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ABSTRACT: The Bay of Piru is one of potential fisheries resources of Western Seram District. Extensive mangrove, sea grass bed and coral reefs ecosystem were found in this area, contributing a lot on its productivity. Among many fish resources found there, the mud crab of *Scylla serrata* was one of the resources extensively exploited by local fisher of Pelita Jaya and its vicinity area. High demand on mud crab, high price, and high economy dependence of local fisher has influence the fisher to exploit the resources in unsustainable ways for over than 20 years that lead to resources degradation. The study was aimed to investigate the status of mud crab fishery and the effect attributed to the status then gives some recommendations for the management. The result shows that majority of mud crab captured was small to medium carapace width, of female mud crab harvested, 95% were in their reproductive status, the sex ratio was very between month but in average was almost equal ($p < 0.05$). The Pelita Jaya people were mainly elementary school graduated with relatively low level of environmental knowledge on sustainable natural resources management. Institutional aspect on natural resources management was also poor. Management on size captured, reproductive status, pot mesh size, and sanctuary side agreement should be implemented soon.

Keywords: Management plan, mud crab, socio-economy, institutional

INTRODUCTION

Various species of mud crab, *Scylla spp*, occur throughout tropical to warm temperate zones where they form the basis of small but important inshore fisheries. Also known as mangrove crabs, they are commonly associated with mangrove swamps and nearby intertidal and subtidal muddy habitat. Their size, high meat yield and delicate flavour mean that everywhere they occur, mud crabs are sought after as a quality food item (Rattanachote and Dangwatanakul 1992). As they are easily caught using very simple traps or nets, remain alive for considerable periods after capture and are of high value, the animal is an important source of income for small-scale fishers throughout the Asia-Pacific

region. A taxonomic revision of *Scylla* by Keenan et al. (1998) identified four distinct species in the genus *Scylla* i.e. *Scylla serrata*, *S. Paramamosain*, *S. olivacea* and *S. tranquebarica*.

Coastal area of Piru Bay of Western Seram District is a semi enclosed coastal waters with unique ecosystem consist of three important tropical ecosystem i.e. mangrove, coral reefs, and sea grass bed. Among these three ecosystems, mangrove ecosystem is the dominant one and consequently many fish resources can be found there like many pelagic fishes (skipjack tuna, anchovy, mackerel), some molluscs (blood clam, mangrove oyster, terebralia), echinoderm, and macro algae, all of economic importance and non economic important (Wouthuyzen and Sapulete 1994). By the Government of Indonesia, this area was selected as one of integrated economic development zone (BP_KAPET SERAM, 2012), signifying the productivity of this area.

Mangrove crab or mud crab or sometime called as black crab of *Scylla spp.* is one of fish resources lives in coastal area and in particular in the mangrove area. From ecology perspective, this mud crab plays role in supplying oxygen to an area where oxygen is limited through its mechanism in burrowing itself within substrate for food forage and shelter (Nybakken 1992). This crab has quite high economic value both for domestic market and international market (Shelley, 2008; Gaillard, 2009). In Pelita Jaya and its vicinity area of Western Seram for example, mud crab with 1 kg weight or more priced for Rp. 110.000,00.- especially fully mature female crab since this mature female has weight more than immature one (Kanna, 2002). With hard exoskeleton body structure cause this animal to have less edible portion whilst mature female has more edible portion. This is why the mature female becomes a target in harvesting (Chio-Huang 2003 in Paterson and Mann, 2011). If this situation is allow happening uncontrollable and no regulation available, this will lead to recruitment overfishing and will threatening natural stock. From initial observation at Pelita Jaya it was found that there is a decline in number and size of mud crab captured by mud crab fishers.

As one of economic important fish resources, the population of mud crab of *Scylla spp.* is estimated to have experience high exploitation rate (Syam et al, 2011 in Makatita, 2012). In some parts in Indonesia like North Coast of Java, the exploitation of mud crab had reached the point where there was a decline in number and size captured (Purwanti et al 2003). In Segara Anakan of West Java, there was also decline not only in shrimp and fish but mud crab as well (Rusmidi, 1999). The pressure on all sizes of mud crab for market purposes, juvenile for pond culture and even mature female for *premium markets* have an effect on declining of adult female size for bloodstock. Degradation on environmental also contribute on the declining of mud crab production.

There are three species of *Scylla spp.* crab (*Scylla serrata*, *S. olicacea*, and *S. paramomasain*) commonly harvested at Pelita Jaya and its vicinity area with *S. serrata* was the dominant one. With high price for mud crab, economic pressure faced by local fishermen, force the fishers to harvest the crab without any ecological consideration since many (40.47%) of the population just have elementary school background with very little sustainable fishery knowledge. They tend to harvest even small mud crab and fertile female as well. There was no time lag in crab exploitation, most of fisher works the whole week looking for the crab and this is already happened for more than 20 years. These of course

contribute immensely on the decline of their capture. Based on that information, this study was aimed to investigate the mud crab fisheries status in Pelita Jaya and to recommend appropriate mud crab fishery management for sustainable production.

MATERIALS AND METHODS

Mud crab samples were taken from Pelita Jaya Village of Pelita Jaya Bay of the Sub district of Teluk Piru (Figure 1). During spring tides all mud crabs caught by local fishermen were sampled and measured for internal carapace width and body weight before being sold by fishermen. Samples were taken every two weeks time interval starting from January 2012 to March 2012. Samples were then classified into male and immature and mature female based on the morphology of the abdominal segment. For gonad maturity index (GMI) of mud crab, identification were based on procedure proposed by Siahainenia (2008).

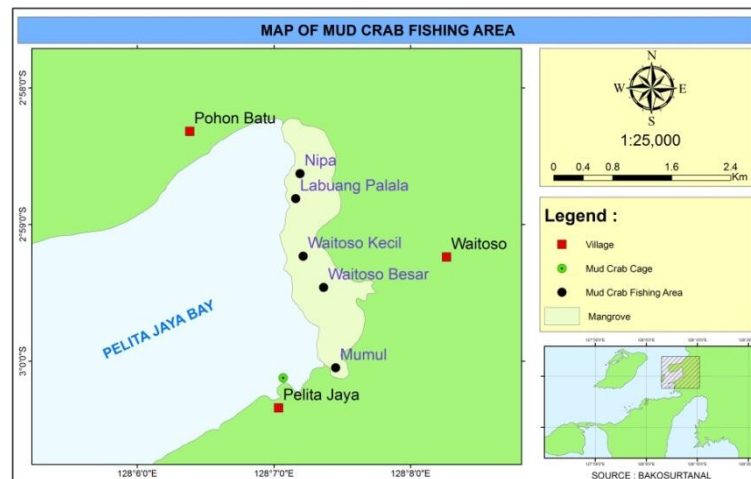


Figure 1. Map of Piru Bay showing study site (Pelita Jaya), District of Western Seram.

For socio-economy and institutional study, structural questionnaire were distributed randomly to both mud crab fishermen, some non mud crab fishermen and some local community. The interviewed were conducted directly with the respondents.

The analysis of variance was applied to identify the relationship of sex on weight which will result in the estimation of carapace length-weight relationship whether it should be estimated separately by sex or whether both sexes should be combined. Then carapace length relationship was subsequently calculated using the equation proposed by Sparre and Venema (1992) as follow:

$$W_{(i)} = qCw_{(i)}^b$$

The analysis was done in the computer software of Microsoft Excel Version 2010 with statistical difference were considered significant when $p < 0.05$. Sex ratio was estimated per monthly sampling and for total observation, then chi-square test were used to determine if the proportion of males and females are significantly

different from 1:1 expected ratio with the probability level was set to 0.05 (Zarr, 1999)

RESULTS AND DISCUSSION

1. Biological aspects of mud crab fisheries

The analysis of variance (ANOVA) for carapace width and body weight both for female and male crab shows significance relationship (Table 1. and Figure 2.). Figure 2. shows that small male and female crab have the same weight at the beginning but later the male weight increase more than female when the carapace width increased.

Table 1. Analysis of variance (Anova) for carapace length and body weight relationship for female and male mud crab.

SV	df	SS	MS	F	Significance F
Female					
Regression	1	5973188,264	5973188,264	362,3662	1,597E-42
Residual	156	2571479,888	16483,845		
Total	157	8544668,152			
Male					
Regression	1	6992747,121	6992747,121	304,9102	1,783E-37
Residual	145	3325399,818	22933,792		
Total	146	10318146,94			

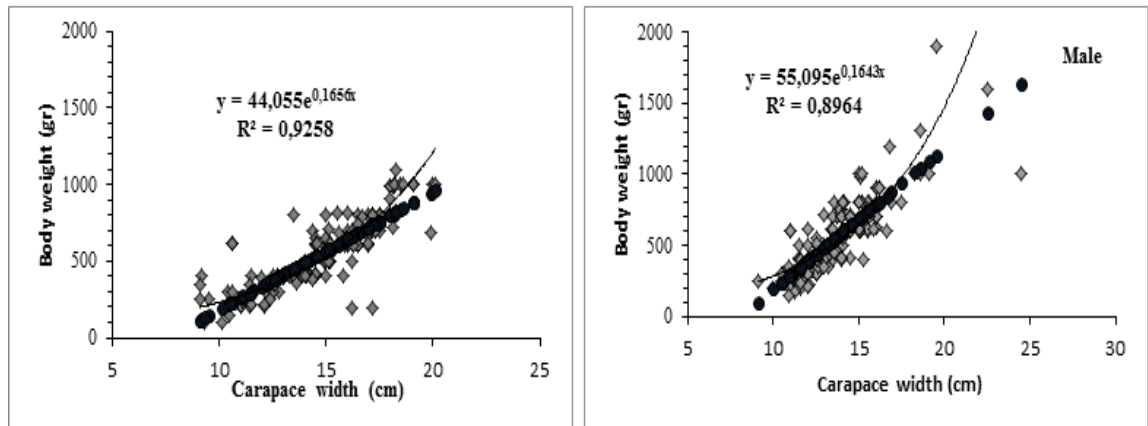


Figure 2. Carapace width-weight relationship of male and female mud crab *Scylla serrata* ($n = 158$ of female crab and $n = 147$ of male crab).

The total numbers of mud crab sampled during study period were 158 males and 147 females. The largest carapace width size of male and female were 24.50 cm and 20.10 cm respectively, whilst the smallest one of male and female were just the same (9.10 cm) with the size most frequently caught was 12.50 cm (male) and 15.20 cm (female). Table 2. summarize average size distribution (carapace width and body weight) of mud crab sampled during study period.

Table 2. Average size (carapace width and body weight) of mud crab sampled during study period

Size Distribution	Female		Male	
	Cw	Bw	Cw	Bw
Min	9.10	100.00	9.10	150.00
Max	20.10	1100.00	24.50	1900.00
Mode	15.20	400.00	12.50	600.00
Mean	14.79	552.65	13.80	571.02

Table 3. and Figure 3. summarize carapace width class interval of male and female mud crab caught in this study. There was a slight differences in number of individual caught at different size class interval. Relatively more female mud crab was caught at higher class interval (Class interval 5; 20.89%) than female mud crab (Class interval 4; 29.93%).

Table 3.

No	Class Interval (cm)	Ind. Number		Percentage	
		Female	Male	Female	Male
1	9.10 - 10.50	9	4	5,70	2,72
2	10.51 - 11.91	13	21	8,23	14,29
3	11.91 - 13.32	22	37	13,92	25,17
4	13.33 - 14.73	30	44	18,99	29,93
5	14.74 - 16.14	33	28	20,89	19,05
6	16.15 - 17.55	29	6	18,35	4,08
7	17.56 - 18.96	15	3	9,49	2,04
8	18.97 - 23.37	7	4	4,43	2,72
		158	147	100,00	100,00

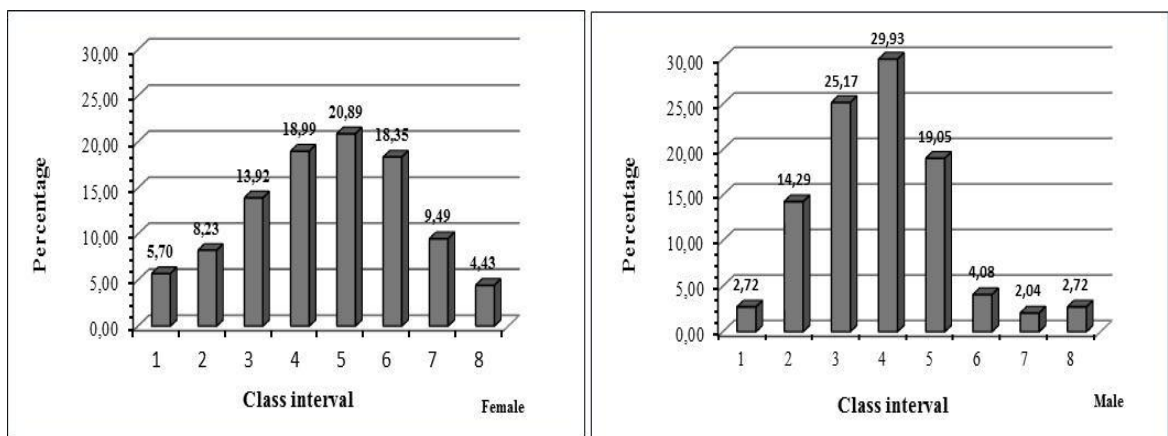


Figure 3. The percentage size class frequency distribution of mud crab *Scylla serrata* caught during study period (January to March, 2012).

The sex ratio of male and female crab harvested during study period vary between month (Table 4.) and from X^2 test, the overall sex ratio (male/female) was not statistically significant deviate form hypothetical 1:1 ratio ($p < 0.05$).

Table 4. Sex ratio of male to female mud crab *S. serrata* sampled during period of study.

Month	Female	Male	M/F
January	41	28	0.68:1.00
February	48	43	0.90:1.00
March	69	76	1.00:0.91
Total	158	147	0.93:1.00

Table 5. and Figure 4. summarized percentage of gonad maturity index of female mud crab collected during November to December 2011 (Hardianti, 2012) and during January to March 2012 (this study). This study shows that majority (94.54%) of female mud crab sampled during January to March were in their reproduction phase and the percentage varied between all reproduction phase. It was also found from this study that first maturity of mud crab of this species was at 9.00 cm carapace width.

Table 5. Percentage of maturity gonad index of female mud crab *S. serrata* between November to December (2011) and January to March (2012)

Month	I	II	III	IV	V
Nov. ^{*)}	4,76	4,44	4,35	0,00	0,00
Dec. ^{*)}	3,17	2,22	2,17	0,00	0,00
Jan.	28,57	17,78	19,57	62,50	0,00
Feb/	20,63	40,00	21,74	25,00	0,00
Mar.	42,86	35,56	52,17	12,50	0,00
	100,00	100,00	100,00	100,00	0,00

^{*)} Source: Hadrianri (2011)

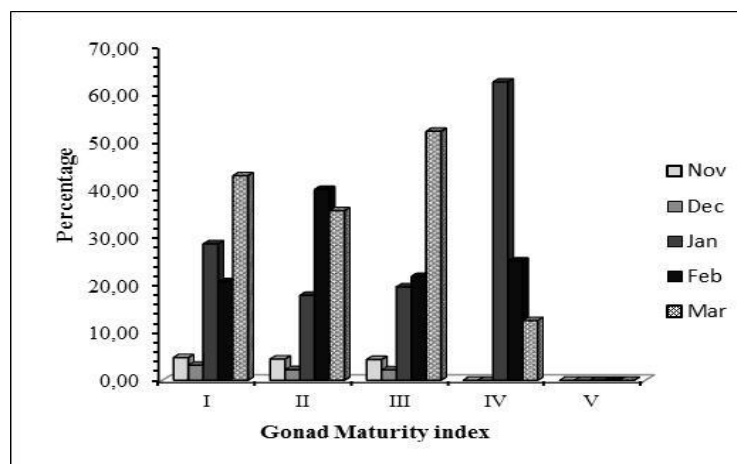


Figure 4. Gonad maturity index of mud crab *S. serrata* from November – December 2011 (Hardianti, 2012) and January to March 2012 (this study)

2. Socio-economy and institutional condition of mud crab fisher

For educational background, majority (55.28%) of Pelita Jaya community finished only elementary school, include mud crab fisher. Most of the community work either is fishermen (34.00%) or farmer (29.60%), and the rest vary between civil servant and local mercantile. For socio-economy and institutional studies related to mud crab fisheries, 38 respondents were interviewed, among them 8 were mud crab fishermen, 10 of other fishermen and 20 of non fishermen. One issue currently faced by mud crab fishermen was production decline either in number and size captured. From interviewed majority (89.47%) claimed that the production was decline over the last 10 years. No one claimed of production increase, whilst 2.63% claimed of stable production.

When respondents were asked about regulation on fisheries resources management, 21.05% claimed that there was such regulation, about 47.37% claimed that there was no such regulation and 31.58% did not know about such regulation. Of 21.05%, 75.00% said that such regulation was not implemented. These two later (no. regulation and did not know) was quite substantial number (78.95%), who we can assumed to have no knowledge on fisheries resources management.

Institutional can be described as an institution or regulation either formal, informal, or traditional that exist and practices in the community (Tuwo, 2011). In order to measure the institutional aspect in the management of fisheries resources, interviewed was made with some Pelita Jaya community. covering 11 attributes (Table 6. and Figure 5.). The result shows that the average institutional component in the fisheries management at Pelita Jaya was 47.09 % of 100.00% level. This result conclude that the status of institutional aspect in fisheries management was an intermediate level.

Table 6. Percentage of institutional attributes condition in fisheries resources management at Pelita Jaya

No.	Attributes measuring institutional component	%
1	Environmental education service frequency	44,00
2	Community. participation in env. Education service	40,00
3	Formal and informal institutional existence	46,00
4	Institution involvement in resources management	50,00
5	Natural resources regulation existence	64,00
6	Mal practices in natural resources management	36,00
7	Regulation sign post employed	52,00
8	Traditional natural resources management existence	50,00
9	Sanction given	54,00
10	Physical development in green belt area	42,00
11	License for physical constrect in green belt area	40,00
Average institutional aspect on natural resources management		47,09

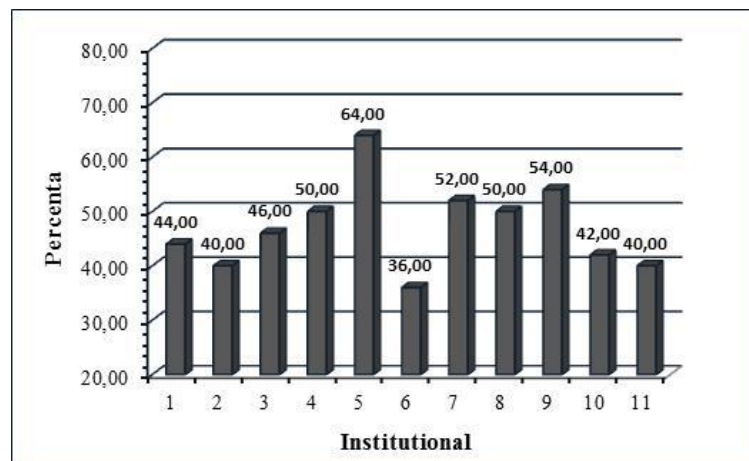


Figure 5. Graphical presentation of institutional component attributes in the management of fisheries resources at Pelita Jaya Village

Community environmental knowledge is one of the important aspect contributes on the sustainable development of natural resources such as fish resources. Ten attributes (Table 7.) were used to measure Pelita Jaya community knowledge on environment and sustainable development. The result shows that in general the community knowledge on environment was intermediate. The highest one was their knowledge on the benefit of associative fish resources followed by uncontrolled habitat utilization. The rest can be found Table 7. and presented graphically at Figure 6.

Table 7. Percentage environmental knowledge attributes of the community at Pelita Jaya

No	Attribute measuring environmental knowledge	%
1	Knowledge on associative resources at mangrove	52,00
2	Use of mangrove by mud crab and others	44,00
3	Benefit of associative fish resources	90,00
4	Uncontrolled habitat utilization	76,00
5	The need for envirn. Management	74,00
6	Agree with unsustainable utilization	25,00
7	Agree with habitat restoration	62,00
8	Agree with physical construct at mangrove ecosystem	42,00
9	Initiative in habitat restoration	16,00
10	The need for fisheries resources management	84,00
		56,50

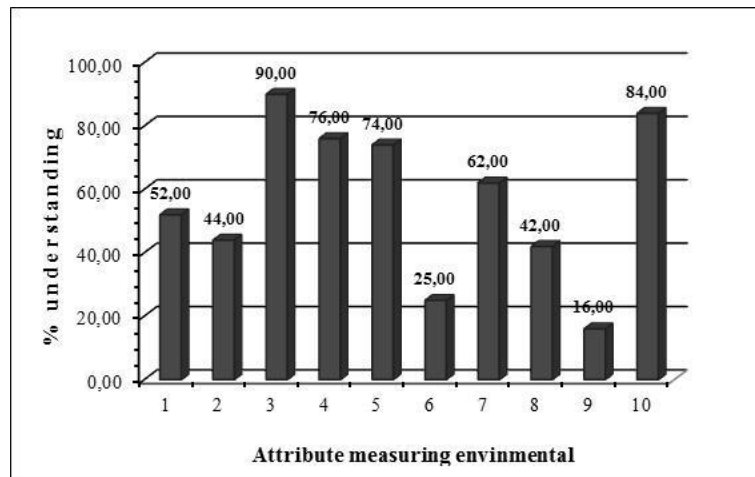


Figure 6. Graphical presentation of environmental knowledge attributes measuring community understanding on sustainable development

Each of mud crab fisher of Pelita Jaya Village own approximately 20 mud crab pots, which they employed all of it in their operation. During the harvesting, pot with mud crab inside will be taken out, emptied, and put it back into to the same site. Mud crab pot checking was conducted on daily basis. Quite recently, the mud crab fishing area has moved far distant away from present site since the harvest tend to decline from time to time. Time requires to the new fishing ground was one day traveling by small motor boat.

The results of gonad maturity analysis shows that of all mud crab captured majority (94.45%) were in their reproductive status, varied between each level. No female mud crab of final stage was found since this crab has moved to a deeper water ready to spawn (Kanna, 2002; Ryan *et al.*, 2003). From ecological point of view and mud crab fisheries sustainability, having such high percentage of crab harvested in their reproductive status is a high threaten to sustainable development. This condition couple with the educational level that related to environmental knowledge will jeopardize the mud crab fisheries of Pelita Jaya.

From carapace width size class distribution, it was found that relatively more (29.93%) male crab of small carapace width (13.33 cm – 17.73 cm) compared to female mud crab (20.84%) of class interval 14.74 - 16.14 cm with relatively more female crab captured (51.80%). It was also found that of all mud crab caught, only small proportion (2.72 – 4.43%) of mud crab with large carapace width. This denote that more small mud crab was captured by fishermen, one of an indication of resource degradation.

Generally speaking, education level has been used as one of the indicator that affected sustainable natural resources development. The higher the level of education, the sustain the resources. This study revealed that majority of the community of Pelita Jaya Village only have elementary school which might be contribute to the unsustainable fish resources utilization. If this situation we relate it with the level of environmental knowledge the we will see some connections. Average level of environmental knowledge of the community was intermediate with the lowest one were initiative in habitat restoration followed by unsustainable utilization. The positive things were benefit of resources, the need

for fisheries resources and environmental management. These three later can be used as an basis in the fisheries resources management plan.

The sustainable of natural resources was determined also by institutional aspects presence in the community. The study shows that institutional aspects in the community of the village was relatively low. Their know of such regulation in the resources management (64%) but apart from that, all aspects explain instructional on the resources management were moderate. Government as a main important agency in managing resources was not involve in a proper way. This contribute to the knowledge of the Pelita Jaya community in resources sustainable utilization shown captured of small mud captured, female mud crab with reproductive status, time used in operation, small mud crab pot mesh size.

CONCLUSIONS AND SUGGESTIONS

The conclusions that can be made based on this study are: majority of mud crab of *Scylla serrata* harvested by the fisher of Pelita Jaya Village was small to medium carapace width; of female mud crab harvested, majority were in their reproductive status; a declined of mud crab fisheries was immanent; level of education, environmental knowledge, and institutional existence were assumed to contribute to this fisheries of mud crab status at Pelita Jaya Village.

Some suggestions proposed following this study are: longer period of study of reproduction status of female mud crab, study on other *Scylla* sp crab since there are also other *Scylla* sp captured, more studies on social and economic of the mud crab fisher, studies on management of mud crab fisheries in more details, management on size captured and reproductive status control, pot mesh size management, and establishment of mud crab site sanctuary agreement should be implemented soon.

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