Managing Coastal Marine Biodiversity and Protected Areas

For MPA managers

Module 5

Sustainable Fisheries Management

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Summary

This module provides much needed information on the basics of fisheries management, and principles and practices of sustainable fisheries management in and around marine protected areas. Apart from providing useful case studies on the subject, this section is also covering challenges and trade-offs with the protection-oriented coastal management, synergies with the MPAs and livelihood security.

Key Messages

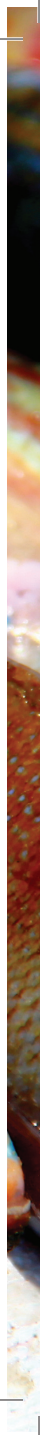
- India has vast potential for fisheries in view of our long coastline of about 8,000 kms apart from the inland water resources and India is the second largest producer of fish in the world contributing to about 5.43% of global fish production. It has been recognized as a powerful income generator and is a source of cheap protein besides being a source of foreign exchange earner.

- Under an Ecosystem Approach to Fisheries, the usual concern of fisheries managers – the sustainability of targeted species – is extended to address the sustainability of ecosystems upon which the fisheries depend, which include people and fish stocks.

- Ecosystem Approach addresses both human and ecological well-being and merges two paradigms: protecting and conserving ecosystem structure and functioning; and fisheries management that focuses on providing food, income and livelihoods for humans. The main challenges facing marine fisheries development in the country include development of sustainable technologies for capture fisheries, yield optimization, infrastructure for harvest and post-harvest operations, landing and berthing facilities for fishing vessels and uniform registration of fishing vessels.

- Artisanal fishing (or small-scale fisheries), uses small inshore vessels and/or fixed gear (e.g., coastal traps, gill nets and cast nets) and whose purpose is to catch fish and other organisms for their won consumption and sale (Pauly 2013).

- Commercial fishing is the activity of catching fish and other seafood for commercial profit, mostly from wild fisheries. It provides a large quantity of food to many countries around the world, but those who practice it as an industry must often pursue fish far into the ocean under adverse conditions. Large-scale commercial fishing is also known as industrial fishing.



5.1 Status of the fisheries in India

The west coast of India is by far the most important area so far as fisheries production is concerned, accounting for over 70 percent of national production.

Gujarat State in the northwest has, for some years, been the major fish producer in India, and, in 2001, accounted for around 37 percent of west coast production and 26 percent of national production. Gujarat is closely followed by Kerala in the southwest which, in 2001, contributed around 30 percent of national production. The other west coast states of Maharashtra and Karnataka, in addition to offshore Islands contribute the remaining 33 percent of west coast production.

The Saurashtra coast in the northwest experiences winter cooling of oceanic waters during NovemberFebruary with no significant upwelling and consequently the fisheries in this area are dominated by demersal species (57.2 percent of landings) such as sciaenids, flatfish, ribbonfish etc.

The fisheries of the west coast of India can be conveniently divided into both artisanal and industrial sectors as well as inshore (<50 meters) and offshore fisheries. Artisanal fisheries dominate the inshore areas while industrial fishing dominates the offshore area, usually operating under the provisions of the Deep Sea Fishing Policy.

Managing fisheries in accordance with sustainability guidelines is not required by legislation either at the State or National/Union level. As a result, many stocks both in the inshore and offshore area are either fully or overexploited although it is generally agreed that offshore areas are more lightly exploited and may, for some species, be underexploited.

Offshore species which are considered to have the greatest potential for increases in exploitation rates are various species of tuna, threadfin bream, carangids and deepwater shrimp (Vivekanandan, 2002).

Marine pollution and coastal degradation has impacted on resources in the coastal areas (including estuaries) and has degraded the marine resource potential and marine biodiversity of these areas. As a result, the issues of overexploitation of many coastal fisheries resources have been becoming more important, even in areas where the number of fishermen and vessels has remained stable.

However, within the context of marine and coastal ecosystem destruction in the Indian Ocean area, overexploitation of fisheries resources and coastal habitat destruction is not as much a problem in India as it is in other countries of the region.

Total fish production from the west coast area of India in 2001 was 1.996 million tonnes with this level of production having been maintained for some years. Table 2 provides data on the catches, by species group, for the period 1998-2001 for the west coast area of India in addition to similar data for 1980.

First, most fisheries statistics in India are collected at landing places although species that are destined for export are recorded at the point of sale or export. Hence aquaculture production is sometimes incorporated into landings statistics, particularly for those species that are exported. In addition, consumption at home, which may be significant, is often not included in statistics collection.

The reason for this increase in production is almost exclusively an increase in fishing effort, both in inshore areas and offshore. For example, in Gujarat, the fishing fleet has increased to 29506 vessels in 2002, 19092 of which are mechanized.

Methods of exploitation of marine fisheries resources vary from simple traps to large trawlers and from handlines to modern purseseiners.

There are also regional variation in fishing vessels and gear. Traditional catamarans, common on the east coast are not used on the west coast to any great extent, with dugout canoes being the more common traditional fishing craft.

Mechanized vessels include stern and outrigger trawlers, gillnetters, purseseiners, longliners and dolnetters (bag nets, mainly for Bombay duck) whereas traditional nonmechanized craft use handlines, gillnets and fish traps. There is a program in place to upgrade dugout canoes in the area by the addition of small outboard motors and, since 1977, 50 922 motors have been fitted to these traditional craft (Vivekanandan, 2002)

The fishery, which in 2001 landed 288 000 t from the west coast is a mixed artisanal/industrial fishery and utilizes dugout canoes (Kerala coast), outrigger vessels (Maharashtra and Karnataka coasts) and purse seiners (offshore areas) to take the fish.

Most of the catch is locally consumed as fresh product although canning, freezing, drying, and production of sardine oil is also undertaken. The fishery fluctuates significantly from year to year in response to oceanic conditions and particularly the abundance of phytoplankton blooms (Fragillaria oceanica, Coscinodiscus spp and Pleurosigma spp).

The fishery for Bombay Duck (Harpodon nehereus) contributes around ten percent of the average national landings and, in 2001, 143 000 t wer

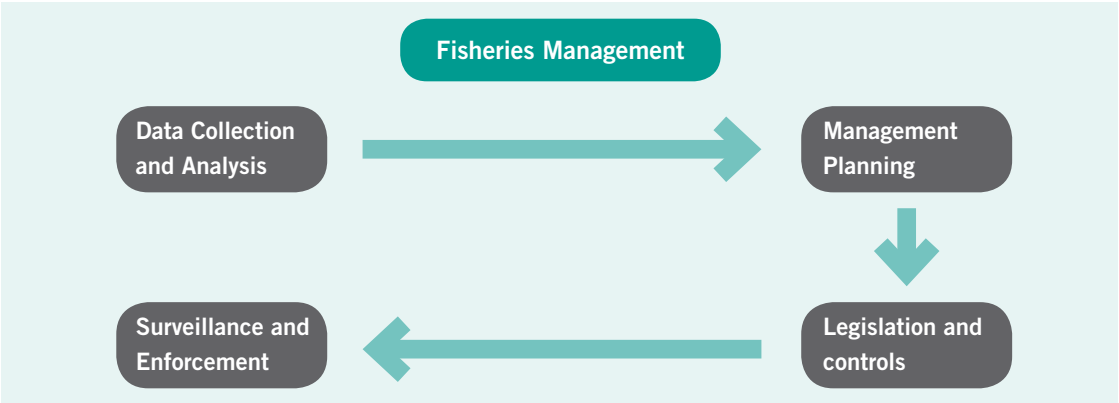
5.2 What is fisheries management?

5.2.1 Overview

Historically, fishing has been a major source of food for humanity and a provider of employment many coastal population. As fish has been considered as renewable natural resources, the tendency of harvesting these resources has been intensified in recent days. As a results, over-exploitation of important fish stocks, modifications of ecosystems, significant economic losses, and international conflicts on management and fisheries economic trade threatened the long-term sustainability of fisheries. At the same time, with increased knowledge and the dynamic development of various fishing technology, it was realized that living aquatic resources, although renewable, are not infinite and need to be properly managed. Then the concept of fisheries management was emerged.

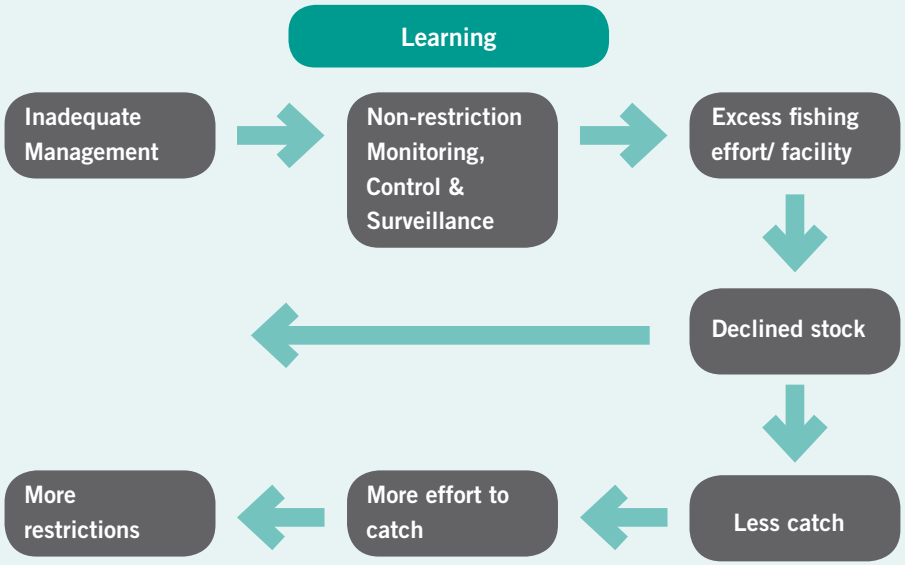
According to the Food and Agricultural Organization (FAO), the definition of fishery management is:

> *The integrated process of data gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives - FAO, 1997.*



5.2.2 Conventional fisheries management

Conventional fisheries managements in which stakeholders are those directly or indirectly involved in fishing activities and the entire fisheries is managed by government fishery authorities. They generally operate through regulations and penalties for non-compliance. This approach is single species or economically important resource targeted and fishery industry focussed. It pays less attention to small scale fisheries.



(Source: FAO 2009)

5.3 Concept of Stock & Maximum Sustainable Yield (MSY)

5.3.1 Stock

The concept of stock is very commonly used term in exploiting the aquatic resources and more specifically in fisheries management.

A stock is a sub-set of one species having the same growth and mortality parameters and inhabiting a particular geographic area (FAO, 1991).

As long as there is no difference growth and mortality, it is preferably making stock assessments over the entire area of distribution of species. In general, the growth and mortality parameters differ significantly in various part of the area of distribution of species, which is called different stocks of a species, that case the stock assessment should be made for each stock separately. The 'growth parameters' are numerical values by which we can predict the body size of a fish when it reaches as certain age. The 'mortality parameters reflect the rate at which the animal die i.e., the number of death per unit time (death may be natural or by fishing). The essential characteristic of a stock is that its growth and mortality parameters remain constant throughout its area of distribution (FAO, 1991).

5.3.2 Population dynamics

Population dynamics describes the growth and decline of a given fishery stock over time, as controlled by birth, death and migration. It is the basis for understanding changing fishery patterns and issues such as habitat destruction, predation and optimal harvesting rates. The population dynamics of fisheries has been traditionally used by fisheries scientists to determine sustainable yields (Thamas and Chang, 1999; Zabel et al., 2003).

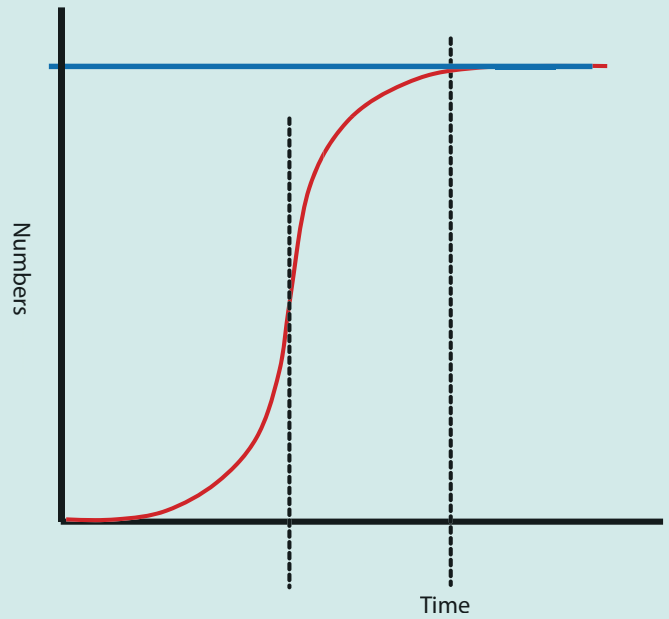
The basic accounting relation for population dynamics is the BIDE model (Birth, Immigration, Death and Emigration model, Caswell, 2001):

$N_1 = N_0 + B - D + I - E$

Where N_1 – is the number of individuals at time 1
N_0 – is the number of individuals at time 0
B – is the number of individuals born
D – is the number that died
I – is the number that immigrated and
E – is the number that emigrated between time 0 and time 1.

While immigration and emigration can be present in wild fisheries, they are usually not measured. Care is needed when applying population dynamics to real world fisheries. In the past, in many stock assessment many aspects of population dynamics such as size, age and reproductive status of the fish has been ignored. Similarly other factors such as targeted single species catch, by-catch and physical damage to the ecosystem which may accelerate the stock collapses (Walter and Maguire, 1996). The basic purpose of fish stock assessment is to provide advice on the optimum exploitation of fishery resources. Fishery resources are limited but renewable and fish stock assessment is described as the search for the exploitation level which in the long run gives the maximum yield in weight from the fishery.

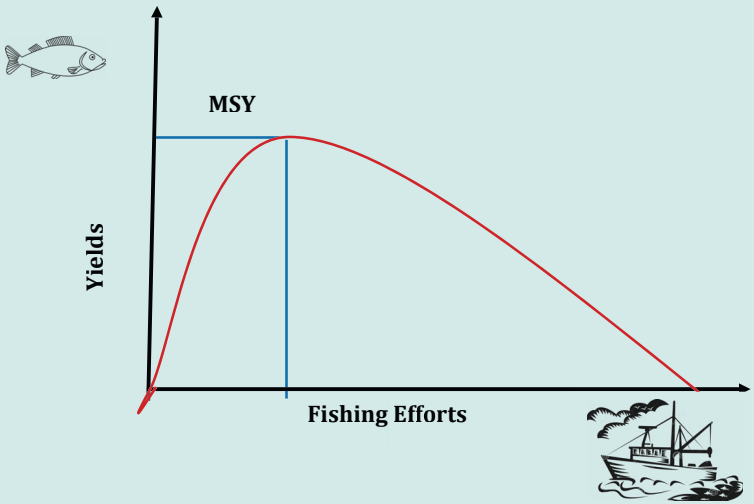
Figure: Illustrates the population growth at different time interval [time 1 – slow growth stage (log phase); time 2 – growth acceleration phase (optimum sustainable yield); time 3 – Carrying capacity of the population (Maximum sustainable yield).



5.3.3 Maximum Sustainable Yield (MSY)

In fisheries management, the maximum sustainable yield or MSY is, theoretically, the highest catch that can be taken from a fishery stock over an indefinite period (Europa, 2006). Under the assumption of logistic growth, the MSY will be exactly at half the carrying capacity of a species, as this is the stage at when population growth is highest. The maximum sustainable yield is usually higher than the optimum sustainable yield. Any small population at initial stage going through a slow growth at first and some point the growth will accelerate and that will start to level off once the species approaches carrying capacity. The idea of maximum sustained yield is to decrease population density to the point of highest growth rate possible.

Figrue : IIlstrate the basic concept of Mean Sustainable Yield



The horizontal axis is the fishing effort measure, for example number of fishing days. On the other axis is the yield i.e length and weight of target species. The graph shows that up to certain level we gain by increasing the fishing effort., but after that level the renewal of the resource (the reproduction and the body growth) cannot keep pace with the removal caused by fishing and a further increase in exploitation level leads to a reduction in yield (FAO 1991).

5.3.4 Application:

Based on MSY, harvest rate can be assessed and predicted. Get to understand species recruitment rate, especially predict the addition of young ones. Based on the population growth, harvest rate can be decided at the point in their population growth rate where it is highest (the exponential phase). Fixed fishing quotas will produce a constant harvesting rate (i.e. a constant number of individuals fished in a given period of time).

5.4 Challenges and trade-off s with the protection-oriented coastal management

- Major challenges in fisheries in worldwide is uncontrolled harvesting of targeted species– even if catch quota systems are imposed they need to be monitored
- Unrealistic and inflexible quotas
- Insufficient data on fish population characters and poor understanding on species ecology
- Intensive fishing, improved fishing technology and fishing industry

5.4.1 Overfishing

The worldwide depletion of major fish stocks through intensive industrial fishing is thought to have profoundly altered the trophic structure of marine ecosystems. Declining trophic levels in fisheries catches have occurred, with fish catches progressively being replaced by invertebrates and non commercially important fishes.

> *Overfishing is a form of overexploitation where fish stocks are reduced to below acceptable levels. Overfishing can occur in water bodies of any size, and can result in resource depletion, reduced biological growth rates and low biomass levels (http://en.wikipedia.org).*

Overfishing has significantly affected many fisheries around the world. As much as 85% of the world's fisheries may be over-exploited, depleted, fully exploited or in recovery from exploitation.[2] Significant overfishing has been observed in pre-industrial times. In particular, the overfishing of the western Atlantic Ocean from the earliest days of European colonisation of the Americas has been well

Overfishing: Case study

The Peruvian coastal Anchovy fisheries crashed in the 1970s after overfishing largely depleted anchovies from its waters. Anchovies were a major natural resource in Peru; indeed, 1971 alone yielded 10.2 million metric tons of anchovies. However, the following five years saw the Peruvian fleet's catch amount to only about 4 million tons (Trade and Environment Database. 1999). This was a major loss to Peru's economy.

documented.[3] Following World War Two, industrial fishing rapidly expanded with rapid increases in worldwide fishing catches. However, many fisheries have either collapsed or degraded to a point where increased catches are no longer possible (Jeffery 2012).

5.4.2 Artisanal fishing (small-scale) Vs Industrial fisheries (large-scale)

Artisanal fishing (often called small-scale fisheries), which use small inshore vessels and/or fixed gear (e.g., coastal traps, gill nets and cast nets) and whose purpose is to catch fish and other organisms for their won consumption and sale (Pauly 2013).

Commercial fishing is the activity of catching fish and other seafood for commercial profit, mostly from wild fisheries. It provides a large quantity of food to many countries around the world, but those who practice it as an industry must often pursue fish far into the ocean under adverse conditions. Large-scale commercial fishing is also known as industrial fishing. Commercial fishermen harvest a wide variety of animals, ranging from tuna, cod, and salmon to shrimp, krill, lobster, clams, squid, and crab in various fisheries for those species (http://en.wikipedia.org).

	Artisanal fishing	Commercial fishing
1.	Uses small boats without any facility for fish processing	Large sized vessels with facility for fish processing
2.	Uses fixed gears	Used large sized commercial trawl nets
3.	Net with bigger mesh size for targeting adult individuals	Net with closed mesh size for targeting all species (small and large body size)
4.	Minimum by-catch and trash fish landing	Huge landing of trash fish, which is wanted for animal husbandry industries
5.	Operates in coastal area and shallow seas	Operates in EEZ and also deepwater
6.	No negative impact on fish stock and ecosystem	Overexploitation of stock and degradation in habitat quality

5.5 Principles and Criteria for Sustainable Fisheries (Source: MSC, 2002)

Principle 1: A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited stock and for those stocks that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery.

Criteria

1. The fishery shall be conducted at catch levels that continually maintain the high productivity of the target population(s) and associated ecological community relative to its potential productivity.
2. Where the exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level consistent with the precautionary approach and the ability of the populations to produce long-term potential yields within a specified time frame.
3. Fishing is conducted in a manner that does not alter the age or genetic structure or sex composition to a degree that impairs reproductive capacity.

Principle 2: Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

Criteria

1. The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to trophic cascades or ecosystem state changes.
2. The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected species.
3. Where exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level within specified time frames, consistent with the precautionary approach and considering the ability of the population to produce long-term potential yields.

Principle 3: The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

Criteria

1. The fishery shall not be conducted under a controversial unilateral exemption to an international agreement.
2. The management system shall demonstrate clear long-term objectives consistent with MSC Principles and Criteria and contain a consultative process that is transparent and involves all interested and affected parties so as to consider all relevant information, including local knowledge. The impact of fishery management decisions on all those who depend on the fishery for their livelihoods, including, but not confined to subsistence, artisanal, and fishing-dependent communities shall be addressed as part of this process.
3. The management system shall be appropriate to the cultural context, scale and intensity of the fishery – reflecting specific objectives, incorporating operational criteria, containing procedures for implementation and a process for monitoring and evaluating performance and acting on findings.
4. The management system shall observe the legal and customary rights and long term interests of people dependent on fishing for food and livelihood, in a manner consistent with ecological sustainability.

5.6 Good practices and case studies
(adopted from Secretariat of Pacific Community, 2010)

5.6.1 An ecosystem approach to fisheries (EAF)

An ecosystem can be defined as a relatively self-contained system that contains plants, animals (including humans), micro-organisms and non-living components of the environment as well as the interactions between them. Managing a resource species or fish stock in isolation from its ecosystem ignores the fact that fish species depend on ecosystems that are being affected by the fishing activity itself and by other human activities. Fishing can affect other components of the ecosystem by: catching unwanted species, causing physical damage to habitats, disrupting food chains and causing changes in biodiversity. Other human activities unrelated to fishing, such as agriculture, forestry and development, can also affect marine ecosystems, including the species that are part of them. The human impacts on ecosystems are often being exacerbated by the effects of climate change. Hence fisheries management with a broader approach that attempts to manage fish stocks as components of marine ecosystems. Under an Ecosystem Approach to Fisheries, the usual concern of fisheries managers – the sustainability of targeted species – is extended to address the sustainability of ecosystems upon which the fisheries depend, which include people and fish stocks. Ecosystem Approach addresses both human and ecological well-being and merges two paradigms: protecting and conserving ecosystem structure and functioning; and fisheries management that focuses on providing food, income and livelihoods for humans.

As the objective of Ecosystem Approach to Fisheries is the sustainable use of entire ecosystems as well as targeted species, it implies that non-fisheries activities that impact marine ecosystems must also be managed, even though these activities may be outside of the responsibilities of fisheries authorities. In addition to fishing, target stocks are affected by non-fishing issues including climate change, coastal development, pollution and the loss of critical habitats by reclamation. (See Box 1 for more information about EAF.). Because of the broad issues involved, the full implementation of EAF requires collaboration and cooperation between communities and a range of government agencies responsible for managing activities that impact on marine ecosystems.

Moving towards EAF – examples of the shifting focus

Conventional fisheries management	EAF
Stakeholders are those directly or indirectly involved in fishing activities	Stakeholders are found throughout the fishery system and in other sectors of society
Management commonly by government fisheries authority (top-down)	Participation and co-management with a broad spectrum of stakeholder groups
Operates through regulations and penalties for non-compliance	Compliance to regulations is encouraged through incentives
Single-species (or target-resource) management	Includes also broader ecosystem management and biodiversity
Focus on the fishery	Focus enlarged to the broader fishery system, including interactions with other sectors
Indicators related to fish catches and status of fish stock	Indicators related to all parts of the aquatic ecosystem and goods and services
Scientific knowledge is the only valid knowledge for decision-making	Traditional, local, and scientific knowledge systems may be used for decision-making

Source: Based on FAO 2009a.

Ecosystem Approach to Fisheries involves making decisions to achieve objectives based on the best available knowledge, whether it is scientific or traditional. Urgent actions are required now and there is no time to wait to collect extensive scientific information. In any case, local communities are repositories of much information on local ecosystems.

5.6.2 Community-based fisheries management (CBFM)

Community Based Fisheries Management refers to a management system under which communities take a leading role in managing fisheries and adjacent coastal areas in partnership with, or with support from, a promoting agency.

Example for CBFM

The Peruvian coastal Anchovy fisheries crashed in the 1970s after overfishing largely depleted anchovies from its waters. Anchovies were a major natural resource in Peru; indeed, 1971 alone yielded 10.2 million metric tons of anchovies. However, the following five years saw the Peruvian fleet's catch amount to only about 4 million tons (Trade and Environment Database. 1999). This was a major loss to Peru's economy.

Source: FAO, 2011

USE OF VARIOUS FISHERIES MANAGEMENT TOOLS IN INDIA

Countries use different approaches to fisheries management as well as different sets of fisheries management tools within those approaches. These depend on numerous factors, for example the types of fisheries and resources, and the preferred governance approach and political reality of the country. This MPA case study has made the following information on India available:

Fisheries management is undertaken mainly through licensing, prohibitions on certain fishing gear, regulations on mesh size and establishment of closed seasons and areas. Under the Marine Fishing Regulation Acts (MFRA), zones are demarcated by each state based on distance from the shoreline (from 5 to 10 kilometres [km]) or on depth. These inshore zones, where trawling and other forms of mechanized fishing are not permitted, are perhaps the most

important spatial fisheries management measure in place. The closed season or 'monsoon fishing ban' is another important spatial-temporal management measure. It is implemented on both the east and west coasts of India for a period of 47 days and 65 days, respectively, during what is considered to be the spawning and breeding season.

Several state-specific management measures exist. In Orissa, for example, fishing regulations have been adopted by the State Fisheries Department, under the MFRA, to restrict and regulate fishing activities in territorial waters. Regulations also protect the nesting and breeding grounds of turtles, both within and outside the Gahirmatha (Marine) Wildlife Sanctuary, through designation of 'no-fishing' and 'no-trawling' areas. There is also a mandatory requirement under the MFRA in some states that trawlers use turtle excluder devices (TEDs). It is important to draw attention to certain fisheries management initiatives of local fishing communities that are 'space-based'. Communities living along the coast often have a spatial perception of their 'rights', in which fishing by outsiders or the use of certain gear is regulated. Traditional fishing communities on the shores of Pulicat Lake, Tamil Nadu, practise a rotational system of access to resources, called the padu system, that serves to reduce conflicts and the pressure on resources. In coastal areas of Kerala, a similar system of rotational access to resources is practised that defines the group of rights holders, resource boundaries and fishing sites. However, these systems of self governance are not legally recognized for management purposes in India.

Source: Ramya (in press). | FAO 2011

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