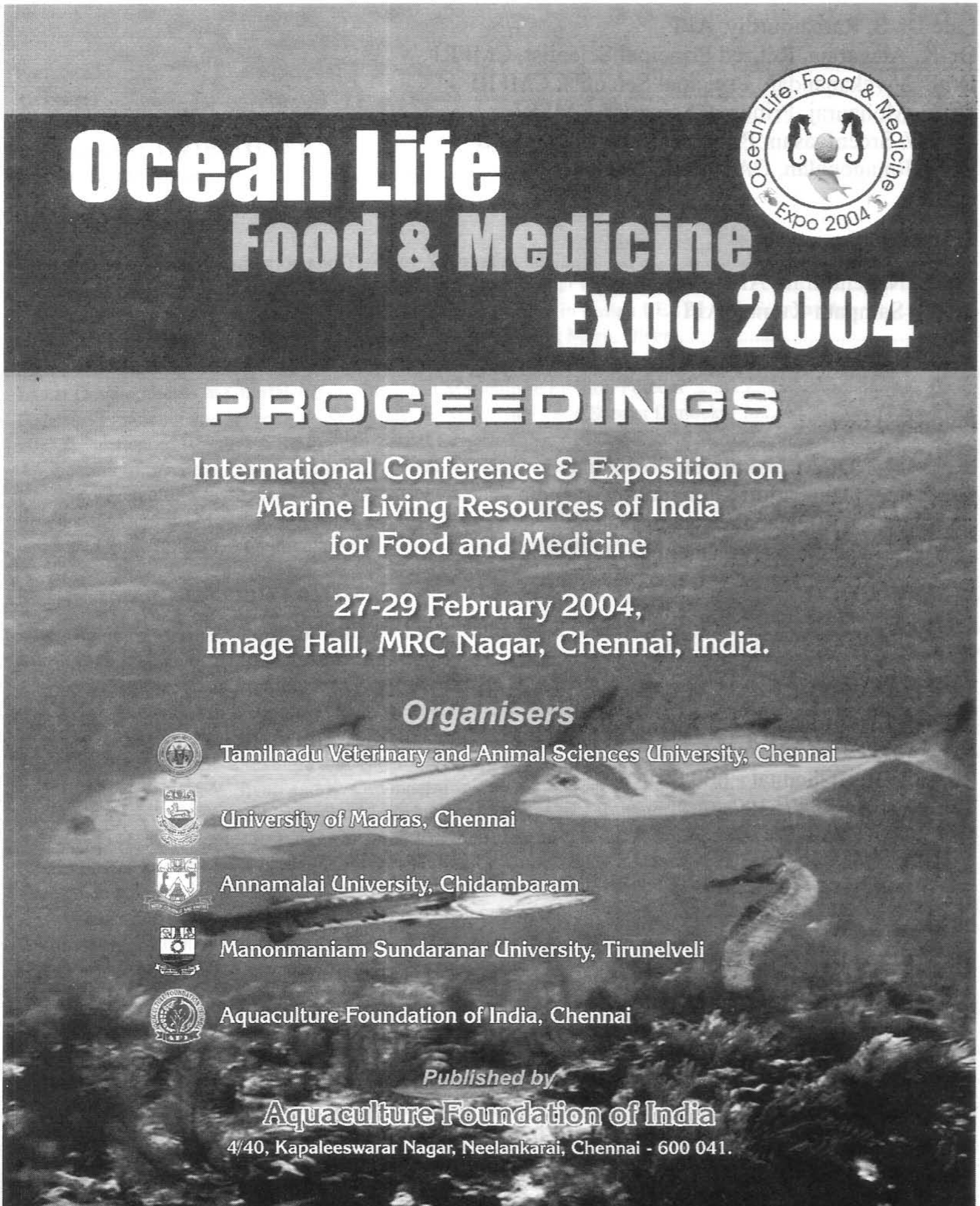

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Editors :

Late Dr. S. Ramamurthy, AFI
Dr. K. Alagaraja, Retired Principal Scientist, CMFRI
Dr. E. Vivekanandan, Principal Scientist, CMFRI
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Dr. M. Sakthivel, President,
Aquaculture Foundation of India
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NEED FOR ECOSYSTEM-BASED FISHERIES MANAGEMENT FOR INDIA

E. Vivekanandan
Madras Research Centre of Central Marine Fisheries Research Institute, Chennai

ABSTRACT

Ecosystem-based fisheries management (EBFM) can be an important complement to existing fisheries management approaches. EBFM calls for recognition of fisheries management and exploitation as an integral part of the marine ecosystem. For moving toward EBFM, protocol has to be developed to deal with complex interactions of institutions and societies. Development of food web based model for each ecosystem is one of the prerequisites. Delineation and implementation of no-fishing zones offer promise not only for fisheries sustainability but also for resource enhancement. Implementation of EBFM by involving all stakeholders is a challenging, but not an impossible task, and is expected to yield immediate and long-term benefits.

INTRODUCTION

Fish and fisheries are deeply embedded within ecosystems. The effects of marine ecosystems on fish and the effects of fishing on marine ecosystems have been widely recognized now. Fisheries are dependent on the productivity of the ecosystem, and fisheries have an effect on, and are affected by the ecosystem of the target species/group. It is, therefore, prudent that fisheries management should take account of the interactions between ecosystems and fisheries. Currently, ecosystem-based fisheries management (EBFM) is a highly topical issue and several developed countries are moving towards EBFM.

As far back as half a century ago, the UN Technical Conference on the Conservation of the Living Resources of the Sea recognized the importance of an ecosystem approach to fisheries management in 1955. However, the impetus to this approach was given only in 1995 in the FAO Code of Conduct for Responsible Fisheries. Since then, several developed countries have begun the process of adopting the ecosystem-based fisheries management. Unlike the single species models in fisheries management, an ecosystem approach is an effective tool since it takes into account the complexity of the marine and coastal ecosystems and it is now believed that such an approach could provide a lasting solution to the problems of declining aquatic biodiversity and fish stock biomass. The EBFM is not about managing or manipulating ecosystem processes, but is concerned with ensuring that fishery management decisions do not adversely affect the ecosystem function and productivity, so that harvesting of target stocks is sustainable in the long-term. Traditional systems of management, which have tended to focus on individual stocks or species, have not achieved this objective.

It is being increasingly realized that most fishing is unsustainable under the existing management regime because (i) rapid growth of human population drives increasing demand, (ii) development of mechanized fishing technologies severely damages the environment and fisheries, and (iii) quicker transportation to fishing grounds makes even the distant fish populations vulnerable to exploitation.

Limitations of traditional fisheries management approach

The diversity of ecosystems along the Indian coast gives a high diversity of fish species and resources, as well as the objectives of exploitation, fishing strategies, tactics and methods. The diversities of fisheries range from industrial to artisanal with a diversity of species depending on the region and season. However, the existing management practices do not give due consideration to these diverse conditions, and are being exercised under the concept of the resource as a functional and self-regulating unit of nature. Management strategies are directed toward avoiding overfishing of recruitment or growth.

The fisheries management measures are executed by the maritime states through Marine Fishery Regulation Acts and Executive Orders. The major regulations that are followed at present are the closed season for mechanized vessels, delineation of fishing areas for mechanized and nonmechanized vessels, and maintenance of minimum mesh size in the codend of the trawlnet. The closed season is followed during different seasons and for varying duration along the east and west coasts. Whereas closed season appears to improve the catch for a few months after the lift of ban, the sustainability of fish stocks and long-term benefits are not known. Moreover, the goal of reducing the annual fishing effort has not been achieved by following closed season. In spite of closed season, the annual fishing effort of mechanized vessels is increasing, offsetting the benefits, if any, of the closed season (Vivekanandan, 2001). The second management measure, *viz.*, delineation of fishing areas, is intended essentially to avoid conflict between mechanized and nonmechanized fishing sectors. However, due to inadequate surveillance mechanism, it is hard to restrict encroachment of the sectors into each other's territory.

In addition to these management measures, Ministries of Government of India have passed Executive Orders to conserve selected groups such as the sharks, lobsters and seacucumbers. Whereas conservation of endangered/vulnerable groups are very important, group-by-group management approach may not yield the desired result. For instance, protecting the sharks would increase the demand for the prey leading to scarcity of food organisms. In the absence of adequate food supply, the shark population will not be sustained. Similarly, the seacucumbers are detritivores and polluted coastal waters and sea bottom will be deleterious to the detritivores.

In spite of scientific efforts, the decline in fish stocks is not always explained by fishing activity. Natural catastrophic effects, long and short-term environmental effects, change in the relative abundance of fish populations for natural reasons, are also some of the possible causes. In the Gulf of Mexico, the annual landings of the pinkprawn *Farfantepenaeus duorarum* decreased from 25,000 t in the mid 1970s to less than 1,000 t in 2000 (Arreguin-Sanchez, 2001). The rate of recruitment continually declined in the 30 years. During the period, fishing increased by several times, but it was found that increase in seawater temperature accounted for more than 50% of recruitment failure. The evidence indicated that the environmental effect is often strong and decisive.

The living aquatic resources are an integral part of their ecosystem and management of the ecosystem is a prerequisite for the well being of fisheries resources. It has been widely recognized that fisheries management should adopt a broad-based spatial management strategy with the management of living resources and temporal restrictions such as closed fishing season appropriately integrated into the management regime depending upon the conservation needs of the ecosystem in question.

Approach for EBFM

A comprehensive EBFM would require taking into account all the interactions in an ecosystem. However, such complete understanding of ecosystems is unlikely to be achieved, and there is need for pragmatism. The EBFM is not an instant replacement for traditional fisheries management, and the shift should be gradual.

According to the National Marine Fisheries Service (1998) and the National Research Council (1999) of the US, an ecosystem-based approach should take into account the following five aspects:

(i) the interaction of a targeted fish stock with its predators, competitors and prey species;
(ii) the effects of weather and hydrography on fish biology and ecosystem;
(iii) the interaction between fish and their habitats;
(iv) the effects of fishing on fish stocks and their habitats, especially how the harvesting of one species might have an impact upon the other species in the ecosystem; and
(v) recognizing humans as components of the ecosystems they inhabit and use.

In the EBFM, fisheries management is not seen in isolation from the wider management of the marine environment and it is integrated with other sectors of marine management. While it is a major conceptual advancement, the practical problems raised by this recognition are immense. There is still uncertainty on how to implement an effective EBFM in practice. Nevertheless, there are pragmatic ways to begin implementation and to deal with complex interactions of institutions and societies.

The following steps should be taken for moving toward EBFM:

(i) Identification of relevant ecosystems, their boundaries and characteristics;
(ii) Agreement of management objectives for each ecosystem by encompassing wider ecosystem factors and all stakeholders, and not just the target stock;
(iii) Development of long-term and immediate objectives;
(iv) Establishment of sustainability indicators such as reference points, targets and limits;
(v) A decentralized approach enabling management measures to be taken that are appropriate to biologically distinct areas; these include technical measures, spatial management and fishing effort-related controls; and
(vi) An effective enforcement capability.

Parallel to this must be an extensive research beyond the traditional single species stock assessment advice for a better knowledge of habitats, ecosystem interactions, fishing-related impacts, trophic interactions, monitoring of bycatch and discards to include information of noncommercial bycatch. Food web based modeling is an essential scientific tool for developing ecosystem approaches for fisheries management. Such models could examine factors that affect primary productivity and their interaction with all components of the ecosystem. These models provide an insight into the harvests of fish species in different parts of the food web, how top predators like the marine mammals, tunas and sharks are related to populations of prey species, and how much of the total primary production is required to sustain fisheries harvest from the ecosystem. Models such as Ecopath (Polovina, 1984; Pauly and Christensen, 1995) have provided insights into some fundamental ecosystem questions. Ecopath with Ecosim software system is designed to describe the trophic fluxes and variables in ecosystems. By using this software, more than 100 ecosystem models have been analysed worldwide. For different ecosystems along the Indian coast, models and simulations are needed.

An ecosystem approach could help manage fisheries in the following ways (Mathew, 2001): (i) Conservation of fisheries resources, protection of fish habitats, and allocation to fishers are the three most important considerations in fisheries management. The vantage point to start from is the fishing gear, because without its cooperation, it would not be possible to adopt effective conservation measures and protect fish habitats from fishery-related stress. The ecosystem models estimate the carrying capacity of the ecosystems and the biomass at each trophic level by taking into consideration the weather and hydrography of the ecosystem and fish biology. It also quantifies the number of craft and gears required for sustainable harvest from the given ecosystem. It helps bring about a greater control over large scale operations of nonselective fishing gears. (ii) The approach can facilitate a better understanding of the trophodynamics in an ecosystem, and also the impact of fishing gear selectivity on marine living resources. Programme designed to conserve marine mammals and turtles may become counterproductive when these resources multiply in large numbers and compete with fish stocks as well as fisheries. The fishermen of the Lakshadweep Islands complain about the proliferation of marine turtle population, which not only predate on fishes, but also cause damages to the fishing gears. Along the north Peru coast, squid jiggers complain about predation on squids by sea lions and dolphins. It is estimated that the annual damage caused by the sea lions is about 64 million US$ along the north Peru coast (Manuel, 1997). (iii) The ecosystem approach can be applied to understand and to prevent land-based sources of pollution that have an adverse impact on plankton, which constitute the mainstay of the food of the small pelagics. In addition, reduction of nursery grounds from destructive activities like construction and reclamation in coastal areas, mangrove deforestation, destruction of coral reefs, as well as the loss of marine biodiversity are the other vital issues that need to be dealt with seriously and effectively in the tropical waters. (iv) It would be helpful to understand the impact of the natural factors such as weather and hydrographic factors on fish stocks. In the Pulicat backwaters (southeast coast of India), for example, the mullet and shrimp stocks perish if the salinity exceeds that of the sea due to evaporation, zero exchange of water (as a result of mud formation at the mouth), and zero discharge into the lagoon from rivers (due to upstream dams). Under such conditions, conservation of the mullet and shrimp stocks is not possible just by refraining from fishing. The *padu* system, a system of rotational access to the fishers to shrimping grounds, practised in the Pulicat, does not mitigate the pressure on shrimp stocks because different groups, in a rotational basis, incessantly harvest the stocks.

Options for EBFM

An indicative outlay of the ecosystem zonation for India along with options for EBFM suggested by Vivekanandan (2002) is given in Table 1. To date, the best known tool for EBFM is networks of fully protected marine reserves. Over the last 15 years, study of more than 100 reserves shows that reserves usually augment fish population numbers and the individual size of overexploited species. In the early 1990s, Canada's Atlantic cod fishery collapsed and thousands of people were put out of work. The conventional methods such as the (i) restrictions on the season's total catch, (ii) controls on the number of days or weeks of fishing, and (iii) regulations on the kind of craft and gear that can be used, did not have the desired effect on the stocks. Therefore, a group of scientists proposed a radical idea. If all forms of fishing in certain areas are banned altogether, the overall catch can be increased in a sustainable way. Since then, a plethora of studies have convincingly demonstrated that the creation of no-fishing reserves allows the rapid build-up of fish spawning stock biomass (Roberts and Polunin, 1991; Dugan and Davis, 1993; Allison *et al.*, 1998). The idea behind reserves is simple. If the fish are protected from fishing, they live longer, grow larger and produce an exponentially increasing number of eggs. It is observed that adult fishes tend to remain in the protected areas while their larvae help replenish adjacent fisheries. Overall (multispecies) levels of biomass per unit area can double in two years and quadruple in ten years of closure. In the Californian reserves, reproductive output of two rockfish species was estimated to be two to three times as great as in the fished areas. On the west coast of the USA, the reproductive output of the longcod in a reserve in Puget Sound was 20 times greater than outside, and for the copper rockfish 100 times greater (Palsson, 1998). These reserves showed average increases of 91% in the number of fish, 31% in the size of fish and 23% in the number of fish species present (Roberts, 1999). These increases occurred within two years of starting the protection scheme. Crucially, the beneficial effects spilled over into areas where fishing was still permitted. In St.Lucia, for example, a third of the country's fishing grounds were designated no-fishing areas in 1995. Within three years, commercially important fish stocks had doubled in the seas adjacent to the reserves.

No-fishing reserves will work well for migratory species also if the reserves are put in the right places. Reserves placed in nursery and spawning areas will protect the migratory species during critical life stages. For example, spawning haddock and groupers are protected in the Georges Bank and Virginia Islands, respectively as the spawning aggregations were fished to extinction. Some reserves will primarily benefit fisheries, some others conservation, but most will benefit both simultaneously.

There are strong evidences to suggest that reserves will work even better in the tropics. However, there is no direct experience of reserves in India barring the marine sanctuaries in the fragile coastal zones to protect coral reefs and mangroves. Considering that the concept of no-fishing zone is a good strategic tool, fisheries managers in India should start working on the questions about how much of the fishing grounds should be placed in reserves, how many are needed, and where should they be. There seem to be three principles, which govern no-fishing zones. According to the first principle, both biological and economic benefits can be maximized through closures ranging between 20 and 40% of fishing grounds. Recently the American Association for the Advancement of Science (AAAS), along with about one hundred scientists called for 20% of the world's oceans to be declared for no-fishing by the year 2020 (Roberts,

Table 1 Considerations for ecosystem-based fisheries management (after Vivekanandan, 2002)

Type of ecosystem	Components	Management options	Type of fishing regulation
I Critical ecosystem	Coral reefs; Sponges; Mangroves	Marine protected area; Coral rebuilding; Mangrove afforestation	Fishing ban altogether
II Vulnerable ecosystem	Declining fish stocks; Concentration of vulnerable/endangered species	No-fishing zone; Resource enchancement programs like searanching	Fishing ban altogether; Alternate livelihood like mariculture
III Polluted ecosystem	Bioaccumulation of pollutants	Ecowatch; Evolve standards for waste discharge; Implement polluter-pays principle	Fishing and marketing of fish with pollutant load to be prevented
IV Estuaries, lagoons & backwaters	Nurseries; Closure of barmouth	Seasonal closure of fishing	Ban all forms of fishing during seasons of spawner & juvenile abundance and closure of bar mouth; Regulate mesh size
V Open coastal waters	Combination of under & overexploited stocks	Seasonal closure of mechanised fishing; Area demarcation for machanized & traditional craft; Limited entry; Part of the area as no-fishing zone either on rotation or permanently	Regular but controlled fishing; Precautionary approach; Alternate livelihood like mariculture
VI Farsea/deepsea	Mostly under & unexploited stocks	Atlas on areas of resources abudance; Devise economically viable craft & gears; Regional cooperation	No restriction for the present; Local fishing communities deserve encouragement

1999). The second principle is based on the expectation of maximization and equitable distribution of benefits through a subdivision of the 20% reserve area to represent both biogeographic and ecological diversities within the reserves. The third principle stems from the question whether the derivation of maximum benefits is from the permanent or rotational reserves. Considering the location of fishing villages close to each other along the Indian coast, the selection of areas for no-fishing and the logistical, economic and social implications of dislocating and rehabilitating the fishers to fishing areas away from the reserves call for pragmatism and extreme care in planning.

The fishing communities are dispersed all along the coastline in the countries bordering the Indian Ocean, and they are dependent on marine ecosystems that are close to them. The nature of the ecosystems is an important determinant of many cultural characteristics, including the social and economic organization and the fishing gear and technologies that are utilized. They develop intimate, detailed and function-oriented knowledge about the marine ecosystems. They are also easily vulnerable to resource depletion. The question is, how are we prepared to adopt the EBFM. The ecological considerations do not expect the halt of traditional management measures. However, the traditional approach will have to be embedded within the domain of the EBFM by involving all stakeholders. A carefully planned protocol and implementation of EBFM within a logistic time frame is expected to contribute to the protection of marine biodiversity and fisheries.

CONCLUSION

The marine fish production along the Indian coast has not declined over the years. However, considering the limitations of the existing management practices and experiences of several other countries, it is of immediate concern that scientific efforts should not halt at sustaining the fisheries, but should be redirected toward evaluating options for restoration of resources. The best way to achieve this would be to establish large scale marine reserves, and implement other forms of rigorous protection of fisheries in non-reserves. This major shift in management strategy needs support from all institutions and stakeholders.

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