

Final Report

Palau National Marine Sanctuary - Socioeconomic Baseline Project



Kirsten Oleson, PhD, Principal Investigator
Rachel Dacks, PhD, Graduate Research Assistant
Staci Lewis, PhD Graduate Research Assistant
University of Hawai'i Mānoa

Silvia Ferrini, PhD, University of East Anglia and University of Siena
Carlo Fezzi, PhD, University of Trento and University of Exeter
Phil James, PhD, SPC

Funding:
National Geographic Society Pristine Seas

Partner:
Palau International Coral Reef Center

PICRC Technical Report 19-07

May 2019

EXECUTIVE SUMMARY

As Palau approaches the 2020 date when it will establish the Palau National Marine Sanctuary (PNMS) protecting 80% of its Exclusive Economic Zone from export-driven fishing, key questions remain about the potential socio-economic impacts and how best to design complementary fisheries policy. This research set out to gather baseline data on specific aspects of the economy, with the intent of providing information relevant to tracking eventual impacts of the PNMS and designing complementary policies. Specifically, the PNMS could cause changes in the volumes and market prices of reef and offshore fish flowing through the domestic supply chain, so we evaluated the supply chain structure, flow volumes, and values. Further, a reduction in supply (or an increase in price) of offshore fish could cause people to alter what they eat, so we surveyed both residents and tourists to better understand their fish preferences, consumption habits, and willingness to pay for fish and other kinds of proteins. Finally, we investigated possible public revenue impacts of changes in fisheries and tourism.

Our results show a complex supply chain with the vast majority of reef fish being locally consumed by residents and the vast majority of tuna being exported. The 2016 total current local market demand for tuna and other pelagic fish is likely at the lower end of the range of 160-288 metric tons per year. Residents likely eat about half of the pelagic fish that tourists do. Tourists are responsible for a fraction of reef fish consumption (less than 4% of total and less than what is exported), suggesting that tourists are not the primary driver of any decline. Commercial supply of both reef and pelagic fish was reported to be unpredictable and inconsistent, prompting actors in the supply chain to adapt (e.g., import). Prices, however, have remained relatively stable, a characteristic of the market that may be attributed to the importance of relationships in Palauan society. For both pelagic and reef fish, there is minimal value added along the supply chain until caterers and restaurants.

Our results are consistent with reports of high reef fish consumption by residents, though our estimate of non-commercially acquired fish (~80% of meals) is higher than previously reported, highlighting the importance of non-commercial interventions to affect consumption. Interestingly, we found that urban individuals consume reef fish more frequently than their rural or peri-urban counterparts. This counterintuitive finding could be attributable to reef fish's social and market value (for rural dwellers) and accessibility and affordability (for urban dwellers). We found that urban and peri-urban residents prefer reef fish over all other protein sources, and have a willingness to pay for higher quality tuna. The demand model we elicited can predict residents' (urban and peri-urban only) demand for reef and pelagic fish, as well as substitution to non-fish protein (e.g., chicken, beef) at different price points.

We found that tourists as a group prefer raw reef fish, raw tuna, and non-tuna pelagic fish, with distinct preferences by nationality. We elicited a demand model for tourists that is capable of predicting demand for both reef and pelagic fish under different market price scenarios. Tourists are willing to pay a premium of \$10 above the meal's base price for local sustainably sourced tuna and other non-tuna pelagic fish; this willingness to pay differs by nationality, income range, and fish type. A local sustainable brand could both capture this willingness to pay and draw tourists to eat more pelagic meals. By contrast, tourists will eat more reef fish if the price of pelagic meal increases and no sustainable brand is available.

A key concern related to the PNMS is its impact on public revenues. The effect on fisheries-related revenues (particularly income from vessel days) is still unclear due to ongoing policy negotiations. A tourist fee was initiated in part to offset revenue losses, and policy makers believe the PNMS will attract more, higher-end tourists. It is difficult to ascertain how much the PNMS specifically contributes to tourism-related revenue as Palau has many attractions. However, over time, one indicator could be awareness of the PNMS and its importance for tourist decision-making. In our survey in 2017, most (64%) respondents said they were not aware of the PNMS prior to making their trip. This rate differed by country, suggesting that targeted marketing may be having an effect. Interestingly, 36% of the all respondents were aware of the PNMS prior to their trip, 15% said the PNMS was important to their decision to travel to Palau, with 7% of respondents indicating they would not have come to Palau if it weren't for the PNMS. These results suggest that there is room to improve awareness of the PNMS, and that the PNMS could serve to motivate tourism.

INTRODUCTION

In 2015, Palau enacted a policy to protect 500 thousand square kilometers of its ocean, representing 80% of its exclusive economic zone (EEZ), by 2020 (Republic of Palau Public Law (RPPL) 9-49). The policy's goal is to preserve and manage the stocks, health, and beauty of Palau's waters and natural resources by limiting fishing in its deep ocean waters. State waters hugging the coasts of the archipelago are not directly affected by the policy. Industrial fishing will still be allowed within the 17% of the EEZ that surrounds the main islands of Koror and Babeldaob, but all catch must be landed in Palau and exports of pelagic fish are effectively prohibited (RPPL 9-49, Section 164-b). Alongside these protections, the Marine Sanctuary Act will support a domestic offshore fishery. This policy, if successful, could be a model for other Pacific Islands on how to preserve the region's resources for future economic benefits and support the development (and restructuring) of a sustainable domestic fishery. However, currently there are major gaps in the understanding of ecological, economic, and social impacts of such a policy. These gaps also hamper the ability to design concurrent domestic fisheries policy.

Our project fills key data gaps related to potential impacts of the PNMS. This research was co-designed and implemented with our in-country partner, the Palau International Coral Reef Center (PICRC). In August 2016, the joint team scoped the project through interviews and background research. During the project period of July 2016 through December 2018, we conducted a literature review on Palauan fisheries, collected primary data through two major surveys of tourists (N=409) and residents (N=335), and interviewed key informants involved in fishing or the supply chain (N=17), amongst other experts. We collaborated with other groups in Palau, including the Palau Sportfisher Association and Palau Community College, and contributed to a concurrent survey of fishers conducted by SPC and The Nature Conservancy.

Key results of this project contribute to knowledge that is important both for establishing a baseline prior to a major policy change, and to design concurrent fisheries policy. We use a value chain analysis to describe the fisheries distribution chain, prices, and volumes. We characterized both tourism and resident consumption, willingness to pay, and substitution between different proteins (for residents) and fish (for tourists). Our demand models for tourists and residents can be used to predict consumption of and substitution between types of fish (and other proteins, in the case of residents) under different price points. This information can be used in the coming effort designing a domestic offshore fishery to predict demand and revenue. We provide critical information (e.g., fish volumes by fish type and price, local assets and obstacles to offshore fishing) to the government for the design of a new domestic fishery

The project has resulted in a number of broader societal impacts, including training of scientists and improved knowledge of the PNMS. We ran a number of training sessions introducing principles of social science, monitoring and evaluation, and survey design and fielding. Two US-based doctoral students and two PICRC researchers hired by the project were trained in fisheries value chain research and economic methods. Throughout the two-and-a-half-year project, we presented multiple science talks at PICRC, met with government officials (including the Minister of Natural Resources, Environment, and Tourism, senior advisors to the Minister, and the President of the Republic), and broadcast results over radio, in addition to discussing our research at international conferences and workshops. While the project ends December 31, 2018, part of our team has joined a multi-institution policy advisory group, and our results are key to this expanded effort to support Palau's efforts to balance conservation and development.

This report is structured into four main sections corresponding to: (1) literature review on the structure of Palauan fisheries (2) fisheries value chain analysis; (3) current market demand for fish (tourism and resident); (4) future scenarios under PNMS. We then briefly discuss study challenges and limitations, outputs and outcomes, summarize what we see as the key take-away messages, and outline some next steps.

1. The structure of Palau's offshore fishery: a synthesis

Background on Palau's offshore fishery provides context for the project, and identifies the baseline fishery structure and revenues that could be affected by the PNMS's implementation.

METHODS

We conducted a thorough literature review and interviews with key informants.

RESULTS

History of Commercial Fishing

Foreign tuna fishing in Palau's EEZ began before WWI. Pole and line was the initial gear used by the Japanese to target skipjack tuna. Foreign fishing activities stopped during WWII and started again in the 1960s when the Japanese returned and the locally based Van Camp Seafood Company carried out fishing with boats crewed by Okinawans. The Japanese also began purse seine fishing in the 1960s and 1970s and limited longline fishing for yellowfin tuna during the same time. During the 1980s, longline fishing began to set their lines deeper, shifting targets to bigeye tuna. During the 1980s Korean and Taiwanese vessels also began longline fishing in Palauan waters for export to Japan (Chapman 2000). There are currently three transshipment companies operating in Palau.

Fleet and catch statistics

Purse seine fishing

Purse seine vessels target schools of skipjack tuna that are used for canning. Compared to other EEZs in the Pacific, Palau's EEZ is not known to be preferred for purse seining (Sisior, pers. comm.). Currently all purse seine boats fishing in Palau's EEZ are Japanese and do not land their catches in Palau (Table 1).

Longline fishing

All longline vessels fishing in Palau's EEZ are foreign owned (

Year	No. Vessels	Catch (mt)
2016	30	130
2015	30	169
2014	21	453
2013	5	246
2012	36	not reported

). Japanese longline vessels do not land their catches in Palau. Locally based, foreign owned longline boats are mostly Taiwanese vessels that are contracted by one of the two main fishing companies (Palau International Traders Incorporated (PITI), Kuniyoshi Fishing Company (KFC)) (

Year	No. Vessels	Catch (mt)
2016	30	130
2015	30	169
2014	21	453
2013	5	246
2012	36	not reported

). Ninety-five percent of the catch from PITI- and KFC- contracted boats is exported to Japan upon landing in Koror. Most of the discards, or portion of the catch that is of too low quality to export, is either sold or donated in Palau. A very small portion of the discards is frozen and transported to Taiwan when the vessels return to their home ports.

Table 1. Japanese purse seine fleet statistics. Data from the 2016 Annual Report to the Commission (Bureau of Oceanic Fishery Management 2017). mt = metric tonnes.

Year	No. Vessels	Catch (mt)
2016	30	130
2015	30	169
2014	21	453
2013	5	246
2012	36	not reported

Access fees

Four Fisheries Associations of Japan (FFAJ)

An agreement between Palau and Four Japanese Fishing associations covers three methods of fishing (longline, purse seine, pole and line) and has allowed Japan to have up to 290 vessels with no limits on catch. Japan paid 4-5% of catch returns, but there was no way to validate their catch (Bureau of Oceanic Fishery Management 2013). Between 2010 and 2014, Japan has paid Palau between \$196,100- \$867,120 annually in access fees (Gillett 2016). Currently, these access fees have been replaced by the vessel day schemes (described below).

Uniform Longline Agreement for locally based vessels (ULA)

Agreements between the Republic of Palau and foreign owned, local based companies (PITI and KFC) (Bureau of Oceanic Fishery Management 2013). Vessels under these agreements are internationally owned, locally based vessels that have paid for annual licenses per vessel based on the size of the vessel. Between 2010 and 2014, total licensing fee revenue was between

\$219,000-\$284,600 per year (Gillett 2016). Currently, these access fees have been replaced by the vessel day scheme (described below).

US Multilateral Tuna Treaty and Federated States of Micronesia Arrangement

These two multilateral treaties grant preferential access to the US and FSM flagged purse seine boats, respectively. The US Treaty was renegotiated in 2016 with stipulations on minimum vessel day fees (more below). Very little purse seine fishing is conducted by FSM and US vessels in Palau's EEZ, but Palau still receives a portion of these treaty funds. Some Pacific Island countries treat this money as foreign aid, not for fishing access (Gillett 2016).

Vessel Day Schemes

Described below.

Other sources of revenue from pelagic fisheries

The export tax for all commercial tuna and billfish, either fresh or frozen is \$0.35/kg. Average revenues from export taxes was approximately \$500,000 annually from 2011-2014 (Gillett 2016). Otherwise there is little additional revenue from pelagic fisheries, especially considering that very few jobs are created by the fishery. Between 80-90 people are employed by offshore fisheries, of these only ~20% are Palauans and average wages are ~50% of all workers average wages in the country (Gillett 2016).

Parties to the Nauru Agreement and the Vessel Day Scheme

The Parties to the Nauru Agreement (PNA) is an agreement between Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu to manage the largest tuna fishery in the world. The Purse Seine Vessel Day Scheme (PS VDS), established in 2006 with the Palau Agreement, is the current method used by the PNA to manage effort in the fishery. Although not a PNA member, Tokelau joined the PS VDS in 2014, with 1,000 transferrable days (PNA 2014b).

Purse seine VDS

In the PS VDS, a total number of annual vessel days for the entire fishery is agreed upon by the parties. Each party's allowable effort (PAE) is then calculated based on historic effort and biomass within each party's EEZ. Sixty percent of the PAE is calculated based on the party's effort over the last seven years and 40% of the PAE is calculated based on the 10-year average of the party's share of estimated skipjack and yellowfin biomass within its EEZ (as explained in Article 12.5 of the 2012 Amendment to the Palau Agreement and in Hagrannsnoknir sf 2014).

A minimum benchmark fee is set for purse seine vessel days (PS VD) which each party can

transfer (i.e., sell to another PNA member) or sell to the highest bidder (i.e., sell to fishing company). Vessel days can be transferred to fish in any PNA party's EEZ, without penalty to the transferred parties VD allocation (PNA 2016). The process of transferring days between parties is described in Article 7 of the Management Scheme (PNA 2016). The mean value of a vessel day has steadily increased since 2007 (Havice 2013). A minimum benchmark fee of \$8,000/day was set from 2015 (PNA 2014a). Detailed records on sales or transfers of vessel days are not publicly available (Havice 2013; Yeeting *et al.* 2018).

Yeeting *et al.* (2018) summarize the PNA 'implementing arrangements' as follows: "foreign vessels [are required] to be registered and licensed, report catches, maintain log books, allow observers on board and maintain transparency over their fishing activities." Further, vessels registered with the Vessel Day Scheme are required to have Automatic Location Communicators (ALC) or Mobile Transceiver Units (MTU) that transmit their locations at least once per hour while they are within the VDS Management Area (PNA 2016). Every entire day that a vessel is within the VDS Management Area is counted as a vessel day used, unless the vessel reports a "no fishing day" (e.g., travel, maintenance, etc.) and periods of less than 24 hours are counted as partial day (PNA 2016). As described in the Palau Arrangement (PNA 2016), fishing days by vessels shorter than 50m or longer than 80m count as 0.5 and 1.5 vessel days, respectively. Parties are responsible for ensuring registered vessels comply with the implementing arrangements and that they stay within the PAE. Parties that exceed their PAE should reportedly be penalized by reductions to the following year's PAE (PNA 2016). However, there are criticisms of the PNA PS VDS claiming that there is a lack of monitoring, compliance, and transparency that could hinder the future success of the SP VDS (Hagrannsoknir *sf* 2014; Yeeting *et al.* 2018). In the case of Palau, the VDS is run by the Bureau of Marine Resources, within the Ministry of Natural Resources, Environment and Tourism.

Palau's currently PS VD allotment is reportedly ~700 vessel days annually (Sisior, pers. comm., Pojas 2018), though historically, this number has been lower (average of 580 days between 2008-2011 (Bureau of Oceanic Fishery Management 2013). Palau sells most of its vessel days to the US for \$12,500 each (as negotiated in the US treaty), regardless of whether US vessels actually fish in Palau's EEZ. The remainder of Palau's PS vessel days are sold for between \$9-10,000 each. When vessel days are purchased to transfer to another EEZ, Palau charges a transfer fee (approximately \$500), for administration costs and future opportunity costs (since vessel day allotments are based partly on historical effort within the EEZ). Though records are confidential, it has been publicly reported that one PNA member party that Palau has transferred PS VD to is Papua New Guinea (Bureau of Oceanic Fishery Management 2013) and this year, PS VD have been sold to a fishing company in the Philippines for the first time (Pojas

2018). This year, Palau has brought in approximately \$9 million USD in PS VDS revenue (Sisior pers. comm.).

Longline VDS

The longline VDS (LL VDS) is in its infancy and has not yet been fully implemented at the PNA-scale, although several countries are now implementing at the country-scale. Palau was the first party to implement the VDS for the longline fishery in 2017. In 2014, longline boats fishing in Palau's EEZ fished 10,500 days (Sisior, pers. comm.). Since 2016, the number of allowed longline VDs has been a fraction of the 2014 days, reducing each year as stipulated in the PNMS Act (Palau National Marine Sanctuary Act 2015). Palau sells its LL VD for \$150-\$250 (Sisior pers. comm.). Because the LL VDS is still new and has yet to be fully implemented by all parties, LL VD are not currently transferable between PNA member EEZs.

2. What is the current fish distribution supply chain?

To better understand how fisheries are adding value to the economy, while supporting livelihoods and food security, we need to know more about the supply chain's current structure (e.g. fleet, ownership, catch, sales, distribution, consumption, prices, processing, etc.). These details provide baseline information for impact assessment, can help identify inefficiencies and opportunities that may improve the economic returns of the fishery, and support modeling of fisheries policy.

METHODS

Stakeholder interviews and a literature review (previous section) informed the supply chain tracing. To sketch out the supply chain, we interviewed key informants involved in the supply and distribution of fish (Table 2). In interviews, we collected information on the suppliers and customers of fish, as well as the volume, price, and species that were bought and sold. Ten follow-up meetings with previous interviewees in July-August 2017 validated value chain initial findings and filled outstanding data gaps. In March 2018 we interviewed the seven major catering operations in the country and held focus groups to understand the volume of fish served in custom events (i.e., weddings, funerals, first birth ceremonies). In June 2018 we tabulated the number of convenience stores and roadside stands and estimated the volume of fish they regularly sell and followed up with caterers who supply tourism operators with lunches for day trips.

Table 2. Number of interviews conducted relative to number of fish selling businesses in Koror, Palau.

	Total No. of businesses in Koror	No. of interviews conducted
Restaurants (serving local seafood)	37	10
Offshore fishing companies	3	2
Fish Market	1	1
Supermarkets	3	2
Prepared Food Markets	2	2

RESULTS

Offshore fishery

Between 1,785-2,620 mt of pelagic fish and 2,115 mt of reef fish are landed in Palau's waters annually (see Table 3 & 4 for all citations). Of these volumes, it is estimated that 165-284 mt of pelagic fish and 865 mt of reef fish enter the local market annually. The vast majority (>90%) of pelagic fish caught in Palau's waters are consumed beyond Palau's borders (Figure 1). Of the pelagic fish that remains in the country, 55-179mt is consumed by residents and 105-109mt by tourists. These ranges are the result of two different methods of calculation. For the tourists, we asked suppliers how much fish they serve/sell to tourists (105mt), and we asked tourists how much fish they ate while visiting (109mt). These two methods resulted in very similar estimates. Our two estimation methods for the residents resulted in a wider range because of uncertainty in the amount of fish entering the local market. To estimate the residents' consumption, we asked suppliers how much they sold to residents (55mt), and we subtracted the tourist consumption from lower and upper estimates of total domestic supply, which resulted in a range (56-179mt). Notably, the lower end of this range is very close to the supplier-derived estimate. We believe that resident consumption is likely at the lower end of the range. Moreover, to estimate total domestic supply, we assumed a "discard" rate of 10% - i.e., boats leave 10% of their catch in Palau – but recent estimates suggest that the rate may be as low as 6%, which would suggest resident consumption is even lower.

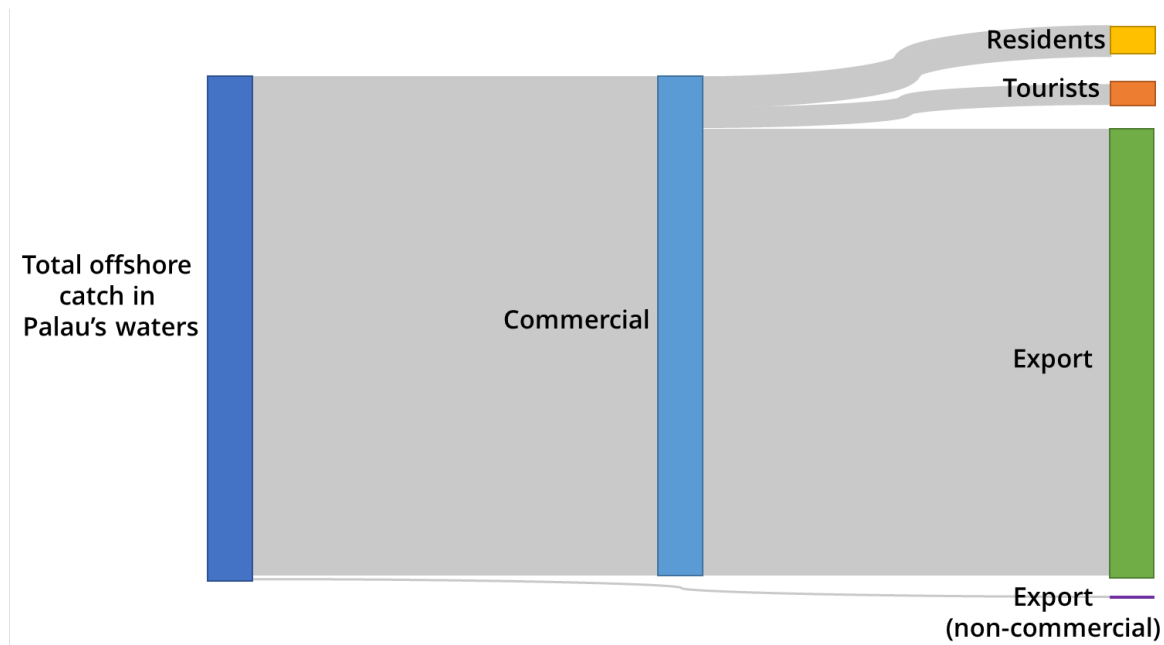


Figure 1. Destinations of pelagic fish caught in Palau's waters. The length of the bars corresponds to the proportion of the total catch.

The foreign-owned, longline and purse seine vessels dominate the offshore fishery, and the vast majority of the catch is exported. We characterized the actors and flows of fish for the fishery in Figure 2 and quantitatively estimated volumes in **Error! Reference source not found..** Almost all of Palau's industrial offshore fishing is conducted by foreign-owned vessels, some of which are based in Palau (A and B in Figure 2 and **Error! Reference source not found.**). In 2016, there were 87 industrial fishing vessels targeting tuna in Palau's EEZ, which caught an estimate 2,458 mt of tuna and 117 mt other pelagics (Bureau of Oceanic Fishery Management 2017). Of these, 30 were Japanese purse seiners and the remaining were longline vessels from Taiwan (33), Japan (19), China (3), and Vanuatu (2) (Bureau of Oceanic Fishery Management 2017). All Japanese vessels directly offload their catch in Japan (A, #1). The Taiwanese longline vessels are locally based and land their catches in Palau (B). These vessels are contracted by the three fishing companies: Palau International Traders Inc., Kuniyoshi Fishing Company, and Palau Tuna. Each vessel hires its crew and purchases bait and other supplies. The fishing companies organize direct export and sales after limited to no processing (Figure 2). The great majority (~95%, 1720mt) of tuna landings from locally based foreign-owned vessels is air freighted to Japan as whole, non-processed fish (#2). Exports to Japan are high quality (grade A, B+), while lower quality (grades B, C, D) tuna and non-tuna pelagics are "discarded" to the local market as whole fish and processed pieces (e.g., loin, belly) (94.7 mt tuna, 83.3mt non-tuna pelagics). A very small portion (approx. <1%) of fish that cannot be sold locally is frozen on the vessels and exported to Taiwan when vessels return to their home ports.

Pelagic fish that remain in Palau is sold directly by the fishing companies, and on-sold to a supermarket (1mt tuna, #3), restaurants (81.3mt tuna, #4), catering companies (6.4mt assorted pelagics, #5), prepared food stores (8.2mt tuna, 16.6mt other pelagics, #6), and an intermediary (at least 25.56mt tuna, 0.26 mt pelagics, #7).

A small, locally based, locally owned (LBLO) small-scale offshore fishery exists. In the two most populous states (Koror and Airai), 581 boats are registered, averaging 8-9m. Unpublished data from a survey of sportfishers suggest few vessels venture offshore to fish for pelagics on a regular basis. Similarly, an SPC study (James 2018) suggests most fishers do not fish offshore, and estimates approximately 45 mt of pelagics are caught by small scale fishers per year (C). Garz (2017) reported purchases by the fish market (2.4mt tuna; 3.5mt other pelagics, #9) and we found restaurants bought about twice that (4.17mt non-tuna pelagics, #11).

We estimate that restaurants, the dominant purchaser of tuna in the supply chain buy 133 mt of pelagic fish (G). Approximately 20% (26.2 mt, G) of pelagic fish bought by restaurants are non-tuna, or “other pelagics” that include mahi mahi, wahoo, marlins, and swordfish. Caterers buy tuna and other pelagics from foreign vessels (13.7mt assorted pelagics, #5), local fishers (3.5mt non-tuna pelagics, #12), and the fish market (1.7mt assorted pelagics, #17).

There is very little price markup of tuna through the value chain as price only experiences a major increase once it is sold by restaurants (Figure 3). The fishing companies sell pelagic discards in Palau as whole fish (\$3.70-5.50/kg tuna, depending on grade) or loins that have been vacuum packed (\$10-12/kg tuna) (Figure 5). (Notably, the unprocessed high grade tuna exports are taxed at \$0.35/kg. In 2014, this tax generated \$498,963 in revenue (Gillett 2016)). Waste is minimal through the chain. Businesses reported only buying what they need, and serving surplus fish before it spoils to employees as part of their benefits. Restaurants serve tuna raw in the couple of days after it is purchased, then in cooked dishes.

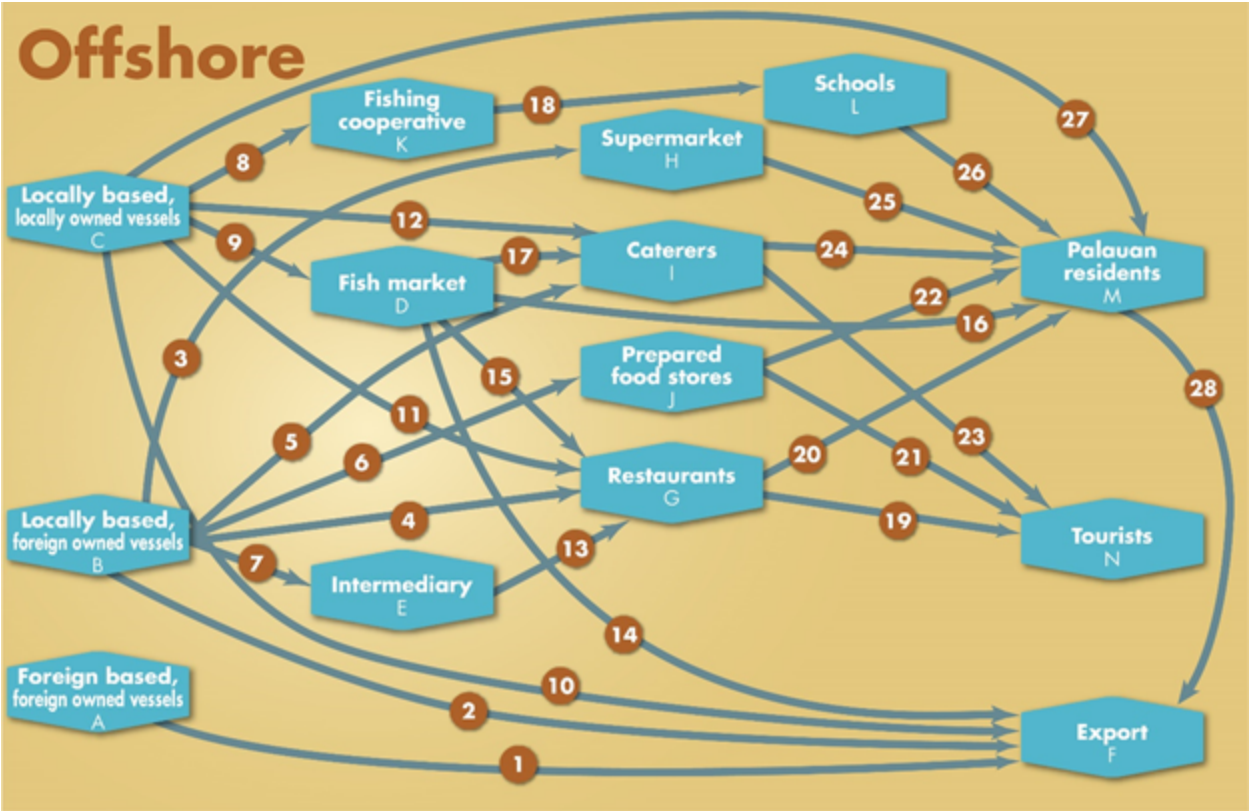


Figure 2. Offshore (pelagic) supply chain. Letters and numbers correspond to descriptions in Table X.

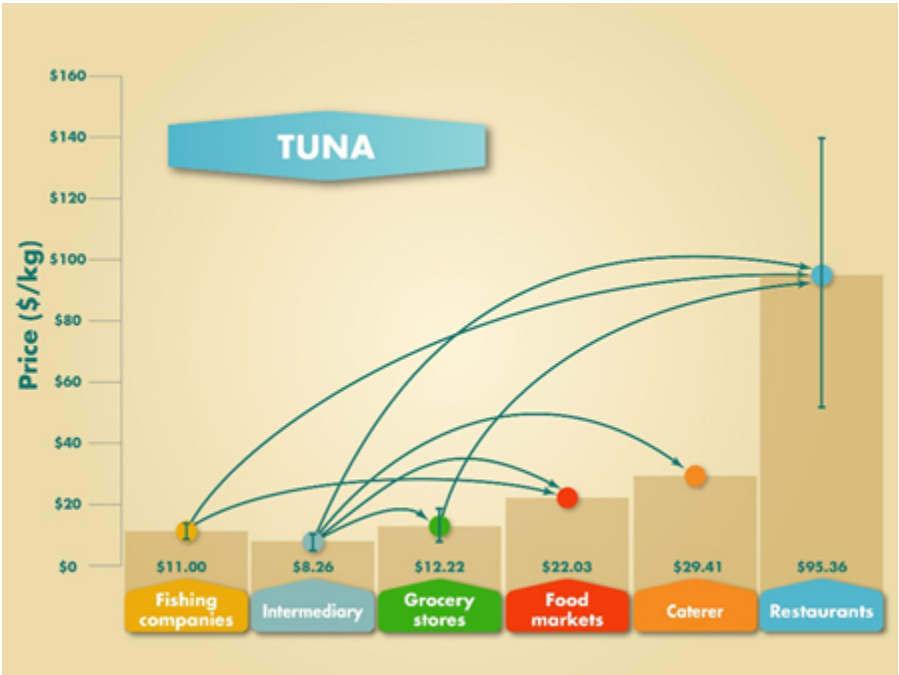


Figure 3. Mean price (per kg) for tuna loins through Palau's supply chain. Error bars represent standard deviations around the mean when more than one estimate was acquired.

Table 3. Offshore fishery flow descriptions and volumes. Flow letters and numbers in the first column correspond to the flows labeled in Fig. 2.

Flow	Description	Estimated annual volume	Estimate source
A	<i>Foreign based, foreign owned (FBFO) vessels.</i> In 2016, Japan had a fleet of 30 purse seine and 19 longline vessels fishing in Palau's EEZ. All of the Japanese fleet catch is transported directly to Japan (i.e., not landed in Palau). It is uncertain whether there are inter-vessel transport boats which transport catch from fishing vessels.	Total catches (all tunas and other pelagics): Purse seine (skipjack): 130mt (2016); Longline 550mt (2016) (516.7mt tuna; 33.7mt other pelagics)	Bureau of Oceanic Fishery Management 2017
B	<i>Locally based, foreign owned (LBFO) vessels.</i> In 2016, there were 33 Taiwanese, 3 Chinese, and 2 NiVanuatu longline vessels based in Palau. These Taiwanese vessels are contracted by three foreign owned companies: Palau International Traders Incorporated (PITI), Kuniyoshi Fishing Company (KFC) and Palau Tuna. Ninety percent of the catch is exported; 95% of exports go to Japan.	Total catches from BOFM reports: 1811mt tuna, 83.3 other pelagics; Tuna reported from interviews: Total: 1015mt (tuna), 44.5mt (other pelagics)	Bureau of Oceanic Fishery Management 2017 and this study (numbers do not add to total because total is based on Bureau of Oceanic Fishery Management 2017 and estimates of fish companies are from interviews).
C	<i>Locally based, locally owned (LBLO) vessels.</i> There are no domestic vessels dedicated to full-time offshore fishing, though small-scale fishers occasionally troll offshore for tuna and other pelagics.	45mt of pelagics, of which 43% is sold (19.35mt)	James 2018
D	<i>Fish market.</i> There is one main fish market in Koror. Locally-owned and operated trolling vessels supply assorted pelagic fish to the market.	Total volume purchased in 2015: 2.4mt (tuna); 3.5mt (other pelagics) (same as #9).	Garz 2017
E	<i>Intermediary.</i> In 2017, several restaurants reported that they purchased fish from an intermediary who bought from the fishing companies and sold to businesses. In our follow up interviews in 2018, we learned that the intermediary is no longer conducting business.	25.83mt (25.56 tuna, 0.26 pelagics) (same as #13)	this study
F	<i>Export.</i> Pelagic fishes are exported by FBFO and LBLO vessels. A small volume is also exported by Palauan residents.	2388.0 mt (total of all commercial exports); 2390.6 mt includes non-commercial exports	sources from A,B (minus 10% that remains in country), and Bureau of Budget & Planning 2016
G	<i>Restaurants.</i> Purchase tuna and other pelagics directly from fishers, from the fish market, from the fishing companies, and from intermediaries. Total volume is the estimated sum resulting from all these flows.	106.9mt (tuna); 26.2mt (other pelagic)	this study (SI)
H	<i>Supermarket.</i> One supermarket sells locally caught tuna belly and loins.	1mt (tuna)	this study

I	<i>Caterers. Cater both custom events (e.g., funeral, wedding, first birth) and non-custom events.</i>	19mt (assorted pelagics)	this study (SI)
J	<i>Prepared food stores.</i>	8.2mt tuna; 16.6mt other pelagics (same as #6)	this study
K	<i>Fishing co-operative.</i>	2.5mt. Likely an underestimate, as this is the estimated volume supplied to the Ministry of Education and does not include smaller volumes sold to local restaurants.	this study
L	<i>Schools. The Ministry of Education purchases fish from the co-operative to serve in schools.</i>	2.5mt	this study
M	<i>Palauan Residents. Estimated total volume only includes purchased fish and does not include non-commercial sources (e.g., family caught or gifted).</i>	55.3mt Likely an underestimate as this does not include volumes from market to resident and some LBLO to residents.	20+22+24+25+26+27 (+16)
N	<i>Tourists</i>	105-109.3mt	19+21+23; alternatively calculated by Lewis et al. as described in SI
1	FBFO to export	680mt (sum of reported purse seine and longline catches for 2016)	Bureau of Oceanic Fishery Management 2017
2	LBFO to export	1720mt (in 2016)	Bureau of Oceanic Fishery Management 2017; Garz 2017; Sisior 2006
3	LBFO to supermarket	1mt	this study
4	LBFO to restaurants	81.3mt (all tuna)	this study (SI)
5	LBFO to caterers	13.7mt (assorted pelagics)	this study (SI)
6	LBFO to prepared foods stores	8.2mt tuna; 16.6mt other pelagics	this study
7	LBFO to intermediary	At least 25.83mt (25.56 tuna, 0.26 pelagics) (same as #13), but could be greater if the intermediary supplied additional businesses beyond restaurants (see #13). Intermediary is no longer in business.	this study
8	LBLO to fishing cooperative	2.5mt (assorted pelagics)	this study
9	LBLO to fish market	Total volume purchased in 2015: 2.4mt (tuna); 3.5mt (other pelagics)	Garz 2017

10	LBLO to export	3.1 mt (tuna) commercial export (non-commercial export 2.6mt) in 2016. Same as #28 because we do not know how much is directly from fishers and how much passes through market first.	Bureau of Budget & Planning 2016
11	LBLO to restaurants	4.17mt (all non-tuna pelagics)	this study (SI)
12	LBLO to caterers	3.5mt (non-tuna pelagics)	this study (SI)
13	Intermediary to restaurants	25.83mt (25.56 tuna, 0.26 pelagics); Intermediary is no longer in business.	this study (SI)
14	Fish market to export	Uncertain. Less than 5mt, as this is total volume of reef and pelagic fish exported.	this study
15	Market to restaurants	5.2mt (other pelagics)	this study (SI)
16	Market to residents	Uncertain	
17	Market to caterers	1.7mt (assorted pelagics)	this study (SI)
18	Fishing cooperative to schools	2.5mt (non-tuna pelagics)	this study
19	Restaurants to tourists	82.6mt (tuna); 7.8mt (other pelagics)	this study (SI)
20	Restaurants to residents	24.3mt (tuna); 1.8mt (other pelagics)	this study (SI)
21	Prepared food store to tourists	3.3mt tuna; 8.3mt non-tuna pelagics	this study
22	Prepared food stores to residents	4.9mt tuna; 8.3mt non-tuna pelagics	this study
23	Caterers to tourists (excursion bentos)	7.3mt (assorted pelagics)	this study (SI)
24	Caterers to residents	4.0mt non-custom; 7.7mt custom (assorted pelagics)	this study (SI)
25	Supermarket to residents	1mt tuna	this study
26	Schools to residents	2.5mt (non-tuna pelagics, same as #18)	this study
27	LBLO to residents (i.e., sales in villages)	0.8mt (assorted pelagics, estimated total of four states)	James 2018
28	Residents to export	3.1 mt commercial export (non-commercial export 2.6mt) in 2016	Bureau of Budget & Planning 2016

Nearshore Fishery

Palauan residents consume the vast majority of the reef fish that are caught in Palau’s waters (

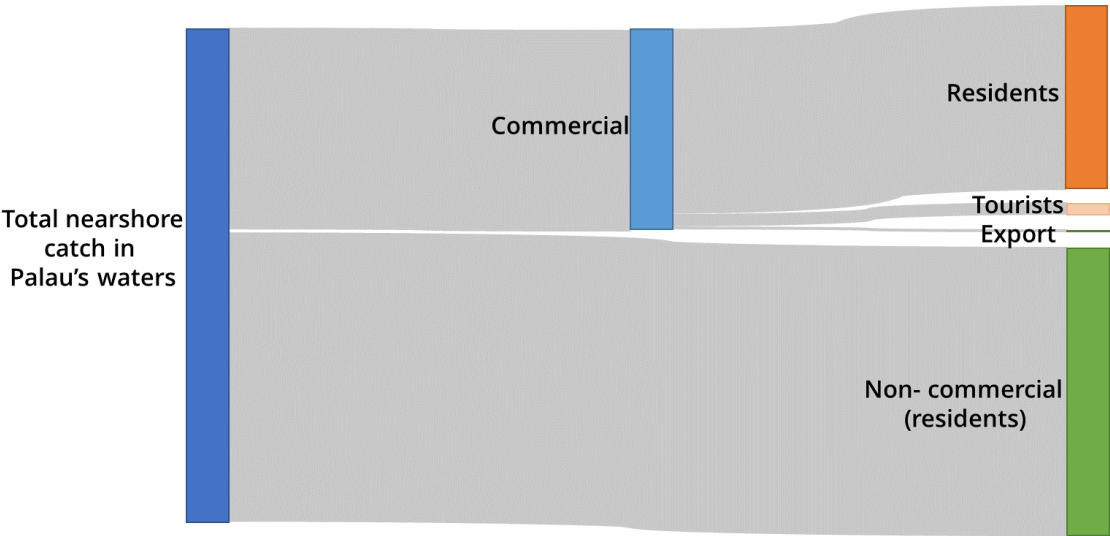


Figure 4), with the majority of residents obtaining reef fish through non-commercial means (e.g., catching themselves, being gifted). We found that tourists are only consuming between 1.9-3.9% of the total reef fish being caught in the country (4.7-9.6% of the commercial catch).

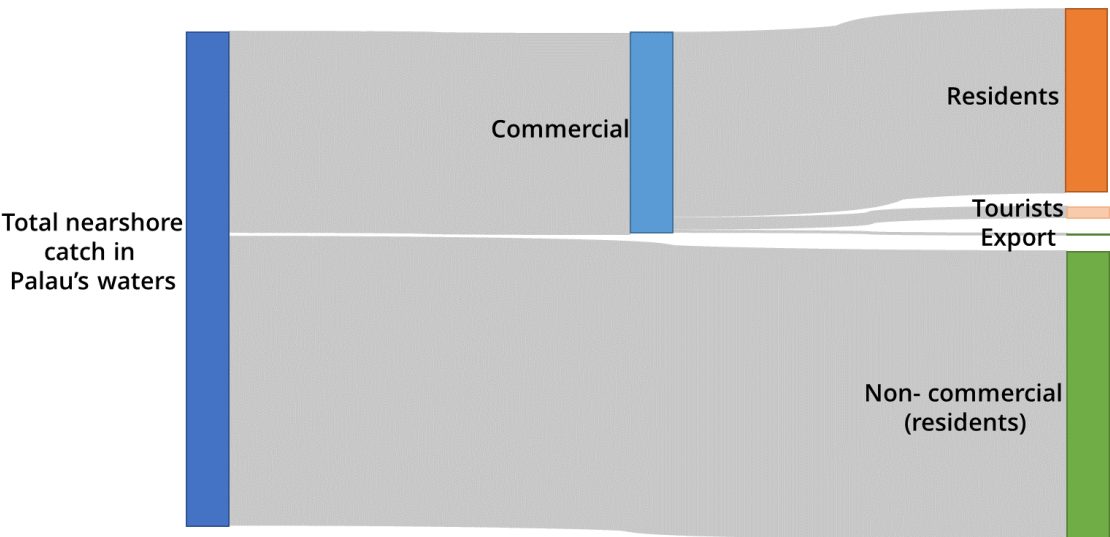


Figure 4. Destinations of reef fish caught in Palau's waters. The length of the bars corresponds to the proportion of the total catch.

Nearshore fishery flows are qualitatively and quantitatively described in Figure 5Figure 4 and **Error! Reference source not found.** Fishing on reefs and other nearshore areas is done by small-scale, local fishers; an estimated 1,700 fishing households in Palau (~35%) catch an estimated 2,115 mt of reef fish annually (A in in Figure 5 and **Error! Reference source not found.**), although a recent fisher survey in four states, when extrapolated to all 16, suggests this could be a gross underestimate; the true catch volume could be up to twice as much (James 2018). These fishers sell about 40% of their total catch (865 mt) (Gillett 2016). The fish market in Koror likely gets 20-50% of the catch (260-430 mt, C), although this estimate is uncertain (#3). As explained by the fish market owner, there are about 80 small-scale fishers that sell their catch to the market in Koror. About half of the fishers that sell to the market are line fishers (i.e., bottom fishing and/or trolling) that mostly fish during the full moon. The other half of the fishers are spearfishers that mostly fish during new moon. Three of the fishers who sell to the market use gill nets and mostly catch rabbitfish (Siganidae). The fish market's customer base includes restaurants (12.0mt, #11), overseas supermarkets (a large but unspecified portion of the 5mt total export from the fish market is reef fish, #13), and individuals (unknown, #14); during the election season, political campaigns purchase large volumes of fish for fundraisers (up to 20% of their supply).

One of the supermarkets (9.8 mt, #7), two prepared food stores (10.7 mt, #5), and all but one of the restaurants (23.7 mt, #8) interviewed buy reef fish directly from fishers. The prepared food stores cater to a mixed resident (6.1mt, #18) and tourist (4.6 mt, #19) customer base, while the supermarket sells almost exclusively to residents (#16), and also serves reef fish to its foreign resident workforce (#17) (9.8 mt total for the latter two flows).

Restaurants buy approximately 35.8 mt of reef fish annually (H) of which 66% is bought directly from fishers (#8) and 34% from the main fish market (#11). Parrotfish (Scaridae), emperorfish (Lethrinidae) (locally known as "white snapper"), and red snappers (Lutjanidae) are the most common reef fish listed on restaurant menus, though we also learned of restaurants serving unicornfish (*Naso spp.*), grouper (Serranidae), rabbitfish (Siganidae), and goatfish (Mullidae). On average, tourists make up 75% (29.3 mt total, #23) and residents 25% (6.4 mt, #21) of restaurant clientele. The fish preferences of tourists and residents reportedly differ; for instance, a popular restaurant that caters largely to local residents is known for its parrotfish dishes. Restaurants that cater more for the tourist market commonly offer "snappers" as their locally caught reef fish (though these dishes are likely to be a mix of emperor and snappers).

Reef fish are available in all interviewed restaurants, though fewer sold reef fish sashimi (76%) than cooked (91%).

115 mt of reef fish is exported (K) directly by fishers, individuals purchasing fish at the market or supermarket, and by the main fish market (#13), which sells fish to supermarkets in Guam. All commercial and non-commercial exports of marine resources are inspected before leaving the country. Coolers packed with fish are a common site at the airport and are required to be inspected at check-in. In 2015, over 60% of the estimated export biomass was made up of just six species of reef fishes, five of which are herbivores: bluespine unicornfish, *Naso unicornis* (29,120 kg), Pacific longnose parrotfish, *Hipposcarus longiceps* (14,842 kg), Bleeker's parrotfish, *Chlorurus bleekeri* (6,638 kg), humpback red snapper, *Lutjanus gibbus* (6,305 kg), orange-spine unicornfish, *Naso literatus* (6,167 kg), and lined rabbitfish, *Siganus lineatus* (4,295 kg) (BMR 2015). Over half of these exports were being sent to Guam, as reported by their exporters. It should be noted that the export volumes are estimates, as Coastal Fisheries Officers conducting the inspections do not always take weight measurements.

Focusing on the value added along the value chain, reef fish remain relatively stable in price until they are sold by food markets and restaurants (Figure 6). Prices for reef fish at the fish market have reportedly remained stable for about 20 years. The market sells whole reef fish with minimal processing for \$5.29-5.51/kg, after purchasing it from fishers at \$3.63-\$3.85/kg (though they noted they will pay slightly more for larger fish). They reported the small markup accounts for spoiled fish, although spoilage is minimal as on most days, all fish tend to be sold by 10am. The increased price at prepared food markets and restaurants reflects value added associated with fish preparation for consumption. Individual entrepreneurs process fish for bento boxes that they sell to small convenience stores and roadside stalls that on-sell the boxes to local customers for approximately \$2.50 (contains ~0.5kg of whole reef fish). Food markets sell prepared fish dishes that can range from \$5.50-\$7.50, depending on species, size, and preparation. The largest markup is seen in the fish sold in restaurants, which shows a large amount of variation (\$11-60/kg, based on whole fish equivalent weight).

Imports

Imports of canned and frozen fish add substantially to fish consumption and are very close substitutes to fresh fish in Palau. Palau Conservation Society (2000) estimated that 610mt of fish and marine products were imported to Palau in 2000 and Bell *et al.* (2009) estimated that only 78% of fish consumed was fresh fish, the remainder being largely canned fish. Several species of imported fish are sold in supermarkets. A supermarket owner explained that basa (*Pangasius bocourti*) is in high demand by caterers and by hosts of large events such as funerals. Imported, frozen basa is relatively expensive (\$19.50/kg) compared to other imported fish, such

as sanma (\$5/kg) and salmon (\$14/kg), etc. and locally available fish (reef at ~\$5.40/kg, tuna at ~\$12.20/kg). Imported canned fish, including tuna (\$1.25/7 oz. can) is also readily available in supermarkets and is purchased by individuals and restaurants.

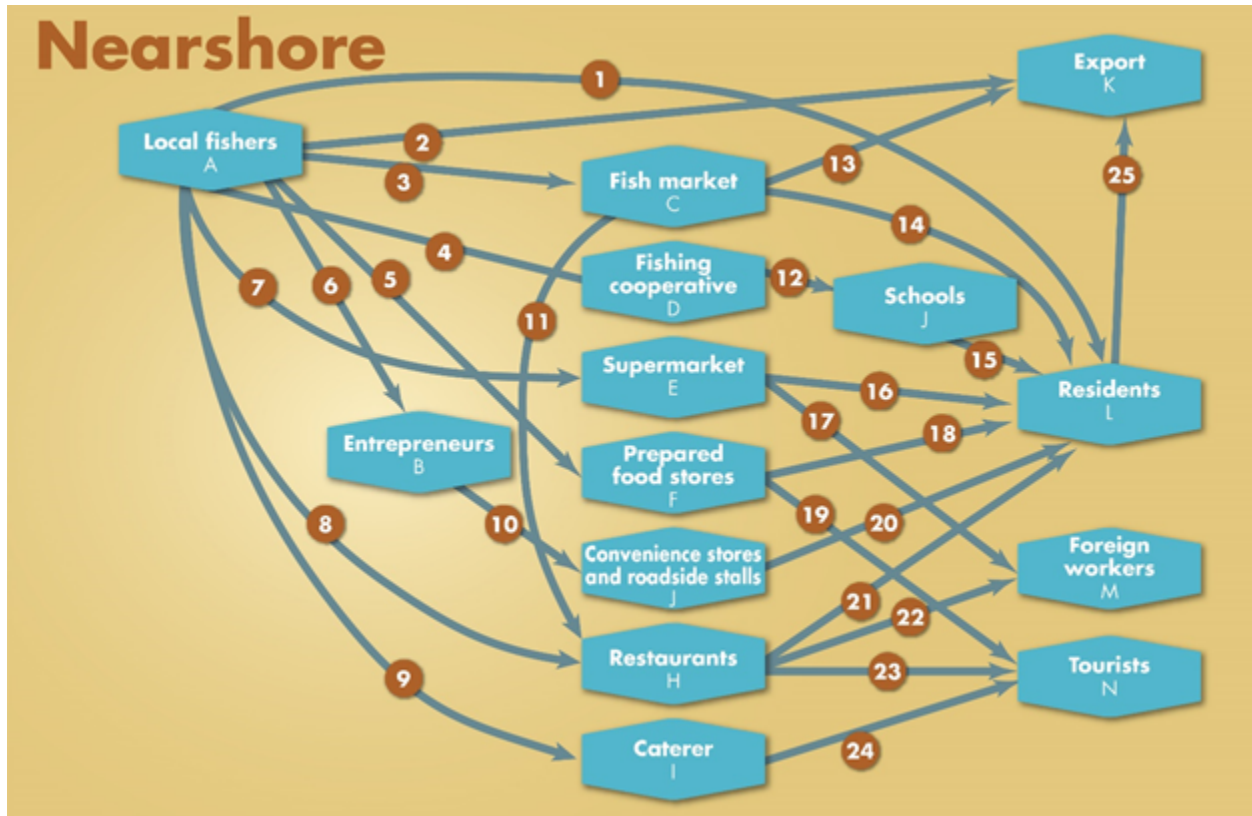


Figure 5. Nearshore (reef) supply chain. Letters and numbers correspond to descriptions in Table X.

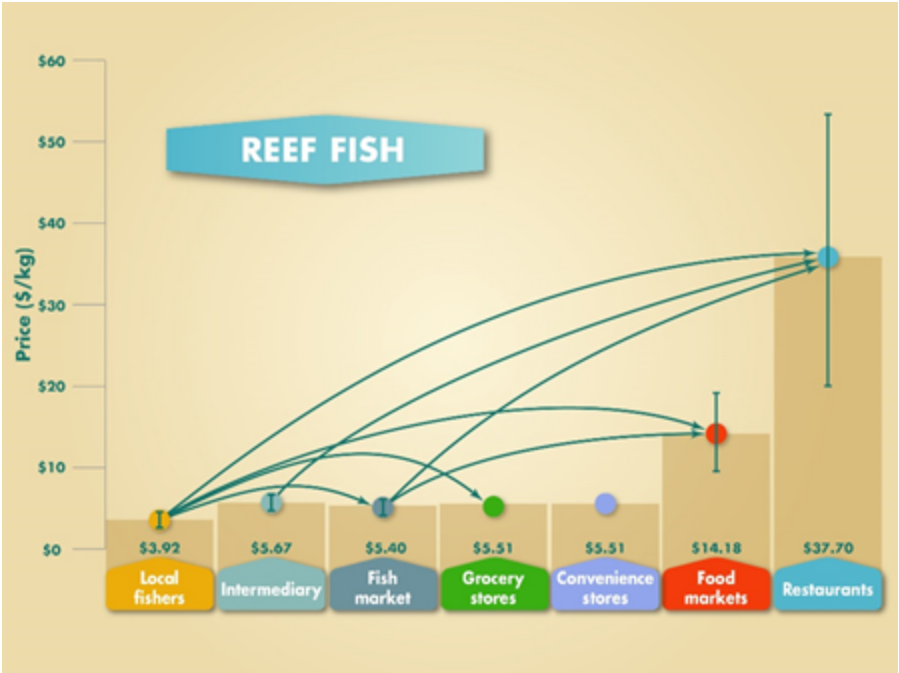


Figure 6. Mean price (per kg) for whole reef fish through Palau’s supply chain. Error bars represent standard deviations around the mean when more than one estimate was acquired.

Table 4. Nearshore fishery flow descriptions and volumes. Flow letters and numbers in the first column correspond to the flows labeled in Fig. 5.

Flow	Description	Estimated annual volume	Estimate source
A	Local fishers	2,115mt total of which 865mt is estimated commercial (in 2014)	Gillett 2016
B	Entrepreneurs. Prepare bento boxes that are sold in convenience stores and roadside stalls.	19.4mt (same as G)	
C	<i>Fish market.</i> There is one main fish market in Koror. Local fishers bottom fish, troll, gillnet, and spearfish for reef fish to supply the market. It is anecdotally estimated that 20-50% of reef fish caught in the country flows through the main fish market.	260-430mt (based on 2014 catch estimates)	Gillett 2016
D	Fishing cooperative. Total flow is likely an underestimate, as this is the estimated volume supplied to the Ministry of Education and does not include smaller volumes sold to local restaurants.	1.3mt. Likely an underestimate, as this is the estimated volume supplied to the Ministry of Education and does not include smaller volumes sold to local restaurants.	
E	<i>Supermarket.</i> A single supermarket sells reef fish that is bought from local fishers and sold frozen. This is a different supermarket from the one in Table X that sells local tuna.	10mt	this study
F	Prepared food markets	10.7mt (same as 5)	this study
G	Convenience stores and roadside stalls	19.4mt	this study (SI)
H	Restaurants	35.8mt	this study (SI)
I	Caterers	same as 9	this study (SI)
J	Schools. The Ministry of Education purchases fish from the co-operative to serve in schools.	1.3mt (same as 12)	this study
K	<i>Export</i>	10.1mt commercial; 104.8mt non-commercial (2016)	Bureau of Budget & Planning 2016
L	Palauan residents (commercial)	43mt (not including unknown #1,#14 and not including non-commercial flows)	1+14+15+16+18+20+21
M	Foreign workers. Employers sometimes provide meals to their foreign workers at the workplace or in company barracks.	unknown	

N	Tourists	40.7mt-83.3mt	19+23+24 and Lewis et al. (forthcoming) (SI)
1	Local fisher to resident (i.e., direct sales)	13% (275mt) of landed fish is sold in roadside stalls	James 2018
2	Local fisher to export	31-33mt	James 2018
3	Fisher to fish market	150mt (in 2015). But see C--this estimate is substantially lower than anecdotal accounts (in Gillett 2016) of half of the commercial catch flowing through the fish market.	Garz 2017
4	Local fishers to fishing cooperative	1.3mt	this study
5	Local fishers to prepared food stores	10.7mt	this study
6	Local fishers to entrepreneurs	unknown, but at least 19.4mt (from 10)	this study (SI)
7	Local fishers to supermarket	9.8mt	this study
8	Local fishers to restaurants	23.7mt	this study (SI)
9	Local fishers to caterers	6.8 (commercial, same as #24); 71.1mt (non-commercial)	this study (SI)
10	Entrepreneurs to convenience stores and roadside stalls	19.4mt	this study (SI)
11	Fish market to restaurants	12.0mt	this study (SI)
12	Fishing cooperative to schools	1.3mt	this study
13	Fish market to export	uncertain. Less than 5mt, as this is total volume of reef and pelagic fish exported.	
14	Fish market to residents	unknown	
15	Schools to residents	1.3mt	this study
16	Supermarket to residents	less than 9.8mt (9.8mt total is used for store sale and served in employee barracks)	this study
17	Supermarket to foreign workers	less than 9.8mt (9.8mt total is used for store sale and served in employee barracks)	this study
18	Prepared food stores to residents	6.1mt	this study
19	Prepared food stores to tourists	4.6mt	this study
20	Convenience stores/roadside stalls to residents	19.4mt (assumes all are sold to residents)	this study (SI)
21	Restaurants to residents	6.4mt	this study (SI)
22	Restaurants to foreign staff	unknown	
23	Restaurants to tourists	29.3mt	this study (SI)

24	Caterers to tourists (excursion bentos)	6.8mt	this study (SI)
24	Residents to export	10.1mt commercial; 104.8 non-commercial	Bureau of Budget & Planning 2016

3. What is the current market demand for reef and pelagic fish?

PNMS implementation includes the development of a domestic fishing fleet, which could supply the domestic market. However, beyond assumptions by Garz (2017), little is known about the local demand for reef and pelagic fishes, and nothing is known about substitution between them. Our project assessed tourists' diet preferences. As tourism visitation grows, tourists' diet preferences will have implications for demand of reef and pelagic fish. Subsequent work from June 2018 evaluated resident preferences, for fish, as well as imported foods. Having a handle on the demand curves (how much of what fish is demanded at what price) is important information for estimating future local demand. This information will be critical to assessing the viability of a domestic, pelagic fishing fleet.

Tourist Demand

METHODS

We evaluated tourists' fish preferences, current consumption rates, and willingness to pay and substitutability for fish types. We deployed tablet-based (Lenovo A10) surveys from August 2017- January 2018. Tourists were surveyed at restaurants, tour sites, and the airport. Tourists were defined as people who were in Palau for 30 days or less. The survey was translated and back translated into four languages: Korean, Chinese (mainland), Chinese (Taiwan) and Japanese. The survey was piloted during three periods (January, March, and August 2017).

Along with demographic questions, the survey contained three major sections: 1. Consumption; 2. Choice experiment (willingness to pay); and 3. Environmental perceptions, PNMS awareness, and fish preferences. For consumption, respondents were asked to count the number of breakfasts, lunches and/or dinners that contained seafood, the type of seafood and the number of days currently and expected to spend in Palau. The discrete choice experiment section was a series of mock restaurant menus with different types of proteins at different prices, including fish, non-fish and non-meat choices (Figure 7). Respondents went through a series of twelve different menus, all with different prices and different types of protein choices (i.e., reef fish, raw tuna, meat, etc.). Menu choices also included a "local sustainable" brand for tuna and pelagic fish. Data collected in the choice experiment was used to estimate respondents' willingness to pay for certain fish and their substitutability to other fish types were assessed. In the final section, tourists were asked a series of questions about their attitudes toward

environmental statements, awareness of the PNMS, and factors influencing what fish they order.



Figure 7. Example choice experiment menu card.

RESULTS

The response rate was approximately 80%, with most observations of refusal during airport surveying in January 2018. Surveyors were trained in surveying techniques and on this survey's delivery and question executions. In total, 426 surveys were collected, of which 409 were valid. The average duration time for surveys was 16 minutes (± 9 mins).

The 409 valid surveys came from the following nationalities (Figure 8): Chinese (98); Japan (74); Korea (43); Taiwan (53); USA (54); Other (Australian/European) (76); and Missing (11). This representation roughly follows tourist trends from 2012-2017. Chinese (73% of all Chinese tourists) and Taiwanese (74%) visitors were more likely to be in the low income category, while Japan (39%), Other (Aus/Eur) (38%) and United States (28%) were least.

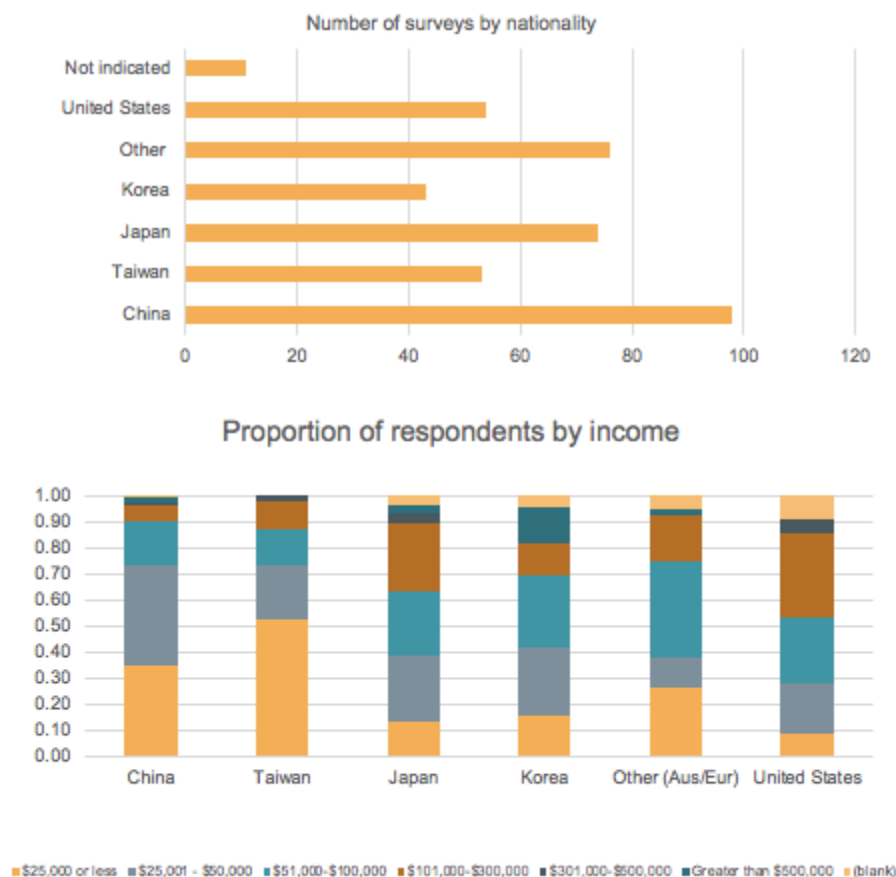


Figure 8. a) Number of surveys by nationality; b) proportion of respondents by nationality and income.

Tourism consumption

Tourist fish consumption for each nationality was calculated using average fish meals per day and average length of stay (both of which differed by nationality, see Table 5) and average meal portion size. US tourists seem to eat fish more frequently than any other nationality. Table 6 enumerates consumption-by-nationality for a given year (2016), based on the above parameters and that year's visitation rates. Notably, using this method to determine tourist consumption to other years will be sensitive to visitation numbers.

Table 5. Average length of stay and average meal per day of three fish types (reef, tuna and pelagic) of survey respondents grouped nationality.

Nationality	Avg stay (days)	Reef fish (# meals/day)	Tuna (# meals/day)	Pelagic (# meals/day)
Chinese	5.71	0.10	0.07	0.02
Japanese	6.15	0.08	0.08	0.05

Korean	6.22	0.05	0.09	0.03
Taiwanese	5.70	0.07	0.07	0.03
US	8.69	0.12	0.13	0.03
Other (Aus/Eur)	10.83	0.08	0.10	0.06

Table 6. Tourists' annual consumption of three fish type by nationality based on 2016 visitation rates.

Nationality	Reef	Tuna	Pelagic	TOTAL
Chinese	38.75	29.66	8.18	76.59
Japanese	15.66	15.60	9.84	41.11
Korean	3.93	7.00	1.98	12.91
Taiwanese	6.56	5.65	2.40	14.61
United States	9.06	9.61	2.49	21.16
Other (Aus/Eur)	9.40	9.97	2.58	21.95
TOTAL	83.37	77.49	27.47	188.33

Tourism choice experiment

Tourists (as a group) prefer raw reef fish, raw tuna, and other pelagic, and are ambivalent about whole reef fish. When grouped by nationality, both Chinese and Taiwanese tourists are ambivalent to the meal's content, except Chinese tourists like raw reef fish and Taiwanese like raw tuna. United States tourists prefer pelagic and raw tuna, and do not prefer whole reef fish. Generally, higher income tourists are willing to pay more than lower income tourists for fish. When nationalities are grouped by income, higher income Chinese look a lot more like United States and Other respondents than their national counterparts, except these Chinese tourists have a very strong preference for raw reef fish. Interestingly, overall 94% of tourists said they

are willing to come to Palau even if they cannot eat reef fish. All income brackets are willing to pay a up to \$10 extra above the existing base price for a meal for “local, sustainable” tuna and other pelagic fish. The additional amount people are willing to pay rises with income, and differs across nationality and type of fish.

The choice experiment enables us to model demand for reef fish and pelagic fish (including tuna) when prices change. Tourists will eat more reef fish if the price of pelagic meals increases. As an illustration, we ran some scenarios to test the effect of a price increase in pelagic fish. Results are reported in Figure 9. The panel on the right-hand side (a), shows that there is a significant substitution effect, i.e. most of pelagic consumption is diverted to reef fish when the price of pelagic-based dishes increases. On the other hand, the demand for other types of food remains roughly the same. For example, a \$10 increase in pelagic meal price would result in a 20% increase in demand of reef fish, and the trend persists as the price goes up. Notably, this substitution effect towards reef fish is strongly mitigated if pelagic fish is provided by a local, sustainable pelagic fishery. Since tourists are willing to pay more if the fish is sustainably caught, a \$10 price increase in pelagic meals AND a switch from the regular pelagic fishery to a sustainable one, would generate consumption patterns very similar to those in the baseline case (panel b). This means that tourist preferences can potentially be exploited to finance a locally sustainable pelagic fishery.

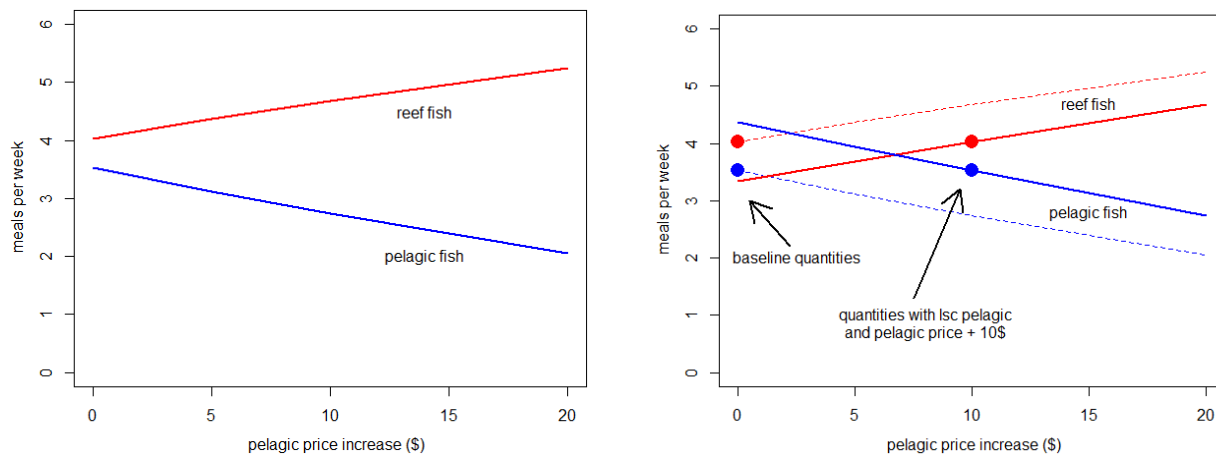


Figure 9 a) Demand function of reef fish and pelagic fish for different levels of pelagic price increase; b) change in the demand functions when pelagic fish is locally sustainable.

When asked to rank the importance of seven factors (type of fish, price, preparation, origin, freshness, cut of fish and environmental impact) to determining the fish they order, freshness was most important to tourists, followed by preparation, price and environmental impact (Figure 10). These preferences differed by nationality.

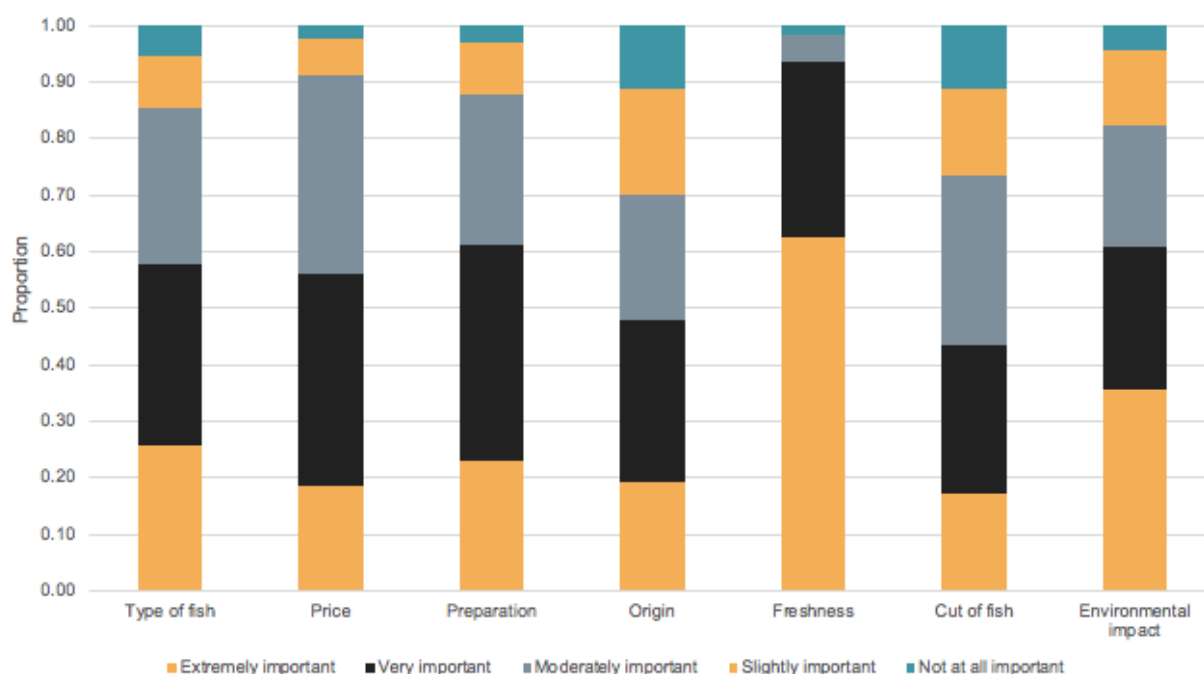


Figure 10. Importance rankings for seven factors that determine what fish meals tourists order.

Resident Demand

METHODS

Trained surveyors conducted structured surveys from June 2018-October 2018 with Palauan residents on tablets. Respondents were adults (over age 18) who identified as being aware of their household's food consumption and purchasing habits. A total of 335 valid surveys were conducted; 95 rural residents (34% female, 66% male), 65 peri-urban residents (57% female, 43% male), and 175 urban residents (38% female, 62% male). 92% of respondents were Palauan citizens.

The urban surveys took place in the states of Ngeremlengui and Ngiwal; peri-urban in Aimeliik; urban in Koror. We designed a protocol to survey a random sample of the households in each state using census data from each of these sites. Surveys contained questions about the frequency of consumption of different proteins, sources of consumed fish, and a choice experiment and contingent valuation questions to estimate the willingness to pay for different proteins. The choice experiment posed a hypothetical trip to the grocery store, and asked respondents to choose between various proteins (e.g., tuna, other pelagic, pork, chicken) with different prices (Figure 11). The design of the experiment allows us to estimate their willingness

to pay for and substitution between the items, and ultimately define a demand function for each. Average survey length was 20 minutes.

These are the odoim choices in the store during your first visit. Which would you choose?

- ☐

Pork chops

\$3.75

per pound
- ☐

Fresh whole reef fish

\$7.50

per pound
- ☐

Fresh Palauan caught tuna loin

\$18.50

per pound
- ☐

Fresh standard tuna loin

\$7.00

per pound
- ☐

I would not choose to purchase an odoim given these choices

Figure 11. Example of a choice card for residents.

RESULTS

Resident consumption

Ninety percent of households report eating fish in the last week. Only three households (<1%) indicated that they never consume fish. Reef fish, chicken, and canned fish products are the most frequently consumed proteins, with slight differences between the rural, peri-urban, and urban populations (Figure 12). Interestingly, the urban population consumes reef fish more frequently than the other populations, with about half of the urban sample reporting daily consumption of reef fish (Figure 12). Tuna and other pelagic fish are not commonly consumed; more than half of the samples in each population report rarely or never eating these types of fish each month (Figure 12). When asked why they didn't eat tuna, most people said that the price of fish was too high (n=140), or that the type of fish was not available (n=68); "I

do not like this fish” (n=24) and “For health reasons” (n=25) were the other responses. A similar pattern held for non-tuna pelagics, although more people than with tuna said they do not like the fish.

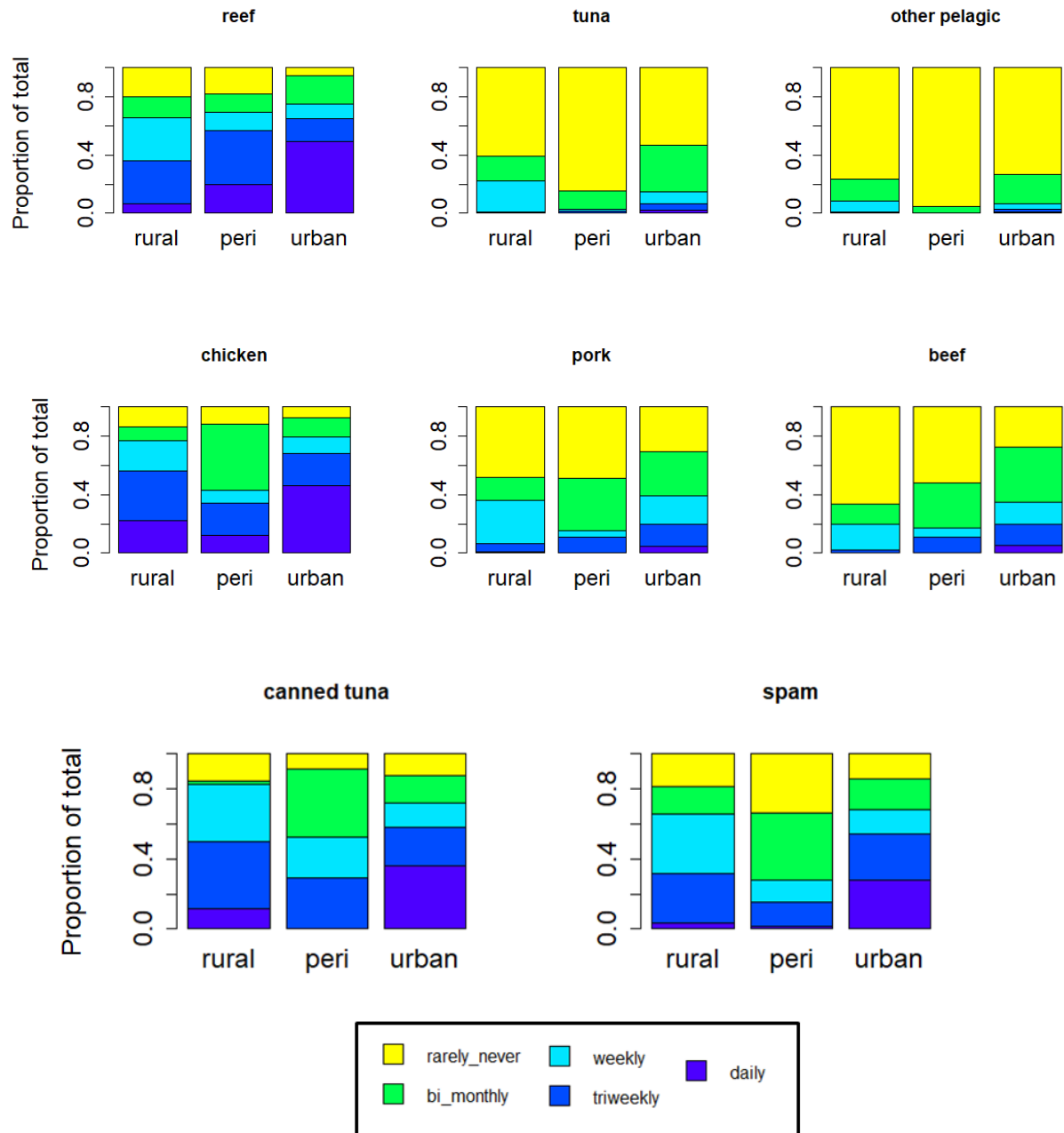


Figure 12. Frequency of a. reef fish; b. tuna; and c. non-tuna pelagic fish consumption. Each bar represents a different population of Palauan residents (rural, peri-urban, urban). Different colors correspond to different frequencies of monthly consumption.

The composition of source of consumed fish is similar across the populations, with less than 20% of fish meals being purchased and the remaining caught or gifted (Figure 13). When we asked specifically about reef fish purchased in the last month, we see more variation between the populations; about half of urban households purchase reef fish at least twice a month, while the same is true for about 20% or less or rural and peri-urban households (Figure 14).

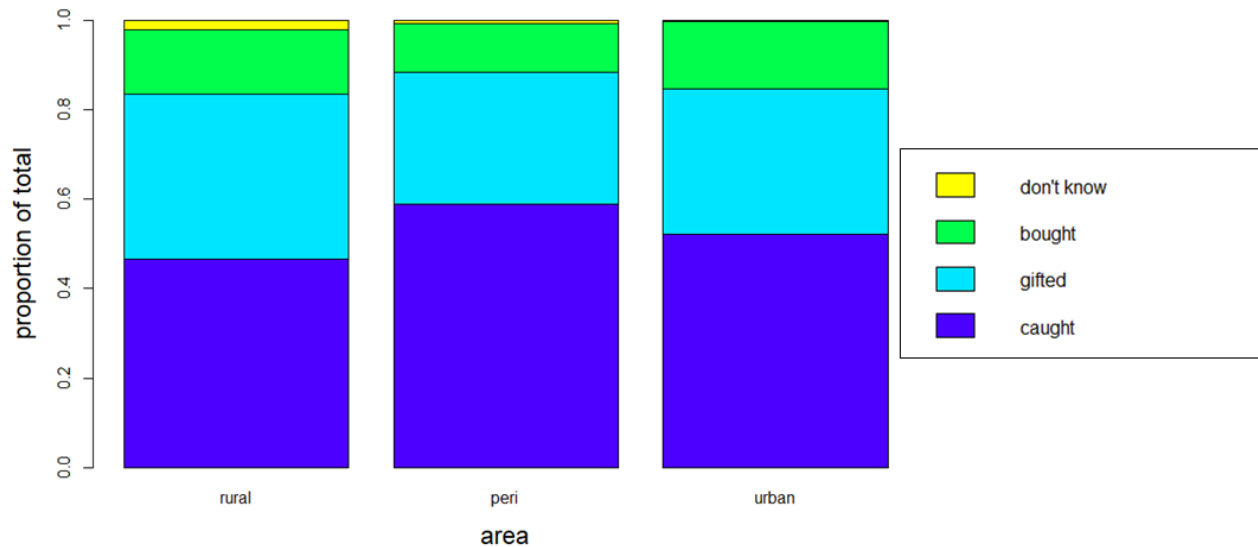


Figure 13. Proportion of total fish meals from different sources (bought, gifted, caught). Data gathered by asking respondents about the source of the fish in meals consumed in the past two days.

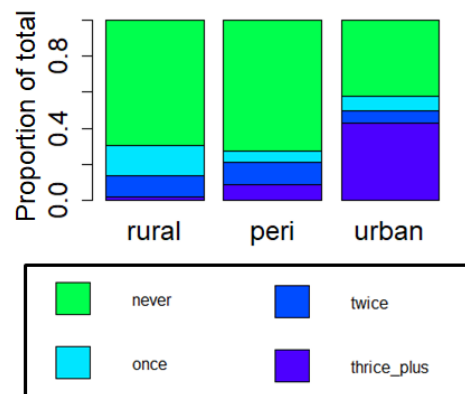


Figure 14. Frequency of monthly reef fish purchases by rural, peri-urban, and urban households.

Resident choice experiment

We focused our analysis on the choice experiment data from the urban and peri-urban respondents. The data from the rural respondents' choice experiments did not pass our data quality control, unfortunately, likely due to the fact that rural residents had a harder time believing the hypothetical scenario of buying fish. Rural households make up only 20% of the country's population. Our estimates based on the urban and peri-urban households should be characteristic of the majority of the country's population, particularly the portion of the population most integrated into the market economy. Willingness to pay estimates from the choice experiment are presented in Table 7. Notably, residents had the highest WTP for reef fish, reflecting a strong preference. Residents also were willing to pay extra for quality tuna, and preferred chicken over beef, pork, fresh pelagic, and normal quality tuna. Notably, the WTP results seem high, but certainly offer insight into relative values.

We used contingent valuation, another method to estimate willingness to pay, to better understand the willingness to pay of the population who do not normally buy tuna or other pelagic. We found that non-buyers were willing to pay \$4.94/lb on average for tuna and \$3.51/lb for non-tuna pelagic. There were Notably, these prices are below the current market price of about \$7/lb and \$6/lb, respectively.

Table 7. Resident mean willingness to pay (WTP) for different protein types. Estimates were calculated from data from the choice experiment.

Protein type	Mean WTP
Canned meat	\$4.36 per 12 oz can
Frozen sanma	\$7.43 per pound
Pork chops	\$11.99 per pound
Beef cubes	\$14.09 per pound
Canned tuna	\$16.22 per 12 oz can
Fresh normal quality tuna loin	\$19.66 per pound
Fresh pelagic fillet	\$20.33 per pound
Chicken quarters	\$23.16 per pound

Fresh high quality tuna loin	\$23.56 per pound
Fresh whole reef fish	\$25.99 per pound

4. What insights does this research provide to potential future impacts of PNMS?

Development of the domestic fishery

Without intervention, the PNMS's area restrictions and export ban could drastically diminish the domestic supply of tuna and other pelagic fish, as it will likely not be economically rational for the industrial vessels to continue to land fish in Palau. Support for a domestic offshore fishery is built into the PNMS Act to mitigate this impact. This fishery would need to be designed to meet local (resident and tourist) demand, at prices they are willing to pay. Ideally, the fishery would take advantage of value added opportunities to maximize economic returns. Finally, the program supporting the offshore fishery would need to address key barriers.

Our value chain results provide insight into the amount of fish currently demanded, and our choice experiments deliver demand models that we can use to predict future demand of fish under different prices. We found a key value-added opportunity in developing a local, sustainable brand for tuna and other pelagic fish, as tourists seem willing to pay extra for these meals. We interviewed retailers about the possibility of value added products (e.g., smoked, dried, salted fish), but most retailers did not think that their customer base would be interested in such products. Encouragingly, both residents and tourists were willing to pay more for higher quality pelagic fish. That said, there is a need for greater capacity building and support in order for a domestic offshore fishery (and sustainable local brand) to be successful. Initial steps have been taken (e.g., tuna handling trainings, connecting well trained local fishers to restaurants willing to pay extra to get high quality tuna), but fisher training is especially needed as it does not seem like many local fishers know how to fish for tuna, and some restaurant owners doubted fisher skills to deliver high grade tuna. Support for infrastructure upgrading is also necessary as most businesses do not currently have the cooling capacity to store high grade fish. A local offshore fishery would also benefit from a market study on how best to promote the new fishery and education of customers on how to recognize high quality and/or local, sustainable tuna.

A number of fishers occasionally troll offshore for tuna and other pelagics, but there are no domestic vessels dedicated to full-time offshore fishing. In the recent past, a single domestic pole and line vessel supplied Palau with an estimated 100 mt of catch (Gillett 2016). The vessel

ceased operations in recent years when the captain became ill and passed away, but there is talk that it is gearing up to start operations again under new leadership (Sisior, pers. comm.). In the resident survey, we asked about households' current offshore fishing activity. Of the 177 respondents that reported fishing, only 15 (<10%) report that they currently fish offshore and 28% report that they would likely or very likely start fishing offshore after PNMS is fully enacted. Respondents cited "fuel price" and "access to a boat and equipment" as the two most common reasons for not currently fishing offshore. Eighty percent of the respondents that do currently fish offshore noted that they would likely or very likely increase their frequency under PNMS. We also investigated fishers willingness to enter the offshore fishery (or increase their efforts offshore) in the sportfisher survey funded by Oceans5. Results of that survey are still being analyzed, though the trends appear similar to what we report here.

PNMS and tourism visitation

The PNMS may increase Palau's attractiveness for some tourists. Palau already has a high profile with eco-tourists due to its natural beauty, coral reefs, and conservation efforts (e.g., the shark sanctuary). We would expect that the PNMS could further influence tourists' choices to vacation in Palau due to perceptions that the PNMS could improve tourists' experience, that the PNMS is yet another indicator of a conservation ethic that tourists want to support, or that the PNMS offers unique educational or research opportunities. It is difficult to ascertain how much the PNMS specifically contributes to tourism-related revenue, as Palau has many attractions. However, over time, one indicator could be awareness of the PNMS and its importance for tourist decision-making. In our survey in 2017, most (64%) respondents said they were not aware of the PNMS prior to making their trip. This rate differed by country, suggesting that targeted marketing may be having an effect (Figure 15). Interestingly, 36% of the all respondents were aware of the PNMS prior to their trip, 15% said the PNMS was important to their decision to travel to Palau, and 7% of respondents indicating they would not have come to Palau if it weren't for the PNMS. These results suggest that there is room to improve awareness of the PNMS, and that the PNMS could serve to motivate tourism.

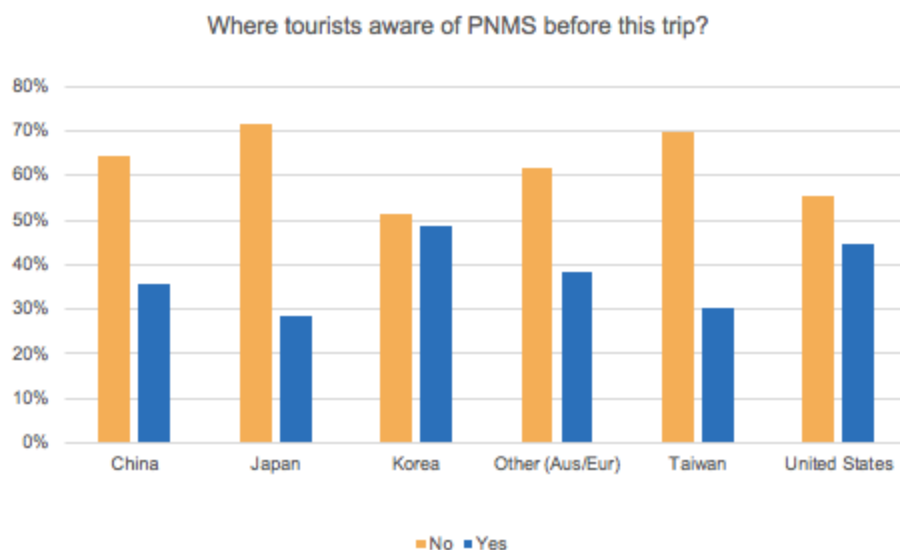


Figure 15. Percentage of tourists aware of the PNMS prior to their visit to Palau.

Changes to government revenue

To prepare for full enactment of the PNMS, the act stipulates a “winding down” period, in which baseline vessel days (i.e., the number of vessel days used in 2014) were reduced by 20% in 2016; and an additional 10% from baseline in each subsequent year until full enactment in 2020. This appears to be occurring for the LL VDS, but it is uncertain whether this is being followed for the PS VDS, because PS VD can be transferred for use in other EEZs. There has been no official statement on what will happen to Palau’s vessel days upon full implementation of PNMS. However, there is a sense that Palau will be able to keep its allotment come 2020 (Hanich, pers. comm.). In the 2015 Micronesian Presidents Summit, a letter was drafted by heads of state, calling on PNA members to be supportive of Palau as they moved forward with the PNMS Act (Senase 2015). Further, other PNA members have not been penalized for other protected area closures (e.g., Phoenix Islands Protected Area in Kiribati) (Hanich, pers. comm.).

Table 8 estimates the potential losses of revenue under full enactment of the PNMS under four scenarios. In Scenario 1, Palau is able to keep its current allotment of purse seine vessel days (700) to transfer to other parties at the current benchmark price (\$8,000/day). Scenario 1 is likely if Palau retains its PAE, but the US no longer purchases its days (note, US is currently purchasing days at \$12,500). Scenario 2 is the same as the first scenario, except instead of being able to transfer its days at the current benchmark price, it is able to transfer its days for \$12,000 (to account for current price to US of \$12,500, which will increase in accordance with the US Treaty, and also the general increasing trend in the value of PS vessel days). It should be noted that if PAE continues to be calculated based on effort and biomass, and if Palau continues to be allocated vessel days, its PAE will decrease as effort in its EEZ reaches zero. In

Scenario 3 and 4, Palau loses all of its PS vessel days, at \$8,000/day and \$12,000/day, respectively. In all scenarios, all longline vessel day and export tax revenue are lost. Longline vessel day loss is calculated using an average value of \$200 for 10,500 days. Export tax loss is calculated given the average tax revenue from 2012-2014 (\$482,236 from Gillett 2016).

Table 8. Estimated revenue losses under different scenarios of PNMS (in USD).

Scenario	PS VDS	LL VDS	Export tax	Total revenue loss
1	0	-2,100,000	-482,236	-2,582,236
2	0	-2,100,000	-482,236	-2,582,236
3	-5,600,000	-2,100,000	-482,236	-8,182,236
4	-8,400,000	-2,100,000	-482,236	-10,982,236

Study challenges and limitations

Understanding the protein preferences of rural people is necessary to accurately model current and future demand, and better estimate the impacts on food security and nutrition of any policy change. The survey techniques used to estimate rural willingness to pay in this study proved inadequate due to the non-market nature of fish in rural areas. We knew this might be an issue, but were unsuccessful in designing a choice experiment that produced results of sufficient quality. One option to document consumption would be household dietary journals, although this would require significantly more effort, and would need to be paired with market surveys to provide information for a demand function.

Our methods relied upon people (tourists, residents, and actors in the supply chain) reporting their consumption, purchases, and preferences. While this is an adequate research approach, ideally, we would have actual data on sales and purchases, from which we could derive preferences.

We had some trouble accessing key pieces of data that we believe would be very helpful to design research and provide sound policy advice to the government on food security and/or fisheries sector development. These included detailed household expenditure and income survey data and spatially explicit catch data, which the government and regional technical support agencies (e.g., FFA, SPC) guard closely.

Outputs and outcomes

In addition to this final report, the team is preparing three publications for submission to peer reviewed journals. Each of these will be co-authored with team members at PICRC:

- Value chain - Fish and Fisheries
- Tourism demand, WTP, and substitution effects - Marine Policy
- Overall demand, WTP, supply, and implications for domestic fishery - TBD

Throughout the project, the team conducted outreach to audiences in Palau and in the US. These included multiple presentations and workshops at PICRC, the University of Hawaii Workshop on Environmental and Energy Policy, the UH West O'ahu Science and Math Seminar Series, and the Albert Tester Memorial Symposium.

The PI and Staci Lewis (graduate assistant) participated in a multi-institution workshop in March 2018 that launched a multi-year policy advisory working group. Results from this project are being used to actively advise PNMS managers and policy makers. Soon-to-be-Dr. Lewis is being hired as a post-doctoral scholar on this new initiative.

Take-aways

Boiling down our research into key takeaways:

- (1) The supply chain is complex, including many actors. The commercial supply of tuna and other pelagic fish is relatively modest (165-284mt per year), inconsistent, and unpredictable. The 865mt/year of reef fish that enter the local commercial supply chain represents less than half of the overall reef fish consumption, most of which remains non-commercial. For both pelagic and reef fish, there is minimal value added until the final stage where fish is prepared for consumption (e.g., caterers and restaurants).
- (2) Tourist consumption represents a small fraction of overall reef fish consumption and about half of all pelagic fish consumption. Indeed, tourists consume less reef fish than what is exported by individuals in coolers. Our demand calculations are sensitive to trends in tourism, and demographic shifts could change the conclusions. Our results also suggest that demand is sensitive to meal price - an increase in the relative cost of pelagic fish will move tourists towards reef fish, and residents towards reef fish and other protein (e.g., chicken).

- (3) Tourists have a higher willingness to pay for pelagic fish than reef fish. The lack of availability of pelagic fish may be driving some of the reef consumption by tourists. Improving pelagic fish availability could reduce tourists' consumption of reef fish. On the other hand, an increase in relative price of pelagic fish (a likely outcome if the industrial vessels depart) will increase tourist demand for reef fish. A restriction on tourist consumption of reef fish would not discourage them from coming, as the large majority of respondents (94%) said they would return to Palau even if they could not eat reef fish.
- (4) Tourists are willing to pay extra for a local, sustainable brand, and urban/peri-urban residents have a willingness to pay for high quality tuna. Capturing this willingness to pay could increase the price commanded for local fish, and therefore help the financial viability of a local offshore fishery.
- (5) We found that most tourists were not aware of the PNMS, although many who said that they were also said that the PNMS played an important role in their decision to pick Palau.
- (6) Residents eat pelagic fish far less frequently than reef fish, and many reported not eating it because of its price or availability.

Next steps

Monitoring. This project provides baseline information in advance of implementing the PNMS in 2020. Future efforts can track key impacts on a regular basis to feed in to any impact assessments and support adaptive management. Key monitoring indicators should include reef and pelagic fish supply and demand, prices along the supply chain, as well as access and availability to address equity concerns. A bit more expansive monitoring could look at residents' consumption of imported substitutes, some of which raise nutritional and public health concerns. While not the focus of this project, estimating total reef fish extraction/consumption is key information needed for conservation, and provides important context for the value chain. The in-flight entry survey could occasionally include a question about tourist awareness of the PNMS and motivation for their visits.

Domestic fishery development. Findings of this project can be combined with SPC's fishing household survey to synthesize the value chain in order to advise on the development of the domestic fishery. Together, the studies provide a solid picture of the current supply chain, from

fisher to consumer. Knowing current capacity and demand, we can build out different domestic fisheries scenarios to assess their catch targets and financial viability.

Local, sustainable brand. A market study would be useful to design a local, sustainable fishery brand that appeals to tourists. The choice experiment showed a strong willingness to pay for this option, but the next step would involve setting up a structure that tourists trust, and which benefits multiple actors along the supply chain, from fishers to restaurant owners.

Policy analysis. The study is rich in information that will be useful in analyzing various policies needed to successfully implement the PNMS, from the domestic fishery, to potential conservation efforts, such as restrictions on reef fish consumption. Ex ante policy analysis can help ensure that proposed policies are efficient (i.e., benefits outweigh costs), while meeting other societal objectives (such as equity and environmental sustainability).

References

- Bell, J.D., Kronen, M., Vunisea, A., et al. (2009) Planning the use of fish for food security in the Pacific. *Marine Policy* **33**, 64–76.
- Bureau of Budget & Planning, M. of F. (2016) Statistical Yearbook.
- Bureau of Oceanic Fishery Management (2017) Annual Report to Commission.
- Bureau of Oceanic Fishery Management (2015) Marine Resources Export.
- Bureau of Oceanic Fishery Management (2013) Performance Audit Report on Managing Sustainable Fisheries (Tuna).
- Chapman, L. (2000) Development Options and Constraints Including Training and Infrastructure Needs Within the Tuna Fishing Industry and Support Services in Palau. Noumea, New Caledonia.
- Garz, S. (2017) Present and Future Domestic Demand for Fresh Tuna in Palau.
- Gillett, R. (2016) Fisheries in the Economies of Pacific Island Countries and Territories.
- Hagrannsoknir sf (2014) Review of the PNA Purse Seine Vessel Day Scheme. Majuro.
- Havice, E. (2013) Rights-based management in the Western and Central Pacific Ocean tuna fishery: Economic and environmental change under the Vessel Day Scheme. *Marine Policy* **42**, 259–267.
- James, P. (2018) Palau ; Lower fisheries value chain.
- Palau Conservation Society (2000) Profiles of Palau's Inshore Fisheries.
- Palau National Marine Sanctuary Act (2015).
- PNA (2014a) Minimum Benchmark Fee for a Fishing Day under the Vessel Day Scheme.
- PNA (2016) Parties to the Palau Arrangement 21st annual meeting. 1–7.
- PNA (2014b) PNA VDS Technical and Scientific Committee 3rd Meeting.
- Pojas, R. (2018) Palau sells PNA fishing days to Philippine company. *Island Times*.
- Senase, J.R.T. (2015) Micronesians Call On PNA To Support Palau Sanctuary. *Island Times*.
- Yeeting, A.D., Weikard, H.P., Bailey, M., Ram-Bidesi, V. and Bush, S.R. (2018) Stabilising cooperation through pragmatic tolerance: the case of the Parties to the Nauru Agreement (PNA) tuna fishery. *Regional Environmental Change* **18**, 885–897.