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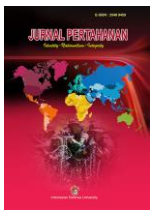

APPLICATION OF OCEANOGRAPHIC DATA ON ILLEGAL FISHING SURVEILLANCE FOR SUPPORTING MARITIME SECURITY (CASE STUDY: NORTH NATUNA SEA)

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Abstract

The North Natuna Sea is full of illegal fishing and endangers Indonesia's maritime security. This is because fishery resources/fishery potential in the Natuna Sea is estimated to be worth IDR 5.32 trillion annually. In addition to the potential wealth of fisheries, the strategic location of the Natuna Sea is also the cause of rampant conflicts and illegal fishing activities in this region. Analysis of illegal fishing monitoring in the North Natuna Sea and the use of oceanographic data (sea surface temperature and chlorophyll-a) to monitor illegal fishing in the North Natuna Sea are the two main objectives of this research. The research method used is descriptive qualitative. The results of this study are that surveillance of illegal fishing in the North Natuna Sea has been carried out by the Indonesian Navy, the Indonesian Maritime Security Agency (Bakamla RI), and the Directorate General of Supervision and Control of Marine Resources and Fisheries of the Indonesian Ministry of Maritime Affairs and Fisheries with their duties and functions each. However, this is still not optimal because institutional capacity in supervision is still limited (facilities, human resources, and operational funds). Further findings indicate that oceanographic data has not been used optimally. This is because each agency has a different way of supervision. Automatic Identification Systems and Ship Monitoring Systems are technologies used by each agency in terms of surveillance. Therefore the implementation of illegal fishing surveillance by utilizing oceanographic data can be applied. This can make monitoring more optimal because by using oceanographic data it can be known directly where the potential fishing zones are. For this reason, an open oceanographic database center that can be accessed by various research institutions in Indonesia needs to be established immediately to facilitate the collection or utilization of data by institutions or researchers.

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INTRODUCTION

Indonesia has extensive marine and fishery resources that have great potential for economic growth and national development. Indonesia has marine waters of about 5.8 million km^2 (75% of Indonesia's total area), which consists of 0.3 million km^2 of territorial sea waters, 2.8 million km^2 of archipelago seas, 2.7 million km^2 of the Indonesian Exclusive Economic Zone (EEZ). The abundance of fishery resources in Indonesian sea waters has attracted the attention of foreign parties to also be able to enjoy fishery resources in Indonesian sea waters illegally through illegal fishing activities (Muhamad, 2012). As a maritime country, Indonesia saves the potential in a year and can reach IDR 14,994 trillion. Indonesia's vast marine potential consists of 31.94 million U.S. dollars for fisheries, 56 million U.S. dollars for sustainable coastal areas, 40 million U.S. dollars for biotechnology, 2 million US dollars for marine tourism, 6.64 million U.S. dollars for petroleum, and 20 million U.S. dollars (Holsti, 2001). With the magnitude and breadth of the value of Indonesia's marine potential, Indonesia should be able to maximize the marine potential to advance national economic development. However, so far, Indonesia has only focused on land resources, so marine resources are wasted. Indonesia has 17,499 islands with a total area of about 7.81 million square kilometers. From the total area, 3.25 million square kilometers is an ocean and 2.55 million square kilometers is the Exclusive Economic Zone only about 2.01 million square kilometers is land. With the extent of the existing sea area, Indonesia has enormous marine and fishery potential. The fishery is one sector that is relied upon for national development. In 2019, the export value of Indonesian fishery products reached IDR 73,681,883,000, which increased by 10.1% from 2018 exports. Marine products such as shrimp, tuna, squid, octopus, crab, and seaweed are highly sought-after commodities. A large number of fisheries production in Indonesia needs to be maintained and maintained. Without good management and supervision, fisheries in Indonesia are vulnerable to violations (Pratama, 2020). Therefore, it is effortless for other countries to enter Indonesian waters by doing illegal fishing. According to data from the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia that from 2014-2020, a total of 745 illegal vessels were recorded as having been arrested. With details, in 2014 there were 38 ships; in 2015 as many as 108 ships; in 2016 there were 163 ships; in 2017 as many as 132 ships; in 2018 there were 109 ships; in 2019 there were 107 ships; and in 2020 there were 88 ships (Beritagar, n.d.).

One of the problems that are familiar in Indonesian seas is illegal fishing. The problem of illegal fishing is a problem that has existed for a long time. Where countries with many seas always face the problem of illegal fishing. However, until now, the problem of illegal fishing has not been eradicated. One of them is Indonesia, where Indonesia is an archipelagic country. This fact of course resulted in the Indonesian state getting a problem of illegal fishing. Areas prone to illegal fishing are located in the Arafura Sea, Natuna Sea, Pacific Ocean, Makassar Strait, and Indian Ocean (Starke, 2008).

This study took a case study in the North Natuna Sea in this study. The Natuna Sea is a water with abundant natural resources, both in the form of living things such as fish and inanimate objects such as minerals and natural gas. A researcher from the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia, Widodo Pranowo stated that the waters of the North Natuna Sea are very fertile. This is due to the abundance of chlorophyll and oxygen in the waters of the North Natuna Sea, the chlorophyll and oxygen used by fish to grow and reproduce. Then he also stated that the chlorophyll and oxygen were also evenly and well distributed throughout the coastal

waters in the South China Sea and North Natuna Sea. So it is no wonder the Vessel Monitoring System (VMS) satellite detects so many fishing vessels there. The activity of fishing vessels is continuous almost throughout the year. Some of these vessels have fishing identities/permits, and many do not have fishing identities/permits (Subandriyo, 2021). The Natuna Sea is included in the fisheries management zone 711 (*Wilayah Pengelolaan Perikanan* 711 or WPP 711). One of Asia's sources of oil and gas is Liquified Natural Gas (LNG). The Natuna Sea has natural gas and oil fields which are estimated at 500,000,000 barrels and oil content is approximately 14,386,470 barrels. The potential for fisheries in the Natuna Sea is estimated at IDR 5.32 trillion per year (Purwatiningsih & Masykur, 2012). The Natuna Sea is one of the locations where many illegal fishing acts occur. In addition to its potential marine natural wealth, the strategic position of the Natuna Sea is also the reason why many illegal fishing acts occur. The Natuna waters are a connecting route to the East Asia region and the Pacific Ocean region. Then the Natuna Sea is also directly adjacent to many countries which can allow conflicts and illegal fishing in border areas to occur.

Minister of Fisheries and Maritime Affairs 2014-2019, Susi Pudjiastuti has calculated that the losses suffered by the state due to illegal fishing per year can reach IDR 240 Trillion. Meanwhile, Indonesia suffered a loss of IDR 30 trillion due to illegal fishing carried out by Vietnam. However, this loss does not include unregistered vessels, which fish illegally in Indonesian waters. And Susi also said that the practice of illegal fishing in Indonesia is the largest in the world. Therefore, decisive action must be taken to stop this illegal fishing (Detik Finance, 2014).

One of the efforts made is to conduct surveillance patrols. The supervision of illegal fishing at sea consists of several agencies, namely the Indonesian Navy or *Tentara Nasional Indonesia Angkatan Laut* (TNI AL), Indonesian Maritime Security Agency (*Badan Keamanan Laut Republik Indonesia* or Bakamla RI), and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (*Direktorat Jenderal Pengawasan Sumberdaya Kelautan dan Perikanan Kementerian Kelautan dan Perikanan* or Dirjen PSDKP KKP). However, the ability to supervise marine and fishery resources is not entirely optimal, and this is due to the vastness of Indonesian waters and the ability to supervise marine and fishery resources which are still limited so there are still many areas that are not covered by the operation of monitoring marine and fishery resources. Then for problems, the technology used is also very limited. The supervision technology of each agency has not been well integrated, so it cannot be used together in the supervision of illegal fishing. Then a crucial issue is the availability of data at the right time. Availability of accurate data at the right time is a major requirement in planning for marine and fishery resource monitoring, with accurate data providing a clear picture of information in the marine and fishery resource monitoring field.

Along with the times, observing all phenomena in the sea requires the right technology. Since the discovery or use of remote sensing technology using satellites, the availability of marine data has overgrown, both in terms of time and space. Various oceanographic phenomena are more clearly revealed with this technology and supported by advances in information technology and computing. Oceanography is the scientific study and exploration of the ocean and its phenomena. In an oceanographic study, an illegal fishing area indicates that the site is a potential zone of fish abundance. This phenomenon in oceanography is called the upwelling phenomenon. In general, oceanographic data used to determine the possible abundance of fish are chlorophyll-

a data and sea surface temperature. Sea surface temperature can be used to estimate the location of upwelling associated with potential areas of tuna. Meanwhile, surface chlorophyll-a indicates the level of fertility and water productivity (Kunarso, Hadim Safwan, Ningsih, & Baskoro, 2011). Oceanographic data (chlorophyll-a and sea surface temperature) have been used to decide the distribution area of fish that will be used as a benchmark for deciding fishing areas (Widodo, 1999). In carrying out supervision of illegal fishing, the Indonesian Maritime Security (Bakamla RI) has implemented it but has not implemented it optimally.

From the explanation above, we can see that there is a relationship between oceanographic data (sea surface temperature and chlorophyll-a) with illegal fishing areas. The utilization of oceanographic data is a solution that will also be discussed in this study, especially how to implement the use of oceanographic data with the supervision of illegal fishing. The results of this study are Analyzing surveillance of illegal fishing in the North Natuna Sea from a maritime security perspective and analyzing the use of oceanographic data (sea surface temperature and chlorophyll-a) for surveillance of illegal fishing in the North Natuna Sea.

METHODS

The method used in this study is qualitative research with a descriptive-analytical approach. This research starts in August 2020. In contrast, the object under study is oceanographic data (chlorophyll-a images and sea surface temperature) as one of the guidelines for determining illegal fishing surveillance areas by the Indonesian Navy, Indonesian Maritime Security Agency, and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries, Indonesian Navy Hydrography and Oceanography Center (*Pusat Hidro-Oseanografi Angkatan Laut* or Pushidrosal). This research will be carried out as descriptive and seeks to describe a specific situation or process based on information that will ultimately produce a new explanation of the phenomenon to be studied.

Qualitative research has an inductive nature, where the researcher allows various problems to emerge from the data or is left open to interpretation. Research data were collected, and observations were made which were then described, interpreted, and analyzed in depth to answer research problems. The data collection method used is in the form of searching data from various sources such as books, agency reports, journals, scientific papers, magazines, newspapers, internet which are closely related to illegal fishing and its handling, especially supervision, as well as through interviews with relevant agencies and sources of information that can be used such as Director of Data and Information of Bakamla RI; Head of oceanography and meteorology of Pushidrosal; representing Indonesian Navy commander in chief of fleet 1 (*Komando Armada 1*); and Staff of Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries. As well as collecting chlorophyll-a image data from the Aqua Modis satellite during 2014-2019 and the data processor with Arc.Gis software and SeaDAS software.

The results of the information in the field are then supported by secondary data in the form of literature searches related to oceanographic data, surveillance, and illegal fishing. The data that has been collected, then the data analysis uses Interactive Data Analysis from Miles, Huberman, & Saldana (2014) in their book Qualitative Data Analysis: An Expanded Sourcebook 3rded which includes data condensation, data presentation, withdrawal, and verification of conclusions.

RESULT AND DISCUSSION

Supervision of Illegal Fishing in the North Natuna Sea

In terms of regulation, each agency already has its regulations and each agency has also carried out the duties and functions of their respective agencies. In Law of The Republic of Indonesia Number 45 Year 2009 concerning Amendment to Law Number 31 Year 2004 Concerning Fisheries, the Navy and Fisheries Supervisors from the PSDKP have the authority to investigate criminal acts in the field of fisheries in the fisheries management area of the Republic of Indonesia. The granting of investigative authority in the investigation of criminal acts in the field of fisheries to Indonesian Navy officers and Fisheries Supervisors has the consequence that each investigating agency has the right to investigate criminal acts in the field of fisheries that occur in all Indonesian waters and the Indonesian Exclusive Economic Zone. This consequence raises concerns that there will be overlapping investigations into criminal acts in the fisheries sector.

To avoid this, the investigation of criminal acts in the field of fisheries is based on an 'unwritten agreement' between investigators, namely that anyone who knows or should suspect that a crime has occurred is the one who has the right to carry out an investigation. In this non-written agreement, it is not without consequences because it can happen at the same location where there are still 2 investigative vessels from different agencies and this means inefficiency and results in less than optimal enforcement of rules. Meanwhile, Bakamla RI has the task of conducting security and safety patrols in Indonesian waters and Indonesian jurisdictions. This is as stated in Law of the Republic of Indonesia No. 32 of 2014 Concerning Marine Affairs.

In terms of strategy, each agency has a variety of strategy patterns. From the results obtained, every agency has an equivalent goal, specifically the creation of Indonesian waters that are safe and free from threats, during this case, particularly the threat of outlawed Fishing. Then in conducting supervision, the flexibility to supervise marine and work resources administered by each agency isn't optimal, this is often because of the extent of Indonesian waters and the ability to supervise marine and fishery resources that are still limited, therefore there are still several areas that don't seem to be cheap in police work operations. This can be seen from the limited fleet owned. The Navy itself only deployed 5 vessels for the vast Natuna Sea area. Then Bakamla RI only has 10 vessels to oversee all Indonesian waters and PSDKP deploys 3 fisheries supervisory vessels in the Batam area and 2 fisheries supervisory vessels in Pontianak. The five ships from PSDKP patrol each other around the Natuna Sea area. From the ship's data, it is far from optimal in supervising the vast Natuna waters. In this case, the budget for patrol fuel, ship maintenance, and so on must also be considered. Therefore, it is necessary to increase the number of fleets for supervision or also to improve coordination between institutions in terms of surveillance patrols.

Furthermore, in determining the monitoring point for illegal fishing, each institution has its method. The Indonesian Navy only carries out mobile patrols with the help of Automatic Identification System (AIS) technology. Then Bakamla RI by utilizing Automatic Identification System (AIS) and Vessel Monitoring System (VMS) technology and the same thing is also done with mobile patrols only. Furthermore, the Directorate-General of Surveillance and Control of Marine and Fishery Resources (PSDKP) also only carried out mobile patrols using Automatic Identification System (AIS) and Vessel Monitoring System (VMS) technology assistance. AIS and VMS are the only tools that can detect ships that use the same technology as well. However, in practice,

there is a possibility that the tool is not installed, deliberately turned off by illegal fishers, or transferred to another ship by a ship that is involved in illegal fishing. This is done by vessels carrying out illegal fishing so that they are not detected by supervisory patrol boats. Then with the very limited number of fleets and only using the mobile patrol method, this is not optimal because there is no clear purpose in the mobile patrol. After all, the level of certainty of finding vessels that are involved in illegal fishing is very small. This is because it does not yet have an area or area which is a focal point in the supervision of illegal fishing. Therefore, data is needed which is the area or area where the potential abundance of fish is located. By having this data, the monitoring point will automatically focus on where the abundance of fish occurs. Availability of accurate data at the right time is a key requirement in planning for the supervision of marine and fishery resources, accurate data will provide a clear picture of information in the field of monitoring illegal fishing.

Another supervisory problem is that the current number and distribution of Fisheries Supervisory Human Resources is still insufficient when compared to the size of the water area and the objects that must be monitored, apart from quantity issues, in terms of quality. This is in line with the statement made by the resource person from the Indonesian Maritime Security Agency (Bakamla RI) during the interview. In addition to the technology used must be sophisticated, the capacity and capability of human resources and supervisory personnel must also be comparable. This is because advanced technology will not work if the equipment being operated is not properly mastered according to the capacity and capabilities of its human resources.

All of the above are related to each other, in this case like a strategic plan, it requires what is called the implementation of a strategy, then a tactical description model in the field, then the number of fleets and personnel in realizing the strategic plan, then the capabilities of personnel and also the technology used. All of this is a unified whole in implementing the strategy that will be made. In terms of the Illegal Fishing supervision strategy, each institution has implemented the strategies, policies, or laws that each institution has. Furthermore, institutional capacity in fisheries supervision is still limited, both in terms of facilities, human resources, and operational funds. This is one of the obstacles to carrying out its duties and functions optimally, especially with a very wide capture fisheries area, of course requiring a strong institutional capacity for fisheries supervision. Then, coupled with the not-yet-optimal coordination between relevant agencies in controlling fish resources, which causes many gaps for violations occur at sea, both in terms of quantity and quality. In addition, due to the lack of cohesiveness in conducting surveillance operations, the cost of supervisory operations will be expensive with less effective results. With the many limitations that each institution has, it is very necessary to have good coordination that is integrated.

Utilization of Oceanographic Data in the North Natuna Sea

The utilization of Oceanographic Data in the supervision of Illegal Fishing until now has not been utilized by each agency. This is because each agency has a different way of conducting supervision. AIS (Automatic Identification System) and VMS (Vessel Monitoring System) are the main technologies used by each agency in conducting surveillance. However, this technological capacity is only for cooperative vessels and cannot fully monitor non-cooperative (illegal) objects, so other means are needed to complete the technology. Based on the information obtained through the in-depth interview process in the Hydro-Oceanographic

Center of the Indonesian Navy (Pushidrosal TNI AL), the Hydro-Oceanographic Center of the Indonesian Navy provides data for the Indonesian Navy's operations have provided data and data models regarding oceanographic data, but in the implementation by the operating unit concerned these data are not utilized. The informant from Indonesian Fleet Command 1 (*Komando Armada 1)* stated that they only used Automatic Identification Vessels or AIS data to carry out surveillance and did not use oceanographic data (chlorophyll-a and sea surface temperature).

Then Hydro-Oceanographic Center of the Indonesian Navy (Pushidrosal TNI AL) also produces processed sea surface temperature data and chlorophyll-a. However, for chlorophyll-a, the data was not published due to respect for the agency that has more authority over the data. From this that there is a lack of coordination between the Hydro-Oceanographic Center of the Indonesian Navy or Pushidrosal and the operating unit, in this case, the Indonesian Navy. In this case, it can be seen that the Indonesian Navy Hydrography and Oceanography Center (Pushidrosal TNI AL) has provided oceanographic data but in practice, these data are not used by related units in terms of surveillance. Then in processing oceanographic data, each agency that manages oceanographic data was running independently without any coordination with each other. This can be seen from the absence of an official institution in Indonesia that is the center of oceanographic data. By having one institution that serves as a center for oceanographic data, it is hoped that will make it easier for every individual and other agency to obtain oceanographic data because there is already a designated permanent institution.

Furthermore, based on the interview from Indonesian Fleet Command 1 (*Komando Armada 1*), they had not used oceanographic data in carrying out the supervision of illegal fishing. However, they confirmed that oceanographic data can help in predicting where the potential zone of fish abundance is located. Then the informant from Indonesian Fleet Command 1 (*Komando Armada* 1) stated that it was the duty of the Ministry of Maritime Affairs and Fisheries in disseminating information about the use of the data. In addition, he also conveyed that the data had also been used by foreign fishing vessels from Vietnam in carrying out illegal fishing. So that the Vietnamese ship knows where the fishing locations will take place. From this explanation that there is still a lack of coordination between institutions that there is still an attitude of not caring about each other by walking with each other. Integrated coordination is needed by establishing a permanent institution as a provider of oceanographic data.

Oceanographic data, in this case, sea surface temperature image data and chlorophyll-a, really need to be utilized and used in assisting the supervision of illegal fishing. This is because low sea surface temperatures and high concentrations of chlorophyll-a at sea level indicate an upwelling phenomenon in the region. Upwelling is a phenomenon in which colder seawater and greater density move from the seabed to the surface due to the movement of the wind above it. Sea surface temperature and chlorophyll-a are important parameters in the potential abundance of fish (Zainuddin et al., 2013). Furthermore, there have also been many studies on upwelling in Indonesia related to sea surface temperature and chlorophyll-a. Initial studies on upwelling were carried out by Wrytki (1961) and followed by several studies conducted in the Banda Sea (Moore, Marra, & Alkatiri, 2003; Tadjuddah, 2016), in Spermonde and South Makassar (Nurdin, Mustapha, & Lihan, 2013; Utama, Atmadipoera, Purba, Sudjono, & Zuraida, 2017), in Southern Java (Varela et al., 2016), in Bali (Tito & Susilo, 2017), Sumbawa (Taufikurahman

and Hidayat, 2017), Bone and Flores Seas (Kunarso, Ismanto, Situmorang, & Wulandari, 2018), Maluku Sea (Atmadipoera, Khairunnisa, & Kusuma, 2018), North Papua (Satrioajie, 2014), and West Sumatra (Pratama, Pranowo, Sunarto, & Purba, 2015).

Then in Japan itself, oceanographic data has been used for forecasting potential fishing areas. In Japan, there are long-term and short-term forecasts for fisheries. Long-term forecasting aims to forecast at least the next few months. Sometimes it covers the fishing season for a year as well as for several years. Short-term forecasting aims to predict the condition of the fishing area with a target in a short period (daily weekly). This information is usually disseminated within five to ten days. An important aspect of this forecast is the forecast of changes in the fishing ground, abundance, and density of exploitable stocks. Short-term forecasts together always contain information issues about the latest oceanographic conditions and fish catch data (Yamanaka, 2011). This short-term forecast helps (a) fishermen and fisheries entrepreneurs to catch fish effectively and (b) research institutions and fisheries administrations to continuously monitor oceanographic conditions, fish stock conditions, and fishing operations. This will ultimately provide benefits in the management of fisheries resources.

The supporting explanation above, further shows that oceanographic data needs to be used in monitoring illegal fishing. By utilizing oceanographic data in monitoring illegal fishing, we can see areas or areas of the potential abundance of fish. Therefore, the stakeholders who are tasked with supervising illegal fishing are no longer patrolling looking for boats that do illegal fishing, but rather arresting vessels that are doing illegal fishing. This is done because in carrying out surveillance and catching will be carried out in areas of potential fish location and that is also what is done by perpetrators of illegal fishing where they also tend to fish in areas of the potential fish location. Then utilizing oceanographic data in the supervision of illegal fishing, also helps in implementing the strategy, namely patrols become more optimal because they are no longer just walking around but directly overseeing areas where there are potential fish spots.

The results of the explanation above present a combined map data between the capture points of vessels carrying out illegal fishing with a map of potential fishing areas or what we call upwelling areas to see how the potential fishing areas or upwelling areas relate to the point of arrest for illegal fishing actors. Figure 1 until Figure 5 show combined the result of a map of fishing points with upwelling zones for 2015-2019 in the North Natuna Sea area.

In Figure 1, on the map that the dominant green and blue colors in the Natuna Sea area are areas that are indicated as potential places for fish abundance. The potential place for fish abundance can be called the upwelling zone. The green color on the map represents the type of potential abundance of fish/upwelling zone at a weak level and the blue color on the map represents the type of potential abundance of fish/upwelling zone at a very weak level. On this map, also see the points of the arrest of illegal fishing boats symbolized in various forms of flat shapes. On the map that the potential abundance of fish that occurred in 2015 was in the weak zone. The arrest of illegal fishing vessels in the potential abundance of fish in 2015 is only up to the sea level area of the continental shelf. Then on the map, we also see that in February the point of capture occurred in the southern region of the Natuna Sea and the incident occurred in the coastal area. Then in March, the point of arrest occurred in the area around the South Natuna Islands and the incident also occurred in the coastal area. Furthermore, the same thing can also be seen in April, July, August, and September from the map image showing that all arrests of

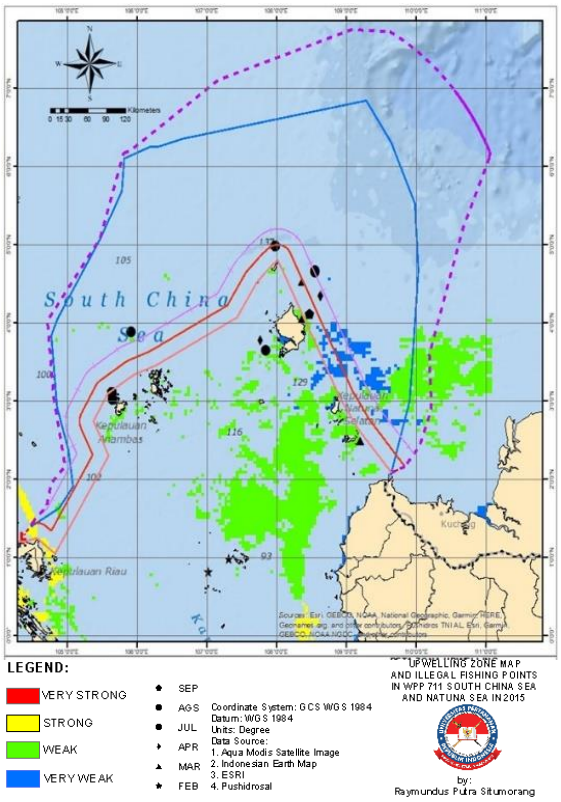

Figure 1. Map of Combined Fishing Points with Fish Abundance Zones in 2015.
Source: Processed by Authors, 2021

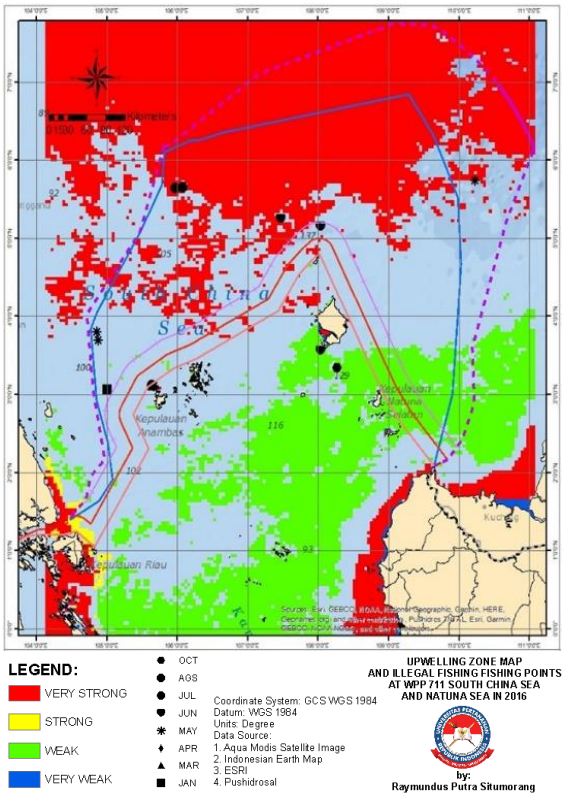

Figure 2. Map of Combined Fishing Points with Fish Abundance Zones in 2016.
Source: Processed by Authors, 2021

perpetrators of illegal fishing predominantly occurred in coastal upwelling areas. Upwelling that occurred this year is a type of weak and very weak upwelling. Although the intensity of the potential fish abundance zone is weak and very weak, monitoring is still focused on that area only. Because the area also has a wealth of fishery resources. The year of 2015 saw a unique phenomenon on the map. The upwelling incident in 2015 was dominant in coastal areas and the arrest of vessels carrying out illegal fishing acts also occurred in the area. This is thought to be related to the presence of high additional nutrients from river runoff. This assumption is to the results of research from Inaku (2015) which states that the high distribution of chlorophyll-a concentrations in coastal and coastal waters is due to the large supply of nutrients through run-off from land, while the low concentration of chlorophyll-a in offshore waters. because there is no direct supply of nutrients from the land. One of the main drivers of coastal upwelling is wind. This is caused by wind friction (the force of the wind pushing across the surface of the water) in combination with the Earth's rotational effect (Coriolis effect). Both forces result in surface water transport in an offshore direction. The drift of surface water away from the coast causes surface water to be colder than subsurface water. The strength of upwelling depends on characteristics such as wind speed, duration, fetch, and direction.

Furthermore, in Figure 2, on the map that the dominant red and green colors in the Natuna Sea area are areas that are indicated as potential places for fish abundance. The green color on the map represents the type of potential abundance of fish/upwelling zone at a weak level and the red color on the map represents the type of potential abundance of fish/upwelling zone at a very strong level. The 2016 map shows that the points of arrest occurred in January, March, April,

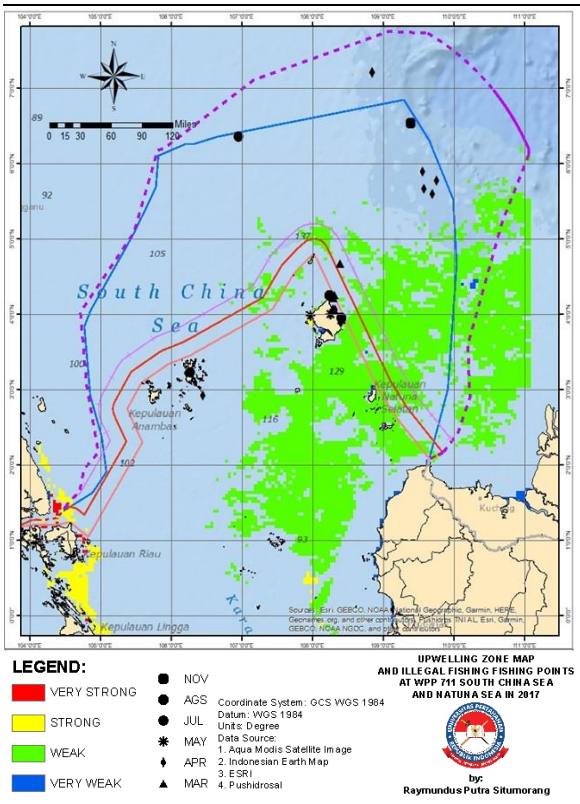

Figure 3. Map of Combined Fishing Points with Fish Abundance Zones in 2017.
Source: Processed by Authors, 2021

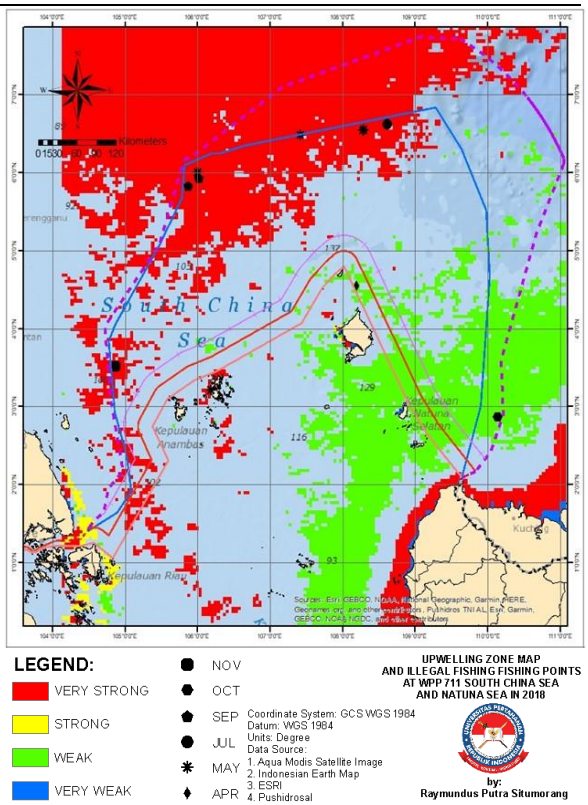

Figure 4. Map of Combined Fishing Points with Fish Abundance Zones in 2018.
Source: Processed by Authors, 2021

May, June, July, August, and October. On the map, there is weak upwelling in coastal areas and the arrest of illegal fishing vessels in the area. This is thought to be due to the presence of high additional nutrients from river runoff which causes high concentrations of chlorophyll-a in coastal areas. Then it can also be seen that very strong upwelling occurs in the high seas, precisely north of the North Natuna Sea and spreads over the southern part of Vietnam. The wind is still the main factor for upwelling on the high seas. This is what was researched by Barnes & Hughes (1999) which states that where trade winds blow throughout the year, the divergent areas develop so strongly, that the thermocline layer moves vertically to the surface. The situation in the divergent area creates a void in the surface layer which is filled by water masses from the layer below. This is what causes the process of upwelling on the high seas. From figure 2, it can also be seen that fishing vessels carrying out illegal fishing activities are dominant in upwelling areas with very strong intensities. For surveillance patrols, tasks can be divided between each institution. In the zone of very strong fish abundance in the EEZ, surveillance patrols can be commanded by the Indonesian Navy due to the capacity and capability of the vessels owned by the Indonesian Navy. Then for the weakfish abundance zone (green color on the map) Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP) can command. This is also by the size and cruising range of the ships owned by the Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP). With this division, it is hoped that the surveillance patrol will be more optimal.

Then in Figure 3, the upwelling zone occurs around the territorial waters of the Natuna Islands. The upwelling that occurs is of weak intensity. This is as shown by the description on the map that the dominant color of green on the map represents the intensity of the weak upwelling that occurs. Furthermore, the same thing happened on the 2017 map with previous years where upwelling was dominant in coastal areas. Then the map also shows the months of arrests of vessels carrying out illegal fishing. In 2017 arrests occurred in March, April, May, July, August, and November. Arrests of vessels carrying out illegal fishing activities also appear to be quite dominant in the area where upwelling occurs. However, we can also see on the map that a unique phenomenon is seen, there is an arrest of a ship that does illegal fishing which is quite dominant outside the upwelling zone. It is most likely that the arrest is a vessel that has just arrived or is about to return/has finished illegally catching fish in an area where there is a potential abundance of fish. In the context of optimization, it would be better if the arrest and surveillance were carried out or focused on the area around the upwelling or within the boundaries of the upwelling area. This needs to be done as a strategy to protect our marine and fishery resources. In terms of the need for a division of tasks in the surveillance patrol. For the EEZ area, it can be handed over to the Navy and for the Territorial Sea to the Continental Shelf, a collaboration between the Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP) can be built.

Next to Figure 4, the upwelling that occurred on the 2018 map is upwelling with very strong intensity and upwelling with weak intensity. Upwelling with very strong intensity is shown on the map in red and upwelling with low intensity is shown on the map in green. Furthermore, the months for the arrest of vessels carrying out illegal fishing occurred in April, May, July, September, October, and November. A glimpse on the 2018 map is almost the same as that shown on the 2016 map, which shows that upwelling is very strong in the high seas area, precisely in the Indonesian Exclusive Economic Zone. For surveillance patrols, tasks can be divided between each institution. In the zone of very strong fish abundance in the EEZ, surveillance patrols can be commanded by the Indonesian Navy due to the capacity and capability of the vessels owned by the Indonesian Navy. Then for the weakfish abundance zone (green color on the map) Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP) can command. This is also by the size and cruising range of the ships owned by the Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP). With this division, it is hoped that surveillance patrols will be more optimal. Very strong upwelling in the area can occur because there is a major factor in the generator, namely wind.

In the last image, Figure 5, the upwelling that occurs is upwelling with a weak intensity. This is as shown in the map caption in green. The pattern of upwelling spreads from the Natuna Islands to the eastern region of the Natuna Sea which is included in the Territorial Sea and the Indonesian Exclusive Economic Zone. Then the spread of upwelling also occurred to the southern region of the Natuna Islands to approach the Karimata Strait. Upwelling that occurs in this area is very dominant in coastal areas. This results in higher productivity around the waters because it gets additional nutrients from land areas through rivers. This is in line

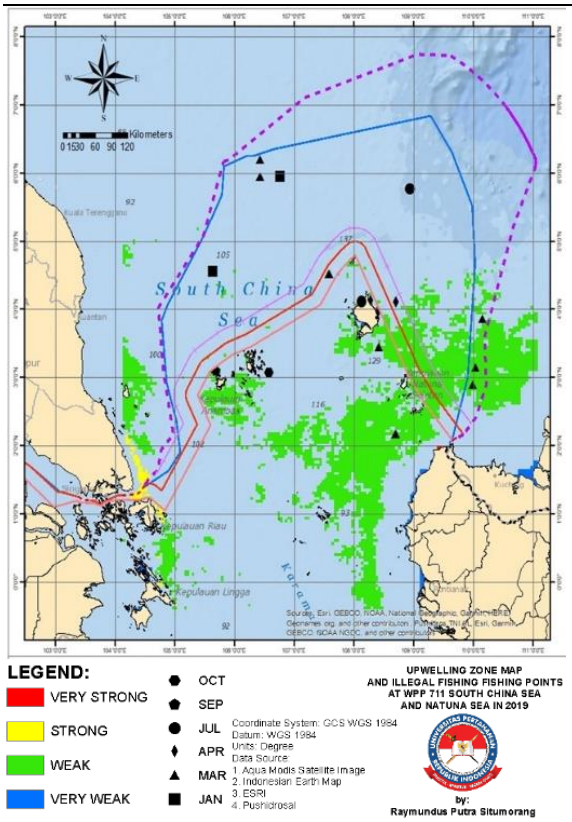

Figure 5. Map of Combined Fishing Points with Fish Abundance Zones in 2019.
Source: Processed by Authors, 2021

with the results of research from Inaku (2015) which states that the high distribution of chlorophyll-a concentrations in coastal and coastal waters is due to the large supply of nutrients through run-off from land, while the low concentrations of chlorophyll-a in offshore waters. because there is no direct supply of nutrients from the land. Then one of the main factors in upwelling generators is wind. After that, on the map, it can also be seen that the fishing vessel is a perpetrator of illegal fishing. The following is presented in the form of a table of events each month along with the symbols used.

On the map, also see that the arrests of vessels carrying out illegal fishing activities occur in upwelling areas. This shows that there is a link between the data on the arrest points of illegal fishing vessels and the data on the upwelling area. However, we can also see that there is a unique phenomenon where fishing is carried out outside the upwelling zone. This indicates that the biggest possibility of catching vessels that carry out illegal fishing in the area is a vessel that is about to enter or a vessel that has just finished illegally catching fish. When we talk about optimization, it would be better to carry out surveillance and arrests that focus on the surrounding area where upwelling occurs or is bordered by the upwelling area. This is done as a strategy to protect our marine and fishery resources. In this case, there is a need for a division of tasks in the surveillance patrol. For the EEZ area, it can be handed over to the Navy and for the Territorial Sea to the Continental Shelf, a collaboration between the Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP) can be built.

From the description of the Combined Fishing Point Map with Upwelling Zones for 2015-2019, it can be concluded that oceanographic data (chlorophyll-a and sea surface temperature) can be used in monitoring illegal fishing. According to Kunarso et al. (2011) statement that information on the spatial variability of temperature and sea surface chlorophyll-a can be used to facilitate the management and utilization of fishery resources, namely as a basis for estimating and determining potential waters for fishing/fishing ground. Then when talking about optimization in the supervision of stakeholders, it can be easier and focus on monitoring. Supervision and arrests are only carried out in the upwelling area or the area around and within the upwelling boundary. So here the supervisors/stakeholders are no longer looking for the perpetrators of illegal fishing by way of patrol around the entire area, but immediately catch the perpetrators of illegal fishing with a focus on the surrounding area where upwelling occurs.

The explanation above shows that there is a need for further development in

increasing the utilization of oceanographic data. We need to look at Japan through the use of oceanographic data. In Japan, the institution that is fully responsible for this activity is the Japan Fisheries Information Service System (JFIC). In this agency, all facilities for data storage and processing in a very large capacity are available as well as a very adequate information network system so that this system runs well. The network of all agencies related to the fishing area information system runs online, for example, catch data from fishermen through fishery cooperatives as well as oceanographic data from related agencies. The seriousness of the Japanese government in developing a fishing area forecasting system can be seen from the number of funds provided by the government in 1987 of JPY 1,614 million or approximately IDR 130 billion.

So far, in Indonesia there have been quite a number of institutions, particularly research institutes and universities, that have carried out measurements of oceanographic parameters, such as National Research and Innovation Agency (*Badan Riset dan Inovasi Nasional* or BRIN), Indonesian Navy (TNI AL), Geospatial Information Agency (*Badan Informasi Geospasial* or BIG), the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP), Bandung Institute of Technology (*Institut Teknologi Bandung* or ITB), IPB University (*Institut Pertanian Bogor*), Diponegoro University (Undip), Hasanuddin University (Unhas), Indonesian Navy Hydrography and Oceanography Center (Pushidrosal) and others. Unfortunately, so far there is no integrated and online oceanographic data center in Indonesia, so most of the existing data is still not optimally utilized, both for research and technical purposes.

In general, the available oceanographic data in Indonesian waters is quite complete to date. Although the data is still scattered in various research institutions and some of them are sometimes difficult to obtain for research purposes. A thorough study of oceanographic phenomena in Indonesian waters is still dominated by researchers from abroad. For this reason, an open oceanographic database center that can be accessed by various research institutions in Indonesia needs to be established as soon as possible to facilitate data retrieval by researchers. With this database center, data-sharing activities between researchers will become easier and faster, so the progress of marine research in Indonesia will be faster and more effective.

Utilizing oceanographic data as one of the guidelines in the supervision of illegal fishing can be one of the guidelines in supervision and can optimize in terms of surveillance patrols because surveillance and catching are only focused on zones of potential fish abundance occurring. By using oceanographic data as a method of monitoring illegal fishing, threats to maritime security can be prevented and maritime security can be realized by eradicating illegal fishing.

CONCLUSIONS, RECOMMENDATION AND LIMITATION

The supervision of Illegal Fishing in the North Natuna Sea has been carried out by each institution. This is still not optimal because the institutional capacity in fisheries supervision is still limited. The use of oceanographic data (sea surface temperature and chlorophyll-a) in monitoring illegal fishing has not been utilized by Chief in Fleet 1 (*Komando Armada 1*), Indonesian Maritime Security Agency (Bakamla RI) and the Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries (Dirjen PSDKP KKP). Low sea surface temperatures and high concentrations of chlorophyll-a at sea level indicate the potential for fish abundance (upwelling) in the region. Oceanographic data can be one of the guidelines in monitoring illegal

fishing. Utilization of oceanographic data in monitoring illegal fishing can be one of the guidelines in monitoring and can optimize surveillance patrols because monitoring and catching are only focused on potential fish abundance zones that occur. For this reason, an open oceanographic database center that can be accessed by various research institutions in Indonesia needs to be established immediately to facilitate the collection or utilization of data by institutions or researchers.

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Appendix

Interview with Director of Data and Information of Bakamla RI

How is the application of the rules/policies/laws regarding the TNI AL in the North Natuna Sea?

Bakamla as an agency engaged in maritime security and safety responds to policies/rules related to IUU fishing by conducting supervision and monitoring both directly and using sensor technology so that Indonesian waters, both in the North Natuna Sea and other areas, can be maintained. Some of the direct implementations carried out by Bakamla include taking action by arresting vessels carrying out IUU fishing and expulsion from areas that still have disputed status with other countries.

What are the objectives that the 'institutions' trying to achieve in handling the North Natuna Sea?

The goal to be achieved by Bakamla in dealing with illegal fishing in the North Natuna Sea is to provide a sense of security for the Indonesian people from IUU fishing actors and improve the economy of citizens by protecting the area from the threat of IUU fishing.

Is there a strategic plan as a guide and reference related to the goals to be achieved?

A strategic plan has been drawn up to deal with the problems that occur in the North Natuna Sea, not only related to the problem of IUU fishing but also related to the issue of the border with Vietnam.

How is the effort in implementing this?

Continuous patrols are carried out by involving other related agencies so that the presence of security officers for the disputed territorial waters can suppress the presence of foreign patrol boats in the area and other threats can be minimized.

How is the image mechanism/model/tactic/ done in the field when performing patrol, etc?

Tactically, it can be said that Bakamla conducts mobilization between the government and the community through official NGOs so that the implementation of patrols is also supported by the presence of the community represented by fishermen in activities at sea, as well as by increasing communication in the field so that, if prominent things are found or if there is an indication of a threat, the nearest ready patrol boat will immediately respond to follow up on the threat while still coordinating with other agencies and the head office.

The number of patrols in a year, is the number always the same every year, how long is the patrol, what type of patrol, and how to determine the location of the patrol?

For patrol data only owned by the Directorate of Marine Operations, including the duration of activities and annual planning.

Who is involved in the implementation of the strategy? Is there any coordinations with other institutions?

Those who involved in implementing the strategy are related units in Bakamla such as the Directorate of Marine Operations, Directorate of Air Operations, KPIML, Directorate of Data and Information, Maritime Zone Office, SPKKL and Earth Stations, and UPH.

In addition, coordination with relevant agencies is carried out to strengthen data and information support as well as the implementation of operations in the field.

How the number of the fleet should support the achievement of the strategic plan?
The number of ships is still very limited with the vast territorial waters in Indonesia, currently, there are 6 ships of 48 meters, 3 ships of 80 meters, and 1 ship of 110 meters.

How does the number of personnel have to support the achievement of the strategic plan?
The number of Bakamla personnel is still very limited, currently around 1000 people.

What kind of technology that is used? Have you used oceanography satellite data? Will the oceanography data help?
The technology used today is quite diverse, namely:
1. Data from AIS satellites to monitor ship activity data.
2. Sentinel satellite data to support the detection of ships that do not use AIS.
3. Oceanographic satellite data has been used, to map fishing points.
4. VMS data as a fishing vessel monitoring tool.

As well as weather data to support the patrols.

Regarding strategy plan development, does the 'institution' have an expert or think tank in developing a strategic plan?
Bakamla has experts or think tanks in formulating strategic plans who are assigned to the strategic directorate and policy directorate, which is also supported by the research and development directorate.

What obstacles were faced in the implementation of the strategy?
The current constraints include:
1. The number of Bakamla personnel is still very limited, currently around 1000 people.
2. The number of vessels is still very limited given the vast area of maritime affairs in Indonesia, currently, there are 6 48-meter vessels, 3 80-meter vessels, and 1 110-meter vessel, which is only focused on the North Natuna Sea area then other areas will have the potential for increased threats.

The limited number of budgets to support patrols and the development of a monitoring system for Indonesia's vast territorial waters.

What efforts are taken to overcome these constraints?
Efforts have been made to determine the priority areas that will be the target of operations, the types of threats that have the most impact, and encourage the existence of a single multi-task agency related to maritime security and safety so that the focus on the use of the fleet, personnel, systems, and budgets can be adjusted to state priorities, not priorities. each authorized agency.

Interview with Staff of Directorate General of Supervision and Control of Marine Resources and Fisheries of Ministry of Marine Affairs and Fisheries

How is the implementation of the law regarding illegal fishing by PSDKP in the Natuna Sea?
Before going there I want to talk from a big perspective first if we talk about eradicating illegal fishing which carried out by the KKP and other agencies too. So we are talking about two approaches, the first is a soft structure approach, so there is a collaborative approach, the diplomacy approach is carried out, and the second is a hard structure, this is through a law enforcement approach. These two approaches are taken not to weaken each other but to strengthen each other meaning that in our efforts to maintain the sovereignty of fisheries management in the North Natuna Sea. We are very focused that all forms of illegal fishing threats in the North Natuna Sea. There are a serious threat that must be joint concerns a

priority to overcome but on the other hand, we also continue to push for approaches that are soft through bilateral cooperation through regional and multilateral cooperation. So, the picture is like that if you look at what the Ministry of Maritime Affairs and Fisheries is doing at a larger level. So, if we talk about the implementation of statutory regulations by the KKP, of course, it refers to existing national regulations and national regulations. So in principle, we have the authority to enforce the law in the fisheries management area of the Republic of Indonesia so that when there are foreign fishing vessels carrying out fishing activities there it is illegal and of course, we will proceed with the law by the applicable laws and regulations.

Is there a strategic plan that will be a guideline and reference regarding goals to be achieved?
Of course, as a work unit mandated to carry out medium and long-term development plans, we certainly have goals in eradicating illegal fishing. We also have a target, so we have a target, for example, an area that is free from illegal fishing, then we have a target coverage for the water area that we are monitoring, and this is revealed in the form of strategies that are attached to the work units in us.
There was a preventive approach that was taken, at that time we were local ships or Indonesian ships, there was a law enforcement approach that was carried out later, and there was monitoring which was also carried out including operations with the fleet of surveillance ships, so all of this was carried out with to achieve this goal in the framework of eradicating illegal fishing in the fishery management area of the Republic of Indonesia.

Are there any obstacles facing the PSDKP in implementing the objectives?
The obstacle is that there must be such a thing as the implementation of supervision in the field, it's very dynamic, isn't it, especially if we look at our maritime dynamics which are quite complex, yes, our vast sea area, while we also have limited human resources and limited infrastructure. Currently, we only have 28 surveillance vessels that are in operational condition. Of course, it's still very far from ideal when it comes to overseeing our maritime area. So that is why the approach used is an integrated surveillance system approach, so we are no longer sawing the sea. In short, yes. So the surveillance ship goes to sea because it will arrest illegal fishing perpetrators, it is provided with adequate information related to the target ship to be arrested and is no longer searching the sea so that the operation of the surveillance ship becomes effective and efficient. However, routine patrols are also still being carried out because it is part of the presence of the state, the presence of the apparatus in demonstrating sovereignty in fisheries management. especially in the North Natuna Sea region, the content is that the delimitation of our border area with Vietnam has not been completed.

Efforts to overcome constraints?
Yes, that effort, was one of the things we did, we developed an approach called an integrated surveillance system. I may be a little more explain this in more detail. So this integrated monitoring system illustrates that we have a marine fisheries control center where all data and information are collected. So what does the data include, a fishing vessel monitoring system, then an automatic identification system, then radar data, then information from the public besides that we also have information obtained from aerial surveillance via aircraft. Now, this information is the key that is managed by the control center which will be informed to our supervisory ships in the field so that when they are detected, for example at the coordinates of such illegal ships, the supervisory ship can immediately estimate. When I chased from here, how long would it take, where is the meeting point so that I can make arrests is it possible or not? These estimates will make it easier, so even though the number of vessels is still far from ideal, if we look at the results of our operations, for example, from October to now we have 100 vessels captured, which means that they are quite effective and quite effective. The

picture is how we try to make peace with the weaknesses or shortcomings that we have, especially those related to good supervision infrastructure.

What kind of technology that is used?
We also carry out conventional AIS, VMS, and RADAR through aerial surveillance and community reports through community supervisory groups and other participations outside the community supervisory groups (Pokmawas).

Interview with representing Indonesian Navy commander in Chief of Fleet 1 (Komando Armada 1)
How to apply the rules/policies/laws regarding illegal fishing by institutions in the north natuna sea
By the Menkopolhukam letter No. B-142/LN00.00/7/2019 DATE 23072019 concerning Guidelines for Law Enforcement in Overlapping Areas at Sea:
1. The Claimant State Foreign Fishing Vessel carried out the expulsion.
2. Third-country foreign fishing vessels: processed.

Is there a strategic plan as a guideline and reference related to the goals to be achieved and how to implement them?
By the Menkopolhukam guideline number 1 of 2020 concerning the coordination of supervision, security, and utilization of fish resources in the Natuna Sea.

What was the development of the mechanism/model/tactics while doing patrols?
Patrol directly and constantly.

How much is the number of patrols in a year, is the number always the same every year, how long is the patrol, what type of patrol, and how to determine the location of the patrol?
Throughout the year, the Indonesian Navy spends 365 days in the Natuna Sea. Determining the location point by walking around and using AIS.

How much fleet has to support the achievement of such a strategic plan?
There are currently 5 KRI ships in the Natuna area, on average every day there can be up to 4 to 5 ships in the Natuna area every day.

How many personnel are having to support the achievement of the strategic plan?
The point is that 510 people are operating in Natuna in one year for 365 days.

What technology is used, have used oceanography satellite data, will the use of oceanography data will help?
We used AIS. Oceanographic data (surface temperature and chlorophyll-a) have not been utilized.

Who is involved in the implementation of the strategy? Is there coordination with other institutions/institutions?
Always coordinate in terms of operations, data, and information in the field.

What obstacles were faced in the implementation of the strategy?
The dynamic factor of the sea, many sea users from various countries, national and international laws, and international customs apply.

What efforts are taken to overcome these constraints?
Follow the guidelines in conducting operations, supervision, and security.

Interview with the Head of Oceanography and Meteorology, Indonesian Navy Hydrography and Oceanography Center or *Pusat Hidro-Oseanografi Angkatan Laut* (Pushidrosal)
What are the duties and functions of Pushidrosal to assist the TNI AL in handling illegal fishing?
As a data provider, if requested, Pushidrosal provides the data for operations, supervision, and security activities.

Means so that the oceanographic data (sea surface temperature and chlorophyll-a) have not been used in the TNI AL?
Pushidrosal is only a data provider, everything returns to the user in this case the unit of operation. Whether the data will be used or not.

Is there a plan for the prevention and control of illegal fishing in pushidrosal?
We already have a plan, but of course, we are improving it all. The point is that our nature is to provide data that is generally accepted, so if it's civil shipping, shipping safety can, if you want to use it for patrols to prevent illegal fishing it can, for sea combat it can. So it's all up to the user, we have provided the data then we made the model which we also sent, the application problem is left to the user.

What is Pushidrosal's view on using oceanographic data in controlling illegal fishing? Is it effective or how?
Still need to add other elements to the data, so that the results are more complex.

What are the obstacles in implementing the use of oceanography data when pushidrosal has been provided?
All back to the user's domain. To be used or not.

In this case, will the Oceanography and Meteorology Pushidrosal Department produce fishing data also every month?
Not from the Pushidrosal domain. Pushidrosal only focuses on shipping safety.

Are the data of sea surface temperature and chlorophyll-a the domain of Pushidrosal?
Sea surface temperature is our domain. Chlorophyll-a is not our domain. If we have chlorophyll-a data, we will not publish the data because it is out of respect for the offices and agencies authorized in the data.