LARGE MARINE ECOSYSTEMS :

EXPLORATION AND EXPLOITATION FOR SUSTAINABLE DEVELOPMENT AND CONSERVATION ON FISH STOCKS

Edited by

Dr.V.S.Somvanshi

February 2004

Fishery Survey of India
Government of India
Ministry of Agriculture
(Deptt. of Animal Husbandry & Dairying)
Mumbai-400 001

OF BOUNDARIES, OVERLAPS AND VARIABILITY IN LMEs THE CASE OF BAY OF BENGAL

K. Vijayakumaran
Central Marine Fisheries Research of Institute, Visakhapatnam-530 003

ABSTRACT

The paper examines the influence of localized studies in enforcing arbitrary boundaries in the ecosystem. How the proliferation of studies in watertight compartments would make the boundaries more rigid and unbreakable is explained. Inadequate attention to overlap of communities and phenomena has been identified as an inevitable outcome of rigid boundary concepts. The issues related to the variability in the system and its influence on the components often remain unnoticed or unresolved because of the limits of perception imposed by the boundaries. Over viewing the global trend, an approach to study the Bay of Bengal as a Large Marine Ecosystem (LME) is suggested.

Introduction

Oceans had fascinated man from prehistoric times. However, the perspective of his studies changed significantly with time. While prehistoric man looked with awe upon the mighty ocean, modern man looks with awe upon the repercussions of his unmindful activities in the ocean. With the changing horizons of knowledge, technologies and priorities, the approaches and methodologies of research and management in marine environment had been changing over the years. During the recent decades, there was a prominent shift from studies of limited dimensions towards a total ecosystem approach. Although the first attempt to deal with the management of LMEs took place in 1901, resulting in the establishment of ICES, much attention to the concept came in eighties. Individual efforts of authors like Longhurst (1981) and collective efforts such as those under the aegis of AAAS (1986, 89, 90, 91, 93) and NOAA had contributed significantly in advancing the concept.

Of the 49 LMEs identified globally, about 29 have been subjected to systematic studies leading to the expert synthesis of the principal forces controlling the biomass yield (Sherman, 1996). Of the two LMEs of the Indian Ocean, the Arabian Sea and Bay of Bengal, only the latter was subjected to a preliminary analysis under the LME framework (Dwivedi, 1993). This is in spite

of the voluminous information generated by a large number of studies, mostly confined to narrow ranges of subjects. Interdisciplinary approaches were very rare and those attempts made had spatial and temporal limitations.

A cursory perusal of the available literature on Bay of Bengal reveals that the concept of LME is yet to make a reasonable degree of penetration into the marine environmental research in this region. There are different factors responsible for the underdevelopment of the LME concept in this part of the globe. Analyzing the historic facts and tracing the evolution of the present state of affairs will certainly provide some useful clues for changing the course of development to the desired end. An attempt is made in this paper to delineate the factors responsible for the present state of affairs and to suggest desirable course of action for promoting the LME studies in Bay of Bengal.

Studies in Bay of Bengal

The studies carried out till the end of nineteenth century in the Bay of Bengal, by and large, had focussed on the biological aspects such as recording and description of fauna and flora. The classic work on fishes of India by Sir Francis Day was the outcome of such efforts. It was Col. R.B.S. Sewell who pioneered oceanographic studies in this part of the globe. Though the work was suspended during World War I, the information generated out of the studies was published by the Royal Asiatic Society of Bengal in its memoirs. After the First World War, *Dana Expedition, John Murray Expedition* and *Galathea Expedition* contributed to the wealth of information on the Bay of Bengal.

The contribution of the researchers at Madras University to the development of marine biology was significant in the pre-independence period while the post-independence period saw the emergence of institutes such as CMFRI. Until the establishment of research stations at Waltair and Kakinada, the research in CMFRI confined largely to the Madras coast and later to the Palk Bay and Gulf of Mannar area. The oceanographic studies conducted by Andhra University under the guidance of Prof. E.C. La Fond during 1952 to 1956 resulted in some commendable publications on different aspects of ocean sciences (Andhra University, 1954 and 1958). Since then the University has made several contributions to the ocean studies in Bay of Bengal. The establishment of Offshore Fishing Station (OFS) at Tuticorin and Visakhapatnam (which later became part of the Exploratory Fishery Project (EFP) and subsequently of the Fishery Survey of India) in 1958 opened the exploratory survey of fishery resources along the Indian waters in the Bay. EFP had bases at Calcutta and Paradeep during some years. The late- comers in marine sciences in

this part of the coast, namely the Annamalai University and Berhampur University had concentrated mainly on the biological and physico-chemical aspects of the nearby coastal ecosystems.

The International Indian Ocean Expedition (IIOE) during 1960-1965 sponsored by UNESCO and the Intergovernmental Oceanographic Commission (IOC), involving 4 ships and 20 countries was an important milestone in the history of ocean research in this region. Apart from filling up the gaps in information, the expedition helped to empower the Indian researchers with the experience, vision and techniques needed to advance the ocean sciences independently. The establishment of National Institute of Oceanography (NIO) in 1966 filled the long felt need to have an organization to carryout systematic research in the ocean sciences.

There was a profuse output of literature in the country as Institutes and Organizations concerned with marine sciences proliferated. These outputs could be grouped under the following four categories, more or less denoting their origin.

1. The exploited fishery related research publications from CMFRI,
2. The exploratory fishery related publications from CMFRI, EFP and FSI,
3. The oceanographic research results of NIO and CMFRI and
4. The miscellaneous publications from Universities and other organizations.

Of the four categories listed above, the last one can be conveniently ignored as being limited in scope, leave alone the spatial and temporal limitations. The first three are important and relevant to study the Bay of Bengal as an LME. It is appropriate to examine the salient features of these three categories of publications.

The research work of CMFRI is based at five centres along the Bay of Bengal coast namely, Tuticorin, Mandapam, Madras, Kakinada and Visakhapatnam. The basic biology of almost all commercially important species of fish and shellfish had been investigated by the scientists at these research stations. Population models (mainly single species models) borrowed from the west have been extensively used by assuming arbitrary boundaries for stocks such as the seas off Madras, off Kakinada, off Visakhapatnam etc. However, the recent stock assessment exercises assumed extended areas such as east coast, west coast, north east coast, south east coast etc. for working out the different parameters of the population of different species. The National Marine Living Resource Data Centre (NMLRDC) in the Institute has been efficiently functioning as a reliable source of marine resource landing data.

Fishery Survey of India's attention is exploration and charting of the fishery resources of the deeper waters of the EEZ. Earlier the scientists of CMFRI were responsible for the collection and analysis of the exploratory survey data. From around eighties, a number of publications providing valuable information on the resources along the upper and lower East coast and Andaman waters had been brought out by FSI. The resource potentials of various zones had been arrived at based on the catch per unit effort. Recently they have been paying attention to the biological aspects of some of the species abundant in deeper waters.

The works done by NIO in Bay of Bengal are mainly on physical and chemical oceanography. Biological oceanographic work confined largely to the primary and to some extent secondary productivity. Tertiary productivity and fisheries, by and large, remained beyond the purview of their research, as it was being taken care of by other institutes like CMFRI. The NIO had established a regional station at Visakhapatnam for facilitating research related to Bay of Bengal.

Boundaries

As we examine the literature output from these three sources, we find interdisciplinary approaches very rare and multidisciplinary approaches almost lacking. Research seems to have been carried out within certain boundaries, which, of course, are not imposed by the ecosystem. The boundaries imposed over these studies can be classified under the following types :

1. That imposed by political limits
2. That imposed by structural limits
3. That imposed by technical limits
4. That imposed by perceptual limits

The territorial jurisdiction of maritime states has little influence in imposing any boundaries on the studies of adjacent seas. However, the international limits of EEZ had definitely imposed boundaries in the case of Bay of Bengal. Fortunately, the extent of the Bay within the jurisdiction of other countries is comparatively less.

The boundaries imposed by structural limitations are more severe in the Indian context. The research works are carried out in Indian organizations under distinct divisions or sections (FSI is an exception). Often a sort of territorial

behaviour is exhibited by the researchers in these divisions and encroachment is strictly prohibited. Unless induced by some external force or agency, an interdisciplinary approach and interdivisional cooperation is a rare occurrence. The scientific results of **FORV Sagar Sampada**, a vessel meant for multidisciplinary research, is a glaring example of this syndrome. The research papers emanated from the cruises programmes of this vessel show clear demarcation of disciplines with very little integration or explaining any interrelations (Anon, 1990 and 1994). Of course, there are some exceptional cases where some biological aspects such as plankton abundance are related to some chemical parameters such as nutrients or benthic production is related to demersal fishery production (Parulekar *et.al.*, 1982). There are also many works attempting to arrive the fishery potential from the fragments of data on primary and secondary production. In some isolated cases such as Rao (1985) and Vijayakumaran (MS), the fishery was being related to the circulation in the Bay of Bengal.

Imposition of boundaries by the lack of technical capabilities of an organization is rather a universal phenomenon. The Fishery Survey of India, though has vessel capabilities, is devoid of any technical or manpower capabilities to study the vital oceanographic features of the potential grounds. The case is more or less reverse with NIO where the vessel capabilities and manpower required for assessment of fishery potential is lacking. CMFRI can boast about having little of both aspects but its capabilities have weakened in many ways over the years. If the changing emphasis and priorities of research in the institute is any indication of the shape of things to come, CMFRI is heading for a manpower scarcity in ocean disciplines.

The boundaries imposed by the limitations in perception are the most dangerous of all because it cripples the scientific process. The evolution of the perceptual boundaries has been catalyzed by the combined effect of structural and technical limitations. It is important to break the barriers in order to make progressive strides in any science.

Overlaps

The Bay of Bengal is landlocked on the east, west and northern side while it merges with the tropical Indian Ocean at the southern side. Sri Lanka, India, Bangladesh, Myanmar, Thailand, Malaysia and Indonesia are the countries bordering the Bay of Bengal. The bottom topography of the Bay beyond the continental shelf is more or less even except east of Andaman and Nicobar Islands. Even the ninety degree ridge of the Indian Ocean does not form any

extensive barrier along the bottom of the Bay. The surface current system, which alternate direction along with the monsoon, allow mixing of water throughout the Bay. Thus the real boundaries of Bay of Bengal - the LME, has to be drawn somewhere along the equatorial region connecting the edges of Sumatra and Sri Lanka, overlapping the international waters as well as the Exclusive Economic Zone (EEZs) of different countries. However, it must be noted that the boundaries of LME are not firmly fixed.

When an exploratory vessel surveying between 30 and 200 m reports the stock abundance of a species, what is happening within 30 meters to the same stock is beyond the boundary. Similarly if two researchers working at adjacent stations a few hundred kilometers apart arrive at significantly different values for population parameters for the same species of fish, a bias induced by boundary is evident. If people question the validity of data when species commonly occurring in pelagic gears at one locality is reported to be abundant in certain seasons at another locality in demersal gears, it is the boundary assigned to the fish posing contradiction.

The geographic distribution of many species is much wider in the Bay than what the researchers have traditionally presumed. An often-made statement is that the deep-sea resources are under-exploited compared to those within 50 m depth. Validity of this statement is questionable since the distribution of the species under question overlap over nearshore and offshore waters. Vijayakumaran (1998) observed that about 14 major groups of fish showing such overlap and doubted whether it is really a loss to leave these resources under-exploited or unexploited in the deepsea. Yellowfin tuna, which is a dominant highly migratory species of the Bay, has distribution beyond the equator and into the tropical and sub-tropical Indo-Pacific waters, where it is being exploited by international fleet (FAO, 1994).

Operational jurisdiction of the fleet is yet another factor which goes beyond the conventional boundaries. Rao (1987) had the vision to identify the entire upper East coast as a single unit for fisheries management. The concept of territorial limits of maritime states will be of use only to safeguard the operational interests of the artisanal fishermen. Since the waters beyond territorial limits are open for vessels of all states, considering fisheries management as a state affair is erroneous. Fortunately the concept of resource sharing and consequent fish wars as occurring in the North Atlantic waters has not yet entered in the Bay. This is probably because none of the countries bordering the Bay are traditionally fishing nations. For the management of migratory fishes such as tuna and tuna-like fishes, the boundaries have to go beyond the LMEs.

Variability

Over the years the ecosystem is subjected to various degree of stress due to different human interventions. The immediate effects of some of these interventions such as pollution are being studied at micro level. However there are many subtle aspects, which go unnoticed or are ignored as irrelevant to the management of subsystems. Oil sardines, which did not form any significant fishery some years ago, have come to form the bulk of the sardine landings along the East coast. Many dominant species of fish had been totally replaced by other species. Larger size groups of many species became less abundant in the demersal trawl fisheries. The percentage composition of different species of sciaenids, catfishes, lizardfishes etc. has changed over the years in their group's contribution to the fishery. This could be the type of change leading to the situation predicted for highly exploited fishery by Parish (1995).

The changes that take place during the upwelling period (February, May) along the Andhra Pradesh - Orissa coast are extremely interesting. The onset of upwelling and its spatial and temporal variation are phenomena worth studying. *Nemipterus mesoprion* which dominate the fishery during this period has failed during some years, disrupting the pattern of landing. The percentage composition of other deeper water species such as *Ariomma indica, Priacanthus hamrur* and *Decapterus sp.* also showed changes over the years. *Psenopsis cyanea* another deep-water species occurred in good quantities in 1998 after a gap of nearly five years. A less known deep-water species *Callionymus sp.* was one of the dominant species in the upwelled catch for a short period during the 1998.

The occurrence of certain species which form a dominant fishery in certain region is another interesting phenomenon. *Amblygaster sirm*, a dominant fishery south of Madras and Sri Lankan waters occurred along North Andhra Pradesh coast during certain years. Large trawlers operating off North Orissa often cut open the cod end to release the huge quantities of mackerel caught in their nets. Mackerel is a dominant fishery along the West Coast and a minor fishery along the East coast. Oil sardine which occur predominantly in the pelagic gears in the West coast is available in the demersal gears during certain periods along the East coast.

The thrust areas and options

The question whether the fish population models used in the Bay of Bengal are capable of explaining the abundance of the exploited stocks cannot be answered conclusively. But a logical deduction would explain that it would not

be. None of the models have been applied in the real time management of fisheries. A recent article stated that the research outputs of fishery biologists in India are goods supplied without demand (Vijayakumaran, 1998). Almost all research outputs on the fishery biology and population dynamics have remained just as intellectual exercise of academic value. Had these results been put to the acid test by applying in the field, they might have proved insufficient or not capable of explaining the unexplained. Sharp (1995) has voiced his concern that fisheries studies have simply ignored climate signals or have buried these and other environmentally mediated signals in mystical parameters. He called for truly interdisciplinary approaches to aquatic ecology and marine fisheries research and reincorporating of operational oceanography and climatology in to fishery science. While observing that for some obscure reason, fisheries management has become welded to biomass as the principal measure of resource status', he points out that stock assessment tools need to be expanded to cope with ecosystem status. In fact Sverdrup (1952) had succinctly explained much earlier the practical aspects of fishery oceanography with respect to prediction of the availability and size of the stock of any exploited species of fish.

The importance of predator - prey relationship studies in the multispecies fishery of the tropics need no emphasis and conventional food and feeding studies, which are in plenty, are no answer for understanding the relations. Studies similar to that of Bax and Laevastu (1990) to estimate the abundance of all species of interest within a defined ecosystem in relation to top-down predator-prey interactions and arriving at the energy budget need to be emulated in the Bay. The larval abundance, their survival is crucial factors contributing to the success of any fishery. Yet significant works similar to Lasker (1975, 1978 and 1981) are wanting in this region. It is high time that attention is paid in this vital area by researchers.

Modeling is an area where a lot has to be achieved. The question of sufficiency of data depends on the type of models being attempted. Daan (1986) analyzing the time series observation derived from commercial catch data for 70 years from North sea found that the prevailing monitoring programmes are capable of delineating the long term trend but not sufficient to unravel the mechanism behind it. Obviously the existing database in our country may not be sufficient to attempt a modeling exercise such as the one done by Pauly and Christensen (1993) for South China Sea. The utility of LME approach is being increasingly understood among the ocean scientists, geographers, economists, and Government representatives all over the world. Levin (1990) argues that LMEs are useful testing areas for ecological theories. He suggests a hierarchical movement from statistical observations of distributional patterns of physics and biology to examination of patchiness, testing of competing models and

integration of validated component models as part of an interactive, intellectual, experimental and field observational process. LME management regimes will necessitate well-orchestrated research programmes to be pursued vigorously. The investigations on LMEs has shown that perturbation in biomass yield in ecosystems associated with major current systems such as Kuroshio Current, California Current etc. were attributed to principally large scale natural changes in the ecosystems (AAAS, 1990). In contrast, fishing pressure has been attributed as the principal driving force in the semi-enclosed ecosystems such as Gulf of Thailand ecosystem. Bay of Bengal has a well-defined current system and a well developed industrial fishery. Therefore the perturbations in the biomass yield in the Bay could be influenced by both these dimensions.

Regarding the oceanographic parameters, Sankaranarayanan and Reddy (1968) have stated that conditions in the Bay necessitate the use of extensive small regional and temporal observations to obtain integrated pictures of the property distribution. Sherman (1986) discussed the utility of combined hydrographic and ichthyoplankton surveys conducted on mesoscale grids of 20-100 km at frequencies of 2-12 times per year. The sampling pattern for exploited fishery need intensification in the light of the observation made by Daan (1986) quoted elsewhere.

The study of Bay of Bengal, among other things, warrants the breaking of the structural, technical and perceptual barriers existing among the researchers and research organizations. A sort of opening up of the ocean research is needed for this effort. Considering the limitations and constraints within individual organisations, it is imperative to pool up expertise and resources of different agencies for a collective venture. An inter-institutional set-up with the participation of CMFRI, NIO, FSI, NRSA etc. under the aegis of DOD would be ideal for the purpose. Participation of similar institutes of other countries must be ensured for effectively transpiring the LME ideas and evolving management programmes. There is a strong need to educate the policy makers on the utility of LME approach. Though the cost of implementing the research programme can be arrived at more or less accurately, the benefits is highly difficult to assess. When resource crunch is severe, the alternative would be to divert resources from non-priority areas. Technological advancements will surely play a decisive role in reducing the burden of the programmes in coming years, tough initially they may cost high.

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