GEOGRAPHIC INFORMATION SYSTEMS AN ANAYLSIS INSTRUMENT FOR OCEANOGRAPHIC PARAMETERS OF CATCHES: A REVIEW OF RESEARCH

Izza Mahdiana Apriliani1, Pringgo KDNY Putra2, Nora Akbarsyah3, Lantun P Dewanti4

Departement of Fisheries, Faculty of Fishery and Marine Science, Padjadjaran University, Indonesia

ABSTRACT

Exploitation of marine resources is not professional enough, so it is highly dependent on experience and instinct of fishermen, ultimately have an impact on less optimal resource use. Therefore, complete and accurate information about oceanographic character of a waters is indispensable for the purpose of sustainable marine resource management. Measurement of these parameters can be done optimally using geographic information. Development of remote sensing technology and Geographic Information System (GIS) computerization has provided insight for the ease of planning and developing marine territories in Indonesia. This satellite observation will also be very useful for observing oceanographic phenomena which are indicators of high fishery potential areas. Oceanographic parameters that can be observed are sea surface temperature, chlorophyll-a and currents which will affect of fish distribution. Sea surface temperature is one of the factors to determine the spread of fish, feeding ground, migration pattern, growth metabolism and fish abundance. High chlorophyll-a levels will increase nutrient levels and increase primary productivity in the waters. The reason why Indonesia's marine biodiversity is very diverse is because Indonesia's position is very strategically flanked by 2 large oceans that carry Indonesia throughflow water mass which contains high nutrient levels. Distribution and abundance of biological resources in a waters are influenced by conditions and variations in oceanographic parameters. Therefore, complete and accurate information about the oceanographic character of a waters is very useful for understanding its relationship with distribution and abundance of fish resources.

Keyword: chlorophyll-a, current, oceanographic, sea surface, resources

1. INTRODUCTION

Indonesia is an archipelago with 17,499 islands, 5.9 million km2 of coastal areas and a coastline length of 81,000 km [1] and there is biodiversity with high economic value because it is an export commodity. Based on data from Ministry of Marine Affairs and Fishery, the potential for marine and fishery in Indonesia consists of small pelagic fish, large pelagic fish, demersal fish, reef fish, shrimp and other crustaceans, molluscs, other aquatic animals (turtles, jellyfish, etc.), and seaweed. According to SWA online daily news, the data based on Central Statistics Agency data shows that Gross Domestic Product od fisheries has gradually increased from 2011 (Rp. 154.545,2 trillion) to 2017 (Rp. 227.278,9 trillion).

The increase in fishery production that occurs proves that in the future, the prospect of developing Indonesian fisheries is one of strategic economic activities and is considered bright [2]. The exploitation of marine resources that is often carried out is not professional enough, so it is highly dependent on experience and instinct of fishermen, ultimately have an impact on less optimal resource use [3]. Fishermen determine of fishing grounds based only on hereditary experience by looking at natural signs, such as foam on surface of the sea, seeing the presence or absence of flocks of birds on the surface of the sea, and others so that it is still considered less effective [4].

The main problem of fishing operation is existence of fishing grounds that are dynamic in nature,
always changing or moving along with the movement of fish. Naturally, fish will choose a more suitable habitat, while this habitat is very much influenced by oceanographic conditions of the waters. Distribution and abundance of biological resources in a water cannot be separated from the conditions and variations in oceanographic parameters [5]. Therefore, complete and accurate information about oceanographic character of waters is indispensable for the purpose of sustainable marine resource management [6].

The movement patterns of water masses affect the fluctuation of oceanographic variables such as sea surface temperature and chlorophyll-a [7]. Sea surface temperature and chlorophyll-a are two important oceanographic parameters that are useful in increasing fisheries resources [8]. Almost all fish populations that live in the sea have an optimum temperature range and chlorophyll-a for life [9]. By knowing oceanographic parameters, especially temperature and optimum chlorophyll-a of a fish species in a waters, we can predict the presence of fish schools and can be used for fishing purposes (exploitation) [10]. Measurement of these parameters can be done optimally using geographic information. Development of remote sensing technology and geographic information system computerization has provided enlightenment for the ease of planning and development of marine areas in Indonesia [11].

2. GEOGRAPHIC INFORMATION SYSTEMS AS ANALYSIS INSTRUMENTS

International standards regarding geographic information have been contained in ISO / TC 211 N 573. The ISO states that geographic information is supported by the following 10 technologies: (1) Digital survey instruments, (2) Global Positioning System, (3) Remote Sensing, (4) Geographic Information Systems, (5) Spatial Systems Engineering Tools, (6) Spatial Database Management, (7) Automated Cartography, (8) Visualization, (9) Modeling, (10) Spatial Analysis [12]. Cases that occur in Indonesia regarding ineffective fishing and lack of availability of oceanographic data presentation to determine fisheries potential can utilize geographic information supporting technology in the form of remote sensing and Geographic Information Systems. Geographic Information System is one of the information systems that is currently developing rapidly and is widely used for analysis and mapping of natural resources, including presenting data on fisheries potential based on spatial data [13]. Geographic information system is widely used because of its ability to present complete, accurate, cheap and easily accessible information.

Using of remote sensing data and GIS has been widely used in relation to coastal areas and oceans, especially the fisheries sector and the management of coastal and marine areas, such as remote sensing applications to provide information on potential fishing zones [14]. Utilization of remote sensing technology in the field of exploitation of several fisheries resources using the SeaStar satellite, TOPEX / Poseidon satellite (Topographic Experiment for Ocean Circulation) 1002, AQUA / Terra MODIS satellite, NOAA satellite and OKEAN satellite which means ocean 1995. SeaStar is a satellite that is commercially financed by a private company, namely Orbital Science Corporation (OSC), based in Dulles and installed SeaWiFS (Sea Viewing Wide Field of View Sensor) so this satellite is able to measure the growth and concentration of phytoplankton at sea level. The TOPEX-Poseidon satellite can be used to map the topography of the oceans and model changes in global circulation and sea level. The OKEAN satellite is operated to monitor sea surface temperature, wind speed, sea color, ice coverage status, rainfall and cloud coverage. NOAA-USA weather satellites carrying AVHRR sensors can also be used to assist exploration of marine resources. AQUA / TERRA MODIS (Moderate Resolution Imaging Spectroradiometer) satellite imagery can be used for monitoring and study of SST and chlorophyll-a because it has a high thermal band and temporal resolution, so that the dynamics of SST changes can be observed continuously [15].

Resulting of satellite imagery can be analyzed and interpreted to determine the value and distribution of sea surface temperature in waters that are quite broad synoptically (covering the entire territory of Indonesia in only two consecutive trajectories). This satellite observation will also be very useful for observing oceanographic phenomena, especially upwelling and front temperature which are indicators of high fishery potential areas. It is hoped that the availability of such information will increase effectiveness and efficiency of fishing in the sea.
3. DATABASE DEVELOPMENT

Database is a collection of one or more data files or tables that are stored in a structured manner so that the relationship between different items or different data sets can be used for manipulation and retrieval purposes and in general it will serve the availability of data from various users. Divides the database into three models formed from spatial data, namely the hierarchical database model, the network database model and the relational database model. States that database design using GIS consists of: (1) The data used has a georeference system, (2) In building a spatial database it is necessary to pay attention to the error limits allowed so that the topology can be built appropriately, (3) Using relational data model for designing databases, (4) Defining attribute data fields correctly, (5) If possible, each attribute data field needs to be formulated correctly, (6) Every variable for the purpose of data manipulation must be represented in the database [16].

Database management facilities or commonly known as Data Base Management System (DBMS) are needed when managing data to function as an information system. DBMS plays a role in manipulation, analysis and presentation of spatial data. Defines DBMS as a software package for data storage, manipulation, and presentation. The software commonly used is ArcGIS which is capable of digitally creating thematic maps [16].

1. Digitization.
Digitization has a role in digital mapping (features on the map / analog form are transferred to digital form).

2. Creating spatial data.
Creating vector data from raster data and then saving it in the form of shapefiles (*.shp) can be done with ArcGIS because it is equipped with on-screen digitizing facilities. This process begins by digitizing the georeferenced raster data.

3. Vector and attribute editing.

4. OCEANOGRAPHIC PARAMETERS

4.1. Sea Surface Temperature

Sea surface temperature is one of factors to determine the spread of fish, fish feeding speed, migration pattern of fish, growth metabolism and fish abundance, where this effect will be evident when fish are spawning, perhaps even with a certain seasonal cycle [17]. Wind movement affects the dynamics of surface current movement, surface currents affect the distribution of sea surface temperature [18]. Characteristics of different currents and wind movements in Indonesian waters are caused by movement of monsoons. Some studies usually use time comparisons, namely west and east monsoons to compare sea surface temperatures in Indonesia [6]. Many water masses were transported by Armondo (Indonesian Monsoon Flow) from the west (South China Sea, Natuna Sea, Karimata Strait, and Java Sea) to east (Bali Sea, Flores Sea and Banda Sea) and south (Hindi Ocean) through straits in the East Islands including Bali Strait during west monsoon [19].

The difference in temperature will certainly affect distribution pattern of fish, especially pelagic fish that have a swimming layer depending on sea surface temperature. Low sea surface temperatures indicate upwelling so that nutrient content also increases [20]. Judging from its physical effects, surface temperature can cause upwelling, which brings nutrients to surface and makes a feeding ground for fish, while chlorophyll-a is an indicator of primary productivity OF fish, especially pelagic fish [6].

![Figure 1 Distribution pattern of sea surface temperature (SST) during east monsoons in Java Sea [5](image)](image)

![Figure 2 Distribution pattern of sea surface temperature (SST) during West monsoons in Java Sea [5](image)](image)
4.2. Chlorophyll-A

One of parameters indicator of fertility level in waters is chlorophyll-a [21]. Chlorophyll-a is a phytolplankton pigment that plays a role in the photosynthesis process [22]. Phytoplankton are microscopic plants and live floating and hovering so that their movements are influenced by currents. Chlorophyll-a is able to absorb blue and green light, so the presence of phytoplankton can be detected based on ability of chlorophyll-a [23].

![Figure 3 Distribution of chlorophyll-a in Java Sea Waters (above) [5] and fish density catches based on hydroacoustic survey (below) [5]](image)

Based on Figure 2, show the distribution of chlorophyll-a in the eastern Java Sea [5]. Spatially, there is a movement of chlorophyll-a concentration where between October and December, chlorophyll-a concentration increases sharply in eastern part of Java Sea (115-117°E) which is adjacent to the southern coast of Kalimantan. During El Nino Southern Oscillation (ENSO), rainfall in Indonesia was very low and intensity of the sun was higher. The high intensity of irradiation is thought to be a factor in high concentration of chlorophyll-a at the time of the ENSO [5]. Increasing nutrient levels will increase primary productivity resulting in high chlorophyll-a levels [7].

4.3. Current

Current speed is one of oceanographic parameters that is partially correlated with the presence of pelagic fish [24]. Current is a very important parameter in the marine environment and affects directly or indirectly marine environment and biota that lives in it, including determining fish migration patterns [25]. Current movements in Indian Ocean are strongly influenced by monsoons, and regional circulation of water masses [26]. In east monsoon, southeast wind blows which makes the South Equatorial Current widen to north, moving along the south coast of Java to Sumbawa, then forcing it to turn to southwest. This causes surface water to come out away from the beach and a vacuum which results in rising water from below (upwelling)[27].

Currents have an effect on two things, namely small pelagic fish and the stability of the fishing gear used. Small pelagic fish will give a passive response, if they are in a current that has a moderate speed, whereas if the current speed is low, then small pelagic fish will react actively (against the current)[28]. If current speed is high, small pelagic fish tend to avoid it [29].

![Figure 4 Indonesia Throughflow [30]](image)

Figure 3 shows that current phenomenon that occurs in Indonesian waters is Indonesian Throughflow which plays an important role in the thermohaline cycle chain and global climate phenomenon [31]. Indonesian Throughflow brought the Pacific Ocean water masses to enter Indonesian waters through two routes, namely western route that enters through Sulawesi Sea then to Makassar Strait, Flores Sea, and to Banda Sea. The second route is eastern route through Maluku Sea and Halmahera Sea then to Banda Sea. This water mass will exit into Indian Ocean, especially through of Timor Sea. Another exit route is through the Ombai Strait, namely strait between Alor and Timor, and through Lombok Strait [32].

In marine and coastal ecosystem areas, fish migration patterns are greatly influenced by the water masses carried by Indonesia Throughflow. A reason why Indonesia’s marine biodiversity is very
diverse is because Indonesia's position is very strategically flanked by 2 large oceans that carry Indonesian Throughflow's water mass which contains high nutrient levels [6]. Water mass of Indonesian Throughflow comes from water mass of North Pacific as much as 92%, and water mass of South Pacific as much as 8%. Water mass from South Pacific Ocean that enters Indonesian waters is carried by Papua Coastal Current (NGCC) and water mass from North Pacific Ocean is North Equatorial Current (NEC) to west [31].

5. CAPTURE FISH DISTRIBUTION

The distribution and abundance of species groups or fish species in a waters need to be known in order to manage pelagic fish resources in a sustainable manner [24]. Distribution and abundance of biological resources in a waters are influenced by conditions and variations in oceanographic parameters [5]. Therefore, complete and accurate information about oceanographic character of a waters is very useful for understanding its relationship to distribution and abundance of fish resources [6]. States that presence of pelagic fish, such as tembang and selar fish is more or less influenced by the presence of plankton as the main food. Pelagic fish always perform migration when they are looking for food or spawning. For this reason, natural conditions indirectly affect the number of pelagic fish caught by fishermen [19]. Based on determination of distribution of sea surface temperature combined with distribution for chlorophyll-a and variability of fish catches, areas suspected to be potential areas for pelagic fishing are areas that have the optimum temperature and have high chlorophyll-a content as an indicator of water fertility (source food), then validated with fishing operation areas by fishermen [23].

Figure 5 Map of distribution of fish catchment areas and potential fish areas in November 201 for waters of Java, Bali, Nusa Tenggara [34]

Figure 4 is an overview of the map that has been made by Marine Research and Observation Agency of ministry, regarding the distribution map of fishing areas and potential fish areas in the period November 2020. This map was made based on analysis of Aqua / Terra MODIS satellite data, as well as wind data and waves from BMKG at any time (Marine Research and Observation Agency 2019).

6. CONCLUSION

Development of remote sensing technology, information on the characteristics of potential fishing areas will be obtained as seen from oceanographic factors periodically, quickly and with a wide area coverage. Geographic Information System (GIS) will assist in visualizing fisheries data in tabular form spatially and temporally so that it can provide information on fishing areas. Remote sensing technology and geographic information systems are clearly needed in order to determine the optimum conditions for target catch and to be able to analyze the distribution of oceanographic conditions periodically so that regional mapping can be obtained which can be used as data information to predict potential fishing areas for fishermen in Indonesia. It is proven that oceanography parameters of sea surface temperature, chlorophyll-a distribution and current velocity can affect distribution and abundance of fish in a waters

REFERENCES


