

Issue 35 – July 2015

TRADITIONAL

Marine Resource Management and Knowledge

information bulletin



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Produced with financial assistance from the Australian Government, the European Union, France and the New Zealand Aid Programme

Editor's note

This edition contains four contributions. The first, "Local benefits of community-based management: Using small managed areas to rebuild and sustain some coastal fisheries", by Glenn Almany and three co-authors, begins by discussing the scientific evidence that underpins the theory that marine reserves can play an important role in precautionary fisheries management. Marine reserves are then discussed in a western Pacific context, highlighting some costs and benefits that coastal communities may consider when establishing one on their traditional fishing grounds. Almany et al. then summarise the results of a recently published study, where they worked with five fishing communities on the south coast of Manus Island, Papua New Guinea, to test whether and how communities benefit from a small managed area. In that study, scientists relied on recent genetic methodologies, local knowledge and the participation of over a hundred fishermen to quantify the distances that coral grouper larvae dispersed from a managed fish spawning aggregation (FSA). Their findings were encouraging for community-based management, with 50% of coral grouper larvae travelling less than 14 km from their birthplace, and the highest retention of larvae occurring near the managed FSA. In the Manus example, the community that protected its FSA received the greatest benefit from its actions, with a large amount of the larvae produced at the managed FSA spilling over onto their nearby reefs that remained open to fishing. This study also showed that because some larvae and fish travel across customary marine tenure boundaries, the Manus coral grouper fishery represents one large stock that would be best managed collectively. The article ends by reporting how communities from southern Manus, inspired in part by the results of the coral grouper study, recently created a collaborative governance structure, the Mwanus Endras Asi Resource Development Network. This tribal network covers eight tribal areas spread across approximately a third of Manus Province, and seeks to make collective fisheries management decisions.

The second article is "Ancestral fishing techniques and rites on 'Anaa Atoll, Tuamotu Islands, French Polynesia, authored by Frédéric Torrente. His article is an important contribution to the environmental knowledge and fishing techniques of traditional societies on Polynesian atolls. An important feature is that some of the fishing techniques used by the community on 'Anaa before the evangelisation of the Tuamotu Islands are described, based on local knowledge narrated by Paea-a-Avehe and Teave-a-Karaga, the last two holders of 'Anaa's pre-Christian local knowledge.

The third article, “Making Hong Kong’s coastal wetland a resource for tourism development: A cross-cultural and multi-disciplinary project to understand historical background and coastal heritage,” is by Sidney C.H. Cheung. From some perspectives, some of the challenges that confront Hong Kong resonate with those facing many Pacific Islands; a large population, small area, congestion, rapid changes that diminish resources, and limited options for supporting development. The latter demands particularly creative thinking. This article describes how small-scale and seemingly mundane resources can be promoted to help diversify the resource base for tourism. I include it in the hope of stimulating similar thinking in Pacific Islands. This article examines Hong Kong’s northwestern coastal wetland area, which is facing a threat resulting from the decline of freshwater fishing industry that might cause the loss of both traditional occupation and environment balancing conservation and community lifestyles. The article demonstrates a book project designed to enhance the awareness of this unique coastal wetland resource through nature-based tourism. It aims at transferring knowledge generated by various groups or stakeholders (farmers, bird watchers, conservation groups, among others) to visitors (both domestic and international) to Inner Deep Bay and neighbouring communities through an integrated design of an ecotourism package from a multi-disciplinary perspective and attracting the public’s attention to coastal development through creating a “four seasonal models of wetland tourism package”. The emphasis on seasonal change in the area not only serves to attract people for multiple visits, but also enhances the appreciation of lifecycles both in nature and in local rural communities.

It is my sad duty to record that the lead author of this edition’s first article passed away shortly after completing the contribution. Thus, the fourth contribution to this edition is an obituary to Glenn R. Almany, prepared by Richard Hamilton, his co-author and close friend. Although I never had the pleasure of meeting Glenn personally, through his co-authored article published here and from the obituary, I feel that I have.

Kenneth Ruddle

PIMRIS is a joint project of four international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the Pacific Islands Forum Fisheries Agency (FFA), the University of the South Pacific (USP) and the Pacific Regional Environment Programme (SPREP). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information



on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

Local benefits of community-based management: Using small managed areas to rebuild and sustain some coastal fisheries

Glenn R. Almany^{1,2}, Richard J. Hamilton^{3,2}, Manuai Matawai^{4,5} and Pongie Kichawen⁵

Introduction

Many coastal fisheries around the Pacific are in decline from overfishing (SPC 2013) and are threatened by climate change (Pratchett et al. 2011). Overfishing has been driven by a number of factors, including more people and a greater demand for fish; improvements in technology that make it easier to harvest fish (e.g. monofilament fishing line and nets; snorkelling and scuba equipment, spear guns, underwater diving lights, outboard engines, better boats) and greater access to local, regional and global markets to convert catch into money (Dalzell et al. 1996). Many Pacific Island communities have taken advantage of the economic opportunities that are available by fishing for export markets. Sea cucumber, shark fin and trochus are important export commodities for remote communities because they do not require refrigerated storage. In addition, fishing for grouper and other high-value species, particularly at fish spawning aggregations (FSAs), supplies the live reef food fish trade (LRFFT). All of these fisheries are in trouble in many parts of the Pacific (Bell et al. 2009; Purcell et al. 2013; Sadovy et al. 2003), and it is a high priority to restore their health and devise strategies for sustainability so that they can continue to serve the needs of coastal communities (SPC 2013).

Pacific Island communities have interacted with their fisheries for thousands of years based on accumulated, detailed knowledge about their environment and the animals they harvest (Johannes 1981; Allen et al. 1989). Although traditional forms of community-based management are extremely diverse (Johannes 1981; Ruddle 1996; Veitayaki 1997), the basis for their effectiveness is the ability of certain community members (e.g. community leaders or chiefs, family groups, clans, and whole communities) to control fishing in a particular area

(i.e. who can fish, how they can fish, when they can fish, and what they can take). This type of “spatial management” is made possible by the existence of customary marine tenure (CMT) systems that remain common throughout the Pacific (Johannes 2002; Ruddle 1996; Ruddle et al. 1992). A common management strategy is the practice of closing an area to some or all types of fishing for a certain period of time. There are numerous reasons why an area is closed: increasing the number of fish in the area; taming the fish inside the area to make them easier to catch once fishing resumes; allowing for more equitable access to resources; and stockpiling for important events such as funerals, weddings, feasts, or to raise funds for a particular goal such as building a church (Fabinyi et al. 2013; Foale et al. 2011).

More recently, scientists studying Pacific Island cultures and other traditional management systems have suggested using area closures to help rebuild and sustain coastal fisheries in industrialised countries (e.g. European nations, United States and Australia). Although rare in Pacific Island traditional management systems, scientists have suggested that using areas that are permanently closed to fishing — called “reserves” — might be the best way to rebuild and sustain coastal fisheries in the long term. Around the world, there are many barriers to using reserves for fisheries management, including the cultural acceptance of a new practice. But perhaps the largest barrier is that scientists are only now beginning to understand, and more importantly, test through studies, how reserves can rebuild and sustain coastal fisheries.

This article begins with a discussion of how reserves and managed areas could be used to improve coastal fisheries in theory, a summary of some recent scientific evidence about how they work, and

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by highlighting some of the costs and benefits of using reserves for Pacific communities. The results of a recent study are then summarised; the authors worked with five fishing communities on the south coast of Manus Island in Papua New Guinea to test whether and how communities benefit from a small managed area (Almany et al. 2013). The article concludes by reporting on how these five communities and their neighbours, inspired in part by the results of the coral grouper study, have created a collaborative governance structure to make collective management decisions for their fisheries.

How reserves could rebuild and sustain coastal fisheries – theory and evidence

The life of most fish species can be divided into two distinct phases: the larval phase and the non-larval phase (Leis and McCormick 2002). With only a few exceptions, all fish produce eggs. Some, like damselfish or triggerfish, lay them onto something (e.g. coral, rocks, shells, nests they make in the sand or rubble) and guard the eggs until they hatch. Others, like grouper or snapper, release their eggs directly into the sea, where after a day or so, they hatch. Both types of eggs hatch into tiny fish called larvae, and these larvae — depending on the species — spend days, weeks and even months growing and developing in open waters away from the coast. This period of a fish's life is called the "larval phase." At the end of the larval phase, larvae are much larger and more developed, and if they find a suitable place to live, leave the open water in a brief process called "settlement" and begin the "non-larval phase" of life. This non-larval phase, which from this point on we shall refer to as "fish" (this includes newly-settled larvae known as recruits, as well as juveniles, sub-adults and adults), is the one that scientists are most familiar with, and it takes up the rest of the fish's life. It is during this phase that fish can be caught, managed and studied. The larval phase has been much more difficult to study. Where do these larvae go? How far away from their parents do they travel before they settle? Answering these questions about the larval phase is important for understanding how reserves can work, and how the benefits of reserves are distributed among fishing communities.

When fishing stops on any reef or within a certain area, it is no surprise that with time, the number and size of fish inside that area increases. Numerous scientific studies have shown this effect clearly (e.g. Fenberg et al. 2012; Lester et al. 2009), although depending on species, it may take many years to see that increase after fishing stops (Abesamis et al. 2014). While fishers are not allowed to fish within the reserve itself, reserves can help rebuild and sustain fisheries in two major ways (Gell and Roberts 2003; Russ 2002).

The first way is called "spillover", and this refers to fish leaving the reserve and traveling to fishing areas where they can be harvested by fishers. After the larval phase fish are relatively easy to study, and so there is much evidence that spillover occurs from studies that tag fish within the reserve and then catch or observe them outside the reserve at some later time. However, it is also known from these and other studies that most fish do not move far (Green et al. in press), and so the movement of fish from reserves to fished areas is common over a few hundred meters, but not much farther (Abesamis and Russ 2005; Halpern et al. 2009).

The second way in which reserves can help rebuild and sustain fisheries is through the increased production of larvae from inside the reserve (Russ 2002). Because there are more and larger fish inside the reserve, there are significantly more larvae than a similar sized fished area. Not only do more fish produce more larvae, but also the large fish inside the reserve produce far more larvae than small fish. For example, a 50-cm female leopard coral grouper (*Plectropomus leopardus*) can produce more than three times the number of eggs than a 35-cm female (Carter et al. 2014). Most of these larvae will die during the larval phase — scientists estimate as much as 99% — because they are eaten by other animals, starve, or are swept far away from suitable coastal habitats by currents and tides. During the larval phase, larvae have the potential to travel far from where they were born as they ride the currents and tides and, after growing, begin swimming. Until recently, answering a seemingly simple question — where do larvae go during the larval phase? — had been impossible.

Recent scientific breakthroughs in several fields, most notably genetics, combined with research partnerships between scientists and fishing communities, have for the first time allowed measurement of where larvae go. These studies began in the late 1990s, and most have worked with a few small, non-fishery species as scientists refine the techniques and methods (see reviews by Green et al. in press; Jones et al. 2009). In recent years, a few studies have measured where larvae go in fishery species such as grouper and snapper on the Great Barrier Reef in Australia (Harrison et al. 2012) and grouper in Papua New Guinea (Almany et al. 2013). Across all these studies on non-fishery and fishery species, and contrary to what was expected, results show that some larvae do not travel far from where they were born, moving only a few hundred meters to several kilometres during the larval phase before they settle. This suggests that reserves can benefit nearby fisheries by supplying larvae to fished areas near the reserve, thereby replacing the fish caught by fishermen and helping to sustain the fishery over the long term.

Costs and benefits of using reserves for Pacific Island communities

As noted previously, community-based fisheries management is widespread in the Pacific. In particular, the concept of customary marine tenure (CMT) is common, and here we define a CMT area as a coastal area that is owned and fished by a particular community, and where that community sets rules that determine who can fish within their CMT area. Depending on the country, the government often officially and legally recognises such community rights over coastal fisheries, and there has been a recent shift in some countries to return to, and strengthen, CMT arrangements to improve management. The key point is that communities have the ability and legal right to make decisions about how to manage the resources in their CMT area — who can fish, and where, when and how. Several fisheries management and non-governmental organisations (NGOs) working in the Pacific have suggested that communities establish permanent no-fishing areas — reserves — within their CMT area to improve fisheries management. However, for a number of reasons, reserves have both known and unknown costs and benefits for communities, and it is important to understand these before communities decide whether to set up a reserve.

Costs of reserves

CMT areas are often small, and many Pacific Island communities rely heavily on harvests from them for food and as a source of income. In many places, CMT areas consist of just a few kilometres of coastline and its associated habitats (e.g. coral reef, mangrove or seagrass). As a result of small CMT area size and heavy reliance on harvests, setting up a reserve represents a significant cost to the community — the community is giving up the ability to obtain food and income from that area. This is a known and obvious cost to the community.

Less understood and unknown is the cost to the community of the reserve underperforming or not performing its function of rebuilding and sustaining that community's fishery. This relates to the two main ways in which a reserve can provide fishery benefits: 1) spillover of fish from the reserve to nearby fished areas, and 2) increased production of larvae by fish living within the reserve.

Spillover of fish from the reserve to fished areas does occur and is likely to benefit the community that established the reserve because fish generally do not move far. Thus, any fish that do move from the reserve are likely to remain within that community's CMT area. However, will spillover be enough to make up for the amount of fish historically taken from the reserve area where fishing is no longer

allowed? And if so, how long will it take for the reserve to make up for this lost catch? Answers to these important questions are unknown and require further study. But at least for the first several years after establishing the reserve, we argue that the answer is probably "no" for most small, community-based reserves — the amount of spillover from the reserve will be less than the amount of fish they have lost by establishing the reserve.

However, as we argued above, the key way in which a reserve is likely to benefit fisheries is through the increased production of larvae from the more numerous and larger fish living inside the reserve. Again, depending on species, the build up in abundance and increase in average size will take time (Abesamis et al. 2014), but it is the increased larval production by the reserve that will be the main, lasting fishery benefit of it. Furthermore, once fish abundance and average size increases to its maximum, and provided the reserve remains safe from other disturbances and no fishing occurs, the reserve should continue to produce lots of larvae year after year. But the important question from the community's perspective is, who benefits from the reserve? If all the larvae produced by the reserve are thought of as benefits, and remembering that larvae can travel long distances, then to understand who benefits from a reserve and how much, and where those larvae go, must be determined.

Because many CMT areas are small, and any reserve established within a CMT area will be even smaller, there is a strong possibility that many larvae will leave both the reserve and CMT area during the larval phase. If all the larvae produced by the reserve leave a community's CMT area, then the community that established the reserve receives no larval fishery benefits from its reserve; those larval benefits end up in some other community's CMT area (Foale and Manele 2004). This is clearly a cost to the community that established the reserve and gave up the opportunity to fish inside it. The community to which those larvae travel therefore benefits not from its own actions — after all, they did not set up the reserve — but from the actions of the community that set up a reserve. In this scenario, communities that set up reserves to improve their own fisheries would not receive the benefits from their actions; other communities would realize those benefits wherever those larvae settle.

Benefits of reserves

An alternative scenario is that some larvae produced by the reserve do not travel far during the larval phase, but instead settle somewhere within the CMT area belonging to the community that set up the reserve. In this case, the community that set up the reserve will benefit directly from it. As

discussed above, evidence so far suggests that some larvae do indeed travel only short distances before settling, but others will no doubt travel outside a community's CMT area. However, the exchange of larvae between both fish populations and CMT areas can be beneficial. For example, larval exchange between fish populations has important benefits for the long-term persistence and resilience of those fish populations (e.g. Almany et al. 2009). If a fish population declines owing to overfishing, because of a natural disaster, or from some other cause, larvae that come from nearby healthy populations will allow the damaged population to rebuild and recover — something it could not do without those larvae from elsewhere.

From a community perspective, and provided at least some larvae produced by the reserve remain within the CMT area of the community establishing the reserve, the exchange of larvae between CMT areas could be beneficial under certain conditions. For example, in many places adjacent CMT areas consist of communities that are related by a common language, traditions, customs, marriage and trade. These communities, therefore, have a history of working together on some level. Understanding whether and how much these communities and their CMT areas are connected by the exchange of larvae between them — something that will always remain hidden from local knowledge systems because of the difficulty of observing the larval phase — could provide an important foundation for strengthening working relationships among communities, and lead to collaborations between communities to collectively, and therefore more effectively, manage their connected fisheries. When CMT areas are strongly connected to each other by the exchange of larvae, actions taken by one community will affect its neighbours, and collective

management decisions taken together by all communities should result in better management outcomes across these connected CMT areas. This last point also emphasises the value of research partnerships between communities and researchers; in working with researchers, communities gain access to important information about their fisheries and how they can best be managed that is not otherwise available through traditional knowledge mechanisms, and researchers benefit from the detailed local ecological knowledge, fishing expertise and assistance of communities (Almany et al. 2010).

Coralgrouper (*Plectropomus areolatus*) study at Manus Island, Papua New Guinea

Here we summarise the results of a study designed to answer some of the questions discussed above and discuss the study's implications for community-based management (Almany et al. 2013). The three main research questions were:

1. How far do larvae that are produced at a small, managed squaretail coralgrouper (*Plectropomus areolatus*) FSA travel?
2. Do some larvae from the managed aggregation settle within that community's CMT area?
3. Do some larvae and fish from the managed aggregation travel to other CMT areas?

We worked with five communities along the south coast of Manus Island, Papua New Guinea in 2010 (Figs 1 and 2). A complete explanation of how we worked with communities can be found in Almany et al. (2010). We also report on information not reported elsewhere, involving the movements of adult fish between their normal home ranges and the aggregation site.

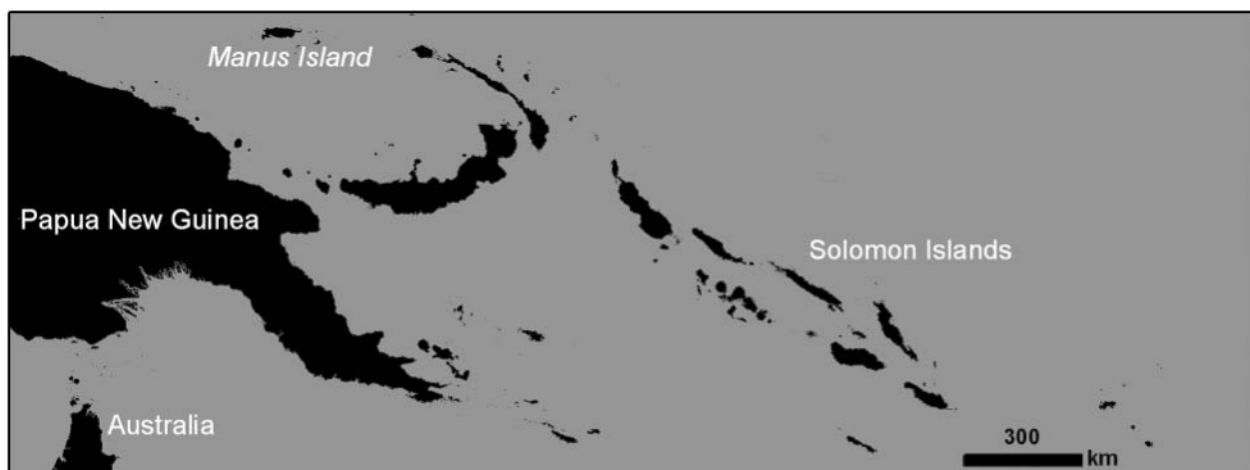


Figure 1. Location of Manus Island, Papua New Guinea within the region. (Land is black, water is light grey.)

The five communities, from west to east, are Timonai, Tawi, Locha, Pere and Mbunai (Fig. 3). These are communities of the Titan people who also occupy several offshore islands to the south and southeast of this area of coastline (Fig. 2: Mbuke, Baluan, Lou, and Rambutyo). Titans are almost exclusively fishermen who rely predominantly on the sea for their livelihoods. They obtain agricultural products and building materials by trading marine resources with inland communities. Each Titan community has its own CMT area and has the customary rights to control fishing and enact management within its area. The boundaries

between CMT areas (Fig. 3) are well defined and well known by fishers within all communities. Each of the five community CMT areas includes one or more FSA site where several species of grouper and other species gather for reproduction (i.e. to produce larvae). These FSA sites are well known to fishermen, and some FSAs have been fished to supply the LRFFT in the past few decades (Hamilton and Matawai 2006). The length of the coastline of our study area, between the western boundary of the Timonai CMT area and the eastern boundary of the Mbunai CMT area, is approximately 75 km (Fig. 3).

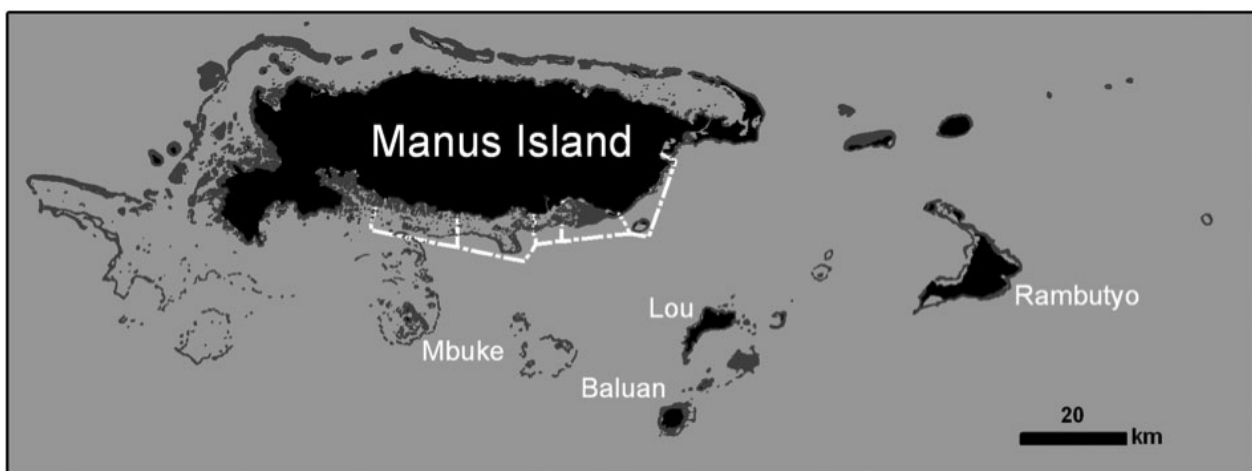


Figure 2. Manus Island, Papua New Guinea, and its offshore islands and coral reefs. White dashed lines on the south coast of Manus Island outline the squaretail coral grouper study area consisting of five communities and their customary marine tenure areas. (Land is black, coral reefs medium grey, and water light grey.)

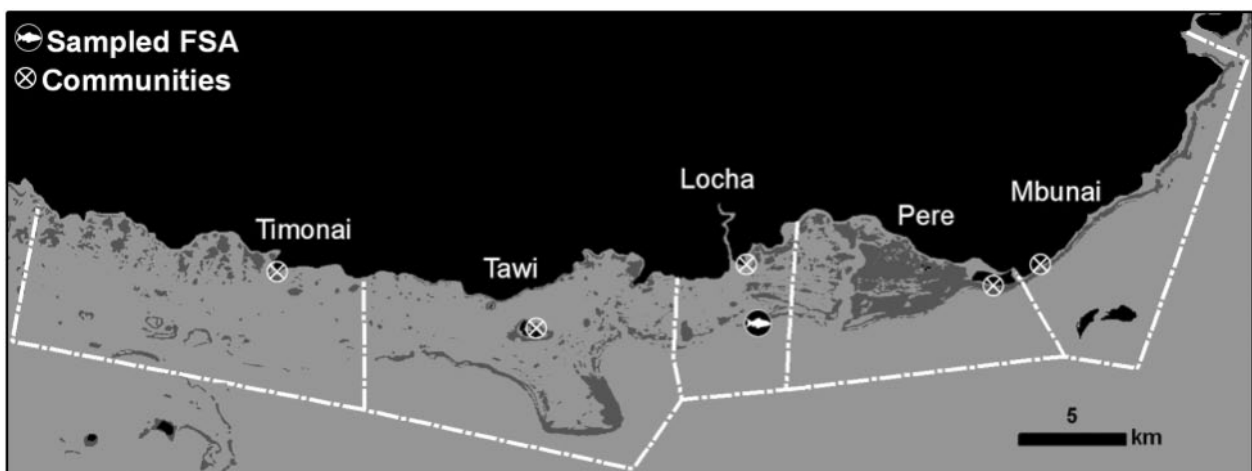


Figure 3. Study area on the south coast of Manus Island, Papua New Guinea. White dashed lines delineate customary marine tenure (CMT) boundaries between communities. A circle with a white X indicates the location of the main population centre in each CMT area, and the name of that population centre and CMT area is in white text. The black circle with the white fish inside indicates the location of the fish spawning aggregation (FSA) within Locha's CMT that we sampled. Note that the locations of eight other FSAs within the study area are not shown. (Land is black, coral reefs medium grey, and water light grey.)



Figure 4. Small Titan outrigger canoe. These were used by spearfishermen to collect juvenile coralgroupers from the study area (Photo: Glenn Almany).



Figure 5. Fishers record local names of reefs on satellite imagery (Photo: Michael Berumen).



Figure 6. Study authors Hamilton (left) and Almany (right) discussing results with fishermen (Photo: Tom Almany).

We focused our research on one FSA within the Locha community's CMT area (Fig. 3), and we do not show the locations of other FSAs in our study area to prevent exploitation of these sites by outside fishermen. We also focused our research on a single grouper species, the squaretail coralgroupers (*Plectropomus areolatus*), known in the Titan language as *kekwa*. In Manus, this species forms aggregations at FSAs throughout the year, but aggregation size is

largest during the peak spawning months of April–August (Hamilton et al. 2012a). Studies from other places show that male and female *P. areolatus* leave their normal home range sites and travel anywhere from 0–30 km to an FSA site for reproduction, after which they return to their normal home range site (Green et al. in press). Local fishers primarily target this species during aggregation periods, using both hook-and-line and spearfishing, both during

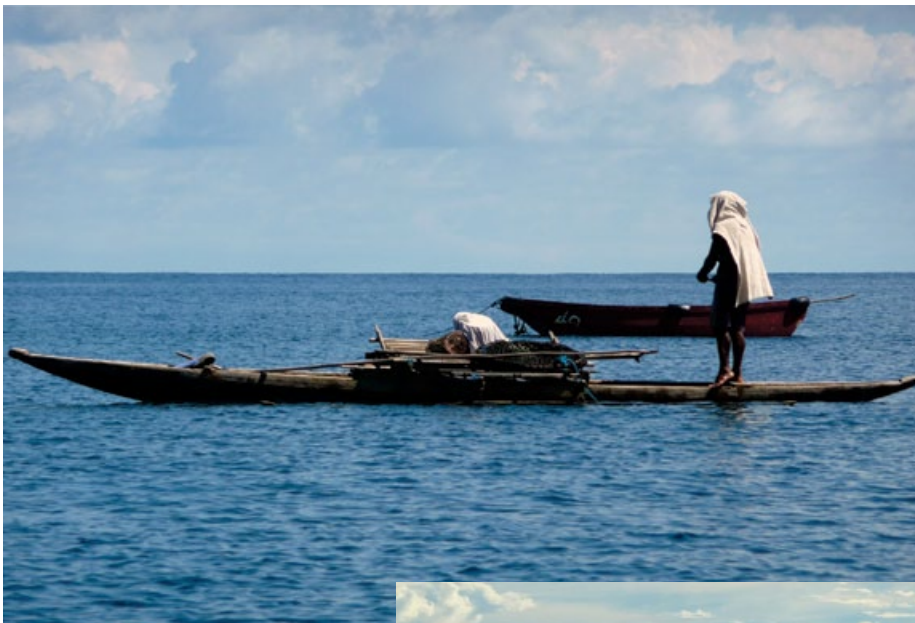
the day and night. This species is particularly vulnerable to night-time spearfishing as it sleeps in shallow water, often just a few meters deep (Hamilton et al. 2012b). In Manus, some of the catch is consumed locally and some smoked and transported to markets for sale in the provincial capital of Lorengau several hours away by sail (Fig. 4) or outboard engine. In many places in the Pacific, the demand for coral grouper to supply the LRFFT has driven overfishing of many FSAs and, throughout its range, *P. areolatus* populations are declining (Rhodes and Sadovy de Mitcheson 2012). In 2008, the species was designated as “vulnerable” by the International Union for Conservation of Nature (IUCN) (Chan et al. 2008).

Working with The Nature Conservancy (TNC), some communities in the study area initiated community-based monitoring and management programmes at of three FSAs in 2004 (Hamilton et al. 2005). One community, Locha, responded to declines at its FSA

by creating a 36 ha management area around their FSA in 2004, which consists of 13% of their total CMT area. Within this managed area, the community permitted hook-and-line fishing for local consumption and banned all forms of spearfishing.

We worked closely with the Locha community to design the study, and also worked with the four adjacent communities. Fishermen from all five communities provided the local names of all individual reefs and parts of reefs in the study area, which were added to maps based on high-resolution satellite imagery (Figs. 5, and 6). (Copies of these maps were then provided to each community at the beginning of the study.)

From 29 April to 14 May 2010, approximately 20 fishermen from Locha fished for aggregating coral grouper at the Locha FSA using hook-and-line gear during the day (Figs. 7 and 8). Each captured fish was measured (total length, TL), its sex (male



Figures 7 and 8.

Locha fishers fishing for adult squaretail coral grouper at the Locha FSA
(Photos: Glenn Almany).

or female) was determined by examining a sample of gametes (eggs or sperm), and a small piece (1 cm x 1 cm) of the rear part of the dorsal fin was removed with scissors and preserved in ethanol for genetic analysis (Figs. 9 and 10). Before returning captured adults to the FSA, we tagged each fish with a 100-mm long, individually numbered, external tag (Fig. 10). We asked fishermen from all five communities to provide us with the tags and capture location of any tagged fish that they captured during the 6 months after we sampled adults at the FSA to determine whether adult coralgroupers moved across CMT boundaries when they travelled between their normal home sites and the Locha FSA.

From 04 November to 15 December 2010, approximately 100 spearfishermen from all five communities collected juvenile coralgroupers from their respective CMT areas and, using the maps we created, recorded the name of the reef from which each fish was collected. For collected juveniles, each fish was measured (total length, TL) and a small piece (1 cm x 1 cm) of the dorsal fin was removed with scissors and preserved in ethanol for genetic analysis. In the laboratory, the DNA from the tissue samples taken from adults and juveniles were compared to each other using a method called parentage analysis. Specific details about this analysis can be found in other publications (Harrison et al. 2013; Saenz-Agudelo et al. 2009), but essentially this method compares the DNA of adults with those of juveniles, and can determine parent-offspring relationships. In other words, by comparing DNA taken from adults and juveniles, it can be determined whether those adults are the parents of those juveniles. Because we know both the location of the Locha FSA from which we sampled adults and the location from which each juvenile was collected, for any juvenile born from parents sampled at the Locha FSA, we can measure the distance it travelled during its larval phase.

Results

Fishermen captured 416 adult coralgroupers from the Locha FSA. We used underwater visual census surveys of the FSA to determine the total number of adults present, and estimate that there were approximately 967 coralgroupers present at the FSA. We therefore captured and sampled approximately 43% of all coralgroupers at the FSA. Six months later, spearfishermen collected 782 juvenile coralgroupers from the five community CMT areas: 43 from Timonai, 221 from Tawi, 204 from Locha, 235 from Pere and 79 from Mbunai.

Using genetic parentage analysis, we identified 76 juveniles that were born from adults at the Locha FSA. From these data, we estimated how many



Figure 9. Research team members measuring and tagging an adult squaretail coralgroupers captured at the Locha FSA (Photo: Glenn Almany).



Figure 10. Tagged adult squaretail coralgroupers about to be released back to the Locha FSA (Photo: Glenn Almany).

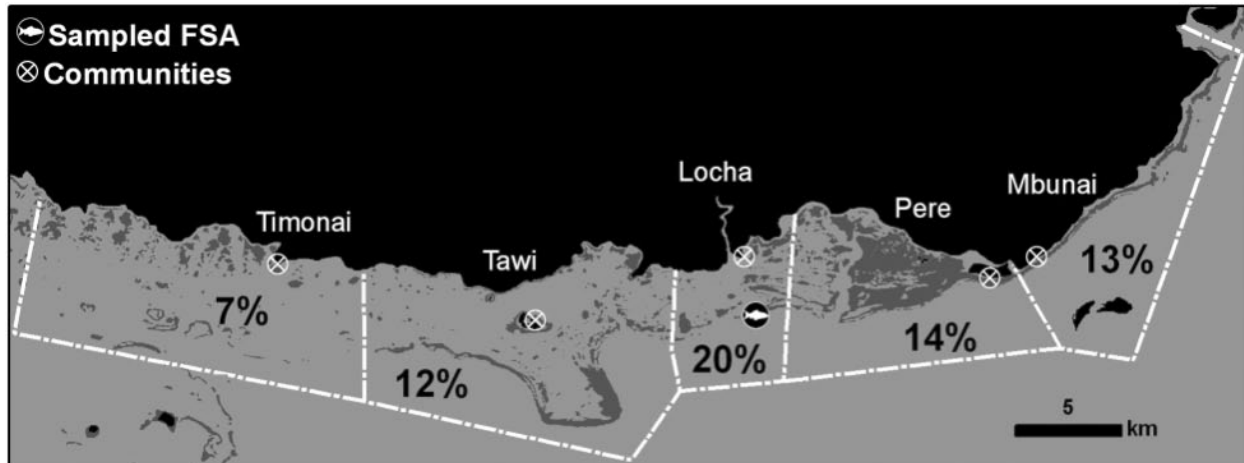


Figure 11. Results of the study measuring the dispersal of squaretail coralgroupers (*Plectropomus areolatus*) larvae from Locha's FSA to each of the five CMT areas. Black numbers are the estimated percentage of all juvenile coralgroupers in each CMT area that were born at Locha's FSA. (Land is black, coral reefs medium grey, and water light grey.)



Figure 12. Capture locations of 10 adult squaretail coralgroupers (*Plectropomus areolatus*) that were tagged at the Locha FSA in May 2010 and were captured by fishers during the following six months. Males (N=5) are indicated by circles with a solid white centre, females (N=5) by solid white diamonds. Five adults, all males, left the Locha FSA and returned to home sites within Locha's CMT area. Five adults, four females and one male, left the Locha FSA and returned to home sites within Pere's CMT area. (Land is black, coral reefs medium grey, and water light grey.)

larvae were produced by the 551 adults (57%) that we did not capture and sample from the Locha FSA (see Almany et al. 2013 for details), we calculated the percentage of juveniles in each of the five CMT areas that came from Locha's FSA (Fig. 11). This analysis indicates that 20% of all juveniles in Locha's CMT area were born at Locha's FSA. The percentage of juveniles born at Locha's FSA in the other four CMT areas decreased with distance from Locha's FSA, indicating that fewer larvae successfully travelled long distances during the larval phase (Fig. 11). Using the distances measured between the locations where the 76 parentage-assigned juveniles were collected and the Locha FSA, we modelled the relationship between the distance larvae travelled

and the percentage of larvae that travel that distance. Results from this analysis predict that 50% of all larvae produced at the Locha FSA travel less than 14 km before they settle (Almany et al. 2013).

During the six months after capturing and tagging adult coralgroupers at the Locha FSA, fishers captured 10 tagged adults on other reefs (Fig. 12). Five tagged fish, all males, were captured from reefs within the Locha CMT area. The remaining five tagged fish, one male and four females, were captured from reefs to the east of the Locha FSA, from within Pere's CMT area. The average distance travelled by the 10 tagged adults was 2.8 km (range = 1.3 to 4.9 km).

Conclusions and recommendations

Locha, the community that protected its FSA, received the greatest benefit from its actions — we estimate that 20% of all juvenile coralgroupers in Locha's CMT area were born at Locha's FSA. Some larvae from Locha's FSA travelled to other CMT areas to the east and west, and so these neighbouring communities also benefited from Locha's actions to protect its FSA. Importantly, our results demonstrate that some coralgroupers larvae do not travel far from where they were born are similar to results observed in previous studies on both small, non-fishery species and larger fishery species (Jones et al. 2009; Green et al. in press). This suggests that short-distance movements by at least some larvae are common, and that communities can benefit from setting up reserves in their CMT areas.

We recognise that setting aside no-fishing areas can be difficult for coastal communities because their CMT areas are already small and they rely heavily on their CMT areas for food and income. As a result, any no-fishing area will be small. However, our study suggests that these small no-fishing (or restricted-fishing) areas could be very effective for rebuilding and sustaining the populations of some species, such as those that form FSAs. Increased fishing pressure on FSAs has led to rapid declines of these species in many locations around the Pacific (e.g. Hamilton and Matawai 2006). Protecting FSAs is wise because most (perhaps all) reproduction for these species occurs at the FSA site; so this is only source of larvae for replacing the fish taken by fishers. Community protection of FSAs works well, as shown in a recent study from New Ireland Province in Papua New Guinea where protection of grouper FSAs resulted in substantial increases in grouper abundance after five years (Hamilton et al. 2011). Furthermore, as our coralgroupers study from Manus demonstrates, some larvae stay close to the FSA and replenish local fisheries, and under many scenarios these larval benefits should increase with time. For example, if fishing pressure on FSA species is not too high after they leave the FSA site, then both the number of adults and average adult size should increase at the FSA (up to a point at which it reaches its natural capacity). This will result in a greater number of larvae produced by the protected FSA. Because, as we have shown, many of these larvae travel short distances, the coralgroupers population within the study area will increase, thereby rebuilding and sustaining this important fishery.

Our results also suggest that increased cooperation between communities in managing their fisheries would benefit both fish populations and communities. First, each of the five CMT areas contains one or more coralgroupers FSAs, and based on our results, it is almost certain that larvae are exchanged

between, and connect together, all five CMT areas to each other. If each of the five communities provided some protection for its FSAs, each community could expect to directly benefit from its actions (the larvae that stay within that community's CMT area), and indirectly all communities would benefit together (by exchanging larvae between CMT areas). Furthermore, the coralgroupers populations in each CMT area would benefit from an increased exchange of larvae, which would increase their resilience to and recovery from decreases caused by disturbance (e.g. storms, overfishing). Under this scenario, where all communities provide some protection to their FSAs, we would expect the entire coralgroupers population within the study area to increase, ultimately providing more fish to fishers. Second, some adult coralgroupers moved between their normal home sites in one CMT area (Pere) and travelled to an FSA in another CMT area (Locha) for reproduction. By taking similar management actions across all CMT areas and FSA sites, communities would ensure that all adult coralgroupers have the same chance to reproduce successfully, no matter which CMT area or FSA site they use. These observations reinforce our conclusion that cooperation and collective decision-making between communities should result in better outcomes for fish and fishers.

Governance and management responses by Manus communities

After obtaining the final results of this study, we presented and discussed our findings and recommendations in November 2011 at all five communities that participated in the research and at Mbuke, the largest community among the offshore islands to the south of the study area (Fig. 13). We emphasised three main conclusions from this work. First, small managed areas that protect FSAs can help rebuild and sustain a community's coralgroupers fishery because many larvae stay close to the FSA. Second, because some larvae and fish travel across CMT boundaries, the coralgroupers fishery represents one large stock that would be better managed collectively. Third, the results of our coralgroupers study are similar to results from other studies on both fishery and non-fishery species, all of which suggest that some larvae travel only short distances from their parents (see reviews by Green et al. in press; Jones et al. 2009). As a result, we conclude that community-based management can definitely provide local benefits for some fishery species, and possibly for a wide range of fishery species. The authors and other researchers around the world are conducting similar studies on other fish species and invertebrates (e.g. sea cucumber) to test whether this third point is indeed true.

Although many community members immediately saw the value in collective community-based

fisheries management, in 2011 there was no formal framework in place to support collective management. Communities had traditionally made independent decisions about the fisheries within their CMT area. However, two of the authors who are from southern Manus (Matawai and Kichawen) were convinced of the need for collective management, and were inspired by an example of an effective tribal governance network, the Lauru Land Conference of Tribal Communities in Choiseul, Solomon Islands (Kereseka 2014). They travelled throughout the communities of southern Manus to discuss the idea of establishing a tribal network to make collective decisions about resource

management and other issues that would benefit network members. Those communities in support of the idea, which consisted of eight Titan tribal areas, including the five CMT areas that participated in the coral grouper study, sent 70 leaders to a gathering in June 2013 to officially establish the MwanusEndrasAsi Resource Development Network (MEnARDev NET). Hereafter, we refer to MEnARDev NET as the "Network."

The eight tribal areas of the Network contain more than 10,000 people spread across approximately a third of Manus province (Fig. 14). The Network



Figure 13. Study authors Hamilton and Matawai presenting results to the Tawi community (Photo: Tom Almany).

was established around existing socio-cultural boundaries, with all members sharing a common language (Titan), common religion (WIN Nation) and a maritime culture. The stated mission of the Network is: "We will build the resilience of our people through sustainable use of our ocean, our land and our natural resources that we depend on for our survival." Some of the Network's strategies for achieving its mission include: advocating for and supporting equitable and sustainable development to improve livelihoods; preservation of cultural heritage; developing a learning forum to share experiences among Network members

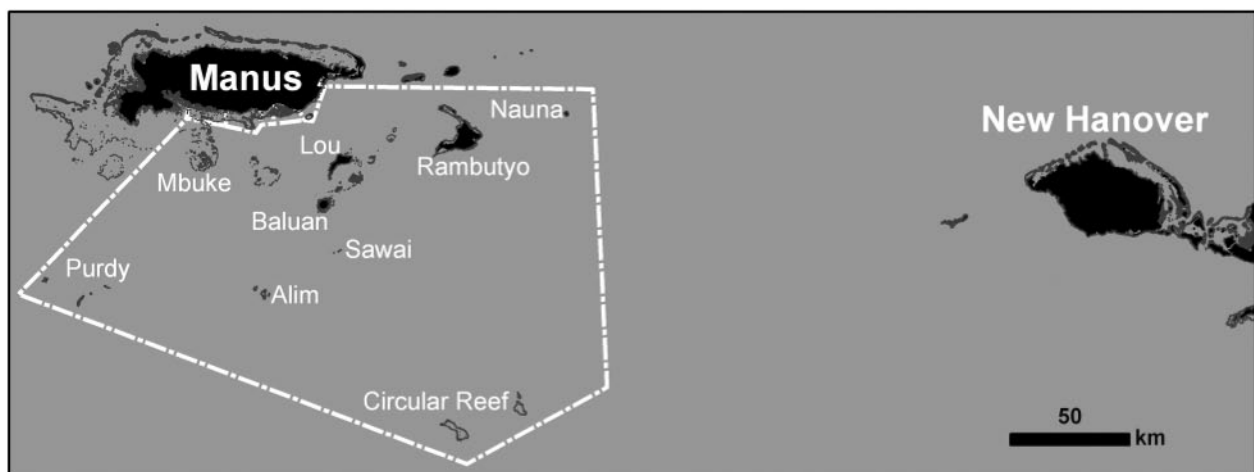


Figure 14. Approximate boundaries of the new MwanusEndrasAsi Resource Development Network (MEnARDev NET) are shown as a white dashed line, and encompass a total area of ~24 000 km². The Network consists of eight tribal areas and includes the five coastal communities that participated in the squaretail coral grouper study, several communities on offshore islands (Mbuke, Baluan, Lou, Rambuty and Nauna), uninhabited islands (Purdy, Alim and Sawai), and two submerged reefs (Circular Reef). All communities in the Network are Titan and share a common language, religion and ethnic identity. (Land is black, coral reefs medium grey, and water light grey.)

to build local capacity; improving communities' resilience to climate change through community-based projects; supporting research partnerships between communities and scientists that benefit communities; and establishing a network of managed and protected areas.

The governance structure of the Network is as follows. Voting members are elected individuals who represent the interests of three groups from each of the eight Titan tribal areas: 1) the Tribal Council of Chiefs, 2) Women Leaders (Pilapan) and 3) Youth Leaders (Wuluo-Pinchuel). These elected representatives report to the Board, and the Board is chaired by the elected Secretariat (currently one of the authors, Kichawen). The Secretariat coordinates Network activities and chairs meetings. Network meetings occur approximately every six months, which has allowed for rapid progress; since its inception in June 2013, the Network has crafted and signed an official charter establishing the Network, registered as a business, developed and agreed on a strategic plan, and established a formal relationship with the Papua New Guinea National Fisheries Authority (NFA) to coordinate fisheries management activities. A recent outcome of this link with NFA has been a pledge from NFA to provide shallow water fish aggregating devices to each community in the Network to reduce fishing pressure on reefs.

At the September 2014 Network meeting, the Tribal Council of Chiefs, acting as representatives of their tribal areas, approved the establishment of a comprehensive system of managed and protected areas across the entire area under Network jurisdiction (Fig. 14). The two main goals of this system of managed and protected areas are to ensure the sustainability of a range of fishery resources and to protect cultural heritage sites. A participatory planning workshop is scheduled for May 2015 to integrate community priorities and conservation targets, local knowledge, and scientific data into a comprehensive spatial management plan for the area (see Game et al. 2011; Peterson et al. 2012 for examples of this process).

Acknowledgements

We thank the communities of Timonai, Tawi, Locha, Pere and Mbunai for their assistance with the coral grouper study; the community of Mbuke for their hospitality; and W. Almany, M. Berumen, C. Costello, T. Potuku and K. Rhodes for field assistance. For reading and suggesting improvements for this manuscript, we thank W. Almany, P. Hertz and C. Stier. The coral grouper study was funded by the Australian Research Council (ARC), the ARC Centre of Excellence for Coral Reef Studies, The Nature Conservancy's Rodney Johnson/Katherine Ordway

Stewardship Endowment, National Fish and Wildlife Foundation, and The David and Lucille Packard Foundation. MEnARDev NET is supported by the Australian Agency for International Development and The David and Lucille Packard Foundation.

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Ancestral fishing techniques and rites on 'Anaa Atoll, Tuamotu Islands, French Polynesia

Frédéric Torrente¹

Introduction

The Tuamotu Islands comprise the world's largest concentration of coral islands. They include 76 (of which 42 are inhabited) of the 84 atolls within French Polynesia. 'Anaa (Ganā) Atoll, located in the western Tuamotus, is about 30 km long and 6 km wide. It is slightly elevated (+ 6 m) and has a terrestrial area of some 37 km². 'Anaa's shallow lagoon, which has an area of 89 km², lacks passes, but is linked to the sea by channels (*hoa*).

This article — which does not claim to be comprehensive — aims to contribute to the environmental knowledge and fishing techniques of traditional societies on Polynesian atolls, which today are seriously endangered by increasingly Westernised lifestyles. A few of the fishing techniques used by the community on 'Anaa before the evangelisation of the Tuamotu Islands are described, based on a body of traditional knowledge shared by Paea-a-Avehe and Teave-a-Karaga, the last two holders of 'Anaa's pre-Christian traditional knowledge (*vanaga*). These unusually rich ethnographic materials were collected by the linguist Frank Stimson during extensive expeditions conducted by the Bishop Museum between 1924 and 1934. Of the thousands of pages in vernacular language², which provide an insider's view of traditional life on a Polynesian atoll, only a few items are mentioned that relate to fishing. In ancient times, in the Tuamotus and elsewhere, subsistence activities were based on a careful balance between a system of beliefs and symbolic values designed to control resource abundance through rites and prohibitions and a hierarchical power system that ensured the redistribution of resources. This delicate balance was maintained by the chiefs who had ritual control over the resources. Traditionally in ancient Polynesia, culture was not seen as being in opposition to nature, but rather as a genealogical continuum that tied the invisible spiritual world to the elements of the tangible world

(mineral and biological), in which humans were simply one part of a whole. In this holistic vision of the environment all marine organisms were considered to be descendants of Tangaroa, the god of the original ocean deeps (Torrente 2012). Large marine species hold an important position in Pacific Islanders' thinking, given that they are seen as incarnations of the divine beings of the deep-sea world, or as protecting ancestors and messengers. Paea-a-Avehe's list of vernacular terminology mentions for 'Anaa Atoll, 14 varieties of shark, 181 big fish (*paru toreureu*), five varieties of sea turtles, 15 varieties of moray eels and a very detailed list of all the island's molluscs and crustaceans (Torrente 2012). The goal of traditional taxonomies was not only to classify species for food purposes, as is often claimed, but also to categorise those that were dangerous for humans (myths concerning which abound, with varying degrees of detail) or else to categorise certain species of symbolic or religious importance. It should be noted that in the same way as fish, marine mammals are part of the semantic category *ika*, marine creatures that swim (Malm 2010) or *par*, "inhabitants of the deeps" (Hooper 1991); the same is true for turtles (*tifai* or *honu*), with the latter representing the perfect sacrificial offering, called by extension *te ika nui* (Conte 1885, 1888; Emory 1947, 1975; Stimson and Marshall 1964; Torrente 2012). Shellfish and crustaceans are placed in the category of marine organisms that move by crawling: *te haga paru e torotoro* (literally, "marine creatures that crawl"), probably corresponding to the term *figota* that continues to exist only in western Polynesia. Harvesting them (*fangota*) was done mainly by women and children (Malm 2010). The importance of giant clams (*Tridacna maxima*, *T. squamosa*) in this island group will be dealt with in another paper.

Ancient fishing techniques on 'Anaa

In the Tuamotu Islands, the terms *tautai* or *ravakai* cover the action of fishing and everything related to

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² Only part of this work was translated and forms the basis for the ethnographic materials of a doctoral thesis entitled "Ethnohistoire de l'atoll de 'Anaa, archipel des Tuamotu" presented by the author in 2010 and edited by Jean Guiart (Torrente 2012). These documents are part of the microfilms of the unpublished notes of Frank Stimson held at Peabody Essex Museum of Salem (copy in the "Fonds Polynésien" at the University of French Polynesia), parts of which was re-transcribed and translated into French.

it. In his manuscript, Paea-a-Avehe uses the generic term *ravakai* (or *ravagai*) which means “to get food for oneself”. The definition of the term given by Stimson and Marshall (1964) includes three meanings: 1) one used throughout the Tuamotus, “to go fishing or to look for food such as turtles, fish, birds or any other edible marine creature”; 2) “the act or method of obtaining or looking for live food”; and 3) “to fish, fishing trip”, the synonym of which is *tautai* (Stimson and Marshall 1964). It is with the latter meaning that the term *rava'ai* is used in Tahiti.

Unless otherwise noted, the list of ancestral fishing methods explained here is based on the same semantic categories that appear in Paea-a-Avehe's body of work (in Stimson and Marshall 1964). They supplement the fragmented information provided by Montiton (1874), Seurat (1904), Danielsson (1956), Ottino (1965), Emory (1947, 1975) and Conte (1985, 1988). Some of these techniques are no longer used or they have been transformed by the introduction of European artefacts (e.g. iron hooks, spear guns, synthetic nets, fish cages made of wire fencing). The ancient *pa'umotu*³ rarely went anywhere on the island without their spears (*oka parū*). Fish were “stabbed” right on the reef (*fātau*) or else while diving (*okaoka*).

Hook-and-line fishing (kānehu)

Fishing with a single weighted line and hook (*tate, matau*) on the seaward edge of the reef was called *kānehu*. Fishing with a baited hook and line in holes in the reef that contained abundant fish was called *titomo*. Crabs were also caught in the same way with baited lines (*pātekatēka*). Hooks were carved from wood, bone or the shells of pearl oysters (*Pinctada margaritifera*).

Pole-and-line fishing on the reef (matira)

Generally, fishing was done at night in a break in the reef (*gutū kohae*) with a hook attached to a short line on a pole (*matira*). According to Paea-a-Avehe, the following species were caught in this way: *ruhi* (*Caranx lugubris*), *hokahoka* (*Variola louti*), *tarefa* (*Aprion virescens*), *kokiri* (*Balistoides* spp.), *meko* (*Lethrinus obsoletus*), *tamure* (*Lutjanus fulvus*), *mu* (*Monotaxis grandoculis*), and *taea* (*Lutjanus gibbus*). In pole-and-line fishing for black jack (*ruhi*), fishers would approach a spot by canoe while slapping the surface of the water or skimming flat stones across it.

Catching flying fish (tupe maroto)

Flying fish (*Cheilopogon pitcaimensis*, *C. spilonopterus*), called *maroto* on 'Anaa and/or *marara* on the



Figure 1. *Maroto* (flying fish) fishing, according to Paea-a-Avehe (in Stimson and Marshall 1964).

other atolls, were caught in the following way: on very dark nights, canoes would go to sea, normally with two fishers; they used torches (*rama*) to attract the *maroto*, which would begin flying towards the light and then were caught with dip nets, *tupe maroto*. This technique required considerable dexterity and speed by both the person handling the *tupe* and the person steering the canoe (Fig. 1).

Moray eel fishing (here kamia)

The generic name for moray eels used in Paea-a-Avehe's list of terms is *tāvere* (which comes from its undulating movement), although that seems to apply more precisely to the Javanese moray eel, *hamorega* (*Gymnothorax javanicus*, Bleeker, 1859) as Stimson and Marshall have indicated in their dictionary (1964). Paea-a-Avehe's list mentions seven identified species: *koiro* for the longfin African conger (*Conger cinereus*, Ruppell, 1828); *kuiru* for the snowflake moray (*Echidna nebulosa*, Ahl, 1789) and the paint spotted moray (*Gymnothorax pictus*, Ahl, 1789); *kiari* for the vagrant eel (*Gymnothorax buroensis*, Bleeker, 1857) and the undulated moray (*Gymnothorax undulatus*, Lacepède, 1803); *makiki* for the whiteface moray (*Echidna leucotaenia*, Schultz, 1943) and the longfang moray (*Enchelynassa canina*, Quoy and Gaimard, 1824); and *kakakuru* for the zebra moray (*Gymnomuraena zebra*, Shaw, 1797). Other names cited could not be identified: *revareva*, *gute*,

³ *Pa'umotu*: Indigenous people of the Tuamotu Islands

houhougaere, kivakevake, kohinahina and *mamea*. The moray eel harvest was quite important on 'Anaa because in addition to the food it supplied, congers' jaws (*niho kamia*) were used as the part of warriors' attire designed to shred the skin of their adversaries during combat (Torrente 2012) or as a kind of saw called *kamia* or *oreore* (Emory 1975). The first technique for snaring morays (*here kamia*) consisted of luring them from their holes with bait (*tanoka*), which was usually consisted of small octopuses (or balls of ground fish meat) attached to the end of a stick that was inserted into the hole. The eel was then caught by a snare (*here*) made of a rope of braided fibres attached to the end of another stick. The second technique called *reke* used a hook baited with crushed fish (*paru tukituki*).

Fishing on *karena* (coral heads)

Karena or *kanaparua*, coral heads that rise to the surface of the lagoon, were well known to *pa'umotu* fishers, because large numbers of fish, giant clam and turtle species gathered there (Conte 1985, 1988). Seen as veritable cornucopia, in part owing to the invisible presence of a spirit called *kanaparua*, these *karena* were owned by island family units and carried names designed to transfer ownership to succeeding generations. A technique called *here paru* consisted of trapping fish in the holes because the animals could then be caught either by hand or speared.

Fishing in reef crevices

On 'Anaa, the technique of grabbing fish with bare hands in reef crevices was called *tinaonao*. The fisher would make sure there were no dangerous animals in the hole such as moray eels (*koiro*, *Conger cinereus*), urchins (*vana*) or scorpion fish (*tatara-i-hau*, *Pterois antennata*, Bloch, 1787). The fish was grabbed (*tago*) by its stomach, and the index and middle fingers were sometimes inserted into its gills (*kamikami*) to carry it to the basket. Rock lobsters (*komaga*) were seized from behind. When a stick was used to force the animals out of their holes, that technique was called *eneene* (Emory 1975).

Catching octopus

While octopus was caught with specific shell lures throughout ancient Polynesia, in the Tuamotu

Islands they were also pulled directly from their holes. On 'Anaa, the technique *tārena kanoe* consisted of pulling an octopus (*kanoe* or *heke*, *Octopus* sp.) directly out of its nest using a stick. The fisher would kill the octopus immediately by biting it between the eyes (Emory 1975). Octopuses were then put out to dry, usually stretched out on *gagie* (*Pemphis acidula*) branches or on drying racks, known as *hokirikiri*.

Net fishing

A technique called *takope* made it possible to trap fish in small narrow channels using coconut palm nets (*gaofe*), both sides of which were attached to stakes at either end of the bottleneck. The fish were chased into the trap. Another technique consisted of using a small deep-set net (*kope*) placed on the outer side of the fringing reef where ocean waters foam, to catch the fish when the waves retreated. The net could also be put at the end of a stone trap (*kaua paru*) in shallow water. The best time for using the technique was at nightfall, when the sea was rough and the fish were returning to deeper waters (Emory 1975). Finally, the technique known as *keke* consisted of setting a long circular net in reef crevices (*koropihi*) that the fish rushed into.

Group fish drives

Fishers worked in a group to drive (*tuehi*) schools of fish either towards the shore or to the back of a bay, using draglines or garlands of foliage that the men pushed, or by scaring the fish from canoes that formed a semi-circle. Such group fishing took place particularly before a great feast, in order to gather enough fish for the rituals and festivities, or when hosting high-ranking visitors. The group fishing technique used on 'Anaa was called *taugaru*: "Many fishermen each take one coconut leaf; forming a line floating on the sea, facing shoreward, they dive, holding the leaf vertically, base downwards, and thump on the bottom, driving the fish towards the shore; when they reach shallow water, the leaves are held horizontally forming a barrier to drive the fish on shore" (Paea-a-Avehe, in Stimson and Marshall 1964). Several types of drag net were used. One called *rona* (Figure 2) was made of 40–60 coconut fronds attached to a line that could reach up to 30 m long. The ends of the rope (*gogo*)

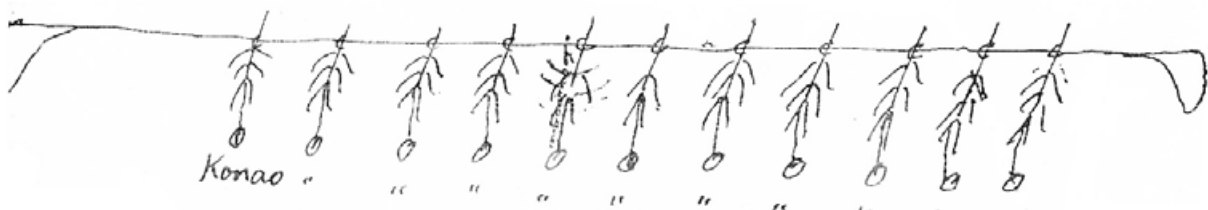


Figure 2. Line of coconut fronds (*gaofe*) weighted with stones (from Stimson and Marshall 1964).

were looped and placed around the waists of two men who held the line that drove the fish forward. Entire schools of tropical halfbeaks, *fanea* (*Hyporhamphus affinis*, Günther, 1866), were baited with pieces of *gora kegokego* (spoiled coconut) spread out over the selected zone. The dragline was then drawn tight to drive the fish towards shallow water, where people on the shoreline simply had to grab many fish (Paea-a-Avehe, in Stimson and Marshall 1964). This group fishing method, for *fanea*, was used in the two deep bays located on the ocean side of the southern part of the island. Large quantities of *fanea* fish were cooked in special earthen ovens (*kopihe fanea*), memorialised in the area's place names (Torrente 2012).

Driving fish by slapping the water

On 'Anaa, the *hakakopakopa* method consisted of slapping the surface of the water with the hands to drive fish towards the beach and shallow water. The following fish were caught in this way: *paruku* (*Caranx lugubris*), *marai*a (*Cheilinus undulatus*), *hami* (*Archanturus* sp.), *takire* (*Parupeneus* sp.), *magumagu* (*Lutjanus fulvus*, Forster, 1801), *tero* (*Lutjanus monostigma*, Cuvier, 1828) and *tatihi* (*Naso brevirostris*). This technique could be used also outside the reef, with swimmers using the waves to force the fish over the reef (Emory 1975).

Driving fish in canoes (tuehi)

Another technique used on 'Anaa was to drive schools of fish using a fleet of canoes that formed a semi-circle. The fishers would strike the surface of the water in front of the canoe with a stone attached to a rope, one end of which was attached to a coconut frond. This type of fishing began in water 4–7 m deep; the fish were then driven into shallower water and caught by nets (*takope*). This method was used to catch *kiokio* (*Albula glossodonta*, Forsskal, 1775), *tegatega* (*Chlorurus microrhinos*, Bleeker, 1854), *komene* (*Selar crumenophthalmus*, Bloch, 1793), *vete* (*Mulloidichthys mimicus*, Randall and Guézé, 1980), *kanae* (*Crenimugil crenilabis*, Forsskal, 1775), *kukina*

(*Scarus ghobban*, Forsskal, 1775), *kutu* (*Gomphosus varius*, Lacepède, 1801) and *kōperu* (*Decapterus macrosoma*, Bleeker, 1851).

Fishing with poison (hora)

The *hora* technique consisted of using stupeficient plants so that fish would be easier to catch. On 'Anaa, fishermen used either *nau* or *horahora* (*Lepidium bidentatum*), or *hora* or *nono* (*Morinda citrifolia*) to knock out the fish. The fruit of the *hutu* (*Barringtonia* spp.) was also used for this purpose, but it can now only be found on Makatea Atoll (Butaud 2009). According to Teneehiva-a-Horoi, on 'Anaa fishermen also used sun-dried sea cucumbers (*rori*), which were grated and spread over the fishing grounds (Torrente 2012).

Lure fishing

In a type of fishing called *ravakai taoga*, live lures were used: a live fish was attached by its tail to a line linked to a fishing weight. Fish that came near the lure were then speared. Sometimes a dead fish could be put directly on the end of a spear as a lure. When the fish got close, it would be speared with a single thrust.

Mullet fishing

On 'Anaa people caught squaretail mullet, *hōpiro* (*Ellochelon vaigiensis*, Quoy and Gaimard, 1825), using very thin lines made of *miro* (*Thespesia populnea*) bark known as *kuei*, together with pieces of *gatae* (*Pisonia grandis*) or coconut wood that served as floats (*uto*). Several baited hooks were hung from it. The line was pulled behind the canoe and shaken from time to time (Fig. 3). This method, called *uto hōpiro*, was still used in the 1930s (Paea-a-Avehe, in Stimson and Marshall 1964).

Stone structures

One special feature of 'Anaa is its shallow lagoon with about 50 channels that extend into the sea. Fish

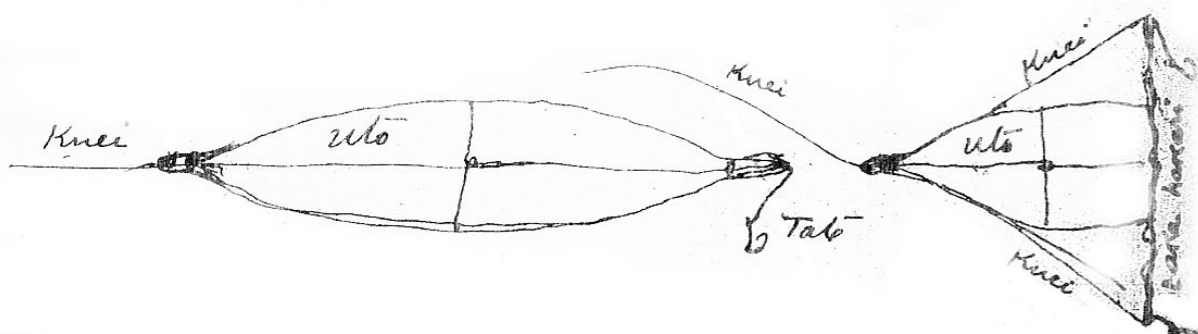


Figure 3. *Uto hōpiro* floating device (from Stimson and Marshall 1964).

were trapped by using the current in fixed durable structures called *kaua paru*, enclosures made of coral rock. These pens belonged to extended families (*kai*) who lived scattered around the island. Their use was strictly private and the structures carried specific names. Fishing in these enclosures was called *tavai kaua*, literally “waiting in the coral compound”. Their complexity in terms of architecture ranged from simple coral walls, *kaua takeke*, that converged towards a narrow bottleneck with a net at the end, all the way to several traps with openings on both the ocean and lagoon sides. Fish were corralled by means of a seine net made of plant materials and then caught with a dip net, *kope* (Emory 1934, 1975). *Tipua* (fish ponds) were stone enclosures or poles erected to demarcate the boundaries of an area where live fish were kept and raised. Some traditions mention turtle farming (*fagai tifai*) reserved for *pa’umotu* chiefs, such as the one for Honohonotai, the chief of Raraka Atoll, who had a *tipua tifai* for that purpose (Paea-a-avehe).

Shark and marine mammal harvests

Fishing for lagoon or reef sharks involved specific wooden hooks (Lavondès 1971; Emory 1975). Some species were snared by canoe in the open ocean, a common practice throughout the Pacific Islands (Conte 1987; Bataille-Benguigui 2003). Hunts for large marine mammals (*parāoa*) were important events in the atolls because they provided large amounts of meat for the community. Traditions on Makemo Atoll talk about the famous *kapea*, Whale Master, who could call whales and lead them into a certain part of the lagoon (*roto parāoa*) where they were slaughtered (Torrente 2012). On the atoll of Faaite, Tetumu described the technique for hunting porpoises, dolphins and whales in fleets of canoes by drumming on the hulls to attract them (Emory 1975). On ‘Anaa, Paea-a-Avehe described the use of a specialist (*tahuga*) to draw whales, dolphins and related species into shallow water. He would direct the community during the hunt (*tauahi parāoa*) and could even ride on the back of one of the animals to guide it to shore, where its head was cut off and the meat cut into pieces (Emory 1975).

Catching turtles

Turtles, called *tifai* or *honu* (*Chelonia mydas*), were the most prized animals in the Tuamotu Islands. They carried the name *ika nui*, (i.e. one of the greatest sacrifices for the god Tangaroa, son of the god Atea, the island group’s creator) (Torrente 2012). So, turtles were subject to very specific rituals in terms of catching and eating them. ‘Anaa’s myths explain turtles’ sacred origins: “The original couple of turtles *takero* (male) and *matariki* (female) lived in the ‘belly of Atea’ in the depths of Havaiki, in a place called Raga-titi” (Paea-a-Avehe, in Stimson and Marshall 1964).

The male turtle is linked to Orion’s belt (*Takero*) and the female to the Pleiades (*Matariki*), whose appearance corresponded to the sign in the star calendar (*tuakaveiga*) indicating that female turtles would be coming to lay their eggs on land.

In Paea-a-Avehe’s list of terms, the names for turtles referred to either their appearance or size: *tifai hekaheka*, species with a brownish yellow shell; *tifai marega*, loggerhead turtle (*Caretta caretta*), voracious species with a big head and long bill; *tifai moko*, falcon-bill turtle; *honu kea*, hawksbill turtle (*Eretmochelys imbricata*) with a curved bill and yellowish fat; *honu tari* or *tifai raparapa*, variety with a hexagonal shell; *tifai konao*, “this rare variety lifts its shell clear from the sand, as it ‘walks’ rather than crawls”. Again according to Paea-a-Avehe, the turtle’s growth stages were very well defined: new-born turtle *tororiro*, small-sized turtle *torearea*, medium-sized turtle *kopue* and finally adult *tifai-noa* (Stimson and Marshall 1964).

Turtle (*Chelonia mydas*) fishing techniques on ‘Anaa

1. *Tāvai nekēga* is the name of a method for catching turtles on land. In early November, when females emerge from the water to lay their eggs on the beach at night, men would wait in certain spots hidden by rocks to closely watch their arrival (Emory 1975). On ‘Anaa, the place called Fakaokao (which means “observe, watch closely”) is well known for turtle watching. On the first night, female turtles come out of the ocean and crawl on the land (*ragamimi*) simply to find a good place to lay their eggs (*touo*). On moonlit nights, they are easy to spot because of the bright light that reflects off their shells. The following night, they then come out to lay their eggs (*hanau*) on the beach. According to Paea-a-Avehe, the elders could determine a turtle’s size by counting the number of eggs laid on the beach. They were counted by pairs of 10 (i.e. 20): *hā-takau* “4 twenty eggs indicate a very big and fat turtle named *apo*. Tū-takau et peka-takau 7 or 8 twenty eggs indicate a more little (*sic*) turtle” (Paea-a-Avehe, in Stimson and Marshall 1964). The hunter would wait until the turtle had dug a hole, laid its eggs and carefully covered the hole with sand to hide them. He would then mark the spot with a stone. The turtle would then be caught when it tried to go back out to sea and simply turned over or else tied up and brought back up onto the beach.
2. *Tago tifai*: during the breeding season, when turtles came together to mate, fishers would swim behind the animals and grab them right with their bare hands (*tago*). If the turtle continued to swim, the swimmer would violently strike the

water making a loud sound that would cause it to stop swimming. It was then seized by one of its fins, which the fisher would twist to force it back up to the surface. In the event that the turtle dived down more than 18 m from the surface, the fisher would then use a hook.

3. *Tūagera tifai*: during the breeding season, before sunset, divers would take their spears and hooks and go out to coral heads (*karena*) that broke the surface of the lagoon. If a hunter was close enough, the turtle was speared directly; otherwise he would dive down and use his hook, as in the above technique.

Ritual aspects of ancient fishing practices on 'Anaa

These practices, both individual and in groups, sometimes mobilising an entire bloodline, could be implemented only in continuity with the invisible realm, through sacrificial rites designed to ensure abundance and following a calendar (Table 1) that was well

known, at least by certain experts in that area. This ritual control of resources was backed up by a social control system that instituted temporary bans (*rāhui*) on given species, depending on the yearly cycle. Large-sized species, such as whales, dolphins or turtles, were surrounded by sacrificial rites at specially designated *marae* — communal or sacred places that serve religious and social purposes. The chief had the right to impose resource restrictions (*rāhui*), whether that involved certain *tapu*⁴ species of fish (trevallies, skipjack, certain sharks) or turtles, which were supposed to be eaten ritually by the elders. On 'Anaa, the rite of *tiorega* consisted of offering the first pieces to the gods and the spirits of the ancestors in a sacred area called the *marae tiorehaga katiga* (*marae* of the first food; Fig. 4). These first food items could then be offered to a high-ranking person (*ariki, tahuga, kaito*), who would himself offer them to his gods. This ritual allowed the ban to be lifted so that the community could eat the food. Fish remains were kept in stone structures called *pāfata* or in hanging woven baskets but were never thrown back into the sea, for fear of permanently frightening the species away.

Table 1. Fishing calendar for 'Anaa Atoll — *No te mau kavake e horo haga ika* (moonlit nights when fish run) (Paea-a-Avehe, in Stimson and Marshall 1964).

Lunar cycle / Month	<i>Te paru</i> (fish)
<i>Higaia</i> (June)	<i>Kukina</i> (<i>Scarus ghobban</i>), bluebarred parrotfish <i>Homohomo</i> (<i>Scarus psittacus</i>), common parrotfish <i>Pitika</i> (<i>Chlorurus sordidus</i>), daisy parrotfish <i>Kakavere</i> (<i>Tylosurus crocodilus</i>), crocodile longtom <i>Korai pakeke</i> (<i>Chaetodon lineolatus</i>), lined butterflyfish <i>Korai gutu keo</i> (<i>Forcipiger longirostris</i>), longnose butterflyfish
<i>Napea</i> (July)	<i>Tatihi</i> (<i>Naso brevirostris</i>), spotten unicornfish <i>Herepoti</i> = <i>Tatihi</i> <i>Kokiri</i> (<i>Balistapus undulatus</i>), triggerfish <i>Karaua</i> (<i>Naso vlamingii</i>), bignose unicornfish <i>Kuripo</i> (<i>Naso exacanthus</i>), sleek unicornfish <i>Kanae</i> (<i>Crenimugil crenilabis</i>), mullet <i>Paruku</i> (<i>Carangoides ferdau</i>), banded trevally <i>Kautea</i> (<i>Caranx papuensis</i>), trevally <i>Nohi nimo</i> (<i>Alectis cyllaris</i>), trevally <i>Tapiro, Maraia</i> (<i>Cheilinus undulatus</i>), humphead wrasse <i>Kito</i> (<i>Epinephelus polyphekadion</i>), tiger grouper <i>Marava</i> = <i>Kimo</i> (?)
<i>Kauhune</i> (August)	Abundance of all species
<i>Kametika</i> (September)	Fish lay their eggs
<i>Herehu</i> (October)	The eggs grow
<i>Fakahu</i> (November)	Month when the weather is hot, fish begin to lay their eggs
<i>Piripiri tau ai manu</i> (December)	Birds come on land and make nests in the trees Fish begin to scatter their eggs It's the end of abundance and the beginning of the difficult months (<i>paroro</i>)

⁴ The Proto-Polynesian term *tapu* designates that which is "sacred, prohibited or under ritual restriction" (Kirch and Green 2001). But other meanings have been noted for the Tuamotu Islands by Stimson: "a sign, token... which is considered a portent of future events" (which is why the term *tapu-fakahira* is used for rainbows on 'Anaa). The concept "*noa*" meant that which is not considered *tapu*, thereby forming an antonym that translates that which is secular and free from restrictions.

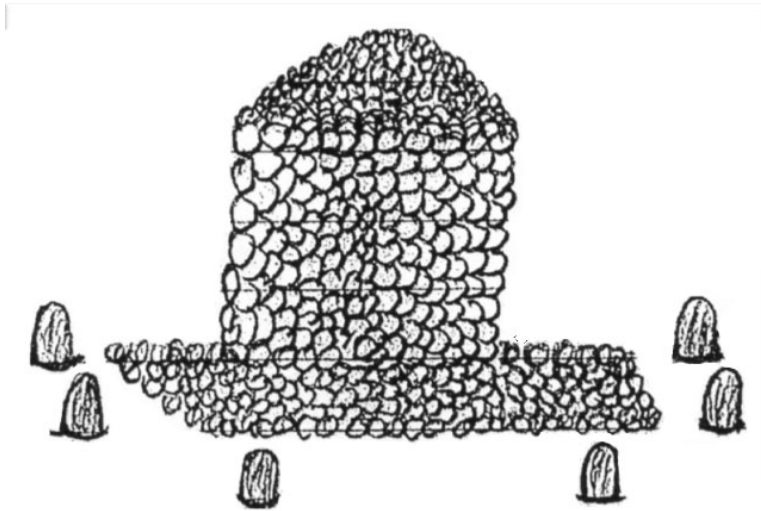


Figure 4. *Marae tiorehaga katiga*, *Marae* for offering the first food items on 'Anaa; drawing based on Paea-a-Avehe (in Stimson and Marshall 1964).

In reference to sacrifices in the *marae*, Montiton (1874) mentioned that:

“the victims were generally turtles, sea-breems, skipjack, etc. On both the day of the sacrifice and on the one that preceded it, everyone who was supposed to take part in it observed abstinence. They usually slept next to their canoes so as to be able to go out at the break of day in search of a turtle, skipjack or any other large fish. The fisher who caught it would remove the shiniest scale and offer it to the god whose image was on the prow of the canoe.”

Stones of plenty and talismans

Besides the control exercised by numerous marine divinities who received sacrificial offerings so as to ensure, in return, an abundance of species (*kauhune*), there were other means designed to influence fishing. Fish-shaped stones, called *puna-ika* (literally “source-fish”), were used to promote that species' natural reproduction (Babadzan 1993). After being filled with *mana* in the *marae* and pointed in a certain direction, they were supposed to attract the species towards land or to inside the lagoon.

Different kinds of fish-talismans, which were wrapped up and tied in a ball (*pōpō*), were also used. According to Stimson and Marshall (1964),

“After been sun-dried it is taken to a *marae* and subjected to rites and incantations by the *tāura*. It is then sewed into a small plaited pandanus receptacle and is ready to be taken on a voyage to another land, and is believed to draw all the fish of the same species to the new land. = *popoika*, *polo-i-fano*, *take-kāoa*.”

Ritual turtle eating

On 'Anaa, when a chief wanted to eat turtle, the religious expert *tahuga* carried out the *Huki no Matariki e Takero*⁵ rite, a ceremony where conciliatory incantations were made to Matariki (the Pleiades, associated with female turtles) and to Takero (Orion's belt, associated with male turtles). The priest and his men would go to the designated spot at the end of the day just before dark. Each one had a ceremonial spear (*rakau huki*) about a metre long and decorated with red feathers (*kura*). The day following the ceremony, a turtle was supposed to appear on the shore. If the spear had been pointed towards Takero, it would be a male turtle, if it had been pointed towards Matariki, it would be a female turtle. Following the ceremony, a prayer (*pure no te honu i te moana*) was recited before the fishermen went out to sea, while at the same time passing the upturned hull through the heat of a torch (Stimson and Marshall 1964). Catching a turtle was always a big event in the Tuamotus and brought about a series of protocols that made it impossible to describe in detail here (Emory 1947; Conte 1988).

⁵ The *huki* was a chant or an incantation designed to make a turtle appear during a ceremony where ceremonial spears were pointed at Takero and Matariki; as on 'Anaa *huki* means “to point the finger or a stick at” (Stimson and Marshall 1964).

Conclusion

The ancestral fishing techniques of the ancient *pa'umotu* were the result of adapting centuries of empirical observation of the biodiversity to the atoll environment, which then allowed them to establish very precise terminology. However, this “science of the concrete” as described by Levi-Strauss (1962) cannot be separated from the symbolic and religious context in which it evolved. We were able to provide an overview of how the ancient *pa'umotu* of 'Anaa used their marine resources, with the help of the outstanding information from Paea-a-Avehe that Stimson collected in the 1930s. Other resources not mentioned here, such as shells (particularly giant clam), crustaceans, and certain edible seaweeds, were also important as additional food items on these coral islands.

While in the Tuamotu Islands, changes related to evangelisation and colonisation took effect more slowly than in the other island groups, thereby allowing very precise knowledge about fishing to be preserved, but that knowledge is now endangered. The goal of this article is to keep such knowledge from gradually disappearing from our collective memory.

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Making Hong Kong's coastal wetland a resource for tourism development: A cross-cultural and multi-disciplinary project to understand historical background and coastal heritage

Sidney C.H. Cheung¹

Introduction: Wetland tourism

Wetlands are ecotones, or transition areas, where aquatic and terrestrial sets of ecological or environmental characteristics coexist and interact in marshes, swamps, and bogs, among other types of environment. Besides their ecological characteristics, wetlands offer a rich landscape for understanding changing life ways, including such phenomena as an influx of migrants, the formation of fishery villages, relationships with traditional villages such as the South Chinese lineage settlements in the case of Hong Kong's wetlands, and the communal livelihoods of former fishermen. Such phenomena all demonstrate coastal resource management from local perspectives.

As an example, the coastal area of Inner Deep Bay, in northwestern Hong Kong, has been changed according to the needs of Hong Kong society. The Inner Deep Bay now contains of: 1) the Mai Po marshes, an internationally renowned wetland and a Ramsar Convention site; 2) major freshwater fish farming grounds; and 3) residential areas with both old and new dwellings.

The social and cultural aspects of wetlands, therefore, should not be overlooked. Further, the development of wetlands for tourism could serve as an excellent educational device to understand the fast-changing modern society of urban Hong Kong, and the transition of wetlands from agriculture to other types of usage for visitors coming from both urban Hong Kong and overseas.

The ecological characteristics of the Mai Po wetlands have received special attention since 1976 when they were designated a reserve site and resting place for migratory birds travelling between Siberia and Australia. However, fish farming communities along the buffer zone have been neglected because of both their migratory historical background and the shrinking importance of primary industry in contemporary Hong Kong.

In this article, I use the example of Inner Deep Bay to illustrate and understand the competition between agriculture, fishery heritage management, and environmental conservation (Cheung 2007, 2008). In other words, I explain the historical development of the co-existing three components in the coastal wetland, and from that suggest reconsideration of the importance of fishery heritage in the context of wetland conservation.

Along the coastal area of Inner Deep Bay, there exists traditional lineage settlements, the history of which can be traced back some 800 years, and whose rice cultivation practices supposedly have been used for several hundred years (Cheung 1999, 2009). Besides those inland agricultural areas, at the beginning of the last century a major conversion of coastal wetlands into agricultural land took place in Tin Shui Wai. These wetlands underwent different land-use stages, including a mudflat, rice paddies, reed fields, and shrimp and fishponds. Finally a part of the wetland was retained as a reserve (Mai Po Marshes Nature Reserve) and public park (Hong Kong Wetland Park), whereas the rest is now modern public and private residential areas, like Tin Shui Wai. Fishpond areas are maintained as farms by senior fishermen whose average age is over 60.

Understanding natural conservation on the coast

With intensive rural development and increasing property values since the late-1970s, land administration in the New Territories of Hong Kong has become vastly more complicated than before. Much of the complication is a result of land usage having shifted from the primary production of agriculture and fishing to industrial and new town development. Hong Kong society increasingly needs more land for development. At the same time, however, the government has become more aware of the importance of environmental conservation and sustainable development as priorities in future land and social policies.

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The Mai Po marshes, in northwestern Hong Kong, are an internationally renowned wetland area, known for decades as a resting place for migratory birds. The ecological characteristics of Mai Po have received special attention since 1976, when they were designated a “Site of Special Scientific Interest” (SSSI). The surrounding fishpond areas of the Inner Deep Bay are an integral buffer zone that serves as a water storage facility and hence reduces seasonal flooding. The bay contains species similar to the ecological system in the Mai Po marshes (Chu 1995; Irving and Morton 1988). Given the various kinds of social, economic and physical pressures faced by contemporary Hong Kong, the fishponds and buffer areas of the wetland in Mai Po are under great threat of being lost. The threat is particularly serious because the fishponds of Inner Deep Bay serve not only as a mitigation zone and source of traditional local food, but also as a major food supplier for migratory birds. This adds to the conservation value of Mai Po marshes in particular, and Inner Deep Bay in general.

Further, Inner Deep Bay has its own traditional freshwater fishing industry that probably dates back at least 70 years (Cheung 2007, 2011). Since the mid-1940s, Inner Deep Bay has been the main site for cultivating *gei wai* shrimp, grey mullet, snakehead, and other freshwater fishes; and for decades it has provided the major supply of freshwater fishes in Hong Kong. Inland freshwater pond cultivation was a major industry in the 1970s, when it supplied most of the freshwater fish for the local market. For example, until the 1980s, grey mullet comprised 40–50% of the local inland fish catch in Hong Kong, and was used widely for banquets and ceremonies. Migratory birds resting in the marsh consumed “remainders” from fish farming.

Agriculture is certainly not a major industry in contemporary Hong Kong; however, that does not imply that it should not be understood or maintained for purposes other than its economic contribution to society. Just as the history of the local fishery reflects social development and cultural change in Hong Kong, it is important to strive for a holistic understanding of the industry in both the past and the present. With less than 300 fishing households, the fishing communities located mostly at the buffer areas of the Mai Po wetland are now facing tremendous changes. Apart from the emphasis on traditional industries as a kind of cultural heritage among scholars, the debate on heritage conservation has successfully attracted the attention of urbanites, who consider traditional industries an important part of their collective memory of society (Cheung 2013).

Cultural history of Hong Kong’s northwestern coast

Before presenting a detailed description of the coastal resources for a tourism development project, some cultural background information about villagers in the New Territories should be provided. For example, by looking at the physical nature or geographical landscape in the New Territories, one could imagine that there is a greatly different cultural tradition between the east and west sides of the hinterland. Divided by a mountain range located almost in the middle of the entire New Territories, the western side is fertile flat land consisting of a few early-settled clans with their lineage network in many parts of the Pearl River Delta area (Fig. 1). These are fundamental in the cultural history of the New Territories, and should serve as significant cultural attractions for tourists visiting Hong Kong. Therefore, based on this objective, a knowledge transfer project was designed for this area.

Tourists arriving in Hong Kong are often guided to shop and sample a variety of cuisines in the Central, Tsimshatsui, Causeway Bay, Mongkok areas, among others, and thereby to enjoy the unique atmosphere of Hong Kong as an Asian metropolis. However, the dominant image of Hong Kong as a “destination of consumerism” fails to impart either much sense of local culture or provide a chance to experience tradition and heritage. Hong Kong is unique, and this aspect is not done justice by featuring only its business-oriented and materialistic character. At the same time, local residents, particularly the younger generation, that are brought up in an urban lifestyle do not necessarily have the time and knowledge to enjoy the nature, heritage and culture that rural communities can provide.

Promotion of the landscape, foodways, and community lifestyles through tourism can regain the public’s awareness and educate visitors about the unique heritage of Hong Kong and enhance the overall quality of life. Thus, the project described below is being undertaken. The project is developed jointly by the Department of Food and Nutritional Sciences, of the Faculty of Science, the School of Hotel and Tourism Management, of the Faculty of Business Administration, and the Department of Anthropology, of the Faculty of Arts, all of the Chinese University of Hong Kong, with support from the World Wide Fund (WWF)-Hong Kong and eTV online of Radio Television Hong Kong (RTHK).

A book project for tourism promotion

The project aims to transfer knowledge generated by various groups or stakeholders, including



Figure 1.

The Pearl River Delta

(Map by Croquant: https://commons.wikimedia.org/wiki/File:Pearl_River_Delta_Area.png?uselang=fr).

farmers, bird watchers, conservation groups, and others, to both domestic and international visitors to Inner Deep Bay and neighbouring areas such as Yuen Long, Tai San Wai, through an integrated ecotourism package designed from a multi-disciplinary perspective. Based on these research findings, this project aims to attract the general public to coastal development through creating “a four seasonal models of wetland tourism package”. The emphasis on seasonal change in the area would serve not only to attract people to make multiple visits, but would also enhance their appreciation of life cycles in both nature and local rural communities. The seasonal model is based on the following three major categories of attractions available during the four seasons:

1. **Scenery and landscape** – mangroves in autumn, flowers and plants in different seasons, reeds, migratory birds in winter, water birds, buffalo, landscape.
2. **Foodways and nutrition** – fish (grey mullet, eel, carp), shellfish (oyster, shrimp, crab), and wild boar; fruits such as lychee, banana, jack fruit,

papaya, star fruit, dragon eyes; seasonal vegetables; festival cuisine, such as *punchoi* in spring and autumn, traditional cakes and dishes, seasonal delicacies, New Year food.

3. **Rural community lifestyles** – catching mullet fry in winter, fishpond drying in winter, *gei wai* harvesting in summer, Tin Hau Festival in spring, Lunar New Year, ancestor worshipping, fish market operation at midnight.

Methodology

This project will be carried out using the steps described below.

First, to find out what visitors and tourists would like to know regarding their expectations of cultural tourism and ecotourism, I will carry out two field visits or tours in each season. A total of eight tours with 120 visitors, both domestic and international tourists, will enroll. I will work closely with WWF Hong Kong and eTV online of RTHK to advertise the workshops by e-channel. Prior to field visits, a

workshop will be held to brief visitors regarding the key aspects that they can expect to see, and they will complete pre-visit surveys. Visitors will then take a guided walking tour led by one of the project's team members or research assistants. On each tour, participants will experience first-hand, the local context of the coastal wetland area, and will meet contact people and receive background materials. After the visit, participants will be given a post-tour survey questionnaire that attempts to elicit their perceptions, opinions and comments regarding the tour. Interested participants will also be invited for additional focus group sessions to participate in in-depth discussions and receive detailed information.

Second, in-depth interviews will be conducted with stakeholders (e.g. farmers, villagers, green groups, and shoppers) in the local community to tap into their knowledge and stories about their activities and strategies. In the focus group sessions of participants from the seasonal field visits and tours, visitors will be encouraged to express freely their opinions about and interest in visiting the area. Information gathered from these interviews and coupled from the visitors' workshops, surveys and focus group sessions will be used to: 1) produce informational leaflets for general distribution, 2) construct an interactive website, and 3) make walking maps for tourists to explore the history and culture of the Inner Deep Bay area.

Third, a book in Chinese was published for both secondary school teachers of general education subjects and domestic and/or international tour organisers (see Fig. 2 for a sample of one chapter). They will be able to use it for visitors and tourists to achieve a holistic understanding of our coastal development from a seasonal and multi-disciplinary perspective. The book contains information on the four seasonal models of wetland tourism package that will be produced. Besides giving visitors detailed information on migratory birds passing by the area, the guidebook will describe relevant seasonal characteristics of the fishing grounds and community life in the area.

The following are two short sample descriptions.

1. Starting from the last month of the lunar calendar, mature grey mullet lay eggs in waters near the shore for two to four months. The fry that are caught by fishermen during this period will be named according to their time of birth, using such names as Little Chill, Big Chill, Jiaochun and Fanhua (小寒、大寒、交春和翻花). These names may sound strange to consumers, but for fishermen income during the coming year depends on the birthday of the small fish. Those fish that are born earlier are usually stronger

and have a higher survival rate so that fishermen are often willing to pay a high price for these early-born fry. Fishermen are also willing to pay more to ensure they have an adequate number of fry to utilise fishponds.

2. In Hong Kong, over 90% of the fish farms are engaged in polyculture (grey mullet, bighead carp, silver carp, common carp, grass carp in combination with tilapia or snakehead). In a traditional fishpond, grass carp and grey mullet usually live in the upper zone as they like to forage and stay near the water surface; bighead carp, silver carp and tilapia like to float in the middle zone; while common carp and spotted snakeheads, both of which are carnivorous, are found at the bottom. Local fishermen use these carnivorous species to control the number of tilapia that reproduce in the fishpond because tilapia have less economic value.

Concluding remarks

This project uses cross-cultural, multi-disciplinary, and critical approaches to understand the historical background and coastal heritages of Hong Kong society as a social-cultural basis for sustainable ecotourism development. Besides being a coastal wetland tourism model on the northwestern side of Hong Kong, this kind of nature and community visit contributes to the local awareness through the interactions between visitors and tourists and local communities.

For the long term, the prototype developed in the Inner Deep Bay area may serve as a model so that more coastal natural environments in mainland China would be re-considered for ecotourism development. In this way, communities' awareness of being promoters for Hong Kong tourism can be enhanced, and inbound and domestic tourists can enjoy and benefit from learning how Hong Kong has been developed into a world class city from an everyday life perspective. Most importantly, the collective knowledge of a community can be preserved and passed on from each generation.

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3 香港濕地公園

景觀
 香港濕地公園位於天水圍北部，於二零零六年五月開幕，其所處的土地原本擬用作生態緩解區，以彌償因天水圍的都市發展而失去的濕地，作為一項生態緩解設施，公園集合自然護理、教育及康樂用途於一身，以室內展館和戶外保護區，向參觀者展示濕地生態系統的作用和介紹香港濕地之生物多樣性。

「訪客中心—濕地互動世界」是室內主題展館，分別展出有關生物多樣性、文明發展和自然保育展品。佔地六十公頃的「濕地保護區」包括人造濕地和為水禽而重建的生態環境，設有淡水沼澤、水地、蘆葦林、泥灘、紅樹林、草地及林地。三間分別位於河畔、魚塘和泥灘的觀鳥屋引領遊客走進不同的生態，尋訪各式各樣的有趣生物。還記得二零零三年在天水圍以其發現的兩隻貝貝嗎？牠屬於稀有的品種，遊客現在可以在園內的「貝貝之家」跟牠見面。此外，遊客還可以在「浮神視察徑」、「渡昔之路」和紅樹林浮橋近距離欣賞各式各樣的野生動物植物，是一處成人和小孩都感到身心舒暢的好地方。

公園開放時間：星期一至星期三早晨九時，公眾假期 上午十時至下午五時
 (逢星期二休息)
 (資料來源：香港濕地公園官方網頁 www.wetlandpark.com)

6 流浮山

景觀
 流浮山本來是位於於天水圍西面和鹿村以北的一座山丘，但後來泛指沿海岸一帶的農耕村落。流浮山靠近海灣，與深圳蛇口遙遙相對。自古以來，流浮山以出海海鮮聞名，海產食品交易活動旺盛，是粵界西北主要的海產供應地。直到今天，在每日的破曉時分，大批內地漁船和輪船都會停泊在後海灣的深海水域上，準備卸卸新鮮捕獲的水產。不過由於流浮山岸線水淺，漁民利用駁艇將海產從海中心運到碼頭零售，成為了香港一處有趣的景觀。當很多人還在熟睡的時候，漁民已經忙碌地把一艘又一艘海產拉上流浮山魚市場進行批發，而海鮮檔商人和食肆買家就準備交收、檢驗貨物，然後掛上卡車送到市區。早上九時多，當批發活動完結，流浮山大街就化身成為遊客區，一層又一層的海味手信店，海鮮餐廳開始營業，狹窄的街巷整天都熙來攘往，非常熱鬧。日落時分，位處香港西陲的流浮山是觀賞夕陽晚景之勝地。

楊氏的魚塘面積大，所以都使用機器餵飼以節省人手，每隻員工只有十名。除了飼養羅漢(例如龍蝦)的魚塘外，每個魚塘均放置了一至兩層飼料機，工人只需要每星期把飼料放在機器中便可(平均一百五十斤魚需要九十公斤飼料)，羅漢的魚為了「勢力範圍」的意識，牠們各自有既定的活動範圍，為了使魚塘裏每一條魚都可以吃得到飼料，他們就以手把飼料送到魚塘的不同位置。他又認為單一飼料飼養的方法已經過時，以烏頭為例，烏頭需要百分之廿七的蛋白質，但是羅漢烏頭的飼料有百分之三十是動物和植物蛋白質，花生能含有百分之四十五的植物蛋白質和大量的油分，因為現在農產品的價錢較以前高，所以羅漢良不認為要繼續使用花生飼料，牠用跟啫魚油膠飼全蛋，雖然成本較高，但是味道卻較好。楊福良以科學的方法選擇飼料，是他認為現在要採用科學方法才能跟上時代步伐，台灣的普通法便是一個很好的取經對象。

「楊氏水產」現已打出名堂，楊福良打算將來實行特許經營——准許其他魚塘加盟「楊氏」，但必須遵照楊氏的養殖法和嚴格管理來保證品質。現在香港市場開始轉型，牠會先用兩至三年的時間在內地鞏固其品牌。在二零零八年才在內地建立分銷，地點會以廣東省、福建和海南島一帶為主。

春

花草

老鼠薈
 Spiny Bears Breech
 (*Acanthus ilicifolius* Linn.)
 消比科 *Asarumaceae*

通常被視為一種香港常見的「野紅樹」，普遍只有一至兩米高。花朵白中帶紫藍色，一至五月是開花期。葉子的邊緣呈大鋸齒狀，質地堅硬；果實的形狀和老鼠十分相似，是橢圓形的蒴果加上一條小「尾巴」。

秋茄樹(水筆仔)
 (*Kandelia obovata*)
 紅樹科 *Rhizophoraceae*

香港最常見的真紅樹之一，生長在紅樹林、沙坪和泥灘等地。花果幾乎全年可見，它的蒴果本為兩厘米左右的小圓錐形，後經轉彎發育至約二十厘米長，像一枝枝懸垂的草，掉落在泥土後發芽生長成一株新樹。花開五枚，包含自細圓成繖狀；花萼五裂，呈白色星形。

Figure 2.
 Five pages of a book in Chinese detailing Hong Kong wetlands resources. It has been produced for both secondary school teachers and domestic and/or international tour organisers.

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Glenn Richard Almany, 14 August 1967–24 March 2015

Glenn Almany, dear friend, father of two young children, and husband of Jeanine, passed away on March 24th 2015. His wife and parents were with him in Montpellier, France at the time. Glenn had a larger-than-life personality, and his humour, knowledge and friendship will be sorely missed by all of us who were privileged to know him. A marine scientist who was becoming increasingly renowned for his groundbreaking work on the dispersal patterns of coral reef fish larvae, Glenn will be remembered for the way in which he worked with Pacific Island communities to tackle applied research questions on fisheries management.



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Glenn's path into a career in tropical marine science was unique. At 17 years of age he left his parents' home in Southern California and joined the US Navy on a quest to see the world. He spent the next six years working as a reactor operator on a nuclear submarine. It was while in the US Navy that he developed his love for coral reefs. Glenn spent several weeks in Guam while his boat underwent repairs, and during that time he dove on coral reefs for the first time. Unlike the waters off of California, the tropical Pacific was warm, colourful and full of so many species he had only ever encountered in books. This experience changed Glenn's life forever, and it was during this time he decided to become a marine biologist.

After leaving the US Navy, Glenn completed in 1996 a BSc at San Francisco State University and a PhD at Oregon State University, in 2002. His postgraduate research focused on coral reef fish ecology, with much of his fieldwork conducted in the Caribbean. He received a Fulbright Postgraduate Scholarship in 2003 and travelled to Australia to undertake studies on marine reserves. I first met Glenn in 2005. By then he was working as a research scientist at James Cook University and I had recently begun working as a conservation scientist for The Nature Conservancy. We quickly became very close friends, and from 2006 to 2014 we undertook a series of research programmes to investigate the larval connectivity patterns of large coral reef fish in Papua New Guinea and Solomon Islands. These programmes were ambitious in scale, but the fieldwork was made possible by our participatory approach that drew on the support and engagement of a large number of community fishers.

Glenn was an avid reader and a great story-teller, and over the years I learned an enormous amount from him during the many conversations we had while sitting on canoes in the Bismarck Sea, or camping on remote islands in the Solomon Islands. A brave individual who never shied away from a challenge, he survived crocodile encounters, malaria, being lost at sea, and beating an aggressive form of blood cancer, all the while maintaining his positive spirit. Although Glenn beat the cancer, ultimately he could not survive the many complications that arose from the arduous 15 months of treatment.

Gone far too soon, this photo of Glenn was taken in Pere village, Manus, Papua New Guinea. It sums up how I knew him. A brilliant scientist with a deep green core, Glenn was deeply concerned with making a meaningful difference in this world. Here he is in Manus, surrounded by children, and using his expertise and knowledge to try and make their future brighter.

Rest in peace my friend.

Richard Hamilton

Glenn Richard Almany achievements and contributions

Education

- Doctor of Philosophy (PhD) Oregon State University (USA), September 2002
Thesis advisor: Professor Mark A. Hixon
Thesis title: "Role of priority effects and habitat complexity in coral-reef fish communities"
- Bachelor of Science (BSc) San Francisco State University (USA), January 1996
summa cum laude (3.96 GPA)

Publications (in chronological order)

- Green A.L., Maypa A.P., Almany G.R., Rhodes K.L., Weeks R., Abesamis R.A., Gleason M.G., Mumby P.J. and White A.T. in press. Larval dispersal and movement patterns of coral reef fishes, and implications for marine reserve network design. *Biological reviews of the Cambridge Philosophical Society*.
- Priest M.A., Almany G.R., Braun C.D., Hamilton R.J., Lozano-Cortés D.F., Saenz-Agudelo P. and Berumen M.L. in press. Isolation and characterization of 29 microsatellite markers for the bumphead parrotfish, *Bolbometopon muricatum*, and cross amplification in 12 related species. *Marine Biodiversity*
- Robinson J., Graham N.A.J., Cinner J.E., Almany G.R. and Waldie P. in press. Fish and fisher behaviour influence the vulnerability of groupers (Epinephelidae) to fishing at a multispecies spawning aggregation site. *Coral Reefs*.
- Almany G.R. 2015. Marine Ecology: Reserve networks are necessary, but not sufficient. *Current Biology* 25, R328–R330.
- Green A.L., Fernandes L., Almany G.R., Abesamis R., McLeod E., Aliño P.M., White A.T., Salm R., Tanzer J. and Pressey R.L. 2014. Designing marine reserves for fisheries management, biodiversity conservation, and climate change adaptation. *Coastal Management* 42:143–159.
- Wen C.K.C., Almany G.R., D.H. Williamson, M.S. Pratchett, T.D. Mannering, R.D. Evans, J.M. Leis and G.P. Jones. 2013. Recruitment hotspots boost the effectiveness of no-take marine reserves. *Biological Conservation* 166:124–131.
- Almany G.R., Hamilton R.J., Bode M., Matawai M., Potuku T., Saenz-Agudelo P., Planes S., Berumen M.L., Rhodes K.L., Thorrold S.R., Russ G.R. and Jones G.P. 2013. Dispersal of grouper larvae drives local resource sharing in a coral reef fishery. *Current Biology* 23:626–630.
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- Rhodes K.L., Taylor B.M., Wichilmel C.B., Joseph E., Hamilton R.J. and Almany G.R. 2013. Squaretail coral grouper *Plectropomus areolatus* reproduction in Pohnpei, Micronesia, using age-based techniques. *Journal of Fish Biology* 82:1333–1350.
- Wen C.K.C., Pratchett M.S., Almany G.R. and Jones G.P. 2013. Patterns of recruitment and microhabitat associations for three predatory coral reef fishes on the southern Great Barrier Reef, Australia. *Coral Reefs* 32:389–398.
- Cvitanovic C., Wilson S., Fulton C., Almany G.R. and 31 others. 2013. Critical research needs for managing coral reef Marine Protected Areas: perspectives of academics and managers. *Journal of Environmental Management* 114:84–91.

- Wen C.K., Almany G.R., Williamson D.H., Pratchett M.S. and Jones G.P. 2012. Evaluating the effects of marine reserves on diet, prey availability and prey selection by juvenile predatory fishes. *Marine Ecology Progress Series* 469:133–144.
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Other publications

- Feary D.A., Hamilton R., Matawai M., Molai C., Karo M. and Almany G. 2014. Assessing sandfish population stocks within the south coast of Manus, and a summary report of sandfish connectivity field research. May 19–June 27, 2014. Final Report.
- Hamilton R.J., Almany G.R., Matawai M., Potuku T. and Planes S. 2011. A report on the Kekwa (Bigmaus) connectivity study in Southern Manus, Papua New Guinea.
- Jones G.P., Ablan Lagman M.C., Alcala A., Almany G.R., Botsford L.W., Doherty P.J., Green A., McCook L.J., Munday P.L., Planes S., Russ G.R., Sale P.F., Steneck R.S., Thorrold S.R., Treml E.A., van Oppen M.J.H. and Willis B.L. 2008. Connectivity and the design of marine protected area networks in the Coral Triangle. Background papers, Coral Triangle Initiative. ARC Centre of Excellence for Coral Reef Studies.
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- Pearson D.E. and Almany G.R. 1995. The effectiveness of California's commercial rockfish port sampling program. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-218, June 1995.

Awards

Australian Research Council Future Fellowship	2010–2014
Australian Research Council Fellowship	2006–2009
National Science Foundation Fellowship	2004–2005
Fulbright Scholarship	2003
Oregon Laurels Fellowship	1996–2000
National Science Foundation Fellowship	1996–2000

Editorship

Coral Reefs	2010–2015
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Graduate Student Supervision

PhD thesis	Hempson T.N. Coral reef predator trophodynamics in response to reef condition (2013–).
	Waldie P. Developing a community-based ecosystem approach to fisheries management for large aggregating groupers on Indo-Pacific coral reefs (2012–).
	Robinson J. Disentangling the causes of vulnerability to fishing in reef fishes that aggregate (2012–).
	Wen C.K.C. Recruitment hotspots and their role in the ecology and management of large exploited predatory fishes (2008–2013)
	Bonin M.C. Patterns of microhabitat specialization and the consequences of coral degradation for coral-associated reef fishes? (2005–2010)
	Feary D.A. Effects of coral bleaching and crown-of-thorns starfish predation on coral reef fish communities. (2003–2007)
Honors thesis	Peacock L.F. Effects of predators on diversity of juvenile coral-reef fishes. (2004)

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Original text: English

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