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P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

# POTENTIAL APPLICATIONS OF SATELLITE REMOTE SENSING TECHNIQUE IN OCEANOGRAPHY AND FISHERIES

P. V. R. Nair. V. K. Pillai and V. K. Balachandran
*Central Marine Fisheries Research Institute, Cochin*

A wide range of data collection can be achieved by remote sensing in oceanography and fisheries which by conventional ship-board observation would take considerable time and effort. IRS 1 (Indian Remote Sensing Satellite 1), expected to be launched this year by ISRO, will form the first of a series of operational remote-sensing satellites in resources survey. The Joint Experiments Programme (JEP) for the development of suitable sensors in marine fisheries, organised by ISRO in collaboration with CMFRI and FSI, enabled the development of suitable sensors in the estimation of chlorophyll and bioproductivity. In addition to the IRS Utilization Programme, SPOT, LANDSAT MSS and TM data also will be available for this. The major thrust from these studies will be on the structure and synoptic variability of oceanic fronts, observations on eddies, their formation and evolution, internal waves through panoramic images, precipitation intensity in oceanic areas, ocean currents by drifting buoys with transponders and distribution pattern of chlorophyll in coastal waters by means of differential spectra analysis of radiance. These parameters can provide considerable information to aid in forecasting, exploitation and management of fisheries which have been discussed in this account.

## INTRODUCTION

Remote sensing is emerging as a major application of space technology for the survey and management of natural resources. The entire band of the electro-magnetic spectrum is selectively used to study the surface of the earth and the oceans. Radiations from the target areas are received by suitable sensors in aircraft and satellites and the data are transmitted back to ground stations. Modern data interpretation techniques are then employed in conjunction with sample 'ground truth' or 'sea truth' data to generate a variety of important information required by resource scientists, planners and administrators.

Ocean colour represents mean distribution of radiant energy as a function of wave length. It is well known that the oligotrophic waters are blue and eutrophic waters are green in colour. It is now possible to measure this colour by remote sensing technique. The concept of using radiance ratios for various wavelengths in remote sensing application of ocean colour has thus been well-established.

The use of remotely sensed data in coastal and marine studies was initiated in India sometime around mid-seventies, with the availability of landsat data and also, aerial panchromatic and other types of cameras. The early studies dealt largely with coastal zone aspects such as shoreline change mechanisms at major river deltas, wetland monitoring etc. Another area of marine application that was receiving attention was fisheries.

The application of remote sensing technique for marine fisheries research in India is comparatively of recent origin. However, the erstwhile UNDP pelagic project, in which the scientists of CMFRI were actively involved, had been using aerial survey for observing the distribution and quantification of pelagic resources. But no serious attempt has been made to utilize satellite sensor data in oceanographic and marine fisheries applications until very recently.

In the early eighties a Joint Experiment Programme (JEP) was conceived by ISRO in collaboration with CMFRI and Fishery Survey of India. The major thrust of the work was in the development of suitable sensors for the Indian Remote Sensing Satellite in oceanographic and marine fisheries research. The sea truth data collected during these investigations were codified and presented at a Seminar on Remote Sensing in marine resources held at Cochin in 1985. (Silas *et al.*; 1985; Gopalan and Narain; Narain and Dwivedi; Neera Chaturvedi *et al.*, Dwivedi *et al*, 1985). This seminar mainly dealt with the biological productivity and fishery resources of the Indian waters and the true utilization of LANDSAT-MSS and NIMBUS-7 *CZCS* data in ocean colour sensing and phytoplankton pigment mapping. In addition, the Ocean Colour Radiometer (OCR) commmissioned by the NRSA in collaboration with *DFVIR* of Federal Republic of Germany was used for chlorophyll scanning in experiments in the Arabian Sea in order to establish an algorythm through which chlorophyll, yellow substances and supended sediments could be quantitatively determined (Muralikrishna, 1983). The above investigations have given some insight into the posssibility of remotely sensed data collected from low flying aircraft and through satellites with various sensors in determining the relative variations in the bioproductivity and thereby fish aggregations. The possibility of using IRS data in the coming decades by the Institute (CMFRI) requires an indepth study by a team in order to develop the infrastructure for interpretation and dissemination for the benefit of the industry.

Chapman (1969) has indicated that in marine fisheries resource exploitation, 65% of time is spent as search time, 10% for catching and the balance for travelling to and from the fishing grounds. Hence remote sensor capabilities can have the greatest impact by introducing big improvements in the search time. Some of the properties of the sea that are amenable to remote sensing are sea surface temperature which will make it possible to predict migration of marine fishes and water fronts where fishes tend to aggregate.

*Application potential of IRS systems*

The IRS has two camera systems with sensors in four spectral bands operating between 0.45 to 0.86 microns. The capacities of these bands in terrestrial and marine applications are given in Table 1. Applications to coastal, estuarine and ocean environments as envisaged by ISRO from IRS and LANDSAT- MSS imagery are (1) study of sediment behaviour in estuarine mouth, (2) monitoring littoral processes and effects of the coastal structure, (3) evaluation of suspended matter and (4) nearshore bathymetry (IRS - Data Book DOS - 1986).

TABLE - 1.

*IRS Spectral Bands and Principal Applications*

| Band | Spectral range (microns) | Principal Applications |
|---|---|---|
| 1 | 0.45-0.52 | Sensitivity to sedimentation, deciduous / coniferous forest cover discrimination. |
| 2 | 0.52-0.59 | Green reflectance of healthy vegetation |
| 3 | 0.62-0.68 | Sensitivity to chlorophyll absorption by vegetation, differentiation of soil and geological boundaries. |
| 4 | 0.77-0.86 | Sensitivity to green biomass and moisture in vegetation |

From LANDSAT imagery it has also been possible to monitor pollution by following the plumes of discharging rivers and large seawage outfalls and also plumes of sludges dumped by barges at sea. Besides, interesting biological features such as occurrence of plankton blooms of *Trichodesmium*, have been identified An enhanced False Colour Composite using a combination of band 4 (red), 6 (green) and ratio of 4/5 (blue) was found most useful in distinguishing between areas under algal bloom and suspended sediments (Balachandran, 1985).

*Ocean colour and chlorophyll*

Optical oceanography involving researches on water colour originate from shipboard measurements and theoretical studies. Biooptical classification of the water is expressed in terms of chlorophyll-a concentration or total ceston concentration.

By developing an empirical model it is possible for quantification of chlorophyll contents of the waters using radiance ratios for various wave lengths by MSS scanners of LANDSATS. The NRSA Ocean colour Radiometer built under Indo-German Co-operation has six channels with a spectral band width of 11 nm centred about 445, 525, 550, 600, 700 and 750 nm (Muralikrishna, 1983). Using this spectral data an empirical model was developed for quantification of the chlorophyll content.

The CZCS of the American Satellite NIMBUS-7 enables the discrimination between organic and inorganic materials in water and their quantification to a certain extent. Most extensive measurements were made with CZCS multispectral radiometer in all the seas. Dwivedi *et al.* (1985) used NIMBUS 7 CZCS data collected over the Indian Ocean for phytoplankton pigment mapping. Two sub images, one off Cochin and another off Karwar along with synchronous sea truth data enabled the development of a C-map (Chlorophyll pigment map). From earlier studies conducted in these waters from the fifties it has been possible to quantify the total chlorophyll content for different depth zones. Chlorophyll measurements are indicative of the bioproductivity of the sea. Sea surface chlorophyll has been considered to be significant in the food relations of oceanic fish resources such as tunas since a steady state relationship is possible between the forage of tunas and the chlorophyll through the food chain (Homes *et* al., 1957). A general chlorophyll map integrated for 0-50 m of the whole Indian Ocean as

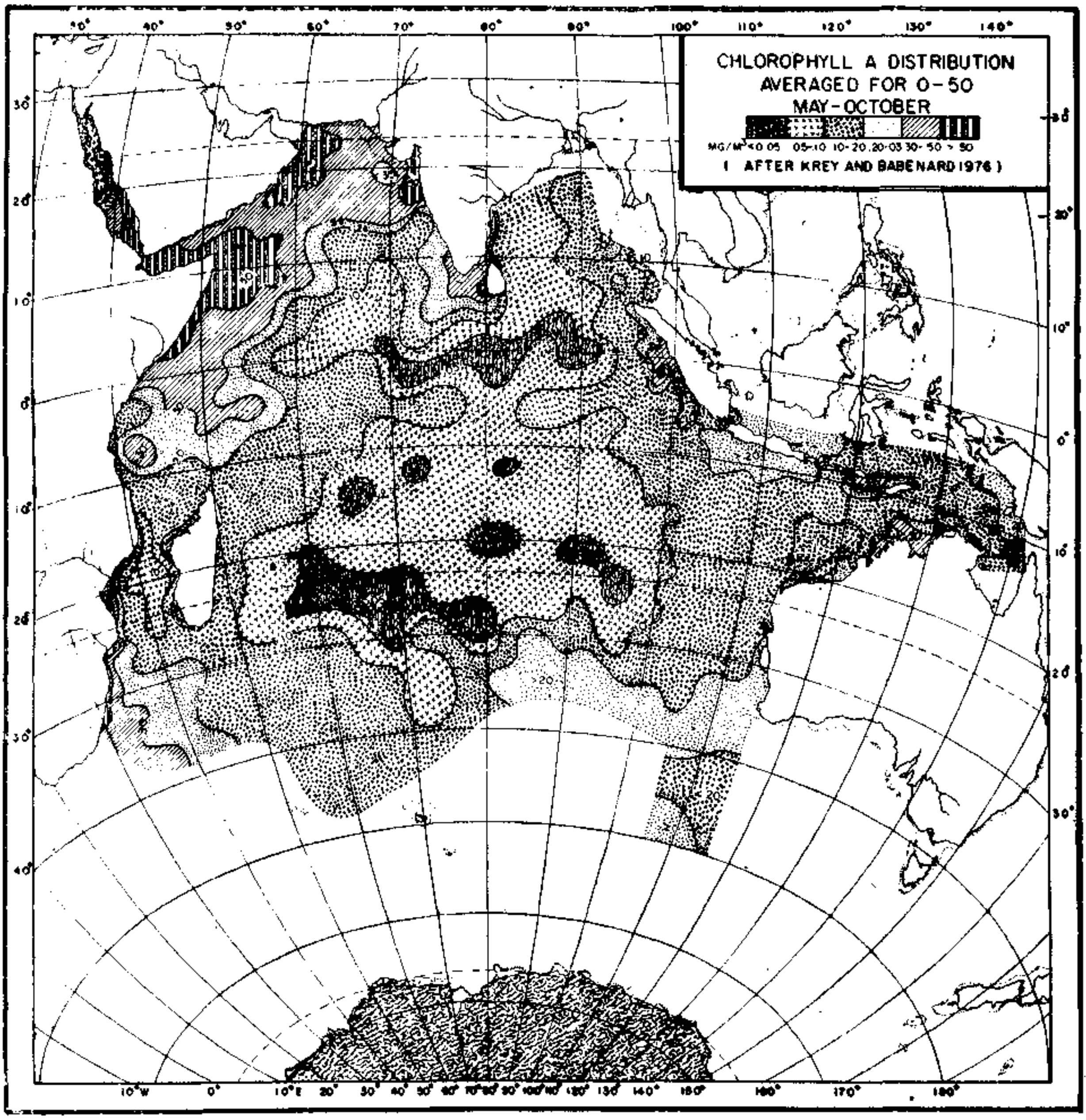


Fig. 1. Chlorophyll map of the Indian Ocean

presented by Krey *et al.* (1976) is given in Fig 1. But it requires intensive study on distribution pattern of chlorophyll both in space and time which will enable the development of models for potential yield data in specific regions. It is in this area that the IRS facility can render repetitive data in shorter time frames on important fishing grounds.

In this connection it is of interest to note that the work carried out by Central Marine fisheries Research Institute indicated chlorophly values of 6.4 mg/m$^3$ during October followed by a sharp fall during November (1.7 mg/m$^3$) and December (1.4 mg/m$^3$) when compared with the available fish catch data by FSI for the years 1977 through 1981 showed that the mean monthly fish catch data for October, November and December were directly proportional to the mean quantities of chlorophyll. This suggest that mapping of chlorophyll distribution either from air-borne sensors optimised for ocean colour sensing or satellite scanners combined with sea truth measurements will facilitate in better understanding of the resource potential.

### *Sea surface temperature and distribution of water masses*

The other important area is the thermal infra-red region of the spectrum (3 to 15m) where water at different temperatures emit different amounts of energy which can be measured by sensors operating in that region. SST operation by remote sensing technique will give considerable leeway in weather forecasting so that the fishermen could be warned sufficiently early about the development of tropical cyclones as well as their direction. The SST distribution also contains information on the underlying dynamical processes occurring in the upper part of the oceans such as eddies, warm water currents, upwelling and thermocline. Thermal pollution from large power stations can also be monitored from these information.

Two major phenomena that has significance for fishery oceanographers are upwelling and ocean fronts. The satellite is able to identify specially the location of the upwelling zones and the timing of their movements which is of great benefit to local fishing operations.

The IR image from satellite can emphasize sea surface temperature difference as white streaks which indicate the presence of cold sea surface water. The sharp contrast between the warm and cold waters can easily be demarcated. Thus other applications of remotely sensed data include structure and synoptic variability of oceanic fronts and major currents, observations on eddies—their formation and evolution, internal waves and precipitation intensity in oceanic areas. Eventually it is hoped that sensors in the microwave region will enable the determination of even salinity through water mass indentification.

### *Future promising areas in Remote Sensing for Marine Fisheries*

In conclusion it can be said that in view of its high synoptic potential, the factors monitored using remote sensing technology can be of use for long term prediction of the size of the stocks several seasons away with forecasts available well in advance of fishing seasons so that the fisherman will have the advantage of planning their investments in time and resources before they go to sea. Commercial fisheries involving sedentary species such as oysters and clams, can also benefit from remote sensor technique as these resources are loacated in fairly fixed stations and hence are extremely sensitive to factors which change the beneficial environment (Lintz and Simonett, 1976). According to Robinson (1985) the most fruitful areas of research are likely to be those in which conventionally gathered data and satellite observations are used to complement each other in order to reveal a fuller perspective of oceanographic process than either of them is individually capable of providing. It is hoped that satellites which are to succeed the present IRS series will have more versatile sensors in infra red and microwave regions in addition to the visible region that would usher in an area in which the entire oceanographic researches could be carried out synoptically from space benefitting the capture fisheries to a large extent by provididg inputs as long-term forecasts on distribution patterns and areas of likely concentrations of fishes.


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