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Blue Ventures Report: Experiences of periodic closures in small-scale invertebrate fisheries

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WIOMSA
Western Indian Ocean Marine Science Association

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List of abbreviations and acronyms

BV	Blue Ventures
CMT	Customary Marine Tenure
CPUE	Catch Per Unit Effort
FAO	Food and Aquaculture Organisation
LMMA	Locally Managed Marine Area
NGO	Non-Governmental Organisation
PICT	Pacific Island Countries and Territories
PNG	Papua New Guinea
WIO	Western Indian Ocean
WIOMSA	Western Indian Ocean Marine Science Association

1. Summary

Periodic closures, which are also known as temporary, short-term, rotational, periodically harvested, or non-permanent closures, temporarily ban the harvesting of marine resources in specific areas (Cohen and Foale, 2013). Use of such closures is increasing in community-based management initiatives across the Indo-Pacific and is supported by a growing evidence base (Cinner *et al.*, 2006; Bartlett *et al.*, 2009; Cohen and Foale, 2013; Oliver *et al.*, 2015).

In the Western Indian Ocean, interest in periodic closures has largely centred on their use in the management of reef octopus *Octopus cyanea*, a regionally important species that is both consumed locally and sold for export to southern Europe (Humber *et al.*, 2006; Moreno, 2011). Closures began in Madagascar in 2003, typically cover 25% of a community's overall octopus fishing grounds and are in place for 2-3 months at various times of year. The apparent success of early closures led to other communities following suit, and as of October 2015, more than 250 closures have taken place.

To help strengthen and support these efforts, this reportuses a case study approach to examine experiences of short-term closures for artisanal invertebrate species other than octopus across the Indo-Pacific. The report's key findings are

- Periodic closures are a commonly used management tool in many parts of the Pacific, especially countries with a tradition of customary marine tenure (CMT) – the right to control access to fishing grounds at the local level. In this context, most closures are used to manage multi-species reef assemblages, though there is little empirical support for doing so.
- In a Western management context, periodic closures have been used for benthic invertebrates such as trochus, scallops, urchins, lobster, coral and abalone. Here too, results have been variable and there is presently little consensus on the effectiveness of the approach from field studies.
- Evidence from modelling studies and preliminary empirical research in New Zealand is more instructive and suggests that longer-lived, slower-growing species will need longer periods of closure for benefits to accrue than faster-growing, shorter-lived species and that periodic closures are generally better suited to short-lived, fast-growing species.
- In tropical artisanal fisheries, periodic closures have also been used to manage single invertebrate species such as octopus (*Octopus cyanea*), trochus (*Tectus niloticus*), mud clams (*Polymesoda spp.*), mud crabs (*Scylla serrata*)lobster (*Panulirus spp*), and blood cockles (*Tegillarca granosa*).
- Evidence from the case studies discussed here suggests that periodic closures can be a successful management strategy for small-scale coastal invertebrate fisheries, improving food security and delivering positive economic benefits to low income fishing communities.
- It is difficult to determine the key factors that underpin a successful periodic closure system for small-scale invertebrate fisheries because approaches are highly varied, even between closures aiming to manage the same species (e.g. trochus).

2. Introduction

Permanent spatial marine closures

Despite their value to humans, marine ecosystems worldwide are threatened by a range of anthropogenic pressures, including pollution, habitat loss, climate change and overfishing (Halpern et al., 2008; Jackson, 2008; Lester et al., 2009). These impacts have drained populations of culturally and economically important fish stocks and reduced structural complexity of various marine communities across a rich range of habitats, species and trophic levels (Fraschetti et al., 2011; Graham et al., 2008; Lester et al., 2009)

In the Western Indian Ocean (WIO) as throughout the world, spatially discrete closures have been a primary management approach in attempts to alleviate anthropogenic pressures (IUCN, 2004). Solid evidence from Marine Protected Areas (MPAs), particularly for permanent No-take Zones (MPAs that allow no extraction), shows that protection can increase average size, diversity, abundance and biomass of species (Lester et al., 2009; Roberts and Hawkins, 1997; Russ and Alcala, 1996) and can also play a role in climate change adaptation, enhancing ecosystem resilience and protecting vital ecosystem services (Hastings et al., 2012; Van Lavieren and Klaus, 2013).

From a fisheries management perspective, the primary expected benefit of permanent reserves lies in the export of biomass beyond protected boundaries. This can occur through two mechanisms: net export of pelagic eggs and larvae (the recruitment effect) and net migration of juveniles and adults from the protected site to fished areas (the spillover effect) (Gell and Roberts, 2003; Russ et al., 2004; Russ and Alcala, 2010).

Despite evidence of their value as management tools for the restoration and maintenance of marine ecosystems, permanent spatial closures often fall short of their original goals and sometimes fail entirely, though published negative evaluations are rare(but see: Caveen et al., 2014). Inadequate long-term funding and widespread management failure have resulted in unenforceable and ineffectual "paper parks" (Jennings, 2009). And because benefits for fishers can take time to accrue, permanent closures may be ecological successes but social failures, causing economic hardship and social displacement among marginalised communities (Christie, 2004).

The most recent global evaluations suggest that less than 16% of MPA managers feel they have adequate funding for effective conservation (Balmford et al., 2004) and that just 15% of coral reef MPAs are effectively managed (Burke et al., 2011). Regional evaluations have reached similar conclusions. In a recent review of marine conservation successes in the WIO, for example, Samoilys & Obura (2011) only mention one example of successful government-established MPAs: those of Kenya.

Periodic spatial marine closures

As a result of these shortcomings, periodic closures, which temporarily ban the harvesting of marine resources in specific areas, may be a preferable approach in certain contexts (Cohen and Foale, 2013). Use of periodic closures, which are also known as temporary, short-term, rotational, periodically harvested, or non-permanent closures, is increasing in community-based management and is supported by a growing evidence base (Bartlett et al., 2009; Cinner et al., 2006; Cohen and Foale, 2013; Oliver et al., 2015). In contrast to permanent marine protected areas, the primary fisheries benefit of periodic closures is not due to increased spillover or recruitment but to stock build up in the closed area that is later subjected to periodic and direct exploitation (Cohen and Foale, 2013). Moreover, temporary closures aim to reduce administration costs, simplify logistics, reduce the complexity of enforcement and facilitate community-led decision making, monitoring and management(Gnanalingam and Hepburn, 2015; Johannes, 1998).

The duration of a temporary closure should ideally be determined by the life history and recruitment dynamics of the species being protected, and the extent to which biomass was reduced before the closure(Gnanalingam and Hepburn, 2015). For some slow-growing, slow-reproducing species, a ten year closure might be required for a population to showsignsrecovery(Gnanalingam and Hepburn, 2015); closures of between two and four years have shown to be promising for a number of relatively sedentary, short-lived species such as clams with demersal larvae and steady recruitment (Cohen and Foale, 2013); while shorter periods of 3-7 months have provenhighly effective for some fast-growing invertebrates (Oliver et al., 2015).

In the Western Indian Ocean, interest in periodic closures has centred on their use in the management of reef octopus (*Octopus cyanea*). In Madagascar, where this approach was piloted in 2003 and hassince been replicated more than two hundred times, closures typically cover 25% of a community's overall octopus fishing grounds and are in place for 3-7 months at various times of year. Adoption of this locally led fisheries management model continues to grow each year, not only in Madagascar but increasingly in other parts of the region, including Mauritius and Tanzania.

Aims and objectives

In recognition of the increasing regional interest and to highlight some of the factors that may improve management outcomes, this short report examines experiences of periodic closures in other small-scale invertebrate fisheries, drawing together case studies from across the Indo Pacific, including the mangrove crab *Scylla serrata* and spiny lobster *Panulirus spp.* in Madagascar;the topshell trochus (*Tectus niloticus*) in Indonesia, the Solomon Islands and the Cook Islands; and the black foot abalone (*Haliotis iris*) in New Zealand,. The following section presents an overview of the history and contemporary use of periodic closures and summarises current thinking on periodic closures for octopus fisheries management.The case studies themselves form the central portion of this report, while the concluding section explores the commonalities and key issues that arise from the studies.

This research formspart of a trio of reports prepared by Blue Ventures for the *Scaling Success In* workshop, held in Stone Town, Zanzibar, from 3-5 December 2014. The other two reports are *The status of octopus fisheries in the Western Indian Ocean* and *Scaling Success In Octopus Fisheries Management. Proceedings of the Western Indian Ocean Workshop*, 3-5 December 2014, Stone Town, Zanzibar.

3. Periodic closures: history and use

In many parts of the Pacific, periodic closures were historically part of informal systems of community-based marine managementand were often used to replenish stocks ahead of feasts, to protect sacred sites, or to mark the death of prominent community members(Christie and White, 1997; Cohen and Foale, 2013; Johannes, 1978). Motivations for closures were thus driven by socio-cultural traditions rather than sustainable use, though fisheries management benefits may also have resulted in some situations (Cohen and Foale, 2013; Foale et al., 2011).

The community-based marine management systems that are currently spreading through the Indo-Pacific have their origins in this approach and have occurred largely as a result of disillusionment with top-down, centralised government interventions (Cohen and Foale, 2013; Govan et al., 2006; Wamukota et al., 2012). According to Govan et al. (2009), more than 500 communities across 15 countries in the Pacific manage 12,000km^2 of coastal resources, 1,000km^{2}of which is within area-based closures. Whilst some of these are afforded permanent protection, most are opened or closed periodically (Cohen and Foale, 2013).

These closures are typically used to manage an entire species assemblage (for example a specific area of coral reef), but may also be employed to protect a single invertebrate species such as trochus (*Tectus niloticus*) or mud clam(*Polymesoda spp.*) (Bartlett et al., 2009; Cinner et al., 2006; Cohen et al., 2013; Cohen and Alexander, 2013; Foale, 1998; Jupiter et al., 2012; Nash et al., 1995; Oliver et al., 2015; Williams et al., 2006). From a fisheries management perspective, there is little empirical support for the use ofperiodic reef closures for multi-species assemblages, with several studies showing no clear positive effects of periodic closures on biomass or fisheries yield(Cohen et al., 2013; Cohen and Alexander, 2013; Jupiter et al., 2012; Williams et al., 2006). However, in areas subject to low fisheries pressure, there is some evidence to suggest that biomass can increase relative to sites without protection (Bartlett et al., 2009; Cinner et al., 2006; Oliver et al., 2015).

Periodic harvesting has also been examined extensively in the Western fisheries literature, where, often termed “pulse fishing”, ithas been proposed as an alternative to stationary or constant fishing yields for at least 40 years (Clark et al., 1973; Hannesson, 1975; Oliver et al., 2015). In this context, several authors have discussed and tested periodic closures, principallyfor benthic sessile and sedentary invertebrates, but also for fish or multispecies fisheries (Cohen and Foale, 2013).

Species	Country/Region	Management	Sources
Trochus (*Tectus niloticus*)	Cook Islands, South Pacific	Co-managed quota system, see case study 5 for details	Govan, 2011; Nash et al., 1995; SciCOFish, 2013
Atlantic sea scallop (*Placopecten magellanicus*)	Northwest Atlantic, US Atlantic fishery	Centralised	Hart, 2003; Valderrama and Anderson, 2007
Red sea urchin (*Mesocentrotus franciscanus*)	California, US and Washington State, US	Centralised	Botsford et al., 1993; Pfister and Bradbury, 1996
American Lobster (*Homarus americanus*)	Magdalen Islands (Quebec)	Centralised	Gendron and Brêthes, 2002
Mediterranean Red Coral (*Corallium rubrum*)	Mediterranean	Centralised	Caddy, 1993

Table 1. Examples of periodic closures in Western fisheries management literature

Here too, results have been variable and there is presently little consensus from field research on the effectiveness of a periodic fisheries management strategy (Cohen and Foale, 2013; Oliver et al., 2015).

Modelling studies are more instructive, suggesting that

- Periodic harvests may provide superior economic yields to stationary harvests, particularly when the fishery is unable to target individuals of a particular age classselectively (Clark et al., 1973; Hannesson, 1975; Oliver et al., 2015).
- Optimal closure durationsdepend on the life-history characteristics of the targeted species, with longer-lived species requiring longer periods for benefits to accrue than rapidly growing, shorter-lived species (Caddy and Seijo, 1998).

In the Western Indian Ocean, much of the research into periodic closures has focused on their potential as a tool for octopus fisheries management. For instance, a recent bio-economic analysis(Oliver et al., 2015) of eight years of landings data from the first area of Madagascar to pioneer the periodic closures for octopus fisheries has shown that:

- Impacts on fishery catches, village fishery income, and net economic benefits from 36 closures were significantly positive.
- Octopus landings and catch per unit effort (CPUE) increased significantly in the 30 days following a closure's reopening, relative to the 30 days before a closure.
- Results in open-access control sites where fishing was permitted depended on whether the focal closure occurred independently of other management ("no ban") or the focal closure extended a seasonal fishery shutdown affecting all sites during the closures' first six weeks ("ban"). Control sites showed no before/after change during "no ban" closures, but showed modest increases during "ban" closures.
- In villages implementing a closure, octopus fishery income doubled in the 30 days after a closure, relative to 30 days before. Control villages not implementing a closure showed no increase in income after "no ban" closures and modest increases after "ban" closures. Villages did not show a significant decline in income during closure events.
- Landings in closure sites rapidly generated more revenue than simulated landings assuming continued open-access fishing at that site. Benefits accrued faster than local fishers' time preferences during 17-27 of the 36 closures. High reported rates of illegal fishing (poaching) during closures correlated with poor economic performance.
- In several cases, the periodic octopus closures in Madagascar have provided the catalyst for encouraging stakeholder buy-in to broader marine resource management efforts, including the creation of permanent marine protected areas, now established at numerous sites by communities in parallel with the closures.

For more information on this work, please visit http://discover.blueventures.org/marine-management-pays/

4. Case study 1: The mangrove crab fishery of Southwestern Madagascar

Prepared by Steve Rocliffe, Lucy Anderson and Charlie Gough

Background to the fishery

In November 2010, Blue Ventures Conservation began monitoring catches of the mangrove or mud crab, *Scylla serrata*,in Southwestern Madagascar. The programme focused on the villages of Andika, Andranolava and Antanimanimbo in the Toliara region of Madagascar, and the village of Belo sur Mer in the district of Morondava.

Traditionally a subsistence activity with low export volumes, in recent years the fishery has witnessed a huge surge in foreign buyers, principally from China,purchasing crab for the live export market. This has increased both the value of the catch and the quantity harvested, intensifying pressure on the resource and raising concerns over overexploitation.

Targeted species

The mangrove crab is found in tropical and sub-tropical inshore areas from the East and South Africa to the Pacific Islands, typically in muddy areas associated with mangroves and seagrass beds in the mouths of rivers and sheltered bays (SPC, 2011a). The crabs burrow in the mud and generally have a restricted home range, feeding on small clams, worms, shrimps, barnacles, small fish, plant material and other crabs. The main predators of juvenile mangrove crabs include wading birds and a wide range of fish. Adult crabs have been found in the stomachs of sharks and larger fish.

Mangrove crabs may spawn at any time of the year. They reach reproductive maturity in approximately 2 years and live for about 3 to 5 years, by which time they can weigh up to 3.5 kg with a shell width of up to 24 cm (SPC, 2011a). Each breeding season, females produce over one million eggs each and carry them for approximately 12 days (SPC, 2011a).

Catch methods

Across the Indo-Pacific, a variety of methods are used to catch mud crabs, including the following:

- Simple hand collection, sometimes with the aid of a hooked stick to remove crabs from their burrows;
- The use of spears or hooks to capture crabs in their holes at night using torchlight;
- The use of long-handled scoop nets in seagrass beds;
- The use of gill nets set at the edge of the mangroves to catch crabs as they move into deeper water;
- The use of baited traps and dillies made of string or wire mesh (SPC, 2011a)

Traps are considered to be one of the best ways of catching mud crabs, as they do not damage the crabs, allowing for the release of berried females, or crabs which do not meet minimum size criteria (SPC, 2011a).

In Southwestern Madagascar, the most popular techniques for crab harvesting are hand collection (48.5% of fishing trips) and spear fishing (26.7% of fishing trips). Crabs with a shell width of over 10cm were previously sold for export, however in August 2014 anational minimum landing size of 11cm was introduced by the Malagasy Ministry of Fisheries Resources (Arrêté No. 32101-14). Further research is being conducted to identify the optimal landing size and this may result in further revisions to minimum landing size in future (Arrêté N°32101-14). Small crabs (typically < 10cm) are eaten locally.

The closures

Temporary closures to the mangrove crab fisheries in the Toliara region began in 2011. As of December 2014 there had been 23 closures across ten sites (Table 2).

Village	Site	Area (ha)	Time of year	Predominant season	Current management body	Closure dates (duration)
Antanimanimbo	Bezaha	117	July – November (4 months) March – December (6 months) March – July (4 months) April – July (3 months)	cold end of hot and cold end of hot hot	Community	01.07.11 – 11.11.11 20.03.12 – 23.09.12 26.03.13 – 19.07.13 26.04.14 – 02.08.14
Belo sur Mer/Marofihitra	Andompingo	60	July – November (4 months)	cold	Discontinued	01.07.11 – 11.11.11
Belo sur Mer/Antsira	Asangara	27	July – November (4 months)	cold	Discontinued	01.07.11 – 11.11.11
Andika-sur-Mer	Tsarafihango et Ambotry	31	December – April (5 months) April – September (4 months) March – October (7 months) March – August (5 months)	hot cold end of hot and cold end of hot and cold	NGO partner and community	15.12.11 – 29.04.12 30.04.12 – 10.09.12 07.03.13 – 20.10.13 28.03.14 – 07.08.14
Andranolava	Tsimatamoy et Nakolovo	135	May – October (5 months) October – January (3 months) February – November (9 months) May – November (6 months)	cold hot end of hot and cold cold	Community	22.05.12 – 22.10.12 30.10.12 – 30.01.13 07.02.13 – 13.11.13 13.05.14 – 28.11.14
Belalanda	Ambotsy	86	August – November (3 months)	cold	Community	19.08.12 – 19.11.12
Belalanda	Mokotra	86	July – November (4 months) April – November (6 months)	cold cold	Community	27.07.13 – 30.11.13 30.04.14 – 18.11.14
Lovobe	Bekola	1	February – May (3 months)	hot	NGO partner and community	06.02.13 – 08.05.13
Lovobe	Antsakody		March – N/A	hot	NGO partner and	15.03.14 – ?

					community	
Antsatsabo	Anbatsakoa	19	May – November (6 months)	cold	NGO partner and community	27.05.13 – 28.11.13 25.04.14 – ?
Manometinay	Ankazofoty		February – July (5 months)	hot	NGO partner and community	12.02.14 – 09.07.14
Begamela	Begamela		April – June (3 months)	cold	NGO partner and community	03.04.14 – 23.06.14

Table 2. Details of the ten sites in Southwestern Madagascar that have implemented temporary mangrove closures since 2011. Hot season in the region runs November to late April, cold season from May to October.

Before each closure begins, Blue Ventures works with members of the the village(s) championing the reserve, and all other communities adjacent to the fishing area who also use those resources,to determine:

- Where the closed area(s) will be located (taking into account the locations of key transport routes between villages, seasonality of semi-permanent ponds etc.);
- Which communities are located near the closed area (it is vital that all communities that use the fishery are consulted and in agreement for the reserve to go ahead);
- Who fishes/uses the mangrove;
- How the reserve will be guarded from fishing during the closure;
- If movement of people in/out of the closed site will be allowed and if so how will this be monitored;
- How the closure will be enforced. Agreement on fines and how this will be implemented if people are found to disobey the closure;
- The optimal timing of the closure (taking into account the target species' growth rates);
- The optimal timing of the opening day (taking into account tidal cycles and different fishing practices)
- Who will be allowed to fish during the opening day(s)

The information forms the basis of a *dina:*a customary law unique to Madagascar that is designed to manage potential sources of social conflict. Dinas are anchored in custom and tradition but are also legally recognised.

During a closure, the entire mangrove channel is closed, as well as the mangrove surrounding it (approximate areas provided in Table 1). The beginning of each closure is announced on the radio, and a flag and a sign mark the closed mangrove channel.

Since mangrove crabs thrive in undisturbed habitats, all forms of access are generally prohibited during the closures, although access is sometimes allowed if it is essential to access a farm or major thoroughfare. Some of the villages employ guardians to protect stocks during the closure. In other areas, management committees take it in turns to act as guardians on a rota system.

The closures are funded by each village's fisher contribution scheme. When the crab fishery reopens, fishers are charged either by the boat or by the kilogram. The income pays for management expenses, signs, radio adverts and the employment of guardians to enforce the closure. Although the closures were initially implemented in partnership with Blue Ventures, three communities are now managing them independently of NGO support. That said, other closures have been less successful. The two reserves (Andompingo and Ansangara) piloted near to the village of Belo sur Mer were discontinued after the first year because a consensus about when and how the closure should be managed could not be reached between the large community in Belo sur Mer and the surrounding villages that share the same mangrove. Preliminary data on the effectiveness of the closure have yet to be verified.

In addition to the community-managed fishery closures, in 2014 the Malagasy Ministry of Fisheries Resources introduced two obligatory closed seasons during which no mangrove crab collection, sale, transportation or export is permitted (Arrêté N°25830-14). The two closed seasons run from 01 Feburary - 31 March, and again from 01 September and 31 October each year. Fishers caught violating the law face prosecution (Arrêté N°32101-14).

Challenges

One issue that threatens the success of the fishing closures is the use of laro, a type of fish poison derived from a local endemic euphorbia (splurge). So far, however, community enforcement of the closures has proved effective, and laro use appears to be more of a problem outside the closures than within them. Another potential set back is the location of Sopemo, one of the country's major crab buyers, in the north of Morondava. The company has not sent collectors to the mangrove crab fisheries in the south of the region when closureshave reopened, creating potential market barriersfor these fisheries.

5. Case study 2: The spiny lobster fishery of Sainte Luce, Madagascar

Prepared by Steve Rocliffe, Lucy Anderson, Emma Quilligan, Charlie Davis and Stephen Long

Background to the project and fishery

Between 2003 and 2012, 54% of Madagascar's annual spiny lobster catch was landed from the Fort Dauphin regional fishery[1,2]. The regional fishery is made up of around 40 fishing communities along the coast of the Anosy and Tandroy regions between Androka and Manantenina.

Within the region, the near-shore lobster fishery in the isolated village of Sainte Luce provides an average of 21 tonnes of spiny lobster each year: approximately 8.5% of the region's annual catch[3]. Sainte Luce is an extremely impoverished area, and lobster fishing is a core income generating activity for 80% of households in the village (Azafady, 2015). The pressure to catch lobster has seen the number of lobster fishers increase from just 10 in 1950 to over 400 in 2015 (per comm. S Long, Azafady), now including migrants from outside the area.

Likely as a result of this long-term overexploitation,lobster catches in the regional fishery more than halved between 2005 and 2012[1]. With concern mounting, Project Oratsimba was launched in June 2013. The initiative, run by the UK/Malagasy social development NGO Azafady and funded by the EU and the Food and Agriculture Organisation of the UN (FAO) SmartFish initiative, aims to build the capacity of communities to sustainably manage their own fisheries, engage with wider stakeholders to ensure long term support for the fishery and develop a monitoring system to inform and evaluate the effectiveness of management measures (Azafady, 2015). The ten-month pilot phase (hereafter Phase I) included the development of a 160km^2 LMMA with a 10km^{2}No-Take Zone (NTZ), the development of a*dina* (customary law, now recognised by national legislation) and the establishment of a committee of locally elected fishers, responsible for patrolling the area and enforcing the *dina*.

Targeted species

The fishery is dominated two species: the long-legged spiny lobster*Panulirus longipes*, and the scalloped spiny lobster *Panulirus homarus*. *P. longipes* and *P. homarus* have a maximum body length of 30cmand typically inhabit rocky coastal areas to depths of up to 18m and 5m respectively (Holthius, 1991).

P. longipes is found from East Africa to Japan and Polynesia (Holthius, 1991). There are two subspecies in the Indo-Pacific: *P. l. longipes*, which occurs from East Africa to Thailand, Taiwan, the Philippines and Indonesia, and *P. l. bispinosus,* which is found in Japan, the Moluccas, New Guinea, eastern Australia, New Caledonia and Polynesia(Holthius, 1991; MacDiarmid et al., 2013). Both subspecies are common and harvested throughout their range by artisanal fisheries and are likely to be locally overexploited(Holthius, 1991; MacDiarmid et al., 2013).

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[1]Unpublished data 2003-2012. Sources: Les Directions Régionales des Ressources Halieutiques et de la Pêche (Fort Dauphin) and Unité de Recherche Langoustière. Supplied by Azafady, Madagascar.
[2]FAO Global Capture Statistics http://www.fao.org/fishery/statistics/global-capture-production/en
[3]Unpublished data 1991 to 2012. Source as [1]

P. homarus's geographic distribution is the Indo-West Pacific region: East Africa to Japan, Indonesia, Australia, New Caledonia and probably the Marquesas Archipelago. The nominotypical form (*Panulirus h. homarus*) is found throughout the range of the species; *P. homarus megasculpta* is only known from the northern Arabian Sea (Socotra, south coast of Arabia, perhaps west coast of India); *P. h. rubellus* inhabits S.E. Africa (Mozambique to Natal) and S.E. Madagascar (Holthius, 1991).

Catch methods

In Sainte Luce, lobsters are caught by small teams of fishers using handmade lobster traps and are landed at two natural harbours from traditional wooden *pirogues*, or canoes. The *pirogues* are often owned by middlemen known as *collecteurs*, whose local *rabbateurs* purchase lobster directly from the fishers on the beach at set prices. The *collecteurs* transport the lobster to Fort Dauphin before *opérateurs*, chiefly the companies Madapêche (55% of exports in 2012) and Martin Pêcheur (45% of exports in 2012)[4], export the product to Europe, the Middle East, Southeast Asia and Japan.

The closure

Phase I of Project Oratsimba began in June 2013 with the goal of establishing sustainable community-based management of the lobster fishery and averting further declines in the regional lobster stock through the creation of a 160km^{2}LMMA which includes aperiodic 10km^2 NTZ around Sainte Luce. The NTZ is closed for nine months of every year between October and June (Figure 1).

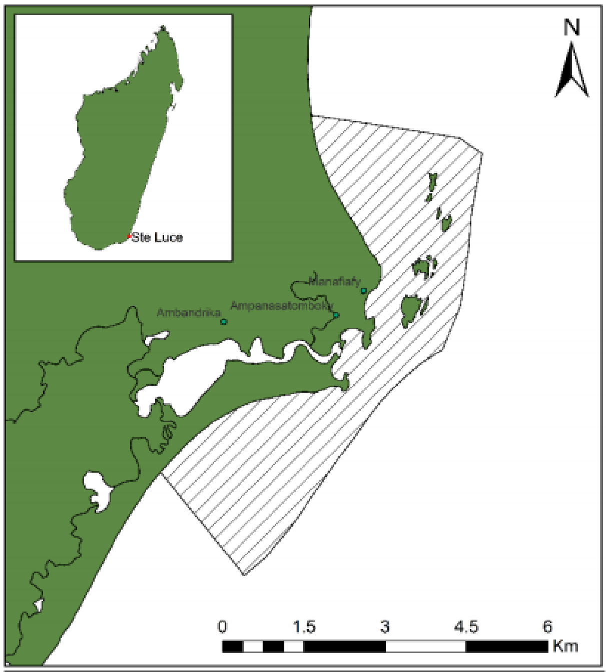

Figure 1. Map showing the NTZ established around Sainte Luce in 2013 which is closed between October and June each year (Azafady, 2015).

[4]Unpublished data from Les Directions Régionales des Ressources Halieutiques et de la Pêche (Fort Dauphin), 2012. Chinese operators have since entered the market but no quantitative data on their market share are yet available.

Phase I also involved the establishment of the Riaky (meaning *sea* in the local dialect) Committee – a 15-strong committee of local fishers – tasked with developing and enforcing the*dina*that introduced a number of management measures, including the NTZ. Five fishers were nominated from each of the three hamlets that make up Sainte Luce to ensure it was representative of the whole community.

Drawing up the *dina*

In September 2013, a draft of the *dina* was prepared by the Riaky Committee and discussed with over 100 members of the community, including the Head of the Village (the Chef Fokotany). The resulting 45-article *dina*, signed by the Chef Fokotany, was sent to the communal authorities (district level) for it to be passed, and then to the regional office of the National Ministry of Fisheries. A second community meeting was then held, attended by 400 community members along with representatives from the EU project funder, Azafady, the regional ministry of fisheries representatives and GOLDS, a trade group representing buyers in the region. Some provisions were controversial, particularly those relating to national laws that were previously unknown to Sainte Luce (e.g. a minimum lobster size of 20cm rather than a previous minimum of 18cm). At the time of writing the*dina*was being ratified officially in the Anosy regional Tribunal, howeverfor it to become official law further legal steps, revisions or addition of articles are likely to be required.

Mapping the No Take Zone

In October 2013, the Riaky Committee, together with Azafady, mapped the Sainte Luce fishing area and the proposed NTZ using GPS. The map was displayed to fishers and discussed at a*dina* meeting later that month before being approved. A poster was developed for display at the pirogue landing sites, and 150 buoys were deployed to mark the 10km^2 NTZ.

Timings of the closure

In the first year of the project, the NTZ was closed for a period of 10 months, from 01 October 2013 to 01 August 2014 before being opened for two months. Responsibility for scientific surveys to measure the biological effectiveness of the zone was outsourced to a local research institute, Unité de Recherche Langoustière (URL). However this research did not take place due to a lack of capacity. Nonetheless, fishers perceived there to be dramatically increased catches after the closure, creating buy-in from both the community and exporters (Azafady, 2015)

The first three months of the closure corresponded with the government-mandated national closed season for lobster. Prior to 2004, this season ran from January to March, instead of from October to December. The change has proved unpopular in Sainte Luce as the previous closure time corresponded with the rainy 'cyclone' season, when fishing is more dangerous and fishing opportunities are naturally fewer. Many fishers also believe that the previous period was more closely aligned with the peak reproductive season, based on local perceptions of the number of gravid females. It was anticipated that data collection (catch and release surveys, also planned by URL) would establish the ideal closed season, but unfortunately this research did not take place.

Monitoring

URL was initially tasked with conducting baseline UVC surveys of lobster populations, as well as collecting data on the species, sex and size of lobsters caught by fishers. However, due to a lack of funding and an inability to source necessary equipment, this work was not conducted. The lack of reliable baseline data means that the biological and fisheries impacts of the Phase Iof the project could not be assessed quantitatively. Recognising the lack of monitoring capacity by URL, Azafady has since (2015) employed a research manager to design and implement a participatory monitoring program, to be undertaken by trained community data collectors. Briefly, the monitoring program will include landings and effort surveys to calculate CPUE and catch composition surveys to monitor the species, size, sex and presence of eggs on female lobsters.

Enforcement

Although the Riaky Committee drafted the *dina*successfully, and delineated and marked out the NTZ, enforcement has proved to be a challenge. Compensation for the committee's time spent patrolling (and hence loss of time spent fishing) was not budgeted as part of the project, nor was the provision of a dedicated patrol pirogue. As such, the committee has reported feeling ill-equipped and unsupported to conduct this activity. With no formal enforcement powers until the *dina* is officially ratified, the committee relies on community recognition of their authority, which it believes would be increased by 'official' uniforms. Members have spoken of feeling embarrassed by their lack of authority. More recently, a series of twice-monthly training to teach the Riaky committee about fisheries management, meeting facilitation, patrol procedures and finance (Quilligan et al., 2015) as well as the endorsement of the regional Director of Fisheries has helped to raise morale (pers comm. S Long, Azafady). Despite the low morale, members continue to be motivated by the project and have recently taken the initiative to develop an action plan and patrol timetable indicating commitment to the project into the future.

Once the *dina* is formally established, half of the fines paid (typically 100,000 Malagasy ariary per transgression, around USD $38) will be reinvested into the Riaky Committee. However, this is unlikely to occur in the near future and may not sustain the committee indefinitely.

Recent developments, challenges and next steps

Phase II of Project Oratsimba began in October 2014 and will continue for 18 months funded by a US$37,000 grant from the EU and FAO-SmartFish program. The second phase of the project has already seen the community choose to extend the NTZ from 10 to 13km^2; to improve the demarcation with taller, more visible buoys; and to increase the reserve opening from two to three months to account for missed fishing days due to inclement weather during the open season (Quilligan et al., 2015). Other initiatives include the introduction of a participatory fisheries monitoring system. Compliance with both the minimum landing size (>20cm) and the restriction on landing berried females currently remains low, likely because the lobster price is not sufficiently high for fishers to adopt sustainable behaviours (Quilligan et al., 2015). However, initial participatory monitoring data from 2015 suggests an increased Catch per Unit Effort(CPUE) following the NTZ opening in July 2015,compared with the previous six months(Azafady, 2015).

As a direct result of the success of the project in Sainte Luce, the neighbouring community of Elodrato initiated its own lobster management measures and has requested to join Project Oratsimba during Phase III. Perhaps most significantly, project coordinators Azafady facilitated a landmark meeting of local stakeholders (fishers, exporters, URL and buyers) in Sainte Luce during which a 33% increase in the price fishers receive for every kg of lobster was achieved. This is key to the overall strategy, ensuring that it is economically feasible for fishers toadopt sustainable practices.

The aims of the third and final phase of Project Oratsimba are to increase the long-term sustainability of lobster fishing in Sainte Luce, as well as potentially extending it North to the community of Elodrato and South to Itaperaby:

- Building the capacity of communities to sustainably manage their own fisheries by developingknowledge of management approaches and implementation;
- Formal ratification of the *dina* and enforcement of its rules
- Engaging the private sector in ongoing partnerships to promote the long-term interests of the fishery;
- Strengthening the existing management model in Sainte Luce whilst developing and extending this tothe neighbouring communities of Elodrato and Itapera;
- Agreeing and defining the extended NTZ to include Elodrato and Itapera, which will then to be marked with buoys, and amendment of the *dina* to include the NTZ extension to Elodrato and Itapera
- Conducting robust scientific research on the lobster fishery and disseminating results and lessons learned regionally, nationally and internationally.

6. Case studies 3-5: Contrasting approaches to managing trochus fisheries in Indonesia, the Solomon Islands and the Cook Islands

Prepared by Steve Rocliffe

Background

The topshell *tectus niloticus* is an important resource in many parts of the Asia-Pacific region. This sea snail, commonly called *trochus*, is valued for both its meat, which is non-perishable and consumed locally, and its shell, which is processed into buttons, jewellery and handicrafts for international export(Pakoa et al., 2008; Pinca et al., 2009). Demand for trochus is such that it has made a substantial contribution to fishery exports in Fiji, the Cook Islands, the Solomon Islands, New Caledonia, Vanuatu, Papua New Guinea (PNG), Wallis and Futuna and the Federated States of Micronesia (Pinca et al., 2009). Over the past 70 years, combined trochus shell production from Fiji, the Solomon Islands and PNG alone has exceeded 50,000 tonnes, worth in excess of US$200 million (Pinca et al., 2009). Primary export markets include Italy, Korea, Japan and increasingly China (Comtrade, 2014).

Trochus'svalue means that it is heavily fished throughout much of the region, leading to concerns about overexploitation. Since the species has a low potential for natural recovery once densities drop below a certain threshold, overharvesting of trochus may have serious social and economic consequences in communities reliant on them for food or income generation (Pinca et al., 2009).

Targeted species and catch methods

*Tectus niloticus*is a large species of marine gastropod (up to 150 mm across the shell base) with an off-white shell with reddish stripes (SPC, 2011b). The species' natural range is from the Andaman Islands in the Indian Ocean to the Pacific islands of Fiji and Wallis, including the Solomon Islands, Papua New Guinea, Palau, Vanuatu, Yap and New Caledonia, as well as the north and northeastern coasts of Australia(Pakoa et al., 2008; SPC, 2011b). However, there have been extensive introductions beyond this range to help develop the resource in other Pacific Island countries and territories (Pakoa et al., 2008; Pinca et al., 2009).

Adult trochus are found on high-island reef slopes and atoll reef crests(SPC, 2011b). They tend to cluster together in areas of shallow water, traits that make them particularly susceptible to overexploitation (Pinca et al., 2009; SPC, 2011b). They are usually harvested by free diving or gleaning at low tide, though use of SCUBA apparatus is increasing (SPC, 2011b).

Trochus have separate sexes and are comparatively fast growing, reaching reproductive maturity at two years of age and a harvestable size at three (Pinca et al., 2009; SPC, 2011b). Reproduction is through broadcast spawning and is followed by a short larval stage, thereby reducing the likelihood of local recovery of depleted stocks from spawn from distant reefs (Pinca et al., 2009). However, when trochus are afforded protection from collection, there is evidence that local stocks increase rapidly (Pinca et al., 2009).

Trochus closures in West Nggela, Solomon Islands

At West Nggela in the Solomon Islands, the management of trochus fisheries is based on a system of Customary Marine Tenure (CMT), common throughout much of coastal Melanesia (Foale, 1998). Under this system, fishing is regulated at the local level through a series of periodic closures known as *tambu* or *tabu*(Foale, 2000). The most common closure duration is 9-10 months with an annual harvest over the Christmas period, but periods from two years to three months have also been reported (Foale, 1998). Closures of more than one year in duration are unusual, typically due to community perceptions that too many trochus would be lost to hermit crabs or borers, both of which degrade the shell, rendering it unsuitable for export (Foale, 1998).

Most of the trochus habitat in West Nggela is subtidal, soshells are chiefly collected by breath-hold diving (Foale, 2000). There are no quotas, but a minimum size limit of 8cm basal shell diameter is reasonably well enforced (Foale, 2008). After harvesting, the meat is cooked and consumed locally, whilst the shells are sold to buyers in the capital Honiara for international export (Foale, 2000).

Household surveys in the late 1990s found that, whilst finfish sales were the most important income earners for most community members, trochus was perceived as having the greatest return for the least effort(Foale, 1998). Most villagers in Nggela were said to regard trochus as “pure cash just sitting on the reef” on account of the ease with which they could be collected, stored and transported, and were able to obtain in excess of US$4 per kilo for shells delivered to Honiara (Foale, 2000, 1998).

However, results of a parallel stock assessment found that the *tambu* system of periodic closures was only moderately successful in managing local trochus fisheries (Foale, 1998). For example, yields were much lower at West Nggela than at Aitutaki in the Cook Islands (see below), though differences in reef type between the two sites (fringing at Nggela, atoll at Aitutaki) make direct comparisons difficult (Foale, 1998). The research highlighted a lack of knowledge amongst villagers about the planktonic dispersal larval phaseof trochus and recommended improving linkages between the community and NGOs to increase technical capacity and improve management. More recent research (Cohen and Foale, 2013; Foale, 2008)has argued that introducing quotas alongside periodic closures could also improve outcomes, but acknowledged that establishing and enforcing such a system could be challenging.

Trochus closures in the Maluku region of Indonesia

In the Maluku region of eastern Indonesia, trochus, like other natural resources, are managed under a traditional system of rights and rules called *sasi*(Novaczek et al., 2001). *Sasi*is a type of locally managed periodic closure similar to the *tambu* system noted above.The length and timing of *sasi*closed and open periods and harvest restrictions differ from community to community within the region and are set by community leaders (Evans et al., 1997), but the minimum harvestable size is comparable (Table 2).

Research suggests that in the late 1990s at least, *sasi*appeared to be effective in many parts of the region. For example, in the Kei islands, harvests were stable between 1988 and 1994 and *sasi* was strictly observed(Evans et al., 1997). Transgressors were ostensibly fined, but poaching rarely happened since villagers believed that they would be cursed if they poached in a sasi closure (Evans et al., 1997). However, stocks declined in nearby Saparua where the *sasi*system was less well enforced

(Evans et al., 1997). At that time several recommendations(Evans et al., 1997; Thorburn, 2000) were made to optimise trochus fisheries management in the region, including:

- Shortening of closure periods to one year to better serve the export market, with parallel increase in minimum size to 80mm basal shell diameter to maintain appropriate recruitment
- Annual community quota and complementary system of rotational closures
- Closure of fishery across April-August spawning peak
- Management and enforcement shared between government and local community
- Official legal recognition of *sasi* for trochus

Site	Closed season	Open season	Harvest size (tonnes)	Minimum size limit	Harvest restrictions
Saparua Island	1967-1984: 3-4 years; 1-2 years from 1984	1-2 weeks	1t per year; 0.5t after 1984	~60mm base diameter	Daylight only; other resources can be harvested. Village residents > 15 years old
Run Island	2 years	1 week	1-2t per year	~60mm	Day and night; other resources can be harvested. Village residents only
Hatta Island	2 years	1 week	Unknown	~60mm	Daylight only; other resources can be harvested. Village residents, but they may hire outsiders if they are unable to swim
Warbul (Kei Kecil)	1 year	4-8 weeks between Oct and Dec	2 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Ur Pulau (Kei Kecil)	1 year	4-8 weeks between Oct and Dec	1.2 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Yamtel (Kei Kecil)	1 year	1 week in Dec	2 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Waurtahit (Kei Besar)	1 year	1 week in Nov or Dec	1.75 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Ngitfuttahit (Kei Besar)	1 year	3 days in Dec	1.5 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Ohoiel (Kei Besar)	1 year (2 in 1990)	1 week in Dec	5 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Ohoiwait (Kei Besar)	1 year	2 weeks in Dec	1 (in 1994)	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Ohoirenan (Kei Besar)	Usually one year	2 to 3 days	Average of 7-10t per year	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*. Reef split into 4 equal zones & rotated so that entire reef is harvested every 2 to 3 years.
Weduar (Kei Besar)	1 year	1 week between Oct and March	Unknown	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*
Tutrean (Kei Besar)	1 year	1 week in Jan or Feb	Unknown	~60mm	Other resources can be harvested. Male village residents > 15 years old. Fines for breaking *sasi*

Table 3. Details of periodic trochus closures under the *sasi* system in the Maluku region of eastern Indonesia. Sources: (Arifin et al., 1998; Evans et al., 1997; Thorburn, 2000)

Trochus closures in Aitutaki, Cook Islands

Trochus are not native to the Cook Islands and were first introduced in 1956 from Fiji (Tiraa-Passfield et al., 2011). Since the first commercial harvest in 1981, approximately 600 tonnes worth more than US%$ 1.5 million has been collected during 14 separate harvests (Table 3).

Year	Yield (tonnes)	Estimated value per tonne (NZD)	Estimated fisher total earnings (NZD)
1981	~200.0	850	170,000
1983	35.7	Unknown	Unknown
1984	45.7	Unknown	Unknown
1985	27	Unknown	Unknown
1987	45.1	2,000	90,200
1988	18	3,000	54,000
1990	26.2	7,000	183,400
1992	28	6,350	177,800
1995	34	6,000	204,000
1997	18.4	6,250	115,000
1998	34	6,500	221,000
1999	18	8,250	148,500
2001	37	8,500	314,500
2011	18.9	Average 4,405 (5,500 for A-grade)	82,953

Table 4. Aitutaki trochus harvests, 1981–2011. Source: (Tiraa-Passfield et al., 2011)

The Aitutaki fishery operates on a simple quota system based on regular stock assessments. Before each harvest, staff from the Ministry of Marine Resources conduct an underwater visual assessment of stocks(SciCOFish, 2013). The total allowable catch is set at between 30 and 40% of trochus biomass of harvestable size (basal shell diameter of between 80 and 110mm) (SciCOFish, 2013). This quota is split between community households, and all women, men and children are permitted to participate in the harvest (SciCOFish, 2013; Tiraa-Passfield et al., 2011). Before 2001, harvests generally occurred every two to three years. After 2001, with export prices dropping and an expanding tourism sector providing income and employment, the fishery was closed(SciCOFish, 2013). After a 10-year hiatus, trochus were harvested again in 2011 during a two-week open season. At NZD 4,405t^{-1}, the value per tonne was around half what it had been in 2011 and only 19 tonnes were collected. The reason for the low harvestable population despite a 10-year hiatus is unclear (Tiraa-Passfield et al., 2011).

7. Case study 6: Periodic closures for blood cockles and mud clams in Roviana Lagoon, Solomon Islands

Prepared by Steve Rocliffe

Background to the project and fishery

In the Roviana Lagoon in the Western Solomon Islands, as in many other parts of the tropics, marine invertebrates resources are vital sources of protein and income for local communities. The most sought-after species in the Roviana area are *Tegillarca granosa* (blood cockle) and *Polymesodaexpansa and P. erosa* (mud clam), although others such as oysters (*Crassotrea rhizophorae*), Venus shells (*Gafrarium tumidum*), and mudwhelks (*Terebralia palustris)* are also collected, predominantly by local women(Aswani and Weiant, 2004).

In the 1990s, Roviana women began noticing decreases in the size and abundance of mud clams and blood cockles as a result of overharvesting and habitat degradation (Aswani and Weiant, 2004). In July 1999, with concern about declining resources mounting, two communities in eastern Roviana established a new resource management initiative: the Baraulu/Bulelavata Women's Shellfish Project(Aswani and Weiant, 2004). The project's aim was twofold: 1) to create a periodic and permanent marine closure to better manage key invertebrate stocks; and 2) to offset the consequential loss of access to shellfish by establishing an alternative livelihoods project (Aswani and Weiant, 2004).

Targeted species

Tegillarca granosa is a species of arc clam known as the blood cockle because of the red colour of its tissues(Yurimoto et al., 2014). The red is due to oxygen-carrying haemoglobin, which enables the clams to live in murky, poorly oxygenated environments (SPC, 2012). Blood cockles are widely distributed across the Indo-Pacific and live mainly in the intertidal zone at depths of one to two metres, burrowed into mud, sandy silt or seagrass beds (SPC, 2012; Yurimoto et al., 2014). Blood cockles are separate-sexed and reach reproductive maturitywhen they are about one year old and about 20 mm long (SPC, 2012).

*Polymesodaexpansa and P. erosa*are large and fleshy bivalves that attain shell lengths of up to 11 cm(Gimin et al., 2004). They are widely distributed across the Indo-Pacific and have been collected from the landward side of intertidal mud and mangroves, where they both occupy a filter feeder niche (Rintelen, 2011)

Catch methods

In Roviana, woman collect blood cockles by wading into the water and using their hands and feet to dig in the muddy substrate (Aswani and Weiant, 2004). The women usually fish in a depth where theycan stand with their heads above water (SPC, 2012). Harvesting mud clams is less involved: women spot them from mangrove land adjacent to the waterand remove them by digging (Aswani and Weiant, 2004).The primary season for collecting the three species is between May and August, when diurnal low tides make it easier to enter the mangrove forests (Aswani and Weiant, 2004).

Closures

The Baraulu and Bulelavata communities implemented a periodic closure system under which they two closed two mangrovescovering 34 hectares to shell gleaning and crab collecting for 8 months from September to April and opened them for four months between May and August(Aswani and Weiant, 2004; Niesten and Gjertsen, 2010). The community selected the two areas due to high fishing pressure and a perceived decrease in shell abundance and size, and also established in-situ (in the field) and ex-situ (household surveys) monitoring to evaluate the effects of the closures (Aswani and Weiant, 2004).

Results from the monitoring indicate that the closures were broadly successful, with statistically significant increases in abundance vs. control sites, though some poaching of closure areas did occur(Aswani and Weiant, 2004). Community perceptions were sufficiently positive that the periodic regime, which was initially planned for two years, remains in place (Niesten and Gjertsen, 2010). Moreover, the experience seems to have catalysed the establishment and subsequent extension of a community-managed permanent no-take reserve (Aswani and Weiant, 2004). However, although the closures were a qualified success, the parallel alternative livelihoods initiative, a small-scale sewing project, had less positive results and has since ceased (Niesten and Gjertsen, 2010).

8. Case study 7: Temporary closure for *Haliotis iris* (blackfoot abalone), Huriawa Peninsula, New Zealand

Prepared by Lucy Anderson

Background to the project and fishery

New Zealand'sFishery Act has two legislative mechanisms (186A and 186B) designed to establish temporary closures of up to two years (subsequent renewals permitted), with the primary objectives of responding to the localised depletion of populations and recognising the fishery management practices of New Zealand's indigenous (Māori) people.

Name	Location	Area	Start date	End date	Closure type
Umupuia Beach	Auckland	1	26/10/2012 26/10/2014	25/10/2014 24/09/2016	No person may take cockles
Maunganui Bay	Bay of Islands	1.5	01/12/2012 01/12/2014	30/11/2014 29/10/2016	No person may take any species of fish, aquatic life, or seaweed, with the exception of kina
Marsden Bank	Whangarei Heads	0.3	17/02/2013	16/02/2015	No person may take pipi
Kaikoura-Wakatu Quay	Kaikoura Peninsula	<1	18/08/2000 18/08/2014	17/08/2014 16/07/2016	No person may take any species of aquatic life or seaweed
Huriawa Peninsula	East Otago	<1	?/10/2010 26/10/2012 26/10/2014	01/10/2012 25/10/2014 24/09/2016	No person may take Pāua
Hicks Bay (Wharekahika)	East Cape		8/02/2003 18/02/2005	7/2/2005 17/02/2007	No person may take any shellfish including rock lobster and kina
Mount Maunganui	Bay of Plenty		28/06/2004 20/7/2006 7/12/2007	21/10/2007 21/10/2007 6/12/2009	No person may take green lipped mussels
Pukerua Bay	Porirua		20/12/2002 21/12/2004 8/6/2007 8/6/2009	19/12/2004 19/12/2006 7/6/2009 7/6/2010	No person may take any fish, aquatic life or seaweed except byhand held line
Ohiwa Harbour	Bay of Plenty		5/12/2003 21/7/2006 7/11/2008	4/12/2005 20/7/2008 22/10/2010	No person may take green lipped mussels
Kaipara Harbour	Northland		15/07/2005 14/09/2007	14/07/2007 13/09/2008	No person may take scallops
Western Coromandel Peninsula	Bay of Plenty		19/12/2002 19/12/2004	18/12/2004 18/12/2006	No person may take pipi or cockles

Table 5. Details of historic and current temporary closures across New Zealand. Source: (Gnanalingam and Hepburn, 2015).

Blackfoot abalone (*Haliotis iris*), locally known as pāua,is an endemic species of mollusc that is wild-caught and farmed in New Zealand for its meat and pearlescent shell (The Paua Industry Council, 2016). The species has high recreational and commercial value in New Zealand but also has cultural significance to the iwi (Māori). In 1992,Kāti Huirapa Rūnaka Ki Puketeraki,a local Māori organisation, applied to the Ministry of Primary Resources for the creation of a Taiāpure on the East Otago coastline in response toconcerns about decliningpāua stocks. Taiāpure are customary management areas that can be applied for in areas of special significance either to respond to a depleted food source, or for spiritual or cultural reasons.

The East Otago Taiāpure(EOT) would enable the local Maori community to reassert their 'rangatiratanga' (sovereignty)to ensure the productivity and health of the fishery was maintained for current and future generations (Kāti Huirapa Rūnaka Ki Puketeraki, 2015). Applications typically take a year to agree and implement, but the initial EOT application divided the Iwi and Kiwi communities to such an extent that ittook a total of seven years, numerous public meetings and political changes before it came into force in 1999(Kāti Huirapa Rūnaka Ki Puketeraki, 2015).

The EOT is overseen by a management committee made up of representatives fromthe East Otago Boating Club, Kati Huirapa Runaka ki Puketeraki, Karitane CommercialFisherman's Co-operative, University of Otago and the River-Estuary Care: WaikouaitiKaritane. Both the Taiāpure itself and the management committee are recognised underthe New Zealand Fisheries Act 1996.

The objectives of the East Otago Taiāpure are:

- To ensure customary, recreational and commercial fishers have access to and use of abundant supplies of fisheries resources;
- To actively promote the use of traditional tikanga (customs) and kawa (protocols) such as rahui (temporary closures) through the management regulations for the Taiāpure (using "lore" to create the "law");
- To ensure that the adverse impacts of human activities on the marine environment, nursery areas, spawning grounds, fisheries habitat and associated and dependant species are avoided, remedied or mitigated.
- To ensure all fisheries resources from the Taiāpure are fit for human consumption.

Targeted species

The New Zealand blackfoot abalone *H. iris* is a species of marine mollusc endemic to the rocky reefs surrounding New Zealand, typically at depths of up to 6m (Will et al., 2015). The species grows up 180mm in length (legal harvest size >125mm; National Institute of Water and Atmospheric Research, 2016) and takes between 6 and 10 years to reach minimum size (Wilson, 1987). Adult pāua broadcast spawn (typically less than once a year in wild populations) and fertilised eggs float in the water column for around a week before settling on rocky substrate. The survival rate of pāua is very low as many juveniles do not find a suitable habitat and are subject to predation, primarily from starfish(The Paua Industry Council, 2016). Pāua are farmed in approximately 12 on-shore aquaculture farms across New Zealand (The Paua Industry Council, 2016).

Catch methods

Pāua are caught by hand by free divers who use blunt instruments to prise the shellfish from the rock(The Paua Industry Council, 2016).

Closure

Surveys conducted in 2008 within the East Otago Taiāpure revealed that pāua stocks had been fished to very low densities compared to populations managed outside the EOT, and that populations displayed truncated size distributions (Hepburn et al., 2008). An area of particular concern was the Huriawa Peninsula at the northern end of the EOT where less than one percent of individuals found were above the minimum harvestable size of 125 mm (*Ibid*).In 2009, in response to the findings, the management committee implemented a voluntary rāhui (closure) prohibiting the harvesting of *H. iris*from the coast to 50m from the mean high water mark around the Huriawa Peninsula. The rāhui was given legal effect for two years from 2010 (Gnanalingam and Hepburn, 2015).Both the EOT gazetted area, and the rāhui within itare marked with signs (http://www.puketeraki.nz/site/puketeraki/Taiapuresign2.pdf).

Challenges

In 2012, two years after the initial rāhui was established, the same reefs were re-surveyed to determine whether the rāhui had had an effect on pāua populations, and whether a renewal was warranted (Gnanalingam and Hepburn, 2015). Although individuals over the minimum harvestable size were recorded in the closed area, the density of individuals had declined both within and outside the closed area (Gnanalingam, 2013). This was an unexpected result, particularly as the closure had been tightly enforced. Managers concluded that two years was an unrealistic timeframe for a long-lived slow-maturing species like paua to recover. The closure was therefore renewed in 2012 and again in 2014.

New Zealand's temporary closure provisions do show promise: anyone can apply for them, they are not species specific and anyone caught harvesting prohibited species can be legally prosecuted(Gnanalingam and Hepburn, 2015). However, their requirement for lengthy government approval(and re-approval for renewals), the inflexible two yearduration, and the fact that ultimate authority rests with the government has disadvantages, particularly when compared to legislation in the Pacific Islands that protects traditional customs without restriction (Cinner et al., 2012; Graham, 1994; Johannes, 1998).

9. Conclusions

Several conclusions emerge from an analysis of the seven case studies and broader evidence presented above

- Periodic closures are a commonly used management tool in locally managed marine areas in many parts of the Pacific, especially countries with a tradition of customary marine tenure (CMT) – the right to control access to fishing grounds at the local level. In this context, most closures are used to manage multi-species reef assemblages, though there is little empirical support for doing so and several studies show no clear positive effects of periodic closures on biomass or fisheries yieldin areas subject to high fisheries pressure.
- In a Western management context, periodic closures have been used for benthic invertebrates such as trochus, scallops, urchins, lobster, coral and abalone. Here too, results have been variable and there is presently little consensus on the effectiveness of the approach from field studies. However, evidence from modelling studies is more instructive and suggests, *inter alia*, that longer-lived, slower-growing species will need longer periods of closure for benefits to accrue than faster-growing, shorter-lived species and that periodic closures are generally better suited to short-lived, fast-growing species.
- In tropical artisanal fisheries, periodic closures have also been used to manage single invertebrate species such as octopus (*Octopus cyanea*), trochus (*Tectus niloticus*), mud clams (*Polymesoda spp.*), mud crabs (*Scylla serrata*)lobster (*Panulirus spp*), and blood cockles (*Tegillarca granosa*).
- Evidence from the case studies discussed here suggests that periodic closures can be a successful management strategy for small-scale coastal invertebrate fisheries, improving food security and delivering positive economic benefits to low income fishing communities.
- It is difficult to determine the key factors that underpin a successful periodic closure system for small-scale invertebrate fisheries because approaches are highly varied, even between closures aiming to manage the same species (e.g. trochus). However, in general, optimal closure frequency and duration is a function of several interrelated factors, including the life history, habitat and ecosystem conditions of the targeted species, harvesting restrictions such as minimum size limits, the preference of the fisher for immediate versus delayed reward (the discount rate), and the goals and objectives of the closure itself: to meet commercial, subsistence or ceremonial needs, for example (Cohen and Foale, 2013; Oliver et al., 2015).

10. References

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