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Carrying Capacity of Mantang Sub District Waters Bintan District, Riau Islands Province for Aquaculture Activities in Floating Net Cages

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Abstract: ***Observations were conducted during four months from November 2013 to February 2014 to determine the carrying capacity of Mantang Sub district waters for aquaculture activities based on the parameters of physics, chemistry and plankton abundance as bio indicators and estimate the impact on economy and ecology in the development of aquaculture in coastal areas. The sources of data in this research were obtained from the determination of sampling locations for 6 stations, the analysis of waters existing was carried out by the measurement of physical, chemical and biological parameters as well as the carrying capacity for floating net cages with phosphorus method.The analysis results of waters environmental existing of Mantang sub district are still in good condition that is adapted to Government Regulation No. 51/2004 where the parameters of temperature, pH and DO still below the Quality Standard but for Phosphate parameter have shown an alarming condition. Stations that can not be developed for aquaculture activity are Mantang baru Island, Pasir Merah Island and Alang Island. While the calculation of the waters environmental carrying capacity of Mantang sub district is still able to accommodate 650 units of cage.***

Keywords: Carrying Capacity, Phosphorus Method, Mantang Sub District Waters, Bintan District, Riau Islands Province

1. Introduction

Marine culture is one of the utilization of coastal waters to nurture the various types of marine organisms that have high economic values as much as possible (Dahuri et al, 2002). Bintan has a very long coastline. Almost 90% of this district coastline is deserve to be used as a commercial marine culture. These conditions support very large potential for marine culture in Bintan district and spread evenly in almost every sub district. Marine culture development is supported by strait and lagon bay waters that suitable for fish nurture in floating net cages or brackets step systems (DKP Bintan, 2009).

Mantang sub district included in the Provincial Government of Riau Islands, has implemented various efforts in the economic development sector, especially marine and fisheries. Through that development much progress has been made in order to improve the lives of people. However, there are many programs and activities that need to be developed.

Nevertheless, aqua culture activities that carried out without considering the principles of sustainable development can resulting impact on the Mantang sub district. Development planning of sustainable aquaculture become important related to the carrying capacity of Mantang sub district. Because technically sustainable development in the context of fisheries and marine resource management is defined as an effort to use natural resources and which contained in fisheries and marine areas for human being, especially stakeholders, so that the use of natural resources and environmental services does not exceed the carrying capacity of fisheries and marine areas to provide it.

The concept of waters carrying capacity can be interpreted as a maximum condition of ecosystems to accommodate biotic components that contained there in (Odum, 1993). In other words, the condition of a particular resource that is contained in such marine ecosystem will vary from year to year due to the influence of the biotic and abiotic factors and the influence of interspecies in the ecosystem.

The aim of this observation is to conduct an analysis toward the carrying capacity of waters and its areas in Mantang sub district for aquaculture activities in floating net cages especially water quality and socio-economic in fish farmers. Specifically, this observation aims to analyze the environmental carrying capacity of Mantang sub district waters that can be used for sustainable aquaculture, to know the number of cages development for sustainable aquaculture activities in the Mantang sub district and to estimate the impact on the economy and ecology of aquaculture development in coastal areas.

2. Methods

This observation was conducted on November 2013 to February 2014, the analysis of the field performed in the Mantang sub district waters, Bintan district, Riau Islands Province, while laboratory analysis performed at the Laboratory of Ecology and Waters Environmental Management Faculty of Fisheries and Marine Sciences University of Riau Pekanbaru.

Sampling was using field survey methods where the areas of aquaculture in floating net cages as the main focus of observation. Primary data collection includes data on the water quality of Mantang sub district waters with sampling and laboratory analysis methods and performed every month as well as water sampling performed 3 times

replicates at each station with the study period during 4 (four) months. The secondary data obtained by field survey questionnaire that was made and distributed to every fish farmers in every station and conduct the interview with relevant instances that support the achievement of the aims and objectives of the observation.

The Location of observation was in Mantang sub district waters which includes 6 stations such as station I around Sirai Island, Station II around Belakang Sidi Island, Station III around Kekep Island, station IV around Mantang Baru Village, Station V around Pasir Merah Village and Station VI around Alang Island. The location of research stations was determined based on high intensity of fish farming with floating net cages (FNC) system, FNC location close to population centers and the waters of shipping lanes which are suspected as a source of contaminants.

Storet method is a common method used to determine the water quality status. In principle, the Storet method compare water quality data with water quality standards that are tailored to the designation.This observation of water quality analyzes is adjusted to Kepmen–LH number 51 of 2004 on marine water quality standards for aquatic biota.

3. Results and Discussion

Physical parameters

Temperature

The results of temperature measurement ranges between 28-31^{0}C, the lowest temperature was during the rainy season on November to December ranges 28-30^{0}C and the highest was in the dry season on January and February ranges 28 to 31^{0}C. Temperature range at all observation stations had the same tendency that the temperature increases and decreases as the seasons change.

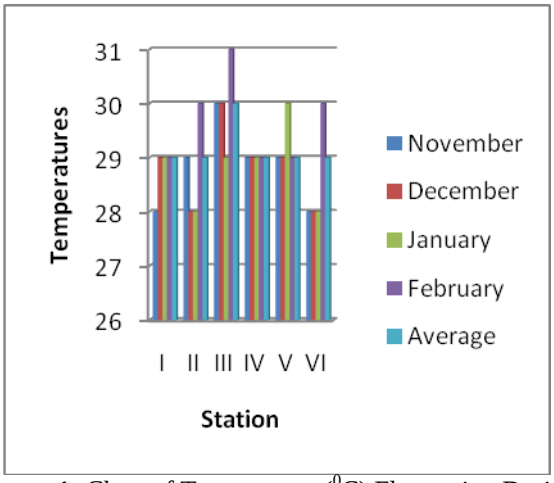


Figure 1: Chart of Temperature (^{0}C) Fluctuation During Observation

The water temperature was influenced by climatic conditions and weather of observations. observation on November and December was a transitional season with erratic temperatures or tend to be unstable where the temperature fell to a minimum and also coincides with the hard wind and heavy rainfall so that the value of the surface temperature on November-December was lower than on January and February, which was the beginning of the dry season. This is in accordance with the statement of Effendi (2003) which states that the temperature of waters is influenced by season, latitude, altitude from sea level, long exposure of the sun, air circulation, cloud cover and waters depth and flow.

Brightness

Brightness measurement results using secchi disc on the whole of observation station from month to month have comparatively variations with values ranging between 290-560cm or 2.9-5.6m. The average of brightness observed in low levels allegedly in Belakang Sidi waters get increased suspended solids in the water originating from the surrounding environment such as residential wastes, sludge particles of ocean flowings. Brightness values of Mantang sub district waters was generally in tolerable limit.

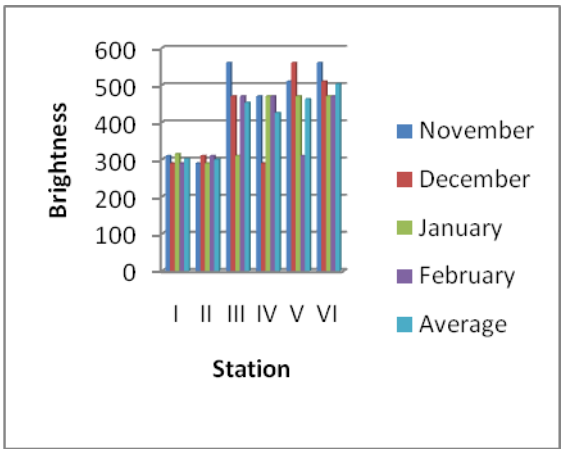


Figure 2: Chart of Brightness Fluctuation During Observation

The average value of the brightness in Mantang sub district waters on a monthly sampling was fair to support life of aquatic organisms that was in accordance to the provisions of Kep. MEN LH no.51 of 2004 set the brightness limit for waters with coral reef ecosystems is >5 m and >3 m for seagrass ecosystems.

Flow Velocity

Flow velocity measurement results of observation stations throughout the month to month has relative variation value of the speed range 0,15 to 0,51m/sec. Flow velocity Mantang sub district waters greatly influenced by the type of landscape, rock type and rainfall. The larger the size of the rock and the more rainfall, the water movement getting stronger and flow speeds faster (Effendi, 2003).

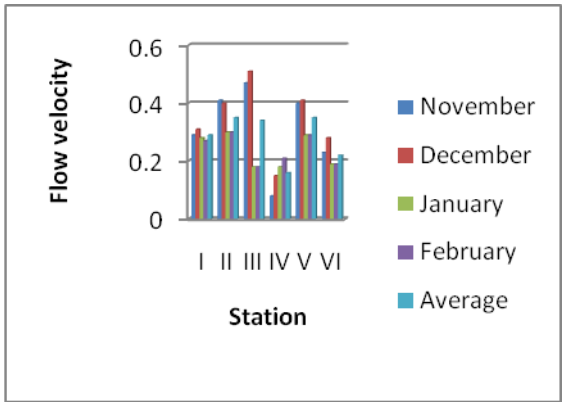


Figure 3: Chart of Flow velocity Fluctuation During Observation

In general, Mantang sub district waters can be classified as moderate flowing waters and ST4 and ST6 includes as slow flowing waters, adjusted to the results of BRKP Maros research (2004) that the flow velocity 0-25cm/sec are classified slow flowing, flow velocity of 25-50cm/sec are classified moderate flowing, flow velocity 50-100cm/sec are classified fast flowing and flow velocity>100cm/sec are classified very fast.

Chemical Parameters

pH

pH is a parameter that is used to determine the chemical nature of the compounds contained in the water, especially to determine the nature of the acid or base. pH is also one of the chemical properties of waters that have an important role in the life of aquatic organisms.

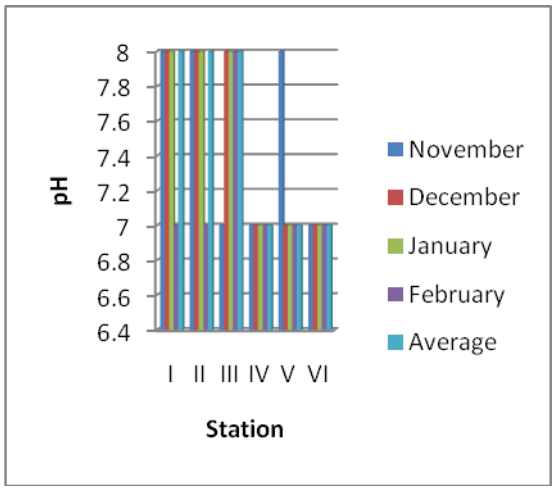


Figure 4: Chart of pH Fluctuation During Observation

pH value of Mantang sub district waters during the observation ranged from 7-8. The Results of this observation showed that the pH value of Mantang sub district waters can be classified tolerable and still able to support the life of aquatic organisms. Brine water has a relatively stable pH value and typically ranges from 7, 5 to 8,4.

Dissolved Oxygen (DO)

Dissolved oxygen levels in Mantang sub district waters during the observation the average range was 3,69–6,08 mg/l.

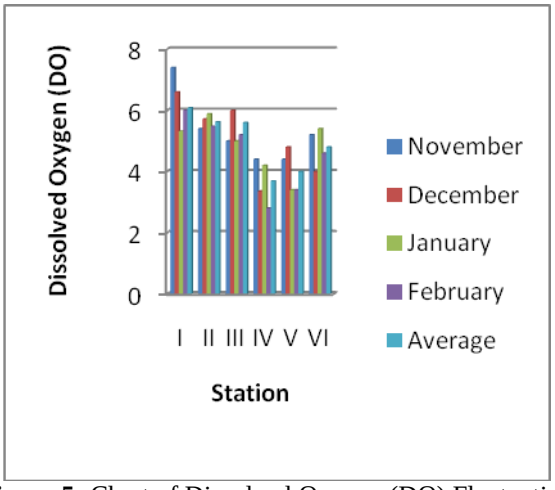
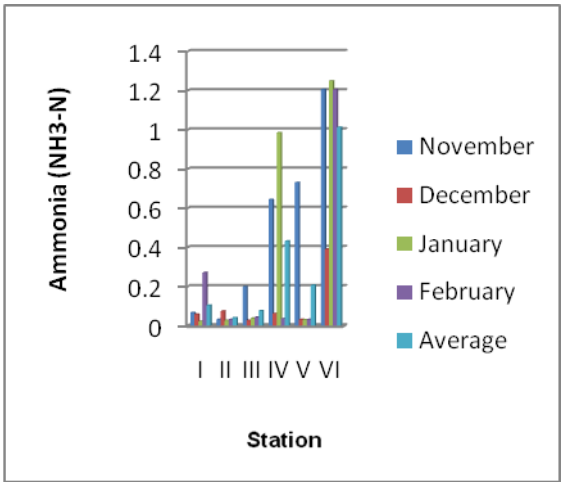


Figure 5: Chart of Dissolved Oxygen (DO) Fluctuation During Observation

Over all concentration of oxygen contained along Mantang sub district waters showed the value that still support aquatic organisms life. For the benefit of marine fish farming, tolerable dissolved oxygen is 5-8 ppm (Hastings and Botsford, 2003).

Ammonia (NH3-N)

The results of ammonia (NH3-N) measurement throughout the observation stations from month to month ranging from 0,023-1,250 mg/l. This means that the value of ammonia in Mantang sub district waters still fairly safe for marine life and is not toxic to aquatic organisms and indicate had not occurrence contamination of organic material derived from domestic waste.



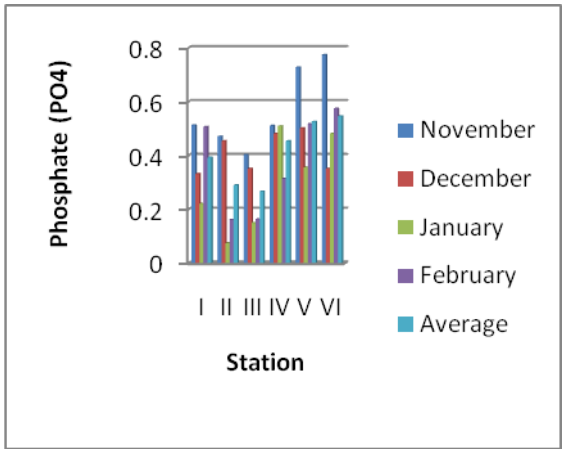
Figuer 6: Chart of Ammonia (NH3-N) Fluctuation during Observation

High and low values of ammonia contained in Mantang sub district waters allegedly affected by the presence of both organic waste disposal of household waste and industrial waste. November-December is rainy season

period which making high-speed flow that carries the waste in to the waters. The content of ammonia is also produced from feed residue that settles on the bottom of cages and experiencing decay process to produce ammonia. Ammonia on the bottom of cages will rise to the waters surface in the rain because the differences of water temperature.

Phosphate (PO4)

The data of analysis results shows the value of the water quality of total P content in all observation stations ranged between 0,075-0,774 mg/l. According to the water quality standards KepMen LH No.51 year 2004, total of maximum P content recommended is <0.015 mg/L. Thus the total P content had crossed the determined threshold value.



Vertical distribution of total phosphorus at each station tends to increase related to the depth, the deeper waters the higher phosphate content, but the conditions are different every month, getting to the end of the year, the phosphate concentration decreases. The condition was suspected because of the season, the rainy season tends to decrease phosphorus content, it's because the total of phosphorus down to lower layers. Phosphorus dynamics were also influenced by temperature and pH. Rain causes the temperature and pH conditions change.

Nitrate (NO3-N)

The results of nitrate measurements during the observation ranged from 0,198-0,764 mg/l, while the distribution of average values for each station ranged between 0,297-0,491mg/l.

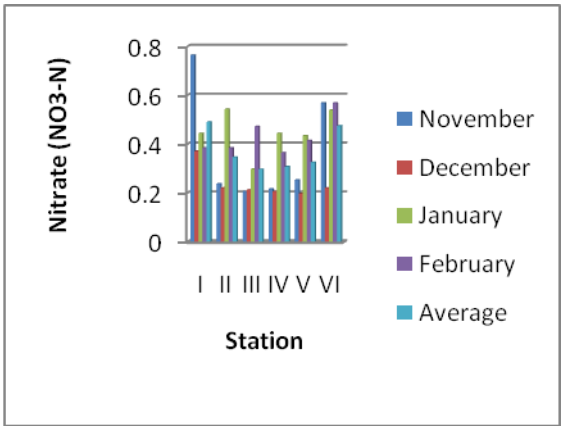


Figure 7: Chart of Phosphate (PO4) Fluctuation During Observation

Nitrate content in waters, can be classified based on the level of fertility, oligotrophic waters have nitrate levels between 0-1mg/l, mesotrophic waters had nitrate levels between1-5mg/l and eutrophic waters have nitrate levels ranging from 5-50mg/l (Garno, 2002). This means that the value of nitrate in waters still in fairly safe limits for marine biota despite leading the occurrence of enrichment of waters but not toxic to aquatic organisms.

Biological Parameters

Abundance of Phytoplankton

The results of phytoplankton abundance throughout the observation stations from month to month with values ranging from 960 – 7920 cell/m. The abundance of plankton obtained on November-December 2013 ranged from 1180-7920 cells/ml and abundance values on January -February 2014 ranged from 960-3480 cells/ml.

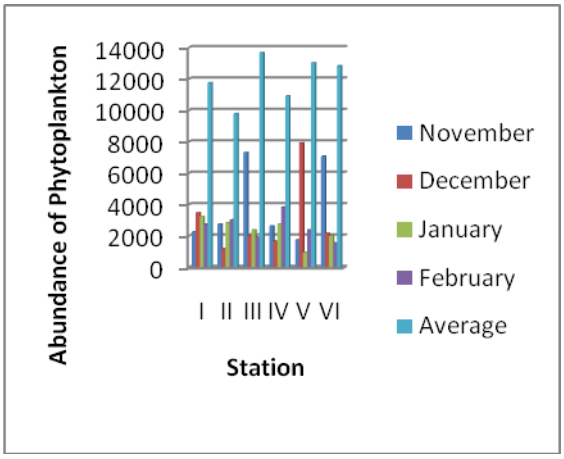


Figure 8: Chart of Phytoplankton Abundance (sel/ml) During Observation

The difference in the abundance values thought to be caused by seasonal factors. On November-December was relatively heavy rainfall (west monsoon) compared with January-February2014. On rainy season more nutrient are available that can be utilized well by plankton.

Evaluation of Water Quality of Mantang Sub District Waters Bintan District

Water Quality

The parameters used in the calculation of Storet index values on this observation was the temperature, which represents the physical parameters, DO, pH and Total P represents the chemical parameters. Evaluation of water quality at each station of observations show that the contribution of pollutants at each station is the total P which value does not meet water quality standards. At each station has its own scores where the score of 4, 5 and 6 are higher compared to the other stations1, 2 and 3.

Table 1: Comparison of Storet Indice Value with Water Quality Standard on Each Station Result of Measurement in the Waters of Mantang Sub District Bintan District

		STATION I						
Parameters	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Physics:								
Suhu (^{0}C)	26 - 32	28	29	29	0	0	0	0
Chemistry:								
pH (mg/l)	7 - 8.5	7	8	8	0	0	0	0
DO	> 5	5.32	7.4	6.08	0	0	0	0
Total P(mg/l)	0.015	0.22	0.51	0.393	-2	-2	-6	-10
Total Score								**-10**

		STATION II						
Parameters	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Physics:								
Suhu (^{0}C)	26 - 32	28	30	29	0	0	0	0
Chemistry:								
pH (mg/l)	7 - 8.5	7	8	8	0	0	0	0
DO	> 5	5.4	5.89	5.62	0	0	0	0
Total P(mg/l)	0.015	0.08	0.47	0.29	-2	-2	-6	-10
Total Score								**-10**

		STATION III						
Parameters	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Physics:								
Suhu (^{0}C)	26 - 32	29	31	30	0	0	0	
Chemistry:								
pH (mg/l)	7 - 8.5	7	8	8	0	0	0	
DO	> 5	5	6	5.6	0	0	0	
Total P(mg/l)	0.015	0.15	0.4	0.267	-2	-2	-6	
Total Score								**-10**

		STATION IV						
Parameters	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Physics:								
Suhu (^{0}C)	26 - 32	29	29	29	0	0	0	
Chemistry:								
pH (mg/l)	7 - 8.5	7	7	7	0	0	0	
DO	> 5	2.8	4.4	3.69	-2	-2	-6	
Total P(mg/l)	0.015	0.31	0.51	0.454	-2	-2	-6	
Total Score								**-20**

		STATION V						
Parameter	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Fisika:								
Suhu (^{0}C)	26 - 32	29	30	29	0	0	0	0
Kimia:								
pH (mg/l)	7 - 8.5	7	8	7	0	0	0	0
DO	> 5	3.4	4.8	4	-2	-2	-6	-10
Total P(mg/l)	0.015	0.36	0.73	0.526	-2	-2	-6	-10
Total Score								**-20**

		STATION VI						
Parameter	*Quality Standard*	*Min.*	*Max.*	*Average*	*Min.*	*Max.*	*Average*	*Score*
Fisika:								
Suhu (^{0}C)	26 - 32	29	30	29	0	0	0	0
Kimia:								
pH (mg/l)	7 - 8.5	7	8	7	0	0	0	0
DO	> 5	3.4	4.8	4	-2	-2	-6	-10
Total P(mg/l)	0.015	0.36	0.73	0.526	-2	-2	-6	-10
Total Score								**-18**

Centralized of fish farming around the settlement like FCN location on Station4, 5 and 6, contributed to the high concentration of total P due to the household activities that generally produce household waste water that flows into FCN location which is a combination of accumulated total P concentration of each the station, while for stations 1, 2 and 3 are rather far from the residential and cultivation that use fish feed. This is in accordance with the opinion of Yosmaniar (2010) that the fish feed is the main ingredient that affects the water environment. Excess of feed in puts in the production process will flow into the water and decay into organic matter.

Carrying Capacity of Mantang Sub District Waters, Bintan for Aquaculture Development In Floating Net Cages

By using storet method according to the suitability of water quality classification of the station, it was known that the more suitable station for the development of cages were carried out at Station 1, Station 2 and Station 3 because the value of the score at the third station is still considered in good condition and lightly polluted. Based on the water quality categories according to the status of quality standards which include oxygen and ammonia levels, and the speed of the flow was still quite good for the whole station, water transparency and nitrate values are in moderate good category and bad percentage classified was phosphate.

The total area of Mantang sub district waters, Bintan district that feasible to FCN aquaculture development for grouper is 5855,45m^2, equivalent to 0,5 ha, based on the feasibility of biotech which determines the physical carrying capacity of water are the temperature, pH, dissolved oxygen and the total of P carrying capacity of the marine environment for development grouper in FCN is 1301,21 tons/year or 650 units for 2 times/year production, the number of cages that are operating in the waters is 155 units, the number of cages that can still be developed further is 495 units of cages with productivity assumption @0,69 tons/cage/season nurture with volume of cages @27m^3 (3x3x3 m). Within cropping pattern 2 times in 1 year, the total production of fish can be generated was equal to 683,1 tons of grouper.

Mantang sub district waters are still tolerable for FCN activity compared with Noor's observation results (2009) The feasible wide of Tamiang Gulf waters for aquaculture development in FCN is 2,340 m^2 or 0,2 ha of the total waters area of 380 ha with a total carrying capacity ranged from 18,8 to 62,5 tons of fish cages and the development of number ranges 80-260 FCN, this number is lower compared with the number of cages in the Mantang sub district waters as by the abundance of plankton can be seen that the waters has an abundant natural feed (plankton organisms) and has not in pressure of pollution.

Socio-Economic Conditions of MantangSub District Society

Population

The fisheries sector is the dominant livelihood for people who living in Mantang sub district coastal areas. Specifically in the Mantang besar village fishing is a livelihood main occupation for the majority of the population. The number of people who work as fishermen as much as 86% and for the aquaculture as much as 13,87% of the number of fishing households in this district.

Economic Impact Estimation Development of FCN in Mantang Sub district

The results of the fish nurture in the Mantang Sub district waters obtained level of productivity is 25.61 kg per cage with a stocking density 11 fish per m^3 in size of fish stocking as much as 200g per fish or 300 fish per cage in which the survival rate can reach100% by the period of nurture for 6 month

In the economic development of floating net cage culture of grouper is promising profits assuming a marketable size of 500g/fish with the level of prices between Rp. 70.000-Rp.120.000 per kg and the total cost between Rp. 90.000 per kg fish then the benefits to be gained Rp. 4.650.527, - cage/month. The assumption of profits are not much different from Noor (2009) who gained Rp.53,379,000,- in FCN aquaculture of Tamiang Gulf waters.

4. Conclusion

The number of active cages as much as 155 units is still in line with the carrying capacity of the waters environment for the development of fish farming in FCN with a total production of 310 tons/year. Waters carrying capacity for the FCN development in Mantang sub district obtained 1.301,21 tonnes of fish/year or about 650 units FCN so that further could be developed as much as 495 units of cages.

The results of the calculation of the Storet index values, water conditions at Station1, 2 and 3 include of classification class B (fair), lightly polluted criteria with a value of-10, while Stations 4, 5 and 6 in classification of

class C (medium), criteria of medium polluted the value of 18-20. Development of Cages can be performed at stations 1, 2 and 3 that is expected to improve the welfare of fishermen through increased business and employment in Mantang sub district.

In terms of social, people livelihood is still dominated by the fisheries sector in general is fisherman (99.87%). In the economic development of floating net cage culture of grouper quite promising with the assumption that the benefits to be obtained Rp. 4,650,527, - cage/month.

Acknowledgements

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