LARGE MARINE ECOSYSTEMS :

EXPLORATION AND EXPLOITATION FOR SUSTAINABLE DEVELOPMENT AND CONSERVATION ON FISH STOCKS

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APPLICATION OF REMOTE SENSING TECHNIQUES FOR LOCATING PELAGIC FISH CONCENTRATIONS ALONG THE KERALA COAST (SW COAST OF INDIA) AND MINICOY WATERS

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ABSTRACT

Intensive validation programme on Potential Fishing Zone (PFZ) forecasts carried out by the MARSIS Centre of Central Marine Fisheries Research Institute, Cochin, at 17 selected fish landing centres along the Kerala coast and around Minicoy Island between November 1995 and May 1997 revealed positive relationship between PFZ and occurrence / abundance of commercially important pelagic fishes. An attempt is made to identify possible reasons for the above, based on results of oceanographic investigations undertaken in the area and also taking into consideration their behaviour in relation to environment based on past data. Future plans for evolving a suitable prediction system for commercially important pelagic fisheries in the coastal waters of the mainland and skipjack tuna fishery in the Lakshadweep Islands based on PFZ forecasts are also discussed in view of its importance to the artisanal and small mechanised sector fishermen for reducing the searching time and thereby effecting an overall reduction in the cost of fishing operations.

Introduction

Tropical marine fisheries are essentially multispecies and multigear in their characteristics. Tropical fish stocks are distinctly different from their temperate counterparts in their behaviour, migration, food and feeding habits, reproduction, recruitment, growth and mortality. Central Marine Fisheries Research Institute (CMFRI) under Indian Council of Agricultural Research has been actively collaborating with the Department of Space and the Department of

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The marine fish landing in India was provisionally estimated at 2.26 million t during 1995 (CMFRI Annual Report - 1995-96). A decrease of 3.9% (92,000 t) was observed over the estimate for the previous year. Pelagic groups contributed 48.5% and demersal groups 51.5%. Among the major groups, reduced landings were observed in mackerel (29,000 t), ribbon fishes (39,000 t), croakers (28,000 t) and Bombay duck (17,000 t). During the previous year a declining trend was noticed in the landings of oil sardine (49,000 t), white bait (12,000 t) and mackerel (45,000 t). The marine fish landings along the south-west coast of India has shown a decline of 67,000 t during 1995 over those of 1994. Major contributors to the decline were mackerel by 42,000 t, ribbon fishes by 18,000 t, perches by 14,000 t and croakers by 7,000 t. The estimates for tunnies was 13,000 t with a reduction of 4,000 t compared to previous year.

Under the Marine Satellite Information Service (MARSIS) Programme was initiated by the Department of Ocean Development. The main objectives have been to develop operational remote sensing capabilities for extraction of coastal zone and oceanic parameters and providing data to downstream users. Models are to be developed for simulation and prediction of oceanic processes. During the first phase of the programme, which was completed in March, 1993 operational products of Sea Surface Temperature (SST) data sets, Potential Fishing Zone (PFZ) advisories and coastal maps of Kerala and Tamil Nadu states have been generated and disseminated. Effective sea truth data was collected through ship cruises and drifting and moored buoys. In the second phase, which is under progress, operational services such as SST and PFZ advisories have been further strengthened.

Studies conducted both within the country and abroad have revealed that, sea water temperature, dissolved oxygen content, salinity, phytoplankton and zooplankton concentrations play an important role in the distribution and abundance of fishery resources, especially the pelagic resources. PFZ advisories are being generated by the National Remote Sensing Agency, Hyderabad, twice a week to over 160 centres all along the Indian coast based on the images of sea surface temperature. Validation campaign are regularly undertaken to enhance the accuracy, format and dissemination aspects. PFZ awareness/training programmes are regularly conducted at various fish landing centres. Institutions such as CMFRI, FSI and ORSAC and State Fisheries Departments are being associated for validation. The CMFRI has taken up a special programme for the intensive collection of marine fish catch data on exploited fishery resources in relation to PFZ forecasts. Even though the dissemination of PFZ forecasts to

groups of active fishermen and obtaining feedback from the same groups was taken up on a priority basis since the beginning of 1993, especially along the Kerala coast, the response was comparatively poor till 1995 mainly because of the fact that, the fishermen were not convinced about the usefulness of the information provided to them through the PFZ forecasts.

Data and methods

Since 1995, the MARSIS Centre of CMFRI, Cochin organized an intensive dissemination and feedback data collection programme based on PFZ advisories received from NRSA at a total of 17 selected landing centres along the Kerala coast (between November 1995 and May 1996 and also between November 1996 and May 1997) and around Minicoy Island (Lakshadweep) (between November 1996 and May 1997). The forecasts received were translated into local language and passed on to groups of active fishermen at these centres. Arrangements were made through the local daily "Malayala Manorama" to publish this information twice a week immediately in receipt of the advisories from NRSA for the benefit of Kerala fishermen. At Cochin Fisheries Harbour, a writing board of suitable size was installed wherein the salient features of each forecast was written in the local language. The information was also broadcast through the AIR services at Cochin on the same day evening. The above mentioned fish landing centres were selected for the campaign mainly based on the positive response received from active fishermen groups operating from these centres.

The feedback information with details of craft, fishing methodology adopted, fishing gear employed, fishing effort expended, haul-wise and species-wise fish catch, location of fishing activity along with depth, distance from the coast and bearing were collected from the same group of fishermen on their return from fishing activity. Detailed analysis and processing of the basic data was undertaken at the MARSIS Centre against individual PFZ forecast and the results of validation were passed on to NRSA immediately.

The required sea truth was collected onboard the DOD vessel **FORV Sagar Sampada** by occupying fixed oceanographic stations representing one degree square during the pre-monsoon, south-west monsoon and post-monsoon seasons.

Results and discussion

It is well known that, the adaptation of fish to the surrounding marine environment is controlled by various physico-chemical and biological parameters. Fishes are known to react to changes in environmental conditions and migrate to areas where favourable environmental conditions in terms of sea surface temperature, dissolved oxygen levels and salinity exist. Availability of food is an important factor, which controls their occurrence, abundance and migration. Sea surface temperature is the most easily observed environmental parameter and is quite often correlated with availability of fish, especially pelagic fishes. Squire (1982) found that many oceanic pelagic species concentrate at current boundaries especially in areas with sharp horizontal temperature gradient. Laurs *et.al.* (1984) found higher catch rates in the vicinity of temperature fronts sometimes extending up to 100 km offshore from the boundaries of the front.

The European Commission Fisheries Report published by the Nansen Centre provides an excellent review of the successful use of satellite-based observations in fisheries applications. Fiuza (1990) has discussed the application of satellite remote sensing to fisheries. In Portugal the SATOCEAN Project has since 1989 been providing operational service to the Portuguese tuna and swordfish fishermen (Santos and Fiuza, 1992), wherein, fishermen are provided with charts with location of thermal fronts and isotherms derived from AVHRR data.

The salient results of PFZ validation undertaken by CMFRI, MARSIS Centre at the above mentioned 17 landing centres along the Kerala coast and those around Minicoy Island between November 1995 and May 1996 and also between November 1996 and May 1997 are summarised below :

(a) Positive relationship between PFZ resulting out of comparatively high gradients of SST (2C and above) and fishable concentrations of commercially important fishes was found only in respect of pelagic and column fishing activities such as purse seining, gill netting, trolling, and tuna pole and line fishing (around Minicoy Island). In the case of bottom trawling activity, the relationship was found to be negligible or nil during the same period.

In catches by purse seine, the average fish catch/boat varied between 4,480 and 3,200 kg for PFZ and non-PFZ respectively at Cochin Fisheries Harbour landing centre during the month of November, when maximum number of purse seine boats were operating off Cochin. In the case of gill netting, it varied from 480 to 187 kg for the same month. For tuna pole and

line fishing for skipjack tuna around Minicoy Island the average catch/boat varied from 83 to 28 kg for PFZ and non-PFZ areas respectively.

An average increase in catches of 40% for purse seining and 260% for gill netting was observed in the PFZ along Kerala coast. Around Minicoy Island, an average increase of 300% in skipjack tuna catches for pole and line fishing activity was observed in the Potential Fishing Zones.

Between end of February and May, with the coastal waters getting heated up to greater vertical extent caused by summer heating and with the disappearance of high gradients of SST from the area under study, many of the commercially important pelagic shoaling fishes like oil sardine (*Sardinella longiceps*), mackerel (*Rastrelliger kanagurta*) and tunas remained in comparatively deeper waters thereby getting themselves caught in bottom trawling gear which cannot be interpreted as any kind of relationship between sea surface temperature and demersal fish. However, Sloggett *et.al.* (1995) observed that, demersal fish are equally likely to thrive at zones of high pelagic production, since their benthic food resources are directly enhanced by the high primary production in the euphotic zone.

(b) The sea truth data collected onboard **FORV Sagar Sampada** during different seasons in the area under study clearly revealed factors, which contributed towards the formation of high gradients of SST (2°C or more) characteristic of the months, November, December and January along the Kerala coast and around Minicoy Island. The Presence of comparatively strong surface currents caused by the prevailing NE monsoon (winter monsoon) in the SE Arabian Sea which carried comparatively warmer equatorial waters towards northern latitudes would have resulted in comparatively high thermal gradients in the area under study. The SST in this area during November-January is comparatively low resulting mainly out of winter cooling. When comparatively warmer waters were carried northward through the winter monsoon circulation, it resulted in strong temperature gradients at surface levels in the SE Arabian Sea. This is especially so in the island territories of Maldives and Lakshadweep.

The northerly current became weak and slowly died out during January-February resulting in medium to low thermal gradients in the locality between February and May. Exceptions were mostly found on the windward side of oceanic islands (Maldives and Lakshadweep) where the divergence would have resulted in the formation of comparatively high gradients of temperature. This is clearly revealed from the maps of potential fishing

zones brought out by NRSA between November and May, the period during which the cloud cover was comparatively minimum.

(c) Seasonal variations are characteristic of the thermocline in the eastern Arabian Sea bordering the Indian subcontinent. In the southeastern Arabian Sea, the top of the thermocline is deepest between November and April (80-130 m) and shallowest between July and September (10-30 m). During the southwest monsoon season in areas of strong upwelling activity, the thermocline reaches the very surface.

Considering the presence of a well-defined seasonal thermocline, which exhibits a periodic up and down movement, the correlation of SST with occurrence / abundance of pelagic fish is possible within a reasonable limit. Correlation of SST with the occurrence/abundance of demersal fish should be attempted with caution since many of the commercially important demersal fish are known to be stenothermal, not capable of tolerating wide variations in sea water temperature. They are also known to occur below the seasonal thermocline.

(d) An organized tuna pole and line fishery using live bait is practiced from small sized mechanized boats around Lakshadweep Islands. During 1996-97, 558.5 t of tuna was landed in the Island territory of which 490.8 t was constituted of skipjack tuna (*Katsuwonus pelamis*). The fishery showed a drastic reduction when compared to the previous year when the total catch of tuna was 1541.2 t of which 1299.9 t was comprised of skipjack tuna. It was also observed that during 1995-96 the fishery was fairly good except total failure for the months, November and January.

Rao and Jayaraman (1966) reported upwelling around Minicoy Island due to divergence in the vicinity of the island during late November and suggested that the phenomenon may have considerable impact on the peak tuna landings in the region between December and March. Pillai and Perumal (1975) observed that surface currents which head toward the island of Agatti in December on its southern tip diverge into two branches, one on the eastern side and the other on the western side. The comparatively low temperature and high salinity waters found at surface levels on the southern side of the island indicated presence of upwelled water. According to them the concentration of skipjack tuna shoals on the southern side may perhaps indicate a possible relationship between skipjack tuna and upwelling zones. It is well known that tuna gather around areas of upwelling and areas where the thermocline is shallower (Nakagome, 1973). Uda and Nakamura (1973) have observed the region of maximum hooking rate localised either in the

marginal area, water boundaries or along oceanic fronts. According to Pillai and Perumal (1975), it seems quite likely that the divergence zone which leads to a favourable environment is shifting from one area to another depending on the direction and velocity of prevailing currents, geographical local of the islands, bottom topography of the atolls etc. They have also opined that probable fishing areas for skipjack tuna in Lakshadweep waters could be predicted sufficiently in advance by keeping a constant watch on the formation and shifting of divergence zones around the islands during the period September-April, the season for skipjack tuna fishery.

Thermal boundaries, diverging currents and the phenomenon of upwelling can be observed by monitoring various hydrographic parameters such as direction and velocity of currents, sea water temperature, salinity and dissolved oxygen content (both in the horizontal and vertical plane) in space and time. Unless continuous monitoring of these parameters is carried out in and around all these islands using research vessel facilities, one may not be able to draw conclusions with regard to the occurrence, continuance/shifting of the above mentioned phenomenon. Such surveys are time consuming and expensive in view of the vessel facility requirement. Silas and Pillai (1982) indicated possibilities of utilizing satellite imageries for locating oceanic features such as ocean temperature, chlorophyll distribution, current boundaries, slicks and ocean fronts to understand likely areas of concentration of tunas, especially skipjack and yellowfin tunas. The PFZ advisories being brought out by NRSA Hyderabad clearly gave indications of the presence of thermal boundaries originating out of divergences and resultant upwelling, current boundaries etc. These maps have the added advantage of real time coverage of the entire island territory. Skipjack tuna fishery being pelagic in nature, mainly employing a single fishing method namely tuna pole and line, is expected to give better correlation with PFZ advisories generated from sea surface temperature data provided by satellite imageries. Evolving a suitable prediction system will help the fishermen of the island to reduce the searching time for skipjack tuna shoals and thereby effect an overall reduction in the cost of operation of tuna pole and line fishing vessels.

Discussion

Positive relationship between PFZ and fishable concentrations of commercially important fishes were found in respect of pelagic and column-fishing activity such as purse-seining, gill netting and tuna pole and line fishing. In the case of bottom trawling activity, the relationship was found to be

negligible or nil. An average increase in catches of 40% for purse-seining and 260% for gill netting was observed in the Potential Fishing Zones along Kerala coast. Around Minicoy Island, an average increase of 300% in Skipjack tuna catches for pole and line fishing activity was observed in the Potential Fishing Zones.

Considering large scale fluctuations observed in the availability of fishable concentrations of some of the commercially important pelagic/column fishes like oil sardine, mackerel and tunas from year to year and the high cost of fuel and human effort, it is very important that the searching time for the pelagic shoaling fishes is reduced to the possible extent. This is especially so in the case of small mechanized sector, also the artisanal sector and above all the Island fishermen engaged in tuna pole and line fishing activity. Potential Fishing Zone advisories do provide information pertaining to possible areas of fish concentrations in respect of pelagic/column fishing activity. Being a short-term fishery forecast the PFZ advisories have to reach the active fishermen by the quickest possible means. The acceptance/adoption of the technology would, certainly to a large extent, depend on the usefulness of the information for the end user to be proved in terms of higher fish catches and also an overall reduction in searching time and resultant saving in the cost of fishing operations.

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