Fishing taboos: Securing Pacific fisheries for the future?

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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

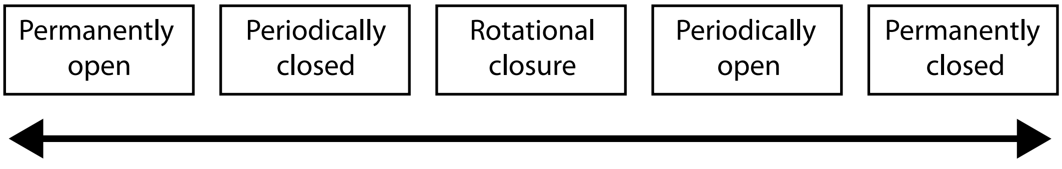

Figure 1. The spectrum of area closure and fisheries opening regimes practiced in the Pacific.

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,

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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.

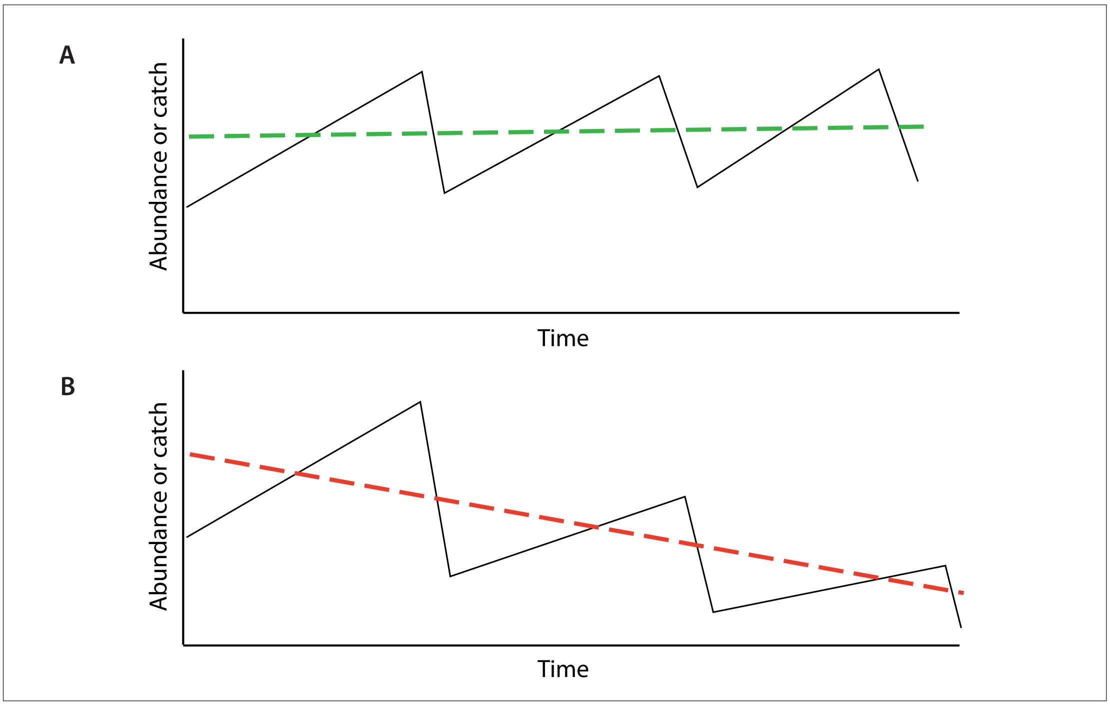

Figure 2.

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 wellbeing 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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