Sys Rev Pharm 2019;10(2):270-278
A multifaceted review journal in the field of pharmacy

Study of Management of Marine Bio-resources of Mahakam Delta Area of East Kalimantan

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Article History: *Submitted: 15.09.2019* *Revised: 23.11.2019* *Accepted: 07.12.2019*

ABSTRACT
The objective of current investigation is to study management method of sustainable marine bio-resources in Mahakam Delta. To attain this objective, relation between aquatic productivity and food availability was focused.This research conducted on northern side coastal area of the delta. The sampling was carried out while keeping in focus different salinity, in the fishing ground and shrimp pond during April 2008 to June 2009. All findings of this study provide significant insights for the practitioners.

Keywords: Aquatic productivity, carbon sources, trophic structure, bio-resources, Mahakam Delta

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DOI: 10.5530/srp.2019.2.36

1. INTRODUCTION

Background of the Study
Mahakam delta is situated in Kutai Kertanegara Regency of East Kalimantan Province. Its water is supplied by Mahakam River. It has been used for various purposes including natural-resources extraction and domestic needs, which are fishery, shrimp pond culture, wood industry, gas and oil exploration, coal mining and for recreation activities. Industrial activities in this area are damaging quality of environment for aquatic ecosystem and fisheries resources.

Mangrove in this area, dominated by Nypa fruticans along with many other species, has been reduced rapidly. Most of its original area has been changed into land during the past decade. In less than two decades, up to 70% of the mangroves, were converted to shrimp ponds. This process mainly characterized by the construction of ponds for international market-driven shrimp farming. The economic crisis of 1997 pushed the people related to shrimp farming to further explore the area in order to generate domestic income from exporting shrimp.

During this activity, Mangrove ecosystems have faced severe degradation. After a small but quick earnings - a large part of which enjoyed by external investors - local people were left with a ruined environment. Water quality has deteriorated in brackish water areas as well as in rivers in the entire Mahakam Delta. Shrimp farming has been plagued by diseases, erosion has occurred in river banks and coastal zones, conflicts over land use had been recurrent and the population of fish and shrimps that used to be abundant in the mangrove areas has been dramatically decreased and consequently, decrease in growth of plankton community. This is expected to affect the productivity and buffering function of intact mangroves, observable shift in the composition and possible reduction in productivity of the coastal fisheries.The ecological linkage between mangrove ecosystem and aquatic food production is of great importance for fishery management. However, the complexity and diversity of natural food webs make it difficult to demonstrate this ecological link.

To deal with these challenges and to promote the sustainable use of coastal resource, we have been working on management of sustainable marine bio-resources based on the environmental analysis, fisheries biology and food web in the coastal area of Mahakam Delta - East Kalimantan. During this research, we have carried out:

1. Monitoring of current condition of Marine Bio-Resources in Mahakam Delta that consists of fishery and aquaculture characteristic.
2. Water quality analysis of mangrove and investigation carried out by using ALOS interpretation.

MATERIAL AND METHOD

Research points
Eight research points were selected in Muara Badak area and Muara Jawa. The point 1, 2, 3 and 4 are located on Muara Badak. The point 5, 6, 7 and 8 are located on Muara Jawa.
Point 1 and 5 are at the river mouth, point 2 and 6 in the water area with the fishing ground, point 3 and 7 in the water area with the shrimp pond, and point 4 and 8 are inside river area. The point 1 and 5 have higher salinity, point 2, 3, 6 and 7 have middle salinity, and point 4 and 8 have lower salinity.

Current Condition of Marine Bio-Resources in Mahakam Delta
Fisheries data collected by Fisheries Management Institutes have been obtained. This data (1980-2004)

was obtained from statistical yearbooks published by the "Dinas Kelautan dan Perikanan" at Samarinda and Tenggarong. Data was used to examine developments in fishes and marine culture, trends in overall productivity of ponds, potential to detect changes in marine production. Identification of trends in pond productivity and changes by pond farmers was examined with data obtained from a survey on the management and productivity of the pond culture conducted by the Faculty of Fisheries and Marine Science, Mulawarman University, Samarinda, commissioned by Total Indonesia.

Fishing information was collected by using 25 fishing methods, but we have categorized the numbers of gears and total fishing methods into the six main categories recorded before 1988: large trawls, small trawls and seines: shrimp trawls, lampara and Danish, beach and purse seines, gill nets: drift nets, encircling nets, shrimp gill nets, stationary gill nets, trammel nets, lift nets: boat/raft nets, bagan, scoop nets, other lift nets and hooks and lines: tuna long lines, long lines, set long lines, other poles and lines, troll lines. A category traps: guiding barriers, stow nets, portable traps, other traps were also included with other categories; shell fish, muro-ami and others recorded only occasionally with low levels of output.

Procedure of the fish sampling was implemented on 4 research points in each area of Muara Badak and Muara Jawa of Mahakam Delta. The productivity of shrimp ponds was estimated by dividing the total annual production and the production by species category with the estimated area of ponds in hectare during that year. Concavity and explained variance of the quadratic and linear terms of significant polynomial models were evaluated to obtain an indication of direction, timing and strength of the reversal in long-term trends. Trends were tested over the period from 1989 onward, when pond opening rates increased dramatically.

An indication of recent change relative to the long-term trend was obtained by examining the short-term trend over the last 5 years. Serial correlation, producing additional variability obscuring long-term trends, was examined in a time-series of shrimp-pond productivity by cross-correlation at lag of one year of the residuals of the linear trend analysis.

Variants of fish community on Muara Badak and Muara Jawa had evaluated using by Student-Test. Population dynamics on Muara Badak had been carried out by Mark and Recapture Method and Schnabel methods.

Analysis of Marine Environmental and Water Quality in Mahakam Delta

The objective of this research is to find the content of heavy metals in water and sediment as an indicator to the stability of aquatic environment. The outcomes of this research is expected to be useful in determining the quality of aquatic environment of Mahakam Delta based on aquatic ecology, and providing this data and information to the policy and decision makers of aquatic resources and fisheries management on Mahakam Delta coastal area-East Kalimantan.

The research was conducted during 2003-2007 on Muara Badak area, northern side of Mahakam Delta Coastal Area, East Kalimantan. The sampling was carried out during each period in 2003-2004, 2004-2005 and 2007. The sampling areas were different than the above-mentioned research points, as it was changed for each period, and 25 sampling points were set up in all. It was performed on the sampling point 1-7 during the period 2003-2004, on sampling point 8-17 during the period 2004-2005, and on the sampling point 18-25 during the period 2007 (Table 3.1).The sampling points were selected with aim to cover all different salinity area in Mahakam Delta.

Table 1. The Location of Sampling Points

Sampling period	Name	Place	Zone division	Salinity	Attendant circumstances
2003-2004	Point 1	Muara Pantuan	Mid river	middle	Shrimp pond site
2003-2004	Point 2	Muara Pantuan	Mid river	middle	
2003-2004	Point 3	Muara Pantuan	River mouth	high	
2003-2004	Point 4	Muara Pantuan	Coastal	high	
2003-2004	Point 5	Tani Baru	Mid river	middle	
2003-2004	Point 6	Tani Baru	River mouth	high	
2003-2004	Point 7	Muara Ilu	River mouth	high	
2004-2005	Point 8	Muara Badak	River mouth	high	
2004-2005	Point 9	Muara Badak	Mid river	middle	
2004-2005	Point 10	Muara Badak	Inside river	low	
2004-2005	Point 11	Muara Badak	Coastal	high	
2004-2005	Point 12	Muara Badak	Coastal	high	
2004-2005	Point 13	Muara Badak	River mouth	high	
2004-2005	Point 14	Muara Badak	Mid river	middle	
2004-2005	Point 15	Muara Badak	Inside river	low	

2004-2005	Point 16	Muara Jawa	Coastal	high	
2004-2005	Point 17	Muara Jawa	Coastal	high	
2007	Point 18	Muara Badak	River mouth	high	
2007	Point 19	Muara Badak	Mid river	middle	Fishing ground site
2007	Point 20	Muara Badak	Mid river	middle	Shrimp pond site
2007	Point 21	Muara Badak	Inside river	low	
2007	Point 22	Muara Jawa	River mouth	high	
2007	Point 23	Muara Jawa	Mid river	middle	Fishing ground site
2007	Point 24	Muara Jawa	Mid river	middle	Shrimp pond site
2007	Point 25	Muara Jawa	Inside river	low	

Measurement of concentration of heavy metals in water samples was performed at College of Bioresources Science, Nihon University using Inductive Couple Plasma, Atomic Emission Spectrometer and Plasma Spectrometer SPS 1700 R. These physical and chemical parameters determine water quality of northern side of Mahakam Delta and measured by Standard Methods for Examination of Water and Wastewater (APHA 1989).

4. RESULTS

Current Condition of Marine Bio-Resources in Mahakam Delta

Improvement of fishing facilities

The fisheries around the delta are small-scale and multi-gear and also have a limited spatial range: at 2002, up to 50% of the vessels are non-motorized; the remaining had diesel engines of < 5 hp or outboard engines (Figure 1). Most gears are more or less stationary: gill nets and traps/barriers each account for about 30% of the gears and lift nets/bagans account for another 18%. The transition of fishing facilities have presented on Figure 2.

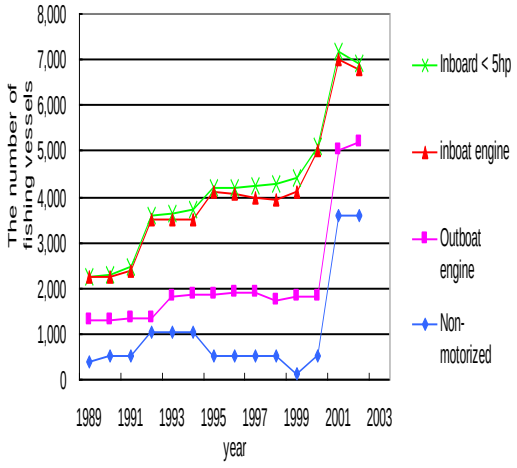

Figure 1. Improvement of of fishing vessels

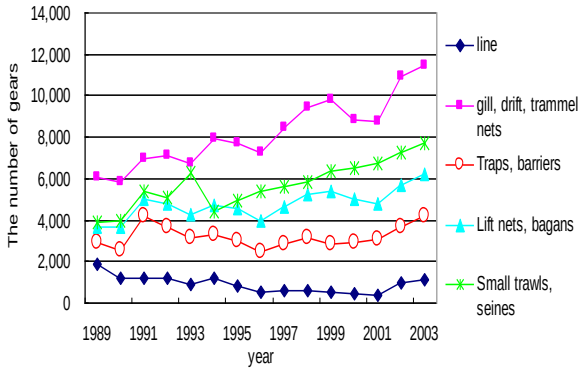

Figure 2. Improvement of fishing devices.

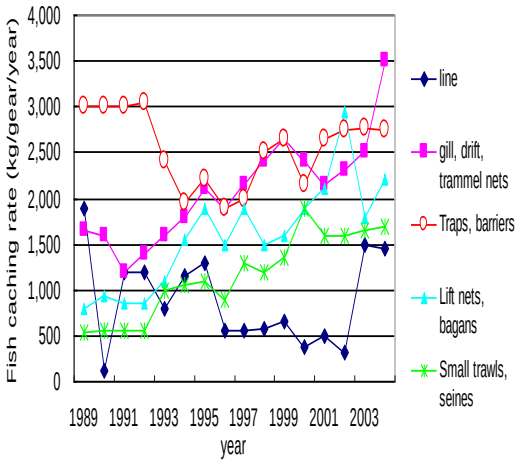

Figure 3. Fluctuation of fishing rate (kg/gear/year)

The active fishing gears, trolls, lines, and trawls each account for about 10% of the gears. The annual catch of 1000–3500 kg/gear/year is comparable with that of any small-scale fishery (Jul-Larsen et al., 2003a). Three gear categories show variation but with increase fishing rates over the past 15 years (gill nets, trawls and lift nets), whereas those of lines and traps also show variation but are stable (Figure 4.3).

Fishing facilities and devices for fishery activities in Mahakam Delta have been increasing every year.

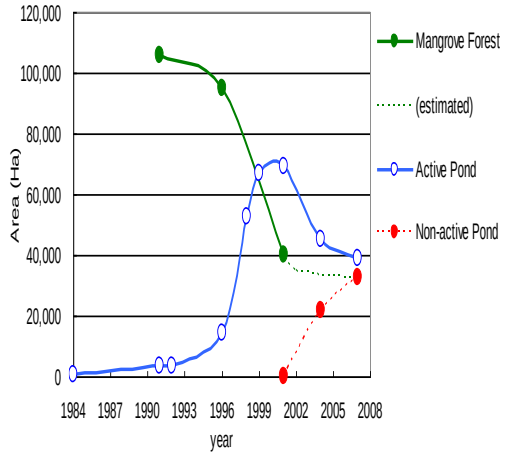

Figure 4: Fishing facilities and devices for fishery activities in Mahakam Delta have been increasing every year.

Modification in used land

Research on modification of used land in Mahakam Delta carried out to find out the changes due to the exploitation of mangrove forest, productive and non-productive shrimppond during 1984-2007. Within 20 years, up to 70% of the mangrove forest of the Mahakam Delta was converted to shrimp ponds, resulting in the destruction of large tracts of essential fish habitat. We can reasonably hypothesize that these rapid changes will be reflected in the daily and annual resource outcome of coastal fishermen and pond farmers as well as in the existing time-series of fisheries monitoring data. The modification of land by which mangrove forest was converted to the shrimp pond was effective until 2001 to raise productivity of the shrimp pond. However, the productive shrimp pond has decreased after a peak of 2001. This suggests the non-productivity shrimp pond had increased.
Deforestation and aquaculture shrimp farming in the Mahakam delta has resulted in loss of productivity of the coastal ecosystem. Fishing and productivity of shrimp farms are declining, which affect the livelihood of coastal users. The unregulated exploitation or lack of ownership enhances the crisis of resource ' s exhaustion. Forests extend along a coastline and are connected by coastal currents, impacts on coastal fisheries may only be noticeable when most of the functional part of the forest would have disappeared. Type, spatial arrangements and connectivity of mangrove forest are important patterns of mangrove–water interface, while tree communities and age of mangrove stands have suggested as affecting the fish and crustacean production.

The transition of fish catching and crustacean productivity

Mangrove forests are important for fish and crustaceans: as a corridor for diadromous species and as nursery, spawning and feeding areas for a host of marine organism species. Conversion to pond changes are essential to the fish and crustacean habitats by closing off areas to the dynamics of sea–river–land interactions. This results in increased cultured production, but there is evidence that it also leads to decrease coastal productivity and diversity.
Research on the transition of fishing and crustacean productivity in Mahakam Delta has been carried out to find out changes of fishing and crustacean production total. The objective of this research also included to known the trend of fishing and crustacean productivity in Mahakam Delta by time series data during 1980 to 2005.

The result of this research showed that total production of fishing, and crustaceans has been decreasing since 1997, especially crustacean productivity on the brackish water pond was lowest until area of Mahakam Delta opened by converting mangrove to shrimp pond. Insufficient data collection, lower variability, poor data quality resulted in high variability in fishery statistics, resulted the potential for detecting changes in marine production. Moreover, the observed trends, variability and shifts in fishing have biological implication. Although a significant shift in fishing towards shorter-lived species took place from 1993 to 1999, almost 4 to 10 years after the start of boom in pond construction, but fishery statistics gave no direct evidence of a trade-off between the pond construction and fisheries.

These changes are cyclical or represent irreversible change related to mangrove habitat destruction or upstream processes in the Mahakam River. Next, fishing patterns -gears used, spatial effort allocation – changed with the increased effort throughout the 1990s as well. Changing fishing patterns at small-scales are often an adaptation to changing fish community structures. Lastly, a certain minimum area of mangrove is necessary for the maintenance of coastal productivity.

The kinds of fishing in Mahakam Delta
Fishing in Mahakam Delta had found 38 fish species. The southern side of the delta have fish species more than northern side. Southern side of the delta had found 31 fish species, and otherwise in northern side had found 22 species. Muara Badak and Muara Jawa area had found 4 fish species such as Leiognathus elongates, Otolithoides sp, Clupea sp and Arius talassinus.

Table 2. The kinds of fish species in Mahakam Delta

No	Scientific Name	Local Name	Research Point								Σ	%
			1	2	3	4	5	6	7	8		
1	*Leiognathus elongatus*	Pepetek/Bete-bete	21	31	39	2	11	9	8	8	129	21.7
2	*Otolithoides sp*	Gulamah	2	12	4	2	14	33	2	1	70	11.8
3	*Clupea sp*	Sembula/Bula-bula	2	2	2	3	1	3	1	4	18	3.0
4	*Valamugil speigleri*	Belanak	1	3	8	28	1	1			42	7.1
5	*Chanda sp*	Beseng/Ceri Tedong	2	4	8	14					28	4.7
6	*Lethrinus spp*	Lencam	1	1	7	15					24	4.0
7	*Arius talassinus*	Mayung/Otek	2	3		6	1	9	19	12	52	8.7
8	*Syllago analis*	Beloso/Kaso	1				24	8	29	27	89	15.0
9	*Cynoglosus sp*	Lidah					1	1	1	1	4	0.7
10	*Anodontostoma chacunda*	Selangat					1	1	1	1	4	0.7
11	*Caranx spp*	Terkulu/Baung	26	4	4		2		1		37	6.2
12	*Rastrelliger neglectus*	Kembung/Peda-peda	8	1		3					12	2.0
13	*Lobotes surinamensis*	Kakap batu	1	1		1		1	1	1	6	1.0
14	*Chanos-chanos*	Bandeng	1				2		1	4	8	1.3
15	*Thryssa satirotris*	Bulu ayam		5	2		4			1	12	2.0
16	*Hemirhampus far*	Julung-julung	1	1			2		1		5	0.8
17	*Sardinella fimbriata*	Tembang	2	2							4	0.7
18	*Epinephelus tauvina Forskal*	Kerapu		3		1					4	0.7
19	*Eleutheronema tetradactylum*	Menangin			1		2		2		5	0.8
20	*Stolephorus indicus*	Teri		1			3		1		5	0.8
21	*Scatophagus argus*	Kipar	1					1	1		3	0.5
22	*Dussumieria sp*	Teri Japuh/ Luray					5			1	6	1.0
23	*Ephinephelus merra*	Kerapu Balong					1		2		3	0.5
24	*Lagocephalus sp*	Buntal						2		1	3	0.5
25	*Upeneus rittatus*	Biji nangka						1		1	2	0.3
26	*Plotosus sp*	Sembilang							1	2	3	0.5
27	*Periopthalmus*	Tempakul							1	2	3	0.5
28	*Arius maculatus*	Berukang							1	1	2	0.3
29	*Drepane punctata*	Tampar Betik	1							2	3	0.5
30	*Decapterus spp*	Layang/Lajang	1								1	0.2
31	*Dasyatis sp*	Pari		1							1	0.2
32	*Cromileptes altivelis*	Kerapu Bebek					1				1	0.2
33	*Platycephalus sp*	Lampa-lampa						1			1	0.2
34	*Trychiurus sp*	Layur						1			1	0.2
35	*Scomberomorus commersonii*	Tenggiri						1			1	0.2
36	*Paratrypauchen microcephalus*	Dato/Com Goby								1	1	0.2
37	*Toxotes jaculatrix*	Sumpit								1	1	0.2
38	*Clupeichtys goniognathus*	Pelipis/Bilis								1	1	0.2
	total										595	

Sumber : Data primer yang diolah, 2006

Point 1-4 is Muara Badak area, point 5-8 is Muara Jawa area
Point 1 and 5: river mouth area, Point 2 and 6: waters have fishing ground area
Point 3 and 7: waters have shrimp pond area, Point 4 and 8: inside of river

DISCUSSION

Facilities and devices for fishery activities in Mahakam Delta have been increasing every year. The modification in fishing facilities and devices have not significantly increased fishing rate. Land used by mangrove forest converted to shrimp pond is a major reason of increase in productivity of shrimp pond in Mahakam Delta since 2001. Decrease in Productivity of the shrimp-pond in Mahakam is caused by mangrove degradation and increase in non-productivity of the shrimp-pond.

The outcomes of research showed that total production of fish catching, and crustaceans had been decreasing since 1997, especially for crustacean productivity on the brackish water pond have lowest productivity until area of Mahakam Delta made available by converting mangrove to shrimp pond. Standard criteria to monitor environment quality for living organism and aquaculture activities confirm that analysis of physics and chemical characteristics of water on Mahakam Delta still indicate good conditions, which can support living organism. Muara Badak coastal area, has been an important fishing ground since old time. The mangrove ecosystem of Mahakam Delta has been supplying most quantity of nutrient for the coastal area, including Muara Badak coastal area, which located on the northern side of Mahakam Delta. Recently, most of Mangrove ecosystem area in Mahakam Delta has been converted to the brackish pond, and consequently to the growth of plankton community.

Deforestation and aquaculture (shrimp farming) in the Mahakam delta have resulted in loss of productive functions of the coastal ecosystem. Fishing and productivity of shrimp farms are declining, which affect the livelihood of coastal users. Unregulated access and lack of ownership over resources further enhances resource degradation. Deforestation and aquaculture (shrimp farming) in the Mahakam delta has resulted in loss of productivity of the coastal ecosystem. Fishing and shrimp farming are declining, which affect the livelihood of coastal users including fishermen, fish farmers and other stakeholders.

In the Mahakam Delta, ability to detect any change in related indicators is limited, while high variation in individual outcome also limits the utility of local observations of fishermen and shrimp-pond farmers. The acceptance of measures to protect mangrove habitat could be limited, because any positive impact will be difficult to observe in the short term on a local level as well as on cumulative fishery statistics, limiting their use for evaluation of impacts. Over the long term, application of monitoring data appears quite effective, but further improvement in data quality and capacity to evaluate information will increase diagnostic capacity. Challenge is to design methods for informed decision-making process with limited available data in a spatially and temporally complex environment with a high fish and crustacean diversity. Better utilization of existing data, information and knowledge will facilitate in improvement of evaluation capacity of those involved in management of coastal resources.

CONCLUSION

Transition of land used by mangrove forest has converted into shrimp pond, which have affected productivity of shrimp pond in Mahakam Delta. Productivity of shrimp-pond and fisheries in Mahakam Delta have been decreasing after2001, caused by mangrove degradation converted to shrimp-pond.

From 1980 to 2001, total pond area undergoes rapid changes by opening reconstructed shrimp-pond in Mahakam Delta. Since 2001, there has been increase in areas for non-productive shrimp pond. Estimation of development of total pond area based on interpretations of satellite imagery and aerial photography and interpretations of maps, including mangrove degradation area. Despite this, it can be concluded that in 2004 at least 50–70% of the total brackish and saltwater mangrove had converted.

To repair mangrove degradation and to promote the sustainable use of the coastal resource's management, mangrove rehabilitation is very important. The mangrove management and rehabilitation can be applied by seedling plantation in mangrove. To increase aquatic productivity and promote sustainable use of the aquaculture shrimp-pond in Mahakam Delta-East Kalimantan, design and application of management method using by Silvo-fishery programhas been recommended.

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