CHAPTER 2

LITERATURE SURVEY

The chapter includes review of literature related to research carried out and the present status in the field of remote sensing application to fishery resources The brief descriptions of important studies and global Research and Development efforts made in these fields are discussed here.

CHAPTER 2: LITERATURE SURVEY

Satellite remote sensing applications in fisheries have concentrated on the measurements of ocean temperature, ocean colour and computation of ocean water transport based on satellite measured wind stress. Laurs and Burcks (1985) reviewed fisheries applications of satellite remote sensing in U.S. Examples of potential use of satellite imagery in the eastern North Pacific fisheries were given by Fiedler *et. al,* (1985). Yamanaka (1982) described the utilization of satellite imagery in Japanese fisheries. Njoku *et. al.,* (1995) reviewed applications of thermal infrared imagery in oceanography.

Variations in environmental conditions affect the recruitment, distribution, abundance and availability of fishery resources. It is not possible to measure remotely from satellites the entire spectrum of information needed to assess changes in the marine environment. However, information about important oceanographic conditions and processes affecting fish populations, such as surface temperature isotherms, oceanic frontal boundaries, current circulation patterns, and coastal upwelling may often be deduced by using ocean surface temperature measurements made by satellites.

A relatively large number of studies of marine fish habitat and research on pelagic fish migration have utilized satellite remote sensing data. Laurs *et al.* (1994) using AVHRR and CZCS data demonstrated the role of oceanic frontal structure in the habitat and migration patterns of albacore. CZCS imagery and albacore tuna catch data obtained from daily logs submitted by fishermen were used to investigate the relationship between albacore fishing success and ocean colour boundaries off U.S. Pacific West Coast. In near shore water colour imagery showed a sharp colour front marking the boundary between the coastal and oceanic water masses and corresponding to the temperature front visible in the AVHRR images. The boundary generally had a meandering north-south distribution with intrusions of oceanic water in to coastal water. Albacore fishing efforts were distributed mostly with lesser amount in coastal water. The catch rates were highest in the bluish oceanic waters near colour boundary marking interface between coastal and oceanic waters. The shoreward intrusion of oceanic waters had particularly large catches concentrated at the colour boundaries. The oceanic boundaries defined by colour front marked an area of high fishing activity and large mean catches in relatively productive water with chlorophyll concentration of 0.3 – 0.4 mg/m^3. Satellite imageries and concurrent albacore catch examined by Laurs *et. al.*, (1994) and demonstrated that the distribution and availability of albacore are related to oceanic fronts. They substantiate the conventional wisdom of many fishermen who use temperature and/or colour "breaks" to locate potentially productive fishing areas for albacore. Authors speculated that the behaviour mechanism(s) related to feeding might be responsible for tuna aggregation on the warm side of temperature front. To support this argument the authors use CZCS measurements along with knowledge that tuna are visual feeder. The distribution of colour boundaries, apparent in CZCS imagery collected concurrently with albacore acoustic tracking, showed a gradient nearly coincident with the SST gradient patterns in AVHRR images. The influence of the water clarity on detection and capture of pray may play a key role in the mechanism(s) underlying the aggregation of tuna. The aggregation of commercial concentration of albacore in clear water on the oceanic side of the front in near shore areas found by authors may reflect an inability of albacore to capture efficiently large, mobile pray in turbid coastal water and a dependence of food that has migrated or has been dispersed across the coastal–oceanic boundaries. In offshore region, the aggregation of albacore in relatively productive waters presumably occurs because relatively higher amounts of food organisms are present, yet the water is clear enough for albacore to detect the prey. This study has shown that both infrared and visible color data from satellites can define environmental limits on the spatial distribution of fishable aggregation of albacore more effectively than ship. On other observational perspective so convincingly reveals the shape, size and continuity of meso-sacle features, which are important in determining the distribution and availability of migratory species. Maul et al. (1984) combined in situ observation from four research vessels, CPUE for ABT (Atlantic bluefin tuna, *Thunnus thynnus thynnus*), visible (CZCS) and thermal infrared (GOES, NOAA) satellite data of Gulf of Mexico. The boundaries gulf loop current was located using satellite data during 1980 in fishing areas. CPUE was analyzed and it was observed three fold increase in ABT catch in 1980 over that in 1979 using available satellite infrared and visible imagery.

Sugimoto and Tameishi (1992) observed that warm and cold streamers entrained the periphery of the warm core ring, which form excellent fishing ground for pelagic fishes such as skipjack, mackerel, flying squid and saury.

Appearance and movement of the fishing grounds associated with the warm core rings and streamers are discussed, using satellite thermal images and fish catch data.

Stretta (1991) used a variety of satellite data as input in a proposed model for tuna fishing in the Gulf of Guinea region. Using satellite data and advance image analysis techniques, Podesta *et. al.*, (1993) found that the probability of very high catch rates in US long line fishery for swordfish in the Atlantic was greater in the vicinity of SST fronts. Satellite infrared observations of Kuroshio warm core rings and their influence on pacific saury migration was reported on by Saitoh *et. al.*,(1986). In the Gulf of Mexico, larval fish assemblage has been related to Loop current boundary determined by satellite images (Richards *et al.*, 1993).

Ocean temperature measurements made by satellite remote sensing can be extremely useful in defining the distribution of mere fish habitat conditions. Lasker (1981) have demonstrated that the northern boundary of northern anchovy spawning habitat in the South California Bight may be delimited by using VHRR imagery from NOAA. Similar study was extended by Fidler *et al.* (1983). Base on satellite imageries and confirmed by ship observations during the study, which was conducted during the peak period in anchovy spawning, there are distinct temperature regimes in the general geographic region where anchovy spawning normally takes place. He concluded that anchovy avoid recently upwelled waters and that aerial extent of upwelled water may be mapped using thermal infrared imagery. Fiedler (1983) carried out an investigation of distribution of northern anchovy spawning observed on four intensive surveys of the Southern California Bight. AVHRR and CZCS data were used to describe meso-scale patterns of sea surface temperature and phytoplankton concentration. He observed that spawning to the south of San Diego in 1980-1982 was confined to a narrow band along the coast, with occasional extensions further offshore. Sea surface temperature increased gradually offshore, but no temperature fronts were observed in AVHRR imageries to explain spawning distribution. However, CZCS imageries showed relatively high plankton pigment concentration in a coastal band with a sharp chlorophyll front defining seaward extent of spawning activity. The spatial distribution of northern anchovy can thus be defined by meso-scale patterns in satellite derived SST and phytoplankton pigment images, neither parameter is sufficient, both together may define the spatial distribution. Larval anchovy survival thought to depend on aggregation of nutritionally suitable food organisms in stratified water column (Lasker, 1981). Satellite observations of relatively warm surface temperature along with moderately high pigment levels may indicate stratified water column with a mature phytoplankton community.

Solanki *et al.* (1998a) used AVHRR SST imagery to study various features of the upwelling process in the Arabian Sea. The event is observed along the Arabian coast during pre-monsoon (June-July) and along Gujarat coast during post south-west monsoon (September-October) with benefits to local fishing operations. Solanki *et. al.*, (1998b) used AVHRR data to delineate thermal feature to locate potential fishing grounds and to study seasonal variability in fishery resources based on the patterns of ocean features observed in thermal imagery in the Arabian Sea.

Solanki *et al.* (2001a) synergistically analyzed Sea WiFS ocean colour data and AVHRR. They found that ocean colour features are coincided within thermal boundaries at some locations. This indicated that physical and biological processes are closely coupled at these locations. High fish catch points were found in vicinity of coincided boundaries. An approach for integration of chlorophyll concentration and SST features has been developed by Solanki *et al.* (2000) using OCM chlorophyll concentration and AVHRR SST. Some preliminary results of synergistic application of chlorophyll and SST have been demonstrated by Solanki (2001b) for exploring the pelagic resources in the water of Gujarat coast. Gill nets were used for fishing in suggested PFZs. Pomfret catch was found increased by two folds. OCM chlorophyll concentration images and AVHRR SST images were used by Solanki *et al.* (2003) for fishery forecast. Comparatively high CPUE was observed in the PFZs forecast areas as compared to other areas in the Northern Arabian Sea. They also noted that physical and biological processes closely coupled at some locations, which indicate suitable habitat for distribution of fishery resources. These coupled processes can be explored using both ocean colour and SST images.

Satellite remote sensing played an especially important role during El Nino for monitoring anomalous ocean temperatures along the U.S. Pacific Coast (Fiedler, 1984b). The satellite imagery contains invaluable information for use in assessing the effect of El Nino conditions on fisheries. Virtually all fisheries were affected in varying degrees, some fisheries benefited from El Nino, and others were harmed substantially. Many fish populations experienced changes in their latitudinal and offshore-inshore distribution. For example, using NOAA AVHRR infrared imageries could delineate shift in the distribution of anchovy spawning (Fiedler, 1984b).

Satellite derived oceanic data can save time and money in the planning and execution of fishery research field studies involving vessel operations. This important application of satellite remote sensing usually requires direct reception and processing of satellite data in real time. The cost savings can be significant, since a single satellite image from data received and processed in a few hours can save days of expensive ship time by significant environmental features and permitting optimum allocation of sampling efforts (Fiedler *et al.* 1985). In addition of satellite data collected concurrently with field studies at sea can be especially valuable. It can be used to validate the interpretation and extrapolation of shipboard measurements and as a basis for interpretation of meso-scale patterns and possible mechanisms responsible for spatial and temporal variability observed in shipboard observation (Lasker *et al.* 1981).

Several projects and programs have used or using satellite derived ocean colour and temperature data in fisheries –aid products distributed to fishermen by Radio transmission, facsimile transmission, internet, telephone tele-copier. The first utilization of satellite data in fisheries-aid products was in the early 1970's when visual and infrared imagery received by automatic picture transmission (ATP) were employed in the preparation of advisory charts transmitted to tuna purse seine fishermen operating in the eastern tropical pacific (Laurs, 1971). A prime motivation leading to the expanded use of satellite observation in fisheries-aid products was provided by Seasat Commercial Demonstration Program sponsored by NASA/JPL. This program applies to the development of an operational satellite data distribution system to distribute oceanographic products to users (Montgomery, 1981). Charts showing the locations of oceanic thermal boundaries are derived from AVHRR infrared imagery and are provided to commercial and recreational fishermen for use in locating potentially productive fishing grounds along the Pacific coast from central Baja California to British Columbia (Breaker, 1981). Fishermen use these charts to save time in reaching for productive fishing areas associated with oceanic features. The multichannel sea surface temperature (MCSST) charts (Strong and McClain, 1984), improved versions of the former global operational sea surface temperature computation (GOSSTCOMP) charts, are also used by fishermen in locations around the world where both historical and operationally there is little information on the distribution of sea surface temperature.

Roffer's Ocean Fishing Forecasting Services (ROFFS), a scientific company based in Miami (Florida) provide worldwide fisheries oceanographic consulting services. They combine fisheries data with satellite and other oceanographic data to produce tactic and strategic fisheries forecasts. Their principal product is the "ROFFS Oceanographic Fishing Analysis", which designed to allow fishing incorporates numerous factors including many variables. They are water temperature, water colour, orientation of local current, history of ocean fronts, bottom topography, biological quality of water, forage presence of targeted species, availability of forage and habitat preference of the forage and target species.

There has been only limited use in fisheries applications of satellite data from active sensors. However, it is likely that Synthetic Aperture Radar (SAR) satellite data become more available, its use will markedly increase. SAR can be used as an all weather sensor to define ocean features e.g. eddies, frontal structure, river plumes, etc. that form important habitats for marine resources. Petit *et al.*, 1992 stated that SAR images can be used to study pelagic fish school and fishing effort estimate. Research conducted in Canada by Freeburg *et al.*, 1995 verified the application of space based radar systems for fisheries monitoring, control and surveillance. It is worth pointing out here that several studies have been done to use SAR in fisheries oceanography, especially for NOAA's Fisheries Ocean Coordinated Investigation (FOCI) in Alaska's Shelikoff Strait and bearing Sea (Schumacher *et al.*, 1991: Liu *et al.* 1994). In this environment, SAR can provide very useful information on eddies and waves, where useful SST maps from AVHRR are extremely limited due to cloud cover and annual day/night cycle. Only a few fisheries studies dealing with transport of developmental stages have taken advantages of oceanic wind structure measured from space by scattero-meters (Laurs and Brucks, 1985). Nevertheless, information from scattero-meters has high possibilities for expanded fisheries applications.

The ARGOS satellite location system is widely used in fisheries, marine mammal and sea turtle research investigation. Global Positioning System (GPS) location systems are also in fishing vessel monitoring systems and are under development for use on marine mammals. The eventual development of the operational system using low earth orbit satellite (Seay, 1994) will provide fisheries and protected fisheries and protected species researchers and managers with a huge expansion in the possibilities of satellite networks for both data communication and position determination. Cooperative efforts are underway between the NMFS Honolulu Laboratory and Commonwealth Scientific and Industrial Research Organization (CSIRO) Division of Fisheries in Hobart, Tasmania to use communications satellite technology for transmitting data collected on electronic "archival tags" that will be programmed to disengage from a fish and "pop up" to the surface for relying data via the ARGOS satellite system.

In 1999, NOAA's National Marine Fisheries Service (NMFS) developed a GIS for near real time use of RS data in fisheries management in the gulf of Maxico (Laming *et. al.*, 1999). They developed an ArcView based GIS, which is accessed through the internet via password protected user accounts. The system integrates AVHRR/SST and Sea WIFS/CHL imagery and NMFS shrimp statistical data in the jurisdictional boundaries between US and state waters as well as US and international waters. Stanbury and Starr (1999) discussed the application of GIS to habitat assessment and marine resources management providing a through analysis and explanation of the potential benefits GIS modeling directly applicable to fisheries science and management.