



# Linking Ocean Observation and Fisheries - Relevance to Deep Ocean Living Resources



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## Abstract

Systematic ocean observation for real time data collection during the last three decades, development of sensors and tools, and ocean modelling have paved the way for better understanding of the ocean processes and better prediction of coastal hazards like cyclones, tsunami, storm surge, etc., leading to direct societal benefits globally. In particular global ARGO float data have brought in remarkable changes in ocean science studies. This paper discusses about the growing need to link ocean observation to fisheries and futuristic approach about deep ocean marine living resources

## Introduction

The goal of fisheries oceanography is to understand the oceanographic and ecological processes that affect fishery abundance, distribution, and availability and then apply this understanding to improve fisheries assessment and management. Ecophysiology is the interrelationship between the environment and an organism's physiology [1]. The future of fisheries oceanography lies in the pursuit of multiple hypotheses [2]. Using temperature as an example, a range of biological processes are related to temperature either directly or indirectly [3]. All organisms have thermal limits above and below which death is rapid. Within these limits, temperature controls a number of rate processes, including gene expression, enzyme kinetics, metabolism, activity, consumption, and growth. Organisms also respond behaviourally to temperature through migration, foraging, and resting.

Looking ahead, the core question is whether today's agriculture and food systems are capable of meeting the needs of a global population that is projected to reach more than 9 billion by mid-century and may peak at more than 11 billion by the end of the century [4]. Human activities have profound, possibility irreversible impacts on ocean health, in terms of physical state (warming, freshening, and circulation changes), its biogeochemistry (carbon uptake and acidification) and its ecosystem. The ocean influences climate by storing and transporting large amounts of heat, freshwater, and carbon, and by exchanging these properties with the atmosphere. Ocean warming dominates the

global energy change inventory with warming of the upper (0 to 700m) ocean accounting for about 64% of the total. However, below 700m ocean depth, data coverage is too sparse to produce annual global ocean heat content.

## Deep Ocean Policy, Strategy and Capacity Building

The deep ocean is the single largest ecosystem on our planet. It sustains a great variety of habitats and life forms and is host to potentially valuable resources such as minerals, oil and gas and more traditionally food. Harnessing the full potential of deep ocean resources, whilst mitigating and managing environmental impacts, requires in-depth knowledge and understanding of the complexities of deep sea ecosystem and interconnection of the physical environment and the life forms within it [5].

Deep Ocean is yet to be understood and answered in the context of the role of deep ocean processes and various science questions pertaining to Earth's energy imbalance, heat budget, fluxes, and deep ocean mixing, on climate change. Industrial activities on deep sea mining, bottom trawling and oil and gas extraction need detailed study of the biogeochemical processes and impact assessment, which require systematic ocean data collection. Available reports indicate that inertial-period oscillations have been observed by numerous investigators in deep sea locations ranging from subtropical to polar latitudes [6].

Innovative technologies are a key to study ocean processes in space and time. Today's underwater exploration is supported by vessels operated by a number of skilled crew members, and underwater robots controlled from the vessel. These underwater technologies have been utilised widely by the private sector. Different robotic platforms like benthic landers, crawler, floats, glider, Autonomous Underwater Vehicle (AUV), Unmanned Airborne Vehicles (UAVs) and sensor systems are required for deep sea studies. The use of these new underwater technologies will enhance our capabilities in improving our knowledge on the effects of climate change and ocean observation [7,8].

The deep ocean is our planet's largest biome, and is under increasing pressure from human activities such as resource exploitation and pollution. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) declared the seabed area beyond national jurisdiction (the Area) and its mineral resources as the "common heritage of mankind", to be administered for the benefit of mankind as a whole. All mineral exploration and exploitation activities must be sponsored by the Party to UNCLOS and approved by the International Seabed Authority (the Authority). The United Nations Environment Programme (UNEP) report states "it is important that policies guiding mineral extraction from the deep seas are rooted into adaptive management-allowing for the integration of new scientific information alongside advances in technology. Governance mechanisms for international waters and the seabed need to be strengthened". Hence there is also an unprecedented need to integrate the deep ocean into ocean science and policy. New international regulations (e.g. for mining) and treaties (e.g. for biodiversity), environmental management, and spatial planning also must incorporate climate and the role of deep processes.

New knowledge is critical to climate predictions and societal impact assessments and will require the expansion of deep-water research with experimental capacities, to support the design of marine protected areas encompassing vulnerable regions in deep waters, and to inform environmental management of industrial activities and development of new policies addressing deep national and international waters.

Outreach events on advances in ocean science and technology and their role in judicious and sustainable exploitation and use of the vast resources should target groups of people including schoolchildren, people and local communities and by contributing interactive exhibits and displays for curious visitors of all ages. They can contribute directly to the country's prosperity, benefit humanity, and many non-scientists who have little knowledge of these important issues. The public awareness of science by communicating their work widely, whether it involves explaining climate change, and/or investigating life at the bottom of the world's deepest oceans, will go a long way in knowledge enhancement among the entire cross section of the society.

The deep sea is out of sight, out of mind, and because there is no specific human society that is directly impacted

by the negative consequences of extraction, it is challenging to focus attention on environmental issues of deep-ocean industrialization, including commercialisation of deep sea fisheries. It is imperative to work with industry and governance institutions to put in place progressively strong environmental regulations, even at the planning stage of the industry itself. There is a need for international agreements and multiple sources of research funding that can help provide the scientific information to protect and manage the deep sea environment and its resources. All these will require efforts that bridge several disciplines and engage different stakeholders in these tasks.

### Role of Oceanography in Sustainable Fisheries Management

Often fisheries stock assessment and management has been questioned for failing to account for oceanographic processes. It is clear from the abundant research that fisheries scientists and managers are well aware of the role that oceanographic processes play in controlling fish populations. Debate about the relative roles of fisheries versus the ocean conditions / environment in determining the abundance of fish stocks has persisted for decades. There are numerous examples of academic exercises developing methods to identify relationships between population dynamics and oceanography, to integrate oceanographic data into stock assessment and management, and to evaluate the advantages of using oceanographic data, but there is a lack of successfully implemented examples in the real terms.

Recently, the methodology adopted by USA and Australia have shown success. NOAA Fisheries oceanography program is more than 100 years old and has successfully developed methods for annual outlooks with emphasis on the long-term sustainability of fish stocks. Linking ocean conditions to salmon returns using plankton species, SST and DO revealed important changes in the marine food chain and offshore ecosystem and their "red light-green light" chart has become popular among fishing industry.

Periodic research articles by Oceanographers along the Indian east and west coasts have showed the linkage of Phytoplankton survey, Oxygen Minimum Zone and Upwelling in Arabian Sea, fronts meandering in Bay of Bengal which are linked to fishing, and impact of coastal/ocean pollution to fisheries. The availability of fine spatial and temporal scale oceanographic data from remote sensing and ocean observation system like moored buoys, ARGO floats, etc., ship borne measurements, and oceanographic models allow research on more appropriate scales, which may lead to improvements in the near future, leading to better understanding of the interaction between the ocean parameters and the deep sea fisheries resources.

Unfortunately, the understanding of the mechanisms involved, the available data, or the large scale correlations are limited. In most cases, statistically significant correlations between population dynamics and population processes break

down are yet to be established. This has led to advocating direct monitoring or developing management strategies that are robust to the variation rather than determining the relationships between population dynamics and oceanographic processes. The few successfully implemented examples mainly relate to predicting the spatial distribution of a fish stock. Therefore, use of oceanographic data to determine dynamic spatial closures to reduce by catch appears to be one of the most promising areas of research.

### Indian Context

Of late, in India our enhanced observing and modelling capacity is providing new opportunities to improve fisheries management at both short (e.g., weekly) and long (e.g., climatic) time scales. Indian National Centre for Ocean Information Services (INCOIS) Hyderabad under the Ministry of Earth Sciences develops Potential Fishery Zones (PFZs) advisories and issues them to the coastal fishing community through various media. INCOIS uses satellite measurements of sea surface temperature (SST) and chlorophyll generated from OCEANSAT to develop these PFZ advisories, which consist essentially of curves drawn on a map to delineate the Potential Fishing Zones. Judging by download statistics and the feedback available, the product is popular with the fishing community within India as well as in this region.

In India, there is no industrial fishing fleet operating within the EEZ. Out of 199,141 fishing craft which are presently operating in the Indian seas, non-motorised and motorized traditional fishing crafts constitute 63.41% (126,392), with the remaining 72,749 (36.59%) being the mechanised fishing boats including trawlers. Traditional fishing crafts do day fishing in east coast up to 3 to 5 NM and west coast up to 7nm. The motorized fishing crafts (fitted with Outboard motors of 10-15 HP) do fishing up to a maximum of 70-100m depth. The mechanised fishing craft including trawlers which are less than 20m Overall length (OAL) operate as either day fishing boats or multi-day fishing boats depending on their OAL and the horse power of the inboard engine and do fishing for 7-15 days in the open sea depending

on their endurance. These fishing crafts are landing on an average 3.10 million metric tonnes per annum during 2004-2014, against the projected Maximum Sustainable Yield levels of around 4.5 million m.t. This is in spite of the fact that there had been an increase both in terms of the fishing effort in the form of increase in fishing craft and the fisher population. The existing satellite based technique often does not work close to land and hence there is a need to evolve a unique methodology supported by primary field level data on productivity, coastal ocean monitoring data and fisheries data, which could be integrated and used to supplement the sea surface temperature derived from satellite imageries and other physical and chemical oceanographic data collected from moored and floating buoys for providing information on potential fishing zones along the coastal belt within 5-10nm zone for the benefit of fishers who do fishing using traditional sail powered and motorized fishing boats.

In India pioneering work carried out in the Arabian Sea by the Indian researchers has provided a lot of opportunities for correlating the oceanographic parameters with fisheries resource abundance beyond 100-200m depth zone within the Indian Exclusive Economic Zone and areas beyond national jurisdiction. The data and information collected so far from these studies will be very useful in furthering our studies in the Bay of Bengal and parts of the Indian Ocean abutting the southern tip of the country and the Andaman and Lakshadweep areas. It is proposed to involve all the relevant Government organizations and stakeholders to make a realistic assessment of the deep sea fisheries resources/fish stock assessment and management in correlation with the oceanographic parameters.

### Issues to be Addressed in Fisheries Oceanography

- I. Why do we get a certain fish in a certain region?
- II. Why is the fishery pattern changing ?
- III. Forcing in shelf has any influence.
- IV. Early fish life history to integrate with river run off nutrients which trigger fish to breed mostly after monsoon.

### National Fisheries Outlook

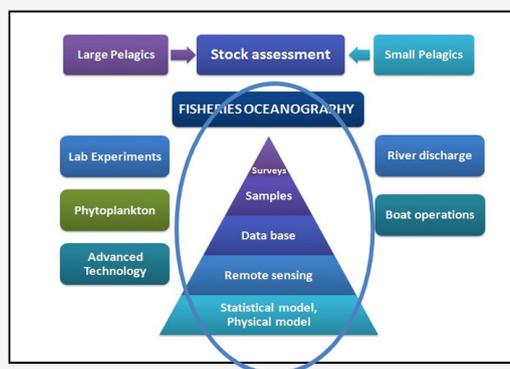


Figure 1: Source: NOAA, 2015.

There is a need to involve national outlook on fisheries and to support ecosystem based fisheries management following the example of NOAA's Fisheries oceanography program on ocean conditions to salmon returns using plankton species, SST and DO, Although traditional single-species management continues to use spawning stock biomass as the primary indicator for recruitment, recent research is being addressed on the early life history of fishes (Figure 1).

## Summary

There is growing demand from funding agencies and public on the sustained fishing practices and relevance of Oceanographic scientific finding to support the society in particular the fishing community / Industry. When a fisherman sets out to sea, he confronts a vast expanse of water and the vagaries of nature. There exist no roads to follow, no tracks to lead him to the fish, which too are not to be found all over the ocean. Fish, being migratory in nature, either tend to congregate in certain regions, or are always in motion and hence it is important for the fishermen to locate them in order that their fishing effort serves its purpose. By seeking to elucidate mechanistic relationships between fish species and their surrounding oceanic habitats, the field of fisheries oceanography will aim to provide a solid understanding of fish behaviour, population dynamics, and life

history with an ecosystem perspective. In future similar weather forecasting. Science would improve to focus on prediction or forecast for fishing using a different data sets available.

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