The Influence of Coastal and Marine Ecosystem Conditions on Fisheries and Socio-Economic Activities of Local Fishermen

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Abstract. Fisheries and socio-economic activities of fishermen, especially traditional local fishermen, largely rely on coastal and marine ecosystem condition. Degradation of coastal and marine resources, particularly coral reefs and fish, is widespread as a result of the increase in pressures on these resources, which tends to continue in parallel with the increase of economic activities in the coastal areas. The high potential of coastal and marine resources has triggered fishermen from outside to utilize these resources for profit without paying attention to their sustainability. This situation creates high competition over resources, leading to conflict of interests and overlapping fishing areas between local and domestic fishermen, as well as those from neighbouring countries. The local fishermen are in a weak position; their fleet, fishing equipment and bargaining position are much worse than the outsiders. Meanwhile, climatic conditions, especially the more frequent extreme weather, also have a major impact on fisheries activities, production and fishermen incomes. This paper discusses these issues in Natuna District, Riau Islands Province, Indonesia. It uses empirical data from Indonesian Institute of Sciences (LIPI) and my related research activities in this location. Data is also collected from secondary sources, including related books, papers, documents, and research results.

1. Introduction

1.1. Background

Natuna District has a very rich coastal and marine ecosystem as the basic capital for the welfare of its people. It is an archipelagic district, consisting of 154 small islands and three large islands, namely Bunguran Island, Jemaja Island and Serasan Island. Most of the district’s area, 138,600 km$^2$ (or 97 percent), is ocean. The Natuna Sea is directly contiguous with the South China Sea, so international ships often pass [1, 2].

Natuna is known to be rich in coral reefs with a huge biological diversity [3]. The condition of coral reef ecosystem in Natuna District varies according to some references; the condition ranges from bad to quite good [4] and moderate [5]. This ecosystem is dominated by a group of non Acropora, Acropora, soft coral, sponge, seaweeds, and coral reef association biota, such as 77 species of reef fish, clams, blue starfish, crown of thorns starfish, top shell, drupella snails, sea cucumbers and sea urchins. [5, 6].

Coral reef ecosystems have high economic value and important ecological functions for environmental balance. The high potential of coral reefs in the Natuna District is an important source of livelihood for its residents. Reef fishes, such as groupers and sunu, are export fishes with a very high economic value, depending on market prices at the international level, such as Hongkong and Singapore. The coral reefs are not only rich, but also very beautiful and unique. The beauty and uniqueness of this 'underwater paradise' are main tourist attractions in Natuna. However, this potential has not been developed properly. From an ecological aspect, coral reefs are the 'home' of fish and a place to grow...
and breed various types of reefs fish and other biotas that live in the ecosystem. Coral reefs also have the function of protecting coastal areas from waves and storms [7, 8, 9, 10].

The Natuna District has a very high potential for capture fisheries, reaching 504,212.85 tons per year. However, in 2014, only 46 percent of the total potential of fish resources were utilized, consisting of pelagic fish with a utilization rate of 37.8 percent, and demersal fish of about 25.4 percent [11]. The dominant fish species caught by local fishermen are tuna (*Auxis sp.*); sea catfish (*Arius sp.*); shark (*Sphiraena sp.*); caranx (*Caranx sp.*); sardine (*Sardinella sp.*); and mackerel (*Rastrelliger sp.*). Local fishermen also catch several species of reef fishes, including napoleon fish (*Cheilinus undulatus*), grouper fish (*Ephinephelus sp.*, *Chephalopholis sp.* and *Plectropomus sp.*), yellow tail fish (*Caesio sp.*), siganidae (*Siganidae sp.*, *Bolbometopon sp.*, *Lethrinus sp.*, and *Plectorhinchus sp.*), and stingrays (*Taeniura sp.* and *Labracinus sp.*) [6].

The above data illustrates that the potential of capture fisheries in the Natuna District is still underutilized and varies by sub-district. However, the capture fisheries production increased significantly, by 84.3 percent, between 2013 and 2018 [1, 2]. In 2013, Serasan, West Bunguran and Pulau Tiga Sub-districts were the main sources of fishery production. Whereas in 2018, the main source of production shifted to West Bunguran, Subi, and Serasan Sub-districts. Particularly, fishery production in Subi Sub-district increased dramatically, more than 7 times during this period. In contrast, fishery production in Pulau Tiga Sub-district decreased substantially, partly due to the reduced area of waters and the number of fishermen in this sub-district because of the expansion of the sub-district.

The wealth of coastal and shallow marine resources in this district has become an important source of livelihood for its residents. According to the Head of Natuna District in 2015, there were 10,857 fishermen or 3,619 fishery households spread across 12 sub-districts. They were traditional fishermen with simple fishing fleets with an average capacity of 3–5 GT, using hand line, longline and trolling rods [12]. The local fishermen began to develop fishing and aquaculture activities, even resort to illegal practices. This was particularly related to the increasing demand for fish and technological changes. With the capability of the fleet and fishing gear, fishermen's activities were still very dependent on natural conditions, especially the seasonal variation where lately extreme weather has become more frequent in Natuna. [7, 8, 9, 10].

Apart from local fishermen, coastal and marine resources are also utilized by fishermen from outside Natuna. They come from various places, not only from within the country (domestic fishermen such as from Tanjung Balai Karimun, Medan, Pontianak and Tegal) but also from abroad (such as from Thailand, China and Vietnam). These fishermen catch fish in Natuna waters using modern fishing fleets and gears with a much higher capacity compared to local fishermen. [7, 8, 9].

The high potential of coastal and marine resources in this district, although not yet optimally utilized, has been suffering from degradation with varying degrees of damage by region due to the increasing pressures to those resources, especially coral reefs and fisheries. Apart from natural factors such as storms, the pressures also come from destructive human behaviour, both by local fishermen and fishermen from outside the district and abroad.

### 1.2. Objectives

This paper aims to discuss the interplay between the conditions of the coastal and marine ecosystems with fishery activities and fishermen's socio-economy, as well as its causative factors in Natuna District, Riau Islands Province, Indonesia. The discussion focuses on the degradation of coastal and marine resources, as well as seasonal variations (winds and waves of the sea) throughout the year which greatly influence the activities of fishermen. The fishery activities and socio-economy of local fishermen include the use of fleet and fishing gears, the area of fishing, the income, and the impact of illegal fishing practices on deterioration of the ecosystem. It also analyses the ability of local fishermen to
compete with fishermen from outside the district and foreign fishermen in the utilization of the resources in this location.

2. Methods
This paper used empirical data from Natuna District, Riau Islands Province, Indonesia. Data were collected by the Population and Oceanographic Research Centres, LIPI (P2K-LIPI and P2O-LIPI), and my own researches that are relevant to this topic. These include assessing basic data on the social aspects of coral reefs in Pulau Tiga Area, West Bunguran Sub-district, Natuna District in 2005; socio-economic condition of community in COREMAP II location, Natuna District in 2007; benefit monitoring and evaluation (BME) research on socio-economic conditions of community at COREMAP II sites in Tanjung and Sepempang Villages and Pulau Tiga area in 2009; social aspects of coral reefs and related ecosystems in Natuna District in 2015; and social challenges and efforts to achieve resource sustainability of coastal and small islands communities in 2017.

All the researches applied qualitative approach, centering on focus group discussions (FGDs), open interviews and field observations. Focus Group Discussions (FGDs) were conducted at village and district levels, with each FGD consisted of 8–15 participants. At village level, the participants (fishermen, fish traders, non-formal leaders, and representative of women) discussed issues, perception, attitudes and their concerns related to socio-economic aspects of coral reefs. They also talked about coastal and marine ecosystems (including potential, type of use, condition, and its influencing factors). Open interviews were conducted with resource persons at village and district levels. At the village level, they were selected by purposive sampling including from fishermen, fish traders, women, youth groups and local community organizations; while at district level, FGD was also done with district government officials (District Planning Agencies, Fishery and Marine District Offices) in Ranai, the capital city of Natuna District. In addition, open interviews were also conducted with various informants such as fishermen who used different fishing gears (fishing line, nets), fish traders, and seafood processors at village level. Interviews were also carried out in district level with leaders and officials from the Fisheries and Marine Office and the District Planning Board in Natuna District. Meanwhile, observation activities include observations of community activities and environmental conditions around the research location. This activity aimed to complete and check & re-check information from interviews and FGDs.

This paper also utilised quantitative approach which was based on the survey method in Sededap, Cemaga Tengah and Kelanga Villages. Using a questionnaire with closed questions, the survey was conducted on 200 households, sampled from the community in three study locations. The number of households varies according to village, adjusted for population size, diversity of socio-economic conditions and their dependence on the use of coastal and marine resources. The number of households that became respondents were 75 households in Kelanga Village, 75 households in Cemaga Tengah Village, and 50 households in Sededap Village. Respondents were randomly selected using an interval from the Family Register (KK) borrowed from the village head/secretary in each location. They were the head of households or household members aged 15 years and over, and understood the socio-economic conditions of the household.

Apart from collecting primary data through surveys and collecting qualitative data, secondary data was also gathered. Secondary data largely relied on desk reviews from various sources, such as related papers, documents, books, and research publications. The literature review was carried out to obtain more understanding about the interplay between coastal and marine ecosystem conditions, and fisheries and social economic activities of local fishermen.
3. Results and discussions

This paper discusses three issues related to the influence of coastal and marine ecosystem conditions on local fishermen in Natuna District. The first and second issues focuses on destructive behaviour that causes degradation of coastal and marine ecosystems on fisheries, and unbalanced competition in the use of coastal and marine resources which affects local fishermen. The last issue analyses the effect of natural factors, especially seasonal changes on fishing activities and fishermen's income.

3.1. Degradation of coastal and marine ecosystems and its impact on fisheries

The degradation of coral reefs and fishery resources in Natuna District’s coastal and shallow marine ecosystems is alarming. Most of the coral reef areas have experienced damaged to varying degrees, ranging from minor to severe damage. Of the 18 coral reef sites in Natuna, 5 are in 'sufficient' status and 13 are in 'poor' status. The degradation mainly occurs in coral reef areas, which are the centre for poison and blast fishing activities. The results of the ecological survey of the P2O-LIPI revealed that most of the Pulau Tiga waters had coral cover of less than 50 percent. [13, 6].

The coral reef in Natuna Islands and its surroundings is a type of fringing coral reef that has a wide variety of coral species and a fairly varied area of cover. According to P2O-LIPI monitoring results on coral cover conditions in Natuna Islands in 2014, the percentage of rock coral cover varied from low to medium category conditions (4.0–40.73%). This condition was getting worse in some coral areas, such as around Pulau Tiga Village where the coral cover was in the low category, only reaching 27–28 percent [6].

Degradation of coral reefs is closely related to the behaviour of fishermen, both fishermen around the reef area (local fishermen) and fishermen from outside the area. The use of destructive fishing gear/materials, such as poison (cyanide), bombs, and trawls are claimed to be the cause of the damage to this ecosystem. The Indonesian government prohibits the use of these materials and fishing gear, but these activities continue in the waters of Natuna District. [6, 7, 8, 9, 10].

The use of illegal fishing gear and materials in Natuna District is caused by several factors. First, it is economic factor to get more fish and income in a shorter time when compared to other non-destructive fishing tools, such as fishing rods and nets. Second, fishermen's knowledge and awareness about the importance of preserving coastal and marine resources as well as fisheries are still limited. This is closely related to social factor in which fishermen carry out illegal activities following other fishermen, both local fishermen and fishermen from outside the district. Third, surveillance and law enforcement for offenders are often absent. When a violation occurs, the local community often resolves it amicably without involving law enforcement officials. [7, 14].

Fishing using explosives (bombs) has been done for quite a long period, namely since the 1970s, and it is still ongoing in a small part of the region, albeit with a significant reduced frequency. Fish bombing activities have a direct and significant impact on coral reefs and surrounding biotas. The coral reefs are destroyed after the bombing. A bomb weighing 0.5 kg have enough power to destroy all living things—including coral reefs—in the area with a radius of 1–3 meters from the centre of the explosion [15]. Some village officials, such as in Pulau Tiga, state that bombing is no longer carried out in their village. However, other informants report that this activity is still being carried out clandestinely and conducted outside the waters of the village, such as in the waters of other villages surrounding Pulau Tiga area.

Poison fishing is method that utilizes chemicals, such as potassium cyanide. It has been carried out since the late 1980s (1988/89) by foreign fishermen, especially by ships from Hong Kong, operating around the Pulau Tiga waters. Local fishermen then learned about this illegal practice, and they started to use it themselves mainly due to the increasing demand for live fish and the availability of cyanide in the area. Afterwards, poison fishing practices has since been increased in frequency, because fishermen could catch a large
number of live fish in a short time. Given the incessant information on the prohibition of the use of poison, some of the fishermen shifted their activities outside the Pulau Tiga area. The use of poison fishing is more dangerous than the use of explosives. The damage to coral reefs done by cyanide according to local fishermen is also greater than bombs. Explosion might destroy coral reefs, but the impact radius is relatively small, and even though the corals are destroyed, they would eventually grow back after some time. This is not the case with the use of cyanide. Cyanide is retained in the sea and easily spread by the currents, affecting a much wider area and might hinder regrowth of other coral reefs. A poisoned coral reef will turn white and eventually die [7, 8, 9, 10, 16].

Fortunately, the use of bombs and cyanide in Natuna District has been declining since the establishment of the Coral Reef Rehabilitation and Management Program (COREMAP) in 2004–2005. COREMAP is a program managed and facilitated by the central government aimed at ensuring the sustainable use, protection and preservation of coral reefs and related ecosystems and improving the welfare of communities in coastal areas and small islands, particularly in program locations. COREMAP develops community-based management with direct involvement of fishermen and coastal communities as a central activity at the grassroots level. Community-based management efforts are supported by a component of increasing public education and awareness of the importance of coral reef management (PA), monitoring and law enforcement (MCS) and research, information and training centres (CRITC). [6, 7, 10]. Therefore, as local fishermen and the community in general have better understanding regarding information on the prohibition of using these illegal fishing practices, so the rate of blast and poison fishing have fallen.

However, this still leaves us with another destructive fishing tool, the trawls. Trawls are very dangerous because they damage marine life’s habitats and catch fishes that are not targeted for fishing. This is mainly due to all fish and marine life trapped in the trawl net, including juvenile fish and small biotas. The young fish usually could not be used, so they (alive and dead fish) are thrown back into the sea. Even though these fish are supposed to grow and develop. According to the Directorate General of Fisheries, about 80 percent of the catch from trawling was not used, and therefore thrown back into the sea.

This fishing gear has begun to be utilized in the Natuna Sea, particularly around the Pulau Tiga area, by Thai fishermen with their boats since the late 1970s. This activity then bloomed in the 1980s, whereas the use of trawling was prohibited in Indonesia with the issuance of Presidential Decree No. 39 in 1980. Regardless of that regulation, the number of illegal fishing boats from Thailand operating around the Natuna Island area was still increasing. Since 2004, fishermen have been complaining about the existence of those intruders. The government responded to this problem by conducting more frequent marine patrols through the KRI and the Navy (AL) posts as well as the Marine’s posts in Ranai City. As a result, the number of foreign ships begun to decrease in the mid-2000s. The presence of foreign fishing vessels in Indonesian marine waters, including the Natuna Sea, subsided in the 2015–2019 period when surveillance over areas bordering international waters became tighter. At the period, the Minister of Maritime Affairs and Fisheries, Susi Pudjiastuti, issued a policy of capturing and sinking illegal vessels that steal marine resources in Indonesian waters.

3.2. Unbalanced competition in the use of coastal and marine resources
The influence of coastal and marine ecosystem conditions on local fishermen is also closely related to their capacity in exploiting these natural resources. Fishery activities in the waters of this district are not only carried out by local fishermen but the high potential of these resources has spurred many fishermen from outside Natuna. They come from outside the district, domestic and foreign fishermen. Domestic fishermen include fishermen from Tanjung Balai Karimun and Batam (within the same province, the Riau Islands Province), Medan (outside the province within Sumatra Island), Tegal (Java Island), and Pontianak
(Kalimantan/Borneo Island). While fishermen from abroad are from Thailand, Vietnam, and China. [7, 8, 9, 10, 16].

The large number of fishermen—both local and outsiders—operating in the Natuna waters has implications for the high competition for coastal and marine resources in these waters. This situation has resulted in conflict of interests and overlapping of fishing areas. The difference in fleets and fishing gears also have created rifts between fishermen, especially local fishermen and fishermen from outside the district (domestic and foreign). Local fishermen with simple fishing fleets (mostly 0–5 GT) are certainly unable to compete and greatly at a disadvantage by the presence of fishermen from outside Natuna District, who are generally equipped with better fishing fleets that are much larger in capacity (100 GT and above). From the starts, this competition—local fishermen versus fishermen from outside the district—is already an unfair one. [7, 10, 16].

Fishermen in Natuna District have protested strongly against the existence of fishermen from Java Island with a high-capacity fishing fleet (100 GT boat) catching fish using cantrang, fishing gear which operation touches the seabed by spreading the rope in a circle and lowering the net, then the two ends of the rope are pulled towards the boat until the entire bag of the net is lifted. They operate in the waters 6–12 miles from the shoreline, especially in Subi Island and Serasan Island, Natuna District. The use of cantrang, according to the chairman of the Natuna District Fishermen's Alliance, disrupt the catch of local fishermen that use simple fishing fleets (mostly 0–5 GT) in fishing areas less than 12 miles. In addition, cantrang can exploit fish on a large scale to the bottom of the waters, thus damaging the underwater environment, such as coral reefs. Natuna fishermen do not actually prohibit the use of cantrang, but the location or zoning must be outside the fishing area of local fishermen [10, 16, 14].

Conflicts of interest between local fishermen and foreign fishermen are also closely related to fishing areas and the use of fishing gear, especially trawl [7,10,20]. The activities of foreign fishing vessels entering the marine waters of Natuna District and even the local fishing areas have been going on for a long time. Late 1990s to early 2000s, Thai ships entered the area around Pulau Tiga area openly; they operated during the day in the high seas (slightly to the middle), but at night the ships started pulling over to the beach. Then, more foreign ships from Vietnam and China also caught fish in Natuna Sea. Meanwhile, the activities of local fishermen have expanded; a small proportion of fishermen also operated in the high seas (more in the middle of the sea) which is the area where Thai, Vietnamese and Chinese ships used to catch fish. Competing head-on, local fishermen were of course at a disadvantage, due to unbalanced 'competition' with those foreign fishermen [7, 10, 18, 19].

The presence of foreign fishing vessels has a substantial impact on the catch of local fishermen. With large boat capacities and trawling gears that 'sweeps' all the fish and marine life, foreign fishermen are able to catch a large number of fish. In contrast to local fishermen, who mostly still use pompong with a very limited capacity and the main fishing gear of trolling line, their catching ability is much lower. This imbalance is of course very detrimental to local fishermen. As an illustration, Thai fishermen could catch tens of tons of fish per day, while local fishermen find it difficult to get 100 kg of fish per day. This situation has had a significant impact on the decreasing the production of local fishermen [8, 16].

This situation also affects the comfort and safety of local fishermen. The existence of Thai, Vietnamese and Chinese boats 'terrifies' local fishermen, especially when they are doing their activities without groups. With a simple fishing fleet capacity, the safety of local fishermen is threatened when they are close to foreign fishing fleets. Natuna fishermen said ‘they were chased and driven away’ by foreign ships’. This incident is caused by the limited security patrols in the border sea waters between countries located in Natuna District.

In the 2014–2019 period, the presence of foreign vessels was significantly reduced as a result of the implementation of the policy of sinking foreign fishing vessels for illegal, unreported, and unregulated fishing (IUUF) in Indonesia, including in the Natuna Sea [20].
Ministry of Maritime and Fisheries Affairs (KKP) policies, which were fully supported by the Minister of KKP, were based on Article 69 Paragraph (4) of the Fisheries Law. However, this ship sinking policy was not continued by the new Minister of KKP who replaced Minister Susi. As a result, foreign fishing boats began operating again and at the end of 2019 and early 2020. Dozens of foreign fishing vessels, especially from China and Vietnam, returned to the Indonesian Exclusive Economic Zone (EEZ) in the North Natuna Sea. [20, 21].

To minimize the presence of illegal foreign fishing vessels in the North Natuna Sea and increase the use of marine resources by Indonesian fishermen, the government plans to bring in hundreds of fishermen from Java, especially from the north coast (Pantura). This government plan was rejected by local fishermen, especially from Sepempang Village, Pulau Tiga. The rejection was mainly related to the cantrang fishing gear used by Pantura fishermen. Local fishermen pointed out that cantrang destroys fish and marine life. They also informed that the damage would be higher because these fishermen used fishing boats that were much larger and modern when compared to the local fishing fleet [19].

3.3. Seasonal changes and their effects on fishery activities and fishermen's income
In addition to non-natural factors, natural factors, especially changes in seasons and extreme weather has a significant influence on fishery activities, production and income of fishermen in Natuna District. This is mainly related to the wind speed and the height of the sea waves, and conditions vary by region. Local fishermen in Natuna have traditional knowledge about climate, especially the variations in the wind season associated with their fishing activities.

Natuna fishermen identify four wind seasons in a year, namely: north, south, east and west seasons [7, 8, 9, 10]. The northern season is characterized by strong winds with high sea waves, accompanied by high rainfall, which usually occurs from November–February/March in Pulau Tiga Island. The southern monsoon is a transition between the strong winds and the shady season which is marked by a decrease in wind speed, although still a bit strong, and occurs from March–July. Eastern season is the shade season in late July or early August–September. Meanwhile, the western monsoon in September–November is a transitional phase, characterized by the return of strong winds.

In the northern season, fishermen only go to waters close to the settlements because wind speed is extreme while their fishing fleet capacity is still limited. This condition has become common place for Natuna residents because it occurs every year. This season, according to fishermen on Pulau Tiga Island, is the season for tuna and (dead) reef fish (reef fish caught and sold dead) using fishing rods. Types of reef fish caught with kelong (fishing tool in the form of wooden structure) include mullet, squid and cuttlefish. The species of fish caught in nets are generally all fishes, including those caught using the kelong above. Nets are used by fishermen all year round, not only during the northern season.

In the eastern season, which can usually take place for up to a month, the fishing area is getting wider, especially in the coral reef area which is still good in the waters of Serasan, Midai, Siantan and Jamaja Sub-districts. In this season, fishermen mainly catch live reef fish (caught and sold alive). Generally, fishermen use fishing rods around coral reefs. Live fish is a target fish for fishermen because it has high economic value as an export fish, especially napoleon, grouper and sunu, with the main market being the Hong Kong market.

The south monsoons and the west monsoons are the transitional seasons between strong winds and shade seasons, and vice versa. This condition affects the fishing area and the species of fish caught. In the southern season, the fishing area of fishermen is wider than the northern season. The species of fish that are mostly caught are anchovy, selayang (shark) fish, squid and small tuna. At the end of this season, there will be a lot of reef fish, such as grouper and snapper. Meanwhile, in the western season, fishermen still catch reef fish, but the area is adjusted to the wind condition. But lately there are frequent extreme weather with a frequency that tends to increase from time to time. This condition, which is closely related
to climate change that occurs in the marine waters of Natuna District, affects the fishing time, the catch area and the species of fish caught. How big is the influence of seasonal shifts on fisheries activities still needs further studies.

Windy season has a significant effect on fishermen's income in the District of Natuna. In general, the lowest income is during the northern season or when strong winds/waves occur, while the transitional season (southern and western season) is higher than the northern season, but less than the eastern season, or the shade season. Figure 1 provides an example of the income of fishermen in three villages (Sededap, Cemaga Tengah, and Kelanga).

Looking at Figure 1, in the north season (strong winds/waves), the average income of fishermen per month is at the lowest position when compared to the average income of fishermen in other seasons. The lowest income of fishermen is in Sededap Village, only around 17 percent when compared to the income of fishermen in Kelanga Village, but only slightly lower than the income of fishermen in Cemaga Tengah Village. The low income this season was due to the fact that most fishermen, especially in Sededap and Cemaga Tengah Villages, did not catch fish during the strong wave season.

In this strong wind season, the low average income is due to the limited technology of the fleets and fishing gears. The limited capacity of the fishing fleets and fishing gears of local fishermen affects the fishing area and their ability to go to sea. Only a small portion of the small boat (pompong) are able to go to sea in areas far enough to match fishing vessels from outside Natuna, such as from Tegal, West Kalimantan, Batam, Tanjung Pinang, Tanjung Balai Karimun and Medan. As a result, the income of fishermen in this season was very low, even lower than the poverty rate in Natuna District in 2015 [22]. Meanwhile, during the southern and western (transition) season, only some fishermen are able to go to sea. This condition of course affects the average income of fishermen per month which is calculated based on the average income of fishermen throughout the year. At this point, the highest average household income of fishermen was in Kelanga Village and the lowest was in Cemaga Tengah Village. The average income of fishermen in Kelanga Village was 1.4 times or IDR 483,685, which was greater than that of fishermen in Cemaga Tengah Village. Meanwhile, in Sededap Village, the income of fishermen was slightly less than that of fishermen in Kelanga Village, only around IDR 143,605 and much larger (IDR 340,080) than the income of fishermen in Cemaga Tengah Village.
Meanwhile in eastern season (calm waves), all fishermen are able to catch fish in the sea; the highest fishermen's income was found in Sededap Village and the lowest was fishermen in Cemaga Tengah Village. The difference in income of fishermen in these two villages was quite significant, where the income of fishermen in Sededap was 1.5 times greater than that of fishermen in Cemaga Tengah. The high income of Sededap fishermen was closely related to the maximum fishermen's activities and the huge potential of fisheries in the waters around the village, which was a coral reef area on small islands on Pulau Tiga. The amount of income was also related to the species of fish that were mostly caught by fishermen, namely live reef fish such as grouper and sunu, which were export commodities with high economic value. Meanwhile, the income of fishermen in Cemaga Tengah Village mostly came from catching anchovies, which was lower in price than live fish, and only a small proportion caught live fish.

In addition to seasons, the capacity of the fleets and fishing gears highly influenced the fishermen income. In general, fishing technology for fishermen in Natuna District is still basic, as indicated by the fishing fleet in the form of pompong with limited capacities. Most fishermen have boat engines with a capacity of only 0-5 and only a small proportion have a capacity of 5–10 GT with a payload of up to 3 tons per pompong. Some fishermen only use boats without motors, namely canoes, ranging from small to medium canoes. Fishing tools that are widely used are fishing rods, nets, traps, and kelong (fishing gear made of wood which is attached by a net and placed on the sea floor) depending on the type of fish caught. Only a few fishermen work on bagan (fishpond), especially reef fish with high selling value. With this simple equipment, the ability of fishermen to catch fish is also limited, whereas the number of fishermen is increasing, not only local fishermen but also outside (domestic and foreign) fishermen. To get more yields, many local fishermen imitate these outsiders by using illegal fishing gear, such as explosives (bombs) and poisonous materials (cyanide), and trawl. These illegal fishing gears are still practiced, they are not only carried out by local fishermen but also fishermen from outside the district. [7, 9, 10, 16, 23].

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**Figure 1.** Average Household Income of Fishermen from Capture Fisheries by Season at Research Locations, Natuna District, 2015 (Rupiah per month)

Source: Primary Data, Baseline Survey of Social Aspects of Coral Reefs and Related Ecosystems, Indonesia, 2015.

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4. Conclusion
The interaction between the conditions of the coastal and marine ecosystems with fishery activities and the social economy of local fishermen is closely related to fishery behaviour, the ability of fishermen to use resources, and natural conditions in Natuna District. Destructive behaviour using illegal fishing gear destroy the ecosystem, characterized by degradation of the coral reef ecosystem and fishery resources. Local fishermen with low capacity have not been able to take advantage of the wealth of natural resources that exist in this district. Apart from these non-natural factors, natural factors, especially changes in seasons and extreme weather whose frequency tend to increase, also greatly affect the activities and income of local fishermen.

The high potential of Natuna resources has spurred many stakeholders, especially domestic (from Tanjung Balai Karimun, Medan, Tegal and Pontianak) and foreign fishermen (from Thailand, Vietnam and China), to utilize these resources and gain profits without paying attention to their sustainability. Capture fisheries activities develop along with the increasing demand for fish, both in the domestic market and the international market, and change in fishing technology, particularly the use of bombs and cyanide by local and domestic fishermen, as well as trawling by foreign fishermen. Local fishermen with traditional knowledge and the low capacity of the fleet and fishing gear are unable to compete with domestic and foreign fishermen who use fishing vessels and gear with much higher technology and capabilities. As a result, they become the weakest and most disadvantaged stakeholders even in their own rich districts.

Therefore, coastal and marine resources in Natuna District need to be managed with an ecosystem approach, so that the dynamics and complexity of ecosystem conditions can be adjusted adaptively, integrated and collaboratively in the framework of conservation and sustainable use of these resources. The application of an ecosystem approach will reduce the inequality between local fishermen and fishermen from outside the district (domestic and foreign) in order to achieve equitable benefit sharing among all stakeholders. For this reason, increasing the capacity of local fishermen, fleets and environmentally friendly fishing gear is very important to enable them to manage biodiversity in coastal and marine ecosystems. Efforts to increase the knowledge and awareness of fishermen (local, domestic and foreign) about the importance of protecting this ecosystem are also very necessary. Law enforcement is also very important, especially for foreign fishing vessels that enter Natuna waters illegally and for fishermen (local, domestic and foreign) who still practice illegal fishing which destroys fishery resources and coastal and marine ecosystems. In addition, efforts to enact supervision need to be continuously developed, whether carried out independently by local fishermen or in collaboration with the Provincial and District Government, the Ministry of Marine Affairs and Fisheries, and the Indonesian Navy until the security of the coastal and marine ecosystem in Natuna District, fish production, local fishermen and their income can be maintained.

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