Intercontinental Geoinformation Days

igd.mersin.edu.tr

# Assessment of spatiotemporal distribution of anchovy catches based on Vessel Monitoring System (VMS) and MODIS satellite data in the Gulf of Thailand

**Nittaya Katekaew*[1,2], Jianzhong Lu[2], Anukul Buranapratheprat[3], Dudsadee Leenawarat [4]**

[1]*Burapha University, Faculty of Geoinformatics, Chonburi, Thailand*
[2]*Wuhan University, State key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan, China*
[3]*Burapha University, Faculty of Science, Chonburi, Thailand*
[4]*Graduate School of Environmental Studies, Nagoya University, Aichi, Japan*

**Keywords**
Remote sensing
Spatial-Temporal distribution
Vessel Monitoring System (VMS)
Anchovy
Gulf of Thailand

**ABSTRACT**

This research was conducted to investigate spatiotemporal distribution of anchovy catches in the Gulf of Thailand in 2019 based on the data from Vessel Monitoring System (VMS) and fishing logbook. Generalized additive model (GAM) was used to analyze the relationship between environmental factors including sea surface chlorophyll-a (Chl-a) and sea surface temperatures (SST) from AQUA-MODIS satellite and fish catches from 3 fishing gears including falling net, surrounding net and lift nets during wet season and dry season 2019. The results showed that anchovy distribution and catches were intense in coastal areas, and the catch volume in dry season was larger than that in wet season. GAM analysis suggests that the highest fishing frequency be related to 0.1-0.8 mg/m$^3$ of Chl-a and 28.8-29.5 °C of SST in dry season. In wet season, high fishing frequency occurred in the area with Chl-a is 0.2-0.6 mg/m$^3$ and SST is 29.5-31.0 °C. This current study provides important information on the relationship of environmental factors to the distribution of anchovies, which can be used for sustainable management of anchovy resource fisheries.

## 1. INTRODUCTION

For commercial fisheries around the world, it is imperative to maintain a sustainable future, and to develop and implement an ecosystem management plan that allows it to take advantage of fish stocks while reducing the number of fishes caught (Hall, Alverson & Metuzals, 2000).

Anchovy, a small pelagic fish, plays an important role in marine ecosystems, not only as herbivorous fish consuming phytoplankton but also as a target fish for local commercial fisheries. Two genera of anchovy namely stelephorus and encrasicholina are found in the Gulf of Thailand (Department of Fisheries, 1993). Despite its small size, its catch volume and economic value are very high. In 2018, the total consumption of economic fish was 860,372 tons or 70.96 percent of the total fish volume, accounting for 24,866.91 million baht or 89.47 percent of the total fish cost, according to the statistics of the Department of Fisheries in Thailand. Anchovy had the highest catch volume of 162,555 tons (18.89%) worth 3,161.17 million baht (12.71%), followed by mackerel in the amount of 99,648 tons (11.58%) worth 3,059.10 million baht (12.30%) (Department of Fisheries, 2019).

The life cycle of anchovy, that is, spawning and foraging are associated with natural environments such as Chl-a and temperature near the coast (Department of Fisheries, 1993). The variations in environmental conditions could change the natural fluctuations of the anchovy stock especially in the coastal area where plankton is abundant and water temperature is varied. These relevant environmental information are essential for the study of the distribution of anchovy for fishery management (Safruddin et al., 2018). In this study, we use Vessel Monitoring System (VMS) data and fishing

* **Corresponding Author**

*(katekaew1559@gmail.com) ORCID ID 0000-0002-6039-8968
(lujzhong@whu.edu.cn) ORCID ID 0000-0002-6432-8481
(anukul_bu@hotmail.com) ORCID ID 0000-0001-7436-9175
(dudsadeelee@gmail.com) ORCID ID 0000-0002-8418-5262

**Cite this study**

Katekaew N, Lu J, Buranapratheprat A & Leenawarat D (2021). Assessment of spatiotemporal distribution of anchovy catches based on Vessel Monitoring System (VMS) and MODIS satellite data in the Gulf of Thailand. 2nd Intercontinental Geoinformation Days (IGD), 127-130, Mersin, Turkey

logbook to investigate the distribution of ancovy and the relationship of Chl-a, SST and fish catches. With high fishing statistics and enormous value, such studies are needed for the future sustainable use of this fishery resource.

## 2. METHOD

The study area is the Gulf of Thailand (Figure 1), a coastal sea located in the tropical zone influenced by monsoon seasons. The data in dry season (February-March) and wet season (July-August) 2019 are specified and used in the analysis.

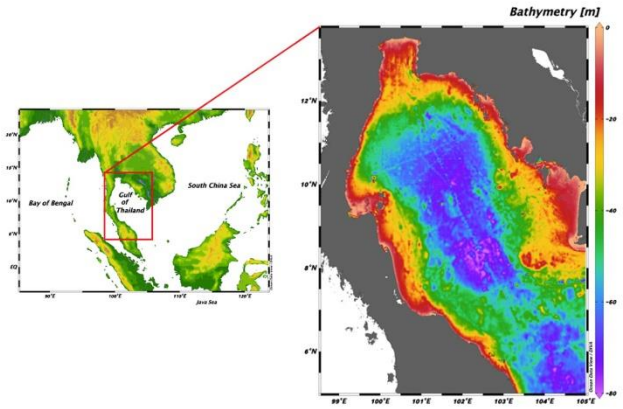


**Figure 1** The Gulf of Thailand

### 2.1. Fishing Data

The tracking information of the fishing vessels was recorded with VMS, which reported the position of the vessels via navigation and communication satellites every 15 minutes to 1 hour. Catch data were obtained from the fishing logbook carried out by the Department of Fisheries. The information included types of fishing gears (falling net, surrounding net or lift nets), fish catch data consisted of fishing date, position, and catchweight (kg).

The vessel tracking information was checked with the fishing logbooks by comparing the locations from the GPS system noted by the fishermen and those from VMS. This was used to check the accuracy of the actual fishing points. The weight of anchovy obtained from the fishing logbook were used for calculations.

### 2.2. Satellite Data

Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data including sea surface temperature (SST) and sea surface chlorophyll-a (Chl-a) of level 3 (4km) were used in the analysis. Only MODIS cloud-free images were taken into consideration.

### 2.3. Generalize Additive Model (GAM)

Information on the abundances and dynamics of the target fish population is effective for fishery management. It is also important to know how environmental factors affect the distributions of target population. International Council for the Exploration of the Sea (ICES) held a workshop in 1991 on the applications of spatial techniques for acoustic-survey data, where spatial statistical methods were discussed (ICES, 1993). One of the methods considered was generalized additive model (GAM). GAM is a non-parametric, regression technique not restricted by linear relationships, but flexible regardless of the statistical distribution of the data (Swartzman et al., 1995).

### 2.4. R Program

The environmental selections were predicted by the R program (R Development Core Team, 2017). The statistical model was constructed in the presence of anchovies based on the falling net, surrounding net, and lift net catches. The responding variable was anchovies in presence (fish number in kg) scenarios and the predictor factors were SST and Chl-a.

## 3. RESULTS

We make anchovy fishing points from VMS data during dry and wet season to determine where fishing vessels were operating in the Gulf of Thailand. Satellite data, Chl-a and SST were averaged for 3 months for each season to be used in the analysis and presented in the results.

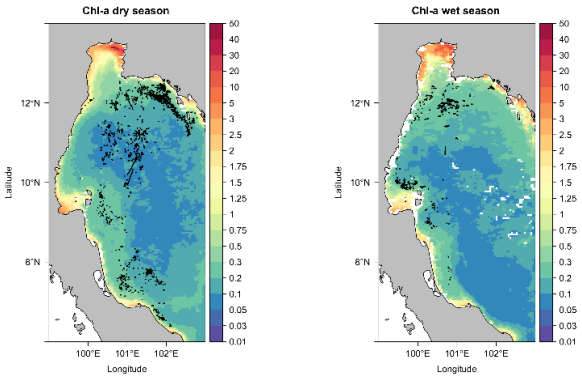


**Figure 2** Anchovy fishing ground (Black points) overlaid on Chl-a in the Gulf of Thailand in dry and wet season

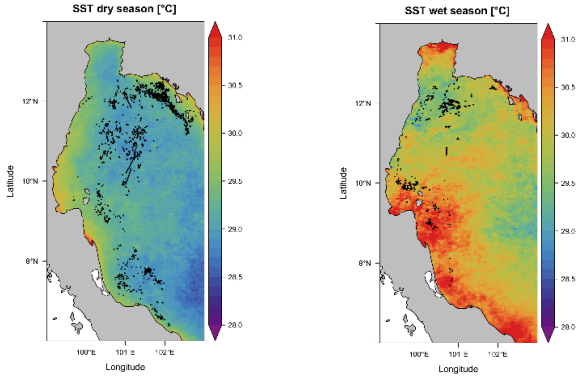


**Figure 3** Anchovy fishing ground (Black points) overlaid on SST in the Gulf of Thailand in Dry and Wet Season

Chl-a was high in the upper Gulf of Thailand near the river mouths located in the northern coast and near the western coast of the central gulf in dry season (Figure 2). Chl-a in wet season was higher and spread wider across the upper Gulf of Thailand. However, the values in western coast of the central gulf in this season was low compared to those in dry season.

SST in dry season was lower than those in wet season (Figure 3). SST along the coastline around the gulf was found to be higher than that in other regions in both seasons.

The relationship between anchovy distribution and environmental factors including SST and Chl-a was analyzed using GAM. The results between dry and wet season were shown in Figure 4 and Figure 5.

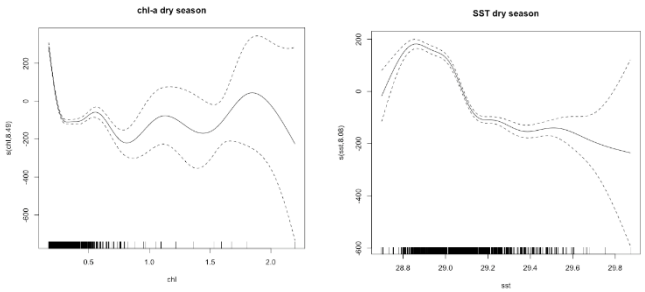


**Figure 4** GAM-derived effect of model predictors (Chl-a and SST) in dry season indicates the 95% confidence intervals. The relative density of data points is shown by the rug plot on the x-axis.

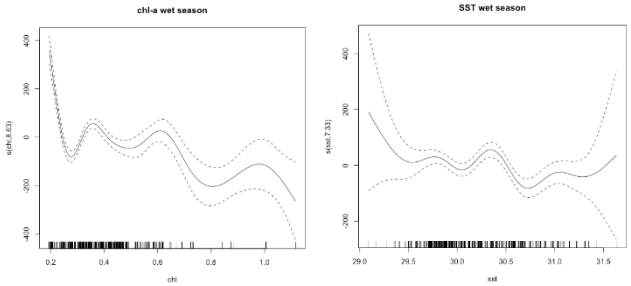


**Figure 5** GAM-derived effect of model predictors (Chl-a and SST) in wet season indicates the 95% confidence intervals. The relative density of data points is shown by the rug plot on the x-axis.

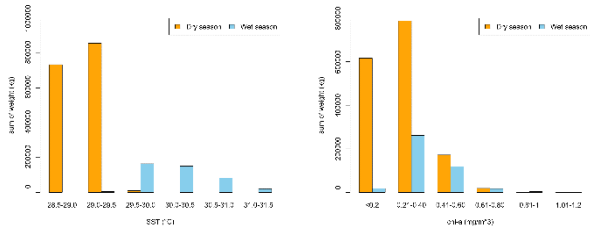

**Figure 6** Sum of anchovy catches (kg) per Chl-a and SST in dry and wet season.

In dry season, the frequency of fishing operation of Chl-a was <0.2-0.6 mg/m$^3$ and high catch weight was 0.2-0.4 mg/m$^3$, and the frequency of fishing operation of SST was 28.5-29.5 °C and high catch weight was 29.0-29 °C. In the wet season, high fishing frequency had the Chl-a value in the range of 0.2-0.6 mg/m$^3$ and high catch weight during 0.2-0.4 mg/m$^3$ and SST is in the range of 29.5-31.0 °C and high catch weight in the range of 29.5-30.0 °C (Figure 4-6).

## 4. DISCUSSION

Spatial distribution of anchovies according to VMS data suggests that anchovies be found in the Gulf of Thailand in both dry and wet seasons. The fisheries area differed seasonally due to the different anchovy distribution. In wet season, the Gulf of Thailand is influenced by the southwest monsoon which prevails over Thailand from mid-May to mid-October. This monsoon brings moist air masses from the Indian Ocean to Thailand, causing cloudy and common rainfall, especially around the coast. As a result, this season has higher Chl-a than that in dry season, especially in coastal areas.

When the fishing sites from VMS data were overlaid with Chl-a map, it was found that the anchovy fishing spots were not in high Chl-a area. A study by Wang et al. (2010) found that high Chl-a concentrations are unsuitable for fish because they create a high-water density, which reduces the oxygen content in the water. However, Chl-a is an important indicator associated with the formation of areas where small marine fish concentrate for foraging (Lanz et al. 2009).

It was suggested that SST has the greatest influence on fish distribution. Previous studies have also indicated that SST is an indicator of fish aggregation and migration (Santos, 2000; Zainuddin, 2011). This present study also found that SST had a higher influence on fish distribution compared to Chl-a. However, Chl-a is essential as a food source for fish survival. Therefore, both parameters are critical for fish production.

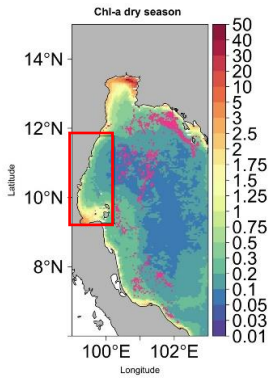


**Figure 7** The red frame showing the area that prohibits the use of certain types of fishing gear.

The Department of Fisheries has imposed a ban on the use of certain fisheries that could affect the breeding of marine breeders in the Gulf of Thailand. This is a measure of aquaculture resource management during the spawning season from mid-February to mid-May.

The major goal is to maintain and restore aquatic animal resources in the central coast of the gulf. The measure covers an area of approximately 27,000 square kilometers, resulting in no fishing boats in this area during the rainy season.

GAM is an important tool in the study of relationships between oceanographic factors and the distribution of anchovies, as the expected relationships are often non-linear. GIS techniques were also used to analyze the distribution of small marine fish (Castillo et al 1996). We found that the environmental influence on the distribution of anchovies could be assessed according to statistical criteria. Therefore, the environmental factors involved in anchovy infestation become extremely important to understand the habitat needs.

The current study provides information and advice on the impact of environmental factors on anchovy proliferation for use in fisheries and sustainable management. Future work needed to be combined with other factors that may affect fertility and distribution of anchovies that were not considered in this study. Factors to consider include a large number of zooplanktons associated with the location of the anchovies, as they are linked to the density of zooplankton as well as wind direction that may influence the distribution of the anchovies.

## 5. CONCLUSION

The distribution of anchovies based on VMS data and the relationship between fish catches and environmental factors including Chl-a and SST in the Gulf of Thailand during dry and wet seasons of 2019 was concluded that:

1. Anchovy distribution and catches were intense in coastal areas, and the catch volume in dry season was larger than in that in wet season.

2. GAM analysis suggests that the highest fishing frequency be related to 0.1-0.8 mg/m3 of Chl-a and 28.8-29.5 °C of SST in dry season. In wet season, high fishing frequency occurred when Chl-a is 0.2-0.6 mg/m3 and SST is 29.5-31.0 °C.

## ACKNOWLEDGEMENT

The authors would like to thank the Fisheries Department of Thailand for VMS and fisheries data, colleagues who contributed to the success of this research and article.

## REFERENCES

Castillo J., Barbieri M. A., Gonzalez A., 1996 Relationships between sea surface temperature, salinity, and pelagic fish distribution off northern Chile. ICES Journal of Marine Science 53:139-146.

Department of Fisheries. 1993. Anchovy fisheries in Thailand. Department of Fisheries, Ministry of Agriculture and Cooperatives. 171 pages.

Department of Fisheries. 2019. Marine Capture Production Of Commercial Fishery 2018. Department of Fisheries, Ministry of Agriculture and Cooperatives. 5/2019

Hall MA, Alverson DL, Metuzals KI (2000) By-catch: Problems and solutions. Marine Pollution Bulletin 41: 204–219.

Lanz, E., Manuel, N.M., Juana, L.M. & Dworak, J.A. 2009. Small pelagic fish catches in the Gulf of California associated with sea surface temperature and chlorophyll. CalCOFI Report 50: 134-146.

Safruddin, Rachmat Hidayat, Mukti Zainuddin (2018). Effects of environmental factors on anchovies Stolephorus sp distribution in Bone Gulf, Indonesia. AACL Bioflux, 2018, Volume 11, Issue 2. 387-393

Santos, A.M.P. 2000. Fisheries oceanography using satellitecand airborne remote sensing methods: a review. FisheriescResearch 49: 1-20

Swartzman, G., Silverman, E., and Williamson, N. 1995. Relating trends in walleye pollock (Theragra chalcogramma) abundance in the Bering Sea to environmental factors. Canadian Journal of Fisheries and Aquatic Sciences, 52: 369–380.

Wang, W., Zhou, C., Shao, Q. & Mulla, D.J. 2010. Remote sensing of sea surface temperature and Chlorophyll-a:Implications for squid fisheries in the north-west Pacific Ocean. International Journal of Remote Sensing 31(17-18):4515-4530.

Zainuddin, M. 2011. Skipjack Tuna in relation to sea surface temperature and Chlorophyll-a concentration of Bone Bay using remotely sensed satellite data. Jurnal Ilmu dan Teknologi Kelautan Tropis 3(1) : 82-90.

*** R Development Core Team, 2017 R: A Language and Environmental for Statistical Computing. R Foundation for Statistical Computing. Vienna, Austria. http://www.R-project.org.