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Final report

project

Exploring options to improve livelihoods and resource management in Timor-Leste's coastal communities

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1 Acknowledgments

WorldFish acknowledges the partnership of the Timor-Leste Ministry of Agriculture and Fisheries (MAF); Roman Luan as an implementing partner in carrying out household surveys across 15 communities in Atauro Island; and all the communities involved in the research. SPC (Pacific Community) provided invaluable inputs on FAD design and deployment in the early stages of the project.

2 Executive summary

As a young post-conflict state with new government institutions and rapid population growth, Timor-Leste faces multiple challenges in lifting her people out of food insecurity and generating wealth to fuel economic growth. Recent research in rural and coastal communities suggests that the fisheries and aquaculture sectors are falling well short of their potential to contribute in a substantive way to improving livelihoods, food and nutrition security and wellbeing. Micronutrients and amino acids available from fish in particular have great potential to improve health and development outcomes in the first 1000 days of life. This project targeted two interventions with potential to improve fisheries yields and sustainability that were given the highest priority by communities and government in fisheries diagnoses conducted under preceding projects – technology development for nearshore pelagic fisheries, and improved community-based management.

Diagnostic and baseline data were collected using a detailed broad-coverage household survey on Atauro Island – a highly fish-dependent area, and through participatory diagnosis methods in the three project focus communities. The survey highlighted that specialising as a fisher was rare, with most households engaging in a number of livelihood activates. Fishing was less subject to shocks than other natural-resource based livelihoods, and where fishing could be practiced year-round, livelihoods were less diverse suggesting some preference for fishing when and if it was an option. Fishing showed a greater contribution to household income than crop farming. The study found that geographic location, rather than livelihood structure, was the best predictor of household wellbeing indicators. Clearly structural drivers of poverty are dominant, and need to be addressed along with livelihoods and resource status in policy interventions.

During previous projects fishers highlighted Fish Aggregating Devices (FADs) – locally called *rumpon* - as a potentially productive approach to diversifying livelihoods within the fishery sector. Nearshore FADs are an anchored floating mass designed to provide a habitat that attracts pelagic (oceanic) fish close to shore, making these fish accessible to small-scale fishers. Timor is regionally unique in that current exploitation rates of these stocks appear quite low. Initial attempts to deploy FADs failed due to extreme bathymetric and current conditions, and a drawn out process of design evolution produced a design that now appears robust and suitable. New FAD designs deployed with communities on Atauro Island have enabled increases of up to 2.5 fold in the catch per unit effort of small pelagic fish.

Moreover, the combination of FADs and new community rules for reef management tested through this project, worked exceptionally well at increasing yields while reducing reliance on vulnerable reef fisheries. The promise of improved access to pelagic resources through FAD deployment provided an equitable mechanism to enable the community to develop and enact rules that would reduce their own fishing pressure and use of unsustainable fishing methods on reef areas. The close proximity of FADs to the community ensured that this change in fishing location did not disadvantage the poorest among the fishers, who rely on small non-motorised canoes to access fishing sites. The use of the traditional *tara bandu* institution for developing community rules was successful, and an *ex-post* case study of a coastal tara bandu established 5 years ago showed sustainability without continued external input, and high levels of community ownership and respect for rules.

To build government capacity to engage effectively in co-management, the project also worked with the fisheries administration towards developing an improved fishery data collection system, which also functioned as a monitoring system for project outcomes.

The governance system in Timor-Leste is 'primed' to adopt co-management as a principal approach to coastal fisheries management, yet there is little guidance on approach, and there has been no government-led implementation to-date. This project provides a clear pathway to implementation and has tested a technological innovation to sustainably improve food and nutrition security outcomes. Project outputs and outcomes will directly influence new policy directions in Timor-Leste through the new National Fishery Strategy currently (2017-18) under development.

3 Background

As a young post-conflict state with new government institutions and rapid population growth, Timor-Leste faces multiple challenges in lifting its people out of food insecurity and generating wealth to fuel economic growth. While the speed of transition to stable, democratic governance has been remarkable, Timor-Leste remains among the poorest nations in the world, ranking 133 out of 147 countries in the UN Human Development Index listing (2015). The country has one of the world's highest rates of maternal, newborn, infant and child mortality and under-nutrition from hidden hunger or micronutrient deficiency. A looming challenge for Timor-Leste is to look beyond the current heavy reliance on oil (currently ca. 90% of national income) to a future with a diversified and sustainable national income making optimal use of renewable natural resources. The urgency of this transition is highlighted in recent projections which suggest that within a timeline of 10 to 15 years oil income will drop significantly.

The Timor-Leste Strategic Development Plan (2011-2030) highlights a national development priority of moving towards self-sufficiency in food production, and holds fisheries up as one of the sectors capable of making a greater contribution to this goal. However food production indicators currently do not tell an encouraging story. Despite the agricultural sector employing some 80% of the active population, and agricultural production accounting for 30% of non-oil GDP, in recent years the food sector component of agricultural GDP has declined on a per-capita basis, reflecting a failure to keep pace with a rate of population growth which is amongst the highest in the world (c.a. 2.8% per annum).

Recent research and community engagement by WorldFish, the FAO Regional Fisheries Livelihoods Program (RFLP) and others suggests that the fisheries and aquaculture sectors are currently falling well short of their potential to contribute in a substantive way to improving livelihoods and food security. In stark contrast to neighbouring nations and small island states globally, Timor-Leste makes relatively little use of its living marine resources. Fish consumption is low, estimated to about 6kg/capita/yr (AMSAT International, 2011) (c.f. Indonesia: 21.3; Solomon Islands: 33.0; Kiribati: 62.2). In neighbouring countries, severe overexploitation and overcapacity in fishing fleets dictate that improved fisheries governance is a priority. In contrast, however, there appears to be scope for further industry development in Timor-Leste. The apparent underutilisation of pelagic marine resources presents as a significant opportunity to improve protein/micro-nutrient supply through promoting sustainable marine resource use. Clearly, however, caution is required. The history of targeted fisheries development projects, particularly in developing countries, is replete with stories of unintended consequences and idealistic conceptualisations of development that have led to negative outcomes.

Community fisheries in Timor-Leste have long centred on reef resources, while offshore resources were primarily the domain of the colonial powers (Portugal and Indonesia). At the time of independence from Indonesia most larger vessels either departed for Indonesia or were destroyed, and there is little extant local knowledge or capacity for offshore fishing. Currently fishing for pelagic resources is essentially limited to small species such as scad, sardines, long-tom and flying fish, caught by gill netting or trolling from small vessels. Within the national fleet there are very few inboard fishing vessels capable of working offshore.

It is appropriate then, that a rejuvenated wild fishery and aquaculture sector is among the key national objectives articulated in Timor-Leste Strategic Development Plan (2011-2030). However strategies to move this objective forwards are not well developed, and capacity within the National Directorate of Fisheries and Aquaculture to conduct research, and to implement contextualised interventions directed at this goal is low – both in terms of human capital and investment.

There is little data available on the current state of fisheries, and a low level of understanding of current exploitation rates. The FAO-led Regional Fisheries Livelihood program undertook a process of fishing vessel registration, registering some 3700 vessels. A consumption

survey conducted by the same project suggests fish consumption within Timor-Leste of about 7000 tons per annum, however imports are not well accounted for, and are substantial. The lack of historical data on catch and effort requires that participatory diagnosis with fishers become central to understanding changes in the sector.

This project targeted two sets of interventions related to fisheries and coastal livelihoods that were given the highest priority by communities in diagnosis work conducted under preceding projects – livelihood development and improved community-based management. While a limited scope within these focus areas was necessary due to the resources available to the project, the project has formed the foundation for a broader livelihoods approach to improving resilience of coastal communities in Timor-Leste. A diversifying WorldFish project portfolio in Timor-Leste provides the mechanism to build on project outcomes.

Our diagnosis work with communities in 2012 warned that reef resources were under pressure from increasing exploitation rates, unsustainable fishing methods and upstream effects from agricultural and forestry practices. Building more diverse fishing livelihoods would fulfil multiple objectives of providing additional high-quality animal protein to improve food security in communities, improving the ecological status of coastal reefs, and increasing resilience of coastal livelihoods to uncertainties associated with declining resources and projected reef impacts of climate change.

During this previous work, in a number of coastal communities fishers highlighted Fish Aggregating Devices (FADs) – locally called *rumpon* - as a potentially productive approach to diversifying livelihoods within the fishery sector (Mills et al., 2011; Park et al., 2014). Nearshore FADs are an anchored floating mass designed to provide a habitat that aggregates pelagic (oceanic) fish close to shore, making them accessible to small-scale fishers. In effect this creates a new productive fishing habitat accessible to communities. Technology previously introduced from Indonesia, involving a substantial bamboo raft roped to cement drum anchors in depths of up to 800m, had been utilised in a number of communities to increase catches of pelagic fish. Over the previous three years during past WorldFish engagements with communities we observed a number of fisher groups investing enthusiastically in FADs. However, this number dropped off as fishers encountered continued loss of investment due to failure of hardware, and were discouraged by the effort required to build and deploy new FADs. Ultimately many fishers returned to reef fishing. Experience from FAD programs elsewhere in the Pacific provide opportunities for testing different designs, and tailoring FAD systems to the Timor-Leste context. The project sought to develop community-focused FAD programs building on experience from the Pacific, and incorporating existing knowledge of FAD systems in Timor-Leste.

FADs potentially provide an alternative to reef fishing and therefore can be an important tool in restoring the health of reef fisheries. However global research suggests that providing alternative opportunities may not, in itself, be adequate to reduce pressure on existing resources. Indeed, perverse effects have been demonstrated where new sources of income allow for increased investment in existing fisheries, resulting in negative outcomes from interventions. This project sought to test a combined approach, with the introduction of improved FAD technologies alongside the development of community-based management systems for reef fisheries. Again, learning from experience throughout the Pacific, the project sought to work directly with men and women in communities to facilitate active use of traditional institutions to effectively and sustainably manage reef resources.

The second area of project research is in resource management. Structurally in Timor-Leste there is very little devolution of responsibility, capacity or financial support for managing natural resources below the national level (Weaver 2008). Existing fisheries regulations provide limited direct scope for the active involvement of communities in resource management, although The General Regulations of Fishing (Decree 5/2004 (article 37)) provides a mechanism whereby co-management committees have a "consultative" voice in national policy fora but do not provide scope for local rule-setting or management actions at the local level (See Mills 2013 for more detail).

There are a number of studies suggesting that centralised, top-down regulation of natural resources has eroded and undermined the power and legitimacy of traditional coastal tenure systems (see McWIlliam 2003). An alternative view posits that the reality of minimal implementation capacity of centralised systems, and a confusion of often contradictory colonial policies, means that communities have used customary tools available to them to get on with the essential processes of resource management (Miyazawa 2010). Of particular note, a customary system of rule-setting and resource management called 'tara bandu' (literally 'hanging prohibition' - the name refers to the hanging of symbolic items on an altar to mark the enactment of new regulations) is broadly applied at the community level in Timor-Leste to manage diverse resources.

There is considerable interest among government departments responsible for natural resources in incorporating tara bandu systems into formalised resource management at the sub-national level. Implementation in marine systems at the time the project commenced was rare, and the project sought to assess outcomes from an existing system, and work with focal communities to catalyse and understand the process of tara bandu implementation for coastal systems.

4 Objectives

The overall aim of this program was to pilot systems to improve food and nutrition security, productivity and resilience of fisheries systems, and community livelihoods in coastal areas of Timor-Leste. These were achieved through four objectives:

1. Work with three coastal communities to understand livelihoods, vulnerabilities and pathways to improved resilience and food security.
    - Contextualise and apply community level participatory gendered diagnosis methods developed by WorldFish and partners
    - Develop livelihood calendars to understand seasonal variation in livelihood composition and vulnerabilities from the perspective of men and women
    - Map decision-making networks to facilitate sustainable interventions in focus communities
    - Develop implementation pathways and strategies for major interventions in each community.

2. Conduct participatory action research with partners and communities to test interventions designed to increase livelihood resilience
    - Conduct participatory research with community co-operatives on the cost benefit and efficacy of community-managed fish aggregating devices (FADs) at providing increased access to pelagic resources for small boat owners
    - Work with Seeds of Life and communities to introduce new crops, high-yielding varieties of seed and improved seed storage systems
    - Work with communities and external agencies as appropriate to design and test specific interventions identified from diagnosis workshops

3. With communities, design and test approaches to community-based management of reef and coastal resources that integrate with traditional management systems
    - Catalogue and document traditional resource management systems in focus communities
    - Work with informal and formal decision-makers towards appropriate formulations for community-based resource management
    - Provide expert input to formulation of legislation to support community-based management

4. Build capacity for monitoring and managing coastal fish resources within the National Directorate of Fisheries and Aquaculture
    - Ensure active participation by MAF staff in project diagnosis and intervention trials
    - Provide regular training and feedback sessions to MAF staff
    - Review and refine systems, processes and outcomes from the fishery data system initiated by FAO RFLP in partnership with MAF

5 Methodology

Project activities were built around community level diagnosis, participatory action research, and a strong partnership approach to capacity building. The project linked directly to national objectives for agriculture and fishery sector development, promoting integrated, sustainable outcomes while improving food security and livelihood resilience. WorldFish provided access to international experience through partnership (SPC) and engagement with our international staff.

The four project objectives worked across multiple tiers of governance and with multiple stakeholders to model collaborative approaches to resource management and development. This project was implemented in parallel with initiatives directly engaged in fisheries policy development for Timor-Leste, and provided valuable input into contextualising approaches.

Objective 1: Work with three coastal communities to understand livelihoods, vulnerabilities and pathways to improved resilience and food security

Community-level activities and diagnosis were fully participatory and guided the development technological trials and governance innovations. This project component built heavily on work completed by WorldFish and MAF in 2012, which in turn integrated recent advances in participatory social research for development. Community engagements were staggered to facilitate adaptive learning and improvement of diagnosis methodology. In a previous project in 2012 WorldFish worked in two highly fish-dependent communities (Beacou and Atauro Island) selected by MAF. These sites continued to be focal sites in this project, and accordingly researchers knew well the context of these communities. Lessons from preliminary diagnosis in these two communities were incorporated into approaches in this project.

Preparatory and diagnostic work with communities occurred in four phases:

1) Familiarisation/orientation: Focus communities were selected by MAF, and site details are presented in Appendix 3. Early meetings were held with the Chefe and male and female community members to familiarise them with project objectives and request their partnership on the project. These meeting also facilitated early collection of information on dominant livelihoods, of importance for structuring later diagnosis meetings.

2) Participatory livelihood diagnosis: This series of workshops used a gendered approach to examine livelihoods, strengths and vulnerabilities among community members. The process used methodologies adopted, developed and refined during the preceding livelihoods and community adaptation projects (ADB and SEWPaC funded). Separate men's and women's groups produced livelihood calendars, showing seasonal changes in livelihoods, weather patterns affecting and driving these changes, and livelihood vulnerabilities. Community assets were catalogued through processes including livelihood group interviews and gender-disaggregated transect walks. Interventions targeted to reduce exposure and/or sensitivity to identified threats were listed and ranked for desirability and feasibility.

3) Fisheries sector analysis: Participatory resource use mapping with separate men's and women's groups lead onto a process of resource status assessment, providing information on change in availability of major resources now compared to 'Indonesian times' (prior to 2000). In parallel we collected information about the most important species for market and for home consumption.

4) The growing focus on Atauro Island among NGOs and government development programs, and the opportunity to partner with a very capable local NGO enabled the project to develop a comprehensive livelihood survey on Atauro Island. The

survey was conducted using a structured questionnaire in 15 coastal and inland villages of Atauro Island between December 2014 and April 2015. The study was designed to collect both integrative long-term indicators and short-term indicators that could be re-sampled on a seasonal basis with a reduced survey; (only results from the initial survey are presented in this report). Gendered focus groups were held to ensure that questions were appropriate to local context, and that 'closed' questions employed in the survey contained appropriate options.

The survey team comprised six Atauro Islanders who were familiar with the culture, and were fluent in Tetum (one of two official languages spoken across Timor-Leste) and at least one of the 3 dialects of Wetarese spoken on the island (Rahesuk, Resuk/Wawa and Raklungu). Training of the team included a day of classroom training prior to conducting any surveys, a day of field testing, and a review of data after each of the team had completed five surveys. Data were entered into an MS Access database by the field team leader, allowing for further questioning of the field team if answers were unclear. The survey was applied following multi-stage cluster sampling methods. Respondents for the survey were the household heads (as defined by the respondents themselves), with 460 male and 35 female respondents. Full details of the survey design and implementation can be found in Appendix 1.

Objective 2: Conduct participatory action research with communities and partners to test interventions designed to increase livelihood resilience and food security

Outputs from objective 1 highlighted priority intervention strategies targeted at improving livelihood resilience or addressing food security issues in each focus community. Ultimately, the size of the project limited the range of interventions that we could develop, however unsurprisingly access to fisheries resources, and the current state of the fishery were highlighted as priorities by all communities. Diagnosis work in some communities (notably Beacou, near the western border with West Timor) became the basis for seeking further funds, and this research is now being applied in parallel projects.

Fish aggregating devices (FADs): The project partnered with SPC for the first set of 3 FAD deployments on Atauro Island. This provided the first opportunity for training an 'expert FAD team' comprised of MAF field officers and WorldFish staff. A former Indonesian pole-and-line inboard fishing vessel was chartered for the deployments. These FADs were based on Pacific experience, and quickly proved unsuitable for the extreme conditions encountered in Timor-Leste. Anchors for these original deployments were 2 large steel grapnel anchors, which did not provide the traction required. The FAD team undertook a process of design evolution lasting approximately 2 years that ultimately led to a robust design that has proven far more suitable in the prevailing conditions of steep bathymetry and strong currents (see Appendix 2 for details). Critical in this process was bringing two WorldFish field staff from Solomon Islands to provide inputs to the FAD program, and further train the FAD construction/deployment team. During this time, FADs were deployed in 2 sites to test designs, and while these FADs did not always last well, this facilitated data collection on value and impact of FAD systems to livelihoods.

Outcomes from FAD deployment were monitored through the initiation of a catch monitoring system funded through a parallel project. Focus groups and key informant interviews provided first-hand accounts of the impacts of FAD systems in communities for FAD fishers, women and non-FAD fishers.

Objective 3: With communities, design and test approaches to community-based management of reef and coastal resources that where appropriate integrate customary rule-making and resource management systems

The project was conducted in close collaboration with the Ministry of Agriculture and Fisheries, Timor-Leste (MAF). Focus sites for community-based management research (figure 1) were recommended by MAF due to high levels of fishery dependence. Sites on Atauro Island were selected as the island is an area of exceptionally high marine biodiversity, with a high concentration of fishers, and a strong need for participatory governance interventions. Beacou was selected as a case-study with a longer history of participatory governance, in order to provide lessons applicable to new sites.

We worked with men and women fishers and influencers on Atauro Island, and village and sub-district decision-makers to design and implement local management of selected reef or nearshore resources. Much of the engagement and preparation work builds directly off Objective 1 above, with diagnosis activities directly feeding into the design of community based management systems. Management centred on a traditional institution - tara bandu. The Environmental Base Law (Article 8, point 1, 2, and 3) recognizes tara bandu as a customary institution to be used in regulating the relation between humans and the environment. Tara bandu refers to local laws used by communities and is closely related to cultural perceptions of the environment. Tara bandu refers broadly to prohibitions (Hicks 2004) that can be applied to agricultural, forestry or fisheries harvesting in a given area for a set period of time (Shepherd 2013), or for more general protection of ceremonial sites. In Aileu, tara bandu is used to prohibit tree-cutting to prevent flooding; in Bemalae Lake in Maliana to restrict fishing to once a year (Needham, Alonso et al. 2013). Given the complex ritual beliefs underpinning the mechanism, it is believed that if people break a tara bandu they will be cursed (Miyazawa 2013) – see **Appendix 3** for further analysis.

An organic, largely community-led process of specifying objectives, understanding capacities, rule making, and ultimately launching the tara bandu was undertaken. Ongoing monitoring activities are captured under objective 4.

Objective 4: Build capacity within the MAF for monitoring and adaptive management of coastal resources.

The MAF has struggled to implement existing fisheries policy, in part due a lack of investment and a lack of human capacity/training. WorldFish experience over the 2-3 years prior to project implementation demonstrated that there was enthusiasm amongst staff members to be exposed to new concepts of management, and to engage in the processes of management and management formulation. Close partnership with MAF staff across all project objectives provided exposure to scientific endeavour, management actions and innovative management systems beyond what is normally available to department staff. This forms an important pillar of the work WorldFish undertakes in Timor-Leste. MAF staff were directly involved in facilitating diagnosis processes, planning

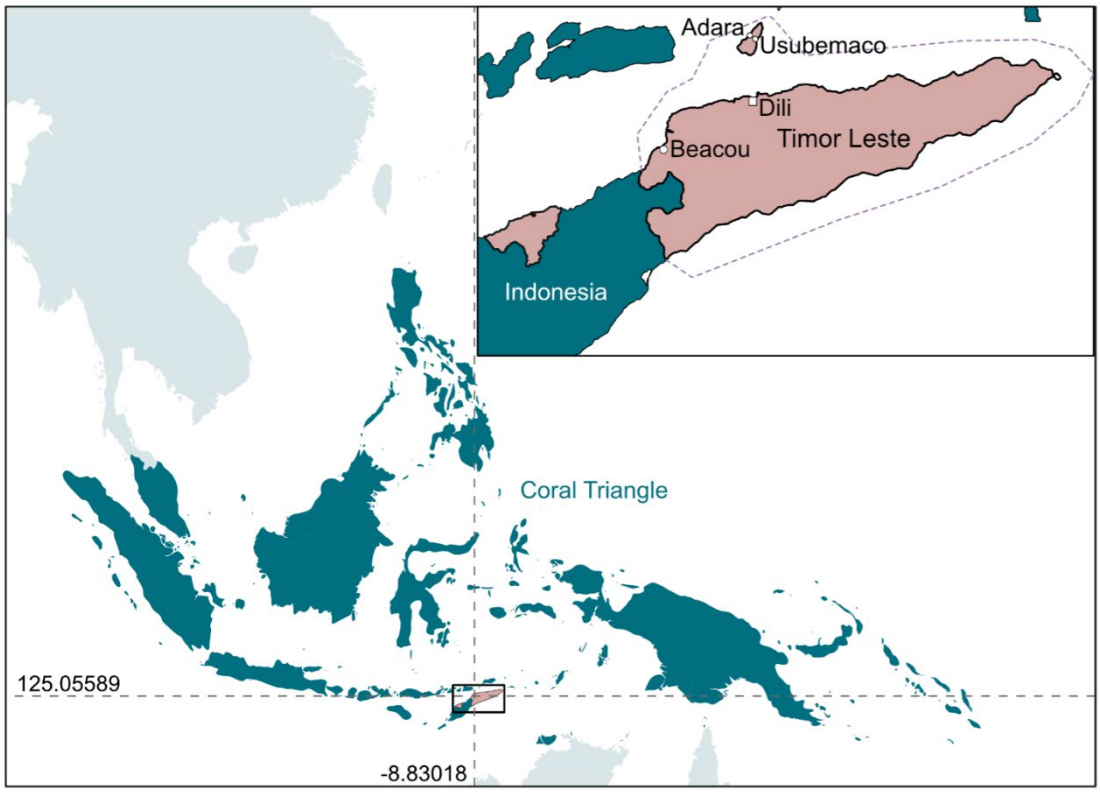

Figure 1. Study sites Adara, Usubemaco and Beacou were selected by government project collaborators in consultation with communities

community actions, scientific analysis of intervention outcomes and dissemination of results.

A core objective of the project was to contribute to increasing the capacity within MAF for effective monitoring of fisheries. In the post-colonial years, there has been no functional system for monitoring of fish landings in Timor-Leste. The FAO Regional Fisheries Livelihoods Program (RFLP) trained and supported a handful of MAF field staff to collect fisheries landing statistics at a small number of sites over about a year, and instigated a simple, web based system of data entry and database system called *Peskador*. These data were never analysed and the collection of data ceased as soon as the project ended. For project monitoring purposes, the data system was reactivated, and field officers from our project sites utilised the system, however separate records were also kept to ensure more detailed analysis of results was possible. We worked with former RFLP staff and MAF staff to clean and analyse existing data in the system. The data system included a boat registry and catch information collected over a period of about a year. These data were screened and preliminary analysis completed, enabling identification of the benefits and limitations of the current data system. Results were presented to MAF staff in a workshop, and plans for future development of a fisheries monitoring system discussed.

6 Achievements against activities and outputs/milestones

Objective 1: To Work with four coastal communities to understand livelihoods, vulnerabilities and pathways to improved resilience and food security.

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
1.1	Inception and Selection of focus communities	Inception meeting held, 3 focus sites selected	Inception workshops held in 3 communities (2 on Atauro Island, 1 on the western border).	Following discussions with initial focus communities, in two instances engagement was expanded to adjacent communities that regularly shared fishing grounds.
1.2	Diagnosis and pathway analysis in communities	Diagnosis workshops (2 per community) complete	Gendered focus groups held to understand livelihood systems and natural resource use patterns. Gendered livelihood calendars, resource use maps, and resource status studies produced. As Atauro Island was the building focus of multiple interventions, and we identified and excellent local NGO partner, diagnosis was expanded to a household survey on livelihoods and food security, which also forms a resource for others engaged in development work on the Island. The survey provides a picture of spatial distribution of livelihoods and vulnerabilities, as well as additional detail on fishing livelihoods. It provides important information to be considered in policy design.	Paper published in Marine Policy special edition on Livelihoods in the Arafura/Timor Seas Region Mills, D.J., Tilley, A., Pereira, M., Hellibrand, D., Fernandes, A. and Cohen, P.J (2017). Livelihood diversity, vulnerability and food security among small-island fishing communities in Timor-Leste. *Marine Policy* 82: 206-216 Manuscript in prep: Tilley, A., Cohen, P.J., Pereira, M, Guterres, A., Mills, D.J. (in prep) Characterising the fisheries of Timor-Leste

Objective 2: Conduct participatory action research with partners and communities to test interventions designed to increase livelihood resilience

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
2.1	Priority livelihood interventions selected	Interventions agreed for all focus communities	All communities were already heavily invested in the idea of FAD development, and due to limited traction with Seeds of Life, we were restricted to marine resource domains. Adara selected tourism as a second intervention, and development of a no-take LMMA as a component of their local management system has significantly boosted tourism to the village.	
2.2	Local FAD rules devised and FADs deployed	FADs deployed in focus sites as requested by communities	In all communities, systems for shared FAD ownership were established, with a group responsible to ensure local villages were aware of trials, and that the FAD was maintained. FAD system development took substantially longer and was significantly more expensive than anticipated due to issues with extremes of bathymetry and current, and possible vandalism issues in 1 site Initial deployments guided by SPC were unsuccessful due to inappropriate anchoring, inadequate community engagement, and an insistence that FADs must be set deep (beyond the area where the community where comfortable fishing) WorldFish Solomon Islands team provided excellent training, mentoring and safety advice for FAD deployment Anchor system trials to accommodate small vessels were unsuccessful, although training	WorldFish story at: https://soundcloud.com/worldfish/inshore-fish-aggregating-devices-in-timor-leste

			from Solomon Islands team improved safety of small vessel deployments. Through the steps above, and broad consultation we have developed a FAD system appropriate for Timor-Leste, and have now developed a program that will see FADs rolled out in a number of additional communities in numbers that may drive new opportunities for communities.	
2.3	Community seed production groups	Seed provided and groups established in all focus communities	Links with Seeds of Life group were ultimately limited. While seed distribution occurred on Atauro Island, this came late in the project cycle for both our project and SoL, and no monitoring was carried out	
2.4	Adaptive learning meetings	Community workshops conducted	An adaptive learning cycle was established in Adara and Beacou, with regular reflective meetings with key operators and groups. This was critical in the process of developing local management rules, and improving FAD systems.	

Objective 3: With communities, design and test approaches to community-based management of reef and coastal resources that integrate with traditional management systems

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
3.1	Document traditional NRM systems	Analysis complete in all focus communities	Traditional NRM systems were very limited in all communities. A fishing area was recognised, as was the authority of the chief, but few formal rules were in place. There was some limited recall of historic rules in limited cases, and understandings with nearby communities regarding shared fishing areas	

3.2	Strategies for CBFM in focus communities	Strategies developed with at least 2 communities	Among the 3 sites/clusters we worked in: In Adara we worked with the community to develop a CBFM system that included rules for fishing and (as requested by the community) a no-take zone to promote tourism In Beloi (Atauro Island) the fishers were open to the notion of CBFM, but only if FAD systems were first shown to be viable. Disagreement and distrust among 'factions' within the fishing community made further work in Beloi increasingly difficult. In Beacou, a traditional tara bandu system was in place following an FAO project. This provided the opportunity to research aspects of sustainability and perception.	Draft manuscript in collaboration with Conservation International and FAO: Cohen, P.J., Mills, D.J., Pereira, Alons- Población, E., Tilley, A., Guterres, A. (draft) Status and potential of community based fisheries management in Timor-Leste (This paper is a simplified version of Appendix 3) Draft manuscript lead by FAO (M. Pereira is project scientist) Alonso-Población, E., Rodrigues, P., Wilson, C., **Pereira, M.,** & Lee, R. U. (2017). Tara bandu as a hybrid mechanism for coastal and marine governance in Beacou, Timor-Leste. *Maritime Studies*, (Special Issue). See media at: http://www.abc.net.au/news/2016-07-14/timor-development-since-independence/7441168?pfmredir=sm http://www.worldfishcenter.org/content/communities-tackle-coral-reef-sustainability-timor-leste
3.3	Impact assessment of CBFM approaches	Community surveys and data analysis complete	Focus groups and individual interviews were conducted in Adara and Beacou to understand the outcomes of CBFM approaches. The Adara tara bandu is new, but has had considerable impact on tourism in the community The Beacou tara bandu has been maintained and 'normalised' within the community. While there are recorded instances of sanctions being employed, the general feeling is that some 5 years after declaration, it has had positive outcomes for the community	See WorldFish story at: http://worldfishcenter.org/pages/adara/

3.4	Provision of policy advice	Policy brief on implementation of CBFM	Policy brief to be developed as a more accessible version of the paper highlighted in 3.2 above and translated into Tetun (budget quarantined for this)	

PC = partner country, A = Australia

Objective 4: Build capacity for monitoring and managing coastal fish resources within the National Directorate of Fisheries and Aquaculture

No.	Activity	Outputs/ milestones	What has been achieved?	Comments
4.1	Assess quality of existing fisheries data	Report on data quality and use	• Data from the existing database have been cleaned (extensive process due to absent data checking protocols) and analysed using the PasGear software system. • No data has been entered into the system (other than from WorldFish field staff) since the FAO fisheries program finished • Data quality is poor, and potential use of the data is very limited due to non-structured sampling and a lack of useable effort data • Development of a reduced but functional data system is now being pursued through a recently initiated linked project	
4.2	Training of NDFA staff in data use	Training workshop completed	The analysis component of the project was delayed significantly due to the loss of key staff for this component at WorldFish HQ. This was completed in Q4 2016, and a training workshop on a) data outcomes from the existing database, b) system currently being pilot-tested, c) proposals for moving forwards with MAF collaboration/ownership conducted in January 2017	

4.3	Improved systems of monitoring	Policy brief produced	As the project progressed, it was recognised that a policy brief was not the right communication tool here. Instead, printed matter was produced for the training session with MAF staff. Component outputs will feed directly into the development of the National Fishery Strategy, providing advice on priorities for a fisheries data system.	
4.4	Collaboration with Indonesian scientists	Workshop held	Due to delays in this component, and non-continuation of an ACIAR project in Indonesia, this has not proceeded. A carry-on ACIAR project now under development will expand links with Indonesian scientist in the areas of FADs and CBRM	

7 Key results and discussion

7.1 Objective 1: To Work with three coastal communities to understand livelihoods, vulnerabilities and pathways to improved resilience and food security

7.1.1 Participatory diagnosis in coastal communities

Key Results

- Tools were developed or refined to facilitate a standardised system for diagnosis, encompassing livelihood structures and assets, seasonal changes, vulnerabilities and fisheries resource status.
- Simple fishing technology means that, with few exceptions, community fishing activities occur within a range of five kilometres from the community, and often within 1 km from shore.
- In the two communities dependent on reef resources, a 'resource crisis' was evident.
- Women's engagement in fishing is variable by community, but generally high, and gleaning is important to all communities for food security and income.
- Customary management for marine resources is very limited, with the traditional institution of *tara bandu* recognised, and applied to terrestrial resources. Communities were enthusiastic about applying *tara bandu* to marine resources.

Discussion

Participatory diagnosis is a key first action in any coastal community-focussed project, and can take many forms. Key questions for this project were:

- What resources are critical for men and women's livelihoods in the community, and has this changed over time?
- What is the current status of these important resources, and how has this changed over time?
- How do livelihood mosaics change throughout the year for men and women, and what are the drivers of these changes?

Building on previous project methodology and outcomes, a key set of tools to answer these questions was developed. Outcomes from this analysis are provided in detail in diagnosis section of **Appendix 3**.

Atauro Island encounters two weather patterns in a year; an easterly and westerly season. Analysis showed that those communities subject to stronger winds in both seasons had on average more diverse livelihoods, and livelihood calendars showed a different range of agricultural and labour activities substituting for fisheries when fishers were unable to go to sea, or there were reduced numbers of days that were suitable for fishing. Adara's location on the west coast of the island facilitates year-round fishing when strong westerly winds (May-Aug) inhibit fishing from east coast centres such as Usubemaco (see appendix 1). Women in Adara engage in spear fishing and line fishing, and often fish with their husbands when netting. Gleaning fisheries are largely the domain of women and youth in all sites, although men do participate at times. The dominant fishing gear-types have different peak seasons driven by weather conditions and fish abundance. In Adara, net fishing peaks in April through to July, hook fishing in July and October, while spear fishing is generally not conducted in the rougher seasons of December to March. In Beaco, sardine fishing is the

most important fishery during the wet season – sardines are not caught on Atauro Island in significant numbers.

On land, the long dry (westerly) and short wet (easterly) seasons, coupled with poor access to freshwater, limit the productivity of crops. The participatory seasonal livelihood calendar developed with men and women in Adara, show this clearly with year-round fishing, and a fairly limited range of agricultural crops. Beacou again differs substantially from the sites on Atauro Island with agricultural activities dominate by rice farming.

In Adara, livestock are critical for income resilience. Sales in August relate to the 'wedding season', while those in December are for Christmas and New Year celebrations. We note that as a dominantly Christian and Protestant community, the ritual traditions formerly associated with livestock consumption (see Alonso 2013) are no longer practiced. While staples of banana and cassava are listed as being cultivated year-round, harvest times are also seasonally limited.

Participatory marine resource mapping in all communities showed that the rudimentary fishing gear types and small boats limit exploitation mainly to areas very close to shore. Gleaning areas are typically those reefs or rocky areas within easy walk of communities.

While some consistent patterns relating to structural, technological and geomorphological drivers are seen, livelihood mosaics differed considerably between communities. Clearly, interventions that target livelihoods must use participatory tools to understand how best to build on community strengths, and how to optimise the outcomes from interventions.

7.1.2 Comprehensive livelihoods survey in Atauro Island

Key Results

- Fishing was less subject to shocks than other natural-resource based livelihoods.
- Where fishing could be practiced year-round, livelihoods were less diverse suggesting some preference for fishing when and if it is an option.
- Location, rather than livelihood structure, was the best predictor of wellbeing indicators.
- Policy-makers must understand livelihoods and contextualised drivers of poverty.

Discussion

This study resulted in a primary publication, presented in full as **Appendix 1**. Using data from 495 households across 15 communities on Atauro Island, Timor-Leste, we evaluated the importance of fisheries within a suite of livelihoods; the correlation of livelihoods structure with wellbeing; and the spatial and temporal variation of those livelihoods. The research showed that in Timor-Leste specialisation as a 'fisher' is uncommon compared to diverse livelihoods that can be adapted as opportunities and challenges emerge. Understanding this dynamic "livelihood landscape" is important for improving governance and livelihood opportunities associated with natural resources.

Activities linked to primary production were nominated by 67% of households as their primary livelihood, 41% fished, and of those 54% considered fishing their primary livelihood. Almost all households (95%) owned livestock, and even respondents who considered themselves 'fishers' ranked livestock disease, rather than fisheries related concerns, as their most critical livelihood challenge.

This research highlights that even if governance and livelihood interventions are focused on fisheries, interactions with other livelihoods must be considered. That is, if interventions were to work with people who rely principally on fishing, they would only be focused on a fraction of the population that derive benefit from fisheries resources; they would overlook the greatest vulnerabilities fishers (and broader coastal communities) face and, in the case of Atauro Island, they would be focused on the most food and income secure sector of the natural resource dependent population. Measures of wellbeing were better explained by geography and socio-cultural settings, rather than dominant income sources. The results

emphasise the value of cross-sector development interventions informed by contextualised analysis of livelihoods and wellbeing outcomes.

Livelihood diversity is a feature of these and indeed many rural coastal communities. Livelihood diversity can be a positive attribute where it allows households to cope or adapt to shocks or economic or environmental changes. With this in mind, policies that promote fishers to specialise (i.e. by privatising resources, monetising the right to fish and increasing capital entry requirements) will make it harder for fishers to switch and adapt if resource abundance or other shocks face the fishery. Caution is recommended against interventions that rely on livelihood diversification as a sole means of reducing resource pressure. The potentially additive nature of livelihoods highlights that livelihood programs which seek to reduce pressure on resources should go hand-in-hand with reforms that improve resource governance. Where a reduction in fishing pressure is deemed necessary, such coordinated programs may be effective in improving resource status without negatively impacting fisher households. This analysis also highlighted that structural realities faced by communities, which cannot be overcome through local or livelihood based interventions, can be a powerful determinant of wellbeing outcomes emphasising the need for cross-sector engagements in policy development and intervention planning. This study's results emphasise that if policies are to be formulated that strive to improve both resource status and the wellbeing of resource dependent households, they must be built on an in-depth and locally contextualised understanding of livelihood structures, drivers and vulnerabilities.

7.2 Objective 2: Conduct participatory action research with partners and communities to test interventions designed to increase livelihood resilience

7.2.1 Evolution of artisanal FAD technology to suit local conditions

Key Results

- Initial FAD deployments based on designs used in the Pacific were not successful in Timor-Leste due to the combination of extreme bathymetry and exceptionally strong currents.
- Continued evolution of an artisanal FAD designs throughout this project has resulted in a composite design fit for the steep bathymetry and currents of Timor-Leste.
- Anchors with weight and 'grip', as well as a buoy systems sized to support the FAD but pull underwater when currents are at their maximum, proved resilient.
- A sub-surface buoy in a depth range suitable for diving provides for replacement of the top part of the FAD without losing the anchor system.
- The project strengthened partnership with MAF through development and training of a core FAD building team.

Discussion

A detailed report on initial FAD deployments, design evolution and current community strategies is given in **Appendix 2**. Fish aggregating devices (FADs) provide a 'habitat' for pelagic fish, aggregating them in areas accessible to coastal fishers. As such, FAD programs can provide access to new resources, and potentially reduce pressure on resources currently heavily exploited: in this case reef fisheries. While fishers in Timor-Leste have for some time used *rumpon* FADs - bamboo raft FAD technology introduced from Indonesia - small-scale fishers have had ongoing issues with the longevity of FADs, and for this reason the technology has not been widely adopted. Bathymetry is challenging on Timor-Leste's north coast: in places depths exceed 4000m within a few kilometres of the coast. This combined with rapidly changing strong currents and very limited sheltered

waters dramatically decreases FAD longevity. These factors have been the major drivers for developing a FAD design specific to Timor-Leste, building from years of experience in the Pacific.

The Pacific Community (SPC) partnered on the early stages of this component of the project, providing expertise in FAD design and deployment, staff time to oversee FAD deployment, and materials for FAD construction for the first site (Atauro Island). A former Indonesian pole-and-line inboard fishing vessel was chartered for the deployments, and WorldFish and MAF team members were trained in FAD construction and deployment by SPC staff. Unfortunately of the 3 FADs deployed, 2 were not seen again after deployment. The third was visible for about 1 week, but not after that. From these early deployments it was clear a) that anchor designs were inadequate, and b) fishers soon asserted that deployments were too far offshore for safe fishing. Interestingly, the furthest from shore was less than 1km from the high tide mark. These FADs were in set in about 700m depth – the SPC team asserted that the diversity and quantity of fish attracted would be much greater than if the FADs were set closer to shore.

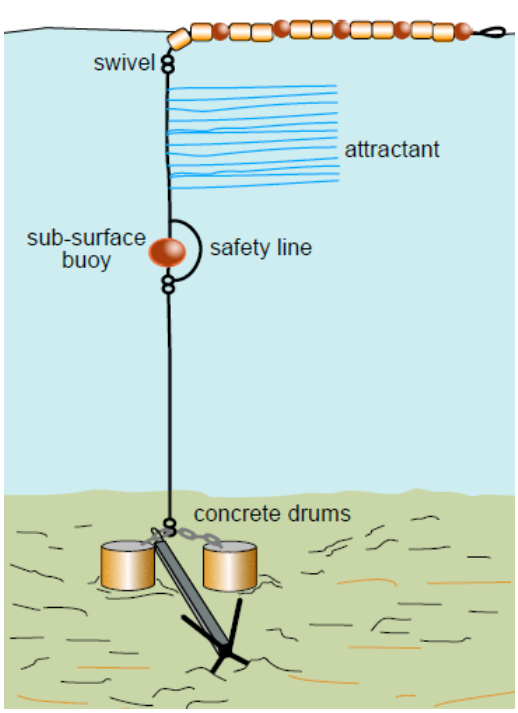

Figure 2. Final FAD design now used in Timor-Leste

Following this experience, an incremental improvement process was undertaken that culminated in a robust design that lasts well in the prevailing conditions. Two technical staff from WorldFish Solomon Islands visited the project and provided new inputs into ways to improve FAD resilience, and deploy FADs safely from small boats. Critical modifications included anchors that had grip (grapnels) and weight (concrete blocks); the addition of a sub-surface buoy within a depth appropriate for scuba diving to facilitate maintenance, and; reduced floatation in the buoy system. If a large number of plastic floats are used, extreme currents occurring once or twice a year will put extreme pressure on the mooring system. Reducing the flotation of the buoy system so that the buoys can be pulled under in extreme conditions reduces strain on the mooring and rope. This does, however, require increasingly regular FAD maintenance. Goose barnacles grow rapidly on components of the FAD that are less than 20m deep. These can start to weigh down the surface system, and will eventually sink the FAD if they are not removed.

Currently there are 12 FADs deployed using the design in Figure 2. These are all in 200m of water or less as requested by community members. This puts FADs within reach of paddle canoes, and provides the greatest potential benefit to all fishers.

7.2.2 Enhanced local fish catches through FADs

Key Result

- Monitoring of communities where the project had deployed FADs and instituted local management provided an opportunity for development and testing of new data systems for catch monitoring in Timor-Leste.
- Monitoring of the longest FAD deployment among the project sites showed empirical evidence of improved local catches as a result of FADs, as well as related anecdotal benefits to multiple livelihood strategies.

Discussion

A near-complete absence of data on fisheries yields and income means that quantitative estimates of economic impact from FAD deployment have previously been impossible for

Timor-Leste. Previous estimates of the benefits of sustained FAD programs suggest that they can bring considerable increases in fish yields and access to alternative, underutilised pelagic resources. In Mauritius, catches of pelagic and deep water resources increased from 5kg/boat/day in open water to 56kg/boat/day around FADs (FAP/UNDP Southwest Indian Ocean Project reported in Beverly et al., 2012). The program reported a substantial and associated decrease in fishing effort in nearby lagoons; analogous to the reef impacts sought in the project proposed here. FADs in Nuie increased catch rates by between 27% (nearshore) and 113% (offshore). In addition to increased fish landings, documented and anticipated benefits from FAD programs include development and modernisation of fishing fleets, development of local boat building industries, improvement of work conditions and safety, job creation, decrease in search time and fuel use by fishers, stabilisation of benthic resources exploitation, and reduced incidence of ciguatera poisoning among reef-dependent communities (Detolle et al., 1998).

A data collector from the Adara community was hired to collect daily landings from Adara, and opportunistic sampling in Beloi and Biqueli to provide control data. Effort data was collected as time fishing according to gear type. Catch sampling was started prior to FAD deployment to identify any effect of the FAD presence on fish CPUE. CPUE was clearly much higher from the FAD than from reef or from open water away from the FAD (Figure 3).

The FAD in Adara was lost 7 months after deployment due to rope failure (this was an older design and has since been replaced with the updated design). The change in catches associated with this loss, and the difference between Adara catches and control sites clearly show that the FAD was having a substantial positive influence on the catches of small pelagic species (see details in Appendix 2). Prior to FAD deployment, landings data from Adara show catch per unit effort was at 1.4 kg (SD ± 0.46) per fisher per hour, which rose to a mean CPUE of 5.28 (± 1.26) over the months of February-April 2016 once the FAD had started attracting fish. Using the Beloi landing site as a control site (without a FAD), results show that where landings sampling exists for both sites, Adara consistently reports higher CPUE over time since the FAD deployment in November 2015.

It is clear from these results that at least in Adara, the FAD design used has the potential to add substantially to catches of pelagic fish. Discussions with women and men in the community indicate that the added fish made a transformative change to the livelihoods of fishers, with consistent supply close to home negating the need for long fishing trips, and providing new marketing opportunities. New projects in this community will address post-harvest processing to optimise the additional income opportunities from increased fish supply.

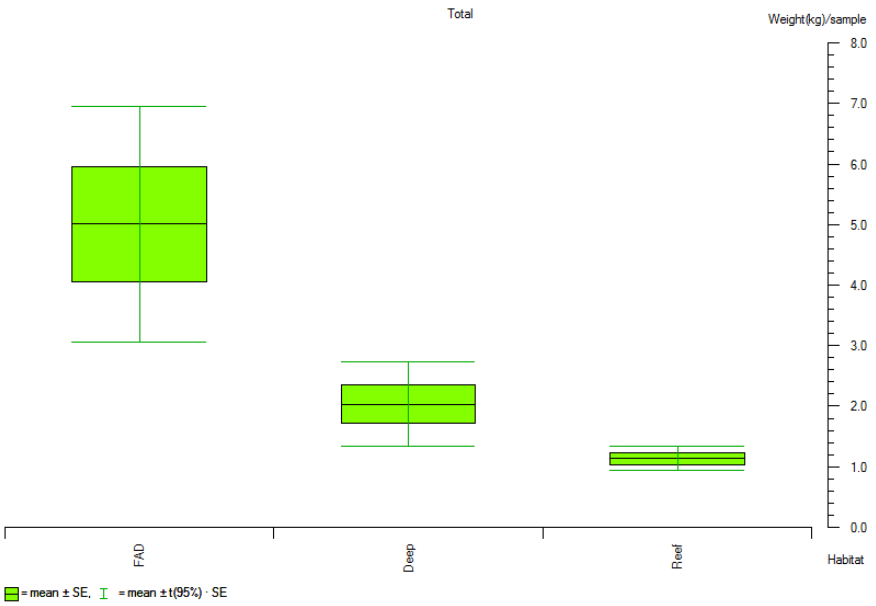

Figure 3. Comparison of catches from FAD (left), open water (middle) and reef (right) area in the Adara community fishing zone

7.3 Design and test approaches to community based resource management

Key Results

- The governance system in Timor-Leste is 'primed' to adopt co-management as a principal approach to management, yet there is little guidance on approach, and there has been no government-led implementation to-date.
- The traditional tara bandu institution, in various forms, is appropriate and fit-for-purpose for implementation of CBFM, or community components of a co-management system.
- A successful community tara bandu initiated by the project was remarkable for its rapid positive outcomes.
- Analysis of an established marine tara bandu showed surprising levels of impact, acceptance and sustainability with no continued external input.
- Project outcomes will feed directly into policy formulation for SSF management in Timor-Leste.

Discussion

A detailed report on this objective is available in **Appendix 3**. This appendix is currently being developed further into a primary publication for submission to a peer-reviewed journal.

The philosophy behind co-management is that those who are affected by management (e.g., fishers and other resource users) should be involved in making management decisions (Berkes 2009). Fisheries co-management is defined as a relationship between a resource-user group (e.g., local fishers, processors etc.) and another entity (e.g., government agency or non-government organisation) in which management responsibilities and authority are shared (Evans *et al.* 2011; Pomeroy & Berkes 1997). The form and function of co-management is contextual, depending on the nature of small-scale fisheries and the resource they access, informal and formal governance institutions and the capacity, influence and authority of nation states and fishing communities.

While the intent to move towards co-management of marine systems in Timor-Leste is clear in policy, there is no current roadmap, guidance or policy regarding details of implementation. The project sought to work with communities to understand application of a traditional institution – tara bandu – to co-management. The approach was to observe outcomes from an established community tara bandu, and to work with select focus communities to implement a new tara bandu for coastal resources.

Analysis of existing tara bandu – Beacou case study:

A component of the Regional Fisheries Livelihoods Program for South and Southeast Asia (RFLP) implemented by FAO was piloting systems for community-based coastal resource management. A detailed account of the process of establishing the tara bandu in Beacou is given by Alonso et al. (2016). The *tara bandu* was developed in the community between 2010, when first conversations were had among local authorities and villagers, until the declaration ceremony in August 2012. At the time or reporting, this was the only existing marine tara bandu in Timor-Leste, and provided an excellent opportunity to observe a functioning system. The *tara bandu* rules in Beacou covered sacred spaces, conflict (particularly between youth groups), terrestrial resources (protection of forest resources, banning swidden agriculture burning) and marine resources (protecting coral, mangroves, banning bomb and poison fishing, protecting turtles and their eggs).

Men and Women interviewed in the community stated that the tara bandu regulations were still in force, and were strictly enforced:

> *"Every point listed under the tara bandu has been enforced, and people follow them. The community, the local authorities and the rai nain (land owners) are making sure the rules are followed" (Men's FGD).*

Both groups noted that "almost all" people in the community were happy with the tara bandu as it had increased their knowledge of resources, and had shown good results. Women noted that not being able to cut mangrove wood had a significant impact on workload, as they could no longer be "lazy" and had to go the forest. On occasions they are given permission to take wood from specific mangrove trees that have died. Positive impacts of the rule application reported by focus-group members included:

1. Healthy mangrove ecosystems, with the presence of "7 or 8 species" among the mangroves that hadn't been seen for many years prior to the *tara bandu* declaration. These included sea birds, bats, cuscus and snakes. The men noted that the *tara bandu* should now be extended to include the banning of bird shooting within the mangrove area to ensure continued benefits from the management measures.
2. Increased vegetation on the hills due to better control of burning for agriculture.
3. A visible difference in the coral reefs and the numbers of "fish fry" seen near the shore.

It was evident that men and women from the community had integrated the coastal tara bandu as a new cultural norm. There were clear behavioural changes due to the regulations (agricultural practice, fishing locations, mangrove cutting) all of which would be expected to have positive dividends for sustainability of natural systems. While villages reported increases in vegetation on the surrounding hills, diversity of fauna in the mangrove systems and numbers of small fish, there are no empirical baseline data to test these assertions against. Consequently, while perceptions are important, we do not have direct evidence of changes in resource condition due to the tara bandu.

Importantly and in contrast to our case study in Adara (see below), there are no direct financial returns from the declaration of the tara bandu, primarily because there is no tourism in Beacou. Yet it is clear that the villagers value the institution, and are generally convinced of its importance to the community's natural resource base. Given this, it seems highly likely that the regulations will continue to be active and effective into the forseable future. Indeed, there was considerable keenness to extend the tara bandu to other resources. The important role of the Chefe Aldea (village chief) in socialising rules and enforcing the tara bandu was very clear, and continued success may be dependent on this strong and engaged leadership.

Our first participatory diagnosis was conducted 2 years after the tara bandu was declared and was notable for the apparent health of a number of important and exploited fishery stocks. It is implausible to claim that the lack of crisis narrative around the status of fish stocks relates to the declaration of the tara bandu, as the timeline is too short, and the area covered by restrictions quite small. Indeed, it could be argued that the success and sustainability of the tara bandu may in fact relate to the relative health of the natural resource base, and therefore a relatively limited impact from the new regulatory measures imposed. Nonetheless, the Beacou stands as a 'poster child' for tara bandu implementation, and as an early example of a sustained application of this institution to marine resources.

Establishing a new coastal tara bandu – Adara case study:

Early focus group discussions with the Adara community highlighted principal motivations for community rule-making of improving patronage of a small eco-tourism venture in the community, and of improving the status of reef fish stocks for food security. The strongly participatory nature of the project saw a bottom-up development of management measures over a period of 12 months. Early meetings following on from diagnosis focus groups centred on the nature of the rules to be included in the tara bandu. There were two clear

areas: rules pertaining to a closed area to be declared adjacent to the tourism venture, and rules relating to the entirety of Adara's fishing area.

Livelihood activities noted to be most impacted by the closed area were line fishing and gleaning. Women's fishing activities stood to be impacted more than men's. However, in FGDs, women also noted that they stood to gain substantially from increased tourism, as the tourism enterprise was staffed by women. Women believed the advantages gained from increased tourism and protection of fish stocks more than offset the issues of not being able to fish in the closed area adjacent to the village.

Rules pertaining to general fishing practices were developed through a series of meetings often involving the suggestion of a rule by the community, the research team adding comment as to the implication of this rule, with agreement ultimately being reached at the next meeting, when the community had considered the available information. Rules banning traditional and non-traditional fishing techniques that were seen as destructive were non–contentious. The banning of taking turtles and turtle eggs was the outcome of months of discussion, and considerable input from the project team on the implications of continued harvests, and the tourist potential in the protection of turtles.

As is customary, a set of incremental penalties were put in place. When a *tara bandu* rule is broken, the offender has to provide the prescribed items to the community, to be collectively consumed in a feast of reparation for the wrong committed. Notably, in contrast to the Beacou case, alcohol was not included in the penalty in Adara due to the strict protestant adherence to abstinence within this community.

While traditionally *tara bandu* is symbolised by the hanging of a totem, and preserved orally, a written document was requested by the community and was important for formal recognition. As part of the development process, a Timorese artist was commissioned to work with the community on designing a logo (See appendix 4).

The *tara bandu* declaration ceremony was performed on May 13, 2016 and was attended by over 200 people from Adara and nearby communities, church authorities, local and island authorities, government representatives, international organisations, NGOs and interested onlookers. A substantial feast was prepared by the community. Again, due to the strong protestant culture in the community, the traditional hanging ceremony was not conducted, but rather a ribbon cutting ceremony with a prayer by the village Pastor was substituted. The ceremony included speeches by a Ministry of Agriculture and Fisheries representative, the village Chefe, the Pastor, Marine Police, WorldFish and the chief fisherman. Notable statements among the speeches included:

> Pastor: *"Our grandfathers used to wade in the water to their knees and get enough food to eat. Our fathers went to their chest. Now, the water is way over our heads and we still don't find enough food". He then quoted Genesis 1:26, 27 saying that the Bible tells us that we have power over the animals, but this means we need to protect them. In the past …"we have eaten all our fish, but never taken care of them. Now we must take care of them"*
>
> District Chief: *"In Biquele and Beloi, the reefs are mostly gone now. If Adara can be used as an example to others, we can help the reefs recover"*
>
> District administrator: *"Just because you grow it today, it doesn't mean you can pick it tomorrow. These things take time. We started working with WorldFish two years ago and today we announce this tara bandu. In five years we will have more resources, bigger fish and beautiful reef. Some researchers came here last year and said that our reefs are so much better than elsewhere. The rules say you shouldn't destroy the reef, you shouldn't use a spear, if you do you will destroy your own sea."*

The ceremony was in part funded by the project, but was organised by a committee appointed by the community, and involved many community members. Project staff were approached by Chefe's from two other Island communities, asking for assistance with setting up a marine *tara bandu.*

Conclusions:

The case studies presented here add significant weight to the idea that tara bandu can be the basis for the community-led components of a co-management system. We have shown that the legislative framework currently in place supports the notion of co-management while perhaps not providing a strong basis for its implementation. Co-management implementation has certainly not been a strong focus of government to-date. Recent devolution and deconcentration initiatives bring this effort to the fore. The development of a new National Fishery Strategy, facilitated by WorldFish, provides the opportunity to act directly on the findings of this research in mandating a way forward for fishery co-management in Timor-Leste.

7.4 Data systems

Key Result

- The project review of existing landings data found substantial flaws with previous sampling regime. Existing data were analysed and presented to senior fisheries staff in a workshop. Options for the development of a new system were put forward, and components of this tested through monitoring of project focus sites.

Discussion

Details of this analysis are presented in **Appendix 5**. Archived data stored in the MAF web system "Peskador", from the landings surveys conducted under the Regional Fisheries Livelihood Project (Alonso et al., 2012), was reviewed to evaluate if they could be used as a baseline for a landings monitoring system. The RFLP attempted to survey every district of Timor-Leste. In terms of effort the sampling was coarse, with only the total number of boats that contributed to a cumulative catch on a given day being recorded. The data were useful in providing species level information from specific areas, allowing analysis of catch composition, species biogeography and distribution of fishing types. However, price information was inexplicably stochastic, and no technical methods manual on the sampling regime could be found, so varying methods of reporting is likely to be a major cause of inconsistencies. Detailed analysis made it clear that application of this data to any form of fisheries management was very limited. Accordingly a new survey was designed and deployed to obtain much higher resolution data in a standardised sampling design, modelling a possible new national system.

Initially paper landings forms were used in the field, which were then transcribed into a purpose built MS access database. In mid-2016 a new tablet based system of landings data capture was developed on the ODK platform through the Kobo Toolbox server. Existing data were integrated with the new online data storage system.

The tablet app was piloted in Adara, Atauro Island through June-August 2016 and launched at 2 other community sites in Timor-Leste in August 2016 as part of a subsequent project. As such this application (app) development has now provided the basis for detailed catch sampling at sites throughout Timor-Leste, to use for small-scale fisheries stock assessment.

The app was designed to provide a standardised and efficient method of collecting landings data in the field, as well as providing improved data security and backup through uploading the data directly to a cloud server. These data were used to characterise the fisheries around Atauro Island, and to measure the effectiveness of the FAD deployment in increasing catch volume, and improving access to more abundant and sustainable pelagic species.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Scientific impact now:
A central focus of WorldFish SSF research currently is looking at outcomes from co-management arrangements at scales beyond communities. Learning from different systems, and building a diverse set of case-studies will lead to a deeper understanding of requirements and limitations for scaling effective co-management. The analysis of existing and new community based management arrangements produced by this project will help facilitate this unique in-depth analysis.

Similarly, FAD systems are increasingly seen as a productive method for sharing pelagic stocks with SSF communities, reducing climate change vulnerability and potentially improving food security. Research approach, baseline information and current data will feed directly into method development and novel analysis of the impact of FAD systems throughout the Pacific.

The project has provided a unique opportunity to use detailed household socio-economic information from fish-dependent communities to feed directly into the development of fishery policy. WorldFish, in a related project, is funded to work directly with MAF on developing the Timor-Leste National Fishery Strategy. The approach presents an example of the use novel social research directly in the formulation of policy.

Scientific impact in 5 years:
The timing of this project was critical in enabling the establishment of a permanent WorldFish office within the Ministry of Agriculture and Fisheries. The close engagement with MAF has led to a substantial increase in recognition the role of research in fisheries management. The project has worked with MAF staff to build on the very limited portfolio of research and research outputs relating to the marine living resources sector. MAF are increasingly recognising the need to attract donor funding for research initiatives. While MAF is unlikely to have either budget or the capacity to autonomously engage in research for the next 5 years, better and more productive partnerships for research will lead to improved research quality, and better outcomes for management. Moreover, the relatively 'blank slate' state of the Timor-Leste marine sector provides an excellent learning environment for conducting research on implementation and outcomes of policy. This can provide scientific dividends on a regional and global basis.

The project forms an important part of a research portfolio in Timor-Leste and the Pacific looking at community based management, resilience and adaptation processes. Currently, there are available multiple case studies of development of community adaptation plans, and community level implementation of co-management arrangements. Lacking are case studies that follow this process through to longer term outcomes and analyse higher level institutional arrangements. This project has provided one such case study in the analysis of outcomes from a CBFM arrangement initiated under a previous project, but more importantly has gathered baseline fisheries and socio-economic data that will facilitate innovative and detailed review of the outcomes from newly initiated co-management systems, and interventions towards more resilient fishery livelihoods.

The project has enabled the initiation of a longer-term study of the outcomes from technology development in terms of FAD systems. While outputs at this point are limited to products and workshops with MAF, continued engagement with communities through future ACIAR and other investments will provide a new, long term perspective on outcomes from technology introduction. A central hypothesis of this project is that through working directly with communities towards improving livelihoods and food security in concert with design and introduction of locally specified management measures, outcomes would be both more effective and more sustainable. While critical tests of system changes can only be completed beyond the timeline of this project, activities and baselines are in place to complete such analyses.

8.2 Capacity impacts – now and in 5 years

Capacity development among national and local government staff, community leaders and fishers is critical for sustainable project outcomes and moving towards active management of living marine resources. The engagement by WorldFish with MAF, supported through this project, has been very positive and has developed in a number of areas beyond the scope of this project.

1. **MAF skills in natural resource management**. Exposure of MAF staff to engagement with co-management concepts has been transformative. A major limitation to effective sector management is that current law posits quotas and Total Allowable Catches (TACs) as the major tools for fishery management. A degree of 'management paralysis' was evident in MAF, as tools to set TAC or quota limits in this type of data-poor fishery are not available. MAF staff were involved in community diagnosis activities, in community meetings for rule-making, and in the formalisation of the tara bandu management system in Adara. While co-management was implicit in existing law, exposure of key staff to mechanisms for co-management prior to this project was very limited. Ongoing exposure to integrated and systems approaches to resource governance will continue to broaden the perspective on small-scale fisheries management in Timor-Leste. This new exposure and experience with components of a co-management approach has been important in framing the future of co-management in the new National Fishery Strategy, currently under development by MAF with advice and assistance from WorldFish.

2. **MAF and community skills in FAD construction, deployment and monitoring**. Notably, MAF is developing a linked program on FAD deployment. Through workshops and exposure to a wide range of experience in the region (from SPC and WorldFish Solomon Islands staff), MAF staff were trained in all aspects of FAD construction and deployment, and formed part of the team that went on to successfully build FADs for a number of donor-funded projects.

3. **Communities managing resources:** Focus communities, notably Adara and Usubemaco, were exposed to new concepts in community-based management. In Adara this has led directly to a fully functional locally managed area that is primed for integration with government co-management structures once they are implemented. In Usubemaco, the project was not successful in establishing a new management system, yet may well have been influential in a recent move by the community to autonomously establish temporary and permanent closed areas in their fishing area.

4. **Fisheries monitoring**. Analysis of limited existing fishery data from the post-colonial era provided the basis for re-developing a fisheries statistics system for Timor-Leste. Importantly, a move from a fisheries 'accounting system' to one that facilitates active management of resources gained good traction. While this has been a significant step forwards, MAF is yet to incorporate fisheries monitoring as a core task, and the only data being entered currently comes from WorldFish field staff and those of collaborating organisations such as Conservation International. WorldFish will continue to work with MAF to press home the importance of regular monitoring of fish catch and effort.

8.3 Community impacts – now and in 5 years

While relatively small, this project provided a critical and timely foundations for developing a much broader program focussed on improving nutrition security and coastal livelihoods in Timor-Leste. While the immediate impacts on communities beyond the project focus sites will be modest, there is substantial potential for impact at longer time scales from the research learning and outputs of this project.

8.3.1 Economic impacts

The Timor-Leste Strategic Development Plan (2011-2030) clearly articulates a government goal to see subsistence and commercial fisheries contributing in a substantial way to food security and agricultural GDP. However, the only government actions in place to address this objective have been assistance programs involving the provision of nets, boats and outboard motors to fisheries cooperatives. Again, the timely nature of this project has facilitated the establishment of a WorldFish in-country presence, enabling a more innovative and positive approach to sustainable increases in fish production. Of note, a focus on CBFM, co-management and improving FAD technologies for accessing pelagic fish resources will provide benefits in the longer term. This will be institutionalised through the National Fishery Strategy currently under development by MAF with the assistance of WorldFish.

While an ongoing lack of effort data for the fishery sector means that we are currently not in a position to provide quantitative estimates of potential gains from co-management and FAD system introduction, preliminary indications are very positive. Analysis presented in Appendix 2 shows that in Adara, catch rates increased by a factor of 2 – 2.5 through the introduction of FADs. We believe this can be increased further through better targeting of fish around FADs through using improved gear types – currently fishers are still limited to using the simple handlines and gill nets previously used for reef fishing. The potential economic benefit goes well beyond this catch rate factor. FADs were also shown to provide for a more consistent supply of fish; supply has been a critical block to the establishment of effective and lasting value chains. With consistent supply, investments in cold chains, distribution and marketing systems will be less risky, and more profitable.

While improved reef management through CBFM initiated in this project will not, in the short term, provide direct financial benefits to communities, improved sustainability in the longer term has multiple potential benefits. The 'no intervention' alternative (counterfactual) is likely to lead to highly depleted and unproductive reef resources in the foreseeable future. In project focus community Adara, men and women have already seen substantial direct economic benefits from the closed area within the tara bandu locally managed area. A reputational benefit was almost instantaneous, with a substantial increase in eco-tourist numbers visiting the village. A 'reef contribution' of $1.50 per snorkeler or diver in the closed area had, within 9 months, contributed $1500 to a community fund. At the time of writing, there had been no decision on how this would be spent. A note of caution is that this is a community that had already been proactive in investing to attract eco-tourists, in terms of developing a local accommodation enterprise; these benefits cannot be expected without such pre-conditions, and cannot be a general expectation for communities that initiate local management. The natural assets of the community, including position on the island and the presence of the reef wall dive site, were central to achieving this benefit.

8.3.2 Social impacts

Throughout the design stages for the tara bandu in Adara, the importance of the role of women in decision making was continually emphasised and promoted. This is particularly relevant for Adara due to the high level of fishing engagement by women. Social impacts in Adara can be seen in the engagement of men and women fishers and other community members in the monitoring of the tara bandu, and the management of the community fund generated from tourists paying to snorkel or dive in the closed area. Empowerment to manage the resources that define their livelihoods is clearly articulated as a positive change by the community. While the engagement of women in these processes is not a normal practice in island culture, participation was well received when it was encouraged. In Beacou (established tara bandu) the ongoing role of women was less clear, although they expressed a high degree of ownership of the process of developing the rules, and of tara bandu as an institution.

8.3.3 Environmental impacts

Monitoring of a tara bandu site set up some five years ago by the Regional Fisheries Livelihoods Program (Beacou) provided strong but anecdotal evidence that community based management built around the traditional institution of tara bandu has capacity for enduring positive environmental and wellbeing impact. Similarly, the new tara bandu in our Adara focus community has already resulted in community enforcement of new rules designed to reduce destructive fishing methods. The no-take area adjacent to Adara will undoubtedly have localised benefits for biodiversity, however currently its small size and isolation as a reserve would limit any wider-scale benefits. If the closed area is expanded in the future, and/or a network of community managed closed areas is created, a broader impact on reef fish and biodiversity may be seen.

While in these early stages catch and effort monitoring was unable to detect an overall reduction in reef fishing effort in the Adara focus community, interviews with fishers certainly reflected a preference for fishing around the community FAD when it was functioning. Monitoring is in place to enable longer term trends in effort and catch of reef fish to be monitored.

8.4 Communication and dissemination activities

Internally, the participatory process for CBFM and FAD components of the project fostered a regular system of result-sharing between communities and the WorldFish/MAF team. Additional communication products in Adara included the tara bandu event, and printed copies of the tara bandu document (in Tetun). A copy was distributed to each house in the focus community, and a stockpile retained by the tara bandu management group that could be distributed to outsiders as deemed necessary by the community. Posters and signs were also developed in English and Tetun to display in the community for the benefit of visitors, outlining the tara bandu rules.

The primary vehicle for scaling and dissemination of project outcomes is national policy development. WorldFish is currently working with MAF, stakeholders and resource owners to develop a National Fishery Strategy (NFS), legal framework, development roadmap, and policy. This project has provided topical and timely case studies for the design of an approach to co-management suited to the unique context of Timor-Leste. Early focus groups with senior MAF staff supporting the design of the NFS have included discussion of these case-studies. Co-management case-studies will be presented to the Fisheries Policy Technical Working Group to be appointed by the Minister for Agriculture and Fisheries over the next month. Community members form Beacou and Adara will be encouraged to present at stakeholder fora to be held in three locations around Timor-Leste early in 2018. A 13 minute movie (in Tetun) of project activities was made with the Adara community, and will be used to show other communities the activities and processes undertaken in FAD deployment and declaration of the tara bandu.

Case study outcomes will ultimately feed into regional analyses being undertaken by WorldFish. Learning from CBFM sites in Timor-Leste, Solomon Islands, Vanuatu and Kiribati will provide for a regional synthesis of lessons learned. This diverse set of cases provides an opportunity to understand the dimensions of CBFM approaches that are transferable at a broad scale, and those that perhaps only apply at national or smaller geographic scales. This is critical for regional roll-out of CBFM practices under the New Song initiative in the Pacific, and other regional initiatives.

Scientific results will be communicated via primary publications. The project will directly produce two primary papers, and contribute to at least two other broader syntheses.

9 Conclusions and recommendations

As a small, three-year project, perhaps the most significant direct impacts relate to the timing of the funding support to WorldFish. The project (together with a parallel aquaculture initiative) provided stability that enabled WorldFish to establish a permanent office within the Ministry of Agriculture and Fisheries. This partnership has led to further collaborative initiatives with the Ministry, and ultimately significant influence in sector development and policy. Additionally, project science and intervention will make a substantial contribution to the direction of fishery sector development in Timor-Leste.

9.1 Conclusions

Community-based fisheries management in Timor-Leste: This project worked with the people of Adara, Atauro Island to initiate a highly successful locally managed marine area. The primary mechanism for this was the customary institution of tara bandu. Women, and women's livelihoods were integrated into both decision-making and implementation processes, and women continue to be prominent in the management of the LMMA and the community fund generated from tourist contributions to reef protection. The project also reviewed the status and outcomes from an existing coastal tara bandu established by a donor project 5 years ago. It is clear that with appropriate community leadership, resourcing and facilitation, tara bandu is a very effective institution for community based management of resources. While the form of tara bandu will vary greatly based on history, culture and perceptions in the community, a facilitated, flexible community-led process has been modelled with very positive results.

Fisheries in livelihood mosaics: Fisheries livelihood and management interventions will likely be unsuccessful unless framed in local context, understanding livelihoods, their gender dimensions, and divers of livelihood structuring. Comprehensive participatory assessments in project focus communities, and a broad-scale household survey on Atauro Island provided for highly detailed analysis of these factors. Fisheries appears to be a 'livelihood of choice' on the island, rather than a livelihood of last resort. While multiple agricultural livelihoods are the norm, diversification in coastal communities is at least in part driven by the inability to fish at times of the year due to weather conditions. While livelihoods were a significant driver of human wellbeing indicators, geographic location of households was a stronger contributor. Clearly, structural and geopolitical drivers including service provision are very important for wellbeing, and must be considered when formulating policy aimed at improving wellbeing and livelihoods in fishing communities.

FAD systems for resilient fishery livelihoods and fisheries management: Developing FAD systems that were appropriately robust to withstand conditions commonly encountered in coastal Timor-Leste proved difficult. Early attempts failed due to extreme bathymetric and current conditions, and a drawn out process of design evolution produced a design that now appears suitable. FADs deployed in Adara, Atauro Island have been highly successful. Data clearly show increases of about 2.5 fold in the catch of pelagic fish. Moreover, the combination of FADs and new community rules for reef management clearly reduced reliance on reef fisheries in Adara. The promise of improved access to pelagic resources through FAD deployment provided a mechanism to enable the community to enact rules that would reduce their own fishing pressure, and use of unsustainable fishing methods on reef areas. The close proximity of FADs to the community ensured that this change in fishing location did not disadvantage the poorest among the fishers, who rely on paddling to fishing sites.

Data System Development: Analysis of existing fish data conducted under this project was important mostly in demonstrating the unsuitability of the online system that currently exists (although no data has been entered by Fisheries staff for a number of years). Fishery monitoring is yet to be incorporated as an integral function of the Fishery administration in Timor-Leste, however the project was an important step towards developing a system that could be useful in future fisheries management.

9.2 Recommendations

The fishery sector in Timor-Leste is in a dynamic phase: policy directions are being solidified, while donors, international agencies and overseas commercial interests are paying increased attention to the sector. Project outcomes and outputs have been very timely in providing key inputs into this development process.

1. The further development of a co-management roadmap for Timor-Leste is a current priority; this is very much a contested space. A focus on resilient coastal communities and sector sustainability risks being side-lined by strong voices for biodiversity conservation, often built around high-level international priorities rather than contextualised need. Continued advocacy for livelihoods, food and nutrition security and the rights of communities and fishers to be central to the process is much needed. Continued research on implementation of effective and equitable co-management systems has a strong role in this process.

2. For functional, adaptive co-management systems to proliferate and be sustained, government must invest in new systems, assuming a role in co-ordination, communication, facilitation and monitoring. Substantial capacity building and resourcing with a firm eye on local context is required to facilitate these changes.

3. Timor-Leste appears unique in the current potential of fisheries to contribute at a much higher level towards livelihood security, food and nutrition security and economic wellbeing of coastal communities. Continued research and technical assistance to the sector is required to ensure organic, appropriate, equitable and sustainable growth with benefits flowing to communities and local economies. Risks from external investment or external interventions in markets and extraction are considerable if not coupled with appropriate and effective governance.

4. The project highlighted the active role of women in fisheries in Timor-Leste. Knowledge of women's fishing activities and their contribution to household food security remains low. Continued research in this area will provide for appropriate protections and promotion in national and community level management systems.

5. The profile of fisheries in food security discourses in Timor-Leste (and elsewhere) remains low. This is concerning considering the high profile of food and nutrition security in government investment and development plans. A clear future objective is to engage directly with food security initiatives and promote the role of fish in securing adequate nutrition and diversified diets, particularly in the first 1000 days of life. This will require greater direct engagement with the science of fish and human nutrition in the specific context of Timor-Leste.

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10.2 List of publications produced by project

Primary publications:

Mills DJ, Tilley A, Pereira M, Hellebrandt D, Fernandes A and Cohen PJ (2017) Livelihood diversity and dynamism in Timor-Leste; insights for coastal resource governance and livelihood development. *Marine Policy* 82: 206-216

Tilley A, Mills DJ, Cohen P, Periera M, Alonso Pablicion, E (in prep) Status and potential of fisheries co-management in Timor-Leste. (this is a truncation of Appendix 3)

Online articles and blogs:

WorldFish

Beyond the reef: Strengthening the livelihoods of coastal fishers in Timor-Leste

Kate Bevitt, WorldFish

Improved fisheries in Timor-Leste a path to greater well-being.

Alex Tilley, WorldFish Timor-Leste

Against the tide: A FAD fit for Timor-Leste's artisanal fishers

Mario Pereira, WorldFish Timor-Leste

Partner organisation – Blue Ventures

Talking tara bandu witnessing a marine milestone on Ataúro

Sean Clement, Blue Ventures

Press release:

Communities tackle coral reef sustainability

WorldFish, 13/4/2016

Traditional media:

ABC National radio interview

ABC Rural news report

11 Appendixes

11.1 Appendix 1: Livelihood diversity and dynamism

Appendix 1_Mills et al. 2017 Livelihoods.p

11.2 Appendix 2: FAD systems

Objective: Conduct participatory action research with partners and communities to test interventions designed to increase livelihood resilience

Summary

1) Outcomes from FAD research and development

- Enhanced MAF capacity through training and experience of a core FAD team for construction and deployments
- An evolved FAD design fit for purpose in high current, steep bathymetric profile of Timor-Leste's north coast
- Enhanced catches for small-scale fishers from FADs, but gear and fishing improvements should bring much greater gains.

2) Landings analysis

- Nearshore FADs aggregated small-bodied, semi-pelagic scads as the primary fishery species, with catches of larger pelagic fish limited by simple gear types.
- FADs are an effective way of increasing catch per unit effort with existing gears, while reducing fishing pressure on reefs.

3) Moving forwards

- FAD deployments to other sites along north and south coasts of Timor-Leste to test utility in different environments and conditions
- More data capture around ongoing FAD deployments for better idea of the effect of FADs on income and food security.
- Cost-benefit analysis of FAD deployment potential in terms a nationwide scaling up of by MAF
- FAD fisher training and capacity building including the testing of different pelagic gear types with local fishers.

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FAD design and development

Introduction

Fish aggregating devices (FADs) provide a 'habitat' for pelagic fish, aggregating them in areas accessible to coastal fishers. As such, FAD programs can provide access to new resources, and potentially reduce pressure on resources currently heavily exploited: in this case reef fisheries. While fishers in Timor-Leste have for some time used *rumpon* FADs, bamboo raft FAD technology introduced from Indonesia, small-scale fishers have had ongoing issues with the longevity of FADs, and for this reason the technology has not been widely adopted. Bathymetry is challenging on Timor-Leste's north coast (Figure 1): in places depths exceed 4000m within a few kilometres of the coast. This combined with rapidly changing strong currents and very limited sheltered waters dramatically decreases FAD longevity. These factors have been the major drivers for developing a FAD design specific to Timor-Leste, building from years of experience in the Pacific.

The Secretariat of the Pacific Community (SPC) has considerable expertise in the deployment and operation of early in the life of this project, providing expertise in FAD design and deployment, staff time to oversee FAD deployment, and materials for FAD construction for the first site (Atauro Island).

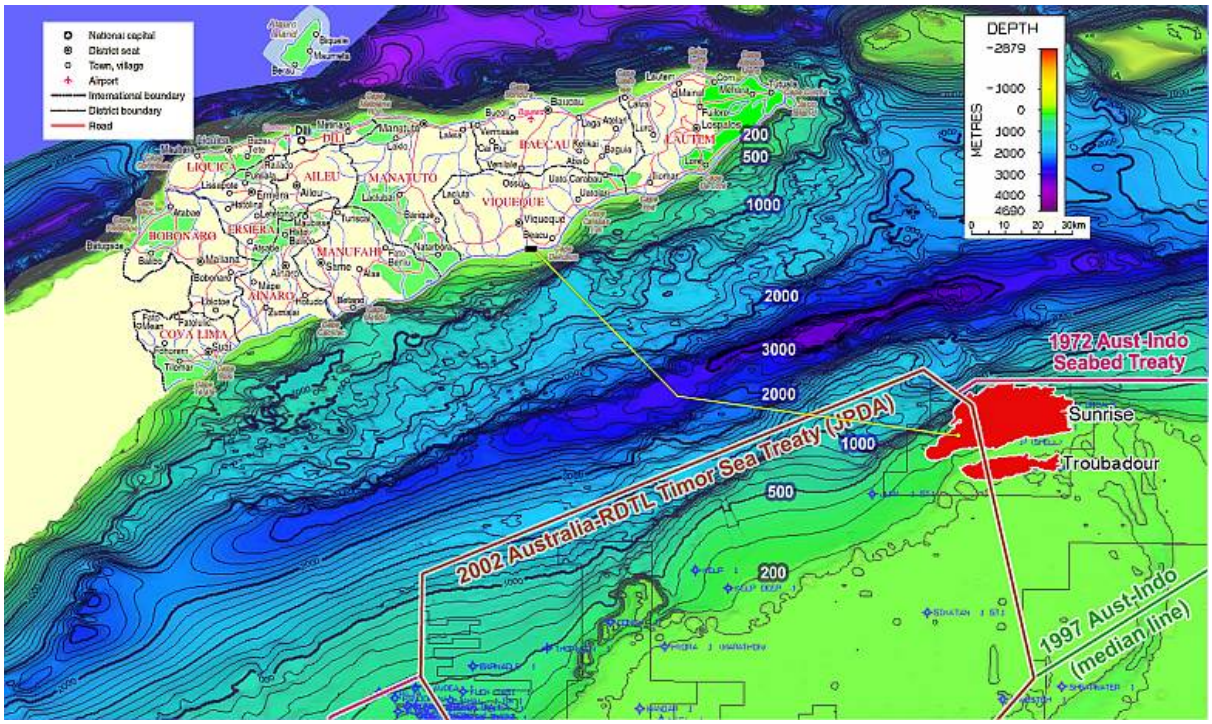

Figure 1. Depth contour map of eastern Atauro Island from depth profiling for optimal FAD placement (from Hoffman, 2007)

WorldFish have also developed considerable expertise in FAD design and deployment in Solomon Islands and Vanuatu. In June 2016, WorldFish facilitated twelve experts from the Pacific region came together in Santo, Vanuatu, to share knowledge and experiences in the design, planning and implementation of nearshore FAD programmes. The lessons learned from this workshop corroborate the development of our design in Timor-Leste, indicating ideas around anchor design, minimising drag, and optimal float system buoyancy.

FAD design evolution

First FAD deployments for the project were facilitated by a team and consultant from SPC (Pacific Community). Both surface and sub-surface FADs were built and deployed. A former Indonesian pole-and-line inboard fishing vessel was chartered for the deployments. Anchors were constructed as per example 1 in Figure 2, using 2 grapnel anchors only. Unfortunately of the 3 FADs deployed, 2 were not seen again after deployment. The third was visible for about 1 week, but not after that. From these early deployments it was clear a) that anchor designs were inadequate, and b) fishers soon asserted that deployments were too far offshore for safe fishing. Interestingly, the furthest from shore was less than 1km from the high tide mark. These FADs were in set in about 700m depth – the team from SPC asserted that the diversity and quantity of fish attracted would be much greater than if the FADs were set closer to shore.

A 'serial' block design of anchor was then tested (Figure 2, design 2), with the idea that it may hold well in 'mountainous' bathymetries. A single FAD was deployed using this design. Despite lasting a number of weeks, it too was eventually lost. It seems likely that the lighter individual concrete blocks were lifted by the buoy system, starting with the front block, and ultimately smashed, one by one. While the chain was linked through the blocks, the chain would soon be left with the single grapnel only.

Ultimately, a design with twin concrete drums and a single grapnel anchor was found to work well. Once this design was tested on a number of FADs, failures in other areas were detected, but anchors held well, even in conditions of very strong currents. Two other FAD modifications were critical. The addition of a sub-surface buoy within a depth appropriate for scuba diving meant that if vandalism occurred (cutting the FAD) or the surface components failed, the anchor system could be re-used. Secondly, the buoy system was reduced. If a large number of plastic floats are used, extreme currents occurring once or twice a year will put extreme pressure on the rope systems. Reducing the flotation of the buoy system so that the buoys can be pulled under in extreme conditions reduces strain on the mooring and rope. This does, however, require increasingly regular FAD maintenance. Goose barnacles grow rapidly on components of the FAD that are less than 20m deep. These can start to weigh down the surface system, and will eventually sink the FAD if they are not removed

Currently there are 12 FADs deployed using the design in Figure 2. These are all in 200m of water or less as requested by community members. This puts FADs within reach of paddle canoes, and provides the greatest potential benefit to all fishers.

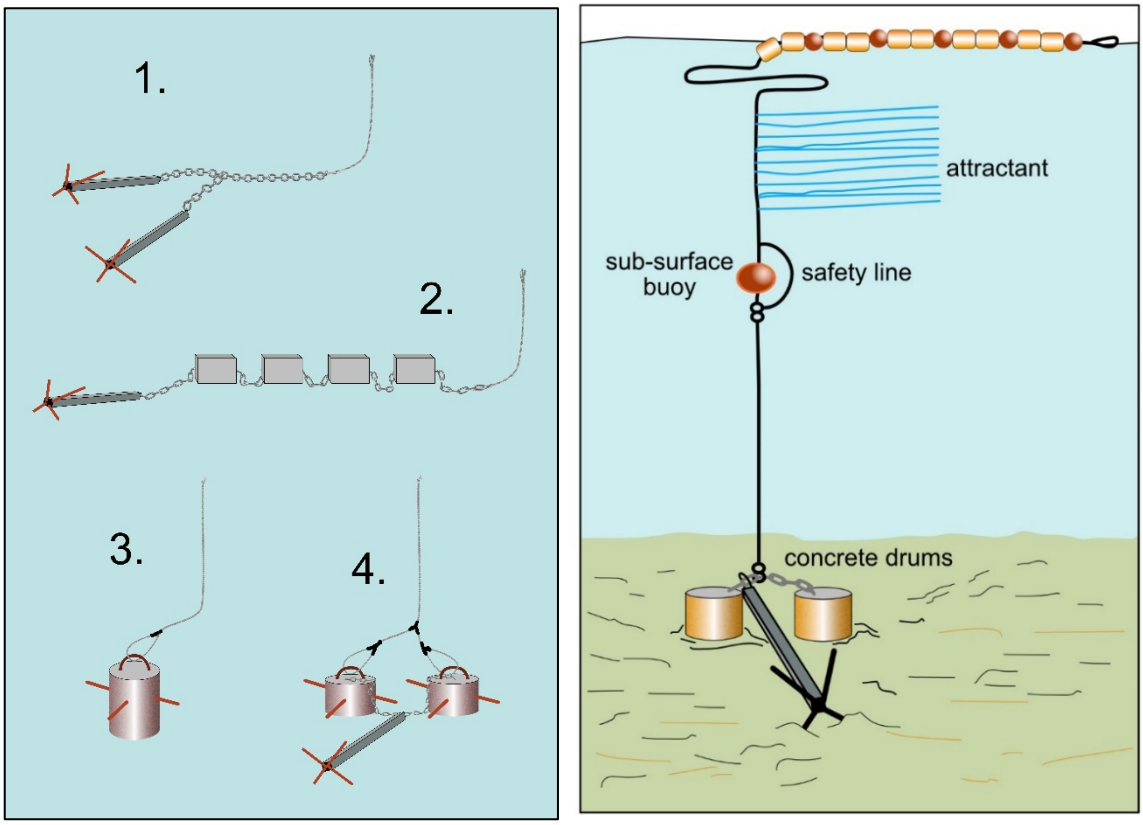

Figure 2. Left pane: Evolution of FAD anchor design for Timor-Leste between 2011 and 2015. Final complete FAD design used for deployments in Timor-Leste

Deployments of Timor-Leste design

Stage 1: Anchor building and drying

Four holes are drilled through the sides of two halves of a metal '44 gallon' oil drum. 1m lengths of 20mm diameter rebar are inserted through the holes to form a cross within each of the half-drums. A chain is linked through the rebar cross of each drum, connecting them together. Each drum is then filled with cement and locally gathered rocks and left to set for 1 month. For the grapple, a 2m long square tube wraps around 30mm rebar grapple, into which cement and small rocks are poured. This is also left to set and dry upright for 1 month prior to deployment.

Stage 2. Depth profiling

There is very little high-resolution bathymetric data available for Timor-Leste. At each potential site, it was necessary to obtain detailed depth profiles of the sea bed in order to choose the optimal location for the FAD. A flat or gently sloping area not close to a steep drop off, was found to extend the longevity of the FAD and lessen the risk of premature loss. Depth profiles were achieved using a Furuno fish finder with a 1 KW Airmar transducer, which was deployed on local boats undertaking traversing transects back and forth across the depth gradient within the desired area.

Tracks from the Furuno sounder were then downloaded so that positional information could be plotted into ArcGIS software. The depth data were then interpolated in ArcGIS using the geospatial tools and exported to a raster contour layer. This layer was then exported as a .kml file for overlaying google earth imagery to provide the image as below in Figure 3. Once the appropriate deployment location was chosen, the known depth was used to measure the length of the FAD to be constructed.

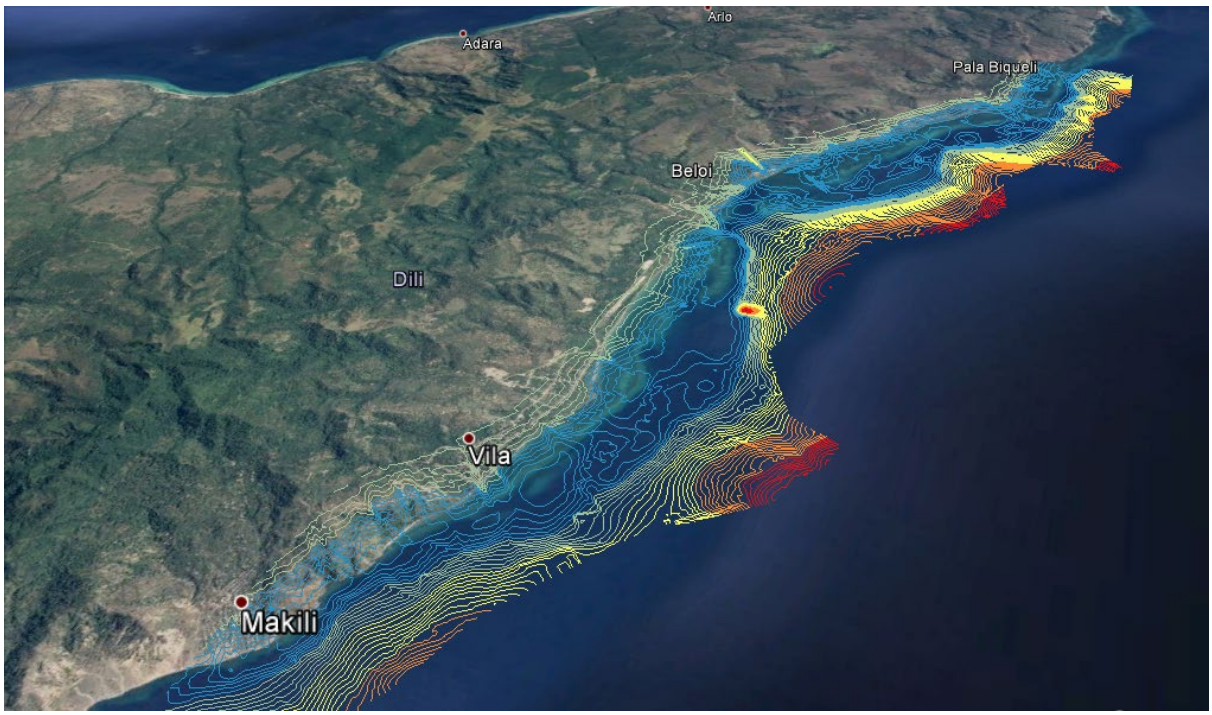

Figure 3. Contour image created from depth profiling carried out prior to deciding FAD locations for deployment

Stage 3. FAD construction

Rope and buoys for the tested FAD systems were imported in bulk from Taiwan, as products of equivalent quality could not be found locally. All other equipment was obtained locally in Timor-Leste. WorldFish staff from the Pacific (WorldFish Solomon Islands) brought valuable techniques to share regarding FAD building such as the need for 32-38mm diameter clear plastic hose around the rope passing through the line of surface buoys, and for knots and joins to be wrapped in thin tyre rubber (recycled car inner tubes) to prevent chaffing. 18mm swivels at key points allow the FAD to spin without ropes twisting and tightening to minimise wear and tear. A subsurface buoy (SSB) is integrated into the rope at approximately 15 m below the surface. Small changes in deployment location and measurements can cause the SSB to sit further or nearer to the surface. A safety line connecting the main lines above and below the SSB was included at a late stage to prevent the loss of the entire FAD if only the SSB was lost. See FAD design evolution diagram and complete anatomy diagram (Figure 3). Regular inspections of the FAD should show if the SSB is wearing on the rope, or indeed if the rope has parted at this point. The safety line provides a time buffer to detect this failure, and allows for the replacement of the SSB.

Stage 4. Floating, towing and deployment

For safe deployment, the anchors were moved by teams of fishers to the low tide mark prior to deployment and large floats fixed tightly to the anchors so that the high tide will float them. (This rope is later cut to release the anchors in deep water). The grapnel was loaded horizontally on top of the two float barrels. At high tide upper unit of the FAD was connected to the anchor chain using a large galvanised 'D' lock shackle (19mm). The upper unit was then loaded into the boat and an additional line was tied to the floats and both lines used to tow the anchor out into deeper water.

One hundred metres prior to reaching the GPS mark for the drop location, the FAD upper unit was thrown out gradually to trail away behind the boat, so that it was full extended out in the water by the time the drop location was reached. Upon reaching the drop site, the rope of the FAD upper unit was released from the boat, and the grapnel toppled into the water to hang beneath the floats.

When all boats and crew were safely out of the way of ropes and anchors, the anchors were cut away from the floats to drop into position. Surprisingly, the release happens quite

slowly in a safe and controlled manner. The FAD upper unit and floats may move across the surface of the water rapidly as the anchors pull downwards. After final settling of the FAD a GPS position was taken at the site to record the location.

The effects of an artisanal FAD on small-scale fisheries landings in Timor-Leste

Introduction & Background

A near-complete absence of current data on fisheries yields and income means that quantitative estimates of economic impact from FAD deployment have previously been impossible for Timor-Leste at this stage. Previous estimates of the benefits of sustained FAD programs suggest that they can bring considerable increases in fish yields and access to alternative, underutilised pelagic resources. In Mauritius, catches of pelagic and deep water resources increased from 5kg/boat/day in open water to 56kg/boat/day around FADs (FAP/UNDP Southwest Indian Ocean Project reported in Beverly et al., 2012). The program reported a substantial and associated decrease in fishing effort in nearby lagoons; analogous to the reef impacts sought in the project proposed here. FADs in Nuie y increased catch rates by between 27% (nearshore) and 113% (offshore). FAD programs in La Reunion and Comoros increased pelagic fish production by 340% and 100% respectively (Rey-Valettea *et al.* 2000 cited in (Steve Beverly 2012). The FAD program in Mauritius also saw a substantial increase in sports fishing; this may be a plausible supplemental income stream for fishers in Timor-Leste with appropriate vessels (such as the government-supplied 'Nautilus' vessels), particularly in the Dili region.

In addition to increased fish landings, documented and anticipated benefits from FAD programs include development and modernisation of fishing fleets, development of local boat building industries, improvement of work conditions and safety, job creation, decrease in search time and fuel use by fishers, stabilisation of benthic resources exploitation, and reduced incidence of ciguatera poisoning among reef-dependent communities (Detolle, E.Tessier et al. 1998)

Methods

Study sites

Following initial FAD deployments along the east coast of Atauro Island by the SPC in 2013, 3 FADs were deployed in this project in communities of Adara (west coast of Atauro Island), and Beacou (at the western end of mainland Timor-Leste, on the border with Indonesia)(Figure 4).

Field sampling

A data collector from the Adara community was hired to collect daily landings from Adara, and opportunistic sampling in Beloi and Biqueli when possible. Fishers generally go out early ~5am and finish fishing activity by 8am. Gill net fishers set their nets early and leave them to soak while they return to the village. Effort data was collected as time fishing according to gear type. Catch sampling was started prior to FAD deployment to identify any effect of the FAD presence on fish CPUE.

Results

Artisanal fisheries landings monitoring recorded catch from 48 fishers from 3 communities at 41 fishing sites from May 2015 – August 2016. 455 primary samples. A total of 2703 kg of 47 species were landed using gill nets (92%), spear guns (6%) and hand lines (2%).

Species composition

The most abundant and frequently captured species in landings was the mackerel scad, *Decapterus macarellus.* This is a small bodied (max 46cm) schooling pelagic found in circumtropical waters in 0-200m depth. *D. macarellus* made up ~45% of catch weight (Figure 5). The Hound needlefish (long tom), *Tylosurus crocodilus* is the second most

important pelagic fish. It is a circumglobal surface dwelling fish restricted mainly to coastal waters reaching a maximum size of 135cm.

This diversity of species (total of 43 species landed) is driven by the reliance on the reef gill net fishery, which has limited selectivity related to small mesh sizes (Figures 5 & 6). *D. macarellus* is captured both on the reef edge by scaring into gill nets, and so is represented in both semi-pelagic and reef fisheries. The second and fourth species in order of overall importance in the fishery are scissortail and yellowtail fusiliers (*Caesio caerulaurea* and *Caesio cuning* respectively) and soldierfish (*Myripristis* spp.) (Figures 5-7).

The importance of *D. macarellus* was even more pronounced in landings from FAD fishing alone, with it forming over 90% of the fishery in terms of catch weight and number (Figure 8). Gear types for fishing around the FAD in Adara are rudimentary, having had no alteration to better exploit aggregating pelagics or larger bodied, deeper dwelling scombrid fishes. Hence landings are restricted to small, near surface pelagics captured in gill nets such as *D. macarellus* and *T. crocodilus*. However, it appears from the limited pelagic fishing landings data that there are larger-bodied pelagic fishes occurring locally (Figure 9).

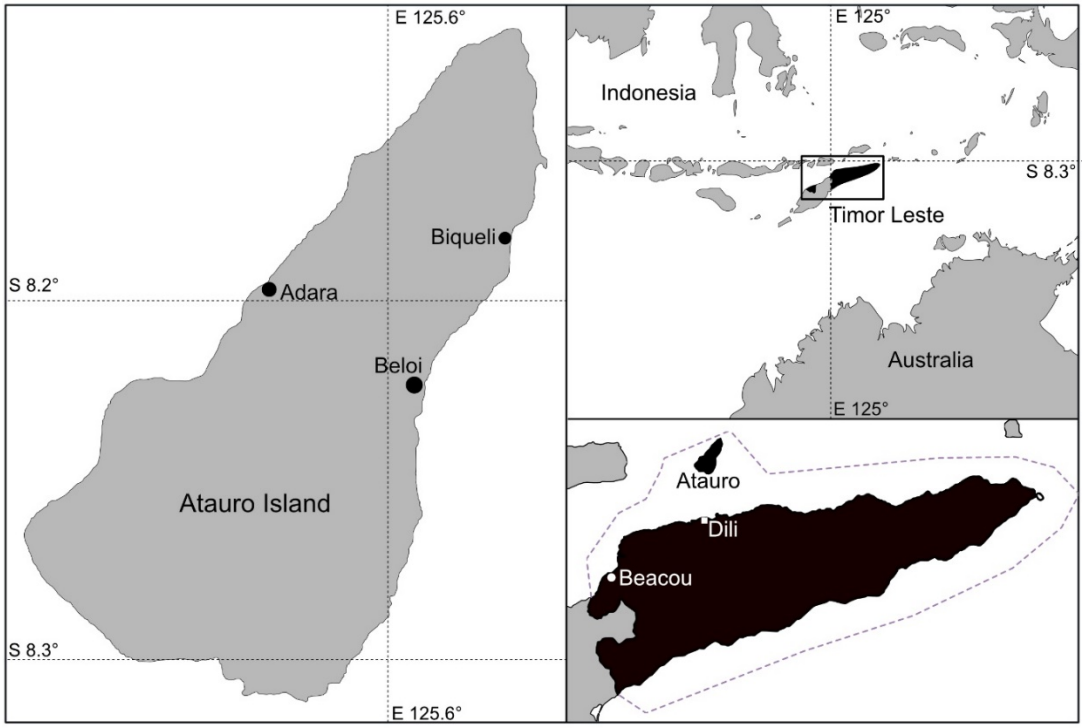

Figure 4. Map of sampling locations on Atauro Island, Timor-Leste

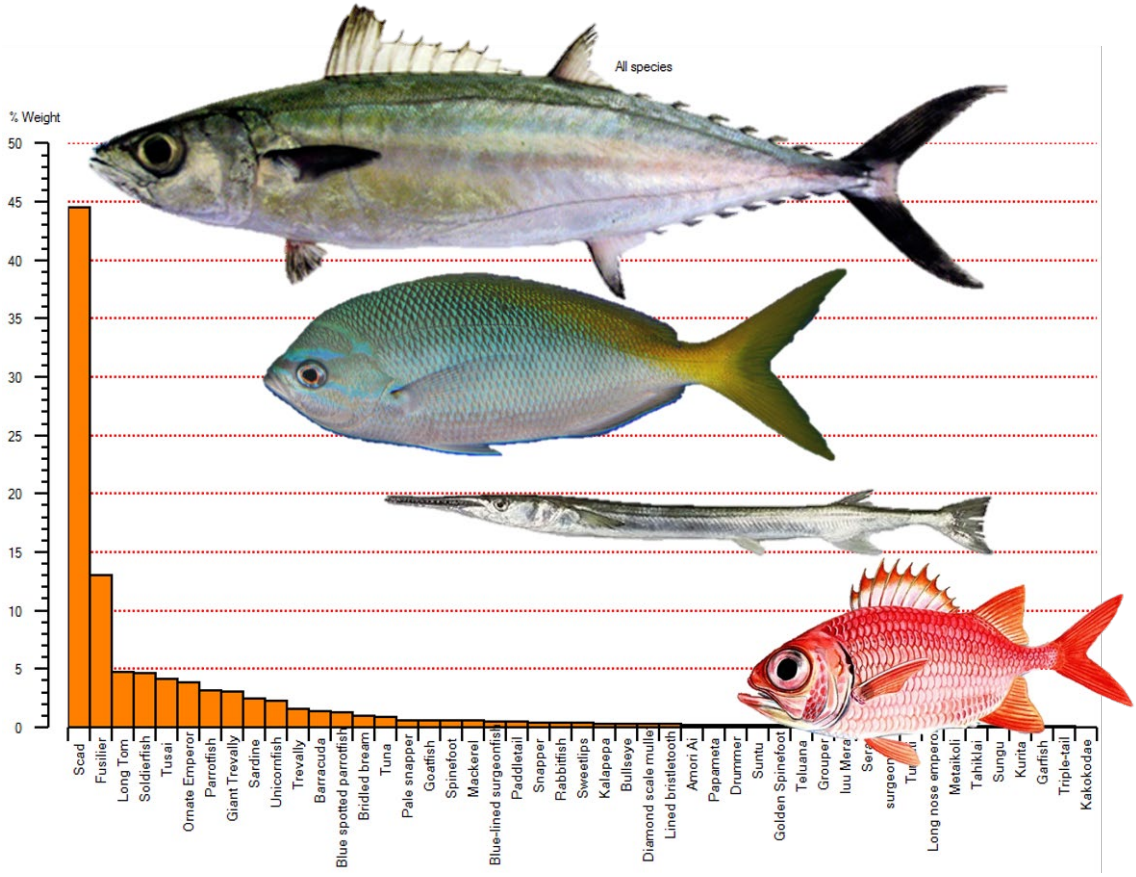

Figure 5. Species composition by proportional weight of landings across 3 landings sites in Atauro Island, Timor-Leste

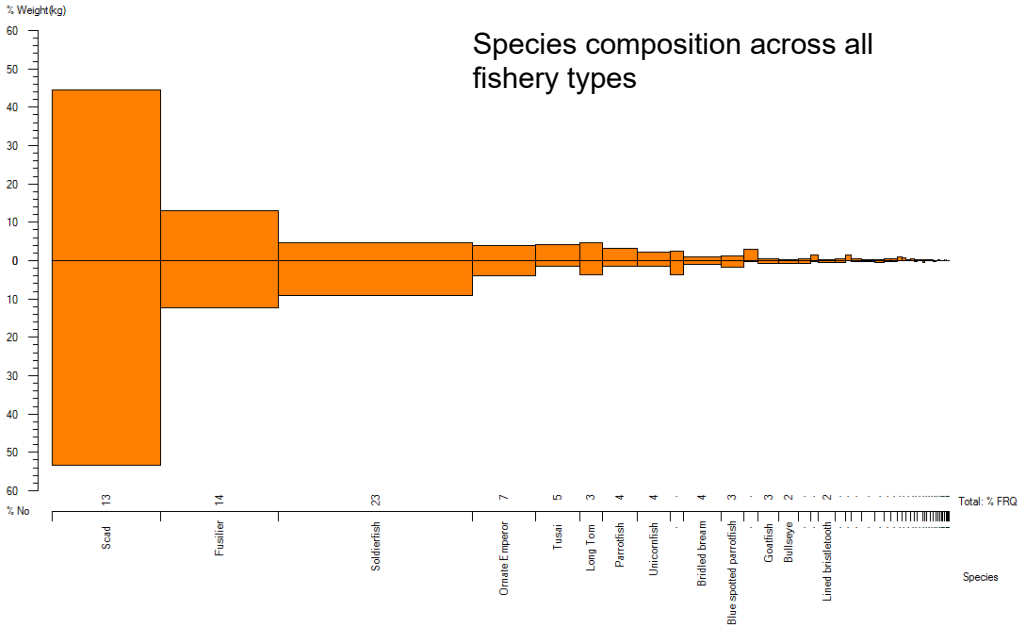

Figure 6. Index of relative importance (IRI) of species in all fisheries landings, Atauro, Timor-Leste

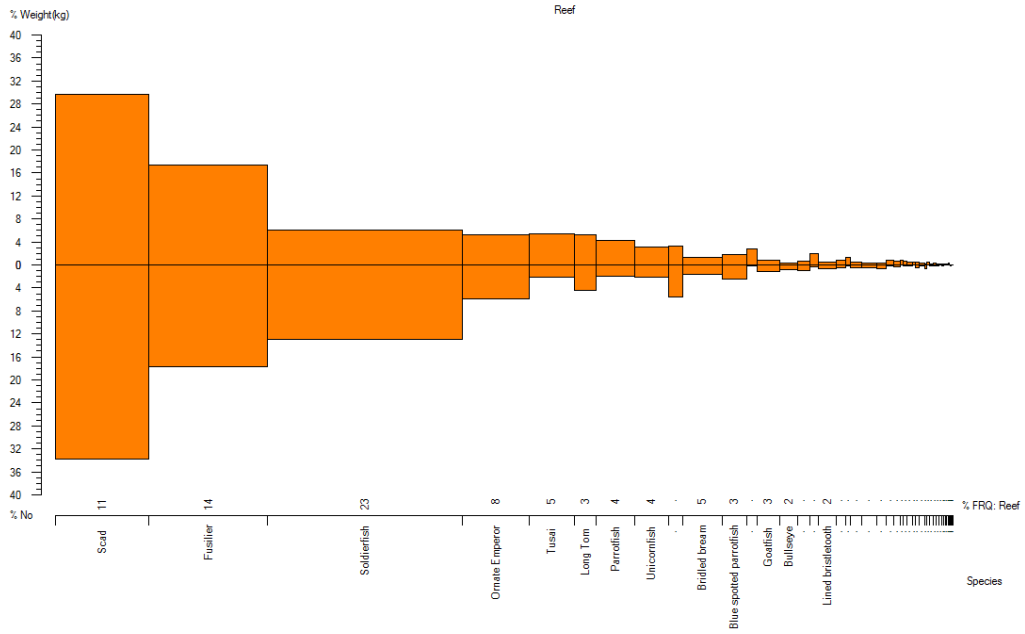

Figure 7. Index of relative importance (IRI) of species in reef fisheries landings, Atauro, Timor-Leste

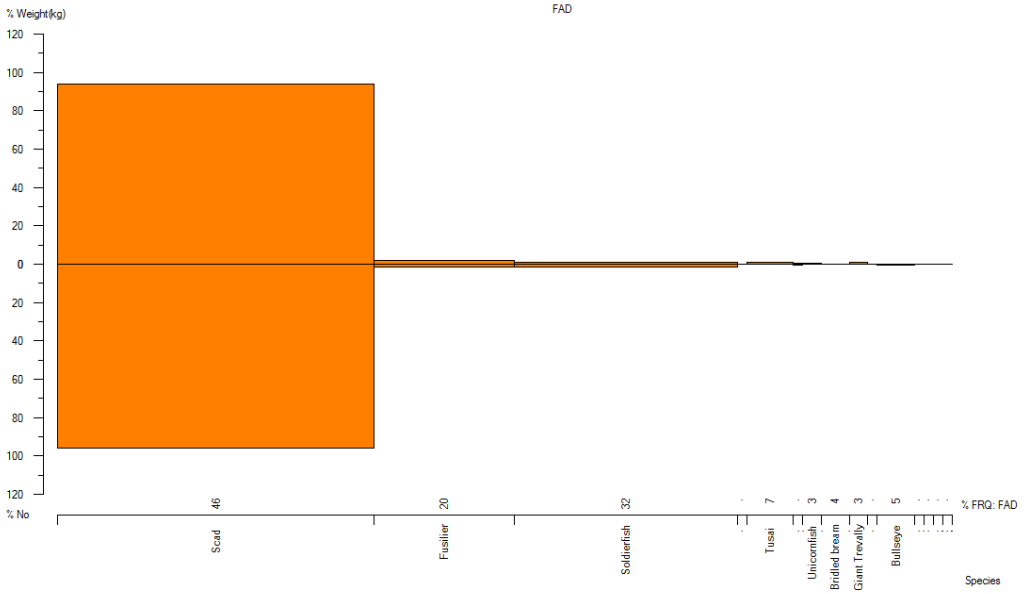

Figure 8. Index of relative importance (IRI) of species in landings from FAD fishing, Adara, Atauro Island, Timor-Leste

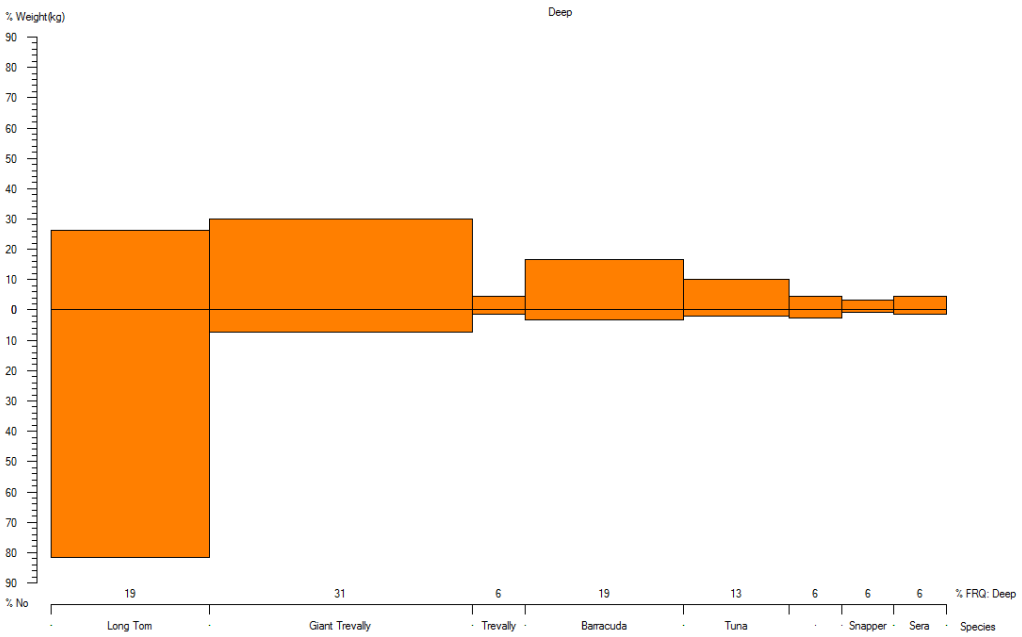

Figure 9. Index of relative importance (IRI) of species in pelagic fisheries landings, Atauro, Timor-Leste

The effect of the Adara FAD on relative abundance

The FAD was deployed in November 2015 and was recovered and brought shallower (as a temporary measure by fishers) in April 2016. The FAD was finally lost in June 2016 (Figure 10). This timeline allows for the exploration of landings data under various fishing conditions. Various climatic, cultural and unforeseeable events affected sampling frequency.

Prior to FAD deployment, landings data from Adara suggested their catch per unit effort was at 1.4 kg (SD ± 0.46) per fisher per hour, rising to a mean CPUE of 5.28 (± 1.26) over the months of February-April 2016. (Figure 10).

Using the Beloi landing site as a control site (without a FAD), we can see that where landings sampling exists for both sites, Adara consistently reports higher CPUE over time since the FAD deployment in November 2015 (Figure 11).

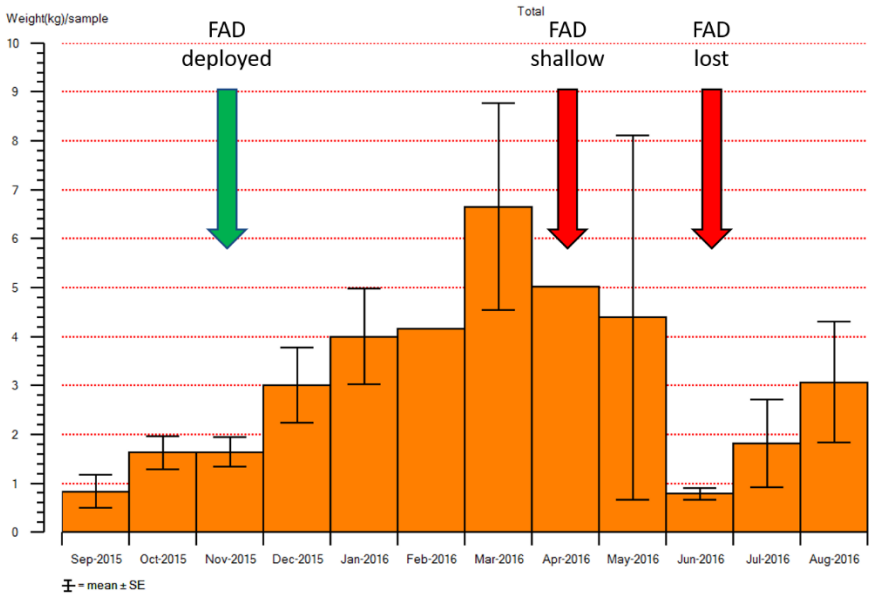

Figure 10. Mean monthly CPUE over time in Adara. Arrows depict FAD events. Error bars represent stand error. Where error bars are not present reflect very low sample size

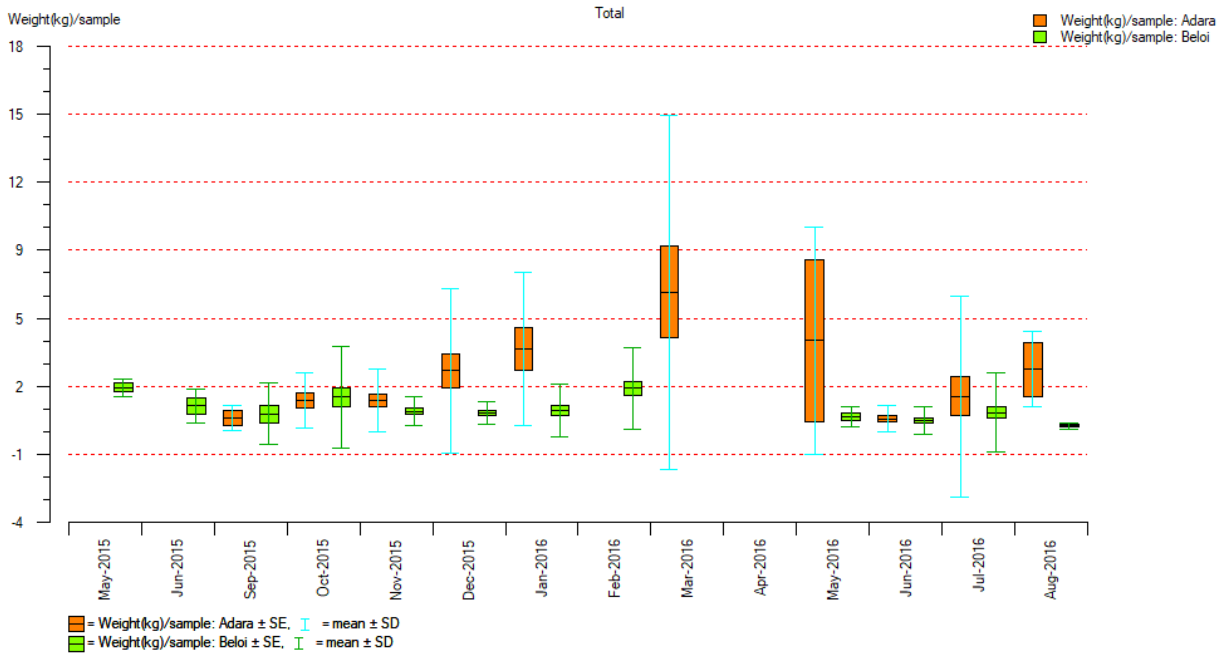

Figure 11. Monthly mean catch per unit effort (kg per fisher per hour) at landings sites of Beloi (green) and Adara (orange), between May 2015 and August 2016

The enhanced catch per unit effort in Adara can be directly attributed to the effect of a much higher CPUE for *D. macarellus* specifically. When we look at CPUE by species, we can see that *D. macarellus* exhibits abundance almost 3 times higher than the next species *Caesio* spp. (Figure 12).

One might consider that enhanced CPUE in Adara is merely attributable to better fishery health, or a larger standing stock size. If we consider the 3 fishing zones to be FAD, reef and deep and separate catches accordingly, we can separate out catches and catch rates by each. Figure 13 shows that the FAD fishers are achieving much catch rates at least twice as high as pelagic fishers, and an even greater separation from reef fisheries.

Gear diversity is low in Atauro, with fishers predominantly using gill nets set on the reef. Locally made spear guns and hand spears (rudimentary thick metal wires) are used nearshore to target small reef species. Hand lines are used more in Beloi than in Adara. No hand line catches were recorded in the sampling period in Adara. Spear gun catches were relatively similar, but gill net CPUE was significantly higher in Adara as a result of the FAD catches (Figure 14).

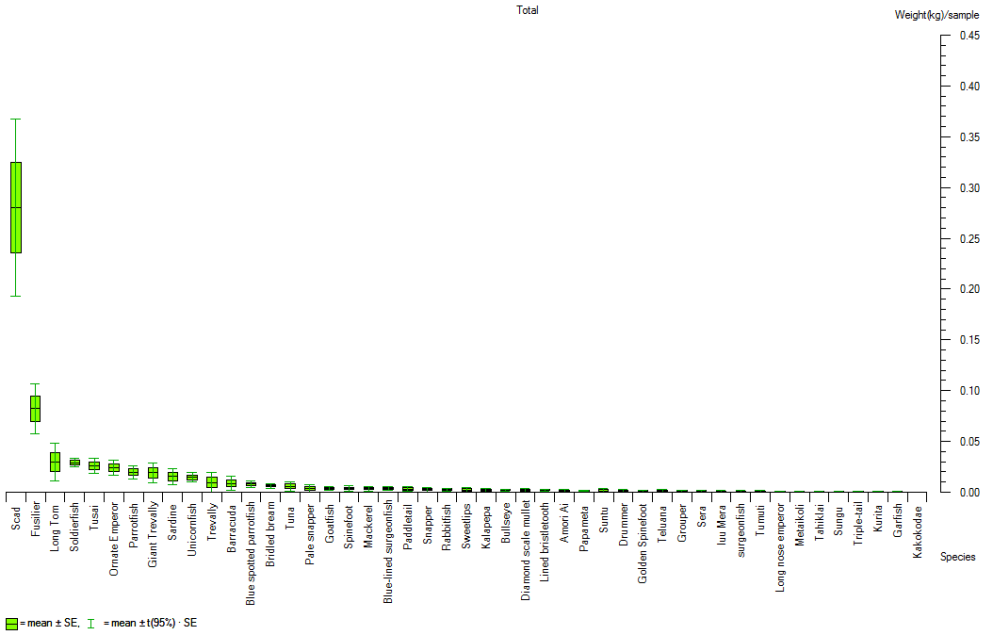

Figure 12. Catch per unit effort (kg per fisher per hour) for all species across all habitats in 3 SSF sites of Atauro, Timor-Leste

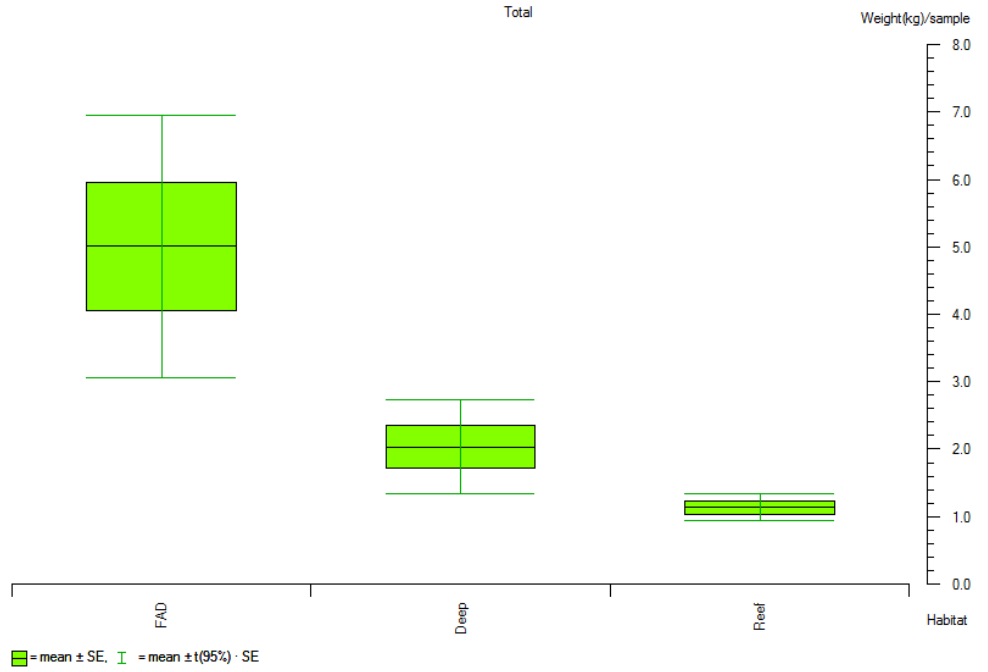

Figure 13. Catch per unit effort (kg per fisher per hour) for all species in 3 habitats at 3 SSF sites of Atauro, Timor-Leste

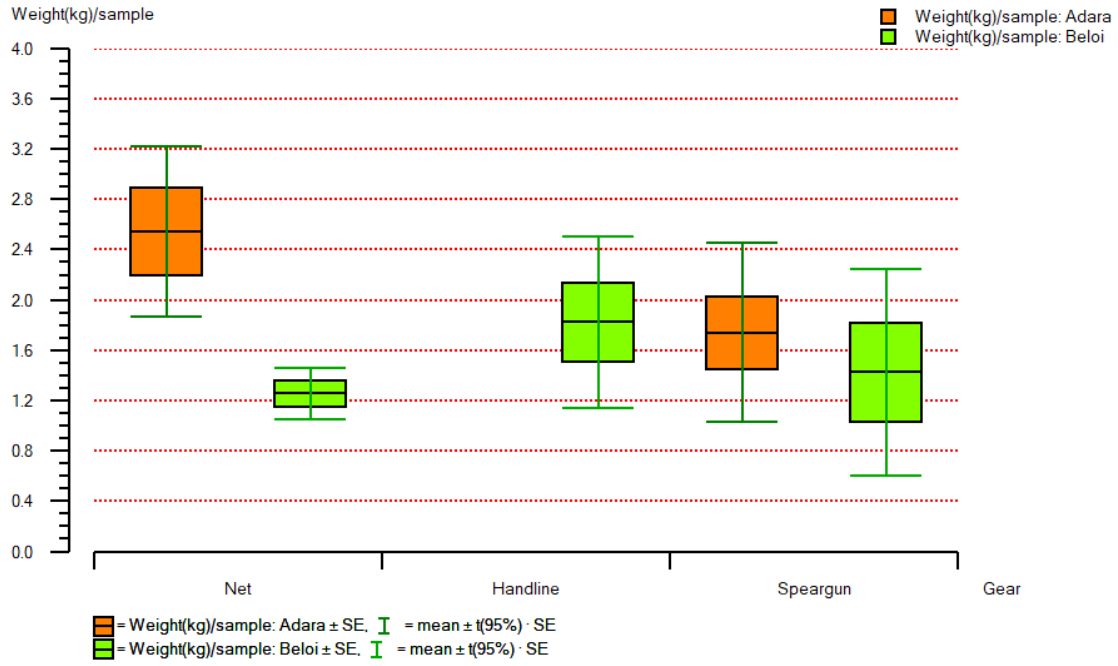

Figure 14. Catch per unit effort by gear type for landing sites of Beloi and Adara, Atauro Island

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11.3 Appendix 3: Implementing co-management for the governance of small-scale fisheries in Timor-Leste

Summary

WorldFish is working closely with MAF in 2017/18 to develop a National Fisheries Strategy. This project component aimed to test processes and approaches appropriate for coastal fishery co-management in the context of community and higher level institutions in Timor-Leste, and outcomes will be used directly in policy formulation.

Our overarching research question in this project component responds to the swell of enthusiasm for co-management, but simultaneously the relatively low levels of grounded implementation. We asked; does co-management offer a valid and viable governance solution for small-scale fisheries in Timor-Leste considering the a) characteristics of small-scale fisheries b) customary and formal institutional foundations, and c) political and fisher capacity to govern? Principle findings were:

- The fisheries 'system' in Timor-Leste is neither diverse nor technologically developed, yet is important locally for food security and livelihoods
- The governance system is 'primed' to adopt co-management as a principal approach to management, yet there is little guidance on approach, and there has been no government-led implementation to-date
- The traditional *tara bandu* institution, in various forms, is appropriate and fit-for-purpose for implementation of CBFM, or community components of a co-management system
- A successful community *tara bandu* initiated by the project was remarkable for its rapid positive outcomes, while sustainability and influence were demonstrated in an established system.
- Project outcomes will feed directly into policy formulation for SSF management

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INTRODUCTION

On June 9, 2014, the Committee of Fisheries of United Nation's Food and Agriculture Organization (FAO) adopted the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). Of the worlds' 51 million fishers, 98% are those operating in small-scale fisheries, upon which hundreds of millions of people rely on in terms of nutritional and economic benefits (Mills *et al.* 2011). The development and endorsement of the SSF Guidelines seeks to address concerns that the security of these benefits is at risk, particularly for the world's most poor and marginalized. After extensive consultations and negotiations the SSF Guidelines provide a range of high level, but voluntary, commitments related to human rights, fisher representation, economic and social development and sustainability. The challenge facing countries now is to implement the SSF Guidelines (Jentoft 2014), by way of aligning, adapting, reconfiguring and strengthening existing SSF governance arrangements.

Co-management has captured global attention as an approach appropriate for SSF governance, and, as conceived, is well aligned to commitments to participation, representation, collaboration and coordination emphasized through the SSF guidelines (Cinner *et al.* 2012; Evans *et al.* 2011). The philosophy behind co-management is that those who are affected by management (e.g., fishers and other resource users) should be involved in making management decisions (Berkes 2009). Fisheries co-management is defined as a relationship between a resource-user group (e.g., local fishers, processors etc) and another entity (e.g., government agency or non-government organisation) in which management responsibilities and authority are shared (Evans *et al.* 2011; Pomeroy & Berkes 1997). The form and function of co-management is contextual, depending on the nature of small-scale fisheries and the resource they access, informal and formal governance institutions and the capacity, influence and authority of nation states and fishing communities. Much has been written about the evolution, role and performance of co-management in the Pacific Island Countries and Territories (Davis & Ruddle 2012; Govan *et al.* 2009; Jupiter *et al.* 2014). However, despite the recent attention focused on the Coral Triangle Region (Figure 1), there are very few critical accounts of governance approaches for SSF of Timor-Leste.

In fact, McWilliam (2003) suggests that "*comparatively and culturally speaking, most Timorese turn their back to the sea", and that* researchers and governments have had relatively little concern for the sea compared to other Island nations. Nonetheless, peoples reliance and relations to coastal areas should not be considered of low significance (McWilliam 2003). The unparalleled nutrition value of marine resources is of major importance globally to the poor, and particularly to those beyond the reach of markets. Clearly there is substantial potential in Timor for the sector to contribute significantly to the nation-building process. Local and traditional relationships around coastal resources and management were historically ignored by the Portuguese and Indonesian regimes (McWilliam 2003). In contrast, post-conflict Timor-Leste emerged into a landscape where the spotlight of global attention and opportunity were shining on coastal resources and fisheries via the Coral Triangle Initiative (CTI Secretariat 2009), national concern was raised on fisheries contributions to food security (GOTL 2017), and, in line with a global trend the national government was actively looking to strengthen local governance "*as a cost-effective mechanism for managing natural resources*" (D'Andrea 2003; Miyazawa 2013). Currently Timor, on the one hand is in a relatively unique situation of likely having underexploited pelagic fish stocks (Mills et al. 2013), but simultaneously experiences commonly-faced concerns about the sustainability of nearshore marine resources for meeting subsistence functions and conservation commitments (Alonso et al., 2012). In recognizing the importance of small-scale fisheries for many peoples food security and livelihoods, the (then) Minister of Fisheries Mariano Assanami Sabino stated that "*Co-management provides a mechanism for establishing effective partnerships between different stakeholders and Government agencies, ensuring*

that people are involved in decision making processes that will directly affect the way in which they interact with their surrounding resources" (in Costa Pereira *et al.* 2013).

Our overarching research question for this component of the project responds to this vote of confidence in co-management, but relatively low levels of grounded implementation. We ask; does co-management offer a valid and viable governance solution for small-scale fisheries in Timor-Leste considering the a) characteristics of Timor-Leste's small-scale fisheries b) customary and formal institutional foundations, and c) political and fisher capacity to govern? To put the Timor-Leste context under the microscope we use the Interactive Governance Framework (Chuenpagdee & Jentoft 2013) to analytically examine features of the *system-to-be-governed* (i.e., the diversity and complexity of the small-scale fisheries) and the *governance system* which includes customary and formal institutions, and roles and capacity of governors (including the national state, fishing cooperatives and fishing communities).

Finally, we ask; how do the characteristics of Timor-Leste's small-scale fisheries render them more or less governable using the co-governance approach? To explore this we examine the interactions between the *system-to-be-governed* and the *governing system* in two cases where community-based forms of co-management options have been pursued, and a third where project interventions did not directly lead to improved management outcomes. What do lessons from these cases and our broader findings mean for the future of small-scale fisheries governance in Timor Leste? Chuenpagdee and Jentoft (2013) highlight decentralized governance, such as co-management faces, its own set of challenges. We aim to unpack some of the particular challenges and opportunities for our case and critically analyze co-management as a principle vehicle with which to govern small-scale fisheries of Timor-Leste.

METHODS

The Interactive Governance Framework (Chuenpagdee & Jentoft 2013) breaks analysis of small-scale fisheries down into three main components. First, to describe the *system-to-be-governed* we provide a precis of the very limited published and unpublished literature that provides information on SSF in terms of levels of participation, species targeted, fishing gears employed, and the geographic range and focus of fleets. Second, to examine the *governance system* we drawn previous reviews of the formal legal and policy instruments that implicate how state and decentralized governments play a role in SSF governance. We review published reports that explain how customary institutions can be invoked in community efforts to manage natural resources. Further, we examine census data and published literature to describe the demographic and social situations of fishing communities. We use published reports to describe the formation and function of fishing cooperatives as potential co-management partners. Finally, to examine *governance interactions* we draw on empirical experience from the three case-study sites in this study. Each site provides a decidedly different and even divergent set of interactions, providing a useful basis for analysis and reflection.

Case-study development

The project was conducted in close collaboration with the Ministry of Agriculture and Fisheries, Timor-Leste (MAF). Study sites were recommended by MAF due to their high levels of fishery dependence. Sites on Atauro Island were selected as the island is an area of exceptionally high marine biodiversity, with a high concentration of fishers, and a strong need for participatory governance interventions. Beacou was selected as a case-study with a longer history of participatory governance, in order to provide lessons applicable to new sites.

Within communities, the following processes were loosely followed, although the degree of implementation was adaptive, and varied at all sites. Engagement at Beacou was as a

diagnosis process only. Our methods were heavily participatory, and integrally gendered. Community engagement began with courtesy discussions with the village Chief (locally called the Chefe Aldea), and other local authorities when deemed appropriate by the Chefe.

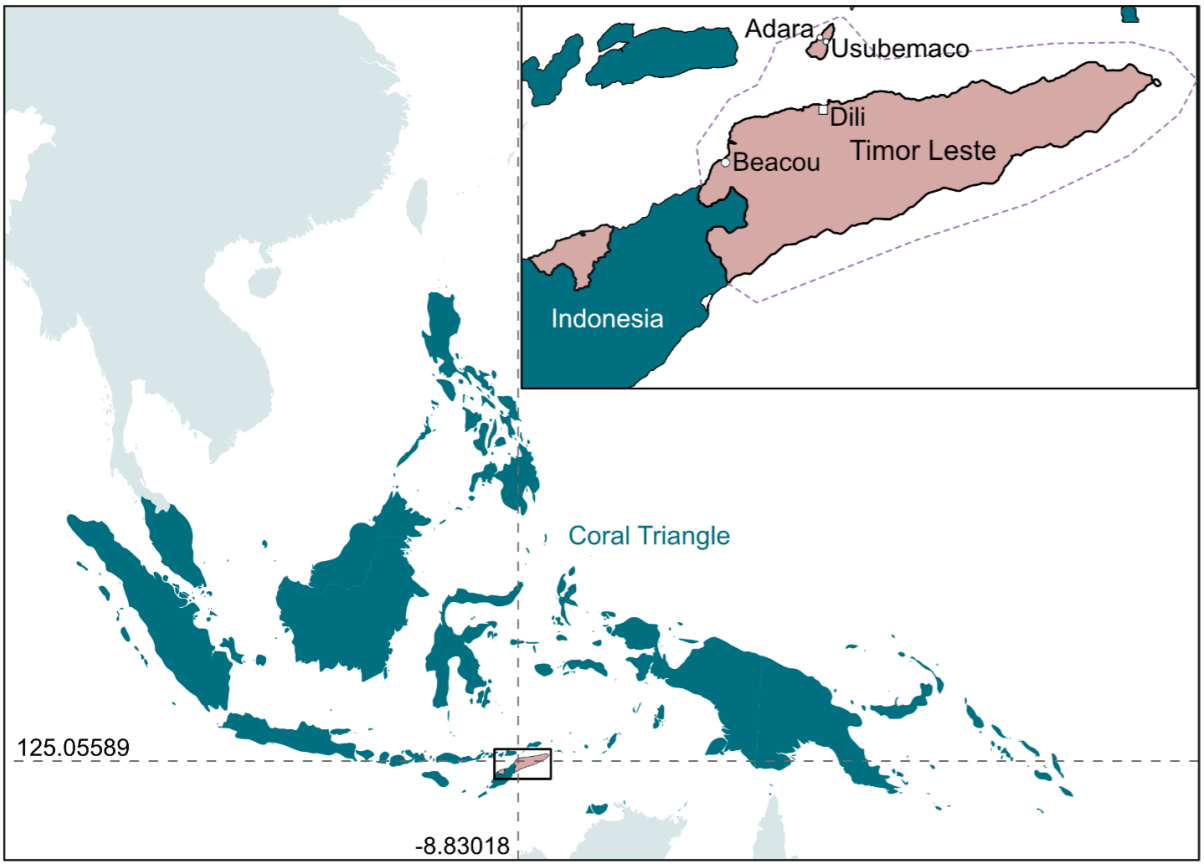

Figure 1. Map illustrating Timor-Leste within the Coral Triangle region. Inset map illustrates the three case study locations for the study – Adara, Usubemaco and Beacou

Participatory diagnosis:

Except for initial community engagement meetings, all interactions were in gendered groups. First, a **livelihood calendar** was developed. This catalogues the important shifts in livelihoods and resource reliance throughout the year. The process involved listing (in table form, in local language) all the major livelihood activities and resources. A circular diagram with the 12 months of the year as sectors was used to annotate seasonal livelihood activities, threats and weather patterns.

Participatory resource mapping started with presenting a large printed Google Earth imagery map of the communities fishing area. The participants annotated the map with the location of fishing and other marine-associated livelihood activities. Lastly an **inventory of marine resources** was produced, with annotations of major use (subsistence or sale) and trends in abundance comparing years before independence with current resource condition.

These methodologies were rolled out with communities over a number of meetings across several months, then consolidated and reported back to communities allowing for verification and final adjustments.

Implementing community-based resource management:

In Adara, the community indicated a high level of enthusiasm and engagement for the development of a CBRM system. The process again involved gendered focus groups and regular joint group meetings and leaned heavily on experiences from WorldFish CBFM engagements in the Pacific (e.g. WorldFish 2013, Sulu *et al.* 2015). Given the pilot nature

of this project, details of development processes are better classified as results than methods, and as such are reported below.

RESULTS

System to be governed

The fisheries sector in Timor-Leste is almost exclusively small-scale, dominated by simple, non-motorized vessels and low-cost, low-efficiency, shallow water gears types at subsistence and semi-subsistence levels. Fishing often serves as part of diverse livelihood strategies including agriculture and foraging (Wever 2008; Población 2013; Mills et al. 2017), and occurs throughout the year or seasonally. Recent figures suggest there are ~5000 fishers in Timor-Leste, with 1500 on the island of Atauro (NDFA 2005; Wever 2008). The fishing fleet is comprised of 1-2 person wooden outrigger paddle canoes (63% of the fleet), or larger mechanized outrigger canoes and fibreglass dinghies (35% of the fleet) for fishing groups of 2-4 persons (NDFA n.d.). As such, fishing activity is concentrated within a few kilometers of the coast, targeting reef fish and small open-water species (e.g. sardines, scad, mackerel, small tunas) in reef, seagrass, mangrove, river mouths and surface waters (<10 m depth). Fishers use simple low-cost gear types such as single or multi-hook hand lines and small mesh gill nets. Hand lines are equipped with 1/0 or 2/0 sized hooks with homemade lures made from chicken feathers or nylon fibres. Small groups of fishers in canoes equipped with small outboard engines (5.5-15 hp) (Población 2013) target pelagic tuna, jack and trevally species using tangle nets and gill nets. Traditional fish aggregating devices (FADs) made of bamboo are used to attract fish outside the reef, and are fished using hand lines and small purse seine nets (Población 2013).

In one study of fish landings across 5 districts of Timor-Leste, snappers (48%), sardines (36%) and mackerels (24%) were the most frequently caught groups among more than 12 commonly targeted fishery species groups (AMSAT International 2011). This contrasts with data collected by MAF officers in 2011/12 and entered in the 'Peskador' fisheries information system set up by the FAO Regional Fisheries Livelihoods Program. This data was cleaned and analysed under the ACIAR project (see appendix 5), and records that 90% of the entered catch was sardines, garfish, frigate mackerel and flying fish, while snappers did not appear in the top 20 species landed. This dichotomy highlights well the lack of quality data available on the fishery sector in Timor-Leste.

Gleaning for molluscs, fish, crustaceans and cephalopods in the intertidal zone of reef, mangrove and seagrass habitats represents an important fishery livelihood undertaken by women, children and non-fishers for subsistence or sale (Sandlund et al. 2001; Anon 2002) (AMSAT International 2011), but finfish are the most important group for fisheries livelihoods. Sea grass beds are generally utilized for spear and net fishing and seaweed farming, coral reefs used for spear, net and line fishing, and sea cucumber harvesting, and mangroves utilized for firewood and crab harvesting (Park et al. 2014).

Details of the individual 'system to be governed' at the community level are included with the case study results below.

Governing System

Central government: The Constitution (article 61) stipulates that "Everyone has the right to a humane, healthy, and ecologically balanced environment and the duty to protect it and improve it for the benefit of the future generations". The Ministry of Agriculture and Fisheries is formally charged with management of fisheries (Miyazawa 2013), however, effective enforcement and monitoring have been issues due to institutional, human resource and financial capacities. This shortfall has been particularly apparent post-conflict where the Ministry was left with only 19% of the staff that were employed during the Indonesian administration (Fisheries 2007; Miyazawa 2013). The government census in 2015 puts 60% of the workforce in the agriculture and fisheries sector, but the budget for the Ministry of Agriculture and Fisheries is 1.7 % of the national budget (GOTL 2015). From a total operating budget of USD16.19 million in 2017, the budget provided by the Ministry for fisheries and aquaculture implementation activities is approximately USD

0.5M, of which $184,000 is for a training centre, and only $40,000 for specific fisheries development activities (Minutes of the Agricultural Development Partners Meeting, Feb 2017).

Decentralisation: The National Constitution supports a decentralised model of governance, Despite this intent, coastal waters fall entirely under the jurisdiction of the central government; the exception is the waters of Dili that are administered by the Port Authority. Currently governance systems nominally operate under a four-tier structure (central/district/sub-district/village), however governance functions and spending remains highly centralized. Wever (2008 citing RDTL, 2006) points out that in 2006, local government spending accounted for less than 1% of government funds. Moves towards decentralisation would view districts as the second tier of government, and would effectively become 'municipalities' with elected mayors and municipal assemblies (Shoesmith 2010).

The decentralization process, originally set to commence in 2009, is taking place at an administrative and financial level in 2017. A recent Decree (3/2016), established a technical working group composed of the line ministries and local authorities charged with identifying portions of work from each ministry to be devolved to municipalities. Cummins & Leach (2012) warn that whilst there are benefits to decentralisation in theory, in practice imposing an additional level of formalized governance onto the existing local institutional adds substantial complexity, and capacity development to allow for decentralisation to lead to improved governance, remains a critical need. Mills et al. (2013) state that for co-management "systems to be sustainable in the long term, devolution of governance authority and resourcing, development of processes and institutions for vertical and horizontal interaction and information flow, and strong political will to devolve power are required".

The decentralised structure and push for strengthening decentralised governance capacity has considerable implications for co-management of terrestrial and marine coastal resources. The lack of formalized, consistent institutions below the national level brings particular challenges in the area of communication and institutional support. Central to developing sustainable co-management systems is a level of vertical integration allowing for influential interaction between stakeholders and government. Building such systems within the dynamic and incomplete governance structures of Timor-Leste will require careful design. The question of the capacity of District government to support SSF management and development, and their role in co-management efforts remains unanswered, and a difficult point on which to speculate.

Communities: Experience throughout Timor-Leste shows that local governance systems i.e., at the community level, can be resilient, remain functional, and even flourish despite a lack of technical and financial government support (Miyazawa 2013). In this paper we consider 'community' to be the geographical distribution of people at the levels of suco (Tetum for village) and aldeia (Tetum for hamlet) (consistent with Miyazawa 2013). Natural resource related decisions are made by traditional authorities within communities (whose authority is conditionally respected within the Constitution), such as liu rai (traditional "Kings" or land owners), Datu Lulik/Na'in (religious custom) or Na'in (elders or cultural leaders) (Costa Pereira, Pinto et al. 2013). The government law on community authorities states that the Suco Council is the responsible entity for coordination of any development activities in the Suco (i.e., village). The roles and responsibilities of Suco Council include: (a) protection of the environment, (b) striving to achieve food security, (c) establishing local group/s to address specific problems (Democratic Republic of Timor Leste 2004). Further, government law allows for establishment of co-management committees to help manage fisheries (Democratic Republic of Timor Leste 2004) and it is recommended that for community-based forms of co-management, the Suco council, and village leaders are critical points of engagement in management establishment and the establishment of new committees with resource management responsibilities (Costa Pereira, Pinto et al. 2013).

Tara bandu: The Constitution (Article 2.4 9) states that "The State shall recognise and value the norms and customs of East Timor that are not contrary to the Constitution and to any legislation dealing specifically with customary law". The Environmental Base Law (Article 8, point 1, 2, and 3) recognizes tara bandu as a customary institution to be used in regulating the relation between humans and the environment. Tara bandu refers to local laws used by communities and is closely related to cultural perceptions of the environment. Tara bandu refers broadly to prohibitions (Hicks 2004) that can be applied to agricultural, forestry or fisheries harvesting in a given area for a set period of time (Shepherd 2013), or for more general protection of ceremonial sites. In Aileu, tara bandu is used to prohibit tree-cutting to prevent flooding; in Bemalae Lake in Maliana to restrict fishing to once a year (Needham, Alonso et al. 2013). Given the complex ritual beliefs underpinning the mechanism, it is believed that if people break a tara bandu they will be cursed (Miyazawa 2013).

Whilst tara bandu has been painted by development and conservation NGOs as a "longstanding and important tradition", its formation is much more recent than that (McWilliam, Palmer et al. 2014). In fact the institution is actively promoted and elevated (Miyazawa 2013), for example, fisheries strategies suggest tara bandu is "an inherent part in the development of local ordinances to protect the forest-watershed areas" (MAFF 2004, p38 in Miyazawa 2013) and should form the basis of community-based efforts of fisheries management (Needham, Alonso et al. 2013). Given relatively limited government capacity to manage the scope, scale and diversity of small-scale fisheries, efforts to devolve management responsibility via community-based, co-management approaches have been both promoted and criticized (Davis and Ruddle 2012). In Timor's case, the Ministry of Agriculture and Fisheries "has been encouraging the revival of tara bandu for both technical and political reasons" which is perceived as "benefiting both governmental authority and customary leaders" (Miyazawa 2013). Nonetheless, tara bandu's contemporary use in restricting access to, and use of, natural resources and spaces is based on more recent imaginings, and even appropriation, of the institution to contribute towards conservation and sustainability objectives (McWilliam, Palmer et al. 2014). Nonetheless, in this contemporary setting tara bandu appears to hold legitimacy with communities, NGOs and government alike (see section 3.3) and its invocation in community-based management seems almost inevitable.

Cooperatives and co-management further up the market chain: Despite the emphasis on community-based forms of co-management in many countries and regions (Cohen et al. ; Govan et al. 2009), the SSF Guidelines promote a much broader view of fisher participation and representation along multiple points of the value chain. For example, the SSF Guidelines recommend that "States and small-scale fisheries actors should encourage and support the role and involvement of both men and women, whether engaged in pre-harvest, harvest or post-harvest operations" and that small-scale fisheries are "represented in relevant local and national professional associations and fisheries bodies and actively take part in relevant decision-making and fisheries policymaking processes". This justifies some consideration of co-managers not only as "community" but also other stakeholder associations. The Government of Timor-Leste is mandated to support co-operatives in rural industry, although despite funding opportunities few are currently extant in the fishing industry.

Governance Interactions

Environmental Base Law (similar to an Act) contains provisions consistent with co-management i.e., a local community can participate in the protection and conservation (Article 11), and allows for integration of community and civil society in the decision making (Article 12). Article 6, lines A and D states that the government must involve community leaders and fisher groups when designing fisheries management plans and establishing marine spatial plans (Democratic Republic of Timor Leste 2004). Most CBRM in Timor-Leste has taken place at the instigation of the community. For example in Beacou, the community recognised that they face environmental issues that affect their dependence upon natural resources. Beacou and Miguir communities therefore actively sought information and opportunities for outside help to design and declare a Tara Bandu

system. On the contrary, in the case of Lautem and the communities within and around the National Marine Park of Nino Konis Santana, declared by the government, there remains a need to develop and incorporate a system of tara bandu to regulate communities' use of natural resources in the context of top down protection (Costa Pereira, Pinto et al. 2013). The case-studies presented here provide three very different outcomes from engagements for community-based resource management, and each provide complementary lessons in implementation and sustainability.

Beacou case study

The village of Beacou is situated on the north coast of mainland Timor-Leste, some 70km SW of Dili, and 30km from the border with West Timor - Nusa Tenggara Timur. The 2010 National Census report 507 people and 84 households in the village. Access to the village has improved substantially in recent years, with driving time from Dili cut from four hrs to two due to improved road systems.

The Beacou case-study presented here provides valuable lessons for future *tara bandu* implementation. Rather than a new engagement with a community wanting facilitation in managing resources, this case study revisits a marine *tara bandu* established by a previous project. As a relatively new approach to marine resource management, this was seen as an invaluable opportunity to gain insights about implementation and longer-term enactment of the *tara bandu.*

Participatory Diagnosis:

As for other focus communities, the project team conducted detailed participatory diagnosis activities with men's and women's groups in Beacou (fig XX). Livelihoods in Beacou are extensively based on natural resources, with limited external trade, although this is increasing due to infrastructure improvements. Women's marine-based activities include collecting oysters, clams, crabs, octopus and seaweed, and salt-making. All women's activities are conducted within walking distance of the village. Men engage in line, spear and net fishing, and share fishing grounds with the nearby community of Sulilaran. The RFLP census of fishing boats reports 44 vessels licensed in the community, most of which are dugout canoes either paddled, or powered by small outboard, or slightly larger fiberglass vessels with 15hp outboards. Most vessels are crewed by one to three fishers. Fishing is almost entirely for pelagic and deeper demersal species, as there are no substantive areas of reef within the community's fishing grounds. In contrast to sites on Atauro Island, we also found no ubiquitous 'crisis narrative' around fish stocks. Among the top 10 harvested species, fishers stated that stocks of four had decreased, four had remained substantially unchanged, while two (demersal species) had increased or were noted to be in high abundance.

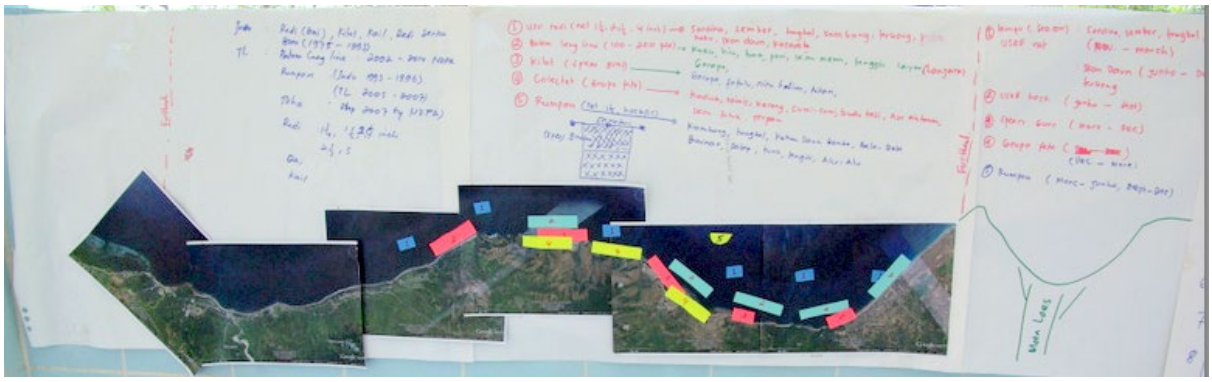

Figure 2. Participatory resource map of Beacou's community fishing area

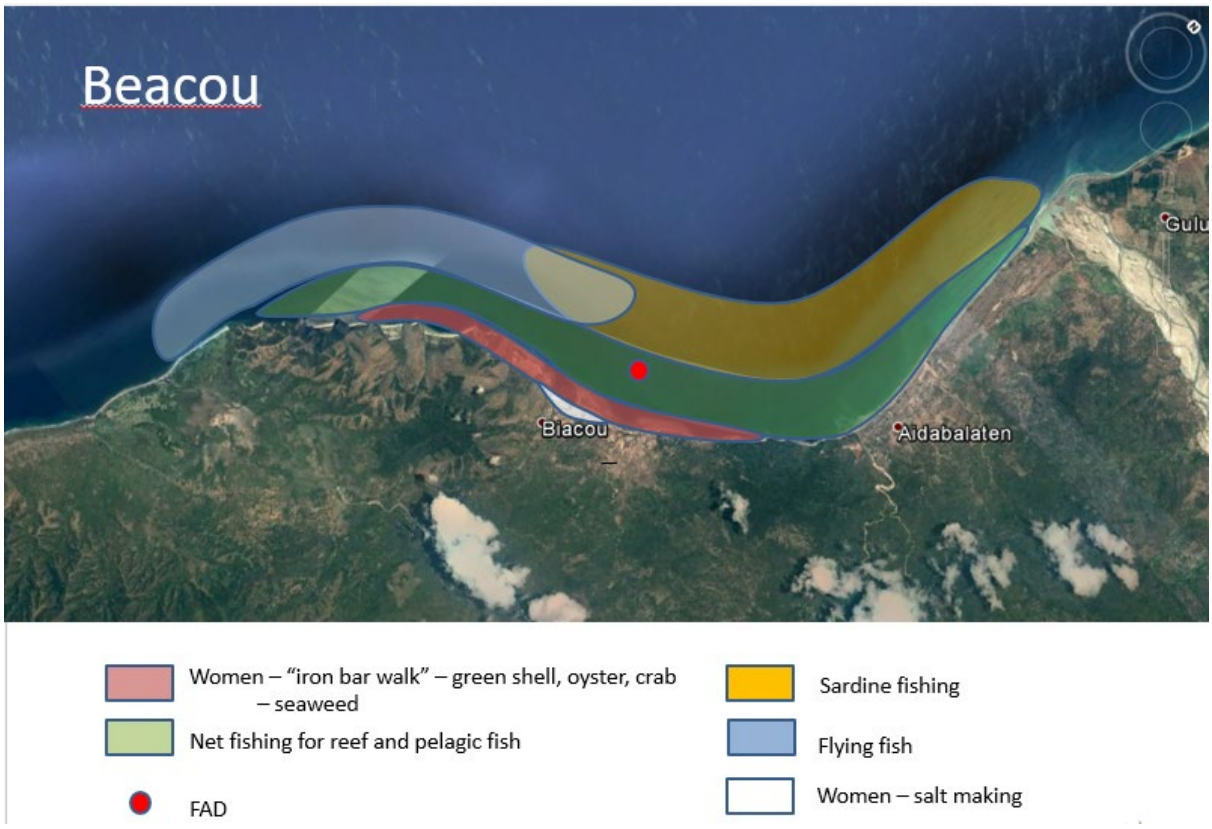

Figure 3. Resource use map for the immediate waters adjacent to Beacou and Sulilaran

Table 1. Fisher's observations of change in status of dominant species in catch since independence (2002)

Local name	English name	Status since independence
Sardina	Sardine	unchanged
Tokong	Flying fish	decreased
Sember	Gar fish	unchanged
Daun	Long tom	decreased
Tongkol	Tuna	unchanged
Kombong	Mackerel	decreased
Kokuh	Trevally	high abundance
Mean	Snapper	high abundance
Layar	Sailfish	unchanged
Tubiraun	Shark	decreased

Fishers noted that these in high abundance were due to lower fishing pressure since independence, as many boats had left to Indonesia, and only smaller boats remained.

Beacou differed from other case study sites in that rice growing provided an additional source of external cash earning. Rice growing was undertaken by men, but overlapped substantially with the time of year when fishing was easier (the dry season). The period from December through to the end of February was highlighted by women as the 'hungry season' as the weather is often too rough for fishing, while crops had been planted but were not necessarily ready for harvest. During this period, it is common to rely on selling livestock for household income. Notably, men still included fishing through this period as important to their livelihood. This dichotomy likely reflects the difference in the ultimate outcomes from fishing activities, with little input to household income through the wet season, despite men's optimism in waiting for the days when fishing is possible.

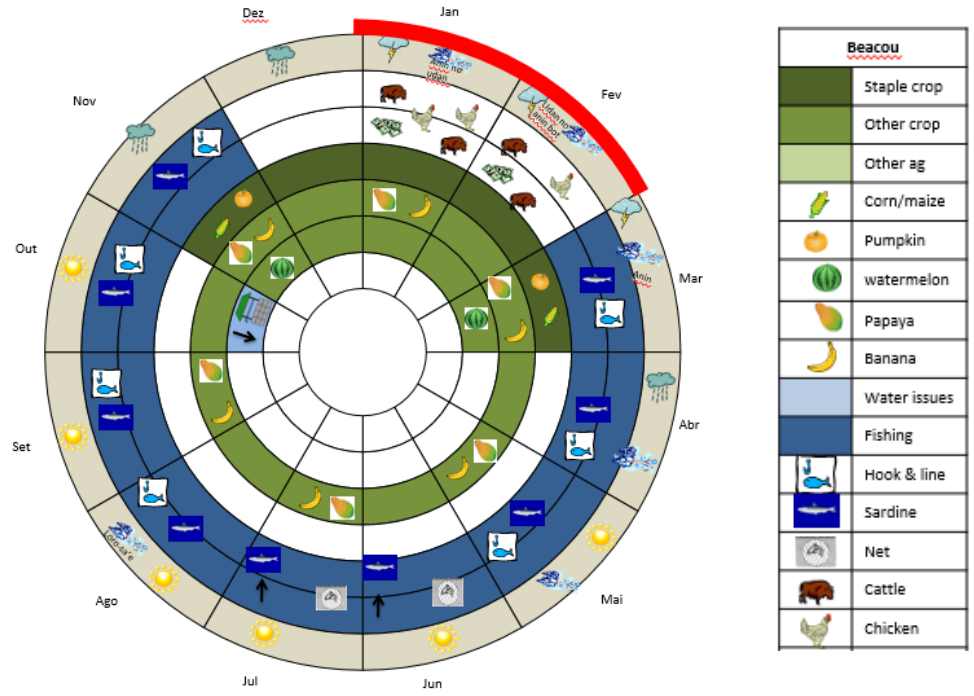

Figure 4. Beacou Women's livelihood calendar showing main agricultural crops, the importance of fishing for women, and most notably the importance of selling livestock in January and February, as there are few other reliable income sources at this time

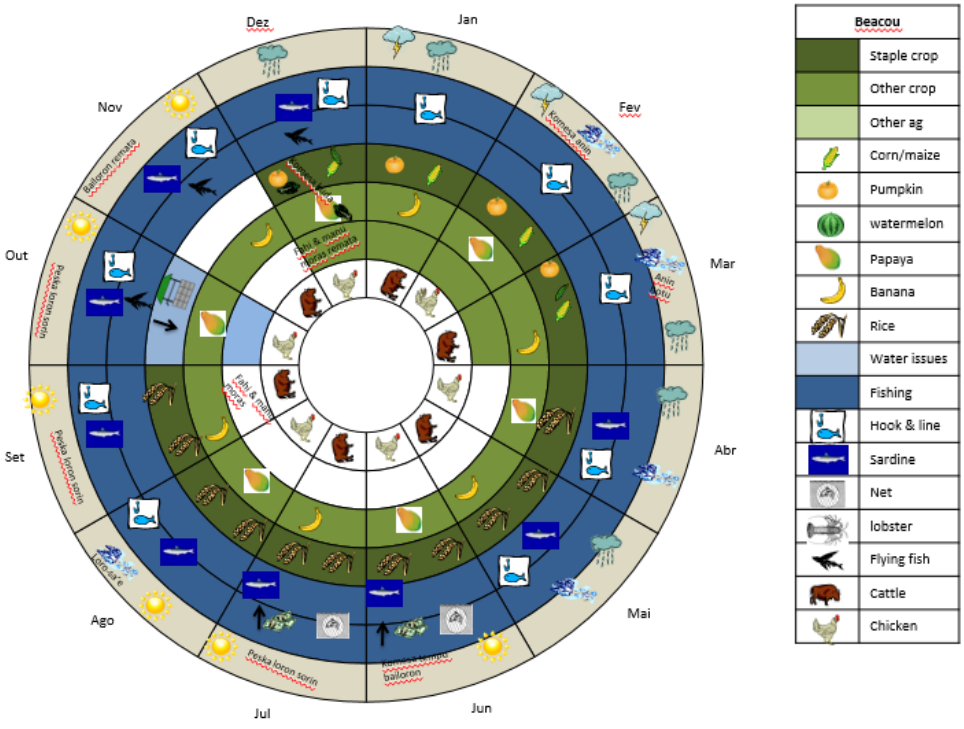

Figure 5. Beacou Men's liveilhood calendar showing the importance of rice, but also noting year-round fishing activities

Tara bandu:

The Regional Fisheries Livelihoods for South and Southeast Asia Programme (RFLP) was funded by the Kingdom of Spain, and implemented by FAO in six countries including Timor-Leste. A component of the program in Timor-Leste was piloting systems for community-based coastal resource management. A detailed account of the process of establishing the tara bandu in Beacou is given by Alonso et al. (2016). Alonso notes:

> *"This* tara bandu *was not a measure imposed by the state institutions or by development agencies, although community leaders received further external support during the process to establish the governance arrangement. Far from being an alien measure imposed anew, it represents an example of the revitalization of a customary practice and a claim for the assertion of land, coastal and marine rights, resource exploitation and management by the local community."*

The *tara bandu* was developed in the community between 2010, when first conversations were had among local authorities and villagers, until the declaration ceremony in August 2012. The process engaged the village authorities, MAF officers, and ultimately political authorities to sign and witness the document. The *tara bandu* rules covered sacred spaces, conflict (particularly between youth groups), terrestrial resources (protection of forest resources, banning swidden agriculture burning) and marine resources (protecting coral, mangroves, banning bomb and poison fishing, protecting turtles and their eggs). A three-step graduated penalty system was devised, with second and third offences giving rise to increasingly harsh penalties. In line with traditional practice, penalties involve the offender providing food (goat, buffalo, rice), cash and other supplies (alcohol, cigarettes, betel nuts) to the community, which would be consumed in a community feast once a reconciliation agreement had been reached.

Alonso (2016b) recounts the first enactment of the *tara bandu* penalties, when a group of men who had been drinking under a 100 year old tamarind tree failed to extinguish their fire, and the tree burned. They were penalized one goat, two bags of rice, two boxes of beer, two cartons of cigarettes, USD100, betel leaves and areca nuts. They also planted a new tree to replace the destroyed one. As per the rules, these were consumed in a community feast.

Five years on:

Women's and men's focus group discussions and key informant interviews with Beacou community members provided insights into the status and effectiveness of the tara bandu five years after it was declared.

Both groups stated that the tara bandu regulations were still in force, and were strictly enforced by the Chefe Aldea, and that the MAF security guard at the landing site building worked closely with the chefe on this; "Both men are regularly reminding people of the rules" (Women's FGD). However, others were also active in ensuring there was a broad understanding of the rules: "Every point listed under the tara bandu has been enforced, and people follow them. The community, the local authorities and the rai nain (land owners) are making sure the rules are followed" (Men's FGD). Both groups noted that "almost all" people in the community were happy with the tara bandu as it had increased their knowledge of resources, and had shown good results.

Interestingly, men and women both highlighted that a ban on using gill nets in front of the mangrove area has had the biggest impact on their lives (both in terms of constraints and positive outcomes). This is not a rule that was in the original tara bandu document for the community. The men mentioned that some fishers have asked for this rule to be relaxed, but that this has not yet been considered by the tara bandu committee and the community members.

Women noted that not being able to cut mangrove wood had a significant impact on workload, as they could no longer be "lazy" and had to go the forest. On occasions they are given permission to take wood from specific mangrove trees that have died. An

anthropologist (from Charles Darwin University) who works in the community noted that there is significant regrowth of small mangroves in the area protected by the tara bandu. The project team has noted that this is quite rare in Timor-Leste, with most stands having only mature trees. Positive impacts of the rule application reported by focus-group members included:

4. Healthy mangrove ecosystems, with the presence of "7 or 8 species" among the mangroves that hadn't been seen for many years prior to the *tara bandu* declaration. These included sea birds, bats, cuscus and snakes. The men noted that the *tara bandu* should now be extended to include the banning of bird shooting within the mangrove area to ensure continued benefits from the management measures.
5. Increased vegetation on the hills due to better control of burning for agriculture.
6. A visible difference in the coral reefs and the numbers of "fish fry" seen near the shore.

Conclusion:

Men and women from the community have integrated the tara bandu as a new cultural norm. There are clear behavioural changes due to the regulations (agricultural practice, fishing locations, mangrove cutting) all of which would be expected to have positive dividends for sustainability of natural systems. While villages report increases in vegetation on the surrounding hills, diversity of fauna in the mangrove systems and numbers of small fish, there are no empirical baseline data to test these assertions against.

Importantly and in contrast to our case study in Adara (see 3.3.3 below), there are no direct financial returns from the declaration of the tara bandu, as there is no tourism in Beacou. Yet it is clear that the villagers value the institution, and are generally convinced of its importance to the community's natural resource base. Given this, it seems highly likely that the regulations will continue to be active and effective into the forseable future. Indeed, there was considerable keenness to extend the tara bandu to other resources. The important role of the Chefe Aldea in socialising rules and enforcing the tara bandu was very clear, and continued success may be dependent on this strong and engaged leadership.

Our first participatory diagnosis was conducted 2 years after the tara bandu was declared and was notable for the apparent health of a number of important and exploited fishery stocks. It is implausible to claim that the lack of crisis narrative around the status of fish stocks relates to the declaration of the tara bandu as the timeline is too short, and the area covered quite small. Indeed, it could be argued that the success and sustainability of the tara bandu may in fact relate to the relative health of the natural resource base, and therefore a relatively limited impact from the new regulatory measures imposed. Nonetheless, Beacou stands as a 'poster child' for tara bandu implementation, and as an early example of a sustained application of this institution to marine resources.

Adara case study

Atauro Island, some 26km due north of Dili, sits at the junction of the Ombai and Wetar Straits, and the Banda Sea. The island exhibits extreme topography and bathymetry, rapidly descending from a highest point of ca. 1km to depths in excess of 3km. Of volcanic origin, this topography has been accentuated by numerous geological 'uplift' events due to continental collision, and 'gravitational collapse to the east' (Ely, 2006). Intriguingly, these events are catalogued by marked terracing visible on approach to the south and south-west coasts of the island, where areas of coral reef have been serially lifted and re-formed at the new water level. These multiple terraces continue to a height of some 700m above sea level. This extreme topography and bathymetry have profound implications for the fishers of Atauro Island.

Home to some 9300 inhabitants from around 2100 households, the island claims the longest fishing tradition in Timor-Leste (Barros Duarte 1984; Magalhaes 1918), and remains one of the most fish-dependent regions of the nation (Mills et al., 2013). Located at the mid-point of the long north-western coast of Atauro Island, the community of Adara is both isolated and heavily fish-dependent. Fish sales on the island and to Dili, and more recently tourism, form the only regular sources of external cash income. This reflects the community's isolation, with access only by sea or by walking approximately 3 – 4 hours from the economic centres of the island – Villa and Beloi.

Fishers of Adara:

As is almost universal in rural Timor-Leste, our baseline socio-economic study (Mills et al. 2017 –see Appendix 1) shows livelihoods, even amongst those self-identifying as fishers, to be a diverse mix of natural-resource based activities. Nonetheless, a long tradition of fishing, and Adara's geographic isolation have brought about a relatively high dependence on fisheries within these livelihood portfolios. Indeed, the strong fishing tradition, and specifically the extent of women's involvement in spear fishing, has been highlighted in the award winning documentary film Wawata Topu – Mermaids of Timor-Leste (Alonso-Población et al., 2016a).

Atauro Island encounters two weather patterns in a year; an easterly and westerly season Adara's location on the west coast of the island facilitates year-round fishing when westerly winds (May-Aug) inhibit fishing from east coast centres such as Usubemaco (see appendix 1). On land, the long dry (westerly) and short wet (easterly) seasons, coupled with poor access to freshwater, limit the productivity of crops. The participatory seasonal livelihood calendar developed with men and women in Adara (Figure 7), show this clearly with year-round fishing, and a fairly limited range of agricultural crops. Livestock are critical for income resilience, and as shown in the livelihood calendar are largely sold for ritual purposes. Sales in August relate to the 'wedding season', while those in December are for Christmas and New Year celebrations. We note that as a dominantly Christian and protestant community, the ritual traditions formerly associated with livestock consumption (see Alonso 2013) are no longer practiced. While staples of banana and cassava are listed as being cultivated year-round, harvest times are also seasonally limited.

Participatory marine resource mapping (Figure 8) clearly shows that the rudimentary fishing gear types of shallow water gill nets and close range spear guns utilized in Adara limit exploitation mainly to reef areas very close to shore. The limited extent of these coastal reef systems is due to the extreme bathymetry of the island, and as a result reef fisheries have been under heavy pressure and are likely overfished.

Figure 6. Participatory diagnosis with women's and men's groups in Adara

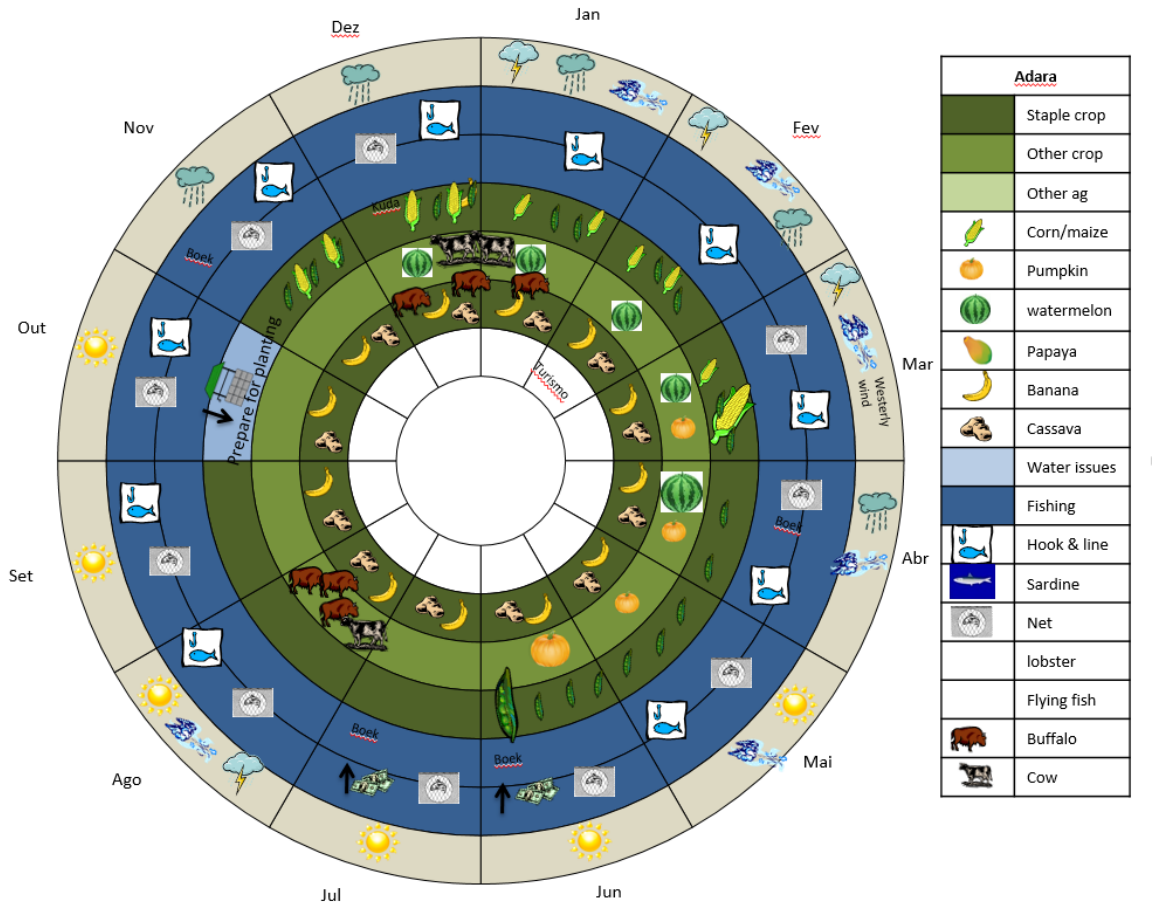

Figure 7. Livelihhod calendars for Adara, covering input from both men and women

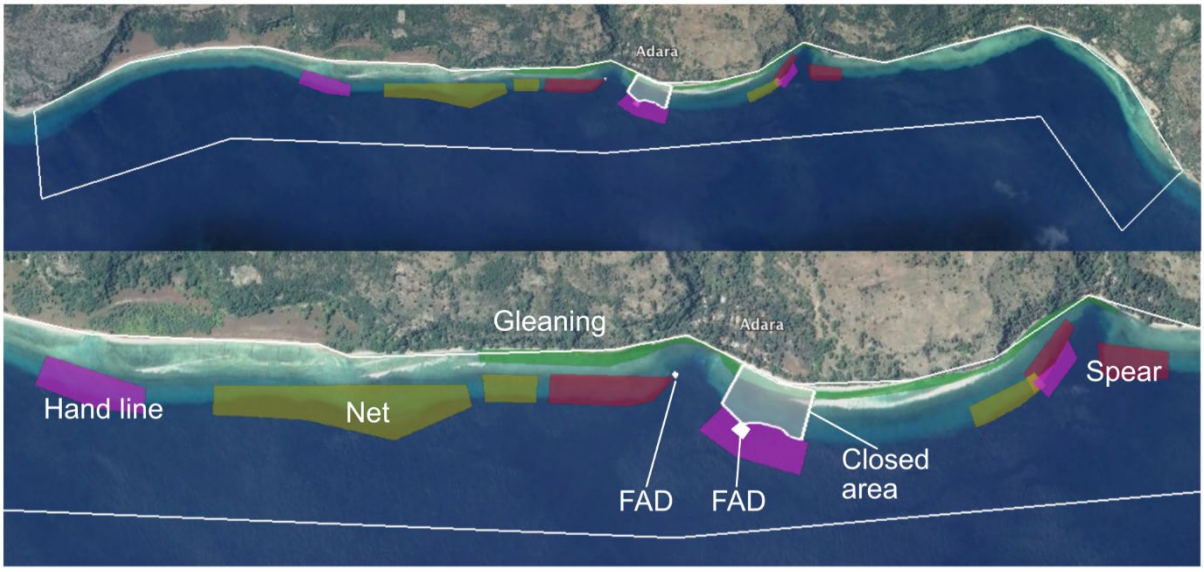

Figure 8. Participatory resource use maps combining input from men's and women's groups. The top map shows the full extent of what the community consider to be their fishing grounds, while the coloured polygons show the most frequently used areas for the various fishing activities. Note the protected area (marked tara bandu) impinges most on gleaning activates, but to some degree also hand lining.

Women in Adara engage in spear fishing and line fishing, and often join their husbands when netting. Gleaning fisheries are largely the domain of women. The dominant gear-types have different peak seasons driven by weather conditions and fish abundance. Net fishing peaks in April through to July, hook fishing in July and October, while spear fishing is generally not conducted in the rougher seasons of December to March

Facilitating tara bandu implementation:

The initial engagement with Adara was set up following the less-than-straightforward introduction in Usubemaco (see 3.3.4 below). While it was clear that the process in Usubemaco would be drawn-out at best, the project team had been directly approached by the Chefe Adara to work with his community, our Atauro Island field officer is from this community, and ultimately it was seen as an ideal pilot site.

Early focus group discussions highlighted two principal motivations for the strength of enthusiasm in the community for project activities. Firstly, a small, locally run tourism venture had met with some success in attracting 'eco-focused tourists', and the tara bandu was seen as a way to add value to this endeavour. Secondly, there was a strong narrative that protecting the reef would improve fish stock status in the area. Clearly, a degree of socialisation of marine protected areas had occurred in the area, and the Chefe had been promoting these ideas. There was a firm view expressed that other stakeholders (nearby villages, dive charter operators who use the area etc) should not be involved in the tara bandu development, as this sea area was owned by the community. Focus group participants noted that there had been a tara bandu for marine resources once before in 'Indonesian times', relating to the harvest of trochus. It was forbidden to harvest trochus unless the Chefe gave permission. The Chefe would give permission when he knew a Chinese buyer was coming to the Island. As such, the tara bandu was about maximising the value obtained from the trochus fishery.

Development of the new tara bandu rules took place over a period of 12 months, with monthly consultative meetings in this period. The participatory nature of the project saw a strong bottom-up development of management measures. The research team did not enter the partnership with the community suggesting a tara bandu for marine resources, but rather to assist with the establishment of CBRM. Tara bandu has been enthusiastically embraced by the conservation community as a way to integrate conservation-focused projects into community life, and we were very wary about the appropriation of this institution. Nonetheless, from our first meeting it was clear that the community wanted, and assumed, that a tara bandu would be instituted. They noted that this would ensure compliance from both within and outside the community. Early meetings to discuss management rules, which followed on from diagnosis focus groups, centred on the nature of the rules to be included in the tara bandu. There were two clear areas: rules pertaining to a closed area to be declared adjacent to the village tourism enterprise, and rules relating to the entirety of Adara's fishing area.

The proposed closed area was immediately adjacent to the eco huts, and included an area of reef flat, and a wall extending from the reef flat at ca. 5m into ca. 30m of water. Snorkelling on the reef flat revealed extensive damaged/denuded coral rubble areas interspersed with more intact zones, often deeper and protected by large boulders. The reef drop-off had surprisingly intact coral communities, large numbers of small fish, and was undoubtedly worth of promotion as a dive and snorkelling site. The wall had been utilised for a number of years by a local dive charter company. Protection of this asset, and realising some of the value from visitors was clearly a viable activity.

Livelihood activities noted to be most impacted by the closed area were line fishing and gleaning. Line fishing was often conducted on the reef drop-off that is inside the outer edge of the protected area, and the reef flat represents the closest gleaning area to the community. Women's fishing activities stood to be impacted more than men's through the declaration of a no-fishing zone in this area. However, in FGDs, women also noted that they stood to gain substantially from increased tourism, as the tourism enterprise was staffed entirely by women. It was clear that the women believed the advantages gained

from increased tourism and protection of fish stocks outweighed the issues of not being able to fish in the closed area.

Rules pertaining to general fishing practices were developed through a series of meetings often involving the suggestion of a rule by the community, the research team adding comment as to the implication of this rule, with agreement ultimately being reached at the next meeting, when the community had considered the available information. Rules banning small-mesh nets and breathing apparatus were entirely uncontentious. The Chefe had already instituted a local rule banning the use of small-mesh nets (1 inch or smaller). These nets are commonly used on the eastern side of the island (in FGDs the community particularly noted fishers from Biquele and Beloi) and the tara bandu was seen as a good way to ensure they would not be used in Adara's fishing area. Similarly, fishers from Biquele had been seen using compressors ("hookah") in the area, and this was considered very bad for sustainability. Poisoning fish using a particular root powder (from highlands) or a fruit that grows along the foreshore (particularly used by local women) has at times been common (in our Beloi FGDs, fishers noted that if crops fail, farmers come down from the hills and use the poisons, creating conflict with fishing communities). The community recognised that as this killed fish, invertebrates and corals indiscriminately, it was not a sustainable practice. While bomb fishing has not taken place since Indonesian times in the community area, including it in the tara bandu was seen as prudent. A local customary fishing method that involves using a palm frond and a stone to make sound that scares fish out of the reef was also highlighted by the community as being detrimental to fishing in the area. There was a strong belief that fish scared in this way, if not caught, will leave the area.

Prohibitions in the entire community fishing area

(Direct translations from the Tetun wording)

1. Scaring fish out of reef in order to fish
2. Using compressor to dive and to catch fish
3. Using mesh size of less than one inch (<1").
4. Using explosives to catch fish
5. No chemical and traditional use of Tuhak, Koti, Wua, Nuwano etc. where poison is used to catch fish and other marine species.

Turtles: Sea turtles are a highly protected group of marine reptiles worldwide. However, their abundance in Adara is significantly reduced in recent years due to their capture and consumption. The local community of Adara has seen this as an important issue, and believes in the need for protection of sea turtles in the area for the benefit of tourism development. As such**,** *the capture of sea turtles is prohibited within the community fishing extent of the Adara community.*

Lastly, the banning of taking turtles and turtle eggs took months of discussion, and considerable input from the project team on the implications of continued harvests, and the tourist potential in the protection of turtles. Generally, there was a low level of understanding of breeding site fidelity, and this was explained to the community. At a community meeting, it was clear that some members thought that this was a rule for the protected area, rather than the entirety of the community fishing zone. Among all the rules, this was the most contentious, and the one where the project team had the greatest input. While most of the *tara bandu* fishing rules (2, 3, 4 and prohibitions on turtle capture and egg collection) are already covered by fisheries law, awareness of fishing law is exceptionally low, and the *tara bandu* legitimises these rules at a local level.

All fishing and collection activities were banned in the protected area. However, within the *tara bandu* document certain activities are specifically highlighted to ensure there was no ambiguity about what constituted 'fishing'. Specifically highlighted are: collection of coral;

collection of shells; collection of juvenile fish from tide pools; catching of octopus; and, taking of sea cucumber.

As is customary, and indeed in accord with the principals of co-management espoused by Elenor Ostrom, a set of incremental penalties were put in place. When a *tara baundu* rule is broken, the offender has to provide the prescribed items (Table 2) to the community, to be collectively consumed in a feast of reparation for the wrong committed. Note that in contrast to the Beacou case, alcohol is not included in the penalty in Adara due to the strict protestant adherence to abstinence within this community.

Table 2. Incremental penalties for breaking the tara bandu rules

First offence	Second offence	Third offence
Cash US$25	Cash US$50	Cash US$75
1 pig (weight ~ 25 kg)	1 pig (weight ~ 50 kg)	1 pig (weight ~ 75 kg)
1 sack of rice (25 kg)	2 sacks of rice (25 kg)	3 sacks of rice (25 kg)
5kg of Coffee	10kg of Coffee	15kg of Coffee
5kg of sugar	10kg of sugar	15kg of sugar

While traditionally *tara bandu* is symbolised by the hanging of a totem, and preserved orally, a written document was requested by the community and was important for formal recognition. As part of the development process, a Timorese artist was commissioned to work with the community on designing a logo (See appendix 4). The document was written in Tetun, and enough copies printed for each household in Adara, and additional copies to be given to nearby communities, or fishers from other communities that fish in Adara waters. The final document was signed by Chefe Adara, Chefe Beloi, District administrator, Community and Marine Police and a women's group representative.

The *tara bandu* declaration ceremony was performed on May 13, 2016 and was attended by over 200 people from Adara and nearby communities, church authorities, local and island authorities, government representatives, international organisations, NGOs and interested onlookers. Again, due to the strong protestant culture in the community, the traditional hanging ceremony was not conducted, but rather a ribbon cutting ceremony with a prayer by the local Pastor was substituted. The ceremony included numerous speeches. Notable statements among the speech included:

> Pastor: *"Our grandfathers used to wade in the water to their knees and get enough food to eat. Our fathers went to their chest. Now, the water is way over our heads and we still don't find enough food". He then quoted Genesis 1:26, 27 saying that the Bible tells us that we have power over the animals, but this means we need to protect them. In the past …"we have eaten all our fish, but never taken care of them. Now we must take care of them"*
>
> District Chief: *"In Biquele and Beloi, the reefs are mostly gone now. If Adara can be used as an example to others, we can help the reefs recover"*
>
> District administrator: *"Just because you grow it today, it doesn't mean you can pick it tomorrow. These things take time. We started working with WorldFish two years ago and today we announce this Tara Bandu. In five years we will have more resources, bigger fish and beautiful reef. Some researchers came here last year and said that are reefs*

> *are so much better than elsewhere. The rules say you shouldn't destroy the reef, you shouldn't use a spear, if you do you will destroy your own sea."*

The ceremony was in part funded by the project, but was organised by a committee appointed by the community, and involved many community members. At the ceremony, speeches were given by a Ministry of Agriculture and Fisheries representative, the village Chefe, the Pastor, WorldFish and the chief fisherman. A feast was prepared by the community. Project staff were approached by Chefe's from two other Island communities, asking for assistance with setting up a marine *tara bandu.*

One year on:

WorldFish and MAF have remained actively engaged in Adara, although not directly with the tara bandu process which is now managed by the community. Notably, we have continued to work with fishers on development of FAD systems, and on monitoring of catches (see Appendix 1). Immediately prior to the completion of the project the team conducted interviews to ascertain behaviour changes, attitudes and knowledge regarding the tara bandu, and its impact on the community. Focus groups noted that the tara bandu was "working well' with no transgressions of the rules to-date. A number of fishers from other communities had come to fish in the protected area, but once the tara bandu was explained to them, they left to fish elsewhere. A woman noted that:

Figure 9. Tara bandu ceremony in Adara. Due to the strong influence of the protestant church, a ribbon cutting was used to mark the occasion instead of the traditional hanging totem

> *"One boat from Makili came, then another. The Chefe Suco and Chefe Adara explained to them about the* tara bandu*, Since they didn't know about the* tara bandu *they were just warned. The Chefe gave them a copy of the rules, and told them if they break the rules again they will have to pay the penalty"*

In the women's focus group, it was clear that participants saw the protected area as a long-term investment for the future of the community. However, members did believe they were already seeing more small fish among the coral in the protected area. They noted that a turtle had come in to lay eggs, and had not been caught. However the eggs were washed out to see in a storm. Some women tried to rescue eggs, but they were broken. The women noted that because of the *tara bandu* they had to change their fishing

locations, but that this had not changed their overall catch. A woman suggested that *"maybe in the future it would be good to make the closed area bigger, and also help with other communities making* tara bandu".

While not formally part of the *tara bandu*, with the declaration, the community put in place a 'reef sustainability contribution' for all users of the protected area. WorldFish helped develop signs and information sheets to highlight the reason behind this to tourists. Anyone who wished to dive or snorkel on the reef was to provide a contribution of $1.50 to the community. Commercial dive operators agreed to collect this on behalf of the community. This formed the basis of a community fund that would be used for community development projects agreed on by community consensus. Joanna, from the focus group, was the treasurer of the protected area management group, and noted that the fund was going well. Tourists who came to the village always contributed, and the commercial diver operators were either paying per trip, or sometimes on a monthly basis.

The men's focus group provided similar information to the women's group, with an overwhelmingly favourable view of the *tara bandu*, the increase in tourist numbers, and the combination with the FAD to provide an additional fishing area and improved catch. A male fisher noted:

> *"During Indonesian times, our father's time, we had* tara bandu*. It is good to have* tara bandu *again after so long. Now that the* tara bandu *is here we can find the 'Banabe' fish. Before* tara bandu*, we had not seen this fish in our area. The* tara bandu *is providing shelter for fish, and also a good income for the community"*

Usubemaco case study

The community of Usubemaco, as for Adara, is on Atauro Island some 20km offshore from Dili. While Aldea Villa to the south is the administrative hub of Atauro Island, Usubemaco (frequently known as 'Beloi') is the location of the port for docking of all large vessels, and the tourism hub of the island. While Adara and Usubemaco are both within Suco Beloi and are of similar sizes (122 and 127 households, respectively), there are stark contrasts between the two communities. Households in Adara rely essentially on natural resources for a subsistence existence, and as noted above, is very isolated. In contrast Usubemaco is fairly central to the islands economy, and well connected to other centres. Livelihoods in Usubemaco are more diverse (tourism, transport, administration, construction labor) although natural resources remain a focus for many. Beloi was selected as a project site due to the importance of both fisheries and tourism to livelihoods.

Participatory Diagnosis:

Initial diagnosis and focus group meetings in May 2016 revealed similar issues to elsewhere on the Island, with declining reef fish catches and limited capacity to access other resources. Fishermen from Usubemaco notably fish in areas along most of the eastern coast of the island, while women fish either using handline or 'reo-bar' (for gleaning) very close to the village. Notably, men and women fish in both the wet and dry season, in contrast to Adara, where fishing is often not possible in the wet season due to exposure to prevailing winds. Due to proximity to the market, which is held in Beloi each Saturday, fishing later in the week is common.

As the first community where we conducted diagnosis activities, livelihood calendars were developed in a combined group of men and women. As a result of this experience, all subsequent diagnosis activities were conducted in gender- disaggregated groups. Given the lack of success in achieving buy-in for CBFM in this community, we did not repeat the exercise.

Livelihoods are essentially driven by two seasons – the wet, from November to March, and the dry for the remainder. During the wet season, the

Guarded enthusiasm:

A community meeting held at the community centre in June 2016 was well-attended by some 30 fishers (Figure 11). While there some enthusiasm for developing a closed area, and including a new set of fishing rules in a tara bandu the enthusiasm was not universal among the group. The issue of rampant use of illegal small-mesh nets by community fishers was not broached at this time. The final conclusion of the meeting was that they understood the benefit of reducing fishing pressure on reef areas, and fishing pelagic species, but they would only consider reducing reef fishing once it was clear that FADs would provide an alternative that produced equal or better returns for them. As this was prior to the first project FAD deployments, the project team agreed to work with the fishers on FAD fishing first.

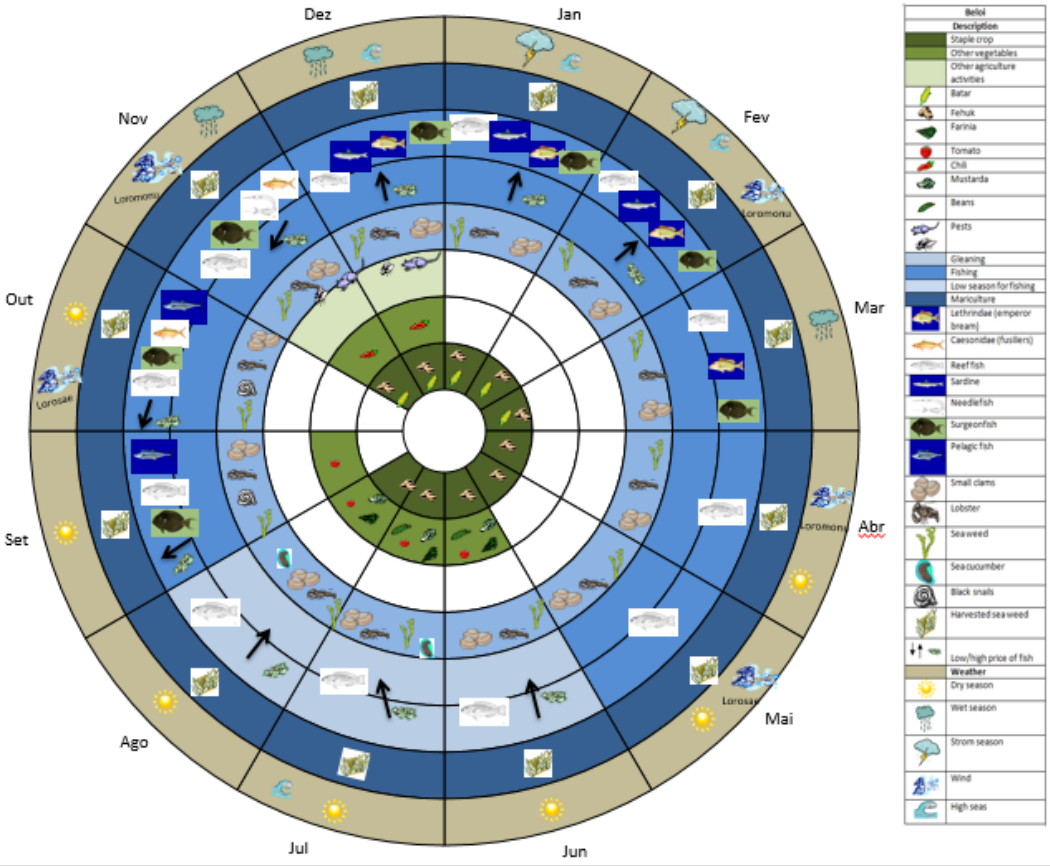

Figure 10. Livelihood calendar for men and women in Usubemaco. Following analysis of this meeting, all subsequent livelihood calendars were developed separately for men and women.

Figure 11. Fisher meeting in Beloi community centre

Following the failure of the first set of FADs due to inadequate anchor systems, conversations were more difficult, and disagreements among factions of fishers about project engagements were obvious. Community cohesion was notably low, making moving forwards with project activities difficult. We continued to actively monitor the situation in the community via the project field officer, however it was clear that the project did not have the timeline or resourcing to continue actively working with the Beloi community.

'Organic' spread:

The tara bandu and FAD developments in Adara continued as project activities, resulting in high-profile successes in terms of improved fish catch, and improved tourism livelihoods relating to the unique nature of the tara bandu protected area. At the time the project was wrapping up, the project field officer was asked to be involved in community meetings in Beloi organised by fishers from the community. It was made clear at an early meeting that the community wanted to act autonomously to set up a tara bandu closed area. In the months that followed, two small closed areas on the outer reef were declared. This, along with requests to WorldFish to engage in a number of other villages, reinforces the notion of 'organic spread' of CBRM occurring on Atauro Island due to the obvious successes of project activities.

Discussion and conclusions

Our three project case studies give us a perspective on an established *tara bandu* (Beacou), a new implementation (Adara) and a problematic implementation with 'some hope' of moving forwards. Perhaps missing from this set is an unsuccessful implementation. We are not aware of any such instances in Timor-Leste, however they likely exist by have not been publicised or reported.

There are contrasts and similarities in the Beacou (sustained) and Adara (implemented) case studies that provide useful insights for our research. Both actions were initiated through proactive engagement from the Chefe Aldea (village chief). Engagement by external agencies in both cases was participatory, at least gender-aware and conducted by skilled practitioners with a resource sustainability and livelihood perspective. First and possibly most critically, both communities have strong, supportive and engaged leadership. This is increasingly recognised as critical for implementing management systems (Evans et al. 2015, Case et al., 2015) and the ultimate sustainability of these systems. The tara bandu in Beacou has persisted with no external support – a relative

rarity with reasonably recently established LMMAs – for in excess of five years. As noted, perhaps a factor in persistence is the relative health of natural systems in this area as revealed in the participatory resource mapping exercise. Nonetheless, from our ex-post assessment through interviews and focus groups, it is clear that not only has the tara bandu substantially altered behaviours (notably unsustainable use of mangroves for firewood, swidden agriculture) and further enhanced resource status (effective closed areas to small-mesh netting in and in front of the mangrove area), but it is also respected and viewed positively by women and men in the communities. The women in Beacou have noted that the tara bandu places an extra burden on their workload, but are still positive towards the institution and it's impacts. The women in Adara see substantial benefit from the Community Fund that is rapidly building through the user-pays system for the closed area of the LMMA.

For the Usebemaco case study, community engagement was quite different in nature. The original approach to WorldFish had come from fishers, with the support of a local tourism enterprise. The Chefe was not actively engaged, and it was clear that he was not respected by significant proportions of the community. While a lack of community cohesion was undoubtedly a reason for the work not moving ahead, hindsight shows that our actions may not have considered local political ecology to the degree they perhaps should have. The engagement by WorldFish with a local NGO was functionally very useful in terms of providing support, including meeting facilitation and translation services. However, after the engagement it was revealed that there is a history of mistrust between some in the Usubemaco community and the community the NGO are based in. Discussions with local actors about reasons for a low level of enthusiasm in this community for a LMMA pointed at this lack of trust. Indeed, in the months since this project finished the community of Usubemaco have initiated an endogenous process of developing a tara bandu area, and have been clear that they do not want external assistance. WorldFish staff will monitor and report of the future of this initiative.

The combination of FADs and fishing restrictions imposed through tara bandu appears to be a very promising approach to livelihood sustainability in Timor's fishing communities, at least on the northern coast. While relatively little is known about the pelagic fish stocks in this area, it is notable that particularly in Adara, increases in catches were rapid, and largely consisted of small, mobile neritic species such as scads. Notably absent were juvenile tuna – the cause of management issues with FAD fisheries in Indonesia.

The case studies presented here add significant weight to the idea that tara bandu can be the basis for the community-led components of a co-management system. We have shown that the legislative framework currently in place supports the notion of co-management while perhaps not providing a strong basis for its implementation. Co-management implementation has certainly not been a strong focus of government to-date. Recent devolution and deconcentration initiatives bring this effort to the fore. The development of a new National Fishery Strategy, facilitated by WorldFish, provides the opportunity to act directly on the findings of this research in mandating a way forwards for fishery co-management in Timor-Leste.

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11.4 Appendix 4: Local artwork logo and poster (English version) developed to tell the public about the tara bandu site

TARA BANDU ADARA
Locally Managed Marine Area

History & background

The protection and management of the Adara reef is important for the future of the Adara community and their livelihoods, for fish habitat, and also for the development of Atauro Island as an ecotourism destination.

Villagers rely on this reef for food and income from fishing and gleaning, however, they have recognised the gradual decline of the reef and fish stocks through the increasing time fishers are spending to catch less and less fish.

On 15th April, 2016 the Adara community welcomed national and international dignitaries and press to the inauguration of Atauro Island's first locally managed marine area. This area is governed by a traditional rule system called "Tara Bandu". With the help of a team from the international fisheries research organisation WorldFish, and the Ministry of Agriculture and Fisheries, the community developed their own set of rules to manage fishing in the area, and improve the sustainability of fishing practices in Adara.

As rules were proposed by the community they feel a proud ownership and responsibility over their marine resources, but the incentive also has the strong support of local government authorities and departments. However, it is the people of Adara that have made sacrifices to develop this fisheries management. As a tourist to Adara you have an important role to play in supporting this initiative.

What is Tara Bandu?

Tara Bandu is a well known tradition in Timor-Leste that is used to regulate individual or group interactions with the environment. Tara Bandu began during the Portuguese administration of Timor-Leste, but was stopped during Indonesian occupation. It has been actively and widely promoted since independence in 2002, and is well known amongst the younger generation, born towards the end of Indonesian occupation.

Recognising this tradition, the community of Adara have decided to adopt and implement Tara Bandu to manage aquatic resources in their area. The community believe that their livelihoods are very closely connected to natural resource utilisation, so wanted to manage fishing activities to promote sustainability and a healthy ecosystem. The expectation is that in the future, this management will benefit the community of Adara and especially younger generations.

Reef sustainability contribution

The $1.50 you pay to enter the area is your support of this community initiative to reduce fishing pressure on the reef and promote its recovery. This contribution will be collected and managed by the Adara LMMA Management group. This group decides how the money raised will be used to maintain the area, but also how it will contribute to village development projects. In the first year of operation more than $1000 was raised. This money funds community projects such as school construction, so please consider making a larger donation to support this community.

Take only pictures, leave only bubbles!

Snorkelers! Please take care to not damage the reef. Please do not take any marine creatures or shells from the LMMA. Waste disposal on Atauro is very limited, so please dispose of your rubbish responsibly where directed at Mario's Place - or take it with you!

WorldFish · Ministério da Agricultura e Pescas · Gabinete do Director Geral das Pescas · Australian Government, Australian Centre for International Agricultural Research

11.5 Appendix 5 - Data systems

Objective: Building capacity for monitoring and managing coastal fish resources within the Ministry of Agriculture and Fisheries

Summary

1) Outcomes from RFLP data evaluation

- In a situation where there are no alternative sources of data, some useful information was produced on catch species composition and fleet size
- Landings sampling was not carried out under a sufficiently rigorous or organized sampling protocol to be of use for management
- A lack of consistent or standardised sampling protocol resulted in numerous data collection and entry errors, coding inconsistencies, and uninterpretable data ranges.
- Data showed a clear relationship between landed volume and price, suggesting when landing are high they saturate usual markets. This is likely exacerbated by poor transport infrastructure.
- Quantity of fish sold varied markedly among sites, with households distant from Dili appearing to consume a higher percentage of their catch.

2) Why an improved system is required

- A lack of data on fishing effort and irregular sampling of landings across sites means even simple measures of relative abundance are not attainable. As a result outputs will not be useful in stock assessment and management efforts.
- Numerous errors in data entry inform the need for a collection system where data fields are restricted by data type, characters and length.
- The online SQL database of information is not readily accessible or user friendly, and is largely inaccessible to anyone not involved in setting the system up.

3) Moving forwards

- The nationwide boat survey/registration process serves as a very useful baseline to estimate fleet size and national fishing effort.
- A new landings collection system is needed with which to estimate catch per unit effort, to effectively measure impact of interventions in each place.
- A tablet form system developed to compile data from various landings sites in a simple platform online will enable easy data collection, storage.
- Simple fisheries analysis scripts built into the system will facilitate the use of data for management purposes

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Background

Objective 4 sought to assess the quality of existing fisheries data and data systems in Timor-Leste. Here we provide a summary of the data available, analyse their utility in characterizing fisheries in Timor-Leste, and suggest where errors exist and modifications might be made.

There have been ongoing issues of MAF not integrating data collection into the job requirements of field staff, and the national system named "Peskador" has previously been updated only during the lifetime of its implementing project (Regional Fisheries Livelihood Program), or by WorldFish staff under current projects.

Further to objective 4, we report on field trials of an enhanced and digitised data system designed by WorldFish, and a workshop with MAF senior staff to discuss the way forward for integrating this system to frame national data collection processes by MAF field staff.

Review of existing small-scale fisheries data in Timor-Leste

Overview

The Regional fisheries livelihoods program (RFLP) represented a large investment in the fisheries sector commencing in 2008, with the aim to strengthen capacity among participating small-scale fishing communities and improving the livelihoods of fishers and their families, while fostering more sustainable fisheries resources management practices. Funded by the Kingdom of Spain, the four-year (2009 - 2013) RFLP was implemented by the Food and Agriculture Organization of the United Nations (FAO) working in close collaboration with MAF.

In Timor-Leste RFLP operated along the north coast, (including Atauro Island), the south coast and the Oecussi enclave, and set out to increase information available on coastal fisheries.

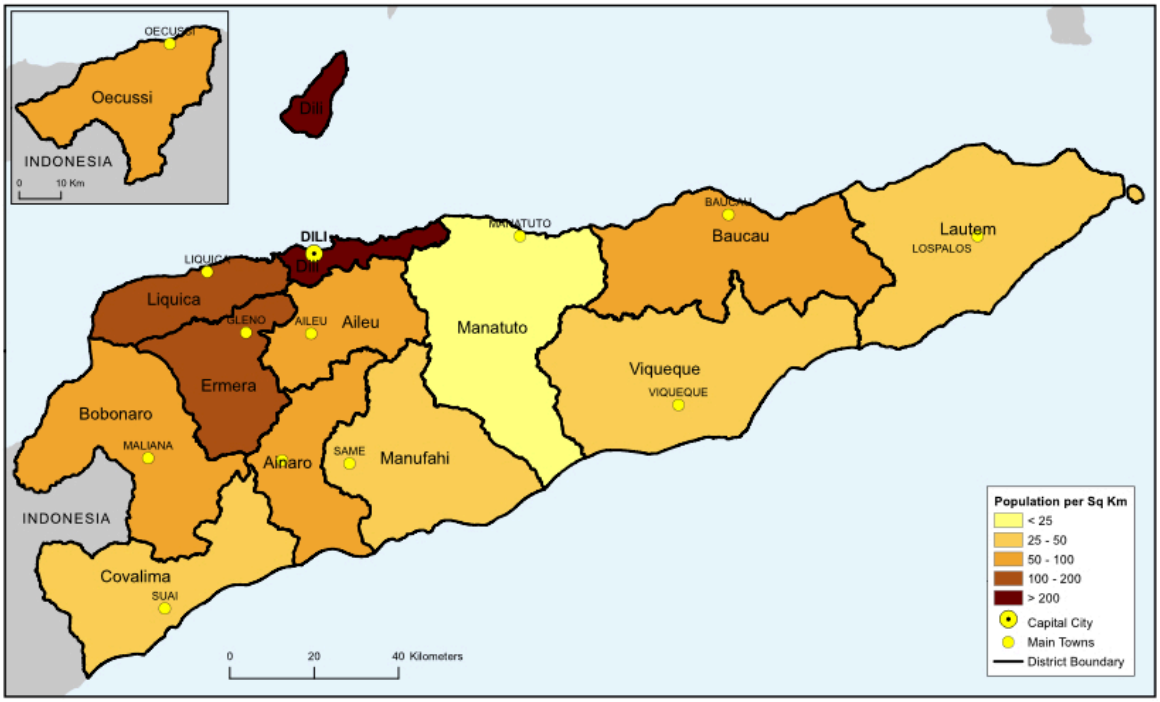

Figure 1. Map of districts in Timor-Leste (showing population density)

The data cleaning process was time-consuming and frustrating. The apparent lack of an organised protocol for data collection led to discrepancies between data collectors, data transcribers and data analysts over the definition of terms and the units of values. As a result a large amount of data was incomplete or had to be omitted from further analyses.

The data contained a range of error types, but the most obvious was lack of consistency with terms (coding) and numerical errors in magnitude. In many cases, variables were entered as ranges (e.g. net mesh sizes, or length of net) making data indecipherable, or multiple variables were entered into one column, in different orders, making data editing a laborious exercise of separating variables manually. Limiting data fields to specific integer lengths, checks on text fields, and range tests are required to reduce transcription errors, or raise queries about data format during transcription from data sheets. A need for better training, and continued follow-up on data quality was clear. Training data collectors to see the whole process: to understand what the data mean, how they are going to be used; and how it should be entered to facilitate analysis; would greatly enhance the accuracy and overall utility of the landings database.

Project staff were aware of sensitivities when speaking to staff involved in the initial data efforts. Errors were interpreted to be mistakes, and there was a tendency to take personally problems highlighted with the data and the system.

Boat registry database

The most comprehensive data in the Peskador system was the boat registry, which provided very useful baseline figures for boat ownership as a coarse proxy for overall fleet size and fishing effort (Table 1). The district with the largest number of boats was Liquiça with 507, but Dili and Bobonaro had the largest boats (length). Measures of total boat length or HP provide an alternative crude indicator of fishing power by district.

Table 1: Summary of boat registry data from 11 (coastal) districts of Timor-Leste

District	*# Boats*	*Sum of Length*	*Mean length*	*± SD*	*Sum HP*	*Mean HP*	*± SD*
Liquicia	507	2495	5	1.9	2389	11	28.8
Baucau	412	2076	5	1.8	1969	10	4.7
Bobanoro	330	1937	6	20.5	1135	8	4.0
Dili	310	1818	6	2.8	1557	14	4.2
Oecussi-Ambeno	278	1391	5	1.3	559	9	9.6
Lautem	248	1227	5	1.4	1205	9	4.6
Covalima	166	587	4	1.1	108	10	4.9
Manatuto	144	785	5	1.9	791	8	4.2
Viqueque	116	563	5	1.4	423	10	4.8
Manufahi	78	271	3	0.8	50	10	4.8
Ainaro	8	22	3	3.0	62	10	5.2

Fisheries Landings database - *Peskador*

The collected data consists of 2238 individual records compiled in 1085 sampling events from 9 districts (Table 2) and 86 individual landing centres over the period November 2011 to October 2012. The sampling was sporadic and non-systematic. Total landed weight was 298.7 tonnes, with a mean catch (per boat per day) of 146 kg +/- 6.9 SE. In analysing the data, we have concerns that zero catches were not recorded systematically, so these catch rates are likely unreliable.

The Beacou landing centre collected the largest number of samples (183), and Bobonaro district collected the largest number of samples overall (Table 2). Of the 86 landing centres, 55 were sampled less than 10 times, and on average, each landing centre was only been sampled 12 times during the period. Given the inconsistency of the sampling design and the low number of samples, it is therefore questionable how representative the data are for the Timor-Leste fishery.

Beacou, in Bobonaro district, was the most important fishing centre according to the sampling. This was influenced significantly by large sardine landings, seen also in the neighbouring landing site of Tasi Mean. In general there was high variability in the relative importance of different species at different landings sites. The most important fishing centre for barracuda was Pala, Atauro Island, with abundance appearing to peak in June and July, but it was not possible to infer if this was an effect of variable sampling effort and standardisation, or if this reflects actual differences in species biogeography and abundance, or fishing behaviour.

In terms of effort, the only metric included was the number of boats associated with each individual species record, so a real measure of effort in terms of time spent fishing, number of fishers, and gear type was impossible to decipher. Table 3 shows the average number of boats per fish sample.

Table 2. Number of individual samples by month and district

District	Nov-2011	Dec-2011	Jan-2012	Feb-2012	Mar-2012	Apr-2012	May-2012	Jun-2012	Jul-2012	Aug-2012	Sep-2012	Oct-2012	Total
Baucau	13	18	8			7	5	4	9	18	20	10	112
Bobonaro			23	6	21	27	37	26	1	1	92	90	324
Cova Lima						3	1		5	4	3		16
Dili				20	16	16	2	8	17	11	3	4	97
Lautem									3	8	9	12	32
Liquica	3			1	11	55	33	14	20	27	36	44	244
Manufahi									3	12	9		24
Oecussi-Ai	2	1	3	9	4	106	31	15	27	1	19	4	222
Viqueque											2	12	14
Total	18	19	34	36	52	214	109	67	85	82	193	176	1085

Table 3. Average number of boats per fish record by sampling month and district

District	Nov-2011	Dec-2011	Jan-2012	Feb-2012	Mar-2012	Apr-2012	May-2012	Jun-2012	Jul-2012	Aug-2012	Sep-2012	Oct-2012	Total
Bobonaro			11	12	6	6	9	2	5	1	5	6	6
Baucau	12	2	3			1	1	1	1	1	2	1	3
Liquica				2	2	2	3	3	3	2	2	1	2
Cova Lima						1	1		1	1	3		2
Manufahi									1	1	2		1
Oecussi-Ambeno			2	2	1	2	1	1	1	2	1	1	1
Dili						1	1	1	2	3	2	1	1
Lautem									1	1	1	1	1
Viqueque											2		0
Total	11	2	10	5	3	3	5	2	1	2	4	4	4

Species composition

The sampled catch consisted of 135 species, of which 10 were recorded as 'Not identified'. Four species (Sardines, Garfishes, Frigate mackerels, and Flying fish) constituted 83% of the total catch, while 8% of the catch was recorded as 'Unknown' species. The vast majority of the catch was thus composed pelagic fishes (Table 1). Spinefoots are the most important demersal group but make up a tiny fraction compared to the landed weight of pelagic species. Sardines represented the largest mean catch by species (i.e. when a species is caught, what is the average size of the haul in kg?), but was caught in a restricted fishing season between January and April (see figure 7 below).

Table 4. Total catch volume sold in the Timor-Leste dataset by species

Common name	Total catch (kg)
Sardine	92496
Garfishes	83997
Frigate Mackerels	39911
Flying Fish	29847
Mackerel Scads	5999
Mackerel Tuna	4961
Bullet Tuna	2981
Long Tom	2627
Skipjack Tuna	1966
Spinefoots (Rabbitfishes)	1436
Dark-Banded Fusilier	880
Indo-Pacific Sailfish	842
Longfin Emperor	765
Barracudas	636
Rainbow Runner	630
Thumbprint Emperor	570
Hump-Headed Parrotfish	403
Giant Trevally	363
Goldspotted Trevally	340

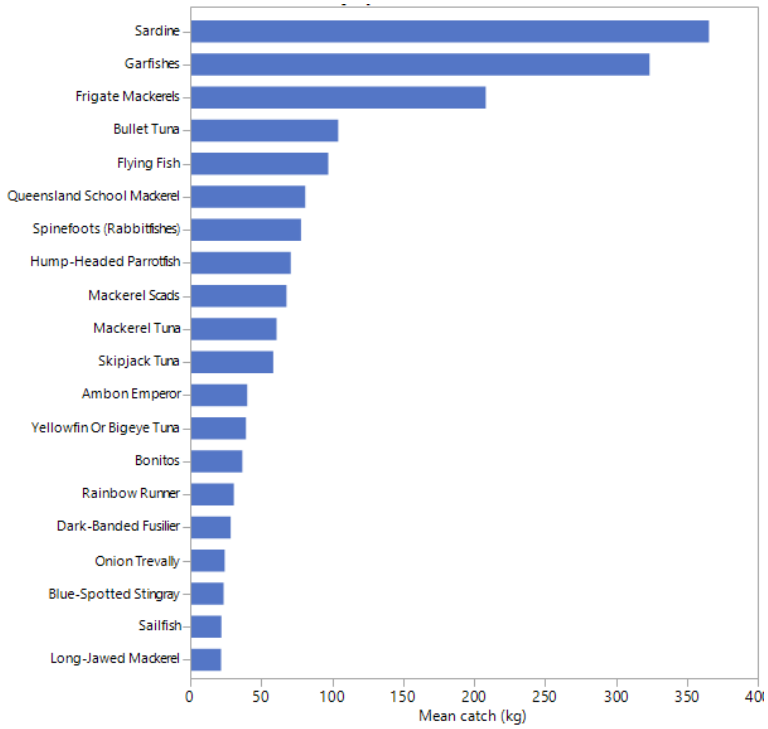

Figure 2. Mean catch volume (kg) around Timor-Leste for the top 20 species between October 2011 and 2012

Flying fish were the most frequently caught species on trips, being present in catch on >15% of trips (Figure 3). However, this should be considered with caution given the irregular sampling, and the bias likely to be present from sample size from Bobonaro district.

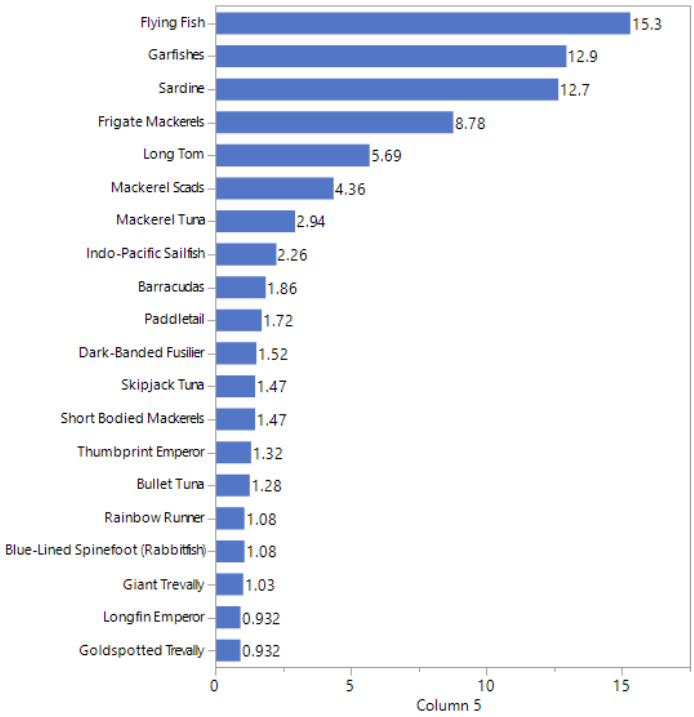

Figure 3: The most important fisheries species across Timor-Leste in terms of the percentage of trips in which they are caught (= N trips when caught/N trips total *100)

Fish consumption

Volume kept for consumption was directly proportional to volume sold, i.e. the more caught, the more was kept for personal use. What is interesting, however, is how that ratio

various among the fishing centres. The reasons for this may be due to variable market access, different price structure, socio-economic context etc.

In general the mean proportion of fish catch kept by fishers for consumption was less than 5% of total catch. The districts of Dili, Viqueque and Lautem showed the highest proportion of catch for consumption, around 10%, but with high variance (Figure 4). Both these districts are distant from Dili, and population densities are quite low.

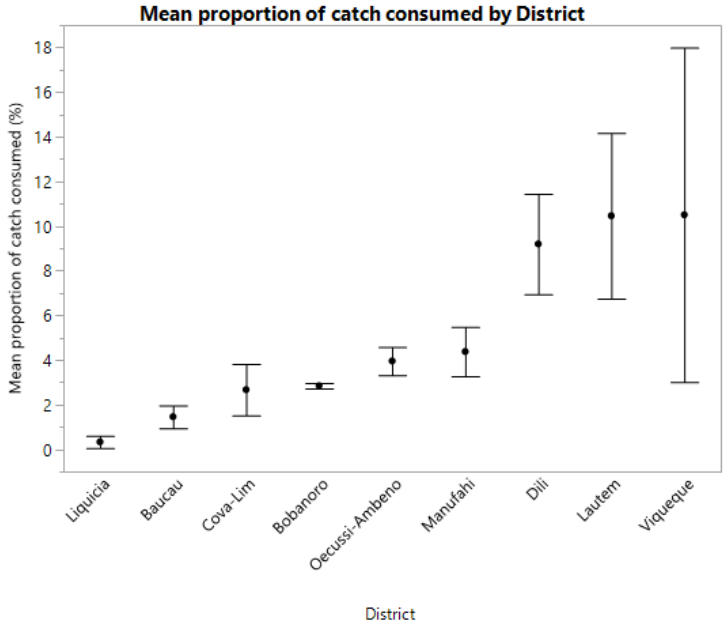

Figure 4. Mean proportion of fish catch kept for consumption by district

Landings and prices

This dataset contains information on landings, the prices obtained for each landing, and the proportion that was retained for food versus that which was sold for cash. Specific geographic location of each landing site was not mapped to data points, so spatial analysis of species landings and price variations were not possible. Figure 5 shows the demand driven price fluctuations directly related to catch sizes (for all species and locations) over the year.

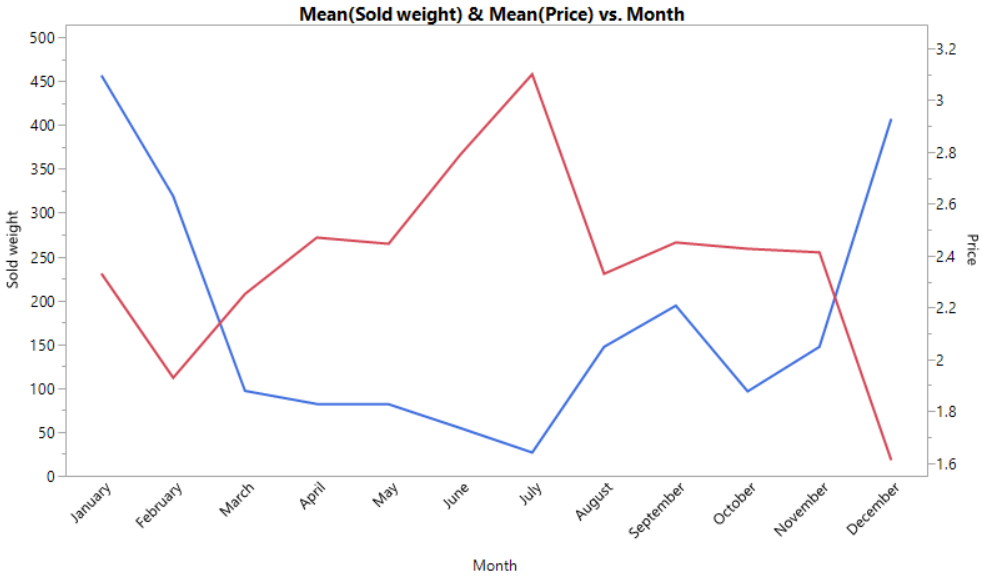

Figure 5. Monthly mean landed weight of all species combined (blue line) and mean fish price (red line) in between October 2011 and 2012

Seasonality

The abundance of sardines, garfishes, and frigate mackerels shows marked seasonality, with the sardine catch peaking between December and April (Figure 6 & 7).

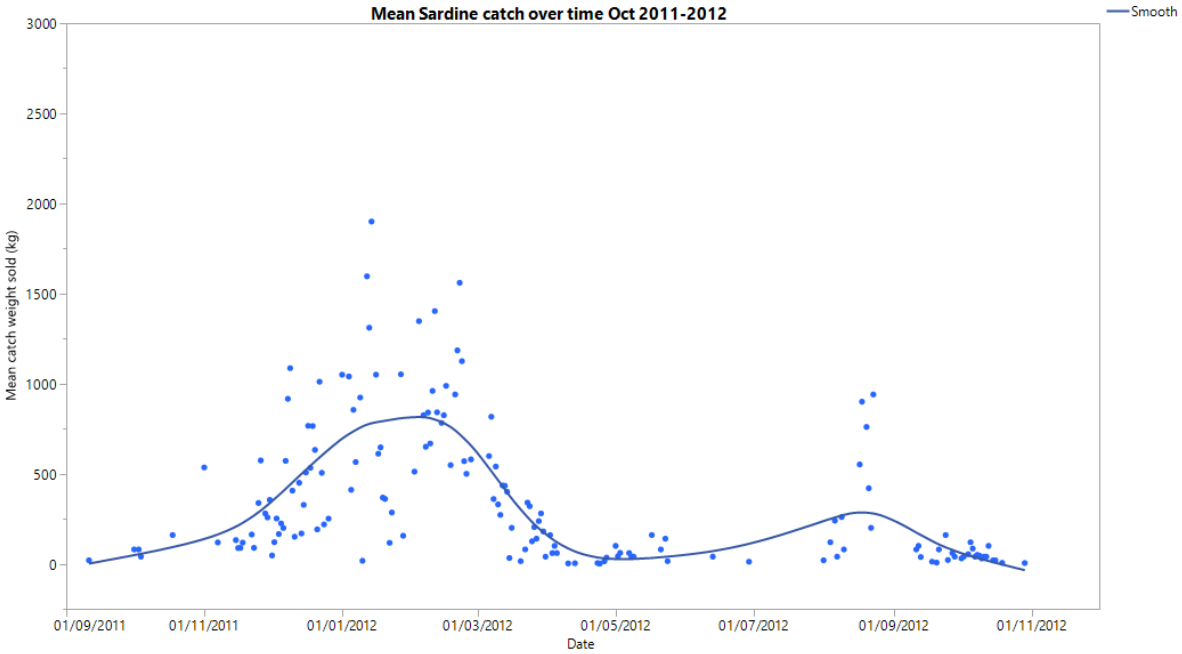

Figure 6. Mean sardine catch weight over time between October 2011 and 2012

Figure 7: Fish landings around Timor-Leste (top 20 species by weight only) between October 2011 and 2012

Data systems feedback and workshop with MAF

On 24 January 2017, a seminar and discussion group was held in the office of the DG of Fisheries with three primary objectives:

1. To present findings on analysis of existing data in Timor-Leste (from 4.1 above)
2. To present preliminary analyses of WorldFish trial data system (data from project sites)
3. To discuss opportunities and constraints to developing MAF data collection, storage and analysis for stock assessment and monitoring.

The workshop was attended by the Director General of Fisheries – Acassio Guterres, the Director of Inspections and enforcement - Lorenco Amaral, and the Director of Marine Resource Management and Conservation - Celestinho Cunha, Pedro Rodrigues and Joni Freitas, and staff members of the two directorates.

Fisheries staff were very receptive of feedback concerning RFLP data and interested in new data from Atauro collected from project activities since August 2015. After initial presentations there was an engaged and fruitful discussion about the scale and design of a fisheries database. MAF would like to develop a system based on ours trials that allows for better and faster management response, analysis and communication. MAF are eager to designate a specific point person to manage and monitor data, and develop monitoring systems, but currently lack the funding or technical capacity to do so, so seek the further assistance of WorldFish in this regard.

There is strong pressure from certain members in MAF to develop indicators of national level catch per unit effort through detailed stock assessment, most likely driven by partner agency FAO that compiles this information globally. However, by the end of the workshop it was clear that MAF understood the need to collect high quality data from selected areas for fishery management purposes, rather than prioritising the estimation of landings nationwide. That said, there is real value in developing an organised and digitised system of fisher licensing, which would be a relatively small and straightforward task given the fleet size and number of active fishers in Timor-Leste.

Going forward:

It was decided that the next step would be to hold a meeting specific to design the system according to the scale and resolution of data monitoring that MAF requires. This should be a key component to be integrated into the development of a national fisheries strategic plan for Timor-Leste.

Improved systems of monitoring

As a result of unsolvable factors and lack of a standardised sampling regime in the *Peskador* database, it was decided that a new survey should be designed and deployed to obtain much higher resolution data in a standardised sampling design.

Initially, a paper landings form was developed for use in the field, which were then transcribed into a purpose built MS access database. In mid-2016 a new tablet based system of landings data capture was developed on the ODK for Android platform on the Kobo Toolbox server. Existing data were integrated with the new online data storage system. This system allows for offline form completion, then utilises mobile data networks to upload completed form data to a cloud server. This can then be centrally accessed, downloaded, and analysed.

The tablet app form was designed to collect individual fisher trip landings by species and length. Fisher names, locations, fish species, gear types and habitat types were prepopulated into the app to minimise input error by refining selection of these criteria to multiple choice radio buttons. The app gathers effort information in the form of number of

fishers, duration of trip, gear type and mesh size if using nets. Fish lengths are measured using a fish board and grouped into size categories for reporting. These lengths are then converted to weights using *a* and *b* parameters for the species during data manipulation and analysis.

The landings app form was piloted in Adara, Atauro Island through June-August 2016 and launched at 2 other community sites in Timor-Leste in August 2016 as part of a subsequent project. As such this app development has now provided the basis for detailed catch sampling at sites throughout Timor-Leste, to use for small-scale fisheries stock assessment.

The app form was designed to provide a standardised and efficient method of collecting landings data in the field, as well as providing much more secure data storage and back up through uploading the data directly to a cloud server. These data were used to characterise the fisheries around Atauro Island, and to measure the effectiveness of the FAD deployment in increasing catch volume, and improving access to more abundant and sustainable pelagic species.

Future developments

The development of the app is continually in progress as more communities, fishers, species are added. It is our aim to develop a system capable of live updating, where new items added to the form by data collectors can be verified and added to the form itself for reuse. Furthermore, to reduce linguistic and literacy barriers to working in diverse districts and areas, it is our aim to convert as much text as possible to icons and photos (e.g. fish species, gear types, habitats etc.). This system also has the potential to link directly with a digital database of fisher licenses if such a system was developed in Timor-Leste, where fisher IDs could be scanned to associate trip and catch information with specific fishers.

In terms of analysis of this system, the automatic generation of data files in the same format online, allow for scripts to be generated in R to manipulate and run basic analyses on the data for use in rapid management capacity.

In Timor-Leste, the work developing the app and evaluating existing databases and systems under this project has allowed for the rapid deployment of landings monitoring to 5 sites throughout Timor, with 3 more to be deployed in the next month in the far east of the country through a partnership with Conservation International.

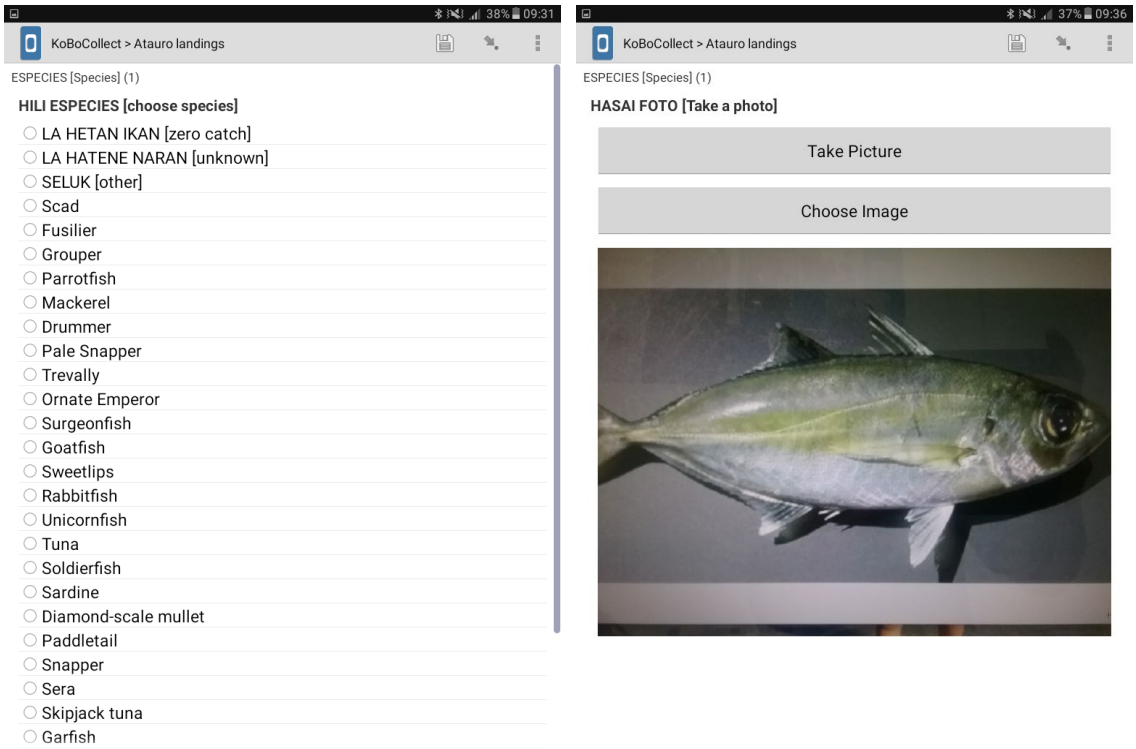

Figure 8. Screenshots of the WorldFish small scale fisheries landing app form