EBFM - can it manage and conserve tropical Asian fish stocks?

by **K Sunil Mohamed and P U Zacharia**

Sustainable use of living marine resources must consider both the impacts of the ecosystem on the living marine resources, and the impacts of fishery on the ecosystem. This holistic approach to fisheries management has been termed as "Ecosystem Based Fisheries Management" (EBFM).

A lot of attention has recently been directed at assessing the impacts of fisheries on whole marine ecosystems. This has in part been driven by the need to ensure conservation of biological diversity and sustainable use of the biosphere, key provisions of the convention agreed at the UN Rio Summit. The utilisation of sound ecological models and indicators as tools in the exploration and evaluation of ecosystem health and state has been encouraged and endorsed by the leading bodies in ecosystem-based fisheries research and management. The potential of the available dynamic ecosystem models to make measurable and meaningful predictions about the effects of fishing on the ecosystems has not, however, been fully assessed. Let us first look at some of the science behind the need for EBFM.

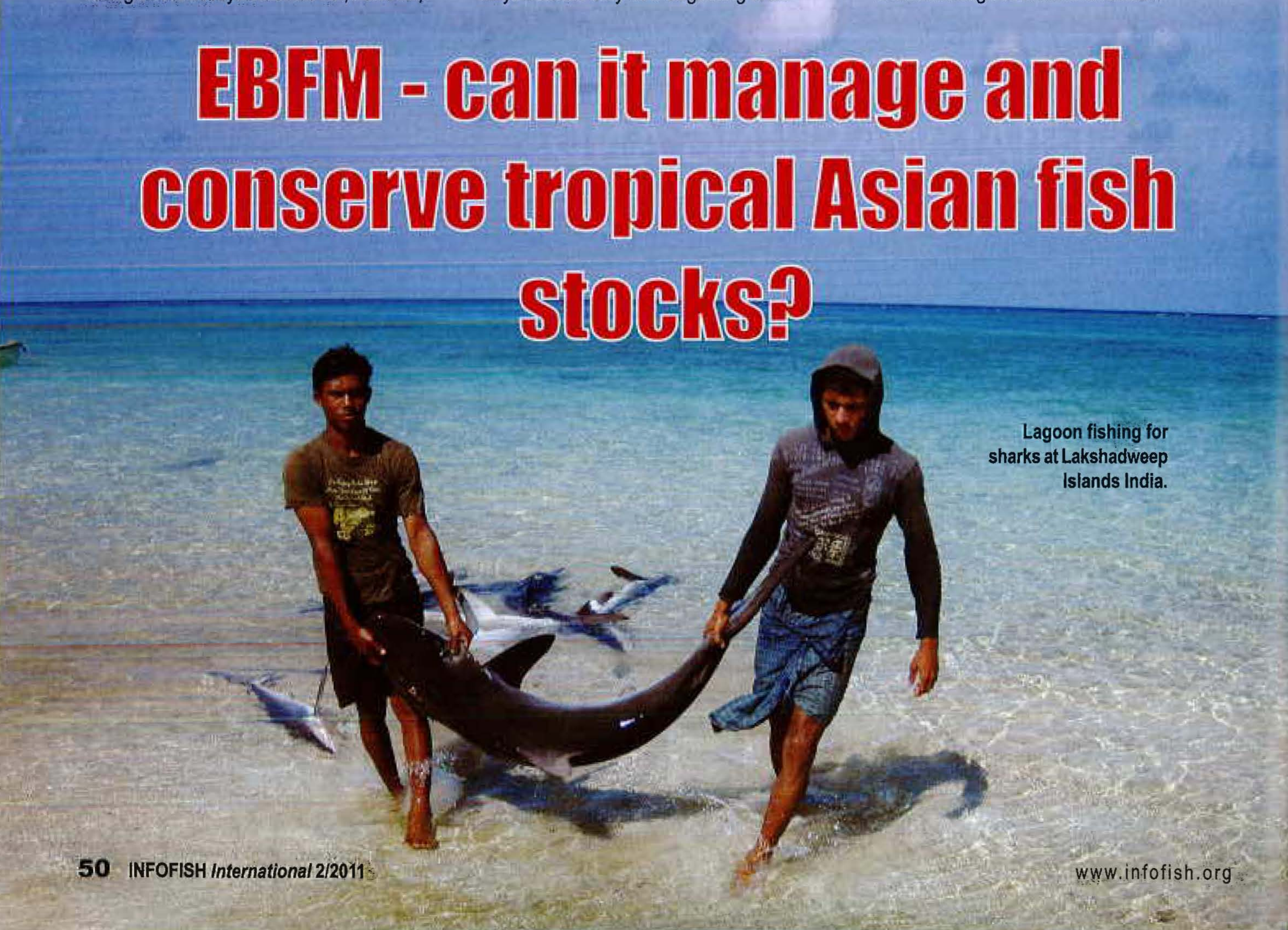
Ecosystem Based Fisheries Management (EBFM), a holistic approach to fisheries management, contributes positively to biodiversity, governance and human well-being aspects. Many Asian countries have adopted this principle.

Changes in fished species

Harvesting alters ecosystem structure in ways that are only now beginning to be understood. It is argued that long-term heavy commercial harvesting is likely to shift the ecosystem to high-turnover species with low trophic levels. The biological mechanism underlying species shifts is that the relatively large, long-lived fishes which have low mortality rates are more strongly affected by a given fishing mortality rate than are smaller fishes which are part of the same community. A second shift-inducing biological mechanism is habitat degradation caused by various fishing gears, especially bottom trawls. Here, the effect is through destruction of bottom

K Sunil Mohamed

P U Zacharia



Lagoon fishing for sharks at Lakshadweep Islands India.

Examples of documented shifts towards smaller, high-turnover species in exploited multi-species communities

Fishing grounds/ Stocks (period)	Documented species shift
Gulf of Thailand Demersal stocks (1960-1980)	Overall biomass reduced by 90%; residual biomass dominated by trash fish
Philippine shelf Small pelagics (1950-1980)	Gradual replacement of sardine-like fishes by anchovies
Carigara Bay, Philippines All fish (1970-1990)	Fish replaced by jellyfish, now an export item
Black Sea	Small pelagics and jellyfish replace large table fish
North Sea	Halibut and small sharks extinct; cod and haddock threatened; demersal omnivores and small pelagics favoured
Humboldt Current, Chile	Large hake depleted, small pelagics favoured
North Pacific	First marine mammal depletions, followed by huge trawl fisheries: Pollock favoured
South China Sea, Hong Kong	Croakers and groupers almost extinct; small pelagics bulk of fishery
Northwest Coast and Southeast Coast of India	Decline in large predators such as sciaenids, perches and Bombay duck and increase in abundance of oil sardine

structure, depriving benthic fishes of habitats and prey.

Thirdly, the above and the fishery induced reduction of predatory pressure by benthic fish, may then lead to an increase of small pelagic fish and squids which becomes available for exploitation. This may mask the decline in catches of the demersal groups. In the Gulf of Thailand, in Hong Kong Bay and other areas of the South China Sea, extremely heavy trawl pressure has resulted in a shift from valuable demersal table fish such as croakers, groupers and snappers to a fishery dominated by small pelagics used for animal feed and invertebrates such as jellyfish and squids.

These mechanisms almost often lead, through a positive feedback loop, to a fourth biological mechanism: harvesting small pelagic fish species at lower trophic levels reduces the availability of food for higher trophic levels, which then decline further, releasing more prey for capture by a fishery that finds its targets even lower down the food web, a process now occurring throughout the world. The growing abundance of arrowtooth flounder (*Atheresthes stomias*) in Alaska has been a concern for a decade, while the recent explosion of Humboldt squid (*Dosidicus gigas*) off the US west coast and the high densities of spiny dogfish (*Squalus acanthias*) in New England and the US Atlantic states have led to calls for "ecosystem"-based predator control. Scientists have used trophic models to evaluate the potential to improve fish yields by culling seals.

Single species assessments

The tools developed for single species population dynamics are an essential part of any new methodology. Detailed information on growth, mortality and recruitment schedules and their associated errors and uncertainties are essential for the implementation of the ecosystem approach advocated in the Rio Summit.

When considering the management of single components of the ecosystem, such as the target fish stocks, it is possible to set target and limit reference points for particular measurable properties of the species. For example, the implementation of precautionary fisheries management in the North Atlantic has progressed through the setting of reference points for various measures of the status of the exploited species, *eg* the spawning stock biomass (SSB). Two types of reference points are considered - a limit reference point and a target reference point. Management measures are aimed at achieving the target reference point in the medium term and ensuring that the limit reference point is never exceeded.

In theory, it should be possible to apply reference points to any or all taxa in the ecosystem. ICES (2000) have contended that even if this was practical for a significant number of taxa, it may not ensure adequate protection of all the ecosystem components at risk. There is a need, therefore, to develop reference points for system level emergent properties as a measure of ecosystem health.

Ecosystem modelling using trophic interactions

There are many recent developments in building of trophic models of aquatic ecosystems. Such modelling can now be performed more rapidly and rigorously than ever before, providing a basis for viable and practical simulation models that have real predictive power. This was made possible by the development of Ecopath, for construction of mass-balance models of ecosystems, based mainly on diet composition, food consumption rates, biomass and mortality estimates.

Ecopath applications to ecosystems, ranging from low latitude areas to the tropics, and from ponds, rivers, and lakes to estuaries, coral reefs, shelves, and the open sea, but all using the same metrics, allowed identification of several general features of aquatic ecosystems:

Multivariate comparisons demonstrated the basic soundness of E P Odum's (1969) theory of eco-system maturation, including a confirmation of his detailed predictions regarding ecosystems near carrying capacity. Conversely, this theory can now be used to predict the effect of fisheries on ecosystems, which tend to reduce their maturity, as illustrated by the comparison of Ecopath models for the Eastern Bering Sea in the 1950s and early 1990s, and to guide ecosystem rebuilding strategies implied in "Back to the Future" approaches.

Mechanised gillnetters at Tuticorin, southeast India.

Performance measures

It is generally agreed that reductions in single species fishing mortality levels is perhaps the most significant step one could take towards ensuring the persistence of marine ecosystems. It is also clear that ecosystem based fisheries management is still in its formative years, although substantial developments have been seen in some countries and regions. Among these, North America, Antarctica, Europe, Australia and New Zealand are the most notable. Probably the most advanced implementation of EBFM in the US context is the North Pacific Fisheries Management Council approach.

Unfortunately, despite the legislative imperative and clearly articulated principles, arriving at an operational framework for an ecosystem based approach to fisheries management is fraught with difficulties. This difficulty is due, not only to the inherent challenge in establishing and quantifying the effects of fishing at an ecosystem level, but also due to the social and political dimensions associated with harvesting fisheries at an environmentally sustainable level.

The two aspects of EBFM

Very recently, EBFM was classified as consisting of a core and extended EBFM. The "core" consists of three primary features: (a) doing single species management right, *ie*, keeping fishing mortality at or below MSY, and keeping fleet capacity in line with the potential of the resources, (b) preventing by-catch of non-target species, which can be achieved by gear modification, providing incentives for by-catch avoidance, or by area and seasonal closures, and (c) avoidance of habitat modifying fishing practices primarily by closing areas or banning of specific fishing methods or gears in sensitive areas. Consideration of trophic interactions and area-based management characterise "extended" EBFM. There are two elements of "extended" EBFM that are underway. One is founded in detailed studies, as exemplified by wide-scale multi-species data collection on food habits and trophic connections sometimes combined with ecosystem models. There are now ecosystem models for many ecosystems. It is possible that ecosystem models will bė used to identify "problem" species and potentially direct fisheries to deliberately reduce their abundance.

The second element of extended EBFM is area-based management. Examples of existing area-based management include closed areas to protect spawning stocks, juvenile fish or sensitive habitats. There is a growing use of area-based management to reduce by-catch, such as short term closures in the eastern Bering Sea and the North Sea, or the larger and longer closures to protect cod in New England and rockfish off California. There is also the implementation of large-scale systems of marine protected areas in many parts of the world. Area based management is currently a reality, and it is certainly going to continue to expand. Nevertheless, the cost of ecosystem models and area-based management is very high. Just doing stock assessments for every species instead of the current practice of the economically important ones will likely require a multi-fold increase in science and management costs. Integrated Ecosystem Assessment (IEA) has emerged as one approach to solve the problem, by seeking important indicators of ecosystem condition rather than tracking all species in the ecosystem. Rather than doing single species assessment for each species, simpler ecosystem based indicators could be used in the management control rules.

EBFM in the Asian context

Application of EBMF implies a balanced approach to addressing ecosystem wellbeing and thus contributes positively to biodiversity, governance and human well-being aspects in order to contribute to social development and poverty alleviation and many Asian countries have adopted this principle. EBFM is very useful in situations where conflict resolution is required. All Asian countries have EBFM aligned activities and there are many initiatives that are aimed at implementing the Code of Conduct for Responsible Fisheries. For example, India has stated in its Marine Fishery Policy of 2004 that marine fisheries management should be placed in the context of EBFM. Many traditional systems have practices that broadly conform to EBFM principles but are not recognised as "ecosystem-based" approaches and there is a lack of appreciation of what is already being done. EBFM can also be used for addressing adaptation/resilience of fisheries and aquaculture to climate change impact/effects. Each country has its own context for policy development and resource allocation, therefore implementation of EBFM will differ depending on that context. Many countries note that existing legislation and/or policy may not explicitly support the EBFM and will require amendment or updating.

A regional consultative workshop on practical implementation of the Ecosystem Approach to Fisheries and Aquaculture in the APFIC region was held at Jeju, Republic of Korea, 6-8 September 2010 and adopted an action plan and recommendations from the APFIC Regional Consultative Workshop on "Practical Implementation of the Ecosystem Approach to Fisheries and Aquaculture" held at Colombo, Sri Lanka during 18-22 May 2009. Member countries were of the view that mainstreaming EBFM as a national system for management requires strong commitment of government and other relevant stakeholders.

The Fisheries Improved for Sustainable Harvest (FISH) project in the Philippines is likely the first EBFM project in the tropics and is at early stages of implementation. The FISH project is a seven-year effort focused on strengthening the capability of local and national institutions to manage coastal resources and marine fish stocks (www.oneocean.org). It is funded with an

Small-scale fishers landing pearlspot from Aghanashini River, southwest coast of India.

eight million dollar grant from 2003–2010 from the US Agency for International Development (USAID) to the Philippine government with technical assistance provided by *Tetra Tech EMI*, a private consultant agency, and other institutions (*eg* University of Washington).

India has also taken the initiative to construct models of trophic interactions of food webs of some of the important aquatic ecosystems. For example the Arabian Sea off Karnataka has been modeled and preliminary ecological simulations have been done to aid fisheries policy. Similarly an inland reservoir has been modeled and changes in management policy were compared on a temporal basis. Similar modeling exercises are also underway in Thailand and Malaysia.

Future of EBFM

Scientists predict two possible futures for EBFM that are not mutually exclusive. The core elements of EBFM, getting single-species fishing mortalities right, reducing by-catch, and protecting sensitive habitats, are widely accepted, being implemented, and are reasonably inexpensive. This will mean lowering fishing mortality on all species below the levels that produce MSY and probably lowering even more the exploitation rates on forage species. Various agencies are now using ecosystem indicators to modify their regulations. Essentially, ecosystem impacts of competition and predation are ignored when single-species assessments are used on a stand-alone basis. This aspect of EBFM could significantly modify management since the US and many other countries use estimates of unfished biomass when making harvest decisions.

The second phase of EBFM is true ecosystem-based control rules, supported by ecosystem models and ecosystem indicators. This second phase will not be likely to occur for many years because of the high cost and lack of ecosystem-based objectives. There is a great deal of science going into using ecosystem indicators and there is little sign of implementation and acceptance with ecosystem models replacing current single species models.

Lastly, EBFM does need to take into account the role of people in the ecosystem. Much of the current implementation of EBFM relates primarily to the natural ecosystem and regulation of harvest and gears are the key control variables. Another major element of fisheries management is allocation of access to fishing. There is considerable dispute over this area of fisheries management, and allocation often consumes as much management energy as does harvest regulation. Meanwhile, increasing evidence points to an interrelation between how fish are allocated and the ecosystem consequences of fishing. These new vistas need to be studied in the Asian and tropical seas context, but it is quite clear that the holistic EBFM is the way forward in fisheries management and conservation.

Dr Mohamed heads the Molluscan Fisheries Division and Dr Zacharia the Demersal Fisheries Division at the Central Marine Fisheries Research Institute (CMFRI), Kochi, India. Both have been working on tropical marine fisheries for more than two decades.

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