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Editor's note

This issue contains two articles. Both examine the protection of marine biodiversity and ecological functions through a management framework that hybridises local beliefs and/or institutions with modern management systems.

The first, "Fishing taboos: Securing fisheries for the future?", is by Philippa Cohen and Simon Foale, both of the Australian Research Council Centre of Excellence, Coral Reef Studies, at James Cook University, in Townsville, Australia. The authors review current knowledge from the tropical Pacific on periodic closures for fisheries management and conservation, demonstrate how contemporary fisheries science can be applied to the use of taboos for helping meet social, ecological and fisheries management objectives, and note important questions and issues to be asked and raised when either researching or using taboo closures for fisheries management and conservation. The authors caution that it is unwise to generalise about taboo closures, in particular owing to the great variability of ecological conditions and harvesting strategies among sites. They also caution that the use of taboo closures must also be understood within the complex and inter-related changes in social, economic and ecological contexts. Although undoubtedly useful, it is also important to keep in mind that the use of taboos will not address the deep-seated and underlying causes of overfishing. That must be dealt with at the national, regional and global scales.

The second article, "Hybrid customary and ecosystem-based management for marine conservation in the Coral Triangle" is by Shankar Aswani, of the University of California, Santa Barbara, USA. The author's general objective is to provide applied research guidelines for designing hybrid management systems to increase the social and ecological resilience of coastal communities in the Coral Triangle region (CTR), as they become increasingly confronted by resource overexploitation and the effects of global climate change. He examines ways of enhancing coastal and marine resources management and conservation, based on alliances among international institutions and local communities, community-based organisations, non-governmental organisations, and regional and national authorities in the CTR. In concluding, Shankar Aswani notes that although hybrid programmes offer an alternative way of managing marine ecosystems comprehensively, it is important to realise that this is not a panacea for all terrestrial and marine resource management problems.

In this issue, we have included a larger than usual number of fairly recent publications. These are, first, "Poverty mosaics: Realities and prospects in small-scale fisheries", edited by Svein Jentoft and Arne Eide, both with the

Norwegian College or Fisheries, located at the University of Tromso. Second is "Managing coastal and inland waters: Pre-existing aquatic management systems in Southeast Asia", edited by Kenneth Ruddle and Arif Satria. Ruddle is affiliated with RECERD (Research Centre for Resources and Rural Development) in Hanoi, Vietnam, and Arif Satria is a Dean at Bogor Agricultural University, Bogor, Indonesia. Third is "Fisheries management in Japan: Its institutional features and case studies", authored by Makino Mitsutaku. Dr Makino is on the staff of the National Research Institute of Fisheries Science, Fisheries Research Agency of Japan. These three books were published by Springer, in Dordrecht and Heidelberg.

It is with particular pleasure that I bring to your attention **"**Explaining human actions and environmental changes**"** by Andrew P. Vayda who, in some hundred articles and several books, has specialised mostly in methodology and explanation at the interface of social and ecological science. His research, often crossing disciplinary boundaries, has focused both on philosophical issues and on subjects ranging from warfare and migration to forest fires and insect pest management. He has directed and participated in numerous research projects on people's interactions with forests in Indonesia and Papua New Guinea. Still very actively involved in research on fire in Indonesian wetlands, "Pete" Vayda is now Professor Emeritus of anthropology and ecology at Rutgers University, in New Jersey, USA, and was formerly a professor at Columbia University, in New York City. He founded the journal *Human Ecology,* and for five years was its editor.

Although A.P. Vayda does not specialise in fisheries societies, we can all benefit by studying his approach to research and integration in the social sciences. Particularly refreshing is his perspective that integration will not occur if theory and methods are prioritised, as is now the vogue. Instead, Vayda argues that social research should focus first on the analysis of concrete events and the causal connections among them, and that theory and methods should be relegated to supporting roles. Please read this book; you will be enlightened and thereby rewarded. For sure it will make you think. And I, for one, hope you decide to emulate the approach Vayda advocates so lucidly.

Kenneth Ruddle

PIMRIS is a joint project of five 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), the Pacific Islands Applied Geoscience Commission (SOPAC), 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.

PIMRIS

Pacific Islands Marine Resources Information System

Fishing taboos: Securing Pacific fisheries for the future?

Philippa Cohen[1] and Simon Foale[1]*

Abstract

Taboos that temporarily close areas to fishing have long been practiced in the Pacific as a mark of respect for the death of a prominent community member, to protect sacred sites, affirm rights to fishing grounds, or allowing the replenishment of stocks in preparation for feasts. The use of customary taboos has declined, but contemporary initiatives to establish community-based management of marine areas promote their reinvention as small closed areas that may be subject to periodic harvesting. Taboo areas are now a prominent feature of many community-based initiatives and are touted as being a successful, traditionally based measure for marine management. There is evidence that taboo areas may confer fisheries benefits in certain conditions. However, there is little evidence that periodic closures will sustainably manage fisheries of the range of taxa exploited by small-scale and subsistence fisheries. This paper reviews current knowledge of periodic closures used for fisheries management and conservation, focussing on examples from the tropical Pacific. We highlight how contemporary fisheries science can guide the use of taboo areas as a tool to assist in meeting social, ecological and fisheries management objectives. We then outline critical questions and issues that need to be considered when researching and using taboo closures for fisheries management and conservation in the Pacific.

Introduction

Subsistence and small-scale fisheries exploitation form critical elements of food security and livelihoods of the largely rural and coastal populations of the Pacific. Pacific populations display very high rates of participation in fisheries and consumption of fresh fish (Bell et al. 2009). With relatively low population densities and rich marine resources, the Pacific has been somewhat shielded from the global fisheries crisis (Newton et al. 2007). Yet declines in catch rates, local extinctions and stock collapses due to intense fishing have all been reported in the region (Dalzell et al. 1996; Green et al. 2006; Uthicke and Conand 2005). Fishing pressure is projected to increase as populations rise and global pressures (e.g. climate change and trade) build, threatening biodiversity, ecosystem function and the well-being of Pacific peoples dependent on marine ecosystem goods and services (Bell et al. 2009). Community-based fisheries management and conservation initiatives are attempting to address this challenge by employing a range of resource use controls and governance strategies. This paper discusses the use of taboo areas or periodic harvesting of closed areas as tools to address some of the management challenges faced by small-scale and subsistence fisheries in Pacific Island nations and communities, now and into the future.

Traditional origins

Pacific societies are known globally for their intimacy with marine environments, including their cultural uses of marine resources and customary controls placed on those uses. Most famously, Johannes (1978, 1982) described some of these customary controls: tenure systems that limited access and fishing rights, bans on sectors of society consuming some species, prohibitions on fishing certain species or small individuals, and temporary closures or "taboos" placed over fishing grounds (henceforth referred to as taboo areas but known by many names throughout the Pacific; see Govan 2009b). Taboo areas that temporarily (rarely permanently) close areas to fishing have long been practiced in the Pacific as a mark of respect for the death of a prominent community member, to protect sacred sites, affirm rights to fishing grounds, or as part of preparation (i.e. allowing the replenishment of stocks) for customary feasting (Allan 1957; Hviding 1998; Johannes 1978). While customary taboos controlled the use of and access to resources, it appears that the main motivation for their use was socially and culturally driven and less likely motivated by the need or intent to manage resources sustainably (Foale et al. 2011). Conservation and fisheries management benefits may have resulted from the use of customary taboo areas in some cases. However, in

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others, customary closures did not result in resource management or conservation outcomes in any practical sense (Carrier 1987; Polunin 1984).

This paper reviews the contemporary use of taboos and their impacts on fisheries, largely leaving aside the discussions of the origins and intentions of customary taboo practice (this is discussed in depth in Foale et al. 2011). Yet in this discussion, it is critical to remember that social conditions, including the maintenance of social relationships, rather than ecological sustainability, were likely a primary motivator of taboo area use traditionally. This has important implications for their use in contemporary contexts, which we discuss.

Contemporary use

Community based or co-management systems currently employed in the Pacific embrace a hybrid model that considers and combines conventional approaches to marine resource management with traditional governance systems, calling on scientific, traditional and local knowledge (Govan 2009a; Johannes 2002; Ruddle 1998). These approaches have found traction in addressing small-scale and subsistence fisheries management challenges, where centralised management institutions had less success due to a lack of capacity and difficulties resolving state and traditional controls (Ruddle 1998). Community-based initiatives that aim to manage marine resources have been met with enthusiasm in the literature and in implementation. The result is that there are now many coastal communities in the Pacific employing a range of rules and resource use regulations that have been developed in consultation with partner support agencies; both government and non-government organisations (NGOs).

Many community-based resource management initiatives throughout the Pacific have promoted the re-establishment or re-invention of taboo areas as a key way of regulating resource use (Govan 2009b; Johannes 1978; Johannes 2002). In many areas where the traditional use of taboos had declined or ceased, contemporary taboos have been newly established. For example, in 27 villages in Vanuatu, fishing taboos re-commenced from 1990 for the first time in living memory (Johannes 1998b). Taboo areas can cover areas of reef, mangrove or shorelines and are generally small in size (e.g. in Fiji 179 areas had a median area of 1 km^2 (Govan 2009b)) and in Vanuatu down to 0.02 km^2 (Johannes 1998b). Govan (2009b) reports that now there are 595 area closures in the Pacific covering an area of 1,107 km^2. These closures range from "permanent" no-take marine reserves to areas that are predominantly opened and "periodically closed" to harvesting, to areas predominantly closed and "periodically open" (Fig. 1). While permanent no-take marine reserves do exist throughout the Pacific, they tend to receive lower levels of compliance and acceptance at the community level than closures that will at some point be harvested (Foale and Manele 2004). For example, within a sample of 81 marine area closures in Solomon Islands, 31% of closures were reported as rotational, 15% as periodic and 54% as permanent, where those classified as "permanent" may include areas that are intended to be periodically opened or opened if circumstances change (Govan 2009b).

While the tool is reportedly used for both fisheries management and conservation, there is little evidence that a strategy of periodic harvesting of taboo areas will confer greater benefits to habitats or biodiversity than continuous fishing. For example, no differences were observed in fish species richness and coral diversity between periodically harvested areas and openly fished sites in Muluk, Papua New Guinea (PNG) (Cinner et al. 2005a). On Ahus Island, also in PNG, species richness, live coral cover, or coral diversity did not vary significantly inside, compared with outside, of three periodically harvested areas (Cinner et al. 2005b). Conversely, anecdotal evidence from a periodic closure in Vanuatu suggests increases in biodiversity (Bartlett et al. 2009b). Unregulated fishing events on two reserves in the Philippines caused a decline in fish species richness in one reserve but not the other (Russ and Alcala 1998a). While ecosystem health relates to fisheries performance, there is a paucity of research pertaining to biodiversity and habitat responses to periodic harvesting strategies of management, and henceforth we concentrate on fisheries impacts.

Closing an area to fisheries exploitation can be a relatively simple fishery management action, particularly within community-based approaches or where

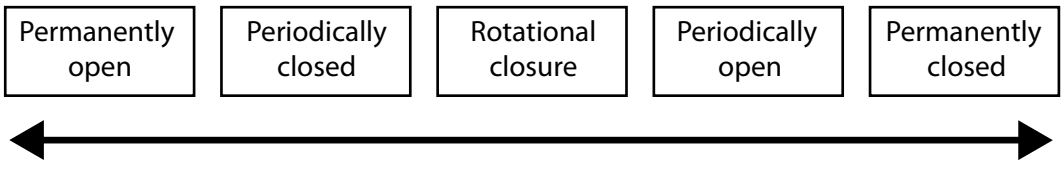

Figure 1. The spectrum of area closure and fisheries opening regimes practiced in the Pacific.

data to inform management is limiting (Hilborn et al. 2004; Johannes 1998a). Area closures are a useful tool for a holistic approach to management suited to multi-species fisheries; managing at the ecosystem level rather than species level (however, see discussion of scale in the section "Recovery and replenishment during closure") (Polunin and Roberts 1996). The characteristics of small-scale and subsistence fisheries (i.e. multi-species, multi-gear fisheries with large numbers of dispersed landing sites and high numbers of participants that can enter and exit the fishery as needs or challenges arise) offer many challenges to most forms of management. Taboo areas are touted by NGOs and some scientists in the Pacific as being a successful mechanism, with a traditional basis, to contribute to marine management and conservation. NGO enthusiasm for this tool may be due to the relative eagerness with which it is employed by Pacific communities. Community enthusiasm, at least in part, arises from its similarities with customary practice alongside observations of stock replenishment or increased catchability (i.e. the probability of an individual fish being caught) after the closure is lifted (further discussed in the section "Closures in combination"). Many communities may in fact be employing taboos in a contemporary context primarily to ensure a ready supply of fish and invertebrates for special events, rather than for any longer-term goals of sustainable management or conservation (Govan 2009b).

To date, there is sparse empirical evidence that taboo areas, and the closure-opening cycles employed in practice, can achieve sustainable management of a range of taxa exploited by small-scale and subsistence fisheries. The fisheries management benefits of periodic harvesting of taboo areas will be determined by the relationship between population recovery patterns during times of closure with patterns of population depletion when areas are opened to fishing. To illustrate elements of stock recovery and fisheries extraction and the implications for fisheries management outcomes, the following two sections of the paper review published case studies of taboo or periodically harvested areas in tropical zones, focusing on the Pacific.

Recovery and replenishment during closure

The recovery of exploited stocks and habitats that occurs when a fishing ground is closed to fishing is a complex process (Jennings 2001). There is little information specifically about recovery during closures of taboo areas, however we can also draw lessons from the permanent no-take marine reserve literature (Jennings 2001; Russ and Alcala 2003, 2004). Rates of stock recovery or replenishment will be *mechanism specific*, *site specific*, *time period specific* and *species specific* (Russ et al. 2005). For example, environmental and oceanographic conditions will influence the supply of new individuals (recruitment) or nutrients to local sites (Birkeland 1997). Food webs and habitat dynamics will have indirect effects on the recovery of populations (i.e. recovery rates of one species such as a predator) may be influenced by or be dependent on the abundance of another species (e.g. prey) (Russ et al. 2005). In addition, habitat recovery after an area is closed (e.g. increased coral cover due to less breakage by fishers) will increase the potential of some fish or invertebrates to replenish.

Life history characteristics make some taxa particularly susceptible to overharvesting and others more resilient (Cheung et al. 2005). It is anticipated that short-lived and fast-growing taxa will be more suited to periodic harvesting than those that are longer lived and slower growing (Jennings et al. 1999; Russ and Alcala 1998b). *Trochus niloticus* (trochus) is an example of a relatively short-lived, fast-growing species that was, however, observed by Bartlett (2009a) to be vulnerable to a periodic harvesting strategy employed in Vanuatu. In the Solomon Islands, taboos are commonly employed to manage trochus fisheries (Foale 1998) and communities perceive periodic harvesting regimes as a successful strategy for trochus due to observable recoveries during closure (A. Schwarz,[1] pers. comm.). In West Nggela, Solomon Islands, taboos were commonly placed on reefs to control the harvest of trochus. However, Foale (1998), observed that trochus populations were low when compared to well managed stocks and suggested that the fishery performed poorly where taboo areas were the main tool for managing the resource. In Aitutaki, Cook Islands, it was demonstrated that with adequate pre-fishing biomass, size limits and quota restraints, short periods of harvest of a periodically closed area was a successful management strategy for the trochus fishery (further discussed under "Closures in combination") (Nash et al. 1995).

Species within a multi-species fishery will recover at different rates and recovery can be non-linear (McClanahan et al. 2007). This adds to the complexity of managing multi-species fisheries where community expectations to harvest areas may not coincide with sufficient replenishment of some species. Higher trophic-level species, such as predatory fish, are often of higher economic and social value and, therefore, preferentially targeted by fishers (Jennings and Polunin 1995). However, high trophic-level species are often slow-growing,

Dr Anne-Maree Schwarz, Solomon Islands Country Manager, WorldFish Center.

long-lived and exhibit slow rates of population increase (Cheung et al. 2005) and, therefore, may not be well suited to a periodic harvesting strategy. Only after three to four years after a fishing event could a change be detected between the biomass of predatory fish in two fish reserves in the Philippines compared with nearby openly fished areas (Russ et al. 2005). The density and biomass of predatory fish were still increasing after 9 years of protection in one reserve, and 18 years year in the other (Russ and Alcala 2003). These are not examples of Pacific taboo areas, but rather of lapses in compliance with permanent closures where both duration of fishing and closure were longer than might be anticipated in Pacific taboos. They are, however, illustrative of replenishment times after fishing.

There are several cases that report positive fisheries benefits of a periodic harvesting strategy over a strategy of continuous fishing. Cinner (2005b) examined three periodically harvested areas on Ahus Island in PNG and observed that the average size of reef fish, but not fish abundance, was greater in taboo areas compared with adjacent openly fished areas — indicating growth but not population recovery. In the North Efate region of Vanuatu, higher abundance and biomass of fish were observed in periodically harvested areas compared with continuously fished areas (Bartlett et al. 2009a). Significantly more fish with vulnerable life histories and tridacnid clams (which also are slow-growing and long-lived) were observed in periodically harvested areas than in openly fished areas. However Bartlett et al (2009a) maintained that clams were susceptible to overfishing via a periodic harvesting strategy. In Muluk, PNG, three families of long-lived fish species with low population doubling times appeared to respond positively to a closure-periodic harvesting regime compared with continuous fishing (Cinner et al. 2005a). Additionally the mean trophic level of fish communities inside the periodically fished area was greater relative to openly fished control sites. Notably, these studies occurred in regions with low fishing pressure, indicating that taboo area strategies can have fisheries management benefits when fishing pressure is low, even for species deemed vulnerable to exploitation.

The ability of marine reserves to confer fisheries benefits is affected by size of the closures and scale at which ecosystems function (Nowlis and Roberts 1999). Generally, marine tenure and taboos operate on relatively small scales (Foale and Manele 2004). Species with relatively sedentary habits and with short-lived or demersal larvae may be well protected and display population increases within small reserves. Impressive evidence for this comes from Fiji, where a small taboo area, specifically designated to rebuild *Anadara* spp. stocks, resulted in increased abundance after 3 years, with a 13-fold increase in the closed areas and a 5-fold increase in adjacent fished areas, where fishers also experienced a doubling in catch per unit of effort (Tawake and Aalbersberg 2002). Conversely, species that have larger home ranges and long-lived larvae that disperse widely would not be as likely to be significantly protected or to self-recruit to small reserves (Roberts et al. 2001). Such species are, however, still of importance to small-scale and subsistence fishers in Pacific communities, and this emphasises the importance of employing management strategies that are alternate to or in conjunction with small area closures.

The ability of a population to replenish during a period of closure is also significantly influenced by recruitment processes. Recruitment at a particular site is affected by health of the standing stock at the commencement of the closure, oceanographic conditions, local and distant supplies of larvae, and habitat characteristics of the settlement site. There can be large variations in recruitment, both spatially and temporally, making it difficult to predict how a species will replenish in an area closed to fishing. For example in the Philippines, over a 17-year period, Sumilon Island reserve experienced two grouper recruitment pulses that resulted in 200% and 300% increases in density at the reserve, and a 1,000% increase in density in a non-reserve site. However, no such recruitment pulses were observed at the reasonably nearby Apo Island reserve over the same 17-year period (Russ and Alcala 2003). Additionally, the ability of populations to rebuild can become reduced or even lost when densities of mature adults are very low. This is known as the "Allee affect", and can occur in cases of severe overfishing (Stephens et al. 1999). In these situations, population growth is less than the rate of natural mortality and the population can continue to decline even in non-fished situations. In these cases, local closures to fishing and national moratoriums would need to be very prolonged, or may even be insufficient to recover populations. Examples from Pacific Island nations include sea cucumbers (Bell et al. 2008) and green snail (Ramohia 2006).

There is no consensus on the rates of replenishment of fished taxa after the cessation of fishing. Evidence ranges from a rapid 1- to 3-year recovery of abundance after fishing ceased (Halpern and Warner 2002) to evidence that full recovery of predatory fish may take 30–40 years (McClanahan et al. 2007; Russ and Alcala 2004). It is likely, however, that for some species, replenishment rates during closed periods may not meet community expectations or match the levels of exploitation during taboo openings. To achieve a goal of medium- to long-term sustainable fisheries management the duration of closure matters.

Patterns of harvesting and stock depletion

Harvesting patterns are the other key determinant of achieving sustainable fisheries management with a periodic harvesting strategy. It is, therefore, critical to understand the duration, frequency and drivers of opening areas to harvesting; only a handful of studies have documented these factors, however. Within the Pacific, the scheduling and duration of taboo area openings are generally under the control of the local community, clan or family that has tenure to the area. Many communities may in fact use taboos in contemporary contexts to ensure a ready supply of fish and invertebrates and base the timing of openings on occasions where need is high (e.g. Christmas or feasts) rather than on any higher goals of sustainable management (i.e. more akin to customary taboos) (Govan 2009b). In many contemporary contexts there is some level of influence about scheduling and duration of openings from a supporting agency (e.g. NGO or government partner), although the degree and nature of influence can be difficult to discern in the literature.

A wide range of durations, frequencies and drivers of opening contemporary taboo areas are reported throughout the Pacific. On Ahus Island, PNG, taboo area openings occurred between zero and three times per year where the opening was instigated for ceremonial events (Cinner et al. 2005b). In Muluk, PNG, the closure of a 50-ha area of reef occurred two to three times in a decade and remained closed for one to two years each time (Cinner et al. 2005a). Here it is reported that the decisions about where, when and for how long to place the taboo were made considering indicators of social and ecological factors (i.e. closing an area until fish become "tame" and easier to catch when spear fishing). In communities of Vanuatu's North Efate region, taboo areas had been subjected to single day harvest events, no more than twice per year and were harvested predominantly for subsistence or celebration purposes (Bartlett et al. 2009a). In West Nggela, Solomon Islands, closed areas were generally opened annually and late in the year for commercial trochus fisheries (Foale 1998). The clan with tenure to the area undertook intense harvesting for around three days and subsequently opened the area to harvesting by the wider community; the taboo could be installed again immediately or after several months. In Vanuatu, closure periods varied from between one to five years, to areas that were closed indefinitely and an area that would be opened only when "the area is ready" (Johannes 1998b).

In some cases, communities might commit to a more rigid schedule of opening and closure. For example, two bays in Roviana lagoon, Solomon Islands, commenced using temporal closures in 1999 to prohibit harvesting of *Anadara granosa* and *Polymesoda* sp. Areas were closed for eight months (September–April) and then harvested for four months (May–August) each year (Weiant and Aswani 2006). These case studies, alongside anecdotal evidence from the region, suggest that currently employed cycles of opening-closing of taboo areas can be fixed or dynamic, are generally driven by community decision-makers, and harvesting can be done to meet subsistence, commercial, cultural or ceremonial needs.

In addition to the duration and frequency of openings, the timing of harvesting openings can also be critical to fisheries management outcomes. Seasonal or biological changes in catchability can impact on the efficiency of harvest and the total quantities harvested during openings. A well-known example is the harvesting of grouper or other fish spawning aggregations that occur around the new moon, which can rapidly deplete the standing stock (Hamilton and Matawai 2006). Another example is from West Nggela, Solomon Islands, where fishers are aware of the fact that trochus are easier to catch a few days after full moon (Foale 1998). While harvesting at times or in areas of high catchability results in efficient returns for fishers, the impact on the breeding population and potential for overharvesting are increased. Management based on local or traditional knowledge may not explicitly lead to fisheries sustainability (Baines and Hviding 1993). In Milne Bay, PNG, fishers do not possess an awareness of the vulnerabilities of some species to overexploitation and their local knowledge was unlikely to translate to periods of closure or restraint in fishing that would be sufficient to avoid dramatic depletion or collapse of vulnerable stocks (Sabetian and Foale 2006). Where catchability varies through time, this should be considered in the planning of area openings and closures.

Alongside duration, frequency and timing of opening areas, the intensity of fishing and taxa targeted during times of area openings are equally critical to fisheries management outcomes. Again, only a handful of studies have documented fishing patterns during taboo openings, and few of these studies address impacts on abundance and long-term viability of the strategy. On Ahus Island, a single one-day harvest event (where harvesting occurred between zero and three times within any year) removed between 5% and 10% of fish biomass (estimated through underwater visual census and recording catch) from the taboo area (Cinner et al. 2005b). Although underwater visual census did not detect an impact of fishing on fish biomass in the area, a key and undeniably challenging question remains: "was the recovery of biomass during closure greater than or equal to the biomass extracted during fishing?" In cases in Hawaii and the Philippines, this proved not to be the case. A study of an area in Hawaii that experienced a

cycle of equal periods of opening and closure found that increases in fish biomass during closed periods were not sufficient to compensate for declines during open periods (Williams et al. 2006). In fishing reserves in the Philippines, where increases in biomass and abundance of predatory fish had occurred slowly during closure, unregulated fishing during reserve openings rapidly eliminated density and biomass gains (Russ and Alcala 2003).

Although differing from many taboo areas, the Philippines and Hawaii cases capture a critical point - that harvesting must at most match, but not exceed replenishment occurring during closure to achieve long-term fisheries sustainability (Fig. 2a). In situations where fisheries depletion is greater than recovery, we would expect an unsustainable situation (Fig. 2b). This highly simplified model is complicated by many factors previously discussed in detail. In summary, the same pattern of fishing in the same area will have different effects on different species. The same opening-closure cycle and fishing patterns will have different effects between areas. Importantly, in any one community or area, neither fishing patterns nor opening-closure cycles of taboo areas will be constant — in most cases these are dynamic and flexible — and will change with need, opportunity and local social and ecological conditions.

Shifting effort in time, space and sectors of society

Implementing taboo areas can shift normal patterns of fishing in both time and space. An area may have been open to continuous year-round fishing, whereas after taboo implementation, fishing effort occurs in that area only when it is open, resulting in "pulse fishing". Cinner et al (2005a) suggest that the positive fisheries effects observed in Muluk (particularly on more vulnerable species) may have been due to an overall lower or reduced fishing pressure inside that area compared with the continuously fished area. Yet "pulse fishing" when taboos areas become open can also be intense, particularly when fishers anticipate[1] higher catch rates and yields or social demands and needs are high (Murawski et al. 2005; Russ and Alcala 1998b). Periodic closures experiencing levels of effort and exploitation higher or equivalent to that experienced in openly fished areas would be unlikely to accrue benefits to fisheries (Russ and Alcala 2003).

Alternatively, or additionally, closing an area to fishing can shift effort onto other fishing grounds; if total fishing effort (e.g. of a community in their broader fishing grounds) is not reduced, this will intensify efforts on open fishing grounds (Hilborn et al.

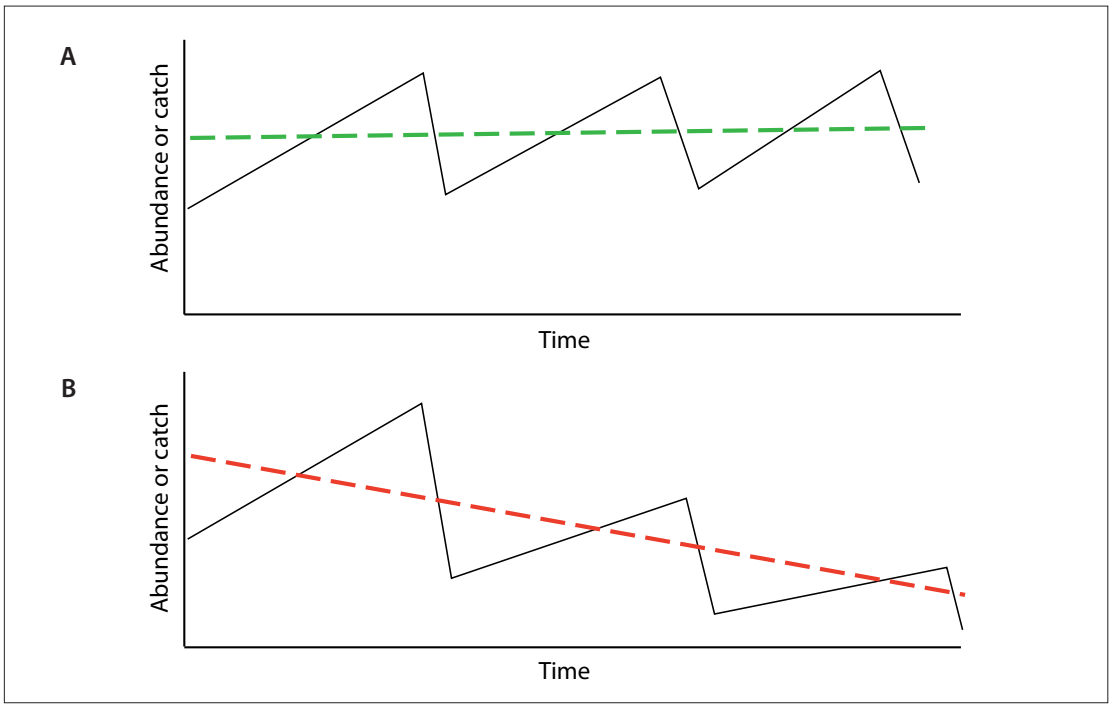

Figure 2.

A schematic of the stock or catch response to a closure-harvesting cycle; where closure to fishing supports the replenishments of stocks, while opening to fishing causes a decline. A) Represents a sustainable scenario, and B) represents an unsustainable scenario. The time and abundance or catch scales are subjective; dependent on on standing stock, frequency and duration of harvesting, fishing pressure, susceptibility of stock to harvesting and capacity of stock to recover.

[1] Murawski et al (2005) demonstrated that although fishers intensified fishing efforts on newly opened closed areas, higher catch rates and yields were not realised.

2004). Women from communities in Roviana Lagoon observed that when their two taboo areas were closed to harvesting, other open areas were more heavily exploited and impacted (Weiant and Aswani 2006). Periodic closures are unlikely to achieve overall fisheries benefits if effort is simply shifted from one place to another. The other potential effect of closing an area to fishing, particularly if effort is not reallocated to another ground, or open grounds are inferior, is a short- to medium-term decline in catch (McClanahan and Mangi 2001). A decline in catch or the increased effort (e.g. increased paddling time to fishing grounds) required to maintain catches imposes a cost on food security and livelihoods of community members. However, where areas are small relative to total accessible fishing grounds (as with many Pacific taboos) these effects may be minimal (Leisher et al. 2007). A final, but important, point on altering the accessibility to fishing grounds is that some sectors of society (e.g. women or migrants) may be differentially affected or excluded by closing areas; this should be considered in planning, particularly when the goals of management relate to well-being or food security (Vunisea 2008).

Closures in combination

Community-based management initiatives generally develop a range of rules in consultations between local communities and their NGO or government partners. Many NGOs and supporters of community-based approaches in the Pacific have emphasised that a whole-area management approach is required for successful fisheries management, with taboo areas as just one of a suite of management tools employed. Using taboo areas in combination with other strategies, such as alternative or other resource use controls, can alleviate or reduce the effects of concentrating effort into pulse fishing events, re-distributing effort to other fishing grounds, or in the case of alternative livelihoods, minimising impacts of immediate declines in catch. In this section we use examples from the literature to illustrate the concurrent use of resource-use controls, including limited access, size limits, species bans, catch limits and gear restrictions. We also discuss the roles of governance and monitoring.

Often, community-based management is developed using and sometimes reaffirming customary tenure boundaries and traditional governance institutions. Holders of tenure (clan, chief or family) have mechanisms for limiting entry and controlling use of areas or resources, and intact tenure is a likely prerequisite for the use of taboos (Cinner et al. 2005a; Foale and Macintyre 2000). Achieving compliance with a closure, or limits placed on harvesting, is an ongoing challenge for communities, even where traditional governance is intact and social capital is high (Cinner et al. 2005a). Some cases report "no limits on harvest" during opening seasons (Foale 1998; Weiant and Aswani 2006), although intact tenure will be one mechanism that works to limit the number of people harvesting. In sites in Vanuatu, Bartlett et al (2009a) reported that the intensity and frequency of harvests was regulated to ensure that ecological gains were not lost during harvests, although the regulatory measures and the factors contributing to their design were not explicitly stated.

Size limits and gear restrictions may be used in conjunction with taboo areas to minimise the impacts of fishing and better ensure sustainable harvests. Unregulated fishing events on Sumilon Island reserve included explosives and nets that can be destructive to habitats and very efficient at catching fish (Russ and Alcala 1998b). Both of these attributes significantly increase the period of time that habitats and stocks take to recover. In Vanuatu, at least four areas employing taboo closures were reported to apply regulatory measures when taboo areas were opened; these included bans on night spear fishing, commercial gillnetting, breaking corals while gleaning, and size restrictions on sea cucumber and mangrove crabs (Johannes 1998b). Some communities also emphasised the observation of government fisheries regulations, and resulting compliance with national size regulations on trochus was "rigorous in some villages but not in others" (Johannes 1998b). Also in Vanuatu, Bartlett et al (2009a) reported a concurrent ban on clam harvests in both taboo areas and openly fished areas. In the case of West Nggela, where taboo areas were employed to manage the trochus fishery, trochus populations were observed to be low. It was demonstrated with population modelling that both yield and egg-production could be significantly increased with enforcement of the (currently un-enforced) official minimum size limit of 8 cm (Foale and Day 1997).

The successful management of the Aitutaki trochus fishery via periodic harvesting demonstrated the value of quantitative assessment of stock condition prior to harvest to decide on sustainable catch limits. However, the reality is that other situations can be more challenging to assess and the level of effort and technical expertise required to accurately determine quotas may not be feasible for many Pacific fisheries (Johannes 1998a). Quantitative participatory research provides an option for monitoring and assessment of stocks, but to date, community-based, low-cost and minimal training underwater visual census techniques appear to be low in accuracy and precision and may be subjective (Leopold et al. 2009). Village-level perceptions of recovery, decline and fishing limits may be more appropriate. For example in Muluk, chiefs decided to close fishing grounds using their own fishing experience and reports of other fishers to determine if catches were too low, and then

employed closures so that fish would become easier to catch (Cinner et al. 2005a). However, perception-based assessments can be unreliable (Dulvy and Polunin 2004; Roberts and Polunin 1993). For example, Bartlett (2009b) found that community members provided perceptions of the success of periodic area closures based on assumption, as opposed to observation, in 90.2% of cases.

While long-term, detailed monitoring datasets are expensive and logistically demanding, there are issues that should be noted in the interpretation of shorter term monitoring data. In a review of many studies it was found that rapid rates of response to protection were reported by short-term monitoring whereas longer term studies indicated slower average rates of recovery, accounting better for variability (Russ 2002). Using relatively recent baselines for either quantitative or qualitative monitoring can be misleading. For example, observers may detect an increase in abundance when comparing pre- and post-closure abundance, and local perceptions could accurately account that "there are more fish"; however, this analysis would fail to highlight that the long-term trend is a decline (Fig. 2b). To further complicate monitoring, removing disturbance by fishers affects fish behaviour and makes fish tamer (Feary et al. 2011). This observation is common to Pacific fishers (Cinner et al. 2005a). If not accounted for then monitoring fish by perceptions may overestimate recovery after a period of closure or underestimate stocks after periods of fishing.

Periodic harvesting versus permanent closure

The main expected fisheries function of permanent reserves is the export of adults ("spillover") and propagules ("larval export") to sustain fisheries operating outside of the area (Russ 2002). The main expected fisheries function of taboo areas is to build stocks within the closed area to be directly and periodically exploited (there may be secondary effects of spillover and larval export but this discussion is not dealt with here; however, see Abesamis and Russ 2005; McClanahan and Mangi 2000). When employed as fisheries management tools both strategies aim to reduce fishing mortality (Russ 2002). Partial protection or periodic harvesting did confer fisheries benefits (e.g. higher fish biomass and abundance as observed at site in PNG and Vanuatu) over a strategy of continuous fishing (Bartlett et al. 2009a; Cinner et al. 2005a; Cinner et al. 2005b). However, permanent closures will accrue greater ecological benefits to populations and habitats within their boundaries than areas subjected to some level of use or fisheries exploitation (Lester and Halpern 2008). It is suggested that permanent closures can deliver fisheries benefits, but that benefits of rotational closures accrue slowly and are lost quickly (Russ and Alcala 2003). This is well illustrated with a quote from a Vanuatu village council member, explaining her preference for a permanent closure over a periodically harvested closure.

> "Well, when the chief opens a taboo and takes out the custom maker, we go catch fish, lots of fish. There are lots of resources when you first go in, but that is only for a short time. After we keep going in, then the numbers go down. So it is always up and down, up and down. But we want up and up."
>
> (Bartlett et al. 2009b).

However, increases inside a permanent closure will take time to deliver benefits to fishers (Hilborn et al. 2004) and the reduction of fishing grounds or catch may be something that some Pacific communities cannot or are unwilling to bear. Throughout the Pacific, permanent closures do not necessarily fit well with social, economic and consumptive needs of communities (Cinner et al. 2007; Foale and Manele 2004), whereas the implementation of periodically harvested closures appears to be met with relative enthusiasm, provides regular access to resources and does have potential to contribute to long-term fisheries management.

Conclusion

Taboo areas are a widely employed and relied on tool in community-based management of marine resources in the Pacific. Contemporary taboo areas: 1) resemble customary closures, 2) can be governed by local governance institutions, and 3) have been embraced as a management tool by governments, NGOs and communities alike. The successful governance and implementation of this tool are critical factors that can contribute to sustainable fisheries management. However, success in implementation does not equate to sustainable fisheries management. Generalising about the success, failure or potential of taboo closures is problematic due to the variability of ecological conditions and harvesting strategies; namely the period of closure, harvesting intensity, harvesting frequency, target species and ecological conditions, all of which vary greatly between sites and times.

Studies to date have not confirmed whether yield from periodically fished areas can remain comparable to that from areas open to continuous fishing, and this is critical to determining the local fisheries management value of this strategy. The strategy must also be understood in changing social, economic and ecological contexts; shifting respect for traditional or local authority, changes to fishing intensity driven by increasing or decreasing reliance on the sector, growing and urbanising populations, advances in fishing technology, developing commercial markets and climatic impacts on ecosystems. The root causes of overfishing will continue to challenge community based approaches and tools and must be

concurrently addressed at national, regional and global scales. Community based approaches to marine resource management, including the establishment of contemporary taboo areas, do convey a variety of important benefits that are not directly associated to fisheries (Govan 2009b). However, failure to meet expectations of "more fish" will no doubt result in disillusionment and a squandered opportunity to harness community enthusiasm. This can be avoided or at least minimised by applying best available local and scientific knowledge to periodic harvesting management and planning.

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Hybrid customary and ecosystem-based management for marine conservation in the Coral Triangle

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Introduction

Climate change has dramatically increased the levels of climatic and environmental unpredictability in the Pacific Islands region and, consequently, the vulnerability and survival of coastal communities. Understanding the social and ecological complexities that mediate between humans and the environment are extremely challenging. This is particularly true in coastal ecosystems, given the complex interactions among ecological, social, economic and political factors that occur within them (Cinner et al. 2005; Gelcich et al.2006; Liu et al. 2007). As marine ecosystems have become increasingly degraded, emphasis has been placed on finding more effective and holistic management tools to halt or ameliorate human impacts. These include, the implementation of multiple fishing regulations and quotas, marine reserves, and, more recently, ecosystem-based management.

Building on 20 years of multidiciplinary natural and social science research and applied conservation and marine resource management in the Coral Triangle region (CTR) (Fig. 1) (e.g. Ruddle 1998; Johanness 2002; Aswani and Hamilton 2004a; Cinner et al. 2006; Aswani et al. 2007), in this article I examine ways to strengthen coastal and marine resource management and conservation, while forming lasting alliances among international institutions (e.g. universities, development agencies) and local communities, community-based organizations (CBOs), non-governmental organizations (NGOs), and regional and national authorities in the CTR. The article illustrates ways for protecting marine biodiversity and ecological function of vulnerable ecosystems — and, consequently, peoples' livelihoods and food security — within a management framework that hybridizes local beliefs and institutions with modern management systems, such as ecosystem-based management (EBM). The general objective of this article is to provide research-applied guidelines for designing hybrid management systems to increase the social and ecological resilience of coastal communities in the CTR, as they face human-induced widespread resource overexploitation and the effects of global climate change during the coming decades.

Areas of interest of an hybridized customary management (CM) ecosystem-based (EBM) (Aswani et al. 2012) approach for the CTR should include:

1. Expansion of marine protected area (MPA) networks (as one of the primary tools of EBM) to protect biodiversity and ecological function of CTR marine ecosystems. Such expansion could be conducted autonomously and/or with the assistance of foreign institutions (e.g. NGOs, universities) in partnership with local churches, CBOs and NGOs, and traditional and provincial authorities. MPAs should incorporate local ecological knowledge and sea tenure institutions in their design.

2. Expansion of coastal and forest reserves for watershed protection across the CTR, using a similar approach to MPA design. Protecting terrestrial biodiversity is justifiable not only as an end in itself, but is also important for protecting adjacent marine environments susceptible to watershed environmental damage (e.g. logging and mining). Safeguarding coastal forests, mangroves and estuaries in tandem with all major marine ecosystems can better ensure the food security and livelihoods of coastal populations in the region.

3. MPAs may not always be feasible or can be complemented with additional management strategies. These could include gear and size restrictions, bag limits, bans on fishing certain reef functional groups (e.g. parrotfish), and other fishing restrictions. These should be incorporated into customary systems of management with the assistance of provincial governments' sanctioning and, where logistically possible, enforcement through monitoring and policing.

4. Document local understandings of ecological- and climate-related changes and possible

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adaptive measures, and match these data to existing scientific research for designing or adjusting existing adaptive and preventive management protocols. These data should be used to build at different scales (from local stakeholders to government departments) greater understanding of ecological- and climate change-related processes, and their relationship to coastal and marine resource mangement for increasing social and ecological resilience to environmental unpredicatability.

5. As part of a hybrid CM-EBM plan, develop the capacity of relevant national government ministry personnel, as well as local groups, including youth, women, and church groups, to undertake present and future assessments of climate and environmental change. This would allow for the development of adaptive and preventive management protocols that could be applicable across CTR coastal communities for responding to ecological and climate change-related transformations in the coming decades.

Integrating customary management and EBM for marine conservation

Customary management persists in many coastal communities of the CTR, despite economic and sociocultural modernization. Customary management systems are historically rooted practices that regulate the use of, access to, and transfer of resources locally, and which are generally informed by local ecological knowledge and embedded in customary land and sea tenure institutions (Cinner and Aswani 2007). A wealth of information has been gathered about how different socioeconomic, demographic, and political variables affect human territorial strategies and how such influences determine forms of governance in informal customary rights-based fishery management institutions (e.g. Acheson and Wilson 1996; Hviding 1996; Johannes 2002). In fact, mounting evidence shows that localized and largely community-oriented rights-based fishery management systems in Oceania, albeit context-dependent, can sustain biological resources and be successfully adapted to modern fisheries management, such as EBM. For instance, interdisciplinary studies have analyzed the effects of changing demographics and socioeconomic factors on customary management systems (Aswani 2005; Cinner et al. 2005), as well as the relationship between changing customary (traditional) or semi-customary (hybrid or nascent) management systems and the status of artisanal fisheries (Cinner et al. 2006; Turner et al. 2007), food security and health (Aswani and Furusawa 2007), and the effects of introducing diverse fishery management schemes (McClanahan and Cinner 2008; Aswani and Sabetian 2010).

These theoretical and practical insights are increasingly suggesting that these customary practices actually display many of the core principles of EBM, including protection of ecosystem structure and processes, focus on placed-based socioecological

Figure 1. The Coral Triangle region.

processes, recognizing interconnectivity within and between ecological systems, and integrating human socioeconomic and political processes (as per COMPASS 2005 definition). For instance, CM-inclusive stakeholders can enact resource access and use restrictions, gear restrictions, minimum size and catch limits, protection of breeding aggregations, and the establishment of temporal or permanent marine closures, all of which are management practices that are at the core of EBM plans, thus offering a significant socioecological context for their cross-fertilization (Aswani et al. 2012). More explicitly, how does CM overlap with EBM?

CM studies in Oceania, including cases from Polynesia (e.g. Malm 1999), Micronesia (e.g. Thomas 2001), Melanesia (e.g. Johannes 1998), and Australia (Peterson and Rigsby 1998), have shown that governance rights to sea space not only constitute tenure to geographical space, but can also encompass rights to specific habitats, technologies, and species, or a combination of these. These studies indicate that traditional institutions are diverse and dynamic (Ruddle 1998), and that they are capable of being amalgamated with EBM for a number of reasons. First, indigenous people in Oceania conceptualize their territorial estates holistically; that is, they do not dichotomize land and marine spheres of ownership. Sea and land spaces exist as a continuum, and indigenous cognitive categories do not dissociate these realms as westerners do (Klee 1980). Classical examples include the Fijian *vanua* (Veitayaki et al. 2005) or the Marovo (Solomon Islands) *puava* (Hviding 1996). For instance, Roviana people in the Western Solomon Islands do not cognitively disjoin land and sea spheres. The word *pepeso* literally means "ground," but it is employed as an inclusive property domain that is divided into four main zones: the mainland, the lagoon, the outer barrier islands and their adjacent sea-facing habitats, and the open sea. In the marine context, people then divide each of the above sea domains into named sites that represent biophysical resource exploitation areas, geomorphological features that allow or obstruct people from navigating, cultural and historical markers that define seascapes, areas of significant biological events (e.g. spawning aggregations), and areas nesting major and minor marine habitats (Aswani and Vaccaro 2008). This indigenous world vision corresponds with one of EBM's core principles — one that emphasizes the interconnectivity between and within terrestrial and marine ecosystems (Fig. 2). The indigenous environmental conceptualization differs, however, in that it is embedded in indigenous sociocultural and religious practices in a way that EBM is not in Western society, and this presents some challenges in reconciling these distinct world views.

Second, people in Oceania have exclusivity and/or excludability rights over their territories, and this permits islanders to limit effort through a number of management strategies (e.g. taboo sites) — strategies that are at the core of EBM. Recognized sea tenure stakeholders (and this recognition can be very complicated, owing to frequently existent nested rights) have sole rights over resources and the ability to keep out nonmembers

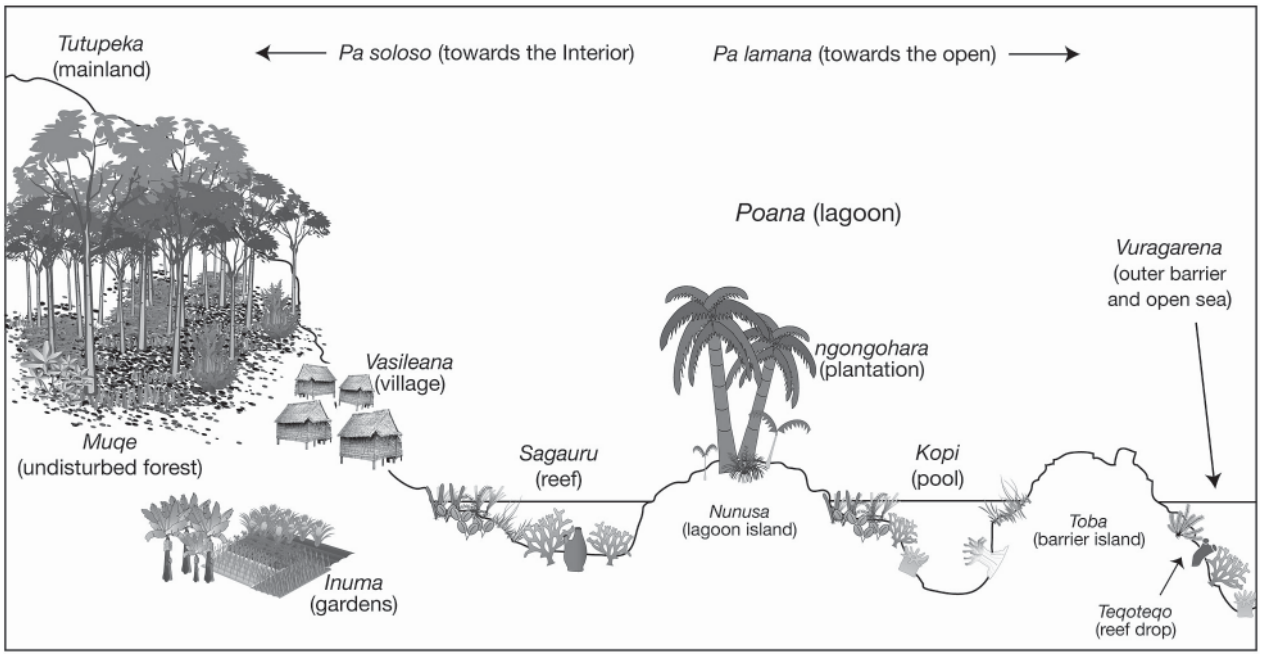

Figure 2. Roviana zoning of land and sea domains, or *pepeso* (Aswani and Vaccaro 2008).

from accessing and using their marine resources. Membership rights are allocated through various sociocultural rules, including those based on birth (primary rights), marriage and residence (secondary rights), and the direct transfer of rights by local authorities (usufruct rights). Rights of any form afford users access to marine resources while excluding nonmembers, albeit exclusionary rights to resources varies from one region to another, and are often conditioned by the strength of traditional self-governance, demographic and economic pressures, and a country's legal recognition of customary management practices, among other factors. Significant to this discussion is that territorial rights gives stakeholders the capacity to institute spatial, temporal, gear, effort, species, and catch restrictions, or strategies that are central in fisheries management and EBM. Such locally established restrictions can potentially 1) protect vulnerable species and habitats (i.e. biodiversity and ecosystem function), and 2) protect susceptible life history stages (i.e. spawning and nursery grounds). CM, like EBM, therefore, can result in the protection of ecosystem structure and function, and is place-based, which allows owners to restrict human activities that are damaging to the marine environment.

Lastly, CM is not only about resource ownership and access control; it also includes indigenous practices and a world view that are embedded in the whole indigenous sociocultural, economic, and political system. Following Berkes (2008:17–18), we can conceptualize this socioecological system as nesting: 1) indigenous ecological knowledge of plants animals and the land- and seascape; 2) a resource management system in which indigenous ecological knowledge (IEK) is practiced to use and manage natural resources; 3) a set of social institutions such as marine tenure, which sets the codes of social relationships between resource users and managers; and 4) a worldview that shapes environmental perceptions and gives meaning to the observed natural environment. The success of this integrated system, in turn, is shaped by *adaptive management*, or the capacity of the system to change when faced by new social and environmental circumstances, and *social learning*, when people learn about environmental uncertainty and feedback this knowledge into the management system.

A fundamental goal of EBM is to integrate "ecological, social, economic, and institutional perspectives, recognizing their strong interdependences" (COMPASS 2005). Yet this objective has not been realized in real life management situations. So, why duplicate efforts and try to impose a state-sponsored command and control EBM plan, when analogous management systems already exist in many parts of Oceania, and particularly, the CTR? While the origins of these management systems are diverse — one born from scientific managerialism and the other from adaptive socioecological and historical processes — their conceptual and operational principles, as illustrated above, intersect at a number of junctions. This provides a fertile ground for cross-fertilization between traditional and modern environmental management systems, having the former not only limited to Oceania but also occurring informally in many parts of the world, including the USA (e.g. Acheson 2003). Then we need to identify, for both systems, the governance and management mechanisms at various spatial and temporal scales that result in positive institutional outcomes in terms of environmental sustainability, social equity, and institutional endurance if we are to cross-fertilize EBM and CM to create a holistic hybrid management strategy (Fig. 3) (Aswani et al. 2012).

The following six principles, which are by no means exhaustive, should guide the effort to hybridize local institutions with modern management such as EBM (from Aswani and Hamilton 2004b: 10–11; Cinner and Aswani 2007: 211–212):

1. CM strategies are heterogeneous and specific strategies are more appropriate under certain socioeconomic conditions. Factors such as market conditions and population may detrimentally effect certain types of customary systems but strengthen property rights, influencing whether spatial (i.e. MPA) or rights-based (i.e. individual transferable quotas) hybrid strategies are most viable. The presence of complex tenure institutions can also restrict the ability of individuals to switch between occupations, fishing grounds, and gear types, potentially limiting the available options for hybrid conservation strategies. This should be taken into account when designing CM-EBM hybrid plans.

2. Hybrid CM-EBM institutions will have to match the varying spatial scales at which resources are owned, used, and governed under CM systems with the scale of ecologically relevant processes. Part of the matching scales challenge involves gaining a better understanding of gaps in marine science dealing with using CM as resource management tools, including the types of ecological processes that CM techniques protect, determining the minimum "reserve" size necessary, minimum distance between "reserves", and the trophic effects of limited fishing activities that customary institutions often allow (Sale et al. 2005). In addition, complicated use rights and ownership systems mean that a specific area of conservation interest may be governed by a heterogeneous network of social units that operate at different scales (e.g. individual, sub-clan, clan, village) and may have historical patterns

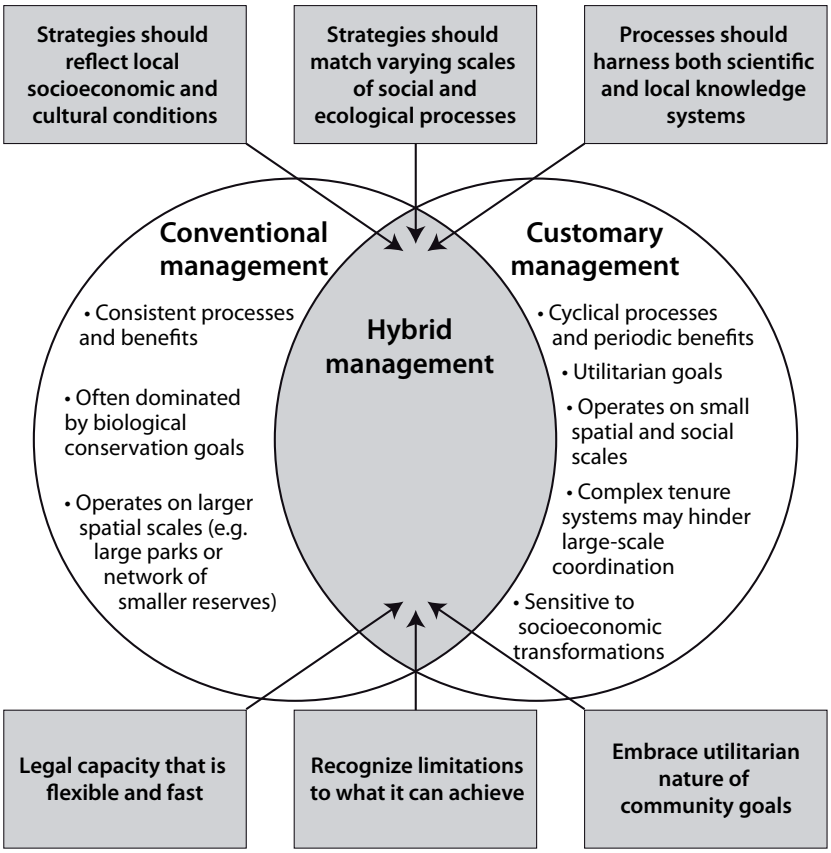

Figure 3. Establishing hybrid management and overcoming differences (Cinner and Aswani 2007).

of non-cooperation with each other. Existing customary institutions may create incentives for conservation or overexploitation in unexpected and unfamiliar ways and present commons dilemmas at varying spatial scales (i.e. people within a clan or community may be willing to cooperate with each other, but communities may attempt to "free ride" on the efforts of their neighbors).

3. Hybrid CM-EBM should understand and harness both scientific and local knowledge systems and mechanisms for detecting and reacting to changes in socialecological systems. The participatory process during the establishment of hybrid strategies is critical to capturing local knowledge and explaining scientific knowledge. It is important to realize that local knowledge is always changing and that current ¨indigenous knowledge¨ is likely to be an amalgam of traditional and introduced knowledge systems.

4. The adaptive nature of hybrid management systems requires a legal capacity to enact and enforce decentralized management (either through recognized customary marine tenure institutions or village bylaws) at the local level and co-management arrangements as CM and EBM are integrated at varying institutional scales (e.g. provincial and national governments).

5. Hybrid management strategies should embrace the utilitarian nature and goals of CM institutions. Although preserving biodiversity and maintaining resilience are often primary goals of modern conservation, these must not be prioritized over utilitarian community goals, such as allowing occasional harvests for feasts. Maintaining important customary characteristics such as utilitarian goals will mean that a CM-EBM hybrid management will include humans and, therefore, be a compromise between conservation and exploitation as well as modern and customary practices. Finding strategies that can meet conservation and community goals will require understanding the ecosystem benefits conferred by different strategies and their social benefits and costs.

6. Hybrid management has limits to what it can achieve and may not be appropriate everywhere. As with customary counterparts, hybrid management will be limited in the scope and scale of threats it can address and its resilience to some socioeconomic processes. Understanding complex social processes, such as the historical,

socioeconomic, governance, political, and environmental conditions within which socioecological systems are embedded are critical to translating customary governance into hybrid management. These processes often take social scientists years to begin to unravel and may not fit with conventional project timeframes for donors and conservation.

Coastal management in the CTR needs to conform with local sociocultural practices (e.g. governance, socioeconomic, and cultural idioms) for its acceptance and successful integration with local systems of management, whether traditional or otherwise. Research and practical experience in the region demonstrate the importance of incorporating lessons learned from modern integrated coastal management (ICM) and CM, and the necessity to building from these existing management frameworks, which have evolved locally and been tailored in these particular regional contexts (e.g. Christie et al. 2007, 2009). Therefore, EBM (or other tailored management programmes) needs to be presented as an adaptation and addition to existing coastal management paradigms.

In Melanesian Coral Triangle nations, for instance, the current legal framework provides indigenous people some *de jure* legal rights over their marine natural resources. However, statutory law does not, in most cases, provide *de facto* legal tools to control use of coastal resources on which the livelihoods of these communities depend. Creating an improved CM-EBM institutional framework does not unavoidably require transferring full ownership of coastal resources to local communities, but could encompass co-management by governments and local communities that would allow, for example, the participation of local people in decisions concerning the long-term management, including development and utilization, of these marine resources. The goals of EBM may be easily and cost-effectively pursued by strengthening the often informal institutions governing user access to resources rather than deconstructing CM practices. The creation of a legal support system for CM and community-based resource management can lead to legal action against large-scale commercial interlopers. Further, as coastal populations expand, it is possible that informal CM and community-based institutions could be compromised. Government support or formalization of these institutions can have positive conservation incentives associated with a sense of resource ownership (e.g. habitat protection, spawning stock protection) without much financial investment from states (Aswani et al. 2012).

In sum, CM-EBM hybridized programmes may not be the solution for all marine ecosystem-management problems in the region. But, as argued in Aswani et al. (2012), there is a moral and ecological necessity for slowing the degradation of marine ecosystems in the region. To this end, we must find practical solutions to everyday problems and, therefore, it is important not to lose sight of practical "lessons learned" and alternative models that can and should be adapted. Researchers of Oceania´s CM systems should communicate to practitioners, managers, communities, and resource users that EBM or other forms of modern coastal management are not a new paradigm but rather are there to build upon the best practices of existing management systems. Accordingly, local traditional and/or hybrid systems should be seen as a subset of EBM. The cultural and institutional contexts of CM are logical platforms from which to build hybrid EBM programmes — programmes that include at their core networks of permanent and temporal marine reserves.

Creating and expanding networks of MPAs in the CTR

MPAs are at the core of an hybridized CM-EBM system because they can protect the ecological function of marine ecosystems as well as enhancing spawning stock biomass, allowing for larval dispersal and the export of adults to adjacent non-protected areas, maintaining species diversity, preserving habitat, and sustaining critical functional groups (Bergen and Carr 2003; Halpern 2003; Hughes et al. 2005; Mumby et al. 2006). Reasons for support of no-take marine reserves are that other types of MPAs, such as periodic marine closures, are less likely to protect biodiversity, key functional groups, and other ecological processes longitudinally, particularly in a changing climate (McClanahan et al. 2009). In addition, others have argued that for MPAs to be effective they should cover areas in the magnitude of hundreds or even thousands of square miles, depending on the type of marine environment (Man et al. 1995; Walters 2000). In practice, however, coastal stakeholders usually prefer smaller and temporal MPAs because they limit the negative economic effects of management restrictions. In the context of MPA design, this argument boils down to how much attention should be paid to science-driven vs stakeholder-driven considerations when designing MPAs (Agardy 1997; Alder et al. 2002; Jones 2002).

In the CTR, state-sponsored management plans that focus on protecting biodiversity and ecosystem function through strategies such as no-take and/or large marine reserves, which although important for sustaining and fostering ecological services (Worm et al. 2006; Barbier et al. 2008), are likely to be ignored, owing to overarching concerns for human socioeconomic welfare. Despite governmental intervention, or lack thereof, many local communities in the CTR, as well as Southeast Asia and other Pacific Island countries have begun to independently experiment

with small and temporal closures as a means to deal with increasing marine resource scarcity. Any hybrid CM-EBM should allow community-based marine closures, or sections of them, for the periodic harvest of resources either during set periods of time or according to the cultural, political, and economic needs of a given community. Indeed, researchers have a limited understanding of the complexity of these socioecological management regimes because they incorporate community socioeconomic and cultural concerns with associated human-environmental interactions (e.g. differential foraging strategies during periods of harvest), but case studies from the Solomon Islands (Aswani and Weiant 2004), Vanuatu (Bartlett et al. 2010), Papua New Guinea (McClanahan et al. 2006), and eastern Indonesia (Evans et al. 1997) are increasingly suggesting that under certain social circumstances (Daw et al. 2011), temporal community-based MPAs can still be successful biologically. In addition, research in this region is showing that spatiotemporal closures are socially more acceptable than permanent reserves because they resonate more closely with local utilitarian cognitive frames of references in governance, socioeconomic, and cultural processes (Aswani et al. 2007). Many questions, however, remain regarding the biological and social effects of permanent and periodic closures in the region, which will necessitate additional research.

MPAs of any type should aim to protect the prime habitats of a variety of vulnerable species, the spawning aggregations of vulnerable fish species, and habitats and species that have a significant ecological function in marine ecosystems. To this end conservation programmes in the region should work towards fostering and strengthening good resource governance with the assistance of traditional authorities and local churches through various strategies including (Cinner et al. 2010: 3–4):

1. Developing a standard (but flexible) system of socioeconomic, governance, and ecological monitoring to survey MPAs throughout the CTR to improve management effectiveness. Monitoring should include local processes (ecosystem and social) and potential for adaptation to climate change. Existing networks of MPAs in the CTR should be surveyed to determine baseline efforts and priorities for improving individual MPAs as well as their expansion into networks.
2. Agree on the minimum acceptable data required to plan functional MPA networks, which should carefully integrate local ecological knowledge and sea tenure institutions.
3. Protect the ecological function of major marine environments by increasing the number and size of MPAs, and refining locations and spacing of MPAs in accordance with multidisciplinary research to build resilience to climate change.
4. Determine, through multidisciplinary research and local consultation, effective coordination and enforcement regimes at MPA and network scales.
5. Determining viable revenue streams associated with MPA management through user fees, returns on the investment of maintaining a viable resource base for fisheries, tourism, and other economic activities to factor into management planning.
6. Build on previous experience so that new consultants and researchers in the CTR can contribute more effectively to marine conservation.

Obviously, protecting marine biodiversity has to be done in a context that supports the traditional beliefs and cultures of the peoples of the CTR and Oceania in general. For instance, we have designed more than 30 MPAs in the Solomon Islands (Fig. 4) through various multidisciplinary and participatory research strategies, including:

1. ethnographic studies of regional customary sea tenure (CST) to assess, among other factors, the feasibility of implementing fisheries management in the Solomon Islands (Aswani 2005);
2. the incorporation of the visual assessments of local photo interpreters, who identified benthic habitats, resident taxa, and spatiotemporal events of biological significance, into a geographical information system (GIS) database (Aswani and Lauer 2006a);
3. the coupling of local ecological knowledge with marine science to study aspects of life history characteristics of vulnerable species (Aswani and Hamilton 2004a; Hamilton et al. 2005); and
4. the incorporation of fishing time-series data (1994–2004) into the GIS to examine spatial and temporal patterns of human fishing effort and yields (Aswani and Lauer 2006b) [See Aswani 2010, 2011 for a discussion on methods].

Countries in the CTR have already evolving systems of MPAs at national and/or local levels and conservation practitioners should build on this. Strategies for more and better managed MPAs are highlighted in the next section including:

1. establishing new MPAs in the region for sustaining the ecological function and resilience of marine ecosystems as well as protecting adjacent watershed terrestrial ecosystems;
2. working with local authorities to establish context-specific fisheries restrictions, particularly banning technologies that affect particular functional groups detrimentally (e.g. parrotfish),

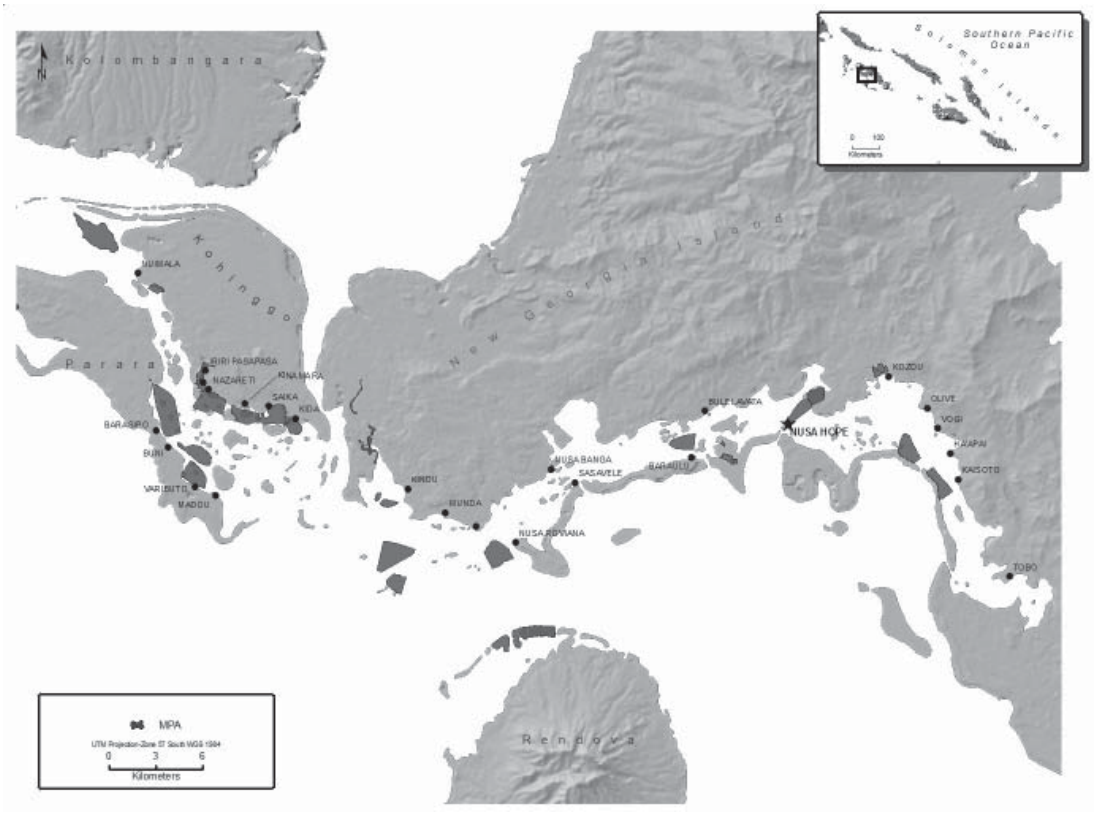

Figure 4.

The Roviana and Vonavona lagoons, New Georgia, Solomon Islands
(MPA sites established under our research and conservation programme shown in dark grey).

3. assisting local, provincial, and national authorities to develop and establish the institutional infrastructure at the local or village level to sustain MPAs (e.g. create Resource Management Committees [RMCs] and involve local churches in conservation);
4. work with government partners to establish hybrid community-based and co-management governance to sustain conservation initiatives;
5. foster MPA environmental education and awareness through community workshops and field schools;
6. facilitate participatory development to increase possibilities for MPA implementation in a minority of sites in which there exists contention over resource management;
7. carry out marine and social science research at MPA sites (e.g. baseline ecological data and social impact assessments) and train local rangers in monitoring and management; and
8. develop a regional protocol for researching sea tenure and IEK to facilitate the design and implementation of CM-EBM hybrid systems of marine conservation in the CTR.

MPA establishment, expansion, and consolidation

As a general rule, no-take and spatiotemporal MPAs in the CTR should have two primary purposes: 1) to protect vulnerable habitats and species (i.e. biodiversity and ecosystem function), and 2) to enhance fisheries productivity in the region (i.e. food security and livelihoods). In selecting locations and the design of each MPA, one should employ a research strategy that integrates local ecological knowledge with marine science, particularly knowledge that is commensurable with scientific approaches to biodiversity conservation and the protection of particular endangered species and which can improve stock abundances. In addition, sites should have minimal public contest over natural resources. Conservation practitioners should seek tenurial contexts with boundaries that are well-defined and recognized regionally, in which 1) there is little or no poaching by neighboring groups; 2) there is a capacity to monitor and enforce rules; and 3) most of the inclusive stakeholders endorse the management initiative.

Networks of coastal reserves are critical for protecting vulnerable life history stages of many heavily exploited coral reef fishes. In lagoon and atoll

contexts, which are common in many parts of the CTR, conservation practitioners should focus on protecting nursery areas, as the number of juvenile coral reef fish will increase within reserves. The connectivity of shallow coastal and inner lagoon habitats and coral reefs in many parts of the CTR means that such protection has the potential of enhancing adjacent coral reef fisheries via increased rates of juvenile recruitment (Hamilton 2003). In addition, practitioners should focus on protecting outer lagoon or atoll coral reefs because the long-term benefits of inner lagoon protection of vulnerable juvenile life stages of coral reef fishes relies on an adequate supply of dispersive larvae from adult populations. These adult populations do not, as a whole, occur within the inner lagoons, and if adult population numbers were to decline dramatically over a wide geographical area it could lead to widespread recruitment failure (i.e. shortage of eggs and larvae) and the subsequent decline of juveniles within protected inner lagoon reserves (Nagelkerken et al. 2000; Hamilton 2003).

In addition, practitioners should work with local authorities to establish context-specific fisheries restrictions, particularly banning technologies that affect particular functional groups detrimentally (e.g. parrotfish). McClanahan and Cinner (2008) have fittingly argued that in many contexts (particularly in urbanized areas), MPAs may not be a realistic strategy, and alternative strategies that combine approaches such as gear-based fishery management with other managerial approaches, such as government sanctioned spatiotemporal closures, may be more suitable to protect crucial functional groups such as parrotfish.

Finally, rapid human population growth is causing increasing development of watersheds, which invariably results in serious stresses to coastal marine ecosystems. For coral reefs, the result is invariably disastrous because watershed discharges affect the key parameters of water and substrate quality, which in turn control the success or failure of coral reproduction and recruitment. Therefore, any form of marine management, particularly MPAs and EBM, needs to be extended to the whole watershed and ultimately to other terrestrial ecosystems to ensure the survival fof coastal coral reefs. In this respect, any form of EBM cannot neglect the big picture of the watershed, particularly in light of how slowly human behavior and institutions react to developing environmental issues (Richmond et al. 2007).

Establishing an institutional and financial infrastructure to sustain MPAs

Establishing community-based MPAs is not as hard as sustaining them in the long term. Hybrid co-management in the region needs to be designed with the participation of officials at local, provincial and national levels. At provincial and national levels, Ministry of Environment, Forestry, and Fisheries officers need to be closely involved in conservation and resource management initiatives. Nonetheless, considering the absence of any legislatively binding and enforceable regulatory conservation apparatus in most CTR countries, true success can only occur if local institutions are empowered and local stakeholders are closely involved. To this end, conservation practitioners should, among other things: 1) establish and strengthen villages' RMCs in conservation sites; 2) create and consolidate local CBOs (where possible and relevant); 3) build up church-conservation initiatives where possible and desirable; and 4) work with provincial and national ministries as well as international donors to establish various initiatives to ensure long-term financial sustainability.

A. Creating and strengthening RMCs: At conservation and/or management sites, practitioners should work with village authorities to establish RMCs, each formed by various village constituencies, including: a) the chairperson, who is a member of the Village Leadership Committee; b) a secretary and treasurer; c) a church representative; d) a women's representative; e) youth representatives; and f) various resource owners. The responsibilities of the RMC are to: 1) ensure that MPAs are secured and free from disputes and ensure that adjacent watershed land is protected; 2) enforce all agreed–upon regulations by warning, educating and fining offenders; 3) run awareness workshops detailing the objectives of MPAs; 4) organize workshops that will bring together other RMCs to discuss successes, problems and issues related to MPAs and conservation more generally; and 5) encourage exchange and educational programmes with outside institutions.

Practitioners should promote the creation of RMCs in all villages with new and existing MPAs. Second, they should assist communities in drafting a set of rules and regulations regarding the MPAs that are ecologically, culturally, economically and politically appropriate, making them clear and easy to enforce. Third, practitioners need to standardize the RMC institutional framework and the rules and regulations across all sites in a given region (e.g. Marovo Lagoon) (when and where appropriate given existing variation) in order to facilitate the eventual gazetting of all MPAs. Finally, practitioners should assist RMCs in formulating and implementing a Resource Management Constitution and work together to form Regional Resource Management Committees (RRMC) (for cultural areas with more than one MPA) to be incorporated into local CBOs and nationally into locally managed marine areas (LMMAs) programmes, such as those in Fiji and Solomon Islands.

B. Constituting and ratifying CBOs and resource management constitutions at project sites: Establishing local CBOs, which can supervise all existing RMCs in their respective area of operation, is a first step in creating a permanent presence in each programme area. They can provide local stakeholders with a venue for gaining access to information about management and conservation activities, for drafting resource management constitutions, and for local people to voice their opinions and concerns. More generally, successful CBOs can help local communities or groups of people, tribes or clans who own resources within their respective areas, to manage their resources and to safeguard their indigenous rights. Once established and consolidated, CBOs can be important for: 1) networking with other CBOs or NGOs for solving common problems; 2) bringing together stakeholders from different communities in the region that have formed small autonomous tribal associations for workshops or meetings to discuss common marine conservation strategies, monitoring, and issues of financial sustainability; 3) lobbying provincial governments to bring CBOs together in a loose association for exchanging experiences; 4) transferring knowledge and experience about managing the marine environment back to village members and students (e.g. "MPA ambassadors"); 5) developing radio networks to link all RMCs for idea exchange and reciprocal capacity building; 6) ensuring that all MPA communities working with the CBO meet basic MPA consolidation benchmarks (e.g. memoranda of understanding, buoys to mark the boundaries of an MPA, MPA notice and sign boards, permanent rangers, functioning RMCs); and 7) addressing the role of RMCs and CBOs in the wider sociopolitical context of the CTR through workshops and publicity campaigns, among other activities. Eventually, local members of these organizations will manage their programmes and seek research and institutional grants for expansion autonomously with little need for foreign intervention.

C. Creating community and church-based management structures in the context of RCMs and CBOs: Research experience in Melanesia shows that although traditional communities can be ardent supporters in the creation and expansion of MPA networks, their interest can also diminish. Involving local churches, therefore, is vital for establishing long-term sustainability plans in many rural areas of the CTR. Conservation work in the CTR has shown that great moral authority, particularly in rural Melanesia, can be vested in local churches (Barker 2002; Hviding and Aswani n.d.). In fact, any long-term marine conservation programme in the region will have to have the blessing and cooperation of local churches. Innovative and creative approaches to sustaining biodiversity conservation and improving human well-being in rural areas of the CTR can come from a nexus between local churches and environmental conservation initiatives by way of local (CBOs) and foreign (NGOs and universities) initiated conservation. In our Western Solomons work, the Christian Fellowship Church (CFC) has been instrumental in working with us to establish an MPA network. The CFC was founded in the 1950s as a breakaway movement from the long-established Methodist denomination, and it is an indigenous church that fuses old-style Methodist doctrines with customary hierarchical organization and rural development. The CFC has not only endorsed and cooperated with some aspects of conservation outlined in this paper, but is also in the process of incorporating a biodiversity conservation agenda into its religious programme.

Conservation practitioners should work with churches in a creative context for "rural development" in which conservation is a primary objective of "development", thus a powerful means for alleviating rural poverty and inspiring biodiversity conservation. Practitioners should work with church leaders at project sites to transfer the message that environmental conservation is in their best interest, and help these churches establish closer ties with politicians to strengthen conservation in provincial and national governments, which in places like the Solomon Islands and Papua New Guinea, have lost some interest in environmental conservation. More specifically, conservation practitioners can: 1) link all village RMCs to the churches in each region (where possible and/or desirable); 2) involve church leaders, pastors, and ministers in supervising RMCs; 3) involve churches in environmental education (to be included in their school curricula); 4) work with local churches to establish yearly fundraisers (e.g. "bazaars") for RMCs; and 5) bring leaders of the main churches together to discuss a regional conservation strategy.

In sum, involving the churches offers a unique opportunity to manage and conserve critical ecosystems in a culturally, politically, and economically sound fashion. The nexus of conservation, rural development, and the church provides an innovative context for achieving the successful and long-lasting conservation of marine and terrestrial ecosystems in this region of the world (where Christianity principally has a very strong foothold). In particular, recognizing churches for their efforts and achievements through their inclusion in environmental decision-making (e.g. managing MPAs) further strengthens the church's resolve to protect the fragile environment of their areas. This approach is an opportunity to protect marine and terrestrial ecosystems and to accomplish the often-elusive goal of long-term project sustainability.

D. Achieving financial sustainability of RMCs and CBOs: This is the most challenging task of sustaining MPAs and MPA networks. In principle, sustaining MPAs requires little operating costs, as the traditional political and tenure system of a hybrid management system indirectly subsidizes enforcement and monitoring via traditional avenues, albeit this is not always true. Financial sustainability, then, is of paramount importance to sustain any conservation initiative. Conservation practitioners should encourage each RMC to fund its operating costs through various activities, including: 1) collecting diving fees (for certain villages); 2) conducting church and village fundraisings (which are very common); 3) fees paid by foreign researchers and tourists visiting MPAs; 4) church donations; 5) involving provincial and national governments to fund part of the operational costs of RMCs; and 6) finding foreign funding in the form of grants and endowments (for particular sites of critical biological importance).

Practitioners should favor local self-sufficiency and work hard with village leaders and RMC coordinators to establish local venues for collecting funds for MPA monitoring and enforcement. Based on our experience in the Western Solomon Islands, we are aware of the difficulties that arise locally to collect funds, which often result from divergent local political and economic agendas and internal conflict and competition between local stakeholders. Consequently, for the Western Solomon Islands case, we have been contemplating the possible creation of a trust fund with donor assistance. A trust fund could assure the continuation of all the established institutions (e.g. RMCs, CBOs, local coordinators) at very low operating costs. Conservation interventions in the CTR have shown that these types of problems are likely to happen for many conservation practitioners and that there is no simple remedy for addressing the issue of programme sustainability, which is the desired goal of conservation. In sum, the challenging goal is to create the institutional and financial infrastructure to sustain programmes long after their implementation.

MPA-hybrid management environmental education and capacity building

Existing MPAs and their associated biological and social outcomes (real and/or perceived) can be a tangible means of demonstrating the significance of resource management in the region. For Melanesians in particular, "to see is to believe," and in many sites across the CTR, currently established MPAs have been effective educational tools to allow local people to witness actual management results (e.g. rapid replenishment of various invertebrate resources). However, conservation practitioners have to work with partners to press forward with MPA environmental education and technical capacity building to continue invigorating local, regional, and national strategies for marine resource management. To this end, they should, among other things: 1) train local coordinators at national, provincial, and particularly *local* levels; 2) build capacity by integrating islanders into marine science, socioecology, and climate change field training programmes (e.g. participatory GIS); and 3) expand MPA environmental education campaigns through touring and media (e.g. radio, news, posters, theatre) across the CTR.

A. Training local coordinators: Training national personnel for long-term capacity is often difficult but necessary. Even more essential is to build capacity locally (a crucial step often ignored by large projects). This is an essential step if community-based management plans are to succeed in the long term. So, as practitioners work with local partners to create new MPAs and expand old ones, they should train local coordinators, rangers and students to further build capacity in: 1) basic GIS techniques; 2) various marine and social science survey techniques (e.g. Reef Check surveys); 3) thinking of how to formulate hybrid CM-EBM-MPA programmes; 4) grant writing (for eventual financial independence); and 5) basic managerial and financial skills to sustain the programme in the long term. National, regional, and local coordinators from the CTR can also gain skills through their participation in field training programmes.

B. Integrating islanders into field training programmes: MPA environmental education and technical capacity building is of paramount importance to enhance local, regional, national, and international strategies for marine resource management and conservation. Local programme coordinators, along with regional and national personnel can also be integrated into field training programmes. For instance, in our conservation work in the Western Solomon Islands, we have brought islanders to our University of California at Santa Barbara Zela Field Research Station in Roviana Lagoon, Solomon Islands to undergo field training and "hands-on" research. Training at the station combines interdisciplinary research, which focuses on human dimensions of marine resource utilization, with a long-term educational programme that trains islanders in research as they participate in conservation, cultural, and educational activities. The idea is to train national, provincial, and local coordinators from CTR nations in quantitative and qualitative ethnographic, spatial, and marine science field methods as these relate directly to the design and maintenance of community-based MPAs and hybrid EBM plans. Also, mentoring locals improves their skills while simultaneously enhancing their interest in MPAs and regional resource management and conservation in general.

C. Environmental education workshops and media: Standard awareness campaigns include workshops to promote conservation and resource management in general, the sharing of information, involvement of government officials at various levels, discussion of issues of local enforcement and monitoring, and understanding among all parties of both project objectives and expected results. Practitioners and partners also need to design awareness protocols to diffuse information regarding the advantages and disadvantages of establishing MPAs as well as other forms of coastal management. In the Western Solomon Islands programme we have produced standard awareness campaign materials, including: 1) posters of MPAs and endangered species (in local languages); 2) leaflets underlining the objectives and successes of the programmes; 3) conducting provincial and national radio programmes (e.g. in Radio Happy Isles); 4) writing articles for local newspapers; and 5) producing a video of our effort in the region for local and international education. Such promotional materials should be part of conservation programmes in the CTR, as they heighten peoples' awareness of resource management issues.

Participatory rural assistance

The reality is that given the current economic and political milieu of nations in the CTR, it is unrealistic to expect community-based conservation projects to succeed with only short-term expert guidance and financial support. Islanders have development needs that far exceed the assistance provided to them by their central and provincial governments. Through programmes in the Western Solomon Islands, for instance, we have assisted some communities with development needs, particularly in biodiversity-rich areas in which resource management is contentious and local communities have been unwilling to forfeit income from fishing unless alternative means for income were offered. Given the widespread failure of cash-generating enterprises in the region, however, we have assisted some communities with building low-cost infrastructural projects such as schools, clinics, and community halls, but *only when* the communities provided labor and timber and covered other expenses (e.g. fuel for chainsaws).

Conservation practitioners should be aware of the potential risk of launching community-based MPAs under a programme that pairs economic incentives with environmental conservation. However, after 20 years of experience in the Solomon Islands, we can say the following. There are, indeed, cases in which participants are more interested initially in the economic incentives than in resource conservation. Yet, as community members begin to notice the biological and social impacts of MPAs, they start to understand the benefits for the community, which results in broadening their focus beyond just economic incentives. For instance, the biological and social benefits of the MPA network are increasingly visible in the Roviana region (see Aswani et al. 2007; Aswani and Sebatian 2010), and the discourse surrounding our MPA programme has shifted from dependency and rural development to marine conservation, self-governance, and self-reliance.

While conservation practitioners have generally resisted such approaches, this model of conservation could work in other rural areas of the CTR because success there would not only help to conserve marine habitats but would also show how strategically paired conservation and development initiatives can succeed. In the end, it would generate immeasurable political and social capital for widespread marine conservation in many parts of the region. We have confirmed, through experience, that when local people witness tangible management results and participate in environmental education it is possible to move beyond the economic dependency created by financial incentives as a component of conservation projects. It is crucial, however, to maintain a relatively long-term presence in a region and to provide communities with some initial infrastructural assistance because government organizations and NGOs in the region have failed to do so. Note that our approach in the Western Solomon Islands differs from integrated conservation and development programmes launched during the 1980s and 1990s (by groups such as WWF) in that, unlike NGOs that quickly come and go with no significant understanding of local economic and sociocultural processes, we have studied the local context for decades and have a long-term presence in the region — ingredients that are necessary for successful paired conservation and development programmes in the CTR.

Integrated biological and social monitoring/ research

There are various ways of conducting integrated social and biological research, and the following summary rests on different aspects of our work in the Solomon Islands as it relates to MPAs only. The effort has constituted a combination of targeted marine and social science research, local capacity building, and effective communication with local resource owners to ensure integration of MPA projects into existing reserve-management structures and to provide long-term benefits to community-based marine resource management in the region. The principal socioecological research (conducted by S. Albert, University of Queensland and S. Aswani, UCSB) has: 1) assessed ecological and social impacts of existing MPAs or marine reserve network through various methods; 2) mapped current water-quality conditions in the region and

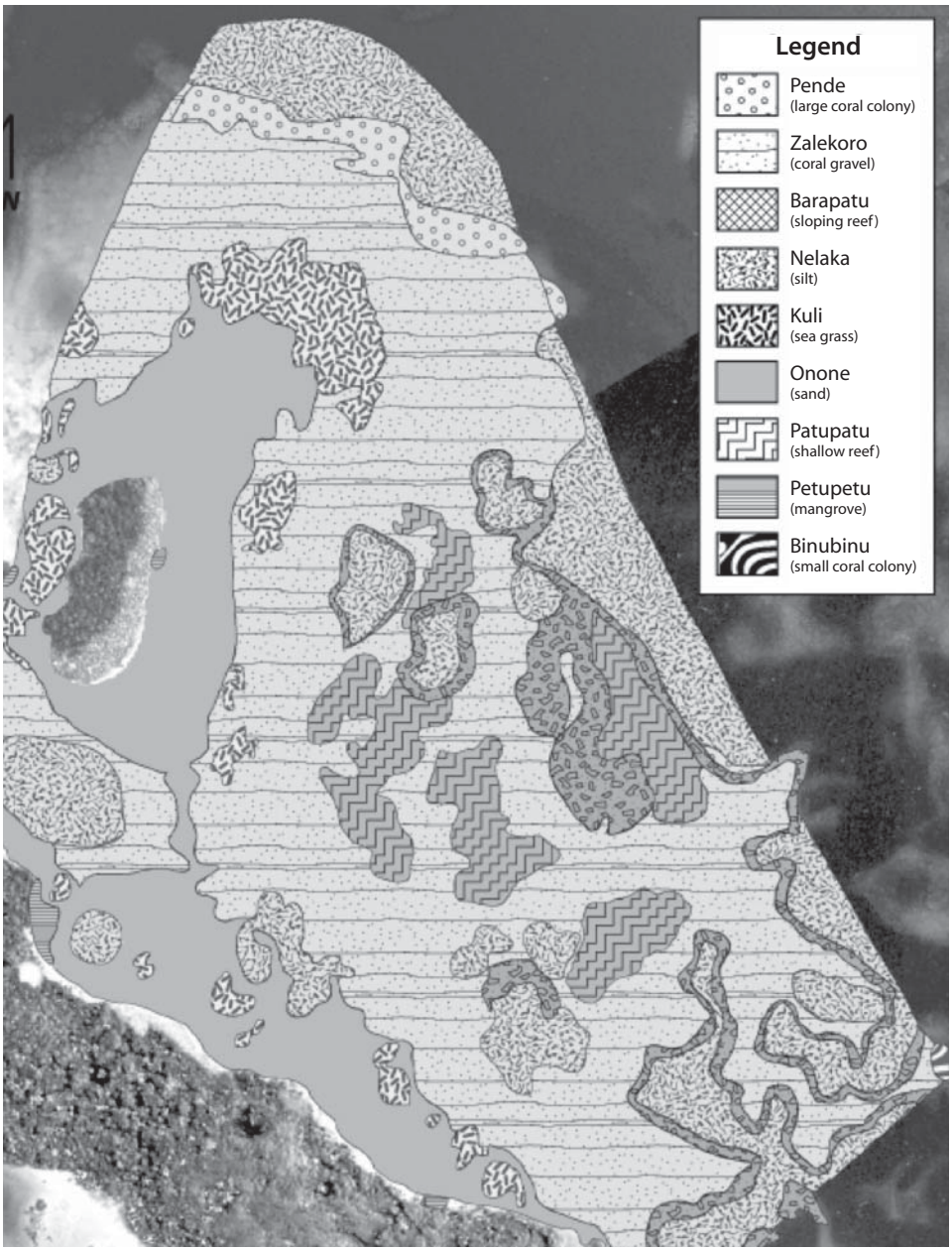

Figure 5. Informants' demarcation of predominant abiotic and biotic substrates on aerial photographs of the Olive MPA, Roviana Lagoon (Designed by Matthew Lauer).

assessed historic changes due to catchment land use; 3) trained community members in locally relevant marine and social monitoring methods; 4) provided scientific information to communities in a locally appropriate form; and 5) integrated scientific information with existing local knowledge to adapt management regimes where needed, particularly as MPA networks have expanded.

Collecting biological baseline data at various spatial and temporal scales and determining the biological effects of the existing reserve network on targeted lagoon, coastal and nursery fish species has been critical to: 1) identify the targeted species that respond to this form of management and determine how this effort affects adjacent fisheries, and 2) reinforce and validate the local perception that the MPA network has a positive fisheries value and helping to ensure its permanent acceptance and protection. During this work we have directed great effort toward increasing the level of participation and involvement of communities, especially by women and children, through the training of participants in monitoring methods, encouraging local participation in monitoring, and discussing the meaning of the monitoring results.

Melanesian people generally learn through observation and participation. Hence, to provide true understanding of the benefits of MPAs, it is useful to train local community members to monitor changes in reef conditions that occur as a result of management decisions. In the marine training programme, we have trained local marine rangers in monitoring algae and water quality and in conducting reef community surveys, and to continue monitoring without external assistance. The marine rangers have been responsible for the coordination of regular data collection, its synthesis and interpretation by the existing RMC-CBO, a process that has not always been successful. The key component of the monitoring programme has been the communication of results back to community members.

It is equally important to assess the socioeconomic impact of reserves in individual villages and in the region as a whole. In our Solomon Islands research, we have assessed: 1) livelihood strategies in relation to pre- and post-MPA implementation (e.g. time allocation and income-expenditure patterns); 2) food security (e.g. nutrition and sharing patterns); 3) marine resource contestation (e.g. public-good games, household questionnaires, cultural consensus analysis); and 4) marine resource harvesting strategies (e.g. creel surveys and focal follows). Local coordinators have been trained in these methods too. Another social science objective has been to deepen and broaden the participation of local communities in the management of their marine resources by training them in the use of GIS for generating maps (Fig. 5). In sum, these are examples of socioecological research that can be conducted by conservation practitioners working in the CTR, and which help in integrating marine and social science for designing hybrid CM-EBM resource management programmes (see Aswani 2010, 2011 for a discussion on specific research methods).

MPA design and implementation protocol

In the CTR, fishery scientists will rarely achieve ecological sustainability and the protection of marine biodiversity in coastal areas unless they seriously consider local forms of sea tenure and IEK and their adaptability to, and hybridization with, introduced management regimes. This has been recognized by various researchers (e.g. Ruddle 1998; Johannes 2002), but more work is needed to show how to incorporate these indigenous practices into co-management. Conservation practitioners should develop research protocols that examine two main features of customary management: IEK and CST. To study relevant aspects of IEK, practitioners can develop various rapid assessment social and natural science methods to examine: 1) spawning aggregations (e.g. indigenous mapping of spawning sites complemented with GIS and underwater visual census [UVC] work); 2) nursery areas for various species (e.g. habitat mapping and UVC); 3) species diversity, distribution, and abundance (e.g. various ethnoichthyological methods, UVC, GIS); and 4) habitat mapping (e.g. indigenous mapping complemented with GIS and Reef Check[1]).

On the other hand, to investigate CST, researchers can develop various ethnographic methods for: 1) identifying all sea tenure regimes in a given locale; 2) mapping the spatial distribution of inclusive rights holders (for each tenure regime) and recording their attendant cultural attitudes concerning resource use and access (e.g. using questionnaires, GIS for mapping spatial distribution of stakeholders, and various cognitive anthropological methods for understanding cultural attitudes); 3) identifying local conflict patterns (e.g. structured and open-ended interviews); and 4) identifying economic activities across regional hamlets in order to identify levels of household dependence on marine resources and the influence of such dependency on the creation and enforcement of territorial rules (e.g. income and expenditure analyses). Researchers and conservation practitioners should strive to develop a handbook that outlines the application of these methods and explains how to integrate research findings into the design of community-based conservation initiatives in littoral areas that are formally or informally under customary control in the CTR and western Pacific in general.

MPAs for strengthening coastal management in the CTR

MPAs are an integrative management tool of hybrid CM and EBM management plans, and are an indispensable adaptive strategy to climate change in the region. Safeguarding the ecological function of marine habitats in the CTR is of key importance in fostering ecological resilience to changes brought about by a changing climate. The Bismarck-Solomon Seas Eco-region (the core of the Coral Triangle Initiative, or CTI), is a large marine ecosystem that extends through the Solomon Islands, the north coast of Papua New Guinea, and the northern West Papua region. The coral reefs and other marine environments of this region are highly diverse, productive, and moderately undamaged by human activities (WWF South Sea Program 2003), making this region a biodiversity conservation priority for those interested in marine resource conservation globally. However, a population explosion and developmental pressures are increasingly

1 See http://reefcheck.org/about_RC_Reef/about_us.php

threatening the ecology and social stability of the region. Marine and terrestrial habitats are deteriorating as they continue to be exploited by fishing, mining, and timber multinationals. The region, nonetheless, remains rich in biodiversity and is still a viable ecosystem in need of protection.

While the CTI has addressed the importance of protecting the environment of this eco-region, little effort has yet translated from planning to actual projects on the ground, and much of the funds designated for actual projects have been squandered in regional meetings and workshops. Thus, conservation practitioners need to step up their efforts to safeguard critical habitats and species through the expansion of MPA networks. Why MPAs? From a scientific perspective, current MPA studies suggest that a network of reserves buffers against the vagaries of environmental variability and provide significantly greater protection for marine communities than single reserves (Hastings and Botsford 2003; Lubchenco et al. 2003; Roberts et al. 2003). From a practical standpoint, simply because in many parts of the CTR local authorities and fishermen generally agree that MPAs (of various types) neighboring a village is a feasible management strategy. Catch, size, and gear restrictions are difficult to enforce given certain cultural preferences and the extent of coastal areas in the region, but the spotting of interlopers entering and exiting a neighboring MPA is not as difficult. In terms of size, the large edge-to-area ratios of small reserves result in higher rates of spillover by juveniles and adults into adjacent non-reserve areas and increased regional benefits through greater larvae export. As a general rule, reserves within a network should be 4–6 km in diameter and should be spaced 10–20 km apart. This allows for individual reserves to be large enough to contain the short-distance dispersing propagules, and to be spaced far enough apart so that long-distance dispersing propagules released from one reserve can settle in adjacent ones (Hastings and Botsford 2003). Note that recent research has also found that these benefits can accrue in smaller reserves (Hamilton et al. 2011), so any size MPA is better than none.

The riparian and marine habitats conserved should include outer lagoon and shallow inner lagoon coral reefs, inner lagoon seagrass beds, mangroves, and coastal swamps and strand vegetation (Nagelkerken et al. 2000). In addition to protecting marine biological communities, particular prime habitat for flagship species should be targeted for conservation. For instance, these could include habitats in which vulnerable or endangered bumphead parrotfish (or other parrotfish that are a functional group essential for maintaining reef health), Maori wrasse, green and hawksbill turtles, and dugongs are found. Spawning aggregations of square-tailed, brown-marbled and camouflage groupers, among other fish aggregating species, should also be protected (Hamilton et al. in press).

To implement MPAs successfully, practitioners need to understand local forms of ecological knowledge and resource management institutions, or CM in general. Therefore, in finding ways for comprehensive biodiversity conservation, as mentioned, practitioners need to design adaptive and precautionary management strategies that evaluate the compatibility of IEK with marine science and the institutional reliability of sea tenure institutions prior to their incorporation into plans to protect tropical habitats and species. In other words, not only do practitioners need to select sites rich in biodiversity based on local and scientific assessments, but they also need to select sites in which there is minimal public contest over natural resources. Harnessing local forms of sea tenure and knowledge is an important step towards creating hybrid CM-EBM systems of management, and is an effective strategy when governments cannot effectively monitor and enforce resource-use limitations, as has been the case in most of the CTR.

In sum, this article proposes a comprehensive attempt to strengthen marine biodiversity management and conservation as well as enhancing fisheries productivity in the CTR by: 1) enlarging, expanding, and consolidating MPA networks; 2) creating comprehensive plans for hybrid CM-EBM marine conservation in these countries; 3) providing technical assistance and training in MPA design and monitoring; 4) fostering MPA environmental education at local, national, and international levels; 5) gazetting MPAs and other regional coastal co-management plans (where desirable and possible); and 6) formulating a comprehensive set of guidelines for implementing marine conservation initiatives in this region. These initiatives dovetail nicely with the economic, environmental, and sociocultural parameters set by the Action Strategy for Nature Conservation in the Pacific Island Region. Audiences that could be interested in hybrid approaches include a wide variety of global institutions and individuals, including universities, government agencies, NGOs, and area specialists (e.g. fishery scientists, marine biologists, anthropologists). Conservation practitioners still have the unique opportunity to manage and conserve critical ecosystems in the CTR in a culturally, politically, economically, and environmentally sound fashion, but this requires innovative approaches to conservation and less talk and more action. In addition, we are faced with new challenges, particularly the fact that coupled human-natural systems in the CTR are already facing the effects of global climate and environmental change, and such a dynamic context requires research and the design of adaptive plans that build on the establishment of MPAs.

Building socioecological resilience to climate change in the CTR

Climatic and environmental unpredictability in the Pacific Islands, as mentioned, has grown and, consequently, the vulnerability and survival of coastal communities. Given this uncertainty it is fundamental to protect the ecological function of vulnerable ecosystems (as detailed above) in the CTR within a management framework that integrates local beliefs and institutions with modern management systems. In the context of climate change, researchers can work towards increasing the social and ecological resilience of coastal communities by: 1) utilizing MPA networks as tools for retaining and safeguarding ecological resilience; 2) documenting local understandings of climate change and possible adaptive measures and match these data to existing scientific research; 3) building greater understanding of climate change and its relation to resource mangement for increasing social and ecological resilience to environmental unpredicatability; 4) developing capacity of the groups involved, including youth, women, and church groups to undertake future assessments of climate change and better manage their coastal resources; and 5) creating a set of adaptive management protocols that are applicable to CTR coastal communities for responding to climate change related transformations.This work could serve coastal communities across the Pacific Islands to design adaptive management strategies that allows them to better cope with rapid ecological transformations brought by global climate change.

Climate change and theoretical consideration

Pacific Island communities are already experiencing the impacts of global and local climate change. They are especially susceptible to specific changes brought about by climate vulnerability (e.g. temperature variations, modifications of water flows and weather patterns, soil and water salinity or acidity, rain cycles, erosion, coral bleaching). These changes have dramatically increased the levels of climatic unpredictability (Barnett 2001) and, consequently, the risks associated to the primary productivity and survival for coastal communities. Coastal communities are often also experiencing disproportionate levels of poverty, exposure to pollutants, or abusive external appropriation of the resources of their area. Climate change exacerbates the negative impacts of these marginalizing characteristics (Crate and Nuttall 2009). The possible socioecological adaptations associated with climate change may present multiple forms, including environmentally driven migration, changes on economic practices such as fishing and agriculture, forestry (e.g. intensification), institutional transformations, or new trading strategies (Adger 2003; Cooper 2010).

The long-term well-being of coastal populations is dependent on coastal ecosystems and the critical economic and ecological services that they provide, including storm buffering and fisheries production. Yet the services provided by interface habitats such as mangroves, seagrass beds, and coral reefs are being degraded worldwide at an alarming rate (Barbier et al. 2008). This ecological degradation makes coastal populations increasingly vulnerable to massive environmental disruptions such as earthquakes and ensuing tsunamis, as demonstrated by the 2004 Asian tsunami, as well as rising sea level due to global climate change. A number of authors have recently suggested that rural populations with functioning customary or local management systems possess enough adaptive management qualities to make them more resilient (i.e. they have the capacity to absorb shock and transformation) to rapid and protracted environmental change (Berkes et al. 2003; Hughes et al. 2005; Folke et al. 2005). Such resilience has been suggested as emerging from social factors such as cultural norms, economic strategies, and regulatory enforcement (e.g. customary practices such as sea tenure and taboos), and ecological factors such as high biodiversity, greater abundance of key species, and a complete community structure (Hughes et al. 2003; Liu et al. 2007; Richmond et al. 2007). Today, uncovering the processes that make a socioecological system more or less resilient to environmental disruption caused by climate change is of paramount importance. Even so, it has been very difficult to demonstrate or test ecosystem resilience at scales relevant to resource management.

Conventional frameworks for studying environmental change and vulnerability that separates biophysical aspects of a system from social ones are inadequate (Scoones 1999; Gunderson and Holling 2002; Berkes et al. 2003; Moran 2007). A mounting body of research suggests that social and ecological systems are strongly coupled, highly complex, and evolving, which places the socioecological system at the center of research that addresses the impacts of ecological change on human societies (e.g. Turner et al. 2003; Liu et al. 2007). It is an important perspective for revealing the source and role of change in interdependent, or coupled, social and ecological systems and assessing variable levels of system resilience when under the stress of shock or discernable change (e.g. sea level rise) (e.g. Walters and Holling 1990; Folke et al. 2002; Bellwood et al. 2004; Allenby and Fink 2005; Adger et al. 2005; McFadden et al. 2007; Orlove et al. 2008). Resilience has long been recognized as an important component of effective resource management (Holling 1973), but it has become increasingly important with the new emphasis on EBM of coastal and marine ecosystems (e.g. Pauly et al. 2002; Levin and Lubchenco 2008) to sustain

ecological function in the face of rapid change caused by a changing climate and associated processes (e.g. ocean acidification).

Research on climate change is predominantly done by physical or natural scientists. Socioecological research on climate change, however, affords research that measures the perceptions of local populations to the effects of climate change (Roncoli et al. 2009). Socioecological research on climate change combines scientific with local perspectives on the issue. The advantage is that the local perspective allows researchers to gauge, on the ground, the social and ecological effects of an elusive macro-scale phenomenon such as climate change. A local analysis is fundamental because climate change research requires the combination of diverse geographical scales (local, regional, international) and different levels of analysis. Climate change-related events, therefore, raise critical questions regarding the social and ecological parameters that may lead some communities to be resilience when faced by rapid and protracted change. What are the ecological, socioeconomic, and health consequences of ongoing changes brought about by climate change on coupled human and natural systems? What are the socioecological responses of coastal populations to ecological and social disturbances caused by climate change (e.g. rising sea level)? What social drivers, such as cultural norms, property regimes, economic welfare, and regulatory enforcement, as well as ecological factors such as high biodiversity, greater abundance of key species, and a complete community structure allow some communities to be more or less resilient to environmental disruption? And, do CM systems increase the ecological and social resilience of coastal communities in the face of rapid and/or protracted change? (Vaccaro and Aswani, unpublished data)

To explore these questions, my team and I have recently conducted a multidisciplinary research and applied programme that integrates indigenous and scientific knowledge to assess the vulnerability of local communities in the Solomon Islands to the impact of climate change on coastal marine and terrestrial natural resources people rely on for food and other key requirements. The programme has involved social and natural scientists from various institutions in partnership with the Solomon Islands government to: 1) document local existing understanding of climate change (e.g. using GIS to map perceived changes) and possible adaptive measures and match these data to local scientific research (also conducted by our team); 2) build greater understanding of climate change, assess vulnerability to the changes, and consider optional responses locally (especially to sea level rise); and 3) develop capacity of the groups involved, including youth, women, and church groups to undertake future assessments of climate change, and better manage their coastal resources into the future. More specifically, this multidisciplinary research and applied initiative has measured the social and ecological effects of climate change, and rapid and protracted environmental disruption, and assessed the concomitant responses of coupled human and ecological systems across a gradient of socioeconomic and local governance systems across the Western Solomon Islands. We have asked the following questions:

1. What are the local perceptions of "change" and "adaptation," and how do local people actually adapt to ecological transformations?

2. What are the socioeconomic, ecological, and health or nutritional consequences of rapid and protracted environmental changes on coupled human and natural systems?

3. What are the human ecological responses (e.g. provisioning strategies) of coastal populations to environmental change and also to climate change-related catastrophic events?

4. What social factors — such as cultural norms, property regimes, economic welfare, and regulatory enforcement, as well as ecological factors such as high biodiversity, greater abundance of key species, and a complete community structure — may lead some communities to be more or less resilient than others when faced with environmental disruption?

5. Do CM systems increase the ecological and social resilience of coastal communities in the face of rapid and/or protracted change?

This research and applied programme is resulting in socioecological research on climate change that not only is generating novel information, but is also leading to improvements in the capacity of Solomon Islands coastal communities to respond to climate change-related transformations (e.g. already occurring sea level changes) (Dovey et al. unpublished data). In terms of scientific relevance, the research is allowing us to determine the levels of impact of climate change-related phenomena on household food security, well-being, health, and local ecology, and, more importantly, it is allowing us to elucidate the social and ecological drivers that may lead some communities to be more resilient than others when faced with environmental change. For that reason, we are beginning to gauge what makes a socioecological system in interface coastal zones more or less vulnerable to rapid and protracted environmental disruption. More generally, this work can potentially assist CTR researchers to analyze local responses to change and the associated asymmetries

between less or more resilient communities, and help fine tune a resource management plan (e.g. MPA networks) across the region.

Climate change in the CTR

In sum, as a result of changing global climatic conditions, humanity will be faced with increasing pressures from the natural world such as droughts, floods, hurricanes, and sea level rise. While extensive modeling has been conducted on the impact of these factors on the developed world, little regard has been given to impacts on rural societies. In the CTR, where societies are still directly reliant on the natural environment for food and shelter, it is likely that impacts from environmental disturbances will be significant. Today, the primary stress on coral reefs in the CTR originates from local commercial and artisanal fishing and runoff sedimentation caused by logging and mining. Simultaneously, global-scale changes from a warming climate, due to an increase in anthropogenic carbon dioxide, are expected to significantly and progressively increase the vulnerability of many reefs, including those of the Western Pacific, to local stress (e.g. Hughes et al. 2003; Hughes et al. 2005; Richmond et al. 2007). The combination of more extreme climate change and traditionally chronic forms of stress could act synergistically to accelerate the deterioration of coral reefs (Langdon et al. 2003). Rapid environmental disruptions, such as tsunamis, are likely to accelerate these processes and affect the livelihood of local communities profoundly in very short time scales. Therefore, CTR coastal communities are good candidates for climate change and adaptation research because: 1) they are directly dependent on the environment and still have a predominantly subsistence economy (fishing and horticulture), and 2) the environment they rely on is fragile and fragmented and the different ecological patches of its landscape react differently to climate change.

Socioecological research on climate change can help decision-makers and stakeholders at the local, regional, and global level understand the coupled ecological and social processes that underlie a social group's or community's capacity to cope with and adapt to change as well as the causes of differential susceptibility. The analysis of how CTR communities manage social and environmental change will help reveal possible solutions and potential obstacles for sustainable use of resources — knowledge that needs to be incorporated in coastal management plans such as the hybrid CM-EBM system outlined in this paper.

Discussion

MPA and climate change research and applied approaches outlined in this paper are potential components of the CM-EBM integrated hybrid management plan that considers the social, political, economic, and cultural context of communities within CTR nations and addresses the fundamental concerns of these countries, including coastal degradation, climate change, weak governance, limited resources and staff, and increasing poverty. Recent research on hybridization of management systems strongly suggests that ample opportunities exist for the establishment of context-appropriate EBM that includes watershed and adjacent coastal ecosystems. With the existence of CM in some CTR nations and the establishment of ICM (which can also be hybridized with EBM) in other areas of the CTR, a considerable base exists for rapid progress towards EBM if appropriate strategies are employed. This hybridization process should be undertaken quickly because of the rapid degradation of our ocean ecosystems and because there are really no other viable alternatives for holistic and potentially successful management of watershed and marine ecosystems.

The following "SESAME" principles formulated by Patrick Christie (see Aswani et al. 2012) should give researchers and conservation practitioners a practical guideline to use when designing management programmes in the CTR. First, any management system should be *Simple* and readily understood by policy makers and resource users (who are frequently *de facto* policy makers). Empirical studies show that the success of MPAs and common-pool resource-management regimes are dependent on a clear understanding of rules. Overly complex rules and management boundaries are a recipe for confusion and non-compliance. Priorities should be transparent and threats to ecosystem health should be identified in a way that considers the costs and benefits of management intervention and is informed by local knowledge.

Second, one should take an *Experimental* approach — that is, maintaining an attitude of curiosity about local histories, customs, socialecological interactions, and management options, which are the hallmark of a seasoned, effective practitioner. Management interventions, designed from this position of curiosity, will necessarily adapt over time as new information is assimilated. Each intervention ought to be conceived as an experiment based on diverse sources of information, which likely will have both anticipated and unanticipated outcomes.

Third, management programmes should be *Strategic* and evolve from early successes in response to local challenges, which may include previous success via CM or ICM. The art of effective management requires a keen ability to listen, synthesize, and create strategic partnerships to solve complex problems. If deemed helpful to improve resource management in any context, the evolution of EBM requires a decadal implementation time horizon.

Sustaining initial successes will require long-term investment and institutional support by all relevant parties. If this commitment falters before institutions have reached a self-sustaining level of development, it is possible that local resource users and managers will be less likely to extend their trust to future purveyors of management techniques and scientific advice, ultimately eroding the chances of long-term conservation.

Fourth, a standardized approach to management will fail unless made context *Appropriate*. Research teams need to create effective ICM and EBM programmes that cater to the local context. CM is grounded in millennia of learning and adaptation. The conclusion that methods and logics cannot mechanically be applied globally has been re-learned over the course of decades of development, health, and environmental management planning.

Fifth, a hybrid approach needs to be *Multi-disciplinary*. EBM has emerged from particular, and not wholly balanced, disciplinary roots. As a framework that has its strongest grounding in the natural sciences, and not social science or planning disciplines, it has the potential to ignore critical challenges and opportunities. As highlighted above, the needs and interests of people living in the CTR emphasize immediate necessities over long-term perspectives. The importance of environmental integrity, as an underpinning of human societies, is increasingly recognized. But righteous indignation over the loss of biodiversity or unsustainability, no matter how strongly felt by some, is unlikely to resonate with impoverished people or those who work in solidarity with them, as policy makers or support personnel.

Finally, practitioners need to establish *Evaluation* programmes. Initial experiments in ICM, conservation, or development did not adequately capture lessons learned. Ongoing, multi-disciplinary evaluation has now been mainstreamed in the most successful programmes and is fundamental to success. Such programmes allow learning and adaptation, and serve to explain failures and document successes. Relying only on beginning, mid-term, and final evaluations (by external consultants) is inadequate. Evaluative programmes are best when they are rigorous and inclusive of local resource users and policy makers through participatory monitoring methods.

Conclusion

Hybrid CM-EBM programmes present a chance to manage CTR marine ecosystems in a comprehensive fashion. It is important to realize, however, that CM is not a panacea for all terrestrial and marine resource management problems in the region. While CM governance includes watershed areas too, for instance, it has been unsuccessful at watershed-based management and controlling concomitant impacts on adjacent coastal ecosystems across the Pacific Islands region today. This can be attributed to modern capital investment pressures such as logging, industrial agricultural plantations, and mining activities, which illustrate that CM is not always effective at regulating environmental exploitation. Simply, CM is not designed to conserve biodiversity but, rather, to manipulate the environment for human benefit and well-being through various socially embedded management techniques (which may or may not be successful in biological terms). Portraying indigenous CM systems as conservationist is as misleading as saying that indigenous peoples are destroyers of nature. In addition, local ecological knowledge is not static; it is rather an amalgam of new and old ideas about the environment that is always changing. Recognizing that the range in variability and possible outcomes of human behavior and ideas are conditional and dynamic is the soundest foundation on which to build a hybrid co-managerial partnership between governments, scientists, conservation practitioners, and indigenous peoples. Ultimately, there is really no alternative to these existing systems regionally, which offer a governance context that under the right circumstances can be effective at fostering environmental sustainability while upholding the indigenous rights of peoples of the CTR.

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Recently published books

Poverty mosaics: Realities and prospects in small-scale fisheries

Jentoft, Svein and Eide, Arne (eds). 2011. Published in Dordrecht, Heidelberg, London and New York by Springer Verlag. ISBN 978-94-007-1581-3. 541 pages, 77 figs. Hard cover. Prices: EUR 128.95; USD 179.00; GBP 117.00.

This book attempts to provide a global perspective by situating small-scale fisheries within the broad academic discourse on poverty, fisheries management and development, based on case studies from 15 countries in Latin America, Europe, South and Southeast Asia, and Africa south of the Sahara. Millions of small-scale fishers work in conditions that are neither safe nor secure, and often they are socially and politically marginalised. Macro-economic and institutional mechanisms are essential to address these poverty and vulnerability problems, along with interventions at the local community level. This requires a profound understanding of what poverty means to fishers, their families and communities, how they cope with it and the challenges they face to improve their lives. Conclusions for policy-making argue that fisheries development, poverty alleviation, and resource management must be integrated within a comprehensive governmental approach that looks beyond fisheries.

The book is divided into five parts: 1) Positioning, 2) Understanding, 3) Coping, 4) Changing, and 5) Imagining.

Part One consists of three chapters: Chapter 2) "Avoiding poverty: Distributing wealth in fisheries" by Eide A. et al; Chapter 3) "Situating poverty: A chain analysis of small-scale fisheries", by Chuenpagdee,R. and Jentoft S.; and Chapter 4) "The meaning of poverty: Conceptual issues in small-scale fisheries research" by Jentoft S. and Midré G. This first section provides a global overview and background for the following parts and chapters.

Five chapters comprise Part Two, which aims to provide a sense of the context of small-scale fisheries and characterises the nature of poverty and vulnerability around world. These are: Chapter 5) "Living on the margin: Poverty-vulnerability nexus in the small-scale fisheries of Bangladesh", by Islam M.M.; Chapter 6) "Occupation of last resort? Small-scale fishing in Lake Victoria, Tanzania", by Onyango P.O.; Chapter 7) "Vanished prosperity: Poverty and marginalization in a small Polish fishing community", by Marciniak B.; Chapter 8) "More than income alone: The Anlo-Ewa Beach seine fishery in Ghana", by Kraan M.; and Chapter 9) "Wealth, poverty, and immigration: The role of institutions in the fisheries of Tamil Nadu, India", by Bavinck M.

Part Three focuses on strategies that people employ to sustain their livelihood. It consists of the following five chapters: Chapter 10) "Addressing vulnerability: Coping strategies of fishing communities in Yucatán, Mexico", by Salas S. et al.; Chapter 11) "Through boom and bust: Coping with poverty in sea snail fisheries on the Turkish Black Sea coast", by Knusen S. and Koçak H.; Chapter 12) "Community response: Decline of the chambo in Lake Malawi's Southeast Arm", by Hara M.; Chapter 13) "To make a fishing life: Community empowerment in small-scale fisheries in the Pearl Lagoon, Nicaragua", by González M.; and Chapter 14) "Learning from the expert: Attaining sufficiency in small-scale fishing communities in Thailand", by Chuenpagdee R. and Juntarashote K.

Part Four deals with factors that might either improve or worsen poverty and with policy reforms required to improve conditions in small-scale fishing communities. It comprises five chapters: Chapter 15) "Facilitating change: A Mekong Vietnamese small-scale fishing community", by Nguyen K.H.Y and Flaaten O.; Chapter 16) "Creating action space: Small-scale fisheries policy reform in South Africa", by Isaacs M.; Chapter 17) "Building resilience: Fisheries cooperatives in southern Sri Lanka", by Amarasinghe O. and Bavinck M.; Chapter 18) "Moving out of poverty: Conditions for wealth creation in small-scale fisheries in Mozambique", by Menezes A. et al.; and Chapter 19) "The merits of consensus: Small-scale fisheries as a livelihood buffer in Livingston, Guatemala", by Andrade H. and Midré G.

Part Five consists of a single chapter, "A better future: Prospects for small-scale fishing people", by Jentoft S. et al. This chapter is envisaged as a joint statement by all of the contributing authors, and summarises the main findings of the book and the authors' views of the lessons learned from it.

Managing coastal and inland waters: Pre-existing aquatic management systems in Southeast Asia

Ruddle, Kenneth and Satria, Arif (eds). 2010. Published in Dordrecht, Heidelberg, London and New York by Springer Verlag. ISBN 978-90-481-9554-1, e-ISBN 978-90-481-9555-8. Pages 188, Figs. 10, Photos 18, Tables 15. Hard cover.

This book consists of seven chapters: Chapter 1) "An introduction to pre-existing local management systems in Southeast Asia", by Ruddle K. and Satria A.; Chapter 2) "Pre-existing fisheries management systems in Indonesia, focusing on Lombok and Maluku", by Satria A. and Adhuri D.S.; Chapter 3) "Open to all?: Reassessing capture fisheries tenure systems in Southern Laos", by Baird I.G.; Chapter 4) "Seasonal ritual and the regulation of fishing in Batanes Province, Philippines", by Mangahas M.F.; Chapter 5) "Pre-existing inland fisheries management in Thailand: The case of the lower Songkhram River basin", by Khumsri M.; Chapter 6) "Vietnam: The *van chai* system of social organization and fisheries community management", by Nguyen D.T. and Ruddle K.; and Chapter 7) "Conclusion: Errors and insights", by Ruddle K. and Satria A.

In their introductory chapter Ruddle and Satria examine the role of pre-existing systems of fisheries management in tropical nations, which have not usually been used as an alternative to introduced Western scientific approaches. During the colonial era, non-Western models were disparaged openly, whereas nowadays, commonly they are dismissively labelled as "traditional" or "special" cases. Often predicated on misguided theories, during the 1950s and 1960s a massive and experimental packaged transfer of social, economic, financial, educational, and legal systems, together with their underlying cultural values and aspirations regarded pre-existing economies, management systems, and often social and cultural systems as obstacles to modernisation. Modernisation provided the justification for foreign designers of fisheries management schemes to claim that pre-existing systems were either primitive or unsustainable or often "non-existent". This was reinforced by a general ignorance of the tropics and prejudice on the part of scientists and educators, whose careers were enhanced by work in temperate regions. The generic "design principles" and functioning of pre-existing systems are summarised, together with the status of knowledge on Indonesia, Laos, the Philippines, Thailand and Vietnam.

As demonstrated by the chapters on Laos, Thailand and Vietnam, pre-existing systems were long established in inland waters. In Chapter 3, using case studies of three pre-existing tenure systems for fisheries management from Champasak Province, Ian Baird debunks the myth that all fisheries resources in southern Laos were historically "open access". In all three of these ecologically and socially very different examples, private resource ownership is socially and culturally sanctioned as part of a common property management system, based on first claims to fishing sites and labor inputs. "Open access" rarely exists in southern Laos, which may not become evident without sustained observations of different fisheries. Field research, in the lower Songkhram River basin (LSRB) of northeastern Thailand by Malasri Khumsri revealed that fisheries resources are managed concurrently by local communities, based on pre-existing or *de facto* rights, and *de jure* by the Department of Fishery, according to the Fisheries Law of 1947. Further, according to the Thai Civil and Commercial Law of 1925, natural resources used in common, such as shores, streams and lakes are state property. However, concurrently, local communities recognise that individuals have ownership of fishing rights in such areas, and that they also have the right to exclude others from fishing within them. The result is a complex and multiple set of overlapping, complementary and conflicting individual, common and state property rights within a single, small geographical area used as a fishing ground. However, as Khumsri demonstrates in Chapter 5, the performance and sustainability of the present joint system of management is constrained both by a lack of clearly defined property rights and rules aimed specifically at sustainable resource use, and a mismatch between local and state institutional arrangements for fisheries management.

As examined in Chapter 6, by Nguyen and Ruddle, in Vietnam the pre-existing fisheries management system known as the *van chai* emerged from the administrative structure of farming villages in the northern provinces of the country, so their administration and social management reflected traditional Vietnamese agrarian culture. Originally, the *van chai* administered inland fisheries. However, with the gradual settlement of ethnic Vietnamese along the coast of the central region, where inland fisheries were insignificant

but marine fisheries became of major importance, the *van chai* was adapted to the needs of marine fishing communities, where it became the focus for spiritual activities related to fishing. Each new fishing community along the south-central coast established a *van chai* to worship the Whale God.

The recent disappearance of pre-existing systems is one reason why they have not been documented. In the case of Indonesia, pre-existing systems of fisheries management were delegitimised during the "New Order Era" (1966–1998), before their importance was recognised. They were revived after a 30-year hiatus, when the "Reform Era" began in 1998. One such system is the *awig–awig* and *sawen* of north Lombok, and another is the *petuanan* and *sasi* of Maluku. These are examined in Chapter 2. Local people revived *awig–awig* and adapted them to the contemporary need of overcoming destructive fishing practices and implementing a system for sustainable fisheries management.

Another common reason for the failure to document pre-existing systems is the absence of recent field research, particularly in remote areas, combined with the common assumption that such systems either do not exist in a given area or that they have little or no relevance to modern fisheries management. Such is the case examined in Chapter 4 of the *mataw* fishers of Batanes — the 10 small and northernmost islands of the Philippine archipelago — who engage in the seasonal capture of flying fish and dorado.

As a group, these cases highlight some important and generally overlooked aspects of the characteristics and context of pre-existing systems. These are: their fundamental role in the management of fishing communities; the existence of multiple, overlapping, flexible and adaptable rights; pre-existing systems often involve a set of human ecosystems and their resources, and not just fisheries, which are managed in a coordinated manner; and pre-existing systems are greatly affected by a constellation of interacting external pressures for change. In overlooking these, policy makers and planners commit a serious error of judgment.

Fisheries management in Japan: Its institutional features and case studies

Makino, Mitsutaku. 2011. Published in Dordrecht, Heidelberg, London and New York by Springer Verlag. ISBN 978-94-007-1776-3. 215 pages, 28 figs., Hard cover. Prices: EUR 99.95; USD 129.00; GBP 90.00.

Dr Makino has written a comprehensive book that is both a detailed reference and a study of fisheries management. The book consists of 10 chapters, the final one of which is a concluding discussion.

Chapter 1, "Introduction", provides an outline of Japan and its fisheries, together with general information on the country, including geography, ocean currents, population, national economic structure, and food culture, among other topics. It contains an overview of the Japanese fisheries sector, and covers aspects of the legal system, administration, insurance structure, and social institutions. The national fisheries infrastructure is examined via fishing grounds, ports and communications, education, scientific information, and the statistical system. Chapter 2 provides a brief institutional history of fisheries management that includes sub-sections on the pre-feudal era, the modernisation of Japan, current fishery laws, fisheries management systems, and major laws and systems.

Japanese fisheries today are examined in Chapter 3. Based on up-to-date statistics, current conditions of the problems facing Japanese coastal fisheries are examined and the major capture fisheries sectors and their management profiled. Aquaculture is examined in a similar manner. Chapter 4, which deals with fisheries management in coastal areas, is based on a description of three cases: the sea cucumber fishery in Mutsu Bay, the sand eel fishery in Ise Bay, and the sandfish fishery in Akita Prefecture. Chapter 5 is devoted to fisheries management in offshore areas, and based on two case studies. The first is of snow crab management in waters off Kyoto Prefecture, and the second is of industrial fishing in the northwestern Pacific that targets sardines, anchovies and mackerel.

In Chapter 6, the institutional relationship between Japanese fisheries management and the ecosystem approach is examined. Emphasis in placed on measures required to adapt Japanese fisheries management to ecosystem-based management. The author asserts that the Japanese system needs to adopt an ecosystem perspective, expand stakeholder involvement, and adopt an ecosystem monitoring system and appropriate use of indicators and protected areas. Next, in Chapter 7, marine protected areas (MPAs) are discussed. In Japan two types exist. Legal MPAs are established based on law and set up by government. In contrast, autonomous MPAs are established on local initiatives, and mostly planned and implemented by fishers. In Chapter 8, the UNESCO World Heritage List is examined, based mostly on the example of the Shiritoko Peninsula, in Hokkaido. Fishing is one of the main industries in the peninsular area, such that they form

an integral component local ecosystem. Given that the participation of the fisheries sector has been integral to the local ecosystem planning from the very beginning of the process, the experiences of the Shiritoko Peninsular are potentially useful for informing ecosystem-based management elsewhere in the world, particularly where large numbers of small-scale fishers are involved. Finally, Chapter 9 examines comprehensive management in terms of the "Grand Plan" for Japanese fisheries during the next two decades, and also future theoretical scenarios for Japanese fisheries — a global competition scenario, a national food security scenario, and an ecological mosaic scenario.

Explaining human actions and environmental changes

Vayda, Andrew P. 2009. Altamira Press (A division of Rowman and Littlefield Publishers, Inc.), Lanham (MD, USA), New York, Toronto, and Plymouth, UK. ISBN 978-0-7591-0323-8; eISBN 978-0-7591-1900-0.

It is with pleasure that I introduce to you the book **"**Explaining human actions and environmental changes**"** by Andrew P. Vayda who, in some hundred articles and several books, specialised mostly in methodology and explanation at the interface between social and ecological science. His research, often crossing disciplinary boundaries, has focused both on philosophical issues and on subjects ranging from warfare and migration to forest fires and insect pest management. He has directed and participated in numerous research projects on people's interactions with forests in Indonesia and Papua New Guinea. Still very actively involved in research on fire in Indonesian wetlands, "Pete" Vayda, now professor emeritus of anthropology and ecology at Rutgers University, was formerly a professor at Columbia University, in New York City. He founded the journal *Human Ecology*, and for five years was its editor.

The essays re-published in this volume all examine aspects of explanation, and the methods of explanation-oriented research. Some were stimulated by the author's desire to understand the causes of particular phenomena, such as extensive fires in the humid tropical forests of Indonesia, whereas others arose from dissatisfaction with assumptions, explanations, or research methods used in political ecology, Darwinian human behavioural ecology, and local knowledge studies.

The first chapter examines causal explanation and research, and includes invaluable "dos and don'ts" in explanation and explanation-oriented research. The following chapters expand on the illustrations, points or arguments. Among the topics examined are confirmation bias, naïve functionalism and adaptationism, the misdirection of interdisciplinary research, the practical defects of holistic approaches, the reification of processes or systems, and the importance of clarity about our objects of explanation.

The chapters contents are: 1) **"**Causal explanation as a research goal: Dos and don'ts**"**; 2) **"**Both ends of the firestick: Causal explanation of Indonesian forest fires**"**; 3) **"**On knowing what not to know about knowing: A critical view of local knowledge studies**"** (with Bradley B. Walters and Indah Setyawati); 4) **"**Do we need an anthropological perspective on tropical deforestation?**"**; 5) **"**Seeing nature's complexity but not people's**"**; 6) **"**Against political ecology**"** (with Bradley B. Walters); 7) **"**Failures of explanation in Darwinian ecological anthropology**"**; 8) **"**Concepts of process in social science explanations**"** (with Bonnie J. McCay and Cristina Eghenter); 9) **"**Explaining why Marings fought: Different questions, different answers**"**; and 10) **"**The anthropology of war: Polemics and confusion**"**.

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