gas emissions scenarios in 2035 and 2100**

Pacific Island Country or Territory	% Change in Skipjack Catches			% Change in Bigeye Catches		
	2035	2100 (B1)	2100 (A2)	2035	2100 (B1)	2100 (A2)
Melanesia						
Fiji	+26	+24	+33	+1	+1	-1
New Caledonia	+22	+19	+40	+1	+1	+6
PNG	+3	-11	-30	-4	-13	-28
Solomon Islands	+3	-5	-15	0	-3	-7
Vanuatu	+18	+15	+26	-3	-6	-10
Micronesia						
FSM	+14	+5	-16	-11	-11	-32
Guam	+16	+10	-8	-13	-13	-33
Kiribati	+37	+43	+24	-5	-5	-17
RMI	+24	+24	+10	-10	-10	-27
Nauru	+25	+20	-1	-7	-7	-19
CNMI	+23	+22	+13	-5	-5	-23
Palau	+10	+2	-27	-11	-11	-45
Polynesia						
American Samoa	+41	+48	+58	-5	-8	-18
Cook Islands	+40	+50	+47	-3	-8	-15
French Polynesia	+41	+49	+77	-2	-8	-12

Niue	N/A	N/A	N/A	-5	-8	-15
Pitcairn Islands	N/A	N/A	N/A	-2	-4	-4
Samoa	+44	+49	+55	+1	+1	-4
Tokelau	+61	+69	+63	-3	-6	-16
Tonga	+47	+50	+58	-4	-5	-10
Tuvalu	+37	+41	+25	+3	+2	-6
Wallis and Futuna	+44	+49	+46	0	0	-7
Regional						
Total	+19	+12	-7	+0.3	-9	-27
Western fishery	+11	-0.2	-21	-2	-12	-34
Eastern fishery	+37	+43	+27	+3	-4	-18

**Model results are the same in 2035 for both emissions scenarios, so only one change given for 2035; Model simulations for A2 in 2050 were used to approximate B1 in 2100 – though while CO2 emissions for these scenarios/times are similar, the multi-modal mean of sea surface temperature is 0.18 degrees C (plus/minus 0.23) higher under B1 2100 than A2 2050.; Source: Bell et al. (2011)*

Based solely on the projected changes in catch, and holding fishing effort, tuna prices, GDP, levels of taxation and the value-added component of the fisheries constant relative to 1999 – 2008 levels, changes in contribution to GDP and to public revenues were estimated, as shown in Table 10 below.

Table 11. Estimated Changes by 2035 in Percentage Contributions of Tuna Fisheries to GDP and Public Revenues relative to 1999 – 2008, based on projected changes in skipjack catch due to climate change

Pacific Island Countries	Change to GDP by 2035 (%)		Change in Public Revenues by 2035 (%)	
	Lower Limit of Projections	Upper Limit of Projections	Lower Limit of Projections	Upper Limit of Projections
FSM	0	+1	+1	+2
Kiribati	N/A	N/A	+11	+18
PNG	0	+0.1	0	0
RMI	+2	+6	0	+
Solomon Islands	+0.1	+0.2	0	+0.2
Tokelau	N/A	N/A	+1	+9
Tuvalu	N/A	N/A	+4	+9

Source: Bell et al (2011)

The above estimates are preliminary and indicative only, to provide an indication of the direction and magnitude of possible economic impacts from changes in the distribution of skipjack by 2035.

Increased operating costs for WCPO tuna fishing. Bell et al (2011) note that cyclones and storms are projected to possibly become progressively more intense, increasing the risk of damage to shore-based facilities, processing operations and domestic fleets. Fleets operating in cyclone-prone areas, and particularly longline vessels, may need to be upgraded to provide for improved safety at sea. Additionally, rising sea levels may eventually make many existing wharfs and shore-based facilities unstable, with the most significant economic damages relative to the size of the economy expected to occur in FSM, Palau, RMI and Nauru (IPCC, 2014). Taken together, increased costs associated with repairing and relocating shore-based facilities, and addressing increased risks to occupational health and safety for fishers, may affect the profitability of domestic tuna operations.

Key considerations for the future

The initial modelling led by SPC suggests the following key considerations for future impact of climate change on the economic benefits PICs derive from the WCPO tuna fisheries:

- For skipjack, abundance is not expected to change, but an overall shift in the distribution to the central and eastern Pacific is expected to change the catch rates in the waters of many PICs, providing positive benefits for all PICs, with the largest increase in benefits expected in Kiribati, Nauru, Tokelau and Tuvalu.
- For bigeye, a projected eastward re-distribution of the stock is expected to have significant consequences for the status, given that purse seine by-catch rates of the species are much higher in the central and eastern Pacific than in the western Pacific, potentially due to shallower depths of the mixed layer of surface waters rendering the fish more vulnerable to purse seining.
- The potential re-distribution of tuna stocks throughout the WCPO (and beyond) due to climate change reinforces the importance of flexible management systems that can cope with spatial shifts in fishing activity, e.g. to avoid the need for eastern countries to continually purchase purse seine vessel days from countries in the west.
- Additionally, given the potential significant impacts of climate change on WCPO tuna stocks but the high levels of uncertainty in predicting these impacts, the importance of maintaining healthy and resilient tuna stock sizes becomes magnified.

Source: Bell et al (2011)

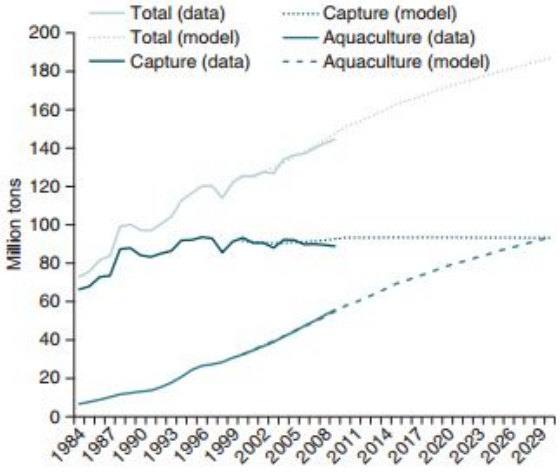
Direct Driver #2: Markets and the Economy

This section focuses on: (i) *the role of global markets*, and specifically the potential changes in global prices for tuna products and raw materials, reflecting changes in both supply and demand (including possible shifts in consumer preferences); and (ii) *the role of the global economy*, and specifically the potential changes in fixed and operating costs along WCPO tuna fishery value chains, notably changes in the cost of fuel and hence of harvesting operations, as well as processing and distribution costs.

Markets. As mentioned previously, the markets and value chains for the canned tuna and fresh tuna (e.g. sashimi) produced from purse seining and long-lining in the WCPO are global, with the largest proportion consumed in Europe, Japan and the United States. As such, the price of tuna along the value chains is considered a (partially) exogenous driver in the WCPO fisheries and the benefits that PICs capture from them. Price is a key variable in determining the overall economic value of the WCPO tuna fisheries, and the revenues captured at each segment of the supply chains (see Figure 4). This section considers past trends, and information available on the possible future directions, of global prices for tuna, as a function of supply and demand, drawing heavily from the work of Hamilton et al. (2011).

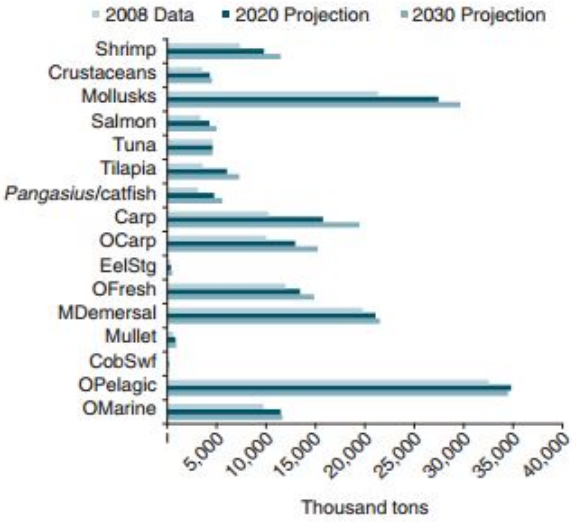
Firstly, before focusing specifically on the markets and prices for specific tuna products, the projected global demand for animal protein and more specifically fish products is a useful reference point. Broadly speaking, with the global population projected to reach 9.6 billion by 2050, seafood consumption is expected to rise, notably as an 'animal protein gap' opens up between demand and available supply (Waite et al., 2014). More specifically, in 2013 the World Bank, FAO and IFPRI modeled global fish supply and demand to 2030, and projected an increase in supply from 154 million tons in 2011 to 186 million tons in 2030, with almost all of the growth coming from aquaculture (see Figure 41 below) (World Bank, 2013). Per capita fish consumption was projected to decline in Japan, Latin America, Europe, Central Asia and Sub-Saharan Africa, even as total consumption increases in some regions with population growth (World Bank, 2013). The study notes that China is expected to increasingly influence global fish markets, accounting for 38 percent of food fish consumption by 2030 (World Bank 2013). Even a relatively small percentage shift in consumption of tuna in China or similarly India, could have a significant impact on the volume demanded and price.

Figure 41. Global Fish Production: Data and Projections 1984 – 2030



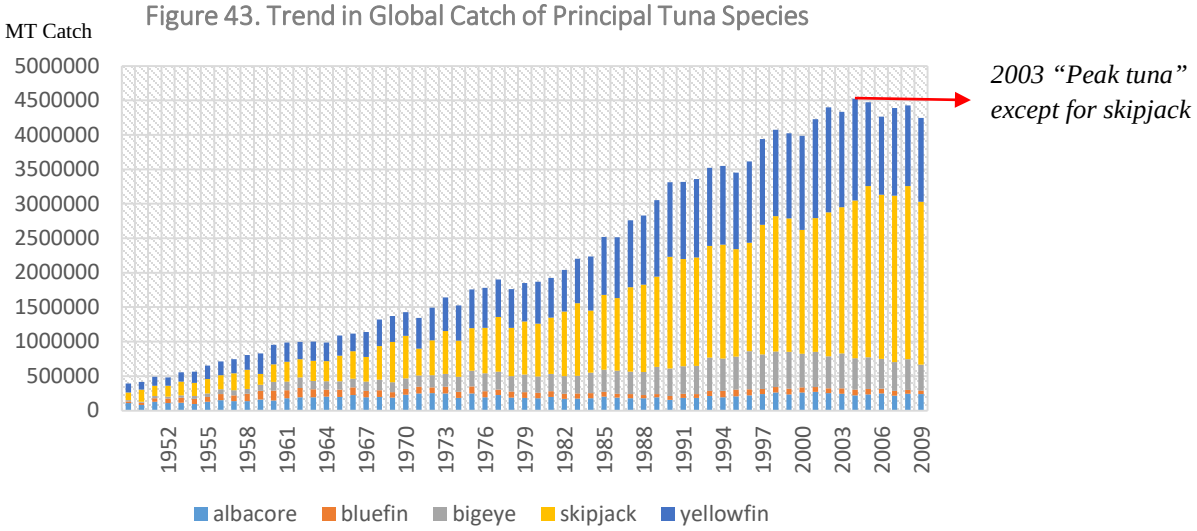
Source: World Bank (2013)

Figure 42. Projected Global Fish Supply by Species to 2030



Source: World Bank (2013)

Figure 43. Trend in Global Catch of Principal Tuna Species



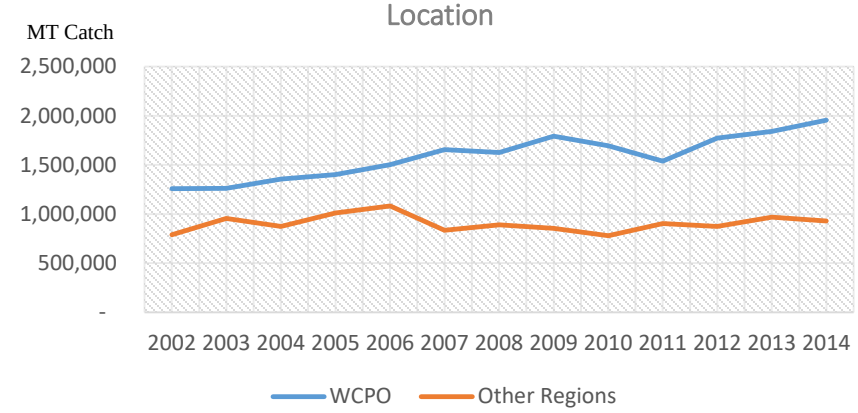
Source: FAO Fishery Statistical Collection http://www.fao.org/figis/servlet/TabSelector#lastnodeclicked

With global population growth and general (albeit modest) increase in per capital consumption, overall volume demanded will continue to increase, even while supply remains flat. The projected global supply of tuna in 2030 (see Figure 42) reflects the recent trends in catch shown in Figure 43 above, where catches of all principal tuna species peaked in 2003 or before, except for skipjack (FAO, 2015). At the same time, aquaculture production of tuna as a potential shift in supply is projected to be negligible in 2030 (World Bank, 2013). Hence, even though global tuna prices have been fairly stable in nominal terms and decreasing in real terms since the early 1990s (Miyake et al., 2010), the World Bank (2013) projected a modest increase in the real price of tuna – 10 percent above 2010 levels – by 2030.

Food safety and price are expected to remain the priority of consumers, but growing consumer preferences for sustainability (based on eco-labels) and traceability are expected to potentially reward first movers by establishment of brand recognition, while over time constituting barriers to entry rather than price premiums (Conservation International, 2015). Eco-labels are likely to be a requirement of many markets for tuna products in the future, with little difference on price in the long run (Conservation International, 2015).

The Canned Tuna Market. The supply of skipjack as raw material for production of canned tuna as a global commodity is increasingly dependent upon the WCPO, as catch levels in other regions have remained relatively flat over the last decade (see Figure 44 below).

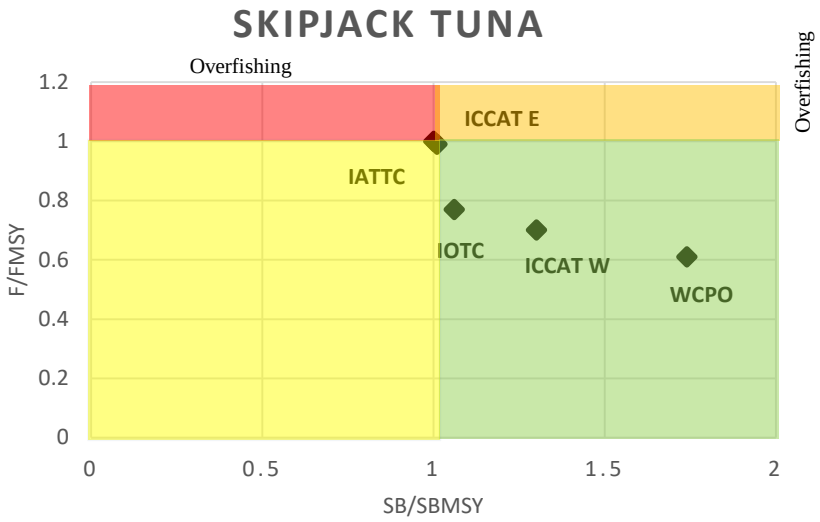
Figure 44. Trends in Global Skipjack Tuna Catch, by Location



Sources: FFA, 2015; IATTC, 2015; IOTC, 2015; ICCAT, 2015

This reflects to some extent the size and status of the resource base in other regions, which in some cases is reaching maximum sustainable limits, as shown by Figure 45 below.

Figure 45. Biological Status of Global Skipjack Tuna Stocks



Note: *ICCAT = International Commission for the Conservation of Atlantic Tunas (East Atlantic & West Atlantic stocks)*
IATTC = Inter-American Tropical Tuna Commission
IOTC = Indian Ocean Tuna Commission
Sources: ISSF (2015), ICCAT (2015), IOTC (2015), Rice et al (2014b)[20]

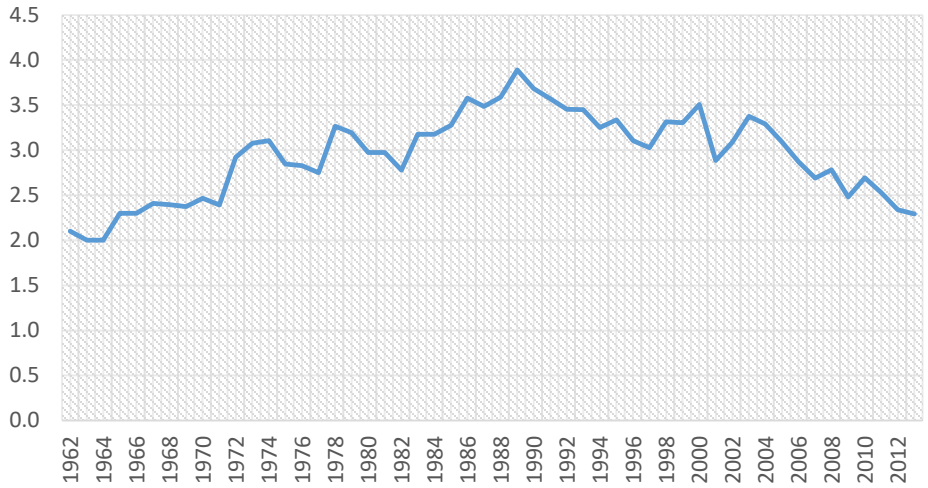
Given the size and status of skipjack resources around the world, the total supply would not be expected to increase significantly by 2040, with the possible exception of modest increases from the WCPO in the short term resulting from continued growth in fishing effort – though in order to maintain the region's stock at a level that can sustain maximum yields, scientists have recommended catch levels should grow no further. Similarly, the WCPO's position as the biggest supplier of skipjack for canned tuna would not be expected to decline, if current trends continue.

Global demand for canned tuna has increased in the last few decades, as a relatively cheap but price-sensitive source of protein. The largest markets for canned tuna in the first half of 2015 were the United States, Western Europe (particularly Spain, Italy, France, the United Kingdom) and Egypt (FAO Globefish, 2015). The traditional or 'mature' markets in the U.S. and Western Europe have been relatively flat in recent years, while emerging markets in the Middle East and North Africa grew in the first half of 2015 (FAO Globefish, 2015).

More specifically in terms of *the U.S. market*, the trend in consumption (one of the largest and longest-running canned tuna markets) can be seen in Figure 46 below:

[20] ISSF: http://iss-foundation.org/wp-content/uploads/downloads/2015/03/ISSF-2015-03-Status-of-the-Stocks-Feb-2015.pdf; ICCAT: https://www.iccat.int/Documents/SCRS/ExecSum/SKJ_EN.pdf; IOTC: http://www.iotc.org/documents;

Figure 46. Trend in US Canned Tuna Consumption*



** Per capital pounds of canned tuna available – as a proxy for national consumption*
Source: USDA (2015)

As shown above, per capita consumption of canned tuna in the U.S. has fallen by over 40 percent since the peak in 1989 of 1.77 kg/capita, to 1.05 kg/capita in 2013 – the lowest level since 1966 (USDA, 2015). Given population growth, total volume of consumption has lagged behind per capita consumption, but followed the same trend, peaking in 2000 at 450,000 metric tons and declining since to 330,000 metric tons consumed in 2013 – the lowest level since 1982 (USDA, 2015). As such, U.S. industry representatives describe the canned tuna purchasing behavior of the consumers as being in 'precipitous decline': household penetration has declined from 68.1 percent in 2009 to 62.1 percent at the close of 2013 (Havice et al., 2014). This declining appetite for canned tuna in the U.S. is reported to reflect changing diets and perceptions of food, as the country has shifted away from canned foods such as packaged, pre-cooked tuna (Washington Post, 2014). Reasons cited for this shift include the health concern that surfaced in the 1970s, spread in the 1980s and has persisted since, that tuna contains unsafe levels of methylmercury, as well as concerns in the 1980s about dolphin by-catch that led to shifts in harvesting practices and the promotion of government-defined 'dolphin-safe' labels (Washington Post, 2014).

Over this time period imports have played a growing role in meeting demand: between 1979 and 1982 the U.S. imported an average of 27,700 mt of canned tuna annually, but by 2009 this figure had grown to 138,000 mt of canned tuna in brine and 31,000 mt of tuna in pouches (Havice et al., 2014). In the period 2008-2013, annual US imports of *all* tuna products averaged 283,963 mt and US$1.397 billion in value (NMFS 2014). Thailand is the clear leader in supplying the U.S. market in volume of canned and pouched product, supplying 52 percent of all imports (NMFS 2014). The U.S. also offers an important market for pre-cooked loins. Since a second plant that processes loins into cans opened, the volume of loin imports has grown. In 2007, the U.S. imported 43,800mt of pre-cooked loins (Globefish 2010). That number jumped to 69,792 mt in 2013 (NMFS 2013). Pacific Island Countries export on average less than 15,000 mt/year of loins to the US market between 2008 and 2013 (NMFS 2014).

While the dollar retail sales of tuna products increased between 2006 (US$1.4 billion) and 2013 (US$1.685 billion), tuna volume retail sales have remained relatively flat or in decline, indicating that the US market can be considered 'mature' (Havice et al, 2014). In 2009, 29.2 million cases of canned tuna were sold in the U.S. retail market,[21] while only 27.2 million cases were sold in 2013 (Melbourne 2014). The discrepancy between dollar and volume sales reflects the increasing price of canned tuna, and in turn of raw material

[21] Data excludes food service industry.

prices. Between 2001 and 2007, average canned retail prices in grocery outlets increased 21% to US$ 1.15 per can (Havice et al., 2014).[22]

Canned tuna remains a key retail category in the broader U.S. market. It is the second most popular seafood product. Shelf stable tuna sales represent 74 percent in value and 72 percent in volume of all shelf-stable seafood products (Havice et al., 2014). Tuna is heavily promoted to drive volume sales in supermarkets. In 2007, 46 percent of all tuna was sold on promotion (Hamilton et al., 2011).[23] Several market outlets compete for tuna purchases, driving steep competition in which traditional retailers have lost sale shares to superstores such as WalMart and various warehouse clubs. From 2001 to 2005, shelf stable tuna sales were down 4.6 percent in traditional grocery stores while super-center tuna sales were up 68.8 percent and warehouse clubs up 15.6 percent (Hamilton et al., 2011). Meanwhile, consumer interest in lower cost private label product is gradually deepening. In 2009, private label accounted for 20 percent of tuna dollar sales, compared with 14.5 percent in 2005 (Hamilton et al., 2011). Despite gains made by private label, the 'big three' brands still command upwards of 77 percent of volume sales in US retail markets (Bumble Bee, Chicken of the Sea and Starkist), which is largely differentiated into light meat and white meat (albacore) segments (Hamilton et al., 2011). In addition to tuna in cans, there is a small, but profitable market segment of tuna in pouches, most commonly a premium product. This market segment has remained stagnant in recent years.

The increasing market share of the largest retailers and growing private label sales illustrates the highly competitive and low price dynamic that dominates the U.S. market. Price pressure from supermarket buyers, along with competition between processors in Southeast Asia, Latin America and elsewhere explains a reported 68 percent decline in *real* prices for light meat product between 1980 and 2004 (Havice et al, 2014). This trend is significant to Pacific Island producers seeking to access the US market because it translates into lower profit margins for suppliers lower down the supply chain, such as firms canning or loining for brands and private labels (Havice et al., 2014). In addition to the low price dynamic, the US market volume is flat, leading industry observers to refer to the 'low margin' or 'lousy' U.S. market (Havice et al, 2014). Over the last five years, branded tuna labels have continued to launch category-wide and brand specific campaigns that emphasize the health and convenience of tuna products, though growth has not emerged (Havice et al., 2014). In some cases, price premiums may be available for niche products, though U.S. consumers' familiarity with low cost tuna products – particularly in cans – might limit this possibility.

The U.S. market is expressing some interest in 'sustainable' products, with several major retailers making commitments to purchase sustainably sourced seafood. However, given that the U.S. market for such products is only beginning to evolve, there is no estimate of its size and value available. Sustainability commitments can come in two forms, either commitments to sustainabilty labels (e.g. MSC eco-label), or internal procurement specifications (e.g. FAD-free or pole and line caught). The sustainability market segment is one that is likely to grow, though there are constraints for this market segment. First, it is not clear that such products will be sold at a price premium. Second, in shelf-stable sector, realizing such commitments is limited by lack of supply of product that meets sustainability specifications. Third, this market segment is relatively small and new, which, as noted, limits the publically available data on the overall size and value of the 'sustainability' market. Anecdotally, there is some evidence of the development of a growing sustainability segment of the shelf-stable tuna market. For example:

- Tri Marine has introduced it's 'Ocean Naturals' label, which labels product according to specific species, gear type (e.g. FAD-free) and markets it as 'responsibly caught'.[24]
- Bumble Bee, in association with WWF has launched its 'Wild Selections' range of MSC certified tuna.

[22] Note that this data reflects grocery outlets. Warehouse clubs and Walmart prices are likely lower.

[23] Excluding WalMart sales.

[24] See: http://www.oceannaturals.com

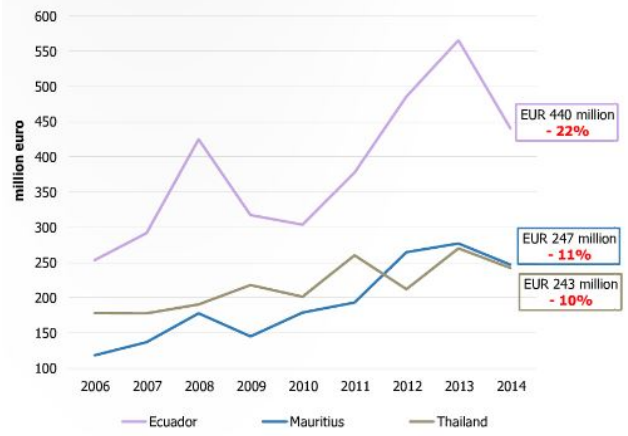
- Club store, Costco, is in the process of introducing a chunk light meat producer under its private label (Kirkland) which is free-school caught and species specific (i.e. 100% skipjack, rather than yellowfin, bigeye or albacore).

Though there is growth in this segment, it is critical that PICs keep the opportunities associated with niche products in perspective. As noted, in the short- to medium-term, it is unlikely that there will be a major shift in which major brands and retailers make broad commitments to sustainable products, not least because of the very limited volumes of eligible raw materials and the unwillingness to date of U.S. consumers to pay premiums for shelf stable products (Havice et al., 2014).

While the U.S. market is significant in terms of its massive volume, it is stagnant and characterized by deep price pressure and discounting. In all cases, while the size of the market makes is attractive to producers, those producers must anticipate the very small margins necessary for product to be competitive in this highly price sensitive market (Havice et al., 2014). It is not clear if and how the U.S. market will evolve to offer producers higher margins for niche products or otherwise (Havice et al., 2014).

Over the last decade *the Western European market* has not exhibited the downward trend in consumption seen in the U.S., but has remained relatively flat in both per capita consumption and volume imported (EUMOFA, 2015; Conservation International, 2015), though with modest growth in prices and value as shown in Figure 47 below. In 2014, the European Union imported some 560,000 tons of canned tuna, with the average price of canned tuna from Thailand at 3.53 EU per kilogram (EUMOFA, 2015).

Figure 47. Values of processed tuna imports to the EU by main countries of origin and % variation 2014/2013



Source: EUMOFA (2015)

In 2002, the majority source of supply for the EU volume market for canned tuna shifted from domestic production in favor of imports from non-EU countries. Behind this broad trend is significant losses in market volume for canned tuna production based in France and Italy, but not for the major Spanish processors which have successfully expanded their export markets in Italy and France (Hamilton et al., 2011). Major trends for imported canned tuna over the ten year period 2000-2009 include the following:

- Declining market volume between 2008 and 2009, contrary to predictions that it would continue to grow;
- Continued growth in Spain's exports to the EU import market, indicating that the current EU tariff regime on canned tuna successfully protects this country's processing industry, a trend that could in the future present new market opportunities as tariff protections continue to decline;
- Continued growth of share of EU imports by Thailand and the Philippines (the latter of whom recently gained market access under the GSP+ categorization); and
- Canneries in small island states in the Indian Ocean have had variable success in profiting from the EU market (Hamilton et al., 2011).

Per capita consumption of canned tuna is stabilizing in the principal EU15 markets and the EU is now broadly considered to be a mature market for canned tuna (Hamilton et al., 2011). Eastern Europe has the most probable growth potential, albeit from a very low baseline. Aside from emerging markets in Eastern Europe, another area of growth is in product innovation where so-called 'value added' products offer potential in terms of enhanced profitability, though the markets are likely to stay relatively small in the future.

In terms of *the Japanese market*, for over two decades (mid-1980s to mid-2000s), canned tuna consumption in Japan remained stable at around 100,000 mt/year (finished weight) (Hamilton et al., 2011). From 1995 to 2007, consumption had declined by almost 20% to 145,000 mt (around 1.6% per annum) (Hamilton et al., 2011). The share of domestically produced canned tuna has also declined due to high production costs, with increasing volumes of imports (mostly from Thailand and the Philippines) (Hamilton et al., 2011). At best, Japanese canned tuna consumption can be expected to remain stagnant, but is more likely to continue to decline over time. Domestic production of canned tuna will also continue to decrease, given increasing competition faced from cheaper imports, particularly from Thailand (rather than products processed in PICs).

While demand has been flat in the major markets in recent years, *emerging markets* are consuming more of this relatively cheap source of animal protein, not just in the Middle East and North Africa, but also in Brazil, Chile, Eastern Europe and Russia among others (FAO Globefish, 2015; Conservation International, 2015). Essentially, canned tuna is filling the same niche in emerging markets that it used to fill in developed countries years ago, as an easy product to work with that can be stored for years (Conservation International, 2015). With demand for canned tuna unlikely to increase significantly in the U.S. and Europe in the future, the focus of processors and exporters is expected to turn to these emerging markets (FAO Globefish, 2015).

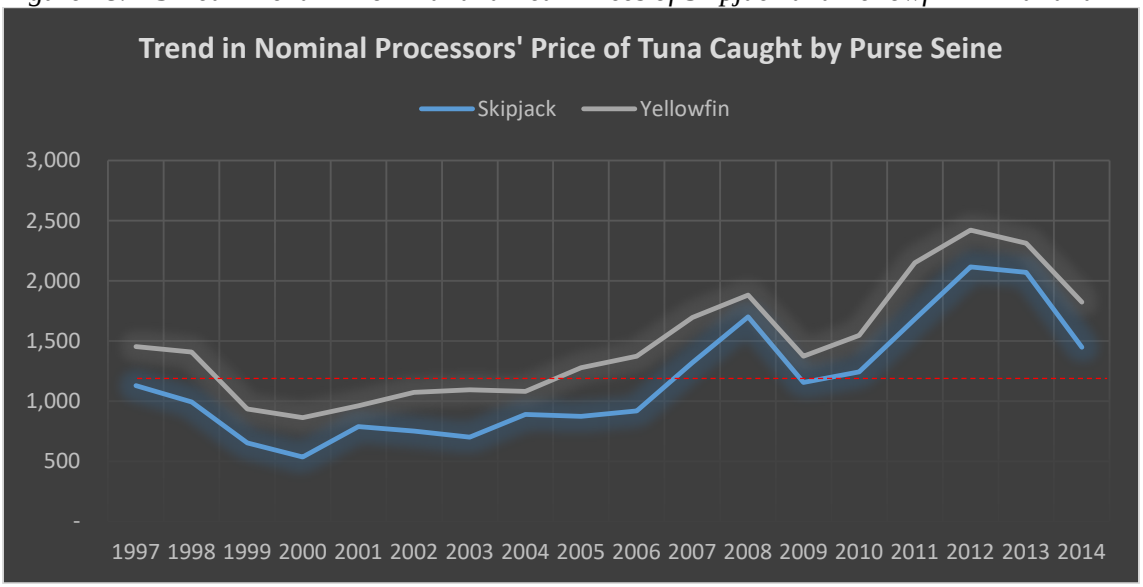
In terms of *the Chinese market*, the volume of consumption to date has not been perceived to be significant. Culturally, it is an unknown product and where it is known, it is not associated with either expensive tastes or mass consumerism. The latter point is reinforced by a high cost per unit of protein relative to other products. Industry sources believe that the main consumers of canned tuna in China at present are foreigners, including foreign students who are used to eating it in their own country. In spite of these attitudes, there are continuing and persistent efforts being made by both Thai and European canners to enter and expand the market for canned tuna in China. These are efforts aimed at the long-term, with the goal of tapping into changing tastes of a growing middle class. Early attempts to develop a market in China for canned tuna were made by Century Canning of the Philippines, who began exporting to China in 1994 with just one container load according to one source in the industry (Hamilton et al., 2011). In 2005, Thai Union Frozen Products (TUF) invested $US4 million for a 50 percent stake in Century Union (Shanghai) Foods Co. (Hamilton et al, 2011). The major impediment to increased consumption of canned tuna in China appears to be consumer acceptance. Unlike tuna sashimi, which is perceived as a prestigious food well-suited to situations where a degree of ostentation is desired, canned tuna is recognized as a utilitarian item. That said, as Asian economies continue to grow, demand for tuna in general, and canned tuna products, is expected to grow in China and also in India – where even marginal shifts in demand could have significant impacts on the volume consumed (Conservation International, 2015).

In conclusion, demand for canned tuna is declining the U.S., flat in Western Europe, growing in a number of emerging markets in the Middle East (e.g. Egypt, Kuwait, Saudi Arabia, and the United Arab Emirates, all of which do not have domestic canneries), North Africa and Latin America, and expected to grow in Asia in the coming decades, as well as potentially Eastern Europe and South Africa. Of note, many of these markets do not have domestic purse seine fleets, and may be expected to import products (Conservation International, 2015). Similarly, in Middle Eastern markets there are not significant tariff barriers, nor product traceability requirements.

With the potential direction of supply likely to remain flat, and demand expected to slowly/steadily grow albeit from shifting markets, the global price of skipjack for canning (taken as the Bangkok price where the majority of the world's canned tuna is produced) could also be expected to increase steadily to 2040. However, canned tuna has extremely elastic pricing, where small increases drive disproportionately fewer sales (Conservation International, 2015). Such price elasticity can make producers sensitive to increases in supply and exert downward pressure on prices offered to harvesters/fleets operating in the WCPO and providing access fees and value added to PICs. Canneries do maintain inventory and hence can build up supply and reduce price accordingly. This certainly appears to have been the case in the last two years, where the price has dropped significantly since 2013 in response to continued growth in catches in the WCPO and hit a 6-year low in 2014 (FAO Globefish, 2015). In response, the World Tuna Purse Seine Organization[25] decided to reduce fishing effort by 35 percent from May 15 to December 31 in 2015, which did trigger a response from producers and a rebound in price (FAO Globefish, 2015).

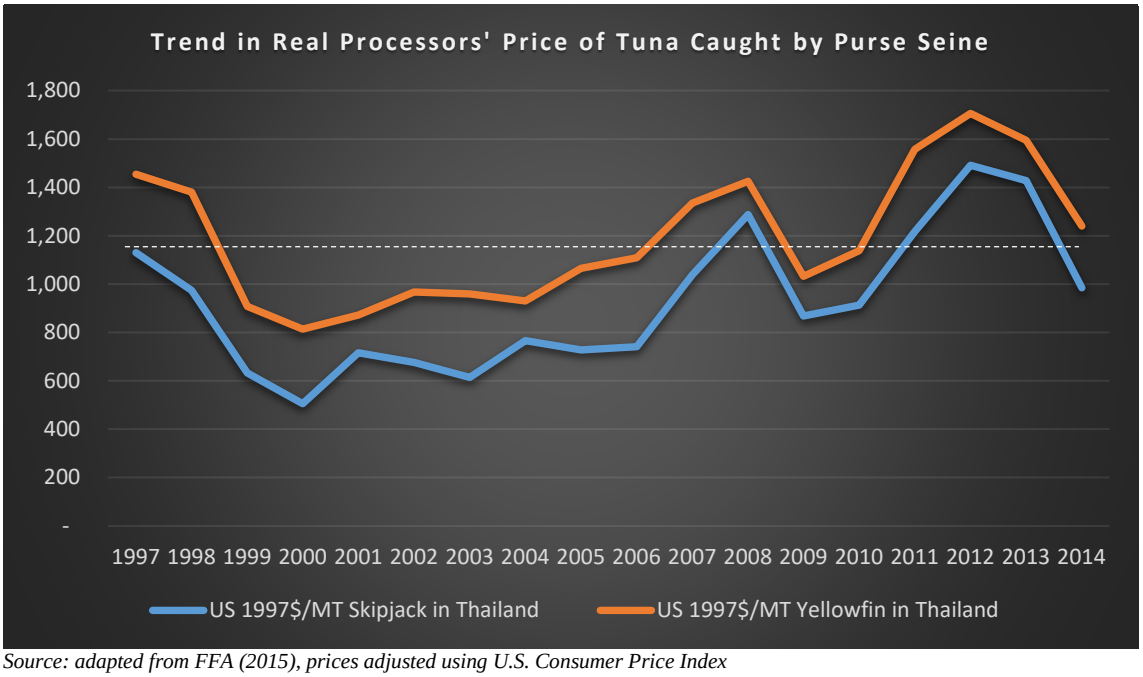
Figure 48 below indicates the trend in nominal and real prices for skipjack in Bangkok over the last 15 years, and particularly the recent drop beginning in 2013:

Figure 48. 15-Year Trend in Nominal and Real Prices of Skipjack and Yellowfin in Thailand



Source: FFA (2015)

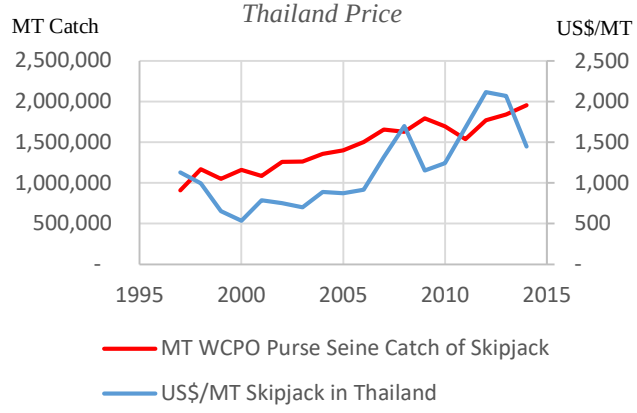
[25] In response to a drop in prices at the time, purse-seine owners organized in a World Tuna Purse Seine Organization (WTPO) in March 2001, essentially functioning as a cartel of producers and adopting on a voluntary basis, self-limits on catches (Miyake et al, 2010).



Source: adapted from FFA (2015), prices adjusted using U.S. Consumer Price Index

As nominal and real prices of skipjack in Thailand hit a six-year low in 2014 (the key marketplace where global prices are formed (Miyake et al., 2010), catches and raw material produced from the WCPO hit a new record, as shown in Figure 49 below. Typically the price of skipjack in Thailand reflects demand rather than supply, and the specific relationship, or flexibility, between skipjack prices in Thailand and WCPO catch has been estimated in the past at 0.52 – i.e. a 1 percent increase in the quantity of skipjack supplied from the WCPO would result in a 0.52 percent fall in the Bangkok landing price (Miyake et al., 2010).

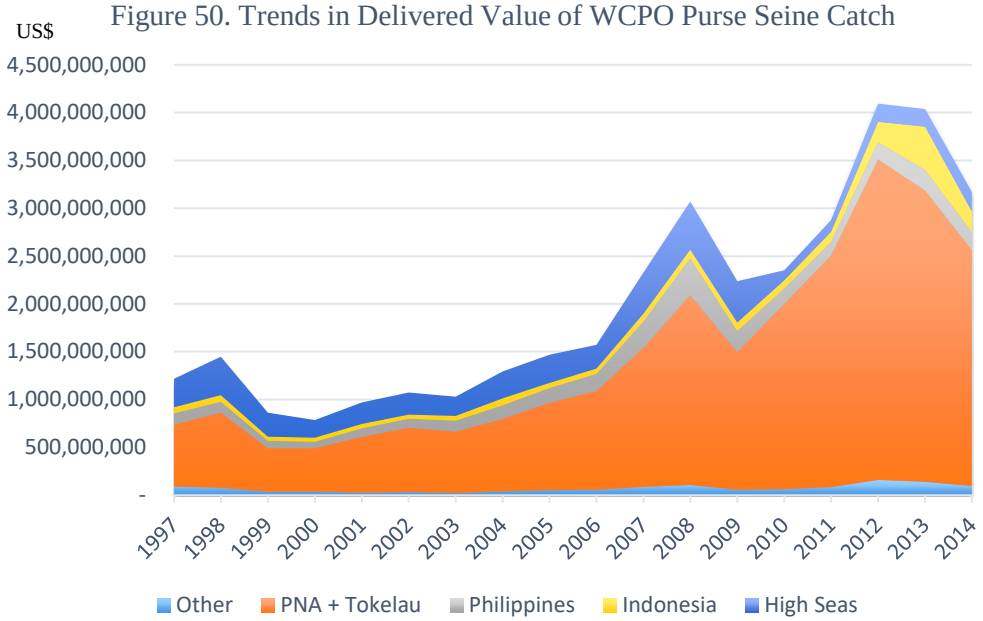
Figure 49. Trend in WCPO Skipjack Catch & Thailand Price



Source: FFA (2015)

Given that both consumers and Thai processors are price sensitive, increased supply of skipjack from WCPO purse seine operators has not generated higher returns for this segment of the supply chain in recent years, as the total value of harvests (Thailand price multiplied by the catch volume) has decreased even as volume has increased (see Figure 50).

Figure 50. Trends in Delivered Value of WCPO Purse Seine Catch



Source: FFA, 2015; Delivered value = WCPO catch x Thailand price for unprocessed fish

Given the price elasticity of canned tuna and the expected slow (but perhaps steady) growth in demand as traditional markets stagnate and new markets emerge in Asia, the Middle East and Latin America among others, increased returns to purse seining in PIC waters for canned tuna are unlikely to come from increasing catch volumes, but rather catch values. The direction of real canned tuna prices may be expected to slowly increase to 2040, but remain sensitive to supply volumes (which may generate greater returns at lower levels). At the same time, retailers are expected to continue to diversify skipjack products in the traditional markets, for example by offering flavored pouches or vacuum-sealed tuna – particularly if demand begins to grow faster than supply and canned tuna prices increase (but sales decrease given elasticity) (FAO Globefish, 2015; Conservation International, 2015).

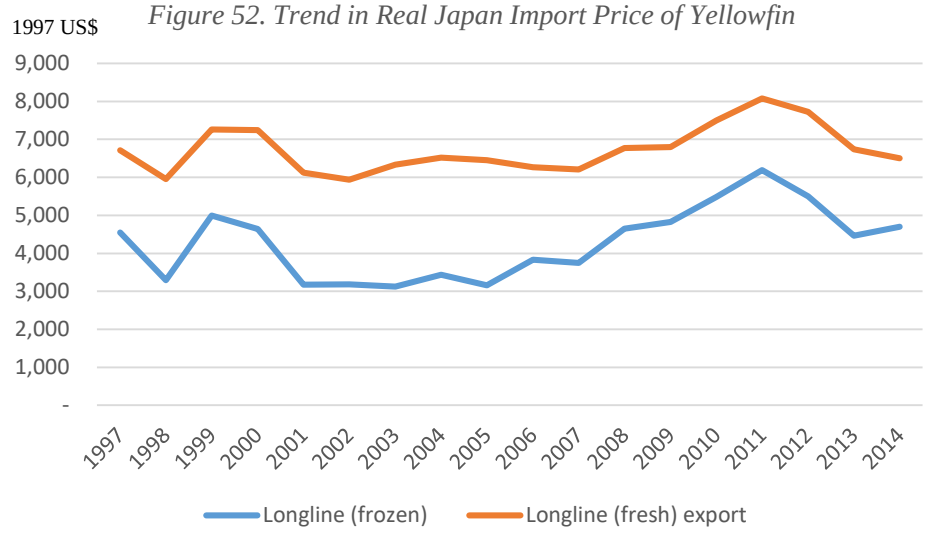
In addition to skipjack, prices for albacore in canned tuna have declined in recent years, again owing to combination of stagnant demand in the U.S. and expanded supply from increased longline catch (notably from the entrance of the 'mini-longline' vessels from China and increased effort by other existing fleets). For example, the Chinese longline fleet has increased from 23 vessels in 1990 to 286 by 2012 (SPC, 2013, in Gillett, 2014).

Figure 51. Trend in Real Thailand Import Price of Albacore

Source: FFA (2015), prices adjusted by U.S. Consumer Price Index

The Fresh Tuna Market (including Sashimi). Although Japan has always been the world's largest market for fresh tuna, most of which is consumed as sashimi, imports have declined in the past six years (FAO Globefish, 2015). With demand stagnant in Japan in recent years as the younger population seeks other protein alternatives (Conservation International, 2015), the U.S. has emerged as the second largest market for fresh tuna (FAO Globefish, 2015). Nonetheless, for the time being, Japan is the market for at least a quarter of the world's non-canned tuna, and a major driver in the price of yellowfin (see Figure 53).

Figure 52. Trend in Real Japan Import Price of Yellowfin

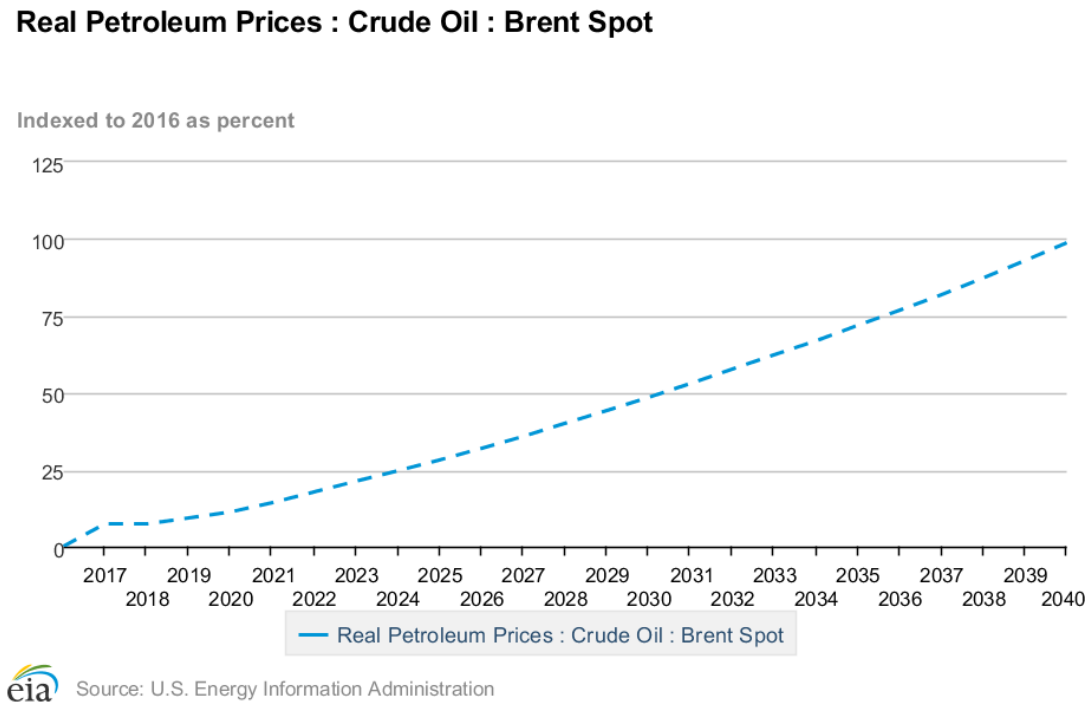


Source: FFA (2015), prices adjusted by U.S. Consumer Price Index

Again, similar to canned tuna, while the traditional market is expected to decline in the future, fresh tuna imports to the U.S. are growing, while such higher-value products can be expected to see growth in new markets as the global population grows, notably China and other Asian markets.

Role of the global economy. A number of global economic drivers can impact the fixed and operating costs along WCPO tuna fishery value chains, notably in terms of harvesting production costs for fishing fleets. For both purse seine and longline fleets, the single largest cost component is fuel – estimated to constitute 44 percent of longline vessel operating costs and 25 percent of purse seine costs, though considerably higher in some cases (Conservation International, 2015; Miyake et al, 2010) – which is determined globally as the aggregated of a number of different forces. This is essentially the major variable influencing the operating costs of the harvesting segment of the value chain (Miyake et al, 2010), notably for a longliner which may on average use over three times the amount of fuel to harvest a metric ton of albacore than a purse seiner would to harvest a ton of skipjack (Gillett, 2014). As a key driver of operating costs, the cost of crude oil has decreased in recent year, but is current projected by the U.S. Energy Information Administration to slowly and steadily increase to 2040 in the 'reference case' scenario, from an annual price of US$55.62 in 2015 to US$141.28 per barrel for Brent Spot, and from US$52.72 to US$135.67 per barrel for West Texas Intermediate Spot, in 2013 US$ (US Energy Information Administration, 2015). This trend is consistent with the World Bank's most recent forecast to 2025 (World Bank, 2015).

Figure 53. Projected Percentage Increase in the Price of Crude Oil, from 2016



As shown in Figure 53, crude oil prices are projected to increase roughly 100 percent in real terms by 2040 in a relatively steady but significant rise (U.S. Energy Information Administration, 2015). Fuel costs can be expected to put continued pressure on longline fleets, particularly the distant water longline fleets, even as catch rates are declining.

Key considerations for the future

A brief summary of recent trends and available projections of the direction of change in global tuna markets and key economic drivers of tuna fishing fleets suggest some key considerations for PICs:

Trends in supply:

- Global catches of all principal tuna species peaked in 2003 or before, except for skipjack from the WCPO. With scientists recommending that catches of skipjack in the WCPO not be further increased, the world is likely approaching the limits of the supply that can be sustained, and significant sustainable increases would not be expected.
- Supply is expected to continue to depend heavily on the WCPO, whose share of global supply would be expected to at least be comparable to current levels if not higher, given the status of the stocks in other regions.

Trends in demand:

- Population growth is one of the key factors that can drive a shift in demand curves, and the global population is projected to grow to 9.6 billion by 2050. With population growth, seafood consumption is expected to rise, notably as an 'animal protein gap' opens up between demand and available supply. China is expected to increasingly influence global fish markets, accounting for 38 percent of food fish consumption by 2030. Even a relatively small percentage shift in consumption of tuna in China or similarly India, could have a significant impact on the volume demanded and price.
- Consumer demand for sustainably sourced seafood products, including tuna, will continue to increase, particularly in European markets – notably for 'FAD-free' and 'pole and line' tuna, though volumes are likely to remain relatively small.
- Canned tuna is price sensitive in consumer markets, with slow (but perhaps steady) growth in demand expected as traditional markets stagnate and new markets emerge in Asia, the Middle East and Latin America among others. At the same time, retailers are expected to continue to diversify skipjack products in the traditional markets, for example by offering flavored pouches or vacuum-sealed tuna – particularly if demand begins to grow faster than supply and canned tuna prices increase (but sales decrease given elasticity). Processors' price for tuna in Thailand has typically been responsive to consumer demand more than supply changes from fishing fleets (with the exception of increased fuel costs), but current supply levels may be playing a greater role in the price and changing flexibility.
- Demand for sashimi and other fresh tuna products is expected to continue to decline in Japan, while the U.S. and other markets show growth.

Trends in Global Price:

- While price is affected by a range of variables over time, the direction of real canned tuna prices may be expected to slowly increase to 2040, but remain sensitive to supply volumes (which may generate greater returns at lower levels).
- Similarly, the direction of fresh tuna prices can be expected to increase slowly over time, given the combination of population growth and supply constraints.
- Recently, tuna prices in aggregate were projected to increase modestly by 10 percent in real terms from 2010 levels to 2030, and that trend could be expected to continue to 2040.
- Eco-labels and product traceability are likely the future for tuna products, but rather as a requirement of the marketplace than having any impact on price.
- The market power of large retailers in the mature markets will likely continue to increase in the future, potentially exerting downward pressures on prices down the supply chain.

Trends in Harvesting Costs:

- The single largest cost item for harvesting operations is fuel, with crude oil prices projected to double in real-terms from 2016 to 2040.

Direct Driver #3: Science and Technology

This section focuses on: (i) *changes in harvesting technology*, and specifically the potential changes in the efficiency of fishing vessels, gear and methods; and (ii) *changes in fisheries monitoring, enforcement and traceability technology*, and specifically the potential benefits that PICs may derive from technology advancements to simultaneously enhance enforcement capacity and reduce costs.

Harvesting technology. From the 1950s to the early 2000s, tuna fishing technology has changed in a number of ways to increase efficiency, including:

- Continuous improvement in fishing gear and procedures (net or line materials and gear construction, line/net casting and hauling);
- Improvements in fishing vessels (motorization and increasing engine power, construction materials and increasing length and carrying capacity);
- Improvements in navigational instruments (wide use of satellite positioning since the mid-1970s);
- Improvement in freezer systems on longliners (blast freezing replaced ice wells in 1953) and the start of distant water fishing;
- Introduction of 'super freezers' in the 1960s which allowed for the production of sashimi-quality tuna by distant water longliners;
- Deployment of deep longlines in the 1970s to target bigeye;
- Invention of the power block resulting in a rapid increase in the number of modern purse seiners;
- Rapid increases in fish holding capacity beginning in the 1960s and continuing to the present;
- Various improvements in gear and procedures such as net pursing, catch brailing and storage, conservation of large catches through handling and freezing techniques, and rapid unloading beginning in the 1960s and continuing to the present;
- Improvements in searching and catch rates through the use of helicopters, bird radar, sonar, global positioning system (GPS) and GPS radio buoys; and
- Establishment of FAD fishing in the 1990s (Miyake et al, 2010).

During this time period, longline fishing efficiency was essentially maximized in the 1990s, although there have been some technological improvements since that time – including greater freezer power and capacity (Miyake et al, 2010), and more recently lighter vessels such as used by the fleet from China. For purse seine vessels, catch rates have been growing, and combined with high capital costs and deprecation have contributed to less efficient vessels exiting the fleet over time. New vessel construction has continued in recent years, in some fleets including helicopter spotters. In general, the purse seine fleets can be expected to continue to advance harvesting technology (e.g. nets, storage, FADs, etc.) (McCoy et al., 2015)

One area that has received particular attention in recent years and can be expected to increasingly be the subject of research, is the development of new technologies for purse seining that can reduce by-catch on drifting FADs. From 2000 to 2009, 52 percent of the skipjack catch in the WCPO was taken with FADs (Daghorn and Restrepo, 2011), becoming an increasing cause of juvenile bigeye mortality (who are associated with skipjack schools under FADs) and contributor to overfishing of the stock. As mentioned previously, some 41 percent of the bigeye catch in the WCPO was via purse seining in 2014, where nets are set around FADs. For this reason, a number of companies and organizations have initiated research on alternative purse seine gears and methods to reduce the by-catch of bigeye, including re-designing FADs, the use of sonar buoys to detect juvenile bigeye around FADs, and various acoustic and visual means to assess species composition of fish aggregations (ISSF, 2015b).

To some extent, while technology advancements and innovation more broadly can be almost impossible to predict, given past trends above, there is certainly reason for optimism in expecting continued efficiency gains in harvesting technology in the region, including for enhanced product quality (e.g. alternatives to brine-freezing tuna, even canning on board in larger vessels). For example, a company in Seattle has

developed molecular ice technology (nano-ice) to produce microscopic ice particles in a flow format (essentially to freeze water like liquid ice), in order to freeze fish faster and preserve the flesh at a higher grade with more nutrients retained (World Fishing and Aquaculture, 2015), with costs likely to become competitive in the near future.

However, the development and uptake of such technology and improved efficiency is not completely exogenous to the WCPO, but will to some extent depend upon the policy incentives in place. For example, McClurg (2014) writes that a fishery access framework which provides security to companies that long-term access to sustainable fishing opportunities will be available, can help reduce the risk of not just of their harvesting operations, but also the risk they transmit into other investments along the value chain, e.g. can today's transaction to purchase raw material for processing be repeated for the same quantity, quality or price, or even with the same counterpart. Essentially, the more that future operations and transactions can be anticipated as a result of secure access to sustainable supply, the lower the risk to companies and the greater the incentive to innovate and enhance efficiency (McClurg, 2014). The benefits of a secure access regime that ensures a sustainable supply of fish can be felt throughout the entire value chain – anywhere fish or components of fish are a valuable factor of production – and hence encourages investment in technology development to enhance efficiency (McClurg, 2014).

In conclusion, given past trends, purse seine fleets can be expected to continue to develop technology to improve efficiency including to reduce by-catch, assuming that economic incentives from secure access remain in place in the WCPO. For longline fleets, similar advances can be expected as shown by the recent fleet from China, but these may depend upon the return of incentives and profitability to the WCPO longline fisheries.

Lastly, although not related to harvesting technology, developments in the global aquaculture sector could have an impact upon WCPO tuna fisheries in the future if farmed replacements for wild-caught tuna were introduced. To date, global production of farmed Bluefin tuna has reached an estimated 35,000 metric tons in 2014, with some potential to exert downward pressure on prices of bigeye and yellowfin tuna for the sashimi market (FAO Globefish, 2015). At the same time, the first attempt to farm bigeye and yellowfin tuna in Mexico has been unsuccessful due to a high mortality of juveniles, linked to feeding issues, and has resulted in commercial farming of these species halting for the time being (FAO Globefish, 2015).

Fisheries monitoring and surveillance technology. Enforcement is costly (North, 1990), particularly in the case of the rules governing fisheries throughout the WCPO – though relatively little data and analysis is currently available on the estimated current levels of illegal tuna fishing taking place, or its economic impacts for PICs.

With the introduction of satellite-based vessel monitoring systems, PICs can now track the movements of fishing vessels licensed to fish in their waters, via a system maintained by FFA. This monitoring is supplemented by human observation (i.e. 'observers') on all purse seine vessels operating in the region. PIC waters are vast, with monitoring of all fishing activity costly and difficult, hence the 2015 Regional Roadmap for Sustainable Fisheries prioritizes continued efforts to reduce illegal fishing through investments in cooperative monitoring and surveillance programs as one of its six strategies (Pacific Islands Forum Secretariat, 2015). Fortunately, assuming that such investments are made, a number of monitoring and surveillance technologies are developing that could supplement observer efforts and likely reduce enforcements costs over the next 25 years, including:

- *Continued expansion of satellite tracking*: the vessel monitoring system maintained by FFA shows the signals of fishing vessels that transmit their location as required by regulation, however vessels that do not comply cannot be viewed. Fortunately, systems are developing that can extract signals sent by vessels to other satellite-based systems for safety and navigation purposes, as well as combine other information systems to track movements of almost all vessels operating in a

country's waters. For example, Pew Charitable Trusts and Satellite Applications Catapult have developed a system for officials to integrate satellite tracking with other sources of information such as fishing vessel databases and oceanographic data (Pew, 2015). Google, Oceana, and SkyTruth have developed a tool that will capture and publicly display satellite feeds from Automatic Identification System (AIS) data – a system used by many ocean-going vessels— and classify the vessels' movements as "fishing" or "non-fishing" (Global Fishing Watch, 2015). Given these developments, in the future PIC officials might view signals of all fishing vessels in their waters via FFA's platform, with data extracted from a range of systems to ensure near-universal coverage.

- *Use of unmanned aircraft systems (i.e. 'drones') for patrols:* The technology for unmanned aircraft systems (UAS) has advanced quickly in recent years, with small crafts capable of traveling long distances to collect large volumes of data from even the most remote locations. For example, UAS have been used recently in South Africa to monitor for poaching of rhinos, capable of sending real-time information up to 30 kilometers (Moe, 2014), and some universities have begun to open research and training facilities for use of UAS in marine science and conservation – including analyzing marine debris in remote locations, monitoring endangered species and their habitats, monitoring effects of climate change and sea level rise, and following fishing fleets and stocks (Johnston, 2015). Such systems could in theory be used from various regional bases and reduce the need for costly sea patrols, perhaps in conjunction with smaller fleets of PIC patrol vessels responding when data collected requires boarding or interception, operating under the Niue Subsidiary Agreement. As such, in conjunction with expanded satellite tracking through FFA's system, small hubs for UAS and PIC sea surface patrol vessels to respond on demand in order to intercept vessels committing infractions, could reduce the need for and costs of fisheries surveillance in the region.

- *Electronic monitoring systems:* Electronic logbooks are already phasing out paper logbooks as the record of fishing catch and effort in the WCPO, and before 2040 the entire fleets would be expected to use electronic, real-time reporting. Similarly, video camera technology has been increasingly tested for installation on vessels and recording of catch amounts and composition, en lieu of observers (Lowman et al, 2013). Although still in its infancy, electronic monitoring has been trialed to record catch and by-catch on vessels fishing for Atlantic Bluefin tuna (NOAA, 2015) and such trials are beginning now in the WCPO (McCoy et al, 2015), and could even make human observers obsolete by 2040. This could have significant implications for the longline fisheries, where fleets with thousands of boats whose conditions and duration of trips make observer coverage practically impossible.

Key considerations for the future

Harvesting technology is expected to continue to enhance efficiency.

- From the 1950s to the early 2000s, tuna fishing technology has changed in a number of ways to increase efficiency.
- Purse seine fleets can be expected to continue to enhance efficiency, including to reduce by-catch on FADs, provided that economic incentives remain in place.
- For longline fleets, efficiency was essentially maximized in the 1990s, and the direction of future efficiency gains may depend upon the return of incentives and profitability to the WCPO longline fisheries.
- In addition to improved efficiency, in both the purse seine and longline fleets, technology developments offer promise to enhance quality, for example through new freezing technology.

Fisheries monitoring and surveillance technology significantly reduces enforcement costs

With sufficient investment by PICs, a number of monitoring and surveillance technologies are expected to reduce enforcements costs over the next 25 years, including continued expansion of satellite tracking of fishing vessels drawing data from a wider range of systems; use of unmanned aircraft systems for patrols; and electronic monitoring systems of fishing catch and effort.

Indirect Driver #1: Demographic Change

The population in Pacific Island countries and territories is estimated to increase from an estimated 10.8 million people in 2015 (UN Desa, 2015), to roughly 15 million in 2035 (Bell et al, 2011), as shown in Table 11. Growth rates are of course not uniform throughout the region, and are highest in Melanesia, while some of the smaller islands and territories are actually declining due to emigration (Bell et al, 2011). Throughout the region, rapid urbanization is expected - in 25 years one third of the population in Melanesia, one half in Polynesia and three quarters in Micronesia will live in urban areas (Gillett, 2014).

Table 12. Project Population Growth in Pacific Island Countries and Territories to 2035

Pacific Island Country or Territory	2015 Est. Population	2035 Projection
Melanesia		
Fiji	892,000	977,600
New Caledonia	263,000	322,538
PNG	7,619,000	10,822,300
Solomon Islands	584,000	969,900
Vanuatu	265,000	400,033
Micronesia		
FSM	104,000	105,300
Guam	170,000	250,400
Kiribati	112,000	144,600
Marshall Islands	53,000	62,700
Nauru	10,000	14,400
CNMI	55,000	76,200
Palau	21,000	22,700
Polynesia		
American Samoa	56,000	87,300
Cook Islands	21,000	16,900
French Polynesia	283,000	330,800
Niue	2,000	1,200
Samoa	193,000	202,000
Tokelau	1,000	1,200
Tonga	106,000	115,000
Tuvalu	10,000	12,800
Wallis and Futuna	13,000	13,600
Total	10,800,000	14,949,471

Sources: 2015 estimates: UN Desa; 2035 estimates: Bell et al, 2011

Fish is a cornerstone of food security for many Pacific communities, providing 51-94 percent of animal protein in the diet in rural areas, and 27 – 83 percent in urban areas, across the region (PNG is the exception, where the large inland population generally has much less access to fish) (Bell et al, 2011). Most of this fish is supplied by the coastal fisheries (Bell et al, 2011). Currently many of the stocks supporting coastal fisheries are overfished, and overall the opportunities to increase production from these fisheries are limited (Bell et al, 2011). With projected population growth in the region, as well as urbanization, fishing effort and pressure on the coastal fisheries is expected to grow, while a gap between the fish they supply and demand will grow – raising the cost of fish and decreasing household consumption (Bell et al, 2011). For a number of countries and territories, this food fish gap is expected grow by 2035, including American Samoa, Fiji, Guam, Nauru, CNMI, PNG, Samoa, Solomon Islands and Vanuatu, due to population growth alone, and will only be further exacerbated by the projected impacts of climate change. Many of these countries will need to supply an additional 20 to 30 kg of tuna per person per year by 2035 to supply the

fish recommended for good nutrition, though it should be noted that some – such as PNG – are currently below consumption levels recommended (Bell et al, 2011). Hence, the food fish gap illustrated here is not actual, but rather the gap between recommended consumption levels and projected supply at the expected future population level.

Nonetheless, Table 13 below from Bell et al. (2011) indicates a concern for food security and nutrition in the region, as the population grows while supply from coastal fisheries likely remains constrained. Additionally, climate change impacts are expected to place additional stresses on coral reef systems and their capacity to support fisheries (Gillett, 2014).

Table 13. Projected Gap between Supply and Recommended Fish Consumption Levels in 2035

Country	Gap in fish needed for good nutrition per person per year (kg/person/year)
PNG	27
Solomon Islands	7
Vanuatu	25
Guam	32
Nauru	34
American Samoa	22

Source: Bell et al, 2011

Again, as mentioned previously, many if not all of these PICs are currently consuming fish at levels significantly below those needed for good nutrition, such that the gap in Table 13 should be seen as theoretical rather than actual. That said, studies such as Bell et al (2011) have noted that if current levels of fish consumption are to be maintained in Pacific Island countries and territories given projections of population growth, urbanization and impacts from climate change, than tuna will need to help fill the gap – and hence local demand for use of the region's tuna resources would grow.

Currently, small-scale fishers take only a tiny fraction of tuna in the WCPO, and of the numerous attempts to encourage increased small-scale harvests, one of the few that have been successful has been the use of inshore FADs (Gillett, 2014). Few countries currently have publicly-funded networks of inshore FADs (Gillett, 2014), but active and well-managed programs may likely be needed in order to for tuna to help fill the projected food fish gap in 2040. Additionally, greater retention of the roughly 20,700 mt of purse seine by-catch (not including bigeye) could be part of the solution in key transshipment hubs where the population (and hence demand) is relatively large, e.g. Solomon Islands (Noro) and PNG (Rabaul) – given that currently the WCPO has the lowest retention rate of tuna by-catch of the major tuna fisheries (Lewis, 2014).

Key considerations for the future

- The population throughout the region is expected to grow by almost 50 percent by 2035, though not uniformly across countries and territories.
- Throughout the region, rapid urbanization is expected - in 25 years one third of the population in Melanesia, one half in Polynesia and three quarters in Micronesia will live in urban areas
- Most of the food fish in the region is supplied by fully or overfished coastal fisheries, with population growth, urbanization and impacts from climate change expected to put more pressure on these resources.
- For a number of countries and territories, including PNG, the Solomon Islands, Vanuatu, Guam, Nauru and American Samoa, a gap is expected by 2035 between recommended levels of consumption, and what the coastal fisheries are expected to supply.
- In these countries, a viable option may be to ensure that some portion of the production from the tuna fisheries are utilized for local food fish. To date, the use of inshore FADs has shown considerable success in supporting small-scale tuna fisheries. Greater retention of purse seine by-catch (not including bigeye) may also contribute towards a solution, for ports or transshipment hubs with relatively large nearby populations (e.g. PNG, Solomon Islands).

Indirect Driver #2: External Governance

This section recognizes that external governance measures will drive outcomes from the WCPO tuna fishery in the coming decades as well, notably preferential trade regimes, foreign fishing subsidies and the decisions of the WCPFC.

Preferential trade regimes. Currently key processing centers in Pacific Island countries enjoy preferential access to the European market, notably tuna products from PNG and the Solomon Islands can be exported duty free – in comparison to a 24 percent tariff on canned tuna from Thailand. Additionally, Palau, FSM and RMI also have limited preferential access to the U.S. market. The trade preferences have in essence been a requirement to allow processors in PNG and the Solomon Islands to compete with canned tuna produced in Thailand at lower cost. Globally trade preferences have been eroding and the efforts under the World Trade Organization while moribund are expected to remain relevant (Bagwell et al, 2015), and though certainly slower for fragile states like PICs, it seems more likely than not that such preferences will not exist in their current form in 2040, if at all.

Foreign fishing subsidies. Despite significant international attention since the 1990s (e.g. Milazzo, 1998; Virdin, 2001), subsidies in the fishing sector have persisted, now the subject of one of the targets of the 14th Sustainable Development Goal to conserve the oceans, which aims "by 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation" (United Nations, 2015).

In the WCPO, subsidies in the harvesting segment of the tuna fisheries value chain, notably for construction and operation of vessels, has had an impact. For example in the southern albacore longline fishery, Chinese vessels are reportedly heavily subsidized (e.g. for shipbuilding, fuel costs, etc.) and able to operate even when it is unprofitable for others to do so given declining catch rates (Gillett, 2014). While information and data are often difficult to obtain, recent studies (e.g. Sumaila et al, 2010; 2012) suggest that global levels of fishing subsidies have continued at current levels. Given the trends to date, even with the target in SDG 14, it seems likely to consider that foreign subsidies to the harvesting segment of the value chains (including vessel construction) may still be a feature of WCPO tuna fisheries in 2040.

WCPFC Policies and Measures. A brief discussion on the WCPFC is included here in the context of external governance drivers, considering that while PICs are members of the organization and certainly have influence, the decisions taken currently involve 26 member countries, 7 participating territories and 7 cooperating non-members, and are at least partially outside of their control. PIC representatives have expressed frustration with the lack of consensus at the Commission (see Gillett, 2014), and most recently the 12th meeting left PICs voicing frustration (FFA, 2015c). Although the pace of decision-making is slower than PICs have wished, the number of measures adopted to date (see Annex 1) indicates that consensus is possible (and in many cases has followed or endorsed sub-regional decisions and efforts taken by PICs themselves). The United Nations Fish Stocks Agreement under which the Commission was established, obliges states to adopt measures 'to ensure long-term sustainability of straddling fish stocks and highly migratory fish stocks and promote the objective of their optimum utilization" (United Nations, 1995). As such, questions over harvest limits for WCPO tuna stocks, notably rebuilding the bigeye stock, will continue to be in front of the WCPFC in the years ahead, though history to date suggests that PICs will lead resource management efforts through sub-regional cooperation, with the Commission to follow. The Fish Stocks Agreement and the WCPFC's Convention also require the Commission to ensure that sustainability measures do not place a disproportionate burden on developing states, though to date negotiations have not led to an agreed process to evaluate the distribution of costs and benefits from potential measures (Hanich and Ota, 2013).

Key considerations for the future

- Current trade preferences with the European Union may be expected to erode by 2040, in comparison to Thailand and other canned tuna producers.
- However, globally foreign fishing subsidies have shown no signs of diminishing, and should be considered a continuing factor in the operations of some foreign fleets.
- The members of the WCPFC are obligated by the UN Fish Stocks Agreement to take measures necessary to ensure long-term sustainability of the region's tuna stocks, however history to date suggests that consensus will be reached after leadership by sub-regional groupings of PICs.

Table 14 below summarizes both the recent trends in WCPO tuna fisheries, as well as the expected future direction of change in selected variables of key external drivers of performance:

Table 14. Summary of Key Trends in Recent decades in WCPO tuna fisheries and Expected Direction of Future Changes in Selected Variables for Key External Drivers in the Fisheries

Key Trends in WCPO Tuna Fisheries over Recent Decades	Expected Direction of Future Changes in Selected Variables for Key External Drivers to 2040

The purse seine fishing 'revolution'
• Explosion in purse seine vessels and catch
• Changing composition of the fleet
• A more efficient fleet, notably increased FAD technology
 	
Stagnation and possibly senescence in the longline fisheries
• Declining profitability in the southern albacore longline fishery
• Flat trend in catches from the tropical longline fishery supplying sashimi markets
• Overall, little benefit for PICs (though by-catch from locally-based vessels has contributed significantly to local food fish supply in some cases)
 	
Establishment of a regional management body for the tuna fisheries
• WCPFC met for the first time in 2004
• PICs have expressed frustrations with pace of decision-making
 	
A new model of cooperation by a sub-regional grouping of PICs to manage purse seine access
• The PNA and introduction/implementation of the VDS
• Access fees have increased by at least a multiple of four since 2009
• PNA members have held the limit on purse seine access, but throughout WCPO catch and effort continue to grow
• Following the VDS model, similar arrangements have been introduced for the longline fisheries.
 	
Failures of state-led efforts to capture more of the value chains in PICs
• State fishing and processing companies have generally not succeeded
• Pre-eminence of trading companies in the canned tuna supply chain
• Continued dominance of the Bangkok canning cluster, despite a lack of trade preferences
 	
Relatively steady global market for tuna products
• Canned tuna relatively flat
• Sashimi market pioneered in Japan, now becoming global
 	
Decline of bigeye stock, while fishing on other stocks approaches recommended limits
• Bigeye stock overfished and declining
• Albacore, skipjack and yellowfin stocks relatively healthy but at the limit
• Overall, WCPO tuna fisheries are moving towards the need to reduce catch and rebuild the bigeye stock according to scientists
	Direct Driver #1: Climate Change
	• Skipjack and bigeye abundance (no change)
	• Skipjack and bigeye distribution (overall shift to central and eastern Pacific)
	
	Direct Driver #2: Markets and the Economy
	• Supply (approaching global limits, little further increases expected, highly dependent on WCPO
	• Demand (in aggregate, modest increase given flat supply and population growth)
	  o Canned tuna (no change expected with mature markets declining but new markets emerging, greater diversification of products from purse seining)
	  o Sashimi and other fresh tuna products (Japan market expected to continue decline, U.S. and others to grow)
	• Global price
	  o Canned tuna (slow increase expected, but remaining sensitive to supply volumes)
	  o Fresh tuna (slow increase expected)
	  o In aggregate (projected 10% increase in real price from 2010 to 2030, potentially further to 2040)
	• Harvesting costs (fuel: crude oil prices projected to double in real terms)
	
	Direct Driver #3: Science and Technology
	• Harvesting technology is expected to continue to change in order to enhance efficiency (ongoing in purse seine fleet, eventually in longline fleet with return of incentives) as well as to enhance product quality
	• Fisheries monitoring and surveillance technology expected to advance to significantly reduce enforcement costs, including expanded satellite tracking of vessels, use of unmanned aircraft systems for patrols and electronic fishing catch and effort monitoring – while global markets and regulatory regimes continue to strengthen to increase the costs of illegal fishing
	
	Indirect Driver #1: Demographic Change
	• Pacific Island pop. expected to grow by some 50% by 2035
	• Rapid urbanization expected throughout Pacific Islands
	• Coastal fisheries largely stagnant, food fish gap opens in PNG, Sol. Islands, Vanuatu, Guam, Nauru & Am. Samoa
	
	Indirect Driver #2: External Governance
	• Current trade preferences expected to erode, in comparison to other producers
	• Foreign fishing subsidies expected to continue
	• WCPFC expected to take measures to conserve bigeye stocks, slowly

4.2 Proposed Key Policy Decisions to Drive the Opportunity in 2040

Given the past trends described in the baseline, and the expected directions of key external drivers of change in the WCPO tuna fisheries, this section proposes a collection of policy decisions or strategies that Pacific Island countries might take in the coming decades, towards a best-case or opportunity scenario in 2040, as defined by increased economic benefits to the countries. There are of course infinite pathways that the region might take in the governance and use of the tuna resources, and this section does not aim to offer definitive routes, nor predict or project specific outcomes. Rather the intention is to highlight possible opportunities and key policy decisions that may arise in the coming 25 years, and give an indication of the magnitude of potential economic benefits that might be realized as a result.

Following the methodology in Chapter Two, the description of potential policy decisions and strategies, and the pathways to opportunity that they might provide given expected external change, is bounded by first principles, as articulated in the Framework for Pacific Regionalism (see Chapter Two). Within the context of these shared values in the region, key policy decisions or strategies highlighted over the coming decades begin with the Regional Roadmap for Sustainable Pacific Fisheries (i.e. the Roadmap) approved by Forum Leaders in September 2015, and build upon opportunities created by measures PICS have taken in recent years (e.g. PNA efforts, the Tokelau arrangement, etc.). Taking the Roadmap as the starting point, key policy decisions or strategies are organized around the four key goals for WCPO tuna fisheries in the Roadmap: (i) sustainability, (ii) value, (iii) employment and (iv) food security. For each of these four policy goals, step-wise strategies or decisions are highlighted. At the end of the section, indicative estimates of potential additional net economic benefits to PICs from these strategies are suggested, with underlying assumptions described.

Based on the above, this section is organized as follows:

- Policy goals from the Roadmap,
    - Proposed key policy strategies or decisions for each goal, and
- Indicative estimates of net economic benefits of policy strategies.

Overarching Policy Strategy: Regional Cooperation between PICs. Quite simply, regional cooperation between PICs is required for almost all of the following policy strategies and their potential benefits. This point has been made many times before of course, notably in the *2010 Future of Fisheries report*, but is essentially dictated by the biophysical characteristics of the resource itself: the stocks migrate across national borders and span multiple jurisdictions across a vast area – no one country can solely influence the size of the stocks and hence the value that can be generated from their use. Essentially, the pathway to opportunity in 2040 depends upon cooperation. Within the wider context of the area defined in the convention of the WCPFC, two sub-regional 'coalitions' of PICs have emerged in recent years around the specific tuna fisheries, though they are different in nature and stages of evolution: (i) the Parties to the Nauru Agreement and subsequently the associated Palau Arrangement, cooperating around the two equatorial fisheries: the purse seine fishery and the tropical longline fishery; and (ii) the parties to the recent Tokelau Arrangement, cooperating around the southern longline fishery. The PNA coalition is supported by a secretariat (the PNA Office), as well as FFA (e.g. fisheries monitoring and surveillance) and SPC (e.g. provision of scientific information and analysis). FFA is currently providing secretarial services to the parties of the nascent Tokelau Arrangement.

The continued cooperation of PICs through mechanisms such as these coalitions towards the shared goals of the Roadmap will to a large degree determine the opportunities available from all subsequent policy strategies or decisions suggested here. This is not of course guaranteed in the future, and Arnason (2015) notes that in game theory an equilibrium between players implies that each party receives at least what they might be able to obtain individually or in another coalition. Given the current shifting distribution of stocks and fishing opportunities between PICs' waters, which are likely to be exacerbated by climate change, flexible and transparent distribution arrangements between coalition members that allow for bargaining,

will likely be essential to maintaining coalitions. Arnason (2015) suggests the development of models that allow parties to clearly see the benefits of different allocation formulas may be helpful.

Key Overarching Policy Strategies or Decisions

- Maintain/strengthen sub-regional coalitions around defined fisheries, matching institutions to the spatial distribution of fishing effort as much as possible.
- Continue to enhance cooperation among the members of these coalitions, for example through increased information-sharing within the group, as well as the use of models and similar tools to illustrate and communicate the benefits of cooperation.

Roadmap Goal #1: Enhance sustainability of the resource as a prerequisite for greater benefits – essentially building up the value of the region's tuna assets in the bank, or water. There is broad scientific consensus that fishing activity is generally the single biggest determinant of the size or abundance of ocean fish stocks such as WCPO tuna assets (MEA, 2005; CEA, 2012). While there is no single determinant of human behavior such as fishing activity, Ostrom's (2005) Institutional Approach to Development (IAD) framework is a useful guide, considering behavior such as fishing that interacts with the natural environment to be determined largely by the: (i) biophysical characteristics of that environment in a given context, (ii) social characteristics, and (iii) governance institutions (the rules, norms and shared strategies in use). Of these three types of characteristics in any given fishery, the governance institutions may be the most feasible to change (Ostrom, 2005), and a wide body of literature has identified failures in governance[26] as the primary reason for current levels of overfishing worldwide (Garcia, 2005; Cochrane, 2009), and the key determinant of changes to fishing effort (Grafton et al, 2008).

Given the above, governance of fishing activity by tuna fleets, shaped by the policy goals and strategies adopted by states and their organizations or agencies, is considered as the key mechanism by which PICs can influence the size and value of the tuna stocks or assets in the WCPO. While there are no blueprints for fisheries governance in any given context, two key characteristics of fisheries governance arrangements are particularly relevant for PICs' goal in the Roadmap to enhance sustainability and build up the value of the region's tuna assets in the water: (i) determining fish catch and effort limits for each of the tuna fisheries based on sound science; and (ii) matching the spatial scale of the institutions applying these limits to the ecological scale of the resources as much as possible.

In terms of setting limits on fishing effort based on sound science, PICs have been working directly with companies and through the WCPFC to collect operational data on fishing catch and effort, and drawing upon the SPC for assessments of stock sizes. This information has been translated by PICs into proposed objectives (i.e. 'target reference points') for the minimum size to be maintained of the four tuna stocks, with only the skipjack target agreed at the WCPO-level by the WCPFC in December 2015 (FFA, 2015), as the basis for the fishing effort limits fixed by the PNA for the tropical purse seine and longline fisheries. Given the uncertainties in stock distribution and abundance introduced by climate change in the coming decades, as well as the experience to date with adoption of limits at the WCPO, continued and perhaps expanded investment by PICs in collection and analysis of scientific information on the state of the tuna stocks, for setting multi-year objectives and translating these into firm limits on fishing in the waters under their jurisdiction, would be the basis for ensuring sustainability of the resource per the Roadmap. Essentially, PICs would be cooperating and collaborating with partners in order to determine fish catch and effort limits for their waters based on sound science, to maintain skipjack and yellowfin stock sizes, potentially rebuild albacore stock size, and rebuild bigeye stock size – as shared natural capital assets that can provide a sustainable economic return. Some trade-offs between these objectives or target reference

[26] Drawing from the work of North (1990), Ostrom (20015) and Kooiman et al (2005) among others, governance is defined broadly here, as the rules, norms and strategies that govern fishing, and the organizations emerging from these rules and articulating policies to implement or change them, or articulate new rules.

points may be required in the short-term, e.g. effort reductions to rebuild the bigeye stock may lead to biomass and stock sizes above the target for skipjack (and hence lower sustainable economic returns from that species during this period).

For rules limiting fish catch and effort to maintain minimum stock sizes to targeted levels so that they can sustainably generate the intended benefits for PICs, it is well established that a close match with the spatial extent of the fisheries is needed – otherwise limits introduced may only affect fishing on the stock for one time period or area, while greater or unregulated fishing takes place on the stock in other waters (e.g. Ostrom, 1990; Folke et al, 1998; Kooiman et al, 2005; Wilson, 2006). Spatial mismatches between scales of governance and ecosystems are common (Crowder et al., 2006), and the Code of Conduct for Responsible Fisheries states that management efforts "should be concerned with the whole stock unit over its entire area of distribution" (FAO, 1995). For PICs, the coverage of the fisheries under their jurisdiction is as follows:

- Purse seine fishery: with the 'closure' of fishing in the high seas for vessels seeking license to fish in national waters, in 2014 an estimated 77 percent of the purse seine catch took place in the waters of PNA members (plus Tokelau), an additional 13 percent in the waters of Indonesia and the Philippines, 3 percent in the water under the jurisdiction of other countries and territories, and the remaining 7 percent on the high seas;
- Tropical longline fishery: in 2014 some 27 percent of the bigeye and yellowfin was caught in the waters of PNA members (specifically FSM, Kiribati, RMI, Palau and the Solomon Islands), another 20 percent in the waters of Indonesia, 6 percent in the waters of Japan, and 27 percent on the high seas, among others; and
- Southern longline fishery: in 2014 some two-thirds of the albacore was caught in the waters of the parties to the Tokelau Arrangement (largely in the Cook Islands, Fiji, the Solomon Islands and Vanuatu), while some 30 percent was taken on the high seas (FFA, 2015).

In the case of the purse seine fishery, under present distribution of the stocks, cooperation between PNA members (and Tokelau) and Indonesia and the Philippines could place some 90 percent of the fishery and much of the skipjack stock under the same limits and rules. Similarly, cooperation between PNA members and Indonesia on the tropical longline fishery would almost double the fishery under the same rules and limits (e.g. longline VDS), to a total of 47 percent. Of course expanding the club to new members such as Indonesia will take time to build cooperation, recognizing that the characteristics of tuna fishing may be different in these contexts. In the case of the Tokelau arrangement, if parties can set limits over some two-thirds of the fishery, with much of the remainder in the high seas, the example of the PNA's purse seine VDS may be useful, where access to the high seas was 'closed' to vessels purchasing licenses to fish in parties' national waters.

With rules governing fishing activity continuing to be based on sound and robust scientific analysis and setting hard limits to ensure target stock sizes are maintained (e.g. the effort by the PNA to set a target reference point for skipjack), and expanded where opportunities allow in order to enlarge coverage of the stocks, PICs could be expected to be well-positioned to grow their natural capital assets in the water. However, the types of rules used to set limits will become increasingly important over the years. The coalitions mentioned above have or will likely develop EEZ-based limits on fishing effort, e.g. days fished, combined access fees (i.e. taxes) that increase harvesting costs. As Arnason (2015) noted, there is a wide body of theoretical and empirical literature describing or documenting the incentives of commercial fishing fleets to expand investments in fish catching capacity in response to rules that limit certain dimensions of fishing effort (e.g. days fished, number of hooks used on a line, etc.) – i.e. to catch more fish via unregulated methods (e.g. catching more fish per day fished, etc.) in order to expand profits of individual firms, while overall returns from use of the common pool resource decrease. Arnason (2015) suggests that this issue could be expected eventually with the VDS, such that current efforts to adjust fishing days and access fees to match the catching capacity of vessels may lag behind actual catch, and hence limits will not be met and stocks may decrease. Similarly, the ability of the governance regimes for longline fisheries to deliver policy

objectives could eventually expect to face this same issue of fishing effort 'creep' as/if effort limits are introduced by the PNA and parties to the Tokelau Arrangement, and pending sufficient impact on overall fishing effort for the stocks and subsequent stock growth (or maintenance at current levels, depending on the limits), companies begin to see profit incentives for investing in additional and unregulated catching capacity.

While a wide spectrum of rules and adjustments have been employed to account for 'effort creep' in fisheries, transitions to 'output-based' limits are frequently cited as effective options in certain contexts, given that they regulate output (i.e. quantity of fish harvested) rather than inputs (e.g. days fished) (Arnason, 2015). Transitions to such rules can involve higher enforcement costs, as for example inputs may be easier to monitor for compliance than outputs (FAO, 2000). Some PICs are currently anticipating this future challenge, and PNAO has commissioned a study on the costs and benefits of transitioning from the VDS to output-based rules (PNAO, 2015). The operational complexity involved in output-based systems can be significant, for example in a mixed fishery such as the purse seine, questions of the units of output to be used can be complicated (e.g. convert yellowfin to 'skipjack-equivalent' or define units in terms of both yellowfin and skipjack). While it will remain to be seen if more investment in precision in adjusting input or effort limits per zone of PIC coalitions will be more cost-effective in the short term than conversion to output-based rules, over the longer term technology advances in monitoring and surveillance (e.g. ubiquity of electronic logbooks and vessel video cameras) may change this calculus. By 2040, the complexity and transaction costs of output-based rules that could obviate concerns for 'effort creep' may be significantly lower in real terms, making the transition much more feasible – though still likely to be a gradual one.

Lastly, while no further increases in catch are recommended for yellowfin, the bigeye stock is considered overfished and in need of rebuilding now – assuming a target stock size that could sustain maximum yields (based on the internationally-agreed objective of the Sustainable Development Goal). Bigeye is targeted by the tropical longline fishery, but an almost equal amount was caught in 2014 as by-catch in purse seine nets set on FADs. Given the projected shift of bigeye stock distribution towards the central and eastern Pacific due to climate change, the volume of purse seine by-catch might be expected to increase, as FAD fishing is more prevalent in the east (Bell et al, 2011). Were PNA countries to assume the entire costs of reduced fishing effort to rebuild the stock of long-lived species by 2040, depending on the distribution of catch reductions between the tropical longline and purse seine fishery within their waters, the burden could be significant (and fail the provisions in the UN Fish Stocks Agreement and WCPFC Convention on equitable distribution of conservation costs, per Hanich and Ota, 2013) – as skipjack stocks could grow beyond the target reference point and harvests fall below sustainable economic optimum. Arnason (2015) suggests that rebuilding the bigeye stock solely via reductions in purse seining under current fishing methods, could reduce the potential access fees to PICs from the VDS by up to 40 percent.

While the tropical longline fishery under the VDS may bear some of the costs of rebuilding the bigeye, as mentioned previously, almost 75 percent of the fishery occurs outside of PNA waters, reducing the efficacy of rule changes via the VDS. At the same time, given the high unit values of bigeye for the sashimi markets, rebuilding the stock could generate significant additional value for the tropical longline fishery (though not the purse seine fishery). Compliance with the UN Fish Stocks Agreement would suggest an obligation by the WCPFC to take measures to restore the long-term sustainability of the stock, but these might be less favorable to PICs and somewhat beyond their control. Alternatively, rather than a reduction in fishing effort or catch through the purse seine VDS, PNA members may begin to put in place incentives to speed the technology change expected to happen by 2040. Initial research has already begun on the design of FADs or gears that might reduce purse seine by-catch, and additional investment could accelerate results. PNA members might regulate or license FADs in order to introduce the economic incentives for investment into reduced purse seine by-catch (e.g. creating a FAD registry and requiring monitoring of use via satellites). Purchase of FAD licenses together with vessel days and alteration of fishing methods would increase costs for purse seine operators and reduce profits, and likely demand for access, but a well-designed and monitored system of FAD licensing may provide incentives for both greater investment into research for

alternatives as well as shifts in fishing patterns. This would come at a cost, though potentially less than externally-imposed measures by the WCPFC, or increasingly in the future by foreign markets demanding 'FAD-free' or by-catch free tuna (already the object of eco-labelling).

In conclusion, a key determinant of the size of WCPO tuna stocks and hence PICs' natural capital assets, is fishing mortality. Regulating this effort is essentially a question of fisheries governance – broadly defined – and notably the scientifically-based limits set on fishing and the match between these limits and the distribution of the stocks. PIC coalitions such as the PNA, working through secretariats and with regional agencies including FFA and SPC, have invested significantly in determining targets for the stocks and in the case of the purse seine fishery hard limits. A key policy strategy or decision to enable future opportunities, particularly given climate change and external governance factors, is expected to be continued PIC commitment and investment in setting and maintaining scientifically-determined fishing limits that will ensure healthy stocks and valuable assets for the region. Towards this efforts, PIC coalitions may be able to enhance coverage and impacts significantly by expanding cooperation to include other WCPO countries where the stocks may be fished, for example Indonesia and the Philippines in the case of the purse seine fishery, and Indonesia in the case of the tropical longline fishery. Linking avoidance of high seas fishing to access to waters under the jurisdiction of parties to the Tokelau Arrangement may hold potential to expand coverage of rules for south Pacific albacore fishing. Over time, given advances in monitoring technology PICs can potentially transition to output-based rules in order to obviate concerns over fishing effort creep, after having continuously adjusted rules to keep up with any shifts in fishing capacity and effort within the fleets. Finally, the status of the bigeye stock will likely become a limiting factor on the tropical purse seine and longline fisheries as the stock shifts towards the east, but particularly the former given that so much more of it is under PICs' jurisdiction. Effort reductions necessary to rebuild the stock could incur significant costs to PICs, but creation of incentives for investment in alternative technology – including additional controls on FADs – could be expected to support a gradual reduction in by-catch.

Key Policy Strategies or Decisions for Roadmap Goal #1

- Sub-regional coalitions introduce, maintain and adjust target reference points for tuna stocks, and total fish catch and/or effort limits for each – mindful of the tradeoff between targets (e.g. bigeye vs. skipjack stocks).
- Expand sub-regional coalitions to better match the spatial scale of regulations and fishing effort on the targeted stocks, notably working with Indonesia and the Philippines on the purse seine fishery, and Indonesia in the tropical longline fishery.
- Continue or expand restrictions on fishing effort in the high seas, linked to national access, while promoting robust management and monitoring of high seas fishing through the WCPFC.
- Adjust the rules and/or access fee levels adopted by sub-regional coalitions in order to account for effort creep in the regulation of fishing mortality to maintain the stock at levels consistent with the target reference points, while eventually transitioning to output-based rules as technology advances.
- Rebuild the bigeye stock sequentially, through rules for management of FADs that provide economic incentives for alternatives, as well as gradual catch reductions equitably shared between the purse seine and tropical longline fisheries.

Roadmap Goal #2: Enhance the economic value of the tuna fisheries without increasing production - managing these assets for increased economic benefits to PICs. As mentioned previously, the economic value of renewable natural assets such as tuna stocks is linked to their environmental status, where increases in stock size lead to higher values and conversely a reduction in asset value may reflect resource degradation. More specifically, the asset value is measured as the present value of the future consumption (i.e. value of consuming current and future benefits from all economic items, in this case given as the economic super-profits or resource rents generated along the fishery value chains). Thus efforts to increase net economic benefits from the region's tuna fisheries are linked to sustainably increasing the present value

of these assets, i.e. the sustainable benefits they can produce, rather than just their annual contribution to GDP. Essentially, the economic returns from the fisheries and the contribution they can make to poverty reduction are tied to the abundance of fish in the ocean. As such, there is significant overlap between goals one and two in the Roadmap.

The resource rents or profits above a normal rate of return that are created in the harvesting segment of the tuna fishery value chains, can be transmitted along the different segments of the chains, as can both risk and innovation, in both directions (McClurg, 2014). PICs are currently resource owners, and hence have the comparative advantage of controlling access for harvesters to supply, which they can regulate to increase productivity and resource rents while maintaining harvesting viability and healthy working conditions (e.g. consistent with the International Labor Organization Work in Fishing Convention).

Arnason (2015) writes that for commercial fisheries where profit maximization is the primary objective of fishing fleets such as in the WCPO tuna fisheries, it is well established that efficiency and the size of resource rents generated from fishing depend on the extent to which inputs and outputs include characteristics of property rights[27] (see also Anderson and Seijo, 2010). Similarly, North (1990) wrote that such characteristics determine the opportunities for efficiency in productive activities, and therefore generation of net economic benefits. Such property rights are complicated multi-dimensional social arrangements produced by rules, and are also the corollary of duties, because one participant has an interest protected by a right only when all others have a duty to respect it (Bromley and Cernea, 1989; Ostrom and Schlager, 1996; Ostrom, 2005). The extent to which the rules for access to the WCPO tuna fisheries create or mimic some form of 'property rights' and 'duties' for fishing companies (Charles, 2009), is said to depend on the extent to which of the following independent characteristics are aggregated or bundled in the access or use right: exclusivity (ability to keep others from using the property); security (how likely is it that the owner can hold on to his property right); duration (how long lasting is the property right); transferability (to what extent can the property right be divided and traded to others); and flexibility (in what way can the property right be used) (Scott, 2008; Arnason, 2015). The quality of a property right is therefore measured by the extent to which it comprises some or all of these key attributes (Arnason, 2015).

Thus in summary, the rules that PIC coalitions put in place to govern access to the portions of WCPO tuna fisheries under their jurisdiction – within the limits set as described under the first goal of the Roadmap – can create or mimic various attributes of property rights that help increase the value of access, without increasing catch volume or production.[28] Within the framework of the United Nations Convention on the Law of the Sea (UNCLOS) Treaty, PICs have created relatively strong 'property rights' to access the tuna fisheries in the waters under their jurisdiction or zones, but Arnason (2015) notes that the quality of the access rights that they have created for users (i.e. fishing fleets) could be strengthened to create more value.

Interviews conducted recently by Conservation International (2015) with a number of companies indicated that more efficient, transparent and flexible access rights to the purse seine fishery would reduce their harvesting costs and risks and thus create value or resource rent, for which they would be willing to pay. Such rights may become even more important in the future given the projected steady increase in fuel prices (and thus harvesting costs) shown in section 4.1, from relatively low levels of the present. Taking this example of the PNA's purse seine VDS – though applicable to the opportunities that can be created to some extent (albeit lesser given the portion of the fishery under jurisdiction and opportunity for greater substitutability on the high seas) under the PNA's longline VDS and by parties to the Tokelau Arrangement – Arnason (2015) discusses a number of strategies and decisions that PICs could take to potentially increase the value of access to the fishery:

[27] Property rights are defined here as a claim to a benefit stream that some higher body – usually the state – will agree to protect through the assignment of duties to others who may covet, or somehow interfere with, the benefit stream (Bromley, 1992).

[28] It is important to note that as Bromley and Cernea (1989) state that "property is not an object [such as a fish in the water], but it is rather a right to a benefit stream that is only as secure as the duty of all others to respect the conditions that protect that stream."

- *Durability*: Currently vessel days are allocated to countries for a duration of one year, and then are re-calculated (and may change significantly). A longer duration of allocation to countries would allow for greater planning and visibility, for example Arnason (2015) suggests allocating a percentage of the TAE that is reviewed after every 5 to 10 years. At the same time, the access rights that the countries then issue to companies are short-term, providing limited incentives for resource conservation and longer-term investment (e.g. in alternative gears and methods to reduce by-catch on FADs) (Arnason, 2015). Increasing the duration of access would likely reduce risk and increase efficiency and value for companies, though could actually lower the share of the benefits captured by PICs if the price paid for longer-term access over two or more years is less than the aggregate fees countries would have received during each year of the period. Alternatively, PICs may wish to link more durable access rights to local investment in other aspects of the value chain, such as processing, with a preference for creation of local employment over any reduction in fees (see Goal #3 below).

- *Transferability (including secondary markets)*: Arnason (2015) writes that currently, the formula for allocation of PAE in the VDS creates an incentive or cost to parties to trading vessel days (as trades might affect future PAEs), which reduces efficiency in the system. Similarly, over time developing rules that allow for trading of access rights between companies can be expected to enhance efficiency, building upon the registry of vessel days currently operated at PNAO, as secondary markets emerge and even private exchanges or clearing houses (see for example experiences with the European Carbon Market – EC, 2014). Such rules must be designed carefully, for example to provide oversight to protect against fraud, market manipulation by those with large holdings, or abuse of asymmetric information, among others.

- *Reducing substitutability ('the competitive fringes')*: In addition to the benefits from the standpoint of sustainability discussed under Goal#1, expanding cooperation with Indonesia and the Philippines (in the case of the purse seine fishery, and perhaps Indonesia alone in the case of the tropical longline fishery) could reduce potential substitutions for purchasing vessel days – via access to the stock in these waters, as well as increase overall value. A key question here is how the distribution of PAE might change, and Arnason (2015) suggests that the PAE for new parties not exceed the contributions that they make to the TAE. Perhaps more importantly to PICs, access to the stock on the high seas has a zero cost, and although harvesting costs such as fuel may be higher in some instances, such substitutes become more attractive the higher the cost of vessel days. For this reason, the Roadmap envisages progressive restriction of fishing on the high seas by non-PIC vessels as a condition of access to countries' national waters, extending the initiative taken to date by PNA members.

- *Pooling of access rights to increase homogeneity*: Because the stocks migrate across different parties' waters and fishing activity and productivity can differ from year to year – more so in the future given climate change – vessel days or access rights are extremely heterogeneous (Arnason, 2015). Companies may face transaction costs in purchasing access from different parties to follow differences in fishing opportunities. Increasing the homogeneity of access rights would reduce transaction costs and increase value, i.e. 'pooling' between countries. Trials conducted to date by sub-groups of PNA members have indicated significant value and increased willingness to pay by companies for pooled days. Essentially, if the allocation formula to distribute benefits between parties is agreed, by 2040 there may be little benefit to maintaining national access rights en lieu of pooled rights that are more efficient and thus valuable. Starting now, countries may wish to progressively pool a greater percentage of days (e.g. 5 to 10 percent of the total), while maintaining a level of national sales for some countries to discount in order to support local fleets and processing.

- *Auctioning access rights*: Arnason (2015) points out that the equilibrium price of access in the purse seine fishery is not known, and as such auctions may be a promising mechanism to establish an equilibrium (and can also enhance transparency). However, the authors caution that there are infinite types of auction designs and many have failed due to collusion among bidders, so this process should start slowly and gradually. They indicate that some characteristics of well-designed auctions include: attraction of as many bidders as possible to reduce chances of collusion, and ensuring that rights auctioned are as homogenous as possible (Arnason, 2015). As with pooling, the potential increased efficiency of access could yield significant benefits for PICs, but should be approached with care and introduced progressively in order to test what works, as many have already begun to do.

A key decision for PICs will be any potential impacts from increased efficiency of operations on domestic fleets. FFA (2014) estimates roughly US$551 in value added per metric ton caught by domestic vessels, so if changes to access rules enhance efficiency of the fleet and overall resource rent or value generated in the fishery, but at the expense of domestic fleets for foreign fleets, than local value added and contribution to GDP may be reduced in favor of increased access fees (though FFA notes that these value added estimates are based on multipliers that should be treated with caution). While hypothetical, and changes may be phased to encourage innovation by the domestic fleets, there will likely be a trade-off for PICs to consider. Again, countries may wish to proceed progressively, pooling and auctioning a portion, e.g. 10 percent, of vessel days, while allowing for a cushion of days that can be sold or exchanged nationally for local fleets and processing. To help better measure this trade-off, countries with processing clusters could conduct a controlled experiment: auction a portion of vessel days without any requirements for local processing, but require bidders to also quote a price for days together with guaranteed local processing. Adding increased durability to the days, e.g. for 5 years, would only increase their value to companies, and potentially allow for both local processing and access payments. Lastly, increased efficiency could come at the expense of working conditions on vessels throughout the harvesting sector, depending upon the incentives created. PICs will need to ensure as a condition of access that minimum standards are maintained on vessels, such as agreed in the International Labor Organization's Work in Fishing Convention in 2007.

The question of fishing 'effort creep'. A conundrum of changes to rules for access that enhance efficiency such as described above, may provide profit incentives for fleets to invest in increased fishing capacity and effort, or 'effort creep' as mentioned previously, which would increase harvests beyond the effort limits regulated and eventually undermine sustainability and profitability (Arnason, 2015). This reinforces the importance of investment by PICs to be flexible and adjust rules to keep up with effort shifts in individual vessels, and eventually a transition to an output-based system. In the short term the current conversion ratios that are used to adjust fishing days issued to reflect the catching capacity of vessels, could be further refined to be more precise (Arnason, 2015).

Investing in capacity for administration, monitoring and enforcement at regional and national levels. In addition to a sound scientific basis for decisions on the regulation of fish catch and effort, and rules that enhance efficiency in commercial fisheries as discussed above, additional common features of effective fisheries governance from experiences around the globe include effective administration, monitoring and enforcement of rules (OECD, 2011). The administration and monitoring of the purse seine and tropical longline VDS, as well as rules introduced by parties to the Tokelau Arrangement, will only become more complex over time given changes in harvesting technology and distribution of stocks resulting from climate change. Uniform measurement of days or access rights and application of rules is critical – as Arnason (2015) estimates that small overruns do not translate into large losses (e.g. 5 percent overrun in sales of days could lead to a loss of $1.5 million for parties), but losses increase significantly as the percentage rises. This will require skilled technical expertise at both regional and national levels, and PICs would likely need to invest heavily in training the next generation of technicians and administrators to support these complex access regimes as they evolve – particularly given the current and potential level of benefits they can generate. To support this effort, in the case of the PNAO Arnason (2015) proposes establishing a permanent

board of directors named by each of the parties, in order to ensure longer-term service by technicians/experts and investment of time, as well as expanding the staff of the office to support administration and for parties to charge the Administrator to ensure consistent application of days across parties.

In terms of enforcement, in the short term costs can be expected to increase with access fees, as incentives for companies to seek cheaper access on the high seas or non-compliance with rules grows. However, expanded investments in cooperative monitoring and surveillance programs through the Niue Treaty, can build upon the platform at FFA to take advantage of technology change over time and eventually reduce costs, for example expanding satellite tracking of vessels towards near-universal coverage; use of unmanned aircraft systems for patrols via regional bases or hubs; and expanded electronic monitoring of catch and effort on vessels via electronic logbooks and video camera technology – together with greater controls and monitoring at ports. Additionally, infractions are based on perceptions of cost (Arnason, 2015), so increasing sanctions may deter additional non-compliance at relatively low cost to PICs. Crucially, expanded investments in communication of the rules and procedures for access set by PIC coalitions in the different fisheries could increase awareness (including of sanctions and the cost of non-compliance) and potentially reduce infractions (given that prevention is cost-effective in terms of enforcing compliance).

Branding Pacific Island tuna products. Given current catch rates in the tropical long-line fishery and the large portion of fishing occurring on the high seas, efforts from the PNA longline VDS are likely to take time to reduce overall fishing effort and increase catch rates and profitability. However, PICs could aim to partner with large retailers to co-create a PNA island brand to differentiate the product and lift market value, in exchange for medium term security of supply (Conservation International, 2015). Essentially, PICs would offer secure access to outsource harvesting, as well as outsource processing for frozen tuna, supplied to a retailer in exchange for a portion of profits in sales (Conservation International, 2015). Given trends in tuna steaks discussed in section 4.1 as well as the interest in product differentiation, this could capture opportunities for greater value at the opposite end of the value chain, in the form of public revenues to PICs largely, but also modest increased employment in the brand and potentially through in-sourcing processing. Additionally, PICs could aim to enter into a specific and long-term supply relationship with a retailer to guarantee supply of tuna – e.g. from tropical long-lining – in exchange for equity in the brand, whereby the retailer's brand differentiates based on sourcing from a specific location and commands higher prices in the market, some of which are returned to PICs as revenues (Conservation International, 2015).

Box 5. Examples of Seafood Branded by Location: Maine Lobster

Successful seafood brands have been able to generate a price premium on the order of 10 to 20 percent, based on a story about the location where they were caught, together with sustainability. For example, Maine lobster generates a premium over the same species of lobster harvested in the waters of neighboring states.

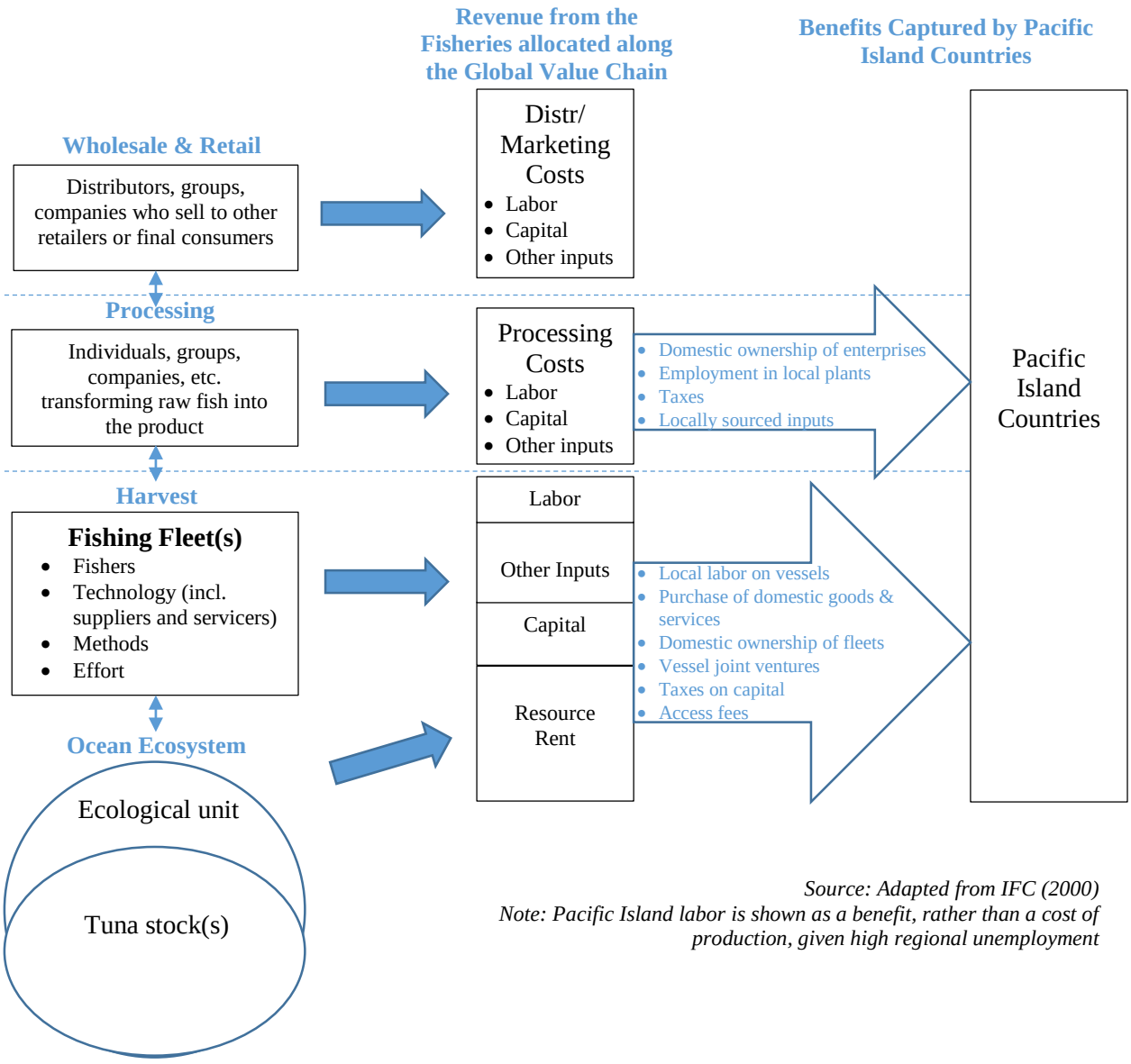
Sources: Conservation International (2015); www.getmainelobster.com

Key Policy Strategies or Decisions for Roadmap Goal #2

- Increase the efficiency and property rights characteristics of access, including:
  - Enhanced durability among parties and potentially for companies,
  - Enhanced transferability of access rights,
  - Reduced substitutability of access via high seas closures, and
  - Increased homogeneity of access through pooling.
- Progressively auction access rights to better identify the equilibrium price.
- Invest in regional and national capacity for administration, monitoring and enforcement of access rights and limits.
- Establish partnerships with interested retailers for Pacific Island branding of fresh/frozen products from the tropical longline fishery.

Roadmap Goals #3: Increase Pacific Island employment in WCPO tuna fisheries - translating the benefits from a healthy portfolio of tuna assets into jobs. The previous two goals have related to growing the size of the economic benefits generated from WCPO tuna fisheries, while this goal focuses on one aspect of how these gains are distributed within PICs – e.g. captured as access fees and/or local investment to create employment. Figure 55 below has been shown previously in Chapter Two, but is repeated here to illustrate the various opportunities for increased employment in PICs along the value chains, but also trade-offs that may be present in some cases. Some trade-offs may be minimal, such as PIC requirements for vessels accessing the waters under their jurisdiction to use a certain proportion of Pacific Island crew members in order to generate jobs on fishing vessels. Others may be more substantial, such as where PICs are not cost-competitive for foreign investment in local fleets or processing facilities, yet as resources owners the countries can leverage their comparative advantage to give reduced access fees in exchange for local investment and employment. Particularly for processing, there is generally a clear trade-off between access fees and local processing jobs, though to date little analysis of such trade-offs has taken place (or methodologies agreed).

Figure 54. Current Economic Benefits to Pacific Island Countries from WCPO Tuna Fisheries



Source: Adapted from IFC (2000)
Note: Pacific Island labor is shown as a benefit, rather than a cost of production, given high regional unemployment

A recent survey of a number of industry professionals identified several opportunities for PICs to capture more of the value chain shown in Figure 54, in ways that would increase the overall net economic benefits received (Conservation International, 2015). Although certainly others may exist, among these opportunities included the following:

- *Regional processing clusters for canning*. As mentioned previously, several PICs have leveraged concessional access for fishing in exchange for investment in canning facilities (though in many cases these are operating below capacity), notably PNG and the Solomon Islands, together with preferential access to the European market for products. Otherwise, PICs would struggle to be cost-competitive with processors in Thailand and other countries, who do not have trade preferences with Europe but have lower operating costs – notably utilities and shipping costs. Assuming such trade preferences erode towards 2040 (see section 4.1), demand for canned tuna shows modest growth and processing retains low margins, PICs are likely to continue to be at a cost disadvantage compared to other countries, likely requiring a reduction in access fees in exchange for investment,

together with regulatory reforms to reduce the cost of doing business (e.g. in the 2016 Doing Business rankings, Solomon Islands, RMI and PNG are ranked 112, 140 and 145 respectively out of 189 countries).[29] Given projected population growth and urbanization in many PICs, this may be an exchange that countries choose to make.

- *Vessel support service hubs.* Interviews with industry by Conservation International (2015) suggest that a number of vessels are incurring significant additional costs to travel for basic services, or using services at sea. With investment in the ease of doing business to reduce transaction costs, Conservation International (2015) found that companies would be willing to come to additional Pacific Island ports for reliable support services to fishing operations, such as vessel repair, food supplies, bait, fuel and net repair. While such services would depend on specific contexts for PICs, the development of vessel support hubs could be an opportunity to increase employment and respond to a need in the value chain. For example, fishing vessel maintenance and consumables can be provided without significant additional infrastructure or extensive expertise (Conservation International, 2015), likely in PNA waters where there are already facilities for landing or transshipping fish, e.g. in PNG, Solomon Islands, RMI and FSM.

- *Consolidated trading.* As mentioned previously, several large companies provide services to the fleets in the WCPO and buy their catch (rather than taking a commission on a trade), with guaranteed delivery to processors and often with exclusive relationships with vessel owners and fleets (and in some cases vertical integration). These three trading companies provide logistics and coordination for much of the supply chain. Given this level of control over the supply to Bangkok, these three traders are in a position to exert significant influence over the purse seine value chain. As Conservation International (2015) proposed, PICs could form a trading company and retain ownership of harvested fish, essentially contracting harvesting operations at lowest prices and controlling the trade of raw material (potentially influencing volume of supply to processors and the price per section 4.1). Essentially, PICs could control significant portions of the global tuna supply (e.g. over one third from PNA waters) via occupying the trading segment of the value chain (following the model of OPEC for example), including purchasing and storing catch for shipment to processors, and managing logistics systems (Conservation International, 2015). The opportunity carries significant risk, given the massive logistic systems and efficiency required, the large volume of freezing capacity needed, and strong governance, among others, but also carries high opportunity that merits further analysis (Conservation International, 2015).

Key Policy Strategies or Decisions for Roadmap Goal #3

- Establish/expand regional processing clusters where a critical mass already exists and where feasible – e.g. PNG, Solomon Islands, potentially Majuro – in exchange for concession of access and together with regulatory reforms to reduce the costs of doing business.
- Build reliable fishing vessel support service hubs where feasible, e.g. potentially expanding services in PNG, Solomon Islands, RMI and FSM.
- Research the potential to establish a Pacific Island tuna trading company to control supply of skipjack, and capture profits from this segment of the supply chain.

[29] *See: http://www.doingbusiness.org/rankings*

Roadmap Goal #4: Enhance Pacific Islands food security - using the region's tuna assets to enhance PIC food security in the face of population growth, urbanization and climate change. As mentioned previously (see section 4.1), given current levels of fish consumption and projected population growth, urbanization and impacts of climate change, a food fish gap has been projected in a number of PICs. Continued definition of access rights as discussed in Goal#2 could help provide a mechanism by which countries could secure access for small-scale fishers, together with public investment in an inshore FAD network to provide fishing opportunities. As such, a dedicated portion of the total limit on fish catch and effort (see Goal#1) could be allocated to coastal fishing communities to prevent a food fish gap, with PICs adjusting in the event that demand and risks to food security grow beyond current projections. Additionally, PICs can increasingly trial dedicated revenue streams from access fees to invest in public goods in coastal communities, as Tuvalu has proposed – establishing a social fund with a portion of access fees that would fund priority infrastructure and public goods from communities (World Bank, 2014). Finally, in some cases where relatively large populations are close to ports or transshipment hubs (e.g. PNG and Solomon Islands), measures to ensure greater retention of purse seine by-catch (not including bigeye) for local sale may provide part of the solution (Lewis, 2014).

Key Policy Strategies or Decisions for Roadmap Goal #4

- Consider utilizing a fixed percentage of strengthened access rights together with public investment in inshore FAD networks (as public goods) to secure a portion of the allowable catch of tuna for coastal communities, where food fish gaps appear.
- Trial establishment of dedicated streams of revenue received from access fees, as social funds targeted to priority infrastructure and public goods in coastal communities.
- Trial measures to require greater retention of purse seine by-catch (not including bigeye by-catch), and support increased distribution near ports/transshipment hubs with relatively large nearby populations.

Policy Delivery Capacity. A key point of emphasis in the strategies and decisions under each of the Roadmap Goals is continued and expanded investment in policy delivery capacity, notably in terms of regional agencies that support the information base for setting fishing limits and the monitoring of compliance, the secretariats of sub-regional coalitions setting fishing limits, and the national agencies developing and implementing policy within countries' waters. Expanded staffing, training and partnerships with regional and international organizations could help ensure the delivery capacity is in place, together with dedicated regional programs and activities towards this end.

Indicative Estimates of Net Economic Benefits. Based on the data and literature available, indicative estimates of potential net economic benefits from various policy strategies and key decisions are described here and summarized in Table 15 below, based on the expected direction of change for key external drivers of performance in the WCPO fisheries. These estimates should be interpreted with caution and considered as indicative of the magnitude of potential benefits from various strategies and decisions over time, towards 2040. They are synthesized from existing data and literature, rather than generated via extensive bio-economic modeling of scenarios. However, the estimates and the subsequent 2040 scenario serve to highlight the magnitude of opportunities and choices before PIC decision-makers in the coming years, and should be seen as an initial step, with the Roadmap as the starting point.

It should be noted that these estimates err on the side of caution, assuming that in the absence of the policy decisions described here in the context of the Roadmap, the status quo of net economic benefits generated from the WCPO tuna fisheries for PICs could be sustained. This is somewhat unlikely, given the limits that could be imposed externally by the WCPFC and/or markets on bigeye by-catch, the potential for continued expansion of purse seine effort on the 'competitive fringes', and the shifting distribution of catches resulting from climate change, to name a few. Essentially, the status quo may result in overfishing and economic costs over time, which would further reduce the baseline from which these estimates are generated. Nonetheless, the estimates are provided in order to indicate the magnitude of the opportunity that could

emerge for WCPO tuna fisheries to contribute even further to economic growth in PICs over the coming decades.

Assumptions:

Pre-requisite policy decisions are taken for enhanced regional cooperation and sustainability of the resources – but are not expected to have significant economic or financial costs:

- **Overall: maintain/enhance regional cooperation between PICs**
    - Individual Pacific Island countries see greater or equal benefits over the long-term to maintaining sub-regional coalitions around defined fisheries, where institutions are matched to the spatial distribution of fishing effort as much as possible (e.g. the PNA for purse seine and tropical longline fisheries, the Tokelau Arrangement for the southern albacore longline fishery), reinforced by enhanced flexibility, communication and transparency between coalition members.
- **Roadmap Goal#1: Enhance sustainability of the resource as a prerequisite for greater benefits**
    - PIC sub-regional coalitions introduce, maintain and adjust target reference points for tuna stocks in order to ensure levels commensurate with local objectives and international principles and obligations for sustainability, accompanied by total fish catch and/or effort limits to achieve each of the targets.
    - PIC sub-regional coalitions cooperate with additional countries or even expand as needed to match the scale of institutions to the spatial distribution of fishing effort, for example cooperating with Indonesia and the Philippines (part of the competitive fringes) in the purse seine fishery; cooperating with at least Indonesia in the tropical longline fishery; and working to restrict fishing on the high seas for all three tuna fisheries (purse seine, tropical longline and southern albacore longline).
    - Catch limits that are translated into rules regulating effort, such as the VDS, are continuously adapted to changing fleet capabilities, and eventually transition to output-based rules as monitoring technology further develops.
    - The bigeye stock is gradually rebuilt (precluding costly regulations introduced at the WCPFC or barriers to traditional markets for FAD-caught tuna), through a combination of FAD management rules in the purse seine fishery that help encourage technology innovations to reduce by-catch, as well as reduced longlining on the high seas as a result of national restrictions taken cooperatively by the PNA and Indonesia.

Decisions are taken to increase the value of access to tuna fishing in PIC waters:

- **Roadmap Goal#2: Enhance the economic value of the tuna fisheries without increasing production**
    - The durability, flexibility and transferability of access rights in each of the three fisheries is strengthened for both coalition members and fishing companies, in order to enhance the efficiency of fishing operations and hence the value of access to the resources.
    - Access rights to each of the three fisheries become more homogenous via pooling, reducing transaction costs to operators.
    - Rights are auctioned in order to better establish the equilibrium price.
    - PICs make additional investments to administer, monitor and enforce compliance with the rules governing fishing in each of the three fisheries, equivalent to an additional US$50 million per year in real terms by 2040 (with a baseline of US$50 million per year) – assuming a standard of 5 percent of the delivered value of the catch is reinvested in fisheries management, but also reducing this figure based on monitoring technology advancements discussed in section 4.1.
        - On the basis of the above policy decisions, PICs are able to capture 20 to 25 percent of the estimated US$3 billion in delivered value of the purse seine catch in PNA waters at 2014 catch levels (from a baseline of US$400 million in annual access

fees for purse seine fishing in PNA waters, with a real delivered price of skipjack in 2040 of US$1,800/mt and US$2,100/mt for yellowfin) – i.e. total public revenues from access fees for purse seining in PNA waters on the order of US$600 to 750 million per year, or roughly US$13,000 to $16,500 per vessel day with a total of 45,608 available days.
        - Potential adverse impacts of these policy decisions on local value added and food security are minimized, such that decisions are phased slowly to allow the domestic fleet to innovate and improve efficiency over time to avoid any losses in current contributions to GDP, and local consumption of canned tuna in PNG is not reduced.
        - Likely benefits would eventually emerge for the tropical longline fishery, though are not included here.
        - An estimated US$28.6 million per year in additional access fees in real terms is captured by PICs as a result of the introduction and maintenance of secure access rights in the southern albacore longline fishery under the Tokelau Arrangement (MRAG, 2012).
    - PICs are able to establish a brand around tuna caught in their waters, in partnership with a number of retailers who share a portion of the profits on their private labels.
        - On the basis of this decision, PNA members capture a premium (or brand value) of 5 to 8 percent of the processed value of on one third of tuna caught via purse seining in their waters (i.e. 500,000 tons with a processed value of some US$1 billion), outsourcing harvesting and processing at costs equivalent to 10 percent of the value at each level.

Decisions are taken to capture opportunities to move up the value chain:

- **Roadmap Goal#3: Increase Pacific Island employment in WCPO tuna fisheries**
    - PICs support the development of regional tuna processing clusters via access fee concessions and regulatory reforms to ease the cost of doing business
        - An additional 120,000 mt of tuna are processed in PICs, generating an additional US$711/mt in value added, at a cost of full concession of access equivalent to 4,000 vessel days at a price of $13,000 to $16,000 per day and assuming productivity of 30 mt/day – split between PNG (66 percent), Solomon Islands (17 percent) and RMI (17 percent).
    - PICs support the development of vessel support service hubs through regulatory reforms to ease the costs of doing business
        - Such services represent 10 percent of estimated operating costs of purse seine vessels fishing in PNA waters, or approximately US$20 million in expenditures, from which 15 percent is value added, split evenly between PNG, Solomon Islands, RMI and FSM.
- PICs consider establishing a tuna trading company, with PNA members as shareholders, which purchases and sells a majority of the purse seine tuna catch from PNA waters, with potential for public revenues, employment and value added benefits (e.g. from storage and transshipping) not included, as well as price effects from control of supply.

Pacific Island food security maintained:

- **Roadmap Goal#4: Enhance Pacific Island food security**
    - Estimates are not available of the cost of redirecting tuna catch to coastal communities to help fill food fish gaps, but notably in PNG, Solomon Islands the Governments may need to secure access to some portion of the tuna catch in their waters for communities.
    - Additionally, greater retention of purse seine by-catch (not including bigeye) could provide additional sources of food fish where relatively large populations are nearby ports and transshipment hubs (e.g. PNG, Solomon Islands).

- Vanuatu may be a concern, as the levels of recommended fish consumption for the population will exceed the total tuna catch in its waters.

Table 15. Indicative Magnitude of Net Economic Benefits to PICs of Opportunity Scenario to 2040

Policy Strategy or Decision	Additional Public Revenues (US$)	Additional Contribution to GDP (US$)	Additional Employment	Food Security	Assumptions
Overall: Maintain/enhance regional cooperation between PICs					
Maintain sub-regional coalitions around defined fisheries, matching institutions to spatial distribution of fishing effort as much as possible, e.g. PNA for purse seine and tropical longline fisheries, parties to the Tokelau Arrangement for southern longline fishery - Enhance flexibility, transparency among parties - Communication, models to illustrate costs and benefits to individual parties of cooperation	Pre-requisite for benefits below				Individual PICs see greater or equal benefits over the long term to cooperation than alternatives
Goal#1: Enhance sustainability of the resource as a prerequisite for greater benefits					
PIC coalitions introduce, maintain and adjust target reference points for tuna stocks, and total fish catch and effort limits for each	N/A				Assumed not to have significant economic costs, prerequisite for benefits below
Enlarge coalitions to expand scale of fish catch and effort limits for stocks - Indonesia and the Philippines participate in purse seine VDS - Indonesia participates in longline VDS - High seas restrictions continue/expand linked to national access	NA				
Combat effort creep, and eventually transition to output-based rules as monitoring technology advances					

Rebuild bigeye sequentially - Develop FAD management rules, e.g. licensing scheme, to encourage innovation alternatives - Invest in catch reduction in PNA waters (both purse seine and longline)	N/A	N/A	N/A	N/A	Rebuilding solely via reductions in purse seining under current fishing methods, could reduce the potential access fees to PICs from the VDS by up to 40 percent
Goal#2: Enhance the economic value of the tuna fisheries without increasing production					
Strengthen the durability, flexibility, transferability of access rules to enhance rights and efficiency - Enhance durability among parties, and potentially for companies - Enhance transferability, incl. secondary markets - Substitutability reduced – per Goal#1 above Pooling of access among parties to coalitions Auctioning of access rights	$228.6 to 378.6 m	Currently est. $551 in value added/mt caught by domestic fleet (approx.. 52% Value Added ratio to dockside value of catch), so if catch by domestic fleet reduced in favor of more efficient foreign fleets, then potential negative impact on GDP	N/A	N/A	- Baseline of $400 m in access fees from purse seine fishery - Real Delivered price of skipjack in 2040: $1800/mt - Real Delivered price of yellowfin in 2040: $2100/mt - Catch levels maintained at 2014 levels - 20 to 25% of the est. $3 bn in delivered value from PNA purse seine fishery is captured, for total revenues of $600 to 750 m per year (or roughly $13,000 to $16,500 per day) - Local consumption of canned tuna in PNG not reduced - Changes phased slowly such that domestic fleet innovates and improves efficiency over time, no loss in domestic fleet and value added - No estimates available of increased access fees captured from tropical longline fishery - Estimated US$28.6 m in additional access fees captured by PICs in southern albacore longline fishery

Invest in capacity for administration, monitoring and enforcement of access rights and limits	-$50 m	N/A	N/A	N/A	Baseline of $50 m in public expenditures, increase to 5% of delivered value, with reductions for advancements in monitoring technology
Branding of PIC tuna products	$50 to 80 m	N/A	N/A	N/A	- Capture an increase in the price of 500,000 tons of PNA purse seine-caught tuna, equivalent to 5 to 8% of the processed value (US$1 billion in real terms) - Outsource harvesting (pay 10% mark-up) - Outsource processing (pay 10% mark-up)
Goal#3: Increase Pacific Island employment in WCPO tuna fisheries					
Regional processing clusters	-$52 to 64 m	$85.3 m	7,500 to 15,000	Potential impact on local supply of food fish	- Double 2013 purse seine catch volume processed locally - $711 va/mt processed - Baseline of 120,000 mt processed locally 2013 - Assumes full concession of days (4,000 for 120,000 mt; 30 mt/day), at $13,000 to $16,000/day - Based on PNG and Solomon Islands range of 1 employee for every 8 to 16 mt processed
Vessel support service hubs	N/A	$3 m	N/A	N/A	- Islands could sell consumables and maintenance services, but would not enter bait or fuel servicing markets - Consumables and maintenance services make up 10% of operating costs across all vessel types - Margins for maintenance and consumables would be 15%

Goal#4: Enhance Pacific Island food security					
Allocate portion of access rights to coastal communities Invest in inshore FADs	N/A – though in cases of individual PICs, governments may likely need to allocate some portion of access to coastal fisheries, to shift food and livelihood opportunities into the tuna fisheries where feasible	N/A	N/A	PNG allocates access equivalent to needed levels of food fish per year Solomon Islands may also need to do the same	PNG would need to allocate roughly half of its PAE for coastal fisheries, at 292,000 mt food fish gap, considering 30 mt catch per vessel day, to supply 35 kg fish per person at projected population levels. Solomon Islands would allocate roughly 250 vessel days for inshore Vanuatu would allocate total albacore catch in its waters of 6,898 mt in 2014, insufficient to raise consumption of fish to recommended 35 kg/person/year
Trial efforts to retain more purse seine by-catch (not including bigeye)	N/A	N/A	N/A	Greater retention of by-catch (e.g. fin fishes, etc.) could increase food fish available near ports or transshipment hubs	PNG and Solomon Islands would aim to support greater distribution and sale of purse seine by-catch landed at Rabaul and Noro for example.
TOTAL	176.6 to 344.6	88.3	7,500 to 15,000	Food fish gap filled in PNG and Solomon Islands, Vanuatu in deficit	

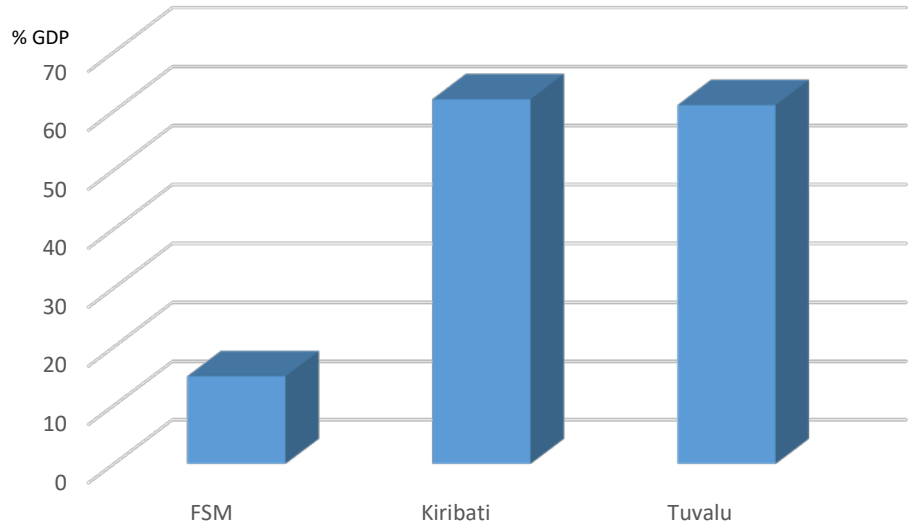
Sources: Conservation International (2015); calculations from FFA (2014), FFA (2015); Arnason (2015)

Table 16. Indicative Distribution of Net Economic Benefits to PICs of Opportunity Scenario to 2040

	Additional Public Revenues (US$)	Additional Contribution to GDP (US$)	Additional Employment
Fiji	5.3 m	-	-
FSM	26.1 – 48.7 m	0.7 m	-
Kiribati	56.1 – 104.5 m	-	-
RMI	-1.4 – +5.0 m	15.3 m	1,275 – 2,550
Nauru	10.0 – 19.0 m	-	-
Palau	3.2 – 6.0 m	-	-
PNG	32.8 – 84.0 m	57.0 m	4,950 – 9,900
Samoa	3.9 m	-	-
Solomon Islands	14.7 – 29.1 m	15.3 m	1,275 – 2,550
Tokelau	4.4 – 8.4 m	-	-
Tonga	2.0 m	-	-
Tuvalu	14.5 – 23.6 m	-	-
Vanuatu	5.1 m	-	-
Total	176.7 – 344.6 m	88.3 m	7,500 – 15,000

Note: in terms of benefits from the purse seine fishery, distribution estimated from distribution of the location of catches and indicative only, while distribution of southern albacore revenues based on Table 3 of MRAG (2012)

Figure 55. Upper Bound of Additional 2040 Public Revenues in Real Terms as % of 2013 GDP



V. The Opportunity Scenario in 2040

Sub-regional coalitions of PICs are entrenched around the three tuna fisheries – purse seine, tropical longline and southern longline, with norms of transparency and trust established, as well as flexible formulas for distribution of returns on access to accommodate spatial shifts in the stocks as impacts from climate change are felt. Countries continue to see greater benefits from cooperation to invest in growing shared natural capital assets and many count upon their annual returns for stability funds and public investment. Working together, these coalitions have set target reference points for the four tuna stocks as a basis for firm total allowable catches from the zones under their jurisdiction, based on regular assessments from the world's top tuna biologists at SPC. The equatorial coalition comprised largely of PNA members operates as a well-functioning organization, with a permanent board of global experts from within the region, and a secretariat of professional staff from strong education and training programs within the region, built over recent years with public revenues from the fisheries. Similarly, the Tokelau Arrangement's successor is governed by a permanent board with a well-staffed secretariat. Staff in both organizations are highly skilled and focus on managing registries of tuna catch quota, monitoring trends in use and synthesizing key biological, ecological and economic research for the board, as well as managing quota auctions. FFA provides monitoring and surveillance services, among others, to the coalitions, recognized as a world leader in cutting-edge surveillance technology that includes a series of unmanned aircraft facilities. The sum of these institutional reforms allows the region to match fishing rules to the spatial extent of the fisheries, allocate scarce resources to fit comparative advantages, and effectively administer, monitor and enforce access rules to increase value rather than production from the waters.

Seeing a future constraint on returns and potential external influence from the WCPFC, PNA members moved quickly in 2017 - 2018 to invest in research and development for by-catch reduction, and to implement an innovative FAD licensing scheme to spur industry investment – particularly given projected eastward shifts in distribution of the stock. The combination of technology advances and some initially painful catch reductions, coordinated with similar action through the longline VDS, placed the bigeye stock on a slow recovery path, with biomass eventually and steadily increasing towards 40 percent of unfished levels. Albacore, skipjack and yellowfin stocks continue to remain healthy, with a slightly stricter target reference point to provide some reserve should climate change make it necessary. These stocks provide the world's last healthy tuna stocks and have become an even more international fishery system, as global demand for tuna products has remained steady with Asian and Middle Eastern markets becoming more mature.

Inclusion of Indonesia in the purse seine and tropical long arrangements, and the Philippines in the former, has enhanced the total allowable catch limits for both and placed most of the world's skipjack under robust management. Strong restrictions for fishing on the high seas, linked to access to national waters, was recognized in 2020 by the WCPFC together with robust management and monitoring, and even with shifting stocks high seas fishing is minimal. Some three quarters of the southern albacore longline fishery operates on rules set through successors to the Tokelau Arrangement, with profitability on an upward trend.

As an example, gradually over the years PNA members enhanced the flexibility of internal vessel day trading while increasing durability of allocations – with some countries moving slowly in order to give domestic fleets time to adjust and improve efficiency (and thereby maintain contributions to local value added). Days with longer duration were progressively issued to companies for higher returns, or in some cases in exchange for local investment. Continued trials in pooling with successful results, as well as improved auction designs, led to an agreement whereby the parties directed the secretariat to pool all access rights, allocated via auctions, with revenues distributed to parties via the agreed formula. Several parties opt to continue to invest access revenues in processing clusters, reducing the TAE and their distribution accordingly. After years of investment in effort adjustments at the individual vessel level, the parties made sufficient preparations for a transition of rules towards a quota-system. Secondary markets for quota

developed, regulated by the parties and enhancing overall fleet efficiency. The efficiency gains, together with the enhanced visibility and reduced risk for firms, led to significant investment in technology for higher quality products, generating value throughout the supply chain. As a result of healthy fish stocks and a well-functioning access market, resource rents and revenues are between 50 percent higher and double 2015 levels in real terms (after management costs and concessions for domestic processing are subtracted).

Building off of healthy stocks and efficiently-regulated access, the PNA countries (plus Indonesia and the Philippines) have created a trading company that controls much of supply to processors and in some cases direct to retailers, supported by freezing/storage facilities in key hubs throughout the region. A number of PICs have well-developed vessel support systems that provide services to the fleets. Utilizing the pooled access regime, several countries exchange revenue distributions for allocations to secure access coastal tuna fisheries developed through nearshore FAD networks to help ensure sufficient flow of food fish. This process began in the 2020s in advance of continued stagnation in coastal fisheries. Some countries have established dedicated coastal community funds with tuna revenues, to invest in reef restoration and key infrastructure and social goods.

As a result of the policy strategies and decisions pursued under the Regional Roadmap for Sustainable Pacific Fisheries, public revenues are some US$177 to 345 million per year higher for PICs in real terms, after concessions for onshore investment and investments in administration, monitoring and surveillance are subtracted (this likely underestimates efficiency gains to harvesting from incentives created by the quota market). This provides additional revenues equivalent to 16, 62 and 61 percent of 2013 GDP for FSM, Kiribati and Tuvalu, respectively. A number of countries have increased local value added by an aggregate US$88 million per year in real terms due to processing cluster and vessel service hubs (though many processing facilities operate under capacity and at a loss given erosion of European trade preferences). These efforts have created some 7,500 to 15,000 additional jobs in the region for processing, without including the additional employment from service hubs. Over time an Oceanic Tuna Export Company (OTEC) could develop and generate significant profits shared, as well as employment at storage facilities throughout the region.

In retrospect, five strategies stand out:

1. Regional cooperation around a shared resource, expanded to include key resource owners like Indonesia and the Philippines,
2. Hard fishing effort and catch limits that maintained valuable natural capital assets in the water (and helped constrain supply and hence increase price), with proactive efforts and up front investments to rebuild the bigeye stock before further declines,
3. Flexible access and eventually output rights for harvesters that enhanced the value of the fisheries without increasing production, and provided a tool for interested PICs to lever greater foreign investment in processing,
4. Significant investment in skills and capacity to develop the world's top tuna managers, and
5. Inclusion of coastal communities in the fisheries where feasible, through dedicated access and inshore FAD networks, as well as targeted investments maintain food security with coastal fish supplies stagnating and growing populations.

Annex I. Overview of Scenario Analysis as a basis for the Methodology

Definition of scenario analysis. Scenarios tell compelling stories that capture the imagination and communicate future risks or opportunities, often for policy decisions (Swart et al., 2004). They are neither predictions nor forecasts, but rather should be thought of as coherent and plausible stories, told in words and numbers, about the possible co-evolutionary pathways of combined human and environmental systems (Nakicenovic et al., 2000; Swart et al., 2004; Carpenter et al., 2005). Each scenario is one plausible alternative image of how the future might unfold under particular assumptions, and a set of such scenarios can support understanding of possible future developments in complex systems and policy making (Nakicenovic et al., 2000; Carpenter et al., 2005). In this way, they assist policy-makers to understand the upcoming choices that need to be made and highlight developments in the present (Carpenter et al., 2005). Scenarios are typically developed through the joint involvement of decision-makers and scientific experts, and they represent a promising mechanism for linking scientific information to decision-making processes (Carpenter et al, 2005).

Scenarios generally include the following elements:

- description of step-wise changes in the future state of society and the environment;
- driving forces, the main factors that influence the changes described;
- base year;
- time horizon and time steps; and
- the storyline, a narrative description that highlights the scenario's main features and the relationship (or assumptions or theories about the relationship) between the driving forces and these main features (Alcamo, 2001).

Scenarios have been used in a wide array of contexts, including: (i) ''business strategy scenarios'' that explore uncertainty in a world that the business does not control in order to test the robustness of decision-making and to identify opportunities and challenges; (ii) ''new conversation scenarios'' that explore new and unknown topics and can be used as an educational tool for wide audiences; (iii) ''groups-in-conflict scenarios'' that use scenario techniques to understand differences and jointly explore consequences of actions; (iv) ''public interest scenarios'' that aim to shape the future by articulating a common agenda

Origins of Scenario Analysis

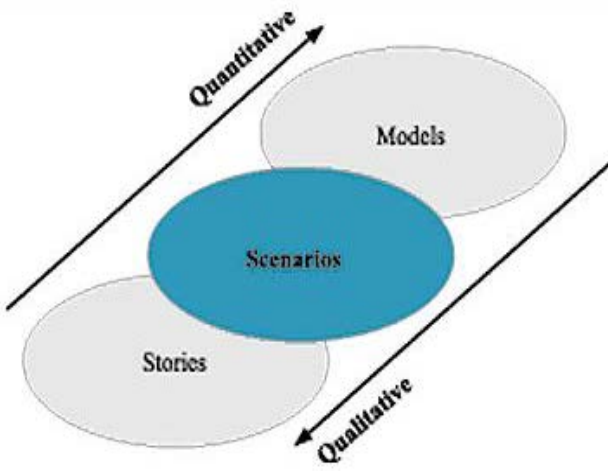
This field arose in response to strategic questions about the possible future states of complex systems that are either inherently unpredictable or have high scientific uncertainties, where long-range predictions or forecasts were often not feasible (Nakicenovic et al, 2000; Swart et al, 2004). While predictive modeling is appropriate for simulating well-understood systems over sufficiently short times, as complexity increases and the time horizon lengthens, the power of prediction diminishes (Peterson et al., 2003; Carpenter et al, 2005). Quantitative forecasting is legitimate only to the degree the system state can be well specified, the dynamics governing change are known and persistent, and mathematical algorithms can be devised to validly represent these relationships (Carpenter et al., 2005). However, one method for thinking about future opportunities and risks is the construction of scenarios, particularly in terms of complex systems such as fisheries and their sustainability (Alcamo, 2001; Swart et al., 2004).

The term 'scenario' has its origins in theater, describing the actions of performers or changes in the stage setting, before being applied to war game analysis after World War Two by Herman Kahn and his colleagues in the 1960s (Alcamo, 2001; Carpenter et al., 2005). Beginning in the 1970s, Carpenter et al. (2005) note that scenario analysis was increasingly used in questions of sustainability and human-natural systems, including ambitious mathematical simulation models as well as speculative narrative. Michael Porter's (1979) work during this time established the basis for applying scenario analysis to the development of business strategies, and a new round of integrated global analysis began in the late 1980s and 1990s in response to concerns with climate change and sustainable development (Carpenter et al, 2005). The time frame of climate change spurred a number of scenario analyses, perhaps the most well-known of which was the Intergovernmental Panel on Climate Change's (IPCC) scenarios for greenhouse gas emissions (Swart et al., 2004). Subsequently, a significant effort to develop scenarios of potential changes in ecosystems and their impacts on human welfare was conducted in the early 2000s as part of the Millennium Ecosystem Assessment (MEA), which included a detailed history of scenario analysis up to that time (Carpenter et al., 2005).

and highlighting potential actions and their consequences; and (iv) ‘‘scientific scenarios’’ examine the possible long-range behavior of biophysical systems as perturbed by human influence (Carpenter et al., 2005).

In all of these cases, scenarios can be either qualitative or quantitative, with qualitative scenarios taking the shape of diagrams, phrases or outlines, or more commonly narrative texts (i.e. ‘storylines’), while quantitative scenarios present numerical information in the form of tables or graphs (see figure one below) (Nakicenovic et al, 2000; Alcamo, 2001). The qualitative scenario gives voice to important qualitative factors shaping development such as values, behaviors, and institutions, providing a broader perspective than is possible from mathematical modeling alone, while the quantitative scenario offers structure, discipline, and rigor – in many cases the two are blended (Carpenter et al., 2005). Alternatively, scenarios may be classified as (i) exploratory, where the scenario begins in the present and explores trends into the future in a sequence of emerging events, and/or (ii) anticipatory, where the scenario starts with a prescribed vision of the future and then works backwards in time to visualize how this future could emerge (Alcamo, 2001). Scenarios may also include policies to depict the effects of a policy reform, or ‘non-policy’ scenarios that aim to describe changes in other drivers.

Schematic illustration of alternative scenario formulation, from narrative storylines to quantitative formal models



Source: (Nakicenovic et al., 2000)

General methodology for constructing scenarios. A good scenario should be plausible, transparent and understandable (Alcamo, 2001). An example of a process for building a qualitative scenario might include literature reviews and consultations to (Nakicenovic et al, 2000; Alcamo, 2001):

- Identify the main drivers that will shape future events for the system under analysis (e.g. demography, technology, etc.),[30]
- For each of these drivers, select key variables (e.g. 10 to 15),
- Outline mini-scenarios about the future changes to each variable,
- Reduce the list of key variables for each driver to 5 or 6 priority variables (i.e. variables expected to best measure the magnitude and direction of the drivers),
- Combine similar groups of mini-scenarios into full scenarios, and
- Develop a ‘storyline’ around that scenario (e.g. 3,000 words).

[30] The discussion of drivers is often organized around the IPAT equation: Impact = Population x Affluence x Technology. Essentially, environmental impacts (e.g. emissions) are the product of the level of population times the affluence (i.e. income per capita) times the level of technology deployed (Nakicenovic et al, 2000).

Once narrative 'storylines' or qualitative scenarios are developed, they can be quantified into prototype scenarios with the use of models (i.e. formal representations of a system that allow quantification of relevant system variables) that assign internally consistent values to the various scenario characteristics (Nakicenovic et al, 2000).

Example of scenario analysis for climate change

A well-known recent example of scenario analysis was the development of greenhouse gas emission scenarios as a basis for modeling projected impacts on the climate (Nakicenovic et al, 2000). In this example, a set of scenarios for future emissions was developed based on extensive assessment of the literature, six alternative modeling approaches, and consultation and comments from the public. More specifically, four storylines were developed through an iterative process that identified driving forces, key uncertainties, and modeling to produce quantitative scenario families (Nakicenovic et al., 2000). While there is an infinite number of possible scenarios, the team consciously applied the principle of Occam's Razor (i.e. economy of thought) to identify the minimum number of scenarios that could still serve as an adequate basis to assess climate change – deciding eventually on four (Nakicenovic et al., 2000). The development of these scenarios for future emissions allowed other teams to model their impacts on the climate system (Nakicenovic et al., 2000).

Annex II. Selected WCPO Tuna Fisheries Policy Statements and Instruments

Policies		Organizations	Policy Instruments & Agency Activities
Document	Objectives, Strategy		
Level: WCPO			
Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean [*entered into force in 2004*]	***Context:*** In the early to mid-1990s there was a growing awareness of the need for a tuna management agency that would cover an area larger than that encompassed by PICs and which would include foreign nations with vessels fishing in the WCPO. After 6 years of complex negotiations between the PICs and distant-water fishing nations known as the Multilateral High Level Conference, the treaty was opened for signature in Sept. 2000. ***Objective:*** To ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the WCPO in accordance with the UN Convention on the Law of the Sea Treaty and the UN Fish Stocks Agreement ***Strategy*:** Established the Western and Central Pacific Fisheries Commission (WCPFC) to carry out this objective, as a Regional Fisheries Management Organization (RFMO) recognized under international law (Article 64 of the UN Convention on the Law of the Sea Treaty).	***Member countries*:** Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America, Vanuatu. ***Participating Territories*:** American Samoa, Commonwealth of the Northern Mariana Islands, French Polynesia, Guam, New Caledonia, Tokelau, Wallis and Futuna. ***Cooperating Non-Members*:** Ecuador, El Salvador, Mexico, Panama, Liberia, Thailand, Vietnam. ***Secretariat*** established in 2004 based in Pohnpei, FSM. Decisions are generally taken by consensus of members, participating territories and cooperating non-members at meetings held annually. These decisions are informed by the work of four subsidiary bodies: the Scientific Committee (best available scientific information), the Technical and Compliance Committee (recommendations on compliance with decisions), the Northern Committee (recommendations on species found north of 20 degrees north), and the Finance and Administration Committee (recommendations on the Commission's budget). The SPC's Oceanic Fisheries Program serves as	Selected Conservation and Management Measures (binding decisions by the WCPFC): ***WCPFC Record of Fishing Vessels (2013)*:** Requires members to authorize all vessels flying their flags who wish to fish in WCPO, and transmit information to WCPFC for record of fishing vessels, and prohibit vessels from landing fish caught in the WCPO at their ports that are not listed in the record. ***Regional Observer Program (2007):*** Requires all vessels fishing in WCPO waters to have an observer, collecting data on fishing catch and effort ***Satellite-Based Vessel Monitoring System (VMS) (2014)*:** Establishes a WCPFC VMS, requiring all vessels fishing in WCPO to send signals to the VMS, and accepting signals from the FFA VMS ***High seas boarding (2006):*** members agree that vessels flying their flag may be boarded for inspection by vessels of participating countries recognized by the WCPFC when fishing in the high seas, for compliance with Commission measures ***List of vessels fishing illegally (2010):*** WCPFC will establish and maintain a list of vessels documented by members as fishing illegally ***Transshipment (2009)*:** No purse seine vessels may transship at sea, and no longline vessels may transship in the high seas. ***South Pacific Albacore (2010):*** Members shall freeze the number of fishing vessels targeting albacore in the South Pacific at 2005 levels ***Conservation and Management Measures for Bigeye, Yellowfin and Skipjack Tuna (2014):*** *For the purse seine fishery*: (i) use of fish aggregating devices (FADs)* in WCPO prohibited for 3-month period, with additional measures to increase the closure period or reduce total number of FADs, and all FADs in high seas to be prohibited in 2017; (ii) purse seining in the EEZs of PNA countries agreed to be regulated by the VDS, with total fishing effort fixed at 2010 levels; while non-PNA coastal states in WCPO with at least 1,500 fishing days in their EEZs over the period of 2006 to 2010 shall limit total effort to 2010 levels; purse seine effort on the high seas to limited 2,282 fishing days per year by an identified group of distant water fishing fleets; and all purse seine vessels should carry an observer, in EEZs or high seas; and (iii) excluding PICs and Indonesia, countries with purse seine fleets shall ensure that the number of vessels above 24 meters and with freezing capacity does not increase. *For the longline fishery: (i)* bigeye catch by longline fishing limited to 55,687 tons annually in 2017 by the fleets of China, Indonesia, Japan, Korea, U.S. and Taiwan, China; *(ii)* countries shall ensure that their longline catch of yellowfin does not increase; and *(iii)* excluding PICs and Indonesia, countries with longline fleets targeting bigeye shall not increase the number of vessels. *Additionally*, requires countries with fleets fishing in WCPO to provide operational catch and effort data, i.e. from logbooks, to the Secretariat on a confidential basis. ***Harvest Strategy for each Stock (2014)***: Requires development of harvest strategies for each key fishery, including: (i) definition of management objectives for the fishery or stock; (ii) target and limit reference points for each stock; (iii) acceptable levels of risk to breach reference points; (iv)

		the Commission's *Science Services Provider and Data Manager*.	monitoring strategy; (v) decision rules to achieve target reference points and avoid limit reference points; and (vi) management strategy evaluation.
Policies		**Organizations**	**Policy Instruments & Agency Activities**
Document	Objectives, Strategy		
Level: Pacific Islands Region			
South Pacific Forum Fisheries Agency Convention [*entered into force in 1979*]	***Context***: In the late 1970s, many distant water fishing nations wishing to fish in the Pacific Islands area negotiated bi-laterally with PICs in what was perceived as a 'divide and conquer' strategy. Partially in response, FFA was established to help countries sustainably manage their fishery resources that fall within their 200 mile Exclusive Economic Zones (EEZs). FFA is an advisory body providing expertise, technical assistance and other support to its members who make sovereign decisions about their tuna resources and participate in regional decision making on tuna management through agencies such as the WCPFC. The FFA was originally involved with all fisheries, but in the early 1990s, refocused almost entirely on tuna. FFA originally provided secretariat services to the PNA, until the PNA Office was established in 2010. ***Objective:*** To drive regional cooperation to create and enable the maximum long term social and economic benefit from the sustainable use of members' shared offshore fishery resources	***Member Countries***: Australia, Cook Islands, FSM, Fiji, Kiribati, Nauru, New Zealand, Niue, Palau, PNG, RMI, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu ***Governing body*** is the Forum Fisheries Committee of member countries, aiming to take decisions by consensus in annual meetings. ***Secretariat*** established in 1979 in Honiara, Solomon Islands.	***Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region (1992, 2012 subsidiary agreement):*** Agreement among FFA members to cooperate on enforcement of national fisheries laws and regulations, including agreement on regional surveillance procedures and patrols, cross-vesting of enforcement powers to enable cooperative surveillance and enforcement activities, information sharing and development of a shared Treaty Information System, etc.; as well as establish harmonized minimum terms and conditions for foreign fishing vessel access to their waters, specifying consistent tuna access conditions throughout waters of PICs, including requirements in national regulations for: (i) vessels to be in good standing on the FFA tuna fishing vessel registry in order to receive a fishing license for PIC waters, (ii) vessels licensed in PIC waters to provide uniform minimum reporting on fishing activity and catch, as well as common identification markings, (iii) vessels fishing in PIC waters to have coverage of observers; PICs to share of national information with FFA and utilize its satellite-based vessel monitoring system (VMS), among others. ***Multilateral Fishing Treaty with the United States (1987, amended in 2003)***: Agreement between FFA members and the United States for the country's tuna fishing fleet to access waters of PICs on common conditions and fees, together with targeted bi-lateral aid from the U.S. ***FFA Functions***: Provides advice, information, policy recommendations, regional strategies, technical support and development opportunities to members at the national and regional level, to assist them to carry out three broad tasks: 1. *Developing and implementing effective regional and national policy*: supporting policy harmonization and advisory services to members, supporting consensus on regional policies, assisting members on relations with distant water fishing nations; 2. *Providing national and regional tuna fisheries management services*: supporting monitoring and surveillance of fishing activities and compliance with member regulations, including maintaining a tuna fishing vessel registry and a regional satellite-based vessel monitoring system (VMS) (transmits to secretariat and to monitoring stations of members, conducting regional surveillance patrols, providing training to national enforcement agents, training and advisory services on research national management functions, and maintaining a regional observer program; and 3. *Providing regional tuna fisheries development services*: provides information, analysis and training to members to develop the fishery to harvest, process and market tuna

Policies		Organizations	Policy Instruments & Agency Activities
Document	Objectives, Strategy		
Level: Pacific Islands Equatorial Belt Sub-Region			
Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Interest [*agreed in 1982, amended 2010*]	***Context***: Building from the context of the 1979 FFA Convention, PICs in the equatorial belt began to discuss more specific cooperation around the tuna fisheries in their waters. ***Objective***: to coordinate and harmonize the management of fisheries with regard to common stocks shared across the zones of the parties. ***Strategy***: to set uniform terms and conditions of access, including a centralized licensing system, reporting, identification, etc.	***Parties to the Agreement***: FSM, Kiribati, Nauru, Palau, PNG, RMI, Solomon Islands, Tuvalu (Tokelau is an observer) ***Governing body*** is an annual meeting of the representatives of the parties, aiming to take decisions based on consensus if possible, if not then by a vote of at least 5 Parties ***Secretariat*** services provided by FFA until 2010, when the Agreement was amended to establish a PNA Office (PNAO) as a legal entity acting as secretariat. FFA requested to support PNAO and Parties with fleet information and fishing catch and effort data.	***First Implementing Arrangement (1983, amended in 2010)***: Sets out the minimum terms and conditions for foreign fishing vessels to access the waters of Parties, including registration on the FFA vessel registry, uniform licensing, reporting, minimum inclusion of Party nationals as crew, etc. ***Second Implementing Arrangement (1990)***: Prohibits transshipment at sea by any foreign vessels licensed to fish in Party waters, requires reporting of high seas catch by any foreign vessels licensed to fish in Party waters ***Federated States of Micronesia Arrangement (1995)***: Mechanism for Parties' domestic vessels to access the fishing resources of other parties, aiming to provide access for Parties' domestic vessels to other Parties' waters on terms no less favorable than those granted to distant water fishing nations; secure maximum sustainable economic benefits from tuna resources; promote greater participation by nationals of Parties in fisheries & assist in development of national fisheries industries; allow access to vessels on terms consistent with Palau Arrangement. Domestic vessels are eligible based on a number of criteria, including good standing on FFA's vessel registry, details of the vessel, and home-Party license, among others. Fee for entering other Parties' waters is calculated as 5% of the multiple of average regional catch for preceding 3 years and average tuna price for corresponding years. ***Third Implementing Arrangement (2009, amended in 2010)***: Closes the following high seas areas to foreign vessels wishing to obtain/maintain a license to fish in party waters: (i) the area of high seas bounded by the national waters of the Federated States of Micronesia, Indonesia, Palau and Papua New Guinea; (ii) the area of high seas bounded by the national waters of the Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Papua New Guinea, Solomon Islands and Tuvalu; and (iii) any additional high seas areas located within 10˚N and 20˚S latitude and 170˚E and 150˚W longitude; requires purse seine vessels to retain all tuna catch fit for human consumption. ***Palau Arrangement for the Management of the Western Pacific Purse Seine Fishery (1995, amended most recently in 2015)***: Aims to enhance management of purse seine fishing vessel effort in Parties' waters by encouraging collaboration between them, and (i) promoting optimal utilization and conservation of tuna resources, (ii) maximizing economic returns, employment generation and export earnings from sustainable harvesting of tuna resources, (iii) supporting the development of domestic locally-based purse seine fishing industries, and (iv) promoting effective and efficient administration, management and compliance. Creates the vessel day scheme (VDS) to manage access to Parties' waters for tuna fishing vessels, replacing a previous vessel number limit of 205 vessels by setting a total collective limit on fishing days in those waters by licensed purse seine vessels each year (total allowable effort or TAE), and allocating that TAE among the Parties (Party allowable effort or PAE). All Parties agree to limit fishing effort in their water to the respective PAEs, using standard criteria for reporting fishing days. Parties may transfer unused days within their PAEs, or agree on arrangements to pool them for sale. Effort expended under the FSMA and US Treaty is included in the calculations for TAE and PAEs, and Parties must allocate a portion of

			their PAEs to account for any days fished by their national fleets in other Parties' waters. To combat 'effort creep' (increasing fish catch per the same measure of fishing effort, i.e. increasing catch per fishing day), the following conversion factors are used: (i) every fishing day by a purse seine vessel with a length overall of less than 50 meters shall equate to a deduction of one half of a fishing day; (ii) every fishing day by a purse seine vessel with a length overall of between 50 meters and 80 meters shall equate to a deduction of one fishing day; and (iii) every fishing day by a purse seine vessel with a length overall in excess of 80 meters shall equate to a deduction of one and one half fishing days. Oversight of the VDS carried out by a sub-committee of the annual meeting of the Parties, the Vessel Day Scheme Committee, meeting as needed. Governance of the scheme is set by the annual meeting of the Parties, including setting the TAE and taking decisions on any other measures needed to implement the VDS. The VDS is implemented as part of a Conservation and Management Measure agreed at the WCPFC. ***Palau Arrangement for the Management of the Western Pacific Tuna Fishery – Management Scheme (Longline Vessel Day Scheme) (2015)***: Aims to enhance management of longline fishing effort in the waters of the Parties in order to (i) promote optimal utilization, conservation and management of tuna resources, (ii) maximize economic returns, employment generation and export earnings from sustainable harvesting of tuna resources, (iii) support the development of domestic locally-based longline fishing industries, (iv) secure an equitable share of fishing opportunities and equitable participation in the tropical longline fisheries for the Parties; (v) increase control of the tropical longline fishery for the Parties; (vi) enhance data collection and monitoring of the fishery; (vii) promote effective and efficient administration, management and compliance; and (viii) encourage collaboration between the Parties. Creates VDS to manage access to Parties' waters for longline tuna fishing vessels, by setting a TAE and allocating as PAEs to Parties. Parties undertake similar commitments to limit effort as purse seine VDS, with transferability of days between Parties. To combat 'effort creep' the following conversion factors are used: (i) every fishing day by a longline vessel with a length overall of less than or equal to 40 meters shall equate to a deduction of 0.8 of a fishing day; (ii) every fishing day by a longline vessel with a length overall greater than 40 meters shall equate to a deduction of 1.6 fishing days. Artisanal vessels are exempt from the VDS. Oversight of the VDS carried out by a sub-committee of the annual meeting of the Parties, the Longline Vessel Day Scheme Committee, meeting as needed. Governance of the scheme is set by the annual meeting of the Parties, including setting the TAE and taking decisions on any other measures needed to implement the VDS. ***PNAO Functions***: Coordinate implementation of the Nauru Agreement, develop fisheries conservation and management initiatives for the Parties, formulate initiatives to maximize sustained economic benefits to the Parties and administer PNA management initiatives. PNAO maintains a register of purse seine vessels established (VDS registry), with registration on the FFA register as a pre-requisite and monitoring via the FFA VMS.

*Sources: Gillett, 2014; WCPFC (www.wcpfc.int); http://www.austlii.edu.au/au/other/dfat/treaties/1979/16.html; FFA (www.ffa.int); http://www.state.gov/e/oes/ocns/fish/bilateral/c33153.htm; http://ro.uow.edu.au/cgi/viewcontent.cgi?article=5085&context=theses *FADs defined as including: "any object or group of objects, of any size, that has or has not been deployed, that is living or non-living, including but not limited to buoys, floats, netting, webbing, plastics, bamboo, logs and whale sharks floating on or near the surface of the water that fish may associate with"*

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