across sites, can provide a surrogate for gauging the likely dispersal potential of larvae in the absence of studies of larvae in the wild (e.g. Uthicke and Benzie, 2000; Uthicke and Purcell, 2004). Such studies also help to understand the geographic boundaries of populations (i.e. stock delineation). Inevitably, management agencies will (in most cases) need to best-guess the dispersal potential of larvae from reserves to decide how close they should be spaced in a fishery to furnish recruits to all target fishing grounds. Conservatively, a network of reserves would include breeding populations spaced closer than the maximum distance that larvae can commonly disperse.

At the level of individual reserves, managers then need information to know what habitats they should include and how big they need to be. Ecological studies on commercial species should be reviewed. How far can they move in a lifetime and what habitat do they most seem to prefer? Multivariate analyses on the relationship between abundances of individuals and biotic and environmental variables will indicate the affinities of species to various habitats. Mark-recapture and short-term movement studies will be the basis for understanding the movement potential of the animals. Such information allows the manager to suitably site the reserves in good habitats and set them to be large enough such that most of the animals do not migrate beyond the boundaries where they can be legally removed by fishers – a phenomenon known as "spillover" (Purcell and Kirby, 2006). After all, it is the build up of sufficient densities of breeders inside the reserve that allows it to perform its function in fisheries management.

After the planning and declaration of marine reserves, managers and stakeholders will want to know whether breeding populations have built up to at sufficient densities to expect significant reproduction and larval export to neighbouring fishing grounds. In a depleted fishery, this may take many years. In this regard, it is useful to conduct some underwater field surveys to describe the species abundance, diversity and habitats within the reserve (see *Examples and lessons learned* below; Section 6.1.2). These data provide a baseline for future reference. Data exists for few species on the threshold densities or distance between sea cucumber adults at which reproduction becomes broadly successful (Babcock *et al*., 1992; Shepherd *et al*., 2004). The required densities of adults for effective reserves will naturally vary among species. Some scientists have postulated that, as a minimum for successful reproduction, tropical sea cucumber populations should be denser than 10–50 individuals ha^{-1} containing some groups of breeders <5–10 m apart (Bell, Purcell and Nash, 2008). These threshold densities currently remain as "best guesses", even by experienced ecologists, in the absence of empirical studies on fertilisation kinetics and mating behaviour of target species.

EXAMPLES AND LESSONS LEARNED

Malaysia

Malaysia has a number of marine reserves, which are not especially for sea cucumbers but for fish and invertebrates generally. There are five marine parks comprising a total of 40 islands in Peninsular Malaysia and Labuan Federal Territory in East Malaysia and three marine parks in Sabah in East Malaysia. In addition, there are three Fisheries Prohibited Areas (FPAs) in Sarawak in East Malaysia, two in Melaka and one in Negeri Sembilan located in the west coast of Peninsular Malaysia. The FPAs are under the administration of the Department of Fisheries (DoF) and fishing is prohibited in waters within two nautical miles from the outermost points of the islands.

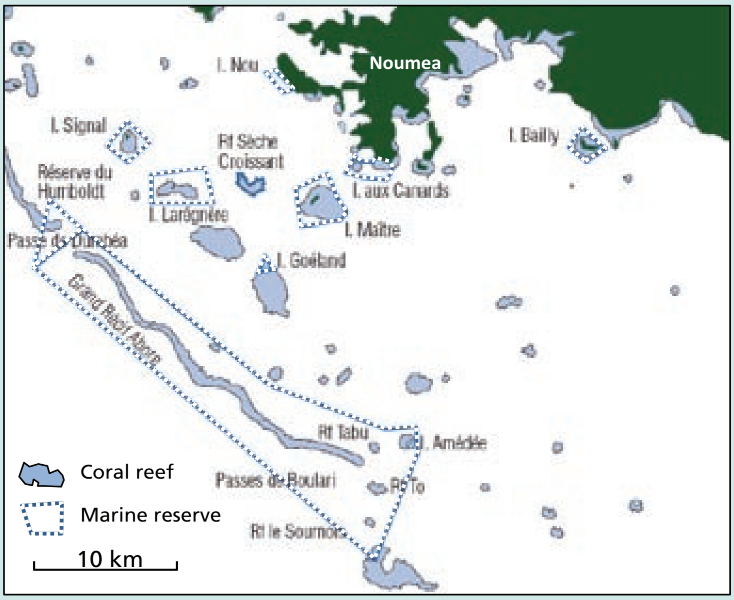
Generally, the marine parks in Peninsular Malaysia are well protected from illegal fishing and fishers tend to keep their distance for fear of being spotted by officers based in the parks. A survey conducted by Coral Cay Conservation (CCC) indicated little poaching of sea cucumbers in the Redang Island Marine Park, which contributed to the highest overall invertebrate abundance (Comley *et al.*, 2004). In Peninsular Malaysia, poor people are also not financially desperate enough to gather sea cucumbers either legally in the coastal areas or illegally in marine parks (Butcher, 2004). However, the marine parks in Sabah have a large population of illegal immigrants and poor fishers, and incidences of fishing with illegal methods (e.g. dynamite and cyanide) have been reported quite frequently and enforcement officers have stepped up efforts to prevent poaching.

The system of national marine parks and the fishery zoning regulations in Peninsular Malaysia have met with some successes and Malaysia's national coral reef management efforts are some of the most successful in Southeast Asia. Malaysia also has effective fisheries regulations, separating different user groups to different fishing zones thus helping to reduce conflicts and overfishing. Management of marine parks in Malaysia can be further enhanced by strengthening state capacity especially in East Malaysia, improving the integration of state and federal authorities to achieve sustainable coastal development and addressing destructive fishing in East Malaysia.

Source: P.Z. Choo.

New Caledonia, France

There are a number of marine reserves in New Caledonia for broad fishery and conservation purposes, but these represent a very small percentage of the available areas for fishing sea cucumbers. Some of them seem to be working effectively as spawning refugia for sea cucumbers because adult populations in the reserves are now relatively dense compared to populations in neighbouring fishing grounds. However, more reserves are probably needed (e.g. 20–30 percent of habitats) to give the best insurance against the potential loss of breeding capacity in fished areas. Most of the reserves cover several hundred to several thousand hectares and most are in the Southern Province, where the human population is greatest (see map below). In many cases, the reserve boundaries surround one entire reef, with a central small island, and bordering lagoon seabed. Most appear to be well respected by fishers.



Above: marine reserves in New Caledonia are most numerous in the vicinity of the capital city, Noumea. In this area, the no-take reserves form a network of sanctuaries for sea cucumbers and other biota, on nearshore, lagoonal and barrier reefs.

Source: ISEE, New Caledonia, with modification.

One, relatively long-established, reserve (Ilot Maître; see map) has an impressive abundance and diversity of sea cucumbers; over 9 000 ind. km^{-2} of species of high and medium value (across five habitats) and a total of 19 species recorded (Purcell, Gossuin and Agudo, 2009a). However, the proliferation of sea cucumbers on the reef flat at that site seems to have stunted the growth of many species.

The only marine reserve in the Northern Province is large and includes mostly coastal seagrass beds and mangrove habitats. Although the area was previously fished, probably for more than a century, densities of sandfish (*H. scabra*) in that reserve are now quite high (site density varying from 81 to 244 ind. ha^{-1}). This at least shows that populations of some species can build up in reserves to represent important breeding groups for supplying larvae to neighbouring fishing grounds. Unfortunately, there have been recent cases of poaching, which were brought to the national courts.

Importantly, although long-term reserves in New Caledonia tended to have greater sea cucumber populations than reserves established recently, they did not always lead to a huge build-up of sea cucumber breeding populations (Purcell, Gossuin and Agudo, 2009a). Some recently established reserves did not yet have dense populations of sea cucumbers. The lesson from these comparisons is that reserves may relieve fishing pressure so that dense breeding populations of sea cucumbers can build up, but the site characteristics will play a large role in this and it may take many years or decades for populations to become dense. Therefore, a network of many reserves is needed in a fishery to account for the fact that some sites may not be ideal for sea cucumbers.

The study also showed that species richness of the sea cucumber communities was significantly greater on mid-shelf reefs within the lagoon than on barrier reefs. The lesson in this example is that more marine reserves should be placed on lagoon reefs for conservation purposes. Some barrier reef reserves are also needed to protect some breeding populations of species not often found at lagoonal sites.

Source: S.W. Purcell.

Solomon Islands

Stock surveys of sea cucumbers at the Arnavon Island Marine Reserve (AIMR) in the Solomon Islands were completed three times before, and three surveys after the declaration of the Islands as a conservation area (AMCA): January–February, April–May and July–August 1995 (before); and September 1998, January–February 1999 and April 1999 (after) (Lincoln-Smith *et al*., 2000).

PHOTO: GOOGLE EARTH

PHOTO: M. LINCOLN-SMITH (CARDNO ECOLOGY LAB)

Left: Arnarvon Island in foreground. Right: a researcher on SCUBA conducts a belt-transect survey for sea cucumbers on a shallow reef in the Arnavon Islands.

After the islands had been protected by the 82 km^2 reserve, surveys at the AMCA revealed that the establishment of the conservation area had not caused a significant increase in the number of all holothurians, but it may well have prevented declines in abundance that was evident elsewhere in the region. This suggests that over this short time period, the AMCA maintained populations but was mostly ineffective at enhancing them. The lesson may be that it takes many years, perhaps decades, for some species of sea cucumbers to rebuild breeding populations inside marine reserves. Abundance data indicated that sea cucumber numbers declined on average by one-third outside the Arnavon group, but remained relatively similar in the protected area from before to 3+ years after the declaration.

An exception was the abundance of amberfish, *T. anax*, with more individuals within the AMCA relative to surveys of the surrounding areas, from before to after declaration. The ratios of observed proportional differences between AMCA and control areas from before to after declaration were generally quite small, suggesting a relatively small effect after 3 years of closure. The more notable response was that the abundances of white teatfish, *H. fuscogilva* increased in the AMCA relative to fished (control) areas, but this result was statistically non-significant.

One cannot exclude the possibility that the AMCA caused a redistribution of harvesting effort to surrounding areas, including the controls areas that were surveyed. Declaration of marine protected areas without any changes in the level of activity of fishers would result in increased activity in the fishery outside the reserve. In fact, if this was the case, then the declaration of areas of insufficient size as protected, could accelerate declines across the fishery, so overemphasizing the benefits of the reserves. Managers need to ensure there is sufficient spawning mass across the fishery, to ensure the sustainability of harvests.

The study at the AMCA shows that the time needed for a species to recover from harvesting might be longer than expected, and will depend on factors such as generation time, severity and extent of previous fishing, local oceanographic features, location and size of the reserve, infringement of the reserve and availability of nursery and adult habitat. This study suggests that it may take many years to restore each of the target species to preharvest levels, assuming the reserve is an effective mechanism for mediating fishing.

Source: K. Friedman and J.P. Kinch.

5.7.2 Rotational harvest closures

Definition

A periodic temporal and spatial shifting of fishing effort, in a systematic way among demarcated fishing grounds.

Use

The ethos of rotational harvest closures is to allow populations to recover in some fishing plots for a couple years, while fishing is shifted to other plots. For example, the fishing ground in front of a community is partitioned into four plots and fishers are only allowed to collect animals in one plot each year, which is then shifted to a different plot the following year, and so on. It is a concept with origins from rotational harvesting of agricultural crops.

An assumption is that the same areas will be fished again after some time or after reaching some certain state. Where populations can recover fairly quickly, then it is possible for rotating fishing effort over relatively short time intervals, e.g. two to three years. In this way, rotational closures allow the sizes and abundance of sea cucumbers in the closed plots to recover for a couple years before being fished again. Rotational closures can also be used to reduce costs of field surveys to estimate stock size because the fishable area for any given year are only a fraction of the whole fishery (see *Examples and lessons learned* below).

Rotational closures are a novel approach in sea cucumber fisheries and their success as a management tool is yet to be proved.

Limitations

Rotational closures have received support in some industrial-type sea cucumber fisheries with high technical capacity, like those in western Canada and north-west United States of America (Humble, Hand and de la Mare, 2007; Hamel and Mercier, 2008a), and on the Great Barrier Reef, Australia (Kinch *et al*., 2008a) (Section 2.3). This may be appropriate where user rights are well defined and respected, but the system will quickly breakdown elsewhere. In addition, the demography and growth of some species may render them unsuitable in some cases (see Purcell, Gossuin and Agudo, 2009a) (Section 2.1).

A principal assumption of rotational harvest closures is that population numbers and animal sizes will recover relatively quickly, e.g. over a couple years. As reviewed earlier (Section 2.1), some species appear to grow slowly and have relatively slow rates of recruitment. To have confidence in rotational closures, managers should verify that the commercial species in the fishery are likely to have fast growth rates and regular annual recruitment. This management tool may therefore be useful for species with fast rates of recovery after fishing but inappropriate for populations with slow turnover or in multispecies fisheries (see Sections 2.1 and 2.3).

The rate of exploiting stocks, per unit of fishing ground, can also rise sharply with rotational closures. This could occur where the fishing ground is divided into multiple units and fishers allowed to collect sea cucumbers only in some of them, instead of across all possible fishing grounds. Fishing impacts must be, therefore, well regulated through imposed, or *de facto*, quotas or effort limitation for each fishing ground (see *Examples and lessons learned* below). Related to this constraint, the different fishing plots will probably not have equivalent population sizes of animals – so the impact of a given fishing rate will be harsh on those with smaller population sizes. Managers should take steps to find out if population sizes vary greatly among plots so those with relatively sparse populations are not over fished. Some safeguards also need to be set so that populations in fished plots will not be depleted below critical levels. These types of provisions place a burden of research and monitoring on the fisheries agency or local management institution.

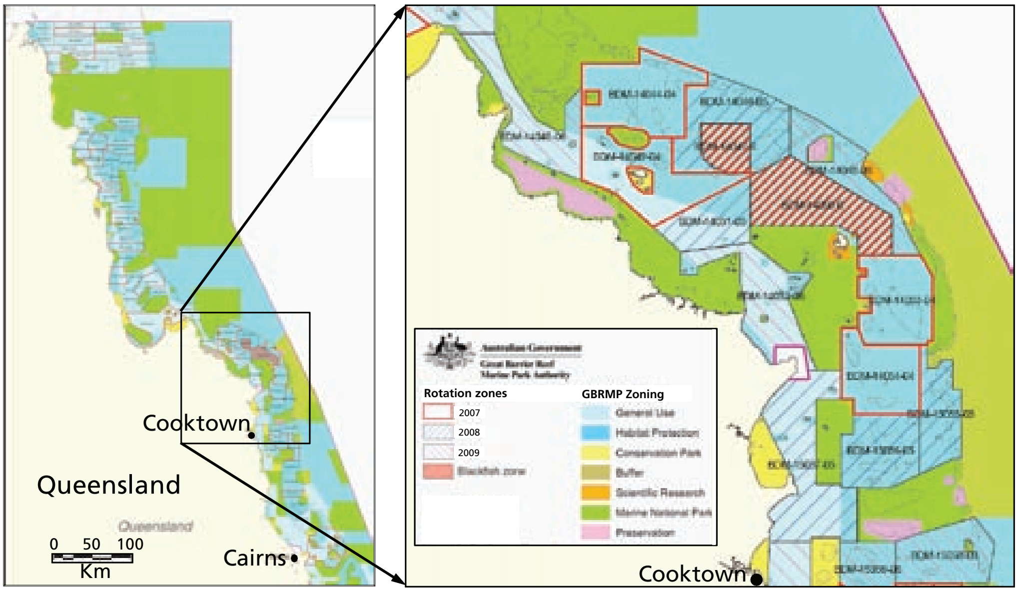
In small-scale fisheries, fishers with limited access to distant or deep fishing grounds may be disadvantaged by rotational closures in years when nearby or shallow fishing plots are closed. Many fishers in the Philippines, particularly women and children, glean for sea cucumbers on shallow reef flats and lack the gear to fish in deeper plots (Choo, 2008b). Fishers may traditionally have access to a small area in front of a village, so multiple plots would become unrealistically small. Compliance is a problem in these situations, as it is difficult to verify if sea cucumbers were collected from open plots or poached from closed plots, particularly if plots are close together.

How to implement

Rotational closures can only be implemented if sociological and biological conditions in the fishery allow it. An ecosystem approach to fisheries in this regard would include a review of stakeholder needs and constraints and the biological potential of the fished species to adapt to periodic fishing pulses (Section 3.3). Sociological studies or meetings with stakeholders should be conducted to appraise whether rotational harvesting of plots can be well understood and respected by fishers and other groups with vested interests in the resource (Section 6.6). Importantly, the current access rights of fishers and other stakeholders should be determined. The constraints fishers have to getting to sites or accessing the resource in different plots should also be understood (Section 6.1.4).

FIGURE 25.

Maps showing plots for a rotational harvest strategy in the sea cucumber fishery of the Great Barrier Reef, Queensland, Australia, for the years 2007–2009. Sea cucumbers in the demarcated plots (right) can be fished by licensed fishers in the designated year only and then the populations are excluded from fishing for 2 years. The blackfish (*Actinopyga spinea*, *A. miliaris* and *A. palauensis*) zones are controlled by quotas and are not part of the rotational zoning



Source: Great Barrier Reef Marine Park Authority, Zoned Sea Cucumber Fishery Waters – Northern GBR – Detailed Zoning map, with modification.

The fishing grounds for each fishery unit need to be divided into a logical number of plots. For example, for a 3–year rotational harvesting strategy the fishing grounds could be zoned into 3 plot types, of which plots of any one type are fished each year (Figure 25). The decision depends on the administrative resources, compliance issues and the needs of fishers. Although more plots increase the administrative work, there may be advantages to opening multiple smaller plots.

The size of plots does not need to be similar. It may be sensible to partition the fishing grounds based on population sizes of sea cucumbers in the resultant plots rather than on the surface area of suitable habitats. For example, larger plots are assigned where populations are at lower densities and vice versa.

The number of years for cycling the fishing in plots should be determined from biological data on recovery times for animals to grow to larger size and time needed for population densities to recover to levels well above those needed for successful spawning. The periodicity of the rotational opening of fishing plots will probably be in the order of 2–10 years. Resource managers should either ascertain or acquire estimates of how many years populations would take to recover from being fished down to a certain density. This requires some understanding of the regularity of recruitment and population turnover. Likewise managers should have information on the average growth rates of juvenile and small adults of the species being fished (see Section 2.1). Demographic and life-history estimates of this nature are generally pre-requisites for using rotational harvest strategies for sea cucumbers because they inform the manager of the appropriate time intervals to rotate fishing among plots.

Where managers have sufficient technical capacity and data on life-history and population dynamics of fished species, rotational harvest strategies can be determined through mathematical modelling (Humble, Hand and de la Mare, 2007). Most fisheries will lack the basic data to prescribe rotational closures with any scientific confidence. Alternative management measures should then be considered or managers should apply best guesses for biological parameters or proxy data from similar species to design the rotational strategies and adapt them as reliable data become available.

Some field surveys should be undertaken to estimate the abundance or densities of each commercial species to be fished in plots (Section 6.1.2). For example, dive surveys are conducted prior to the fishing season in rotational plots in southeast Alaska, United States of America (Hamel and Mercier, 2008a). These measures may also need to be monitored, possibly during fishing, and at least to verify recovery of populations in plots after fishing.

EXAMPLES AND LESSONS LEARNED

Alaska, United States of America

Current sea cucumber management measures in Alaska, using rotational harvest strategies, have provided sustainable harvests and consistent quality of *Parastichopus californicus*. Divers rotate their effort between 16 harvest areas, some of which are divided into more than 20 sub–areas in an effort to maintain sustainability throughout the fishing grounds (Ess, 2007).

In southeast Alaska, each fishing area operates on a three year rotation and is harvested (each three years) at a rate of 6 percent per year (Bo Meredith, Alaska Department of Fish and Game, personal communication). Thus, in years of harvest, approximately 18 percent of the surveyed biomass is removed, then the area is left unfished for the next two years. Before the sea cucumber fishing season opens on the first Monday of October, dive surveys are conducted in each of the harvest areas. Two other conservative measures are added into the development of the harvest rate managed by the Alaska Department of Fish and Game (Woodby, Smiley and Larson, 2000): 1) a 50 percent reduction to account for the possibility that the model assumption is incorrect; and 2) an approximate reduction of 30 percent to account for sampling error in the assessment survey. A third safety measure consists of counting only sea cucumbers occurring at depths above 15 m in the population size estimates.

Underwater surveys are conducted by Department divers prior to fishery openings in each management area. In this example, the 3-year rotation was put into place as a means of reducing management costs for surveys and management and not as a method to allow stock rebuilding between harvests. Additionally, a minimum biomass density threshold of 1 kg of sea cucumber per linear meter of shoreline is set for the fishery. The plan also identifies 20 sub-areas closed to commercial sea cucumber fishing to provide for subsistence harvests and research sites.

Source: A. Mercier and J.-F. Hamel.

Sagay, The Philippines

The 32 000-hectare Sagay Marine Reserve in northern Negros Occidental, is a marine protected area (MPA) managed by the Sagay Marine Reserve-Protected Area Management Board (SMR-PAMB), a multisectoral body co-chaired by the City Mayor and the Regional Technical Director of the Department of Environment and Natural Resources.

While there are about 10 commercial species of sea cucumbers found within the MPA, the fishery regulation is specific to *Phyllophorus proteus* (locally called *bola-bola* meaning ball-shaped) which is the most abundant. Rotational closures of harvesting *P. proteus* started in 2004, were then suspended in 2005, and resumed the following year up to the present. The implementation of this measure consists of the following:

(1) the SMR-PAMB determines the harvest season, plots (areas) and fishing time; the maximum number of boats per season; the minimum size limit of the sea cucumbers; and, the maximum number of *N. proteus* per season;
(2) only boat owners who are local residents with duly registered boats can bid for the harvest; the highest bidders get the permit to harvest the sea cucumber for one season;
(3) the Licensing and Permit Section and the Coastal Law Enforcers (Bantay Dagat Team) monitor the catch per boat at a duly designated weighing station within the Reserve; and
(4) a price "floor" is established and shared among the City (80 percent), Barangay (smallest political unit) (10 percent) and the Sagay Marine Reserve (10 percent). The profit of boat owners and fishers comes from the difference between the market price and the price floor.

Some measures of social success are:
(a) increased stewardship of the resource as a result of making local residents the watchers and guards of the Reserve, requiring them to register their boats, to obtain permits and then giving them the preference to bid;
(b) better governance brought about by the multisectoral monitoring group and the full implementation of the regulations of the reserve led by the SMR-PAMB with support from the city officials;
(c) sense of economic equity in the practice of sharing profit based on consensual agreement and the premium for resource use; and
(d) increased awareness of the community about sustainable fishing of the resource by practicing rotational closure and harvest.

Despite the temporal and spatial respite offered by the rotation of the harvest, data on the first 3-year catch showed a declining harvest. The SMR was quick to acknowledge that their management plan and some of their technical decisions have to be reviewed based on sound data. Nonetheless, the SMR was the first runner up for the 2007 Best Managed Reef in the country given by the MPA Support Network.

Source: T. Dacles and R. Gamboa.

Great Barrier Reef, Australia

In the state of Queensland, the sea cucumber fishery on the Great Barrier Reef is broken up into 154 fishing sectors, each averaging 548 km^{-2} in area (roughly 160 square nautical miles each). These sectors are divided into three fishing years for any 3-year cycle (see Figure 25). The rotational sectors occur only in open fishing areas, exclusive of the existing marine reserves in the Marine Park.

During the permitted year of fishing in the 3-year cycle, each sector can only be fished for 15 days per year. This management measure is implemented by the fishing industry and agreed to in a Memorandum of Understanding with the management agency, The Great Barrier Reef Marine Park Authority. Also, no more than four divers are permitted to be in the water at any time from a fishing vessel. The plots are allocated to the fishing licence holders (of which there are just two in this fishery), who are then allowed to trade them for convenience of location. The agreed trades are then conveyed to the management agency. Thus, each fishing business has exclusive rights over any particular rotational sector, providing an incentive to harvest for long-term productivity.

Surveillance and enforcement of such a management scheme can be difficult. In the GBR this is possible; however, since all fishing vessels are equipped with vessel monitoring systems (VMS). This system relays precise information about boat locations to management agencies to show where the vessels are located, which is matched against logbook records of fishing days at each rotational sector.

It should be noted that rotational harvest strategies are a relatively new idea in sea cucumber fisheries and there are no data available to show whether this approach is sustainable, or not. At present, it seems to be working relatively smoothly on the Great Barrier Reef, owing to three factors: 1) the VMS system, which allows monitoring of fishing locations and durations for each licensed boat; 2) there are few fishing businesses in that fishery (only two businesses hold all the licences), so the process of allocating plots and reaching agreement among fishers is simplified; and 3) the rotational sectors are relatively large, such that fishers cannot easily deplete the resource within each sector during the year of rotation. A final lesson is that the rotational scheme can operate without needing to be set in legislation – in this case, a simple Memorandum of Understanding between the fishers and the management agency sets the conditions for the scheme.
Source: S. Uthicke and S.W. Purcell.

5.7.3 Territorial user rights in fisheries

Definition

The provision to certain users, e.g. fishers or sea ranching proponents, of exclusive privilege to exploit certain resources and/or access certain areas of sea bed.

Use

In the words of R.E. Johannes (1981) on secured access to fishers: "Where such tenure of marine fishing grounds exists it is in the best interest of those who control it not to overfish […]. In contrast, where such resources are public property, […] it is in the best interest of the fisherman to catch all he can. Because he cannot control the fishery, the fish he refrains from catching will most likely be caught by someone else."

Although leading fisheries scientists have proposed differing solutions for turning the tide of depleting stocks, there is solidarity over the need for managers or institutions to afford fishers with predictable and exclusive access to the resources, whether in the form of rights to specified proportions of the allowed catch (i.e. ITQs, Section 5.4) or to tracts of fishing grounds (Hilborn, 2004; Pauly, 2008). Place-based, or "spatially-explicit", tenure systems have been used especially for sessile, sedentary or benthic organisms (Hilborn, Oresanz and Parma, 2005; Hilborn, Parrish and Litle, 2005; Defeo and Castilla, 2005). Sea cucumbers fit squarely into this category. Territorial user right in fisheries (TURFs) are one form of exclusive access to defined portions of sea bed for harvesting sedentary or sessile animals, which may be granted to fishers or fishing cooperatives (Hilborn, Orensanz and Parma, 2005). TURFs can provide a potent incentive to the sustainable management of sea cucumber populations in many cases. The rights over areas could be at the local, national, regional or international level. At a local level, Customary Marine Tenure in Melanesian countries is a traditional system giving exclusivity to certain tribal or family groups or families (Kinch *et al.*, 2008a).

Another benefit of TURFs is that resources can be best allocated to those people who need it or those complying with management regulations. Resource access privileges, or "rights", allow fishers or fishing groups/firms to plan their operations (Pauly, 2008). They bestow more accountability and ownership over stocks and their sustainability than open access scenarios because the changes in population abundances over time can be accredited to the rights holders. In this way, place-based access rights minimise the problem of fishers racing to collect all animals in an area or taking small animals because "if they don't someone else will"; the so called "tragedy of the commons" (Hardin, 1968). Enforcement of fishery regulations also becomes easier because the users of each fishing ground are well known.

Limitations

With all of the benefits of TURFs or other place-based access rights, it is a shame that a place-based access right is not an appropriate tool in all situations. When territorial rights are established in open access fisheries, conflicts can naturally erupt. In some cases, it is very difficult for people to respect the access rights. Users can become angry over the way in which rights were given, or because the areas of exclusive access are overstepped or ambiguous. Modern governments, changes in lifestyles and imposing religious doctrines, have in cases reduced the access rights and lead to free-for-all access (e.g. throughout most of the Philippines). Poaching can occur in areas allocated to other people-groups through dislocation or jealousy.

TURFs seem most easily implemented and maintained in fisheries with relatively few fishers or fisher groups. The demarcation of fishing grounds and administrative work to define them coherently and survey infringements can be arduous (Orensanz *et al.*, 2005). This may be a significant limitation in cases where institutions lack technical and/or human resources. Human population size and fishing pressure are so high in some places that it is very difficult, or unfeasible, to partition fishing areas into a large number of small plots (e.g. in Indonesia or the Philippines) (Figure 26; Section 2.3).

In some cases, giving territorial access rights to users may not lead to greater sustainability of the resource. An assumption is that access rights like TURFs will create incentives to reduce fishing effort. Management authorities should, therefore, appraise whether the provision of access rights to fishers is likely to lead to reduced effort. That is, the provision of access rights must lead to better ownership and stewardship of resources by the fishers for this measure to be successful.

How to implement

The immediate questions in assessing the utility of TURFs concern the choice of who gets access and who is left out, and whether plots of fishing grounds can be sensibly partitioned among the users and demarcated. Managers should also know or seek information on the human populations, their behaviour and whether access rights are culturally compatible (Section 6.1.4).

The decision of who gets territorial access rights and who does not is often predicated on knowing who the current fishers are and who most deserve them. Traditional or cultural links attachments to the fishing grounds or resources are important considerations. The decision process should ensure that current users, with valid needs for harvesting the resource, are not marginalised through the access rights. Decisions can also be based on historical behaviors; e.g. which of the fishers have

FIGURE 26
Left: fishers gleaning sea cucumbers and other invertebrates on a sandflat in the Philippines. The sheer number of resource users makes access rights for individuals a difficult proposition. Right: a day's gleaning catch (2–3 hours) off a small coastal village in southern Philippines

PHOTO: R. GAMBOA *PHOTO: R. GAMBOA*

respected management measures in the past? The management agency must also decide if the user groups pay for the access rights and how much. Commonly, there is an initial or annual license that bestows and defines the fishing rights.

Governments themselves will normally incur a cost in administering and establishing the spatial boundaries or resource-specific privileges in allocating TURFs. The planning phase in allocating TURFs should examine, or collect, data on the abundance and distribution of the resource (Section 6.1.2). Once granted, government or local management agencies will need to invest time and resources in enforcement at sea to ensure that users are not breaching boundaries set by the TURFs (Section 6.6).

To implement territorial use rights, the socio-economic and legal structure of the fishery should firstly be known (Sections 6.1.4 and 6.2.1). This step may reveal that authority to give access rights to users is best devolved at a local level through community-based management or organised alongside communities through co-management. As noted above, the managing body should consider traditional user rights, equity and enforcement issues. In industrial fisheries, a randomised allocation of fishing areas to fishers is an alternative to formal planning and may avoid conflicts with users about the fairness of the rights allocation process.

Assigning TURFs to fishers, fisher cooperatives, or fishing communities can be a rather elaborate process (Orensanz *et al*., 2005). The available fishing grounds within the jurisdiction of the management institution may need to be mapped to define habitat types and to estimate the abundance of target sea cucumber species. Consultant ecologists, NGOs or regional development agencies may be able to assist in this process. There will likely be certain fishing grounds to which fishers have existing (sentimental, traditional, or cultural) attachment and other grounds that are less desired. The fishery manager, or an assigned impartial body, will need to mediate the decisions about who gets what, in a transparent and equitable way. In some other fisheries, rights to certain fishing grounds are allocated to fishers through an auction process (Hilborn, Parrish and Litle, 2005). In comparable invertebrate fisheries in Chile, TURFs are assigned for a short number of years and renewable upon compliance with the regulations (Orensanz *et al*., 2005). Within Australia's Great Barrier Reef Marine Park, TURFs for sea cucumber fishers are also broken into rotational harvesting zones (Kinch *et al*., 2008a).

EXAMPLES AND LESSONS LEARNED

Japan

Japanese holothurian fisheries are doubly regulated in the existing fisheries law (practiced since 1949) by the "fishery rights" and the "fishery permit" systems. The "fishery rights" system was established to maintain order and adjust fishery operations in public waters. The system applies to *common fisheries* like those for sedentary animals such as holothurians. Only local fishery cooperative associations are eligible for the right. Thus, no one except the fishery cooperative association members can collect sea cucumbers for any purposes.

However, if a member of a fishery cooperative association wants to employ a heavy gear, such as dragnet, in the capture of sea cucumbers he needs to apply also for a "fishery permit". This is because the dragnet fishery for holothurians is regulated under the Governor Permitted Fishery (GPF). The permit is valid for ten years and to renew it fishers are required to discuss with the prefectural government the fishing-ground plan. For conservation reasons, it is more difficult to apply for new permits than to renew old permits.

Source: J. Akamine.

Australia

In the state of Queensland, the sea cucumber fishery on the Great Barrier Reef is divided into 154 fishing zones of approximately 100 to 150 nautical square miles. Access to commercial fishing in this fishery is limited to just 18 licences. However, these licences are in the hands of two companies.

The Torres Strait fishery, between the northern tip of Queensland and Papua New Guinea, also has a restriction on the number of commercial fishers. Licences are issued only to Traditional Inhabitants of the Torres Strait.

Source: S. Uthicke.

The Philippines

An experimental sea ranching project is underway in the Philippines, coordinated by scientists from national universities, the Bureau of Fisheries and Aquatic Resources (BFAR) and the WorldFish Center, through funding from the Australian government. Its objective is to test the feasibility of village-based sea ranching of sandfish (*Holothuria scabra*) by producing thousands of juveniles in hatcheries and releasing them into sub-tidal seagrass beds allocated exclusively to communities who harvest the sea cucumbers once they reach market size.

Fishing communities at several of the project's sites generally have de-facto rights over the adjacent shallow seabeds. But poaching and the temptation to harvest small sea cucumbers are potential problems that need to be resolved by formal access rights. The communities apply for permits from the local municipal government and village council to have exclusive access to inshore plots (5–10 ha) for the sea ranching. The granting of access rights requires public consultations on proposed sea ranching, implementation mechanisms and arrangements including sharing of costs (e.g. labour, guarding of area) and benefits (i.e. harvest and access rights). Enforcement of the size limits and access to the managed areas is at the local level – the Municipal governments deputise fisheries wardens from communities to do the enforcement.

Source: S.W. Purcell.

Pacific, Polynesia

In Tonga, a large island group in the Polynesian Pacific, problems of overfishing have been exacerbated by a lack of local ownership of reef resources, enabling commercial collectors to harvest even close to local communities.

In 1875 Tonga's first constitution removed chiefly privileges, placing control in the hands of the Crown/State and opening access to all Tongans. At this time economic pressures were such that communal and extended family activity was commonplace, but was not a major issue, and even as late as the 1920s, marine area ownership was still reportedly strong. In Tonga today, open access has replaced traditional ownership arrangements, and some commentators believe the Crown/State may be less able than local communities to regulate the use of marine resources (Malm, 2001). Urbanization, development of the cash economy and increases in commercialisation of marine resources, coupled with changes in life styles have exposed flaws in today's open access system of marine resource management.

One example of the direct consequences of Tongan law was recounted from an island in the Ha'apai group, where fishermen knew that increasingly intense commercial exploitation of invertebrates was too taxing on the lagoon resources to be sustainable, but felt that there would be no point in reducing the intensity of exploitation because the resources could be exploited by fishermen from other islands in the district. This example of the effects of open access on common property under today's economic environment may not have had the same outcome under the social conditions faced 50+ years ago.

State ownership in Polynesia has not always resulted in a breakdown of local controls. In American Samoa for example, where the American military governor declared all submerged lands and reefs to be a part of the public domain, American Samoans continued to claim exclusive fishing rights to their adjacent reefs (Hill, 1978). Similarly, in neighbouring Samoa (formerly Western Samoa), the reef and lagoon areas are owned by the State, but customary ownership by the village of local fishing rights is recognized and remains firmly entrenched (Fairbairn, 1992). One must also note that despite these controls, overfishing has also occurred in Samoa, especially in urban and populated areas, even with customary ownership in place.

Whether local reef ownership across the ages was due to a "conservation ethic" or just inter-groups rivalry, it has generally been recognized as having some limiting effect on the rate of exploitation. In the last 5–10 years, the state fisheries agency in Tonga has been re-developing local area management networks, to rekindle some of the original strengths of local tenure arrangements. All this is happening in the face of increasing external pressures to commercialise marine resources, pressures that are beyond the production capacity of most coral reef inshore systems.

Source: K. Friedman.

Madagascar

The fishery is mostly located in villages on the west coast (Rasolofonirina, 2007). The traditional fishery has expanded in the last decades, often bringing overexploitation of the high valued species. Fishers now go from one area to another, depleting stocks in succession. For instance, with the depletion of resources in the north of Madagascar (Nosy Bé Island) in the 1990s, fishers started to operate along the west coast to the Mahajunga region. Recently, migrating fishers were observed in temporary villages organized in the Radama islands. This situation, which occurs due to the lack of well defined access rights, often raises conflicts with local communities and leads to heavy depletion of the wild stocks.

Source: C. Conand.