Sea Surface Temperature and Chlorophyll-a Concentration for General Potential Fishing Ground of Peninsular Malaysia and its Surrounding Area

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Abstract: Straits of Malacca is an international passageway that links to the major maritime trade and the highest traffic routes. Therefore, it may disturb the existing fishing ground. Sea surface temperature (SST) and Chlorophyll-a (Chl-a) concentration are the two important water quality parameters that were usually used to indicate sea conditions and marine life. These two parameters are regularly used for searching potential fishing ground. Conventionally, SST and Chl-a are collected by taking a seawater sampling using a probe such as YSI multi-parameter. Using a remote sensing and Geographic Information System (GIS) method, SST can be derived by using an infrared band and Chl-a by using a visible band. In this study, a 4-km MODIS product, Aqua Level 3 (L3) Standard Map Image (SMI) SST11µm daytime, and Chl-a concentration obtained between January 2010 and June 2020 were used to derive the temperature and chlorophyll using Union Analysis. There is a strong positive correlation between SST and Chl-a with r = 0.68. This relationship can derive useful information to study the global temperature changes and how this could affect marine life.

Keywords: SST, Chl-a, Aqua, Fishing Ground, Malaysia

1.0 INTRODUCTION

SST is the independent variable and strong indicator for the marine environment such as fish, coral, pollution, and climate change (W.J.Emery, 2015). Phytoplankton is a fish source of food and detecting chlorophyll-a which is found in the phytoplankton can determine the fish habitat. With these two parameters, SST and Chl-a, potential ground fishing can be located.

According to the Food and Agriculture of the United Nations (FAO), Malaysian marine fisheries products mostly come in fresh and frozen form, which are the main animal protein sources for the Malaysian community. Also, Malaysia is the major country for exporting fisheries products, exported around USD 976.6 million (1.7 million tonnes) in 2017.

Therefore, potential ground fishing is important to give fishermen the general view of where to search for the fish. Remote sensing and Geographic Information System (GIS) technology may able to locate the fishing ground.

2.0 MATERIALS AND METHODS

The study area was conducted at Peninsular Malaysia water bodies, which cover the Straits of Malacca and parts of the South China Sea and the Gulf of Thailand.

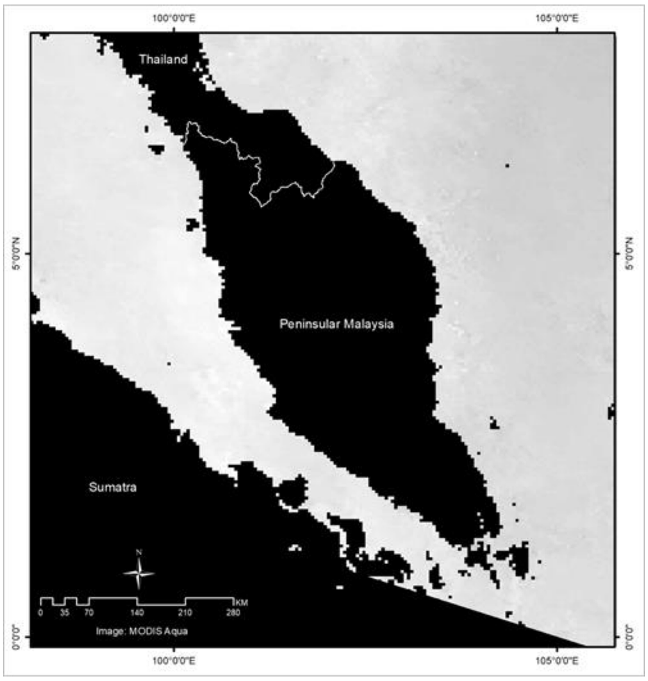

Figure 1: Peninsular Malaysia and its surrounding area neighborhood

A 4-km Modis Aqua Level 3 (L3) SST and Chl-a Standard Map Image (SMI) data were downloaded from (www.oceancolor.gsfc.nasa.gov). Data from January 2010 to June 2020 was exported to the TIFF format from the original NetCDF format using a multi-dimension tool in ArcGIS software. Since these products show the global coverage, it is subsetted to the regional scale as shown in Figure 1. To subset the image, the area of interest need to be determined based on projection in GCS WGS 84. After the image has been subsetted, all images were combined and averaged to get the general of the potential fishing ground per year for every season.

Rastrelliger kanagurta (R. *kanagurta*) is a species of mackerel fish which strongly affected by season. Studies by S.M. Yusof & M.A Mustapha (2019) and Yeny Nadira et al. (2019), have predicted a potential fishing ground for this species in the South China Sea, and shown that fishing ground for this species is affected by season; northeast and southwest monsoon. Other findings by Nurdin et al. (2013) used the habitat suitability index to identify the potential fishing ground for R. *kanagurta* by using the empirical relationship that integrates data extracted from satellite, SST, and Chl-a concentration (Table 1).

Table 1: Ranges of SST and Chl-a Concentration for general fishing and R.*kanagurta*

Num.	Researchers	Month	SST (°C)	Chl-a (mg/m³)
1	S.M. Yusof et. al (2019)	Nov- Mar	29.05 - 29.94	0.32 - 0.42
	R. *kanagurta*	Apr	31.18 - 31.47	0.27 - 0.66
		May-Sept	31.17 - 31.48	0.21 - 0.30
		Oct	30.34 - 31.11	0.22 - 0.39
2	S.M. Yusof et. al (2019)	Nov- Mar	28.80 - 29.18	0.34 - 0.39
	Highest fishing activities (general)	Apr	30.70 - 30.91	0.09 - 0.15
		May-Sept	31.05 - 31.45	0.21 - 0.26
		Oct	30.25 - 30.41	0.26 - 0.32
3	Yeny Nadira et al (2019)	Apr-May	30.30 - 30.70	0.32 - 0.37
	R. *kanagurta*	Sept-Oct	29.10 - 29.70	0.31 - 0.32
4	S. Nurdin et. al (2013)			
	Habitat Suitability Index (general)	–	30.75 ± 0.21	0.31 ± 0.10
	R. *kanagurta*	–	29.91 ± 0.33	0.27 ± 0.03

This study classifies raster data based on the Suitability Index (SI) using the criteria of SST and Chl-a concentration as shown in Table 1. SST was then extracted based on the same pixel location as Chl-a concentration and later correlated using band collection statistics. The output includes a standard statistic with covariance and correlation matrix. Conversion of raster to vector data was done to provide annual potential fishing ground data by using union analysis. Output with negative (-1) means, there is no intersection between both parameter SST and Chl-a, and the selection of features is only with positive (1) value. The mapping of outputs are based on cumulative yearly data.

Based on the Department of Fisheries, Malaysia (DOF), inshore and deep sea landing of capture fisheries from 2013 to 2018 shows that Perak recorded as the highest landing of capture fisheries (1,931,142 tonnes) in northern Peninsular Malaysia , while Kelantan recorded as the highest landing of capture fisheries in the east coast region (780,095 tonnes). Table 2 and Figure 2 shows the capture fisheries landing for states in Peninsular Malaysia from DOF.

Table 2: Landing of Capture Fisheries for states of Peninsular Malaysia (source from: DOF, Malaysia)

LANDING OF CAPTURE FISHERIES, 2013 - 2018												
(Tan Metrik / *Tonnes*)												
(Year)	**2013**		**2014**		**2015**		**2016**		**2017**		**2018**	
ZON *Zone*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*	Laut Pantai *(In shore)*	Laut Dalam *(Deep-sea)*
PANTAI BARAT (*West Coast)*	**625,397**	**90,287**	**667,447**	**81,259**	**681,377**	**78,367**	**721,534**	**92,224**	**644,765**	**78,781**	**697,081**	**90,657**
Perlis	82,687	16,905	85,158	11,293	73,678	11,821	87,269	12,597	78,751	27,142	68,279	27,716
Kedah	105,138	7,739	152,174	3,936	154,361	2,740	159,467	4,411	139,916	2,633	146,160	3,119
Pulau Pinang	58,201	0	45,880	0	49,783	0	56,748	264	48,647	2,537	54,226	628
Perak	242,236	64,950	264,120	65,224	283,047	63,806	292,395	74,952	220,087	46,469	254,663	59,193
Selangor	104,867	693	91,632	805	90,026	0	93,460	0	125,517	0	141,271	0
Negeri Sembilan	568	0	806	0	704	0	717	0	659	0	670	0
Melaka	1,790	0	1,936	0	2,019	0	1,790	0	1,769	0	1,913	0
Johor Barat (*West Johore)*	29,911	0	25,742	0	27,759	0	29,687	0	29,416	0	29,898	0
PANTAI TIMUR (*East Coast)*	**206,335**	**131,361**	**181,383**	**130,377**	**165,880**	**218,898**	**195,391**	**240,023**	**222,655**	**179,249**	**204,673**	**97,465**
Kelantan	27,586	29,525	28,477	33,761	39,095	107,348	69,819	148,939	76,987	119,145	57,984	41,430
Terengganu	61,326	10,898	51,618	7,167	46,025	5,160	40,833	3,869	43,103	4,165	36,776	4,954
Pahang	61,159	46,189	45,267	45,879	49,134	62,403	62,471	57,947	80,245	37,822	89,722	31,488
Johor Timur (*East Johore)*	56,263	44,749	56,021	43,570	31,626	43,987	22,267	29,268	22,320	18,117	20,191	19,592
Sources: Department of Fisheries, Malaysia												

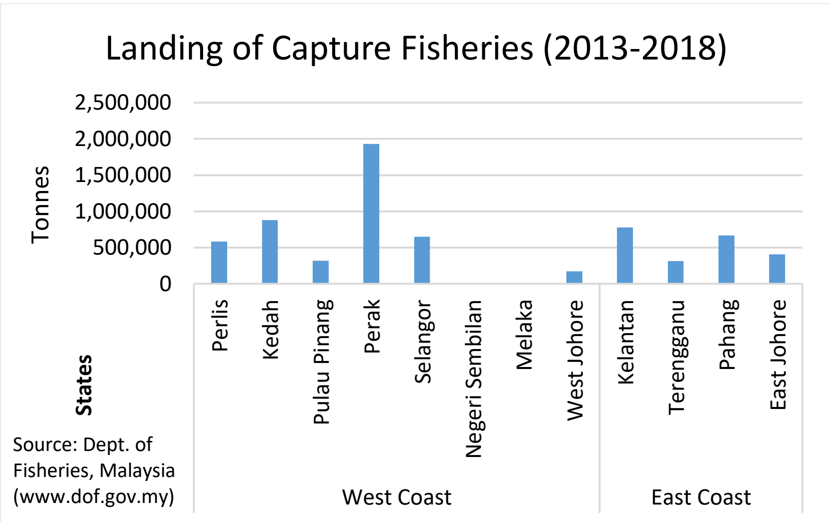

Figure 2: Graph of Landing of Capture of Fisheries from 2013 to 2018

3.0 RESULT AND DISCUSSION

Table 3 (a) shows the minimum and maximum values of SST and Chl-a from 2010 to 2020. In the same pixel location, the range of SST is from 27.73 to 34.80°C, which shows that Peninsular Malaysia water bodies experience warms surface temperature throughout the years. While Chl-a reading is ranged between 0.09 and 8.99 mg/m³.

Table 3: Min and max value from 2010 to June 2020, (a) SST and (b) Chl-a

SST (°C)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
min	28.66	28.97	28.05	28.69	28.79	28.59	28.39	28.50	28.49	27.73	28.98
max	34.80	34.00	31.87	33.58	33.84	38.93	33.13	32.43	32.63	32.90	33.20

(a)

Chl-a (mg/m³)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
min	0.09	0.13	0.13	0.13	0.13	0.20	0.12	0.12	0.13	0.14	0.12
max	8.99	3.59	4.48	7.80	5.06	3.98	4.63	5.39	4.63	5.12	5.02

(b)

Correlation between both parameters on yearly data shows a coefficient correlation of *r* between +0.32 and +0.68. Table 4 shows the correlation matrix between SST and Chl-a. SST and Chl-a have a positive relationship.

Table 4: Correlation coefficient, *r* for SST and Chl-a

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Correlation coefficient, r between SST and Chl-a	0.42	0.64	0.36	0.55	0.32	0.36	0.44	0.49	0.68	0.63	0.59

Union analysis for the whole years from 2010 to 2020 shows that the intersection between the SST and Chl-a concentration derives a cumulative potential fishing ground that focuses on the northern parts of Peninsular Malaysia and near the coast of east Peninsular Malaysia.

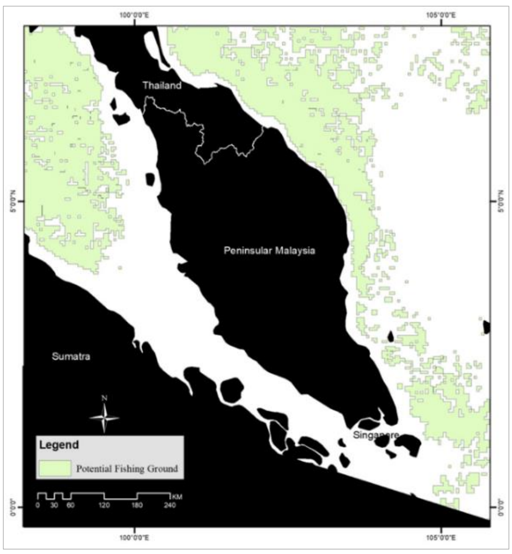

Figure 3: Potential Fishing Ground Around Peninsular Malaysia Water Bodies

Table 5: Hectares of the potential fishing ground of the study area

Area (ha)	Location
5,457,951	West (Straits of Malacca)
8,334,712	East (Gulf of Thailand and South China Sea)

The union method from this study successfully identifies 5 million hectares of the potential fishing ground at the west part of Peninsular Malaysia and 8 million hectares of the potential fishing ground in the east part of Peninsular Malaysia. Further investigation needs to be done to improve searching for the fishing ground, including additional field data and comprehensive data validation.

4.0 CONCLUSION

The average data used in this study gives a general location of the fishing ground around Peninsular Malaysia water bodies which will assist fishermen in fishing. Collective average monthly data may not be as accurate as daily data. Field data, including Catch Per Unit Effort (CPUE) data, fishing activities, other parameters such as wind surface, sea surface height, seasonal monsoon should be included for potential fishing ground prediction efficiency.

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