FIGURE 20
Large mother boats in Philippines are used to take groups of skin divers to more distant reefs in search of sea cucumbers. Left: boat with smaller "tender" canoes on bow, used by individual fishers at the fishing sites. Right: an outrigger boat equipped with salting bins and large pots for boiling sea cucumbers at sea. These boats carry 10–15 crew on trips of 2–3 weeks in the Spratly Islands

PHOTOS: J. AKAMINE

Effort and capacity controls serve to avoid overfishing of stocks by limiting the rate of exploitation. Excess capacity and fishing effort in fisheries are common conduits for overfishing, so States should prevent excess fishing capacity and ensure that fishing effort is in harmony with the productive capacity of the resources (FAO, 1995; Sections 3.1 and 3.2).

A common effort control is to place a limit on the number of fishers allowed to collect sea cucumbers. More specifically, they could place limits on the number of fishers allowed per boat or the number of fishers licensed to fish in a given area. In the Seychelles, sea cucumber fishing operated with open access until 2001 when capacity was limited to 25 licensed boats, each permitted to have a maximum of four registered divers to collect sea cucumbers (Aumeeruddy and Conand, 2008). Effort controls could also restrict fishers to collecting sea cucumbers only at certain times of the day or days of the year.

On the other hand, a capacity control could be to prohibit the use of boats above a certain length (e.g. Figure 20). This measure is useful for protecting sea cucumber populations on remote reefs, accessible only by large boats, thereby safeguarding some breeding stocks and refuges for biodiversity. Limiting boat size and other gears can also help to prevent fishers from continuing to harvest even when resource becomes depleted because they have loans for capital investments to repay.

These measures are a means of manipulating catch through control of fishing pressure (i.e. input controls). Effort controls can be adapted relatively easily to respond to changes in socio-economic variables or availability of stock but, as noted below, are difficult to enforce and are often considered ineffective as a management measure.

Limitations

It can be quite difficult to control behaviour of fishers despite being able to manipulate their numbers. For instance, it is hard to regulate fishing to just certain hours of the day. Most small-scale sea cucumber fisheries are open access and therefore managers have no control over the number of fishers.

In cases where the number of boats is limited, conflicts can arise with other fishers that have been excluded from obtaining a licence. For example, there is a waiting list of fishers in the Seychelles who would like a licence and they complain that licences should be revoked for those in the fishery who are not fishing actively for several months (Aumeeruddy and Conand, 2008).

Many fishers in small-scale fisheries collect other marine animals alongside sea cucumbers. It is therefore impractical to limit fishing of sea cucumbers to certain times or days, if fishers are then allowed to collect other resources. Enforcement of effort limitations becomes quite problematic in these situations.

How to implement

Managers need to know the number of fishers and vessels in the fishery. It is also complementary to know the number of households reliant on the fishery (Sections 3.6 and 6.1.4). The socio-economic impacts of regulating or reducing the number of fishers or amount of time they can spend fishing should be considered.

Managers should also establish or understand the legal framework for implementing effort or capacity controls. Is it possible to limit boats or fishers, and what legal body defines these? There should be a means of licensing fishers, and this can be accompanied by a mandate for fishers to complete and submit logbooks as a condition of licence renewal (Section 5.5). Naturally, this demands that managers establish a system to periodically evaluate the outputs of logbooks.

Enforcing controls on the number of fishers per boat or hours permissible to fish will require inspections of boats and fishers at sea (Section 6.5). Managers should also establish a system for managing data on licences, infringements and the response of the resource over time. This data can then inform advisory committees and decision-makers on the merits of this measure and whether it should be adapted over time.

EXAMPLES AND LESSONS LEARNED

Galápagos Islands, Ecuador

According to the Galápagos Special Law enacted in 1998, only small-scale fishers may take part on fishing activities within the Galápagos Marine Reserve (GMR). All fishing vessels have a set of regulations that should be met by owners and the maximum beam length for mother boats is restricted to 18 m. The restriction on boat size is a form of capacity control, which may be called a "technical control". The number of fishers has been regulated by means of a moratorium (effective as of 31 March 2003) which allows only sons and daughters of active fishers to become new registered fishers of the GMR. However, both, the fishing cooperatives and the Galápagos National Park Service (GNPS) are in the process of eliminating from the fishery non active fishers, hence leaving only fishers that depend on the activity as their primary source of income.
Source: V. Toral-Granda.

Pacific, Melanesia

Customary marine tenure practices vary across Melanesia. Access to the shorelines and lagoon reefs is often controlled by individual communities or family groups that consider these areas and their associated commercial resources as being exclusive property, not dissimilar to property on land.

In a recent cross-Pacific study (SPC PROCFish, 2002–2009), Vanuatu's customary fishing controls stood out as being one of the most intact local management systems, especially on Islands distant from the capital on Efate Island. On Malekula Island, communities on the Maskelynes group of islands still practice a complex system of fishing controls, especially for resources like *Trochus* and sea cucumbers. Aggregations of *Trochus*, by individual reef, came under the control of family groups, and high value sea cucumbers such as sandfish, *Holothuria scabra* were protected by harvesting tabu's, even close to the village forefront that was accessed by the whole community. In this case *H. scabra* had a mean density of 2131±662.4SE individuals/ha from forty-two, 40 m^2 transects close to the foreshore

(PROCFish data, Secretariat of the Pacific Community). This stock was protected from fishing as the local community leaders were waiting for the fishery to recover before commercialising their resource.

In addition, there are controls of effort over small "garden" areas and tabu reserves. "Garden" areas in front of family houses are commonly stocked with important species and protected from fishing in parts of Melanesia. This practise of concentrating resources (generally giant clams, but also other species) in "gardens" has been long documented in northern Papua New Guinea (Mitchell, 1972), and is seen across much of Melanesia. Greater areas under total protection from fishing were also found in Maskelynes. For example, in front of Pellonk village on Uliveo Island in the Maskelyne, the Ringi Te Suh Marine Conservation Reserve limits effort from a one kilometre square reserve. Ringi Te Suh has two meanings; to leave something to multiply and to leave something alone. This fits well with the aim of this reserve, where clam and sea cucumber species are found at higher stock densities, to facilitate successful reproduction, and thereby recruitment to surrounding reefs.

Source: K. Friedman.

5.4 CATCH QUOTAS

Definition

A catch limit set for a particular sea cucumber fishery, generally for a year or a fishing season. Quotas, also called "total allowable catch" (TAC), are usually expressed in tonnes of live-weight equivalent, but are sometimes set in terms of numbers of individual animals.

An overall quota, or TAC, can pertain to the whole fishery or be assigned on an individual basis to fishers or fishing vessels, e.g. individual transferable quotas (ITQs). Individual quotas (a form or access rights) can be transferrable, or not.

Use

Catch quotas are appropriate when fishing is spread over large areas (e.g. regions) and/or when fishers do not necessarily have an intimate (i.e. traditional or cultural) geographic association with the resource (Hilborn, Parrish and Litle, 2005). A primary goal of catch quotas is to control the quantity of animals removed by fishing each year, aligned with the fishery objectives (Section 3.4). A second goal of individual catch quotas is to remove the "race for fish" that can prevail if relatively low quotas are set for a whole fishery. They may be used as a companion management measure alongside other regulations like size limits (see Section 8.3).

Catch quotas can pertain to the entire fishery (a "global" quota for fishers collectively), in which case all fishers are allowed to collect sea cucumbers until the annual limit is reached. This mode, however, does not stop the "race for sea cucumbers". Alternatively, they can be allocated separately to various regions in the fishery and licensed to fishers as individual quotas (which can be transferrable [ITQs] or not [IQs]) or fishing vessels (IVQs). ITQs can provide a relatively secure use right, creating incentives to maximise value and husband resources (Parma, Hilborn and Orensanz, 2006).

Individual quotas, allocated to each fisher or licensed fishing group, can provide a way to equitably distribute potential earnings from the resource among fishers. In some invertebrate fisheries, quotas have been given to communities, which sub-allocated them to families (Defeo and Castilla, 2005). By providing fishers with secured access to a given proportion of the stock, individual quotas can help to maximise the value of the overall catch. For example, fishers then collect only large or valuable sea cucumbers because there is an incentive to be choosy and fill their quota with high-grade animals. Individual quotas relax the timeframe for fishing, thereby improving safety because the choice of when to fish is not determined by short-term competition (Hilborn, Parrish and Litle, 2005). In some fisheries with individual quotas, fishers are happier to see some of the fishery revenue spent on research and science, become more involved in the management of the resources, and work cooperatively (Parma, Hilborn and Orensanz, 2006).

Limitations

In as much as quotas are an effective tool, they suffer from being inequitable and difficult to monitor in small-scale fisheries. They demand technical competence and resources for monitoring, often beyond the limits of fisheries agencies in low-income countries.

Quotas, in general, can lead to monopolization of the fishery in the hands of few fishers. Where a single ("global") quota is set for an entire fishery, those with aggressive fishing strategies will gain the "lion's share" of the quota and leave little to the small-scale fisher collecting just enough each week to meet household needs. Fishers can overcapitalise, e.g. buy larger boats, to gain a competitive edge to secure a large personal catch before the quota is reached (King, 2007). Conflicts then arise when the quota is reached early in the year and the small-scale fisher, who was harvesting modestly, is forced to stop fishing for the remainder of the year. Likewise, ITQs can be bought out by fishing companies to later deprive resource owners of traditional income streams. However, it is worth noting that marine resources generally remain a public good (Hilborn, Parrish and Litle, 2005) and as such, the public can be compensated for its use.

An early dilemma is the allocation of individual quotas among fishers. Fishers reliant on sea cucumbers will argue they deserve larger quotas, while occasional fishers with alternative income streams will argue that it is inequitable to give them smaller quotas.

There are a number of approaches to setting a catch quota. The common process for setting quotas involves three steps:

1) Set the target reference point (in accordance with management objectives; see Section 3.4).
2) Determe the current stock status (see Section 4).
3) Set the quota to achieve the target reference point within a certain timeframe.

Estimating how many (or the weight of) animals that can be removed to obtain the target reference point can be a complex task. Such estimates arise through mathematical models, e.g. of maximum sustainable yield (MSY) (see Hilborn and Walters 1992; King, 2007). Stock assessment of this nature is more often tackled by teams of fisheries scientists in high-income countries with large fisheries, but is intangible for fishery managers with limited technical support.

The use of MSY models as a basis for assigning quotas in sea cucumber fisheries is further problematic. One difficulty with models to calculate MSY is the need to estimate (1) the annual rate of natural mortality (M) or the intrinsic rate of population growth and (2) the "virgin" (i.e. original, unfished) biomass of sea cucumber populations. These biological parameters are lacking for most sea cucumber species at most locations (Conand 2006a; c.f. Conand, 1990). For stocks of species that are long-lived or with very low productivity, as seems to be the case for many sea cucumbers (Section 2.1), the sustainable yield may be only a few percent of the virgin biomass (King, 2007). Additionally, the very premises of using MSY or "surplus yield" models are not well supported by field studies on sea cucumbers. For example, MSY theory assumes that the proportion of animals removed by fishing in one year can be reliably renewed by recruitment in the following year – but annual recruitment in some sea cucumber species appears to be quite irregular (Uthicke, 2004; Uthicke, Welch and Benzie, 2004; Section 2.1). Therefore, MSY theory is not appropriate for many (most?) sea cucumber species, and removing more than a very small fraction (e.g. 2–4%) of the virgin biomass each year may soon deplete breeding stocks such that replenishment of population losses from fishing becomes increasingly unlikely.

Simpler approaches for setting catch quotas can be based on knowledge of historical catches and whether annual catches were sustainable, or through adaptive harvest strategies (see below). However, catch quotas based on subjective criteria can be flawed if they can be based on political pressure rather than scientific information (Toral-Granda, 2008b). Regardless of the method, the implementation and compliance of catch quotas will be quite difficult for most tropical fisheries because, more often, fishers are numerous, catches are difficult to monitor closely, and multiple species are collected (Section 2.3).

Firstly, the fishery manager will normally need to update referenced points for catch quotas in subsequent years, based on fishery-dependent data or new modeling (Grafton *et al*., 2007). Secondly, individual quotas should be set for each species in multispecies fisheries that predominate the tropics (Section 2.3); otherwise, the relatively uncommon high-value species will be vulnerable to being fished to depletion within the overall fishery quota. Thirdly, managers must monitor catches regularly to know exactly when the quota is reached and have an effective communication programme to alert fishers. In fisheries of most developing countries, data from fishers on a monthly basis is difficult to obtain. The periodicity of collating data from logbooks is thus a limiting factor to implementation. Where fishing grounds are remote, difficulty in contacting fishers once the quota has been reached can allow the quota to be exceeded – as occurred in the Galápagos Islands (Toral-Granda, 2008b).

For restoring depleted stocks, TACs alone tend to be inappropriate unless combined with other regulations (Caddy and Agnew, 2005). For example, spatial closures and limited entry (reducing the number of licenced fishers) may also be required. In such cases, the uncertainties in estimating and implementing sustainable catch quotas are high, so there is risk of causing irreversible impacts on stocks.

Quotas, if not allocated to limited areas, will not help avoid serial depletion of stocks. For example, the annual quota could be reached from depleting a few inshore fishing grounds, while leaving stocks in other grounds temporarily intact.

How to implement

Implement TACs through cooperatives and advisory committees; they will be instrumental in passing on the regulations to fishers in local dialects and marshalling the support of stakeholders. Seek their agreement of the goals of the quotas (i.e. to maintain or rebuild current stocks) and predefine the management actions if quotas are exceeded or if follow-up surveys indicate that stocks are not supporting the harvest rates.

The information requirements for setting TACs may be demanding on a fishery agency. To base TACs on an assessment of MSY, managers must have reliable and precise estimates of stock distribution and abundance to sensibly define them in the first instance. These can only come from underwater field surveys, which are costly and time-consuming to conduct over large areas. Additionally, the calculation of abundance will normally require technical competence with geographical information systems (GIS) and field ground-truthing. Based on the estimated standing biomass of each species, TACs can be proposed for those species in sufficient abundance only (Figure 21).

In place of using classical (e.g. MSY-based) stock assessment to determine quotas, an alternative approach is the use of adaptive harvest strategies (Hilborn and Walters, 1992; King, 2007). These approaches will be most useful for fisheries that lack the biological

FIGURE 21
Left: a catch of large sea cucumbers, mainly *Thelenota anax*, at Nabaina Beach, Milne Bay, Papua New Guinea. Fishers may start to target one particular species in a multispecies fishery, so species-specific TACs should be used. Right: fishers setting off on a sea cucumber fishing trip off Enivala Island, Papua New Guinea, using outboard driven dinghies

PHOTOS: J.P. KINCH

parameters of sea cucumber species for classical MSY models or for fishery agencies that lack the technical capacity to conduct statistical modelling (see Section 2.3). In new and developing fisheries, managers could set a conservative TAC for several years and monitor whether catch per unit of effort (CPUE) and densities of sea cucumbers are maintained at a target reference point (Figure 12; Section 3.4). Subject to operational objectives being met, the TAC could then be increased a little and the response of catch rates and sea cucumber populations monitored and re-evaluated. In an existing fishery, TACs may already be too generous, so the manager may downsize the following year's TAC if catch rates or population densities decline. However, both approaches rely on having the sustainable catch level exceeded to know the biological limits of the system (King, 2007), whereas the precautionary approach (FAO, 1995; Section 3.2) urges managers to control effort and capacity to within these limits. Another adaptive harvest strategy involves the use of different management measures in different regions of the fishery and comparing the response of the stock to the different strategies. In either the classical (modelling) approach or adaptive management approach, time-series data on the abundances of stocks after imposing TACs will be required to show whether the harvest rates are sustainable.

Managers need to review published studies and seek the advice of fishery scientists with expertise in sea cucumbers to obtain information on the population dynamics and sustainable harvest rates (e.g. MSY) of the commercial species. This information is generally lacking for sea cucumbers. It can be gained from biological studies on growth, size-at-maturity, rates of natural mortality and recruitment (see Section 2.1). The adopted harvest rates should be in harmony with the productivity of species and the role of the species in the ecosystem. When faced with uncertainties, TACs should be set conservatively. With our present understanding, a sustainable harvest rate would probably be between 2 and 5 percent of the virgin adult biomass per year.

The manager will also need updated information on captures to be able to close fishing once the TAC has been reached. This would need fishery officers to receive and collate log sheets from fishers, and preferably separate captures for each species. Managers may stipulate that if the TAC is exceeded, the surplus amount will be deducted from the following year's TAC, as has been practiced in Papua New Guinea (Kinch *et al.*, 2008b).

Catch quotas should be implemented through an adaptive management process, by which field monitoring and fishery-dependent data (e.g. landing surveys, logbook records or export statistics) are used to lower the quotas for species when stocks show signs of depletion. Zero quotas (i.e. no collection permitted) should be set for species that appear to be becoming sparse. These measures could be set as agreed actions in the management plan if an indicator of stock density depasses a specified limit reference point (Figure 12; Section 3.4).

EXAMPLES AND LESSONS LEARNED

Japan

Global catch quotas exist in some prefectures. For example, the Semposhi Fishery Cooperative Association set an annual quota of 50 tonnes, divided into seasonal quotas of 30 tonnes in spring and 20 tonnes in summer. Fishing is prohibited for the rest of the open season as soon as the annual quota of 50 tonnes is reached by all fishers.

Source: J. Akamine.

British Columbia, Canada

Fishing in British Columbia (BC) was initially permitted along the south coast areas only. The north coast was opened in 1986 with a quota of 500 tonnes. Landings of sea cucumbers have since been recorded from all management areas. The central and north coast currently supports about 80 percent of the fishery. The total allowable catch has augmented incrementally since 1998.

Canada restricts the permits to a single species for two reasons. First, it is much easier to manage and control the catches/quotas (both on board and upon landing). Second, it prevents fishers from opportunisticly starting to target other species for which management plans are not yet developed. With a single species quota and license, the fishers must return any bycatch to the sea and keep only the authorized target species.

Although sea cucumbers have been harvested for more than 20 years, little biological information exists to base quotas and harvest practices. The fishery was therefore incorporated into the "phased approach" described in the Pacific Region Policy for New and Developing Fisheries. Based on existing biological and fishery data in British Columbia and elsewhere, a framework was designed for an experimental fishery to provide data on stock abundance and on the response of the populations to different levels of exploitation.

The existing arbitrary quota of 233 tonnes of *Parastichopus californicus* is maintained in an area comprising about 25 percent of the British Columbia coastline. Another 25 percent of the coast is dedicated to experimental fishing, and the remaining half is closed until the biology of the species is well understood. The quota was justified over this proportion of the coast by extrapolating:

1) an estimated "density" of 2.5 sea cucumbers per meter of shoreline,
2) an annual exploitation rate of 4.2 percent, and
3) a mean individual weight ranging from 263–327 g, depending on the area.

Landings at designated ports are monitored by an independent industry–funded firm, funded through license fees (Bruckner, 2006c). The global quota is considered the most conservative of estimates used in sea cucumber fisheries in the states of Alaska and Washington (United States of America). The management plan allows for abundance surveys to be undertaken in the open areas to defend potential quota increases.

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

Australia

In addition to other regulations, the sea cucumber fishery on the Great Barrier Reef (GBR) also has a total ("global") TAC and in some instances regulates a TAC for individual species. For instance, in 2004 the total TAC was 380 tonnes, consisting of 127 tonnes of white teatfish, zero catches of black teatfish and 253 tonnes for all other species.

In addition, the fishers in the industry agreed on species-specific limit reference points (Figure 12; Section 3.4), sometimes called "trigger values", for the annual catch. If these

are exceeded, in any given year, a stock assessment must be undertaken to establish "biologically-based sustainable yield estimates". Examples of limit reference points in the GBR fishery have been: sandfish, 15 tonnes; golden sandfish, 10 tonnes; prickly redfish, 40 tonnes; surf redfish, 25 tonnes; and deep water redfish, 25 tonnes.
Source: S. Uthicke.

5.5 MARKET CHAIN LICENSING AND REPORTING

Definitions

Requirements imposed on fishers, processors and traders to declare and report on their activities within the fishery.

These can be divided into actions for various stakeholder groups:

1. *Records on catches*: data on the quantity (number and/or weight) of sea cucumbers collected by fishers for each species, collected and reported by fishers and buyers.
2. *Records and statistics on trade*: volumes (weights), processed state and sale grades of sea cucumbers exported and imported for each country, collected by trade departments of government.
3. *Monitoring of catch and trade data*: an assessment of changes in catches and trade through comparison of data averages or totals over time, conducted by resource managers.

Uses

Monitoring of the catches and exports of fishers within a country can provide a means of revealing changes in the rates of exploitation (e.g. per year, not per unit of fishing time) of the resource or in the types or locations of species collected. For example, fisheries agencies that collect and closely monitor data from fishers' logbooks can see whether the annual catches of certain species are increasing or decreasing. States (i.e. fishery agencies) are urged, through the Code of Conduct for Responsible Fisheries (FAO, 1995), to maintain statistical data on fishing operations and update them at regular intervals. The data can be used as a proxy for monitoring the "condition" of the fishery in the absence of rigorous data from underwater population surveys (see Sections 3 and 4). The data can reveal the amounts of sea cucumbers removed, where fishing took place, how the animals were processed and the prices paid.

Licensing can be used to limit the number of buyers/exporters in the fishery to a manageable number. In doing so, collection of trade statistics by the resource manager is simplified. It improves the accountability of trading sea cucumbers since the exporting agents are recognized and have vested interests in abiding by the fishery regulations. Likewise, licences for buying or exporting sea cucumbers can act to limit the illegal and unreported trade by stipulating licence renewal conditions. Illegal buying and transport can be a key problem in fragmented small-scale fisheries (Kinch *et al*., 2007; Kinch *et al*., 2008b). The market for fishers to sell their catch is improved if licences are issued to separate companies that will act in competition to buy sea cucumbers.

Licensing of exporters can also be a way to initiate trade labelling to improve the reputation and prices for beche-de-mer. Similarly, the labelling can distinguish beche-de-mer arising from responsible fishing practices; e.g. "eco-trepang". Ecolabelling can involve the public in preferentially purchasing fish from sustainable fisheries (Pauly, 2008), although the benefits of these marketing tactics have yet to be demonstrated for beche-de-mer sold in Asia.

Limitations

A principal limitation is that the data collation and analysis of captures and trade require human resources and some technical capacity. This may be limiting in some countries for the detail needed to properly manage multispecies sea cucumber fisheries (see Section 2.3). Customs officers and fishery officers need to be able to identify sea cucumbers to species level, both in the unprocessed and processed (e.g. dried) forms. Although some guides are available to help them with this task (see Section 6.1.1), customs officers are commonly unfamiliar with identifying sea cucumbers, and so need appropriate training (see Section 6.5).

One obstacle in comparing trade statistics among countries is the harmonisation of trade names. Sea cucumbers are sometimes coded or grouped, which only hampers the ability to compare levels of trade across countries.

While exporters can be licensed, there are usually informal "middlemen" that buy from fishers and sell to other buyers or exporters. When the market chain is divided into multiple links in this way, licensing becomes problematic and difficult to regulate.

Exporters may be secretive about their sales and unwilling to provide data on prices and grades of exported beche-de-mer. In the Seychelles, logsheets required fishers and processors to state prices of sea cucumbers sold but compliance was difficult because they were reluctant to give that information, so the logsheet was revised to only include quantities sold (Aumeeruddy and Conand, 2008). In Madagascar, it has proven difficult to obtain accurate data on exports because exporters under-report their trade to avoid paying the corresponding taxes (Rasolofonirina, 2007).

A further underlying difficulty in obtaining accurate catch and trade data is the presence of illegal, unreported and unregulated (IUU) fishing. It is relatively easy to export beche-de-mer illegally in many countries, or it can be transhipped and re-exported from other countries, making the inferences about captures less reliable.

How to implement

Resource managers should gain an understanding of the market chain (including shipment routes to markets or harbours). To whom do the fishers sell sea cucumbers; who processes them; are there middlemen; and who exports the final product? These questions can be answered from sociological studies and discussion with fishers and buyers (Sections 6.1.4 and 6.1.5).

It is also important to understand how the grading of beche-de-mer works and the factors that affect sale price (Section 6.1.4). Obtain relevant conversion factors to harmonise the trade data to a common unit of measure (e.g. whole-animal weights) – most of these are published for the common commercial species (see *Examples and lessons learned*, Section 6.1.3).

Managers should find out the legal framework under which licensing requirements can be established for buyers and exporters. In some cases, legislation may afford some rights to the exporters or fishers to keep their transactions confidential. Managers should also find out if there are over-arching regulations from governments and international agencies on the trade of sea cucumbers (e.g. CITES).

Supply custom agents with the information needed to identify different species and grades of sea cucumbers. If possible, seek to harmonise the data format with other countries in the region and participate in some form of regional monitoring and trade controls.

Prepare or adopt logbooks with blank data sheets and examples to be completed by fishers, buyers and exporters. The logbooks should oblige them to record the weights and grade of sea cucumbers sold or exported for each species separately and include the product form (i.e. whole, fresh gutted, salted, dried). Recording the product form will allow data on the weights of each species to be converted to a standardised unit, e.g. fresh (whole) animal weight or dried weight. Rejected and discarded animals should also be recorded (e.g. Appendix 3). Kinch *et al.* (2007) proposed that carbon-copy receipt books should be used for transactions; the seller, buyer and fisheries authority should each receive copies.

Fishery managers should arrange or define the mechanisms for data collection from fishers and exporters – do they submit logbooks or are these collected routinely by a fisheries officer? For example, landing logsheets are required to be filled by fishers and submitted after each landing to the management authority in Newfoundland and Labrador, Canada (Appendix 3). Compliance with this reporting is a condition of renewal for their fishing licences. In the Seychelles, licensed fishers are required to submit logsheets of their catches on a monthly basis (Aumeeruddy and Conand, 2008). Managers should establish a chain of custody to follow shipments from different areas, for example by coding shipments by fisher licence number, site and date and have this information passed on to buyers along the market chain. Government agencies responsible for trade should collate and summarise the data in a way that can easily reveal changes in the data over time.

Establish an industry "code of conduct" whereby licences are renewed on a condition of compliance with the fishery regulations. Incentives could be given to fishers and exporters for reporting completely and on time.

The critical stages should be regulated in the market chain – i.e. stages that are easy to identify and where important information can be collected and verified with available resources. For example, managers should develop and implement a strategy for active monitoring of the main harbours (i.e. export hubs).

EXAMPLES AND LESSON LEARNED

Galápagos Islands, Ecuador

The Galápagos Marine Reserve (GMR) has a Fishery Monitoring Programme (FMP), in which information is collected on fishing sites, fishing effort, total catch and fishing methods, etc. Presently, the FMP is carried out by the Galápagos National Park Service (GNPS). Information is collected throughout the chain of custody. The chain starts in the GMR fishing site and ends with the exporter in mainland Ecuador. By the Special Law of Galápagos, fishers are obliged to provide all the required info to the FMP. The chain of custody involves the following steps:

1. Upon arrival of the fishing boat to one of the ports: (1) GNP personnel will record catch information, fishing sites, biological information; and (2) GNPS verifies compliance to fishery regulations; any catch not complying with these is impounded. A Fishing Monitoring Certificate (FMC) is issued to the owner of the catch. This certificate verifies the amount of *I. fuscus* harvested and state of the produce (i.e. fresh, in brine, dry).
2. The owner of the catch must present the FMCs to the sea cucumber merchant, who will present all FMCs to GNPS personnel upon inspection. The total amount presented by the dealer must be equal to the sum of FMCs. The merchant is then issued a Merchant Monitoring Certificate (MMC).
3. Once the sea cucumber merchant has gathered enough products to send to mainland Ecuador, he/she will present all MMCs to the GNPS in order to obtain authorization to send the product out of the Islands. The GNPS will issue a Transport Authorization Docket (TAD) and a CITES official export permit (*I. fuscus* was included in Appendix III of CITES on 15 August 2003).
4. The sea cucumber merchant must present all TADs and CITES official export permits in the airport or cargo pier in the Galápagos Islands. Upon arrival in mainland Ecuador, all cargo will be presented to the Undersecretary of Fishing, in mainland Ecuador, who in turn will verify the amount intended to be exported from the amount stated in the certificates and permits. Then the cargo can be exported internationally.

   Source: V. Toral-Granda.

Cuba

The fishery for sea cucumbers is not a traditional activity in Cuba; hence there is little local interest in fishing them unless there is a known legal market. All fishing activities for *Isostichopus badionotus* are controlled, with monitoring of the landings, follow-ups and a strict comparison between what is caught, the sales to the exporters and the actual export figures. There is one exporting company authorized in Cuba (NENEKA C.A.) which ships "Class A" product to China, Hong Kong Special Administrative Region, and "Class B" product to China or the Republic of Korea. Additionally, there is a Sanitary Registration that must be issued to the export product which will be checked by customs upon departure. All paperwork must match precisely in order to leave the country. Up to date, there has not been any illegal shipment detected.
Source: I. Alfonso.

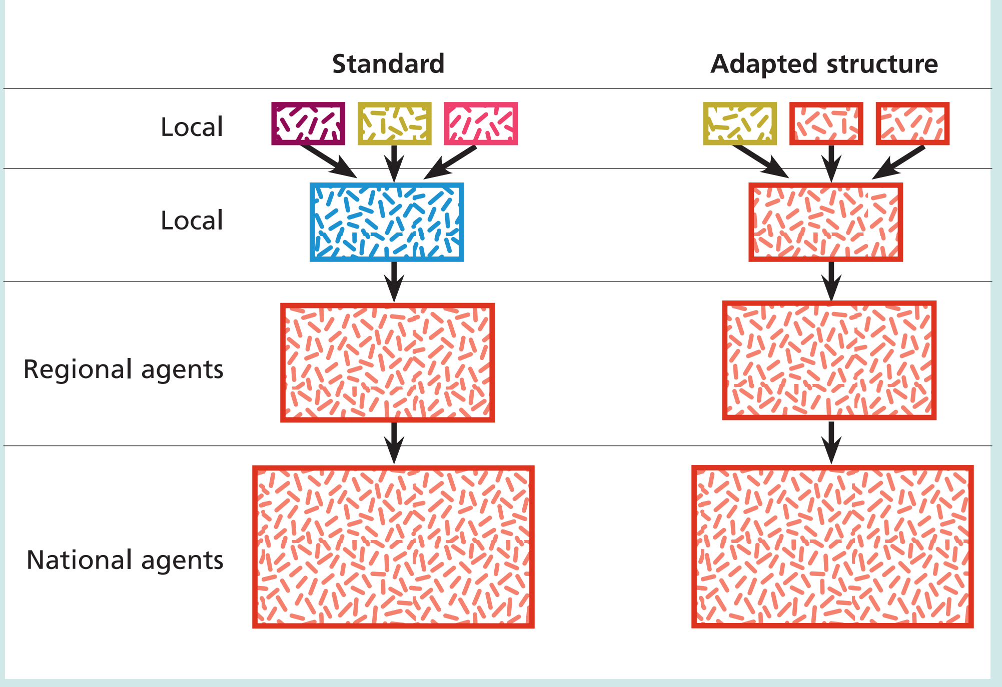
New Caledonia

In both the Northern and Southern Provinces of New Caledonia, fishers are registered through a licensing system. They are required to present themselves at the fishery service and renew their licence each year, for a nominal fee. In the Northern Province, the fishers must also apply for a special "Concession" to harvest sea cucumbers. The licensing system allows the fishery services of the Provinces to monitor the number of fishers, and provides an opportunity to update them on any new regulations. At the time of licence renewal, each fisher is given a booklet, the "Carnet de pêche" that contains the fishery regulations and log sheets (blank forms) to record their catch, in terms of numbers and weights of sea cucumbers collected on each fishing trip. One limitation is that the log sheets are submitted once per year (Purcell, Gossuin and Agudo, 2009a), so the fishery service cannot regularly monitor catches, e.g. as would be required if a TAC limit was in place.
Source: S.W. Purcell.

Fiji

Fiji, a large island group of 332 islands in the mid-Pacific, provides a relevant example of a market chain between sea cucumbers in the lagoon and a dried beche-de-mer consignment ready for shipping to international markets. If we take the northern Island of Vanua Levu and the eastern Lau group of islands as examples we can see that a number of variations exist in the type of market chain present. These scenarios reflect changes in market chain structures across the Pacific.

Usually there are at least four stages along the route from lagoon to export warehouse, although in some cases there may be more (see Figure below). The fisher or community of fishers collects and sells product to local/island middleman who passes it to regional agents and eventually national agent/capital warehouses. In the more traditional structure, fishers in the western lagoon of Vanua Levu and the Lau Group catch sea cucumbers and process the catch into dried product (beche-de-mer) before marketing to local buyers or saving it up until they have enough to take to buyers in larger regional centres. This market chain has changed somewhat in recent years, with a tendency for fishers to be employed on wages and be working for managers employed by the larger export license holders. These fishers, recruited from local villages, dive at numerous areas where they have access, collecting sea cucumbers which are transported directly to the regional centres for processing. In addition, some marine agents prefer to buy wet product from independent fishers and process it themselves to the strict levels of quality requested by the market. Due to the increasing value of the product and the lack of post-harvest skills of some fishers, there is also a tendency for agents to re-process the product they buy, to enhance its appearance and value.
Source: K. Friedman.



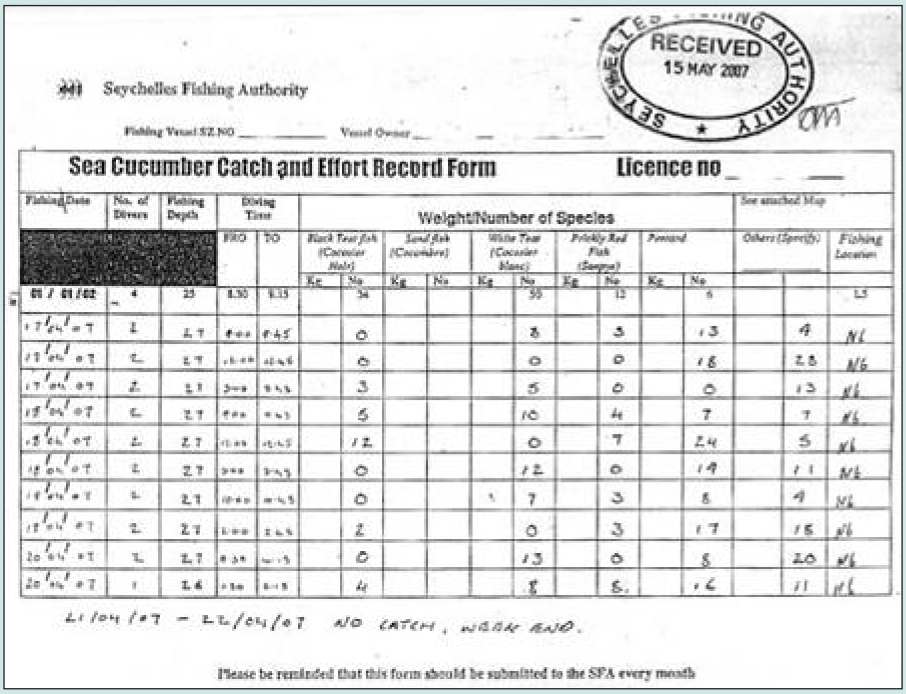
Above: More traditional market chain (left) and variations currently seen (right). Each box texture represents a different stakeholder (i.e. person or company) along the market chain. In the adapted structure, the exporting company employs regional agents, local agents, processors and fishers, thereby controlling or taking away traditional employment of middlemen and local fishers.

Western Indian Ocean

The Seychelles and Madagascar could again be taken as examples of two contrasting fisheries, one with effort and capacity controls (Seychelles) and the other under an open access regime without controls (Madagascar) (Conand and Muthiga 2007; Conand 2008; Aumeeruddy and Conand 2008).

In the Seychelles, fishers, processors and exporters are licensed and monitored by the fishing authority. A management plan came into effect in 2008, with the adoption of the plan by the Cabinet of Ministers; it is the public statement and legal basis for management of Seychelles's sea cucumber three sectors of activity: harvesting, processing and export. The sea cucumber fishery is controlled through a limit of 25 fishing licences to Seychelles citizens. Licences are issued to individuals and registered companies possessing a valid local fishing licensed vessel, to prevent monopoly on fishing licences. The licence fee varies according to fishing vessel type. A maximum of four divers with life insurance are authorized to fish under a sea cucumber fishing licence. The fishing season has been set for nine months starting from 1 October to the 30 June. Licence holders are provided with sea cucumber catch and effort forms, along with a grid map of the Mahe Plateau, which guides them in reporting their fishing locations.

Real-time monitoring is undertaken at designated landing sites. Monitoring of the activities of the processors is constantly done to ensure that illegally caught sea cucumbers are not traded. The processors are required to keep detailed records of their purchases and stocks in a logbook which is then reported back to the Seychelles Fishing Authority (SFA). Most of the sea cucumbers harvested are processed to a dried state and exported by air cargo to main Asian markets. At export the consignment is jointly certified and sealed by the SFA and Custom Officers. A small management fee charged for each kilogram of sea cucumber is paid in Seychelles Fishing Authority's account to better manage the resource.



SEYCHELLES FISHING AUTHORITY RECEIVED 15 MAY 2007

Seychelles Fishing Authority

Fishing Vessel SZ NO ______ Vessel Owner ______

Sea Cucumber Catch and Effort Record Form Licence no ______

Fishing Date	No. of Divers	Fishing Depth	Diving Time		Weight/Number of Species										See attached Map		
[redacted]			FRO	TO	Black Teat fish (Cocosier Noir)		Sand fish (Cocombre)		White Teat (Cocosier blanc)		Prickly Red Fish (Sanpye)		Pentard		Others (Specify)		Fishing Location
					Kg	No	Kg	No	Kg	No	Kg	No	Kg	No			
01 / 01 /02	4	25	8.30	9.15		34				50		12		6			L5
17/04/07	2	27	[illegible]	[illegible]		0				8		3		13		4	NL
17/04/07	2	27	[illegible]	[illegible]		0				0		0		18		23	NL
17/04/07	2	27	[illegible]	[illegible]		3				5		0		0		13	NL
18/04/07	2	27	[illegible]	[illegible]		5				10		4		7		7	NL
18/04/07	2	27	[illegible]	[illegible]		12				0		7		24		5	NL
19/04/07	2	27	[illegible]	[illegible]		0				12		0		19		11	NL
19/04/07	2	27	[illegible]	[illegible]		0				7		3		8		9	NL
19/04/07	2	27	[illegible]	[illegible]		2				0		3		17		15	NL
20/04/07	2	27	[illegible]	[illegible]		0				13		0		8		20	NL
20/04/07	1	26	[illegible]	[illegible]		4				8		8		16		11	NL

21/04/07 – 22/04/07 NO CATCH, WEEK END.

Please be reminded that this form should be submitted to the SFA every month

Above: a stamped sheet from a fisher's logbook showing the fishing dates, number of divers, depth, fishing times, number of individual sea cucumbers captured and the fishing location.

The lesson from the successful monitoring of catch and trade in Seychelles' sea cucumbers is that licensing and monitoring must be conducted at the 3 levels: harvesting, processing and export. The data collected on the catch and effort allows the evaluation of the state of the resource.

In Madagascar, on the other hand, monitoring and controls have been difficult to implement. In the last decades, the fishery has partly shifted from a low tide gleaning by family groups including women and children, to a semi-industrial activity with motorised boats and diving equipment, although SCUBA diving for sea cucumbers is illegal (Rasolofonirina, 2007). The traditional exploitation is very active in remote villages.

Source: C. Conand.

5.6 TEMPORAL CLOSURES

5.6.1 Seasonal and short-term closures

Definition

A cessation or prohibition of fishing for a short specified time period, generally for less than a year and often over the breeding season.

Temporal closures could be a seasonal or cyclical closure, or just a one-off closure for a short period.

Use

Seasonal closures have been used in some sea cucumber fisheries (Bruckner, 2006b; Toral-Granda, Lovatelli and Vasconcellos, 2008). Two principal uses of seasonal closures are: (1) to prevent fishing of sea cucumbers in a period when they are more easily collected, because they are forming groups or less cryptic, such as when they are breeding; and (2) to limit the number of days in a year that fishers have to collect the animals. However, Purcell, Gossuin and Agudo (2009a) argue that the biological precept of the first use is not valid for the majority of sea cucumber species. In the uncommon cases where the behaviour of the species makes them more vulnerable to fishing (more easily collected), seasonal closures have a biological basis.

Only two fisheries in the Western Central Pacific have seasonal fishing closures (Kinch *et al*., 2008). A large benefit of temporary closures lies in the reduction of annual fishing effort. They can limit annual effort by reducing the total number of days per year that animals can be harvested. For example, the fishing season in some parts of Japan is closed for 10 months of each year (Choo, 2008a). Evidence from field population assessments indicates that this measure, in addition with other companion regulations, has increased the densities of wild stocks (Choo, 2008a). On the other hand, while fishing in the Galápagos Islands is restricted to two months between March and August, in addition to other regulatory measures, stocks have continued to decline (Toral-Granda, 2008b). Likewise, a 5-month temporal closure in the sea cucumber fishery in Eritrea apparently did not prevent depletion of stocks (Conand, 2008).

Temporal closures could be viewed as measure to protect sea cucumbers at certain critical times of the year, such as during spawning (Bruckner, 2006b). In this way, fishing does not disturb them in a biologically vulnerable period, but this idea is unfounded if the seasonal closure causes heavier fishing pressure. That is, seasonal closures may backfire as a management measure if heavy fishing prior to the spawning season lowers the densities of spawning animals to levels lower than if there was no seasonal closure in the first instance (see Figure 22).

Temporal or seasonal closures can have some benefit for export marketing of the beche-de-mer. For instance, fishing may be closed when the animals would be of poorer quality for processing, e.g. during aestivation. For example, a long annual temporal closure in British Columbia, Canada, allows fishing for only three weeks, at a time of the year when the muscle weight is greatest and the animals have reabsorbed their internal organs (Hamel and Mercier, 2008a).

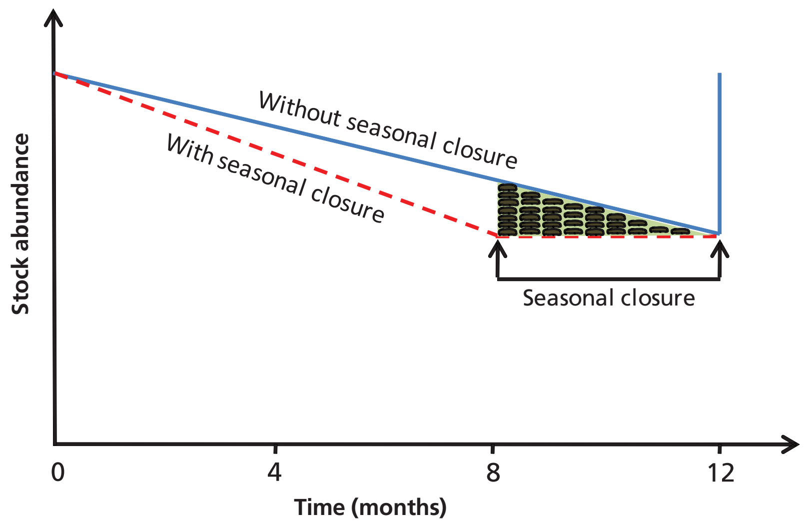
Limitations

There are clear reasons why seasonal closures can reduce the likelihood of overfishing if their purpose is simply to reduce effort. This assumes that fishers do not then fish more intensely during the open season, and that annual harvests are lowered because there is less time for fishers to collect sea cucumbers. In this case, seasonal closures could be placed at any time of the year. In other fisheries, closures are commonly set during the spawning season of the animals to prevent exploitation of spawning aggregations or to avoid disturbance to spawning behaviour. That would only hold true if animals were more vulnerable to being caught during the spawning season or if spawning behaviour was somehow deterred (e.g. by chemical cues of released by distressed animals when captured) by the collection of some animals – which are probably not the case for the majority of commercial sea cucumbers. Most species do not form aggregations for spawning and there is no evidence that they are much more visible to fishers during the spawning seasons. Therefore, there is no behavioural basis to close fishing when animals spawn or during breeding seasons because sea cucumbers do not appear to be more vulnerable to being collected during these periods. In addition, closures based on spawning seasons will be problematic in multispecies fisheries (see Section 2.3) if species spawn in different months.

Shorter fishing seasons can prompt stronger fishing pressure in the open season, thus taking adults out of the population even before they spawn. A seasonal closure can therefore decrease the number of breeders in the spawning season if fishers try to catch an equivalent number of sea cucumbers in the fishing season as they would have without a seasonal closure (Figure 22). Seasonal closures should be used with some form of output control, e.g. a reduced TAC (Section 5.4), if this may be the case (see Section 8.3). Managers may therefore need to monitor catches following the implementation of temporal closure to ensure that rates of fishing do not increase in the open season.

FIGURE 22

A simplified representation of declines in stock biomass through the fishing season with an equivalent annual catch, with and without a seasonal closure. The solid line (blue) shows a gradual decline in stock biomass though the whole 12 months, from a constant fishing rate, followed by recruitment of new animals the following year. The dashed line (red) shows a faster decline in the stock in the first 8 months (before a 4-month seasonal closure) because fishers collect at a faster rate to obtain the same annual catch in 8 months. The seasonal closure in this case coincides with the spawning season. The number of adults harvested annually is the same in both scenarios. The shaded area shows the deficit in spawning biomass at various times during the spawning season with a seasonal closure compared to a fishery without a seasonal closure



Conflicts can arise due to a clash between the timing of temporal closures and the economic needs of fishers or environmental factors. For example, the closures could be set during months when fishers need cash for certain expenses or when sea conditions are conducive to fishing. For example, fishers in Oman usually collect sea cucumbers for six months each year (Conand, 2008) and may object to closures during months of economic need or convenient weather.

How to implement

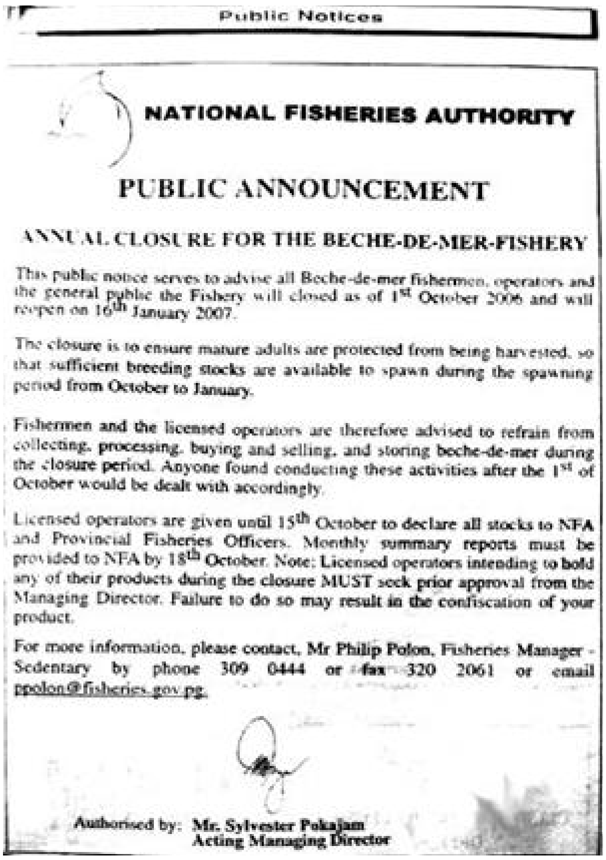
Managers should determine if there are good reasons for imposing temporal closures and consider the potential shortcomings of basing these on spawning seasons. The reproductive cycle of the commercial species should be known. How many months are needed for the gametes in sea cucumbers to become mature and what is the spawning periodicity?

Managers should find out if the season or periods of closure will accommodate fishers' cultural and economic needs (Section 6.1.4). Will the temporal closure prevent fishing in months of favourable seas or at a time when monetary needs are greatest? In addition, find out if there is a demand from exporters or from the market in certain seasons. Are there limitations on processing in certain months? Will temporal closures cause a disruption to relationships with exports, if they expect regular delivery of beche-de-mer? Seasonal closures should be notified to fishers, through meetings, newsletters or news media (Figure 23).

Care should be taken to monitor and ensure that fishing does not intensify in the open season. Temporal closures should be used only in combination with other management measures, such as minimum size limits (Section 8.3).

FIGURE 23

A notice in a newspaper in Papua New Guinea, notifying fishers of the upcoming seasonal closure. It tells why the closure is put in place, that fishers and traders cannot collect, process, buy or sell sea cucumbers in the period and that traders must declare their inventory of sea cucumbers by a specified date



Public Notices

NATIONAL FISHERIES AUTHORITY

PUBLIC ANNOUNCEMENT

ANNUAL CLOSURE FOR THE BECHE-DE-MER-FISHERY

This public notice serves to advise all Beche-de-mer fishermen, operators and the general public the Fishery will closed as of 1st October 2006 and will reopen on 16th January 2007.

The closure is to ensure mature adults are protected from being harvested, so that sufficient breeding stocks are available to spawn during the spawning period from October to January.

Fishermen and the licensed operators are therefore advised to refrain from collecting, processing, buying and selling, and storing beche-de-mer during the closure period. Anyone found conducting these activities after the 1st of October would be dealt with accordingly.

Licensed operators are given until 15th October to declare all stocks to NFA and Provincial Fisheries Officers. Monthly summary reports must be provided to NFA by 18th October. Note: Licensed operators intending to hold any of their products during the closure MUST seek prior approval from the Managing Director. Failure to do so may result in the confiscation of your product.

For more information, please contact, Mr Philip Polon, Fisheries Manager - Sedentary by phone 309 0444 or fax 320 2061 or email ppolon@fisheries.gov.pg.

Authorised by: Mr. Sylvester Pokajam
Acting Managing Director

PHOTO: M. KRONEN, SPC PROCFISHIC

EXAMPLES AND LESSONS LEARNED

Japan

Each prefecture in Japan manages its own fishery. Harvesting of sea cucumbers in most fisheries is allowed during winter and there is a closed season for several months, starting in April. This is because spring is thought to be a spawning season in most of the Japanese archipelago. However, prefectures in Hokkaido, in northern Japan, are an exception. Each fishery cooperative association set down their fishery regulations and regulate their fishing activities on a voluntary basis. For example, Semposhi Fishery Cooperative Association self-regulates their fishery season: from March 1 to April 30 and June 16 to July 20. In another prefecture the fishery is closed from May 1 to June 15.
Source: J. Akamine.

British Columbia, Canada

In British Columbia, the annual *Parastichopus californicus* fishery lasts for about three weeks in October. The open season is set at this time because muscle weight is greatest and the animals have reabsorbed their internal organs (DFO, 2002).
Source: A. Mercier and J.-F. Hamel.