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Suitability Area of Groupers (*Serranidae*) Cultivation in Floating Net Cage (FNC) System in Kepulauan Seribu

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***Abstract*— Aquaculture is one of the steps taken by the DKI Jakarta Provincial Government to manage fishery resources. Kepulauan Seribu, in recent years, has experienced a decline in the production of fresh fish; therefore, the cultivation of the Grouper floating system has become an alternative solution. Successful breeding is supported by site selection due to assembling on the terms of Groupers life that includes water quality and oceanography. Water quality parameters include salinity, pH, dissolved oxygen, and oceanographic parameters, that is, sea surface temperature, depth, and current velocity. The method of analysis in this research is descriptive spatial based on the overlay results of Landsat 8 image data processing and in situ measurement data during the field survey. The analyst statistics was descriptive to analyze the relationship between the region of conformity with the results of Grouper fish production. The results of the statistical and spatial analysis found that the location of floating net cages in the Kepulauan Seribu in the class is very appropriate and appropriate. Meanwhile, the relationship between regional suitability and Grouper production in the Kepulauan Seribu is weak because production is related to other driving factors.**

***Keywords*— Fishery cultivation; floating net cages; oceanography; suitability area; water quality.**

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I. INTRODUCTION

Aquaculture is the activity of producing aquatic organisms, including fish, mollucs, crustaceans, and aquatics plants to gain profit [1,2]. In contrast, to capture fisheries, production from aquaculture is obtained through the maintenance of marine biota in containers and controlled environments that include seeding, maintenance, and harvesting [3]. The development of this cultivation activity is supported by the government to assist the supply of fresh fisheries production and reduce environmental water damage due to the use of destructive fishing gear [4].

One type of cultivation conducted in Indonesian waters is Grouper *(*family *Serranidae*) cultivation. Groupers are one of important food fishes with high commercial value in Asian countries as well as being a vulnerable group of fishes [5,6]. Indonesia as an archipelagic country, is the primary producer of Grouper fish from aquaculture, from Sumatra to Papua, especially in North Sumatra, Riau Islands, Lampung, East Java, Bali, Lombok and North Sulawesi [7]. The development of grouper cultivation in Indonesia mostly uses popular technology for grouper maintenance, namely floating net cages (FNC; local: *Keramba Jaring Apung (KJA)*) with certain criteria [8].

Grouper cultivation with FNC system influenced by the selection of the location assessed with suitable parameters of water quality as a requirement of Grouper habitat [9]. Site selection, a term of using facilities, and applied technology must follow the Indonesian National Standard [10]**.** The choice of the right location is very determining the suitability of fish production facilities that will affect the farmers' condition and also the status of the water environment [11]. The location feasibility is the result of conformity between the requirements of life and the development of a cultivation commodity to the aquatic physical environment [12].

In determining the suitability of the cultivation area within floating net cage, there are several variables used in the study; such are depth, water flow, temperature, salinity, degree of acidity (pH), and dissolved oxygen [13]. Water quality parameters that become the condition of Grouper's living are salinity, pH, dissolved oxygen, while the parameters of cultivation location of floating net cage (FNC) are temperature, depth, and current velocity [9].

One of the territories of Indonesia that conducted fish cultivation is Kepulauan Seribu. Approximately 70% of the

population rely on marine waters of the Kepulauan Seribu, and as many as 21-40% are fishermen of catch fisheries around the coral reef ecosystem, however about 69-92% of fishers from 5 villages (Panggang Island, Kelapa Dua Island, Pari Island, Harapan Island, and Untung Jawa Island) said that the production of catch fisheries is decreasing [14]. This phenomenon and habitat degradation have raised concerns of the Kepulauan Seribu residents about the scarcity of fish resources [15]. Responding to the condition, in 2004, the Kepulauan Seribu district government tried to develop a combination of marine aquaculture with catch fisheries based on the concept of sea farming [16]. The provincial government of DKI Jakarta also supports the cultivation activities in Kepulauan Seribu. In 2017 the Kepulauan Seribu received the grant, 46 units of FNC distributed to the cultivators.

Determining the right location is one of the critical success factors of marine aquaculture, besides the availability of breed, feed, and market [17]. Through today's general technological developments, Remote Sensing (RS) and Geographic Information Systems (GIS) can be used in determining the ideal location for marine aquaculture development [18]. Remote sensing in this term uses electromagnetic spectrum, ranging from short wavelengths to long wavelengths, to acquisition or obtain information [19]. Geographic Information Systems in this term are used to capture, store, analyze, and display geographic data or information [20]. Remote sensing and GIS are two-way interaction; remote sensing is used to generate digital maps that can be entered into GIS, whereas GIS data can be used to interpret remotely sensed data [21].

Several researches had been conducted related to suitability area using RS and GIS in aquaculture landscape, such as on the coast of Mazandaran Province, the southern part of the Caspian Sea [22], in southern coastal region in India [23], in Santa Catarina, southern coast of Brazil [24], in Funka Bay, southwestern Hokkaido, Japan [25], the Bay of Plenty, and on eastern coast of New Zealand's North Island [26].

This study focuses on determining the suitability area of Groupers cultivation in floating net cages in Kepulauan Seribu using RS and GIS. Remote sensing data in the form of Landsat 8 satellite imagery data is used to identify sea surface temperature and salinity as a requirement for determining the location. GIS is used to analyze parameters, such as water quality and environmental conditions. Determination of the suitability of the location obtained from the analysis of the relationship between parameters (water quality and environmental conditions) and the amount of production of Groupers at the location of FNC placement.

II. Material and Method

This study aims to determine the suitability of the area in the location of the floating net cages of Kepulauan Seribu. Therefore, the variables used to consist of water quality and oceanographic variables, i.e., salinity, pH, and dissolved oxygen, referring to the condition of Grouper life [9]. Therefore oceanographic variables consist of sea surface temperature, depth, and current velocity.

Primary data used are Grouper cultivation production data in Kepulauan Seribu, water quality, and oceanographic data. Primary data were obtained from field surveys by measuring *in situ*, plotting the location of the floating net cage. In addition to primary data, secondary data is also needed from relevant agencies. The secondary data consist of temperature, salinity obtained from Landsat April 8, 2018, image, depth, current velocity, pH, and dissolved oxygen from Marine Fisheries Research Center 2017. The field survey was conducted on 26-29 April 2018 in Kepulauan Seribu District. The time for doing the field survey is to be as close as possible to the time of downloading the image and processing of sea surface temperature and salinity data on April 1, 2018.

Before the field survey for the measurement process, Landsat 8 image processing on April 1, 2018, was the first extraction of image values for sea surface temperature and salinity, which was then processed using *overlay* technique. The value of the sea surface temperature is found by using an algorithm, which is by entering channels 10 and 11 as the water area, while salinity value uses an algorithm [27].

Sea surface temperature algorithm [28] is as follows:

$$L\lambda = ML \; x \; QCAL + AL \quad (1)$$

$$TR = K\,2 \ln (K\,1\, L\lambda + 1) \quad (2)$$

Where:
Lλ = spectral radiance (wm-2 sr-1 μ m-1)
ML = scale factor
QCAL = digital value (DN)
A = adding factor
TR = radian temperature (K)
K1 and K2 = calibration constants 1 and 2
Salinity algorithm [27] is as follows:

$$Sln = 29{,}983 + 165{,}047\,(B2) - 260.227(B3) + 2.609\,(B4) \quad (3)$$

Where:
Sln = Salinity (ppt)
B2 = reflectance value of channel 2 (blue) from Landsat 8
B3= reflectance value of channel 3 (green) from Landsat 8
B4 = reflectance value of channel 4 (red) from Landsat 8

This algorithm is used based on assuming the depth and distance from the coast of the observation point is not much different from this study.

After the sea surface temperature and salinity values are obtained, then the overlay becomes the conformity zone as the basis for determining the sample point from the field survey. The sample point boundary of the island [29] was determined using a buffer of 250 meters, 500 meters, and more than 1000 meters. The field survey aims to validate and measure water quality, oceanographic parameters, and tagging the location of floating net cages in the Kepulauan Seribu.

As a basis for considering the influence of the variables that determine the success of cultivation [30] next, use the weights and scores of measurement data in Table 1. Furthermore, giving values 1, 3, and 5 following the specified criteria and limits. If the measurement result of a physics-chemical parameter of the waters is in optimum condition, then the score given is high, i.e., 5.

TABLE I
CRITERIA OF MATRIX SUITABILITY (SOURCE: DATA PROCESSING, 2018)

Parameter	VS			S		US	
	Weight	Score	Total	Score	Score	Score	Score
Salinity	2	5	10	3	6	1	2
DO	2	5	10	3	6	1	2
Ph	1	5	5	3	3	1	1
Temperature	2	5	10	3	6	1	2
Depth	3	5	15	3	9	1	3
Current Velocity	3	5	15	3	9	1	3

Note: VS: Very Suitable, S: Suitable, US: Un-Suitable

On the contrary, if the measurement result is at the less optimum limit, then the score given is lower, i.e., 1 or 3. From the calculation above, the class of conformity parameters of water quality and ocean oceanography can be obtained as presented in Table 2 by summing all value of each parameter, then sorting its suitability class. Table 3 shows how water quality and oceanographic classification are categorized to determine the suitability of Grouper cultivation areas.

TABLE II
CLASS VALUE AND SUITABILITY RATE [31]

Total Score	Class Value	Suitability Rate
52-65	1	Very Suitable=VS
26-52	2	Suitable=S
13- < 26	3	Un-Suitable=US

TABLE III
CLASSIFICATION AND SCORING [32]

Parameters	Range	Rating (A)	Percentage (B)	Score (AxB)
Salinity (ppt)	30 - 35	5	2	10
	20 - 30	3		6
	<20 & >35	1		2
pH	6,5 - 8,5	5	1	5
	4 - 6,4 & 8,5 - 9	3		3
	<4 & >9,5	1		1
DO (mg/l)	>6	5	2	10
	4 - 6 & 8,5 - 9	3		6
	<4 & >9,5	1		2
Temperature (Celcius)	28 - 30	5	2	10
	25 - 27 & 31 - 32	3		6
	< 25 & >32	1		2
Depth (meter)	15 - 25	5	3	15
	5 - 15 & 26 - 35	3		9
	<5 & >35	1		3
Current Velocity (m/s)	20 - 50	5	3	15
	10 - 19 & 51 - 75	3		9
	<10 & >75	1		3

III. RESULTS AND DISCUSSION

Kepulauan Seribu has 13 fish farming groups (Pokdakan), each manages their own floating net cage in groups. Pokdakan in Kelapa Dua Island consists of Pokdakan Mandiri and Pokdakan Samudera Kerapu. In Panggang Island, it consists of Pokdakan West Park, Pokdakan Pelangi, and Pokdakan Kerapu Cantik. In Lancang Island it consists of Pokdakan Barakuda, Pokdakan Lancang Kuning, Pokdakan Pasir Putih, Pokdakan Usaha Baru and Pokdakan Kerapu Selatan. In Pari Island it consists of Pokdakan Pari Indah and in Tidung Island it consists of Pokdakan Tidung Mandiri and Pokdakan Mina Taruna Muda.

A. Area Compatibility Location of *FNC*

The image processing results before the field survey showed that the location of the FNC was in an unsuitable area or vice versa. Initial image processing only includes the extraction of sea surface temperature and salinity values. Furthermore, based on field measurement and calculation of conformity criteria score, it is known that 8 of the 13 FNC locations have very suitable values, and only 5 FNC locations are categorized in the appropriate classes. There are no FNC locations that have inappropriate classes, as in Table 4, Table 5 shows the classification of each Island according to the water quality measurement and scoring.

Spatially, the grouping of results is based on sub-districts, namely North Kepulauan Seribu and South Kepulauan Seribu sub-districts. From Table 4 and (e.g., Fig. 1), it is known that spatially increases as it inclines to the south of the Kepulauan Seribu, increasingly unsuitable for water quality and oceanography for Grouper cultivation in floating net cage systems. Increasingly south, the Kepulauan Seribu region is frequently affected by currents from the Jakarta Bay, which carry waste from the Jakarta mainland.

TABLE IV
SCORING OF WATER QUALITY AND OCEANOGRAPHIC PARAMETERS

No. FNC	Salinity	DO	pH	Temperature	Depth	Current Velocity
1	10	10	5	10	15	9
2	10	10	5	10	15	9
3	10	10	5	10	9	9
4	6	10	5	10	15	9
5	10	10	5	6	15	9
6	6	6	5	6	9	15
7	6	10	5	3	9	15
8	6	10	5	6	15	15
9	2	6	5	6	15	15
10	10	6	5	10	9	15
11	10	10	5	6	9	15
12	10	6	5	10	9	9
13	10	10	5	6	9	9

TABLE V
CLASSIFICATION OF SUITABILITY EACH FNC

No. FNC	Location	Total Score	Class
1	Kelapa Dua Island	59	Very Suitable
2	Kelapa Dua Island	59	Very Suitable
3	Panggang Island	53	Suitable
4	Panggang Island	55	Suitable
5	Panggang Island	55	Suitable
6	Lancang Island	47	Suitable
7	Lancang Island	48	Suitable
8	Lancang Island	57	Suitable
9	Lancang Island	49	Suitable
10	Lancang Island	55	Suitable
11	Pari Island	55	Suitable
12	Tidung Island	49	Suitable
13	Tidung Island	49	Suitable

B. *Grouper Production in the Kepulauan Seribu Utara District*

The results of water quality and oceanographic measurements in the North Kepulauan Seribu, which consist of Kelapa Dua Island and Panggang Island, show that they are categorized as very precise and precise. The FNC location on Kelapa Dua Island has water quality and oceanographic parameters that are very suitable for Grouper cultivation. The site of the FNC is far from the settlement, and the harbor or dock also supports the suitability of the Grouper cultivation area. Meanwhile, the FNC location on Panggang Island has above-average water quality, which is suitable for Grouper cultivation. There are 2 FNCs with qualified sea surface temperature and salinity. Seen from the characteristics of the FNC location from the oceanography, which is only in the appropriate class; this is because the FNC location is in the proper depth. The depth has a very high weight to determine the suitability of Grouper cultivation (See Fig. 1).

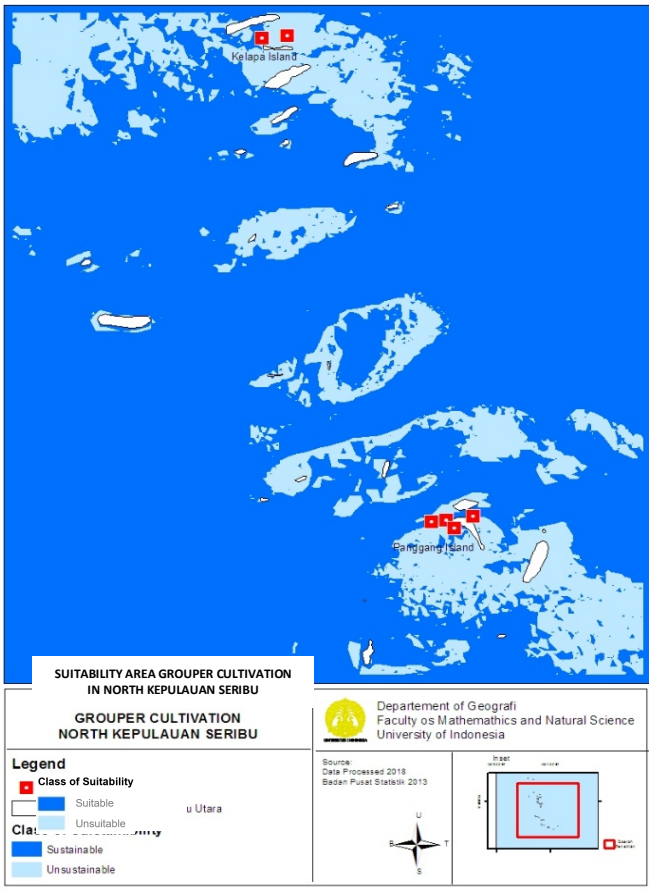

Fig. 1 Suitability Area in Kepulauan Seribu Utara

Fish cultivation activities by residents in Kelapa Dua Island are carried out by two fish cultivation groups (*Pokdakan*), namely Mandiri Pokdakan and Pokdakan Samudera Grouper. In addition to the two *Pokdakan*, On Kelapa Dua Island, private companies work on KJA. Fig 2 shows the Grouper production results from 2 sample groups in Kelapa Dua Island in 2017. Fig 2 shows that the Mandiri Pokdakan cultivates more types of Grouper fish than Samudera Kerapu Pokdakan. However, Samudera Kerapu Pokdakan produces the most Cantang Grouper. In one year, both *Pokdakan* can harvest once to two months. The length of time waiting for harvest depends on the type of Grouper fish cultivated and the time of storage of the seeds.

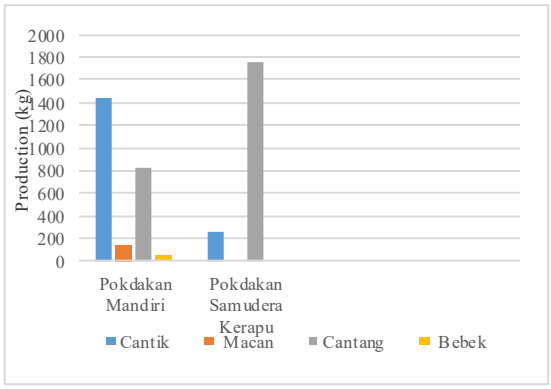

Fig. 2 Grouper Production on Kelapa Dua Island (kg) in 2017

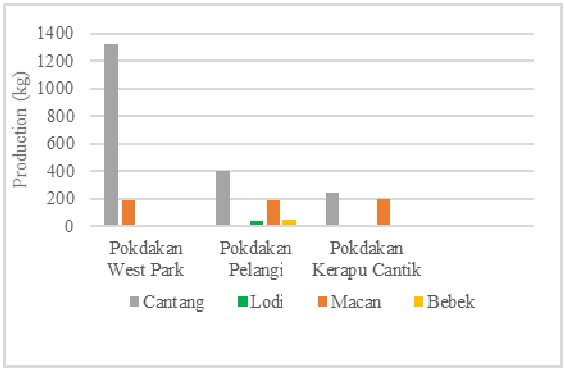

Fig. 3 Grouper Production on Panggang Island (kg) in 2017

In Panggang Island, there are three Grouper Cultivation Pokdakan, namely West Park *Pokdakan*, Pelangi Rainbow Pokdakan, and Beautiful Grouper Pokdakan. Fig 3 shows the results of the three *Pokdakan* productions in 2017. On Panggang Island, there is Fisheries College, which helps *Pokdakan* to optimize Grouper cultivation activities. Fig 3 shows that the most Grouper production on Panggang Island in 2017 was the Cantang Grouper species. Pokdakan Pelangi is the most *Pokdakan* that produces various types of Grouper.

C. *Grouper Production in the Kepulauan Seribu Selatan District*

The islands observed in Kepulauan Seribu District include Tidung Island, Lancang Island, and Pari Island. The data measurement and analysis show that the whole Island has water quality and oceanographic parameters suitable for Grouper cultivation. However, in detail, the water quality and oceanographic conditions of each Island vary (See Table 4 and Fig 4).

The results of the suitability analysis of the waters of the Grouper producing Island show that the condition of water quality decreases when approaching Jakarta waters. Bay due to contamination with household waste and other liquid waste. Tidung has appropriate water quality, but the depth and current oceanographic conditions are only classified accordingly. The waters of Tidung Island have water quality that is quite suitable for NFC locations. However, the depth and requirements of oceanography are currently only suitable because the position of the FNC is affected by

current fluctuations due to its location between the Love Bridge (Love Bridge), which is a bridge between Tidung Besar Island and Tidung Kecil Island.

Grouper cultivation activities FNC system is done in Pulau Tidung Besar by two Pokdakans, namely; Pokdakan Tidung Mandiri and Pokdakan Mina Taruna Mandiri. Tidung Island has about 60% of the area suitable for the FNC system Grouper cultivation, and 40% of FNC location is in the village on the Island of Pulau Pari and Lancang Island. Pari Island has about 84% of the area, which is well suitable for FNC system Grouper cultivation and 16% Suitable territory. Despite having a reasonably high suitability area for the Grouper cultivation, the cultivation in Pari Island appears to be passive. On Pari Island, two FNCs appear to be empty without any activity. Pokdakan on Pari Island only processes the FNC locations that are still active. Based on the results of in situ measurements, the FNC is in a very appropriate place. This is because Pari Island is a tourist destination for residents of DKI Jakarta. Also, Pari Island has tourism activities that tend to be active, so the public appeal is more on tourist management than fish farming.

From (e.g., Fig. 4) shows that spatially further away from the mainland, it becomes increasingly inappropriate because the waters are becoming deeper, although the FNC for Grouper cultivation only needed 5-25 meters. The seas and beaches of Pari Island at the time of the survey showed that there was much rubbish so that the conditions were not suitable for Grouper cultivation.

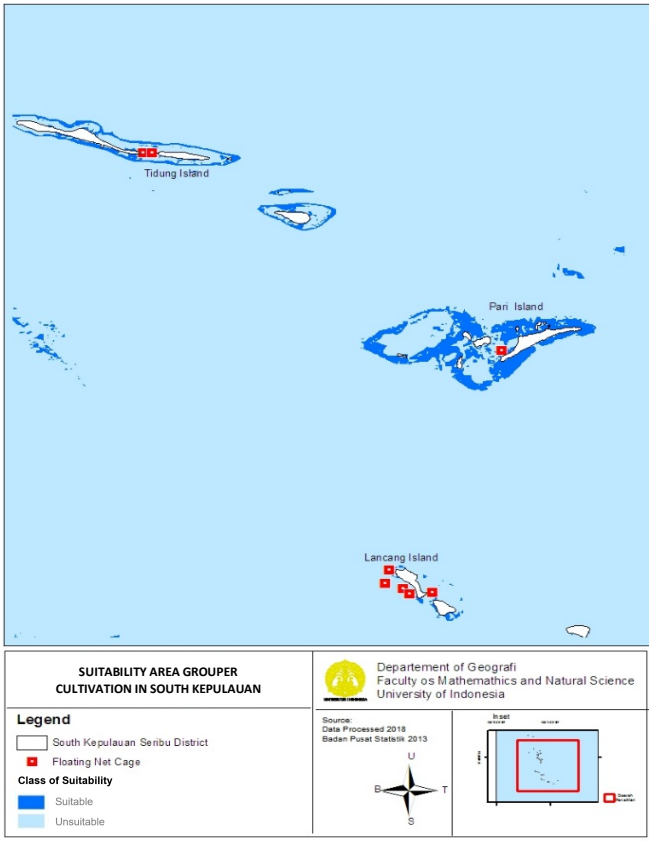

Fig. 4 Suitability Area in Kepulauan Seribu Selatan

There is a difference between secondary data processing and *in situ* measurements at the second sample point. Data processing results show that the area does not match with the criteria, but the results of in situ measurements are an appropriate criterion. Samples 1 and 2 are applicable criteria. The pretest preview image processing looks like a very suitable area. Still, on the field survey, the location is at the dock of Tidung island, whose water quality is currently very inappropriate because of contamination by ship fuel and waste disposal from the settlements.

Tidung Island in the Kepulauan Seribu Selatan District consists of Tidung Besar Island, Tidung Kecil Island, Payung Island and other smaller islands. Grouper fish farming activities on Tidung Island are carried out by two Pokdakan, namely Pokdakan Tidung Mandiri and Pokdakan Mina Taruna Muda. KJA location there is located between Tidung Besar Island and Tidung Kecil Island. On Tidung Island, there is a Fish Seed Hall, a place for spawning or enlarging fish seed assistance from the government. The most Grouper production of these two groups is Cantang Grouper (e.g., Fig. 5).

Similar to other Pokdakan in both the Kepulauan Seribu Utara and Kepulauan Seribu Selatan, it can be seen that the most Grouper production on Lancang Island and Pari Island is Cantang Grouper (e.g., Fig. 6 and Fig. 7). There are 5 pokdakan in Lancang Island, namely Barakuda Pokdakan, Yellow Lancang Pokdakan, South Grouper Pokdakan, Pasir Putih Pokdakan and New Business Pokdakan. Lancang Island has more active Grouper aquaculture activities than Pari Island.

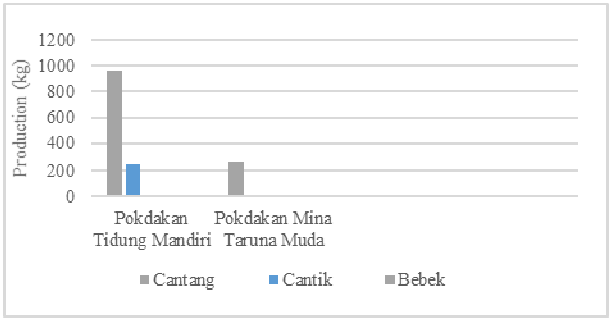

Fig. 5 Grouper Production on Tidung Island (kg) in 2017

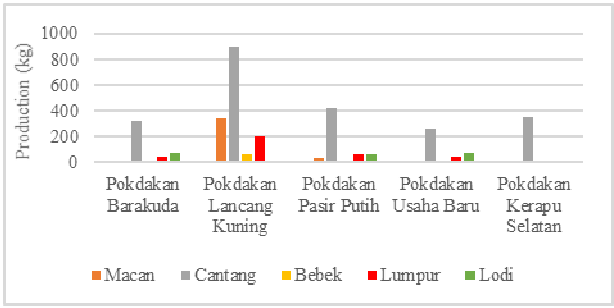

Fig. 6 Grouper Production on Lancang Island (kg) in 2017

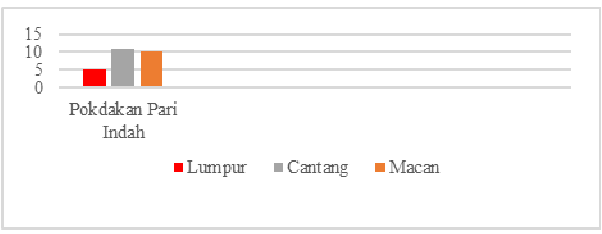

Fig. 7 Grouper Production on Pari Island (kg) in 2017

On Pari Island, the economic activities of the population tend to be more active in the field of tourism compared to fish farming. There is only one active Pokdakan on Pari Island, namely Pokdakan Pari Indah. This Pokdakan is the oldest pokdakan in the Kepulauan Seribu. Pokdakan Pari Indah only produces small amounts of Grouper and is only sold to local tourists.

Distance factors from drains, ship crossings, and settlements can influence water quality such as pH, salinity, and dissolved oxygen levels, which are essential factors for Grouper living conditions. The selection of the FNC location determines the productivity of aquaculture activities in the Kepulauan Seribu District. The small islands around the FNC location protect the FNC from high waves and fast currents. The wave conditions and water currents make it difficult for fish to adapt and can cause death.

Grouper production and FNC location do not have a strong relationship. Other factors such as FNC management, the number of seeds stocked at the beginning of hatchery, the number of fish species being cultivated, or other conditional factors such as fish mortality or Pokdakan inactivity to renew the farmed fish species affect the amount of Grouper production. However, the suitability of FNC greatly influences the many kinds of Grouper that can be cultivated.

IV. Conclusion

The waters suitable for Grouper cultivation locations in FNC in the Kepulauan Seribu District with Very Suitable categories are found on Kelapa Dua Island, Panggang Island. Meanwhile, on Lancang Island and Tidung Island, there are corresponding regions. Spatially the location of Grouper cultivation in the south of the Kepulauan Seribu is less appropriate. The quality of the waters of the Kepulauan Seribu, whose site is getting closer to Jakarta Bay, is getting worse. The location of FNC that is very suitable is at a distance of 250-500 meters from the beach because its depth is still categorized as suitable for Grouper cultivation, not too shallow but not too deep. Driving factors of production, such as KJA management, the number of seeds stocked at the beginning of hatchery, the number of fish species being cultivated, or other conditional factors such as fish mortality or Pokdakan's inactivity to renew the cultivated fish species affect the amount of Grouper fish production.

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