Relationship between the abundance of chlorophyll-a from Aqua Modis Satellite Imagery data with the abundance of phytoplankton in seawater and in the stomachs of Indian mackerel (Rastrelliger kanagurt

by Frida Purwanti

Relationship between the abundance of chlorophyll-a from Aqua Modis Satellite Imagery data with the abundance of phytoplankton in seawater and in the stomachs of Indian mackerel (*Rastrelliger kanagurta*) in East Kalimantan waters

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Abstract. East Kalimantan's fishery resources can be found along the waters of the Makassar Strait to the Sulawesi Sea. Oceanographic parameters are very influential factors on fishery resources, especially fish catches. Chlorophyll-a is closely related to the primary productivity of the environoment and it is capable of sustaining large amounts of phytoplankton biomass. Sampling of phytoplankton was done in the field by seawater filtration and samples of phytoplankton were collected from the stomach contents of Indian mackerel (*Rastrelliger kanagurta*), while the data on chlorophyll-a distribution was the result of SeaDAS data processing in form of Ancillary Satellite Image Modis. The highest abundance of phytoplankton from seawater sampling was found in Station 3 in amount of 206,010 specimens/liter where the Bacillariophyceae class was represented by 17 species out of 29 species found. The highest abundance of phytoplankton in the stomachs of Indian mackerel (*Rastrelliger kanagurta*) was found in the specimens caught at Station 3, with as many as 252.0 specimens/liter, where Bacillariophyceae class contained 18 species out of 28 phytoplankton species found. The data obtained from the Modis Ancillary Image Satellite and processed with the SeaDas Program, showed the highest abundance of chlorophyll-a is at Station 3, with as much as 0.9389626 mg/m^3. The fluctuation of chlorophyll-a abundance was in accordance with the fluctuation of phytoplankton abundance from the result of seawater sampling and fish stomach sampling.

Key Words: oceanography, primary productivity, pelagic fish, remote sensing.

Introduction. The potential of biological natural resources in a aquatic ecosystem is largely determined by primary productivity. Fishery resources in East Kalimantan waters along the Makassar Strait to the Sulawesi Sea, especially pelagic fish, show great potential for the local settlements. Oceanography parameters are highly influential on fish catches, such as chlorophyll-a and surface temperature. An important factor affecting the aggregation of pelagic fish in tropical waters is food availability, which is very much influenced by phytoplankton production (Fonteneau & Marcille 1993). The number of pelagic fish tends to be high in the areas where there is a great number of phytoplankton and zooplankton indicating that the areas are suitable feeding grounds. See surface temperature (SST) is closely related to fish activities, so it affects fish abundance and distribution. The waters of Indonesia have unique and dynamic oceanography characteristics. The highest temperatures and the lowest salinity in the southern waters of Sulawesi occur from December to March, while the lowest temperatures and the highest salinity occur from June to November (Hendiarti et al 2004; Susanto et al 2001; Susanto et al 2006; Susanto et al 2012). Transport of deep and nutrient-rich waters to the surface are characterized by an increase in chlorophyll-a concentration and a decrease of sea surface temperature (SST) along the coast. Some sources found phytoplankton blooms in the Southern Makassar Strait during the Southeast Monsoon based on chlorophyll-a data from satellite imagery (Habibi et al 2012; Setiawan & Kawamura 2011; Syahdan et al 2014) and water sampling (Afdal & Riyono 2004). Chlorophyll-a is closely related to the primary productivity indicated by the large amount of phytoplankton biomass. Phytoplankton, like plants that contain the pigment chlorophyll-a, are microscopic organisms in the sea that are autotrophs or are able the produce organic matter from inorganic materials through photosynthetic reactions to sunlight. Because of the ability to produce organic substance from inorganic substance, phytoplankton is called a primary producer (Kavanaugh et al 2009; Nielsen 1975; Nontji 2002; Nybakken 2005; Raymont 1980). Each species of phytoplankton has their own optimum temperature which highly depends on other factors such as light. The optimum temperature for plankton growth ranges from 25°C to 32°C (Wyrtki 1961 in Hartoko 2013). The types of phytoplankton that contain a lot of chlorophyll-a substances in their cells and are most often found are the Chlorophyceae class and Cyanophyceae class (Nontji 2008). The distribution and abudance of phytoplankton can be estimated from their chlorophyll-a content through remote sensing technology, such as using the Aqua MODIS satellite imagery. Moderate Resolution Imaging Spectroradiometer (MODIS) data, such as SeaWiFS OC4 and MODIS OC3M, can evaluate sources of chlorophyll-a in open sea water (Ab Lah et al 2013). The abundance of various kinds of pelagic fish, especially plankton-eating fish (planktivore), is highly affected by the growth and density of plankton (Hickman et al 2009). Pelagic fish generally schoal and can group with other types of fish. Small pelagic fish are phototaxis positive (attracted to light), they are attracted to floating objects and they tend to schoal by size group. Most pelagic fish include plankton eaters, both vegetable plankton and animal plankton (Bakun 1996; Cury et al 2000; Fréon et al 2005; Palomera et al 2007; Widodo et al 1995). Indian mackerel (*Rastrelliger kanagurta*), which is a pelagic fish, forms large schools in coastal waters and they consume phytoplankton (diatoms) (Nurdin et al 2015). Distribution and growth of fish are influenced by food availability. Indian mackerel (*Rastrelliger kanagurta*) food consists of diatoms (31%), other organisms (9%), and unidentified particles (60%) (Almuas & Jaya 2006; Suwarso & Hariati 2003; Najamuddin 2004; Palomera et al 2007).

Material and Method. The sampling was done in the waters of East Kalimantan, in the east of the island of Kalimantan (Figure 1). The research was conducted for 15 months from November 2017 to February 2018. The research stations were determined to conduct purposive sampling (Arikunto 2006). The data for plankton and mackerel caught were taken at the same locations and days. Meanwhile, the coordinates to find the chlorophyll-a values were taken from the accurate images of the plankton and mackerel sampling locations. Data on plankton samples from sea water consists of plankton data from sea water filtration. The phytoplankton samples were collected using conical plankton nets with a net mouth diameter of 30 cm, net body length of 150 cm, and mesh size of 30 µm. The plankton net was descended to a depth of 5 meters then pulled to the surface. The plankton samples obtained from the result of seawater filtering from 5-meter depth until the surface were then taken out of the container bottle, moved into the collection bottle and preservaed in 4% formalin solution. The bottles were labeled with the following data: station number, collection location, type of tools used, day and time of collection of plankton samples. Indian mackerel (*Rastrelliger kanagurta*) specimens were collected using a fishing rod, and each specimen was dissected to collect the fish's stomach, weigh it, and store it in a labeled collection bottle, with a preservative solution of 4% formalin. Chlorophyll-a data was taken daily from Aqua MODIS level 3 satellite imagery and then processed using the SeaDas 8.1 program to obtain grided data at each phytoplankton sampling station.

The identification of phytoplankton was based on the methods of Yamaji (1976) and Davis (1995). While the calculation of phytoplankton abundance used APHA (1992) following formula:

$$N = \frac{T}{L} x \frac{P}{p} x \frac{V}{v} x \frac{1}{w}$$

where : N = abundance of phytoplankton individuals (individuals/liter)
T = total area Sedgwick-rafter grid (1000 mm^2)
L = the scope of microscope (mm^2)
P = the number of phytoplankton
p = the observable amount of view
V = volume of filtered phytoplankton samples (ml)
v = volume of filtered phytoplankton samples in the Sedgwick-rafter (ml)
w = volume of filtered water sample (L)

The daily chlorophyll-a images were processed using SeaDAS program to crop the research areas and to obtain the ancillary data in the stations of water and fish sampling, on www.oceancolor.gsfc.nasa.gov. According to McClain and Feldman (2004) and Tampubolon et al (2016), OC3M algorithm is used as a standard in Aqua MODIS satellite image processing to obtain data of chlorophyll-a in waters globally. The equation of OC3M algorithm (O'Reilly et al 2000) is:

$$Ca = 10^{(a_0 + a_1 R + a_2 R2 + a_3 R3 + a_4 R4)}$$
$$a = 0.2830, -2.753, 1.457, 0.659, -1.403$$

$$R = \log 10 \left(\frac{Rrs(443)}{Rrs(550)} > \frac{Rrs(490)}{Rrs(550)} \right)$$

where : Ca = concentration of chlorophyll-a (mg/m^3)
R = reflectance ratio
Rrs = remote sensing reflectance

Results and Discussion. The results of measurements of phytoplankton per liter at seawater sampling stations in East Kalimantan waters are presented in Table 1. Based on the results presented in Table 1, it can be seen that there were 29 genera of phytoplankton and 5 genera had abundant populations, namely *Chaetoceros* in Station 6 in number of 7182 specimens, *Chaetoceros* in Station 3 in number of 4536 specimens, *Bacteriastrum* in Station 6 in number of 3780 specimens, *Bacteriastrum* in Station 3 in number 2835 specimens, *Oscillatoria* in Station 2 in number of 2709 specimens, and *Guinardia* in Station 3 in number of 2709 specimens. The kinds of phytoplankton found consisted of 29 species, belonging to the Bacillariophyceae class (17 species), Dinophyceae class (10 species), Chlorophyceae (1 species), and Cyanophyceae (1 species). Phytoplankton in Bacillariophyceae class (Diatom) were the species most common. The domination of Bacillariophyceae (Diatom) was presumably because the species that belonged to the class had high adaptability and survival rate in various conditions including extreme conditions. According to Odum (1998), the large number of Bacillariophyceae (Diatom) in waters is caused by their ability to adapt to the environment, their cosmopolite property, their endurance against extreme conditions, and their high reproductive potential. The highest phytoplankton abundance was found in Station 3 in number of 206.01 specimens/liter followed by Station 6 in number of 162.54 specimens/liter and Station 2 in number of 123.30 specimens/liter.

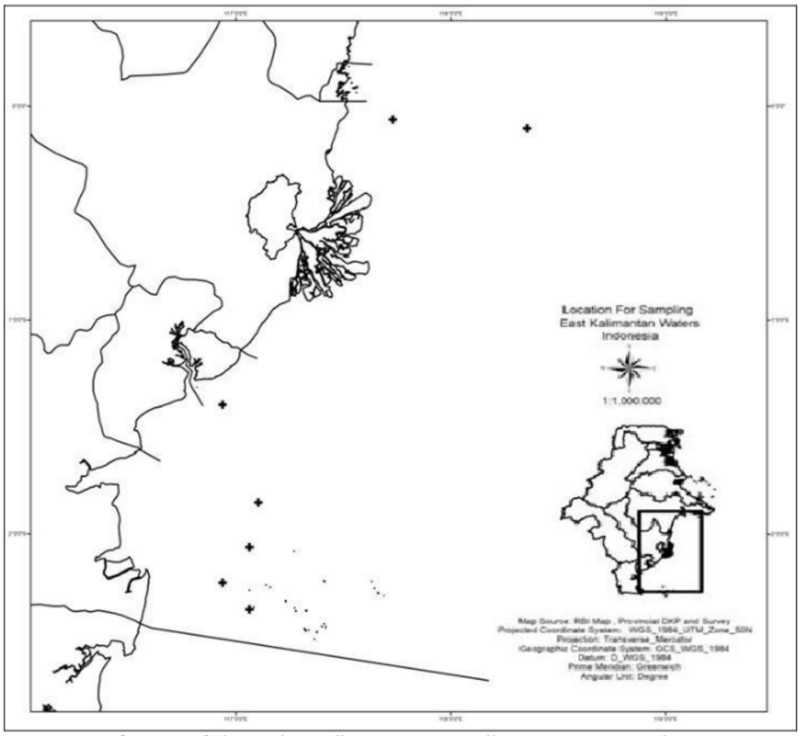

Figure 1. Location of water, fish, and satellite imagery collection in East Kalimantan waters (map generated using ArcGis ver. 10).

Table 1

Phytoplankton distribution in each station

No	Types of phytoplankton	*Sampling station*						
		Station 1	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*	*Station 7*
1	Bacillariophyceae							
	Bacillaria sp.	252	63	1134	-	-	315	126
	Bacteriastrum sp.	1008	819	2835	63	126	3780	-
	Biddulphia mobiliensis	-	-	-	-	63	63	-
	Biddulphia sinensis	-	252	-	-	-	-	-
	Climacosphenia moniligera	-	-	-	-	-	-	189
	Chaetoceros spp.	1764	1935	4536	441	189	7182	567
	Coscinodiscus spp.	504	1197	1764	189	189	63	252
	Eucampia zodiacus						252	
	Melosira borrerii	189	189	1071	-	-	378	63
	Thalassiothrix frauenfeldii	1197	1071	2583	252	63	441	189
	Thalassionema sp.	252	126	819	-	63	315	
	Pleurosigma sp.	-	63	-	-	-	315	
	Guinardia sp.	63	1008	2079	126	-	693	252
	Nitzschia sigma	63	189	63	63	-	126	-
	Synedra tabulate							189

	Rhizosolenia bergonii	756	1134	1764	252	63	1071	252
	Rhabdonema adriaticum	63	63	-	126	-	63	-
2	Chlorophyta							
	Stichococcus sp.	-	-	189	-	-	-	189
3	Cyanophyceae							
	Oscillatoria spp.	1449	2709	189	126	63	63	504
4	Dinophyceae							
	Ceratium fusus	63	63	-	-	-	126	2394
	Ceratium furca	567	252	-	-	63	63	-
	Ceratium tripos	126	-	-	-	-	-	-
	Ceratium macroceros	63	126	-	-	-	315	126
	Dinophysis caudata							63
	Dinophysis homunculus	-	-	378	-	-	-	-
	Prorocentrum minimum	-	189	504	-	-	-	-
	Protoperidinium spp.	189	693	252	126	126	378	-
	Ditylum sol	126	63	315	-	-	63	-
	Ditylum brightwellii	-	126	126	63	-	189	-
Abundance specimens/liter		86.94	123.30	206.01	18.27	10.08	162.54	53.55

Table 2

Phytoplankton distribution in fish stomach in each station

No	Types of phytoplankton	*Sampling station*						
		Station 1	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*	*Station 7*
1	Bacillariophyceae							
	Bacillaria sp.	-	-	63	-	-	-	252
	Bacteriastrum sp.	-	378	252	-	-	1575	189
	Biddulphia mobiliensis	-	504	252	-	-	-	126
	Biddulphia sinensis	-	6300	5607	63	-	252	-
	Climacosphenia moniligera	-	-	-	126	63	-	-
	Chaetoceros spp.	126	126	504	-	-	-	-
	Coscinodiscus spp.	1071	4095	7119	252	126	1323	1512
	Melosira borrerii	378	756	882	189	-	63	504
	Thalassiothrix frauenfeldii	1260	-	63	756	-	567	504
	Thalassionema sp.	882	126	63	252	-	63	126
	Pleurosigma sp.	-	-	-	252	-	63	63
	Navicula sp.	63	-	-	-	-	-	-
	Guinardia sp.	-	2520	2961	63	-	189	-
	Nitzschia sigma	63	189	-	441	252	-	441
	Synedra tabulate	-	126	-	189	-	-	-
	Rhizosolenia bergonii	252	756	1386	63	252	3780	-
	Rhizosolenia alata	-	-	-	-	-	2520	-
	Rhabdonema adriaticum	-	-	504	-	-	1197	-
2	Chlorophyta							
	Stichococcus sp.	-	-	63	63	-	-	-

3	Cyanophyceae							
	Oscillatoria spp.	-	-	-	-	189	-	-
4	Dinophyceae							
	Ceratium fusus	126	189	189	-	-	-	-
	Ceratium furca	63	819	1071	-	63	-	-
	Ceratium tripos	189	126	63	63	-	-	-
	Ceratium macroceros	63	63	-	-	-	-	-
	Protoperidinium sp.	126	189	63	63	-	-	-
	Triposolenia truncata	-	189	63	-	-	-	-
	Ditylum sol	-	1260	2520	-	-	-	-
	Ditylum brightwellii	-	-	1512	126	-	-	-
	Abundance specimens/liter	46.62	187.11	252.0	29.61	9.45	115.92	37.17

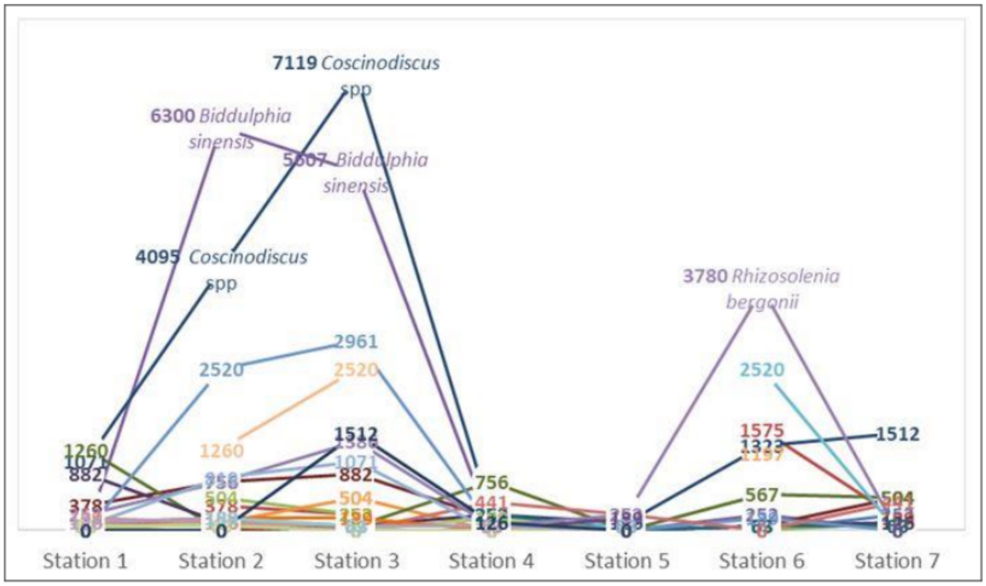

Figure 2. The abundance of phytoplankton in Indian mackerel stomachs.

The results of abundance of phytoplankton in the stomachs of Indian mackerel (*Rastrelliger kanagurta*) at each sampling station are presented in Table 2 and Figure 2. Based on the result of the study, there were 28 genera of phytoplankton, of which 5 genera with abundant populations: *Coscinodiscus* spp. in Station 3 in number of 7119 specimens, *Biddulphia sinensis* in Station 2 in number of 6300 specimens, *Biddulphia sinensis* in Station 3 in number of 5607 specimens, *Coscinodiscus* spp. in Station 2 in number of 4095 specimens, and *Rhizosolenia bergonii* in Station 6 in number of 3780 specimens. The kinds of phytoplankton found consisted of 28 genera, including Bacillariophyceae class (18 species), Dinophyceae class (8 species), Chlorophyceae class (1 species), and Cyanophyceae class (1 species). Phytoplankton belonging to Bacillariophyceae class was mostly found in mackerel stomachs. The domination of Bacillariophyceae in fish stomachs was presumably because the availability in nature was abundant based on the result of sampling shown in Table 1, and they had high adaptability and survival rate. The highest phytoplankton abundance was found in Station 3 in number of 252.0 specimens/liter, followed by Station 2 in number of 187.11 specimens/liter and Station 6 in number of 115.92 specimens/liter.

Table 3

Data of chlorophyll-a and phytoplankton abundance in each station

No	*Ancillary data Modis Satellite image mg/m³*	*Satellite image pixel coordinates*	*Phytoplankton abundance specimens/liter*	*Phytoplankton abundance in mackerel stomach*	*Coordinates sample*
1	*0*,609072	0°03'45" S 117°43'45" E	86,940	46.620	0°03'55" S 117°47'22" E
2	0,77513963	2°13'45" S 116°56'15" E	123.300	187.110	2°13'8.59"S 116°54'50.11"E
3	0,9389626	2°03'45" S 117°03'45" E	206.010	252.000	2°03'31.4"S 117°03'47.8"E
4	0,561721	1°23'45" S 116°56'15" E	18.270	29.610	1°24'45.6"S 116°55'48.0"E
5	0,159598	118°21'15" E 0°06'15" S	10.080	9.450	0°07'58.6"S 118°20'48.0"E
6	0,8759998	2°21'15" S 117°03'45" E	162,540	115.920	2°20'42.03"S 117°04'54.1"E
7	0,67369723	1°51'15" S 117°06'15" E	53,550	37.170	1°50'05.07"S 117°08'41.1"E

The abundance of chlorophyll-a data from Ancillary Satellite Imagery Modis was determined at the sampling stations for seawater and fish samples. Table 3 shows that the highest chlorophyll-a abundance was in Station 3 in number of 0.9389626 mg/m³, Station 6 in number of 0.8759998 mg/m³, and Station 2 in number of 0.77513963 mg/m³. The chlorophyll-a abundance from the result of Ancillary Satellite Image Modis data was the spectral result of the sea. The fluctuation of chlorophyll-a abundance was in accordance with the fluctuation of phytoplankton abundance based on the result of seawater sampling and fish stomach sampling shown in Figure 3, indicating the chart of satellite image chlorophyll-a content and phytoplankton abundance in each station and phytoplankton abundance in mackerel stomach.

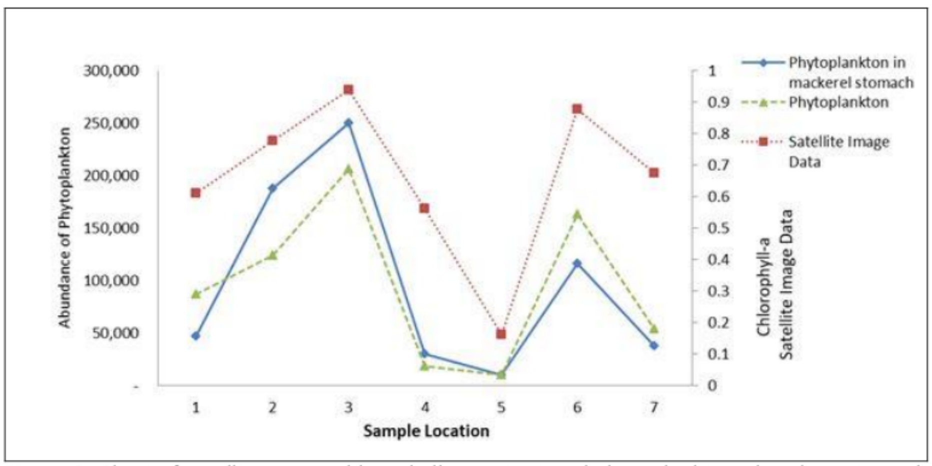

Figure 3. Chart of satellite image chlorophyll-a content and phytoplankton abundance in each station and phytoplankton abundance in mackerel stomach.

Conclusions. Based on the result of observation, it could be concluded that the highest phytoplankton abundance was found in Station 3 in number of 206.010 specimens/liter. 17 species out of 29 species of phytoplankton found belonged to the Bacillariophyceae class. The greatest abundance of phytoplankton in mackerel stomach was found in

Station 3 in amount of 252.0 specimens/liter. 18 species out of 28 species of phytoplankton found belonged to the Bacillariophyceae class. The chlorophyll-a abundance of Ancillary Satellite Image Modis data was in the station of seawater and fish sampling. It could be seen that the greatest abundance of chlorophyll-a was found in Station 3 in amount of 0.9389626 mg/m^3. The fluctuation of chlorophyll-a abundance was in accordance with the fluctuation of phytoplankton abundance from the result of seawater sampling and fish stomach sampling.

Conflict of Interest. The authors declare no conflict of interest.

References

Ab Lah N. Z., Reba M. N. M., Siswanto E., 2013 An improved MODIS standard chlorophyll-a algorithm for Malacca Straits Water. IOP Conf. Series: Earth and Environmental Science 18 (2014) 012113. 8th International Symposium of the Digital Earth (ISDE8).

Afdal, Riyono S. H., 2004 [Distribution of chlorophyll-a and its relationship with hydrological conditions in the Makassar Strait]. Oseanologi dan Limnologi di Indonesia 36:69-82 [in Indonesian].

Almuas, Jaya I., 2006 [A study of potential pelagic fishing grounds in southern China Sea waters in the eastern monsoon season]. Bulletin PSP X(3):102-120 [in Indonesian].

Arikunto, 2006 [Research procedure a practical approach]. Rineka Cipta. Jakarta [in Indonesian].

Bakun A., 1996 Pattern in the oceans. Ocean processes and marine population dynamics. California Sea Grant College System. National Oceans and Atsmopheric Adiministration in cooperation with Centro de Investigaciones Biologicas del Noroeste, La Paz. BCS, México. 323p.

Cury P., Bakun A., Robert J., Crawford M., Jarre A., Renato A., Quinñones, Lynne J, Shannon, Verheye H. M., 2000 Small Pelagics in Upwelling Systems: Pattern of Interaction and Structural Changes in “Wasp-Waist” Ecosystems. ICES Journal of Marine Science 57:603-618.

Davis C. C., 1955 The marine and fresh-water plankton. Michigan State University Press. New York. 562 p.

Fonteneau A., Marcille J., 1993 Resources, fishing and biology of tropical tunas of Eastern Central Atlantic. Rome: [FAO] Food and Agricultural Organization of the United Nations. 447 p.

Fréon P., Cury P., Shannon L., Roy C., 2005 Sustainable exploitation of small pelagic fish stocks challenged by environmental and ecosystem changes: a review. Bulletin of Marine Science, 76(2):385–462.

Habibi A., Setiawan R. Y., Zuhdy A. Y., 2012 Wind-driven coastal upwelling along South of Sulawesi Island. Ilmu Kelautan: Indonesian Journal of Marine Sciences 15:113-118.

Hartoko A., 2013 Oceanographic characters and plankton resources of Indonesia, Graha Ilmu press, Yogyakarta. 166 p.

Hendiarti N., Suwarso E., Aldrian K., Amri R., Andiastuti S. E., Sachoemar, Wahyono I. B., 2005 Pelagic fish catch around Java. Oceanography, 18(4):112-123.

Hickman A. E., Holligan P. M., Mooreet C. M., Sharples J., Krivtsov V., Palmer M. R., 2009 Distribution and chromatic adaptation of phytoplankton within a shelf sea thermocline. Limnol. Oceanogr., 54(2):525-536.

Kavanaugh M. T., Nielsen K. J., Chan F. T., Menge B. A., Letelier R. M., and Goodrich L. M., 2009 Experimental assessment of the effects of shade on an intertidal kelp: Do phytoplankton blooms inhibit growth of open coast macroalgae?. Limnol. Oceanogr., 54(1):276-288.

McClain C. R., Feldman G. C. 2004 MODIS/Aqua Evaluation. NASA Ocean Color Research Team Meeting. April 14-16, 2004. Wasington, DC. Retrived October 3, 2005. 03:40 PM. From The World Wide Web: http//oceancolor.gsfc.nasa.gov/DOCS/Science Team/OCRT_Apr2004/mcclain_aqua_ocrt04.pdf.

Najamuddin, 2004 [Study on sustainable utilization of mackerel scad (*Decapterus* spp.) resources in Makassar Strait Waters [dissertation]]. Makassar. Graduate Program, Hasanuddin University Agricultural Science Study Program. 245 p [in Indonesian].
Nielsen S. E., 1975 Marine Photosynthesis with special emphasis on the ecological aspect. Elsevier sci. Publ. Co. Amsterdam. 140 pp.
Nontji A., 2002 [Archipelago Sea]. 3th ed. Djambatan Publisher. Jakarta. 368 p [in Indonesian].
Nontji, 2008 [Marine plankton]. LIPI Press, Jakarta [in Indonesian].
Nurdin S., Mustapha M. A., Lihan T., Ghaffar M. A., 2015 Determination of potential fishing grounds of *Rastrelliger kanagurta* using satellite remote sensing and GIS technique. Sains Malaysiana 44(2)(2015):225–232.
Nybakken J. W., Bertness M. D., 2005 Marine Biology: An Ecological Approach 6th ed. Pearson Education, Inc.
Raymont J. E. G., 1980 Plankton and productivity in the Oceans. Volume 1 Phytoplankton. 2nd editon. IX, 504pp. Pergamon Press. New York.
Setiawan R. Y, Kawamura H., 2011 Summertime phytoplankton bloom in the South Sulawesi Sea. Selected Topics in Applied Earth Observations and Remote Sensing IEEE Journal. (4):241-244.
Susanto R. D., Gordon A. L., Zheng Q., 2001 Upwelling along the coast of Java and Sumatra and its relation to ENSO. Geophysical Research Letters 29:1599–1602.
Susanto R. D., Moore T. S. II., Marra J., 2006 Ocean color variability in the Indonesian seas during SeaWiFS Era. Geochemistry, Geophysics and Geosystems 7(5).
Susanto R. D., Ffield F. A., Gordon A. L, Adi T. R., 2012 Variability of Indonesian throughflow within Makassar Strait, 2004–2009. J Geophys Res. 117. C09013.
Suwarso, Hariati T., 2003 [Biology and ecology of small pelagic fish in the north coast of West Java and the Sunda Strait]. Indonesian Fisheries Research Journal 9(7):29-36 [in Indonesian].
Syahdan M., Atmadipoera A. S., Susilo S. B., Gaol J. L., 2014 Variability of surface chloropyll-a in Makassar Strait-Java Sea. Indonesia International Journal of Sciences: Basic and Applied Research (IJSBAR) 14:103-116.
Tampubolon A. B., Gustin O., Chayati S. N., 2016 Sea surface temperature mapping using AQUA MODIS Satellite Image in Riau Islands Provincial Waters, 1–11. https://doi.org/10.13140/RG.2.2.11693.08161 [in Indonesian].
Odum E. P., 1998 Basics of ecology (fundamentals of ecology). Translated by Tj. Samingan. Gajah Mada University Press, Yogyakarta.
Palomera I., Olivar M. P., Salat J., Sabatés A., Coll M., Garcia A. A., Morales-Nin B., 2007 Small pelagic fish in the NW Mediterranean Sea: an ecological review. Progress in Oceanography 74:377-396.
Widodo J., Nurhudah M., 1995 [Fish resource management]. Jakarta. Fisheries High School. 151 pp [in Indonesian].
Wyrtki K., 1961 NAGA report (Scientific Results of Marine Investigations of the South China Sea and the Gulf of Thailand 1959-1961) (2 ed). La Jolla, California: Scripps Institution of Oceanography - The University of California.
Yamaji I., 1976 Illustration of Marine Plankton. Japan: Hoikusha Publishing Co Ltd. 371p.
*** APHA (American Public Health Association), 1992 Standard Methods for the examination of water and wastewater. American Public Control Federation. 18th edition, Washington DC. American Public Health Asosiation.
*** www.oceancolor.gsfc.nasa.gov

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1	Agustinus Anung Widodo, Ignatius Trihargiyatno, Regi Fiji Anggawangsa, Wudianto Wudianto. "PEMANFAATAN DAN PENGELOLAAN TUNA NERITIK DI WILAYAH PENGELOLAAN PERIKANAN NEGARA REPUBLIK INDONESIA (WPPNRI) 573", Jurnal Penelitian Perikanan Indonesia, 2020 Publication	1%
2	A Rosdiana, T Prartono, A S Atmadipoera, R Zuraida. "Nutrient and chlorophyll-a distribution in Makassar Upwelling Region: From MAJAFLOX CRUISE 2015", IOP Conference Series: Earth and Environmental Science, 2017 Publication	1%
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Bandırma (the Sea of Marmara)", Biologia, 2021
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4 Catherine Jordan, Caroline Cusack, Michelle C. Tomlinson, Andrew Meredith et al. "Using the Red Band Difference Algorithm to Detect and Monitor a Karenia spp. Bloom Off the South Coast of Ireland, June 2019", Frontiers in Marine Science, 2021 1%
Publication

5 André Rosch Rodrigues, João Carlos Cattini Maluf, Elisabete de Santis Braga, Beatriz Beck Eichler. "Recent benthic foraminiferal distribution and related environmental factors in Ezcurra Inlet, King George Island, Antarctica", Antarctic Science, 2010 1%
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9	Cabello, Ana M., Mikel Latasa, Irene Forn, Xosé Anxelu G. Morán, and Ramon Massana. "Vertical distribution of major photosynthetic picoeukaryotic groups in stratified marine waters : Photo-picoeukaryotes community structure in the DCM", Environmental Microbiology, 2016. Publication	<1%
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Publication

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