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ESTIMATION OF THE POTENTIAL OF LARGE PELAGIC FISH FISHERIES USING SATELLITE DATA IN THE BANDA AND ARAFURA SEAS

Muhammad Faqih Ahkam[1], Ayi Tarya[2]
[1,2] Institut Teknologi Bandung, Indonesia
Email: ahkammhd77@gmail.com

KEYWORDS
Banda and Arafura Sea, Large pelagic Fish, VGPM, Primary productivity

ABSTRACT

The Banda and Arafura Sea possesses significant potential for the fisheries and fishing industry in the country. The large pelagic fish production data studied were derived from satellite imagery data in the Banda and Arafura Seas (2002-2022). The data of chlorophyll-a content, sea surface temperature and Photosynthetically Available Radiation (PAR) derived from AQUA MODIS satellite images were used to estimate the value of primary productivity with the Vertically Generalised Production Model (VGPM). The results showed that the biomass of large pelagic fish fluctuated seasonally, with the Banda Sea and Arafura Sea having high average fish biomass values in the eastern season. With the highest fish biomass peak in August and the lowest in December. The high value of fish biomass in the Banda Sea and Arafura Sea is caused by upwelling events where sea surface temperatures are low but chlorophyll is high. in the Arafura Sea the value of fish biomass is higher than the Banda Sea, this is due to the large amount of nutrient input from large rivers in the area.

INTRODUCTION

The Banda Sea possesses significant potential for the fisheries and fishing industry in the country. WPP 5, out of the total 9 fisheries management areas (WPPs) in Indonesia, encompasses the Banda Sea. External factors like ENSO, Indonesian Throughflow (ARLINDO) and Season impact the Banda Sea. The Indonesian monsoon current or Armondo, is resulting from the seasonal monsoon winds, which leads to monsoon ocean currents within the Indonesian Archipelago. The monsoon system impacts the current circulation in the Banda Sea. During the Southeast monsoon (June-August), the surface water is pushed from the Banda Sea towards the Flores Sea, Java Sea, and South China Sea (Sukresno & Kasa, 2008). The Arafura Sea is included in WPP 718 with environmental characteristics around the Arafura Sea that are very diverse influenced by coastal and terrestrial structures and seawater masses from surrounding waters (Ditjen Perikanan Tangkap, 2009).

Primary productivity is the most important thing in the survival of biota in aquatic ecosystems. The value of primary productivity can be used to determine the level of fertility in a body of water (Kemili & Putri, 2012). The food chain starts from phytoplankton as primary producers who are at the first trophic level, the second trophic level is herbivores or primary consumers who eat phytoplankton directly, the third trophic level is carnivore 1 or secondary consumers who utilise the energy produced by herbivores through primary consumers. The fourth trophic level is a larger carnivore or tertiary consumer that utilises energy from phytoplankton through secondary consumers. The same process also occurs at the next trophic level up to the top carnivore. Trophic levels that occur in the water are related to food habit and feeding habit. Food habit is the food commonly eaten by fish while feeding habit is the eating habits of fish. Feeding habit includes how, when and where to eat. Information on feeding habit is useful for fishing businesses in order to determine fishing areas, planning the time of fishing operations and planning fishing technology (Simbolon, 2019).

The level of primary productivity can affect the size of the fishery potential of a water body. Fisheries potential is the ability of the ecosystem to produce fish resources in a certain unit of time. This is important to know in aquatic resource management efforts. The large potential of fisheries resources in Indonesia, of course, requires special attention in the management process. fishing activities carried out by humans without paying attention to sustainable principles will cause many problems in the future. FAO, (2022), also explained that the management of fisheries resources can encourage the process of preserving and conserving fisheries resources and ecosystems, as well as providing facilities for sustainable use. Remote sensing technology can determine water areas that have the potential for favourable fish resources to determine the distribution of fish biomass. Satellite observations of primary productivity help in accurately assessing the photosynthetic process. Net primary productivity and fish biomass distribution can be estimated using remote sensing data. One of the satellite images that can be used to estimate the net primary productivity and distribution of fish biomass in the Banda and Arafura Sea is the Aqua satellite with the MODIS (Moderate Resolution Imaging Spectroradiometer) level 3 sensor with a resolution of 4 km. By applying geographic information systems, the three data were processed to produce new information on the relationship of seasonal variability to the horizontal distribution of primary productivity and fish catch areas in the the Banda and Arafura Sea.

RESEARCH METHOD

The data used in this study are SST, chlorophyll and PAR from the NASA oceancolour.gsfc.nasa.gov satellite. The technique used in this method uses visual analysis based on spatial and temporal. Spatial here means conducting research based on the scope of space or regional boundaries, namely the Banda and Arafura sea area. While temporal in the scope of a certain time in a span of 20 years, namely 2002 to 2022.

Vertically Generalised Production Model (VGPM) is used to calculate column primary productivity from satellite-derived Chlorophyll-a, sea surface temperature and daily sea surface photosynthetically active radiation (PAR). The VGPM formula can be written as follows (Falkowsky, 1980):

Primary Productivity = 0.66125 x P^{B}opt x ($\frac{E0}{E0+4.1}$) x CSAT x Zeu x D_{IRR}

$$Zeu = \begin{cases} 568{,}2 \text{ x } (C_{TOT})^{-0.746} & \text{jika } C_{TOT} < 102 \\ 200 \text{ x } (C_{TOT})^{-0.746} & \text{jika } C_{TOT} > 102 \end{cases}$$

$$C_{TOT} = \begin{cases} 38 \text{ x } (C_{SAT})^{0.425} & \text{jika } C_{SAT} < 1 \\ 40.2 \text{ x } (C_{SAT})^{0.507} & \text{jika } C_{SAT} \geq 1 \end{cases}$$

$$P^{B}opt = \begin{cases} PBopt = 1{,}13 & \text{jika } T < -1 \\ \quad = 4 \text{ ika } T > 28{,}5 & \end{cases}$$

P^{B}opt = 1,2956 +(2,749 x 10^{-1}.x T)+(6.17 x 10^{-2}.x T^{2})- (2.05 x 10^{-2}.x T^{3})+ (2.462 x 10^{-3}.x T^{4})- (1.348 x 10^{-4}.x T^{5})+ (3.4132 x 10^{-6}.x T^{6})- (3.27 x 10^{-8}.x T^{7})

Primary productivity is the integrated daily carbon fixation at euphotic depth derived from the chlorophyll equation (mg/Cm-2d-1)

T = sea surface temperature in degrees Celsius

C_{SAT} = sea surface chlorophyll concentration (mgchl/m-3)

PB_{opt} = optimal daily carbon fixation rate in the water column [mgCmg Chl)-1h-1 as a function of sea surface temperature

Zeu = deep euphotic depth (metres)
E0 = sea surface daily light intensity (mol quanta m-2d-1)
DIRR = daily photoperiod calculated in decimal hours for the middle of the month

Estimating the potential of large pelagic fish fisheries

Pauly and Christensen (1995) stated that the fish production model can be estimated through the energy transfer relationship between the lower and upper levels of the food chain. If it is assumed that primary productivity is 100%, because the average transfer efficiency between food chain levels is 10%, then the transfer of energy due to predation processes at the upper level is only 10% and so on.

Following the theory of energy transfer through the food chain process, fisheries production or fisheries potential in the Banda and Arafura Seas can be approached using the following equation:

$FP = PP \times (TE)^{(TL-1)}$

Dimana :
FP : Fish Production (mg C/m2)
PP : Primary Production (mg C/m2)
TE : Transfer Efficiency (10%)
TL : Trophic Level

By using a conversion factor from carbon weight to mass with a ratio of 9 : 1, then the potential of fisheries in units of mass can be estimated by the following equation:

$FB = FP \times 9$

FB : Fish Biomass (in tons)

Correlation Analysis

Correlation is used to determine the relationship between 2 variables, in this study the relationship between primary productivity and fish catchment area. Correlation can be calculated with the formula as written in Wirasatriya *et al.*(2017) :

$$r = \frac{N(\sum XY) - (\sum X \sum Y)}{\sqrt{(N(\sum X^2 - (\sum X)^2) - (N(\sum Y^2 - (\sum Y)^2)}} \quad (7)$$

Information :
r = correlation coefficient
x = first variable
y = second variable
N = data

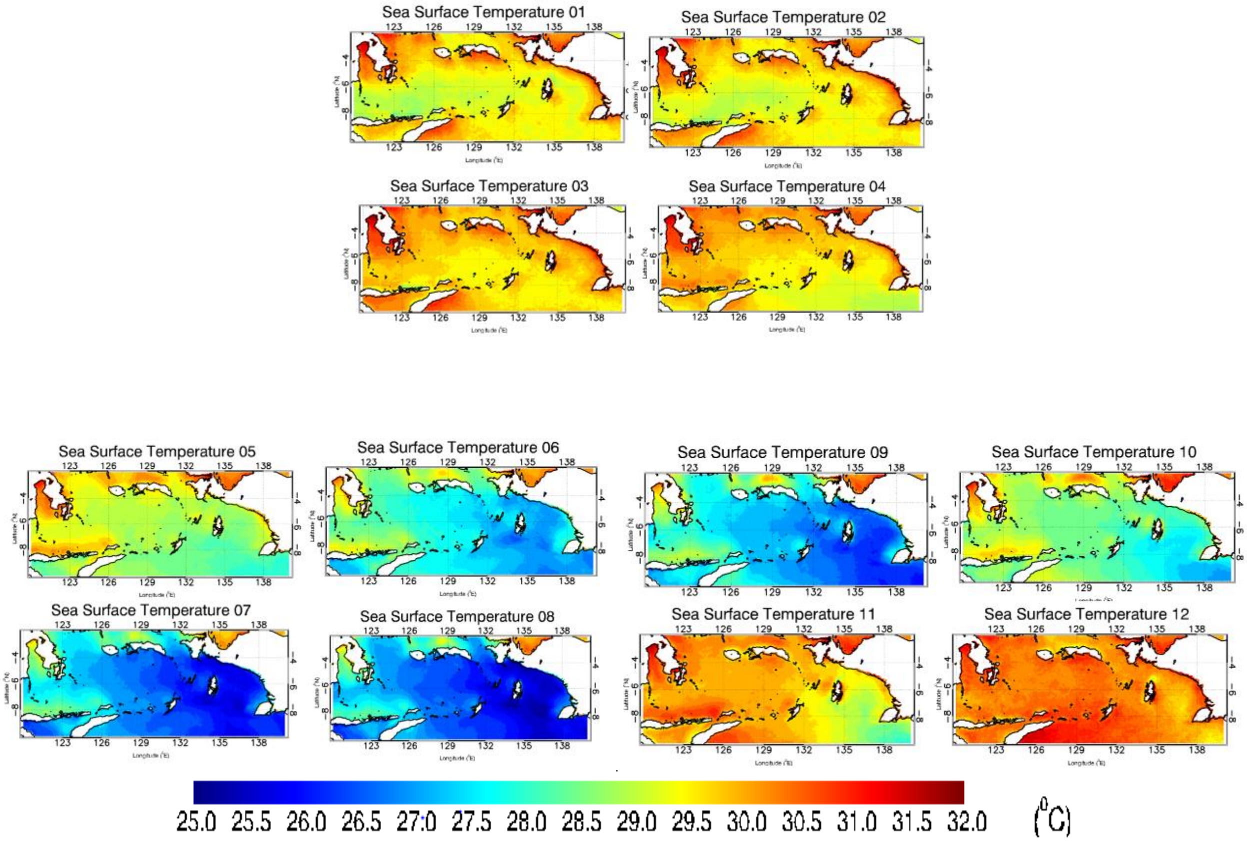
The correlation relationship between two variables is classified in several levels as written by Sudjana (2005) in **Table 1**

Tabel 1 . The value of the strength of the relationship as a result of the correlation coefficient (Sudjana,2005)

Coefficients and Correlation	Relationship Interpretation
0 - 0,2	Very low
0,2 – 0,4	low
0,4 – 0,7	High
0,7 – 1,0	Very High

RESULTS AND DISCUSSION

a) Sea surface temperature



Graph1. Monthly Variation of Climatological Sea Surface Temperature

Sea surface temperatures undergo monthly fluctuations. The elevated range of temperatures in the Banda and Arafura seas oscillates between 27°C and 31°C. Moreover, the highest monthly average SST of 30.54°C transpires in December, whereas the lowest temperature of 26.93°C typically happens in August. By October, temperatures experience an uptick with the sun's southward movement, consequently, intensifying the irradiation's potency.

During the second transitional season, sea surface temperatures gradually increase from September to November and reach an even distribution by November. Sea surface temperatures during the second transitional season in November typically range between 27°C and 30 °C, which is higher than during the first transitional season. This increase is due to the accumulation of cold water masses starting from September and October, with temperatures reaching up to 30.5075 °C. This phenomenon is believed to result from the weakening of southeast monsoon winds passing through the waters of Arafura and Banda Sea, along with the insolation process that takes place during the second transition month.

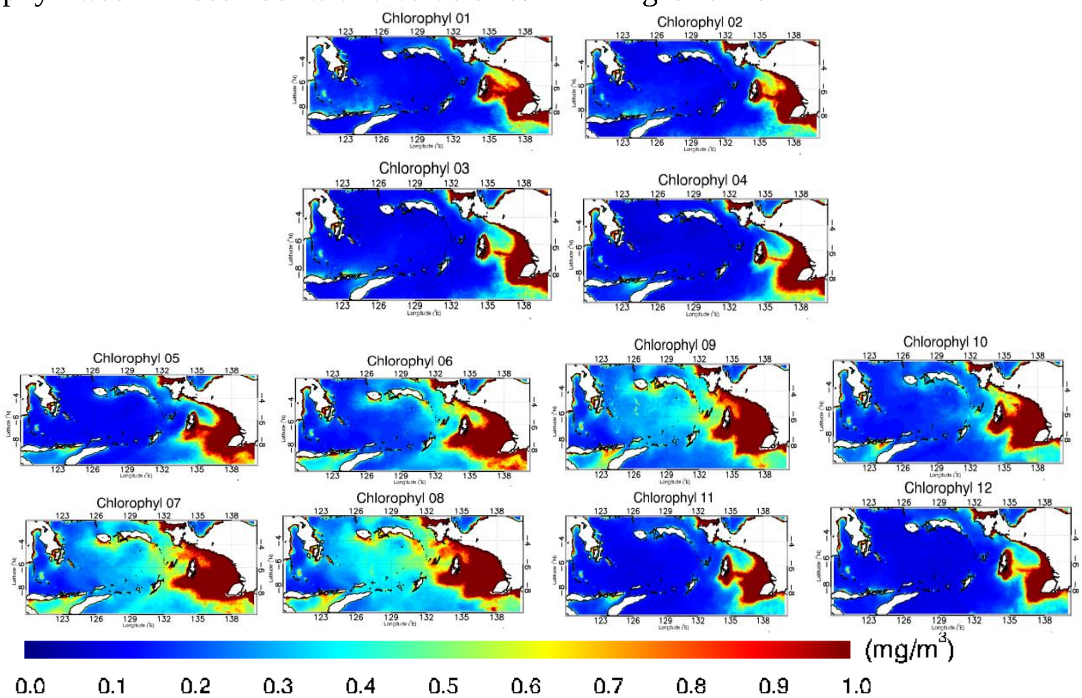
During the West season (December-February), the sea surface temperature in the Banda and Arafura Seas remains consistently high. The monthly average values for December, January, and February are 30.54539°C, 29.78859°C, and 29.842620°C, respectively. Notably, the temperature is at its highest in December. Additionally, the SST in the West season generally peaks in December and remains high throughout the year. From January to February, the sea surface temperature experiences a slight decline, with values dropping below 29^{o}C in some areas, primarily in the central portion of the Banda Sea. Tristianto et al., (2021), posit that the high sea surface temperature is likely caused by low wind speeds and evaporation rates in December, with potential impacts on wind speed, cloud cover, and precipitation during the rainy season. It is noteworthy that sea surface temperatures were higher during the late March downwelling.

During Transitional Season I, the sea surface temperatures in the waters of Arafura and Banda Seas were recorded to be between 28-31.0°C, indicating a decline in temperatures over time. From the observations, it is evident that the temperature was at its peak in March 2016, while it was at its lowest in May.

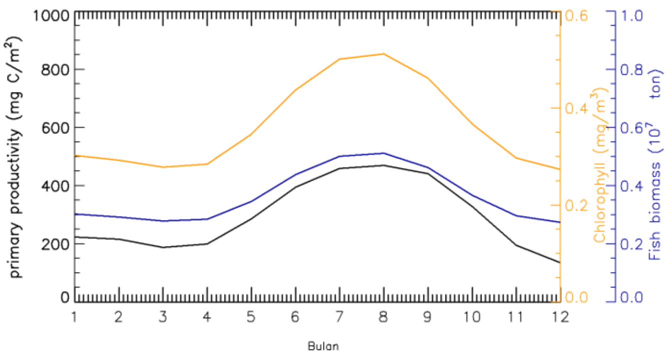
During the East season (June-August), the sea surface temperature in the Banda and Arafura seas experienced a decrease. The average monthly sea surface temperature values for June, July, and August were 28.09088^{0}C, 27.15805 ^{0}C, and 26.93688^{0}C, respectively, with an equal distribution in August. This cooling trend gradually extended to the waters of Southeast Aru towards eastern Tanimbar. It is worth noting that June to October usually exhibits cooler temperatures compared to other months. In June, sea surface temperatures persist to be warm as they are impacted by the initial transitional season. The temporal cold water mass proves, as indicated by Riupassa & Wattimuri, (2016) that cold water masses are sourced from not only northern Australia but also the coast of Papua. While temperatures in northern Australia decrease as seasons change, they continue to remain warmer in June as a result of rapid warming. The decrease in temperature becomes more pronounced in July and August as the cold water mass shifts from the coast of Australia. This low temperature then gradually spreads to the waters off Southeast Aru and the eastern part of Tanimbar.

b) Chlorophyll

Chlorophyll values fluctuate every month. The highest monthly average chlorophyll occurred in August with a value reaching 0.73541 mg Chl/m^3 and the lowest average chlorophyll was in December with a value of 0.44272 mg Chl/m^3.



Graph. 2 Monthly Variation of Climatology Chlorophyll



Graph 3 Monthly Climatologic Fluctuations of Sea Surface CO2 Partial Pressure with Temperature and Chlorophyll in the Java Sea

Temporally when chlorophyll decreases in the west season, followed by a decrease in primary productivity and fish biomass, in the first transition season the chlorophyll value still decreases because it is influenced by the previous season. During the eastern season, chlorophyll values increased followed by an increase in primary productivity and fish biomass. In the second transitional season, the chlorophyll value decreased.

Generally, the maximum changes in chlorophyll-a concentrations in the Banda and Arafura Seas occur in August. The concentration of chlorophyll-a in the Banda Sea decreases as you head south. The concentration of chlorophyll-a in the Banda Sea decreases as you head south. Chlorophyll-a concentrations remain relatively stable throughout the rest of the Banda Sea. This is particularly noticeable in the northern area of the Banda Sea. This suggests that upwelling intensity is greater in the northern part of the Banda Sea. The concentration of chlorophyll-a in the Banda Sea decreases as you head south.

The chlorophyll concentration in the Aru Sea is higher than that in the Banda Sea. This is considered to be due to the area's higher susceptibility to heavy rain, which results in greater discharge of river water and subsequently affects the nutrient input in the sea. Rosyadi, (2018), suggests that coastal chlorophyll-a concentrations are significantly influenced by rainfall, as it brings nutrients through river flow or run off. The infusion of these nutrients into the sea promotes increased fertility in the waters. The elevated concentration of chlorophyll-a is typically more pronounced in coastal waters than in the open sea. Moreover, the increased levels of chlorophyll in the Arafura Sea are a result of the influx of nutrients discharged from large rivers.

During the coastal upwelling in the eastern monsoon, noticeable conditions occur on the Arafura shelf. According to Westeyn et al., (1990), the waters of the Aru Basin infiltrate towards the east over the shelf floor from a depth of 100-150 metres until roughly 40-50 metres, in both the northern and southern regions of the Aru Islands. The high levels of chlorophyll-a found in the Aru Sea are not caused by river flow but are instead due to the enrichment of nutrients in the upper layers as a result of vertical mixing with nutrient-rich water found in deeper layers. During the Northwest monsoon, nutrient concentrations are significantly reduced when compared to those during the Southeast monsoon.

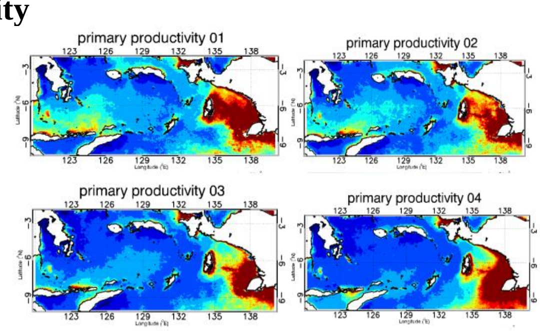
In contrast, throughout the West monsoon period (December-February), chlorophyll levels in the Arafura sea are consistently higher than those in the Banda sea. The monthly average for chlorophyll climatology during December, January, and February is 0.44272 mg Chl/m^3, 0.47864 mg Chl/m^3, and 0.48118 mg Chl/m^3, respectively. Notably, the chlorophyll value in December was lower than that in January and February. During the second transitional season, the chlorophyll value was lower compared to the first transitional season. In April, the chlorophyll value was 0.48218 mg Chl/m^3, while in November of the second season, it was 0.48394 mg Chl/m^3 . In the Western season, chlorophyll levels remained low and reached their minimum peak for the entire year in December. In January and February, chlorophyll levels slightly increased, and in some areas, the value was above 0.48 mg Chl/m^3, particularly on the Southwest coast of Papua. According to Tubalawony et al., (2015), during the Western season (December-February) in the waters of the Banda Sea, there is a northwest munson wind that causes a slight lift in water masses from the thermocline layer. This results in low chlorophyll concentrations.

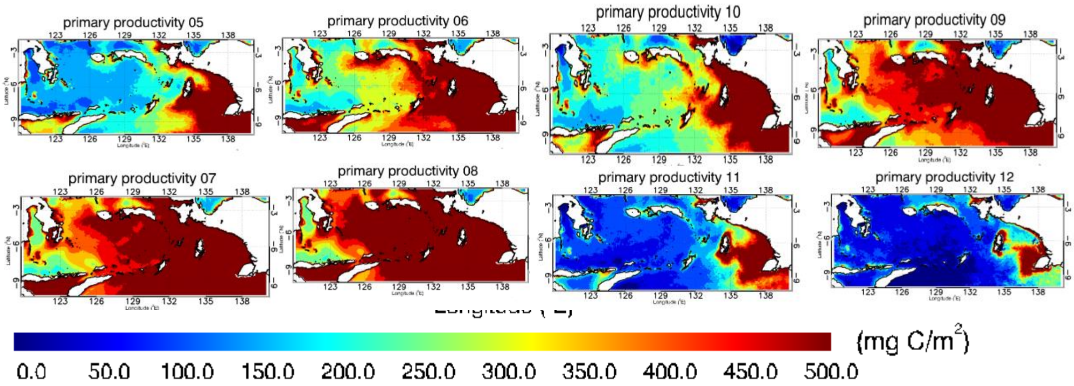
During the first Transitional Season, chlorophyll concentrations in waters of the Arafura and Banda Seas varied between 0.4-0.6 mg Chl/m^3 and demonstrated an overall increase over time. The highest temperature was recorded in March 2016, whereas the lowest temperature was observed in May.

In the East season (June-August), chlorophyll levels in the Banda and Arafura seas rose significantly, with the average monthly concentrations for June, July, and August being 0.62605 mg Chl/m^3, 0.71078 mg Chl/m^3, and 0.73541 mg Chl/m^3, respectively. These values were uniformly distributed throughout August. During the second transitional season (September-November), there was a gradual decline in chlorophyll levels, which became evenly distributed by November. Chlorophyll values tend to be higher between June and October, with the highest concentrations recorded in June, July, and August reaching 0.45 mg Chl/m^3, as reported by Ratnawati et al. (2016), There was an upwelling phenomenon in multiple locations, including the west and south of Buru Island, south of Seram Island, and east of the Banda Sea. The influx of nutrients in the surface layer, supported by the adequate penetration of light, enhances photosynthetic activity of phytoplankton in the Banda Sea and consequently increases water fertility owing to an increase in the chlorophyll-a quantity contained in phytoplankton. Aside from this, winds that run parallel to the coastline next to Buru Island also contribute to the upwelling process, particularly towards the northwest. SPL and chlorophyll-a are significantly impacted by wind speed. When wind speed is high, chlorophyll-a levels increase, while SPL decreases(Nurafifah et al., 2022).

During the second transitional season (September-November), chlorophyll levels begin to decline and reach a uniform distribution by November. In this season, chlorophyll values range from 0.4 to 0.7 mg Chl/m^3. The chlorophyll value is higher than that of the first transition season. At the onset of the second transition season in November, it stands at 0.48394 mg Chl/m^3. The increase in chlorophyll value is attributed to the carry-over effect from the preceding season, specifically the Eastern season.

c) Primary Productivity





Graph 4. Climatological Monthly Variation Primary productivity

Overall, there is a peak in primary productivity concentration in August in the Banda and Arafura Seas. Specifically, this is most pronounced in the northern section of the Banda Sea, with a decrease in concentration towards the south. This suggests a stronger upwelling intensity in the northern part of the Banda Sea. The concentration of primary productivity is greater in the Aru Sea than in the Banda Sea, possibly due to higher rainfall leading to greater discharge of river water and affecting nutrient input into the sea.

The Arafura Sea experiences high primary productivity as a result of numerous nutrients entering the sea via large river estuaries. Taufiqurrahman, (2004)reports that thirty rivers drain into the Aru and Arafura Seas. Several estuaries drain into the Aru Sea, including the Pomako River Estuary, Ajkwa River Estuary, Amapare River Estuary, and Digul River Estuary. Meanwhile, the Maro River Estuary in Merauke empties into the Arafura Sea. Of these, the Digul River Estuary has a significant impact on salinity levels in the Aru Sea. The salinity distribution of Aru Sea waters is significantly influenced by the Digul River Estuary due to the immense discharge of freshwater, which expels low salinity from the area surrounding the estuary. This occurrence arises from excessive rainwater and flowing water from multiple rivers, which enter in large quantities into the Digul River Estuary.

During the western season, primary productivity concentrations varied between 100-200 mg C/m^2. The areas with the highest primary productivity concentrations were around the waters of Southwest Maluku to the waters of the Tanimbar Islands Regency. In December, the Banda Sea Waters exhibited low primary productivity concentrations due to high sea surface temperatures and low chlorophyll values.

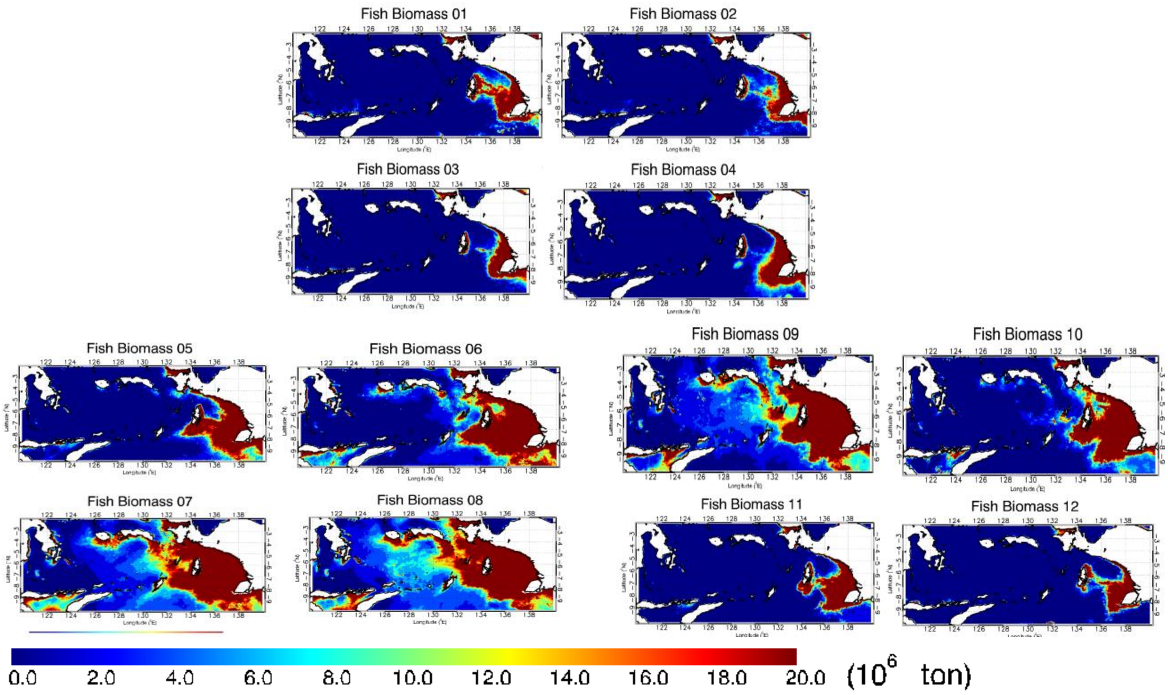
In Transitional Season I, primary productivity concentrations ranged from 100-400 mg C/m^2. High primary productivity concentrations are observed in the months of March and April in the waters around Wetar Island. However, the overall primary productivity concentration pattern in the Banda Sea waters remains low. This is attributed to the high water temperature resulting from the position of the sun, which is still on the equator. The chlorophyll concentration pattern altered in May. While March and April witnessed high concentrations in Wetar Island's waters, Tanimbar Island's vicinity observed them in May due to the onset of the southeast munson wind.

During the East season (June-August), primary productivity concentrations in the Banda and Arafura seas increased. The monthly average primary productivity concentrations for June, July, and August were 395.2 mg C/m^2, 459.5 mg C/m^2, and 470.1 mg C/m^2, respectively, with an even distribution in August. Chlorophyll values tended to be higher from June to October compared to other months. The considerable primary productivity observed during June indicates that the abundance of chlorophyll-a in the Banda Sea's east season (June-August) impacts the primary productivity in these waters. This relationship is suggested by the Banda Sea's low water temperature values recorded during this period (Uneputty et al., 2022).

During the second transitional season (September-November), there was a decline in primary productivity concentration that was evenly distributed by November. During the second transitional season (September-October-November), the values for primary productivity concentration varied between 150-500 mg C/m^2. The concentration of primary productivity was higher during this season compared to the first transitional season, reaching a value of 196 in November.

According to Kemili & Putri (2012), the impact of ENSO is clearly evident in the primary productivity of the Banda Sea. The upwelling process (Wyrtki, 1961) was identified as the factor which initiates the increase of Net Primary Productivity (NPP) from June to September in the eastern season. In this season, the eastern munson wind blows, leading to the movement of the Banda Sea's surface water mass towards the west and the consequent creation of a void. Nutrient-rich water masses are raised from the deep layers to the surface layer to fill this void (Gordon & Susanto, 2001). Technical term abbreviations such as "upwelling" and "deep layers" are explained upon first usage.

d) Fish biomass



Graph 5. Climatological Monthly Variation Large pelagic fish biomass

Fish biomass levels vary on a monthly basis. The outcomes of analyzing fish biomass demonstrated a monthly minimum average of 4,000,000 tons in March and a maximum of 7,480,300 tons in August.

During the West season (December-February), the Arafura Sea's fish biomass is consistently higher compared to the Banda Sea's. The monthly average of fish biomass values in December, January, and February are 2,739,900 tons, 3,031,100 tons, and 2,930,400 tons, respectively. It is noteworthy that the fish biomass value in December was significantly lower than that of January and February. During the second transitional season, the fish biomass value decreased compared to the first season. At the beginning of the first transitional season in April, the fish biomass value amounted to 2,849,900 tons, whereas in November, at the beginning of the second transitional season, it was 2,973,600 tons. The Western season, occurring in

December, experienced the lowest recorded peak of the year for fish biomass. Although fish biomass increased marginally in January-February, it continued to move westward in the Aru Sea and Arafura Sea. Fish stocks in these waters are replenished by fish from the Banda Sea. Moreover, once they arrive in the Aru and Arafura Sea areas, some of the fish will migrate south and eventually exit into the South Pacific Ocean through the Torres Strait.

Fish biomass concentrations in Transitional Season I are high in March and April in Wetar Island waters but overall Banda Sea waters still have a low fish biomass concentration pattern. This is due to the high water temperature caused by the position of the sun still at the equator. The pattern of chlorophyll concentration in May changed, if in March and April high concentrations were seen in the waters of Wetar Island, then in May the concentration of high fish biomass patterns was seen in the area around Tanimbar Island, this is because in May the southeast munson wind began to blow. During Transitional Season I, the circulation of surface fish biomass is dominated by currents from the South Pacific Ocean. This fish biomass moves from the South Pacific Ocean westwards to the Arafura Sea. Furthermore, the fish biomass in the Arafura Sea moves northwards to the Banda Sea and westwards to the Timor Sea. While in the Sea, the fish biomass still has the influence of the Northwest Season which causes the surface fish biomass to move eastward from the west.

In the East season (June-August) the concentration of fish biomass in the Banda and Arafura seas increases, the value of the average monthly fish biomass concentration of June, July, August sequentially is 636,050 tons, 638,770 tons, 748,030 tons and evenly distributed in August. the circulation of surface fish biomass is entirely influenced by currents from the South Pacific Ocean moving from the southeast to the northwest. Then the fish biomass in the Aru Sea and Arafura Sea will move northwards to the Banda Sea and also westwards to the Timor Sea. During this season there is upwelling in the Banda Sea and Arafura Sea which fish biomass will flow into western Indonesian waters.

Entering the second transitional season (September-November), the concentration of fish biomass began to decline and was evenly distributed in November. From June to October, chlorophyll values tend to be higher than other months. In the second transitional season (September-October-November), the value of fish biomass concentration ranged from 4.000.000-7000.000 tons. The value of fish biomass concentration was higher than the first transitional season where at the turn of the second transitional season in November it was 5.054.600 tons. According to (Wyrtki, 1961), circulation is influenced by part of the wind that moves to the southeast and moves to the northwest. In the Arafura Sea there is a meeting of two masses of water from the South-Pacific Ocean moving westward, with the mass of water from the Timor Sea moving eastward. While in the waters of the Aru Sea began to occur currents that move westward and there is a weakening of the current that moves to the east will result in the occurrence of olakan in the waters of the Aru Sea.

Temperature affects the presence, survival, and distribution of fish in the waters. Each type of fish has a different optimum temperature for its metabolic needs (Simbolon, 2019). according to Elasari et al., (2022), the temperature preferred by large pelagic fish ranges from 28°C to 29°C with salinity levels of 29-33‰. In the Banda and Arafura Seas the temperature ranges from 27-31°C, the temperature is favoured by large pelagic fish to grow and reproduce.

The fertility of a body of water is a reflection of its phytoplankton content. The chlorophyll-a content is quite large in April and May, so it will fertilise the waters. Chlorophyll-a concentrations above 0.2 mg/m3 indicate the presence and life of plankton sufficient to sustain or maintain the development of commercial fisheries (Jamal et al., 2014). Plankton (phytoplankton) which is the main producer of the marine food web, contains chlorophyll-a which is able to convert sunlight energy, inorganic materials such as nitrogen, and carbon dioxide (CO2) dissolved in carbohydrates especially in open waters (Saraswata & Subadjo, 2013).

The total biomass of phytoplankton is greater than all marine animals (zooplankton, fish, etc.) The presence of phytoplankton in the water causes light to be absorbed and diffused, and makes the sea surface layer warmer. Phytoplankton use CO2 from the atmosphere to grow, which is absorbed into the ocean. When they die, some parts of the plankton from the sea surface fall to the bottom and become seafloor sediments, so there will be carbon transfer in the system (Jamal et al., 2014).

correlation between parameters

Table. 2 pearson coefficient table between parameters

		SST	Primary Productivity	Chlorophyll	Biomass
SST	Pearson Correlation	1	-,995**	-,993**	-,993**
	Sig. (1-tailed)		,000	,000	,000
	N	12	12	12	12
Primary Productivity	Pearson Correlation	-,995**	1	,986**	,986**
	Sig. (1-tailed)	,000		,000	,000
	N	12	12	12	12
Chlorophyll	Pearson Correlation	-,993**	,986**	1	,1000**
	Sig. (1-tailed)	,000	,000		,000
	N	12	12	12	12
Biomass	Pearson Correlation	-,993**	,986**	,1000**	1
	Sig. (1-tailed)	,000	,000	,000	
	N	12	12	12	12

** Correlation is significant at the 0.01 (1-tailed)

The results of the correlation analysis showed that the four variables were related. Climatologically, the correlation value and significance between SST is -0.95 primary productivity is 0.986, chlorophyll is 0.986, fish biomass is 0.986. The negative Pearson SST coefficient value means there is an inverse relationship between SST and other parameters. According to Wirasatriya et al. (2017), the Pearson coefficient is included in the very high category in the relationship between parameters.

CONCLUSION

The Banda and Arafura seas have high average fish biomass values in the eastern season. With the highest peak of fish biomass in August and the lowest in Desember. The results of the correlation analysis showed that the four variables were related. Climatologically, the correlation value and significance between SST is -0.95 primary productivity is 0.986, chlorophyll is 0.986, fish biomass is 0.986. The negative Pearson SST coefficient value means there is an inverse relationship between SST and other parameters. The high value of fish biomass in the Banda and Arafura Seas is caused by upwelling events where sea surface temperatures are low but chlorophyll is high. in the Arafura Sea the value of fish biomass is higher than the Banda Sea, this is due to the large input of nutrients from large rivers in the area.

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