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prepared by	Neil Andrew, Joelle Albert, Simon Albert, Johann Bell, Cecile Brugere, Brooke Campbell, Karen Charlton, Philippa Cohen, Aurelie Delisle, Hampus Eriksson, Quentin Hanich, Patrik Henriksson, Christina Hicks, Anne Lechner, Josephine Maelaua, Chadag Mohan, Kalo Pakoa, Michael Phillips, Joanna Russell, Michael Sharp, Dirk Steenbergen, Nhuong Tran, and Max Troell
co-authors/ contributors/ collaborators	
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1 Acknowledgments

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This work contributed to the CGIAR Research Program on Fish Agrifood Systems (FISH).

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2 Executive summary

Fish play critical roles in the economic development and food security of coastal people. Despite the high productivity of coastal ecosystems, fishing communities are often amongst the poorest and most vulnerable. Sustained production of fish for nutrition and income was identified as being exposed to many stressors and shocks; notably globalization of trade, poor governance and planning in contested coastal zones, and increased frequency and severity of extreme weather events. Project FIS/2015/031 brought together three contrasting case studies of the role of fish in development.

By many accounts the food system of the Pacific region is failing to provide food and nutrition security for people who live in the region's 16 countries. Many Pacific Island countries (PICs) continue to be affected by the triple burden of malnutrition (undernutrition, micronutrient deficiency and overweight/obesity). The rise of NCDs, childhood stunting and anaemia has major implications for economic growth, aid policy and development. In Malaita Province, Solomon Islands, for example, we found significant malnutrition in all communities studied. Nearly 25% of children under 5 years were stunted and more than a quarter of women were overweight. More than 75% of women and children ate fewer than five food groups and were likely to be micronutrient deficient.

We developed scenarios of alternative futures of the Pacific food system to summarise the most important and uncertain drivers of change, and to develop and test policies. It is clear from these scenarios that it is important to assess the contribution of fish within a broader food system rather than retain a narrow focus on availability or supply. The project co-developed important public domain databases on the composition of food, and fish in particular, that will underpin subsequent nutrition analyses in the region.

Consumption of fish was analysed using Household Income and Expenditure (HIES) data from eight PICs. Consumption of canned fish, pelagic species, and shellfish varies widely among countries. The vast majority of households consumed fresh fish, particularly reef species, except in Vanuatu, Tonga and Samoa where more canned fish was consumed. These differences in fish availability, access and consumption suggest policy responses will need to be tailored to country specific needs and opportunities. Canned tuna from PNG, Solomon Islands and Fiji are important to regional food security. These contributions need to be enhanced through improved range of product development, marketing and policy/trade initiatives.

Coastal Fish Attracting Devices (FADs) make small but growing contributions to the supply of fish in the region, particularly in Vanuatu where the government is developing a national programme. In the wake of Tropical Cyclone Pam, the project demonstrated the importance of fish as a source of food following natural disasters. We supported the Fisheries Department in evaluating the FAD programme through innovative tablet-based monitoring of catch and fishing effort. Vanuatu leads the region in the use of this technology, which is now being extended to other countries in collaboration with The Pacific Community (SPC). Generalizable lessons were learned in deployment of FADs post-TC Pam.

Aquaculture is an increasingly important source of food. In Indonesia, for example, project projections suggest farmed fish will overtake fisheries as a source of fish for human consumption in the coming decades. With this increase in production will come environmental risks and distributional issues. The project recommended policies to maximise the domestic contribution of the sector, including the continued refinement of the Better Management Practices (BMP) framework.

In contrast to the trajectory of aquaculture in Indonesia, for the near future most fish eaten by people from the Western Indian Ocean will continue to be caught from the wild rather than farmed. As mariculture develops it will be critical to ensure that it is enabled by a coherent set of policies and guidelines to ensure environmental sustainability and

equitable growth. The project partnered with national and regional agencies to develop and test a diagnostic framework for mariculture planning and development.

3 Background

Fish[1] play critical roles in the economic development and food security of coastal people. Despite the high productivity of coastal ecosystems, fishing communities are often amongst the poorest and most vulnerable in their countries and regions. Fisheries are beset with many challenges. Of these, governance has attracted the most attention, but as climate changes, extreme events are increasingly influential. Similarly, the rapid rise of aquaculture provokes both optimism and apprehension among those concerned with global food security because, although it has huge potential, policy frameworks used to guide development and assess benefits do not capture who benefitted, nor how. Sustained production of fish for nutrition and income was identified as being exposed to many stressors and shocks, notably globalization of trade, poor governance and planning in contested coastal zones, and increased frequency and severity of extreme weather events. This project brought together three contrasting case studies of the role of fish in development:

Firstly, in the Pacific nutritional security is challenged by rapid population growth and urbanization, shortages of arable land, and cheap, low-quality food imports from burgeoning global trade. Many PICs continue to be affected by the triple burden of malnutrition (undernutrition and overweight/obesity). As a result the rise of NCDs, childhood stunting and anaemia have major implications for economic growth, aid policy and development. A key outcome from the second International Conference on Nutrition - ICN2 (Nov 2014) was a recommendation to United Nations General Assembly for the declaration of a decade of action on nutrition from 2016 – 2025 (FAO 2014). A central problem for the Pacific food system to address these nutrition challenges is how it evolves under a range of economic, ecological and social drivers of change. The project identified a critical need to better integrate fish into the Pacific food system and to understand the feedback loops between trade, supply and demand for fish and other food.

The nutrition transition in the region cannot be addressed by conventional sectoral interventions. Sustainable food systems have been identified as clear areas for action to improve nutrition (FAO 2014). In seeking a broader integration of fish into regional development, the project addressed priorities in a number of regional strategies and policies: Vava'u Declaration (2007), Apia Policy (2008), FFA/SPC Future of Fisheries (2010), and the MSG Roadmap for Inshore Fisheries (2013). Most importantly, the project provided early support to SPC's new initiative in coastal fisheries "A New Song for Coastal Fisheries: Pathways to Change" (SPC 2015).

Secondly, aquaculture is rapidly developing to become the dominant source of fish for people to eat, but is at very different stages of development in the Indo Pacific region. Here we implement two case studies, in the Western Indian Ocean (WIO) and in Indonesia that explore different aspects of aquaculture planning and development.

In the Western Indian Ocean fish is, and will continue to be, the most accessible and widely consumed animal source food for coastal people. As wild fisheries decline there are strong incentives to farm marine species, often to supply export markets. The problem addressed here centred on the absence of effective policies and guidelines to ensure that mariculture developed in the region in a way that promotes and contributes to food

[1] *Unless specified, 'fish' includes all seafood products, including reef, pelagic and shellfish, as well as processed products such as dried and canned fish.*

security. Many private investors seek to engage in the sub-sector, providing both challenges and opportunities for social and economic development in coastal communities. Identification of the synergies and trade-offs and policy options would facilitate the development of a decision-support framework to support mariculture that is responsible, inclusive, equitable and resilient.

This case study aligns with ACIAR's Regional Priorities for Eastern and Southern Africa 5-year research program outcomes (AOP 2014-2015) and provides a stronger technical foundation for the ambitions of the Indian Ocean Rim Association (IORA) to develop mariculture in the region. IORA increasingly promotes regional cooperation focused on optimising the sustainable use of living marine resources. At the IORA council meeting in Perth in October 2014, member States adopted the 'Blue Economy' as a banner for coordinating these actions. The Core Group on the Blue Economy listed among its objectives to promote "[…] cooperation in technology and research and development", "ensuring sustainability." and building "[…] common policy frameworks for the development of the Blue Economy".

At the time of project development in 2015, Indonesia was the fourth largest aquaculture producing country, with a fast growing aquaculture sector, meeting domestic and export markets. Indonesia provided a special case for further learning because the country had ambitious targets for mariculture development and had been the subject of several research and development initiatives, to improve management of small-holder farming. These initiatives included ACIAR research into development and adoption of "better management practices" among coastal pond farmers and diversification of aquaculture species grown in abandoned shrimp ponds. Similar problems were noted in Indonesia as in other countries in the region – the unplanned and poorly regulated development of mariculture presented a significant threat to the sustainable long-term supply of fish.

The project aligns with the ACIAR 2012-2016 research strategy, particularly the priority for "more profitable smallholder aquaculture systems". The drawing together of experiences has provided important lessons in how farm and local improvements in aquaculture management can be supported, and furthermore complement national and regional level policy initiatives for profitable and sustainable aquaculture.

Thirdly, Tropical Cyclone Pam (TC Pam) remains the largest natural disaster to hit Vanuatu and recovery presented a massive long-term challenge. As the immediate humanitarian phase wound down, national priorities turned to rebuilding communities and the nation's agricultural production. TC Pam reset priorities for research and development assistance in Vanuatu. Assessments of new priorities were led by the Vanuatu Food Security and Agriculture Cluster (FSAC), a consortium of government agencies and national stakeholders. Needs assessments by FSAC and SPC were completed with clear priorities for early (6-18 months) interventions in the fisheries sector. The activities in Objective 3 responded to prioritized needs for assistance in the fisheries sector and were developed following discussions with SPC and the Vanuatu Fisheries Department, a member of the Vanuatu FSAC. These activities concentrated on FADs as a tool in providing more fish and potentially taking pressure off reefs.

The project addressed the strategic objectives in the "Strategy for Australia's aid investments in agriculture, fisheries and water" to: (i) enhance food, nutrition and water security, and (ii) increase incomes of poor people (DFAT 2015).

4 Objectives

The overall aim of this project was to improve the understanding and use of fish in national and regional food systems, and the role of fisheries and mariculture as a source of food, income and livelihoods for coastal communities.

Objective 1: To better understand and promote the sustainable use of fish for nutritional security in the Pacific Food System.

- Analyse global data on nutritional content of species targeted by marine capture fisheries
- Update 2009 SPC projections of the 'fish supply gap' to provide policy makers with improved estimates of the challenge facing nations and the region
- Analyse regional and national trends in fish consumption and nutritional status for men, women and children in the region to inform regional policy initiatives, particularly the 'New Song for Coastal Fisheries'
- Collect and analyse data on women's dietary diversity (as a new indicator) and infant and young child feeding practices (to compare with existing national data) through a case study in rural communities in Malaita Province, Solomon Islands to contribute to regional analyses and inform future national survey instruments
- Articulate the role of fish within a food systems approach to nutritional security and public health in the region
- Identify research and policy gaps that act as barriers to better integration of fish into nutrition outcomes in the region
- Develop possible alternative scenarios for the Pacific food system through a multi-stakeholder workshop
- Through SPC channels present the analyses and scenarios to regional leaders to develop momentum for change in fisheries and other public policy.

Objective 2: To improve decision-making on mariculture policy and planning in Indonesia and the Western Indian Ocean.

- Compile and analyse existing decision-making structures for mariculture and planned/ongoing development in the Western Indian Ocean
- Evaluate the mechanisms underpinning benefit sharing from Indian Ocean mariculture and its contribution of mariculture to poverty reduction and economic development
- Identify how coastal mariculture impacts the wellbeing of different stakeholders throughout value-chains
- Test a framework for decision-making for mariculture development and policy making with stakeholders in an IORA forum.
- Highlight constraints to greater gender equity in decision-making around mariculture and related livelihood choices and describe innovations and interventions that would be most effective in addressing these constraints
- Evaluate the economic and environmental outcomes of Indonesia's 'better management programs' focusing on local scale investments in better management practices and small-scale farmer cluster and cooperative arrangements.

Objective 3: To accelerate the recovery of communities and coastal fisheries following Tropical Cyclone Pam.

- Design and implement community-based FAD deployment and fish catch monitoring in selected communities in Epi, Shepherd Islands, Efate and Offshore Islands, and Tafea Islands
- Undertake surveys to assess fisher community needs, status and recovery responses and provide a baseline to test efficacy of long-term recovery initiatives in the sector.

Objective 4: To generate generalizable lessons about the role of fish in development.

- Complete a regional review of fish in Pacific food systems, with particular reference to the rise of over-nutrition in developing countries
- Publish a policy framework for the development of coastal mariculture in the Western Indian Ocean region and its impacts on wellbeing and economic development
- Complete an analysis of generalizable lessons concerning the role of fish and fisheries following natural disasters, using Aceh, Solomon Islands, Philippines and Vanuatu as case studies.

5 Methodology

5.1 Research approaches and locations

Use of currently available data: National and regional leaders responding to the public health crisis posed by rising NCDs, child stunting and anaemia in the Pacific region were identified to need a stronger evidence base and policy narrative to influence patterns of food consumption, trade and production. Fish was noted to be a central part of any pathway to improved public health in the region, but had to be integrated with other production sectors and broadly accepted as being part of the narrative around improved nutrition and health outcomes. SPC is the custodian of a large repository of national and regional survey data in food consumption, fisheries, public health, agriculture and horticulture. Analysis of these secondary data created an integrated evidence-based narrative for trends in fish production and consumption and its relationship with public health in the region. It is well recognised that good nutrition during the first 1000 days (from child conception until two years of age) can have profound impacts on a child's ability to grow and learn as well as shape society's long-term health and break cycles of poverty. Infant and young child feeding (IYCF) practice had been used as a common indicator of nutrition. Recently, however, minimum dietary diversity for women (MDD-W) has been endorsed as a new global indicator to assess micronutrient adequacy of women's diets (FAO 2014) and is proposed as one of the key nutrition indicators for the Sustainable Development Goals (post 2015 millennium development agenda).

Case Studies in Solomon Islands: We worked in partnership with the Solomon Islands Ministry of Health and Medical Services (MHMS) to develop and test primary data collection at the individual level on MDD-W and ICYF through a case study approach in rural Solomon Island communities. The collection of MDD-W data enabled the testing of this indicator in a Pacific context to complement the analysis of existing secondary data as well as inform future national level survey instruments (e.g. national demographic and health surveys). Through complementary activities within the CGIAR Research Program on Aquatic Agricultural Systems (AAS) research program we trialled participatory

interventions and a nutrition sensitive approach to improve women and children dietary diversity in rural communities.

Analysis of mariculture policy environment and drivers of development: Sustainable development of mariculture in the Indian Ocean, particularly in the East African states, requires a coherent policy framework to guide policy trade-offs and to ensure more equitable sharing of the benefits of the emergent mariculture industry. We provided a novel framework for the region that extends long-term engagement by SRC researchers in the region. Development of this framework did not require the collection of primary data on production potential of coastal waters, but rather an analysis of the policy environment and the drivers of development.

Action research in post-cyclone Vanuatu: In Vanuatu our research strategy was heavily influenced by the need to provide direct assistance to cyclone devastated communities, and to learn how to better provide such support after other disasters. The approach for this objective was therefore weighted toward an action research modality, elucidating the learnings from activities that are primarily 'development' oriented.

All analyses and reporting from the project differentiated gender and, where appropriate, youth and children. Insights from these analyses were particularly important in Objective 1, namely in the secondary analyses of food consumption and expenditure surveys from the region. Accounts of particular methods and frameworks applied per project component are detailed as part of outputs of the project.

5.2 Methods per objective

Below we provide headline summaries of methods used. More detailed methods are given for Objective 1 because of the empirical nature of the work and because much of the work is not detailed in published outputs. The reviews and policy frameworks described in Objective 4 were framed within standard political economy analysis.

Objective 1

Scenarios

In 2015 a multi-stakeholder workshop was led by SPC as a combined exercise with their fisheries, land resources, statistics and public health divisions. SPC/WorldFish gathered a diverse group of 34 people from the Pacific region at a workshop in Nadi in August 2015. Individuals were chosen for their experience and did not represent member countries. The group was tasked with imagining the food system in 2030, and the policy implications of events and trends in the interim period. The workshop developed possible alternative scenarios for the Pacific food system under predicted climate change impacts and was co-funded by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Scenarios are not predictive forecasts, but rather plausible 'what if" accounts that help partners acknowledge unknowns and visualize widely different futures. The workshop was facilitated by the CCAFS scenarios team using methods developed and tested by Vervoot et al. (2014).

Household nutrition in Malaita, Solomon Islands

Case study research on women's dietary diversity and infant and young child feeding practices were carried out in North Malaita focal communities of the then CGIAR AAS through which preliminary qualitative research on root causes of poor nutrition, and barriers to improved nutrition had been undertaken in June 2015. Case studies from North Malaita were integrated with work in Western Province through a partnership with the University of Queensland and the American Museum of Natural History.

Objective measures of nutritional status and its determinants were guided by the UNICEF framework of malnutrition, focusing on of women of reproductive age and infants and young children (under 5 years of age) (Figure 5.1).

To determine nutritional status, we concentrated on several key indicators for women and young children, namely the *proportion of women overweight or obese* and the *prevalence of stunting, underweight and wasting in children under 5 years of age*. These indicators were assessed from anthropometric measurements taken from all consenting women of reproductive age (15 to 49 years) and children aged 6 to 23 months and 2 to 5 years. Body weight was measured using SECA 770 weighing scale to the nearest 0.01 kg and height using child/adult height boards to the nearest 1 mm. Height and weight of women, was used to calculate body mass index (BMI). Adult BMI was used to determine the *proportion of women overweight or obese* (BMI > 25) based on guidelines from the Western Pacific Regional office of WHO (WHO 2000, 2010). We note ongoing critiques of the appropriateness of standardized BMI as descriptors of health and risk of NCDs (e.g. Yoon et al. 2015).

Waist and hip circumference were used to calculate *waist to hip ratio (WHR)*, with a ratio >0.85 for women indicating greater risk of developing serious health conditions. For children, age, weight and height were used to calculate the prevalence of stunting. Stunting is estimated as the proportion of children who have a height for age score < 2 SD below the mean. The prevalence of wasting (proportion of children who have a weight for height z score of less than 2 SD below the mean) and the *prevalence of underweight* (proportion of children who have a weight for age z score of less than 2 SD below the mean) (WHO 2005) were also estimated.

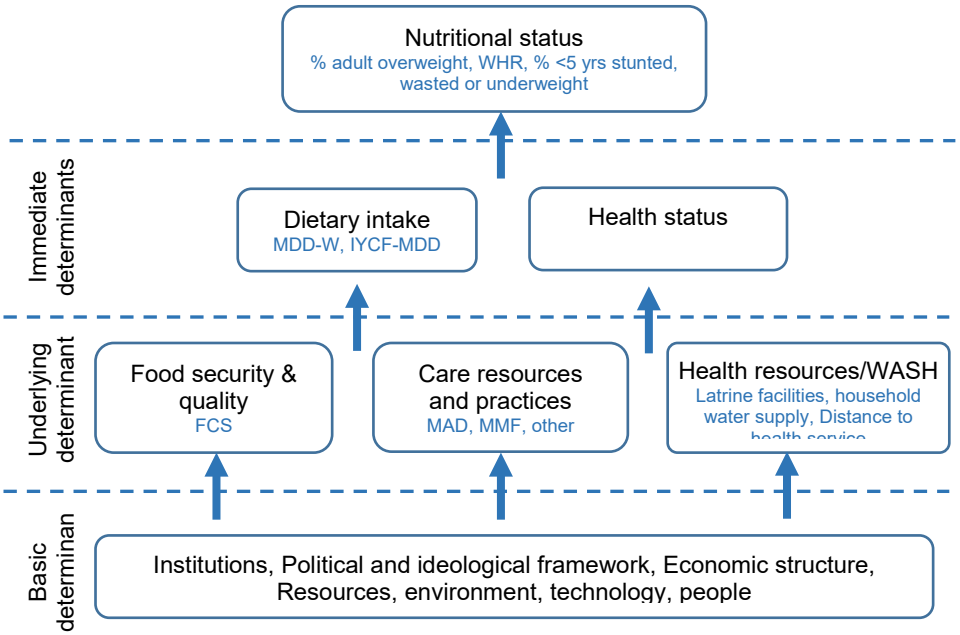

Figure 5.1. Indicators measured in this study relative to the UNICEF framework for malnutrition and its immediate, underlying and basic determinants

Dietary quality of women was measured through 24 hour recall using the *minimum dietary diversity of women* (MDD-W) indicator, a recently validated measure of micronutrient adequacy (Martin-Prevel et al 2015). MDD-W is defined as the proportion of women of reproductive age that consumed five or more of ten key food groups (FAO and FHI 360

2016)[2]. For children, the *minimum dietary diversity for children aged 6 to 23 months* (*IYCF MDD)* was measured - a synonymous indicator to MDD-W (WHO, 2008).

For children, the *minimum dietary diversity for children aged 6 to 23 months* (*IYCF MDD)* is a synonymous indicator to MDD-W. IYCF MDD is defined as the proportion of children (aged 6 to 23 months) who consume foods from four or more of seven key food groups (WHO 2008). In the IYCF MDD, food groups 2 and 3, 7 and 8, 9 and 10 are combined.

The *household food consumption score* (FCS) is a composite index based on household level dietary diversity, food frequency and the relative nutritional value of different food groups that can be used to reflect food availability and food access (two of the four dimensions of food security) (WFP 2008). FCS was calculated for each household based on the frequency of consumption of key food groups (staples, pulses, vegetables, fruit, meat/fish, milk, sugar and oil) in the 7-days prior to interviews, using methods developed by the World Food Programme (WFP 2008). The quantity of rice and sugar consumed by households in the 7-days prior to interviews were also collected. These imported foods are of interest as they reflect the transition to reliance on imported foods and the nutrition transition occurring in rural Solomon Island communities.

To assess care resources and practices as an underlying determinant of malnutrition we collected several standard WHO indicators for infant and young child feeding practices including: minimum meal frequency (MMF), minimal acceptable diet (MAD), and whether a child was ever breastfed (WHO 2008). These indicators were estimated for children aged 6 to 23 months. Minimum meal frequency (MMF), for children 6 to 23 months is defined as the proportion of children who receive solid, semi-solid, or soft foods the minimum number of times or more. For breastfed children the minimum number of times varies with age (2 times if 6-8 months and 3 times in 9-23 months). For non-breastfed children the minimum number of times does not vary by age (4 times for all children 6-23 months). *Minimal acceptable diet (MAD)* is defined as the proportion of children 6–23 months of age who receive a minimum acceptable diet (apart from breast milk). MAD for defined for breastfed children 6–23 months of age who had at least the minimum dietary diversity and the minimum meal frequency during the previous day and for non-breast fed children 6-23 months of age who received at least 2 milk feedings and had at least the minimum dietary diversity (not including milk feeds) and the minimum meal frequency during the previous day.

Average distances to closest health clinics (in km based on usual travel routes) were determined as proxy indicator of access to health resources. The proportion of households with improved sanitation facilities and proportion of households with improved drinking water supply were measured through household surveys as a proxy for access to adequate sanitation and water supply. For the purpose of this study, improved sanitation facilities were defined as facilities designed to hygienically separate excreta from human contact and are not shared with more than two households. Common improved sanitation facilities in rural Solomon Island communities are flush or pour septic systems and pit latrines with a slab), sometimes shared with another household. Improved drinking water was defined as water sources protected from contamination and included, rainwater tanks and public standpipes.

Ethics Approval to conduct this study was obtained from the Solomon Islands Ministry of Health and Medical Services (Ethics Approval HRE10/16).

[2] *The 10 food groups defined by FAO (2016) are: (1) Grains, white roots and tubers, and plantains, 2. Pulses (beans, peas and lentils), 3. Nuts and seeds, 4. Dairy, 5. Meat, poultry and fish, 6. Eggs, 7. Dark green leafy vegetables, 8. Other vitamin A-rich fruits and vegetables, 9. Other vegetables, 10. Other fruits.*

Household Income and Expenditure Surveys (HIES)

Regional research activities focused on analyses of national data held by SPC. Modern standardized Household Income and Expenditure Survey (HIES) data were available for Federated States of Micronesia (FSM), Nauru (NRU), Palau (PLW), Solomon Islands (SLB), Tokelau (TKL), Tonga (TON), Vanuatu (VUT) and Samoa (WSM). Table 5.1a provides key survey data and Table 5.1b presents information on the sample size, fraction and population estimates. HIES have recently been completed for Cook Islands, Niue and Tuvalu - data are currently being cleaned by SPC and national agencies, and these countries will be included in forthcoming journal articles. Unfortunately, HIES for Kiribati, PNG and Fiji are unlikely to be available in the near future (noting that the latter two countries account for 79% of the region's population). Given our focus on food security, the American, British and French Territories were excluded from the analysis.

Data access was granted through Memoranda of Understanding with each country's national statistics office. All data queries were conducted by SPC staff.

The data included modules on demographic information, household expenditures, individual expenditures and income, and household diary information on food production and activities. In common with most analyses at the country level, we used income and expenditure on specific food groups as proxies for consumption.

All data sets containing household food acquisition diary data were imported for analysis into Stata. Common variables and unique household identifiers for each data set were generated and, where necessary, various diary files were appended to create a single diary file per country. All expenditure types (cash purchases, home production and gifts received by the household) and transaction units (both standard and non-standard) were commonly coded.

All countries except Vanuatu classified transactions according to the United Nations Statistics Division's Classification of Individual Consumption According to Purpose (COICOP). For Vanuatu, the national commodity classification was recoded to match that of the Solomon Islands. Subsequent to this, all transactions that did not fall into COICOP Class 01.1.3 ("Fish and seafood") were excluded. Exclusion of non-fish transactions removed households from the survey so data sets were reweighted to ensure that the sampling weights were representative of the total number of households per primary sampling unit (PSU).

Households were coded as being rural or urban except in Nauru and Tokelau. Commodities were coded according to the following four fish categories:

1. Pelagic –tuna and other pelagic fish;
2. Reef – multiple species of reef fish, including snapper;
3. Shellfish – molluscs, crustaceans and other invertebrates; and
4. Canned – canned and other preserved (salted, dried, smoked) seafood.

Cross tabulation, graphical and manual data cleaning methods were used to verify that transactions were correctly classified by fish type and recoded as necessary. In the case of Samoa, a large proportion of fresh fish transactions were coded as "Fish - general". A representative from Samoa's Ministry of Agriculture and Fisheries assisted in recoding Samoan fish names to the relevant fish category and COICOP.

Table 5.1a. Survey documentation

Country	Collection period	Sampling	PSU	Frame	Lowest reporting domain	Food data source
FSM	July 2014 to July 2015	2 stage	Enumeration area	2010 census	Urban-rural, by state	2-week diary
NRU	July 2012 to June 2013	1 stage	Household	2011 census	National	2-week diary
PLW	November 2013 to October 2014	2 stage	Enumeration area	2012 census	Urban-rural	2-week diary
SLB	October 2012 to October 2013	2 stage	Enumeration area	2009 census	Province	2-week diary
TKL	May 2015 to February 2016	1 stage	Household	2013 HH listing	National	2-week diary
TON	October 2015 to October 2016	2 stage	Enumeration area	2015 HH listing	District	2-week diary
VUT	October to December 2010	2 stage	Enumeration area	2009 census	Province	2-week diary
WSM	April 2013 to March 2014	2 stage	Enumeration area	2011 census	District	2-week diary

HH = household

Table 5.1b. Sample size, fraction and mid-point population estimates, by urban-rural

Country	HIES sample			Sample fraction			Mid-point population estimates					
	Households			Households			Households			Persons		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
FSM	957	707	1,664	10%	11%	10%	9,997	6,681	16,678	64,873	38,522	103,395
NRU	460	-	460	27%	-	27%	1,704	-	1,704	11,660		11,660
PLW	316	553	869	32%	11%	15%	985	4,961	5,946	3,247	14,333	17,580
SLB	3,206	1,272	4,478	4%	7%	4%	89,026	19,015	108,041	501,353	114,451	615,804
TKL	119	-	119	47%	-	47%	251	-	251	1,159		1,159
TON	479	1,324	1,803	12%	10%	10%	4,108	13,899	18,007	23,381	78,430	101,811
VUT	3,314	1,063	4,377	9%	8%	9%	36,899	12,695	49,594	167,496	62,705	230,201
WSM	1,858	490	2,348	8%	9%	8%	22,406	5,459	27,865	154,958	36,693	191,651

A variable was created to code transaction units as “standard” and “non-standard” and frequency tables, by COICOP and transaction unit, were produced to identify COICOP commodities where there were too few transactions in standardised units to derive a sufficiently representative median price per gram. These items were systematically recoded to the most frequently reported COICOP from the same fish category if the number of transactions in standard units of measurement were less than 30.

A variable “total quantity” was generated as the product of the variables “number” and “quantity” (e.g., 10 fish of 500 grams each were multiplied to derive a total quantity of 5,000 grams). Outliers in “total quantity” were identified as being more than two standard deviations from the mean, by transaction unit and fish category. Where outliers were detected, the median “total quantity”, for that unit and fish category, was imputed. The variable “total quantity” is critical in the derivation of the median price per gram, which is why identification and imputation of outliers was deemed appropriate.

Where standard units of measurement were reported, these transactions were converted into grams and a price per gram, per transaction, was derived by taking the total value of the acquisition (cash expenditure, or household estimated value of the home produced or gifted item) divided by total quantity (in grams). The null hypothesis that the price per gram was normally distributed was visually (histogram and box plot) and statistically (Shapiro-Wilk-Test) tested and rejected. As such, the price per gram was log normalised and outliers were detected using Tukey’s method (outliers identified as being price per gram that were two times the interquartile range beyond the log normalised median price). Outliers were flagged and the median price per gram, by commodity and excluding the outliers, was derived. All outliers and transactions that were in non-standard units of measurement had their price per gram imputed as the median price.

Quantities per transaction (in grams) were then derived by dividing the transaction value (the expenditure amount in the case of cash acquired goods, or the households estimated value of the home produced or gifted item) by the price per gram. We assume that reported expenditure was correct. Whole fish equivalent acquisitions were then estimated for each transaction.

The final stage in constructing the data set was to estimate apparent consumption, which requires conversion of the volume of the whole fish equivalent acquisition in to edible portions. Edible portion conversion factors were derived from the Pacific COICOP-Food Nutrition Database (Section 7.1.3) merged to the dataset and the whole fish equivalent quantities were multiplied by the edible portion conversion factor to estimate apparent consumption.

Preliminary analyses revealed a small number of highly improbable records were influential in estimates of mean apparent per capita consumption. Records with an estimated apparent per capita consumption of > 365 kg per year (equivalent to > 1 kg per day for every day of the year) were considered outliers and removed from the dataset. These outliers accounted for 0.63% of the 16,118 records in the dataset.

A range of methods may be used to estimate per capita fish acquisition and apparent consumption; none seem universally applied and accepted as best approach, but all use the replacement cost method (Turner et al. 1993, Asafu-Adjaye, 2005, Jackson et al. 2014)

HIES collects household acquisition of goods and services, which is used as a proxy to estimate consumption. Whilst HIES is a common vehicle for the per capita apparent consumption estimates, there are multiple challenges in the use of HIES data, especially in the Pacific context where sample sizes are relatively small and there is limited administrative and supporting data to validate the model, especially in terms of spatially disaggregated prices.

Due to the relatively small sample sizes, the methods presented herein assume:

1. Urban and rural prices are homogenous.
2. Prices for cash purchased and home produced goods are homogenous.
3. Prices within fish categories are relatively homogenous.
4. The household reported expenditure amount for home produced and in-kind receipts is assumed to be accurate, however there are cases where households do not acquire fish and seafood through cash markets, so the estimated values may be unrealistic.
5. Edible portions, especially in the case of shellfish, are assumed to be accurate, however they may differ greatly depending on the commodity and its size.

Global Review of nutritional Content of Fish

The nutritional value of the many species targeted by Pacific fisheries is poorly understood. This gap was filled with a global review of the nutritional value of marine fish in collaboration with Dr Christina Hicks from Lancaster University. We assembled a global dataset containing over 4000 measures of nutrients from fish. In total, the database comprises 1204 unique cases and 4500 data points and represents a two-fold increase in data collated on nutritional composition of marine finfish held currently in the publicly available FAO INFOODs data repository. The data are currently being cleaned and checked and will be published in an open access format in Q2 2018.

We used a three-staged approach to identify sources of nutritional composition data (methods summarised below and extracted from Cohen et al. in prep). First, we extracted data from the FAO/INFOODS food composition database: http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en

Second, we conducted a systematic search of scientific literature published between 1980 and 2015. Third, we conducted a short survey of key informants, identified through the established snowballing search technique. Our objective was to determine firstly if we had achieved comprehensive coverage of key sources (though the first and second stages), and secondly to supplement our data set from, what experts identified as, important non-journal article sources. In total, we received responses from six informants considered by peers to be global experts in the field.

Nutrient data were extracted from each source and entered into a MS Excel database. We focused on a sub-set of 14 minerals (iron, calcium, zinc, phosphorous, magnesium, selenium), vitamins (Vitamin A and B12), fatty acids (omega 3, omega 6, polyunsaturated fatty acid (PUFA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and protein – nutrients prioritized by experts due to their particular roles in human nutrition and relation to public health. We standardised nutrient quantities into units of g/100g, mg/100g or µg/100 g and converted fatty acids to g/100g following the FAO-INFOODS guidelines (FAO 2012). Each species from a particular source was considered a single case which could contain a measure for a single nutrient or measures for multiple nutrients. Each nutrient measure within each case was considered as an individual data point.

Update of the Pacific Islands Food Composition Tables (PIFCT).

The second line of work updated the Pacific Islands Food Composition Tables (PIFCT). Data from the PIFCT are required to estimate calorie and micronutrient intake using a HIES data set. All estimates of consumption expenditure collected through HIES are coded using the UN Statistics Division's Classification of Individual Consumption According to Purpose (COICOP) codes. There is no regionally standardised linkage between COICOP and the Pacific Islands Food Composition Tables (PIFCT). In addition,

there is no agreed set of edible portion conversion factors for primary produce, which limits the use of HIES data for poverty and nutrition analysis as there is potential for overestimation of consumption as conversion factors are not always applied due to their limited availability.

The work generated a regionally standardised commodity-level COICOP for selected COICOP all divisions associated with food and beverage consumption with corresponding caloric and micronutrient data. In addition to this, edible portion conversion factors were estimated for every item on the commodity list. A database user guide documented methods, source data and any statistical methods or assumptions made in the creation of the database was written.

Tabulating food composition requires both standardized coding of food types (e.g. skipjack tuna or taro banana balls (taro patties made using egg and fried with oil)) and estimates of their calorific and micronutrient content. In the absence of standardized coding and food composition tables, different analyses using the same data potentially derive conflicting poverty or nutritional consumption estimates. Further, the significant investment needed to generate estimates of food composition and correctly code them by food type is a barrier to widespread utilization of HIES to better inform national and regional policy.

University of Wollongong, SPC and FAO updated the 2004 *PIFCT version 2* developed by University of the South Pacific and FAO (Dignan et al. 2004). The 2004 tables were funded, in part, by ACIAR. Updates to *PIFCT version 2* were required because of changing dietary patterns within the Pacific region with increasing consumption of imported or branded foods that were not available in *PIFCT version 2*. Specifically, foods included in the current update were based on commonly reported foods reported in the household food diaries collected as part of HIES. Updates in version 3 included:

- Standardized mapping of food types to COICOP codes
- edible portion conversion factors not previously provided
- Imported or branded food products
- Foods commonly purchased/gifted/consumed outside of the home added to the database based on data from existing HIES undertaken in the Pacific region

A list of foods commonly purchased/gifted/consumed outside of the home was created with categories aligned with existing COICOP divisions. Nutrient data from PIFCT 2nd edition was merged with current nutrient values sourced from international food composition tables to provide a complete range of nutrient values. International databases were selected by regional relevance and validity of the data. Estimates for cooked mixed dishes prepared to a recipe were calculated using Foodworks 8 (www.xyris.com.au). Ratios of food components of takeaway items were calculated to approximate the composition of the dish purchased. Data matching was done with reference to the FAO INFOOD Food Matching Guidelines. Proximate values of all foods in the database were confirmed prior to submission to SPC/FAO by assessing whether foods were within ± 10% energy.

Objective 2

To improve decision-making on mariculture policy and planning in Indonesia and the Western Indian Ocean the main research questions asked were: (i) What are the linkages between mariculture systems' ecological and economic functions and the generation of benefits (of any kind) to direct and indirect stakeholders of the sector? (ii) Which mechanisms underpin the sharing of mariculture benefits of different forms of mariculture development?

The first thread of work in this Objective built on a diagnosis and planning framework for equitable mariculture developed by Krause et al. (2015). The framework analyses enabling mechanisms within in the mariculture governance system (including environment

impacts, livelihoods, social justice, food security). The Krause et al. framework had been developed conceptually, but not tested or further refined. We further refined the framework as a tool and then tested its application in the Western Indian Ocean. A stakeholder workshop was used to build consensus and a shared vision for mariculture development in the region. Working with the framework and refining it promoted closer collaboration between the private sector and government agencies responsible for communication and the implementation of mariculture and coastal development policies. Data collection was mainly based on mapping and field surveys, and participatory, social science survey methods such as focus groups, interviews and scenario development. All data collection was gender differentiated to enable policy advice on ways to improve women's' access to decision-making and control over the benefits produced by mariculture's development. This primary data collection increased understanding of the innovation present in the sector and how this could be channelled to increase development outcomes rather than wealth accumulation by elites.

This objective focused on the Western Indian Ocean where mariculture was expected to grow considerably and where a more coherent policy framework was needed and anticipated to have the greatest impact on poverty reduction and economic development (Troell et al. 2011). In addition to engaging with regional organizations and fora, including IORA and WIOMSA, we focused on national agencies in Kenya, Madagascar, Mozambique, Seychelles, South Africa, and Tanzania. Key counterpart agencies for this research were: The Institute of Marine Sciences (IMS) at University of Dar es Salaam, South Africa Ministry of Agriculture, Livestock and Fisheries/State Department of Fisheries, Kenya Ministry of Livestock and Fisheries Development/ Aquaculture Division, Tanzania Ministry of Agriculture and Fisheries/ Department of Marine Resources, Kenyan Marine and Fisheries Research Institute (KMFRI), Madagascar l'Institut Français de Madagascar, Mozambique Instituto Nacional de Desenvolvimento da Aquacultura, Mozambique, Tanzanian Fisheries Research Institute (TAFIRI), and Seychelles Fisheries Authority (SFA).

A second thread of work focused on Indonesia and assessed the learning and development outcomes from earlier ACIAR investment in aquaculture there. The research examined outcomes from investment into 'better management practices' and local collective management structures, such as the farm clusters and farmer groups created by ACIAR and related projects. Social, environmental and economic outcomes were assessed at farm, group/cooperative and community level through field surveys and participatory methods and use of life cycle assessment methods. This second thread of work provided guidance on, the structures that influence equitable mariculture at community levels, and how national and regional policies could support community-led outcomes in Indonesia.

These analyses were integrated to draw lessons about what might be expected as aquaculture production expands and intensifies in the Western Indian Ocean. In particular, these studies shed light on the governance and institutional arrangements as well as factors such as regulations, capabilities, power and individual agency that shape the achievement of fair and equitable developmental outcomes.

Objective 3

To accelerate the recovery of communities and coastal fisheries following Tropical Cyclone Pam the main research questions asked were: (i) What is the role of inshore FADs in community recovery in Vanuatu?, and (ii) What lessons have been learned about the role of fish in post-disaster recovery, and how can those lessons be used to guide future interventions?

FAD deployments and associated fish catch monitoring were implemented in communities selected by VFD and the national FSCP. Community and fish catch monitoring protocols on those developed by WorldFish for Solomon Islands (published as Albert et al. 2014), but modified as relevant for the situation in Vanuatu. VFD staff had experience in FAD

programmes and were central to the design and monitoring of the FADs. The monitoring design was such that it empowered local fishers to monitor catches and capture both FAD and non-FAD fishing.

As part of DFAT's post-cyclone aid package, the project provided fishing materials and canoe construction in affected communities in Shepherd Islands, Efate and Offshore, and Tafea Islands. This predominantly 'development' activity, was guided by VFD. The impact of these interventions was monitored using the survey outlined below and formed part of the more general 'lessons and principles' outputs completed in this objective.

Focus group discussions were completed using designs developed by WorldFish for Solomon Islands (post the 2007 earthquake/tsunami). These surveys concentrated on not just on quantifiable metrics of change such as income and consumption, but also intermediate outcomes such as the capacity of households to cope and respond to the shocks they have suffered.

Funding for development interventions came from a range of sources as international donors responded the Vanuatu's prioritized lists of needs. Monitoring and evaluation activities of an Asian Development Bank project implemented by VFD to deploy FADs was integrated with the current project, resulting in a greater emphasis on monitoring and evaluation rather than on hardware such as FADs and canoe construction/repair.

6 Achievements against activities and outputs / milestones

Objective 1: To better understand and promote the sustainable use of fish for nutritional security in the Pacific Food System

Activity	Outputs/ Milestones	Completion date	comments
Activity 1.1 Understanding and promoting the sustainable use of fish for nutritional security in the Pacific Food System	1.1.1 Stakeholder workshop held through SPC to develop scenarios of the consequences of changes in fish production and consumption	Q3 2015	Completed. Reported as CCAFS (2015), Bell et al. (2016) and CCAFS (2016).
	1.1.2 Workshop with SPC to agree on data sets to be used for analysis	Q3 2015	Completed. First set of standardised HIES analysed from Solomon Islands, FSM, Nauru and Palau.
	1.1.3 Training workshop for statisticians from NSOs of countries supplying HIES data	Q3 2016	Completed. Training courses run in Palau, FSM and Solomon Islands. Two ni-Vanuatu interns hosted by SPC and trained in HIES data management. Reported as a capacity development outcome.
	1.1.4 Complete a global analysis of current state of knowledge on nutritional content of marine fish	Q3 2016	Completed. Analysis completed and reported as Cohen et al.(in prep) and updated FAO database, and an updated Pacific food composition database reported as UoW/SPC/FAO (in review).
	1.1.5 Complete an analysis of Pacific food systems and publish as a journal article and through SPC channels	Q4 2017	Incomplete. Summary completed as text for inclusion in 2018 FAO SOFIA report (FAO in press). Journal article delayed and to be reported as part of FIS/2012/074 in Q4 2017 and further developed in FIS/2016/300
	1.1.6 Complete an analysis of regional and national trends in fish consumption and nutritional status published as a SPC report and journal article	Q4 2017	Completed. Regional patterns in fish consumption completed and reported as Sharp et al. (in prep), and Russell et al. (2017).
	1.1.7 Updated 2009 SPC projections of the 'fish supply gap' published through SPC channels and as a journal article	Q4 2017	Analyses completed (to be published as forthcoming journal article Sharp et al). SPC article to be completed in Q4 2017.
Activity 1.2 Case study on MDD-W and IYCF in rural villages in Malaita Province, Solomon Islands	1.2.1 Develop MDD-W and IYCF quantitative survey instrument	Q3 2015	Completed. Survey instrument developed, tablets purchased, and software coded for use in the field. Survey instrument published as WorldFish (2017a).
Activity 1.3 Case study on MDD-W and	1.3.1 Undertake training of key staff to be involved in surveys	Q2 2016	Completed. Training conducted 25th to 29th April 2016

IYCF in rural villages in Malaita Province, Solomon Islands	1.3.2 Undertake quantitative nutrition surveys in Malaita, Solomon Is and analysis completed for MDD-W and IYCF	Q3 2016	Completed. Nutrition surveys implemented May 2016. Surveys also conducted at an additional two communities in Western Province.
	1.3.3 Journal paper on MDD-W and IYCF: case study in Malaita, Solomon Islands	Q2 2017	Completed as report to Ministry of Health (Albert et al. 2017a) and as draft journal article (Albert et al. in prep).
	1.3.4 Lessons learned paper: Incorporating MDD-W into national surveys in the Pacific region	Q1 2017	Lessons learned paper not completed however lessons discussed in meeting with MHMS and recommendations for future DHS surveys made for Solomon Islands.
	1.3.5 Work with MHMS and SPC to develop and produce nutrition awareness materials for rural communities	Q4 2016	Completed. Posters informed by nutrition survey outcomes published as WorldFish (2017c, d).

Objective 2: To improve decision-making on mariculture policy and planning in Indonesia and the Western Indian Ocean

Activity	Outputs/ Milestones	Completion date	Status report
Activity 2.1 Develop a framework for diagnosing and planning equitable aquaculture development in the Indian Ocean	2.1.1 Compendium of existing documents related to decision making for mariculture in WIO region	Q4 2015	Completed. Documentation collated and used in ensuing analyses for identifying mechanisms and regional policy objectives
	2.1.2 Set of enabling mechanisms for achieving equitable mariculture identified	Q1 2016	Completed. Analyses for identifying mechanisms by reviewing collated policies and decision-making documentation from WIO (Activity 2.1.2).
	2.1.3 Framework for equitable mariculture development in the Indian Ocean developed	Q2 2016	Completed. Tentative model developed ahead of workshop (Activity 2.1.4) and refined for publication as ACIAR monograph 'Diagnostic framework"
	2.1.4 Workshop to test/validate and refine framework	Q3 2016	Completed. Workshop held in May 2016 in Zanzibar with participants from six countries, including representatives from government and non-government sectors, academia, and private sector.
	2.1.5 Journal article on benefit sharing mechanisms for mariculture development in Indian Ocean	Q3 2016	Completed. To be published as Brugere et al. - submission in Q4 2017.
	2.1.6 Journal article on solutions to greater gender equity in decision-making around mariculture and related livelihood choices	Q1 2017	Reporting revised. Gender is an integral component of the analyses in (Activity 2.1.5) and will be reported there.
	2.1.7 Policy brief on the application of the framework for diagnosing and planning aquaculture development in the Indian Ocean published	Q4 2018	Incomplete. The policy brief will follow acceptance of Brugere et al.
Activity 2.2 Review of Indonesian experiences and learning in	2.2.1 Economic and environmental outcomes of Indonesia's better management programs documented	Q2 2016	Completed. Projects identified and documentation collated for review. Reported as Mohan et al. (Activity 2.2.2)

mariculture development	2.2.2 Analysis of Indonesian Better Management Practices cluster management projects completed	Q3 2017	Completed. Reported as Mohan et al. (in prep)
	2.2.3 Journal article and policy brief the development of mariculture within Indonesia	Q4 2017	Completed. Reported as Henriksson et al. (2017a, b) and Tran et al. (2017). Policy Brief drafted and reported here.

Objective 3: To accelerate the recovery of communities and coastal fisheries following Tropical Cyclone Pam.

The activity schedule for Objective 3 was significantly revised to accommodate changes forced by unforeseen duplication of activities with an ADB-funded development project written after the current activity schedule was approved. All changes were made in consultation with VFD and other affected bilateral projects and approved by ACIAR.

Activity	Outputs/ milestones	Completion date	Status Report
Activity 3.1 Assess current status and needs of households post TC-Pam	3.1.1 Household socio-economic surveys undertaken (start point)	Q3 2016	Completed as focus group discussions rather than household surveys.
	3.1.2 Household socio-economic surveys undertaken (end point)	Q2 2017	Completed within above.
	3.1.3 Socio-economic surveys analysed and published as an SPC output	Q3 2017	Survey analysis and report completed, results incorporated into Eriksson et al, 2017
Activity 3.2 Community-based FAD monitoring	3.2.1 Priority locations for monitoring agreed with VFD	Q1 2016	Completed. Meeting held with VFD on the 31st March and 1st April 2016, further expanded during meeting with VFD on 29th September 2016.
	3.2.2 Design fish catch and socio-economic monitoring	Q1 2016	Completed. Meeting held with VFD on the 31st March and 1st April 2016 to confirm design. Subsequently this has been integrated into the regional SPC-led TAILS data collection.
	3.2.3 Development of tablet-based data collection forms and online database	Q2 2016	Completed. Database developed and content refined during a meeting with VFD between 26th to 29th July. Subsequently this has been integrated into the regional SPC-led TUFMAN2 database.
	3.2.4 Fish catch monitoring initiated in five communities	Q3 2016	Completed. Community monitoring training conducted at 13 sites from 21st August to 2nd October 2016.
	3.2.5 Post-FAD deployment fish catch monitoring at five sites	2018	Initiated as part of 3.2.4 and ongoing as part of related projects in Vanuatu. Limited data at all sites due to delays in FAD deployments by VFD means only preliminary results will be reported here.
	3.2.6 Fish catch data analysed (before and after FADs) and journal article on the role of fish and FADs published through SPC channels	2018	Incomplete. Due to delayed FAD deployments, data remains insufficient for robust analysis. Currently 2035 fishing trip records from 18 monitoring locations. Monitoring remains ongoing as part of related project and publication to be incorporated into FIS/2016/300.

Objective 4: To generate generalizable lessons about the role of fish in development

Activity	Outputs/ milestones	Due date of output/ milestone	Status report
Activity 4.1 Synthesis of lessons learned through these and related studies	4.1.1 Regional review of fish in Pacific food systems, with particular reference the rise of over-nutrition in developing countries published as a journal article	Q1 2017	Incomplete. Summary reported in FAO 2018 SOFIA report completed. Full review to be reported as part of FIS/2012/074 and further developed in FIS/2016/300.
	4.1.2 Journal article on The contribution of fresh and canned fish to nutrient intakes and food security in the Pacific region.	Q4 2017	Completed. Reported as Bell et al. (to be submitted Q4 2017).
	4.1.3 Policy guidelines for development of coastal mariculture in the Western Indian Ocean region and its impacts on wellbeing and economic development published as journal article	Q2 2017	Completed. Reported as Troell et al. (to be submitted to *Marine Policy*).
	4.1.4 Journal article on generalizable lessons concerning the role of fish and fisheries following natural disasters, using Aceh, Solomon Islands, Philippines and Vanuatu as case studies	Q4 2016	Completed. Reported as Eriksson et al. (2017) - as per activity 3.2.6.

7 Key results and discussion

Below we summarize activities and results grouped as discrete outputs. The four activities in Objective 4 that report outputs from Objectives 1-3, are summarized in Objectives 1-3.

Published or in press outputs are abstracted and the reader is referred to those articles for more complete discussion. Unpublished outputs are summarized in more detail. See sections 10.1 for references cited and 10.2 for a full listing of outputs produced and under development.

7.1 Objective 1: To better understand and promote the sustainable use of fish for nutritional security in the Pacific Food System

7.1.1 Scenarios of future food systems

This section summarizes activities and outputs from Activities 1.1.1 to 1.1.3 – see Section 6 for tabulated activities and milestones. In presenting this summary we extrapolate material from published outputs related to this component.

The food system of the Pacific region is undergoing profound changes that will be felt for generations. The main pillars of food security – availability, access, and consumption of nutritious food – are being challenged by rapid population growth and urbanisation, shortages of arable land, and cheap, nutritionally poor food imports from burgeoning global trade. As a result, many Pacific Island countries and territories are now dependent on imported food, and the incidence of non-communicable diseases (NCDs) is among the highest in the world. Climate change brings further threats as well as opportunities.

In the face of great uncertainty and complexity, developing ‘scenarios’ can help summarise the most important and uncertain drivers of change, develop and test policies, plans and strategies for the future, encourage the necessary investments to support adaptation to agriculture, fisheries and aquaculture, and ultimately help catalyse policy responses in ways that more technical analyses cannot. Scenarios are ‘what if’ stories about the future – rather than attempting to forecast a single future in the face of many uncertainties, scenarios represent multiple plausible directions that future drivers of change may take. In a time when we are faced with an over-abundance of sometimes conflicting information, scenarios offer meaningful and diverse stories about the future.

The group followed a process used by CGIAR, in its Research Program on Climate Change, Agriculture and Food Security (CCAFS), to first identify drivers of change that were both important and uncertain and then use them to develop scenarios that paint plausible but very different futures. This process resulted in two ‘axes of uncertainty’ that, together, summarised the most important and uncertain drivers of change. The first axis was ‘governance of natural resources’, concerning regulations and policies over both water and land resources at all levels, and the capacity to implement them. The second axis was identified as ‘economic connectedness to the rest of the world’, concerning trends in trade, remittances, migration, tourism and tuna fisheries based on the multitude of choices countries make in the coming decades. The combination of these two axes led to four scenarios, one in each quadrant. Groups were assigned a scenario to explore what their combination of the two extremes of the axes could mean; in 2030 and in the shorter term. Participants considered what would happen to all of the drivers of change identified in the first exercises, and described in detail the consequences of each scenario for various dimensions of food and nutrition security, food system activities and climate change adaptation. Each scenario was named, and a narrative created to describe it. An example of one of the scenarios is presented below (see Bell et al. (2016) for full details).

Cartoons proved an effective way of enlivening the workshop and capturing deliberations and insights. The cartoonist, Roger Harvey, was a gifted observer of social dynamics and had an ability to simplify complex ideas. Cartoons were drawn 'live' during the workshop and used to steer conversations and mark milestones in the scenario process.

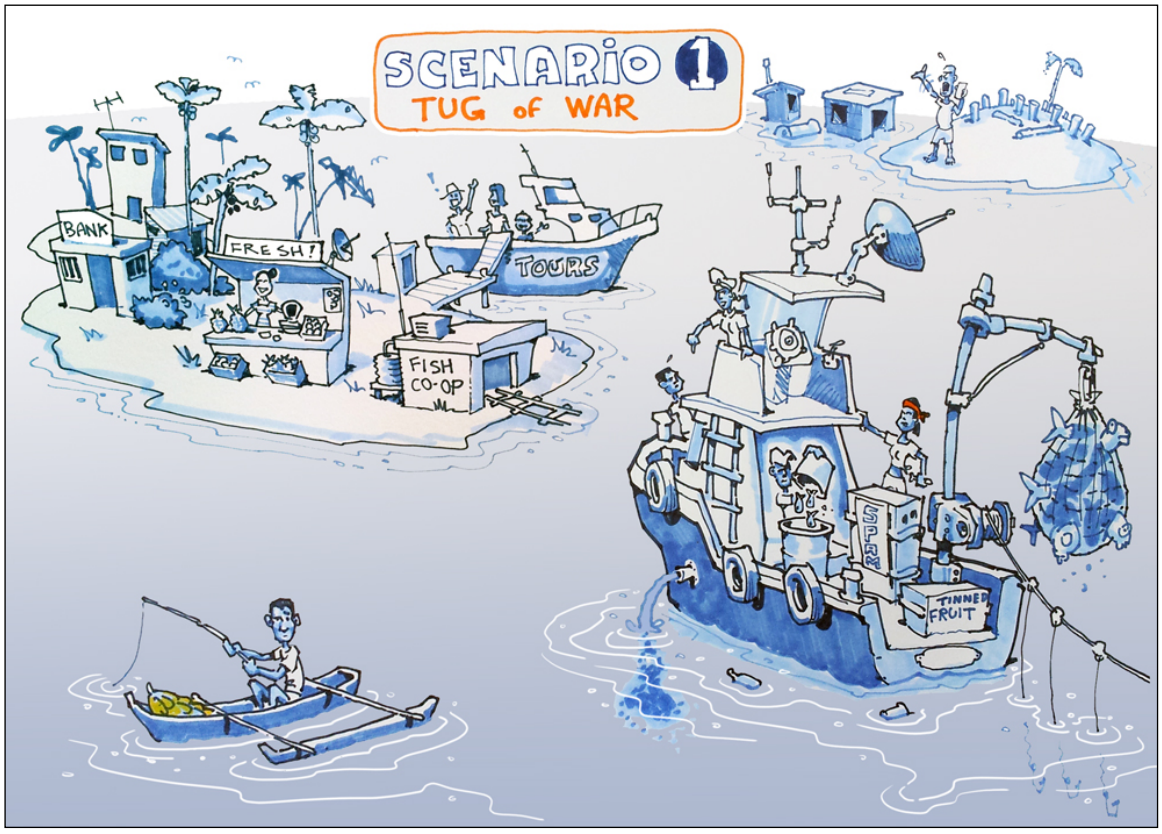

Figure 7.1: Example of cartoon depiction of Scenario One resulting from workshop activities.

Scenario 1 – "TUG OF WAR": High connectedness coupled with well-governed natural resources. Many people are more prosperous and have been able to take advantage of the economic development that has resulted from increased exports, imports and tourism, however there is also increased inequity. Significant progress is booked in terms of management and governance of resource stocks, ecosystem health and productivity. But little attention has been paid to marginalised and vulnerable people, and bottom-up approaches to community development are hampered by lack of capacity and resources. The better-off are doing well, but the poor and vulnerable are not, and as a result, society has more choices but also more gaps.

Recommendations for action towards climate change responses in food systems

Based on earlier research and on the insights from the Scenarios workshop, Bell et al. (2016) offered some general recommendations for responding to changes to the food system under climate change:

1. Conduct national assessments of the vulnerability of agriculture to climate change and identify: (i) implications for food security and livelihoods, and (ii) priorities in agricultural adaptations that minimize threats and maximize opportunities.
2. Identify research needs in each country to implement priority adaptations based on: (i) projected food needs of rural and urban populations, (ii) natural and human capital for producing agricultural and fisheries products, (iii) existing production

methods and capacity, including traditional knowledge, (iv) projected effects of climate change on national food systems and (v) previous research that can be used to help improve resilience of national food systems.

3. Strengthen food systems research for the region by: (i) creating effective partnerships between national research and extension agencies, farmers' networks, non-governmental organisations and advanced scientific institutions to improve national research capacity, (ii) mentoring national research and extension staff and farmers to document results of field trials and share research data and results with counterparts in neighbouring countries, (iii) implementing innovative approaches to overcome constraints to sharing knowledge with farmers and fishing communities in other countries and regions, (iv) improving the understanding of the factors influencing uptake of technology, and (v) providing farmers and fishing communities with climate services to guide their investments and activities.

Outputs produced

Bell J, Taylor M, Amos M, Andrew N. (2016). Climate change and Pacific Island food systems. CCAFS and CTA. Copenhagen, Denmark and Wageningen, the Netherlands URL: https://ccafs.cgiar.org/publications/climate-change-and-pacific-island-food-systems#.WbilYrIjHIU.

CCAFS (2015a) online media reference to Bell et al. 2015 report, URL: https://ccafs.cgiar.org/news/media-centre/in-the-news/climate-change-and-pacific-food-systems-navigating-perfect-storm#.Wbh69rIjHIU.

CCAFS (2015b) 'The future of the Pacific under climate change' animation, URL: https://www.youtube.com/watch?v=bg-PEKDNj3M.

Secretariat of the Pacific Community (SPC) (2015). Alternative futures for the Pacific food system. Suva, Fiji: Secretariat of the Pacific Community, URL: https://ccafs.cgiar.org/publications/alternative-futures-pacific-food-system#.WbilDLIjHIU.

7.1.2 Fish in the Pacific Food System

This section summarizes activities 1.1.5, 4.1.1 and 4.1.2. The work is incomplete but the full analysis will be reported as part of FIS/2016/300 and will be published as:

Andrew, N.L., M. Amos, J. Bell, H. Erikssen, E.H. Allison, J. Fanzo, A. Fink, P. James, J. Sanders, A. Romeo, M. Sharp, W. Snowden, A-M. Thow, C. and Tukiatonga (in prep). The evolution and dysfunctions of the Pacific Food System. Target journal *Global Environmental Change*.

The completed study will provide both an analysis of the food system in a structural sense, but also seek a deeper understanding of its causes and drivers. Among many causes, understanding the roles of trade and trade liberalization (e.g. Thow 2009), migration and urbanization (e.g. Connell and Corbett 2016), and the legacies of colonialism (e.g. McLennan and Ulijaszek 2015) are key to understanding why it is the way it is. In addition to the classical pillars of a food system, we will incorporate the concept of a food environment (e.g. Snowden et al. 2010) as a critical intervention opportunity. Our analysis will use these understandings to map pathways for continued change and evolution of the regional food system.

A headline summary will be summarized as part of the 2018 FAO SOFIA report and is copied below:

A food system is that set of interacting activities and outcomes that encapsulate the production, processing, trade, and consumption of food. Food systems are usually complex, operate at many scales, and have very different outcomes in terms of wealth creation and public health. In addition to the classical pillars of a food system (production, processing, trade, and consumption), environmental change and social drivers of consumption (the food environment) are integral to policy interventions. Such framings of food systems increase the prominence of culture, choice, and politics in influencing activities and outcomes.

The production and consumption of food in the Pacific region is exposed to external drivers of change, both physical and social (Figure 7.2). Among physical drivers, climate change has been recognized as a key source of uncertainty – predicted shortfalls in coastal fisheries production will be exacerbated by climate change. Nutritional security is further challenged by population growth and urbanization, shortages of arable land, and cheap, low-quality food imports from burgeoning global trade.

Figure 7.2: Conceptual framing of The Pacific Food System (from Andrew et al. in prep)

By many accounts the food system of the Pacific region is failing to provide food and nutrition security for people who live in region's 16 small countries. The food system is undergoing profound changes that will be felt for generations to come. Per capita agricultural production is declining and imports of nutritionally less rewarding food are increasing. Many Pacific Island countries are affected by the triple burden of malnutrition (undernutrition, nutrient deficiency and overweight/obesity). As a result the, rise of NCDs, childhood stunting and anaemia have major implications for economic growth, aid policy and development. For example, an estimated 75% of the adults' deaths in the Pacific are

due to NCDs, with the majority of death occurring amongst adults in the economical active age bracket[3].

Fish plays a unique and substantial role in creating wealth and contributing to national economies, and as an animal source food in the region. Fish accounts for 50-90% of animal source food in coastal populations, and most comes from coastal fisheries for reef fish and small pelagic species. In 2015, the total catch of tuna including yellow fin, albacore, big eye and skipjack by national waters stood at more than 587,000 metric tonnes in the Region, but the vast majority of this catch is exported from the region[4]. Canned tuna, much of it from the region, is an important and growing source of fish, particularly in Melanesia. Aquaculture production is modest and has contributed little to food security in most PICs.

A central challenge in securing and increasing the role of fish in the Pacific food system is to guide the production and consumption under a range of ecological and social drivers of change. Although there are many differences in production and consumption across the region, and between coastal and inland areas of the larger nations, such as Papua New Guinea and Solomon Islands, a broad reframing of the challenge is needed to improve the economic, environmental and public health outcomes of regional and national food systems. Policy narratives in support of regional initiatives, such as the Framework for Pacific Regionalism[5] and the 2015 Noumea Strategy[6] seek more integrated approaches.

Adaptations to increase the supply of coastal fish and increase the availability and accessibility of tuna will require interventions at a range of scales, from community-level initiatives to trade and taxation changes, and at all stages of the food system.

Here we have focused on framing the food system in terms of its constituent components. As part of project FIS/2016/300 we will develop a more informed analysis that seeks to understand why the food system and its drivers are the way they are. Chief among these are historical and current processes such as colonialism, modernization, trade regulation, and economic liberalization.

7.1.3 Increasing the contribution of locally-canned tuna to food security in PICs

This section summarizes outputs from activity 4.1.2. The research and key findings here are drawn from a forthcoming journal article to be published as:

Bell J.D., M. Sharp, E. Havice, M. Batty, W. Adams, N. Andrew, K. Azmi, J. Russell, K. Charlton, L. Rodwell, S. Gu'urau, R. Gillett (in prep). Increasing the contribution of locally canned tuna to food security in PICs. Target journal *Fish and Fisheries.*

Problem statement & significance

Fish has been a cornerstone of food security in the Pacific Islands region largely because the opportunities to produce other forms of animal protein are limited. Until recently, most of the fish consumed in Pacific Island countries has come from coastal fisheries, which are based mainly on coral reefs. However, as human populations in the region grow, a gap is emerging between how much fish can be harvested sustainably from coastal fisheries, and the quantity of fish required to support good nutrition.

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[3] *https://sustainabledevelopment.un.org/content/documents/2231Food%20Security%20and%20Nutrition%20in%20SIDS.pdf*

[4] *www.wcpfc.int/doc/wcpfc-tuna-fishery-yearbook-2015*

[5] *www.forumsec.org/resources/uploads/embeds/file/Framework%20for%20Pacific%20Regionalismbooklet.pdf*

[6] *www.spc.int/DigitalLibrary/Doc/FAME/Reports/Anon_2015_New_song_for_coastal_fisheries.html*

Three interventions, based on increasing access to the region's rich tuna resources for domestic consumption, can help to fill this gap. These interventions are:

- assisting coastal communities to catch more tuna by fishing around nearshore, anchored fish aggregating devices (FADs);
- improving the distribution of the small tuna and bycatch offloaded from purse-seine vessels during transhipping operations in major ports to increase the supply of fish for rapidly-growing urban and peri-urban populations;
- making locally-canned tuna more readily available at affordable prices, particularly in Melanesia where the majority of the region's population lives.

The tuna component of the 'Regional Roadmap for Sustainable Pacific Fisheries', endorsed by Pacific Island Leaders in 2015, embraced the challenge of meeting that demand. It specifies that an additional 40,000 mt of tuna is to be made available for domestic consumption per year by 2024.

The canned tuna sector stands to play a significant role in meeting twin goals of improving food security and creating more opportunities for employment. Nutritionally, levels of protein, minerals, and vitamins of canned tuna are similar to cooked fresh reef fish, cooked fresh tuna, and other canned fish. It is moreover a good source of omega-3 fatty acids; important in reducing the risk of cardiovascular disease and high blood pressure. Canned tuna is non-perishable, making it one of the few options for increasing access to fish for the large inland populations in PNG and other areas in Melanesia that do not have adequate cold chains to secure access to fresh fish. For coastal communities that regularly consume fresh fish, canned tuna is a healthy substitute when sea conditions are too rough for fishing from small boats, when fish are seasonally scarce or following natural disasters (e.g. cyclones), and when traditional or institutional restrictions need to be placed on catching coastal fish to restore stocks.

Objective

This research sought to estimate domestic consumption of locally-canned tuna and explore the scope for increasing consumption of these products to contribute to the food security and employment goals of the Roadmap. The benefits of canned fish for food security and improved nutrition were examined, followed by an assessment of current national patterns of canned fish consumption and consumption of canned fish per capita. The study also examined constraints to the consumption of locally-canned tuna; outlined opportunities to increase market share; and identified policies that governments could consider to increase sales of locally-canned tuna. We focused on the three largest countries in Melanesia – Papua New Guinea (PNG), Fiji and Solomon Islands – since most people in the Pacific Island region live here and most of the region's tuna is processed there.

Key findings

Consumption of canned fish: Table 7.1 presents data regarding origin, availability and per capita consumption of canned tuna and other canned fish in selected Pacific Island countries. When all sources of canned fish were combined, unsurprisingly PNG (having the largest population) indicated the greatest total annual consumption, 11,000 mt in 2014, followed by Fiji and Solomon Islands. However, there were large differences in per capita consumption of canned fish. National average per capita consumption of all canned fish combined in Fiji varied from 7–10 kg, and from 5.6–6.6 kg in Solomon Islands, while in PNG, it was only 1.2–1.5 kg.

An SPC (2008) policy brief showed that canned fish was providing 21–28% of the recommended annual per capita fish consumption of 35 kg in Fiji and 16-19% in Solomon Islands. Importantly, canned tuna alone is providing 11–14% of the recommended annual per capita fish consumption in Fiji and 15–17% in Solomon Islands. The lower per capita

consumption of canned fish in PNG is largely due to poor (market) distribution to remote, inland areas where more than 60% of the population lives.

Constraints to consumption of locally-canned tuna: Domestic canned tuna sales are constrained by the relatively limited local spending power of people, making competition with pricing of lucrative international export markets problematic (e.g. red tuna meat export for pet food). Furthermore, increased sales of locally canned tuna may not result in more jobs in canneries if Pacific Island canneries lose market share in Europe. In terms of distribution, extending market chains into remote infrastructure-deficient inland areas is difficult and expensive. Current governance arrangements have also led to processing plants operating under capacity. Permits to fish in PNG EEZ for example are granted on the condition that the company establishes a processing plant. Although processing plants are then established they are underutilised with most catch being landed and exported.

Opportunities to increase consumption of locally canned tuna: Realising opportunities to harness a greater market share for locally canned tuna will help avoid the possibility that canned tuna (promoted for increased domestic consumption) is comprised of fish caught in the region, but processed overseas. Aspiring to a replacement of canned tuna imports into PNG and Fiji (respectively >50% and >30% of the tuna eaten domestically is imported) would see significant impact, as would a continuation in supplying 90% of canned tuna sales in Solomon Islands as expected market growth follows population increase. In particular, for PNG, commissioning surveys to assess the nature and size of the market for canned tuna in inland PNG can provide critical information to meet the demand (e.g. tailor products and upgrade distribution networks). In Fiji, there is opportunity to provide greater incentives for purse-seine vessels to sell skipjack and yellowfin to local canneries. Lastly, supplying more imports of canned tuna by other PICTs can strengthen regional market networks (and its position in the global market).

Recommendations

To harness the full direct benefits of locally-canned tuna the governments of Fiji, Solomon Islands and PNG can implement policies to facilitate the supply and distribution in the region. Such intervention may include: promoting health benefits of tuna; mandating regular delivery of tuna to national processing operations by licensed vessels; removing duties on materials needed by local fish processors; specifying minimum product-quality standards to eliminate low-quality canned tuna imports; and imposing import duties on canned tuna to encourage purchase of domestic products.

To make imported canned tuna from other PICs more competitive with imports from Southeast Asia, governments can use the MSG Trade Agreement and Pacific Island Country Trade Agreement. More specifically for the case of PNG, using revenue from the Vessel Day Scheme can (i) subsidise the cost of canned tuna for inland populations in PNG (colour-code cans to prevent illegal sales to other parts of the country); and (ii) improve systems for distributing locally-produced canned tuna to inland PNG. It will be important to develop links in fishing access arrangements for vertically integrated companies that have processing operations in PNG in order to achieve minimum domestic sales levels at affordable prices. An economic analysis of alternative models for domesticating the production of canned tuna would strengthen policy analysis and the consideration of different interventions.

Evaluation

To measure the success of any new policies, better access will be needed to data on (i) the amount of locally-canned tuna sold on domestic markets, and (ii) the quantities, quality and origin of imported canned tuna. Recent improvements to HIES, which partition fish consumption into a wider range of fish types, including canned tuna, will also help to provide this information. The typical 5-year cycle of HIES, means, however, that information will be out-of-date more often than not. Any evaluation will need to include an

analysis of the economic trade-offs of local production and supply from domestic sources vs importation.

Our analysis provides part of the information required to establish the baseline for the food security goal of the Roadmap so that the annual Report Card can be completed. To determine whether an additional 40,000 mt tonnes of tuna per year has been made available by 2024, Pacific Island fisheries managers need to know how much locally-caught tuna was used for domestic consumption before the Roadmap was released in 2015. Our study showed that in 2014, a total of ~24,000 mt of whole tuna was processed in Fiji, PNG and Solomon Islands to produce canned tuna for local markets (Table 7.1). To establish the baseline, this quantity of tuna needs to be added to the amounts caught by subsistence fishers (derived from HIES), small-scale artisanal (commercial) fishers, and offloaded at regional ports during transhipping operations.

Table 7.1: Summary of the origin, availability and per capita consumption of canned tuna and other canned fish in selected Pacific Island countries. 'TBD' indicates not known at time of writing.

	Country								
	Fiji			PNG			Solomon Islands		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
Weight of whole tuna for canning (mt) [a]	5,330[a]	6,870[a]	7,462[a]	6,533	8,780	9,205	7,022[a]	8,018[a]	7,495[a]
Canned tuna produced & sold domestically (net weight mt)	2,132[b]	2,748[b]	2,985[b]	2,613[c]	3,512[c]	3,682[c]	2,809[b]	3,207[b]	2,998[b]
Imports of canned tuna (net weight mt)[d]	2,159	710	1,081	5,476	3,651	6,215	185	540	239
Total canned tuna available (net weight mt)	4,291	3,458	4,066	8,089	7,163	9,897	2,994	3,747	3,237
Canned tuna derived from local canneries (%)	50	79	73	32	49	37	94	86	93
Other canned fish produced & sold domestic (net weight mt)[e]	1,796	1,638	1,756	TBD	TBD	TBD	-	-	-
Imports of other canned fish (net weight mt)[f]	2,358	1,185	2,057	853	1,884	1,456	267	265	268
Total canned fish available (net weight mt)	8,445	6,281	7,879	8,942	9,047	11,353	3,261	4,012	3,505
Estimated population (#)	855,472	859,200	863,100	7,227,577	7,398,500	7,774,900	582,027	610,800	626,400
Per capita consumption canned fish (kg person^{-1} yr^{-1})	9.9	7.3	9.1	1.2	1.2	1.5	5.6	6.6	5.6
Per capita consumption canned tuna (kg person^{-1} yr^{-1})	5.0	4.0	4.7	1.1	1.0	1.3	5.1	6.1	5.2

a = derived from net weight of canned tuna sold locally divided by 0.4 because the packed weight of fish in a can averages 40% of whole weight of fish processed for canning; b = calculated as 80% of gross weight of canned tuna; whole weight of tuna estimated before processing; c = calculated as 40% of whole weight of fish processed for canning; d = calculated as 80% of gross weight of imported canned tuna given in Table 2; e = mackerel, calculated as 80% of gross weight of canned product; f = mainly mackerel, sardines and pilchards, calculated as 80% of gross weight of canned product; g = source: Statistics for Development Division, Pacific Community; 2012 values are midpoint between 2011 and 2013.

7.1.4 Regional apparent fish consumption

This section summarizes activities and outputs from Activities 1.1.2 and 1.1.7 – see Section 6 for tabulated activities and milestones. The analyses in this section are based on HIES. Delays in data access agreements with national governments meant activities in 2015-16 were re-prioritized and two new outputs added: the food composition tables (reported in 7.1.5) and systematic literature review. Analyses of regional patterns in apparent fish consumption were completed in Q3 2017. See Section 5.2 for general methods. The analyses report household acquisition, it is not possible to further disaggregate the source of fish as coming from domestic production or imported from the region or beyond.

Direct measures of dietary intake – considered by nutritionists as the gold standard to measure intake of micro-and-macronutrients (Fiedler et al. 2012) – in the Pacific are hampered by the lack of nationally representative data due to the financial and logistical constraints of conducting such surveys (Bermudez et al. 2012). The use of HIES-derived estimates as proxies to estimate food acquisition and apparent consumption presents an opportunity to form nationally representative evidence-based food and nutrition oriented policy (Fiedler and Dupriez 2012).

HIES are widely used to estimate food energy intake, poverty lines (Ravallion 1998) and, more recently – in the absence of direct measures – to estimate per capita macro-and-micronutrient availability (Bermudez et al. 2012). Methods to estimate availability and consumption from HIES are available (Dary and Imhoff-Kunsch 2012, Imhoff-Kunsch et al. 2012), but are not without problems, including:

- HIES captures acquisition rather than actual consumption
- based on the survey methodology, food leakages through, for example, gifting to non-household members, spoilage and wastage may not be captured
- there are few examples in the Pacific where HIES collected data on opening and closing food stocks, so there is potential for over or underestimation of food availability
- HIES collects household food acquisition and, as such, there are challenges with allocating apparent consumption among household members
- food consumed away from home through, for example, school feeding programs, is likely to be underreported.

These problems notwithstanding, there are limited alternatives to derive estimates of food consumption to guide food and nutrition policy. There is broad consensus in the literature that, although not perfect, HIES serves as a reasonable proxy for estimating food acquisition and apparent consumption (Dary and Imhoff-Kunsch 2012; Imhoff-Kunsch et al. 2012). HIES have been used in combination with other estimation techniques a number of studies in the region to estimate per capita consumption of fish and seafood in the region (Bell et al. 2009; Gillett 2009, 2011, 2016; Needham and Funge-Smith 2014).

Patterns in apparent consumption of fish in eight PICs

This section summarizes patterns in acquisition and apparent fish consumption[7] in eight PICs. The analyses have been completed and will be published as:

[7] *The term '**acquisition**' is used to signify the availability of fish in the household – got through cash purchase, gifting or subsistence. Fish comes into a household as **whole fish equivalent** (WFE), only part of which is edible. Conversion of WFE to **edible portion** for dietary diversity and nutrition analyses followed FAO guidelines. Canned fish is considered 100% edible. The term **apparent consumption** is used because HIES gathers information on household expenditure on fish which is used as a proxy for consumption. Where the unqualified term 'consumption' is used for brevity, this caveat should be borne in mind.*

Sharp, M., N.L. Andrew, A. Delisle, H. Eriksson, A. Romeo (in prep). Patterns in acquisition and apparent consumption of fish in eight Pacific Island Countries. Target journal *Fish and Fisheries*.

These analyses have only recently been completed and are tabulated here with minimal interpretation prior to further data checking and development for the forthcoming paper.

The vast majority of households in the eight PICs reported acquiring fish in the reporting period, but a surprisingly large proportion did not report acquiring some categories (Table 7.2). Most households acquired reef fish, except in Vanuatu, Tonga and Samoa where fewer than half of rural households acquired reef fish in the reporting period. Acquisition of pelagic fish was greatest in FSM, NRU, TKL and in urban SLB HH. A large majority of HH purchased or were gifted canned fish, with acquisition being greatest in SLB, WSM and VUT. Canned fish was least popular in Tongan households where just over half of HH reported acquiring it. Canned fish was only less popular in urban households in FSM.

Relatively few HH in most countries acquired shellfish in the period, particularly in NRU, TKL, TON and WSM. Acquisition of shellfish in SLB appears to be anomalously high and was driven rural HH. For example, fewer than 13% of urban HH in Vanuatu and rural HH in WSM reported shellfish acquisition. Proportionally more rural households reported fish consumption than urban households. Less than 15% of urban households in VUT reported acquiring fresh fish in the reporting period.

Table 7.2: Proportion of rural and urban households that acquired fish, by product type. Country codes are: Federated States of Micronesia (FSM), Nauru (NRU), Palau (PLW), Solomon Islands (SLB), Tokelau (TKL), Tonga (TON), Vanuatu (VUT) and Samoa (WSM).

Country	Pelagic fish	Reef fish	Shellfish	Canned fish	Total
FSM (Total)	**69%**	**79%**	**29%**	**51%**	**96%**
Rural	63%	87%	38%	59%	96%
Urban	77%	67%	15%	39%	95%
NRU (Total)	**66%**	**55%**	**7%**	**42%**	**91%**
PLW (Total)	**20%**	**50%**	**16%**	**61%**	**80%**
Rural	12%	55%	20%	66%	86%
Urban	21%	49%	15%	59%	79%
SLB (Total)	**45%**	**74%**	**40%**	**83%**	**98%**
Rural	42%	77%	44%	80%	98%
Urban	61%	64%	22%	99%	100%
TKL (Total)	**52%**	**88%**	**14%**	**56%**	**97%**
TON (Total)	**12%**	**50%**	**17%**	**52%**	**79%**
Rural	21%	44%	14%	46%	77%
Urban	10%	52%	18%	54%	80%
VUT (Total)	**31%**	**15%**	**30%**	**72%**	**82%**
Rural	37%	15%	35%	72%	85%
Urban	14%	14%	13%	73%	76%
WSM (Total)	**29%**	**38%**	**12%**	**86%**	**93%**
Rural	29%	40%	13%	88%	94%
Urban	28%	32%	8%	78%	90%

In FSM, PLW, TKL and TON, reef fish was proportionally the most acquired type in those HH that reported acquiring fish of any type (Figure 7.3). Reef fish was least represented in SLB, VUT and WSM and was surprisingly low in SLB. Acquisition of shellfish in SLB appears to be anomalously high and was driven rural HH. Proportionally more rural households reported fish consumption than urban households, where shellfish was most represented.

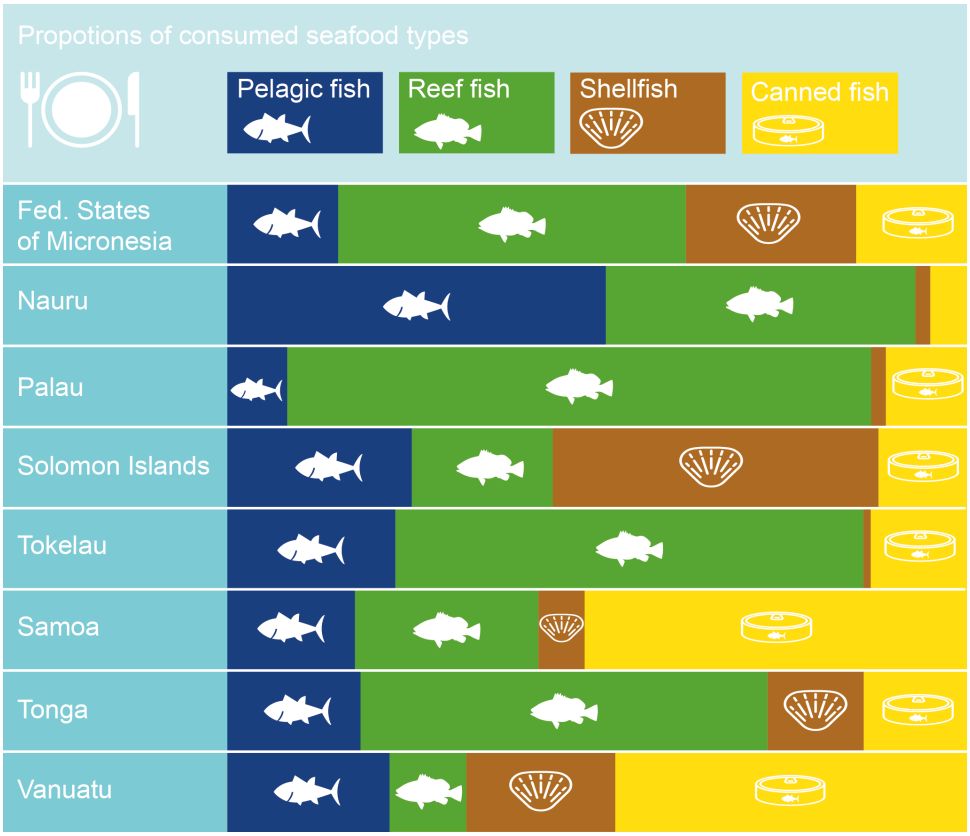

Figure 7.3. Proportions of fish types acquired in eight PICS for households reporting fish acquisition.

Relatively few HH acquired shellfish in the survey period, particularly in NRU, TKL, TON and WSM.

Taken in aggregate, rural households acquired more fish products than urban households (Table 7.3) in all countries except Tonga where there little difference. No urban/rural categorization is made for Nauru, or Tokelau. Per capita fish acquisition by fish category varied between countries. Breaking acquisition down among fish types and urban/rural differences, there are large differences in acquisition. Pelagic fish are most important for households in NRU; reef fish are most important for households in PLW and TKL; shellfish are most important for households in rural SLB, while canned fish are most heavily relied on by urban households in VUT and WSM.

Table 7.3: Per capita whole fish acquisition (kg/person/year), by fish category and by rural-urban

Country	Pelagic fish	Reef fish	Shellfish	Canned fish	Total
FSM	**9.3**	**28.5**	**14.2**	**8.9**	**61.0**
Rural	7.9	33.8	19.5	9.3	70.4
Urban	11.8	19.6	5.5	8.3	45.2
NRU	**21.0**	**17.2**	**0.6**	**2.1**	**40.9**
PLW	**4.7**	**48.0**	**1.5**	**6.5**	**60.7**
Rural	4.8	57.7	3.4	7.7	73.6
Urban	4.7	45.8	1.0	6.3	57.7
SLB	**13.1**	**9.8**	**22.3**	**5.9**	**51.0**
Rural	11.6	10.1	25.1	4.5	51.3
Urban	19.9	8.4	9.7	11.7	49.9
TKL	**23.1**	**62.7**	**1.0**	**13.4**	**100.2**
TON	**5.3**	**16.1**	**4.0**	**4.1**	**29.5**
Rural	7.2	14.3	3.1	4.0	28.7
Urban	4.8	16.6	4.2	4.2	29.8
VUT	**8.5**	**4.0**	**7.8**	**19.1**	**39.4**
Rural	10.6	4.1	9.8	17.9	42.4
Urban	3.0	3.8	2.4	22.2	31.4
WSM	**5.6**	**8.3**	**1.8**	**17.8**	**33.6**
Rural	5.7	8.8	2.0	18.5	34.9
Urban	5.4	6.3	1.2	14.8	27.8

Analysing trends through time in the acquisition and apparent consumption of fish are fraught with danger because of differences in HIES design and enumeration, inclusion of gifting, inconsistent reporting of WFE and edible portions, and the many different time periods of the surveys.

Here we report, without detailed scrutiny, summaries from various sources (Table 7.4). The HIES reported in Bell et al. were done before 2003 and current set of standardized HIES were done between 2010 and 2016. For the current HIES we report two estimators – total mean and a median. Because the data are positively (left) skewed, the mean is higher than the median. We report both descriptors and use the mean as an upper estimate and the median as a lower estimate of per capita fish acquisition.

Using different CPI-inflated price denominators across fish products and including gifts received by surveyed households, FSM, NRU and WSM have reduced the per capita whole fish acquisition between the two survey periods. In contrast, PLW, SLB, TON and VUT have increased the per capita whole fish acquisition between the survey periods used in the Bell et al. HIES and current set.

Table 7.4: Comparison of estimates of per capita whole fish acquisition (kg/person/year) by country. The current study uses two methods to estimate per capita AC.

Country	Bell et al. (2009)	Current study mean	Current study median	FBS[8]	Gillett (2016)
FSM (Total)	**69.3**	**61.0**	**46.9**	**44.0**	72.0 – 142.0
Rural	76.8	70.4	53.3		
Urban	67.3	45.2	37.8		
NRU (Total)	**55.8**	**40.9**	**32.2**	**24.0**	46.7 – 63.9
PLW (Total)	**33.4**	**60.7**	**32.5**	**67.7**	84.0 – 135.0
Rural	43.3	73.6	43.5		
Urban	27.8	57.7	30.7		
SLB (Total)	**33.0**	**51.0**	**32.5**	**32.8**	32.2 – 45.5
Rural	31.2	51.3	31.1		
Urban	45.5	49.9	38.6		
TKL (Total)		**100.2**	**96.6**		119.4
TON (Total)	**20.3**	**29.5**	**21.1**	**35.0**	25.2 – 35.0
Rural		28.7	22.1		
Urban		29.8	21.1		
VUT (Total)	**20.3**	**39.4**	**28.9**	**33.6**	15.9 – 25.7
Rural	20.6	42.4	30.7		
Urban	19.3	31.4	24.5		
WSM (Total)	**87.4**	**33.6**	**22.7**	**46.8**	46.3 – 129.5
Rural	98.3	34.9	23.4		
Urban	45.6	27.8	18.4		

Assessing Dietary Diversity through HIES in the Federated States of Micronesia

Diets in FSM have changed since World War II, and more so in recent years, with increased imported foods including white rice, flour, meat and energy-dense nutrient-poor processed foods (Englberger et al. 2002). According to the WHO, obesity, blood pressure levels and raised blood glucose levels were higher than regional levels, with 30.9% of men and 53.4%

[8] *Per capita food consumption based on Food Balance sheets from FAO (2007-2009 average) in kg/person/year.*

of women categorized as obese in 2008, thus increasing the risk of developing non communicable diseases (NCDs) (WHO 2015). Activities in this component responded to the need for more information on food consumption at the household level.

In November 2016 the project was granted access to the Household Income and Expenditure Survey (HIES) dataset for the Federated States of Micronesia (FSM). Applying *Guidelines for measuring household and individual dietary diversity*, developed by FAO (Kennedy et al 2010), to the data from HIES allowed for an assessment of dietary diversity at household level across the four states of FSM; this was carried out as an alternative to nutrient analysis. As noted in the guidelines, 'dietary diversity is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals' (Kennedy et al. 2010).

The secondary analysis of two-week acquisition diaries (collected in 2013-2014 as part of the FSM HIES data) involved: (i) formulation of 12 food groups to standardise measurement of consumptive diversity (e.g. cereals, tubers vegetables, fruit, meat, eggs, fish/seafood, legumes, dairy, oils and fats, sweets/snacks and spice/beverages, and (ii) calculation of a Household Dietary Diversity Score (HDDS) per household to reflect, in a snapshot form, the economic ability of a household to access a variety of foods. These scores were derived from households' consumptive pattern as presented in diaries, which collected data on all foods purchased, received as a gift or home produced. The scores were categorised into tertiles to reflect low, medium and high HDDS (median: 4.0, 7.0 and 10.0 respectively), and multivariate analysis of covariance was used to compare differences in HDDS scores across a number of covariates.

Preliminary findings suggest fish is a staple food for all households in FSM, irrespective of dietary diversity score. The analysis of household consumption of different food groups indicated that less than 10% of households with a low HDDS acquired any foods in the eggs, legumes, dairy and vegetables food groups. Yet almost 100% of households with a high HDDS acquired cereals, meat, fish, sweets/snacks and spices/beverages. Previous studies have shown that an increase in dietary diversity is associated with socio-economic status and household food security (Hoddinot and Yohannes 2002; Hatloy et al. 2000 In: Kennedy et al. 2010). Our findings suggest similar correlations as those food categories associated to the higher tertiles of HDDS are largely imported processed foods and drinks, and require a certain level of spending power. Given the often low quality and nutritional value of imported foods, continued intake of these foods increases the risk of developing diet related NCDs. No significant differences were found across HDDS based on marital status or education level of the head of household.

Results from this analysis support claims that more recent trends of nutrition transitions pose further challenges to address nutrition-related health risks. Public health strategies are needed to address the region's response to the nutrition transition by encouraging consumption of traditional diets and increasing awareness of the detrimental health effects of imported energy dense nutrient poor foods.

Systematic literature review on methods to estimate national food security status

A systematic literature review (SLR) was done to assess methods that determine national food security status using proxy measures from Household Consumption and Expenditure Survey (HCES) data in Low and Middle Income Countries (LMICs) globally. The review is to be published as Russell et al. (submitted ms).

The literature review responded to a need for more effective policy to reduce food insecurity in low and middle income countries (LMICs), as part of these countries endavoour to meet some of the United Nations' 17 Sustainable Development Goals (SDGs) by 2030. Without adequate indicators that measure the status of food insecurity in a country it remains difficult

for governments to tailor approproiate policy to address it, and so too to progress towards the 2030 SDGs . Routinely conducted HCESs across the PICs are nationally representative and provide potentially valuable datasets for this purpose.

A methodological scoping framework developed by Arksey and O'Malley (2005) was used to carry out a systematic scoping of the literature using electronic databases. A number of scientific databases were consulted, including Medline, Scopus, Web of Science, Wiley and Proquest, based on relevent search terms (e.g. "food secur*", "food insecur*","house* consumption", "house* expend" etc). Search results were sorted by *relevance* and *cited by* database filters. While reviewing articles, tracking and hand searching of reference lists were also used to find any other related literature. Of the 929 abstracts identified, a total of 20 articles were reviewed against strict inclusion and exclusion criteria and included for further analysis.Exclusion criteria were applied (e.g. non-English language; not peer reviewed; survey not defined as a Household Consumption Expenditure Survey (HCES) or similar; countries not classified as LMICs according to World Bank data in the year of publication etc. Only studies published within the past 15 years were eligible for inclusion.

Fourteen LMICs globally were represented in the 20 articles. Several metrics were found to be used in measuring food security; the most significant being those using indicators of (i) economic access and (ii) dietary diversity. The simplest metric used to indicate food insecurity compared household food expenditure against a level of expenditure considered to be below the poverty line. Data on acquisition of food was commonly converted to available energy for the household using local food composition tables, and expressed as a proportion of household total energy requirements. Dietary diversity was also assessed in some studies as well as experience of food insecurity. There has also been considerable progress made in defining and measuring household food insecurity through qualitative and subjective based tools.

HCES data are utilised in a number of quantitative and qualitative ways to assess food security. Additionally, it can also provide considerable evidence regarding external influences that impact population access to food. The review demonstrated that routinely collected HCES datasets provide a useful resource for the measurement of household food security in LMICs. Standardisation of methods used to assess food security is needed to allow for more useful comparisons.

Outputs produced

Russell J, Lechner A, Charlton K, and Hanich Q (2017). Assessing Dietary Diversity through Household Income and Expenditure Survey in the Federated States of Micronesia, poster presented at the Planetary Health Alliance Inaugural Meeting, 29-30th April 2017.

Russell, J., A. Lechner, Q. Hanich, A. Delisle, B. Campbell, K. Charlton (submitted ms). Assessing food security using household consumption expenditure surveys (HCES): a systematic scoping review. *Public Health Nutrition*.

University of Wollongong, SPC and FAO (submitted ms and database). *Pacific Island Food Composition Tables: version 3. Database update and user guide*. SPC/FAO.

7.1.5 Nutritional content of fish

This section summarizes activities and outputs from Activity 1.1.4 and 1.1.6. The outputs are reported as firstly, a global analysis and an accompanying update of the FAO food and nutrition database reported as:

Cohen P.J., C.C. Hicks, M. Roscher, Coralie D'Lima, N.A.J. Graham et al. (in prep). A bite into nutritional values of fish. Targeted at *PNAS* or *Fisheries Research*. To be submitted Q1 2018.

An updated version of the FAO food and nutrition database. The current version of the database may be found at http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/) entitled *FAO/INFOODS food composition for biodiversity (version 4.0)*. Data will be uploaded and made available in Q1 2018.

In addition, in collaboration with SPC and FAO, UoW updated the Pacific standardised food composition database and user manual. The database includes approximately 900 food types. The database, metadata and user manual will be published as:

University of Wollongong, Pacific Community and FAO (2017). Pacific Island Food Composition Tables: version 3. Database update and user guide. SPC report and on-line database.

Global Analysis of marine fish nutrient composition

Fish provide a critical contribution in human nutrition. Shifts in harvesting patterns, resource availability and production methods will influence the species composition of fish available to feed the world's population. Do we have the knowledge to determine the nutritional implications of these shifts? To address this question we assembled a global dataset containing over four thousand measures of nutrients from fish. In total, our database (methods described below) comprises 1204 unique cases and 4500 data points and represents a two-fold increase in data collated on nutritional composition of marine finfish (held currently in the publicly available FAO INFOODs data repository. The data are currently being cleaned and checked and will be published in an open access format in Q2 2018.

We used a three-staged approach to identify sources of nutritional composition data (see Section 5.2 for methods. We focused on a sub-set of 14 minerals (iron, calcium, zinc, phosphorous, magnesium, selenium), vitamins (Vitamin A and B12), fatty acids (omega 3, omega 6, polyunsaturated fatty acid (PUFA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and protein – nutrients prioritized by experts due to their particularly critical role in human nutrition and relation to public health (Figure 7.4).

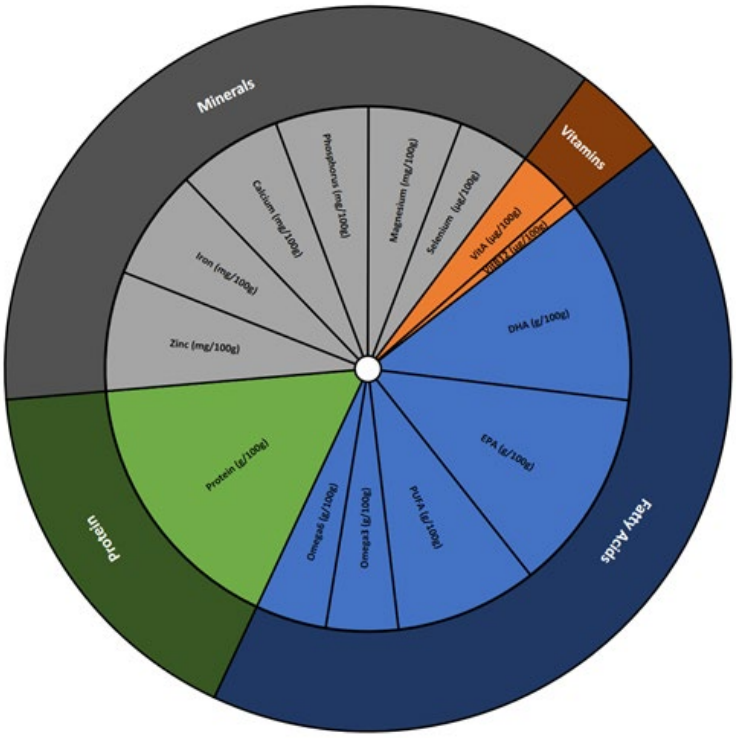

Figure 7.4 Distribution of data points across the 14 nutrients of focus for analysis.

Cohen et al. (in prep) noted five critical knowledge gaps:

i. inter-species variation in nutrient composition is substantial, but rarely accounted for in discussions about the role of fish in food security
ii. nutrient composition varies significantly within any species depending on location of capture, season harvested or parts of fish analysed – yet studies specifically examining intra-species variation are rare
iii. in key geographies and critical habitats from which harvested fish play a vital and difficult-to-substitute role in diets, data are particularly sparse
iv. there are substantial gaps in data from species of high economic value, common in global landings or commonly landed, but overall these species are relatively well covered by nutritional analysis
v. nutritional qualities of species of low value, but critical in subsistence and small-scale fisheries, are particularly scant. Shifts in fisheries harvesting patterns, resource availability and production methods that influence composition of fish available for human consumption are yet to take account of the nutritional variation between fish that our global dataset highlight.

The three pillars of high-quality food composition data provided by the FAO offer some overarching guidance to focus efforts moving forward:

> "… (*1) International standards and guidelines for the generation and compilation of food composition data, (2) National and/or regional food composition programmes exist and food composition tables are updated regularly, (3) Professionals are trained in all aspects related to food composition.*"

Cohen et al. (in prep) suggest there are three windows of opportunity open to the fisheries sector to operationalize such guidance and decrease the gap in knowledge of the nutritional values of fish. First, that partnerships between private sector and public partners may offer

an avenue to improve the accessibility and affordability of nutritional content analysis. Second, development agencies can invest in increased efforts to analyse nutritional content of low value, but highly consumed fish species. And third, increased international collaborations between food anthropologists and nutritionists offer opportunities to determine how food preparation and consumption impact nutritional content and the nutrient availability from fish.

Standardised food composition database

University of Wollongong, SPC and FAO updated the 2004 *PIFCT version 2* developed by University of the South Pacific and FAO (Dignan et al. 2004). The 2004 tables were funded, in part, by ACIAR. Updates to *PIFCT version 2* were required because of changing dietary patterns within the Pacific region with increasing consumption of imported or branded foods that were not available in *PIFCT version 2*. Specifically, foods included in the current update were based on commonly reported foods reported in the household food diaries collected as part of HIES. Updates in version 3 include:

- Standardized mapping of food types to COICOP codes
- edible portion conversion factors not previously provided
- Imported or branded food products
- Foods commonly purchased/gifted/consumed outside of the home added to the database based on data from existing HIES undertaken in the Pacific region

The draft user manual is under review with SPC and FAO and due for release in Q4 2017.

Output produced

University of Wollongong, SPC and FAO (submitted ms and database). *Pacific Island Food Composition Tables: version 3. Database update and user guide*. SPC/FAO.

7.1.6 Nutrition in rural households in Malaita, Solomon Islands

This section summarizes activities and outputs from Activities 1.2.1 to 1.2.6 – see Section 6 for tabulated activities and milestones. The work has/will be published as posters and other communication vehicles (see below) and as:

Albert, J., Bogard, J., Siota, F., McCarter, J., Diatalau, S., Maelaua, J., Andrew, N., Thilsted, S. (in prep). Poor nutrition and diets in rural Solomon Islands communities: a mixed methods approach to framing the problem and its drivers. Target journal *Maternal and Child Nutrition*.

Through this project a new partnership has developed between WorldFish and the Solomon Islands Ministry of Health and Medical Services (MHMS), resulting in the joint development of survey instruments, training and capacity development and the implementation of field activities.

Quantitative survey instruments were developed with Solomon Islands Ministry of Health and Medical Services (MHMS) to assess nutritional status and its determinants in rural villages in Malaita, Solomon Islands.

This case study aimed to better understand and promote the sustainable use of fish for nutritional security in rural Solomon Island villages. The tablet-based survey instruments developed included a data recording tool for nutritional status of women, men and children under 5 years of age (measured using standard anthropometric tools) and a questionnaire on the determinants of nutrition (based on the UNICEF framework of malnutrition) including diet quality, household food access/security, care resources/practices and health

resources/water, sanitation and hygiene. Dietary quality assessments focused on women of reproductive age and children under 2 years, as they are often the most nutritionally vulnerable.

A capacity building and training workshop was held in Auki, Solomon Islands from the 25th to 30th April 2016 to train key staff involved in the collection of data. Following the capacity development workshop, the newly trained team members implemented the survey instruments in North Malaita and Western Province. In total anthropometric data were obtained for 86 women, 23 children aged 6 to 23 months and 28 children aged 2 to 5 years in the North Malaita cluster communities of Fumato and Alea and in the Western Province community of Biche and Zaira - 43 women, 12 children aged 6 to 23 months and 18 children aged 2 to 5 years . Data on dietary diversity were obtained from 95 women and 23 children aged 6 to 23 months in North Malaita and 44 women and 12 children aged 6 to 23 months.

Results from the quantitative nutrition surveys in North Malaita and Western Province were compiled in a report and the key findings were conveyed to the Nutrition Unit of the Ministry of Health during a meeting on the 21st April 2016. A range of indicators were estimated – here we focus on MDD-W.

Figure 7.5: Mother and child being weighed by the Malaita Provincial Nutrition Officer

Key findings include:

- Evidence of the double burden of malnutrition in all four study communities, with a prevalence of overweight or obese women and stunted children. No overweight children were observed.
- Overall half of women of reproductive age assessed from the four study communities were overweight (30.3%) or obese (20.7%), with no evidence of underweight women (BMI<18.5).
- Malnutrition was evident in children under the age of five at all study communities. The most prevalent form of child malnutrition was stunting, with 24.3% of children between 6 months and 5 years of age measured having stunted growth.
- Dietary diversity of women and children aged 6 to 23 months in the rural study communities was extremely low at the time of assessment (Figure 7.6). Based on this assessment, the majority of women (94.2%) and children aged 6 to 23 months (77%) across the four communities are likely to have *inadequate* intake of micronutrients in their diets.
- Diets generally lacked dairy, nuts and seeds, fruit and vegetables.
- In combination with low diversity diets, there was a high proportion of women and young children that consumed energy-dense, nutrient-poor foods (mostly fats/oils and sweet drinks)
- While fish formed an important component of up to 50% of women's diets, fish were generally not fed to infants and young children (typically at least 12 months of age).
- A high proportion of women and young children consumed imported/store foods such as rice and tinned tuna.

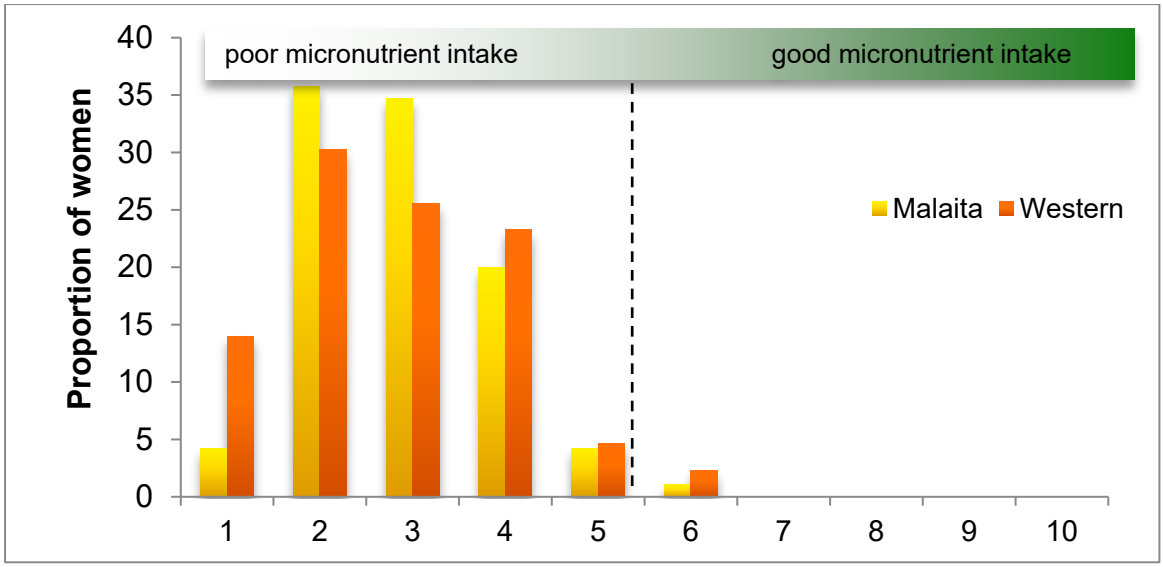

Figure 7.6: Number of food groups (between 1 and 10) consumed by women from Malaita and Western Provinces. The women's minimum dietary diversity score (MDD-W) is defined as the proportion of women that consume 5 or more food groups in a 24 hour period. The results highlight that fewer than 6% of women achieved MDD-W.

During meetings with the Ministry of Health discussions focused on mechanisms for feeding back the information to the study communities and lessons learned from the implementation of MDD-W as a potential indicator for future national level demographic and health surveys, both in Solomon Islands and the broader Pacific Region. Key lessons learned include:

- Tablet-based survey instruments were received well by (often illiterate) rural community members and there were no inhibitions with regards to the use of tables. The tablet-based data collection reduced substantial time in inputting data for subsequent analysis and could be a valuable approach for future national level surveys.
- There was a recent DHS survey implemented in Solomon Island (2015/2016) and therefore a repeat survey is unlikely for another 5 years, however there was interest in including MDD-W in future surveys.
- DHS surveys currently include an analysis of 24-hour food consumption for both mothers and infants, based on the IYCF MDD (within which some of the food groups are combined in comparison to the MDD-W indicator). To enable the calculation of MDD-W only small changes to the existing questions would be required, namely separating the questions on the consumption of legumes and nuts and separating the question on the consumption of other fruits and vegetables.

Using the results from the quantitative nutrition surveys, through this project we have produced nutrition awareness materials for rural Solomon Island communities. Through discussions with the Ministry of Health, it was apparent that the majority of existing nutrition awareness resources focus on basic nutrition awareness including the consumption of a balanced diet from the main food groups (simplified for rural communities as protective foods, energy foods and body building foods) and Non-communicable diseases (NCDs). There was distinct lack of awareness materials that focus on the value of fish for nutrition and importance of good nutrition in the first 1000 days (during pregnancy and the first 2 years of a child's life). Posters on the nutritional value of fish and nutrition in the first 1000 days were developed for rural communities in Solomon Islands.

Based on the recommendations from the Ministry of Health, key findings from this research were shared with communities in North Malaita. While the implementation of this activity was largely part of ACIAR FIS 2012/074, we have also reported as part of this project for completeness. Key findings were presented to the communities in the form of a presentation in combination with nutrition awareness and participatory training to address one of the key determinants of malnutrition identified - the inability to grow garden vegetables due to poor and declining soil quality. The approach of combining research findings with targeted training provided communities with a mechanism to improve nutrition through practical approaches.

Research and interventions planned under ACIAR project FIS/2016/300 will enable an evaluation of this approach and the implementation of additional interventions based on the underlying determinants of malnutrition to improve dietary diversity and nutritional status in Solomon Islands rural communities.

Outputs produced

WorldFish (2017a). Nutritional Survey Instrument.

WorldFish (2017b). Anthropometry Survey Instrument.

Albert J., Siota F., Hasi A., Ngarakana N., Posala R., Orirana G., Saeni E., Teioli H., Suruma B., Sukulu M., Papae R. and Jimuru M (2017). An analysis of dietary diversity and anthropometry of women, infants and young children from rural communities in Malaita and Western Provinces, Solomon Islands, report prepared for the Solomon Islands Ministry of Health and Medical Services, Honiara.

WorldFish (2017c). Fish: food for good health, poster prepared for community development activities in Solomon Islands, Honiara.

WorldFish (2017d). The first 1000 days, poster prepared for community development activities in Solomon Islands, Honiara.

7.1.7 Updated ‘fish supply gap’ analysis

This section summarizes activity 1.1.7. The work will be published as:

Sharp, M., N.L. Andrew, A. Delisle, H. Eriksson, P. James, A. Romeo, J.D. Bell (in prep). National demand for fish and the Pacific supply gap. Target journal *Fish and Fisheries*.

The purpose of this analysis is to update the Bell et al. (2009) projections that forecast substantial shortfalls in the supply of reef fish in the coming decades. We use updated HIES completed since 2010 and make different assumptions in the estimation process. Most notable of the Bell et al assumptions were: (i) the use of whole fish equivalent (WFE) weights for analyses instead of edible portions to estimate apparent consumption, (ii) the assumption that all prices were equivalent, irrespective of location (e,g, rural vs urban), and (iii) the non-inclusion of gifted fish in consumption estimates. Note for this analysis we report WFE because the fish supply gap/surplus is estimated w.r.t. production of whole fish not edible portions. The apparent consumption analyses (Section 7.1.4) report patterns converted to edible portions.

Although broadly similar, there were significant differences among estimates of national WFE acquisition among countries (Table 7.5). Using different CPI-inflated price denominators across fish products and including gifts received by surveyed household FSM, NRU and WSM have reduced the per capita whole fish acquisition between the two survey periods. In contrast, PLW, SLB, TON and VUT have increased the per capita whole fish acquisition between the two survey periods. The most significant reduction was in WSM where the very

high estimate from Bell et al. more than halved. In this report we use the total expenditure divided by the total population for the Bell et al. re-analysis.

Table 7.5: Per capita whole fish acquisition (kg/person/year) by country highlighting population mean and median estimates using new HIES data.

Country	Bell et al. (2009)	Current study mean	Current study median	FBS[9]	Gillett (2016)
FSM (Total)	**69.3**	**61.0**	**46.9**	**44.0**	72.0 – 142.0
Rural	76.8	70.4	53.3		
Urban	67.3	45.2	37.8		
NRU (Total)	**55.8**	**40.9**	**32.2**	**24.0**	46.7 – 63.9
PLW (Total)	**33.4**	**60.7**	**32.5**	**67.7**	84.0 – 135.0
Rural	43.3	73.6	43.5		
Urban	27.8	57.7	30.7		
SLB (Total)	**33.0**	**51.0**	**32.5**	**32.8**	32.2 – 45.5
Rural	31.2	51.3	31.1		
Urban	45.5	49.9	38.6		
TKL (Total)	**n/a**	**100.2**	**96.6**		119.4
TON (Total)	**20.3**	**29.5**	**21.1**	**35.0**	25.2 – 35.0
Rural	n/a	28.7	22.1		
Urban	n/a	29.8	21.1		
VUT (Total)	**20.3**	**39.4**	**28.9**	**33.6**	15.9 – 25.7
Rural	20.6	42.4	30.7		
Urban	19.3	31.4	24.5		
WSM (Total)	**87.4**	**33.6**	**22.7**	**46.8**	46.3 – 129.5
Rural	98.3	34.9	23.4		
Urban	45.6	27.8	18.4		

The new standardized HIES method used in the current round of surveys captured gifting of fish as well as other sources of acquisition (Table 7.6). In some countries, particularly Palau and Tokelau, gifting accounted for more than a third of fish coming into households and so was an important inclusion in the analysis. Unsurprisingly, subsistence acquisition was much greater in rural households than in urban areas, except for Tonga where a very small percentage of acquisition was home produced.

The revised projections to 2050 also used updated population projections (Figure 7.7). High population growth in Melanesia sharply contrasts with declining or stable populations in Micronesia and Polynesia. Population growth is a major driver of patterns in per capita supply of fish in Melanesia. Conversely, the lack of growth in Polynesia and Micronesia makes other variable in the estimation process more influential.

The total demand for fish in a given country can be satisfied by pelagic, reef, shellfish, and canned fish. We assume negligible production from freshwater fisheries in the eight countries used. In terms of the sustainable production of fish to feed people, pelagic fish (mostly tuna) and canned fish (mostly tuna) are external to our analysis. These sources can

[9] *Per capita food consumption based on Food Balance sheets from FAO (2007-2009 average) in kg/person/year.*

Table 7.6: Percentage of per capita whole fish acquisition purchased, home produced or received from gifts, by rural-urban. No urban/rural split is made in NRU or TKL.

	Rural			Urban			Total		
	Cash	Home produced	Gifted	Cash	Home produced	Gifted	Cash	Home produced	Gifted
FSM	22%	59%	19%	60%	24%	16%	33%	50%	18%
NRU							52%	45%	3%
PLW	20%	51%	29%	36%	28%	36%	32%	33%	34%
SLB	21%	72%	7%	74%	13%	12%	30%	61%	8%
TKL							14%	44%	43%
TON	76%	3%	21%	66%	12%	22%	68%	10%	22%
VUT	47%	52%	1%	85%	14%	1%	55%	44%	1%
WSM	45%	26%	29%	64%	4%	31%	48%	23%	29%

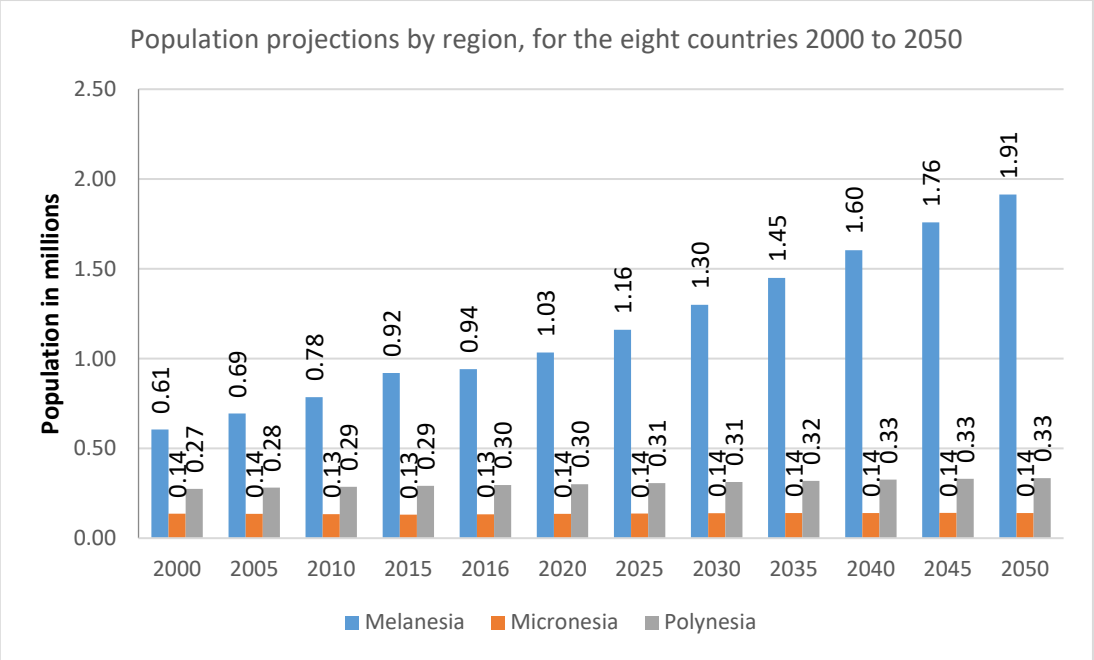

Figure 7.7: Total population projection by region for the eight countries from 2000 to 2050 categorized by sub-region. Number above the bars indicate population in millions. Data from SPC Statistics Division.

be thought of as opportunities to fill the gap between total national demand and the production possible from benthic/'reef' fisheries (Bell et al. 2009). For a given country, the gap between national supply and demand is the difference between per capita acquisition scaled by the population size and the total sustainable production from reef fisheries (inclusive of shellfish).

For our analysis we projected forward to 2050 using the per capita acquisition estimates from Section 7.1.4. Here we report results of projections to 2030 to be consistent with the Bell et al horizon. We used two estimates – total acquisition divided by total population and the median per capita consumption to provide high and low estimates of projected demand. For this summary we concentrate on comparisons among studies using the total population/total acquisition estimator.

Production of reef fisheries is constrained by the regenerative capacity of fish stocks. There is little guidance in the literature on productive capacity of multispecies coastal fisheries. On the basis of a meta-analysis of coral reef fisheries, Newton et al. (2007) concluded that coral reefs (broadly defined to included other shallow water habitats) could sustainably produce 5 mt/km^2/year (median 3 t). Based on Newton et al., Bell et al. used 3 mt/km^2/year as their estimate of sustainable production. For our analyses, given the many assumptions and difficulties in offering a single estimate of sustainable harvest, we present a range of between 1 and 3 mt/km^2/year. We note that these estimates of sustainable harvest may represent the lower end of expectations.

The results obtained from new HIES and estimation methods were broadly similar to those from Bell et al. (Table 7.7). Countries categorized by Bell et al. as being unlikely to supply an adequate amount of fish from reef fisheries by 2030 remain so. Notably, in our subset of countries, these are Solomon Islands, Samoa, and Vanuatu. In FSM, Tonga, and Nauru, the gap is smaller, suggesting sub-national differences in demand and sustainability offer policy opportunities in management, supply chains and marketing (a point well-made by Bell et al). In some countries, notably Palau and Tokelau, a mix of stable populations and large areas of reef relative to the population mean that a fish supply gap is unlikely.

In the forthcoming journal article we will graphically summarize these results projecting forward to 2050 using a high and low estimate of national demand. Here we report results just for Vanuatu to illustrate the types of results obtained (Figure 7.8). In this example the current total production from reef fisheries estimated as the total acquisition from the HIES is 2,700 t per annum. This estimate is well below estimates of sustainable national harvests based on a range of 1 to 3 mt/km^2/year, suggesting either reefs are over-exploited or there is considerable scope to increase harvesting on Vanuatu's reefs. If the former interpretation is correct then there is the potential to increase production through improved management. Under the worst case scenario described in Figure 7.8, in 2050, Vanuatu will need to find an additional ca. 20,000 t to fill the deficit that cannot be filled by reef fish based on current consumption of fish. This gap would need to be filled by pelagic and canned fish and assumes that reef fisheries have stabilised at sustainable harvests of ca. 3 mt/km^2/year.

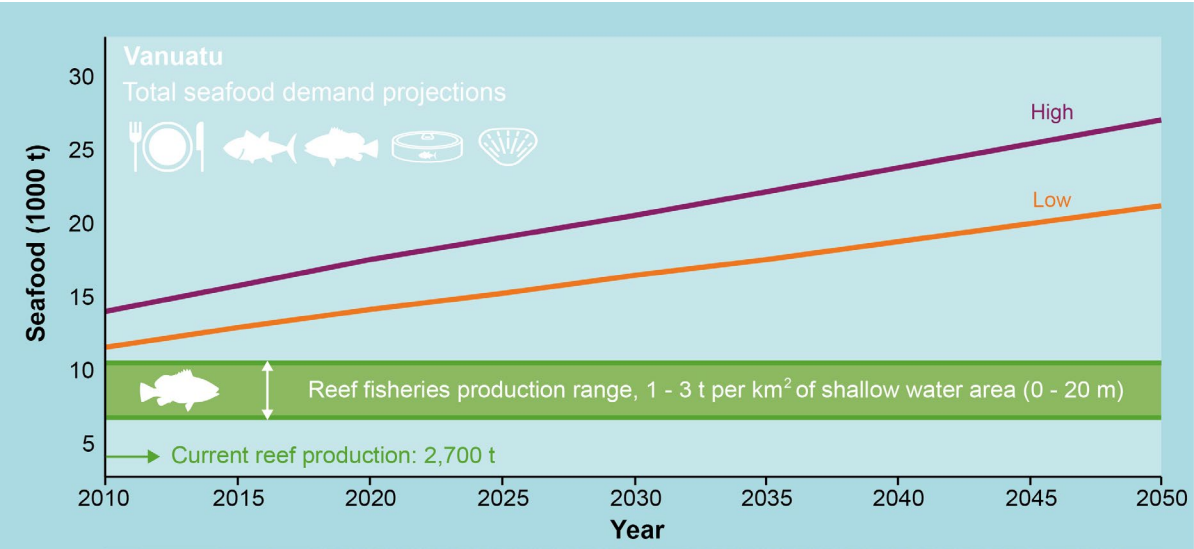

Figure 7.8: The projected fish supply gap in Vanuatu from 2010-2050 (graphic for illustrative purposes only).

		Bell Analysis gap = (sust reef prod - total demand) < 30 m in t						New Analysis gap = (sust reef prod - total demand) < 30 m in t					
		Bell current			Bell HIES at 2030			New current			New HIES at 2030		
Country	ISO3	1 mt	3 mt	5 mt	1 mt	3 mt	5 mt	1 mt	3 mt	5 mt	1 mt	3 mt	5 mt
FSM	FSM	(2,202)	9,894	21,990	(3,872)	8,224	20,320	(259)	11,837	23,933	(594)	11,502	23,598
Nauru	NRU	(611)	(573)	(535)	(871)	(833)	(795)	(458)	(420)	(382)	(476)	(438)	(400)
Palau	PLW	1,875	7,485	13,095	1,805	7,415	13,025	1,738	7,348	12,958	1,713	7,323	12,933
Solomon Is	SLB	(8,009)	11,973	31,955	(19,909)	73	20,055	(21,415)	(1,433)	18,549	(36,029)	(16,047)	3,935
Tokelau	TKL	n/a	n/a	n/a	n/a	n/a	n/a	198	826	1,454	171	799	1,427
Tonga	TON	(1,931)	1,187	4,305	(2,341)	777	3,895	(1,444)	1,063	4,181	(1,934)	1,184	4,302
Vanuatu	VUT	(5,393)	221	5,835	(10,793)	(5,179)	435	(6,263)	(649)	4,965	(12,847)	(7,233)	(1,619)
Samoa	WSM	(14,587)	(13,401)	(12,215)	(15,007)	(13,821)	(12,635)	(5,846)	(5,025)	(3,839)	(6,957)	(5,771)	(4,585)

Table 7.7. Comparison of estimated shortfalls in available fish after 'sustainable harvests' of reef fish and shellfish from coastal waters < 30 m deep have been accounted for. Benchmarks of sustainable harvest of 1, 3 and 5 t/km^2/year are used based on the literature. Comparisons are made between Bell at al. estimates of acquisition as whole fish equivalent based on their assumptions and methods, and the current estimates based on the standardized HIES and revised methods. Estimates are provided for periods at the time of the HIES (current) and forward to 2030 based on population projections. Red highlighted cells indicate shortfalls (t). Bell et al. did not provide estimates for Tokelau.

Conclusions

The analyses reported here broadly support the original Bell et al. conclusions that a subset of PICs will have fish supply gaps in the coming decades. Among the PICs in our analysis, Solomon Islands, Samoa and Vanuatu will need to re-imagine the supply of fish in the coming decades. All have growing and urbanizing populations. The remaining countries have a broader set of policy options open to them, but all will need to invest in fisheries management to secure the fisheries they have.

These conclusions appear robust to assumptions and differences in methods, at least at the macro-scale at which these national analyses are useful in highlighting threats and shifting national and regional narratives around fish futures and the importance of securing coastal fisheries. Beyond that, the analyses are not done at the correct scale to move national agendas forward. With the exception of the smallest countries (e.g. Nauru and Tokelau) national averages hide important differences in sustainability and demand for fish. For example, around 75% of Tongans live on Tongatapu Island, where there is more likely to be a deficit in the future supply of fish than in the Niau, Vava'u or Ha'apai island groups where fewer people live and where many islands are uninhabited. This will also broadly apply to other cities and islands where populations are concentrated and fisheries heavily exploited. National averages also mask important differences between urban and rural populations in the supply and demand for fish. As internal migrations evolve over the coming decades the policy challenge will change to, including other things, a greater focus on markets, supply chains and infrastructure.

Bell et al. framed their analysis in terms of the amount of fish 'required for good nutrition' based on WHO guidance on the intake of protein and the assumption that 50% of the required protein would come from fish. Making further assumptions about population demographics, Bell et al. arrive at 35.5 kg/p.p./year as a baseline for comparisons. This device has served the regional policy narrative well in highlighting broad patterns and areas of concern. We suggest, however, that it has reached the end of its useful life without further context. For the re-analysis summarized here we used estimated acquisition for all countries rather than setting a minimum of 35.5 kg/p.p./year apparent consumption.

It is difficult to make recommendations about the role of fish in good nutrition in the absence of a broader understanding of dietary diversity and the social environment in which people make decisions about food. Section 7.1.6 highlights poor dietary diversity and knowledge of nutrition in rural Malaita, Solomon Islands. Methodologically, the Bell et al. analyses were based on acquisition of whole fish equivalent weights rather than edible portions, thereby over-estimating the actual consumption of fish products. In project FIS/2016/300 we will further develop this work with field-based studies and interventions, policy analysis, and HIES-based analyses of dietary diversity.

There is surprisingly little analysis and guidance on the amount of reef fish that can be sustainably harvested from a square kilometre of reef. This uncertainty is part definitional – what is 'reef'?, part an absence of data on harvests and therefore a body of evidence about what is being taken, and part complex methodological issues in modelling sustainability in multispecies fisheries. Further, levels of sustainable yields will varying depending on stock status and management objectives (e.g. yield maximization, stock rebuilding and so forth). Well-designed adaptive management programs at community scales are rare. Given the importance of having benchmarks on sustainability to support national implementation of the New Song, this issue will be addressed in project FIS/2016/300 through development of data collection programmes and guidelines for sustainable harvest levels.

Surpluses in the supply of fish in some islands and countries offer opportunities for changes in public health policy and economic development. In particular, the development of intra-regional trade in fish and the development of tourism around locations with high biomass of fish offer a range of alternative future possibility for the use of fish (World Bank 2017). In

places like Tonga, Tokelau and Palau, relatively more fish could be consumed in preference to other alternatives.

7.2 Objective 2: To improve decision-making on mariculture policy and planning in Indonesia and the Western Indian Ocean

7.2.1 Framework for equitable decision-making in Indian Ocean mariculture

This section summarizes activities and outputs from Activities 2.1 and 4.1.3. Activities were grouped as a series of sequential steps towards greater understanding and harmonization of mariculture policies and development processes across the WIO. The three outputs are:

Brugere, C. et al. (in prep). Closing the people-policy gap with equitable mariculture development in the Western Indian Ocean. Journal article on benefit sharing mechanisms for mariculture development in Indian Ocean (Activity 2.1.5). This article (Brugere in prep) includes analyses of gender dimensions and so it combines with Activity 2.1.6.

Eriksson, H., M. Troell, C. Brugere, C. Mohan, M.J. Phillips, N. Andrew (submitted ms). A diagnostic framework for equitable mariculture development in the Western Indian Ocean. ACIAR Monograph.

Troell, M., C. Brugere, H. Eriksson (in prep). Developing equitable marine aquaculture in East Africa. Policy Brief.

Zanzibar workshop

Regionally-stimulated growth of mariculture may offer a good opportunity to sustainably expand the industry to meet both needs and demand in the Western Indian Ocean (WIO) region. Mariculture expansion cannot be envisaged in isolation from other sectors. Many of the Indian Ocean countries share common coastal resources that are the foundation for livelihoods and are in various ways interconnected to, and influenced by, mariculture expansion. The future development trajectory of mariculture in the region therefore requires a shared understanding and perspective across geographic boundaries and stakeholders.

A study of existing mariculture development policies and planning processes was initiated by the project members in the Western Indian Ocean with the aims of improving our understanding of mariculture development intensions and decision-making (Activity 2.1.1-2.1.3). Findings from this analysis were used as the entry point for a workshop on “Sustainable and equitable mariculture development in the Western Indian Ocean - Development of a policy framework”. This was held in Zanzibar during 9-11th of May 2016. The workshop was hosted by WIOMSA, with funding from WIOMSA, IORA and the ACIAR project.

The workshop brought together key stakeholders influencing the development pathways of mariculture in the region. Participants represented sectors having interests in such development (i.e. governments, academia, private sector and NGOs) of seven of IORA members countries (Kenya, Tanzania, Madagascar, Mauritius, Mozambique, Seychelles, Reunion). The workshop provided a forum where national experiences in mariculture planning were shared and discussed and laid the basis for a tentative policy framework – or “Roadmap” – aimed at guiding the sustainable and equitable development of mariculture in the Western Indian Ocean.

National representatives shared information about current approaches to manage mariculture development in practice, and how national strategies align with aspirations about equitable and sustainable development. Workshop exercises structured the perceived

challenges, and synthesized a set of aspirational outcomes that mariculture should seek to achieve.

Figure 7.9: Workshop participants representing governments, academia, and NGOs from seven WIO countries

A diagnostic framework for equitable mariculture in the Western Indian Ocean

A key output from the workshop was the development of a practical diagnostic framework. The relatively simple diagnostic framework is designed to assist decision-making for assessment and planning around sustainable and equitable mariculture built on the foundation of benefit sharing. It draws on lessons from earlier and existing mariculture initiatives to support and guide an industry with practice that better aligns with aspirations for equitable growth and the Sustainable Development Goals.

The framework is primarily aimed at people involved in coastal management and decision-making, as well as mariculture planning and policy making. Intended target users of the diagnostic framework are the officers within the fisheries and aquaculture ministries who deal with mariculture development applications and licensing. It was highlighted at the workshop that these agencies need a framework of reference to assess applications and ensure that the proposed (or existing) developments comply with a number of equitability and sustainability criteria that are in line with the country and region's mariculture development aspirations. The diagnostic framework is organised around desired outcomes from mariculture initiatives:

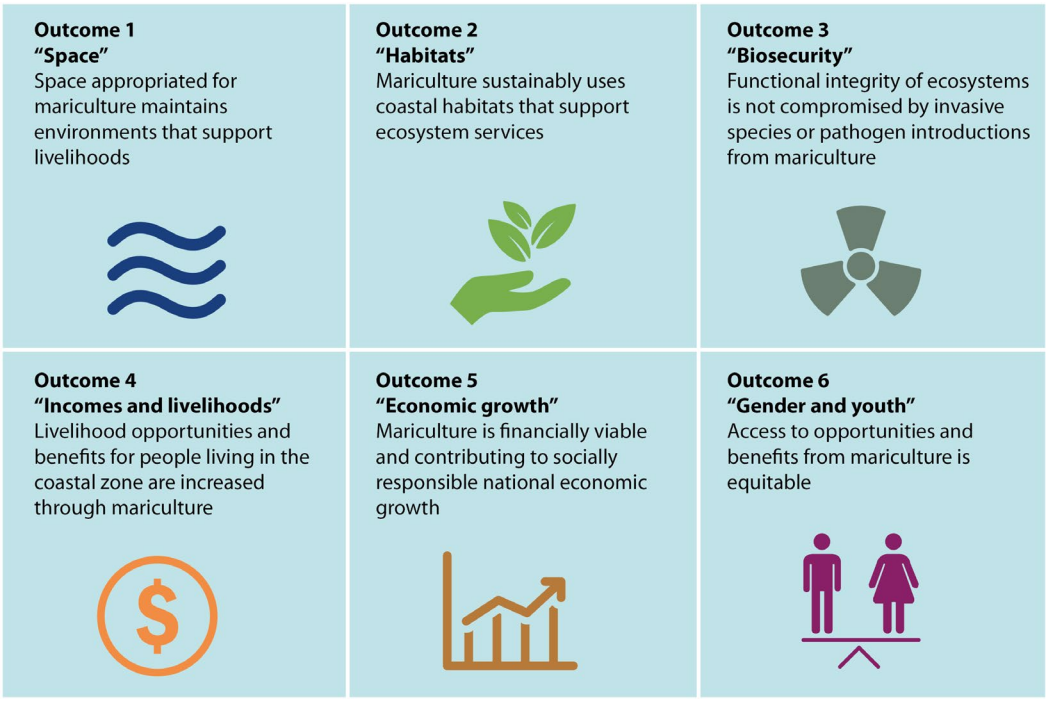

Figure 7.10: Elements of the diagnostic framework for equitable mariculture in the Western Indian Ocean

These thematic outcomes emerged as prioritised areas in the sustainable development of mariculture, and for which equitability concerns were raised and discussed at the workshop (Activity 2.1.4). In the diagnostic framework the outcomes have been framed as aspirational outcomes – a theorised benchmark of what a mariculture initiative should seek to achieve. Each outcome is linked to a diagnostic question to help gauge to what extent an initiative holds potential to deliver this outcome. The framework provides further guidance on how to answer the question and suggests a minimum set of actions if the answer to the diagnostic question is no. Each outcome is accompanied by a suggested set of indicators for its monitoring and evaluation.

The framework has a strong results chain focus and suggests indicators for monitoring and evaluation (M&E). The framework recognises that initiatives will have different requirements for M&E depending on their objectives, scale, species, environment, and mode of implementation. The six outcomes that the framework centers on represent long-term challenges for future mariculture initiatives to overcome. The indicators for each outcome must be relevant to the type of mariculture initiative and be assessed from specific data that is suitable to evaluate outcomes.

The framework articulates how M&E plans should build on results chains that illustrate the theoretical causal chain between the implementation dimensions (inputs and activities) and their intended results (outputs, outcomes and impacts):

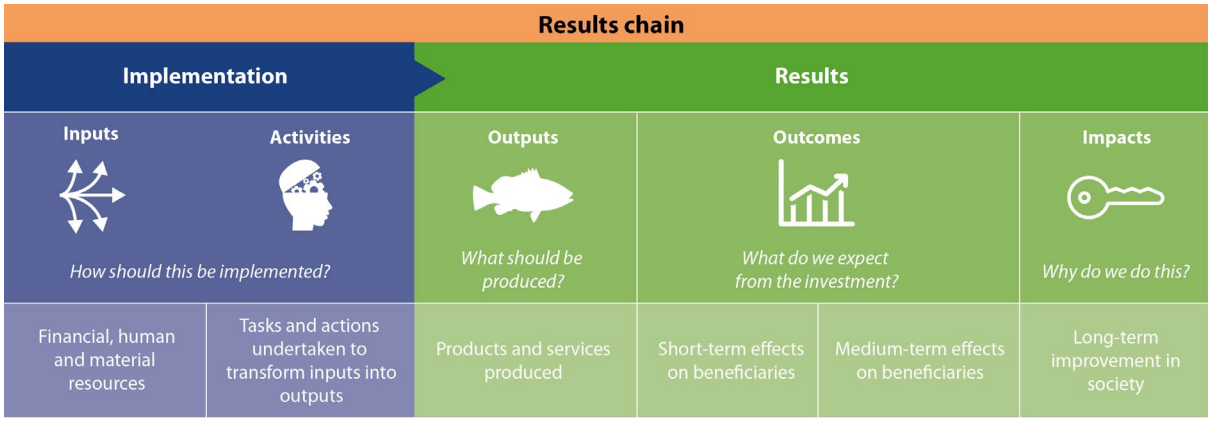

Figure7.11: Results chain with suggested indicators for monitoring and evaluation.

This structure of the framework has received good feedback from internal and external peers and the framework is being incorporated in the ex-ante assessment phase of two WorldFish initiatives in Africa (see Science impact section below).

Journal article on benefit sharing mechanisms for mariculture development in Indian Ocean

A journal article (Brugere et al. in prep) is in late draft form: “Closing the people-policy gap with equitable mariculture development in the Western Indian Ocean” expected to be published by end of 2017 (Activity 2.1.5).

The study centers on a key question:

Does the mariculture policies of countries of the WIO provide a coherent way forward for the equitable development of mariculture in the region? Regional policies and strategy documents were analysed along with key informant interviews to answer this question.

The analyses of national policies finds that there is an overall fair congruence with regional frameworks/policies: EAC, NEPAD’s Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa and AU’s Guide for the implementation of the Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (Table 7.5)

Table 7.8: Overview of key contents of the marine and general aquaculture development policies, strategies, plans and acts of selected countries in the WIO. Criteria for alignment from the African Union Inter-African Bureau for Animal Resources (AU-ICAR 2015)'s Guide for the Implementation of the Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa (provisions relevant to marine aquaculture). A "traffic light" system is adopted to denote: high alignment (green), some alignment (orange), little or no alignment, or no mention (red). Blank indicates unclear or too indirect a link to infer some alignment with sufficient confidence.

Focal area (s) of the AU's Policy Framework and Reform Strategy	Criteria for alignment*	Marine and general aquaculture policies and strategies			
		Kenya	Mozambique	Tanzania (mainland)	Zanzibar
Policy arena** : Conservation and sustainable resource use					
Aquaculture policies, frameworks and tools for national benefits	Aquaculture mainstreamed into national development plans (incl. fisheries policies, national development plans, finance and legislation) and vice-versa	🟠	🟢	🟢	🟢
	Globally accepted best practices (e.g. ICZM, EIA, BMPs) integrated into national policy frameworks and tools	🟠	🟠	🟠	🟢
	Policy and management decisions based on reliable data and information management systems	🟠	🟠	○	○
Healthy ecosystems to support sustainable aquaculture	Scientific research (natural, social, economic and technological) in support of aquaculture development	🟠	○	🟠	🟢
	Tools and programmes in place to protect fishery resources and their habitats	🟢	🟢	🟠	🟢
Policy arena** : Sustainable aquaculture development					
Market-led aquaculture investments	Markets (Price, place, promotion and products, including value addition)	🟠	🟢	🟠	🟢
	Aquaculture infrastructure: for production and in support of aquaculture (e.g. hatcheries, roads)	🟢	🟢	🟢	🟢
	Financing mechanisms and investment incentives (e.g. credit)	🟢	🟢	🟢	🟢
	Quality assurance and standards compliance (incl. traceability, certification and legislation)	🔴	🔴	🟠	🟠
	Capacity and skills development	🟢	🟢	🟢	🟠
	Research and extension services	🟢	🟢	🟢	🟢
	Fish farmers' associations and cooperatives, incl. women's	🟢	🟢	🟢	🟢
	Enabling environment, incl. "one stop shop" facilities	🟢	🔴	🔴	🔴
	Growth in trade of locally produced aquaculture products, incl. protection from imported commodities	🟠	○	🟠	🟢
Regional cooperation in shared ecosystems	Common strategies on management and research on transboundary resources	🟢	🟠	🔴	🔴
	Consistency with EAA and CCRF	🟠	🔴	🔴	🟢
	Conformity of aquaculture production with accreditation mechanisms, e.g. HACCP, BMPs	🟢	🔴	🟢	🟠
Policy arena** : Responsible and equitable fish trade and marketing					
Intra and inter regional trade	Compliance with agreed regional trade protocols and regulations	🔴	🔴	🔴	🔴
	Coherence of fish trade policies with other policies, incl. harmonization of national trade policies	○	○	🔴	🔴
	Compliance with sanitary standards and market requirements (e.g. WTO)	○	🟠	🟠	🟠
Competitiveness of African fish and aquaculture products	Economically efficient aquaculture sector (incl. appropriate infrastructures)	🟢	○	🟠	🟠
	Standards and supportive technology, incl. control labs and accreditation authorities	🟠	🟠	🟠	🔴
	Value chain efficiencies, incl. appropriate pricing, eco-labelling, certification	🟠	🔴	🟠	🟠

	Adequate consumer information	○	○	🔴	🔴
Policy arena** : Regional and sub-regional cooperation					
Harmonisation of national policies with international instruments	Awareness of important international instruments for sustainable aquaculture management and frameworks	🟢	○	○	🟢
	Transparency, accountability and effective participation of stakeholders in national and regional aquaculture development	🟢	🟢	🟠	○
Policy arena** : Awareness enhancing and human capacity development					
Sectoral competencies and proficiencies	Continuous professional education, mentorship and training	🟢	🟢	🟢	🟢
	Accreditation of practitioners and institutions	🟢	○	○	🔴
	Establishment of centres of excellence in aquaculture (or similar)	🟠	🟠	🟠	🔴
Evidence-based decision making	Generation of data and information relevant for policy making and management decisions	○	🟠	🟢	○
	Information shared among policy makers and sector stakeholders nationally and internationally (e.g. networks)	🟢	🔴	🟢	🔴
	Information reflecting real community needs	○	🟠	🟢	🟢
Policy arena** : Cross-cutting issue A: Resilience and vulnerability reduction to climate change in African aquaculture (and fisheries)					
Adaptive capacity and resilience at local level	Capacity building programme on climate smart aquaculture	🔴	🔴	🔴	🟠
	Climate change vulnerability assessments	🔴	🔴	🔴	🔴
	Creation of alternative livelihoods	🟠	🟠	🟠	🟢
	Early warning systems	🔴	🔴	🔴	🔴
Policy coherence and coordination at the national and regional levels	Disaster risk management (DRM) and climate change Adaptation (CCA) policies include aquaculture	○	○	○	○
	Fisheries and aquaculture policies include DRM and CCA	○	🔴	🔴	🔴
Policy arena** : Cross-cutting issue B: Gender and youth					
Increased access to resources	Women and youth's access to suitable land, water and capital	○	🟠	🟢	🟢
	Women and youth's security of investment and access rights and ownership	🟠	🔴	🟠	🟢
Working conditions	Application of ILO's standards of practice	🔴	🔴	🔴	🔴
	Safer and more conducive working environment for women, youths and the vulnerable	🔴	🔴	🔴	🟢
Policy arena** : Cross-cutting issue C: Private sector investments and financing mechanisms for aquaculture in Africa					
Enterprise performance within aquaculture sector	Compliance with the World Bank ease of doing business index	🔴	🔴	🔴	🔴
	Conformity with the Global competitiveness report of World Economic Forum	🔴	🔴	🔴	🔴
	Awareness of diversity of business structures	🟠	🔴	🔴	🟠
Private sector governance	Consistency with industry best practices	🟠	🔴	🔴	🟠

* Wording of the criteria may have been shortened or slightly altered to increase relevance to mariculture. "Alignment" is understood as "consistency and coherence between national policies and strategies with the *Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa* (AUC-NEPAD 2014); the criteria are the elements that are used to assess the consistency or coherence.

** Policy arenas are those spelt out in the *Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa* (AUC-NEPAD 2014) and of direct and indirect relevance to mariculture development.

Acronyms: BMP: better management practices, CCRF: code of conduct for responsible fisheries, EAA: ecosystem approach to aquaculture, EIA: environmental impact assessment, HACCP: hazard analysis and critical control points, ICZM: integrated coastal zone management, ILO: International Labour Organisation, WTO: World Trade Organisation.

Brugere et al (in prep) showcase that there are glaring gaps when it comes to ensuring greater equity across all potential aquaculture beneficiaries. Better nutrition (as part of food security), preferential arrangements for small-scale producers, availability of social protection (through insurance, compensation for losses or illness (e.g. HIV-AIDS), decent work, and/or access to social services) or safety nets for groups less able to claim their entitlements do not figure among the AU's criteria of policy alignment for aquaculture development (Table 7.8) and are barely touched upon in all the policy documentation reviewed. Not only are these issues silenced, mechanisms to address them are absent.

The journal article begins an important discussion about the benefits of regional mariculture development, and of policy coherence. It also touches on a question that permeates several sectors of development: how decisions and choices can be made that reflect some of the aspirational language laid out in policy and strategy documents.

The practical guidance from the "Diagnostic framework for equitable mariculture development in the Western Indian Ocean" (Activity 2.1.3) is one small mechanism to "put policy into practice", by helping to ensure that proposed developments (or existing) align with country and region's mariculture development aspirations (as they are articulated in the outcomes encapsulated in the framework and summarized by Brugere et al).

Output produced

Eriksson, H., Troell, M., Brugere, C., Chadag, M, Phillips, M., Andrew, N. (submitted ms). A diagnostic framework for equitable mariculture development in the Western Indian Ocean. ACIAR monograph No. [TBA].

7.2.2 Indonesia's Better Management Programme

This section summarizes Activity and will be reported as:

Mohan C.V., P. Henriksson, H. Eriksson (in prep). ACIAR investments in Indonesia in mariculture with a special focus on better management practices (BMPs): a review and assessment. WorldFish Report.

Introduction

With a volume of farmed fish produced annually estimated at 4.25 million tonnes, Indonesia is ranked 2nd globally in aquaculture production. The Government of Indonesia has further set itself very ambitious targets in the future (by 2019 is 11.8 million tonnes) in order to meet future food and nutrition needs. This presents challenges to managing impacts of expansion. ACIAR's support in research projects in aquaculture and fisheries in Indonesia, has facilitated both laboratory and field based research and nurtured strong R&D partnerships between Australian and Indonesian R&D organizations.

The desktop review of Indonesian experiences and learnings in mariculture development over the last 15 years had as its main objective: to learn from laboratory and farming systems research carried out in the area of "better management practices" (BMP) in aquaculture in Indonesia, and to identify lessons that can guide future development in aquaculture for Indonesia and globally.

The review first examined the evolution of BMP project focus areas through time, and evaluated outcomes BMP projects. Two kinds of BMP related projects in Indonesia were examined for the analysis; (i) ACIAR-funded projects since 1990, and (ii) projects implemented by NGOs, international organizations, and public institutions. Between 1991 and 2016, ACIAR funded 21 research projects that were directly or indirectly related to development and/or implementation of BMP. These projects were implemented by Australian University researchers in partnership with Indonesian MMAF. The additional 15

field projects that were implemented in the same time frame, employed different methods and approaches for delivering BMP/AIP type of packages to small farmers. Notably, farmer groups formed a very prominent model across all projects examined. The review drew mainly from project reports and publications. For field projects, field staff were approached to provide information (via skype and/or email).

The review

The module 1 assessment identified (i) drivers for funding of these projects, (ii) thematic focus areas of research and development and (iii) sustainability concerns that featured most. We summarize results accordingly:

The principal driver for many projects was the impact that viral diseases were having on the Indonesian shrimp industry. The transboundary nature of viral diseases and the risk it posed to aquaculture industry in Australia was an important contributing factor for ACIAR R&D investment. Consequently, shrimp and disease were prominent focal areas. Among the 21 ACIAR-funded projects, 16 focused specifically on shrimp and 4 projects dealt with marine finfish, with all projects including a disease component. Of the 15 non-ACIAR field projects, 12 of them worked on shrimp farming, with aims to improve productivity, enhance biosecurity, reduce food safety risks and ensure traceability. It was important to consider the shift in scope of the projects over the past 15 years, whereby desired outcomes shifted from disease management through market access/certification to area based/zonal management and certification. Closer examination of the BMP projects clearly revealed attempts to address sustainability concerns (e.g. disease and biosecurity, wild seed, SPF programs, better feeds, certification, group/cluster management, social and environmental issues).

The module 2 evaluation identified (i) what science output was absorbed into science outcomes; (ii) whether that application had generated collective action and; (ii) if it resulted in reduced environmental footprint? We summarize results accordingly:

ACIAR-supported shrimp work provided a science foundation to many BMPs that are advocated and implemented in Indonesia (e.g. management of white spot disease, epidemiology of WSD, remediation of acid sulphate soil problems, mangrove conservation, collective approaches in risk sharing and risk management). ‘ACIAR-science’ driving BMP programs in shrimp farming is evident from the many NGOs and public institutions promoting implementation of BMPs and seeking to transition farmers towards certification (e.g. ASC, IndoGAP). Regarding collective action, the group approach enshrining the ideals of collective responsibility and risk sharing is being widely utilized in Indonesia by research and development partners (e.g. SFP, MMAF, IDH, WWF, ASC). ACIAR proved instrumental in promoting the group approach or cluster management model that was pilot tested and validated in India. Lastly, understanding BMP programs’ impact on environmental footprint of aquaculture was difficult without sound baseline data and KPIs for each project. Although project implementers strongly believed these projects contributed to reducing FCR, disease loss, and dependence on wild stocks, validating these qualitative perceptions requires data which was unavailable or inaccessible.

Conclusions

The policy landscape of aquaculture development in Indonesia is complex and dynamic. In addition to the Government of Indonesia, NGO and private sector engagement is growing rapidly. ACIAR is a relatively small ‘player’ in the evolution of Indonesia’s aquaculture industry within this broader scheme.

This assessment provided lessons that are relevant more broadly. The present focus of BMP/AIP work in coastal aquaculture is focused on shrimp (disease, certification and market access). This focus should be broadened to include low impact aquaculture which promotes resilience and diversification. Greater emphasis on tilapia, milkfish, carps and catfishes, species that support local food security and livelihoods would strengthen the industry.

BMP adoption by farmers is increasing, aquaculture management practices are improving and overall the cases reviewed illustrate that successful changes are possible even for very small scale farmers. Such change has been possible by using clusters, associations and other group based approaches supported by action based research and training/extension. Understanding farmer behaviour changes linked to key drivers in such change processes (here catastrophic disease outbreaks, tsunami disaster recovery and/or market linked price incentives) will be increasingly important in future moves toward more sustainable practices.

7.2.3 Indonesian aquaculture futures

This section summarizes activity 2.2.3 and is reported as Henriksson et al. (2017a, b) and Tran et al. (2017). This text forms the basis of a policy brief to be published in Q4 2017. The analyses and reviews fill gaps in current information in support of the Indonesian government's vision of aquaculture growth in Indonesia and to provide insights and options for planning, policy, and sustainable growth and development.

As the second-largest fish producer in the world, Indonesia's fisheries sector plays a key role in the country's economy and the well-being of its people. The sector generates incomes, diversifies livelihoods, provides nearly 55% of the country's domestic animal protein supply for consumption, and generated US$ 4.2 billion dollars in exports in 2012 (MMAF 2014). Aquaculture contributes 3% of the country's total gross domestic product and has created more than 6 million direct jobs for Indonesians (MMAF 2014).

Per capita fish consumption in the country continues to increase and demand has thus far been matched by a steady increase in supply from primarily wild capture fisheries (FAO 2016). However, landings have plateaued in the last decade and the Indonesian government's focus has more recently turned towards supporting aquaculture development to meet domestic fish supply growth needs and generate economic benefits.

Indonesia's government sees great potential for further aquaculture sector growth and expansion across the country; the sector has grown at an average annual rate of 7.7% since the 1960's, the government has identified an additional 26 million hectares of suitable land for expansion (ADB 2003) and has set ambitious targets for growth (Rimmer et al. 2013). However, past sector growth and expansion has created a number of socio-economic and environmental challenges in the country, and the government's current strategies for further aquaculture development remain under-developed. This raises significant unanswered questions about what the future of aquaculture in Indonesia might look like, what challenges are anticipated, and how the government plans to meet and sustain its production targets.

Tran et al. (2017) explored the seafood sector in Indonesia using fish supply-demand modelling, with a focus on the growing role of aquaculture in the country's food portfolio. It developed six scenario projections for future fish supply-demand dynamics to 2030 that: identified critical influencing drivers of fisheries and aquaculture growth, supply, demand, and trade in Indonesia; considered their interactions; and discussed the resulting implications for future aquaculture development outcomes in the country. Scenarios considered: Business as Usual (BAU); stagnant capture fisheries at 2015 levels; export-driven aquaculture growth; domestic-focussed growth; slow growth; and, disease outbreak. All scenarios indicated that fish supply must continue to grow to meet demand and identified a negative relationship between fish prices and domestic consumption of fish. The best domestic consumption outcomes relied on a scenario where growth of 5% above BAU is focussed on economically low-value species, however export-driven projections also predict an increase in domestic supply and consumption as well as foreign currency earnings.

Projections indicate that Indonesian aquaculture production could increase 2.4-fold to 2030, excluding aquatic plants, and suggest aquaculture will likely overtake capture fisheries as the main supplier of fish in Indonesia approaching 2030. However, even the most optimistic

estimates fall short of government targets and it is therefore suggested that these targets are reconsidered, particularly in light of identified shortcomings in data for accurate analysis, and in spatial planning, infrastructure, seed and feed resources. The modelling work also highlighted that no matter the direction taken, the Indonesian government needs to invest in disease mitigation, maintenance of wild fish stocks, and strengthened institutional and human capacity to support aquaculture farmers and fisheries.

Henriksson et al. (2017a) builds on the scenarios modelling work by quantifying some of their projected environmental impacts using Life Cycle Assessment (LCA). LCA is an environmental 'accounting' tool that has been developed to estimate emissions throughout a product's lifecycle from the extraction of raw materials to the disposal stage. The study also assesses projections of full-time employment and total market value of produced products and uses these as basic indicators of socio-economic impact. Ten dominant aquaculture farming systems in Sumatra, Java, Lombok, and Sulawesi were characterised and benchmarked as part of the enhanced scenario analysis.

The analysis indicates that even under the BAU scenario, environmental impacts are predicted to experience a 3.3-fold increase at minimum; assessed impacts were global warming, acidification, eutrophication, land-use, freshwater consumption (4-fold increase), energy use, and reliance on wild fish. Socioeconomic indicators are also predicted to increase, with total fish output and full-time employment rising 3.3-fold and monetary value increasing nearly 6-fold. The 'slow growth' scenario had the least environmental consequences but left a shortage of supply and higher prices for fish. The domestically-focused scenario is predicted to yield nearly the same economic revenue as the export-driven scenario but produce larger volumes of fish and less environmental harm. However, neither of these scenarios are considered to be realistic using present production practices. The study's authors identify reliance on wild fish, land occupation, and eutrophication as Indonesia's most pressing domestic environmental concerns with respect to aquaculture. They also note that most scenario predictions, including BAU, export-driven, and domestic-focussed growth, require more wild fish and land than is physically manageable using current production practices and will still not meet the current growth targets set by the Indonesian government. The authors conclude by suggesting the need for a major transformation of the industry, supported by policy, in order to avoid potentially extensive environmental damage. They also highlight a need for government to re-evaluate their current production goals, to promote less 'demanding' species (e.g., species other than shrimp and groupers), and to identify more sustainable production systems.

Henriksson et al. (2017b) also uses Life Cycle Assessment but focuses specifically on environmental impact evaluations of aquaculture feed ingredients, an area of aquaculture production that has attracted considerable criticism because of unsustainable practices. For the Indonesian context, the assessment considered local fishmeal, rice and maize, imported soybean, wheat and livestock by-product meal (BPM) and evaluated these against environmental impact categories: global warming, acidification, eutrophication, land occupation, and freshwater consumption. Shrimp BPM was associated with the largest emissions and eutrophication impact, followed by poultry BPM. Australian wheat bran had the largest acidification impacts while rice bran had the greatest freshwater requirements. Cassava and rice bran had some of the lowest of assessed impacts overall but also have the most limited nutrition profiles. Based on the assessed impacts, the study's authors propose a shift away from dependence on local fish stocks for feed inputs. However, they also suggest that the focus on alternative feed sources should remain domestic in order to reduce Indonesia's dependence on imported feed ingredients and reduce the country's vulnerability to global market fluctuations. Aquatic plant-based feeds are proposed as an alternative to explore.

In increasing the information available for responsible planning, policy, and decision-making for sustainable aquaculture development in Indonesia, all three papers arrive at a similar overall conclusion: further aquaculture growth in Indonesia is at once possible, likely, and

necessary but not to extent currently considered by Indonesia's government. Furthermore, the extent of this future growth is heavily dependent on farmers making considerable adjustments to current practice, with strong support from government. As with any resource development initiative, the government of Indonesia will need to consider the social, economic, and environmental trade-offs of different development pathways. Nevertheless, aquaculture is anticipated to overtake capture fisheries as the main supplier of fish to Indonesians within the next 13 years.

Common considerations identified by the three papers included the potential for multiple significant negative environmental impacts, particularly if the focus of future growth is on high-value, export-driven species like shrimps and groupers. A need to invest more strongly in disease mitigation, in the maintenance of wild fish stocks, and in institutional and human resources support for farmers and fisheries was also a common theme. In terms of socio-economic impacts, all three papers highlight the need to consider the potential impacts of development choices on the price of fish and their relationship to consumption patterns.

In light of these considerations, the papers recommend that the government of Indonesia orient its aquaculture development strategies to focus more strongly on the sector's potential domestic benefits, rather than exclusively on foreign earnings. Some of the suggestions made include:

- Focus development growth more strongly on economically low-value fish with lower environmental impacts of production, e.g., *Clarias* and *Pangasius* catfish;
- Look for novel, local, aquaculture feed sources that reduce reliance on wild-capture resources or on volatile international markets, e.g., aquatic plants and by-product streams;
- Improve the sector's biosecurity and disease mitigation practices;
- Invest in sector research and development that helps to reduce environmental impacts, reduce production costs, and increase sector efficiency and competitiveness;
- Consider the impact of development pathways on the provisioning of local jobs;
- Strengthen supporting regulation and policy, particularly at the Provincial level.

Outputs produced

Tran, N., Rodriguez, U-P., Chan, C.Y., Phillips, M.J., Mohan, C.V., Henriksson, P.J.G., Koeshendrajana, S., Suri, S., Hall, S. (2017). Indonesian aquaculture futures: An analysis of fish supply and demand in Indonesia to 2030 and role of aquaculture using the AsiaFish model. *Marine Policy* 79: 25-32.

Henriksson, P.J.G., Tran, N., Mohan, C.V., Chan, C.Y., Rodriguez, U-P., Suri, S., Mateos, L.D., Utomo, N.B.P., Hall, S., Phillips, M.J. (2017a). Indonesian aquaculture futures – Evaluation environmental and socioeconomic potentials and limitations. *Journal of Cleaner Production* 162: 1482-1490.

Henriksson, P.J.G. Mohan, C.V., Phillips, M.J. (2017b). Evaluation of different aquaculture feed ingredients in Indonesia using life cycle assessment. *IJoLCAS* 1: 13-21.

7.3 Objective 3: To accelerate the recovery of communities and coastal fisheries following Tropical Cyclone Pam

Tropical Cyclone Pam that hit Vanuatu in March 2015 was the largest natural disaster to impact the country. In the wake of natural disasters, like TC-Pam, improving access to fisheries resources can provide a coping strategy for food security, while other food production systems or livelihoods are disrupted. Having well maintained and managed

fisheries and early fisheries interventions post-disaster can play an important role in community recovery processes. In the wake of Tropical Cyclone Pam a number of development projects were initiated in Vanuatu. The original activity schedule for this objective was revised to accommodate the unforeseen duplication of activities.

For example, a number of organisations and donors focused efforts on the implementation of fisheries and development interventions to aid community recovery. Fisheries interventions included the provision of fishing gear and the deployment of fish aggregating devices (FADs). The focus of this objective was thus modified to assess the status and needs of households post-TC Pam through community focus group discussions and to implement fish catch monitoring at FADs to assess the role of FADs in coastal fisheries recovery.

7.3.1 Status and needs of households post TC-Pam

This section summarizes activities and outputs from Activities 3.1 and 4.1.4 – see Section 6 for tabulated activities and milestones.

Socio-economic surveys were done between 25th August and 29th September at eleven sites across Shefa, Tafea, Malampa and Sanma provinces in Vanuatu (almost 18 months after TC-Pam). Six of the sites were considered impacted by TC-Pam and five of the sites were considered unimpacted sites. The Key findings from the surveys highlight the profound impact on the terrestrial food and income generating systems in rural Vanuatu communities. Whilst TC Pam clearly had more significant acute impacts, it has been the prolonged El Niño for over 18 months that has perhaps caused the greatest hardship for subsistence communities (see Figure 7.12 for a graphical summary).

Core impacts from the combined impacts of TC Pam and the El Niño have been:

- Damage to house and community infrastructure
- Loss of most garden crops (manioc and banana have been the most resilient for replanting)
- Loss of cash crops (e.g. kava, coconut, cocoa, sandalwood)
- Loss of pandanas leaves for weaving
- Critical water shortages (placing increased burden on peoples time)
- Loss of and reduced productivity of fruit trees

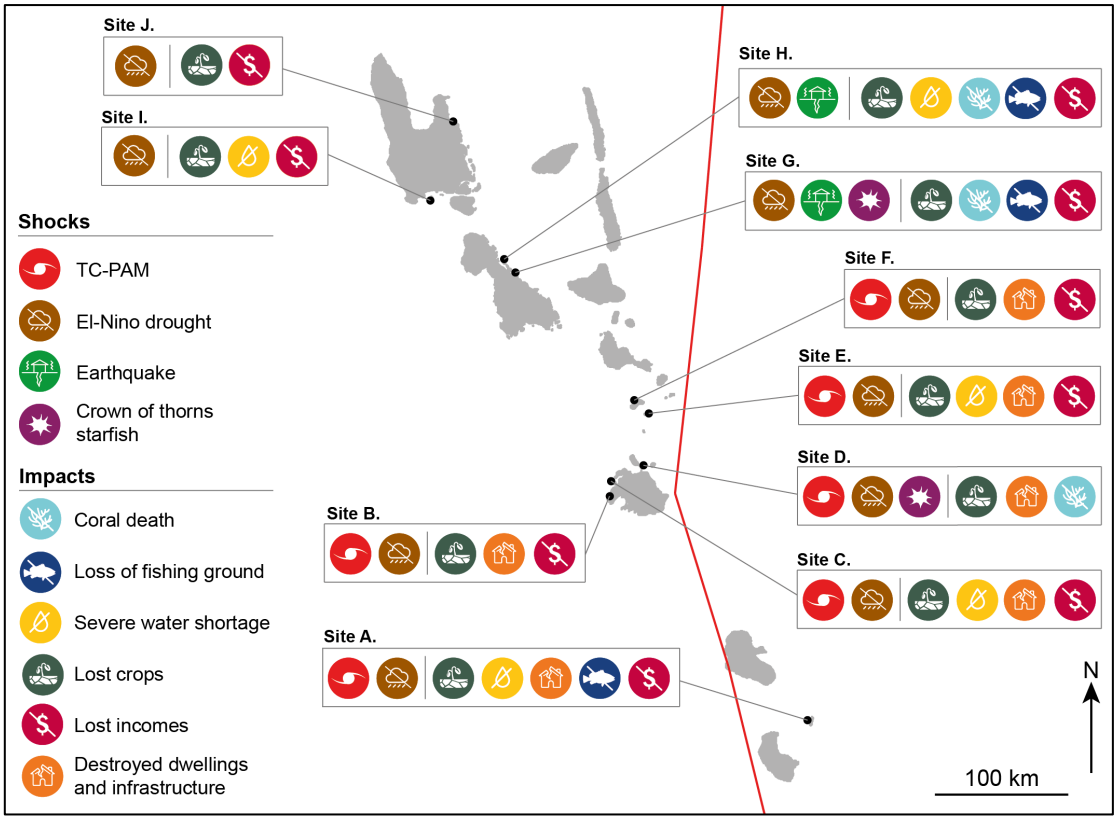

Figure 7.12. Shocks that had occurred within the last two years (2015-2016), and their impacts on daily life, identified by focus group participants at ten sites in Vanuatu in 2016. The red line through the map represents the approximate path of category 5 tropical cyclone Pam that hit Vanuatu in March 2015. Note that the map does not contain the northern Torba province, as there were no study sites there. From Eriksson et al. (2017).

Impacts on the marine system appear to be relatively minor with some reported cases of increased Crown of thorns starfish due to El Niño driven warm waters, some wave damage to fringing reefs from TC Pam and short term impacts on fishing efficiency due to dirty waters in the weeks following TC Pam. However, in all cases fishers reported the fishing had now returned back to normal and no ongoing legacy impacts from TC Pam were noted.

Marine management initiatives that existed prior to TC Pam appear to have supported post-disaster recovery in some cases. An immediate opening of the full closure of *beche-de-mer* throughout Vanuatu for four months provided an opportunity for a rapid injection of income into struggling communities. However, the original quota of 21 tonnes of *beche-de-mer* to be exported under this temporary opening was exceeded, with 71 tonnes worth an estimated USD $3M exported in 2015. In addition, the Government of Vanuatu recommended that communities opened their marine protected areas to provide a source of food and income. In some cases communities did open their MPAs for several months after TC Pam and expressed that this reservoir of fish was important for their short-term survival. In other sites “MPAs” were more traditional closures linked to specific seasonal events (e.g. Yam harvest) and as such TC Pam did not alter their normal schedules for opening/closing of *tabus*.

Fish aggregating devices (FADs) have the potential to provide an alternative source of fish while allowing coastal reef fisheries to recover from disasters such as TC Pam. In this case, despite significant resources being provided for post TC Pam FADs in Vanautu, the lack of human resources to deploy the FAD materials provided has meant the desired outcome was not reached, at least not in the short to mid-term. A similar scenario was identified with the provision of material for communities to rebuild common infrastructure lost (e.g. schools and

community halls), while households were left to rebuild their own homes with limited material resources and human resources to do so. The community assessments highlight that while the provision of materials is of great importance in a post-disaster context, donor and disaster recovery teams need to consider the broader limitations on human resources in the recovery phase. A summary report on the socio-economic surveys is included among the outputs (Albert et al 2016) and the results from this research have contributed to a scientific publication on lessons learned that is in draft manuscript form (Albert et al (in prep)).

Outputs produced

Albert S., Eriksson H., Albert J. and Warren R. (2016). “Disaster is in our blood”: Understanding impacts and recovery mechanisms from natural disasters in Vanuatu, field report to WorldFish, Penang.

Eriksson H., Albert J., Albert S., Warren R., Pakoa K., and Andrew N. (2017). The role of fish and fisheries in recovering from natural hazards: Lessons learned from Vanuatu, *Environmental Science and Policy* 76, 50–58.

7.3.2 Community-based FAD Monitoring in Vanuatu

This section summarizes activities and outputs from Activity 3.2 – see Section 6 for tabulated activities and milestones.

Nearshore fish aggregating devices (FADs) are an important development intervention in Vanuatu. FADs are being deployed in Vanuatu with the objectives to reduce pressure on coastal marine resources, improve sea safety, improve food security and income for coastal communities and fishers and as a development intervention in post-disaster context. While the objectives of nearshore FADs are several fold, the purpose of this project was to establish community-based FAD monitoring at locations in Vanuatu.

During the planning and implementation of this project, additional funding was provided to Vanuatu to support FAD monitoring through the ADB’s Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific, where a sub-project *Expanding the use of nearshore FADs to strengthen food security and reef conservation in Vanuatu.* Being implemented by Conservation International in partnership with WorldFish, SPC and VFD, it provided an opportunity to expand the number of sites intended under this project. Subsequently between the two projects we were able to expand the community based monitoring to 18 landing locations across Sanma, Malampa, Shefa and Tafea provinces (see Table 7.9).

Table 7.9: Community monitoring locations and accessibility to FADs. The highlighted landing locations where training was completed under this project in 2016.

Landing location	Province	Island	Village	FADs accessible
Hog Harbour	Sanma	Santo	Hog Harbour	yes
Tangoa	Sanma	Tangoa	Tangoa	Yes
Uri	Malampa	Malakula	Uri	No
Uripiv	Malampa	Malakula	Uripiv	Yes (2017)
Portindir	Malampa	Malakula	Portindir_Crab Bay	No
Pellongk	Malampa	Maskelyne	Pellongk	Yes
Peskarus	Malampa	Maskelyne	Peskarus	Yes
Lutes	Malampa	Maskelyne	Lutes	Yes
Finoge_Tongamea	Shefa	Emae (south)	Tongamea	No
Marae	Shefa	Emae (north)	Marae	Yes (2017)
Reisu	Shefa	Emae (north)	Emae north	Yes (2017)
Mangalilu	Shefa	Efate (west)	Mangaliliu	Yes (2017)
Lelepa	Shefa	Efate (west)	Lelepa	yes
Warasivu_Pele	Shefa	Efate (north)	Pele	Yes (2017)
Makira	Shefa	Shepard Isl	Makira	No
Taci	Tafea	Aniwa	Aniwa north	yes
Yatoro	Tafea	Aniwa	Aniwa south	yes
Mission Bay	Tafea	Futuna	Mission Bay	2017

Ten monitoring sites were identified with Vanuatu Fisheries Department (VFD) during meetings in April 2016 and July 2016, these sites were synergistic with the sites chosen for socio-economic assessments (Activity 3.1). Monitoring site selection was based on; (i) being a prioritized site for FAD deployment (e.g. a post-TC Pam priority site), (ii) the presence of a strong 'Vanua Tai' (village resource person), community-based authorized fisheries officer or fishers association and (iii) sites that have existing marine resource management activities. The selection of additional sites was undertaken during the ADB project inception workshop held in late September 2017.

Fish catch monitoring was designed and developed using tablet-based data collection. The tablet selected (Samsung Galaxy Tab 3 with 3G SIM) enables the direct upload of data using 3G networks that are relatively accessible across Vanuatu. During the initial stages of the project, data was collected on the tablets using "Open Data Kit" (ODK-collect) application, with a data collection form specifically designed by WorldFish to suit the data needs of VFD and the project. The ODK data collection tool was based on the existing fish catch collection form being implemented by VFD for artisanal fishing, and consistent with the SPC regional approach for artisanal fish monitoring.

Training of community monitors was undertaken at 10 sites between 21st August and 2nd October 2016 (during the same period of post-TC Pam assessment). At each community the Vanua-tai network and/or fishers associations were the entry point to each of the sites. At each site, after initial discussions about the broader project (including Activity 3.1 focus group discussions), the community leaders identified appropriate people to join the fish catch monitoring training. Following the training, community monitors initiated data collection using the ODK system.

In late 2016, VFD requested that data collection methods be transitioned from ODK to *Tails* - the SPC regional artisanal tuna data collection application. The purpose being to better harmonise the collection of artisanal and subsistence data in Vanuatu. A modification of *Tails* was undertaken by SPC to enable the collection of community-based data. In February 2017, existing and new monitors joined a *Tails* training workshop (funded by ADB, with support from personnel within this project) to transition data collection to the new data collection application. This transition was relatively smooth, particularly for those monitors initially trained under this project as they had previous experience in collecting fish catch data using tablet-based technologies. The monitors trained under this project were thus able to support and share learning with the new monitors.

Figure 7.13: Fish monitor recording catches on a tablet as part of training activities

Data analysis and a journal article on the role of fish and FADs in Vanuatu remains incomplete, due in part to a lack of sufficient data for analysis as well as unforseen delays in the deployment of FADs at the sites identified for monitoring. Monitoring activities will continue and the results from this research will be continued and published as a scientific paper under ACIAR FIS 2016/300 project. Key findings have been presented here.

Community monitoring assessment

Monitoring efforts at the community level has been assessed by evaluating the total number of fishing trip logsheet recorded by all monitors between September 2016 and July 2017.

The total number of fishing trip logsheets recorded by all community monitors between September 2017 and end July 2017 was 2035. This is highly commendable, especially given that data collection is reliant upon the voluntary contribution of community member's time and effort. Of note in the graph below is tendency for increased data collection in the time periods after training. The steady decline from March to July 2017 indicates that monitors are losing enthusiasm and incentives are required to maintain monitoring activities. These incentives will be provided as part of the ABD project in the latter part of 2017.

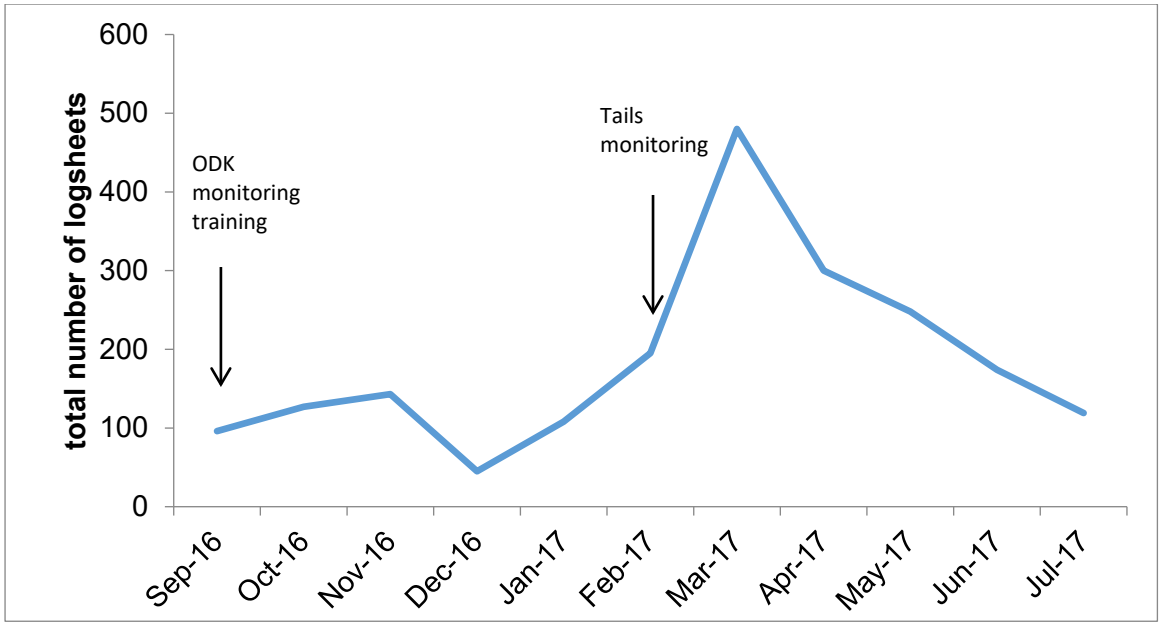

Figure 7.14: Graph showing the total number of logsheets collected by community-based monitors between September 2016 and July 2017.

Basic data analysis

At the time of writing this report, 12 of the 17 monitoring locations have access to FADs, while four remain without access to FADs. Fish catch data has been recorded for 9 of the 20 FADs currently in the water and in the vicinity of the monitoring locations. These FADs are mostly fished using motorized vessels (92% of fishing effort hours) with only three of the nine FADs where data has been collected being accessed by paddle canoe (all of these being nearshore FADs). In Vanuatu, there are few motorised vessels, most of which are generally used for income-generating fishing activities. These results thus highlight that for programs targeting small-scale subsistence fishers using paddle canoes, FADs need to be deployed closer to shore to better enable access by fishers.

Table 7.10: Total fishing efforts at FADs by paddle and motorized vessels

Region	FAD	Vessel Type	Total Effort in Hours
Efate (SH)	Lelepa Subsurface FAD	Motor	9
Efate (SH)	Lelepa Subsurface FAD	Paddle	4
Efate (SH)	Offshore Vatuika FAD	Motor	12
Emae (SH)	Emae Subsurface Fad	Motor	14
Malekula (MP)	Maskelyn Nearshore SS FAD	Motor	86
Malekula (MP)	Uripiv FAD	Motor	138
Santo (SM)	Hog Harbour FAD	Motor	10
Santo (SM)	Hog Harbour SS Fad	Motor	71
Santo (SM)	Hog Harbour SS Fad	Paddle	19
Santo (SM)	Tangoa Araki Subsurface FAD	Motor	4
Santo (SM)	Tangoa Araki Subsurface FAD	Paddle	8
Santo (SM)	Vatuika FAD Inshore	Motor	19
		TOTAL MOTOR	354
		TOTAL PADDLE	31

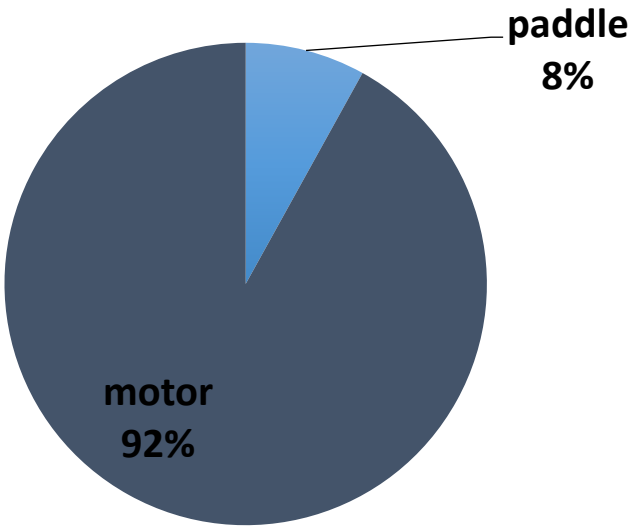

Figure 7.15: Proportion of fishing effort (hours) at all FADs by canoe and motor vessel

Using the limited data available, catch rates (catch per unity effort (kg/line/hr) were calculated for key species at FAD and non-FAD fishing locations. Based on the top 10 fish species caught at FADs, species specific catch rates (CPUE kg/line/hr) for kawakawa, yellowfin tuna and mahimahi were higher at FADs compared to non-FAD fishing areas, showing early positive signs on the role of FADs in improving catch rates for fishers (Figure 7.16).

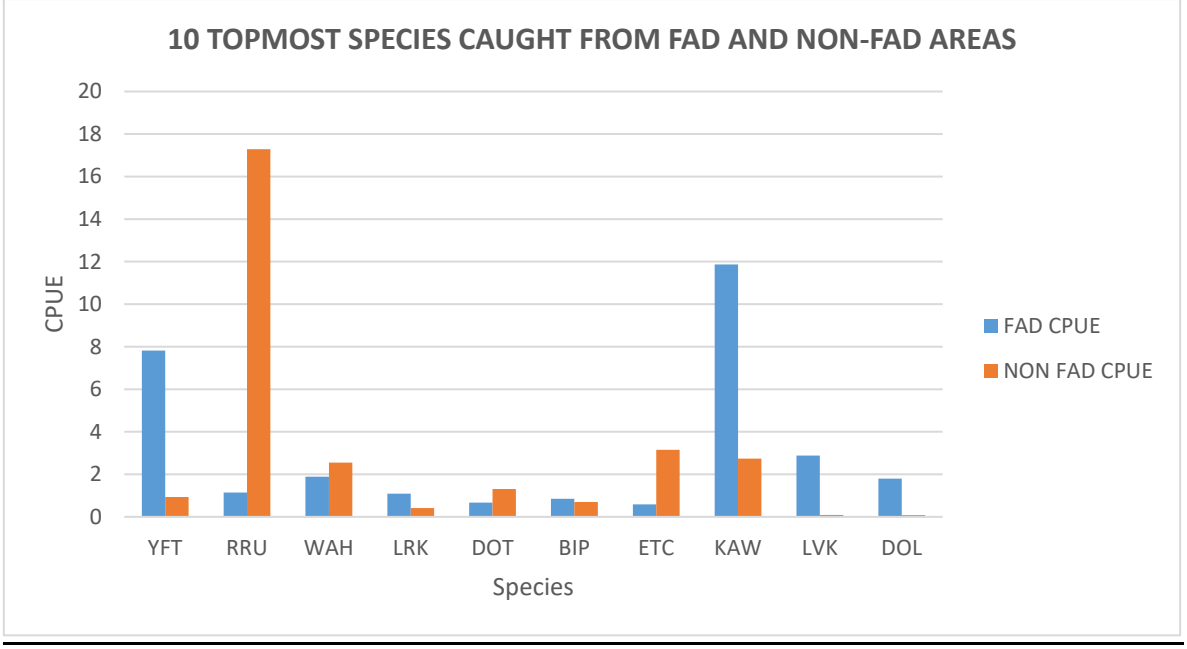

Figure 7.16: Catch per unit effort (CPUE kg/line/hr) at FAD and non-FAD fishing areas (for the 10 most caught fish species at FADs). Abbreviations: YFT – Thunnus albacares Yellowfin tuna, RRU – Elagatis bipinnulata rainbow runner, WAH – Acanthocybium solandri Wahoo, LRK - Paracaesio kusakarii Saddle-back snapper, DOT - Gymnosarda unicolor Dogtooth tuna, BIP - Sarda orientalis Striped Bonito, ETC - Etelis coruscans Deepwater longtail red snapper, KAW - Euthynnus affinis Kawakawa, LVK - Lutjanus kasmira Common bluestriped snapper, DOL – Coryphaena hippurus Mahi Mahi.

Outputs produced

WorldFish (2017e), CPUE Data Instrument.

WorldFish (2017f), Vessel Data Instrument.

WorldFish (2017g), Fisheries data collection, Vanuatu: Efate, Malekula, Maskelynes, Santo, Aniwa, Futuna, Emae and Makira, poster presenting Vanuatu fisheries data collection.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The two public domain databases developed will be widely used for global and regional analyses in the years to come. When paired with other information, such as trade data, HIES and DHS surveys, the information gathered in these complementary databases will enable detailed analyses of nutrition in the region. Both will be available in Q2 2018 and will have a measurable impact in five years' time.

The analyses done on the eight HIES datasets will provide baselines for a range of indicators needed to track progress in achieving New Song and national ambitions in fisheries and food security.

Publication of tests of the MDD-W will be a first for the Pacific region and provide evidence of poor diet quality of women in rural communities in Solomon Islands. The pending publication will highlight the implicit role of fish in the diets of women and young children in rural Pacific communities and the multiple challenges that beset improving nutrition in the region. These surveys will provide baselines for interventions in Solomon Islands and allow quantitative analyses of trends in diets.

The analyses of Indonesian aquaculture development provide a basis for realigning investments in better feeds, enhanced genetic strains, disease control, farmer training, government support, investments, improved water management, and other innovations that can help reduce the environmental footprint of aquaculture. The existing and pending publications (in late draft form) are set to transfer knowledge among regions and across priority areas of research and practice (e.g. biosecurity, disease control, life-cycle assessment, BMP program modalities, benefit sharing and gender equality in production systems).

8.2 Capacity impacts – now and in 5 years

In Activity 1.1.3, SPC undertook training activities to build capacity for national agencies to independently extract, interpret and disseminate data for regular use in policy development and planning:

- Training 1: Palau data analysis workshop, 3 to 8 July 2016 (14 pax, 5M and 9F) from National Statistics Office (NSO) and Ministries of Health, Education, Agriculture, Gender and Culture and Education. A health poster was produced .
- Training 2: FSM data analysis workshop, 12 to 15 September 2016 (20 pax, 10M; 10F) from NSO and Ministries of Fisheries, Agriculture, Education and Health. This training was a precursor to the data dissemination workshop.
- Training 3: FSM data dissemination workshop, 20 to 24 February 2017 (20 pax, 10M; 10F) from NSO and Ministries of Fisheries, Agriculture, Education and Health. The main focus of this training was to build capacity in the production of data dissemination products, including creating infographics using commonly available software. The main output was built capacity in the production of data dissemination products. 9 fact sheets and 13 posters were produced.
- Training 4: Solomon Islands data analysis and dissemination workshop, 22 May to 2 June, 2017 (10 pax, 6M and 4F) from Ministries of Fisheries, Agriculture, Health and the World Bank. This training integrated both data analysis and dissemination. The reason for this is that the training targeted non-NSO employees, who had little prior experience with data analysis, and it was therefore more appropriate to analyse summary statistics, rather than focus on sampling and extraction of raw data from

survey-specific databases. The outputs included build capacity in summarising and interpreting data and in the production of data dissemination products (15 posters were produced and 11 fact sheets were drafted).

- Over the period July 2016 to September 2017, SPC's Statistics for Development Division hosted three ni-Vanuatu interns for a period of three months each. The interns assisted and were trained in HIES data cleaning and development of a regional food trade database, which provides a 10-year time series of imports and exports for 15 PICs (to be further developed and analyzed in project FIS/2016/300).

In Activity 1.3.1: A capacity building and training workshop was held in Auki, Solomon Islands from the 25th to 30th April 2016 for the 10 key staff involved in the collection of nutrition data. WorldFish (Dr Andrew Thorne-Lyman and Dr Joelle Albert) and the Ministry of Health (Josephine Maelaua) jointly facilitated the workshop. The capacity building workshop covered both the accurate collection of nutritional status data (using anthropometric measures) and a comprehensive knowledge and practice with the quantitative survey on the determinants of malnutrition. At the end of the 6-day workshop, a selection of staff from WorldFish and MHMS were trained to accurately collect anthropometric data and all workshop participants were able to implement the quantitative survey. The joint participation between the Ministry of Health and WorldFish enabled the survey instruments to be refined during training to ensure that both partners were obtaining accurate and appropriate information for research and management outcomes. While the timing of this research was unable to influence the design of 2015 National Demographic and Health Survey (DHS), the Ministry of Health has undertaken to incorporate changes required to enable the reporting of women's minimum dietary diversity in the next DHS survey (in four years time).

In Activity 1.3.5, Josephine Maelaua from Solomon Islands Ministry of Health facilitated the training workshops. Ms Maelaua left the Ministry in late 2016 to take a lecturing position in nutrition and dietetics within the School of Nursing and Allied Health Sciences at the Solomon Islands National University. Through the ongoing sharing of research findings, this project has contributed to the development of the nutrition curriculum within SINU.

A data analysis and reporting capacity building workshop was held in Port Vila, Vanuatu from the 25th – 28th July, 2017. WorldFish and SPC jointly facilitated the workshop, while 21 Vanuatu Fisheries Department staff attended from data, compliance, seafood verification and fisheries development sections along with two project specific staff. The workshop covered basic concepts and application of data collection, data analysis and data reporting for management and research purposes. Based on an evaluation conducted at the cessation of the workshop, all participants enjoyed the workshop and believed that the capacity gained through the workshop will greatly assist them in their daily work activities. The VFD director was pleased with the workshop and was looking forward to improved analysis and reporting from his team. Workshop participants recommended that such capacity building workshops should be an annual event for staff, and should be made widely available for other staff that were unable to attend this event. The workshop also helped WorldFish and SPC to better understand the data analysis requirements in Vanuatu, which can assist in the further development of fisheries data collection and reporting requirements in the region.

In Activity 2.1.4, The Western Indian Ocean workshop participants were senior government officials from east African agencies (17 pax, 11M and 6F). Attendees committed to sharing the findings of the workshop with middle and lower levels of management within their respective ministries and departments. Participants reported having gained new knowledge from the workshop, which will be useful in future mariculture policy-related work and discussions, including how to best include equity dimensions in mariculture development.

Examples of outputs produced

SPC (2016a) Palau Data User Workshop, Statistics for Development Division.

SPC (2016b) FSM Data User Workshop, Statistics for Development Division.

SPC (2017a) Solomon Islands Data Dissemination Workshop, Statistics for Development Division.

SI National Statistics Office (2017a) HIES Fisheries in the Solomon Islands, fact sheet prepared by the Solomon Islands in country.

SI National Statistics Office (2017b) HIES Marriage by Age Group and Gender in Solomon Islands, fact Sheet for the Solomon Islands in country.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

The diagnostic framework for aquaculture development to be published as an ACIAR monograph will be used as the *ex-ante* planning tool for a large USAID-funded and WorldFish-led mariculture initiative in Sierra Leone. In addition, WorldFish is planning its use at the inception phase with farmer groups in an aquaculture initiative for cage farming *Oreochromis tanganyikae* in Lake Tanganyika, Zambia. The incorporation into both the Sierra Leone mariculture project and the Zambia aquaculture program is an indication of its applicability and pragmatic scope.

In five years the analyses of fish in the Pacific food system will, hopefully have contributed to improved public health outcomes in the region, particularly in Solomon Islands. These analyses will be extended and refined in project FIS/2016/300.

8.3.2 Social impacts

Engagement with post-TC PAM communities in collaboration with development projects contributed to the national rebuilding program in southern Vanuatu. Social outcomes will be evident over longer time horizons as part of FIS/2016/300 as FAD and CBFM work continues in those communities.

The awareness training and interventions underway in Malaita and Western Province, Solomon Islands will have significant impacts on the wellbeing of women and children. The baselines created in the current project will be used in FIS/2016/300 to continue dietary awareness and other interventions.

The development of community-based fisheries monitoring programmes in Vanuatu has had a serendipitous impact in improved communication mechanisms between monitors across Vanuatu and the broader research team through social media. This has resulted in an unexpected outcome of regular communication between the group and sharing of information and knowledge pertaining to fisheries monitoring and management.

The outputs from the HIES analyses, aquaculture planning and fish nutrition work are long-term strategic investments; social impacts could not reasonably attributed to this work at the end of the project.

8.3.3 Environmental impacts

The long-term strategic nature of the work means that there were no direct environmental impacts within the life of the project. Over a five-year horizon, we foresee environmental impacts from:

- Widespread deployment of FADs in conjunction with improved management of reef fisheries in Vanuatu
- Improved mariculture planning development in WIO
- Improved planning and development in the aquaculture sector in Indonesia.

8.4 Communication and dissemination activities

Throughout the project results have been communicated by partners through various Nutrition awareness materials for rural Solomon Island communities. Through discussions with the Ministry of Health, it was apparent that the majority of existing nutrition awareness resources focus on basic nutrition awareness including the consumption of a balanced diet from the main food groups (simplified for rural communities as protective foods, energy foods and body building foods) and Non-communicable diseases (NCDs). There was distinct lack of awareness materials that focus on the value of fish for nutrition and importance of good nutrition in the first 1000 days (during pregnancy and the first 2 years of a child's life). Posters on the nutritional value of fish and nutrition in the first 1000 days were developed for rural communities in Solomon Islands.

Drawing from HIES datasets, fisheries fact sheets presenting country profiles for example were produced and utilized in workshops. In late 2016 and early 2017 SPC staff carried out a series of trainings with in country fisheries teams in Palau, Micronesia and Solomon Islands on data usage.

Outputs produced

WorldFish (2017c). Fish: food for good health, poster prepared for community development activities in Solomon Islands, Honiara.

WorldFish (2017d). The first 1000 days, poster prepared for community development activities in Solomon Islands, Honiara.

SPC (2017b) Household Income & Expenditure Survey 2013/2014 Fact Sheet, prepared for Federated States of Micronesia.

SPC (2017c) Palau World Health Day fact Sheet, prepared for Palau.

9 Conclusions and recommendations

9.1 Conclusions

The project addressed three main objectives regarding the role of fish in development, namely: (i) to better understand and promote the sustainable use of fish for nutritional; security in the Pacific Food System; (ii) to improve decision making on mariculture policy and planning in Indonesia and the Western Indian Ocean; and lastly to (iii) to accelerate the recovery of communities and coastal fisheries following natural disasters like Tropical Cyclone Pam.

Our framing of the role in the Pacific food system was forward-looking rather than a conclusion drawn from the study, but has served to highlight the changes underway in fish production and use. A food system framing of issues provides a language for addressing emerging issues in production, trade, and consumption of fish that encourages inter-disciplinary solutions.

We confirmed predictions of a fish supply gap in some countries, notably Solomon Islands, Vanuatu and Samoa and described patterns in the acquisition and apparent consumption of fish in eight PICs. Consumption of pelagic, reef, shellfish and canned fish varied markedly across the region, and among urban and rural populations. We found strong evidence of malnutrition in rural communities in Malaita Province, Solomon Islands. We concluded that, while fish will continue to have a central role in Pacific food systems, the evidence base needs to be widened to integrate a better picture of what types of fish, and where, and a more complete picture of dietary diversity to better guide interventions. As part of this process, we developed databases to guide nutrition analyses in the region.

The analyses reported here broadly support the original Bell et al. conclusions that some countries, notably Solomon Islands, Samoa and Vanuatu will need to re-imagine the supply of fish in the coming decades. The remaining countries have a broader set of policy options open to them, but all will need to invest in fisheries management to secure the fisheries they have. Our analysis were based on those countries with updated and available HIES and so did not include Papua New Guinea, Fiji and other countries in the Bell et al. analysis.

Adaptations to increase the supply of coastal fish and increase the availability and accessibility of tuna will require interventions at a range of scales, from community-level initiatives to trade and taxation changes, and at all stages of the food system. The canned tuna sector holds potential in aiding to achieve food availability targets made by PICs that will be necessary in meeting expected future demands in domestic consumption

In the wake of TC Pam, terrestrial destruction (e.g. subsistence and cash crops failure, infrastructure damage etc) was greater than marine environmental, reinforcing the important role that marine resources play in providing sources of food safety and insurance in times of hardship. FADs have the potential to provide an alternative source of fish while allowing coastal reef fisheries to recover from disasters such as TC Pam. Species specific catch rates showed early positive signs on the role of FADs in improving catch rates for fishers. However a lack of human resources to deploy the FAD materials meant the desired outcome of FAD deployment feel short. Similarly the provision of material to rebuild infrastructure did not match the limited human resources to do so. While the provision of materials is of great importance in a post-disaster context, greater consideration is needed of the broader limitations on human resources in the recovery phase.

Aquaculture is predicted to overtake fisheries as the main supplier of fish to Indonesians within the next 13 years. Our analyses indicate that aquaculture growth in Indonesia, while inevitable, is heavily dependent on farmers making considerable adjustments to current practice. As with any resource development initiative, the government of Indonesia will need to consider the social, economic, and environmental trade-offs of different development

pathways. Negative environmental impacts, particularly if the focus of future growth is on high-value, export-driven species like shrimps and groupers will slow development. Significant investments will be needed in disease mitigation and in institutional and human resources support for farmers and fisheries. In terms of socio-economic impacts, consideration is needed for the potential impacts of development choices on the price of fish and their relationship to consumption patterns. The review of Better Management Programmes in Indonesia showed that BMP adoption by farmers is increasing, aquaculture management practices are improving and that successful changes are possible even for small-scale farmers.

The diagnostic framework developed for the Western Indian Ocean provides the basis for improved planning and development of mariculture in the region. Of particular note, the benefit sharing mechanisms proposed should promote more equitable development of the industry than has been observed in other region.

9.2 Recommendations

- Strengthen food systems research for the region to have greater influence in regional and national policy so that the role of fish in development and nutritional security remains an active area in support of regional and national initiatives. Research that is closely linked to interventions will provide the evidence base needed to make progress in addressing the NCD crisis in the region.
- Within a broader focus on food and nutrition security, strengthen understanding of fish as part of dietary diversity in the region to better guide public health policy
- While community assessments highlight the great importance of immediate relief in terms of supplies and food post-disaster, donor and disaster recovery teams need to consider the broader limitations on human resources in the recovery phase.
- Continue to develop tablet-based monitoring programs in support of national agencies for FAD and coastal fishery monitoring in support New Song objectives, and as research tools for, for example, nutrition research and other participatory research
- Surpluses in the supply of fish in some islands and countries offer opportunities for changes in public health policy and economic development. In particular: the development of intra-regional trade in fish and the development of tourism around locations with high fish biomass. In places like Tonga, Tokelau and Palau, for example, relatively more fish could be consumed in preference to other alternatives.
- To harness the full direct benefits of locally-canned tuna the governments of Fiji, Solomon Islands and PNG could implement policies to facilitate the supply and distribution in the region, including: promoting health benefits of tuna; mandating regular delivery of tuna to national processing operations by licensed vessels; removing duties on materials needed by local fish processors; specifying minimum product-quality standards to eliminate low-quality canned tuna imports; and imposing import duties on canned tuna to encourage purchase of domestic products.
- In Indonesia, promote increase focus on low impact aquaculture that promotes resilience and diversification, including developing and implementing strong science-based BMP programs for species like tilapia, milkfish, carps and catfishes which support local food security and livelihoods.
- In WIO implement the diagnostic planning framework developed to enable sustainable and equitable mariculture development.

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10.2 List of publications produced by project

The outputs listed below includes both published or in press articles and those that are at earlier stages of publication (i.e. submitted or in draft form (in prep)). URLs are provided for all publically available material. Email addresses are provided for contacts for material that is not widely available or still being developed.

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SPC (2017b) Household Income & Expenditure Survey 2013/2014 Fact Sheet, prepared for Federated States of Micronesia. Lead contact: spc@spc.int

SPC (2017c) Palau World Health Day fact Sheet, prepared for Palau. Lead contact: spc@spc.int

SPC (2017d), Fisheries data collection, Vanuatu: Efate, Malekula, Maskelynes, Santo, Aniwa, Futuna, Emae and Makira, poster presenting Vanuatu fisheries data collection. Lead contact: spc@spc.int

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