

CMFRI

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Impact of Climate Change
on Indian Marine Fisheries

Lecture Notes

Part 1

Compiled and Edited by

E. Vivekanandan and J. Jayasankar

Central Marine Fisheries Research Institute (CMFRI),
(Indian Council of Agricultural Research)
P.B. No. 1603, Cochin - 682 018, Kerala

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IMPACT ON OCEANOGRAPHIC PARAMETERS



V.N. Pillai

*Former Director, CMFRI (ICAR), Former ICAR Emeritus Scientist,
Project Leader, PFZ Validation Project along Kerala Coast funded by INCOIS,
Ministry of Earth Sciences, Govt. of India.
(vnarayanapillai@yahoo.com)*

Introduction

Availability of resources is perhaps one of the most important factors that determine the success of any industry. In the case of fishing industry, at the basic production level, the availability of fishable concentrations of fishes and other marine life is a decisive factor, which controls the economy of fishing operations. Even when well equipped vessels, fishing gear and experienced fishermen are available, the successes of fishing operation is dependent on the availability of fishable concentrations of commercially important marine life in space and time. By the word “fishable concentrations” the implication is the availability of sizeable quantities of fishes, which could be definitely caught using the available craft and gear in a particular area at a particular time.

Fish shoals are naturally accumulated group of fishes, which under normal conditions show a tendency to remain together. Knowledge regarding the behaviour of shoaling fishes will enable us to see suitable type of fishing gear more effectively thereby increasing the fish catch. Absence of such knowledge can result in wastage of valuable time and effort and an increase in the cost of fuel.

The behavior of a fish shoal is controlled by variations observed on important environmental parameters such as seawater temperature, salinity, dissolved oxygen concentrations, currents, presence of phytoplankton, zooplankton etc.

Marine fisheries scenario

Annual global marine fish production is around 90 million tonnes (m t). The seas surrounding the Indian subcontinent contribute on an average around 2.5 m t of seafood. With a coastline of more than 8000 km and exclusive economic zone of about 2 million square km, the potential yield of seafood is estimated to be around 3.9 m t (2.21 m t from coastal waters and 1.69 million from offshore and deep sea waters). The country has a fishermen population of 11.25 lakhs (full time) and 5.75 lakhs (part time) from coastal states and 2 island territories engaged in fishing activities, In addition, about 15 lakh people occasionally engage in fishing and fishery auxiliary activities.

During the past 5 decades, the country has seen the transformation of a subsistence-oriented traditional sector marine fisheries to market-oriented multi-million industrial sector activity through advancement in marine fisheries research and technology in the harvest and post-harvest scenario. Value earned through export of seafood is around INR 7000 crores equivalent to US \$1750 million.

Total production of seafood remained at about 2.5 m t since the early nineties, probably waiting for another technological breakthrough in the harvesting sector. Gradually the common property came under stress, which led to overharvest of a few easily vulnerable and target species and degradation of certain fish habits. The situation is closely similar to the global marine fishery scenario wherein 70% of the fish stocks are either fully exported, over fished, depleted or slowly recovering.

The contribution to the total catch by the mechanized sector is about 67%, motorized sector 20% and the remaining 13% by the non-mechanised sector. The estimated 32,000 motorised, 47,000 mechanised fishing craft and another 200 large fishing vessels, are in excess of the optimum number by 55%, 60% and 81% respectively. This excess fleet capacity warrants imposition of responsible fishing practices and proper codes of conduct for sustainable growth within this sector.

The sharing of pelagic and demersal fishery resources has created in the recent past considerable tension and conflicts among fishing communities in the coastal belt. There is need to find a solution for the long-term economic utilization of these resources by maintaining the exploited stocks through proper regulatory measures. The effort to reduce the searching time for pelagic shoaling fishes, which contributes more than 55% of the total marine fish landings, assume great significance since this factor can bring down the cost of fishing operations by way of saving valuable fuel oil and human effort.

Biodiversity

The seas surrounding the Indian subcontinent including the island territories of Lakshadweep, Andaman and Nicobar have a rich diversity of marine life. There are nearly 1570 species of finfishes and around 1000 species of shellfishes known from the seas surrounding our subcontinent. The availability as well as abundance of individual species in space and time varies according to changes taking place in the surrounding environment. It is well known that adaptation of fish surrounding marine environment is controlled by important physical, chemical and biological factors. The pelagic inhabitants of the surface layer of the sea up to a maximum depth of 200 m are highly migratory. Most of them attain maturity over short periods of time and breed almost throughout the year. Their availability, which shows large-scale fluctuations from year to year, very much depends on the changes in the prevailing environmental conditions, which ultimately decides the success of spawning activity, mortality of eggs and larvae, recruitment to the fishery, availability of suitable food for further growth and migrations. On the other hand, the demersals which are found near the sea bottom are resident in nature and hence they become highly vulnerable to fishing activities undertaken at the bottom levels of the sea, takes longer time to attain maturity, and breeding occurs during specific seasons except those found in the shallow coastal belt.

Many pelagic species are known to concentrate at current boundaries especially in areas with sharp horizontal temperature gradients. The availability of preferred food is an important factor that controls their occurrence, abundance and migration in the sea. Monitoring the physical, chemical and biological parameters in space and time is time consuming and prohibitively expensive. Indirect method of monitoring selected parameters such as sea surface temperature and phytoplankton pigments (chlorophyll *a*) at sea surface from satellites is found very ideal as it provides high repetivity and large spatial coverage making available a real-time picture of any one of these parameters or a combination of more than one parameter.

Fishing vessels engaged in pelagic fishing activities such as purseseining and ringseining spend time searching for fishable concentrations (shoals) which very often lead to wastage of fuel and valuable human effort. In this context, the possibilities of bringing down the searching time of pelagic shoaling fishes, which constitute more than 55% of the total marine fish landings, assume special significance.

Potential Fishing Zone advisories (PFZ)

In India potential fishing zone forecasts began in the late eighties at NRSA using NOAA-AVHRR derived sea surface temperature data. In the beginning, SST imageries were utilized by Dr. Nath at NRSA to estimate the fish catches in the Arabian Sea. An integrated approach was developed by Dr. Solanki at SAC using IRS-P4-OCM derived chlorophyll concentrations and AVHRR-derived SST for locating PFZ. Dr. Shylesh Nayak and group from SAC attempted to understand the impact of PFZ on the fishermen community along the Gujarat coast. Subsequently analysis of satellite derived chlorophyll and SST features by Dr. Solanki indicated close coupling between biological and physical parameters. Way back in 1996, Dr. Pillai and group at CMFRI established the usefulness of PFZ advisories for locating pelagic fish concentrations based on validation along the Kerala coast. The PFZ forecasting technique was transferred to INCOIS, Hyderabad in the year 2000 under the leadership of Dr. Radhakrishnan who continued as Director of INCOIS till 2006. Dr. Shylesh Nayak took over as Director of INCOIS since then. On the basis of response received from fishermen societies/associations, individual fishermen, and qualitative discussions with institutions and communities, an effective assessment of PFZ penetration status and feedback has been attempted by INCOIS in the year 2001 and recommendations for new directions were implemented in stages.

INCOIS disseminates PFZ maps to about 225 FAX/Telephone based modes in nine local languages free of cost for operational use thrice a week on cloud free days throughout the year except during the total fishing ban period. More than 20 electronic display boards are operational in major fishing harbours in partnership with industry. PFZ use awareness workshops and training programmes are conducted at periodic intervals at major landing centers in Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and the island territory of Lakshadweep for the benefit of active fishermen who have volunteered to accept the forecast to improve their fish catch and reduce the searching time for shoaling fishes. PFZ advisory generated by INCOIS is the only short-term marine fishery forecast now available in the country for the benefit of artisanal, motorized and small-mechanized sector fishermen.

Validation of PFZ advisories among user communities based on feedback received from different types of vessels and fishing operations aiming at a quantitative estimation of advantages derived in terms of increase in fish catches as well as saving on valuable fuel oil/ human effort through reduction in searching time for shoaling fishes has been achieved through the commissioning of research project under the leadership of eminent marine biologist/marine fishery experts in the maritime states of Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Orissa.

Studies undertaken by Project Leaders in the different maritime states revealed the following:

1. PFZ advisories generated from satellite retrieved SST and chlorophyll were found to be good indicators of the availability as well as abundance of pelagic fishes such as sardines, mackerel, anchovies, tunas, carangids etc.
2. They are found more beneficial to artisanal, motorized and small mechanized sector fishermen engaged in pelagic fishing activities such as purseseining, ringseining, gillnetting etc who could generally locate fishable concentrations of highly migratory pelagic species there by reducing fuel costs and in turn the overall cost of operations.
3. PFZ advisories derived from satellite retrieved chlorophyll data were found more advantageous for locating sardine shoals, which are herbivorous in nature with feeding preference for phytoplankton.
4. PFZ advisories derived from satellite retrieved SST data were found more advantageous for locating mackerel, tuna, carangid and anchovy shoals which exhibit feeding preference for zooplankton including small sized fin fishes and shell fishes.

SST based imageries were also found useful for locating concentration of juvenile yellow fin tuna (popularly known as “Kera”). The large sized adult fish is oceanic in habitat, but the juveniles migrate to shallow coastal waters in search of preferred food, which is seasonal.

5. There are instances when mature mackerel gets caught in bottom trawling gear during daytime in summer when they exhibit diurnal vertical migration. On similar occasions PFZ advisories based on satellite retrieved SST data are good indicators of the availability of mackerel at surface levels during nighttime and bottom levels during daytime at the same locality.

Conclusions

The availability of fishable concentrations of pelagic shoaling fishes in Potential Fishing Zones is mainly dependent on the following factors:

1. The time lag between satellite data retrieval and the actual time of fishing activity: since the characteristics of the thermal front as well as surface chlorophyll concentrations are likely to change through horizontal/ vertical circulation processes active in the sea.
2. The fishing method adopted and the time at which fishing activity is undertaken: The top/bottom depth of the thermocline is a major factor, which controls the effectiveness of purseseining/

ringseining operations. Unless the fishing gear has a vertical hanging that extends beyond the depth of the main thermocline, depending on the time of activity, a certain portion of the fish shoal is likely to escape through the bottom before the gear is pursed. This is especially so in the case of tuna and mackerel shoals which are very much influenced by changes in seawater temperature.

3. Type of fish targeted: depending on the behaviour of individual species in relation to the variations in sun light intensity, sea water temperature, salinity, dissolved oxygen demands, feeding habits/feeding preferences and breeding habits, suitable fishing method has to be adopted for catching different species.

A modest computation of quantitative advantages derived through the use of PFZ advisories along Kerala coast varied between Rs. 1.56 lakhs and 6 lakhs for different types of fishing vessels (9.9 HP to 106 HP) for a six-month period when PFZ advisories are utilized by the vessel.

In general, sardine and anchovy shoals are found near to the coast within a distance of 10-20 km whereas mackerel, coastal tuna and carangid shoals are normally found beyond 20 km. The comparatively higher unit returns to a certain extent compensate the extra cost of fuel. In the case of multi-day fishing activities (as in the case of purseseiners operated along Karnataka, Goa and Maharashtra coast), the economics of operations will improve greatly as the vessel does not return to the base everyday, thereby saving fuel. The fish catch can be brought to shore periodically by carrier boats should the total catch exceeds the frozen storage capacity of the mother vessel.

In all cases where the fishing activity is targeted at a migratory pelagic resource, the PFZ advisory definitely provides an advantage in terms of reduction in searching time, consumption of fuel oil and human effort, thereby bringing down the overall cost of fishing operations.

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