The potential study of fishing area and its relationship to marine security in Natuna island

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Abstract. Natuna Island is one of the small outer islands in Indonesia bordering Malaysia, Singapore, Thailand, Vietnam, and directly facing the South China Sea. Natuna seawaters have enormous potential fishery resources and one of the fishing areas used as a fishing activity for Indonesian and foreign fishermen. The potential also made illegal fishing practice rampant in Natuna seawaters and led to the Indonesian maritime security patrol being directed to Natuna seawaters to stop the illegal fishing process. The marine security patrol activities require high operational costs, and this can be minimized in several ways, particularly by knowing the points that can contain extensive fish resources, and the security patrols can be carried out directly at these points of location. To obtain information about these locations, map the potential fishing areas in Natuna seawaters for each period or monsoon. This study aims to apply remote sensing analysis to collect comprehensive information regarding strategic fishing areas prone to violations and security threats related to fishing activities based on monthly analyzes. The data used in this study were chlorophyll-a concentration and SST from MODIS level-3 with a resolution of 4 km from January to December 2019. SST and chlorophyll-a concentration data used pre-process analysis with SeaDas Software to ensure the data projection in the World Geodetic System (WGS) 84 format. The data processing stage uses ER Mapper software to project the distribution of SST and chlorophyll-a concentration into a contour. Post-processing data used ArcGIS software to determine crosses' results on the SST contour and the combined chlorophyll-a concentration. Image data processing results show that the lowest fishing point on Natuna Island in August with 51 fishing points, and the highest fishing point on Natuna Island in February with 584 fishing points. The results showed that fishing points vulnerable to illegal fishing are mostly located in the northern part of Natuna Island. The fishing zone is mostly far from Natuna island's coastal line. The results of this study indicate that the fishing area in the outer regions of Natuna Island needs to be increased in security and protection, especially in regions with a high level of fishing activity. This information is expected to become a reference for the authorities in the marine security sector in Natuna waters to take certain policies related to marine security patrols' operational activities in Natuna waters, particularly in minimizing operational costs of marine security patrols in Natuna seawaters.

Keywords: Fishes, Coral, Small Outer Island, Lutjanidae, Serranidae
1. Introduction

Indonesia’s marine resources’ potential consists of renewable resources such as fishery resources (fishing and aquaculture) [1,2] and non-renewable resources such as oil and natural gas and several types of minerals [3,4]. The large potential of fisheries causes most Indonesian people who live in coastal areas are fishermen. In general, most fishermen in determining the fishing area are only based on experience and direct observation. As a result, fishing operation time is not effective and efficient in determining fishing grounds [5]. Fish resources are differentiated based on their habitat, including pelagic fish [6]. Pelagic fish live in the middle layer of the water surface and generally live in groups either with the same group species or other fish species [7]. Pelagic fish are phototaxis positive and attracted to floating objects and streamline body shape with fast swimmers [8]. Small pelagic fish is one of the abundant fisheries resources and is widely caught for Indonesians’ consumption compared to other pelagic fish groups. This condition also encourages rampant illegal fishing activities to meet small pelagic fish’ consumption needs, both domestically and abroad. Small pelagic fish groups including Anchovies (Engraulidae spp., Stolephorus spp., Thryssa spp., Setipinna spp., Papuaengraulis spp.), Sardines (Sardinella spp., Amblygaster spp.), Herrings (Herklotsichthys spp., Pelona spp.), Round herrings (Dussumieria spp.), Sprats (Spratelloides spp.), Mackerels (Rastrelliger spp.), Scads (Decapterus spp., Selar spp., Selaroides spp., Atule spp.), Fusiliers (Caesio spp., Pterocaesio spp., Gymnoescaesio spp.), Flying-fish (Hirundichthys spp., Cypselurus spp., Cheilopogon spp., Paraexocoetus spp.), Half-beaks (Hemiramphus spp., Hyporhamphus spp., Oxypamphus spp.), Silversides (Atherinomorus spp., Hypoatherina spp., Stenatherina spp.) [9].

Natuna Island is one of Indonesia’s outermost areas bordering Malaysia, Singapore, Thailand, and Vietnam and directly adjacent to the South China Sea. Natuna has potential coastal and marine resources [10], especially fishery resources that can trigger illegal fishing [11]. Illegal fishing is a criminal act of fishing in a country’s sea area, carried out illegally [12]. Illegal fishing efforts cause losses or reduce the income obtained to increase economic fishing management yields and actions. Illegal fishing is a problem frequently faced by countries with a huge coastal area because this problem has existed for a long time. However, illegal fishing has not been eradicated until now due to the difficulty of monitoring multiple marine regions simultaneously. Even countries with advanced technology in the defense and security sectors have also been hit by illegal fishing and reduce their national fishery production and fish resources [13]. An unknown fishing ground area and a lack of strategy to carry out marine protection activities cause the Natuna Sea less effective in protecting fishery resources. The fishing ground area is an area for fishing [14]. The fisherman usually determines the fishing ground area by observing bubbles or ripples on the sea surface and flying birds. The abundance of fish in a region can also be predicted based on oceanographic conditions [15]. Oceanographic conditions greatly affect the fish abundance, particularly the distribution of chlorophyll-a and temperature [16,17]. The vastness of the Natuna Sea also causes finding a fishing location to take a relatively long time.

On the other hand, foreign fishers who carry out illegal fishing with advanced technology can effectively identify fishing ground locations. Knowing the problem of fishing grounds every month in the Natuna Sea, local fishermen’s fishing activities become more effective and increase income. This maritime security strategy focuses on securing area points where illegal fishing is likely to occur. Information on fishing ground points in the Natuna Sea will minimize illegal fishing incidents on Natuna Island in the long term.

2. Research Methodology

2.1. Study Sites Location

The selection of research locations is based on local fishermen’s productive fishing locations [18,19]. This research was conducted in January 2018 - December 2018 in the Natuna Sea as a research location. The Natuna Sea is a region that stretches from the Natuna Islands to the Lingga Islands in the Riau Archipelago province, Indonesia. The South China Sea borders the northern part of the Natuna Sea. The Karimata Strait also bounds the Natuna Sea in the southeast and the Singapore Strait in the west.
2.2. Data Collected
The data used in this study are primary data from the extraction of chlorophyll-a and SST through remote sensing technology information obtained from MODIS sensor recordings processed and provided by NASA. Image downloaded from NASA’s Web Marine Biological Processing Group http://oceancolor.gsfc.nasa.gov. The data is in the form of images from January 2018 to December 2018, at level 3, with 4 km of resolution. The image data from MODIS products for seawater include three characteristics: the color of seawater, SST, and primary seawater production through the detection of chlorophyll content. MODIS level 3 imagery is processed product data with an atmosphere corrected image quality, eliminating the very high light scattering caused by atmospheric components. The corrected components were Rayleigh scattering and aerosol scattering. Also, MODIS level 3 imagery is used for climatological data and ozone data, which are environmental data to improve image output. The advantages of Aqua MODIS imagery are its spectral wavelength (radiometric resolution), more precise land cover (spatial resolution), and more frequent observations (temporal resolution). Research on SST dynamics and primary chlorophyll-a productivity using Aqua MODIS satellite data provides
better results describing field conditions. It is evident from research using SST that satellite image data has a strong relationship with in situ data.

2.3. Data Analysis

download SST and chlorophyll data at http://oceancolor.gsfc.nasa.gov. The downloaded data is then processed first in SeaDas, where the data is reprojected, the function of which must be ensured that the data projection is the World Geodetic System (WGS) 84 [20]. WGS 84 is the Global Positioning System, the standard used in cartography [21]. After confirming that the projection is WGS 84, it will be saved in GeoTiff format for further processing in ER Mapper. Data reprojected on SeaDas in image form of GeoTiff format and entered into ER Mapper to crop zoom data to the Natuna region in Er Mapper software and select appropriate Formula Editor to edit the image selecting variable ranges for SST and Chlorophyll. Change variable 1 to 25, and variable 2 to 31 and the variable change in chlorophyll 1 to 0.1 and variable 2 to 1.2 are the minima and maximum SST thresholds and chlorophyll for pelagic fish [22,23]. The variable modifier is used to project the contours of the distribution of SST and chlorophyll, and the data is stored in the raster data format (.ers).

The data resulting from changing formulas from SST and Chlorophyll data are opened in the ArcGIS software. The data was made into SST and Chlorophyll contours, using a tool available in ArcGIS, specifically Arc Toolbox, then searched for surface click contours, input temperatures, and chlorophyll data. In the raster form, the data input process is carried out alternately with temperature and chlorophyll. The raster input menu is filled with contour intervals for the content temperature of 0.5 and chlorophyll 0.2, and the basic contour is filled with the minimum chlorophyll and temperature ranges. Chlorophyll temperature and contours are mapped and appear in ArcGIS. SST contours and chlorophyll were analyzed by looking at crosses' presence at the combined temperature and chlorophyll contours. The results of these contour crosses can be seen using the tools contained in ArcGIS by combining each temperature and chlorophyll first. After the merging process is successful, the two temperature contours intersect, and the combination's to chlorophyll-a concentration. This intersection menu appears with the output changes to a point, then the area suspected of being a fishing area is adjacent. Warm temperatures and high chlorophyll content meet the contours of SST and chlorophyll [24].

3. Result and Discussion

3.1. Chlorophyll-a conditions from January to December in Natuna Island

The chlorophyll analysis results in January were in the range of 0.8 - 2.79 mg/m³, spread over the seawaters of Natuna, wherein the areas close to the island had more chlorophyll concentration seawaters received additional nutrients from the seawaters. The chlorophyll concentration generally occurs on land due to rainfall that brings nutrients to the seawaters. January is still the western (rainy) season, where there is still a lot of rainfall [25]. In February, chlorophyll-a conditions ranged from 1.84 - 5.73 mg/m³, and the chlorophyll-a concentration in February was higher than in January. Figure 4 shows that the farther away from the island, the chlorophyll-a values concentration is lower because the largest nutrients in the waters mostly come from land [26]. In March, the analysis of chlorophyll data showed that the Natuna chlorophyll conditions ranged from 1.22 - 4.62 mg/m³. The chlorophyll concentration decreased slightly due to reduced rainfall, which reduced the mainland's supply of nutrients.

The factor chlorophyll can develop properly, and lack of nutrients prevents chlorophyll development from being inhibited [27]. In April, the chlorophyll conditions in Natuna conditions ranged from 0.823 - 4.46 mg/m³, with the highest range in Natuna seawaters 0.823 - 1.44 mg/m³. Figure 4 shows that the closer to the island, the increasing chlorophyll concentration conditions [28]. May is the beginning of the eastern (dry) season, and this affects oceanographic conditions and causes chlorophyll conditions to be in the range of 1.33- 3.46mg / m³. The chlorophyll concentration near the island was lower than the previous month. The dry season causes plankton development with photosynthesis due to the high intensity of sunlight, but chlorophyll requires sufficient nutrients to thrive. Nutrient intake from the
mainland has decreased due to reduced rainfall intensity this month [29]. The chlorophyll analysis results in June tended to decrease in the range from 0.127-2.7 mg / m3. The decrease in chlorophyll concentration this month is due to the lack of nutritional intake from the mainland. Besides, improper temperature conditions will inhibit the development of chlorophyll. The decrease of chlorophyll concentration shown in Figure 8, that the largest nutrient intake comes from the land where the sea waters near the island have a higher chlorophyll concentration, while the farther from the island, the chlorophyll concentration tends to decrease [30].

![Figure 2. The distribution of Chlorophyll-a concentration from January to December.](image)

The distribution of chlorophyll in Natuna waters in July ranges from 0.512 - 2.63 mg/m³. The northern part of Natuna has a higher concentration, where the chlorophyll concentration in these waters slightly increases because it is directly adjacent to the South China Sea. The current brings higher chlorophyll concentrations in the northern part to the southern Natuna seawaters. It produces the chlorophyll concentration in July slightly increase due to increased intake from the South China Sea and the presence of intake from the mainland, causing chlorophyll-a concentrations near the Natuna island to be more abundant. August is the end of the eastern (dry) season, and this affects oceanographic factors, which cause the distribution of chlorophyll to range from 0.559 - 3.83 mg/m³. There is a slight increase in chlorophyll because this month usually starts to rain, which transports nutrient intake from land to seawater (Putra et al., 2017). The yield of chlorophyll distribution in September ranged from 0.642 - 3.2 mg/m³. The chlorophyll distribution in this month has a non-significant difference due to the lack of rainfall and the intensity of sunlight, which is an inhibiting factor for the growth of plankton (chlorophyll) in the seawater [31]. The results of the chlorophyll analysis in October ranged from 1.05 - 3.96 mg/m³. In October, the distribution of chlorophyll increases along with the increase in rainfall.
The condition of the increase in chlorophyll is directly proportional to the intensity of rainfall, but this is different in October when there was a decrease in chlorophyll distribution due to the El Nino phenomenon [32]. Chlorophyll conditions in November ranged from 1.25 to 4.19 mg/m³, and there was an increase in chlorophyll concentration due to increased rainfall, which caused the chlorophyll concentration to increase [33]. The results of the chlorophyll analysis in December ranged from 1.25 - 4.89 mg/m³. December is the western season where the intensity of rain has started highly increase and made the distribution of chlorophyll increase significantly, as indicated by the high concentration of chlorophyll found around Natuna Island.

3.2. Sea Surface Temperature (SST) conditions from January to December in Natuna Island

SST (SST) conditions in January range between 21.4 - 29.8 °C in the with SST in January were still warm, current movements and high rainfall cause the SST of seawater conditions in Natuna to become cooler. In February shoe the SST shows in Natuna tend to be warm, ranging from 26.63-29.79 °C, with some points reaching 31 °C in the area around the island. February is the end of the western season, where rainfall is still relatively high but compared to the previous month, February tends to be warmer. In March, the Natuna island's SST range from 26.36 - 31.41 °C, with the seawater conditions in the southern part warmer than the northern part because it entered the transitional season. The western (rainy) season with SST this month tending to be colder, and the east (dry) season with the SST conditions are warmer. In March, the southern part of Natuna shows that SST is warmer due to the influence of currents and winds that transport dry winds so that the intensity of the rain decreases, producing the water conditions tend to be warmer [34]. The SST in April ranges from 27.47-31.41 °C and temperature increases due to the eastern monsoon's influence where this month, the intensity of the

![Figure 3. The distribution of sea surface temperature conditions from January to December.](image-url)
rain decreases. The eastern monsoon's effect with a slightly warmer SST distribution in the south to the north of Natuna. The warmer temperature because the wind from the east had the dry condition and produced the seawaters warmer. Currents and more sunlight intensity also influence warm waters. However, this month, because it is a transitional month, this month is still affected by the western season (rainy), making some parts of the water cooler or has a lower temperature [35]. The east (dry) season tends to be dry and warm [36], and Natuna seawaters are predominantly yellow to red color condition with an SST range of 29.73 °C for the lowest temperature and the highest temperature 33.25 °C. The SST in June is predominantly orange, which indicates that the seawaters of the Natuna are warm. The SST range in June ranges from 29.55-33.18 °C with a dominant temperature range of 30.88 - 31.11 °C where this condition tends to increase this month due to the east monsoon's influence, which tends to be warmer [37].

The SST condition of the Natuna ranges from 28.72 - 30.96 °C. A change in the northern Natuna island's SST tends to be lower because it is directly adjacent to the South China Sea. The low temperature of the South China Sea impact Natuna seawater by distribution from currents. The southern part region in Natuna island was not affected by this change due to the East monsoon (dry) tends to be warmer. SST conditions in August range from 29.08 - 30.71 °C. This month, there was a decrease in seawater temperature due to the intensity of rain and changes in the current direction from the South China Sea with low SST. the condition was a factor in the decreasing SST conditions in Natuna during August [38]. September has entered transitional season two and is influenced by the east (dry) season to the west (rainy) season. In the transition season, the SST tends to decrease because the wind blowing from the Asian continent tends to be lower and influences the northern part of Natuna seawaters, which tends to be lower than the southern part [25] with showing that SST value range from 26.82 - 30.87 °C. October is the second transitional season where conditions are supposed to be lower, but in October, the temperature conditions of Natuna waters can be categorized as warm, ranging from 26.63 - 32.95 °C. The northern region of Natuna was warmer than the southern region. This event occurred due to an El Nino event (increase in water temperature) in the South China Sea waters, which impacted Natuna waters [26]. The results of the analysis of SST in November ranged from 27.65 - 33.38 °C. The SST has decreased due to increased rain intensity, and indicated by there are several locations that had the lower SST. Although there are still many areas that tend to be hot, this happens because the El Nino phenomenon influences it in the northern part of Natuna [39]. In December, SST was 25.84 - 30.6 °C, with the northern part lower than the southern region with warmer conditions. December was the west season with an increase in rain intensity and a cause to reduce SST in Natuna seawater [40]. This condition causes the SST in the southern part of Natuna to be warmer due to the warmer temperature on land carried by the wind.

3.3. Potential fishing ground areas on Natuna Island from January to December

In January, the image data processing found 307 fishing ground areas found mostly in the northern part of Natuna Island. More fishing ground areas from the island to the South China Sea / offshore sea with larger fishing vessels presenting the fishing catch production of small local fishers in Natuna island have decreased. Apart from the inadequate ship facilities, the bad weather discourages local fishers from fishing activities. In February, based on data processing analysis, 584 fishing grounds were scattered throughout the Natuna seawaters. The number of fishing grounds found the impact on the more significant the fish catch production [41]. This month was estimated that the fish catch is more abundant and allows local fishers to get the maximum number of fish with abundant fishing ground areas. In March, there were 136 points of fishing grounds. The number of fishing grounds in this month significantly reduced compared to February. Several factors have reduced fishing ground points, including oceanography conditions that impact fish with less prefer temperature and chlorophyll. The southern part of Natuna Island's fishing grounds tends to be closer to the mainland than the northern part of Natuna Island within the 12-mile fishing ground point. In February, the distant fishing ground causes small local fishers to conduct fishing activities in the southern part of Natuna island to preserve the effectiveness and be more protected than fishing activities on the open seas with inadequate ships and fishing gear. There were 187 fishing ground points in April, and there was an increase in the fishing ground area located close to the Natuna island.
Figure 4. Potential fishing ground areas on Natuna Island from January to December.
The increase in the number of fishing grounds due to several factors, including the waters’ fertility, impacts the abundance of chlorophyll-a. Sufficient rainfall intensity is one factor that makes chlorophyll-a fertile because it receives nutrients from the land. Nutrients from land flow to the sea with rain processes, but the currents also affect rivers' flow and bring abundant nutrients to the seawaters [42]. The higher nutrient in seawater impact the number of fishing ground points were located around the island. It provided increased fishing production of local fisher due to many fishing grounds [43]. Based on the data analysis results, the fishing ground area in May was found 106 fishing ground points. Compared to the previous month, the number of fishing ground points had decreased. This month, the fishing ground points were almost all around the northern part of the island, and local fishers can produce fishing activities. Oceanographic factors strongly influence the decrease in the number of fishing areas. The fishing ground areas around the island are due to river currents that carry nutrients to sea waters so that parts far from the island are inadequate chlorophyll-a conditions for fish.

The results of the analysis of temperature data and chlorophyll-a in July found 105 fishing points. In July, the fishing grounds were mostly located close to the northern mainland of Natuna Island. Several fishing areas were found due to the temperature, and chlorophyll-a conditions were adequate and suitable for the fish growth [44]. Based on the data analysis results, August is the month where fishing grounds were found. There are 51 fishing points because the SST this month was relatively warm for fish. The warmer temperatures more inhibit the growth of chlorophyll, and proceed fishing grounds less common. The seasonal factors also influence the fishing ground this month because the end of the eastern season changed in the current pattern and affects the number of fishing ground points. In September, 103 fishing grounds were found and more expected far from the mainland. There was a small fishing area located in the southern part of Natuna Island close to the mainland. The fishing area tends to be dense and accumulated in one area located in the northern part of the Natuna Islands due to the influence of the South China Sea conditions with more abundant nutrients and relatively lower temperature conditions. October is the month when the transitional season in Natuna and affecting the number of fishing ground points. Based on the analysis results in October, the fishing ground was found more than 100 points. The number of fishing ground not-significant, different from the previous month, and still in a transitional season. The differences were seen in the fishing areas further away from the mainland of Natuna Island. The currents changes cause the distance of the fishing ground point far away from the mainland due to the current pattern that brings chlorophyll-a away from the mainland towards the north location. The significant changes in SST due to oceanographic phenomena also present the fishing ground point was lower in quantity [45]. November is the starting month for the western (rainy) season, where rainfall intensity increases.

Increasing rainfall can affect fishing areas. The number of fishing grounds this month increased to 289 fishing ground points. Increased rainfall causes nutrients from the land to flow into the seawaters, and the increased intensity of rain can reduce the warm SST, provide suitable for fish to grow. The fishing ground points were densely populated in the north and south, while in the eastern part, there is none fishing ground pint because warm temperatures still influence it, and the effect of the east (dry) season was still happening. In December, the image data processing found 112 fishing ground points where the number of fishing points decreased this month. December had high rain intensity, and SST turns low, resulting in the temperature less suitable for fish. Figure 5 shows a relatively small fishing ground point in the eastern part of the mainland because the eastern seawaters of Natuna cool down more slowly. After all, the east monsoon is still influenced by the high seas carried with currents and winds when changing seasons. In the northern part of the Natuna Islands seawaters, the fishing grounds are very dense because the currents carry nutrients and the warm South China Sea. The Natuna seawaters also become warm and making the area's conditions suitable for fish life.

3.4. Linking Potential Fishing Areas and Marine Security

Illegal fishing is a significant problem in most coastal countries. In this case, the authorities do not supervise rampant illegal fishing practices, especially in Natuna seawaters by foreign fishing vessels. In neighboring countries, illegal fishing activities are carried out using several destructive fishing gears, including the Trawl Pair, the Squid Fishing Line, the Hand Line, the Gillnet, and the Hand Fishing Rod. However, most illegal fishing is carried out using Trawl Pair as fishing gear, with the number of fish
caught reaching 1 ton per boat. The fisherman's capacity in conducting surveillance operations is still limited in terms of facilities, human resources (HR), and operational funds. It becomes an obstacle to optimally carrying out its duties and functions, especially with an extensive capture fishery area coverage and requires strong institutional capacity. It is also known that coordination between related agencies has not been optimal, causing many gaps in the occurrence of violations at sea, both in terms of quantity and quality [46]. Also, the monitoring or controlling illegal fishing fleets in the Natuna Sea is ineffective and inefficient because of the vast waters of the Natuna Sea. Routine monitoring activities in Natuna marine waters are insufficient and efficient because of the high costs required for monitoring activities and a long time to reach the maritime boundary area [47]. The security forces need infrastructure and resources to patrol Natuna seaways. The detection of foreign vessels' presence carrying out illegal fishing activities in the Natuna sea border area is not optimal where foreign vessels will depart immediately before BAKAMLA, Coastguard, or the Indonesian Navy arrive at the location.

The results of the feeding ground mapping show that Natuna has a significant potential for fishing areas. The result of our studies can help local communities or local fishers know and take advantage of the potential of marine fisheries in Natuna every month. Most of the local Natuna fishermen still use small boats with limited technology in their fishing activities. Most of the local fishing boats are also not equipped with sonar technology to detect the presence of high potential fishing locations. The fishing zone map will help local fishers find out the potential fisheries in the Natuna Sea to carry out fishing activities in the Natuna Sea optimally. The fishing zone map results provide information on extensive fishing locations in Natuna waters north of the Natuna Sea. This location is the location where foreign fishers found illegal fishing. The utilization of the Fishery Zone Map provides clear and precise information for local fishermen. It is hoped that local fishermen can carry out fishing activities in that location. On another positive side, the local fisherman's fishing activities at that Natuna seawater location will decrease illegal fishing cases because the illegal foreign vessels will reconsider their illegal activities because they consider crossed the border route. The inactivity or non-activity of local fisherman causes most illegal fishing cases by foreign vessels. The optimal local fishing fleet doing the North Natuna Sea fishing activity indirectly impacts Indonesia's National Maritime Security. The local fishing ship has a key role in protecting the sovereignty and showing that the location of these seaways areas in Indonesia, and several foreign vessels consider not crossing national borders and not carrying out illegal activities.

Another benefit for fishermen uses a fishing ground location map, particularly for the local fishermen to improve their personal and state economy. Local fishermen can also provide information if an illegal case occurs in the vast Natuna seaways. The local fishermen can become informants and provide valid information to the coast guard, Navy, and BAKAMLA regarding the certainty that several fishing fleets with illegal fishing activities on Natuna seaways. The illegal foreign fishing fleet will enter illegal foreign vessels fishing areas with high fish production. This study's results are very useful in helping marine security activities become more optimal, effective, and efficient.

4. Conclusion

The AQUA MODIS satellite can determine potential fishing ground points using SST imagery data and chlorophyll-a. There are many fishing grounds in the waters of the Natuna district. The higher fishing ground in Natuna seawater was still gradually influenced by seasonal winds. Most fishing ground points were in November-December and January-April, with more than 110 fishing potential points. The May-October period is a period with fewer potential fishing areas because it tends to decline. The most potential fishing ground points were in February with 584 points, and the least is in August with 51 points. Therefore, Natuna seaways had potential fishing ground points. The number of fishing grounds can provide information that supports marine security activities and functions to optimize marine security activities from violations and threats to maritime security related to fishing activities. The mapping fishing ground location in Natuna seaways also minimized spending budgets to carry out marine security activity by the Navy or BAKAMLA. Information about the potential of fishing grounds in Natuna waters obtained from this study can be used as a reference. From the results of this study, it is known that the areas that have the potential to catch fish. With this information, the marine security patrol can directly patrol the area without always surrounding all Natuna waters to find illegal fishing.
activities in Natuna. That way, marine security patrol activities can be more efficient in terms of time and operational costs. This departs from the fishing potential location search system used by foreign fishermen based on satellite information systems to find potential fishing locations by looking at SST conditions and chlorophyll-a concentrations in the waters using satellite data. Therefore, by applying the same working principles, marine security patrols in Natuna waters will be much more efficient in time and operational costs. It is very useful in supporting marine security activities to become more optimal, effective, and efficient.

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