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Impact of Climate Change on Indian Marine Fisheries

Lecture Notes

Part 2

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APPLICATION OF REMOTE SENSING IN FISHERIES

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Introduction

Satellite oceanic remote sensing is now playing a very important role in India for fishery forecasting, research and management by providing synoptic oceanic measurements. These can be used for evaluating environmental effects, which ultimately affects the abundance and availability of fish populations. Indian seas, which have a coastline of 8118 km, an EEZ area of 2.02 million sq. km and a shelf area of 0.53 million sq. km (Anon, 2002), have multi species composition. It is a well known fact that changes in ocean conditions greatly influence the natural fluctuations of fish stocks. Hence the information on variations in ocean conditions is necessary to understand the influence they cause on fish stocks and their distribution. This knowledge will immensely help in formulating the best fishery management strategies and developing efficient harvesting methods for fishery resources.

Many of the physical features in the ocean such as changes in temperature, wind speed upwelling and eddies directly affect the productivity of the ocean. Due to these changes, particular area in the ocean is richer in nutrients and phytoplankton. Aggregation of fishes of all levels in food chain is usually observed in areas of high productivity. Banse and Macclain (1986) reported that seasonal reversing of winds in the Arabian Sea results in large-scale change in SST (Sea Surface Temperature) bringing the nutrients to euphotic zone. Hence there is an urgent need in understanding the influence of ocean variability on fishery resources for timely prediction of productive fishing grounds. The data pertaining to ocean variability can be obtained by collecting sea truth data with the help of vessels by placing equipments attached to buoys, but data thus collected are on smaller scales, discontinuous and restricted to the time when ships can cover the area of interest. Remote sensing is one of the most effective means for acquiring data as a vast area of ocean can be covered in a single day. It is possible to have a synoptic look at the ocean processes at the shortest possible time.

Fishermen have always been concerned about making the best catch for the amount of time expended in the search of productive fishing grounds and due to the sharp increase in the cost of fuel commercial fishing in deeper waters is becoming economically risky business. To ensure profit by reducing the scouting for productive areas and good catches, it has become necessary to utilize available technological and scientific tools like remote sensing.

Remote sensing is not entirely new to fishery scientist or to fishermen harvesting living marine resources. Traditional fishermen from ages have been using visual form of remote sensing using crow’s nests on ships, hot-air balloons, and aircrafts. The sensor often used has been the naked eye usually aided by binoculars or telescopes. The use of helicopters operating from modern Tuna Purse Seiners fishing on the high seas is common. In addition, aircraft carrying instruments for making oceanographic measurements have been used for supporting fisheries research studies for locating areas favorable for fishing and for locating shoals of fishes. The most successful among all the tools is satellite remote sensing in which a satellite fitted with sensor is used for viewing the ocean. The success is mainly because of its ability to cover vast area of ocean in the minimum possible time.

Evolution of satellite remote sensing

The use of satellite remote sensing in oceanography started in early 1970s, and expanded considerably in the late 1970s. The satellite with dedicated oceanographic sensors was first launched in 1978 (Laurs and Bucks, 1984).

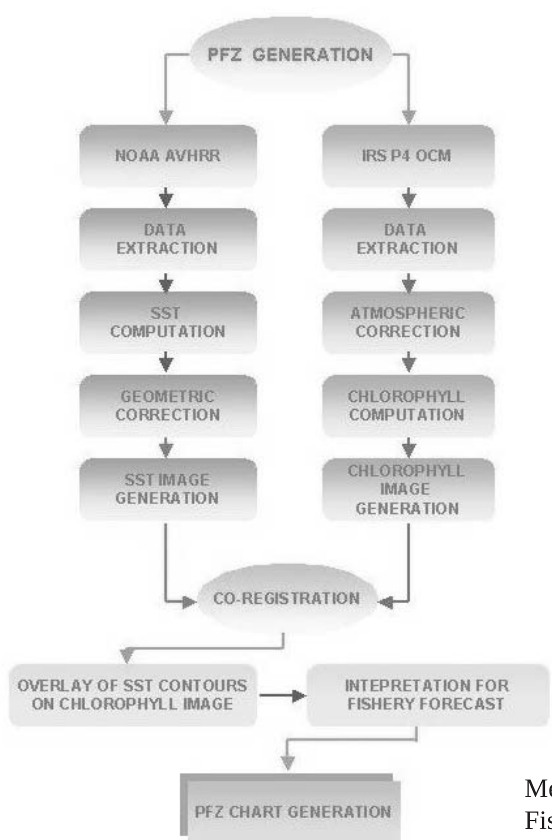
The Indian Remote Sensing Satellite Missions started as early as 1979 with the launch of Bhaskara-1. Subsequently, Bhaskara-2 was launched in 1981. Their payload consisted with TV cameras and radiometers. The first generation remote sensing satellites is IRS-IA. Linear imaging self-scanning sensors was launched in 1988. To meet the growing demand of ocean related information, the need for utilizing space borne remote sensing techniques for ocean related applications IRS-P4 was launched in 1999. This is the first operational ocean remote sensing satellite containing two sensors. The first sensor is Ocean Colour Monitor (OCM), with eight spectral bands having revisit capability of two days. The second sensor is Multi-frequency Scanning Micrometer Radiometer (MSMR), operating with four frequencies with global coverage capability.

OCM is an 8-channel payload in the visible and near infrared frequencies of the electromagnetic spectrum. The radiometric resolution of the sensor is 12 bits. The field view of the optics is plus or minus 43? providing a swath of 1420 km from 720 km altitude. The resolution of the sensor is 360 m (Anon, 1999).

The Department of Space started its initial study on remote sensing of the marine resources using the Advanced Very High Resolution Radiometer (AVHRR) data of National Oceanic and Atmospheric Administration (NOAA) satellite by late 70s. This research activity continued for over a decade. The knowledge thus acquired has resulted in designing Ocean Colour Monitor (OCM) sensor for IRS P4 and algorithms for our tropical seas. This sensor is capable of retrieving chlorophyll intensity using its '8 wavelength bands. The second sensor on board IRS P4 is Multi-frequency Scanning Microwave Radiometer (MSMR), which is capable of retrieving sea surface temperature and sea surface winds that could give information on the wave patterns using the 8 channels.

Applications of remote sensing in fisheries

The remote sensing sensors lodged on many of the remote sensing systems carried by spacecraft have in adequate resolution capabilities for directly detecting fish shoals. Hence it has become necessary to understand and examine all those oceanographic parameters that can be measured by space borne sensors. These parameters can in turn be used in understanding the movement and behavior of fishery resource and thus predicting the potential zones of their aggregation. In this series an array of sensors have evolved giving data like satellite infrared thermal data, scatterometer wind stress measurements (SASS), Ocean colour scanner measurements which includes integrated chlorophyll data from IRS P4. The use of satellite data all over the world demonstrates that satellite oceanic remote sensing can be important tool in fisheries research. The various types of satellite remote sensing data useful for fisheries are described as under:



Methodology involved in generation of Potential Fishing Zone (Courtesy: SAC, Ahmedabad)

Ocean colour data

The potential of using space data for acquiring ocean-colour data from space was first demonstrated by Kemmerer *et al*. (1974). In this study ocean colour measurement from Landsat were used to predict areas of high probability of occurrence of menhaden in the Gulf of Mexico. Ocean colour measurements for locating ocean fronts, their effluence and circulation patterns, and quantitative determination of ocean colour that can then be directly related to chlorophyll concentration and identification of different water masses are generally used in fisheries resource applications.

The satellite images and concurrent albacore catch data examined by Laurs and Bucks (1984) clearly demonstrate that the distribution and availability of albacore are related to ocean fronts. Shannon *et al*. (1983) predicted that the information available on chlorophyll gradients along with the thermal fronts could be possibly used for powerful management tool for fisheries purposes.

In India, the Sea Surface Temperature (SST) is being used for PFZ identification for over a decade. Chaturvedi *et al*. (2000) attempted to establish inter-relationship between satellite-derived chlorophyll (SeaWiFS images) and temperature profile data collected from survey vessels during 1997-98. The constraint in Indian waters was narrow temperature ranges, which could not be always linked to aggregation and availability of fishes. There was now a need for identifying another parameter that could be linked to temperature gradient. Ocean colour information effectively filled in this lacuna. Ocean colour indicates the surface productivity of the ocean. Other processes such as temperature gradient, wind direction etc would help understanding the feature much better. Presently synchronous IRS-P4 OCM and NOAA-AVHRR SST data is used for the identification of PFZ (Solanki *et al*. 2000). The fishery and oceanographic data collected by ship's cruises are being used for the forecast validation.

The features for PFZ selection are indicated taking into consideration the extent of the area, magnitude gradient, shape of the front, possibility for its persistence and operational constraints. Divergent fronts, eddies and meanders are indications of the ongoing oceanic processes resulting in high productivity in that area; which are possible PFZs. The advanced phase of productivity is indicated as chlorophyll features and probably in SST image and also as follows (Somvanshi, 2002):

i. Strong gradients;

ii. Persistence;

iii. Features seen on both colour and SST image;

iv. In the case of upwelling stabilization phase;

v. Centre of the core ring;

vi. Edges of the warm core ring;

vii. Anticyclone eddy;

viii. Cyclonic eddy;

ix. Fishing limits; and

x. Vessel position in case of survey vessels.

The satellite infrared thermal data is being used very effectively for fisheries research in many countries (Laurs and Bucks, 1984). The data is used to define marine habitats of fishery resources using satellite data, which are collected contemporaneously with fishery/biological data and ground truth measurements gathered by research and fishing vessels. It also describes and explains variability in circulation and water mass distributions using satellite data alone or in conjunction with physical oceanographic measurements, with a view toward understanding the influence of ocean variability on fishery resources and fishing grounds.

Brucks *et al* (1984) conducted a case study using SeaSat-A Satellite Scatterometer (SASS) with wind data to establish, quantify, and document the extent of variability of wind-induced ocean flow indices on surface-layer transport. Knowledge of surface-layer transport is important because dispersal mechanisms control the distribution of early life stages and thereby influence the recruitment and future harvest of marine organisms with planktonic life stages.

In the modern days commercial fishing has become increasingly competitive and economically risky business. Although the use of satellite imagery in the preparation of fishery forecasting has been limited, it has the potential to contribute significantly in meeting the increased needs of fishermen. To ensure profits and for judicious exploitation of resources the following satellite products are available which the fishermen can utilize.

Chart showing the location of thermal boundaries derived from satellite infrared imagery can be provided to commercial and recreational fishermen for use of locating potential fishing areas.

Ocean colour charts

The fishermen used the colour boundary charts to locate colour gradients or break which are important in determining potentially productive fishing areas. Integrated chart with chlorophyll and SST can also be used.

CIFT and ocean colour charts

CIFT and SAC (Space Application Centre, Ahmedabad) were involved in a collaborative project in validating the IRS P4 OCM integrated chlorophyll images with the actual sea truth data. The analysis was carried out in three phases. In the first phase the data collected from boats operating off Munambam, Kerala from February to May 2000 was analyzed. The data collected by departmental vessel *Sagarkripa* was analyzed for the second phase in 12 voyages during September to December 2000. For the third phase the data analyzed was collected from the mechanized boats engaged in demersal trawling operating from Veraval port, Gujarat. These vessels were mainly engaged in voyage fishing during November 2000 to January 2002.

During the second week of January 2002, poor catches were reported from deeper waters off Veraval. On analyzing the data with the chlorophyll image of 11th January it is seen that the stations are in the areas with very low chlorophyll concentration (Fig. 1).

During 19 to 24 January 2002, 70 trawlers from Veraval fished in the deeper waters off Dwaraka and landed one tonne each of big eye (*Priacanthus hamrur*). It is observed that the station falls on the edge of a strong gradient when plotted on images of 19, 21 and 23 January 2002 (Fig. 2). In the analysis it is observed the good catches from commercial vessels coincided with the gradients or breaks seen in the integrated chlorophyll images.

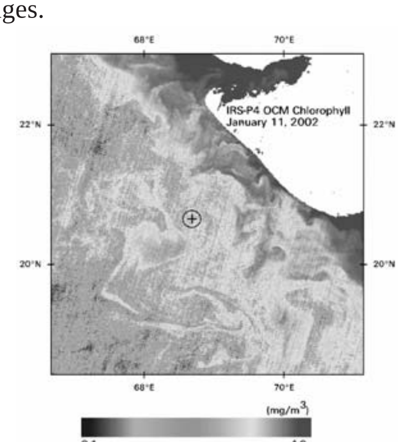


Fig. 1. Integrated chlorophyll images of IRS P4 coinciding with lean catches

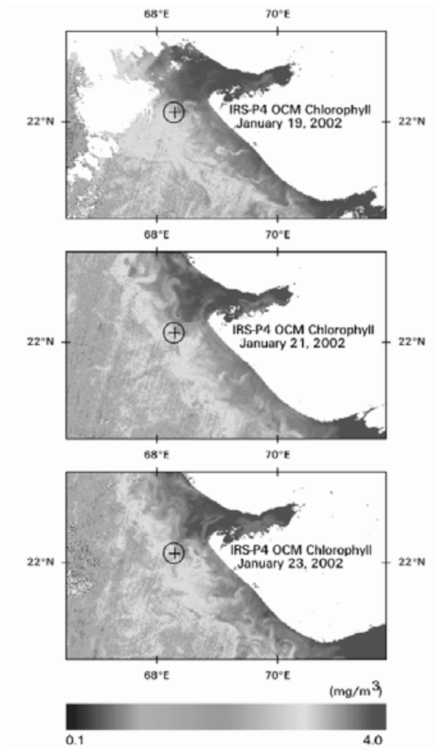


Fig. 2 Sequential integrated chlorophyll images of IRS P4 showing good catches falling at strong gradient or breaks

Use of remote sensing for aquaculture

The aquaculture industry is growing rapidly worldwide and represents an increasingly important source of high value seafood. Most aquaculture activities depend on maintenance of high environmental quality and on routine monitoring of that quality for operational purposes. At the same time there is a concern about effect of aquaculture on water quality and adjacent ecosystem. Ocean colour products can potentially meet operational and conservation and monitoring needs cost effectively, with spatial and temporal coverage unachievable by any other method. The space scales associated with aquaculture application are generally small, requiring special resolution of 100m or better for water quality, 30m or better for benthic habitat (Parslow *et al.* 2000).

Brackishwater aquaculture has tremendous potential due to ever increasing demand of prawns. In India the aquaculture development started with essentially to provide employment in rural coastal area as well as to increase the export to different developing countries. Remote sensing provides information on these aspects due to its repetitive and multi spectral director and synoptic view. In India IRS LISS II data was utilized to prepare postal and use maps on 1:50,000 scale along the Indian coast showing wetland features between high and low water lines and land used for features of the adjoining shore as major element in site selection for brackish water aquaculture (Naik, 2001).

Advantages of remote sensing technology

Application of remote sensing technology helps the fishermen to reduce the scouting time for locating potential fishing zones, thus reducing total fishing time and intake of fuel. This knowledge gathered through remote sensing could be used to provide best possible advice in making fishery management decisions and to develop efficient harvesting strategies for fishery resources and also it is the best way of understanding primary productivity of ocean at a given time. This data can be used for assessment of fish stocks. The satellite data could give information on weather ensuring greater safety for the men out at sea.

Future issues

In evolving the applications and in achieving the precision and perfection in forecasting the PFZ, the following issues need to be addressed:

- The data generated should be disseminated to the fishermen in minimum possible time. A strong network of communication systems has to be developed so that the knowledge of PFZ reaches fishermen in minimum possible time.
- Most of the time in SW coast is with cloud cover. The clouds block the sensors visibility; hence forecasts are not clear this period.
- For using of PFZ for benthic trawling the time lag for aggregation of benthic resources needs to be understood based on the depth of the break or the gradient.
- To examine how various substances and optical processes influence the colour of coastal waters.
- To identify the requirements like review algorithms for remote sensing of coastal waters
- Effects of environmental parameters on the fishery resources need to be studied and co-related with fish aggregation.

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