Putting into practice an ecosystem approach to managing sea cucumber fisheries

Cover design by Emanuela D'Antoni and José Luis Castilla with photos by Steven Purcell

Putting into practice an ecosystem approach to managing sea cucumber fisheries

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Preparation of this document

This document is an abridged version of the FAO Fisheries and Aquaculture Technical Paper No. 520, entitled "*Managing sea cucumber fisheries with an ecosystem approach*". It is intended to provide a more concise and less technical outline of processes and principles to implement an ecosystem approach in the management of sea cucumber fisheries.

The document was written and prepared by Steven Purcell. It draws on outcomes of the FAO Technical Workshop on "*Sustainable Use and Management of Sea Cucumber Fisheries*" held in Puerto Ayora, Galapagos Islands, Ecuador, from 19 to 23 November 2007. The group of experts convened for this purpose consisted of Jun Akamine, Poh Sze Choo, Chantal Conand, Eduardo Espinoza, Kim Friedman, Ruth Gamboa, Jean-François Hamel, Alex Hearn, María Dinorah Herrero-Pérezrul, Jeff Kinch, Alessandro Lovatelli, Priscilla C. Martínez, Annie Mercier, Steven Purcell, Verónica Toral-Granda, Sven Uthicke, Marcelo Vasconcellos and Matthias Wolf. Valuable comments and contributions to earlier versions of this document were made by Alessandro Lovatelli and Yimin Ye, both officers of the FAO Fisheries and Aquaculture Department. The image on the cover was prepared by Emanuela D'Antoni (FAO) from photographs by Steven Purcell and the layout done by José Luis Castilla.

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Abstract

Artisanal and industrialized fishers from more than 40 countries harvest more than 60 species of sea cucumbers. These low-food-chain resources play important roles in nutrient recycling and sediment health in marine habitats.

Owing to ease of capture and vulnerable biological traits, sea cucumbers have been easily overexploited in most countries, sometimes to local extinction. Few sea cucumber fisheries are currently managed sustainably. They differ greatly in the scale of the fishing activities, status of stocks and management capacity.

This document summarizes general management principles and a general framework for developing and implementing a management plan. Through a few questions and simple indicators, managers are guided to choose appropriate sets of regulatory measures and management actions for different sea cucumber fisheries.

Safeguarding sea cucumber stocks for current and future generations will require an ecosystem approach to fisheries (EAF) that applies precautionary measures with the participation of stakeholders. Success in applying an EAF will require consideration of the reproductive productivity of stocks, ecosystem health and the socio-economic systems that drive exploitation.

FAO.
Putting into practice an ecosystem approach to managing sea cucumber fisheries. Rome, FAO. 2010. 81 pp.

Contents

Acronyms

CC	consultative committee
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	catch-per-unit-effort
EAF	ecosystem approach to fisheries
FAO	Food and Agriculture Organization of the United Nations
GBRMP	Great Barrier Reef Marine Park
GIS	geographical information systems
IUU	illegal, unreported and unregulated
MAC	management advisory committee
MPA	marine protected area
MSY	maximum sustainable yield
TAC	total allowable catch
TURF	territorial user rights to fish
UVC	underwater visual census

Background

Sea cucumbers (Class: Holothuroidea) are a significant source of income to many coastal communities worldwide and fulfil an important roles in marine ecosystems. Sustaining these resources through effective management is of paramount importance to biodiversity of the ecosystems in which they live and the livelihoods of people who depend on them.

The current grave status of sea cucumber stocks in numerous countries can be attributed to excessive exploitation, ever-increasing market demand and inadequacy of fishery management and governance. The vulnerability of sea cucumber populations to local extinction and the risk of long-term loss of fishery productivity have prompted recent international and regional meetings of expert scientists and fishery managers. A common recommendation from these meetings is to help improve national fisheries management through advice on appropriate management regulations and activities for sea cucumber fisheries.

To meet these challenges, the Food and Agriculture Organization (FAO) carried out a global programme to improve information support for managing sea cucumber fisheries. An international workshop was convened in November 2007 in Puerto Ayora, Santa Cruz Island, Galápagos (Ecuador) to identify management measures best suited to sea cucumber fisheries. A principal output

from the workshop was a FAO Fisheries and Aquaculture Technical Paper entitled "*Managing sea cucumber fisheries with an ecosystem approach*" (Purcell, 2010). The present booklet summarizes that document with a goal to contribute to improved and effective management and governance of sea cucumber fisheries around the world through successful implementation of an ecosystem approach to fisheries (EAF).

This document summarizes best-practice management measures applicable to most fisheries and situation-specific measures that may be used in some scenarios. Drawing on lessons described in the regional reviews of sea cucumber fisheries (Toral-Granda, Lovatelli and Vasconcellos, 2008), practical examples are presented across a diverse array of fisheries from tropical and temperate regions.

The aim of this document is to assist fisheries managers in choosing regulations and action plans to maintain and restore the productive capacity and biodiversity of sea cucumber stocks and fishery ecosystems, while considering their role in the livelihoods of fishers. This document is meant for fishery managers and fishery officers. It embraces an EAF (FAO, 2003) by recognizing the importance of sea cucumbers to rural coastal livelihoods and the socio-economic impacts of management measures.

Characteristics of sea cucumber fisheries

Sea cucumbers are echinoderms, Phylum Echinodermata, along with sea stars and sea urchins. Within this Phylum, they belong to the taxonomic Class Holothuroidea, so are sometimes referred to as holothurians. At present, 66 species of sea cucumbers are commercially exploited worldwide. Harvested sea cucumbers are usually gutted, boiled and dried before being exported to Asian markets. It is the dried product that is called "*beche-de-mer*", meaning "spade of the sea", or "*trepang*" or "*haishen*".

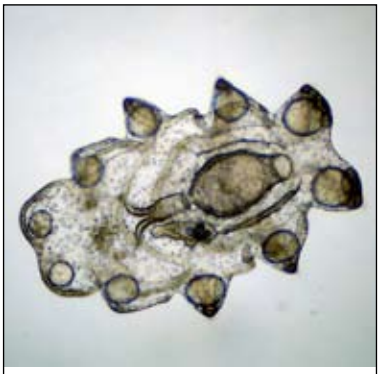
BIOLOGICAL TRAITS IMPORTANT FOR MANAGEMENT

Several life-history traits of holothurians make them especially vulnerable to overfishing: the rates of population turnover are often low, they can be long lived, and populations need to be dense to achieve good reproductive success.

Commercially exploited sea cucumbers mostly have separate sexes. They are broadcast spawners; the sperm released from

A. DESURMONT

A male Bohadschia marmorata *releases sperm into the water column which may find oocytes released from females to form an egg.*



J.-F. HAMEL AND A. MERCIER

A fully developed auricularia larval stage of the sea cucumber Isostichopus fuscus *about 1 mm long.*

males must swim in the water column and find the oocytes released from females to form fertilized eggs. Fertilization success, therefore, depends on mates being in close proximity. So, managers must ensure that populations remain dense for reproduction.

The eggs can develop into free-swimming larvae in less than one day. The larvae then spend weeks in the water column before transforming into the final larval stage that settles on surfaces, like rocks, dead corals or seagrasses.

Genetic studies indicate that the larvae of some species can be transported large distances, e.g. hundreds of kilometres or more. Dispersal in some other species is relatively restricted, resulting in genetic differences in populations over much shorter distances. This is important for the design of marine reserve systems and for restocking.

In addition to sexual reproduction, about ten species reproduce asexually by dividing in the middle of the body. Both halves re-grow necessary organs and form clones of the original animal.

Sea cucumber populations can be slow to recover from moderate to high rates of exploitation. For the Pacific black teatfish, *Holothuria whitmaei*, a fishing rate of just 5 percent of virgin biomass per year still led to depletion

of breeding stocks in Australia. In some locations, populations of sea cucumbers have failed to recover even 50 years after heavy fishing pressure.

Growth in many sea cucumber species is slow and some species may be quite long lived.

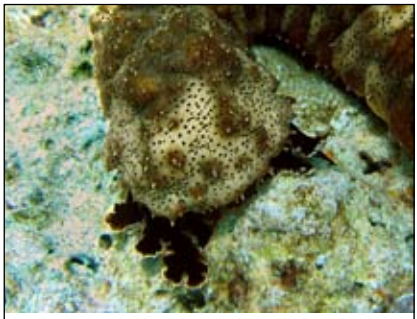
Growth rates of sea cucumbers have been difficult to assess. Some species may reach a good market size in 2–3 years, while others may take many years to reach commercial sizes. For example, *Cucumaria frondosa* from the North Atlantic reaches commercial size after ten years.

Decades ago, research indicated that sea cucumbers could live for 5–15 years. More recently, studies indicated that some species have low rates of natural mortality and are rather long-lived, potentially several decades or more. Consequently, fisheries models should apply conservative estimates of longevity or natural mortality when determining a sustainable fishing rate.

Sea cucumbers can be regarded as sedentary. Some species can move from juvenile habitats to adult habitats. Most animals within populations of reef species probably do not move more than 50–100 m in a year. Marine reserves and no-take zones are therefore a useful tool for protecting breeding populations and may not need to be very large (e.g. 0.5–3 km^2).

ARE SEA CUCUMBERS IMPORTANT TO ECOSYSTEM FUNCTIONING?

Most of the commercial sea cucumbers are deposit feeders that consume fine organic matter (detritus), bacteria and diatoms mixed with sediments on the seabed. Those species on hard reef surfaces "mop up" the particulate organic matter that coats rocks and vegetation. Just a few commercial species are suspension feeders. Holothurians are therefore a low-food-chain group and help to recycle organic matter. Some species bury in sand and mud, so are believed to help oxygenate and mix the upper sediment layers (bioturbation).



S.W. PURCELL

Pearsonothuria graeffei *with black tentacles extended to collect microalgae and detritus on a hard reef surface.*

WHY IS THE MARKET DEMAND STRONG FOR SEA CUCUMBERS?

Chinese and other Asians have eaten sea cucumbers for centuries for their curative and dietary properties. They were recorded as a tonic food as early as the Ming dynasty, around 500 years ago.

S.W. PURCELL

Sea cucumbers served as a sauced dish in China.

They are a rich source of compounds known in western medicine as treatments for arthritis and joint ailments (see articles in Lovatelli *et al.*, 2004).

In the past, sea cucumbers were eaten by wealthy Asians for health treatments, or as delicacies during festive periods. Nowadays, Chinese and other Asians eat sea cucumbers more regularly, owing to increased affluence. Increased demand for beche-de-mer is the main cause of inflated prices of sea cucumbers globally.

The main import markets are China, Hong Kong Special Administrative Region, Singapore and Taiwan Province of China (see Lovatelli *et al.*, 2004). Recently, the United Arab Emirates has also become important. All of these markets are also major re-exporting centres.

WHAT DETERMINES THE VALUE OF SEA CUCUMBERS?

The price of beche-de-mer varies greatly among species and also within species depending on the size of the animal and the care with which it was processed. Larger animals generally command a higher price per kilogram than smaller ones (Friedman *et al.*, 2008). The Japanese sea cucumber, *Apostichopus*

J. AKAMINE

Tropical sea cucumbers, as beche-de-mer, displayed at various prices in a dried seafood markets in Taipei, Taiwan Province of China.

japonicus, can fetch more than USD 300 per kilogram (dried) at retail markets if the animals are in a perfect, presentable state.

Some tropical species can fetch almost an equivalent price for large, well-processed specimens. However, some other species or animals poorly processed would attract only modest prices.

WHERE AND HOW ARE SEA CUCUMBERS FISHED?

Sea cucumber fisheries have different ecological attributes of species, modes of exploitation, history and socio-economic structures (see Toral-Granda, Lovatelli and Vasconcellos, 2008). The fisheries are often small-scale in the way the animals are harvested; fishers collect sea cucumbers by wading or skin diving in shallow waters. On the other hand, fisheries in developed countries are commonly industrialized; teams of fishers use large boats and sophisticated fishing gear.

R. GAMBOA

Artisanal small-scale fisher in the Philippines with three species of sea cucumbers collected by skin diving from a canoe.

The problems facing small-scale and industrial fisheries are different (Purcell, 2010). Small-scale fisheries often comprise many low-income fishers who collect sea cucumbers out of tradition or as an occupation of

last resort. Fishers are reluctant or unable to cease fishing, even when stocks become depleted.

In comparison, industrial-scale fishers are more commonly capable of switching to fishing other resources and are easily contactable. However their capital investment in boats and fishing gear means they must continue high rates of exploitation to cover loans and operating costs.

Most sea cucumber fisheries are multispecies in nature. In the tropical Indo-Pacific, up to 20 or 30 species can be exported from a single country. In contrast, temperate fisheries usually concern one or two species, fished in deeper waters (> 50 m) by divers using compressed air or using "drag" nets from large vessels.

HOW ARE SEA CUCUMBERS CURRENTLY MANAGED?

In developing countries, the limited capacity of fishery institutions hinders the ability to develop or effectively implement complex management measures.

In some countries, access to fishing sea cucumbers is open to all fishers, whereas in other countries access is restricted. For example, fishing grounds in western Canada and the Great Barrier Reef in Australia are divided into fishing plots allocated among a small number of licensed fishing companies. Fishers can leave smaller adults, knowing that they have sole rights to collect them in following years. In contrast, open-access fisheries such as the Philippines or Madagascar are plagued with the "tragedy of the commons", whereby fishers collect even small sea cucumbers because they will be fished by their neighbour if left behind.

The wide diversity of sea cucumber fisheries makes it impossible to prescribe a "one-size-fits-all" solution for management. There are, nonetheless, some regulatory measures that are appropriate for most fisheries and some actions that all fishery managers should undertake – these will be discussed later in this document.

WHAT IS THE CURRENT STATUS OF SEA CUCUMBER FISHERIES WORLDWIDE?

Sea cucumbers are fished all over the world, particularly in tropical regions. The total global catch of sea cucumbers is in the order of 100 000 tonnes of live animals annually. In 2000, about 6 000 tonnes of processed (i.e. mostly dried) animals were exported to Asian markets, worth over USD 130 million.

A decade ago, the leading exporters were Indonesia, the Philippines, Papua New Guinea, Japan, Republic of Korea, the United States of America, Solomon Islands, Fiji Islands, Madagascar, Australia and New Caledonia. However, this has changed in recent years due to overfishing of some fisheries and the development and expansion of others.

L. BARRETT (DFA)

Temperate-water Cucumaria frondosa *harvested using a "drag" net in an emerging fishery in eastern Canada.*

Sea cucumber stocks in many countries are overexploited or depleted (Toral-Granda, Lovatelli

and Vasconcellos, 2008). Overfishing has caused local extinction of breeding populations of some species and a collapse of other stocks in some countries. As a result, moratoria (bans) on fishing have been set in many countries (Purcell, 2010).

The recent collapse of many sea cucumber fisheries should be a warning to manage fishing more conservatively.

Throughout much of the Indo-Pacific, populations of high-value species like *Holothuria scabra*, *H. lessoni*, *H. fuscogilva*, *H. nobilis* and *H. whitmaei* have been overfished. Fishers have now turned to collecting low-value species but continue to collect high-value species.

In China, marine aquaculture and sea ranching of the cold-water *Apostichopus japonicus* has boomed since the early 1990s. The aquaculture-based production of this species currently rivals the total global wild captures in volume. Surprisingly, this has not dampened prices of the wild-caught tropical species.

S.W. PURCELL

Apostichopus japonicus *harvested from an artificial reef previously stocked with hatchery-produced juveniles.*

Advances in sea cucumber aquaculture and management

FAO Fisheries Technical Paper No. 463. Rome, FAO. 2004.

The utilization of sea cucumbers, including for human consumption, has been steadily growing over the years. Up-to-date information on the present status of world sea cucumber resources and utilization is presented with special focus on countries such as China, Ecuador, Indonesia, Japan, Malaysia and the Philippines that have been heavily engaged in the industry for decades. Information from other countries such as Cuba, Egypt, Madagascar and the United Republic of Tanzania, relative newcomers to the sector, is also provided, indicating to some extent the growing interest with regard to the exploitation of holothurians for the demanding Asian markets. Details on the technical advances made in the artificial reproduction and farming of selected commercial species are presented. This document includes the recommendations formulated during the FAO Fisheries Department Workshop on Advances in Sea Cucumber Aquaculture and Management held in Dalian, China, in October 2003, along with the technical papers presented. The report will be useful to those international and regional development organizations and national governments who wish to prioritize their activities concerning sea cucumber conservation and exploitation.

Management principles

THE CODE OF CONDUCT FOR RESPONSIBLE FISHERIES

The FAO and partners developed the Code of Conduct for Responsible Fisheries (FAO, 1995). Although not legally binding, the Code sets out a list of principles for behaviour and practices towards responsible stewardship of marine resources and their environments.

The Code urges managers to take actions to ensure that resource values are maintained for future generations. Recommendations important to sea cucumber fisheries include the following:

- Prevent overfishing and excess fishing capacity.
- Use the best scientific information and promote research for responsible management.
- Monitor fishing activities regularly and use the data in management decisions.
- Train and educate fishers on responsible fishing practices and best methods for processing their catch.
- Respect and protect the rights of indigenous and small-scale fishers.
- Take actions to ensure that stakeholders comply with management measures.
- Taken into account the capacity of developing countries in applying the Code.

THE PRECAUTIONARY APPROACH

The precautionary approach recognizes that undesirable changes in fisheries systems are usually only reversed slowly (FAO, 1996). Conservative measures should be applied to avoid situations where the productive capacity of the resource, or environment health, is diminished.

A key principle in the precautionary approach is that "*The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures*".

Fishery managers should take the following actions:

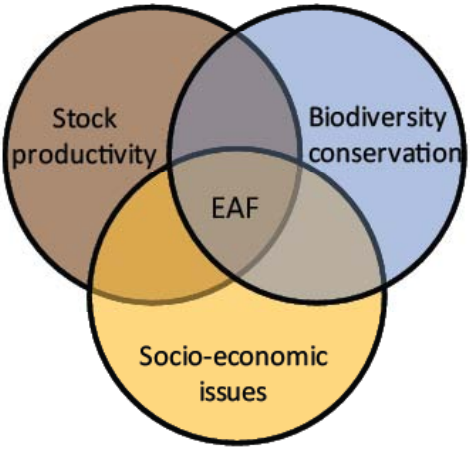
- Develop management plans with "decision control rules" (explained later).
- Take prompt corrective measures in cases where the resource or environment has been impacted, giving priority to restoring depleted stocks.
- Set in place mechanisms for adapting regulatory measures in the light of unexpected events.
- Establish legal or social management frameworks for fisheries.
- Define the objectives of the fishery and set measurable targets in a precautionary manner.
- Ensure that the harvesting and processing capacity is within the sustainable levels of the resource and that fishers report on their activities.

Fishery managers should take into account uncertainties related to the size and productivity of the stocks. This is important because there is not yet clear scientific evidence to reliably predict the productivity of most sea cucumber species and populations.

The ecosystem approach to fisheries

The ecosystem approach to fisheries (EAF) arose from the global awakening to the shortcomings in managing fisheries by focusing primarily on the resource (e.g. sea cucumbers). The broad purpose of the EAF is to include the expectations and needs of stakeholders into management without threatening the options for future generations to gain from the goods and services of resources and ecosystems (FAO, 2003).

A sensible balance should be made between *ecosystem conservation*, which focuses on protecting ecosystems, and *fisheries management* that focuses on providing food and income for people's livelihoods by managing fishing activities.



The ecosystem approach to fisheries involves the overlap of several primary management issues.

The EAF requires consideration of the potential direct and indirect effects of fishing on the dynamics of the ecosystem and potential cumulative impacts from different fisheries. A variety of factors influencing the stocks and their resilience to human impacts must be considered in fisheries management (FAO, 2003).

Management with an ecosystem approach deals with fisheries in a holistic way. The EAF recognizes the wider economic, social and cultural benefits that come from fisheries resources and their ecosystems. Humans should be considered within fishery ecosystems rather than apart from them. Therefore, the EAF strives to include fishers and other "actors" in the decision-making. By considering humans (e.g. fishers, processors, exporters) in ecosystem management, appropriate incentives can be devised to stop the "race-for-fish" and reduce other problems of classical "top-down" fisheries management. In this sense, the EAF promotes institutions for co-management and community-based management of marine resources (discussed later).

Making the EAF operational requires managers to involve stakeholders in the following tasks:

- identify broad and specific objectives;
- set measurable reference points (e.g. certain minimum densities for sea cucumber populations);
- develop rules about how to apply and adapt fishery regulations; and
- objectively evaluate the performance of management plans through monitoring.

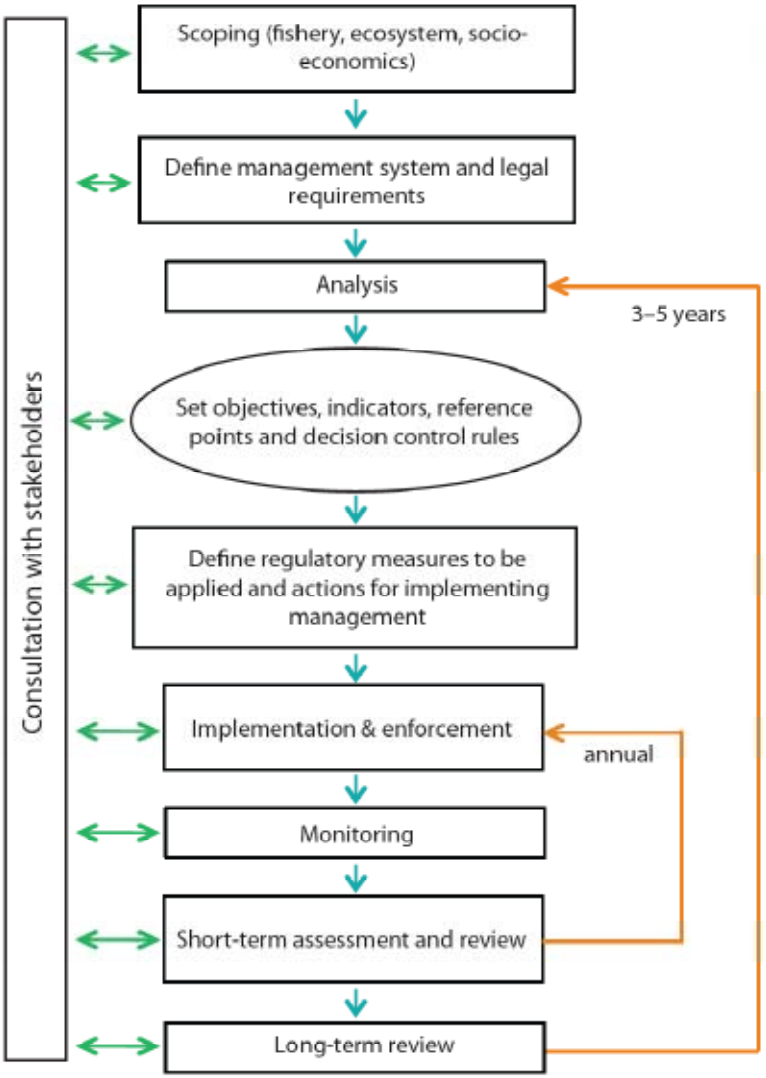
The management process, indicators and reference points

The process of developing and modifying an EAF management plan involves a series of steps (FAO, 2003). A first step should be the collection and analysis of data from fishery-independent and fishery-dependent surveys and socio-economic surveys.

The management system should be clearly defined. For example, if co-management is being applied, which persons or groups have responsibility for various management actions? The process should also set out any legal requirements, such as compliance with local by-laws or regulations on trade from international agreements.

Once the necessary information has been gathered and analysed, the management plan should set appropriate goals and objectives. These should be in line with precautionary principles and a holistic approach to management.

Each step in the management process should involve consultations with stakeholders. The process by which management decisions are made should be open and transparent and separated from personal interests.



Source: adapted from FAO, 2003.

Objectives are statements of the intended outcomes of the management plan. Defining objectives helps to align choices for regulatory measures and actions undertaken

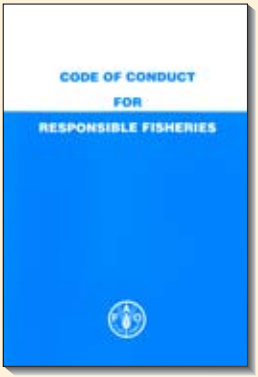
by management institutions and affixes the "goalposts" for judging management success (Hindson *et al*., 2005).

Broad objectives should be made into "operational objectives" that have practical meaning and against which the performance of management strategies can be evaluated (FAO, 2003). For example, a broad objective could be to maintain sufficient breeding populations in the fishery, and the operational objective could define the desired population densities.

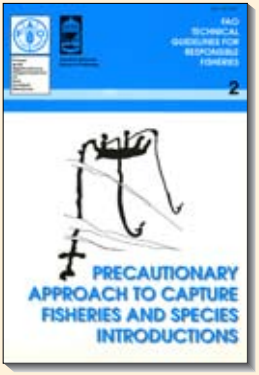
Issues within each objective should be discussed and prioritized, e.g. through a risk assessment. Once managers establish a list of main objectives, strategies must be developed to achieve them. The strategies will include regulatory measures and actions by the managers.

Indicators and reference points should be clearly identified. Indicators describe the state of fisheries resources and fishing activities and provide a measure of the extent to which the objectives are being achieved (see Friedman *et al*., 2008). Reference points should state measurable limits at which management actions will be taken. Those actions should be set beforehand with "decision control rules" that indicate the circumstances under which management measures are to be applied or changed.

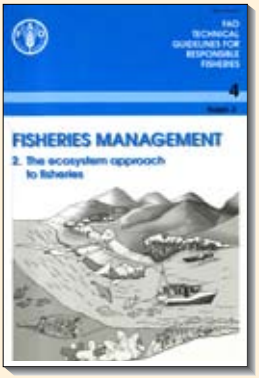
The management plan must then be implemented and enforced. Establishing a process of reviewing the management strategy at regular intervals will allow adaptive management as conditions change in the fishery.



This publication includes the text of the Code of Conduct for Responsible fisheries, background to the origin and elaboration of the Code and Resolution 4/95 as adopted by the Twenty-eighth Session of the FAO Conference on 31 October 1995.



This document proposes a definition of the precautionary approach to fisheries and contains guidelines on fisheries management, how to conduct fishery research and how to develop and transfer fishery technology in a context of uncertainty and responsible fisheries. Guidelines are also provided on voluntary or accidental species introduction.



These guidelines supplement the FAO Code of Conduct for Responsible Fisheries. The Code and many international agreements and conferences highlight the many benefits that can be achieved by adopting an ecosystem approach to fisheries (EAF) and elaborate a number of agreed principles and concepts relating to EAF.

A road map for choosing the right tools

Success in fisheries management seems to require a combination of management "tools" (regulations and actions) from the toolbox. Also, industrial and small-scale fishery problems have to be treated separately.

The FAO workshop on management of sea cucumber fisheries in the Galapagos Islands, 2007, produced a "road map" to assist fishery managers in choosing appropriate regulatory measures and management actions (Purcell, 2010). Three basic questions should be answered to characterize the sea cucumber fishery being managed:

1. What type of fishery is being managed: small-scale or industrial?
2. What is the status of stocks: underexploited, fully exploited, or depleted? Use simple indicators or data from underwater surveys.
3. What is the management capacity in the country: strong or modest?

The questions lead to appropriate sets of regulatory measures and management actions, which are given in the following tables. Management bodies with modest technical and human resources capacity should apply the minimum sets of measures and actions (all ticks). Those with strong capacity should apply additional regulatory measures and management actions (question marks), depending on the circumstances of the fishery system.

What regulatory measures are best to use?

Fishery type	Stock status	Size limits	Gear limitation	Effort and capacity control
Industrialized	**Healthy** (underexploited)	✓	?	?
	Fully exploited	✓	✓	?
	Depleted			
Small-scale	**Healthy** (underexploited)	✓	?	?
	Fully exploited	✓	✓	?
	Depleted			

What actions should managers take in implementing management?

Fishery type	Stock status	Overview of the harvested species	Fishery-independent stock surveys	Fishery-dependent stock surveys	Socio-economic surveys
Industrialized or Small-scale	**Healthy** (underexploited)	✓	✓	✓	✓
	Fully exploited	✓	✓	✓	✓
	Depleted		✓		✓

✓ – Apply as an essential (minimum) measure or action regardless of the capacity of the management institution.

? – Consider applying as an additional measure or action if the management institution has a strong capacity for implementation.

Catch quotas	Market chain licensing and reporting	Seasonal and short-term closures	Bans or moratoria	MPAs and no-take reserves	Rotational harvest closures	Area and user access rights
?	✓	?		?		✓
✓	✓	?		✓	?	✓
	✓		✓			
?	✓	?		✓	?	✓
?	✓	?		✓	?	✓
	✓		✓			

Price monitoring	Support local-scale management	Establish management advisory committees	Legislation of management regulations	Assign accountability	Enforcement	Education and communication with stakeholders	Improve quality of processing through training	Restocking
?	?	?	?	✓	✓	✓	✓	
?	✓	✓	✓	✓	✓	✓	✓	
		?	?	?	?	?	✓	?

Fishery regulations

SIZE LIMITS

Definition: A minimum individual length or weight of sea cucumbers that can be legally fished or traded. These can pertain to fresh or processed and dried animals.

Size limits are needed especially in small-scale fisheries with many species.

Size limits are commonly used in sea cucumber fisheries to protect juveniles and recently matured adults to allow individuals one or more seasons to spawn before they can be fished. Minimum size limits are often based on a size above which the animals first become mature (Conand, 1989; 1990). Size limits may differ among fisheries with different management goals or due to biological variation among regions.

Limitations

- Determining and applying appropriate size limits.
- Live sea cucumbers contract when handled.
- Difficulty for fishers to weigh animals; body length probably needs to be the measure.

S.W. PURCELL

A fishery technician in New Caledonia measures a live sea cucumber.

How to implement

Choose size limits that allow animals to reach maturity *and* have one or two seasons to spawn before being fished (Purcell, 2010).

S.W. PURCELL

Sea cucumbers are more easily measured along their under (ventral) surface.

- Use biological parameters from animals in your fishery to choose size limits, or adopt parameters from other regions conservatively.
- Educate fishers and processors on the biological reasons for size limits.
- Determine what instruments will be used to measure live and processed animals.
- Involve fishers, processors, biologists and enforcement personnel in the decision-making.

GEAR LIMITATION

Definition: A prohibition or limit on the use of certain types, sizes or number of equipment for collecting sea cucumbers.

Examples of gear limitations include a prohibition on compressed air for diving or a specific limitation on the size of net mesh for trawl fisheries. Gear limitations can help to limit the use of overly efficient, or industrialized, fishing systems. Some gear limitations give some respite to the resource from either being fished too rapidly, or being fished in areas not accessible to free-divers.

J. AKAMINE

Drag nets are used in Japan to collect Apostichopus japonicus *from the sea floor.*

Gear limitations can also be set to avoid risks to the environment or the fishers themselves, in harmony with the *Code of Conduct for Responsible Fisheries* (FAO, 1995). The use of SCUBA or "hookah" gears is sometimes prohibited to minimize diving accidents in the fishery.

Limitations

- Compliance of some gear regulations is difficult or costly and may require enforcement from boats.
- Assessing the effectiveness and optimization of new gear requires research.

How to implement

- Find out what gear is currently used.
- Assess the advantages and disadvantages of other type of gear. If a device (e.g. drag net) is used to harvest sea cucumbers, will it damage the sea bed?
- Assess what human and financial resources are available to enforce gear restrictions.
- Consult with fishers to make sure they understand, and will respect, the gear restrictions.

Fishing gears, like SCUBA or hookah, should be prohibited in sea cucumber fisheries with fully exploited stocks.

Source: adapted from Friedman *et al*. (2008).

EFFORT AND CAPACITY CONTROL

Definitions: *Capacity controls* seek to limit the total quantity of animals that can be collected, usually by restricting the number of boats in the fishery. *Effort controls* restrict the fishing activity, such as the amount of time that fishers can collect animals on each day.

J. AKAMINE

A large boat in the Philippines used by groups of fishers to access more distant reefs in search of sea cucumbers.

Excess capacity and fishing effort are common causes of overfishing in sea cucumber fisheries. These management measures aim to regulate the effort and/or capacity to levels in harmony with the productive capacity of the resources (FAO, 1995).

An effort control could be a limit on the total number of fishers or fishers allowed per boat. A capacity control could be a restriction on the maximum length of boats used in the fishery.

Controlling the effort of fishers in established small-scale fisheries will be very difficult.

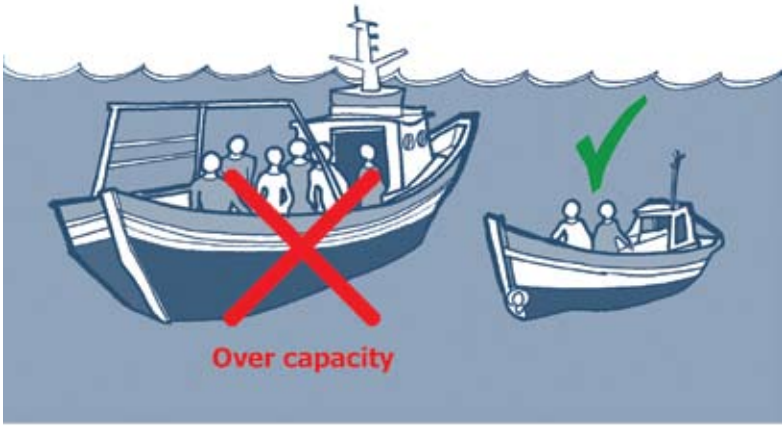
Limitations

- Difficulty in controlling the behaviour of fishers despite being able to manipulate their numbers.
- Conflicts when some fishers are excluded from the fishery.

- Enforcement of effort limitations is problematic.

How to implement

- Find out how many fishers and vessels are in the fishery.
- Assess the socio-economic impacts of capacity or effort controls.
- Understand the legal framework for implementing effort or capacity controls.
- Set limits on the number of fishers, or the times of the day in which they are allowed to fish, and/or the number and maximum size of boats.



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 of animals, but are sometimes set in terms of numbers of individual sea cucumbers. An overall quota can pertain to the whole fishery or be assigned on an individual basis to fishers or fishing vessels.

A primary goal of catch quotas is to control the quantity of animals removed by fishing each year. Quotas are often set with a knowledge about the likely "maximum sustainable yield" (MSY) of the stock (King, 2007; Purcell, 2010). They may be used as a companion management measure alongside other regulations, like size limits. Individual quotas, allocated to a fisher or fishing group, may equitably distribute potential earnings from the resource among fishers.

Limitations

- Information requirements for setting TACs may be demanding on a fishery agency.
- Quotas may be inequitable and difficult to monitor in small-scale fisheries.
- Monitoring of catch volume is demanding on the resources of the management agency.
- Transferrable quotas can lead to monopolization of the fishery in the hands of few fishers.

How to implement

- First, obtain reliable and precise estimates of the distribution and abundance of stocks.
- Set quotas only for species that are sufficiently abundant in the wild.
- Set separate quotas for each species.
- Monitor catches regularly and establish an effective communication programme to alert fishers when the quota has been reached.
- Implement quotas through fishers cooperatives and advisory committees.
- Use adaptive management to reduce quotas promptly if stocks show signs of depletion. Zero quotas should be set for overexploited species.

If quotas are used, they should be set for each species separately.

MARKET CHAIN LICENSING AND REPORTING

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

Reporting can be required for the following:

- records on catches;
- records and statistics on trade;
- monitoring of catch and trade data.

Monitoring of the catches and exports can indicate the rates of exploitation of the resource or the types or locations of species collected. Licensing can be used to limit the number of buyers/exporters in the fishery to a manageable number. Collection of trade statistics is simplified through these measures.

R. GAMBOA

Sea cucumbers processed at a household in the Philippines being weighed and sold to a trader (middleman) who sells the products to exporters.

Limitations

- Data collation and analysis of captures and trade require human resources and technical capacity.
- Customs officers and fishery officers need to be able to identify sea cucumbers to species level.
- Licensing of informal "middlemen" in the market chain is difficult.

- Illegal, unreported and unregulated (IUU) trade of beche-de-mer is relatively easy.

How to implement

- Examine the market chain. To whom do the fishers sell sea cucumbers; who processes them; are there middlemen; and who exports the final product?
- Find out the legal framework under which licensing requirements can be established.
- Provide custom agents with the identification guides and train them to identify different species.
- Harmonize the data format with other countries.
- Supply logbooks to fishers, buyers and exporters. State how the data will be collected from them.

FISHING CLOSURES FOR CERTAIN PERIODS

Seasonal and short-term closures

Definition: A pause or prohibition of fishing for a short specified time period, generally for less than a year.

Seasonal or short-term closures may be particularly useful in temperate fisheries.

Seasonal closures can be used to prevent fishing of animals in a period when they are more easily collected, but this may not apply to sea cucumbers. Seasonal closures may simply limit the number of days in a year that fishers have to collect the animals.

Short-term closures are sometimes used to protect sea cucumbers at certain critical times of the year, such as during the peak spawning period. But the benefit of the closure is lost if fishers compensate by increasing the rate of fishing in the open season (see Purcell, 2010).

Limitations

- Shorter fishing seasons can prompt stronger fishing pressure in the open season, thus taking adults out of the population even before they spawn. Seasonal closures should be used with an output control, e.g. a reduced quota, if this may be the case.
- Catches should be monitored after implementing a short-term closure to ensure that rates of fishing do not increase in the open season.
- Conflicts may arise if the short-term closure clashes with the economic needs of fishers.

How to implement

- Are there good reasons for imposing a short-term or seasonal closure?
- If based on the spawning season, commission research to determine the reproductive cycle of the commercial species.
- Find out if the season or periods of closure will accommodate fishers' cultural and economic needs.
- Find out if there are any issues about post-harvest processing or exporting in certain months.
- Notify fishers of seasonal closures.

Bans or moratoria

Definition: A long-term stop or prohibition of fishing, i.e. for periods of longer than one year.

In contrast with other permanent closures like marine reserves or no-take zones, bans or moratoria are fishing closures and cover a large part, or all, of a fishery.

A "ban" or "moratorium", allows sea cucumber populations to recover and become abundant again. When breeding stocks become dense enough, the populations can once again increase in numbers. Bans are generally set in place where the resource is overexploited to the extent that other management measures would not be enough to allow populations to recover within a satisfactory time frame. Bans can also be placed at the onset of a developing fishery or where the status of the resource is uncertain.

Limitations

- Conflicts with fishers who depend on, or have a traditional attachment to, the resource.
- Bans can promote a black market in illegal capture of sea cucumbers.
- Fishing pressure can increase on other resources.

How to implement

- Collect data on population densities or abundance over different areas of the fishery. Is a ban needed throughout the entire fishery, or just in one sector?

- Impose fishing bans at the first signs that stocks of most species have been overexploited or depleted.
- Communicate frequently with fishers to understand how they will cope with a moratorium.
- Convince decision-makers to maintain the ban in the face of opposition from fishers and traders.
- Define the criteria by which a ban can be lifted and ensure that best-practice management is in place before lifting the ban.
- Inform and educate fishers about the ban.

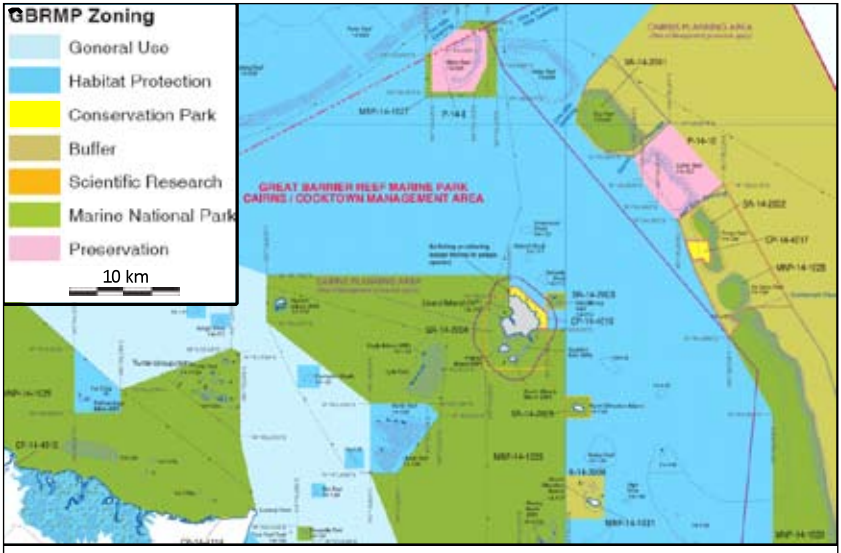
Fishing bans should be imposed as soon as possible after recognizing that stocks are depleted.

AREA-BASED MEASURES

Marine protected areas, including no-take reserves

Definitions: A marine protected area (MPA) is an area reserved to protect part, or all, of the enclosed marine environment. Many MPA types allow fishing at regulated levels, whereas no-take reserves prohibit fishing.

Marine reserves may improve fisheries by adding new animals or larvae to surrounding areas. They also act as an "insurance policy" to safeguard some dense breeding populations. This is especially important for sea cucumbers because successful reproduction seems to require high densities of spawners, which may not occur in most of the "open" fishing grounds. Reserves also provide a baseline reference of unexploited populations by which to compare fished populations.



SOURCE: GREAT BARRIER REEF MARINE PARK AUTHORITY, MPZ5 COOKTOWN DETAILED ZONING MAP, WITH MODIFICATION

A section of the Great Barrier Reef Marine Park (GBRMP) showing coloured zones that allow different activities.

Limitations

- Implementation may be difficult for large reserves that exclude users from traditional grounds.
- Reserves close to communities may force fishers to offshore grounds or exclude fishers who lack boats.
- Active enforcement of reserves can be costly.
- Existing reserves may not be ideal for sea cucumber breeding populations.
- Poor planning of marine reserves, or MPAs, can lead to unfulfilled expectations of stakeholders.
- The effectiveness of marine reserves in improving fisheries is difficult to confirm.

How to implement

- Include stakeholders in the planning of reserves.
- Assess the ease of surveillance of potential sites.
- Decide on a minimum size for the reserves.
- Who will be in charge of doing the surveillance?
- Understand the legal framework in which the MPA regulations are situated.
- Consider a network of marine reserves over a significant portion (e.g. 20–35%) of the habitat.
- Lower fishing effort or catch quotas if a large portion of the fishery is set as no-take reserves.
- Mark boundaries clearly so that stakeholders can identify the reserve borders when at sea.

Rotational harvest closures

Definition: A periodic shifting of fishing effort from one fishing area to another in a cyclical fashion.

Rotational harvest closures allow sea cucumber populations to recover in some fishing plots for a couple years, while fishing is shifted to other plots.

Where populations can recover fairly quickly, a relatively short rotational cycle (e.g. 3 years) is possible. Rotational closures are used in industrialized sea cucumber fisheries with high technical capacity. However, the long-term success of this management tool has yet to be proved.

Limitations

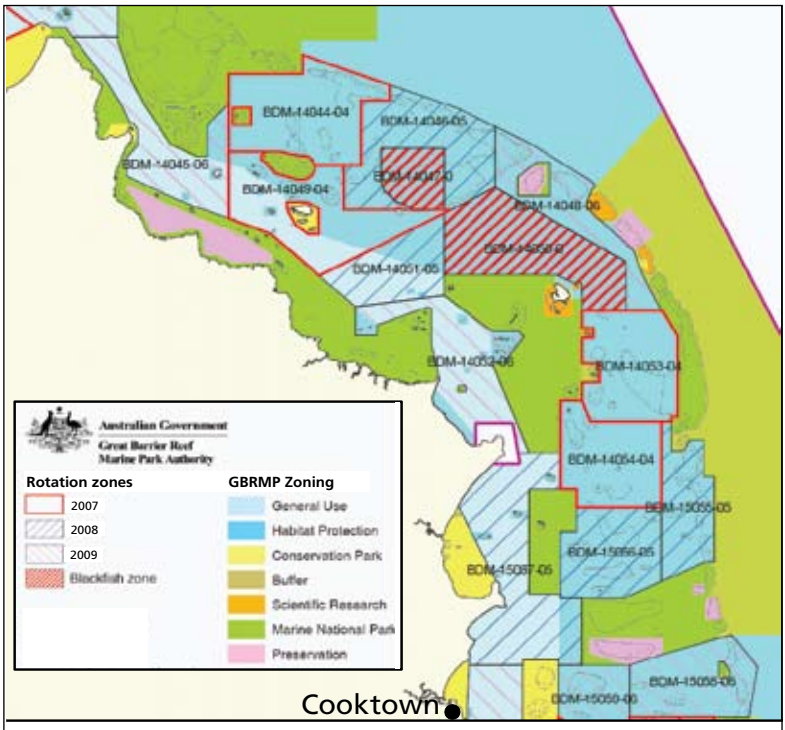
- Only appropriate where user rights are well defined and respected.
- Biological data are usually insufficient to reliably determine an appropriate rotational harvest strategy. Slow rates of growth and population turnover make many species unsuitable for this strategy.
- Fishing effort per unit area may rise because less area is open to fishing at any given time.
- Rotational plot designs may exclude some fishers, e.g. from distant or deep fishing grounds.
- Compliance is difficult to verify.

Most, if not all, sea cucumber fisheries will lack the basic data to apply rotational closures with any scientific confidence.

How to implement

- Critically assess whether the growth rates and recruitment of the target species are fast enough to keep pace with the rotational cycle.

- Determine the rotational cycle (in years), based on the biology of the target species.
- Determine the current access rights of stakeholders.
- Meet with stakeholders and determine if closures of rotational plots will be a suitable strategy.
- Decide on the best number and size of plots to have in the fishing grounds (see Purcell, 2010).
- Conduct fishery-independent surveys to estimate the abundance of each species to be fished in plots.
- Monitor the recovery of sea cucumber populations in plots before and after fishing periods.



SOURCE: GREAT BARRIER REEF MARINE PARK AUTHORITY, ZONED SEA CUCUMBER FISHERY WATERS – NORTHERN GBR – DETAILED ZONING MAP, WITH MODIFICATION

Plots for a rotational harvest strategy in part of the sea cucumber fishery of the Great Barrier Reef, Queensland, Australia.

Territorial user rights to fish (TURF)

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.

Place-based tenure systems have been used especially for sedentary marine animals. TURFs are one form of exclusive access to harvest in defined portions of sea bed, which may be granted to fishers or fishing cooperatives. Access to fishing grounds can be granted to people who deserve it most or who comply with management regulations. In theory, TURFs provide an incentive to harvest resources sustainably because fishers can leave some animals, knowing that other fishers cannot take them.

Limitations

- Conflicts can erupt when some fishers are granted TURFs while others are not.

- Poaching can occur in areas allocated to other people groups as a consequence of dislocation or jealousy.
- TURFs are difficult to implement in fisheries with a large number of fishers or fisher groups.
- Planning and marking out the fishing plots requires much work by the management agency.
- 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

- Obtain information to understand the socio-economic and legal structure of the fishery.
- Try to appraise whether the provision of access rights to fishers is likely to lead to reduced effort.
- Can fishing grounds be sensibly divided among the users and marked out?
- Decide who is to have access and how to divide the territorial rights among fishers or fisher groups.
- Consider traditional or cultural attachments to the fishing grounds or resources.
- Decide whether the user groups will pay for the access rights, and how much.