GENERAL INTRODUCTION

Coastal resource systems are valuable natural endowments that need to be managed for present and future generations. In nature, the coastal systems maintain an ecological balance that accounts for shoreline stability, beach replenishment, and nutrient generation and recycling, all of which are of great ecological and socioeconomic importance.

Population growth in the coastal zone is a major concern. More than 50 percent of the world’s population is already concentrated within 60 kms of the coast, while there is considerable migration of population from the inland areas to the coastal zone. The negative impact of the increased human settlements and industrial development are also more acutely felt in the coastal zone, since it is at the receiving end of land and water-based pollution. Compounding the problem, the coastal zone is often subject to overlapping governance of local, provincial and central governments resulting in inter agency conflicts and unclear policy concerning resource development and management and environmental protection.

Increased coastal resource use conflicts will inevitably intensify social and economic problems. The problems of multiple jurisdiction and competition between users of resources without the benefit of a conflict resolution mechanism, inadequate regulations for protecting resources, and the lack of nationally or locally adapted coastal policies for informed decision making, will translate into a loss of capability for future sustainable development. As the resource base is depleted, conflicts may reach alarming dimensions to the point of threatening human life and public order.

The international scientific community has recognized as real concern over human-induced global warming of the atmosphere, leading to climate change and sea level rise. Accentuating the anthropogenic impacts to coastal systems are changing patterns of global climate and meteorology that drive local shifts in humidity, storminess, sea surface temperature, coastal circulation, as well as a worldwide rise of sea level. These trends sharpen the severity of the specific human influence and, commonly, drive the level of environmental deterioration past the point of natural recovery and into the need for remediation and artificial restoration. With the advantage of hindsight, it is clear that many of these problems are related to poor coastal zone management stemming from lack of scientifically framed policies.
Common problems along our coasts are

- High density development of urban and suburban coastal zones (e.g. High hazard vulnerability, growing financial loss from storms, increased polluted runoff and decreased upland permeability).

- Disruption and degradation of environmental pathways from watershed to the sea. (e.g. Coastal dune and wetland filling, stream channelization, estuarine pollution, disrupted sediment flux).

- Weakened environmental carrying capacity (e.g., inadequate sewage disposal, shore face ecosystem degradation, armored beaches and wetland boundaries).

- Exhausted natural resources (e.g., over-pumping of coastal aquifers, over-fishing, shore face mining, depleted sediment budgets).

The coastal areas are facing serious problems such as erosion, siltation, over population, salt water incursion, flooding, pollution, devastation of natural habitats to name a few. Rational development of India’s coastal areas can only be achieved by understanding various interactive processes that are operative in our coastal environment.

Keeping this in view INCOIS driven state of the art technology of PFZ (Potential Fishing Zone) and OSF (Ocean State Forecast) has been taken to the door steps of the Marine fishing community for better and safe fishing.

Remote Sensing and Geographical Information System (GIS)

Remote sensing is a method of acquisition of information about an object without physical touch. Remote sensing has therefore practically come to mean data acquisition of electromagnetic radiation (EMR) (commonly between 0.4 µ and 30 cm wavelength range) from sensors flying on aerial or space platforms and its interpretation for deciphering ground object characteristics. In remote sensing, EMR serves as the main communication between the sensor and object. Remote sensing is unique in that it can be used to collect data, unlike other techniques, such as thematic cartography, geographic information systems, or statistics that must rely on data that are already available.
In marine waters fish migrate for feeding. It is possible to locate the feeding grounds from SST (Sea Surface Temperature) and/or chlorophyll images generated from satellite data through detection of oceanic features or gradients (Dwivedi et al., 2005). Natural variations in fish stocks are caused by complex interactions of oceanic physical, chemical and biological processes. The prediction of marine ecosystem structures and functions requires understanding of the physical and biological processes which govern the abundance, distribution and productivity of the organisms on a wide range of time and space scales (Solanki et al., 2003).

The use of satellite remote sensing to provide synoptic measurements of the ocean is becoming increasingly important in fisheries applications. Variations in ocean conditions play key roles in natural fluctuations of fish stocks and in their vulnerability to harvesting. Information on the changing ocean, rather than on average ocean conditions, is necessary to understand and eventually to predict the effects of the marine environment on fish populations. The evolving capabilities of satellite sensor and data-processing technology, combined with conventional data collection techniques, provide a powerful tool toward ensuring the wise use of living marine resources.

Potential Fishing Zones (PFZ) forecast was started during 1989-90 using NOAA AVHRR derived SST in India (Solanki et al., 1998). Nath et al., (1991) have used SST images to estimate fish catch in the Arabian Sea. With the launch of Indian Remote Sensing Satellite (IRS P4) on May 26, 1999, Ocean Colour Monitor (OCM) data provided information on chlorophyll concentration. Synergistic analysis of SeaWiFS derived chlorophyll concentration and NOAA AVHRR derived SST for fishery resources exploration was carried out by Solanki et al., (2001a). Later, an integrated approach for fishery resources exploration was developed using OCM derived chlorophyll concentration and AVHRR derived SST (Solanki et al., 2001b).

overview of the different kinds of remote sensing data relevant to fisheries science and oceanography, and Montgomery (1981) discussed the utility of satellite imagery to ocean industries including fisheries.

Identification of Potential fishing Zone

Commercial fishermen are concerned about the best catch for the amount of time spent in search of productive fishing areas. In the last decade, commercial fishing on the high seas has become an increasingly competitive and economically risky business. To ensure a profit it has become necessary for the fishermen to utilize available technological and scientific knowledge to improve their catches.

Remote sensing is not entirely new to fishery scientists or to fishermen harvesting living marine resources. The sensor often used has been the naked eye, usually aided by a telescope or binoculars. Visual forms of remote sensing are common today in many fisheries e.g. the use of helicopters operating from modern tuna purse- seines fishing on the high seas. The era of space technology brought new perspective in remote sensing for fisheries. Man acquired the ability to view the entire oceans and seas in a matter of minutes. Satellite remote sensing applications in fisheries have concentrated on the measurements of ocean temperature and colour and computation of ocean temperature and colour and computation of ocean transport based on satellite-measured wind stress.

Identification of PFZ through SST

Methods for identifying and locating PFZ through NOAA -AVHRR satellite data were developed during the period 1988-89 under IRS utilization programme. The method used was to detect sea surface temperature gradients expressed through ocean features like fronts, eddies and upwelling. These are largely conducive for fish aggregation.

Fishery forecasts are based on various aspects of physical, biological and chemical processes of oceanic waters. This involves basic understanding of topography of oceanic basins, currents, up welling, eddies, distribution of temperature and salinity.
Eddies

A circular movement of water is known as eddy. Detailed studies on currents do not show a simple unidirectional flow, but rather a series of large eddies superimposed on a broad weak equatorial movement. These eddies rotate in the same direction as the current and are thus not a product of looping and meandering.

Coastal Upwelling

It is a term used to describe the coastal process whereby water from depths, generally not exceeding a few hundred meters, is brought upwards. It occurs within a distance from the coast of the order of the baroclinic Ross by radius of deformation (about 10-50km). As cold water from deeper depths which displaces the near water is generally rich in nutrients, upwelling zones are usually regions of high biological activity.

The enhanced growth of phytoplankton and zooplankton in regions provide abundant food supply for the fish community. Consequently the fisheries industry in the world depends heavily upon the regions of coastal upwelling. It is estimated that, in spite of constituting only 0.1% of the area of the world’s oceans, the regions of coastal upwelling account half of the world’s fish productions.

Fronts

The boundary between adjacent water masses of dissimilar properties is known as a surface fronts.

Gyres

These are like loops formed from meandering of major currents. These meanders pinch off and fuse to Form a circulation of relatively rapid current. The width of the ring is sometimes as high as 300 km.

Preparation of PFZ maps

SST derived from the thermal data of NOAA-AVHRR can be used in mapping and monitoring of the ocean processes useful for locating potential areas of fish aggregation. The SST imagery of 3 or 4 days composite covering the entire Indian coast is divided into 9
sectors viz. Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa, West Bengal, Lakshadweep, Andaman and Nicobar Islands.

DERIVATION OF PFZ

MODIS Chlorophyll Image Generation

In ocean-colour remote sensing the radiance backscattered from the atmosphere and/or sea surface (specular reflection) is typically at least an order of magnitude larger than the desired radiance scattered out of the water, known as water leaving radiance \( L_w \). The goal of atmospheric correction is to retrieve, \( L_w \) from the total radiance, \( L_t \), measured at the sensor altitude. The retrieval of chlorophyll pigment from ocean-colour data involves two major steps, a) atmospheric correction of visible bands of 0.41 to 0.55 µm and b) use of a suitable bio-optical algorithm to generate digital chlorophyll distribution map. The MODIS-AQUA data received at the National Remote Sensing Agency (NRSA), Hyderabad bundled in HDF format was extracted and relevant ocean-colour bands were separated. An atmospheric correction technique was developed for the retrieval of water-leaving radiance in blue-green bands of MODIS data. The two infrared bands centered at 0.75 and 0.88 µm were used to characterize the aerosol spectral behavior making use of black pixel assumption (Chauhan et al., 2002) for the aerosol radiance estimation in blue-green bands. The atmospherically corrected bands of 0.412, 0.443, 0.488, 0.531 and 0.551 µm were used for the generation of chlorophyll image using MODIS chlorophyll algorithm. Fig. la shows the distribution of chlorophyll concentration in the Arabian Sea using the MODIS-AQUA data.

MODIS Sea Surface Temperature (SST) Image Generation

The MODIS is the first spacecraft radiometer to have several infrared bands in the 3.7-4.1-µm atmospheric window with characteristics suitable for the derivation of SST. This window is more transparent than that at 11-12 µm (bands 31 and 32) and provides the opportunity to derive more accurate SST fields (Esaias et al., 1998). The 4µm SST algorithm developed by National Aeronautics and Space Administration (NASA) has been used for the generation of the SST image over the Arabian Sea (Minnett and Evans, 1996). Fig. lb shows the SST image derived using band 22 and 23 of MODIS data. We found that the mid IR 4
lam SST image gives better information of sea surface temperature fronts when compared to 11-12 µm thermal IR band SST image.

Composite Product of Chlorophyll and SST

The MODIS derived chlorophyll and SST images were geometrically corrected by using the geo-location information provided along with the MODIS level-IA data. A false colour composite (FCC) image of chlorophyll and SST was generated by assigning red and green colour to chlorophyll image blue colour to SST image. The Arabian Sea and the Uttara Kannada coast belong to the Indo-Australian Marine Biogeographic Region considered to be the richest in the world for biodiversity. The coastal backwaters/estuaries/river-mouths were well known for their productivity - some of them, like the Aghanashini backwaters, are even today so. The rivers from the Western Ghats carry great quantity of forest organic matter and deposit the same in the coastal waters including the sea, accounting for such productivity.

Ecology

Marine ecology is the branch of ecology dealing with the interdependence of all organisms living in the ocean, in shallow coastal waters, and on the seashore. The marine environment for all organisms consists of non-living, abiotic factors and living, biotic factors.

Abiotic: The Abiotic factors include all the physical, chemical and geological variables that have a bearing on the type of life that can exist in an area. Included are

- light
- temperature
- pH
- salinity
- substratum
- nutrient supply
- dissolved gases
- pressure
- tides
Biotic: The biotic factors are the interactions among living organisms.

Ocean is divided into pelagic and benthic zone.

- The pelagic zone includes the productive coastal waters called neritic zone and deep waters of the open ocean known as oceanic zone. Another division in the pelagic zone is related to light penetration known as the photic and aphotic zones.

  The benthic zone extends from the seashore to the deepest parts of the sea.

  The material that makes up the bottom is the substratum and the organisms living there are the benthos.

  Tides uncover parts of this zone and the area uncovered is the intertidal zone, above is the supratidal zone, affected by salt spray but not covered by sea water and below the intertidal zone is the subtidal zone, submerged and extending seaward. The elevation and slope determines the length of time it is exposed. This affects organisms living there because some are restricted to zones according to their adaptations to this type of zone (intertidal etc.).

  Organisms living in pelagic waters also put up with changes in salinity, temperature etc. and inhabit the coastal areas etc. which fit their adaptations. Other zones include the surface waters of the coastal areas called the neritic zone and the waters of the ocean called the epipelagic zone. The open ocean is less productive than the neritic zone which contains plant plankton, fish larva, invertebrate larva that will eventually end up near the coast.

  The open ocean is divided into zones depending on the amount of light it receives from the epipelagic layer to the mesopelagic zone 200-1000m in which daytime inhabitants migrate upwards during the night, bringing back nutrients and some exhibit bioluminescence (light producing organs called photophores). The deep sea layers bathypelagic 1000-4000m
and the abyssopelagic zones (below 4000m) have limited food supplies although bacteria have been found that can make their own food.

Trophic (Feeding) Relationships: - Energy transfer is accomplished in a series of steps by groups of organisms known as autotrophs, heterotrophs, and decomposers. Each level on the pyramid represents a trophic level.

Autotrophs absorb sunlight energy and transfer inorganic mineral nutrients into organic molecules. The autotrophs of the marine environment include algae and flowering plants and in the deep sea are chemosynthetic bacteria that harness inorganic chemical energy to build organic matter.

Autotrophic Nutrition: - Supply food molecules to organisms that can't absorb sunlight.

Heterotrophs: - Consumers that must rely on primary producers as a source of energy. Heterotrophic nutrition is the energy stored in the organic molecules is passed to consumers in a series of steps of eating and being eaten and is known as a food chain. Each step represents a trophic level and the complex food chains within a community interconnect and are known as a food web.

Decomposers: - The final trophic level that connects consumer to producer is that of the decomposers. They live on dead plant and animal material and the waste products excreted by living things. The nutritional activity of these replenishes nutrients that are essential ingredients for primary production. The dead and partially decayed plant and animal tissue and organic wastes from the food chain are detritus. This contains an enormous amount of energy and nutrients. Many filter/deposit feeding animals use detritus as food. Saprophytes decompose detritus completing the cycle.

Energy Transfers in Marine Environments

Primary producers usually outnumber consumers and at each succeeding step of the food chain the numbers decrease. The numerical relationship is called the pyramid of numbers. The energy pyramid is the energy distribution at each trophic level as it passes from producers through the consumers. Some energy is lost as it passes to the next level because

- (a) consumers don't usually consume the entire organism
(b) energy is used to capture food
(c) organisms used energy during their metabolism
(d) Energy is lost as heat.

Scavengers: Feed on dead plants and animals that they have not killed. Crabs ripping chunks of flesh from fish on the beach are scavengers. Most scavengers consume detritus rather than flesh and deep sea animals can feed on both.

Symbiotic refers to close nutritional relationship between two different species...

1. commensalism- one benefits
2. mutualism both benefit and parasitism
3. One benefits at hosts expense.

Population Cycles density or numbers of individuals depends on

1. Natality or rate of production of new organisms and
2. Mortality or rate of death in a population.

Now to be stable the two must be in equilibrium but under favorable conditions, populations can increase numbers (can be seasonal and geographical) but this also increases mortality because of decreased food supply and living space and increased predation. If mortality is greater, then the population decreases. These favorable conditions depend on

- high concentration of nutrient rich water,
- rapid cycling of materials by decomposers,
- high numbers or rapid turnover of producer organisms
- Light
- Nutrients including nitrate, phosphate, silicon, potassium, magnesium, copper, iron.

Silicon dioxide needed for outer glass covering of diatoms and forms internal structural parts of sponges, K and NO₄ and PO₄ needed in plant proteins, lipids and
carbohydrates during photosynthesis and the nutrients can be considered a limiting factor as well as pH, temp, light, depth, salinity, nesting sites and predation.

Pelagic world include the drifting organisms like plankton and the swimmers nekton.

  Plankton comprises the large and small organisms that drift or float while tides and currents move them through the water. Most plankton do have a limited ability to move and can migrate vertically through the water from day to night. Some drifters can photosynthesize while others are consumers. Plankton is very important as it occupies the first two or three links in the marine food chains.

  Nekton use fins, jets of water, strong flippers, flukes and flippers to swim through the water.

Benthic: If the organism resides primarily in or on the substrate and doesn't swim or drift for extended periods as an adult it is considered benthic. They either burrow, crawl, walk, (motile) or are sessile or permanently affixed to the substrate or each other. Demersal organisms, such as flounder alternate between swimming and resting on the bottom.

Plankton: Phytoplankton are the important primary food producers in the pelagic environment. The animal members of the plankton are the zooplankton which range from bacteria size to 15m jellyfish. Phytoplankton are the trees of the sea which float near the surface to make the most of the sunlight for photosynthesis. Two forms of phytoplankton, dinoflagellates and diatoms are particularly important as founders in the planktonic food webs because most of the animal life in the oceans depend on these. The dinoflagellates are usually found in warmer waters, and the diatoms are usually more abundant in cooler waters. Other plankton, coccolithophores and silicoflagellates are also abundant as well as blue-green algae (in certain locations it can become the dominant) and green algae but usually in the coastal water (some are in the open ocean as findings of chlorophyll b indicate. Phytoplankton have adaptations which deal with methods of keeping them in the upper zones to stay in the sunlight. A small size retards sinking. Structure, shape/structure of the diatoms effects sinking rate and density decrease by storing droplets of oil in the cytoplasm. Blooms although unknown, the availability of nutrients, amount of vertical mixing, salinity, density,
temperature, and depth of water affect phytoplankton growth rates. Blooms called red tides have occurred in almost all oceans. Red tides usually refer to the discolouration of the waters as a result of the absorption of light by pigmentation in planktonic organisms. The red water usually results from actions of non-toxic organisms and the term red tide is inadequate when used with reference to PSP (paralytic shellfish poisoning) and toxic dinoflagellates will not always discolour the water (too few) but may be numerous enough to toxify shellfish. Some mysteries have been solved but evidence that PSP may be increasing in intensity and spreading to new areas is surfacing. About 60 species of dinoflagellates may colour offshore waters however only 6 have been shown to produce toxic substances. Some toxins, saxitoxin, is 50x more poisonous than curare (used by SA Indians). Repeated cell divisions as result of long period of dry weather following a violent storm which stirs up bottom sediments, reach concentrations of 25,000 dinoflagellates /ml of water. Bioluminescent phytoplankton bloom in the ocean and produce a bluish-green light. Phosphorescent Bay in Puerto Rico contains high concentrations of bioluminescent phytoplankton throughout the year. One type, *Noctiluca* sp. Disturbing water, passing of boat, wave breaking, initiates bioluminescence.

Zooplankton: 500,000 per gal and range in size from single cell to jellyfish. Almost any animal phylum can be found wandering through the sea but the most common are Copepods (95%). There are two types of zooplankton. Holoplankton or permanent members of the community and temporary residents called Meroplankton. Holoplankton have evolved efficient means of remaining adrift. Special appendages, droplets of oil and wax, tread water, jelly-like layer and gas-filled float. A majority of invertebrates and many vertebrates have planktonic stages (meroplankton) Drifting eggs and larva of fish, crabs, barnacles, worms, clams, snails, sponges, lobsters, etc. They use the water mass to feed and disperse their planktonic young to new habitats. The reproductive cycles often coincide with maximum concentrations of food and favorable currents. In spring phytoplankton bloom triggers increases in zooplankton coinciding with migration patterns of whales, seals and penguins. Vertical migrations refers to Copepods and other zooplankton moving up toward the surface to feed in the evening responding to the changing light reducing predation during the day because they are in deeper layers. This varies among species but light, shadows and pigments of phytoplankton (colour) helps zooplankton locate food. Thus buoyancy, mobility, vertical
migration, and chemical sensing enable Copepods to search open water for concentrations of food. Trophic levels in zooplankton communities Energy incorporated in organic molecules by marine plants flows to the zooplankton community in a complex series of interconnected food chains. Each chain or part of the web serves to link phytoplankton to larger pelagic animals through the zooplankton. Zooplankton feed on phytoplankton while carnivorous zooplankton occupy the third level as secondary consumers. Nekton Free swimming organisms equipped to direct their movements through the sea including cephalopods, fishes, marine mammals, sea turtles and marine birds. Many are at the top of the trophic levels either as carnivores or herbivores without natural predators except man. Swimming allows escape or movement toward food and methods of locomotion are very diverse, from jets of water, flippers, large tail fins and flukes. Planktivorous nektons are animals that feed directly on plankton such as baleen whales and some fish. Herbivorous Nekton are ones that feed on large seaweeds ad sea grasses (turtles and manatees) Carnivorous Nekton are the dominant carnivorous animals of the pelagic environment and generally these animals migrate great distances in search of food. Production Food production occurs mainly through Photosynthesis: It is measured and called Primary food production which will occur in the photic zone as phytoplankton manufacture organic matter during photo. The primary productivity varies seasonally and geographically. It is measured as g of Carbon/mg²/year. It seems that the more vertical mixing that occurs in an area, the higher the primary production is because in the tropics where there is little vertical mixing, their Primary Productivity is low because of the depletion of nutrients in the surface waters. Primary productivity decreases as depth increases as there is less light and less photo. Accessory pigments in algae enable them to make the most of the little light that does get to them. The boundary where the food production (photo) is balanced out by the rate of respiration (the use of the food) is called the compensation depth. Copepods metabolize droplets of diatom oil to liquid waxes and fats which can be used as long-term energy reserves. (Waxes; long/fats short). It is these waxes and oils that get used for blubber when the Copepods/krill are fed on by marine birds and mammals. Detritus food chains are also secondary when decaying material enters the detritus chain as decaying materials, wastes and pieces of animal tissue. The swarms of Copepods feeding on diatoms excrete packets of partially digested matter called fecal pellets.
These pellets usually aren't eaten by other pelagic organisms and provide food for bacteria when they settle as well as a host of detritus feeders on the bottom (transfer of energy from the top to the bottom). While there is a loss of energy to the grazers, many consumers are adapted to feed on detritus thereby returning energy to the food chains. Chitionolytic bacteria can break down chitin which represents an enormous source of organic carbon. Some are even symbiotic and found in the intestines of certain pelagic organisms to help them digest chitin. These bacteria play a big role in making sure the billions of tons of chitin produced in the marine environment each year get broken down and their nutrients are returned to the primary food makers.

Taxonomy

Taxonomy is the science of classifying organisms. Accurate knowledge about the behavior, biology and ecology of organisms comprising marine fisheries is a vital prerequisite for their management. It is estimated that ninety percent of the world’s species have yet to be discovered and described. To formally describe a new species, taxonomists have to manually gather and analyze data from large numbers of specimens, often from broad geographic areas, and identify the smallest subset of external body characters that uniquely diagnoses the new species as distinct from all its known relatives.

The Indian fish fauna is an assemblage of about 2500 species depicting diverse characteristics, of which 1560 species inhabit the marine waters (Talwar and Jhingran 1991).

Food and Feeding

The study of the feeding habits of fish and other animals based upon analysis of stomach content has become a standard practice (Hyslop 1980). Stomach content analysis provides important insight into fish feeding patterns and quantitative assessment of food habits is an important aspect of fisheries management. Lagler (1949) pointed out that the gut contents only indicate what the fish would feed on. Accurate description of fish diets and feeding habits also provides the basis for understanding trophic interactions in aquatic food webs. Diets of fishes represent an integration of many important ecological components that included behavior, condition, habitat use, energy intake and inter/intra specific interactions.
Length Weight Relationship

Fish plays an important role in the development of a nation. Apart from being a cheap source of highly nutritive protein, it also contains other essential nutrients required by the body (Sikoki and Otobotekere, 1999). The length-weight relationship of fish is an important fishery management tool. Its importance is pronounced in estimating the average weight at a given length group (Beyer 1987) and in assessing the relative well being of a fish population (Bolger and Connoly 1989). Consequently, length-weight studies on fish are extensive. Notable among these are the reports Shenouda et al., (1994), for Chrysichthys sp. from the Southernmost part of the River Nile (Egypt), Alfred and Njoku (1995) for mullet in New Calabar River, Ahmed and Saha (1996) for carps in Lake Kapital, Bangladesh, King (1996) for Nigeria fresh water fishes, Hart (1997) for Mugil cephalus in Bonny Estuary; Diri (2002) for Tilapia guineensis in Elechi creek.

Condition factor compares the wellbeing of a fish and is based on the hypothesis that heavier fish of a given length are in better condition (Bagenal and Tesch 1978). Condition factor has been used as an index of growth and feeding intensity (Fagade 1979). Condition factor decrease with increase in length (Bakare 1970; Fagade 1979); and also influences the reproductive cycle in fish (Welcome 1979). Condition factors of different species of cichlid fishes have been reported by Siddique (1977); Fagade (1978, 1979, 1983), Arawomo (1982) and Oni et al., (1983). Some condition factors reported for other fish species include; Chana chana in fresh water swamps of Niger Delta Alfred (2000) and Hart (1997), Mugil cephalus in Bonny estuary, Abowei and Hart (2007), ten fish species from the lower Nun River, and Abowei and Davies (2009), Clarotes lateceps from the fresh water reaches of the lower river.

The study of length weight relationship is usually undertaken with the objective of working out a mathematical relationship between length and weight measurements so as to enable us to find out the other variable when only one is known and also to know whether variations from expected weight for the known length groups are indications of fatness, well-being, gonadal development and suitability of environment (Le Cren 1951). Studies of length-weight relationship in aquatic animals have wide application in delineating the growth
patterns during their developmental pathways (Bagena1 and Tesch 1978). Weight follows a cubic relationship in fish and length-weight relationship is expressed by the hypothetical cube law \( W = CL^n \), where \( W \) is weight, \( L \) is length and \( C \) a constant. The formula therefore is modified as \( W = aL^n \), where \( W \) and \( L \) are weight and length respectively, \( a \) is a constant equivalent to \( C \) and \( n \) is another constant to be calculated empirically from the data.

Fishery of Uttara Kannada

The Uttara Kannada coast has over 80,000 people belonging to various fishing communities whose livelihoods are tied up with the waves and tides of the Arabian Sea and the backwaters. Even today, despite heavy pressure from mechanized fishing crafts, these fishing communities operate about 15,000 traditional boats, and use traditional nets. Fish and various invertebrates such as prawns, shell-fish, crabs, oysters etc. contribute substantially to the nutrition of lakhs of people within the district and outside.

Unfortunately, over the last few decades, the coastal and marine ecosystems are put to severe strains. Developmental pressures, over-exploitation, pollution, destruction of mangroves and beach vegetation and serious interference in the estuaries are threatening the ecology and livelihoods of the inhabitants.

The total marine wealth of the district is estimated at 4 lakhs tones contributing to 35% of the total income of the district. This district has total fishermen populations of 63,000 living in 133 villages. About 2,000 fishermen are actively engaged in industry. The Uttara Kannada coast is known for presence of Mackerel in abundance and is known as Mackerel coast. Besides this Sardine, Clupeids, etc are caught through purse seine where as Sciaenids, Ribbon fishes, Sharks, Flat fishes constitute the trawl net catch.

Sea has been a constant source of food to mankind since time immemorial. The quantum of food available from the sea has been ever increasing to sustain the ever increasing human population. Fresh water as well as marine fish and shell fishes are being successfully exploited as a source of protein rich food. A number of maritime
countries of the world have been developing the commercial farming to meet these ends.

Traditional methods of fishing in Karwar

1. Rampani
   The most important among the indigenous gear is the Rampani which used to account for about 60% of the total fish catch. It is a shore seine of exceptionally large size and consists of 400 to 600 pieces laced together, each piece measuring about 10 to 12 meter long. Unfortunately due to heavy mechanization this fishery has almost vanished.

2. Yendi
   The shore seine “Yendi” is operated up to a depth of 5m from the shore. The material used in the manufacture of this net is either cotton yarn or natural fiber extracted from a plant called ‘Naru’ in Kannada (hemp). Composition consists of all varieties of fishes, Mackerel, Scianeids Constitute major.

3. Pattu Bale
   It is a type of gill net which can be also used as a seine net. The mesh size is uniform throughout the net. i.e. 2 inches. Mackerel and other scromboid fishes, Pomfrets, Scianeids, and Sharks are the main catch.

4. Beesu Bale
   It is a stringed cast net operated in shallow water, backwaters, estuaries, rivers where the bottom is without any rocky projections.

5. Beedu Bale
   Surface gillnets used for capture of Mackerel, horse mackerel, Tuna, Cybium, Pomfrets, sharks, catfish, etc. the length of the net and the mesh varies according to the species.

Collapse of artisanal fishery

Stiff competition from commercial fisheries forced lots of traditional fishermen to go for mechanised crafts through bank loans or to work as labourers in such crafts. Overfishing in the near coastal waters caused great hardships to the artisanal fishermen. These fishermen use non-mechanized crafts such as doni (plank built boats), pandi (boat that carries
the rampani or shore-seine net) pattebale units, pathi (dugout canoe used by a single person) and many other types of crafts. Totally there were 16,153 traditional boats in coastal Uttara Kannada, during the year 1999-2000 according to the fisheries department, Karwar. Several thousand traditional families are dependent on these boats for their livelihoods. They use a variety of nets as rampani (shore-seine- used in sheltered bays by community efforts) cast nets, goru-bale (scoop nets) and many other types of nets in addition to hooks.

Rampani used to be the most spectacular kind of fishing net in operation along the Karnataka coast. It is of four or five kinds ranging from gigantic ones of over one km long, operated by the cooperative efforts of about 50 to 150 fishermen down to much smaller ones, called kairampani handled by fewer people. Even in 1976-77, well after the introduction of 1407 trawlers and 31 purse-seiners in Karnataka, about 150 rampanis contributed 80.4% of the traditional and 47.7% of the total fish catches. By 1986-87, with over 3000 mechanised crafts in operation, the rampani's output plummeted to just about 5.6% of the total marine fish catches.

The present study was undertaken to know the actual potential fishing areas off the Karwar waters and to explain certain ecological aspects and fish composition of the Potential Fishing Zones, for better understanding of the fishing and future conservation measures.

Objectives of the Study

- To evaluate the diversity and abundance of fish in notified and non-notified area off Karwar coast.
- To define the food and feeding habits of fish.
- To estimate the amount of chlorophyll present in notified area off Karwar coast.
- To enumerate age group of commercially important fishes in notified area.
- To quantify the total catch difference in Notified and Non notified regions off Karwar coast.