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Australian Centre for International Agricultural Research

Final report

Project

Improving community-based aquaculture in Fiji, Kiribati, Samoa and Vanuatu

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2 Executive summary

There is increasing concern that the demand for fish continues to increase and a number of Pacific island countries will be unable to supply fish needed from their reef fisheries resources to meet their people. The concern points to two key factors, the increasing populations in several Pacific island countries and impacts of climate change on reef fisheries. Fiji, Kiribati, Samoa and Vanuatu are among some of the countries where coastal fisheries will not be able to meet the fish supply needed by 2035. An additional 34,200 tonnes of fish will be required for Fiji, Kiribati 9,000 tonnes, Samoa 17,600 tonnes and Vanuatu 14,800 tonnes respectively (Bell et al 2011).

The project covers Fiji, Kiribati, Samoa and Vanuatu. Based on a scoping study that conducted in the four countries, the project focused on tilapia (*Oreochromis niloticus*) and freshwater prawn (*Macrobrachium rosenbergii*) in Fiji and Vanuatu, tilapia in Samoa and sea cucumber sandfish (*Holothuria scabra*) in Kiribati. The key objectives of the project are: to address technical and capacity constraints in community aquaculture through interventions in the four countries; apply and evaluate community based approaches to strengthen community impacts of small scale aquaculture; ascertain the impacts that community aquaculture can have on household income, nutrition, and the status of women and children in these four countries and; integrate community sea cucumber aquaculture with coastal fisheries management to strengthen CBFM approaches in one country (Kiribati), and review experiences in another country (Fiji).

Significant progress were made in addressing capacity constraints in the four countries. Hatchery production capacity in terms of technology and new innovation for freshwater tilapia fish have been adopted by two countries, Fiji and Samoa, and this is making a marked impact in producing tilapia fingerlings for farmers. Similarly, for Kiribati, production of sea cucumber (sandfish) has gained significant progress where sea cucumber seed supply are now produced using a simple low tech hatchery in Kiribati. Guidelines on how best to manage broodstock for freshwater prawns and tilapia were developed for Fiji and Vanuatu in order to enhance husbandry practices and quality control for both species.

During the implementation of the project, two project countries were badly devastated by category 5 cyclones. On March 2015, tropical Cyclone Pam damaged Vanuatu and in the following year, tropical Cyclone Winston damaged Fiji on March 2016. For both Vanuatu and Fiji there were significant delays experienced in executing project activities given that both countries experienced significant aquaculture infrastructural damages and as a result post disaster recovery and rehabilitation work became a priority in both countries.

Positive outcomes from this project are:

- Increased production by tilapia farmers arising from introduction of improved management practices.
- Significant increases in capacity amongst national Fisheries staff involved in project activities.
- Development of effective farmer networks and clusters, whereby farmers to talk to each other and share ideas and, in some cases, equipment.
- Significant increases in capability amongst farmers involved in project activities, including the ability to produce their own tilapia fingerlings for on-farm use or sale to other farms.
- Demonstration of the integration of aquaculture with community-based fisheries management (for sandfish).

- Increased awareness of gender issues, particularly within national Fisheries agencies.
- Political recognition of the importance of aquaculture in contributing to food security and livelihoods leading to improved political and financial support for aquaculture development.

Positive impacts arising from this project are:

- Improved food security from the production and home consumption of farmed fish.
- Income generation from sale of farmed fish, and, in some cases, fingerlings.
- Increased ability for tilapia farmers to plan production and predict income, now that they can produce their own fingerlings.
- Increased sense of self-worth arising from increased self-sufficiency in aquaculture production, and decreased reliance on seed stock supply from Fisheries agencies.
- Disaster resilience was provided by tilapia aquaculture. For instance in Fiji, farmed tilapia were the only source of food in villages after tropical cyclones cut off food distribution networks.

Future actions might be required to scale up and scale out nile tilapia and sea cucumber production technologies to improve food and nutrition security and livelihood diversification through:

- Determine how freshwater nile tilapia fish farming contributes to nutrition and income outcomes for cluster farmer and how can equitable benefit sharing and equitable opportunities to participate in value chain be realised for men and women.
- Identify what models of government hatchery and private sector fingerling multiplication ensure that farmers can have a timely access to fingerling while maintaining genetic quality.
- On sea cucumber, out-scaling of hatchery technology to other countries from the experiences in Kiribati and up-scaling of Kiribati activity. An increased focus on social and economic aspects, including economic benefits, gender roles, potential for linkages with community based fisheries management and marketing.

This report presents the objectives and the methodology employed used in the project with a summary of the highlights of activities and the findings from the project.

3 Background

The increasing demand for fish as result of increasing populations in the Pacific island countries raises the concern in the ability of coastal fisheries to meet the fish demand-supply projections.

Studies have pointed out that the Pacific island populations have a high dependence on fisheries products for food and income. In all four targeted countries, proposed, mean per capita fish is over 20kg/person/year, which exceeded the global average. In Kiribati, mean per capita fish consumption estimates at over 60kg/person/year. In Samoa, it is 87kg/person/year. In Fiji, it is 21kg/person/yr. Population growth means that many Pacific island countries will face a shortfall in the supply of fish for food from their coastal waters and nearly all countries are experiencing localised depletion of resources around densely populated areas because of urbanisation (Bell et al. 2011). While maintain coastal fisheries supply, additional production is forecasted to come from other initiatives such as coastal and community type aquaculture to ensure future nutritional requirement of Pacific islanders are met.

Analysis of the problem suggested two main solutions: efforts to improve management of coastal fisheries resources to ensure that they provide sustainable harvests, particularly through community based fisheries management (CBFM), and the development of additional supplies of fish for food from other sources such as aquaculture. There remain significant constraints in aquaculture particularly in areas such as capacity, seed and feed supply and addressing these constraints is more challenging particularly in remote-coastal and inland communities where accessibility to resources and services is often very difficult.

ACIAR has received funding from AusAID to conduct a program of fisheries related research in Pacific island nations (PICs). The research is in two thematic areas, namely community based fisheries management (CBFM) and aquaculture. The Community Aquaculture project is a component of a wider ACIAR-AusAID Fisheries program entitled *Improving Community-based Fisheries Management and Aquaculture in Pacific countries and PNG.* The goal of the program is to improve food and nutrition security, productivity and resilience of fisheries systems, and community livelihoods in PNG and PICs.

Following these concerns, the Pacific Community (SPC) submitted an interest to the Australian Centre for International Agriculture Research (ACIAR) for consideration. The ACIAR approved and provided a contract to SPC for an amount of AUD30,000 to undertake a scoping study in identifying countries needs and priorities. The overall aim of the scoping study was to: prepare the Phase 1 documentation for an ACIAR project on community-based aquaculture in the Pacific Island countries for an ACIAR in-house review process, and to prepare the Phase 2 proposal for submission to ACIAR. Four ACIAR countries were proposed: Fiji, Kiribati, Samoa and Vanuatu. During these stages of scoping and proposal formulation, the project team have also considered reviews of recent regional aquaculture studies such as Hambrey (2011) and Gillet (2010) and the recommendations and lessons from these review have been absorbed in the design of this project.

The key issues that the project intended to achieve in the 4 countries has been in addressing capacity constraints that hinders production particularly around the areas of seed production, improving technologies and new ideas on how to make fingerlings more readily accessible to farmers and providing technical expertise to strengthen local expertise among aquaculture practitioners.

The Community-based Aquaculture project focused on improving food and nutrition security and resilience of fisheries management systems, and community livelihoods in these Pacific countries. In this project, the aim is to develop profitable aquaculture systems, which will improve value of aquaculture production, nutrition and livelihoods in rural communities through better access to aquaculture technologies and management systems. As part of the interventions in addressing the above objectives, the project focuses on the following commodities in each country: tilapia and freshwater prawn culture in Fiji, tilapia and Vanuatu, tilapia culture in Samoa and sea cucumber (sandfish) culture in Kiribati.

Selection of the countries that took part in the project was based to the fact that they were ACIAR member countries and had no existing ACIAR projects being implemented at the time. During the scoping mission, consultation was undertaken with key national stakeholders where a prioritisation process was undertaken. Countries were asked to identify what were the institutional priorities in terms of the species they were culturing, who were the national partner agencies involved at the time and what the overall aim and thrust of future work in the countries were. This included the need for countries to specify what was the objectives of the species they were culturing, what were they constraints they were facing and how would they go about in addressing those constraints. It was evident during the process that countries came up with a high list of prioritised species for culture. Project team then assisted countries to narrow their priorities to not more than two species of focus.

The project team also took into consideration species that each of the countries has had a history of cultivating and activities from previous ACIAR projects that the selected countries have been involved in. These areas assisted enormously in terms of justifying where the project should be focusing on during the early stages of project formulation. The findings of the previous ACIAR projects supported the basis of where the proposed project should be targeting. For instance, Fiji prioritised freshwater tilapia (*Oreochromis niloticus*) and freshwater prawns (*Macrobrachium rosenbergii*) where it has had a long history in tilapia and freshwater prawns farming through previous ACIAR projects. Findings of FIS/2008/031[1] on tilapia genetic assessment and FIS/2005/108[2] that evaluated three strains (Vietnam, Indonesia and Malaysia) of giant freshwater prawns and FIS/2006/138[3] that looked into different feed option proposed for an improved production system through enhancing better aquaculture practices in broodstock management, fry production and feed sources which were built into the project.

Kiribati prioritised sea cucumber through the expertise they have developed over time in sea cucumber propagation initially with white teatfish *Holothuria fuscogilva*. However maintaining white teatfish broodstock in the hatchery has proved to be difficult and as a result Ministry of Fisheries in Kiribati prioritised sea cucumber sandfish (Holothuria scabra) as a species to be introduced into the country for propagation. The selection was based on hatchery techniques that were developed through previous ACIAR projects such as FIS/1995/703, FIS/1999/025, FIS/2003/059 and FIS/2006/138. Through an official request from the Government of Kiribati, an import risk assessment protocol was undertaken by SPC for sandfish introduction from Fiji to Kiribati.

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[1] *FIS/2008/031 An assessment of the extent of genetic introgression in exotic culture stocks of tilapia in the Pacific*

[2] *FIS/2005/108 Freshwater prawn aquaculture in the Pacific region: improving culture stock quality and nutrition in Fiji*

[3] *FIS/2006/138 Regional feed ingredients inventory (ACIAR Mini project)*

Tilapia culture in Samoa has been practiced at small-community type scale prior to the project being implemented. Samoa was involved in previous ACIAR projects that covered tilapia such as FIS/2008/031 which led to prioritising tilapia as new commodity for development in the Samoa National Aquaculture Development Plan and ACIAR Mini project MS0604[4]. The latter highlighted the need for a more cost effective methods to produce tilapia more effectively and efforts be made in commercialising tilapia farming. As a result, the project focused on strengthening capacity of tilapia farmers in commercial production of tilapia farming.

Vanuatu through the national Fisheries Department has been undertaking pilot farming of nile tilapia on Efate Island and Santo since 2015 with stocks introduced from Fiji. A model farm. The interests led to the Vanuatu College of Agriculture establishing a model tilapia hatchery and a accredited tilapia training module developed for certificate of agriculture. Experiences on freshwater prawns on the other hand was through involvement in a previous ACIAR Mini project on native species *Macrobrachium lar* and a successful pilot culture trial of M*. rosenbergii* with stocks introduced from Fiji. These experiences led to the prioritisation processes to up-scale tilapia and freshwater prawns under this project.

Based on the analysis of information from the 4 proposed countries, it is recognised that the main constraints facing any form of aquaculture are seed, feed and market. The following questions were developed to provide a conceptual basis for the project:

1. Can a programme of targeted technical assistance and capacity building help improve the success rate of aquaculture for better nutrition and livelihoods in these four countries?
2. What community-based mechanisms and approaches can be used to strengthen and sustain and increase community impacts of small-scale aquaculture?
3. What issues of gender equity, if any, are emerging as aquaculture develops in Pacific island countries with very different cultures, and how can these be addressed?
4. How can aquaculture contribute towards achieving community based fisheries management (CBFM) objectives in coastal fisheries?

Based on the outcome of the mid project review, an amendment was made to the third research question. The variation became “what factors would enable equitable share of benefits from aquaculture for women and young people?”. The reason was that this would better reflect on what could be achievable during the project phase.

[4] *ACIAR Mini-project MS0604: experimental stocking and community management of tilapia in Lake Satoleapai, Samoa*

4 Objectives

The **overall aim** of this project is to develop profitable aquaculture systems which result in improved nutrition and livelihoods for people in marginalised peri-urban or remote rural communities in Fiji, Kiribati, Samoa and Vanuatu.

The **immediate objective** is to address capacity constraints or knowledge gaps related to scaling up aquaculture sectors and the factors relating to greater uptake among communities. Mutually beneficial linkages between aquaculture and CBFM are of particular interest.

The Scoping exercise showed there are different distributions of aquaculture environments, species, and constraints between the four countries. At the same time there were some strong commonalities, particularly between Fiji, Samoa and Vanuatu.

The key species of focus in the four countries were freshwater tilapia fish (*Oreochromis niloticus*) and freshwater prawn (*Macrobrachium rosenbergii*) culture in Fiji and Vanuatu, tilapia (*O. niloticus*) culture in Samoa and sea cucumber (*Holothuria scabra*) (sandfish) culture in Kiribati.

Specific objectives related to the project aims were:

Objective 1: Address technical and capacity constraints in community aquaculture through interventions in four countries. The emphasis was on strengthening capacity of lead farmers in producing own fingerlings, strengthening capacity of government run hatcheries to produce seed supply as well as addressing issues around feed.

Objective 2: Apply and evaluate community-based approaches to strengthen community impacts of small-scale aquaculture. The emphasis was on develop a mechanism of an aquaculture farm cluster approach and organising farms into clusters as an avenue for an enhanced collaboration among farms and develop economies of scale. Among farm clusters, lead farmers were identified who were then provided with trainings where they then provide support to farms within their cluster.

Objective 3: Ascertain the impacts that community aquaculture can have on household income, fish consumption, and the status of women and children in these four countries. The focus was on through the application of case study methodology across the project countries to determine the level of participation, engagement and gender responsiveness in aquaculture activities, income and fish consumption.

Objective 4: Integrate community sea cucumber aquaculture with coastal fisheries management to strengthen CBFM approaches in one country (Kiribati), and review experiences in another country (Fiji). The application of community based sea cucumber aquaculture using hatchery produced seeds was investigated as an incentive to introduce community based inshore fisheries management to protect grow-out areas but also the use of protected areas and rotational closures to benefit other marine resources

5 Methodology

The Project Commissioned Agency (SPC) selected 4 countries, Fiji, Kiribati, Samoa and Vanuatu on the basis that they were ACIAR countries and did not have an ACIAR project operating at the time. It was an important consideration that the selected countries had to have a track record of previous implemented ACIAR projects which experiences and lessons learned could be drawn from. Choice of species was based on experiences from past ACIAR projects either from the selected countries or from the Pacific region that could be drawn into this project. Based on this understanding, the project undertook a scoping mission to consult with each of the proposed project countries on the project.

During the scoping mission, institutional and country priorities identified based on the followings:

- species that the countries were working on,
- what the objectives of farming those species were whether food security or livelihood,
- what the constraints were
- what strategies were in place nationally to address those constraints, and
- what partners are involved in the countries working in aquaculture

The challenges faced during the scoping mission was prioritising the national priorities. Countries identified between 3 to 4 aquaculture species as priorities. During the scoping mission, the project team assisted the countries to focus on selecting between 1 to 2 species as their top priority species that the proposed project could focus on. This so the project team could identify common areas of constraints, common species of interest and existing expertise that may already be available in country for the project to build on. Based on these priorities, it was agreed that the project focused on the following priority species in each of the countries:

- Tilapia and freshwater prawn culture in Fiji;
- Tilapia and freshwater prawn culture in Vanuatu;
- Tilapia culture in Samoa; and
- Sea cucumber (sandfish) culture in Kiribati.

The project focused on the following key constraints as the basis to undertake work in the four countries for each of the species that were selected. These included addressing technical and capacity constraints in the four countries, strengthening community impacts from aquaculture, assessing how community impacts would be ascertained and finally how best to integrate aquaculture to strengthen a community based fisheries management approach.

To begin work in the selected countries, an inception workshop was undertaken at the start of the project to map out activities on the ground, set timelines for the activities, identify who the key resource persons on the ground would be and if there has been any changes in priorities, which the project may needed to be aware of.

Addressing Technical Constraints

In addressing technical and capacity constraints tilapia, freshwater prawns and sea cucumber (sandfish) in all project countries:

For tilapia:

- 4 lead farmers were identified in Fiji, Samoa and Vanuatu where they received training from the project on tilapia fingerling production through an hapa based (nets in the earthen ponds) method in producing tilapia fingerlings.

- To strengthen hatchery production, Fiji Fisheries staff were provided with refresher training in 2015. Selected national Fisheries staff were nominated by their governments to attend a training on producing mono-sex tilapia (male only tilapia production) techniques at the Asian Institute of Technology and on returning established systems at their national hatcheries for producing male only tilapia as a way to improve production.

- Vanuatu had to receive additional support in rebuilding its national hatchery facility due to damages incurred from tropical cyclone Pam in 2015. This was funded by a separate ACIAR activity.

- An assessment of tilapia broodstock was conducted for both Fiji and Vanuatu by Queensland University of Technology through country visits to determine whether or not new tilapia broodstock would be required. For Vanuatu, there was an interest in re-introducing new stock from Asia simply because the current broodstock was not performing well anymore with smaller sized tilapia produced at market size. The re-introduction could not proceed due to a tilapia lake virus outbreak in Asia causing a suspension of any re-introductions in the region. The project ended and this activity could not proceed.

- An on farm feed trial to compare local feed versus commercial feed was carried out in Fiji at the Naduruloulou Research Station by James Cook University of Australia. Fiji had the facility to undertake comparable feed studies. The outcome of the project mid-review recommended for feed work to be reduced hence there was no comparable studies undertaken in Samoa and Vanuatu. Instead farms in Samoa and Vanuatu were provided with experiences in use of formulated feed against use of their on farm feeds where the feed were imported from Fiji and trialled in the two countries. Results demonstrated tilapia grow faster when fed with formulated feed.

- Consumer awareness activity was undertaken in Samoa on farmed tilapia through two cookery competitions conducted as part of a national agriculture trade shows. This proved successful in raising public awareness on adoption of tilapia as a food fish, where local chefs displayed their cookery arts through using farmed tilapia produced from this project to come up with tilapia dishes. A panel of judges made decision on the best dish produced and prices were given as part of the project.

- Where water shortage is an issue, Samoa tested cage farming trials in lake Satoalepai in Savaii Island with simple floating cages constructed out of locally sourced materials and stocked with tilapia fingerling produced from National Government Hatchery. Proving its success, a second farm was established with cages constructed, deployed and stocked with tilapia fingerlings.

For sandfish culture:

- A major emphasis on hatchery propagation of sandfish was undertaken. National Fisheries staff involved in the project participated in the hatchery training on breeding, larval rearing and on land-based nursery culture. Five in-

house trainings were provided over 3 years including one overseas training Philippines where two national project staff attended.

- Prior to hatchery propagation of sandfish, some improvements in the hatchery by way of purchasing hatchery equipment and materials were undertaken.

- Sites were surveyed to identify best possible release sites. Sites in North Tarawa and in Abaiang Islands were found to be suitable. In addition, unused milkfish earthen ponds were also assessed to determine their potential usage.

For freshwater prawns

- In both Fiji and Vanuatu refresher trainings were provided to national Fisheries hatchery staff in both countries on aspects of prawn hatchery and nursery techniques to improve production, growth and survival of prawn post larvae.
- In Fiji, a green culture technique was used to test against a clear water as a means to compare the effectiveness of both methods in order to improve growth and survival of prawn post larvae.
- In Vanuatu, prawn post larval production was affected by cyclone Pam in 2015 which forced the Department of Fisheries to relocate to establish a new marine hatchery in Santo Islands.

Strengthening Community impacts

In addressing how community impacts are strengthened, the project focused on identifying tilapia fish farmers in Fiji, Vanuatu and Samoa that could be organised to form clusters in order to increase economies of scale and to collaborate in the exchange of knowledge. A lead farmer was then identified for each farm cluster. The lead farmers then received on farm trainings during the course of the project where they then provide support to their cluster of farmers.

In evaluating and determining a farm cluster potential, at the initial stage, an evaluation of the village community tilapia farm was carried out for inclusion in the project through a Participatory Action Research PAR methodology. A meeting with the community tilapia farm committee was held attended by project staff, the national Fisheries Officer responsible for the particular community or province and the farm committee members. During the meeting, the project team developed a profile of the farm which included information such as:

- Name of community farm
- Type of organisation: what type of village community project is it
- Leadership level in the farm
- Vision/goal of the farm
- Level of production in the farm
- Market: if the farm is selling life fish, whole, gilled and gutted etc.
- What the feed costs are and the type of feed used
- Constraints faced in the farm
- Project team and National Fisheries Officers then developed a benchmark and gab analysis of the farm. During the bench marking process, the project team assessed factors such as fish fingerling availability for pond restocking, fish fingerling survival post stocking, water and feed. Issues identified from the Gap analysis were then prioritised in order for what the project should be assisting on.

Assessment of farms that could be identified as lead farms was carried out by determining the followings:

- Capacity of the farm for growth in production and income
- If there is an opportunity for more investment in the farm such as whether additional ponds could be constructed through the farm's own initiative
- Whether there is opportunity for more employment
- Whether there is a critical mass of skills and resources.
- If there is a strong interest in collaborating on key issues such as supply of fingerlings bred from the farm to other farms within the area, sharing of technical knowledge and experiences.

Assessment of all fish farms that would comprise a tilapia fish cluster on the basis of:

- Resources: those farms in this area have resources such as land, water, seed, feed and some experiences in tilapia farming know-hows that exists.
- Growth potential: existing farms can improve their size and production efficiency, and new farms can be established.
- Farms demonstrate a willingness to cooperate as part of a cluster.

Next step was to hold another meeting with the tilapia farmers to

- Inform them of the results of the Benchmarking and Gap Analysis and to obtain any follow up information needed
- Discuss options to improve fish production, and ask them to select those that match their aspirations for the farm.
- Agree on the specific actions to be done next, to meet their aspirations.

Based on the approaches described above, there were four lead farmers selected in Fiji, three in Ra in Western Division of Viti Levu Island and the fourth being the Montfort Boys Town Vocational School run by the Catholic Church in Suva area. From the four lead farmers selected, one was a female. In Samoa, two lead farmers and two farm clusters were established.

Ascertain community impacts

The purpose was to get an understanding on the benefits from aquaculture and how this they are shared within households and communities across the four countries that were involved in the project. The approach was through the collection of case studies across countries to explore impacts of community aquaculture. Focus was also in conducting gender analysis of aquaculture production processes and how benefits used.

However, there were some changes made in the activities under this objective from the original project document during the mid-project review.

- the application of socio-economic surveys and household questionnaires to determine sources of income and fish consumption, and income or fish consumption benefits attributable to engagement in aquaculture within communities at the start and at the end of the project.
- Gender and age analysis to uncover any equity issues and identify opportunities to increase positive or reduce negative social impacts of aquaculture.

Gender assessment work was completed for two countries, Fiji and Samoa with the support of SPC Social Development Programme. A questionnaire was designed to guide key informant interviews. The methodology which was through an interview and assessment process involved the followings:

- Gender roles: what women do and what men do.
- Decision making: how money is spent or saved or used; whose idea is to farm tilapia; how decisions are made, re: farm/family
- Access and control over resources: land, if it is owned or leased and who owns the land; equipment if they are owned or borrowed; what the household good are.
- Access to training and knowledge: who has training; who has other knowledge
- Other issues

Integrate aquaculture and CBFM

In addressing how aquaculture and community based fisheries management could be integrated, the focus was on using sea cucumber sandfish in this case. The following key activities were considered:

- Four communities for integrated sea cucumber aquaculture and CBFM approaches were identified
- Baseline site assessment and monitoring undertaken
- A strategy for utilising sea cucumber aquaculture to strengthen community based fisheries management approach was developed.

The approach to this work were as follows: five communities were selected for sea cucumber sandfish trial and from this two (Buariki and Tabonibara) were chosen to integrated sandfish sea ranching trial with a CBFM approach, on the basis that they were part of an ACIAR Community based Fisheries Management Project that was operating at the time.

6 Achievements against activities and outputs/milestones

Objective 1: To address technical and capacity in community aquaculture through interventions in the four countries.

Fiji - Tilapia

no.	Activity	outputs/ milestones	completion date	Comments
1.1	Identify and encourage "lead farmers" to produce their own fingerlings and sell their surplus to others.	4 lead farmers identified and engaged in fingerling production.	2017/ Feb 2018	4 lead farmers have been identified: 3 in Ra (Joeli Tarovia, Ms Laisana, Nausori Koro community farm) and 1 near Suva (Montfort Boys Town – MBT). All lead farmers are producing own fry through the hapa method (net based system) for pond stocking and are selling surplus to other farmers. All lead farmers indicated that they are happy with using self-produced fingerlings than waiting for Fiji Fisheries, as supply from Fisheries is uncertain due to constraints and total national demand. Producing their own fingerlings enables them to better plan their production, and to expand their farms.
1.2	Promotion of and training in hatchery and nursery techniques (including mono-sex culture) to improve growth and survival of fingerlings in ponds.	Simple guidelines developed for fingerling husbandry under local conditions and 4 lead farmers trained in their application. Refresher training for national/provincial hatchery staff in techniques to improve growth and survival of tilapia at all stages.	2015-2017	Simple guidelines for hapa breeding method were developed. Refresher training has been ongoing for farmers and fisheries officers. Farmer training was conducted in 2015 by SPC in collaboration with Fiji Fisheries in Ra Province and in Central Viti Levu Island. One of the trainings was combined with an FAO-commissioned tilapia training in post- disaster resilience for pond aquaculture after tropical cyclone Winston in 2016. A training in tilapia broodstock management was provided by trainers from the Asian Institute of Technology (AIT) at Naduruloulou Research Station (NRS) in Fiji in February 2017. This was attended by 19 government officers and 4 tilapia farmers.

1.3	Assess broodstock management processes and develop broodstock management plans.	Broodstock Management Plans formulated that separate broodstock maintenance functions from production hatchery functions.	2015-2016	Assessment of tilapia broodstock was carried out in Fiji by Queensland University of Technology (QUT) of Australia between 2015 and 2016, and a report was produced. However, the assessment omits specific recommendations in relation to 'whether introduction of new Nile tilapia broodstock to Fiji is necessary and, if so, then identify a suitable tilapia brood stock variety and source'. This work to assess tilapia broodstock in Fiji was further augmented by leveraging additional funds for a workshop in 2016 to develop broodstock management plans (funded from an European Union (EU) funded Integrated Agriculture Commodity and Trade (IACT) Addendum project and commission a genetic study of Fiji Fisheries tilapia broodstock (funded by NZ Pacific Sustainable Aquaculture Development project).
1.4	On-farm trials of "best-bet" formulation using local ingredients, to compare with local and imported commercial feeds If viable, train farmers in on-farm feed making.	Farmers informed about the real cost of different feed sources for farmed tilapia.	2015	On farm feeding trials have been conducted at Fisheries Research Station (NRS) Fiji, and growth rates, yields and cost of production estimated. Research results showed that manufactured feed is better than locally made feed including on-farm feed. SPC internal report is available.
1.5	Build upon and extend the pilot project conducted under ACIAR PARDI to evaluate other local marketing opportunities for tilapia, find out more about the position of tilapia in the market c.f. alternatives, and find out the best product forms Investigate additional locations for live sales of tilapia.	More marketing options identified to farmers, to help them avoid gluts or delays in harvesting ponds.	Completed in August 2018	University of the South Pacific (USP) Institute of Marine Resources (IMR) undertook this study in collaboration with Montfort Boys Town (MBT) farm harvest in August 2018. Some broodstock fish at MBT were put aside for grow-out to larger sizes for this trial. TORs have been provided by SPC.

Fiji - Prawn

no.	Activity	outputs/ milestones	completion date	Comments
1.6	Promotion of, and training in hatchery and nursery techniques to improve growth and survival of PL in ponds.	Refresher training for national hatchery staff and side-by-side comparison of new/old techniques to improve growth and survival. Recommendations made to improve techniques in order to improve growth and survival of PL in ponds.	2018	Refresher training was conducted by SPC in-house staff. National Fisheries officers from all over Fiji were trained at the government national Galoa Mariculture Hatchery Facility on aspects of prawn hatchery and nursery techniques. The refresher training led to some significant changes in hatchery practice adopted by national staff, particularly in areas of water usage, tank hygiene and filtration, and daily observation of larvae to ascertain their on-going health and nutrition status. Green culture was demonstrated to improve growth and survival of PLs. Adoption of green-water technique eliminated need for daily water changes in LRTs, reducing hatchery seawater pumping and filtration requirements to about 1/7 of former levels.

Vanuatu - Tilapia

no.	Activity	outputs/ milestones	completion date	Comments

1.8	Increase capacity of national government to produce fingerlings Identify and encourage “lead farmers” to produce their own fingerlings and sell their surplus.	National government engaged in tilapia fry production Two lead farmers identified and engaged in production.	2016-2018	Both National Freshwater Master Hatchery at Tagabe (Efate Is) and freshwater hatchery in Luganville, Santo Is damaged during tropical cylone Pam in 2015, utilised the support from this project as well as a separate ACIAR post cyclone Pam recovery support to be re-established and now producing tilapia fingerlings for distribution to the farmers. Two lead farmers were identified in Santo and producing tilapia fingerling. Tropical Cyclone Pam, followed by major drought (an El Nino year) the following year led to a lengthy disengagement and loss of morale by many tilapia farmers in Vanuatu. This also attracted additional direct financial support from other partner agencies such as German Development Bank (KFW) to aquaculture in Vanuatu. This project responded by shifting the focus of our project work to emphasize generic assistance, such as to improve seed infrastructure/operations and to make feed more readily available, with less of direct engagement with individual farmers. Government of Vanuatu has built on from this project in providing financial support to the upscaling of inland aquaculture infrastructure in Port Vila.

1.9	Promotion of, and training in, hatchery and nursery techniques to improve growth and survival of fingerlings in ponds.	Simple guidelines were developed for fingerling husbandry under local conditions and 4 lead farmers trained in their application. Refresher training for institutional hatchery staff in techniques to improve growth and survival. Simple protocols for tilapia grow-out imparted to participating farmers via field days, demonstrations, and knowledge exchange. Research outcomes from project activities incorporated into accredited aquaculture training modules at Vanuatu Agriculture College.	2016-2017	Knowledge product for hapa-based mixed-sex tilapia fry production has been developed. Lead farmers not trained in Vanuatu, due to disruptions caused by TC Pam and 2017 El Nino drought. Government hatchery staff trained on the job by senior Vanuatu Fisheries (VF) project counterparts sponsored to be trained at AIT Thailand. Farm visits made by SPC project staff and VF counterparts in Efate and Santo Islands were opportunities to explain and demonstrate best practices in husbandry and pond management. Farm designs and layouts, and pond sizes, were changed by some farmers as a result of these knowledge exchanges. The result has been a standardisation and codification of farm pond design and size in government policy, as minimum standards to qualify for advanced-farmer status/assistance and be registered as a commercial tilapia farmer. Change in principal of Vanuatu Agriculture College (VAC) led to down-turn of interest and engagement in tilapia farming by the College. Overall, outcomes limited due to the constraints listed.
1.10	Assess broodstock management processes and develop broodstock management plans. Re-introduce Nile tilapia for broodstock and develop capacity for broodstock management.	Broodstock Management Plans formulated and implemented for national master hatchery at Tagape, and for provincial hatchery in Santo.	April 2015	Assessment of tilapia broodstock was carried out in Vanuatu by QUT with a report submitted. However, the assessment omits specific recommendations in relation to ‘whether introduction of new Nile tilapia broodstock to Vanuatu is necessary and, if so, then identify a suitable tilapia broodstock variety and source’. Vanuatu Fisheries requested to SPC for assistance with a planned re-introductions of Nile tilapia broodstock to be imported from WorldFish Centre in Malaysia. With an outbreak of a tilapia lake virus disease this activity was suspended as a precautionary approach.

1.11	Provide farmers with experience in formulated feed and compare with on-farm feed experiences	Formulations, guidelines and evaluations about feed sources made available to farmers.	2015-2018 Oct 2018	Project sponsored importation of a 20 foot container load of commercial feed for farmers to gain experiences on performance of commercial diet. The feeds were distributed to farmers. Feed machines have also been ordered and have arrived in Vanuatu. They would be used once project is completed to prepare on farm feeds for farmers.

Vanuatu - Prawn

no.	**Activity**	**outputs/ milestones**	**completion date**	**Comments**
1.12	Replenish broodstock following TC Pam and relocate to cyclone resilient ponds. Up-scaling of PL hatchery production on Efate Island from pilot phase to commercial phase. Promotion of, and training in, hatchery and nursery techniques to improve growth and survival of PL in ponds.	National hatchery PL output consistently at a level to support a cluster of prawn grow-out farmers on Efate Island. Hatchery production and Broodstock Management Plan formulated and implemented. Hatchery staff trained, and improved methods adopted.	2016-2017	Prawn hatchery production has been moved to Santo Fisheries Department. Santo hatchery is now producing PLs to support the farmers. Re-location of hatchery to Tagape has been achieved by VF counterparts. Santo freshwater tilapia hatchery has been upgraded with a seawater intake system and has been producing freshwater prawn PL for commercial farmers. National hatchery staff have gained the necessary skills and capacity and are able to produce prawn PL locally.
1.13	Identify prospective farmers on Efate for training and induction into the prawn aquaculture industry.	Subject to outcome of pilot-scale production and cost-benefit analysis, 4 farmers identified and trained in prawn pond construction, then mentored into adoption of prawn pond management techniques.	Feb 2018	Farmers identified: 3 farms at Mangaliliu village on Efate Is). Pond liner defects now being addressed, for upgrade of their farm facilities to hold water properly. Use of pellet feed, and post-harvest, mentored by VF project counterparts.

Samoa - Tilapia

no.	Activity	outputs/ milestones	completion date	Comments
1.15	Identify and encourage “lead farmers” to produce their own fingerlings and sell their surplus Promotion of, and training in, hatchery and nursery techniques to improve growth and survival of fingerlings in ponds.	At least 1 lead farmer identified and engaged in fingerling production. National hatchery staff trained and techniques adopted to improve growth and survival of tilapia fingerlings (including mono-sex culture).	April 2018	A small-scale tilapia incubator system has been set up at Samoa National Fisheries hatchery and they are currently meeting national demands for tilapia fingerling. Production is about 5,000 fingerlings every 6 months (2 cycles per annum). Lead farmer (Lau Papese) developed at Lotofagaa -Safata with ongoing support from Samoa Fisheries. Producing fish for sale to Apia markets and fingerlings which are supplied to other farmers. ‘Demonstration farm’ for tilapia breeding and nursing, locally-made feed.
1.16	Assess broodstock management processes and develop broodstock management plans.	Broodstock Management Plans formulated that separate broodstock maintenance functions from production hatchery functions.	December 2016	Broodstock Management Plan for Samoa not yet formulated Based on the results of the JCU genetic assessment (see activity 1.3), SPC assumed that Samoan tilapia broodstock (originating from Fiji) are still performing well.
1.17	Provide farmers with experience in formulated feed and compare with on-farm feed experiences.	Farmers able to make informed choices about different feed sources for farmed tilapia in Samoa.	March 2018	Training of other farmers has resulted in increased demand for farm-made feed. Another mincer machine is to be purchased for use on the northern side of Upolu. Demand for imported commercial pellet feed appears to be strong, but should be quantified. Pellet feed from Fiji has been distributed to farmers nationwide for one-off trial, and followed up by Farmers Feed Perceptions Survey to ascertain demand. Outcome of one-off trial and survey was used to inform negotiations with potential formulated-feed importers and distributors. Formulated pellet fed is now available in Samoa through Samoa Agriculture Stores Ltd. Tuna-waste mincer machine imported from Thailand, and local source of fresh tuna frames identified. Training has been conducted in making local feed, and an on-farm trial is underway to compare this feed with normal plantation feeds and with formulated feed from Fiji.

1.18	Raise consumer awareness about tilapia.	Increased awareness about tilapia among consumers through community events (e.g. cookery competitions).	2015-2017	Three cooking competitions have been conducted through the project by Samoa Fisheries to promote tilapia in Samoa. Trial of Thailand-style live-fish selling using flat trays (to reduce water requirements and fish handling damage) was tested in Samoa for the first time, at 2017 Agriculture show in Apia. The competitions have attracted more participation from the Samoa community and cooking standards have improved every year.
1.19	Provide farmers with experience of cage-culture techniques in brackish- or fresh-water creeks, lakes or pools.	Demonstration sites established to promote the uptake of cage culture as a new production technique.	2016-April 2018	Cage culture farming has been successfully demonstrated in Satoalepai Lake in Savaii. Two cages were installed with 1,000 tilapia each were kept and fed for 8 months until harvest. Survival was 80%. This activity was driven and managed by the Satoalepai community. Second stocking of about 300 fish per cage in September 2017. Growth of the fish is good. TP feels that the feeding of the second batch has improved. The village community is very positive about the outcomes and several 7 families have established their own cages with the project assistance. The cages are family owned, but overall coordination between families, and site security, will be managed by the village committee.

Kiribati – Sea cucumber

no.	**Activity**	**outputs/ milestones**	**completion date**	**Comments**
1.21	Survey to identify possible release sites.	Research results to inform future sandfish stocking efforts in Kiribati.		Three out of five farming trial sites were proven to be appropriate for farming and sea ranching. Characteristics of suitable sites (sea grass cover, sediment, depth) are similar to those observed in PNG. Much work has also gone into developing suitable techniques for the deployment of juveniles into the field, pen construction to keep sandfish contained during assessment of growth and survival. Technical recommendations (objective 4.1) have been in part formulated from this practical experience. Growth and survival of sandfish has been successful in some areas of Abaiang and North Tarawa.

1.22	Provide training and make hatchery upgrades to implement protocols appropriate for sandfish.	Hatchery operational. Regular supply of sandfish seed.	2016-2018 2018 2016 April 2018.	Five training programmes held over 3 years both in-house (x3) and overseas (SEAFDEC, Philippines + Fiji, New Caledonia). Regional hatchery manager and technician network. Hatchery is operational and appropriate protocols are implemented for sandfish production but require proper planning to achieve regular production/supply of sandfish seed. Staff are well trained in hatchery and grow-out techniques. A simple manual for effective hatchery techniques in Kiribati has been produced as a reference for hatchery staff. Factsheets for hatchery and grow-out aimed at potential private investors published. Hatchery targets needed to be prioritised given that the Fisheries hatchery is a multi-species hatchery. Resources (e.g. human, including rearing tanks and a boat) are often used for other cultured species such as giant clams and cage farming of milkfish. There is only 1 fisheries boat that is now being used solely for milkfish. Technical issues largely solved but there remain issues with staff turnover, etc.

Objective 2: To apply and evaluate community based approaches to strengthen community impacts of small scale aquaculture.

Tilapia – Fiji, Vanuatu and Samoa

no.	Activity	outputs/ milestones	completion date	Comments

2.1	Identify potential clusters of fish farmers that can be motivated, via commonality of social ties or economic advantage, to collaborate for exchange of knowledge or economies of scale.	Clusters identified and cluster scoping and gap analysis undertaken (disaggregated by gender) Facilitation and mentoring of at least 3 farm "clusters", and strengthen their ability to produce tilapia fingerlings locally for distribution to members as well as collaboration on feed procurement (farmer participation disaggregated by gender).	March 2018 May 2018 April 2018	All 3 farmers in the Ra, Fiji cluster have been identified but now chosen as lead farmers given remoteness and distance from Nausori Koro lead farmer. One of the lead farmers in Ra is a single mother. All 3 farmers are producing their own tilapia fry. They also are trading fingerlings/knowledge between each other and with other farmers in surrounding districts. An educational institution, Monfort Boys Town has been selected to be a central division lead farmer that will train their own cadets in fish farming practices and act as a hub for distribution of surplus fish fingerlings to other farmers in the district. Many MBT cadets, originating from rural areas, are now proficient in fingerling rearing and fish management methods. Somef the cadets are interested to establish household ponds after graduation. In Samoa, 1 lead farmer is now producing fries for pond stocking and to sell surplus to other farmers. Also in Samoa, a community cage-culture farm is now expanding into a cluster of up to 7 household-based farms. Samoa Aquaculture Farmers Association – holds regular meetings – exchange of information between farmers, and between Samoa Fisheries and farmers.
2.2	Up-skill "lead" farmers, and hold field days at their farms for demonstration, on-site training, and dissemination of best aquaculture practices to other farmers Upgrade lead farms so they are at a standard to demonstrate best practice.	Improved growth and survival of fish, and (where appropriate) adoption of more intensive farm methods		Field days nave been conducted in Fiji and most of the lead farmers have attended on-site visits, training and sharing of knowledge and experiences with other farmers. Recommended pond improvements in accordance with BAP have been adopted by farmers, and essential items of small equipment to adopt BAP have been provided. Big productivity gains of more than 100 or 200% have been achieved by relatively simple improvements. Farmers in Samoa produce fry and sell to other farmers. Tuna waste mincing machine at Lotofagaa used by other farmers to produce feed. This site is also used for farmer field days to generate interest. SPC is evaluating productivity and profitability improvements using the economic models developed by Bill Johnston.

PC = partner country, A = Australia

Objective 3: To ascertain impacts that community aquaculture can have on household income, fish consumption, and the status of women and children in these four countries

no.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Collect case studies across the four countries to explore the impacts of community aquaculture.	Series of in-depth case studies detailing profit reinvestment, sharing of benefits, participation, engagement and decision-making processes (gender and age disaggregated). Report on impacts on aquaculture on communities in terms of income, fish consumption, gender and age group.	Nov 2017	A case study has been carried out in Fiji incorporating gender and youth aspects. The study was conducted by SPC's Social Development Program (SDP) together with the Aquaculture team. Narrative logs have been compiled for each tilapia farm cluster and lead farmer in Fiji Vanuatu and Samoa, to benchmark the farms, document the project interventions and lessons learned, and ascertain their impact assessed by a range of indicators. Gender assessment reports (draft) for Fiji and Samoa were provided. There were 10 individual case studies conducted for Fiji, and 5 individual case studies conducted for Samoa. Narrative log files for each farm cluster were provided. A draft paper on 'Review of the status and impact of aquaculture for food security in Oceania' is in preparation. SPC SDP has submitted an abstract to the 7th Global Conference on Gender in Aquaculture and Fisheries.
3.2	Conduct gender analysis of aquaculture production processes and how benefits are used.	Identification of factors to support equitable shared benefits within households and communities. Policy brief and guidelines developed on integrating gender perspective in.		Similar gender analysis work originally planned for Vanuatu and Kiribati could not be undertaken due to lack of time. Capacity built amongst Fiji Fisheries Extension staff through gender training in 2015. Two staff involved in this training assisted with the case study research as co-researchers along with Women in Fisheries Network Fiji and SPC. A six month follow up to the training demonstrated change in practice. A gender toolkit is being developed for a broader fisheries program, which used case study information from Fiji and Samoa collected through this project, in place of the policy brief.

PC = partner country, A = Australia

Objective 4: To integrate community sea cucumber aquaculture with coastal fisheries management to strengthen CBFM approaches in one country (Kiribati) and review experiences in another country (Fiji).

no.	Activity	outputs/ milestones	completion date	comments
4.1	Identify four communities for integrated sea cucumber aquaculture and CBFM approaches. Undertake initial baseline site assessment, ongoing monitoring, and follow up ecosystem impact assessment survey following the initial introduction of sandfish. Undertake community engagement to prepare an integrated community sea cucumber aquaculture and CBFM approach. Facilitate the implementation and support community based management of sandfish farming and inshore fisheries management.	Technical recommendations developed based on experiences in sea cucumber in other countries. Ponds trialled to investigate the performance of grow out options (with JCU involvement). Ecological impacts monitored and assessed. Strategies developed for aquaculture to strengthen CBFM through community engagement approach. Community based monitoring of sandfish growth, environmental impact and CBFM implemented. Community integrates management of aquaculture and inshore fisheries.	2015	Technical recommendations were developed with the knowledge and experiences acquired through the project and from exchange with similar projects in PNG, Philippines, Vietnam, New Caledonia and Madagascar. 5 communities were chosen for trial sandfish farming and 2 have been chosen to integrate sandfish sea ranching trials with CBFM. Initial pond trials were not successful due to predation by crabs and the low salinity in the ponds due to the state of poor maintenance of the ponds which caused insufficient flow of seawater. Most of the sandfish were found dead after a week in ponds. JCU was not involved as Mr Duy was not available at the time of the trial. Buariki and Tabonibara have agreed to incorporate sandfish aquaculture as part of managing their inshore fisheries.
4.2	Identify strategies for utilising aquaculture to strengthen CBFM approaches utilising experiences in Kiribati and Fiji.	Strategies / guidelines developed for aquaculture to strengthen CBFM .	Not yet completed.	Still liaising with CBFM (Kiribati) project officers on how we can incorporate these strategies into Management Plans that are in place. A draft strategy was produced on: "Sandfish (*Holothuria scabra*) aquaculture to support alternative livelihood in Kiribati" (draft document) and this has yet to be finalised though the project has ended.

PC = partner country, A = Australia

7 Key results and discussion

Technical and capacity constraints

Fiji – Tilapia

In Fiji for tilapia, there is an improvement in the supply of tilapia fingerlings where lead farmers who were identified and trained were able to produce own fingerlings from their farm through a simple pond production using a net based hapa breeding method. All four lead farmers proposed in the project were identified, trained and engaged in the tilapia fingerling production. With the production of their own fries, farmers have been able to produce fish on a more consistent basis to stock their ponds after each harvest. This achievement have also assisted Fiji Fisheries in reducing the number of farmers relying on tilapia fries from their hatcheries. Hence, there was an improved supply of tilapia fingerlings which farmers were accessed to, a reduced effort on reliance of fingerling supply from national government hatchery. There was also an additional income gained by farmers from sale of tilapia fingerlings. For instance, in the Ra Cluster, lead farmers were able to gain additional income by selling excess fingerling supply to farmers within their area for the first time using this on farm breeding method. At Montfort Boys Town (MBT), the school is producing own fries and are now able to stock their ponds. They are also selling some of their fries and broodstock to other farmers. MBT have harvested their first batch of fish this year. Students engaged in the project are trained on the farm and are now competent in fish farming. Most of these boys are originally from the rural areas. On-farm record keeping demonstrated to be a good farm management practice because of such interventions. One of the farmers in Ra is a single mother who indicated that record-keeping using SPC Tilapia farming log book has enabled them to secure loans/financial support from development banks, and government grants.

The application of new hatchery and nursery techniques such as tilapia incubation system have also contributed to the resulting in a reliable supply of quality fingerling production to farmers with such systems being setup at the government broodstock master hatchery at the Naduruloulou Freshwater Aquaculture Research Station (NRS).

Training was an important component for Fiji. Farmers and national Fisheries Officers participated in a range of trainings delivered by the project from 2015 to 2017, both within Fiji and overseas where selected farmers attended trainings at the Asian Institution of Technology (AIT) of Thailand. In February 2017, the project had also sourced external trainers from the AIT to travel to Fiji and delivered trainings at the NRS to government officers and farmers.

On the assessment of tilapia broodstock to determine the genetic quality of current tilapia broodstock at the NRS, the assessment was conducted by the Queensland University of Technology (QUT)[5] which is a collaborating partner in this project. The study recommended for a dedicated national tilapia broodstock facility and that NRS is considered to be feasible and can meet the expected industry seed demand but the facility needs to be expanded to play and effective role in broodstock management and seed production. However the study did not say whether introduction of new Nile tilapia broodstock to Fiji is necessary and, if so then identify a suitable tilapia broodstock variety and source. In 2017, a genetic study, entitled "Genetic audit of the GIFT Nile tilapia breeding nucleus at the Naduruloulou Research Station, Fiji Islands" was commissioned by SPC through a New Zealand funded Pacific Sustainable

[5] *Nandlal S, Mather P and Hurwood D. 2015. Tilapia broodstock management practices (and seed production) for small-scale aquaculture in Fiji. Report to the Secretariat of the Pacific Community. Prepared by Queensland University of Technology (Unpublished).*

Aquaculture Development Project. One of the specific recommendations from the study is that an introduction of an improved GIFT strain is not required at the present[6].

Fiji – Prawns

In addressing insufficient supply of prawn PL to meet farmers' demands, training of national hatchery staff from the government hatcheries of NRS and Galoa Brackishwater hatchery (GBH) to improve the supply of freshwater prawn post larvae (PL) was an important aspect for this work. The applications of clear and green-water culture techniques were used with the latter demonstrated to have improved growth and survival of PLs and eliminated the need for daily water exchange during the hatchery phase.

In addition, a study of the giant freshwater prawn (GFP), *Macrobrachium rosenbergii*, broodstock management practices at the NRS was undertaken by QUT in 2015[7] as part of this project to review the issues affecting broodstock production and seed production. The study included a "refresher" workshop on GFP hatchery techniques in Fiji. Among a number of recommendations provided in the study, some key ones included the need for an effective quality (genetic) management of broodstock, the need for certification of practices to validate seed quality at various levels from broodstock, to production and to point of distribution to other hatcheries.

Vanuatu – Tilapia

The focused for strengthening tilapia fingerling supply to be accessible to farmers has been to provide support to Vanuatu Fisheries Department (VFD) freshwater hatcheries on Efate and Santo. In March 2015, a category 5 tropical cyclone Pam devastated much of the islands in Vanuatu including government infrastructures such as the hatcheries. This led to disengagement and disrupted morale of tilapia farmers in Vanuatu as activities came into a stand still. Additional support was provided by ACIAR[8] under a contract agreement with SPC on post TC Pam rehabilitation that included re-establishment of the two government hatcheries that were destroyed. While rehabilitation work was on-going, government hatchery staff have been receiving refresher trainings as well as selected counterparts nominated to attend a sub-regional training on tilapia hosted by AIT.

In terms of promoting hatchery and nursery techniques to improve growth and survival of tilapia fingerlings in ponds, guidelines were developed for fingerling husbandry and simple protocols for tilapia grow-outs were imparted to participating farmers during field visits. There were plans initially for research outcomes from project activities to be incorporated into accredited aquaculture training modules of the Vanuatu Agriculture College (VAC). Unfortunately, with the change in the management of the VAC, it led to a down turn of interest and engagement in tilapia farming. This has now only recently restored as the project was coming to the end of its term.

In terms of the assessment of tilapia broodstock and determining whether a re-introduction of nile tilapia broodstock was necessary, similar study on nile tilapia stock that was conducted in Fiji by QUT previously was also undertaken in Vanuatu. The study assessed broodstock management practices currently used in Vanuatu, reviewed issues affecting tilapia broodstock production and seed production as well as provided a refresher workshop on tilapia hatchery

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[6] Lal M, Zenger K, Nayfa M, Southgate P, Waqairatu S. 2018. Genetic audit of the GIFT Nile tilapia breeding nucleus at the Nadurulouolou Research Station, Fiji Islands (draft).

[7] Nandlal S, Mather P and Hurwood D. 2015. Giant Freshwater prawn, broodstock management practices (and seed production) for small-scale aquaculture in Fiji. Report to the Secretariat of the Pacific Community. Prepared by Queensland University of Technology (Unpub)

[8] Contract Number C2014/377 Australian Centre for International Agricultural Research – Contract for the Provision of Services for fisheries and cocoa rehabilitation in Vanuatu.

techniques as part of this engagement. The study[9] recommended for the need to establish a dedicated national broodstock centre and proposed that the Tagape Freshwater Aquaculture Centre to provide that role with an effective seed production system in place. The study highlighted that seed supply remains a constant constraint. However, the study did not say whether introduction of new Nile tilapia broodstock to Vanuatu is necessary and, if so then identify a suitable tilapia broodstock variety and source. On 17 May 2017, an official request was received by SPC from Government of Vanuatu requesting technical assistance for facilitation of importation of new strain of tilapia broodstock on the basis that there may be a need for an improved gene of the current tilapia stock. Farmers observed smaller size fish harvested after 4 months of culture and fish raised were not growing to the market size of 250g. On June 27, 2017, the said request was suspended by the Government of Vanuatu following a tilapia lake virus (TiLV)[10] disease outbreak in in Asia.

In terms of tilapia feed given that there were no manufactured commercial fish feed that was available locally, a 20ft container load of commercial fish feed was imported from Fiji to Port Vila. These were distributed to farmers to test and experience formulated feed compared with on farm feed. The latter being kitchen food wastes. The challenges faced being the clearance of feed container from the Wharf in Port Vila, which had appeared to be overly bureaucratic which led to much delay. Additional problem being logistical issues on the distribution of feed bags from Fisheries Department in Port Vila to outer island fish farmers. The impression has been that commercial feed produced a faster growing fish and farmers were able to see the differences in fish growth and performance.

Project Team considered sourcing of commercial feed to be a challenge in future and assessed the various local retail shops and businesses who import goods from countries such as Fiji and who may be able to bring in feeds and sold to farmers. There were interests from locally established shops that were interested in this business. An economic analysis on the different feed options could not be undertaken for Vanuatu when this project came to end.

Two feed machines where purchased for Vanuatu under a separate ACIAR funding activity but the machines took too long to be cleared in the wharf in Port Vila when the consignments arrived. In the end the project ended before any feed formulation trials was possible to compare formulated feed with on-farm feed experiences.

Vanuatu – Prawns

Production of giant freshwater prawn (*M. rosenbergii*) operated out of the main Fisheries Department hatchery in Port Vila. Since after cyclone Pam in 2015 that damaged government infrastructures such as hatchery, Fisheries Department also lost their government site where the marine hatchery and main office was. This made it difficult to produce prawns which requires seawater during its larval phase. As a result, prawn hatchery production was moved to Fisheries Department Sub Centre on Santo Island where the small holding tank for tilapia can allow for access to seawater. A seawater intake system was set up and the Santo hatchery was able to be producing prawn post-larvae. The challenge was deployment of hatchery technical staff who are based in Port Vila to be moved to Santo Island for three to four weeks during the hatchery phase of the prawn production. There were three prawn

[9] *Nandlal S, Mather P and Hurwood D. 2015. Tilapia broodstock management practices (and seed production) for small-scale aquaculture in Vanuatu. Report to the Secretariat of the Pacific Community. Prepared by Queensland University of Technology, 48p (Unpub).*

[10] *Tilapia lake virus (TiLV): What to know and do? 2017. CGIAR Research Program on Fish Agri-food Systems.*

farmers established on Efate Island initially and producing prawns in earthen ponds to market size of 35g in 4 months.

Similar study of the giant freshwater prawn (GFP), *M. rosenbergii*, broodstock management practices at the Vanuatu Fisheries Department hatchery was undertaken by QUT in 2015[11] as part of this project to review the issues affecting broodstock management and seed production. The study included a "refresher" workshop on GFP hatchery techniques in Vanuatu. The study concluded that Vanuatu has developed the hatchery facilities for GFP post larval production but there is a need for additional resources on broodstock management and the need to import new set of broodstock including training to be provided to improve hatchery production.

Samoa – Tilapia

For Samoa, there has been an improved supply of tilapia fingerlings through the adoption of a small-scale tilapia incubator system set up at the Samoa Fisheries hatchery to meet the national demand to meet a national demand of 10,000 fingerlings per annum. In addition, one lead farmer has been provided with training on hatchery seed production and is producing fish for sale to the Apia market and selling fingerlings to other farmers. A lead farmer on Upolu island, Lau Pepese, has increased his farm production by producing his own fries and on farm feed as well as supplying his on farm feed production to other small farmers nearby his village.

In terms of assessment of broodstock quality this was not assessed. Based on the genetic quality assessment that was undertaken for the Fijian stock which was found to be relatively fine, SPC assumed that Samoan tilapia broodstock which originated from Fiji were in much the same condition.

In terms of commercial pellet feed availability, community farmers were provided with commercial feed pellets to trial against on-farm feed experiences. A farmers feed perception survey was conducted and the result demonstrated a difference in terms of faster growth in fish reaching market size in four months as supposed to fish fed with on farm feeds. Formulated commercial feed is now available in Samoa through a local business company, the Agriculture Stores Ltd.

In terms of raising consumer awareness about tilapia as a food fish, three cooking competitions were conducted during the course of the project by Samoa Fisheries to promote tilapia. The competitions attracted participation from communities and cooking standards have improved every year.

In addressing shortage of surface water shortage, two sites using cage culture systems have been established in Lake Satoalepai on the Island of Savaii. One site was constructed initially and following its success a second site was established. Each site had two cages constructed with 1,000 tilapia fingerlings stocked in each cage. Seeing the success, there was interests from farmers to venture into cage culture systems. In Savaii, Satoalepai community for the first time have started producing tilapia fish by cage farming and now have 7 cages for tilapia farming. Some of the challenges foreseen would be security of the cage systems in an open lake. However, the village committee have taken this up to be their responsibility.

Kiribati – Sea cucumber

[11] *Nandlal S, Mather P and Hurwood D. 2015. Giant Freshwater prawn, broodstock management practices (and seed production) for small-scale aquaculture in Vanuatu. Report to the Secretariat of the Pacific Community. Prepared by Queensland University of Technology, 43p (Unpub)*

Kiribati is the only country that has a different focus. The main species trialed under this project is sandfish sea cucumber (*Holothuria scabra*), introduced from Fiji to Kiribati. Surveys of potential sites were undertaken at the start of the project and three out of five sites trialed throughout project proved successful for farming and sea ranching.

Staff from the Kiribati Fisheries Department now have the capacity to produce sea cucumber in the hatchery nationally through the technical expertise they have acquired through this project. Ove three-year period, the project undertook five national in-house hatchery and nursery trainings using the local hatchery facility at the Ministry of Fisheries and facilitated 3 international training for national project staff to SEAFDEC, Fiji and New Caledonia. In addition, manuals and factsheets on hatchery, nursery and grow-out culture of sandfish in Kiribati developed for hatchery technicians and farmers to use. To certain extend hatchery equipment and materials sourced under the project to complement the equipment and facilities to support sandfish culture in Kiribati. The private sector counterpart, the Atoll Beauties of Kiribati who has been involved in the project from the start continued with the sandfish aquaculture work as part of the private sector enterprise development. Atoll Beauties have established their broodstock and producing own hatchery seed production and sandfish became part of a diversification opportunity aside from giant clam aquaculture for Atoll Beauties. Overall, this project proved that introduction of sandfish is possible with the use of appropriate low technology applications through established hatchery and farming (grow-out) techniques.

Apply and evaluate community-based approaches to strengthen community impacts

In Fiji tilapia cluster farmers have been able to demonstrate the practical approach of producing own tilapia fingerling and farmers trading fingerling and exchanged knowledge between each other and their surrounding districts. The Montfort Boys Town school which became involved in the project were able to train their own cadets in fish farming and most of these cadets came from rural areas and were now proficient in fingerling rearing and fish management methods offered through the school with the support of the project.

In Samoa, community cage culture approach has expanded into a cluster of up to 7 household based farms. The Samoa Aquaculture Farmers Association has been active in holding regular meetings with farmers and provided a plate form for exchange of information between Samoa Fisheries and farmers.

To ascertain impacts that community aquaculture can have

The project conducted a comprehensive gender survey in two countries, Fiji and Samoa with technical support for this work provided by the SPC in-house Social Development Program (SDP) through a case study approach. The objective of the study aimed at:

- To understand the division of labour and roles that women and men play in the farming system, with specific emphasis on aquaculture activities;
- To understand the gender issues that may affect equitable benefits for women and men from aquaculture activities;
- To identify entry points for supporting equitable access to natural, economic and social resources and equitable outcomes from aquaculture development for women and men; and
- To make recommendations for effective implementation of a gender mainstreaming approach across the aquaculture programme.

In Fiji, the study focused on community based tilapia aquaculture. The main findings of the study identified the followings:

- In committee run farms (male led), women play a big role in feeding, selling and harvesting of fish but men play a dominant role. Sometimes the roles of men and women are determined by the cane-cutting season. From December to May, men play a major role in tilapia farming which is off-season for cane-cutters.
- In a female headed household, the feeding, cleaning and harvesting of fish was undertaken largely by women or a person hired to undertake certain tasks from time to time. Decision-making was also undertaken by them.
- In a husband and wife managed farms, the role of feeding and cleaning rested with the women while men took the lead role in pond maintenance and harvesting of fish.

The main conclusion of the study for Fiji highlight the following areas, that:

- Women play a major role in aquaculture farming across all the tilapia farm modalities explored but are not often included in training opportunities.
- Aquaculture activities are having impact on the empowerment of women with respect to more decision-making opportunities (outside the household) and are leading in their greater recognition in formal structures within communities.
- Group managed farms – either a women's committee collective or a cluster and large family run farms appear to give women a sense of power, notably as a result of associations of women and the opportunity for a collective voice.
- The impact of natural disasters on the roles and relations between men and women and communities need to be carefully considered whenever rolling out any community based project. Depending on the severity and frequency, natural disasters can affect the everyday roles of men and women and relationships within communities.
- Aquaculture farmers appear to be committee to long term aquaculture farming and appreciate the support and advice of the Ministry of Fisheries and SPC. However, an assessment of active farms and proper record keeping of the involvement of women and men with respect to training and capacity development as well as efficient monitoring, needs to be maintained by the Fiji government to fully recognize the impact of aquaculture in Fiji.

In Samoa, the study had a similar objective as Fiji. Prior to field work, the Samoa National Fisheries counterpart went through a two day training on the methodology and data collection process. This provided the opportunity for officers undertaking this work to review questions that would be asked in the fieldwork and how this would be interpreted in the local Samoan language. The two weeks field assessment on the Islands of Upolu and Savaii ended with a regroup to discuss the findings and followed by a validation workshop a month later. The main findings of the Samoa work included the followings:

- Gender roles are quite clear in the case of Samoa but perhaps more rigid in community settings. Women don't out to fish, that was clear.
- Women play a big role in tilapia farming such as fish feeding, pond cleaning etc. but did not readily identify themselves as the farmer. Men are seen as the face of tilapia farming, meaning they were the ones being engaged in discussion with Ministry of Agriculture and Fisheries on tilapia farming issues as well as attending most of the training.
- For some households, they were less willing to sell their tilapia for income. Farmers often grow their fish and saw them as pets but there appears to be a preference for using farmed fish as contribution to traditional obligations or fish is only harvested when there is a shortage of food in the households.

- Farmers on the island of Savai'i have been able to turn tilapia farming as a business by expanding on their farms, by selling their fish but also sharing it to meet community obligations.
- Tilapia farmed in earthen ponds found to alleviate the pressure on women to always have something ready to cook.

The main recommendation provided for Samoa as a result of this training include the following areas:

- A more structured training on gender analysis and gender mainstreaming to be conducted for national fisheries officers in Samoa.
- The findings of the gender and aquaculture survey are to be shared with the tilapia farmers and communities who participated to provide them with an understanding of the key role of women in aquaculture and how this can continue to be supported
- Fisheries Officers to involve women when conducting training and consultations in communities as well as monitoring visits and to be reported on as part of the regular monitoring activities
- All women involved in aquaculture activities are to be given an opportunity to be trained.
- The involvement of women in aquaculture activities is to be included in monitoring visits conducted by Fisheries Officers and to be reported as part of regular monitoring activities.

Integrate community sea cucumber aquaculture with coastal fisheries management

From five communities selected to pilot sandfish culture work, two were selected and involved in integrating sandfish sea pen culture work as an activity under their community based fisheries management (CBFM) system that was in place. The two communities of North Tarawa, Buariki and Tabonibara had a CBFM plan developed from a parallel ACIAR PacFish 1 Project operating in Kiribati. It is worth highlighting that this involvement happened quite late into the project phase, therefore it was late into assessing the effectiveness of community engagement through sea ranching of sandfish as part of the implementation of CBFM. A draft strategy on sandfish aquaculture to support alternative livelihood for Kiribati was produced but this was not finalised by the time the project came into conclusion.

8 Impacts

Key positive impact that arose from the project are:

- Improved food security from the production and home consumption of farmed fish.
- Income generation from sale of farmed fish, and, in some cases, fingerlings.
- Increased ability for tilapia farmers to plan production and predict income, now that they can produce their own fingerlings.
- Increased sense of self-worth arising from increased self-sufficiency in aquaculture production, and decreased reliance on seed stock supply from Fisheries agencies.
- Farmed fish are provided for community events, enhancing social linkages in villages.
- Disaster resilience was provided by tilapia aquaculture. Farmed tilapia were the only source of food in villages after tropical cyclones cut off food distribution networks.
- Political recognition of the importance of aquaculture in contributing to food security and livelihoods in many of the participating countries, leading to improved political and financial support for aquaculture development.

8.1 Scientific impacts – now and in 5 years

The project has been able to make scientific impacts in terms of practices that have occurred and adopted because of the findings from this project.

In Fiji on tilapia culture, the application of hapa-based technique, with the use of hapa nets placed in earthen ponds, for the production of tilapia fingerling has proven to be successful which reduces the reliance from hatchery based fingerling production at government hatchery such as Naduruloulou National Freshwater Aquaculture Research Station (NRS). This has been a huge setback prior to the project where there was inconsistent and insufficient fingerling supply to meet farmers demands. Prior to the project there were no farmers producing their own tilapia fingerlings. By the end of the project, there were four lead farmers with three in the Ra district of the Western Division of Viti Levu Island and 1 in Suva were able to produce own tilapia fingerlings using this method for their farms while selling excess stock to other farmers in their vicinity.

The application of hatchery based incubator system for tilapia fingerling production tested in this project as a mean to boost tilapia fingerling production to farmers. This technique has proven to be successful and continued to be utilised in Fiji and Samoa. In Samoa, the national fisheries hatchery is able to produce 5,000 tilapia fingerlings in every six months to farmers who needs fingerling supply while lead farmer such as Lau Pepese in Apia are able to produce on tilapia fingerling supply using the hapa-based technique and supplying fingerling to five other farmers near their area.

Tilapia broodstock from both Vanuatu and Fiji continued to be of use for breeding in both countries. Broodstock assessment work conducted in both countries did not recommend whether or not new stocks needed to be replaced. There were other areas that were considered in the study such as producing clear strategies on broodstock management plans and hatchery production plans as well as strengthening hatchery staff skills and capacity in these areas. In addition an outbreak of a tilapia lake virus in Africa and Asia has also discouraged any new introduction of tilapia broodstock from Asia to the Pacific during the course of this project. Broodstocks from Fiji, Vanuatu and Samoa continued to be used and this will be for the next couple of years.

On farm trials of best-bet formulation of tilapia feed using local ingredients by comparing on farm feed with manufactured commercial feed carried out at the NRS for Fiji by comparing growth rates, yields and cost of production. The results showed that manufactured feed performed better with farmers able to harvest their fish in less than 6

months. As a result, farmers are now buying locally produced commercial pelleted feed. Spill of from this result showed that both Samoa and Vanuatu have now been importing commercial feeds from the same Fiji feed supplier for their farmers. In Samoa, formulated feed is now available in Samoa through a private sector (Samoa Agri Store Ltd) that imported directly from Fiji.

On freshwater prawn culture, application of the comparison on performance of green-water versus the clear-water culture technique in a hatchery based system showed that green culture system produced an improved growth and survival of prawn post larvae and eliminated the need for daily water exchange, reduced pumping costs and filtration requirements. The green-water technique approach has a more profound impact on Fiji than in Vanuatu where Fiji national hatchery staff have taken up this approach as part of their hatchery operational activity.

In Kiribati, the sea cucumber culture trial of the species *Holothuria scabra* (sandfish) introduced from Fiji showed that this species adapted well to the local conditions of Kiribati. Of the sites tested, five produced optimum growth and survival and continued to be used for sandfish culture. In Abaiang sites, released stock reached market size of 400-500g in after 17 months, and in North Tarawa sites released stock reached market size of 500-600g in 11 months.

As this species has been established in a similar setting in Asia and other countries (e.g., Vietnam, New Caledonia, and Madagascar), scientific based knowledge used in these countries was applied to the work in Kiribati. The project didn't need to 'reinvent the wheel' therefore based on scientific findings and lessons learnt in other countries, the project proved that sandfish can be cultured through hatchery techniques in a simple low tech facility in Kiribati. As a result, Kiribati continued with the sandfish work, producing seeds from the hatchery and seeding these in the selected sites. The hatchery protocols developed as part of this work continued to be applied in the national hatchery. As a result of this project, sandfish is now listed among the top 4 aquaculture priority target species for aquaculture under the Kiribati 20 year vision plan (KV20).

Given the success in Kiribati, there are now interest from regional countries to apply the same undertaking. Samoa and Vanuatu have expressed their interest to farm sandfish sea cucumber also. At a recent Kiribati Fisheries summit (2017), most of the island council representatives have expressed their interest to farm sandfish on their islands.

8.2 Capacity impacts – now and in 5 years

In an hatchery environment, common problems faced in the project countries at the start of the project has been turnover of experienced hatchery staff and high demand for consistent seed supply to support tilapia and prawn aquaculture industry. In Fiji for instance as the project kick started, experienced hatchery staff were retiring and newly recruited staff required training and continued trainings to bring up that level of capacity at the operational level. However, in the project implementing countries, individuals involved in the project have benefited from project through hands on trainings. The farmers are now more confident in their farming practices and are now able to make more money for their farms. There is an improvement and reliability of tilapia fingerling supply with the capacity developed in the lead tilapia farmers through hatchery and on the farm trainings as well as guidelines produced to assist farmers in this process.

The use of hapa-based methods for on-farm tilapia fingerling production is an approach that has been adopted easily and has greatly improved access on fingerling supply to farmers. Excess fingerling produced from lead farmers generated additional revenue for the farm and this has been the case for farms such as Montfort Boys Town in Fiji. Lead

farmers have developed their skills and capacity in this area and thereby reducing their dependency on seed supply that would otherwise normally be supplied through national government hatcheries. In addition, trained farmers enabled sharing of knowledge and experiences among themselves. This is an area which national fisheries extension officers normally provides to farmers. However, given constraints in national government fisheries administration operational budgets, it is not always consistent and farmers often have to fend for themselves. Through training of lead farmers, exchange of knowledge and experiences among farmers demonstrated to be more frequent with little interventions from national government administrations. In the Nausori Koro tilapia cluster farm of Fiji where 35 villages accessed an on the farm tilapia training on hapa based breeding method, local Committee responsible for the cluster highlighted that through the training they had gone through, they are able to now breed their own fish. This gives them a feeling of pride in being able to give back to their community.

In Vanuatu, key capacity impact has been an increased hatchery production capacity of tilapia fingerlings to 1 million fingerlings per year and 60,000 post larvae per year for freshwater prawns. Government policy direction has been strengthened through the project intervention to ensure that earthen pond sizes are standardised to 20m x 10m for commercial sized ponds and 10m x 5m sizes for household backyard ponds.

Overall, with the support of Fisheries Departments, the project has been able to lift the level of freshwater fish farming in most countries. Most farmers are now practicing good feeding practices and pond management, and are being more business literate. The impacts of the project are very positive and most farmers that were engaged in the project are more confident in maximising production to improve their income.

8.3 Community impacts – now and in 5 years

Clustering farmers has been a positive impact among communities in the project countries through scaling up of their operations, through selling of their fish for income and through collaborations in terms of exchange of knowledge and experiences in farm husbandry.

In Samoa, through project interventions, one household cage culture system of tilapia that harvested 1,800 fish (approx. 450kg) in one crop has expanded from two cages to seven households involved in cage culture systems. The increase in community uptake is because of villagers seeing the amount of fish harvested which encouraged potential farmers to go into cage farming. Seeing a big harvest have encouraged them to expand have their own individual cages. As a result, the Satoalepai community of Samoa are more engaged and working together to farm tilapia.

In Kiribati, of the five communities selected for sandfish farming, two communities, Buariki and Tabonibara of North Tarawa have adopted and integrated sandfish sea ranching into their community based fisheries management plans.

In Fiji in the Ra District of the Island of Viti Levu, three community lead farmers established relationships and linkages among each other in trading tilapia fingerlings and knowledge on farm husbandry work and providing extension support to farmers in their surrounding districts.

In Vanuatu, the implementation of the project activity work on Efate and Santo Islands have gained so much interest that the national government sourced other financial support and established an additional 28 tilapia and prawn farms in 10 islands in Vanuatu using standardised pond sizes being established by the national Fisheries Department.

8.3.1 Economic impacts

Knowledge gained through the project has made farmers to be more confident in their farming practices as well as knowledge on how to operate as a business. For example, in Fiji, one of the Ra farmers said that "with the hapa breeding method, she does not have to wait for Fisheries for her fingerlings to stock her ponds after every harvest. She also added that she now can better plan her farm in terms of production and rotational harvests." Using the SPC Aquaculture tilapia farm log-book which records all farm activities (stocking numbers/dates, expenses and money generated from harvests), she has been able to secure loans and grants." With consistency in fingerling supply, good aquaculture practices, she now knows how to better plan and maximise her income from her farm. She plans to extend her farm in the future.

In Fiji, a tilapia fish marketing study was undertaken by the Institute of Marine Resources (IMR)[12], the University of the South Pacific (USP) as part of this project. The goal was to assist farmers in developing product forms and market channels that will enable them to sell more tilapia fish and bring about growth in Fiji's tilapia industry. An estimated 400 market sized individual fish of around 250g were harvested by some lead farmers engaged in this project for this study. The study found that:

- Physical condition of fish is well maintained in a newly introduced Thai-style shallow trays compared to a deep 1 tonne round tank that is normally used for live tilapia fish sale in Fiji. The amount of water required to sell at least 400 fish was much less (fewer water exchanges needed), and the physical condition of the fish after 3hr of selling was better. The number of selling staff on duty can be reduced from two people to one person, because scooping fish from the tank with a dip-net for each sale (or enquiry with no sale) is no longer necessary.
- The cost to a farmer of direct-retailing fish is an estimated FJD 3.00 per kg, indicating that a whole-green pond-side price of FJD 7.00 or better will be quite favourable to the farmer. This cost was similar for both selling alive or selling in bundles, where the transport cost of the former is balanced by the need to gill-and-gut the fish for the latter. The prices that can be achieved by selling in bundles, particularly for bigger-sized fish for Chinese consumers, is more favourable when selling in this way. The one draw-back of selling by bundles is that bundles are offered in a section of the market different from live-tilapia (the reef fish section), and the people who are actually looking for tilapia do not go there.
- In terms of the preference in price, customers were willing to pay between FJD10 per kg for a 200-250g size fish or FJD12.00 per kg for large size tilapia of 350-400g in size.
- In terms of what component of tilapia production cost (FJD/kg) borne by farmers is attributable to the activity of direct retailing of fish at municipal market compared with production cost of tilapia sold at farm gate, it ranged from FJD0.40 to FJD1.35 per kg.

In Kiribati, the introduction of sea cucumber sandfish (*Holothuria scabra*) prior to the inception of this project and with the technical and capacity developed through this project showed that the species has adapted to the natural environment. Capacity has been developed locally and a private sector enterprise Atoll Beauties that has traditionally been focusing on giant clam farming for the aquarium trade market has diversified into sandfish farming. As a result of this project, sandfish is now listed among the top 4 aquaculture priority target species for aquaculture under the Kiribati 20 year vision plan (KV20).

[12] *Bala S & Morris C. 2018 Tilapia Fish Marketing Research Report. Institute of Marine Resources, University of the South Pacific (draft.)*

8.3.2 Social impacts

The community aquaculture has shown that communities involved are now more confident in producing more farmed fish. They are willing to work and help each other through clusters. In the project countries, farmers are sharing ideas and assisting each by selling fingerlings. Communities are profiting from fish farming and more farmers are interested in farming tilapia.

An in depth gender assessment in aquaculture for this project was covered comprehensively in Samoa and Tonga and the results of this work is mentioned in Section 7 of this report. The results of this work contributed to a regional toolkit on gender in fisheries and aquaculture developed by SPC and collaborating partners. The results of this study highlighted some key significant findings. For instance in Fiji, women play a major role in aquaculture farming across all tilapia farm modalities but are not often included in training opportunities. It raises the concern and the need for partner agencies and institutions delivering training programs in aquaculture to pay closer attention to the right audiences receiving these trainings so that adequate capacity is built at all levels of farm modalities. Aquaculture activities are having an impact on the empowerment of women with respect to more decision-making opportunities outside the household. This contributes to women having a greater recognition in formal structures within their communities.

In the case of Samoa, it is know that the country is steeped in tradition and cultural norms. The result of the study was not surprising to the national fisheries counterpart of Ministry of Agriculture & Fisheries which revealed gendered roles for women and men in aquaculture. Women do play a big part in tilapia farming such as in fish feeding and in pond cleaning, but did not readily identify themselves as farmers. Men were seen as the face of tilapia farming and were the ones attending most of the trainings provided. Tilapia ponds were found to alleviate pressure on women to always have something ready to cook for the unexpected visitor.

The impact of such engagement also strengthened partnerships at the national level with line government agencies. For instance in Fiji, the Ministry of Fisheries have since been working very closely with the Ministry of Women in aquaculture related work in the country and from the assistance being provided 30% are women. In addition, the Foundation of the People of the South Pacific (FSP) established a grant scheme that is accessible to women and men's groups in the community.

8.3.3 Environmental impacts

The project activities implemented have minimal effect on the project as feed is managed well not only to minimise environment 'pollution' but feeding is also managed in order to save costs.

In Kiribati, the sea cucumber sandfish (Holothuria scabra) used in this project has not been present in the country naturally. The introduction of the species from Fiji to Kiribati under a bilateral arrangement between governments of both countries and prior to the inception of the project demonstrated that the species has adapted well under natural conditions in Kiribati. It is a new species for Kiribati both at the hatchery and grow-out context. From the five communities selected and engaged in sea cucumber farming, two integrated sea ranching into their community based fisheries management areas.

For sandfish in terms of undertaking any follow up ecosystem impact assessment following the initial introduction of sandfish, there was insufficient data on impact gathered from this work. The reasons being that with the lack of capacity on the ground nationally, priority was given to hatchery, community engagement and monitoring of seeded sandfish growth. The other contributing factor that made impact difficult to assess was, the scale of the sea ranching work which was small with a few small pens being used and the short time frame that the project had. However, baseline and impact monitoring would be more relevant for large scale sea ranching.

However, climate change has negatively affected the project due to the occurrence of more cyclones and heavy rainfall causing damage to the farm and loss fish in the ponds due to mass flooding. This has caused delays in production of tilapia by the farmers in Vanuatu, Fiji and Samoa through tropical cyclones Pam in 2015 and Winston in 2016.

8.4 Communication and dissemination activities

Most project activities are reported and disseminated using the SPC Fisheries Newsletter. Over 20 articles have been published for public information through this Newsletter. Publication list is provided in Section 10.2 of this report. Banners and posters have also been produced in Kiribati and Samoa to promote project activities in the 2 project countries. In Kiribati, posters, banners and T/Shirts have been produced during Fisheries Week which is an annual event aiming to promote Fisheries work to the public.

Knowledge products have also been produced through this project. A manual for hapa-based mixed-sex tilapia fry production has been developed and have been used in the 3 project countries including manuals on sandfish hatchery and grow-out techniques and used by national Fisheries staff.

Progress on the project have been reported in the Heads of Fisheries Meeting to Pacific Island Fisheries Leaders. In addition in each country visits, summary extract of project officers duty travel reports were provided to national project counterparts to inform them on the outcomes of each mission and follow up tasks that needed to be carried out before the next mission.

Project officers have also attended international conferences where they were invited to present on the project activities. Posters were also produced that contributed to raising the profile of the project.

During the project period, Samoa national project counterparts were involved in two national agriculture show where they organised tilapia cookery competitions as part of the project in raising the awareness of tilapia as a food fish as well as demonstrating the project activities in the country. Appendix 11.1 and 11.2 provides details on how the work is conducted in Samoa.

9 Conclusions and recommendations

The project has demonstrated positive outcomes in terms of benefits to communities in the target countries. These benefits could be strengthened and scaled out to other communities through a follow-on project.

The project contributed to an increased tilapia production by farmers, strengthened aquaculture capacity building for national aquaculture staff in tilapia, freshwater prawns and sandfish. It established and operationalised farmer networks and clusters, which enabled communication and sharing of ideas between farmers. This helped addresses the constraints in extension support in national fisheries counterpart agencies that often struggles financially to deliver on a regular basis. The project strengthened national capacity through the provision of technical equipment necessary for aquaculture production and introduced aquaculture practitioners in the project countries on new technological ideas to improve constraints in seed production supply in the countries. Capacity building among farmers has increased through project intervention and there has been an increased awareness on the contribution of aquaculture in the rural communities setting. There has been greater income generation through project intervention where farmers were able to sell fish to hotels and restaurants as well as sale of fingerlings to other farmers. Farmers are not having to rely on national government hatcheries anymore but produce own fingerling for their grow-out farms as well as selling seeds to other farms in their community.

There has been an increased awareness and recognition on the roles of gender in aquaculture and issues that being faced particularly from the work that was carried out in Fiji and Samoa. For instance in Samoa, women involved in tilapia aquaculture experienced increased sense of empowerment, greater involvement in village activities and increased visibility in the community[13]. The study highlighted areas around capacity building and trainings such as women who were involved in aquaculture were not the actual recipients of the trainings being delivered. The outcome of the gender work contributed to mainstreaming gender into the SPC work in fisheries and aquaculture through the development of a gender toolkit, launched during the 11th Heads of Fisheries Meeting in Noumea in March 2019.

The project contributed to community rehabilitation as part of post disaster response such as post cyclone Winston of 2016 in Fiji. Income from fish sales assisted affected communities in meeting expenses such as repair of community church building damaged by tropical cyclone Winston. For instance in the aftermath of cyclone Winston in Fiji tilapia farms in the affected community provided a source of protein to the community when other food supplies were not available as infrastructure and communication linkages were damaged.

The project has established that sandfish can technically be done in Kiribati. There is now a greater knowledge and understanding of the techniques required for farming/sea ranching in the local context. For the first time aquaculture is part of community based fisheries management (CBFM) in Kiribati or perhaps in the Pacific, and plans are being developed to incorporate sandfish aquaculture or sea ranching as part of the CBFM approach. There has also been greater links and exchanges made with other countries and ACIAR projects.

[13] *Kunatuba J. 2018 Samoan women at the helm of inland fishing. SPC Women in Fisheries Information Bulletin #28:22p*

The outcome of the project also provided a greater political recognition of aquaculture in some of the project countries. For instance in Vanuatu, the national government provided for the first time a grant of AUD250,000 from the national treasury to strengthen the national infrastructure on aquaculture.

It is important to recognise that the delivery of the research aspects from this project have been weak. The project has taken on three species (tilapia, freshwater prawns and sea cucumber sandfish) in four countries which was perhaps a significant number in view of the project duration. Focus could have been on one to two species but not greater than that. High staff turnover and retention in the project countries meant that SPC in-house staff from other aquaculture projects were having to commit to themselves in the delivery of this project in the countries. There was a lot of time and effort invested in the capacity building work in the countries and as a result, key research aspects crucial to this project work could not be delivered by the in-house project team simply because the basics of hatchery production have had to be conducted first. Project officers in each country would have been helpful. However, that was an area project countries had mixed decision on during the scoping exercise. Fiji, Vanuatu and Samoa highlighted during the scoping exercise that they had capacity in place in-house to deliver on the project and it was funds for operational work that they lacked. Only Kiribati expressed interest in having an officer on the ground. Although a project officer for Kiribati was hired it was difficult to sustain the position during the entire project duration due to lack of job security for project positions.

Overall the project demonstrated good outcomes in terms of benefits to communities in the target countries. These benefits could be strengthened and scaled out to other communities through a follow-on project. A follow on project could consider strengthening the outcomes of the project by:

- Upgrading small-scale farmers to commercial/semi-commercial, including tracking performance with economic models.
- Addressing nutrition through health interactions and the role of fish in food systems in rural areas of Pacific Island Countries (PICs)
- Consider aquaculture as a component of food production systems in PIC’s.
- Consider appointing in-country project officers for future ACIAR projects.
- Strengthen stronger linkages with an Australian university partner who will also provide capacity building in scientific research.
- Consider assessing realistic risks of potential impacts of natural disasters and incorporate planning (including budget planning) to take into account such impacts.

10 References

10.1 References cited in report

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11 Appendixes

11.1 Method for taste-panel sensory evaluation of tilapia fish in Samoa.

A tilapia feed cost-benefit analysis is being implemented at Lotofagaa Demo Farm. In addition to fish growth rate, fatness index and cost-of-production parameters, it is of interest to find out whether formulated feed with higher protein and lipid content will affect the flavour of the fish when compared to the regular on-farm leafy-greens and carbohydrates diet normally used to raise tilapia in Samoa. Feedback about tilapia from buyers and consumers in Samoa has included comments about tilapia being "thin" and having less flavour than reef fish. Sensory evaluation methods allow such opinions to be tested scientifically by collecting data.

The feed trial set up at the end of 2017 was terminated early by TC Gita, when the pond level rose above the hapa and the experimental fish escaped. A new batch of bigger fish has since been stocked back into the hapa by SF, and will be grown for a further two months for use in a sensory evaluation. However Government of Samoa places a "no CROP missions" ban each year from April to June, so SPC will not now be present to assist SF with the sensory evaluation as originally planned.

Two types of sensory evaluation test will be used. The Triangle Test is used to find out whether people can tell whether one fish is different from the other, but without asking for their opinion about which fish is better. The Hedonic Scale test asks people for their opinion about each fish type, ranked on a 9-point scale.

The method for the Triangle Test is based upon a worked example that can be found on-line by googling for "triangle sensory test with oreo cookies".

Equipment list

- 2-burner gas ring
- Gas bottle
- Two steamer pots, with internal rack
- Sharp filleting or kitchen knives
- Fresh fish specimens, sufficient for 30-50 people to have about 50g each
- Hand wash or sterilizer
- Paper or polystyrene plates
- Plastic forks sufficient for 30-50 people
- Bottled water sufficient for 30-50 people
- Ballot papers sufficient for 30-50 people
- Ball-point pens sufficient for 30-50 people
- Serviettes

Method

1. Everybody must first wash their hands thoroughly in soap and water plus hand sterilizer.
2. De-spine and de-head each fish, then skin it and remove caudal fin.

3. Wrap each fish (or up to 6 fish together, depending upon size) in tin-foil, and label it A or B for fish type.

4. Bring 6cm depth of water to the boil in each of two steamer pots.
5. Place the foil-wrapped fish on the steamer racks, with all fish of type A in one pot and all fish of type B in the other pot.
6. Do NOT cook fish of both types together in one pot.
7. Do NOT add salt or any other type of flavouring.
8. Steam the fish until cooked (20minutes or so, depending upon amount and size of fish).

9. For general guidance about how to prepare fish samples for sensory evaluation, see http://www.fao.org/docrep/meeting/005/w9253e/w9253e0k.htm
10. Remove the fish and unwrap, allow to cool down a little until able to be handled.
11. Cut up the fish into approximately 50-cent or matchbox sized pieces for the Triangle Test. Save some fish whole for the Hedonic Scale Test.
12. Cook extra fish and taro for everybody to eat afterwards, but don't show it to anyone until the tests are over.
13. Prepare an individual plate with three small pieces of fish for each person participating in the Sensory Evaluation.

14. The two fish types will each have two randomly-chosen 3-digit number codes assigned to them. Following the Oreo cookie worked-example, fish Type A could be assigned 767 and 189, while Type B can be 312 and 570.
15. Each plate will have three codes written upon it, two codes for one fish type and one for the other fish type.
16. Write the codes out in the changing order shown in the Oreo cookie example, so that different participants receive two pieces of fish of one type and one piece of the other type but in a different order for each participant.
17. Label the plates as #1, #2, etc. and then prepare a corresponding ballot paper #1, #2 etc. for each plate that has its three number codes written in the three spaces upon it. Write the numbers in the same order, from left to right, on both plate and ballot.

18. In addition to the three number codes, the ballot Paper will also contain instructions, so it will look like this:

FISH TASTE TEST

Please take a drink of water before tasting the fish samples.

Taste the samples starting from the left one, then the middle one, then the one on the right.

Drink some water in between tasting each fish sample.

Put a circle around the number of the fish sample which is **different** from the others.

_____ _____ _____

19. The room used for the Sensory Evaluation will be separate from the cooking and preparation area. It should be large and spacious to enable a lot of people to come in without feeling crowded. A classroom or meeting room is ideal.
20. The test panellists will have been invited in advance, and will be arriving starting from an appointed time. The best time for the test is in mid- to late-morning, but not after lunch.
21. Long tables will be set with table placings of (i) plate with fish samples, (ii) a bottle of water, (iii) a fork, (iv) serviettes, (v) ballot paper, and (vi) a pen. The room should be quiet and not brightly lit, with no other smells or sounds to distract. A taste test cannot be done in a crowded noisy marketplace or supermarket, for example.

22. An announcement will be made that this is a fish sensory evaluation, there should be “No talking!”, that people can take as long as they want to choose, but if they cannot make up their mind then they must choose something even if they are only guessing.
23. Collect their ballot papers as they finish, then ask them to move to the Hedonic Scale test.
24. For the Hedonic Scale test, two separate tables will have samples of fish Type A at one, and fish Type B at the other. Ballot forms are provided which look like this:

FISH TASTE TEST

B

Drink some water before tasting the fish sample.

Circle your opinion about the fish taste.

Like extremely

Like very much

Like moderately

Like slightly

Neither like nor dislike

Dislike slightly

Dislike moderately

Dislike very much

Dislike extremely

25. Without comparing the fish sample to any other sample, panellists are asked to taste the fish and then circle one of nine options that best represents their opinion about the fish.
26. The ballot can be in English, or it can be translated into Samoan. If translated into Samoan, then a lot of care has to be taken to translate each of the nine options in a way whereby they are divided up into step-like "opinion intervals" whose meanings in Samoan are spaced out evenly.
27. Collect up all the ballots, thank the panellists very much, and then bring out all the extra fish and taro that so far you've been keeping out of sight.
28. To analyse the Triangle Test data, (i) count up how many ballots contain the "right answer", and (ii) count up the total number of ballots. Use these two numbers to carry out a Chi-squared test, which compares the Observed Frequency of "right answers" with the Expected Frequency. This test can be summarised in on-line Triangle Test tables that display, for different Total Numbers of ballots, the cut-off number of "right answers" which your Observed Frequency must equal or exceed in order for peoples' ability to tell the difference between samples to be statistically significant at the 5% level. See, for example, http://www.fao.org/docrep/V7180E/V7180E12.HTM
29. For the Hedonic Scale test, convert each answer into a number from 1 to 9 for the nine opinions from Dislike Extremely to Like Extremely. Type all the numbers for fish Type A into one column in an Excel spreadsheet. Type all the numbers for Type B into a second column. You can now use the spreadsheet column operator functions to calculate the average value of opinion for each fish type. You can also do a t-test to find out whether any difference in the average opinion of the two fish types is statistically significant (but you will need a sample size greater than 30 for a t-test to be meaningful).

11.2 Tilapia – Cooking Competition- Agro Show 2014

Selection Criteria

1. Recipe and Ingredients
2. Presentations of the tilapia on a plate
3. Eye catch name for the Menu
4. Tilapia tasting

Names	Village
1. Lau Pepese	Lotofaga
2 Fuamatu Fuga	Laulii
3 Samoa Small Business Association (SSBA)	Falelauniu
4 Toa Time	Vaivase
5 EFKS youth (congregational church)	Leulumoega Tuai
6 EFKS youth (congregational church)	Faleaseela
7 Analosa Molioo	Ululoloa
8 Tafaigata Penitentiary (Prisons)	Tafaigata
9 Seleni Faiga	Faleaseela
10 Fuimaono Rimoni	Salani

Note: Only 10 registrations for this competition: FIRST COME, FIRST SERVE!!

PRIZES:

1st prize = $300

2nd prize = $200

3rd prize = $150

7 consolation prizes of $100 (= $700)

= $1,350.00 (For Upolu) + $1,350.00 (Savaii) = **Total budget $2,700.00**

11.3 ACIAR Community Aquaculture Project - Institute of Marine Resources (IMR) component: Tilapia fish marketing research in Fiji

Background

The Institute of Marine Resources IMR of the University of the South Pacific USP is a project partner with the Aquaculture Section of SPC Fame in ACIAR project FIS/2012/076 Improving Community-based Aquaculture in Fiji, Kiribati, Samoa and Vanuatu. Two IMR staff, Cherie Morris and Shirleen Bala, are identified in the project document as having roles in "Tilapia research assistance and extension", with experience in tilapia product development and research in marketing.

Tilapia fish marketing research is here included in the project to build upon earlier work, in particular upon a questionnaire-based tilapia marketing study implemented by SPC FAME in 2015 under the EU-IACT project, and to extend these findings out to community-level and cluster-farmer tilapia selling activities in Fiji islands.

Based upon consumers' stated preferences in surveys and questionaires, the authors of the EU-IACT Tilapia Marketing Strategy 2015 report recommended that tilapia farmers in Fiji should:

1) Sell tilapia fish live where possible.
2) Grow tilapia fish to at least 300g.
3) Develop fresh chilled market channel to avoid gluts of live fish.
4) Be able to offer at least 500kg of fish at a time, in order to target bulk sales through wholesalers/ processors, either individually or by farmers grouping together.
5) Organise and coordinate their combined production to ensure on-going consistent supply to all market channels.
6) Regard the hotel/restaurant market channel as one less profitable, lower in volume, and more time consuming for farmers, so may be better left to wholesalers with adequate resources.
7) View wholesalers/ processors as a promising new channel for bulk-selling of tilapia, because the margins appear adequate and it will save the farmer time and cost. This is particularly attractive in cases where the wholesalers/processors are willing to collect from farm gate.
8) Shift from engaging in the entire supply chain (from harvest to marketing and distribution to direct retailing), and analyse their selling price (volume, margin) to wholesalers to ensure the price per kg is still profitable.
9) Consider selling larger tilapia (700g and above) at $15.00 per Kg or more.
10) Promote specialization within the tilapia value chain, and encourage new players to enter the industry to perform distribution and retail functions.

The IACT study was interview/questionaire-based, and delivered results about tilapia product and price preferences couched in terms of what fish consumers *say* they will do. This project's research aims to offer actual tilapia product into the market for fish in Fiji, in order to observe what fish consumers actually do.

In essence, the project work commissioned from IMR comprises practical test-marketing trials to validate the main recommendations of the paper-based SPC EU-IACT Tilapia Marketing Strategy report, but this time using real fish sold by real farmers to real customers for real money.

Scope of Work

Goal – assist community and cluster tilapia fish farmers in Fiji to develop product forms and market channels that will enable them to sell more tilapia fish and bring about growth in Fiji's tilapia industry.

Objectives:

1) Construct and test a better system for sale of live tilapia that minimises the water cartage requirements and degree of fish handling damage (this is a road test in Fiji of the Thai shallow-tray system, using live fish sourced from cluster farmers).
2) Introduce iced or frozen gilled-&-gutted tilapia into small fish shops or in municipal markets, to test consumer acceptance (using fish sourced from cluster farmers).
3) Assess the economics of growing tilapia to larger size (500g, and 750g), compared with 250g size (using fish sourced from cluster farmers):
    a. Estimate the cost of production to 250g, 500g and 750g size fish, and;
    b. Find out what price per kg the market can bear for 250g, 500g and 750g size fish.
4) Find out what component of tilapia production cost ($/kg) borne by farmers is attributable to the activity of direct-retailing of fish at municipal markets, compared with the production cost of tilapia sold at the farm-gate.
5) Link at least one fish wholesaler/processor/middle-seller with a group of tilapia farmers and find out the mutually acceptable terms for developing a wholesale market for tilapia;
    a. Minimum consignment size (kg) needed for processing/marketing
    b. Minimum fish size (g) needed for processing/marketing
    c. Minimum price needed to purchase fish at farm gate

Research questions to be answered by the IMR/SPC Tilapia Marketing data collection activities:

1. Can adoption of Thai-style live fish selling (using table trays instead of 1T tanks) bring any advantages to Fiji live-fish tilapia sellers and tilapia customers?
2. Can chilled gilled&gutted tilapia fish sold in bundles provide a viable alternative product form which Fiji tilapia farmers can use as a new market channel for selling their fish?
3. Is it worthwhile to grow tilapia fish to a larger size for selling in Fiji (either live or bundled)?
4. How much of the full retail price for tilapia fish can farmers afford to discount down by, without losing money, if selling their fish to a middle seller or fish processor either (i) "at the farm gate" or (ii) "as delivered"?
5. Can a wholesale market for tilapia be developed in Fiji, as an alternative to direct-retailing of tilapia fish by tilapia farmers?

Research Outputs

At the time of writing the field work and data collection has been completed, and the raw data is now being analysed by IMR for presentation in a stand-alone report and for dissemination of results to tilapia farmers via cluster group meetings. One such meeting with Tailevu Cluster in Fiji has already been held. Broad trends are already identifiable, and are summarised here.

1) A better system for sale of live tilapia.

A Thai-style shallow tray was compared to the deep 1-T round tank that is normally used for live tilapia fish sales in Fiji. The amount of water required to sell at least 400 fish was much less (fewer

water exchanges needed), and the physical condition of the fish after 3hr of selling was better. The number of selling staff on duty can be reduced from two people to one person, because scooping fish from the tank with a dip-net for each sale (or enquiry with no sale) is no longer necessary. Two tilapia farmers tried out the new system, and both gave very positive feed-back about it. They want to adopt this system, with some minor modifications.

2) Iced gilled-&-gutted tilapia in municipal markets

Trials of selling gilled-and-gutted tilapia in 2kg bundle were carried out in Suva market on consecutive weekends. This was combined with offering different sizes of fish, to estimate willingness-to-pay and establish price points for different fish size classes. Customers were observed and their reactions recorded, along with their estimated age, gender and ethnicity to build up consumer profiles abaout preferences for the different size classes. A time-motion study was conducted for the processing and selling of tilapia in bundles, to (i) find out the margins when compared with selling of tilapia live, and (ii) to find out the margins of selling direct-retail compared with a wholesaler buying whole-green fish at the pond-side.

For fish around 350g size that make up 5 or 6 fish to a 2kg bundle, these readily sold at FJD 25 per bundle or $12.50 per kg, compared with a Suva “best-price” for live tilapia of $10 per kg. An additional $3 per bundle can be charged for scaling the fish at the customer’s request.

For fish around 200g size that make up 10-11 fish per 2kg bundle, these readily sold at $18 or $20 per bundle, or $9-10 per kg, depending upon the selling day.

The cost to a farmer of direct-retailing fish is an estimated FJD 3.00 per kg, indicating that a whole-green pond-side price of FJD 7.00 or better will be quite favourable to the farmer. This cost was similar for both selling alive or selling in bundles, where the transport cost of the former is balanced by the need to gill-and-gut the fish for the latter.

Overall the prices that can be achieved by selling in bundles, particularly for bigger-sized fish for Chinese consumers, is more favourable when selling in this way. The one draw-back of selling by bundles is that bundles are offered in a section of the market different from live-tilapia (the reef fish section), and the people who are actually looking for tilapia do not go there. As a result, the volume that can be sold on a Saturday morning is currently less (about 20 x 2kg bundles or 200 pieces) compared with live sales where there is easy recognition by consumers of the familiar green tanks and they can sell 400 – 1000 pieces. This difference in volume could be addressed through appropriate advertising and promotion of the tilapia sold in bundles.

3) Economics of growing tilapia to larger size (500g, and 750g subject to fish availability), compared with 250g size.

Estimates of the cost of production of 250g, 500g and 750g size fish are still being worked-upon, using interview data with farmers who are diligent in keeping farm records. It may not be possible to find this out for 750g fish because no tilapia farmers in Fiji currently produce this size of fish.

Estimates of price per kg the market can bear for 250g, 500g and 750g size fish, have been made under (2) above by establishing the willingness-to-buy price points for 200g and 350g sizes. The sample size of sales of larger sizes is too small to draw firm conclusions at this stage, due to a general unavailability of bigger-size tilapia in Fiji.

4) Written report based upon “walking the value chain” that estimates and compares the tilapia production cost ($/kg) borne by farmers who sell fish at Suva and Nausori municipal markets, compared with selling tilapia at the farm-gate.

A combination of time-keeping observations and interviews was conducted to find out what it costs a farmer to sell direct-retail in a municipal market, compared with selling whole-green fish at the farm gate. For both live selling and for gilling and gutting, this cost comes out at around FJD 3 per kg, though it reduces with increased volume of sales. This means that any whole-sale price that involves on-farm collection of un-gutted fish by the wholesaler which is $ 7.00 or more will be favourable for tilapia farmers. Any further reduction in price below $ 7.00 would need to be accompanied by a concomitant large increase in sales volume, in order to be advantageous to a farmer.

5) Link at least one fish wholesaler/processor/middle-seller with a group of tilapia farmers.

This part of the research requires that IMR facilitate agreement upon mutually acceptable terms for a wholesale market for tilapia to be created. This is currently still a work in progress. About 6 possible wholesalers or processors have been identified, and talks are now beginning. These will encompass:

a. The agreed value for the minimum consignment size (kg) to be traded on each occasion
b. The agreed minimum fish size (g) and product form
c. The agreed minimum price ($/kg) for the tilapia fish

11.4 Gender Roles and Aquaculture Projects - Analysis Framework

By Brigitte Leduc, Gender Equality Advisor, SPC and

Joanne Lee Kunatuba, Gender Equality Officer, SPC

Suva, September 2016

Background

The Pacific Community (SPC) in collaboration with the Government of Fiji, through the Ministry of Forestry and Fisheries, with funding from ACIAR currently implements the project FIS/2012/076 "Improving community-based aquaculture in Fiji, Kiribati, Samoa and Vanuatu". Objective 4 of this project is to "Ascertain the impacts that community aquaculture can have on household income, nutrition, and the status of women and children in these four countries Vanuatu, Fiji, Samoa, Kiribati".

The gender sensitive implementation of this project directly supports the goals and strategies highlighted in the Fiji national gender policy (201). This national policy sets out a number of objectives that when achieved will promote gender equality in Fiji. These include among others, the removal of all forms of gender inequality and gender discrimination in Fiji and the promotion of active and visible gender mainstreaming in all sectors of government. The strategies outlined to achieve these objectives include sensitization and training on gender issues at all levels of Government, promoting access to all services by women and promoting women's economic empowerment and gender equity in government – in relation to the environment as key to sustainable development.

To date, SPC has conducted a workshop for Extension Officers in the Ministry of Forestry and Fisheries and this activity provides further opportunity to further engage Aquaculture Extension Officers in Fiji in building capacity to implement gender responsive extension programs, and to monitor and evaluate aquaculture development from a gender perspective.

The development of this case study is a request from Extension Officers, expressing the need to have more case studies to learn from and since there are none in the Pacific islands region, there was an agreement among the participants that they should contribute to develop those case studies.

Objective

1) To assess the division of labour and roles of women and men play in the farming system, with a specific emphasis of aquaculture activities
2) To identify gender issues that may affect equitable benefits from aquaculture activities for women and or for men
3) To identify entry points for supporting equitable access to natural, economic and social resources and equitable outcomes from aquaculture development for women and for men
4) To make recommendations for effectively implementation of gender mainstreaming approach in across aquaculture program

Outcomes

X case studies illustrating gender roles in aquaculture

A set of recommendations for supporting equitable outcomes of aquaculture activities

A policy brief on gender in aquaculture in Fiji

Method

- Review of literature (especially project literature)
- Analysis of countries' fisheries and/or marine sector policies and strategies
- Interviews and focus group with community women and men (separately)
- Interviews with resource-persons related to the aquaculture project (SPC and Fiji Government)

Analysis Framework[14]

A. Gender roles in livelihood and use of available resources and technology

1. Who is doing what?
2. Who has access and who has control over resources and technology?[15]
3. What are the local knowledge and skills of men and women in the farm system and in aquaculture?
4. How women and men perceive their roles in the farm system and in aquaculture (and do they see aquaculture as a significant source of incomes or more as food security strategy?)
5. How women and men respectively develop their capacity to do "better" in the farm activities, in particular in aquaculture? Participation to training; access to information (brochure, radio programme, etc). Include questions about when did they start doing aquaculture; what gave them the idea; what they like about it? What they find difficult or disappointing about it, etc)
6. HWhat resources are needed to be successful in aquaculture? Who use those resources more? Who decide about those resources more?
7. YWhat are the benefits of aquaculture – food security (how many time they eat the fish they produce/ day/week/ etc – assess what proportion of protein intake it represent (e.g. half protein intake /week?) In terms of Incomes: what is the investissment in term of time and money; what financial benefits it represent - % of total household incomes; who manage or use or decide for this money; what do people do with the money (buy food, savings, pay for school, etc.)
8. Question about impacts of natural disasters and how it affect aquaculture or their time dedicated to it? Cyclones, drought, etc.

B. Decision-making

9. What is the composition of decision making bodies?[16]

[14] *The following are questions that the case study is trying to answer*

[15] *Technology could be farm equipment, mobile phones or emails/computers as they relate to the management of the farm*

[16] *This might relate to the aquaculture project or decision making in general in the community*

10. What is the process of decision making in these bodies?
11. What is the % of women and men in those bodies?
12. At household level: who decide or how decision are make about investing money in the aquaculture activity (buying equipment; paying for help for harvesting for e.g. selling products; use of incomes generated by aquaculture production, etc.) Are women and men interviewed happy with it? Is there something they think should be differently done?
13. Is this way of making decision is the same for other areas of farm production?

A. Impacts of proposed changes

14. How changes proposed by the project will impact on men?
15. How changes proposed by the project will impact on women
16. How changes proposed by the project will impact on gender relations?

B. Institutional partners

17. Are policies and strategies for aquaculture in Fiji gender sensitive?
18. How do they perceive the role of women in aquaculture; and the role of men?
19. Do partners acknowledge and understand gender issues in aquaculture?
20. Are they committed to address gender issues?
21. What are they doing to address gender issues?

11.5 Participatory Action Research PAR template for community tilapia farms

Proposed lead farm: Montfort, Fiji

23 fish ponds

Fish hatchery

Condition is run down.

Initial consultation attendance list:

Farm profile

Farm name

Type of Organisation:

Leadership:

Brothers will be handling the new farm. Not a one-man show. They rely on volunteers now, because not so many brothers anymore. Technical staff they have 23, but cannot depend upon them, they don't have fish as part of their job description. Fish has to be an after-hours activity.

About 45% of Savusavu graduates est. fish farms later.

Boys need to be attached to farm on a rotational basis, to make it sustainable. Management to be by the brothers + volunteers.

Farm manager? Not any more. Plan is to have 2 boys in charge. Will invite JICA to base volunteers here to run things too. They will have accommodation on-site.

Fish is not now part of the curriculum. But plans to make it a part of the curriculum again. 45mins of theory and 1 hr of practical each day. It would be part of the assessment.

Any selling? Just to show the boys that fish can generate income. But Montforts funding has been reduced, so they do want to make money for the school. He wants the farm to be on a business-like footing, and he has a business background.

School roll has come down to 80, because of low funding. But he now wants to increase again to 120 again.

Farm production records

Frequency of management meetings

Ownership:

Vision/Goal: Aspirations

Integrated farming chickens, ducks, pigs and fish

Students to be involved.

Standby supportive mechanism for the students – as a back-up to their tradeFor last 7 years they were not doing the fish farm properly. Formerly they fed the boys fish 3x per week, 2 fish each. They had a champion for fish but they left and it was directionless after that.

Delivery of benefits: Is the fish farm project meeting expectations?

No.

Expansion plans: More ponds? More fish per pond? More farmers?

Production to date:

Production cycles completed, and fish yield.

Only a few fish left now, and not in good condition. Farm was non-functional for 7 years. So we are now starting form scratch.

Frequency of pond cycles:

Grow-out time:

ABW at harvest

The project has a harvest net?

Market:

Sold?

Given away?

Eaten in own home?

Price?

Feed types and costs:

total feed requirement

total feed cost

Other costs:

Manure

Constraints: (as described by the owners's statements in the meeting)

No funds to revive the farm

Wants it to run on business-like footing, to justify the farm to donors

It is a vital element of students' technical training

Needs injection of expertise.

Gap analysis of constraints and benchmark

SPC /MoFF Benchmark and Gap Analysis of farm:

Verification of constraints

Prioritisation of constraints

Calculate % efficiency of production against BAP

Identify gaps in BAP

Recommendations for interventions to close gaps in BAP

Assessment of farm cluster potential:

- *Capacity for growth in production and income*

- *Opportunities for more investment*
- *Opportunities for more employment*
- *Existing critical mass of skills and resources*
- *Strong interest in collaborating on key issues*

Cluster value chains should self-select, based on their:

- ***Resources*** of land, water, seed, feed, and some experience and know-how already
- ***Growth potential*** –
- ***Willingness to cooperate*** –

Next step:

- Hold a second meeting
    - Inform them of the results of the Benchmarking and Gap Analysis, and obtain any follow-up information needed
    - Discuss options to improve fish production, and ask them to select those that match their aspirations for the farm
    - Agree on the specific actions to be done next, to meet these aspirations
    - Prioritise these actions
    - Assign responsibilities and timelines

Second meeting held by Beero on 22 February 2017.

Request made for replacement fencing, but not clear what length, what height, or what cost. Ponds were measured – 8 ponds will be recommissioned at first. It's not clear whether inlet pipes and keys are still in place, or need to be completely replaced.

Third visit 29 March 2017, Tim and Beero

Draft letter of agreement prepared and shown to Brother Jim for comment.

Brother Filimoni will be the nominated counterpart and Project Leader. Also Siru (retired volunteer, from Canada) will also assist.

Things to discuss:

- Fence – requirement is 200m x 5'
- Inlet pipes and valves – found 5 valves and inlets, 3 are working, 2 need fixing. Ponds 6-9 inlet pipes are not evident, nor valves.
- Cement tank repairs
- Brood stock – use existing fish on the farm.
- Feed storage container – make it serviceable and rat-proof.
- Small equipment items – use Nausori Koro equipment list as a basis for initial planning, plus kitchen scale for sampling.

Next:

1. Sign LoA
2. Make a timeline for works and procurement
3. Start prep of a Business Plan
4. Ask Robert for guidance about fence procurement
5. Initiate procurements of equipment
6. Repair cement tank 8-22 May.
7. Repair valves

8. Trace piping and estimate qty of replacement pipe. 8 May onwards is when boys return from Term Break, so work commence form 8 May to 22 May. MBT will look for as much of their own available pipe as possible, before we use public money to obtain more, and will let us know within 1 or 2 weeks.
9. Set up hapa, select brooders, and start breeding.

11.6 Selection criteria for sandfish grow-out sites

1. Physical parameters

- Current: 25-40 cm/sec
- Wave: under 1 m
- Water depth: 3-4 m high tide and 0.1 m low tide
- Substrate: sandy with 30-40% natural seagrass coverage
- Visibility: above 4-5 m
- Temperature: 26-29 °C
- Chlorophyll *a* content: 0.1-2 µg/ml

2. Chemical parameters

- Salinity: 32-35 ppt
- pH: 7.5-8.2

3. Biological parameters

- Limited herbivorous fish and crabs (idem for other possible predators)
- No fish breeding area
- Presence of other sea cucumber species
- Presence of 30-40% seagrass coverage (sargassum, etc)
- No presence of freshwater sources in the area (rivers, springs, mangroves, etc)

4. Socioeconomic parameters

- Motivated and informed coastal communities
- Clear distribution of roles and responsibilities within the coastal community
- Previous or present knowledge/experience on community based activities (fisheries management, agriculture, livestock, waste management, education, health, etc)
- Previous or present knowledge/experience on aquaculture-related activities (seaweeds, pearl oysters, giant clams, etc)
- Previous or present experience in collaborating with the MFMRD
- Accurate data on invertebrate stocks: area where a detailed invertebrate stock assessment has been conducted
- Limited conflict with other users and uses (fishing activities, boat traffic, seaweed farming, giant clam farming, etc)
- Legal access and use to the selected coastal area by the community members and by fisheries and aquaculture officers
- Easy access to selected farming sites by coastal community members (swimming, walking or by boat)
- Easy access to the selected community and the selected farming sites by fisheries and aquaculture officers (monitoring and follow up activities)

11.7 Sandfish Quarantine Measures - Pathogen Risk Mitigation and Quarantine Measures recommended.

The importing country should implement the following pre-border requirements:

1. The shipment of sandfish stock to be introduced into Kiribati should be of "high health" status and have a clear sanitary certification provided by the Fijian Competent Authority in charge of Biosecurity and Aquatic Animal health Management (following the guidelines provided by the “external check for disease and health of hatchery-produced sea cucumbers”, by Steven Purcell and Igor Eeckhaut, SPC, 2005).

2. Check list of each individual before transportation from the facility of origin:

Disease

• Skin and papillae coloration is “normal” and healthy.

• No white spots, malformation or abnormal retraction of the mouth or anus.

• Oral tentacles, if visible, are yellowish-grey.

• Ventral surface should be generally more whitish or cream-colored.

• No fungal or bacterial infections, involving white spots or fluffy patches on the body.

• Possible bacterial and fungal diseases will be avoided by culturing external tissues and internal organs following traditional methodologies prior transportation.

• No parasitic infestation. Parasite control by traditional methods will be carried out prior transportation.

Health

• No prominent layer of mucus on the skin.

• Body with no open lesions or scars with un-sealed epidermis.

• No infestation of macroassociates.

3. The facility of origin in Fiji will demonstrate a proven track record of main diseases and pathogens, including clinic signs, differential diagnosis, final diagnosis, mortalities and morbidities occurred in the specimens being cultured.

4. The facility of origin in Fiji will have evidence of adherence to strict biosecurity protocols and an over-all health management plan.

5. The facility must provide Kiribati with sufficient guarantees as to the health status and history of its stock.

6. The following treatments will be carried out to the selected specimens or stock at the facility of origin prior transportation:

- Antiparasitic treatment for copepods control: Dipterex (Triclorphon) at 1ppm (1mg/liter/hour) during the week prior transportation.

- Antibiotic treatment: Erytromicyne at 2mg/liter, during 1 day, the week prior transportation.

7. An on-site inspection visit to the production facility by a recognized expert on behalf of the Government of Kiribati will be made to assure that the protocols, diagnostic procedures, security, etc. are adequate to validate guarantees of health status.

8. The production facility in the exporting country will also meet the following pre-border requirements:

- The batch of the stock destined for export should be separated as early as possible from other stocks reared in the facility of origin and should be maintained in tanks separate from the rest of the stocks.
- Detailed records should be kept of the health status and mortality rates of each batch of sandfish to be transported. Such records should be made available to the Competent Authority responsible for health certification.

The importing country should implement the following post-border requirements:

1. The receiving facility will implement standardized and adapted quarantine measures operations such that the risk of pathogen exposure is minimized (described below).

2. The stock will be received at the public sea cucumber hatchery, managed by the Fisheries Division and located in Tarawa. The sanitary certification and related documentation provided by the Fijian Competent Authority will be analyzed and reviewed, either at the airport or at the hatchery site.

3. The health status of the 60 specimens will be monitored at the reception as well as weekly during the quarantine period (two months), by following the guidelines provided by the “external check for disease and health of hatchery-produced sea cucumbers”, by Steven Purcell and Igor Eeckhaut, SPC, 2005).

Check list of each individual after transportation to the hatchery facility:

Disease

• Skin and papillae coloration is “normal” and healthy.

• No white spots, malformation or abnormal retraction of the mouth or anus.

• Oral tentacles, if visible, are yellowish-grey.

• Ventral surface should be generally more whitish or cream-colored.

• No fungal or bacterial infections, involving white spots or fluffy patches on the body.

• No parasitic infestation.

Health

• No prominent layer of mucus on the skin.

• Body with no open lesions or scars with un-sealed epidermis.

• No infestation of macroassociates.

3. The 60 specimens will be counted and measured within the transportation facility, and later on acclimatized to the water temperature and water quality before being released into the stocking tanks (stocking tanks will be cleaned and disinfected with chloride prior the reception of the stock).

4. The specimens will be stocked in two 3000 liters tanks located at the larval rearing area of the hatchery facility. 30 specimens will be stocked at each tank, with an average stocking density of 3Kg/1000 liters. Sea water will be pumped from the normal channel. Water will be sand filtered first and passed by a 1 micrometer filter afterwards. 100% water exchange will be done daily.

5. Water outlet will be passed by a 5 micrometer filter (since copepods are the major constraint regarding diseases to be transmitted and spread to the receiving environment, and they could be easily removed by routine filtering of seawater with 5 micrometers nominal filters).

6. The following treatments will be carried out during the first week after the reception of the stock:

- Antiparasitic treatment for copepods control: Dipterex (Triclorphon) at 1ppm (1mg/liter/hour) during the week prior transportation.
- Antibiotic treatment: Peniciline at 2mg/liter, during 1 day, the week prior transportation.

7. The stock will be maintained during two months at the hatchery facilities; after two months, the health status of the specimens will be checked. If the health status is adequate, they will be released into the broodstock ponds.

8. The hatchery operators will report any occurrences of serious mortalities or disease outbreak.

9. The hatchery operators will follow the health monitoring system previously defined in bullet point 3 at the receiving facility; a historical record of health and mortality status will be established.

10. No animals will be removed from the receiving facility without prior permission from the Ministry.

11. All animals will be destroyed and disposed of in an approved sanitary method and the facility fully disinfected before restocking if there is a serious mortality or disease outbreak.

11.8 Sandfish Pen Building - List of equipment for building sandfish pens

Pen material

- Mesh (3mm oyster mesh in 30m roll, 900mm wide)
- Cable ties (~300mm long): x100 per pen
- Wooden stakes (1.5m long, cross section ~40-50mm): x35 for 100m^2 pen and 25 for 50m^2 pen
- Wooden pole (2m long) for marking center of pen and to hold radius rope
- 30lb monofilament for tying structure (mesh) to wooden poles.

Tools and equipment

- Radius rope (5.6m for 100m^2 pen and 3.9m for 50m^2 pen)
- Spades (at least 2) for digging mesh in
- Crow bar for digging stakes in
- Mallet
- Machete for sharpening stakes
- Gloves
- Booties
- Mask and snorkels (x3 sets)
- Underwater torches (need x1 torch + spare batteries to leave with farmer/caretaker)

Procedure for building sandfish pens

Sizing the pen

Pens are initially stocked at 2 juveniles per m^2 (average weight = 3g) so if you have 200 juveniles you can stock a 100m^2 pen and you will need 100 juveniles to stock a 50m^2 pen.

$$\text{Pen size (m}^2\text{)} = \text{number of juveniles available} \div 2$$

Preparing mesh

For 3g juveniles use plastic oyster mesh size 3mm. The mesh comes in 900mm wide and needs to be cut in half through the middle to obtain a mesh that is 450mm wide.

The length of mesh to cut to make up the pen is the circumference of the pen. To calculate the circumference of the pen:

a. Calculate the radius (r) according to the desired area: r = square root (area ÷ π); eg. for 100m^2 pen r = square root (100 ÷ 3.14) = 5.64m; for 50m^2 pen r = 3.99m; for 35m^2 pen r = 3.34m.
b. Calculate circumference as C = 2 x π x r; eg. for 100m^2 pen C = 2 x 3.14 x 5.64m = 35.42m; for 50m^2 pen C = 2 x 3.14 x 3.99m = 25.06m; for 35m^2 pen C = 20.98m.
c. Add 0.5m to the total and round up to the nearest 0.5m to make sure there will be enough mesh to join the 2 ends. Eg. for 100m^2 pen total length of mesh = C + 0.5 = 35.92m which is rounded up to 36m; for 50m^2 pen total length of mesh = 25.5m; for 35m^2 pen total length of mesh = 21.5m.

Planting center and perimeter stakes

a. Chose the site and plant the center stake using crowbar and mallet;
b. Make a loop at one end of the radius rope and tie a knot at the radius mark so that from the end of the loop the knot the radius rope will be the length of the radius determined previously according to the desired size of the pen (see 2.a above). With r values rounded up the length of radius rope are, for 100m^2 pen radius rope = 5.6m; for 50m^2 pen r = 4.0m and for 35m^2 pen r = 3.3m.
c. Place the loop of the radius rope around the center stake and using the rope as a guide place perimeter stakes every ~1m around the circumference of the pen. TAKE CARE not to pull on the radius rope (just hold it straight without pulling the center stake toward you) or the pen will be much larger than planned and you will not have sufficient mesh. TAKE CARE to

walk and work outside of the pen area from this point on to avoid excessive disturbance of the sediment.

d. Use the crow bar and mallet to secure each stake firmly in the sediment.

Digging in mesh

a. Wear gloves and booties for this, particularly if working in areas where the sediment may be coarse or there may be broken glass.
b. At the lowest point in the tide, dig a trench around the outside of the stakes. The trench has to be deep enough to burry 150mm of mesh in the sediment. Move the sediment to the outside of the pen when you dig so that the sediment can be moved back in easily without having to go inside the pen.
c. Using cable ties (~300mm long), attach one end of the mesh to the first stake and work around the pen to attach the mesh to all stakes making sure the mesh is not too slack. Once the mesh is attached to the first two stakes you can start burying the mesh from the second stake and work your way around the pen. You need to leave the mesh around the first stake uncovered until you finish going around so that the overlapping mesh can be buried as well. Ideally 1 person would be attaching the mesh to the stakes and another one would follow to be burry the mesh.
d. Once the mesh is all around the pen, attached the other end to the start of the mesh to close the pen.
e. Finish burying the mesh and return 1h later to inspect the work once the water has cleared.

Environmental sampling

Before sandfish are released carry out sampling as in Technical Sheet #12. Environmental sampling and site monitoring will assist in understanding how to select best growing sites for sandfish.

Sandfish release

Release juveniles as per instructions in Technical Sheet #10.

11.9 Sandfish packing, transport, storage and release

1. Handling prior to packing

If the sandfish to be released are in a tank with sediment some planning is required to prepare for their handling a few days before transport in order to minimize stress:

a. To avoid digging juveniles out and causing injuries which will cause mortality post-release, sandfish need to be collected in the evening (7-8pm), when they have naturally come out of the sediment. They are then placed in a clean purging tank without sediment that has been prepared and filled with water beforehand. Make sure the tank provides a safe environment with shelter from excessive rain and sun.
b. Place excess number of sandfish into the purging tank so that they can be graded the next day.
c. Placing the juveniles in a clean tank will enable them to purge (empty their guts) which is better for transport.

2. Grading

a. Determine the standard 3g release size by weighing a few sandfish around that size.
b. Using the standard size as a template, carry out a rough grading to remove the smallest individuals from the purging tanks making sure that sufficient numbers are left behind for stocking pens.
c. Return the smallest juveniles to the simulator or the nursery tank.

3. Average weight

a. Once juveniles have been graded select 30 juveniles randomly. Make sure sandfish are not repeatedly taken out of water before weighing as they will tend to retain excess water and this will result in overestimation of weight. To prevent this you can collect juveniles in a submerged bucket that you will then take to the bench where the balance is located.
b. Weigh each individual separately to the nearest 0.1g making sure to remove excess water (laying sandfish on a damp tea towel prior to weighing is effective in removing excess water).
c. Record individual weights and calculate average which will be the weight at release.

4. Preparing for transport

a. Transport conditions should minimize the stress that may be caused by long air exposure, lack of oxygen and excessive heat.
b. It's important to minimise stress on the juveniles so they are in the best possible condition when they are released into the sea (so they will bury quickly, start feeding, fight off predatory crabs, etc). Ways to reduce stress are: least handling, work quickly but carefully, drain water off to weigh them but don't leave them dry for long, or stacked up on top of each other out of water, don't leave them sitting around for long periods in plastic bags, keep them out of the sun, and so on.
c. It is important to be well organized so that no time is wasted and sandfish are transported swiftly. The boat or the car used to transport juveniles should be packed and ready to go before juveniles are taken out of the purging tank and packed.
d. Count juveniles immediately before packing. Juveniles are to be counted in lots (e.g., 100 juveniles to be packed in one eski).
e. Equipment and material required for transport:
    - Eski-40L (25-50 sandfish per eski depending on size of juveniles, duration of transport and use of oxygen)
    - Plastic bags to bag up sandfish (500mm x300mm) – check bags do not leak beforehand
    - Jug to fill bags with seawater (3L per bag)
    - Oxygen to blow up bags before transport
    - Packing tape or elastic bands to close plastic bags and eskis
    - Deep fish bins x3

5. Packing juveniles

a. Fill bag with 3L of seawater

b. Stock number of juveniles per bag according to the weight of sandfish, the duration of transport and the use of oxygen as per the table below.

Weight of juveniles	NO-oxygen used in bag			Oxygen used in bag		
	2h transport	4h transport	8h transport	2h transport	4h transport	8h transport
3g	20	15	7	40	30	20
6g	10	7	5	20	15	10
9g	7	3	3	15	10	5

c. Close bags with a goose neck and attach with elastic band or tape
d. Lay bags on their side inside the eski so that juveniles don't pool in the corners of bags
e. Keep eskis in the shade or under a cover at all time to avoid direct sun heat

6. Storage prior to release

a. Take some deep fish bins to the release site
b. On arrival at the release site and if release is several hours away, place juveniles in the fish bins with clean seawater (the idea is to make sure that time in bags doesn't last more than 8h, with oxygen)
c. Replace water regularly (replace half every hour) to maintain water quality
d. Keep bins in the shade

7. Release

a. The pen should be inspected for the presence of crabs and other potential predators (eg. mantis shrimps) before stocking with sandfish. Crabs tend to be at the periphery of the pen when the first come out inside a newly built pen.
b. Juveniles are released on an incoming tide, at dusk or in the evening at a time when they are normally active (as much as possible, release should be planned so that these conditions can be met).
c. One person walks inside the pen with the sandfish in a bucket and releases sandfish near the center of the pen. Crabs caught inside the pen will initially be found at the periphery, away from the center, so juveniles will be safer at the center.
d. If the water is deep (more than 1m), sandfish should be taken to the bottom in a plastic bag and placed on the floor by someone on snorkel.
e. The pen needs to be inspected again 1-2h after release to make sure predators are removed.

11.10 Sandfish pen sampling sheet

Date _____

Pen ID island/site/pen No _____

Observations _____

Habitat silt ☐ sand ☐ sand+rubble ☐

	Quadrat 1	Quadrat 2	Quadrat 3
Seagrass species present			
% total seagrass cover			
Avg canpoy height			
Anoxic layer			
Depth			
Thickness			
Strength[1]			
Penetrometer			
Reading 1			
Reading 2			
Reading 3			
Core samples for Chl x2	☐	☐	☐
acetone 72h	☐	☐	☐
fluorometer reading			
drying for 72h	☐	☐	☐
stored	☐	☐	☐
Core samples for OM x5	☐	☐	☐
drying for 72h	☐	☐	☐
stored	☐	☐	☐

Sandfish pen _____

Shape round ☐ square ☐

Size (m^2) _____

Mesh size _____

No of sandifsh stocked

Time of release

Tide (coming up/down)

[1] Anoxic layer strength dependning on colour/darkness: weak, medium, strong

11.11 Environmental sampling - sandfish

Equipment

- Quadrat 0.5 x 0.5m
- Syringes (60 ml) for core sampling
- Sample jars (60 ml) for sediment samples
- Tubes (10 ml) for chlorophyll testing
- Fluorometer for chlorophyll reading
- Pencil and sharpener
- Waterproof labels
- Masking tape
- Acetone (small volume in sample jar)
- Pipette or syringe to dispense acetone

Quadrat sampling at the start (before release of juveniles)

x3 random quadrat samples per pen

For each quadrat sample carry out the following observations:

- Seagrass species present;
- Percentage of total seagrass cover (to the nearest 5%);
- Average canopy height of the dominant seagrass species (discounting the tallest 20% of leaves)
- Estimate presence depth and strength of the anoxic layer (using core or digging)
- Core samples for chlorophyll:
  - Label a 60ml sample jar with pencil on masking tape (eg. Abaiang, date, site ID, quadrat No)
  - Label a 10ml tube same as jar with masking tape (eg. Abaiang, date, site ID, quadrat No)
  - Place x2 1cm cores combined in the jar (keep chilled and in the dark if you cannot carry testing immediately)
  - Transfer approx. 4g of sample in the 10ml tube (fill up to black line)
  - Add 5ml acetone to the tube and shake
  - Keep tube in the dark and refrigerate as soon as possible
  - Shake twice a day for 72h until reading, see below
- Core sample for organic and grain size:
  - Using the 60 ml jar previously labelled
  - Place x5 2cm cores combined in the jar (keep chilled and in the dark if you cannot dry immediately)
  - Place a second waterproof label inside the jar
  - Start drying the sediment samples by evaporation asap
  - Drying is best done in Tanaea using a food dehydrator (see Tentaku for this)
  - Take lids off for samples to dry in food dehydrator
  - Once sediment sample is dry, replace the lid and store in safe place (eg. on one of the shelves in the algae room)
  - Stored samples will be taken to Noumea for further processing (dry weight)

  Chlorophyll reading:
  - Taking care not to stir sediment in the tube
  - Draw 2ml from the top of the supernatant and place in fluorometer cuvette
  - Place cuvette in the fluorometer
  - Turn fluorometer ON (wait for 5s count down)
  - Select the correct channel B and press “READ”
  - Wait until “WAIT” signal is off and record reading
  - Take tube back to Tanaea and dry sample in food dehydrator (sit tubes in a sample jar for support)

- Remove lids from the tube for drying
- Leave samples to dry for 72h
- Replace the lids and store sediment tubes in safe place (eg. on shelf in algal room)
- Stored samples will be taken to Noumea for further processing (dry weight, organic matter and grain size)