Sustaining marine biodiversity

Ecosystem-based fisheries management has a special relevance in a multispecies context

Fish, and, more generally, living aquatic resources are an integral part of the ecosystem. (Ecosystem is a natural environment in which living organisms are in continuous dependence and interchange among themselves, and also with the nonliving matter.) However, the management of exploitation of fish and other living aquatic resources has been handled on a group-by-group or species-by-species basis.

One example from India is the recent classification of sharks, rays, gastropods and bivalves under Schedule I of the Wild Life (Protection) Act, thereby protecting only these groups from exploitation. These management options on conservation are under the paradigm that the productivity of fish stocks is a function only of their inherent characteristics such as growth, mortality, fecundity, etc. While this assumption holds good to a certain extent, the reality of the interdependence of fish and the ecosystem components needs to be recognized. Moreover, it is almost impossible to exclude a particular group or species of fishes from exploitation in a multispecies context. This is true for the trawl, gill-net, line and seine fisheries.

Distribution and abundance of fish stocks are related to (i) the dynamics of the marine environment, namely, the weather, and the physical and chemical oceanography; and (ii) the interactions between the predator and prey species.

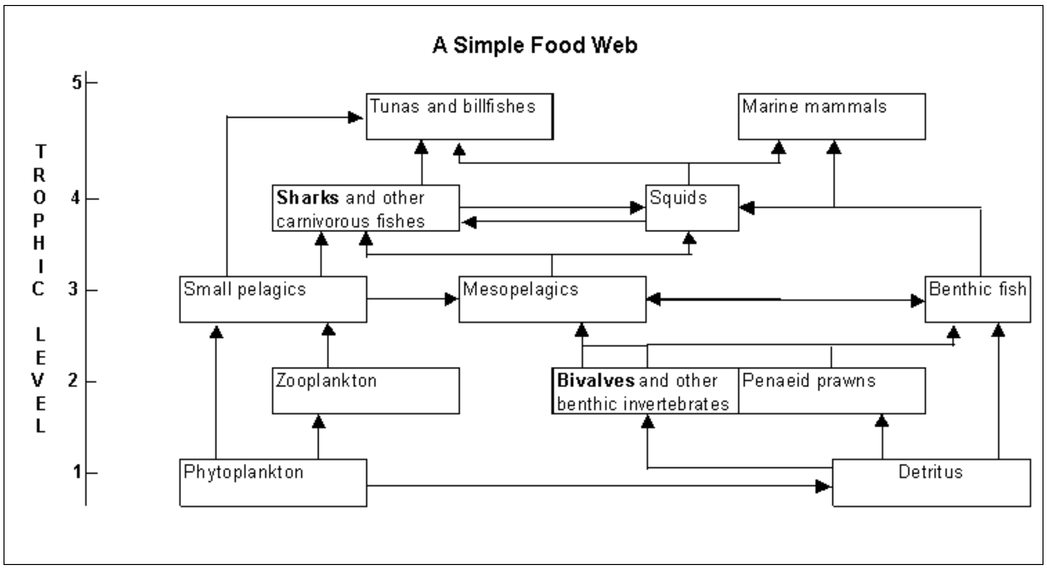
The dynamics of several environmental and oceanic factors such as monsoon, upwelling, currents and productivity, influence the distribution, aggregation and abundance of fish stocks. If the available fish stocks were to be uniformly dispersed in the seas, they would seldom be encountered in the fishing areas. For example, if the yellowfin tuna were to be uniformly distributed in the world oceans, it has been estimated that there would be only one yellowfin tuna of 10 kg for every 2.8 sq km of the ocean. Such a density is of no fisheries value because of the high cost of searching and catching that tuna of 10 kg from a 2.8 sq km area. However, the environmental and oceanographic features do not allow uniform distribution of marine organisms and there are wide spatial differences in the abundance of fish stocks, which is related to the carrying capacity of the ecosystem. (Carrying capacity is the number or biomass that can be supported by an ecosystem.)

Moreover, there are large differences in the composition of fish stocks. For instance, the fishery off Kerala, in the southwest coast of India, is dominated by small pelagics such as sardines, whitebaits and Indian mackerel, whereas the one off Gujarat, in the northwest coast, is dominated by demersals such as sciaenids, cuttlefishes and nonpenaeid prawns.

Thus, there is a vast quantitative and qualitative difference in the fish stocks occurring in different ecosystems. It is important that the uniqueness of each ecosystem is given due consideration for formulating fisheries management. Fish are dependant on the ecosystem for their food.

Flow network

Through the prey-predator relationship and the complicated food web, there is a network of flows of matter (biomass) in the ecosystem. In the marine ecosystem, the network links the phytoplankton (plant matter) with the herbivores (phytoplankton feeders), and the latter with the small carnivores and further with their predators. These networks of flows



are affected directly by fishing. Large, long-lived predators (for example, sharks, tunas, seerfishes) as well as small, short-lived prey (for example, sardines, whitebaits, Indian mackerel, penaeid shrimps) contribute in major ways to marine fish catches.

The figure above gives an example of a simplified food web, the position of major fish groups in the web, and the flow between the various levels in the web. Conservation or heavy fishing at a particular trophic level (an indicator of the position of each group / species within the food web) will lead to ecological imbalance and thereby to species replacements.

For instance, for 46,335 tonnes of sharks (which are predatory and hence are at a higher trophic level), exploited by body weight, the exploited shark populations would have consumed approximately 3,475 tonnes per day or 1.3 million tonnes every year. (Juvenile fishes normally consume about 10 per cent of their own body weight every day; the rate of consumption decreases to 5 per cent per day as they grow old.) If the sharks alone are protected from fishing, they would predate on other fishes, prawns, squids and cuttlefishes at the rate of 1.3 million tones per year, thereby competing for food not only with the human predators but also among themselves and with other predatory fishes.

Take an example of organisms at the lower level of the food web. The bivalves feed by filtering the phytoplankton from the sea water and are at lower trophic level in the food web. If the bivalves alone are protected from exploitation, there is likelihood of phytoplankton depletion in the areas of bivalve abundance, which, in turn, will severely affect the other plankton feeders such as sardines and whitebaits, and the bivalves themselves.

Hence, it is imperative to recognize the reality of the inter-dependence of all ecosystem components, instead of assuming that stocks are independent. Though the practical problems raised by the recognition are immense, there are pragmatic ways to begin implementation of ecosystem-based fisheries management actions aimed at conserving the structure and function of marine ecosystems in addition to conserving the fisheries resources.

The fisheries management agencies and the stakeholders involved in the use of aquatic resources need to identify the different ecosystems under their jurisdiction, the boundaries of those ecosystems and their characteristics. Broadly, there may be six types of ecosystems as outlined in the table.

Modelling tool

Modelling is an essential scientific tool in developing ecosystem approaches for fisheries management. A budget on the potential yield and yield at different trophic levels has to be prepared for each ecosystem. Management options such as optimizing craft and gear combinations could be advocated based on these models. For instance, if the pelagic sharks

Table: Considerations for Ecosystem-based Fisheries Management

Type of Ecosystem	Components	Management Options	Type of Fishing Regulation
I . Critical ecosystem	Coral reefs; sponges; mangroves	Marine protected area; coral rebuild-ing; mangrove af-forestation	Fishing ban al-together
II. Vulnerable ecosys-tem	Declining fish stocks; concentration of vul-nerable/endangered species	No-fishing zone; resource-enhance-ment programmes likes sea-ranching	Fishing ban al-together; alternative livelihood like maricul-ture
III. Polluted ecosys-tem	Bioaccumulation of pollutants	Ecowatch; evolve standards for waste discharge; implement polluter-pays principle	Fishing and market-ing of fish with pol-lutant load to be prevented
IV Estuaries, lagoons and backwaters	Nurseries; closure of bar mouth	Seasonal closure of fishing	Ban all forms of fish-ing during seasons of spawner and juvenile abundance, and closure of bar mouth; regulate mesh size
V Open coastal waters	Combination of Under- and overex-ploited stocks	Seasonal closure of mechanized fishing; area demarcation for mechanized and tradi-tional craft; limited entry; part of the area as no-fishing zone either on rotation or permanently	Regular but control-led fishing; precau-tionary approach; alternative livelihood like mariculture
VI Far-sea/deep-sea	Mostly under- and un-exploited stocks	Atlas on areas of resource abundance; devise economically viable craft and gear; regional co-operation	No restriction for the present; local fishing communities deserve encouragement

are overexploited in a particular ecosystem, the target gear such as lines could be restricted or banned in that ecosystem.

In consultation with all legitimate stakeholders and interest groups, objectives must be agreed upon for each ecosystem. For instance, the short-term objective for a coral reef ecosystem should be protection of the reef and its dependent fauna and flora, and the long-term objective should be to rebuild and extend the reef area (see table). The objectives for an urbanized/ industrialized ecosystem should be to set standards for the effluent discharge, and regularly monitor the pollutant load in the coastal waters and in the body components of the organisms. The objectives for sustaining the open-water ecosystem should encompass a combination of technical measures, closed areas and seasons, input and/or output controls, and a suitable system of access rights for all users. The objectives for the far-sea ecosystem should be to develop the fisheries for increasing the catch in a sustainable way.

Fisheries management programmes thus far remain as independent entities. As one of the multiple users of the coastal zones, some of the fisheries management programmes could be part of the Integrated Coastal Zone Management (ICZM). The ICZM programmes are less involved with control of fishermen or fisheries harvests, but more with habitats of fish and shellfish. In the ecosystem-based fisheries management, there could be a close connection between the ICZM programmes and the management options for the first four ecosystems listed in the table (critical, vulnerable, polluted and estuarine).

Moreover, there could be a closer co-operation between the ICZM programmes and the small-scale fisheries, because the artisanal fisheries are conducted in inshore, lagoon and estuarine waters, where the ICZM programmes would be most relevant.

Ecosystem-based fisheries management is expected to yield short-term and long-term benefits. However, this type of management demands larger participation by the stakeholders initially, and perhaps governance by them at a later stage. A scientifically planned protocol and careful implementation of ecosystem-based management within a logistic timeframe is expected to sustain marine biodiversity and fisheries.

This article is by E.Vivekanandan of the Madras Research Centre of the Central Marine Fisheries Research Institute, Chennai, based on his presentation at the ICSF/IOI Indian Ocean Conference in October 2001. The views expressed here are purely personal and they do not necessarily reflect the views of the organization to which the author belongs.