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STUDIES ON UPWELLING AT THE TURN OF THIS CENTURY

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ABSTRACT

Upwelling in the waters around India and the transformation of physical properties of the neritic waters thereof with a stress on thermal front and the potential utility for fish production in the sea are described. The necessity of obtaining the snapshot pictures with high grade resolution of locations and intensities of upwellings and thermal fronts is stressed for effective management of marine fisheries. The only means of fulfilling this objective is by switching over the observations from the time-consuming ship-borne observations to satellite produced imagery system. Therefore, by the turn of this century, the software suitable for localised conditions should be developed and perfected so that the present day sea truth data collection system by ships would be used only as occasional checking points.

INTRODUCTION

Of all the coastal upwellings, the Peruvian upwelling is world famous because of its tremendous and wide-spread influence coupled with El Nino effect on anchovy fishery fluctuations extended to bird-migration (Causing, 1982; Breaker and Christopher, 1986; wooster and Reid Jr., 1963). Though the phenomenon of upwelling actually means the vertically upward drawn currents from mid-depths towards the surface, the phenomenon is well understood by its effects on the surface and subsurface waters. The impact of southwest monsoon coupled with coastal currents is to generate upwelling along the coast of India. The entire west coast, particularly the southwest coast, and the northern half of east coast experience upwelling in different degrees during the southwest monsoon period (summer). Under the influence of the offshore winds of the northeast monsoon with the least opposition by the weaker northerly currents, upwelling is generated off Bombay region during winter (Carruthers *et al.*, 1959; Banse, 1968; Murty, 1981).

Waters of the southwest and central west coast of India (between 7°N to 17°N) are explored with regards to upwelling and thermocline over a long number of years (Murty, 1965;

Narayana Pillai, 1982; Ramamirtham and Rao, 1973; Ramamirtham and Jayaraman, 1960; Sastry and D, Souza, 1972; Sharma. 1968; Lathipha and Murty, 1978; Anonymous, 1980, Johannessen, Subbaraju and Blindheim, 1981). Studies on upwelling in the waters off east coast were very limited in space and time (LaFond, 1954, 1958r Murty and Varadachari, 1968; Ramasastry and Murty, 1958).

From the predominant commercial fisheries point of view, turbidity and temperature of the neritic waters and the temperature of the offshore waters play a dominant role in determining the species distribution and abundance. In a limited sense, the boundary, the region of transition, between the mixed layer and the thermocline below it may be treated as a "thermal front", the first order discontinuity in temperature.

The effects of the phenomenon of upwelling are manyfold. The upwelling waters are productive with enrichment of nutrients. Therefore they serve as green pastures or nursery grounds of young fish. The locations of thermal fronts are controlled by upwelling. Fish congregations are known to be associated with frontal regions (Taivo Laevastu and Ilmo Hela, 1970; Cushing 1982). Hence the locations of thermal fronts indicate where to fish and a what depth to lower the fishing gear.

The negative effect of upwelling is to replace aerated waters (4-5 ml/1 of dissolved oxygen) with oxygen depleted waters (oxygen content 1 ml/1 or even less). Adult fish may perhaps require normally aerated waters: therefore it migrates away from the oxygen depleted upwelled waters. This is observed in the northwest bottom fishery (Carruthers *et al*, 1959; Banse, 1968). The bottom fishes were found to migrate either nearer to the coast or to the far off region in their effort to avoid the wide belt of upwelled region along the coast with the result that the bottom fishery was not profitable within the belt of upwelling area. Therefore the negative effect of upwelling serves as a precaution in selecting the fishing ground.

Different species of tuna prefer different locations of temperature conditions: the yellowfin tuna prefers the warmer (upper side) of the thermal front associated with the thermocline, whereas the bigeye tuna prefers the colder (lower) side of the front, while albacore tuna is much deeper (colder)-water-living (Laevastu and Ilma Hela, 1970).

It is evident, therefore, for economic exploitation of fishery resources of the sea identification of exact location of upwelling, its intensity and extent are required to be known without delay. Charting out the details of upwelling by making ship-board observations involve a lot of time. And such information is useful mainly to hind-cast the fisheries

Satellite as Ocean Information Centre

Satellite-borne radiometric techniques were developed for ocean use. Radiation emitted by the surface of the earth or sea which is in the infrared range of wavelengths is a function of surface temperature itself. The emitted radiation is absorbed, chiefly by highly variable water vapour in the atmosphere, before it reaches the height of the satellite where it is detected and measured by radiometer. Nevertheless, from the measurements made from the several atmospheric-window channels with the aid of space-borne high resolution radiometer, it was not only made possible to correct for the atmospheric attenuation, but also to attain spatial resolution as close as 1.1 km locally (*Paul Mc Clain*, 1985).

The productivity of the waters is determined by optical radiometer - blue colour representing low productivity and green colour high productivity. Turbidity of the waters is determined by reflectometer. Procedures for ocean surface wind vector retrievals from scatterometer data are being developed.

A satellite-oriented study of albacore tuna catch distributions off the west coast of North America showed clearly that the distribution and availability of albacore tuna are closely related to oceanic fronts. Significant albacore aggregations in nearshore regions were found near fronts associated with upwelling and with shoreward intrusions of oceanic water. Bluefin tuna catch in the Gulf of Mexico was well correlated with the proximity of the surface thermal front which was determined by visible and infrared satellite imageries. Squid jigging within ten nautical miles of the shelf slope front of the northwest Atlantic was of much higher catch rate than the catch rate of other areas (Paul McClain, 1985).

Remote sensing in Marine Fisheries in India

Cushing (1969) feels that the intermittent halts in upwelling process actually sustain greater levels of production. As monsoons and upwellings in Indian waters are closely linked up, breaks in monsoons may lead to such sustained production by resumed upwellings. This view again supports the need for monitoring of upwelling systems of Indian waters by quick and accurate method *i.e.* by remote sensing.

India has started gaining experience in remote sensing of coastal zone and marine resources through chlorophyll mapping with ocean colour scanner and sea surface temperature estimation from infrared radiometer (Pranav Desai, 1985). Regionally applicable software is being developed by Indian Space Research Organisation (ISRO) at its centres at Bangalore and Ahmedabad and also by National Remote Sensing Agency (NRSA) at Hyderabad. The geostationary Indian national satellite, Insat-IB, has successfully completed 100 days of its continuous operation by 7th May 1987. Its very high resolution radiometer has given thousands of meteorological images useful for flood control in specific catchment areas of rivers in the country.

However, the monsoons and their associated thick cloud cover and breaks in monsoon make the problem of atmospheric correction of satellite data more serious. The hinderances posed by the unique climatic conditions of Indian subcontinent and of the seas around it have to be sorted out for their elimination from the remote sensing data. Empirical solutions may not stand the test of time. Nevertheless, various models based on multichannel system have to be evolved in this direction.

It may be pointed out that our Indian space applications to sea conditions are still at the initial stage of having sea truth data to function as yard-stick to calibrate the satellite imagery data every time. It means that we have to wait for a long for the results, as the sea truth data wihch is nothing but ship-borne instrumental data takes time for its final results. Therefore this system should be made perfect for our waters so that by the turn of this century the function of sea truth data reduces to checking points only. Then the satellite imagery perfected in its calibration gives synoptic picture like the bird's eye-view, of what is happening in the surface and subsurface waters, what is needed is consistent quality of monitoring data on locations of upwellings, their breaks and changes of fronts with time (frontogenesis and frontolysis) which are all essential for effective forecasting of fisheries for augmentation and judicious fishing from the seas around India.

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