Satellite Remote Sensing Applications in Mariculture Activities

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Introduction

During the last two decades the marine fisheries sector in India has undergone considerable change. The fishing fleet became larger and more energy-intensive, and the catch and trade of marine fishes increased substantially. Concern arising from the increasing fishing effort and the potential for overexploitation in Indian waters, led to scientific assessment of the status of several fish stocks. Consequently, attempts were made to shift from open to regulated access fisheries through Marine Fishing Regulation Acts (MFRAs). However, conflicts in sharing the limited resources intensified within and with other sectors and this, in turn, had high economic, social and environmental costs (Vision 2050, CMFRI). Thus, in recent years, the sector recognized the need for effective management for sustainable fisheries and a healthy marine environment through ecosystem approach and habitat restoration. Success has been achieved in mariculture, raising hopes of producing a plentiful supply of fish in future by farming marine fish.

Mariculture, the farming and husbandry of marine plants and animals in the marine environment, is the fastest growing subsector of aquaculture. Globally, mariculture produces many high value finfish, crustaceans, and molluscs. In India, the potential of mariculture production remains largely untapped. It has been realized that the vast coastal areas of our country are suitable for mariculture of high value finfish, shellfish and sea plants. Presently, standardized hatchery and farming technologies are available only for a limited number of marine finfish and shellfish species. Hence there is a need to enhance mariculture production fora large number of marine species, extend areas of marine farming, and introduce new production systems. Over a period of time, the proportion of production from coastal and marine aquaculture should be aimed at 40% and in terms of value, at 70% (Vision 2050, CMFRI).

Ecosystem Approach to Aquaculture (EAA) and role of satellite remote sensing

For sustainable mariculture in the country, the mariculture practices should aim at optimum production and maintain a 'green environment'. The lessons learnt from the shrimp farming should inspire caution, as intensive shrimp farming resulted in environmental deterioration and consequent disease problems which called for a need for 'Better Management Practices' and species diversification. A green environment necessitates the need to adopt Ecosystem Approach to Aquaculture (EAA) by taking into account the knowledge and uncertainties of biotic, abiotic and human components of the ecosystem including their interactions, within ecological and operational guidelines. Finally, carrying-capacity assessments are essential before any species is farmed either in the sea or land. This is particularly relevant to expansion of sea cage farming in the country. The total number of cages in a given area, stocking density of fish per cage, and feeding intensities should be taken into consideration. For carrying-capacity assessment of cages, dispersal of toxic waste may be looked upon as an important factor. Toxic and metabolic waste dispersal is a function of local residence time (tides, currents, estuarine circulation where relevant) of the waters at the site under consideration. Along the Indian coastal waters, marked asymmetry exists in the tidal ranges between the southern and northern latitudes. Over the west coast of India, the South West (SW) coast shows a tidal range of 10.90 m at Gujarat coast and the North West (NW) shows 1.34 m at Cochin coast. Hence, there is more mixing in the waters of NW coast, resulting in short residence times compared with SW coast. The East coast of India also shows similar variation in tidal ranges from south to north, but less pronounced than on the west coast. So in general, the residence time is longerin southern latitudes and shorter in northern latitudes along the coastal waters of India. However, the effect of tidal currents should also be considered for proper selection of sites of cage aquaculture and scheduling the cage related maintenance activities. Case studies have delineated the role of tidal currents along the west coast of India. Stronger tidal currents occur along the northern shelf compared with the southern shelf.

The changes in the operating environment of the mariculture sector will have to be transformed into opportunities. This, along with technological advances in other sectors such as remote sensing and GIS, provides an environment for holistic development of the marine fishing sector which benefits the fish, the fishermen and the environment. We need a ‘tool’ for effective delivery of EAA in the marine context. Marine Spatial Planning (MSP) is such a ‘tool’: it maps the varied uses of the marine environment and increases the efficiency of EAA. It is a strategic plan for regulating, managing and protecting the marine environment that addresses the multiple, cumulative and potentially conflicting uses of the sea. MSP will serve both as a framework and a process for more integrated decision making. Its goal is a fully comprehensive, integrated, plan-led system of management for the present and future exploitation and development of marine resources and for the use of contested space. The most important task for mariculture in an MSP regime is establishing the broad aim of MSP and elaborating this through a coherent set of more specific objectives with reference to fisheries.

India is a global leader in satellite technology which can be effectively utilized for managing marine fisheries sector. Deploying a dedicated satellite for mariculture/ marine fisheries would provide several opportunities and applications. SRS can also be used for establishment of “e-infrastructure” in the mariculture sector. The concept of “e-infrastructure” deals with establishment of infrastructure (hardware and software) for greater data sharing and connectivity. The same principle can be used for SRS in mariculture in India. The data collected by SRS on synoptic temporal and spatial scales on various ocean properties, along with *in situ* data, can be validated at dedicated data centres in the country. The advisories sent out by data centres can then be used by various management agencies or de-centralized agencies such as Panchayats for effective management of mariculture sites. SRS can be integrated with GIS for MSP. Mapping the various users of marine ecosystems and their real time occurrences will play an important role in EAA in India. Identification of appropriate environments in the ocean from SRS data for potential cage aquaculture sites as well as for inoculation of algal species for algal bioengineering of the oceans is also a possibility. Identification of suitable off-shore mariculture sites where culture will have minimal impacts on ocean health is also possible with SRS data.

Identification of suitable sites, timing and suitable species for open sea cage culture using satellite remote sensing

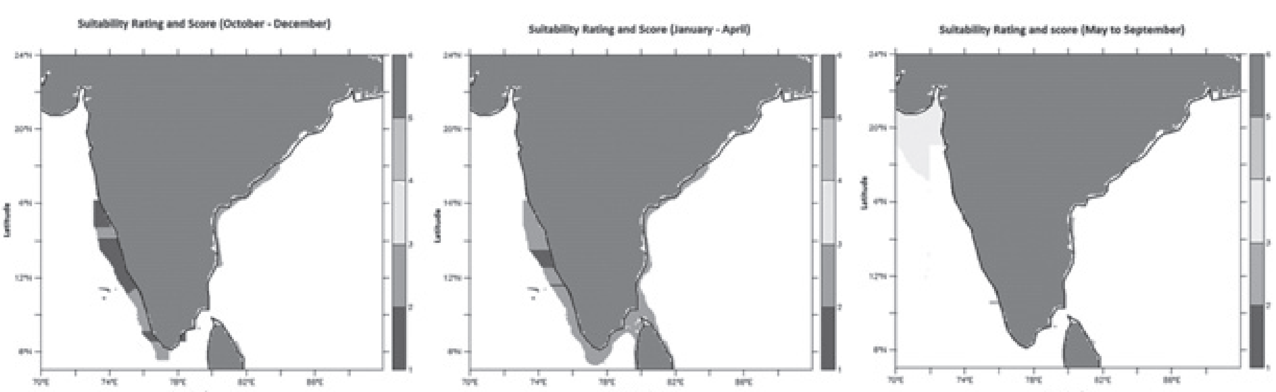
The risks involved in sites of cage installation are to be avoided for successful cage farming. The risks are those arising from severe weather; from toxic phytoplankton; and from accumulation of waste products of metabolism. Protection from severe weather requires analysis of local topography in the context of the prevailing wind and wave fields, as well of the vulnerability to extreme events such as the passage of cyclones. Protection from the toxic phytoplankton requires analysis of the spatial distribution of toxic blooms, such as could be established through remote sensing. In a case study for an all India analysis, we used GIS based multi-criteria analysis (MCA) - a set of evaluation criteria which are quantifiable indicators of the extent to which decision objectives are realised. A suitability score was used as compiled from published literature as Table I (Rao et al., 2013).

Table 1: Scoring for site selection based major physical factors

Score	Wind Speed (m/s)	Temperature (°C)	Salinity (PPT)	Depth (m)	Major Tidal Current (cm/s)
1	d” 2.5	27 - 31	25 - 40	0 - “200	5 - 10
2	2.5 - 5	27 - 31	25 - 40	0 - “200	5 - 10
3	5 - 7	27 - 31	25 - 40	0 - “200	5 - 10
4	7 - 9	27 - 31	25 - 40	0 - “200	10 - 15
5	> 9	27 - 31	25 - 40	0 - “200	>15

Optimal / near optimal site MCA was carried out using Ferret- an open source software to identify appropriate locations for cage culture based on a group of factors and constraints. The data source for the study was Wind Speed – Quickscat Scatterometer, Temperature and Salinity – North Indian Ocean Atlas (NIOA) by Chatterjee et al. (2012), Tidal range and Currents –Susant et al. (2013); Subeesh et al. (2013), Bathymetry – etopo2 and Predicted Tide table (http://tides.mobilegeographics.com).

The data available wereanalysed for different seasons and the results are given in the plots below:



Our study indicated that open sea cages are vulnerable to the coastal oceanographic as well as the bio-geo chemical processes and resultant biology. Southwest monsoon period is not suitable for cage farming and species selection and culture period may be based on the available culture time. Therefore, the months from October to April are ideal for cage farming with the defined criteria. A table size pompano (*T. blochii* and *T. mookalee*) can be farmed during this period with good food conversion ratio.

Conclusion

Any planned sectoral development needs appropriate policies, legislations and acts. As the existing policies are inadequate to meet the anticipated challenges in the sector, it is important to develop effective new policies. In the case of mariculture, as it is an emerging sector, there is a need for developing leasing policies and other regulations. The government's role is to manage the fisheries assets on behalf of society and to derive maximum benefits for future generations. The role of research institutions such as the Central Marine Fisheries Research Institute (CMFRI) is to provide scientific support and suggestions to the governments, and to maintain a watching brief thereafter. A sustainable fisheries and mariculture sector is essential for ensuring seafood for all and forever. State-of-the-art practices such as advent in satellite remote sensing (SRS) as well as Geographical Information System (GIS) will be useful for effective planning and can support the mariculture initiatives and their monitoring in the country.

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