CHAPTER 1

INTRODUCTION

1.1 GENERAL

Pelagic fishes contribute 56% of total Indian marine fish production, out of which the dominant fish commonly known as Oil Sardine (*Sardinella longiceps*) contributes about 15.9%. Hereafter Oil Sardine is called as Sardine. Next to Sardine the Indian Mackerel (*Rastralliger Kanagurta*) contributes about 7.27% to the total marine landings in India. The above species are also available in Tamil Nadu coastal waters, which is one the most biologically productive region in India. The annual marine fish landings in Tamil Nadu in the year 2011 is 6,30,299 tonnes (CMFRI, 2012). Out of which the Sardine contributes 31.5% and mackerel contributes 4.5% (CMFRI, 2012).

The capricious nature of Sardine and Mackerel landing is observed in both Indian and Tamil Nadu coastal waters essentially because of the environmental disturbances. This has been proposed as a major process structuring occurred in ecological systems in most of the ocean causing direct mortality. Climate fluctuations have always affected fish abundance, but their consequences on fish populations were very different when the confounding effects of fishing were not present Larkin (1996). Considering the present ongoing global climate change, it is appropriate to stress the linkage between climate, the ocean ecosystem, fish population dynamics and its landings. In order to understand the complexities and to ameliorate the strategies of
fishery management, it is necessary to study the nature of uncertainty associated with the abundance of fish stocks, the effects of fishing, and particularly the influence of the ocean environment.

Fishermen community requires information regarding fish availability to maximize fish catch with minimal effort. Several studies have shown that ocean environmental parameters like Chlorophyll-a (CHL), Sea Surface Temperature (SST) and Photosynthetically Available Radiation (PAR) influence the fish availability at particular region. However, *insitu* data collection of above parameter over vast stretches on a regular basis is prohibitively costly. Satellite based estimation of above ocean environmental parameters is an established technique now, to map spatial variability and is gaining importance as a reliable, accurate and economic alternative, because of its capability in providing synoptic and repetitive coverage of vast area. The temporal variability of above satellite based ocean environmental parameters is used to provide advisory services to fishermen community to target potential fishing locations.

Most of the satellite based data gathering is possible to give information only for few meters into sea surface. Thus the techniques used in defining the prediction of monthly landing and Potential Fishing Zones (PFZ) using satellite data are valid for pelagic species i.e. fishes living near surface waters. Hence, this study concentrates on the high landing pelagic fishes namely Sardine (*Sardinella longiceps*) and Indian mackerel (*Rastralliger Kanagurta*) for landing prediction and PFZ mapping. Generally, fish landings are nonlinear in nature and this thesis work is an attempt to fill the gap of underutilized Remote sensing parameter’s influence on monthly Sardine and Mackerel landing through Neural Network (NN) Modelling in MATLAB environment. Based on the NN model prediction information the highly influencing ocean parameter for the above two species in the study area are
considered for weight and ranks calculation for PFZ mapping. Consequently, the predicted model information is useful in effective management of Sardine and Mackerel stock in the study area.

1.2 IMPORTANCE OF CHL, SST AND PAR ON FISHERIES

Satellite derived information plays an important role in fisheries applications. Remote sensing techniques can be used directly for detection of fish stocks like visual fish spotting from air crafts or these techniques can be used indirectly to predict the potential favorable zones for fish aggregations by measuring the parameters which affect the distribution of fishes Butler et al (1988). The most frequently used parameter in studies that deal with relations between environment, fish distribution and abundance is SST. Temperature has an important influence over fish species at different stages of their life cycles and also SST is the most successfully measured parameter among the other satellite data measurements Santos (2000).

Phytoplankton biomass, which is the primary source of food within the sea, is another important parameter (Santos 2000). Phytoplankton is microscopic marine organisms which are responsible for most of the photosynthetic activity in the oceans. Phytoplankton, contain the pigment chlorophyll for photosynthesis. This pigment reflects green and absorbs red and blue wavelengths of light. Different algorithms to detect CHL concentrations are developed based on the optical properties of phytoplankton.
PAR is the amount of light available for photosynthesis, which is defined as the quantum energy flux from the Sun light in the 400 to 700 nanometer wavelength range. A determination of the PAR on the surface is the key issue to estimate the primary productivity. Fishing in the ocean environment requires biomass renewal via primary production driven by solar energy. Primary production is needed to replace the fish biomass removed from marine ecosystems as fishing. The aim of the study is to define satellite ocean parameters (CHL, SST and PAR) and their association with fish landings. Consequently, the use of the same information also aids in deriving the potential favorable locations for pelagic fish abundance, marine resources with lower costs by the help of remote sensing. The ability of satellite based data products to provide synoptic and repetitive coverage helps to develop time series data of above ocean environmental parameters for continuous monitoring of marine resources.

1.3 NEED FOR ENVIRONMENTAL TIME SERIES ON FISHERIES

In India, fish catch Time Series (TS) are available with the data banks of different organizations like Central Marine Fisheries Research Institute (CMFRI) and Fishery Survey of India (FSI). But, ocean environmental parameter’s Time Series for a specific area is not readily available in India. Since the advent of satellite remote sensing and its rapid expansion, which leads to deploy ocean colour remote sensors for dedicated ocean colour parameters, satellite derived data on SST, CHL and PAR are available for last two decades in the form of Global Area Coverage (GAC). In this context, the availability of global, daily, systematic, high resolution images obtained from satellites has been a major data source for explaining the relationships between exploited marine organisms and their habitat (Polovina and Howell 2005; Dulvy et al 2009). For that continuous archiving
of satellite remotely sensed ocean parameters to a specific region are necessary to discuss the distribution, abundance and migration of fishes. Since from 1978, (launch of CZCS) remote sensing has played an important role in both the management and utilization of marine fisheries. Although the Sea Surface Temperature based time series are available from 80’s, the CHL and PAR time series are available for research only from the year 1997 (launch of Sea-viewing Wide Field of view Sensor (Sea WiFS). Hence in this study TS for the above three parameters are created from the year 1998.

Further, the conventional fisheries management has focused mainly on single species univariate approach, from there, now it has shifted to ecosystem based approaches for fisheries management practices. Hence, in this study CHL, SST and PAR TS were considered from the year 1998 for the development of ecosystem based Multivariate NN analysis. The traditional Auto-Regressive Integrated Moving Average (ARIMA p, d, q) models using Box-Jenkinson methodology (Stergiou, K.I., 1997), are normally used for obtaining wide variety fisheries time series predictions particularly on univariate linear approach. Monthly landings are generally nonlinear, which is not predicted effectively by ARIMA models, but it is efficient in modeling Linear phenomena in describing and predicting the fisheries time series of with a wide variety of species Saila et al (1980); Hae-Hoon Park (1998); Stergiou, and Christou (1996); Sathianandan (1995); Venugopalan (1998). In this context, a total of five time series (Three from satellite and Two from fish landings) were prepared for NN modeling in this study.

1.4 NEURAL NETWORK ON FISHERIES

Among the various methods available for forecasting nonlinear phenomena, the NN is the best and the efficient method to get a forecast. (Lin sun et al 2009). In this context, the applications of NN to forecast landings using TS have become very popular over the last few years, since
most of the landings TS are in nonlinear pattern. Neural networks are simple nonlinear computing units imitating human neural system, has an input layer, a hidden layer and an output layer. Layers in between input and output layers are generally called as hidden layers and commonly referred as neurons. When data is loaded in the ANN (Artificial Neural Network), it must be preprocessed from its numeric range into the numeric range that the ANN can deal with efficiently to improve the efficiency of the learning results (Kim and Lee 2004).

Artificial Neural Network’s performance over real TS is not satisfactory because the environmental factors and its seasonal fluctuations are not considered in ANN modeling. The advantage of the ANN approach is its ability to predict biomass developments without the need to directly specify parameter values such as growth or mortality rates, which are difficult to establish ahead in the ocean environment. Rather these are specified absolutely in the weights of the ANN by relating input data to the resulting dynamics and use these relationships to train the network. By combining several variables, the network can predict the dynamics given the current state of the input variables. In this study, for NN modeling, time series environmental parameters such as CHL, SST and PAR are considered as three input functions for the prediction of Sardine and Mackerel monthly time series landings as output.

1.5 NEED AND IMPORTANCE OF THE STUDY

Nagapattinam coastal district plays a vital role in fishing with 44 major and fish landing centers in it. This is the second largest coastal district in Tamil Nadu having a coastal length of 190 km with 7300 crafts getting operated in this region. In the recent years, there is a strong evidence of reduction in the amount of landings from this area because of various human and environmental changes. Figure 1.1 shows the landing trend of Sardine
and Mackerel in the study area. This ultimately reflects in the livelihood of local fishermen community and also in the export of fish and fishery products quantity from Tamil Nadu. At the same time, this coastal area was heavily damaged by the 2004 tsunami which damaged 60% craft and gear available in the study area. Thus, there is an immense watch and guidance required in this area for the upliftment of fishermen community. This leads to this study for the prediction of future landing quantity seasonally with the help of remote sensing data and Neural Network analysis. Apart from the prediction analysis, a Decision Support System has also been developed in this study to identify the potential fishing zone for Sardine and Mackerel in the study area.

Figure 1.1 Sardine and Mackerel Landing details in Nagapattinam Dt.
In Indian context currently, advisories are issued on daily basis in terms of Potential Fishing Zone (PFZ) maps using OCM-2 and AVHRR sensor by Indian National Center for Ocean Information Services (INCOIS), Government of India, for the maritime coastal stretches of east and western coast of India. The PFZ maps indicate the potential fishing availability, but do not give any information about the species and the spatial variability of fish abundance.

In this study, a methodology has been developed using freely available HDF, Global Area Coverage (GAC) data of SST and CHL from MODIS for generating Species Specific Potential Fishing Zone (SSPFZ), incorporating spatial variability of specific species in the study area. Neural Network (NN) model using Feed Forward Back Propagation (FFBP) with Gradient Descent Momentum (GDM) has been used to predict the fish catch. The NN model has been trained to predict fish catch from SST, CHL and PAR as input parameters. The association of satellite derived CHL, SST and PAR for Sardine and Mackerel, are considered to develop weightage and ranking in SSPFZ mapping.

A Decision Support System (DSS) is developed in this study to identify the PFZ for Sardine and Mackerel species, so as to provide specific spatial location and direction to the fishermen to fish at locations inside the ocean, which is likely to maximize the catch quantity. This helps the fishermen to reduce his search time for fishes, which in turn minimizes the fuel cost and increase the fishing effort on Sardine and Mackerel. For fisheries managers and to the government this study will give a deep understanding about landings to take decisions for maintaining the sustainability of fisheries in the ocean and to implement policies like change in closed season period, providing loans, subsidies to the fishermen for craft and gear purchase etc.
1.6 OBJECTIVES AND SCOPE OF RESEARCH

This study consists of two major parts. First part of the thesis is to model Sardine and mackerel landings monthly prediction, through NN analysis. The second part is to develop a user friendly DSS to identify the potential location for Sardine and Mackerel to reduce the expenditure of fishing activity, particularly to reduce the fuel and motor oil expenditure. The general and specific objectives formulated for this research study are as follows:

(i) General Objectives

a. To extract satellite derived ocean environmental parameters (CHL, SST and PAR) for the preparation of time series from the ocean colour Remote Sensing Satellite products.

b. To validate the chlorophyll concentration in the study area using OCEAN SAT-2 OCM & MODIS sensor data with insitu measurement data to create validated time series data.

(ii) Specific Objectives

a. To study the prediction capabilities of SST, CHL and PAR in predicting fish catch with long & short time series, and Non-Seasonal & Seasonal orientation using Neural Network.

b. To develop a methodology for preparation of SSPFZ for Sardine and Mackerel species using freely available Global MODIS ocean parameters.

c. To validate the SSPFZ with current PFZ advisory and fish catch data from landing centers.
d. To provide detailed location and direction information for Sardine and Mackerel species fish abundance through a DSS in open source QGIS environment.

1.7 OUTLINE OF THE THESIS

The thesis has been arranged in seven chapters.

Chapter 1 gives the general introduction about the importance of Sardine and Mackerel fisheries, need of ocean colour product time series and Neural Network introduction. The need for the present investigation, the formulated objectives and scope of the research are outlined.

Chapter 2 discusses in detail on the review of literature, with respect to the research carried out on the NN prediction, modeling optimization, analytical and numerical investigations on TS and DSS for SSPFZ mapping in the study area.

Chapter 3 discusses in detail about study area Nagapattinam district with respect to topography of study area, craft and gear used for the capture of Sardine and Mackerel and the climatological condition during the past ten years.

Chapter 4 deals with the methodology of image DN value extraction and spatial averaging for time series preparation, field sample collection details, step by step development of Neural Network models and Decision Support System for SSPFZ development and its validation procedures.
Chapter 5 presents the results and discussion of Neural Network Models on Non-Seasonal, Seasonal, long and short time series models. A total of eight sensitivity analysis parameters were estimated and their result also is discussed in this chapter elaborately. The development of DSS for Sardine and Mackerel PFZ and their validation results are also discussed in this chapter.

Chapter 6 summarizes the conclusions arrived on the basis of this research work with suggestions and scope for further research in this area of NN and PFZ development and their limitations. The list of references is given at the end of the thesis.