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Inside this issue

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Editor's note

This edition consists of three articles, the first two of which deal with weather and fisheries in Melanesia.

The first article, entitled 'Modifications to natural resource use in response to perceptions of changing weather conditions on Takuu Atoll, Papua New Guinea', is by Anke Moesinger of the University of Bremen. Takuu Atoll is one of three Polynesian outliers in the Autonomous Region of Bougainville in Papua New Guinea. One the main environmental concerns for the people of Takuu is the unpredictability of weather patterns, specifically trade winds. This article examines key perceptions of alterations in trade winds and other environmental changes, and explores how fishers, primarily Takuu men, have adapted to these alterations through changes in their fishing methods and giant clam mariculture.

The second article, entitled 'The role of fisheries resources and community-based coastal resource management activities during a natural disaster – Case study of Vanuatu after Tropical Cyclone Pam', is by Kalo Pakoa, of the Vanuatu Department of Fisheries, and six co-authors. Based on surveys, it demonstrates how coastal resources provided an important source of protein for communities after the disaster of Tropical Cyclone Pam, which struck Vanuatu in March 2015. Using questionnaires to interview local people in affected areas, the survey recorded how people in coastal areas coped with the natural disaster. It clarifies the importance of coastal fisheries and effective community-based management in food security, especially in emergencies. The results showed that coastal fishery resources were relatively resilient compared with other food sources, especially crops and livestock, and that such wise use of coastal fishery resources can enhance food security following natural disasters.

The third article is authored by Jay Maclean. It introduces several of his less well-known books, which include a fascinating fairy tale about 'reverse colonisation' and a study of fly flatulence, among other more scientific works. All these books (other than *In Tropical Seas*) can be seen online. Nearly all were intended to be, and originally appeared, free-of-charge (except *In a Perfect Ocean*) in a subsidiary website of MacMillan, but after an independent publisher took over the same role this year, books had to have a minimum price of USD 0.99.

Kenneth Ruddle

Note:

In line with a worldwide trend to limit the impact of producing printed publications on the environment, SPC has decided to stop the production and distribution of printed copies of this and other information bulletins. The SPC *Traditional Marine Resource Management and Knowledge Information Bulletin* is only available in digital format since issue #36. All issues remain accessible from SPC's website at:

http://coastfish.spc.int/en/publications/bulletins/traditional-management

Modifications to natural resource use in response to perceptions of changing weather conditions on Takuu Atoll, Papua New Guinea

Anke Moesinger[1]

Abstract

Takuu Atoll is one of three Polynesian outliers in the Autonomous Region of Bougainville in Papua New Guinea. The local population is inextricably linked to the surrounding ocean for their primarily subsistence-based livelihood needs. One of the main environmental concerns for the people of Takuu is the unpredictability of weather patterns, specifically monsoon wind direction. This causes distress among fishers because these disturbances can affect food security and create dangerous situations at sea. This paper examines key perceptions of wind alterations and other environmental changes. It further explores how fishers, primarily Takuu men, have adapted to these alterations through changes in their fishing methods, including a multitude of line fishing (*matau*) methods, and various net fishing (*kupena*) methods and giant clam mariculture. I conclude that local knowledge and perceptions of changes in weather patterns that necessitate modification of natural resource use strategies are critically important to the adaptive capacity of Takuu Islanders, given their limited livelihood options owing to the infrequent and irregular shipping services that increase economic isolation.

Keywords: Takuu Atoll, local environmental perceptions, food security, fishing practices, environmental change

Introduction

The need for small island developing states to address present and future impacts of climate change has recently been of key concern to academics working in the natural and social sciences. Accordingly, anthropologists, geographers and sociologists have contributed a vast amount of literature exploring the different social aspects of climate change. While literature on the concepts and frameworks of vulnerability, resilience, risk perception, migration and large-scale adaptation is abundant at the regional and global scale (e.g. Adger 2003, 2006; Barnett 2001; Kelman and West 2009), empirical studies of local perceptions of, and responses to, rapid environmental changes remain limited. More specifically, how inhabitants perceive environmental perturbations and adjust their resource use strategies in response is not yet well elucidated.

Inhabitants of low-lying island environments are particularly exposed and sensitive to the impacts of climate change. Changes in sea level, shoreline erosion, increased cyclone intensity, increased flooding, droughts and other changing weather patterns will affect food security and livelihoods, and thus, in some cases, the ability of resident populations to remain in their island homes (Barnett and Campbell 2010; Nunn 2009). However, the potential adaptive capacity and local responses to these negative impacts are poorly understood (Mortreux and Barnett 2009). Not only has inadequate attention been given to the capacity of social and ecological systems to adapt to rapid environmental change, but research has also not determined the constraints and barriers of adaptation as well as the costs of such undertakings. Without the incorporation of detailed knowledge obtained from location- and context-specific studies, discussions of large-scale relocation of low-lying Pacific Island inhabitants remain highly speculative and potentially alarmist.

It is important to note that, at the local level, environmental change is a central feature of everyday life; people understand it that way and have developed coping mechanisms and adaptive capacities to adjust. For example, Lefale (2010) examined traditional knowledge of weather and climate in Samoa, noting that spiritual and mythological views held by participants had a profound effect on how they perceived and reacted to rapid environmental change. Likewise, Duarewa (2009) reports on Fijian women's use of traditional ecological knowledge to adapt to decreases in fish stocks. When faced with having to take on the added dangers of traveling farther out to sea and staying out longer to attain the same amount of fish they typically do, the women collectively decided to

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shift their resource use patterns and bring back the custom of mariculture. Sound scientific studies at the local level present a clear picture of adaptive practices that individuals and communities employ, provide an accurate assessment of local perceptions of climate change, and when coupled with geological, meteorological and ecological data, can provide a holistic view of not only the impacts of, but also the responses to, environmental change. These in turn can inform better adaptation strategies for future climate perturbations on Pacific Island nations.

Acknowledgement of changes by individuals in a local community is precursory to any adaptive practices taking place. It is also increasingly recognised in the literature that adaptation to extreme weather events and natural climate variability increases resiliency in the long term while decreasing vulnerability to perturbations in the short term. This intimates that the examination and documentation of local knowledge systems of resource use patterns and changes thereof, with regards to rapidly changing environmental conditions, is of paramount importance to gaining an understanding of how communities cope with change and, perhaps more significantly, how they will do so in the future (Beyerl et al. 2018).

On Takuu Atoll, a remote Polynesian outlier in Papua New Guinea, the people are said to be among the most vulnerable to the detrimental effects of climate change. These impacts include shoreline erosion, increased flooding from 'king tides', salinisation of the water table which in turn affects swamp taro (*Cyrtosperma chamissonis*) and true taro (*Colocasia esculenta*) cultivation, and changing wind, current and precipitation patterns. Supposed plans by the Autonomous Bougainville Government to relocate the atoll's population as 'climate refugees' by 2015 have not yet been implemented. While global media reports claim Takuu and surrounding atolls could prove imminently uninhabitable (Cochrane 2010) as soon as within the next decade (Vidal 2005), the islanders' resource use patterns, coping and adaptive strategies have received little attention. The failure to include sociocultural and crucial economic factors in these reports has led to conceivably unreliable and exaggerated predictions for the near future of the Bougainville atolls (Connell 2018).

The local population's perceptions and responses to environmental changes on Takuu Atoll are shaped by numerous sociocultural, economic and political factors. While these critical processes are beyond the scope of this paper, the research presented here aims to contribute to a more holistic understanding of adaptive behaviour to the impacts of rapid environmental change by addressing two main questions: 1) What are the key environmental changes? and 2) How have Takuu Islanders adapted their natural resource use in response to these changes?

Study site

Takuu Atoll, often referred to as Mortlock, is a Polynesian outlier located 273 kilometres northeast of the island of Bougainville in Papua New Guinea (Fig. 1). Although geographically part of the Solomon Islands archipelago, the atoll

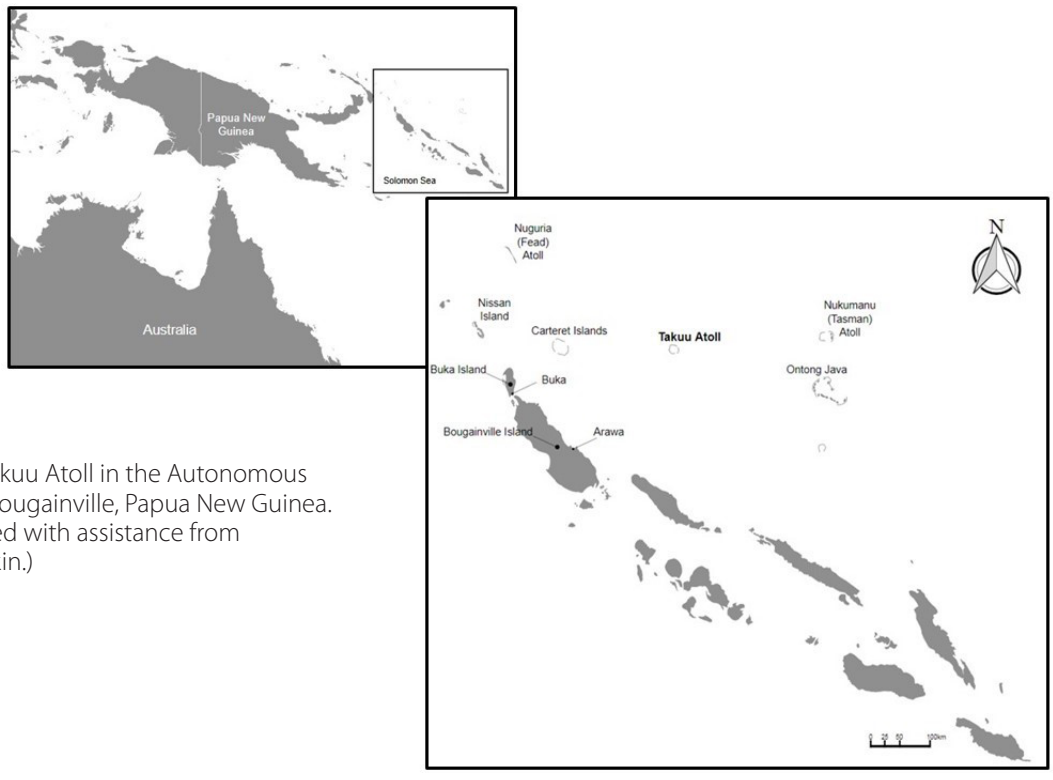

Figure 1. Takuu Atoll in the Autonomous Region of Bougainville, Papua New Guinea. (Map created with assistance from Daniel Boykin.)

is administrated by the Autonomous Bougainville Government. In 1969, the atoll's population was 530 but decreased markedly over the next three decades (Willis 1970; Moyle 2007). By 2014, the population was 316, residing in 86 households. Most of the island's inhabitants are women and children, as the men often travel to urban centres such as Buka, Port Moresby, Lae and Madang for employment opportunities and other socioeconomic activities. Takuu Atoll, at 74 hectares, is the largest and southernmost island within the atoll and serves as the garden island for the population. It is also the island from which the atoll derives its name. All of the inhabitants of Takuu Atoll reside on the village island of Nukutoa, which is approximately 6 hectares in area.

Seasonal variation in the atoll's climate oscillates between the southeast trade winds (*te anake*), which prevail from May to October, and northwest winds (*te laki*), which occur from December to March. There is little seasonality in agriculture, and the island`s population harvests giant swamp taro (*Cyrtosperma chamissonis*) and true taro (*Colocasia esculenta*) throughout the year. Banana plants (*Musa* cvs) and papaya trees (*Carica papaya*) supplement the daily diet of various types of fish and marine invertebrates. Although there are a large number of chickens on the island, they are not consumed regularly. Chickens are butchered primarily for residents who are ill or for special occasions such as the arrival of a ship from Buka, the provincial capital of the Autonomous region of Bougainville. Takuu Islanders overwhelmingly rely on the sea for their protein, and so are experts at canoe construction. Some canoes are designed for the open sea to catch tunas and sharks, while others are crafted for shallow coral reef habitats where men use nets and handlines to catch fish, and dive to spearfish and procure giant clams and sea cucumbers (*lori*). Over the last 30 years there has been a large influx of fibreglass canoes, or *moras*, from the neighbouring atoll of Ontong Java in Solomon Islands. Most types of customary fishing techniques currently employed on Takuu are practiced solely by men, as tradition holds that women contaminate fishing vessels through their presence.

Research methodology

Fieldwork consisted of 14 months of ethnographic research from April 2013 to June 2014 in Bougainville, Papua New Guinea, including 9 months residence on Takuu Atoll. Owing to a lack of shipping services to Bougainville's atolls, five months of research was conducted in the town of Buka with Takuu Islanders who migrated from their atoll for education or employment. Participant observation, augmented by 55 semi-structured interviews with both male and female residents; four focus group discussions with elder fishermen; and myriad informal discussions with key informants, all of whom were at least 35 years of age and long-term fishermen, were utilised to ascertain local ecological knowledge and individual perceptions of changes in wind patterns, rainfall, currents, storms and shoreline erosion. Additionally, the methods used aided in identifying fluctuating marine tenure practices in response to these environmental perturbations. Interviews and discussions were conducted in either English or Tok Pisin.

Results and discussion

Perceptions of changes in environmental conditions

While Takuu Islanders had heard of climate change, few informants said that they understood the scientific underpinnings of this global phenomenon. Despite this, observations of environmental change that were reported in interviews were consistent. The scope of participants' knowledge and perceptions about environmental change are closely tied to land use and their primarily subsistence-based livelihood practices. One main theme about environmental change that emerged from participants was increased monsoon wind variability and overall decreased predictability of weather systems. One fisherman, aged 35, explained:

> We used to ask the elders about good times to go fishing. They will tell you the time the tides and winds are good. But now, they are sometimes wrong. I think they are realising this. At this time, the wind is supposed to come from *te laki* – a very strong wind – but now it is coming from all over the place. When the wind comes from *te laki* we go to fore reef behind the islands, but the last two weeks it has come from the southeast. Now we don't know which way we should go fishing without consulting the elders, and sometimes they do not know now.

Shifting wind and precipitation patterns were the most frequently cited changing aspects of participants' surroundings. Figure 2 shows the direction of the prevailing *te laki* and *te anake* winds in relation to the atoll. During the northwest monsoon winds (*te laki*), strong wind-generated waves make lagoon fishing difficult and force men to fish behind or east of the islands. Participants said that more rain has fallen in recent years than before during the months of December to March, and fishermen stated that this made them less likely to go on longer offshore fishing trips. Southeast winds (*te anake*) were perceived to be less intense, and this season provides more favourable conditions for generally less strenuous lagoon fishing.

Another perceived change in the atoll environment is the availability of fish. There was consensus that one had to spend more time and travel farther away from Nukutoa to acquire fish that were once – just a generation ago – readily available close to the village. Cited reasons for this were numerous: pollution from the island was driving fish away; overfishing on a local scale; and global environmental change caused by industrialised nations were causing changes in migratory patterns of fish in the open ocean. A prominent fisherman, aged 47, asserted:

> We used to have a basket of smoked fish always hanging in the house. This is not our experience anymore. Fish are getting harder to find. The young men now have to go to

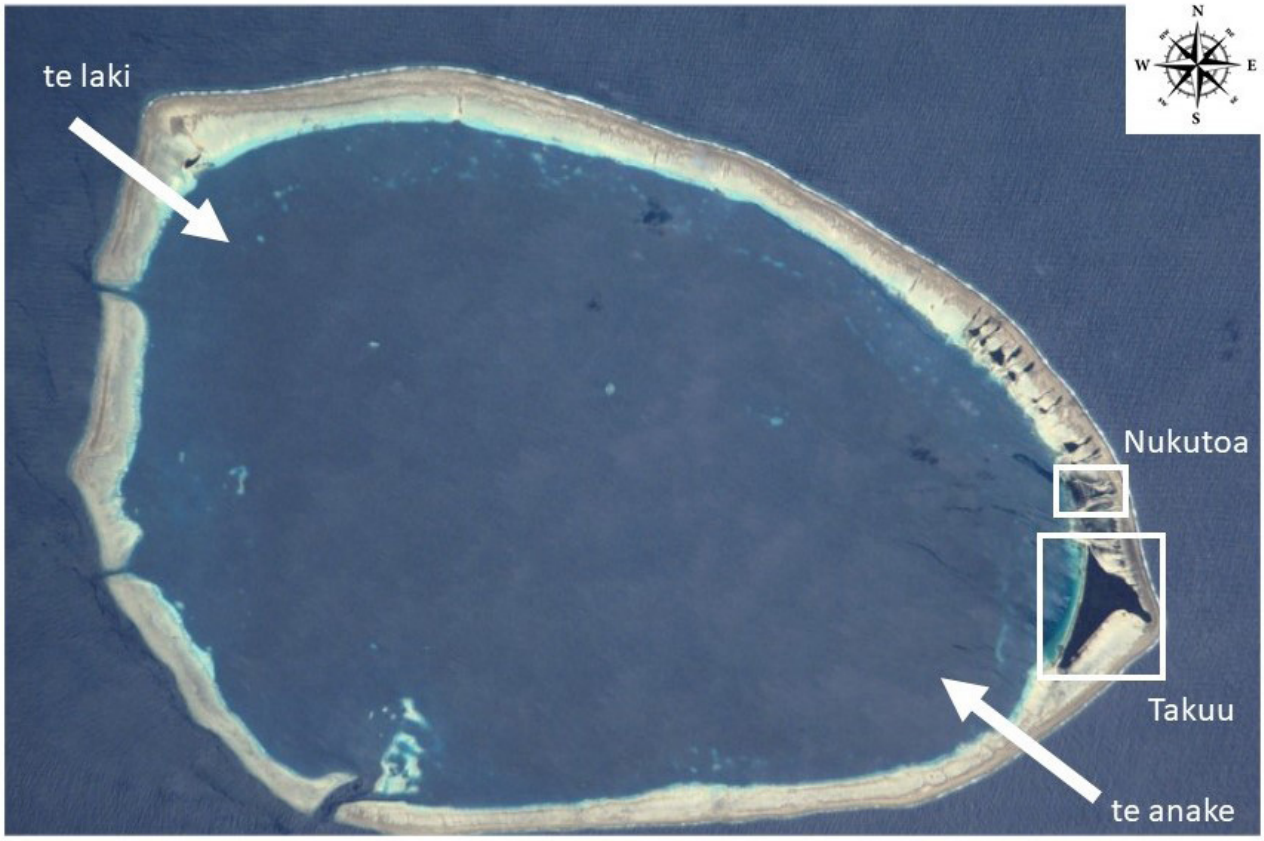

Figure 2. Takuu Atoll, with arrows indicating the direction of the prevailing winds (*te laki* and *te anake*) in relation to Nukutoa, the village island and Takuu, the garden island. (Photo courtesy of NASA)

> the channels or beyond to catch fish large enough for the family. Maybe we used our nets too much. We cannot go with a 3.5- or 2.5-inch net now, we have to go with a 1 inch. There are no big fish around now.

When asked if fish would ever go extinct, all participants stated that they could not envision such a time. The same was asked about sea cucumbers, sea turtles and giant clams. All but one fisherman said that, given the geographically remote location of the atoll, these marine resources were functionally unlimited. However, all fishermen interviewed mentioned the increased difficulty in obtaining giant clams, with the bear paw clam (*vaasua*, *Hippopus hippopus*) being particularly difficult to find in recent years.

Resource use and adaptations to environmental changes

Land and agricultural resource use

Due to the sandy substrate on Nukutoa and Takuu islands, few fruits and vegetables can grow and thrive. Plant propagation from seeds, cuttings or bulbs from most edible plants is not easily achieved. Major food plans include coconuts (*Cocos nucifera*), giant swamp taro (*Crystosperma chamissonis*), bananas (*Musa* cvs) and papaya (*Carica papaya*). Minor plant-based food sources include *aibika* (*Aberlmoschus manihot*), yams (*Dioscorea nummularia*) and breadfruit (*Artocarpus altilis*). Bourke and Bettis (2003) noted that watermelon (*Citrullus lanatus*) was grown next to houses on Nukutoa, but this practice ceased completely by 2014 (see also Willis 1970). Bananas have always been an important food source, and many more banana plants are being newly planted on Nukutoa; one can find them between every house and on all footpaths of the island. Women are active in planting pumpkin (*Curcuma domestica*) patches next to their houses. While this was a rarity as recently as a decade ago, at the time of this research there were seven houses with large pumpkin patches.

On Takuu island, saltwater incursion into the swamp taro (*kano kano*) gardens was a concern voiced by several participants. While quick to attribute salinisation as an effect of climate change, upon further inquiry all informants stated that, given the geomorphology of the island, this has always been an issue. To ameliorate the conditions, farmers replant their crops on slightly higher ground, wherever possible, or when they notice taro leaves beginning to turn yellow. This is not possible for *kano kano*, however, because giant swamp taro plants grow up to six meters in height. Only the suckers can be excavated and replanted.

Marine resource use

Fishing practices

Fishing on Takuu Atoll entails far more than simply putting protein on the table. It is a method of cultural expression, innovation and appropriation. Some knowledge of fishing, such as methods, locations and timing, are closely guarded by families of the five clans that live there as a source of power and prestige. Fishing skill is one way that status is achieved within the community. As in Tokelau and other Polynesian societies, the term *tautai* is a designation for a highly skilled fisherman who is able to lead customary offshore fishing expeditions. A *tautai* possesses vast knowledge about the behavioural ecology of fish, prime fishing locations and fishing methods. This is passed down through generations through each of the clans. Prestige and status are achieved by catching certain highly prized fish such as *parumea* or red emperor snapper (*Lutjanus sebae*), *hailama* or large yellowfin tuna (*Thunnus albacares*) and *alavena* or oilfish (*Ruvettus pretiosus*). On Takuu, fishing meets numerous social obligations, including 'opening houses' after a mourning period with large yellowfin tuna that were caught on customary ritualised fishing expeditions called *sii*. Oilfish are currently used to open houses after a mourning period because *sii* expeditions are no longer performed. Figure 3 depicts an oilfish placed in front of a deceased person's house early in the morning to signify the end of the mourning period. Oilfish are caught on moonless nights using a fishing method known as *hakasoro*. *Hakasoro* is only done by the most skilled fishermen on Takuu, and much ritual surrounds the practice.

Fishing can broadly be categorised as being performed in one of three zones: the lagoon and its shallow reef habitats, the fore reef and the open ocean. Net fishing (*kupena*) is used only inside the lagoon, while line fishing (*matau*) is conducted extensively in all three zones. Although 26 types of line fishing techniques have been documented, only 17 are currently used. The line fishing techniques documented during the research period are described in the Appendix. More than 10 other fishing methods practiced include spearfishing (*korukoru*), and various types of gleaning to procure bivalves, marine worms and crustaceans.

In their fishing activities, fishers have incorporated new adjustments to maximise their catches. Prior to the 2009 Papua New Guinea National Fisheries Authority moratorium on the highly lucrative beche-de-mer trade, many Takuu men harvested and sold beche-de-mer extensively. With their earnings fishermen purchased *moras,* sturdy fibreglass

Figure 3. *Alavena* or oilfish (*Ruvettus pretiosus*) has been prominently displayed early in the morning outside of a house to indicate the end of the mourning period. Before this ritual is conducted, the deceased's family residing there is not allowed to enter the domicile during daylight hours. (image: Anke Moesinger)

canoes popular in Solomon Islands. As the beche-de-mer wholesalers often brought their catch to Ontong Java, where the sale prices were highest, Takuu Islanders often returned with their new sturdy fishing vessels. *Moras* are especially advantageous because they are low maintenance, much more so than traditional outrigger canoes that require extensive repairs after prolonged use. Men go trolling in their *moras* (*paataki*), by paddling rapidly, and catch rainbow runner, several species of tuna and other large pelagic fish by themselves and without having to wait for a supply ship to deliver petrol to fuel small powerboats. More efficient fishing gear has also replaced much of what was customarily used. Stronger test lines, an assortment of steel hooks, and modified rebar fashioned into large hooks for catching oilfish are now used almost exclusively.

Te laki brings strong northwest winds and waves into the lagoon, so the fore reef behind the island chain may be the only place where one can fish during this time. The most common fishing methods employed are *paataki, kkuu, koru-koru* and various *kupena* techniques. If the trade winds are so strong that they create potentially dangerous situations for canoes and *moras,* fishermen opt to stand on the back of the islands on the reef crest to conduct a specific type of handline fishing called *tuutuupaa* or a type of pole fishing called *siisii urutuki*.

Another strategy is to use the net fishing method *osooso sarii*. Several men meet, usually in the early morning, to catch various species of silverside baitfish (*sarii*). Three or four men will hold several nets (*kupena*) and walk in a straight line, generally perpendicular to the shoreline, while another three or four men are tasked with chasing the small fish into the nets. Once they return with the silversides, equal sized piles are divided among the participants. Most men then usually depart for their own fishing excursions in the lagoon or the open ocean. Figure 3 depicts men during *osooso sarii* on the shoreline in front of Takuu, and Figure 4 shows men returning from after netting silversides in front of Nukutoa. If the weather is unfavourable or the wind patterns are unpredictable, men will take their share of the silversides to consume directly rather than using them as bait for further fishing. This is increasingly becoming common practice.

Lagoon fishing is optimal during the southeast trade winds characteristic of *te anake*. *Pepesi, matau va tai, tau muu, taki-taki* and *pakeo* are all commonly used fishing methods (see Table 1) used during this time. Fishermen do not go *paataki* fishing outside of the lagoon during *te anake* winds because the ocean side of the islands experience strong winds and currents during this time.

Figure 4. Fishermen heading out to use the *osooso sarii* method to catch silverside baitfish (*sarii*) early in the morning at the northern end of Takuu island. Forming a line and walking south for the distance of the island, towing their *moras* behind them, men drag their nets while other fishermen are tasked with chasing the *sarii* into the nets.
(image: Anke Moesinger)

Figure 5. Fishermen in front of Nukutoa in the late afternoon after completing *osooso sarii* fishing. (image: Anke Moesinger)

One village elder, aged 72, explained

> December, January and February is the season for *te laki* with strong northwest winds. The strong currents are great for forereef fishing for schooling fish like bonito and rainbow runners, although they sometimes seek shelter in the lagoon. *Te laki* always brings plenty of rain. During *te anake* in March, April and May the wind is always calm with little rain. *Te anake* is good for lagoon fishing like *pepesi, matau va tai* and *tau muu*. *Te laki* starts much earlier and ends much later now, and fishing has become more difficult to provide food for the family. In June, July and August we do not know anymore where the wind will come from.

Another aspect of Takuu fishing culture is the steadily increasing role of women. As weather conditions become less predictable, more fishing is conducted closer to the islands, where women often practice *pakeo, matau mataahiloa* and *matau paaua* (see Table 1) in waist-deep water in front of Nukutoa, and in the shallow channels adjacent to the island. As men become more resistant to travelling away from the islands when the winds or currents are too strong, there will be a greater dependence on nearby resources that engage women more in providing protein for the household.

Mariculture

Much like the example from Fiji, where fisherwomen are intensifying their mariculture practices due to the need to travel farther afield because of depleted fish stocks, Takuu Islanders are also increasing the mariculture of giant clam 'gardens'. Giant clam mariculture has been a part of Takuu Islanders' resource use strategy since precontact time. While previously used to produce tools, weapons, ornaments and other objects of material culture, giant clams are now used solely for their flesh. The gardens are located in the shallow water in front of Nukutoa and the adjacent islands. Three species of giant clams are kept in the giant clam gardens: giant clam, *Tridacna gigas* (*nakohu*), bear paw clam, *Hippopus hippopus* (*vaasua*) and fluted giant clam, *Tridacna squamosa* (*te nai*). While Takuu has a characteristic Polynesian patrilineal kinship system, garden plots are passed down for generations through both male and female family members. Adult men and women possess between one and five garden plots, and married women hold on to garden plots until their sons reach maturity. There is a broad range in the quantity of giant clams that individuals possess. Some may have only a few while others keep up to 200 giant clams in their respective plots.

There is more reliance on the giant clam gardens as a form of nutrition than in previous times due to the unpredictability of winds, currents and precipitation. This adaptation strategy conserves energy and guarantees a meal in unfavourable

Figure 6. A fisherman returning from harvesting giant clams: *nakohu* (*Tridacna gigas*), *vaasua* (*Hippopus hippopus*) and *te nai* (*Tridacna squamosa*). (image: Anke Moesinger)

weather conditions. Figure 6 depicts a fisherman who has returned after harvesting giant clams for a celebratory feast from the three deep channels on the west side of the atoll. Due to overharvesting, one must travel to the far west side of the atoll to collect new replacements for the gardens or to harvest them directly off the reef for large community functions or to send to relatives residing in Buka.

As a village female, aged 39, notes:

> When my grandmother died, I received her garden at *I tai sauti*. It had 30 *nakohu*, but they were close to the beach and covered with sand from *te laki.* There were no *te nai* or *vaasua*. My husband placed 121 inside, but now it is 80 that I am left with. At *te laki* we eat them sometimes. It is so hard to go fishing in *te laki* winds now. When *te anake* comes, that is the best time to replace them.

Greater reliance on the giant clam gardens places more pressure on this resource, and the effects are being felt by all fishermen. Diving for giant clams is a task only suitable for younger more active fishermen, as giant clams can grow at depths of up to 20 meters. As discussed previously, all participants stated that there is no limit to giant clams; some would always be present. However, obtaining replacements for future consumption is proving to be increasingly difficult. The effort that fishermen must expend is compounded by intensifying *te laki* trade winds, which produce stronger currents and waves that affect garden plots inside the lagoon. Fishermen must check their giant clams more regularly to ensure that they are still thriving and not being smothered by sand that gets stirred up from winds and currents.

Implications for food security and adaptive capacity on the atoll

Takuu has not always been as economically isolated as it is today. Even during the Bougainville crisis[2], large supply ships travelled to the island at least on a quarterly basis. At present, not more than two ships visit the atoll each year, and few small fibreglass boats risk the 300-kilometre journey from Buka to bring in supplies. Once a ship arrives bringing large quantities of store-bought goods, fishing activities all but cease for several weeks to a few months until flour-based products and rice supplies have largely been consumed.

Takuu Atoll covers a land area of slightly less 1 square kilometre, and the population has decreased significantly over the last 20 years. As opposed to the neighbouring Carteret

[2] The Bougainville crisis was a bloody civil war that occurred from 1988 to 1998 between PNG's national government and the Bougainville Revolutionary Army. The war caused 20,000 Bougainvillean casualties. The conflict began due to grievances over the Rio Tinto-owned Panguna copper mine, and concluded with the signing of the Bougainville Peace Agreement in 1998, which established the Autonomous Bougainville Government.

Islands with a population of around 1200 and very limited space for agriculture (Connell 2016), the 316 people residing on Takuu still currently place little pressure on the atoll's resources today, even without the regular arrival of supplies. With a larger landmass and lower population than that of neighboring atolls, food security is currently not as dire a concern on Takuu as it is on Tasman Atoll and the Carteret Islands. However, this may well change with increasingly erratic weather patterns, fewer fishermen residing on the island to meet the protein needs of residents, and decreasing levels of fishing skills due to outmigration.

Whereas fishermen customarily had explicit times of the year where they only practiced certain types of fishing, the increasing instability of wind and current patterns necessitate that fishermen possess and continue to pass on extensive local knowledge to adapt to these changing conditions. This knowledge is not replaced by advancements in technology or the use of modern fishing equipment. If the islanders wish to continue their education, students must leave after grade eight because there is no secondary school on the atoll. Thus, adolescents leave the island during their formative years and miss out on much learning with regards to fishing skills and practices. Many men in their 30s and 40s also reside in urban centres. Coupled with a predicted trend towards more environmental perturbations, this hinders adaptive capacity for future generations.

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Appendix I: Summary of line fishing (*matau*) methods currently in use on Takuu Atoll

Takuu name	Brief description	Season(s)	Frequency of use during season(s)	Location	Best tidal and lunar stages	Commonly caught species
Pepesi	A fishing method where a man swings a handline in a lasso-like motion in the direction of a patch reef away from his anchored fiberglass canoe (*mora*) in shallow water (~ 5–10m in depth) inside the lagoon. If a wooden canoe is used, then no more than two men will go on the expedition together to avoid crowding. It is practiced by men only, generally those in their early 20s to late 60s. 20–50 lb test monofilament line is used with J hooks (2/0 or 3/0) along with a small lead sinker purchased in town. Using a sinker is optional.	*te anake*	weekly	lagoon	low tide and *tai maariki* (start of rising tide) all lunar phases	When using octopus as bait: *simu taia mmea* (yellowmargin triggerfish, *Pseudobalistes flavimarginatus*), *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*), *natura* (longface emperor, *Lethrinus olivaceous*) When using *te karo* (juvenile goatfish, *Mulloidichthy sp.*) as bait: *taea* (humpback snapper, *Lutjanus gibbus*), *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*), *hootua* (onespot snapper, *Lutjanus monostigma*)
Tauna	*Tauna* is the same as *pepesi* in terms of equipment and technique used, but is performed solely at night. *Tauna* also refers to the specific places inside the lagoon where this type of fishing is practiced.	*te anake*	monthly to weekly	lagoon	low tide and *tai maariki* all lunar phases	*taea* (humpback snapper, *Lutjanus gibbus*), *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*), *hootua* (onespot snapper, *Lutjanus monostigma*)
Paataki	A fishing method equivalent to the Western method of trolling. Performed by men only, this technique can be done on acanoe while paddling (one person), canoe under sail (one or two people), or fibreglass boats with an engine (four or five people). If lures are not purchased in town, then other common items are used as bait, including condoms, feathers, plastic bags, straws and wool yarn. When practiced on a fiberglass canoe (*mora*), the fisherman drags the line ~ 10–15 m behind the vessel. If a power boat is used, then the line is extended farther, to ~ 20 m. Trolling only occurs early in the mornings (between sunrise and 10:00) and in the late afternoons (15:00 to 18:00 pm). At night, *paataki* is only performed at one of the three channels on the atoll.	both	weekly	lagoon and open ocean	*tai maariki* Daytime: New moon (days 29–5: *maa itu to maa rima*) Nighttime: New moon (days 29–4: *maa itu* to *maa haa*) and third quarter moon (days 20–24: *seni maa rima* to *seni maa sivo*)	Daytime inside lagoon: *naenae* (double-lined mackerel, *Grammatorcynus bilineatus*), *malauseri* (bluefin trevally, *Caranx melampygus*), *kamai* (rainbow runner, *Elegatis bipinnulatus*) Daytime outside lagoon*: *kamai* (rainbow runner, *Elegatis bipinnulatus*), *hoehoe* (mackerel tuna, *Euthynnus affinis*), *te atu* (yellowfin tuna, *Thunnus albacares*), *laueva* (skipjack tuna, *Katsuwonus pelamis*), (*highly variable based on migration patterns) Nighttime at the channels: *matapuku* (bigeye trevally, *Caranx sexfasciatus*), *tahauri* (black jack, *Caranx lugubris*), *tapatuu* (bigeye barracuda, *Sphyraena forsteri*)

Matau va tai	A bottom fishing method performed predominantly by men –aged 18 to late 70s – inside the lagoon on patch reefs in depths of ~ 15–25 m. Men seldom take their wives fishing with them, and this method is not performed by women if they are by themselves. One fisherman may go out on a *mora*, up to three persons will go on wooden canoes, and four or five may go on a small fibreglass boat. A weighted line is dropped next to a patch reef below the fishing vessel. A small lead is used, along with a 20 lb, 30 lb or 40 lb (max) monofilament line and a smaller (2/0 to 3/0) J hook. While some fishers use this method at night, it is mainly a daytime fishing technique.	*te anake*	weekly	lagoon	low tide (occasionally falling tide) all moon phases. When going to the passage, one should go during a new moon (days 5–6: *maa rima* and *maa ono*)	Daytime: *sipopu* (type of wrasse, Labridae), *tausena* (gold-lined snapper, *Lutjanus rufolineatus*), *taea* (humpback snapper, *Lutjanus gibbus*) Nighttime: *taea* (humpback snapper, *Lutjanus gibbus*), *te lona* (spotcheek emperor, *Lethrinus rubrioperculatus*), *saratea* (orange-striped emperor, *Lethrinus obsoletus*)
Saro	A newer fishing technique practiced by younger males (aged early 20s to 50s) during the daytime. It is a type of bottom trolling. Rarely performed in the lagoon, it is primarily done in depths of 30–90 m on a canoe. Alternatively, two men may go on a canoe, or up to five men may go in a fibreglass boat. In preparation for the fishing trip, ~ 50 'stones', pieces of coral rubble (both living and dead), roughly the size of a baseball are collected from the reef crest. A palm frond is also taken along, and the fisherman prepares his lures. These lures are made from cutting the stem off a '*lilly*' plant and peeling the layers. Once the fishing destination is reached, a single leaf from the palm frond is tied around the stone to act as a sinker. A 2/0 to 4/0 J hook with the *lilly* lure is attached to a 70 lb test monofilament line is then placed ~ 5–7 cm below the cut palm frond with the sinker. The line is dropped in the water and, as it hits the bottom, the fisherman thrusts upward in one quick motion to tear the hook and lure from the palm leaf-wrapped sinker. Once detached, the hook and lure are quickly pulled back towards the surface to attract fish swimming by on the fore reef.	both	weekly	starting around 5 m out from the fore reef in ~30–40 m, occasionally extending down to 90 m. On rare occasions performed inside the lagoon	low tide and, if fish are not biting, *tai maariki* new moon (days 30–6: *ku ara* to *maa ono*)	from 5–40 m: *kurakura* (strawberry grouper, *Cephalopholis spiloparae), malauseri* (bluefin trevally, *Caranx melampygus*), *maapilo* (yellow-spotted trevally, *Carangoides orthogrammus*) from 40–90 m: *tahauri* (black jack, *Caranx lugubris*), *kamai* (rainbow runner, *Elegatis bipinnulatus*), *naenae* (double-lined mackerel, *Grammatorcynus bilineatus*)

Kkuu	A deep-sea fishing method introduced from neighbouring Nukumanu Atoll. Seasoned fisherman (males aged at least 20–70) go to catch large pelagic fish. Traditionally, a large sinker was attached to a fishing line and several hooks, separated by wooden spacers, were attached above. The spacers are no longer utilised, and two to four 3/0 to 4/0 J hooks are now attached directly to the 70 lb to 100 lb test monofilament line. While J hooks are the most commonly used hooks, a wide variety of hooks can be used. Very large sinkers, mostly homemade and weighing at least 0.5 lb are produced from cutting iron rods. Alternatively, the lead from old wet cell batteries are removed and melted down over a fire and poured into cylindrical cardboard forms in the ground to harden. Men only go *kkuu* during the day (either early mornings or late afternoons) alone or with a partner on a canoe. No more than two people on one canoe or three people on a fibreglass boat can go because the lines can become tangled, and the valuable sinkers will be lost. This is considered a traditional fishing technique on Takuu that previously involved many rituals, and women are still strictly forbidden from accompanying men on this type of fishing expedition.	both but predominantly *te laki*	monthly to weekly	open ocean	low tide or high tide (least amount of current) all moon phases	*Parumea* (red emperor snaper, *Lutjanus sebae), paru kkehu* (type of deep water snapper, Lutjanidae), *paru natara* (type of deep water snapper, Lutjanidae)
Hakararo	A type of bottom fishing, much like *matau va tai*, but *hakararo* is performed outside of the lagoon on the fore reef. Only fishermen ages ~ 18 to early 70s use this method. A single 30–50 lb test monofilament line with 2/0 to 4/0 J hooks and small lead or iron sinkers are attached and lowered down below a canoe onto the slope of the fore reef. Men who are unsuccessful on a *kkuu* expedition will occasionally move in closer to the atoll to employ this technique. Unlike some other fishing techniques, there is no difference in the species of fish caught during either *te laki* or *te anake*. Marine worms (*te pamu* and *te upo*), octopus and cut bait from *naenae* (double-lined mackerel, *Grammatorcynus bilineatus*) and other reef fish are commonly used as bait.	both	weekly	~5–10m out from the fore reef in water ~30–50 m deep	low tide or falling tide all moon phases	Daytime: *te lona* (spotcheek emperor, *Lethrinus rubrioperculatus*), *taea* (humpback snapper, *Lutjanus gibbus*), *kurakura* (strawberry grouper, *Cephalopholis spiloparae)* Nighttime: *taea* (humpback snapper, *Lutjanus gibbus*), *takape* (bluestripe snapper, *Lutjanus kasmira*), *kainataa* (camouflage grouper, *Epinephelus polyphekadion*), *taamarau* (sabre squirrelfish, *Sargocentron spiniferum)*

Tau muu	A method where a fisherman focuses specifically on catching *te muu* (humpnose bigeye bream, *Monotaxis grandoculis*) on patch reefs inside the lagoon by swinging and throwing a single line about 5 m from the fishing vessel. The fisherman may also go on his *mora* (or up to two fishermen on a canoe) to the fore reef. A 20–50 lb test monofilament line is used with a smaller hook (2/0 up to 3/0) and a very small lead sinker. The fisherman generally dives into the water before fishing begins to look for schools of 20–40 *te muu*, which are mainly found in depths of 7–15 m, near the sandy bottom next to patch reefs. Hermit crabs (*te una*) and marine worms (*te pamu* and *te upo*) are used as bait.	*te anake*	monthly	lagoon (occasionally at the fore reef)	high tide (or *tai maariki)* all moon phases	*tau muu* (humpnose bigeye bream, *Monotaxis grandoculis*), *saratea* (orange-striped emperor, *Lethrinus obsoletus)* (bycatch), *simu taia mmea* (yellowmargin triggerfish, *Pseudobalistes flavimarginatus*) (bycatch)
Tau simu	A fishing method where exclusively men use a large (50lb to 60lb) test monofilament line, 3/0 to 4/0 J hooks and heavy sinkers to target *simu taia mmea* (Yellowmargin tripperfish, *Pseudobalistes flavimarginatus*) and *simu taia uri* (Titan triggerfish, *Balistoides viridescens*) inside of the lagoon. A single line is dropped close to the side of the *Mora* or canoe, and this type of fishing takes a long time as one must "wait" for the *simu taia*. Marine worms are used as bait, but hermit crabs are also occasionally utilised.	*te laki*	rarely	lagoon	high tide or low tide. new moon (days 29–5: *maa itu* to *maa rima)*	*simu taia uri* (titan triggerfish, *Balistoides viridescens)*, *simu taia mmea* (yellowmargin triggerfish, *Pseudobalistes flavimarginatus*)
Takitaki	A fishing method where a (generally older) fisherman uses a large pole called a *tau hakau* – ~ 1.5–2.0 m in length, and 2–3 cm in diameter – made of mangrove or bamboo to fish. The fisherman places the stick upright in the sand on the beach, and then takes the line, baited with marine worms or cut bait, and swims with it to a coral head. There, he drops the line and swims back to shore where he ties the line to the pole and waits close by to see if the pole moves once a fish is hooked. A 20–40 lb test monofilament line and 2/0 to 4/0 J hooks are used. *Takitaki* is thought of as a solitary and casual fishing technique.	both (predominantly *te anake*)	rarely	lagoon	low tide all moon phases	*simu taia uri* (titan triggerfish, *Balistoides viridescens)*, *simu taia mmea* (yellowmargin triggerfish, *Pseudobalistes flavimarginatus*), *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*), *natura* (longface emperor, *Lethrinus olivaceus*)

Pakeo	A fishing technique in which either men, women or children stand in the shallows of the lagoon and cast their single handlines onto the patch reefs in front of the islands. Hermit crabs and cut bait from small reef fish are used along with a 10–20 lb test monofilament line and a small 1/0 to 2/0 J hook attached by a simple fisherman's knot. Two types of *pakeo* are used, *pakeo* and *pakeo va tai*. The latter refers to very shallow bottom fishing performed by older men on canoes with the same single line, small sinker and baited hook.	both but predominantly *te anake*	weekly	lagoon	high tide or low tide all moon phases	*Natara haiahua* (small reef grouper, *Epinephelus* sp.), *sipopu* (small species of wrasse, Labridae),
Siisii urutuki	A fishing method whereby a fisherman takes a bamboo pole that is 3–7 m long and attaches a single 20–30 lb test monofilament line baited with a hermit crab using a 2/0 J hook without a sinker, and stands on the reef crest (during the daytime) and casts the line onto the fore reef. The line is measured to be exactly as long as the pole, and men look for slightly curved poles so that the hooks will attach firmly to the bottom for transport by currents and wave action. Only men between the ages of 20 and 50 practice this type of fishing,	*te laki*	rarely	fore reef	low tide all moon phases	*urutuki* (several species of hawkfishes, Cirrhitidae), *hootua* (onespot snapper, *Lutjanus monostigma*) (bycatch), *natara haiahua* (small reef grouper, *Epinephelus* sp.)(bycatch)
Siisii nanue	The same fishing equipment and technique is used for *siisii nanue* as for *siisii urutuki*, but rather than standing on the fore reef this fishing is performed only at nighttime and at the points of the island towards the lagoon. For bait, either coconut flesh or small balls made from flour and water are used.	both	rarely	lagoon	high tide all moon phases	*Nanue* (topsail drummer, *Kyphosus cinerascens*), *paaua* (white-spotted rabbitfish, *Siganus canaliculatus*), *panoo* (golden rabbitfish, *Siganus guttatus*)
Siisii tanau	*Siisii tanau* is performed mainly by adolescent male and females. The fisher woman stands on the back of the island on rock formations and casts a small baited line, which is attached to a spool made of carved wood or a buoy, into the channels. This technique is used specifically to target juvenile *hootua* called *tanau* (onespot snapper, *Lutjanus monostigma*). A 10–20 lb test monofilament line is used with a hermit crab or silverside baited with a small (2/0) hook. No sinker is used.	both	monthly	lagoon	high tide all moon phases	*tanau* (onespot snapper, *Lutjanus monostigma*), *tapurei* (black-banded snapper, *Lutjanus semicinctus*), *mataahiloa* (several species of juvenile emperors, Lethrinidae)

Matau mataahiloa	A popular fishing method used by both women and children. It is performed daily to catch small reef fish for household meals and for adolescents to feed their pet birds. Women and children wade into the lagoon at low tide (to their waist) and swing the line towards a small coral heard or into the seagrass. A dish that accompanies them is either anchored with a small stone next to the fisher, tethered to the fisher, or left on the beach close by. It contains the hermit crabs that are used as bait as well as the small fish that are caught. No sinkers are attached to a small monofilament line, and the fisher uses the smallest hook available. While the fishing method is named for juvenile *hiloa* (yellowlip emperorfish, *Lethrinus xanthochilus*), a wide variety of juvenile reef fish are targeted and caught.	both	daily	lagoon	low tide all moon phases	*mataahiloa* (several species of juvenile emperors, Lethrinidae), *saaripo* (blacktail snapper, *Lutjanus fulvus*), *sipopu* (type of wrasse, Labridae) *simu* (several species of juvenile triggerfish, Balistidae)
Matau paaua	While identical in technique and equipment as *matauu mataahiloa*, with this method fishers cast their lines into seagrass meadows instead of patch reefs. Women and children often stand on *te pae* (sea wall) and cast their lines from there. This technique targets *paaua* (white-spotted rabbitfish, *Siganus canaliculatus*) and other small rabbitfish that live in seagrass.	both	daily	lagoon	low tide all moon phases	*Paaua* (white-spotted rabbitfish, *Siganus canaliculatus*), *mataahiloa* (several species of juvenile emperors, Lethrinidae)

Tuutuupaa	Rarely used, this method can be used both during the day and at night. Only men aged 20–60 partake in this method. They walk to the back of Nukutoa, and occasionally Takuu, and stand on the reef crest to cast their lines onto the fore reef. Usually performed by a single fisherman, a group of up to three fishermen will each cast a sturdy (50–70 lb test) monofilament line with a single large hook (4/0) and heavy sinker attached, with the fisher standing ~ 10 meters out from the reef crest on the slope. The line is attached to a spool as this technique targets larger reef fish. Men unroll their lines from the spool beforehand and cast out with a lasso-like motion. Some fishermen dive down and jam the line and hook between coral heads, as there is usually a strong current. A firm cut bait is usually used to ensure that it remains on the hook in the swift current. Once a fish is hooked, the fisher will feel the line momentarily go slack, followed by a strong pull. The fisherman must then act quickly since fish will attempt to hide in the crevices in the reef. Rather than standing still and swiftly collecting the line by hand, the fisher holds the line tightly and runs away inland, away from the forereef. This motion pulls the fish out of the water and onto a dry area of the reef crest where the fisher can retrieve it.	*te laki*	rarely	open ocean (fore reef)	low tide all moon phases. Best at new moon (days 29–4: *maa itu* to *maa haa*)	Daytime: *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*), *natura* (longface emperor, *Lethrinus olivaceus*), *sanapiki* (blubberlip snapper, *Lutjanus rivulatus*) Nighttime: *manoo tea* (blacktip reef shark, *Carcharhinus melanopterus*), *hanamea* (red snapper, *Lutjanus bohar*), *sanapiki* (blubberlip snapper, *Lutjanus rivulatus*), *natura* (longface emperor, *Lethrinus olivaceus*), *hiloa* (yellowlip emperor, *Lethrinus xanthochilus*)

The role of fisheries resources and community-based coastal resource management activities during a natural disaster – Case study of Vanuatu after Tropical Cyclone Pam

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Abstract

Packing Category 5 winds, Tropical Cyclone Pam struck Vanuatu in March 2015 and seriously damaged southern parts of the country. In the aftermath of this natural disaster, local community chiefs and area councils temporarily opened their traditional conservation areas, known locally as *taboo* areas. Coastal resources provided an important source of protein for communities after the disaster. Questionnaires were used to interview local people in affected areas to determine how they coped with the effects of the cyclone. This case study clarifies the importance of coastal fisheries and effective community-based management in food security, especially in times of emergency. The results of interviews and questionnaire surveys showed that coastal fishery resources were relatively resilient compared with other food sources, especially crops and livestock. It has been concluded that the wise use of coastal fishery resources enhances food security following natural disasters.

Keywords: coastal fisheries, crop and livestock damage, food security, protein supply, emergency food supply, traditional conservation areas

Introduction

Between 12 and 14 March 2015, a Category 5 tropical cyclone (Pam), struck Vanuatu and caused serious damage, especially in southern Vanuatu. It was reported that 16 people were killed and more than 160,000 were injured. There was enormous property damage (OCHA Regional Office for the Pacific D, 2015-4), and the economic loss was estimated at approximately VUV 48.6 billion (USD 494.4 million) (OCHA Regional Office for the Pacific D, 2015-4). After this natural disaster, people in many areas suffered and had difficulties obtaining food, especially protein.

Because of this, staff of the Coastal Fishery Development Division of the Vanuatu Fisheries Department (VFD) permitted some of the no-take zones (traditionally called *taboo* areas) to be temporarily opened for one to two months after the cyclone, to ensure food security. These *taboo* areas were in some of the pilot sites of the 'Promotion of the Grace of the Sea in the Coastal Village Project phase II' (hereinafter referred to as 'Phase II'), which was implemented from 2011 to 2014 by the Japan International Cooperation Agency (JICA) (Nimoho et al. 2013, 2016; Terashima et al. 2018).

VFD staff noted that the temporary opening of *taboo* areas was undertaken mainly in accordance with a plan made through a community-based coastal resource management (CBCRM) approach, in order to promote community-based resource management and introduce alternative ways to reduce the impact on reef resources. Local collaborators who were enthusiastic about the activities of Phase II took an important role in decision-making and dealing with emergencies in affected communities, suggesting that community-based management of fishery resources is effective in providing food security after a natural disaster, such as Cyclone Pam. In addition, Eriksson et al. (2017) suggested that marine resources are important for coastal communities recovering from natural disasters that reduce land-based food availability.

This case study was conducted in 2017 when the affected areas were almost restored to their former state in order to estimate the role of fishery resources and the response of local communities in southern Vanuatu, and examine the importance of the CBCRM approach for securing food for local communities.

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[6] Tropical cyclones are classified by Categories 1 to 5. Category 5 denotes extremely destructive winds with a speed of, or exceeding, 280 km/h.

Research methodology

Survey sites

The survey sites were selected from the two southern provinces of Shefa and Tafea, which were severely damaged by Cyclone Pam (Fig. 1).

Shefa Province

- Northern remote islands in Shefa Province: Emae Island, Makira Island, Mataso Island, Tongariki Island and Buninga Island
- Lelepa Island and Mangaririu in North Efate

Tafea Province

- Tanna Island (Waisisi)
- Aniwa Island
- Aneityum Island

Literature survey

As part of the case study, a literature survey was conducted to review the documented damages caused by Cyclone Pam, and the emergency support following it. The documents reviewed are listed in Table 1.

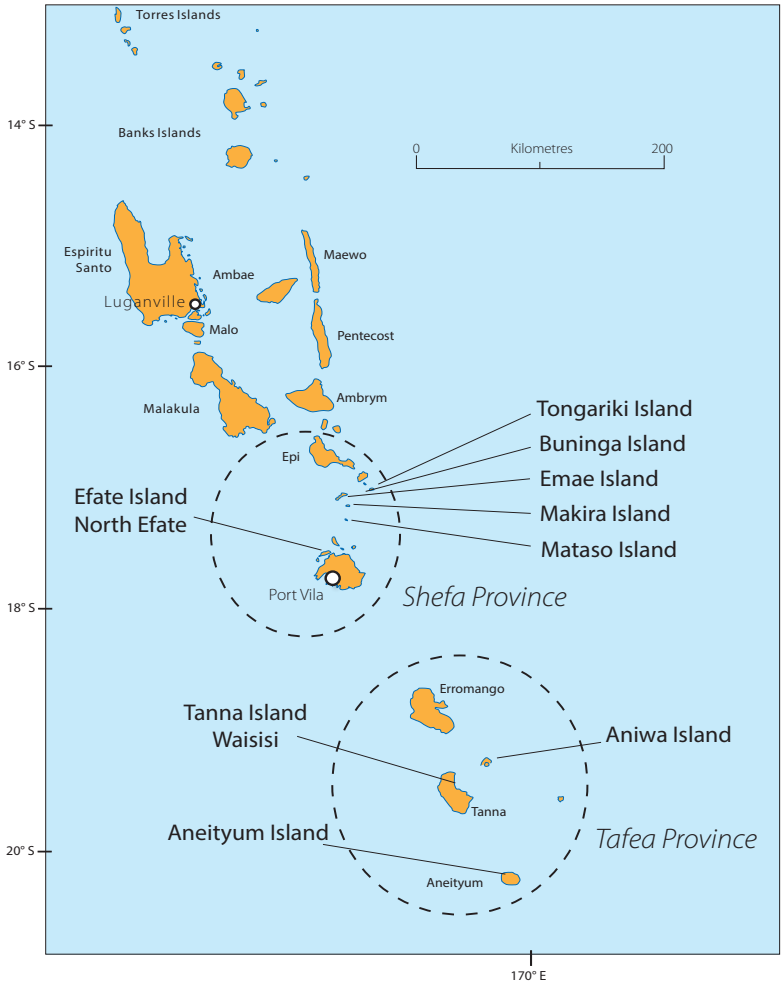

Figure 1. The nine study sites.

Table 1: Documents used in the literature survey.

Source	Title	Publication date
Prime Minister's office, Government of Vanuatu	Vanuatu Post-Disaster Needs Assessment Tropical Cyclone Pam	March 2015
United Nations Office for the Coordination of Humanitarian Affairs (OCHA)	Vanuatu: Severe Tropical Cyclone Pam Situation Report No.2	March 2015-1
OCHA	Vanuatu: Severe Tropical Cyclone Pam Situation Report No.6	March 2015-2
OCHA	Vanuatu: Severe Tropical Cyclone Pam Situation Report No.9	March 2015-3
OCHA	Vanuatu: Severe Tropical Cyclone Pam Situation Report No. 12	March 2015-4
International Federation of Red Cross and Red Crescent Societies	Tropical Cyclone Pam: One-year progress report	March 2016
Pacific Community	Tropical Cyclone Pam Lessons Learned Workshop Report	June 2015
Community of Lelema	Community Based Coastal Resource Management (CBCRM) Plan for West Efate-Lelema Area	October 2014
Community of Aneityum	Community Based Coastal Resource Management (CBCRM) Plan for Aneityum	October 2014

Telephone surveys

For the remote northern islands without regular transportation service such as Makira and Mataso islands in Shefa Province, we contacted area secretaries, chairpersons of fisherman's associations and VFD staff by phone to understand the scope of the damage in those islands and to learn how people were coping due to the lack of regular transportation in the area.

Interview surveys

The authors visited Emae Island, Lelepa Island, Mangaliliu on Efate (Shefa Province), and Waisisi on Tanna Island, Aniwa Island and Aneityum Island (Tafea Province), where regular transportation was available, and conducted interviews in the villages with authorised officers and village representatives such as chiefs.

Questionnaire surveys

A questionnaire survey was conducted to understand the socioeconomic situation before and after the cyclone and the responses of local communities to the natural disaster.

Results

Literature survey

The route of Cyclone Pam

The route of Cyclone Pam, which struck Vanuatu between 12 and 14 March 2015, is shown in Figure 2. It passed quite close to Efate Island and then moved south, passing very close to Erromango and Tanna islands causing severe and widespread damage on those islands.

Damage caused by Cyclone Pam

The damage described in the 'Severe Tropical Cyclone PAM Situation Report No.12' is shown in Table 2.

Table 2. Overall damage of Cyclone Pam.

Fatalities	16
People in evacuation centres	3995
People affected by the cyclone	166,000
Islands affected by the cyclone	22

Source: OCHA Regional Office for the Pacific (2015-4)

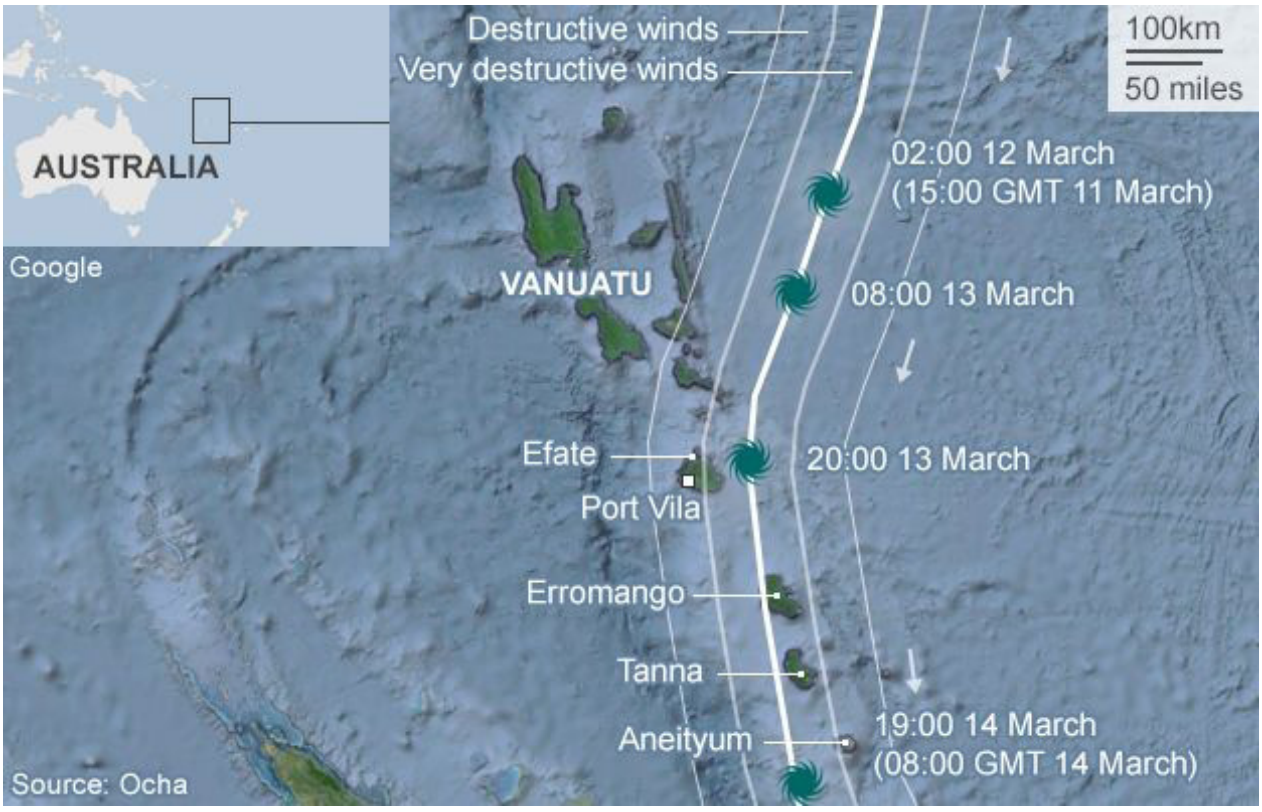

Figure 2. The route of Cyclone Pam. (Source: UN Office for the Coordination and Humanitarian Affairs)

According to the Government of Vanuatu (2015), the total economic damage caused by Cyclone Pam was estimated at approximately VUV 48.6 billion (USD 449.4 million). Of this, VUV 19.3 billion (USD 178.5 million) was regarded as a total loss. All of the damage combined was more than 64% of Vanuatu's gross domestic product. Details of damage are described in Table 3, and some scenes of the disaster are shown in Figure 3.

Table 3. Summary of damage by sector.

	Damage by natural disaster (VUV million)			Ratio of disaster damage (%)		Lost personal income
	Partly damaged	Total losses	Total	Private	Public	VUV million
Productive sector	8526	10,403	18,928	98	2	1607
Agriculture	1421	4641	6062	93	7	227
Commerce and Industry	1196	2152	3348	100	0	487
Tourism	5908	3610	9518	100	0	983
Social sector	14,339	630	14,969	67	33	-
Housing (private)	9452	440	9893	100	0	-
Health	870	107	977	1	99	-
Education	3908	79	3987	0	100	-
Culture	109	3	112	100	0	-
Infrastructure	6403	2926	9329	51	49	-
Transport	3017	2137	5155	43	57	-
Public buildings	532	12	544	0	100	-
Water	414	284	697	63	37	-
Energy	179	106	285	100	0	-
Communication	2261	387	2648	67	33	-
Cross-cutting sector	0	5328	5328	0	100	-
Environment	0	5328	5328	0	100	-
Grand total	29,268	19,286	48,554	69	31	1607

Source: Government of Vanuatu 2015

International aid after Cyclone Pam

International food aid was provided to the following provinces that were damaged by Cyclone Pam: Tanna, Shefa, Malampa, Penama and Torba. The amount of food provided to these provinces is shown in Table 4. Among these supplies, tinned fish was important for providing protein to communities during the emergency period.

Details of the damage and how coastal communities coped are given hereafter.

Remote islands adjacent to the northern area of Efate Island

Damage situation for Makira and Mataso islands

On Makira and Mataso islands, it took approximately one and a half months until emergency food arrived after Cyclone Pam. Some support was transported by the National Disaster Management Office; it was then distributed by the Village Disaster Committee. Distribution amounts were decided on according to household size. While waiting for supplies and support from the government, people asked for support from other islands. Although it was not enough, some support came from relatives of other islands.

Many of the coral reefs were seriously affected by sand that had washed onto them. Sand erosion changed the landscape of beaches and many coastal trees withered. However, there was no information regarding direct damage to fishery resources.

Coconut palms collapsed on a livestock breeding facility in Teoma, Efate Island, Shefa Province.

Houses destroyed in Malalip, Efate Island, Shefa Province.

Collapsed bridge in Teoma, Efate Island, Shefa Province.

Poultry farm destroyed in Teoma, Efate Island, Shefa Province.

Figure 3. Some of the consequences of Cyclone Pam's passage over Vanuatu. (images: William Morris, VFD)

Table 4. International food aid sent to provinces that were damaged by Cyclone Pam.

Province/island	Number of households	Population (household × household size)	Rice		Tinned fish		Tinned meat		Instant noodles	
			Overall (tonnes)	Per capita (kg)	Overall (tonnes)	Per capita (kg)	Overall (tonnes)	Per capita (kg)	Overall (tonnes)	Per capita (kg)
Tafea Province	6116	33,657	193.0	-	17.0	-	8	-	7	-
Tanna Island	5535	30,443	175.1	5.8	15.0	0.5	7.0	0.2	6.0	0.2
Aneityum Island	176	986	5.6	5.7	0.5	0.5	0.2	0.2	0.2	0.2
Shefa Province	22,378	111,944	343.4	-	9.7	-	4.6	-	3.8	-
Emae Island	99	495	2.9	5.9	0.2	0.5	0.1	0.2	0.1	0.2
Tongoa Island	454	2270	13.1	5.8	1.1	0.5	0.5	0.2	0.5	0.2
Buninga Island	23	134	0.8	6.0	0.1	0.5	0.03	0.2	0.03	0.2
Tongariki Island	55	415	2.4	5.8	0.2	0.5	0.1	0.2	0.1	0.2
Mataso Island	20	100	0.6	6.0	0.1	0.5	0.03	0.3	0.02	0.2
Makira Island	37	125	0.8	6.4	0.1	0.5	0.03	0.2	0.02	0.2
North Efate	499	2494	14.4	5.8	1.2	0.5	0.6	0.2	0.5	0.2
Lelepa Island	83	415	2.4	5.8	0.2	0.5	0.1	0.2	0.1	0.2
Malampa Province	4098	9887	51.5	-	0	-	2.1	-	1.8	-
Penama Province	4581	22,903	207.0	-	0	-	5.0	-	5	-
Torba Province	112	582	3.4	-	0	-	0.1	-	0.1	-

Many fishing canoes were severely damaged, but most boats suffered only minor damage.[7] One week after the passage of Cyclone Pam, the *taboo* area was opened, and local people could catch reef fish. The *taboo* area remains open more than two years after the disaster. After Cyclone Pam, fish aggregating devices and solar freezers were provided to support fisheries reconstruction.

In terms of agriculture, most surface crops were damaged, and people survived by eating root crops such as cassava and taro. They also ate fallen bananas until emergency relief supplies arrived. The recovery of farm production requires a long time, such as six to seven months for cassava, and three to four months for sweet potato. The few remaining chickens, goats and pigs were eaten within several months of the disaster. However, fishery products were the only source of animal protein just after the disaster.

On Makira and Mataso islands, reef resources have been recognised as being very important since ancient times, and there is no particular change in people's views on the importance of reef resources before and after the cyclone.

Damage situation on Tongariki and Buninga islands

According to interviews with area secretaries of Bonginga and Tongarika islands, and interviews with heads of the fishermen's association on Tongariki Island, it took two to three weeks until people received support due to the communication network being broken down. Support was distributed through the Village Disaster Committee.

In coastal areas, seagrass and algae beds were destroyed by the waves and many of the shellfish in the rocky areas were washed away.

Approximately 20 fishing canoes were damaged, while two aluminium boats were safely sheltered before the approach of Cyclone Pam. A solar freezer and its contents, donated by the French Embassy, were severely damaged. After Cyclone Pam, it was difficult to catch fish without canoes, and catches declined immediately. Local people consumed crab and clams collected on the reef at ebb tide as sources of animal protein. Although the *taboo* area existed, it had already been opened before Cyclone Pam.

In terms of agriculture, all farm gardens with major crops such as taro, banana, yam and orange were damaged. People survived by consuming fallen bananas and root crops. Cultivation of some root crops such as taro and yam recovered about three months after Cyclone Pam, but due to further damage caused by El Niño-associated bad weather, it took six months to recover completely. Livestock such as cows, pigs and goats starved to death.

The community feels that coastal resources are important because they could only catch and eat crab and clams after the natural disaster.

Interview survey in the target site

Emae Island (Marae, Tongamea and Sangava villages)

The damage status of the three major villages on Emae Island is shown in Table 5.

In Marae, most crops were damaged. Since fishing gear such as spearguns were included in emergency relief supplies, local people relied on fisheries as food and income sources. Due to the long time required for the recovery of agricultural crops, people relied on fishery products more than ever, and fishing

Table 5. Damage status in Emae Island

Damage to houses	Marae	59 houses out of 65 were damaged
	Tongamea	37 houses out of 42 were damaged
	Sangava	95% of the houses were damaged and only four houses were safe
Damage to boats and canoes	Marae	All six boats were damaged
	Tongamea	No damage to boats, although 4 canoes out of 10 were damaged
	Sangava	One boat out of four was damage.
Damage to gardens	Marae	Leaves and stems of crops were broken in all gardens and were devastatingly damaged. However, cultivation was started for cassava (six to seven months until harvest) and sweet potato (three months until harvest) again after the cyclone's passage. However, coconut tree and kava cultivation had not resumed at the time of survey – two years after the cyclone's passage.
	Tongamea	All leaves and stems of crops in all gardens were broken or devastated. As of 2017, field crops were returning to normal.
	Sangava	Crops in all gardens were destroyed. The crop land was still in the process of recovery when we visited. Since this was the most populated area on Emae Island, it had not yet reached full self-sufficiency in 2017.

[7] 'Boat' in this article refers to the small plywood, aluminium or fiberglass boats used by coastal fishers in Vanuatu.

activities increased in the foreshore area. Marae's chief was concerned about the reduction of fishery resources because of these efforts and proposed that the Village Council establish a *taboo* area. A *taboo* area measuring 2000 m × 500 m was established at Marae's foreshore on 3 September 2015, six months after Cyclone Pam. Within this *taboo* area, catching fish, shellfish and crustaceans is prohibited.

In Tongamea, most crops were damaged and the chief decided on 15 May 2015 to open the *taboo* area for three months so that crops could recover and be harvested again. The *taboo* area was closed on schedule in September 2015. According to an interview with the female group, the *taboo* area was at the edge of the village and the foreshore in the centre of the village was open to fishing. Therefore, the *taboo* area was well maintained.

In Sangava, most crops were damaged. Until one month before emergency supplies arrived, local people staved-off hunger with supplies from relatives living in Port Vila and by fishing. There was a proposal by the local villagers for opening the *taboo* area, and it was decided by the Village Council to open it one week after Cyclone Pam's passage. Sangava is the most populated community on Emae Island. Restoration of crops was delayed and supplies could not keep up with demand. Therefore, coastal fishery resources were indispensable in this emergency situation.

Lelepa Island and Mangaliliu Village

The level of damage on Lelepa Island and the village of Mangaliliu on Efate Island (Phase II sites) is shown in Table 6.

On Lelepa Island and in Mangaliliu Village, damage to houses and fishing gear was relatively minor. According to interviews with an authorised officer, a former community counterpart of Phase II, local people predicted Cyclone Pam using a traditional way of checking the movement of stars with certain overlapping branches of trees. They then prepared for the disaster. Nevertheless, farms were severely damaged in Mangaliliu, and it was difficult to obtain staple foods such as cassava, sweet potato and island cabbage. Lelepa Island has a recurrent and serious problem with the supply of drinking water and it was extremely difficult to obtain potable water after Cyclone Pam. Water was transported to Lelepa many times from Efate Island. According to interviews with the authorised officer on Lelepa Island, Mangaliliu people could access Port Vila and its resources by land. But, on Lelepa, there was a shortage of water and food.

Emergency supplies were distributed based on results of the damage survey, and it took up to one to two weeks to distribute them. Until the emergency supplies arrived, private donations were made by individuals and non-governmental organisations such as the World Heritage Committee. Although emergency relief supplies began arriving one week after the disaster, they consisted mainly of rice and tinned foods. Lelepa's authorised officer was concerned about the residents' unbalanced diet, and so consulted with members of the Marine Protected Area Committee in Mangaliliu to open the *taboo* area temporarily and then proposed it to the chiefs. Fishing in most parts of *taboo* areas was then permitted for coastal fishery resources, except for rare and endangered shellfish (i.e. trochus and green snail, the taking of which was banned by the Fisheries Act). However, in the *taboo* area at Hat Island – a World Heritage site – all fishing activities were still prohibited. In addition, fish caught in the *taboo* area were not allowed to be sold. Although fishing in the *taboo* area was only temporarily allowed, it was acknowledged that fishers were thus able to provide protein to the local population, which contributed greatly to alleviating anxiety concerning food security. Approximately one month after opening the *taboo* area, the authorised officer confirmed that the lives of the locals had returned to almost normal and so recommended closing the *taboo* area again. And because this was approved by the community, the *taboo* area was closed again. The authorised officer played a central role in resource management, in part due to his knowledge of the CBCRM planning that he learned about in Phase I and Phase II of the 'Grace of the Sea Project'.

Table 6. Damage in Lelepa Island and Mangaliliu Village.

Damage to houses	Lelepa	Roofs of two houses were broken.
	Mangaliliu	0
Damage to boats and canoes	Lelepa	0
	Mangaliliu	Five to six canoes were damaged because it took a long time to fix the roof above them and there was no time to move them. The sailing canoe that had been provided by Phase II was also damaged.
Damage to gardens	Lelepa	Originally, there were few gardens on the island, and there was little damage.
	Mangaliliu	All leaves and stems of crops such as cassava and yam were broken. As of 2017, these crops had recovered, but it has been difficult to cultivate yams due to salt damage.

In addition, according to an interview with the authorised officer, after the passage of Cyclone Pam, a large group of skipjack was seen around the fish aggregation device (FAD) that had been deployed during Phase II of the project. Approximately 20 fishermen fished around it and caught 10–30 skipjacks each time, selling most of them and keeping some for themselves. It was a precious source of income after the disaster. The group of skipjacks was seen around the FAD for about a month thereafter, but it gradually declined and is now gone.

Waisisi, Tanna Island

The level of damage in Waisisi Village on Tanna Island is shown in Table 7.

Table 7. Damage in Waisisi village.

Damage to houses	All houses collapsed
Damage to boats and canoes	11 out of 15 fiberglass boats, and 60 out of 100 canoes were damaged
Damage to gardens	All gardens were damaged, but crops in the field had recovered to their original state as of 2017

In Waisisi, Cyclone Pam caused serious damage to crops. People ate what remained such as cassava, bananas, mushrooms and fish for two weeks before the arrival of emergency supplies. Originally, speargun fishing was banned in the *taboo* area, but other fishing activities were not restricted. In addition, there was no request for opening the *taboo* area by local people. Fishers of Waisisi community were familiar with offshore fishing so could fish in the surrounding offshore areas without touching the *taboo* area.

Ikoukau, Isavai and Imatu on Aniwa Island

Damage in Ikoukau, Isavai and Imatu on Aniwa Island is shown in Table 8.

Emergency supplies (e.g. rice, tinned food, toothpaste, soap, towels, clothes, water) were delivered by Care International approximately a week after Cyclone Pam struck. The support was continued for several months. As shown in Figure 5, there was a small *taboo* area in Ikoukau and a *taboo* area in the lagoon. Cyclone Pam passed at the time of the usual opening of the *taboo* area inside the lagoon. Therefore, the *taboo* area was opened without special consideration for food procurement during the emergency period. In the lagoon, fish such as mullets and emperors were caught and became a protein source for Aniwa's local population. Following Cyclone Pam, new *taboo* areas were established in Isavai and Imatu (see Table 9 and Fig. 6) as a result of awareness raising by several projects and through initiatives of the chief, who was concerned about the decline in resources.

Table 8. Damage on Aniwa Island.

Damage to houses	Ikoukau	About 80% of houses were damaged.
	Isavai	Before Cyclone Pam, the non-governmental organisation Care International had taught cyclone prevention measures to the local population. As a result, houses were virtually undamaged and only school classrooms were destroyed.
	Imatu	4 out of 22 houses collapsed
Damage to boats and canoes	Ikoukau	20 out of 35 canoes were damaged
	Isavai	No damage to boats, but two outboard motors were damaged
	Imatu	20 out of 42 canoes were damaged
Damage to gardens	Ikoukau	All gardens were damaged, although crops had returned to normal by 2017. However, many orange trees, which are special products, broke and had not completely recovered by 2017.
	Isavai	In about 95% of gardens, there was some damage to crops, although crops had returned to normal by 2017. However, many orange trees had not completely recovered. The gardens also suffered drought damage and restoration was further delayed.
	Imatu	About 100% of the gardens were damaged although crops had returned to normal by 2017, except for most orange trees.

Table 9. New *taboo* areas established after Cyclone Pam.

Isavai	Since 2016, a taboo area (2500 m × 100 m) was established in the eastern part of the island. Within this area, all fishing is banned. This taboo area was established as a result of support by the Vanuatu Coastal Adaptation Project conducted by the Pacific Community.
Imatu	Taboo area (500 m × 50 m) was established in front of Imatu in 2017. All fishing is prohibited within it. At present, there is an open taboo area, but the chief is considering opening and closing two taboo areas alternately.

Figure 5. *Taboo* areas on Aniwa Island before Cyclone Pam.

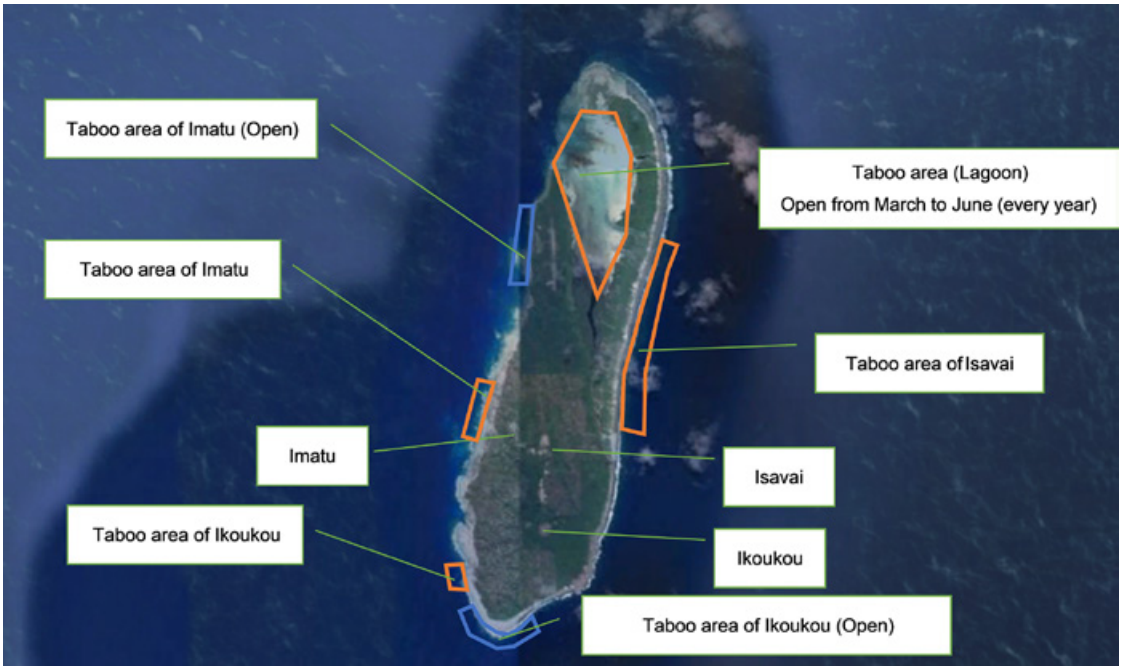

Figure 6. *Taboo* areas established on Aniwa Island in April 2017.

Aneityum (Phase II site)

The level of damage on Aneityum Island is shown in Table 10.

Table 10. Damage on Aneityum Island.

Damage to houses	3 houses out of 400 were completely destroyed; repairs to the roofs And other parts were carried out by community members
Damage to boats and canoes	Community members helped each other move boats and canoes to a safe place before the cyclone arrived, and therefore, they were not severely damaged. Canoe repairs were carried out by community members.
Damage to garden	Analcohat (southern part of Aneityum Island): Nearly 80% of cassava, taro and other crops were damaged. Port Patrick (northern part of Aneityum Island): Damage was significant due to the influence of waves and wind, but details are unknown.

On Aneityum Island, the souvenir shops and airport collapsed but damage on the main island side was relatively minor, because information about the cyclone had been provided one week ahead by the Cyclone Disaster Committee (CDC) in coordination with government agencies. Therefore, two hours before the arrival of Cyclone Pam, local people from the flood zone and the coastal area went to the evacuation centre.

It took a month to receive emergency relief supplies, which consisted mainly of rice, noodles, tinned food and water, which was distributed by CDC throughout the entire island. Furthermore, with the guidance of CDC, many households had stored their water and food safely in advance of the cyclone.

In addition, in the community of Aneityum Island, bananas and bread are prepared as 'preservation food' in preparation for disasters such as cyclones. The traditional preservation method for food was as follows. Bananas and breadfruits were wrapped in banana leaves and put in holes. If wrapping leaves are replaced every six months, bananas and breadfruits can usually be preserved for two to three years. Community members also stockpiled staple food, such as cassava and taro in advance of the cyclone. Cassava, banana and taro can be preserved for three days, three weeks and about one month, respectively. Sweet potato did not suffer severe damage and could be harvested again two months after Cyclone Pam. Cassava could be harvested after three months and taro and banana were harvestable after one year.

The *taboo* area in the Mystery Island off the coast of Aneityum Island, was not opened after the cyclone. However, some other *taboo* areas were opened, after approval of the landowners, but restrictions were placed on certain fishing methods and species. These decisions were advised by the Marine Protected Area Committee. Opening of the *taboo* areas ended after one month in some places and all *taboo* areas were closed again within seven weeks.

Questionnaire surveys

A questionnaire survey was carried out to verify the effects of actions taken for food security during the natural disaster. The questionnaires were distributed as shown in Tables 11 and 12.

Table 11. Distribution of the questionnaire in Shefa Province.

Name of communities	Lelepa Island	Mangaliliu Efate Island	Emae Island (Marae, Tongamea, Sangava villages)
Number of households surveyed	81	25	46
Number of whole households	99	76	168
Percentage of surveyed households in whole household	82%	32%	27%

Table 12. Distribution of the questionnaire in Tafea Province.

Name of communities	Aneityum Island (Analcohat)	Waisisi, Tanna Island	Aniwa Island
Number of households surveyed	36	28	24
Number of whole households	130	100	91
Percentage of surveyed households in whole household	28%	28%	26%

The sex and age ratio of respondents in households in this survey are shown in Table 13.

Table 13. Sex and age ratio of respondents in the surveyed households.

Age		20–29	30–39	40–49	50–59	More than 60	No answer
Lelepa Island	Men	7 18%	6 16%	8 21%	11 29%	5 13%	1 3%
	Women	5 12%	16 37%	8 18%	6 14%	5 12%	3 7%
Mangaliliu	Men	3 18%	5 28%	4 24%	2 12%	3 18%	0%
	Women	0%	5 62%	3 38%	0%	0%	0%
Aneityum Island	Men	1 20%	1 20%	2 40%	1 20%	0%	0%
	Women	1 33%	0%	2 67%	0%	0%	0%
Emae Island	Men	7 23%	6 20%	4 13%	9 30%	3 10%	1 4%
	Women	3 19%	3 19%	2 12%	6 38%	2 12%	0%
Waisisi, Tanna Island	Men	3 17%	4 22%	6 33%	1 6%	2 11%	2 11%
	Women	4 40%	2 20%	4 40%	0 0%	0 0%	0 0%
Aniwa Island	Men	3 25%	2 17%	4 33%	1 8%	2 17%	0%
	Women	1 8%	5 42%	4 34%	0 0%	1 8%	1 8%

The sex and educational background of respondents in households in this survey are shown in Table 14.

Table 14. Sex and educational background of respondents in surveyed households

	Lelepa Island		Mangaliliu, Efate Island		Aneityum Island		Emae Island		Waisisi, Tanna Island		Aniwa Island	
Educational background	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
No school	26 68%	3 7%	1 6%	0 0%	1 20%	0 0%	0 0%	0 0%	3 17%	2 20%	2 18%	2 17%
Primary school	7 18%	34 79%	13 76%	5 62%	2 40%	0 0%	19 66%	10 63%	10 55%	4 40%	4 33%	7 58%
Secondary school	1 3%	6 14%	2 12%	2 25%	0 0%	0 0%	10 34%	5 31%	5 28%	2 20%	4 33%	2 17%
High school	0%	0 0%	0 0%	1 13%	1 20%	2 50%	0 0%	1 6%	0 0%	0 0%	0 0%	0 0%
University	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Other	1 3%	0 0%	1 6%	0 0%	1 20%	1 25%	0 0%	0 0%	0 0%	1 10%	1 8%	1 8%
No answer	3 8%	0 0%	0 0%	0 0%	0 0%	1 25%	0 0%	0 0%	0 0%	1 10%	1 8%	0%
Total	38 100%	43 100%	17 100%	8 100%	5 100%	4 100%	29 100%	16 100%	18 100%	10 100%	12 100%	12 100%

The general focus of the questionnaire survey was on the importance if marine resources for food security, and the role of fishery resource management during and after natural disasters.

1) Importance of marine resources for food security after a natural disaster

Fisheries products became one emergency food source at the time of a natural disaster

The type of food consumed on Lelepa Island and in Mangaliliu after the impact of Cyclone Pam until emergency assistance arrived is shown in Figure 7.

On Lelepa Island and in Mangaliliu Village, many households used fisheries products during the disaster, especially Mangaliliu, where 52% of surveyed households answered that they ate only fish and shellfish after Cyclone Pam for up to three weeks. Before the disaster, community people said that root crops such as cassava and taro were the centre of the meal, and that fish and shellfish were supplementary food. Therefore, it seems that coastal resources are an important source of food during an emergency. In addition, among the sites surveyed, livestock died due to insufficient feed on many islands where damage was severe, and so fishery resources – which were accessible from the coast even when canoes and boats were damaged – became a critical source of animal protein for the population after the disaster. In communities where a *taboo* area had been established, the *taboo* area served as an emergency food store

Fishing days in the *taboo* areas before emergency supplies arrived are shown in Figure 8.

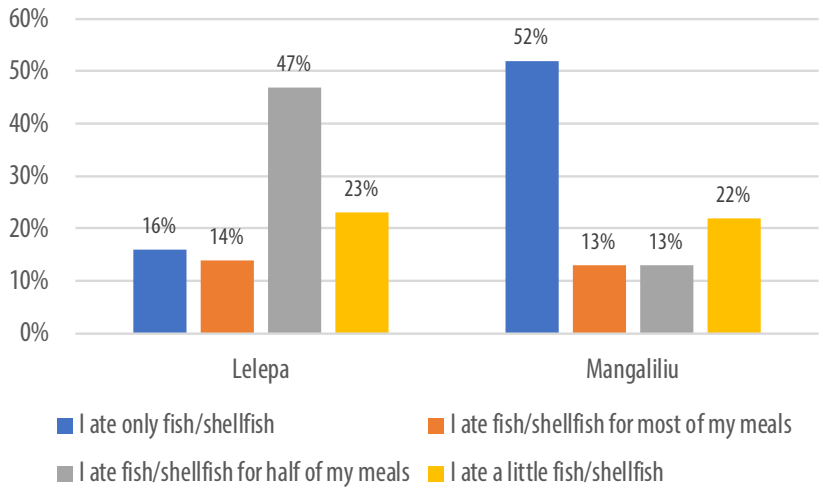

Figure 7. Finfish and shellfish consumption in surveyed households of Lelepa Island and Mangaliliu Village after Cyclone Pam.

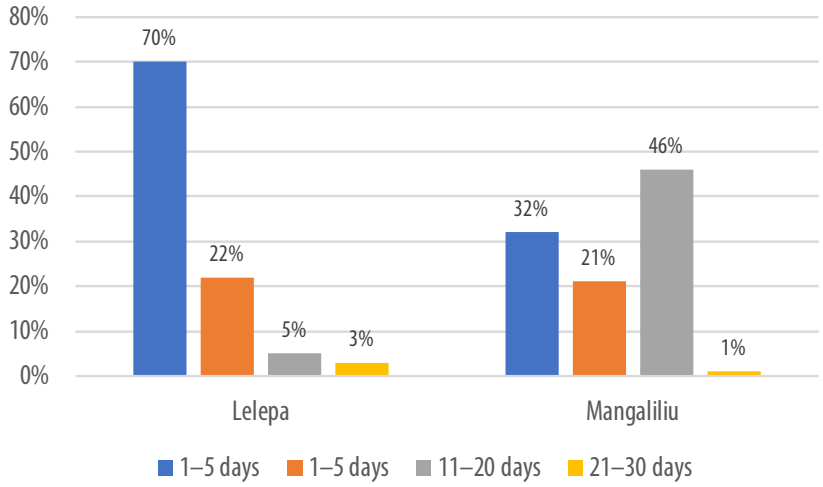

Figure 8. Number of days using the *taboo* area before emergency supplies arrived after Cyclone Pam, Lelepa Island and Mangaliliu Village.

On Lelepa Island, 70% of the surveyed households used the *taboo* area for one to five days. According to interviews, emergency supplies arrived one or two weeks after Cyclone Pam, so many households used the opened *taboo* area during the first half of this period. In Mangaliliu Village, many households used the *taboo* area almost every day until emergency supplies arrived.

2) *The role of fishery resource management during and after natural disasters*

During the survey carried out on Lelepa Island and Mangaliliu, people were asked: 'Do you agree that the expansion of the *taboo* area was useful to secure fishery resources?' Answers are summarised in Figure 9. More than 90% of surveyed households answered that the expansion of the *taboo* area was useful for resource management and the provision of emergency food.

In addition, people were asked: 'Were you mindful of food security by conducting marine resource management activities before Cyclone Pam?' A high percentage of surveyed households answered positively, as show in Figure 10. This may indicate that many community people consider that the *taboo* area is functioning to ensure food security.

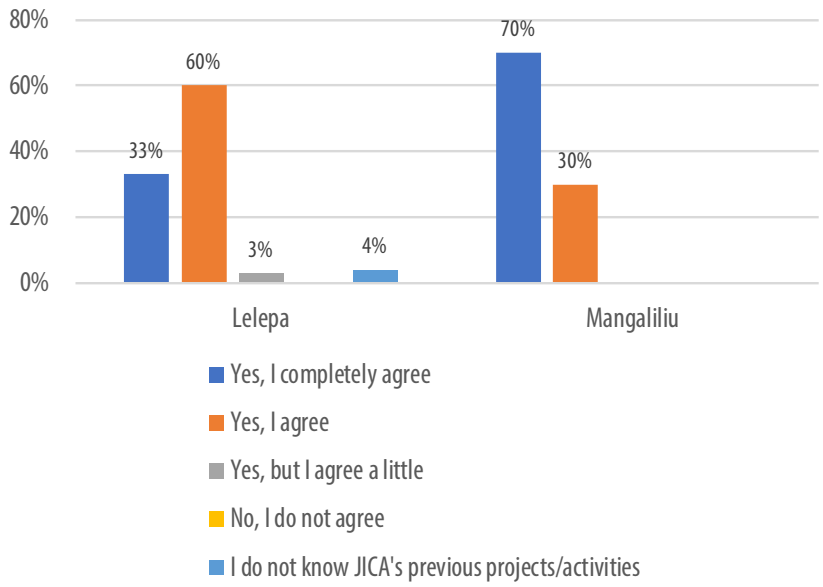

Figure 9. Household responses from Lelepa Island and Mangaliliu Village to the question 'Do you agree that the expansion of the *taboo* area was useful to secure fishery resources?'

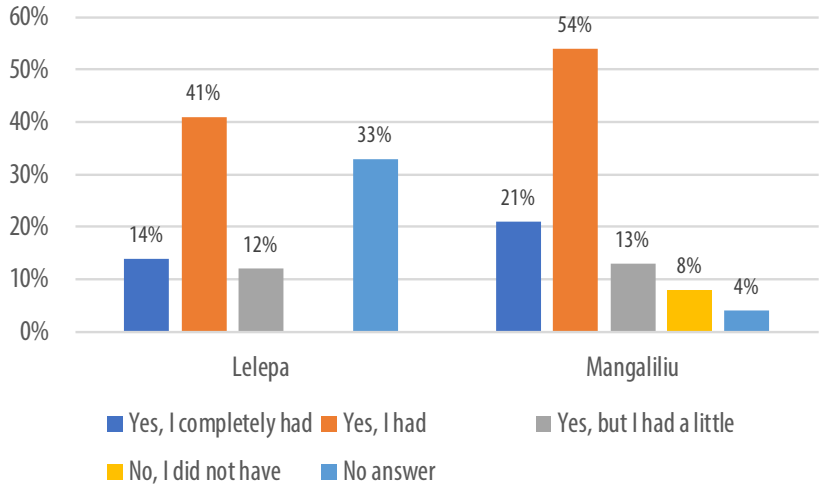

Figure 10. Household responses from Lelepa Island and Mangaliliu Village to the question: 'Have you ever felt that *taboo* areas could help food security before the Cyclone Pam disaster?'

Answers to the question: 'Should resource management activities be continued in your community in the future?' are shown in Figure 11. A high percentage of positive responses were given at every survey site, and every site wants to continue resource management activities in the future.

However, answers to the question 'Is the continuation of resource management possible?' differ by community, as shown in Figure 12.

On Lelepa Island, the entire island is a *taboo* area, so many locals seem to think the *taboo* area may be too large. On Aniwa Island, where a large *taboo* area was established after Cyclone Pam, more than half the people answered that it is possible, but many people also considered that a smaller area is better.

In view of the above, it seems that the motivation for the continuation of fishery resource management has declined over time in the community with a large *taboo* area, although people recognise the importance of fishery resources and fishery resource management.

Conclusion

According to the data we collected, fishery resources are an important source of food, especially of animal proteins, during the emergency situation that follows natural disasters, such as Cyclone Pam. Fishery resources are more resilient to natural disasters than agricultural and livestock products. So, it can also be said that they contribute to the climate change resilience of local population in coastal areas. Aquaculture activities can also contribute to food security in emergencies, and can therefore play an important role in the livelihoods of communities in inland areas.

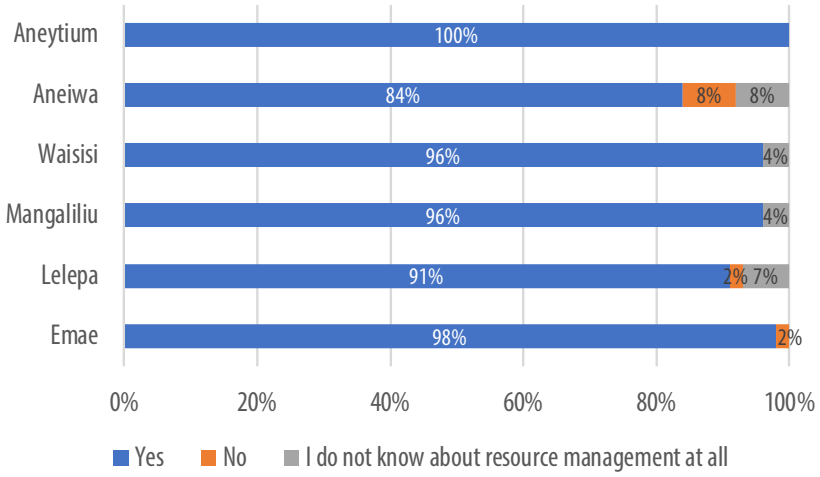

Figure 11. Answer to the question 'Should resource management activities be continued in your community in future?'

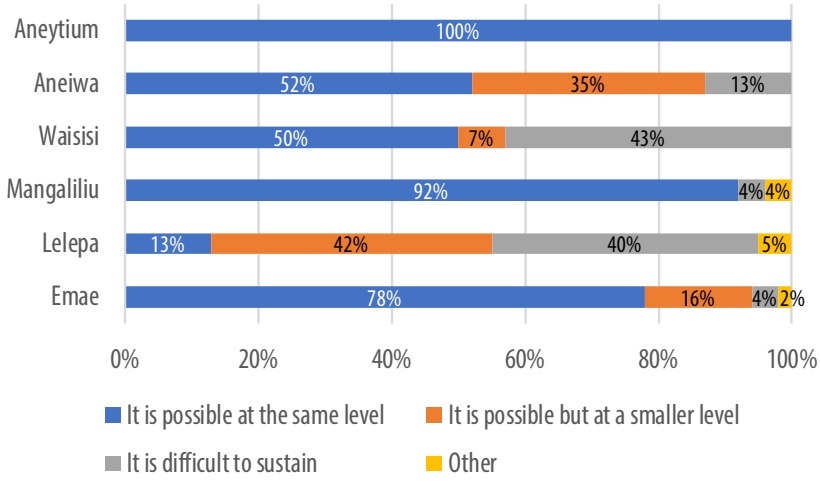

Figure 12. Answers to the question 'Is the continuation of resource management possible?'.

A number of communities opened their *taboo* area for their members. Some communities, especially in target sites of CBCRM activities, opened their *taboo* area for a limited period to survive during a major catastrophe, with rules limiting fishing gears that could be used and target species. The cases mentioned above should be noted as an excellent example of a wise use of marine resources based on community rules.

In addition, after Cyclone Pam, new *taboo* areas were set up in Emae and Aniwa Islands. This might be due to local people realising the importance of fishery resources for their livelihood after experiencing such a tragic natural disaster. It seems that these communities are now concerned about excessive catch of fishery resources. The CBCRM approach seems to contribute greatly to food security and resilience of communities following a natural disaster. We believe that the CB-CRM approach also enhances consciousness of coastal resource management in local communities.

On the other hand, even though local people recognise the importance of fishery resources, it may be difficult to maintain or further expand large *taboo* areas. Although being effective for resource conservation and food security, very large *taboo* areas increase dissatisfaction among local fishers. Therefore, it is necessary to have a balanced approach when defining how much space is appropriate for the *taboo* area as a disaster countermeasure.

It is also necessary to balance the effects of coastal resource management measures, by offering alternatives such as the utilisation of untapped natural resources, the development of new resources with the transplantation of less-mobile organisms, such as clams, or the deployment of artificial reefs in protected areas. When new fishing activities develop, it is of course necessary to ban taboo areas completely, but also to take measures to manage the resource while considering the interests of fishers and the community. In the decision process, VFD and the local population must thoroughly discuss while respecting the opinion of the chiefs.

Fishery products will continue to play an important role in food security during natural disasters. VFD must continue to motivate and support local populations in their coastal resource management activities. It must also encourage their ownership of these management activities. CBCRM has a great role to play, especially in small island nations of the Pacific that are vulnerable to the large-scale effects of climate change.

Acknowledgments

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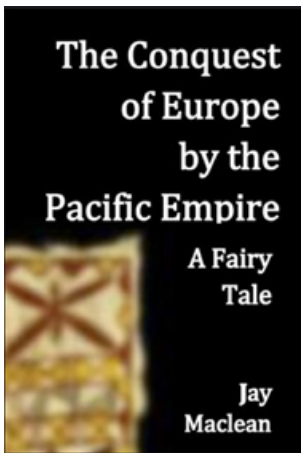
Jay Maclean, other writings

Found, lost, paved and sunk: Paradise

The western Pacific that was, is, might have been, and probably will be

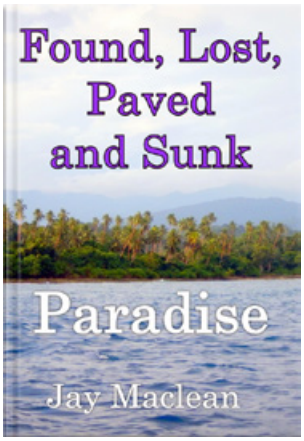
Two new e-books by Jay Maclean look at the history and future of the tropical western Pacific from different perspectives.



In the first, he turns history upside down and explores how Pacific traditions and culture could have transformed Europe instead of vice versa in an e-book entitled *The conquest of Europe by the Pacific Empire: A fairy tale.* The book is based on the awful truth that today, the Pacific islands reflect the best and worst in western society. On the one hand are the bravery and persistence of early European navigators, missionaries, and government officers; the early, well-meaning efforts by many westerners to help the islanders become 'civilised'; the assistance readily given in times of natural disasters; and the grants and concessional loans to help Pacific countries develop into independent economic entities, to name but a few. On the other hand are the persistence of the west in demolishing the islanders' tropical culture and turning them into unwilling citizens or dependents of temperate countries, like puppets; the arrogance of assuming that modern western democracy and societal norms, which date back but a few generations, must replace the islanders' far longer-standing societies; and the continuation of all these efforts to westernise them and their countries in the face of growing awareness in those Pacific countries of the value of their own well tried-and-tested lifestyles – to name but a few.

In short, the west took away the islands' culture and gave them diabetes.

What if history had gone another way? What if the Pacific islanders had taken over Europe instead? That would have been impossible, of course, or would it? Perhaps the Pacific Empire did conquer Europe in the 1600s in response to the prospect of being continually attacked by European adventurers. After all, Europe, particularly England, had just been swept by the third black plague; London was devastated by the Great Fire, and there were continuing, debilitating wars across the channel. Perhaps the islanders brought their lifestyle and biological knowledge to its logical conclusion in a European context, resulting in a peaceful, healthy and harmonious Europe, until, in a prophetic Brexit, Britain broke away. The rest is history, perhaps…



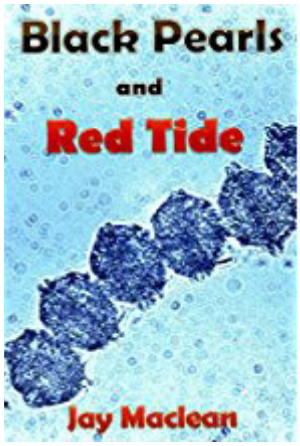
The second book, *Found, lost, paved and sunk: Paradise,* deals with the reality of tropical island history, in the context of the elusive search for paradise. It explores the mind set of artists, beachcombers, colonial administrators, developers, explorers, hermits, missionaries, mutineers, philosophers, scientists and writers, not to mention the native residents who were already living in the paradises that the 'aliens' sometimes describe. The contents include the mechanics and problems of living in a paradise, dealing with neighbours both onshore and offshore, housing, water, and health; the fate of paradises under colonialism and climate change; and last but not least, the opinions of other animals as well as plants; where is their paradise?

Jay worked for nearly 10 years on the book, beginning with the question: Where is paradise on earth? Somewhere far from the maddening crowds, the cold, the politics, and work, of course. People have been searching for paradise even before taxation was invented. The stories of those who wrote about their exploits often reveal more about themselves than the nature of the paradises they sought and sometimes found. Did you know that Sir Walter Raleigh was the world's first pusher of paradise real estate? Or that among the explorers of tropical paradises, the infamous Captain Bligh of the Bounty was quite humane and considerate? Or that Captain James Cook was the first westerner to get a tropical, full body massage – and was pretty coy about describing it? That the original Shangri-La paradise was a mix of ascetic monks on top of a Tibetan mountain and a tropical village of loose women at its foot? That Thor Heyerdahl and his first wife honeymooned for a whole year in a remote tropical paradise, leading to his Polynesian migration theory and the Kon Tiki expedition?

The evidence from past writings builds a convincing case for placing *the* earthly paradise in the tropical western Pacific. The biological and ecological evidence is also compelling – more kinds of fauna and flora, per square kilometer live there than anywhere else. Certainly, it is a paradise for fish, as revealed by the Coral Triangle Initiative. Using some basic math, Jay estimated that Pacific islanders may eat on average about 80 billion fish over their lifetimes, more than 1 billion

fish per year. Some philosophical questions tackled include: Where and how does paradise fit into the Pacific future? And finally, what does it all really mean? The book is punctuated with tongue-in-cheek tips for paradise seekers but is entirely factual and extensively referenced with about 200 sources, from exploits of early explorers and travelers to the writings of prominent scientists and philosophers.

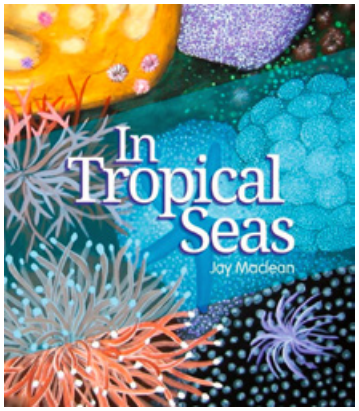
Jay Maclean has been working on the edge of the Pacific, in Australia, Papua New Guinea and the Philippines, for more than 40 years, researching and writing about fisheries and aquaculture and tropical ecosystems. Other works that may be of interest to workers in the region are:



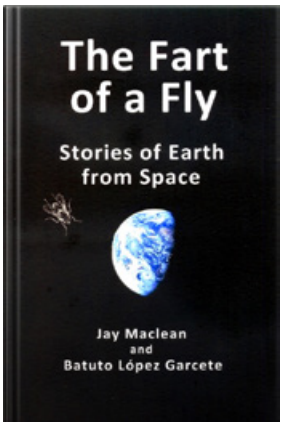
Black pearls and red tide, which follows his research in the 1970s in Papua New Guinea on red tide, and oyster and pearl oyster culture, updated to the present and with projections into the future. The story begins with the strange deaths of three young children in a small coastal village in Papua New Guinea in 1972. They did not rate a mention in the territory's annual report that year to its Australian governors – let alone make a ripple in international ponds. Yet, it was an event of incredible proportions. It marked the end of a chain of traditional knowledge that extended back more than 45,000 years; it heralded the beginning of an era of immense, baffling phenomena and disasters around the world; and it marked the rise of a deadly toxin from the seabed that would spread from country to country. It encompasses much of the globe, from the Pacific islands to Asia – Brunei Darussalam, Indonesia, Japan, Malaysia and the Philippines – to the Middle East – Persian Gulf and Red Sea, and the Egypt of the Pharaohs – to the Pacific and Atlantic coasts of the Americas, and to Australia and Antarctica.

It is a detective story, about who or what killed the three children, involving searches in helicopters, light planes, speedboats and a naval patrol vessel; and underwater explorations. It is also a romantic saga, spanning a period from the tail end of the Paleolithic era, pausing for less ancient events, the exodus of the Jews from Egypt and Cleopatra's dinner with Marc Antony; and leap-frogging through events over the following two millennia via connections with Spanish kings, Napoleon Bonaparte, and the most famous pair to play the part of Cleopatra and Marc Antony in modern times: Elizabeth Taylor and Richard Burton. Finally, it is the story of the author, then a young scientist sent unknowingly as a spy into Papua New Guinea shortly before its independence. How did he find himself enmeshed in the threads of this strange puzzle and what did he discover?

In tropical seas (Manila, Zobel Foundation, 2014; 48 pages, out of print) is a densely illustrated introductory book on coral reef ecosystems for youth, applicable around the Indo-Pacific. It describes the food chain aspects of these ecosystems and takes the young reader along to fossick on a rocky beach, to wade in the intertidal zone and then in the mangroves and seagrass meadows, to snorkel in the shallows and finally to pretend to be a scuba diver and explore a reef drop-off. 'Traditional' fisheries are described and a short section on the future of tropical seas ends the book. The book is set for reprinting in English and Filipino this year as part of a school project in the Philippines.

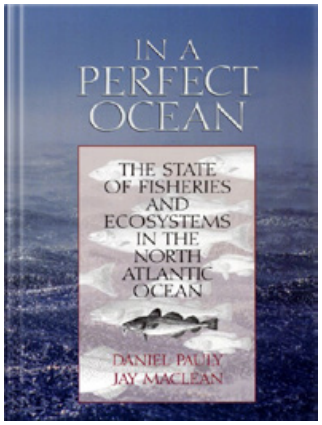


A new book of short stories, *The fart of a fly: Stories of earth from space*, coauthored with Batuto López Garcete and launched in May 2018, addresses broad environmental and social issues, along with a little humor. A kindly visitor from another galaxy arrives to find Earth in a bad state. Humans have overrun the planet and are living on a knife edge, supported by increasingly higher technology to maintain life while the climate changes around them and even the gas from the fart of a fly could tip them off the edge. *The fart of a fly* story itself deals with population and greenhouse gases, pointing out the wisdom of the old adage: save gas – fart in a jar.



Other stories are set in plausible futures as warnings of where we humans are heading, and 'healing' essays on simple changes to our way of life that promote better futures for both the planet and its peoples. Our visitor from space also takes us on humorous or mysterious sidetracks when he finds something interesting for his readers back home.

Of particular interest to some Pacific readers is a story on *The painter of the last coral reef*, about 'rescuing' the last coral reef, through an enormous painting, set in a possible future in which the reefs have all succumbed to climate change. In the end, the book reminds us we are part of, not apart from, nature. Consequently, most of the advice in the stories boils down to the principles of love and respect, not only among humans but across the living planet as a whole. Those principles, incidentally, echo the theme of a book by Philippe Cury and Daniel Pauly[1]). The authors conclude that *Life is one; we must reconnect to the cycles of life, otherwise, life may continue without us.*



Daniel and Jay wrote an earlier book together, on the overall health of an entire ocean, entitled *In a perfect Ocean: The state of fisheries and ecosystems in the North Atlantic Ocean.* (Island Press, Washington DC, 2003). It was a landmark study, the first of its kind to make a comprehensive assessment of an ocean's ecosystems. As the impacts of climate change begin to be felt at an accelerating rate, particularly in the Pacific, where populated atolls have already been submerged and others inevitably will in the near future, it is not too late to consider such an assessment for the tropical Pacific. The intimate relationships of humans and the sea, vis-a-vis the North Atlantic, imply that the assessment would contain a large human component. It would not be a baseline, but at least a reference point, on which to gauge future ecosystem change and the emerging societal consequences.

All these books (other than *In Tropical Seas*) can be seen online. By way of an apology, nearly all were intended to be and originally appeared free-of-charge (except *In a perfect ocean*) on a subsidiary website of MacMillan, but the site folded and an independent publisher took over the same role this year (consequently all the books are dated 2018); however, books had to have a minimum price of USD 0.99. They are on:

Amazon at https://www.amazon.com/s/ref=sr_pg_2?rh=n%3A283155%2Cp_27%3AJay+Maclean&page=2&ie=UTF8&qid=1522031856

Kobo at https://www.kobo.com/us/en/search?query=jay%20maclean&fcsearchfield=author

ITunes at https://itunes.apple.com/us/author/jay-maclean/id529096285?mt=11

[1] Cury P. and Pauly D. 2013. Mange tes méduses ! Réconcilier les cycles de la vie et la flèche du temps. Odile Jacob, Paris, 216 p. Updated in English in early 2018 and to be published soon.

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