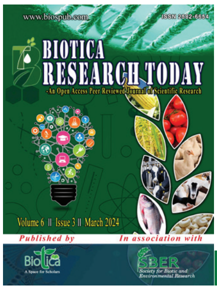
Bio. Res. Today 2024, 6(3):93-96



Biotica Research Today

e-ISSN: 2582-6654
March, 2024

Article ID: RT1576
Popular Article

Application of Remote Sensing and GIS in Fisheries

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Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Sedyaaw *et al*., 2024. *Application of Remote Sensing and GIS in Fisheries*. *Biotica Research Today* 6(3), 93-96.

Abstract

The combination of Geographic Information System (GIS) and Remote Sensing (RS) technology marked the beginning in a new era in fisheries management by providing innovative answers to the challenges of conservation and sustainable resource use. This abstract explores the transformative impact of integrating these technologies in fisheries and their collective contribution to informed decision-making. Remote sensing technologies, encompassing satellite imagery and aerial surveys, have proven instrumental in monitoring and understanding marine ecosystems. Potential Fishing Zones (PFZs) represent a focused application within this integrated framework. This abstract highlights the capacity of these tools to provide timely and accurate information, fostering sustainable resource utilization and supporting the long-term health of marine ecosystems. As technological advancements continue, the collaborative application of RS and GIS stands as a cornerstone in the pursuit of a harmonious balance between meeting global demands for seafood and preserving the vitality of our oceans.

Keywords: Assessment, Biodiversity, Fish, Stock

Introduction

It is highly convenient to identify geological features, as well as additional types of landforms and drainage patterns, using remote sensing technology that is directed by satellite picture data. This is very beneficial for geological mapping, mineral exploration and hydrocarbon exploration. The data used to create satellite images is in the form of rasterized digital images, which are made up of many tiny pixels arranged in rows and columns. These pixels each have a numerical value or digital number that corresponds to a specific region of the Earth's surface. A crucial stage in remote sensing is image processing.

A tool for creating and using geographical information, the Geographic Information System (GIS) focuses primarily on the position and characteristics of features. It supports our collection, processing and display of spatial data for a variety of uses. A GIS quantifies the locations of features by recording their coordinates; these are the numbers that describe these features' positions on Earth (Padua, 2018).

Principle of Remote Sensing

The science of remote sensing entails using satellites or aeroplanes to get information about far-off places or objects. It is dependent on the identification and evaluation of electromagnetic radiation that is emitted or reflected from various objects.

Geographic Information System (GIS) Principle

GIS is written in a wide range of software languages and operates on the whole spectrum of computer hardware, from portable personal computers to multi-user supercomputers.

Applications of Remote Sensing in Fisheries

Technology of remote sensing now extensively utilizes to the fisheries sector and its management especially for the capture fisheries in the marine sector. Since our interest is limited to the use of remote sensing in the fishing industry, the mechanical and digital structure and analysis portions of the system have been left out of this section. The entire system is somewhat complicated with its remote sensing principles, systems and analysis techniques, *etc*.

1. Acoustic Sensing of Fish Schools

Acoustic waves are not included in certain definitions of distant sensing; nevertheless, since they are crucial for

Article History

RECEIVED on 27th February 2024 RECEIVED in revised form 17th March 2024 ACCEPTED in final form 18th March 2024

fish identification, they must be included in this study. In coastal and deep ocean regions, fish schools are frequently found using acoustic methods. One of the benefits of using sonar techniques is that they can yield higher-quality, more precise data on fish distribution and abundance than conventional trawl surveys do. For example, it is possible to predict the abundance (density estimates) of whiting, pollock and herring with over 75% accuracy. In the maritime environment, acoustic methods are also significantly more sensitive than visible light methods. Fuel and ship time can be saved by fisherman by using acoustic sensors to lessen the effort involved in searching and sampling. There are several types of sonar systems available. The most commonly used acoustic technology in fisheries research, monitoring and harvesting are side-scan sonars and echo-sounders.

2. Operational Monitoring Programs

Following Japan, other nations started giving their national fishing fleets access to fisheries environmental assessments, particularly SST charts. More recently, products to aid in fishing have been successfully produced using satellite data. Along with many other fishing-related projects, the Canadian Space Agency (CSA) initiated the SAFARI Project (Societal Applications in Fisheries and Aquaculture using Remotely Sensed Imagery) in 2007 as a means of fostering international cooperation. Accelerating the integration of earth observation data into international fisheries research and management is one of the goals of the Intergovernmental Group on Earth Observations (GEO).

3. Remote Sensing of Ocean Fronts and Gyres

Estuaries and ocean fronts, like air fronts, provide an angled interface as the denser fluid tries to push aside the lighter fluid. Both large- and small-scale fronts have this notable density difference throughout the front that lasts for long periods of time. Since they are produced by a multitude of circumstances, there are several various types of fronts, such as shelf fronts, estuarine fronts, shelf break fronts, coastal upwelling fronts, etc. Viewing coastal plumes and fronts in the open ocean and on the shelf has proven to be a valuable use for satellites fitted with thermal infrared and colour sensors. Microwave radiometers have also been used to detect coastal fronts and plumes due to their salinity gradients.

4. Mapping Sea Surface Temperature

Thermal infrared photography was the main technique used in the past for satellite remote sensing applications in fisheries to produce maps of sea surface temperature. Thermal infrared (TIR) sensors have been on board operational meteorological satellites for over 40 years in order to detect surface temperature anomalies (SSTs) in the absence of clouds and record cloud top temperatures. The Moderate Resolution Imaging Spectro-radiometer (MODIS) on NASA Earth Observing System (EOS) Terra and Aqua satellites, the Advanced Very High Resolution Radiometer (AVHRR) on NOAA Polar-orbiting Operational Environmental Satellites (POES) and the Along-Track Scanning Radiometer (ATSR) aboard the European Remote Sensing Satellite (ERS-2) are just a few of the thermal infrared instruments that have been used to determine SST.

5. Remote Sensing of Ocean Color and Productivity

In comparison to the shallow waters of the continental shelf and coastal upwelling zones, the open ocean is rather barren ecologically. Nutrients are brought to the continental shelves by rivers and surface and bottom water mixing waves. Additionally, there are upwelling locations that credit their high production to the deep water's continuous upward movement, which replenishes the photic zone with nutrients. For example, 50, 100 and 300 g $c^{-1}m^{-2}y^{-1}$ are estimated mean productivities of the open ocean, coastal regions and upwelling areas, respectively.

Applications of Geographic Information System (GIS) in Fisheries

1. Identification of Suitable Sites for Freshwater & Brackish Water Aquaculture

This is a novel application of GIS to work on fisheries. A good location is essential to the success of any aquaculture endeavour. The sustainability of the farming operation is ensured and improved resource management is facilitated by an ideal aquaculture location. The topography of the site, the slope of the land, the water flow, the volume available, the water quality, the weather parameters, the location and accessibility of utilities, the water rights legislation and other factors all play a role in the decision-making process when choosing a site for aquaculture. The greatest way to compile all of this data and determine which locations meet the ideal set of criteria - that is, which would be the most suitable locations for aquaculture - is through the use of GIS (Dineshbabu *et al.*, 2014).

2. Management of Marine Fisheries & Coastal Regulation Zone

The spatiotemporal distribution of fishes in the chosen study region will be clearly depicted by the GIS-based research, which will also assist in identifying important fishing grounds in terms of marine biodiversity and fisheries. GIS is also used to define fish habitat, manage living marine resources (*i.e.*, the dynamics of marine objects), track marine mammals and analyse their migratory and hunting routes. These applications can evaluate the effectiveness of marine protected areas and provide solutions for issues relating to environmental degradation.

3. Distribution of Various Fish Species Considering Physical Habitat Features

The correlations between fish distributions and numerous environmental characteristics will be of great interest to individuals engaged in science or fisheries management. Commonly utilised characteristics include salinity, bottom sediment type, marine chlorophyll abundance, water depth, upwelling indices and temperatures (particularly thermal fronts).

4. Establishing Regional and National Fisheries Databases

Even though there isn't a direct GIS use for fisheries management, it is obvious that fisheries GISs could not operate without significant data inputs. Therefore, a great deal of work has gone into creating databases, metadata sets and regional data centres in certain important fishing locations, such as eastern Canada or the numerous World Data Centres. Numerous fish species with significant worldwide economic value have been subjected to it, including rainbow trout, Atlantic salmon, puffer fish, rohu, puffer fish and zebra fish. Numerous other species are presently being studied. The potential of genome technologies to integrate with the "omics" approach and other parts of the fisheries sector is immense, surpassing the existing limitations that impede aquaculture from reaching unprecedented heights (Singh *et al.*, 2024). Data sets pertaining to fisheries are gradually becoming available online. Table 1 shows the sources of primary and secondary data for GIS on marine fisheries.

Table 1: Sources of primary and secondary data for GIS on marine fisheries

Condition	Primary Data	Secondary data
Data format	Fish, water, fishing vessels, ports, coast	Tables, photographs, maps and charts, books, acoustic images, digital databases
Data sources	The real world	Library, remote sensing centers, Govt. offices, mapping agencies, hydrographic offices, research institutes, digitizing agencies
Data acquisition	Fishery surveys	Networking, digitizing
Methods	questionnaires, sketches, photographs, remotely sensed data	Scanning, online searching, databases
Equipment	Measuring equipment, cameras, data loggers, sensors, acoustic equipment, positioning systems, research vessels	Scanner, digitizer, computers and peripherals, image-analyzing equipment

(Source: Meaden and Do Chi, 1996)

What is Potential Fishing Zone (PFZ) and How it is Developed?

A trustworthy short-term prediction of the open-water fish aggregation zones is the Potential Fishing Zone (PFZ). Information on general techniques for PFZ identification is provided in table 2. The Indian National Centre for Ocean Information Services (INCOIS), located in Hyderabad, publishes PFZ advisories. Satellite-derived chlorophyll data and sea surface temperature (SST) data from the Arabian Sea and Bay of Bengal are the main inputs utilised to produce this data. To locate potential fishing zones along the Indian coastline, data is used from the IRS-P4 OCM/ MODIS Aqua optical bands and the NOAA-AVHRR Thermal Infrared channels.

Table 2: General methods for PFZ identification

Process	Input Data	Algorithm/ Method	Result
GIS based application	Fishery data, SST, SSC	Overlay method	Potential fishing ground
Knowledge based expert system	SST, SSC, Turbidity	Heuristic rule based on expert knowledge	Potential fishing ground
Simple prediction map	SST, SSC, SSHA	Generalized Additive model	Potential fishing ground
Approach using Rough clustering	Bearing, direction, distance from, distance to	K-Means	Fish spot identification

(Source: Natteshan and Suresh Kumar, 2016)

Conclusion

In summary, the application of remote sensing, GIS and PFZ (potential fishing zone) technology in fisheries has become a revolutionary force that is transforming how we manage and preserve marine resources. The integration of these advanced technologies has significantly enhanced our understanding of oceanic ecosystems, providing valuable insights for fisheries management and conservation efforts. By integrating various geospatial data layers, GIS allows researchers and policymakers to visualize and analyze the complex relationships between different ecological variables, human activities and fishery resources. This spatial understanding enhances the precision of management strategies, leading to optimized allocation of resources and effective conservation measures. The comprehensive data generated through these tools empower stakeholders to make informed decisions, promote sustainable practices and mitigate the impact of anthropogenic activities on marine ecosystems. The integration of these technologies will be crucial as technology develops in order to strike a careful balance between addressing the needs of an expanding population and safeguarding the quality of our seas for coming generations.

Acknowledgement

The authors would like to thank the College of Fisheries, Ratnagiri for their valuable assistance in improving this manuscript.

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