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SATELLITE FISH FORECASTING IN SOUTH CHINA SEA

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ABSTRACT: Fish forecasting technology has been applied successfully in many countries. However, most of the forecasting methods used in temperate water were unsuitable to be applied in this region. A fish forecasting model suitable to tropical environment has to be developed. This major project involving several objectives and phases to meet the goal of developing a satellite-based fishery forecasting system in the South China Sea is aimed at supporting the national aspirations of developing an efficient offshore fishery. More importantly, it is aimed at providing the basis for alternate ways towards meeting sustainable harvest of fishery resources. The project is now complete, with most of the major objectives met. Project deliverables include an efficient extraction algorithm of sea surface temperature from AVHRR satellite data which includes an automatic geocoding and cloud masking. Model for extracting ocean colour from SeaWifs was also developed. Based from the multi criteria analysis of these oceanographic conditions, a model suitable for the determination of potential fishing zone in tropical water has been developed. This model is then incorporated into a decision support tool referred as the Tropical Fish Forecasting System (TroFFS). TroFFS is a straight forward and easy to learn software tool that will allow user to process and forecast the potential fishing zone. TroFFS builds upon remote sensing and GIS technology by incorporating aspects of PCI's EASI/PACE and ArcView. In an additional capacity, TroFFS can also be used to detect the warm temperature front and the boundaries of upwelling areas. It is best for the prediction of fishing grounds formed by he oceanographic phenomenon. TroFFS is a cost-effective geomatics system designed specifically for fish forecasting in tropical waters. TroFFS combines remote sensing and spatial analysis functionality with user-guided fish forecasting processes within a fully customizable and expandable environment. The system can be integrated with the ground satellite receiving that enabling real time fish forecasting and further developed into the National Fish Forecasting System.

1.0 INTRODUCTION

Satellite remote sensing (RS) can be a very powerful tool employed in the wise-use of fishery resources, including its utilization to detect potential fishing zones. The first application of satellite remote sensing in fishery advisory operations in the US was in 1971(Laurs, 1993). This operation has had a tremendous impact on the efficiency of American tuna fleets, often reducing search times by 25% to 40% (Simpson, 1992). Fishery advisory products were expended during the early 1980's to include information on ocean colour measured by the Coastal Zone Color Scanner (CZCS) onboard the NIMBUS 7 satellite. The ocean colour charts were extremely important in determining potentially productive fishing areas (Laurs, 1993). Satellite remote sensing had been successfully used to define potential fishing zones and to aid fisheries research in several countries such as North Pacific albacore tuna fishery, Gulf of Mexico shrimp fishery, Portugal swordfish fishery, and monitoring of fishing grounds in Japan, Taiwan, India, Peru, China etc.

According to Mohd. Mazlan (1998), coastal fishing activities accounting for about 85% of the total landings in Malaysia. Due to intensive exploitation, the coastal fishery resource is declining recently. In the east coast of Peninsular Malaysia, most of the big fishing vessel operates the purse seine. Their fishing methods are highly depending on the fish aggregation devices (FAD) that were installed around the

island and coastal waters, in order to reduce the time to search for the fish school. However, this method has limited the exploration of the potential resources in our Exclusive Economic Zones (EEZ).

Under the National Agriculture Policy (NAP), Malaysian government is now promoting the exploration of offshore marine resources. Some of the private corporation has started to look into the investment in deep-sea fishery. The fish forecasting research is inline with our NAP's aim, which is to develop our offshore fishery with modern technology. This research will help our nation to further explore the potential yield in our EEZ by reducing the search time for suitable fishing grounds and operating costs for the fishing vessel. Besides, it enables the fisheries authority to plan for effective fisheries resource management and to evaluate the potential yield of offshore waters.

The major challenge of this research is the development of fish forecasting model for the tropical region. In order to develop the model, the researcher needs to integrate various knowledge and expertise in physical and biological oceanographic, fishery, ecology, satellite remote sensing, etc. The formulation of the forecasting model has to be built on a strong baseline research on marine ecology, fishery biology and its relationship to physical oceanography. The main objectives were as follows:

1. To develop a fish forecasting model using remote sensing data in tropical waters.
2. To produce potential fishing zone (PFZ) maps using GIS techniques.
3. To develop a decision support tool for fish forecasting.

2.0 METHODOLOGY

The study area is located in the South China Sea off east coast of Peninsular Malaysia. It covers the exclusive economic zone with approximately 154,800 km^2. This study covered five major phases, which include data collection, data processing and analysis, model development, output and decision support tool. Three major types of data had been collected for this study, namely satellite imagery, physical oceanographic parameters and fish catch data. Satellite images from NOAA, OCTS, SeaWiFS and MODIS were used in this study. Fishery data was acquired from Department of Fishery and MFRDMD/SEAFDEC.

An oceanographic survey was carried out during 24-29 August 2000 with collaboration from MFRDMD/SEAFDEC. This oceanographic research had surveyed a total area of 11055.6nm^2 with 527.51 miles of survey route. 31 stations had been selected for the collection of physical and biological information, and acoustic survey was carried out along the way. All the satellite images were pre-processed using PCI's EASI/PACE image processing system and exported into ArcView GIS. Other data, such as oceanographic parameter and fish catch data, were input into GIS using tabular format.

Model development stage was the most critical part in this study. Several studies had been conducted, such as the study of SST (Mansor et al., 2000) and chlorophyll *a* seasonal variation and the water enrichment factors in order to find the relevant parameters and phenomenon, which is suitable to be included in the model. Finally, SST and chlorophyll *a* had been determined as two of the most important parameters because their variations were significant to the abundance and distribution of fish in this tropical region. The predicted result will be in the form of a potential fishing zone (PFZ) map . The map was then compared and verified with the historical catch data and some of the secondary information such as acoustic survey results.

3.0 RESULTS AND DISCUSSION

3.1 Fish Forecasting Model

FIGURE 1 illustrates the conceptual fish forecasting model adopted in this study. Two main parameters, ocean colour and SST can be acquired from the satellite remote sensing such as NOAA AVHRR and SeaWiFS. Ocean features such as boundary and upwelling phenomenon can be identified from the SST pattern. If an upwelling is found, the time scale for the development of a suitable fishing ground must be taken into consideration, because from the first emergence of the upwelling phenomenon, it will takes a few weeks before the formation of the fishing grounds. The identified ocean boundaries and fronts can be used to predict the potential fishing zone directly. From the ocean colour, we can determine the area of rich phytoplankton. In other words, this is the area with high abundance of food and one can aspect that there will be an aggregation of fish over this high phytoplankton area.

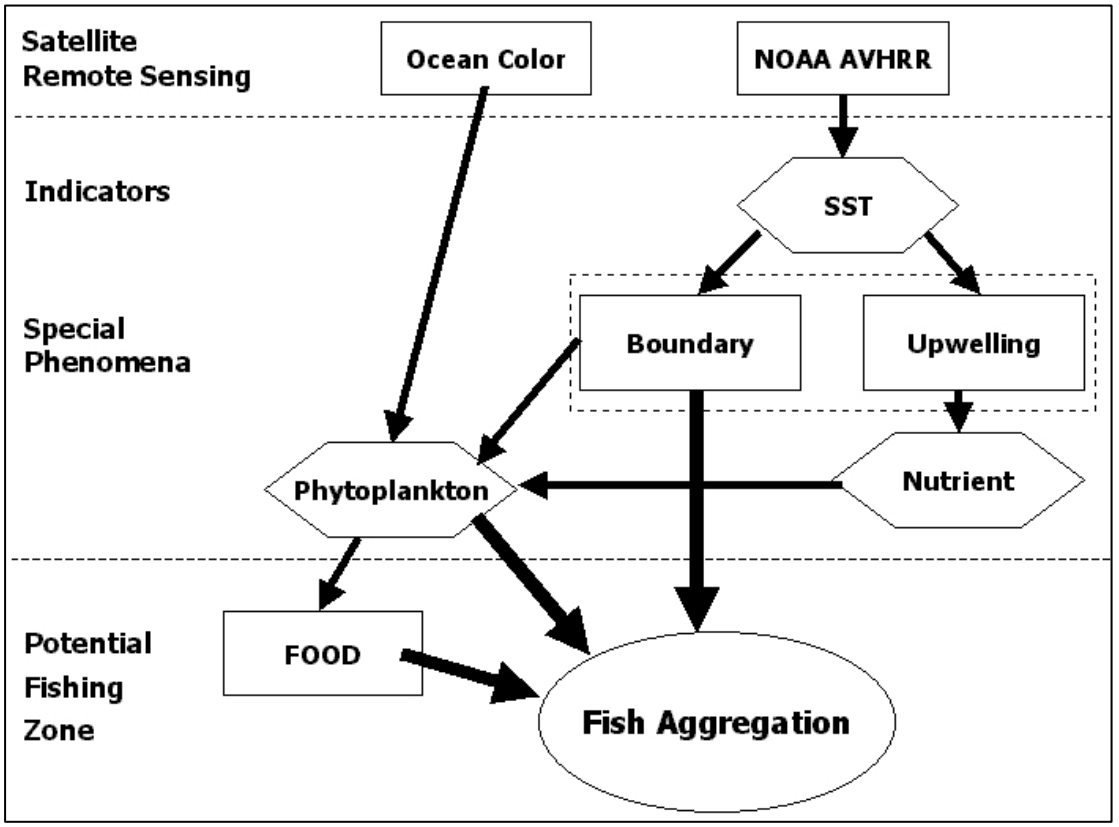

FIGURE 1. Conceptual fish forecasting model

3.2 Potential Fishing Zone

FIGURE 2 shows the potential fishing zone (PFZ) generated using ADEOS/OCTS LAC data on 13th June 1997. ADEOS/OCTS images were selected to produce the preliminary outcome of the fish forecasting model because it provided both SST and chlorophyll *a* images either in Global Area Coverage (GAC) or Local Area Coverage (LAC) format. The most advantageous using these images were they were taken simultaneously at one platform and the time difference error between set of images can be omitted. The result from GAC images shows most of the potential fishing zone during June 1997 was located at

depth less than 50m, which was the coastal water. There were lots of predicted fishing grounds off Pahang and east Johor. This may due to the upwelling phenomenon during southwest monsoon at the southern water. The potential fishing zone product from the LAC images shows clearer fishing ground as compared to GAC images, because the LAC images have higher spatial resolution. Most of the PFZ was showed as linear features, and they were located along with the coastline. The generalization of GAC images had caused the absence of some predicted fishing zones as shown in the LAC images. Obviously, images with higher spatial resolution will give more detail information, thus producing more precise potential fishing zone map.

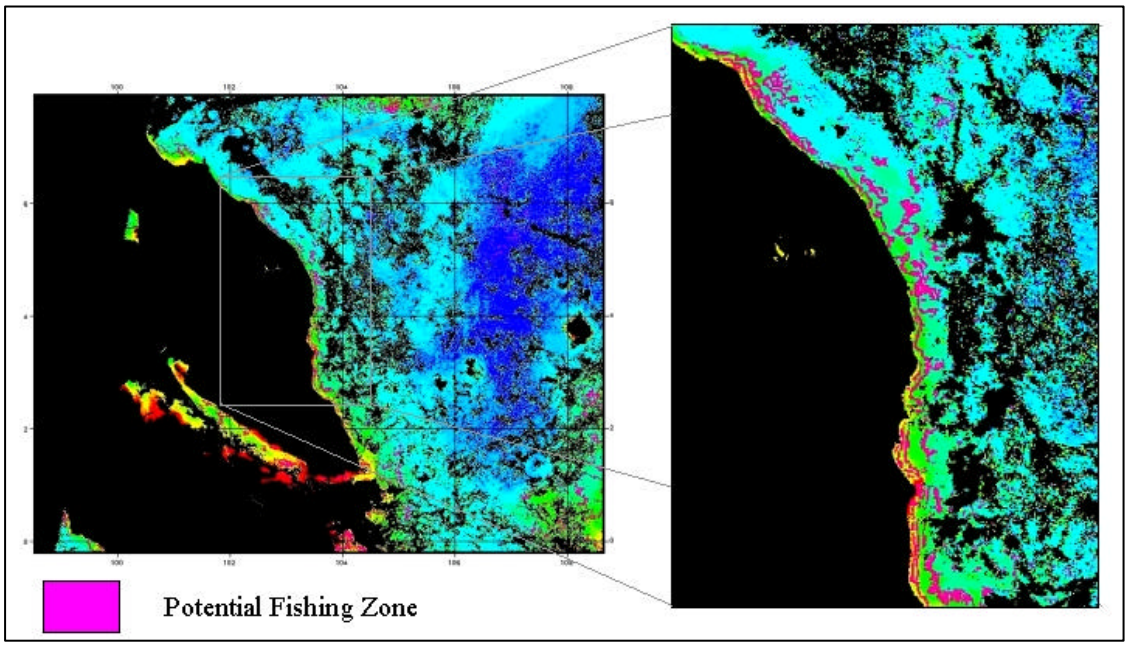

FIGURE 2. Potential Fishing Zone on 13 June 1997 using ADEOS/OCTS LAC images

3.3 In-Situ Oceanographic Survey

The in-situ oceanographic survey was carried out jointly between Universiti Putra Malaysia (UPM) and Southeast Asian Fishery Development Corporation (SEAFDEC) with the aim of observing the relationship between physical and biological oceanographic relationship in the South China Sea during southwest monsoon and also to verify the generated potential fishing zone maps. Acoustic survey was carried out during the route in between the stations. **FIGURE 3** shows the correlation between surface chlorophyll-a and the fish density. The highest fish density (17.16 ton/km^2) was recorded between station 4 and station 5 which was located almost at the boundary of the upwelling area. While, the second highest fish density was located at the northern section between station 25A and station 31. The highest fish density spot were identified as the demersal fish which were recorded at depth of 60 m, very close to the sea bed. The second highest fish density spot was pelagic or semi-pelagic species which were recorded at a depth around 50 m.

It is difficult to establish a clear relationship between upwelling and the high demersal fish density. However, the high concentration of food may be the main contributing factor to the aggregation of fish around this area. Station 25A and 31 did not exhibit high chlorophyll-a during the survey. However, on checking the monthly SeaWiFS image in August 2000, we found that there was a high concentration of chlorophyll-a at the area before the sampling. According to Ideal Thermal Scenario (ITS) from Stretta and

Pitit (1989), it may take several weeks for the formation of a good fishing ground when there is an increase of phytoplankton in the water. This may explained by the high abundance of fish at station 31during the survey where the phytoplankton had been consumed by zooplankton and herbivore fish.

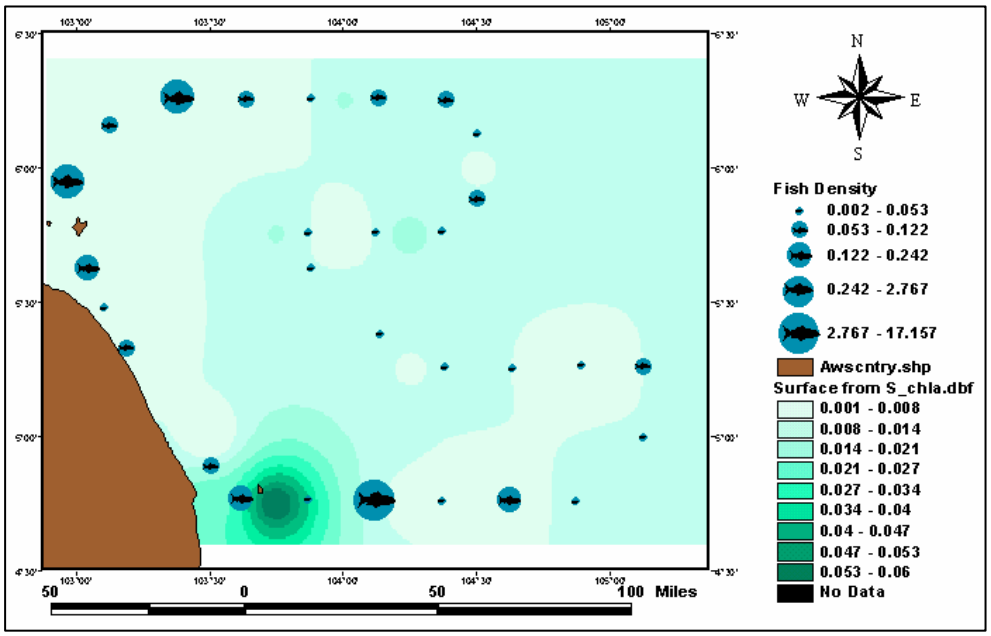

FIGURE 3. Relationship between surface chlorophyll-a and fish density

3.4 Tropical Fish Forecasting System (TroFFS)

To operationalise the production of fish forecasting map, a simple and straight forward decision support tool has to be developed. The fish forecasting model is then incorporated into a decision support tool referred as the Tropical Fish Forecasting System (TroFFS). TroFFS is a straight forward and easy to learn software tool that will allow user to process and forecast the potential fishing zone. TroFFS builds upon remote sensing and GIS technology by incorporating aspects of PCI's EASI/PACE and ArcView. In an additional capacity, TroFFS can also be used to detect the warm temperature front and the boundaries of upwelling areas. It is best for the prediction of fishing grounds formed by the oceanographic phenomenon. TroFFS is a cost-effective geomatics system designed specifically for fish forecasting in tropical waters. TroFFS combines remote sensing and spatial analysis functionality with user-guided fish forecasting processes within a fully customizable and expandable environment.

4.0 CONCLUSION

The developed fish forecasting model is mainly for the phenomena based fish forecasting. Two of the major parameters applied in the fish forecasting model are sea surface temperature and chlorophyll *a*. In an additional capacity, the model is able to detect the warm temperature front and the boundaries of upwelling areas.

The limitations of the model are non-species selective, the precision is depending on the sensor spatial resolution, and the predicted PFZ is valid for southwest monsoon only. The UPM-SEAFDEC oceanography and acoustic survey had provided new finding on the local upwelling off east coast during southwest monsoon. Higher fish abundance was observed close to the upwelling boundaries, which agreed with the previous forecast results. Further study should be conducted to study the time required for the formation of good fishing ground when a high concentration of phytoplankton was spotted.

For the ease of operating the fish forecasting technique, a simple user interface was customized. The interface is called Tropical Fish Forecasting System (TroFFS). It was designed into a user-friendly interface and provides a clear step-by-step procedure to the end user. The advantages of TroFFS are it is simple, easy to use, and less time consuming.

As the conclusion, this research had demonstrated that the developed fish forecasting model is able to predict the potential fishing zones. SST and chlorophyll-*a* data from the satellite images had promised a fast and reliable source of data for the production of PFZ maps. This tool can be further integrated with the real-time satellite data receiving facilities and PFZ reporting system for the development of National Fish Forecasting System.

5.0 REFERENCES

Laurs, R. Micheal. 1993. Integration of various satellite derived oceanography information for the identification of potential fishing zones. In *Lecture notes of International workshop on application of satellite remote sensing for identifying and forecasting potential fishing zones in developing countries*, Hyderabad, India, 7-11 December 1993.

Mazlan, J. Mohd. 1998. Malaysian fisheries policy beyond 2000. In *Fisheries and the Environment: Beyond 2000*, International Conference on Fisheries and the Environment: Beyond 2000, 6-9 December 1993, Universiti Putra Malaysia, Malaysia, ed. B. Japar Sidik, F.M. Yusoff, M.S. Mohd. Zaki and T. Petr, pp 15-20. Serdang, Malaysia: Universiti Pertanian Malaysia.

Mansor, S.B., Q.K. Hassan, A.R. Ramli, M.I. Mohamed and Ku Kassim, K.Y., 2000, Sea surface temperature in relation to fish forecasting, Malaysian Journal of Remote Sensing & GIS, Vol. 1, pp 31- 45.

Simpson, J.J. 1992. *Remote sensing and geographic information systems: implications for global marine fisheries*. California: Sea Grant College.

Stretta, J. M. and M. Pitit. 1989. Teledetection spatiale et peche thoniere en Atlantique Intertropical. In *Teledetection Satellite et Pechefies Thonieres Oceaniques,* FAO Document techniques de Peches, no. 302, pp 109-119. Rome: FAO.