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Size distribution, growth pattern and condition factor of mangrove crab *Scylla serrata* in the coastal waters of Western Seram, Maluku, Indonesia

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Abstract
Research to study size distribution, growth pattern and condition factor of mangrove crab *Scylla serrata* was conducted on September 2013 to April 2014 in the coastal waters of Western Seram. Samples of mangrove crab was collected by using trap from four locations namely Wael, Masika Jaya, Kasuari island dan Manipa island. Width of carapace of the mangrove crab collected was measured and then weighted without separating the sex. A total of 451 individuals of mangrove crab were collected during the study with the carapace width ranging from 10.5-21.3 cm (mean= 15.61 cm; SD=2.19 cm), while the weight ranging from 200 - 2200 g (mean= 759.4 g; SD = 378.24 g). Based on location, minimum and maximum carapace width was represented by mangrove crab from Manipa island whilst minimum and maximum weight were represented by mangrove crab from Wael and Manipa island, respectively. Mangrove crab in the area showed isometric growth for all locations with condition factors closed to unity. Monthly sampling showed that minimum and maximum carapace widths were found in November and March, respectively. Minimum weight was found in October to December and January, whereas maximum weight was found in March. Isometric growth of mangrove crab occurred in all sampling periods except for September (negative allometric) and November (positive allometric). Condition factors for all sampling periods closed to unity.

Keywords: *Scylla serrata*, size distribution, growth pattern, condition factor, Western Seram

1. Introduction
Mangrove crabs (*Scylla* spp.) represent a valuable component of small-scaled coastal fisheries in many tropical and subtropical countries. These crabs are highly sought after luxury seafood items in East Asia. The biggest crab consumer countries are China, Japan, Korea, Thailand, Taiwan, Hong Kong, and Singapore where live crabs especially gravid females command premium prices [1, 5]. Fishing activities of mangrove crabs increase in recent years as a result of market demand both locally and internationally. Population decline is characterized by lesser catches and smaller sizes of mud crabs have occurred in the last two decades, particularly in the Southeast Asian region [9].

Mangrove crab is an important fishery commodity in Indonesia since early 1980s. This commodity comes from catches in the coastal waters especially in mangrove area and estuary as well as from aquaculture. One of the producer mangrove crabs in Indonesia is the Regency of Western Seram, Maluku Province. Crabs from this area are sent to national market especially to seafood reastaurants at big city in Eastern Indonesia regions.

In the recent years, fishing operation of mangrove crabs in Indonesia increased tremendously because of its economic value which can lead to overfishing [18]. According to fishers in Western Seram, population of mud crabs in the area has decreased and the crabs caught are smaller. In addition, the fishers in that area have to do fishing activities further away from their old fishing ground. This information is supported by the result of research as reported by Wouthuyzen and Sapulete (1994) [19].

Scientific information on mangrove crab in Maluku Province is still lacking. This research was conducted to get some information about mangrove crabs in the coastal waters of Western Seram, Maluku Province by focusing on size distribution, growth pattern and condition factor of *Scylla serrata*.

2. Materials and Methods

2.1. Study area

Research to study size distribution, growth pattern and condition factor of *S. serata* was carried out on September 2013 to April 2014 at four mangrove areas in Western Seram namely Manipa island (3º15'S, 127º32'E), Masika Jaya (3º08'S, 128º00E), Wael (3º03'S, 128º05'E) and Kasuari island (2º55'S, 127º54'E) (Figure 1). Mangrove in these areas mainly consists of *Rhizophora* spp and *Sonneratia* spp with the predominant substrates are fine sand, mud and crushed shell.

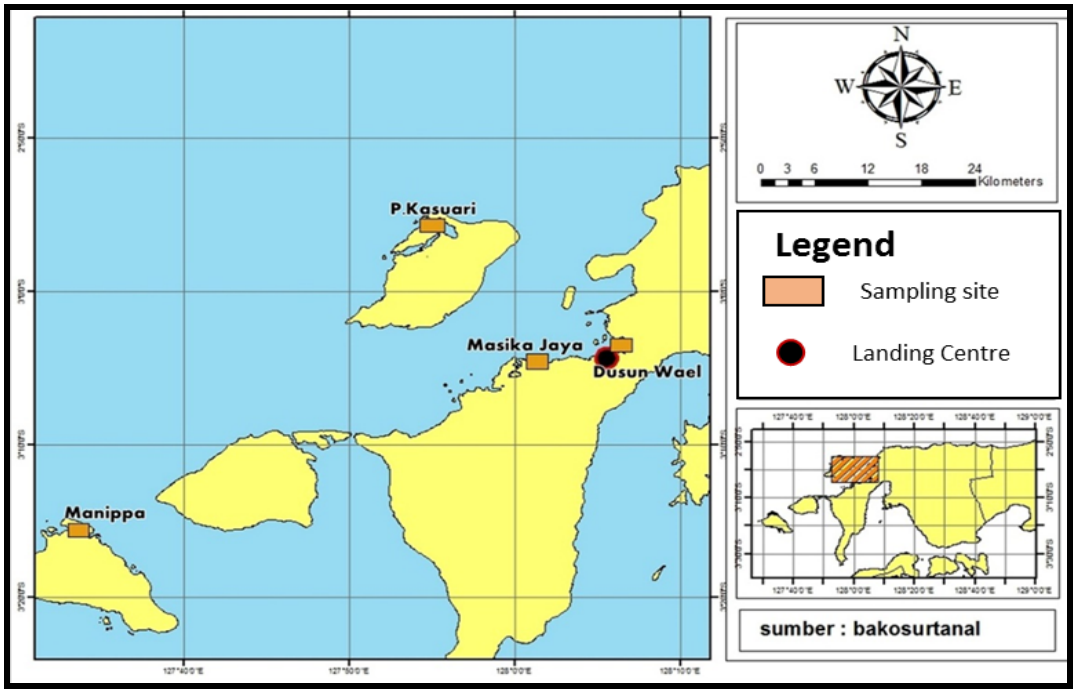

Fig 1: Map showing sampling site

2.2. Sample collection and analysis

Sample of mangrove crab *S. serrata* was collected every month from the catches of fishers from Wael, Kasuari Island, Manipa Island and Masika Jaya which were landed in Wael. Carapace width was measured as the longest part of the carapace by using vernier caliper to the nearest mm, whereas weight was measured by using a portable digital balance to the nearest 5 gram. Data was processed with Microsoft Excel 2010.

Length (carapace width) - weight relationship was analysed using the power function proposed by Pauly (1984) [11]:

$W = a L^b$

Where: W = weight in gram
L = carapace width in cm
a = intercept
b = slope

The value of b was then tested and used to determine growth pattern of crab i.e. isometric growth (b=3) or allometric growth (b≠3) by using *t-Student test* based on Pauly (1984) [11]. The interval value of b was calculated by using formula of Sparre and Venema (1992) [15].

Condition factor was estimated using formula according to King (2007) [7]:

$CF = \hat{W}/W$

Where: $\hat{W}$ = observed mean weight;
W = predicted mean weight = $a L^b$.

3. Results and discussion

A total of 451 individual mangrove crabs *S. serrata* were collected during the study period of September 2013 to April 2014. These crabs come from Wael (29.5%), Kasuari Island (6.7%), Manipa Island (53.7%) and Masika Jaya (10.1%). Manipa Island is the new fishing ground for some of the crab fishers from Wael. Those fishers have to catch crabs farther because population of mangrove crabs in their old fishing ground was declined (Pers. comm.).

3.1. Size Distribution

Size distribution of mangrove crabs for carapace width and weight in Western Seram are presented in Figure 2 and Figure 3. Carapace width of the mangrove crabs collected ranging from 10.5 - 21.3 cm (mean = 15.61 cm; SD = 2.19 cm) whilst the weight ranging from 200 - 2200 g (mean = 759.4 g; SD = 378.2 g).

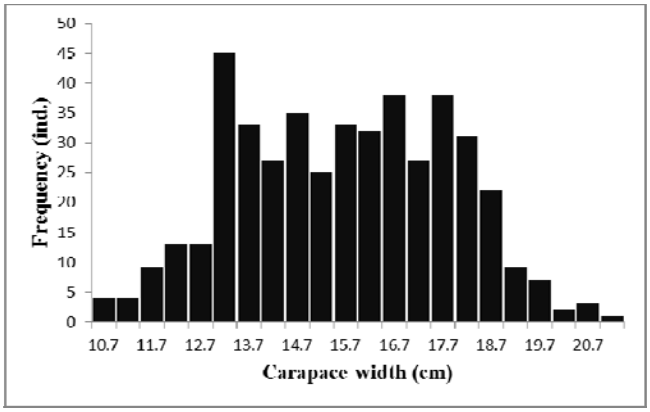

Fig 2: Histogram frequency of carapace width *S. serrata*

Size of mangrove crab found in Western Seram is larger than size of mangrove crab in other parts in Indonesia as reported by [3, 16, 18]. Asmara (2004) [3,], found carapace width ranging

from 3.15 – 12.25 cm with the weight ranging from 53,75 – 286,08 g for male and 7.48 – 12.05 cm with the weight ranging from 69.38 – 229.08 g for female mangrove crab in Sagara Anakan, Central Java. Carapace width of *S. serrata* in Kutai National Park ranged from 5.0 - 14.3 cm and from 4.5 - 15.5 for male and female, repectively [18]. Meanwhile, Syam *et al*. (2011) [16] found carapce width of *S. serrata* ranging from 4.3 - 14.3 cm in which 70% have the size < 8.0 cm in mangrove area of Mayangan Subang, West Java.

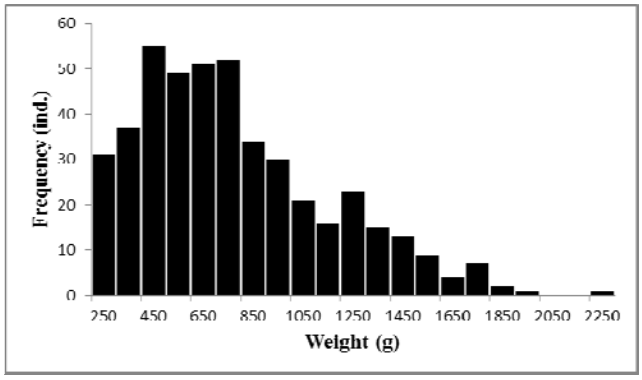

Fig 3: Histogram frequency of weight *S. serrata*

Size at sexual maturity of *S. serrata* varies depending on location. According to Ward *et al. (*2008) [17], first sexual maturity of mangrove crab in Southeast Asia (Phillippine, Malasya and Indonesia) occurs at 9 - 10 cm carapace width at the age of 12 – 18 months. Furthermore, Wijaya *et al.* (2010) [18] have stated that mangrove crabs in Kutai National Park attained their maturity at 9.1 cm carapace width and 170 g in weight. Meanwhile, Siahainenia (2008) [14] found that adult *S. serrata* in Muara Sangatta have minimum size of 11.0 cm carapace width. Based on those statements, it can be concluded that most of mangrove crab caught in Western Seram consist of adult ones and many have spawned at least once.

Sizes frequency of mangrove crab based on location are presented in Figure 4 and Figure 5 and the result of analysis is summarized in Table 2. Weigth of mangrove crab in Figure 5 is based on weight category of the buyer at landing center in Wael as presented in Table 1.

Table 1: Price of *S. serrata* based on weight category

Category	Weight (g)	Price (IDR/kg)
Super 1	>= 1000	120,000
Super 2	700 - 999	75,000
Super 3	400 - 699	45,000
Kacang2	100 - 399	35,000

Based on location, mangrove crabs from Kasuari have prominent carapace width than other locations (Figure 4). Mangrove crabs from Kasuari also have important weight for super 2 category (700-999 g) while Wael, Manipa and Masika Jaya are leading for super 3 category (400-699 g). Meanwhile, the highest percentage of super 1 category (>= 1000 g) belong to the mangrove crabs from Manipa island, whilst *kacang2* category has the lowest percentage in almost all locations (Figure 5).

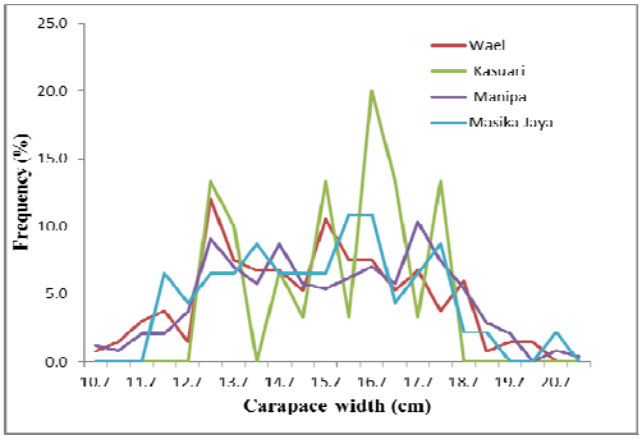

Fig 4: Polygon frequency of carapace width *S. serrata* based on location

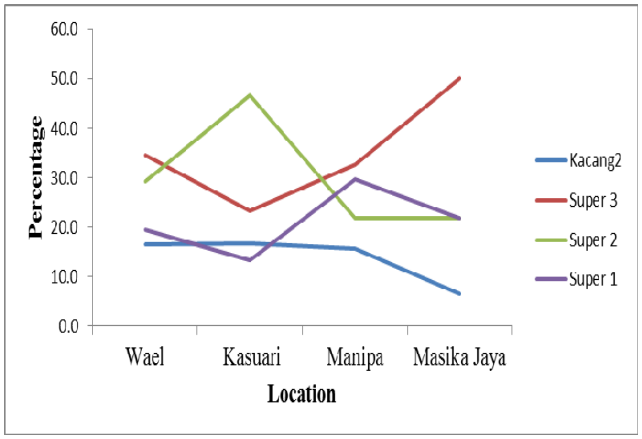

Fig 5: Polygon frequency of weight category *S. serrata* based on location

It can be seen in Table 2 that minimum and maximum carapace width belonged to the crabs from Manipa Island. Manipa Island also produces maximum weight crabs, whilst minimum weight belonged to the crabs from Wael. Kasuari Island has the largest average value with the smallest standart deviation of carapace width. This situation is unique because mangrove crabs from Kasuari Island have the smallest maximum value of carapace width. As far as management is concern, Kasuari Island is the only location in Western Seram in which *sasi* is still applied. *Sasi* is a traditional management system in Maluku that refers to temporal prohibition on particular resources e.g. mangrove crab and when it is applied (*tutup sasi*/closed season), no usage whatsoever is permitted until the *sasi* is lifted (*buka sasi*/ opened season). Violation of the sasi system will cause fine for the violators [12].

Table 2: Sizes of *S. serrata* based on location

Location	n	Carapace width (cm)				Weight (g)			
		Min	Max	Mean	SD	Min	Max	Mean	SD
Wael	133	10.9	18.9	15.36	2.18	200	1800	740.9	378.63
Kasuari	30	13.0	18.2	15.94	1.68	225	1500	724.2	289.66
Manipa	242	10.5	21.3	15.69	2.27	200	2200	780.4	395.16
Masika Jaya	46	12.0	20.6	15.64	2.07	300	1750	725.5	338.23
Pooled	451	10.5	21.3	15.61	2.19	200	2200	759.4	378.24

Sizes distribution of mangrove crabs based on sampling periods are presented in Figure 6, Figure 7 and Table 3. Weight of mangrove crabs in Figure 7 is based on weight classification in Table 1.

There is no clear pattern of sampling period on carapace width distribution because of overlapping (Figure 6). However, there are some periods which have percentage >= 15% for certain mid-class of carapace width i.e. September, October and December for mid-class 13.2 cm, March for mid-class 16.2 cm, April for mid-class 16.7 cm and October for mid-class 17.7 cm (Figure 6).

It can be seen in Figure 7 that mangrove crabs of super 3 (400-699 g) dominates all sampling period, except for September which is dominated by super 2 (700 - 999 g). Meanwhile, category of *kacang2* (< 400 g) had the highest percentage in December, whilst super 1 (>= 1000 g) in April.

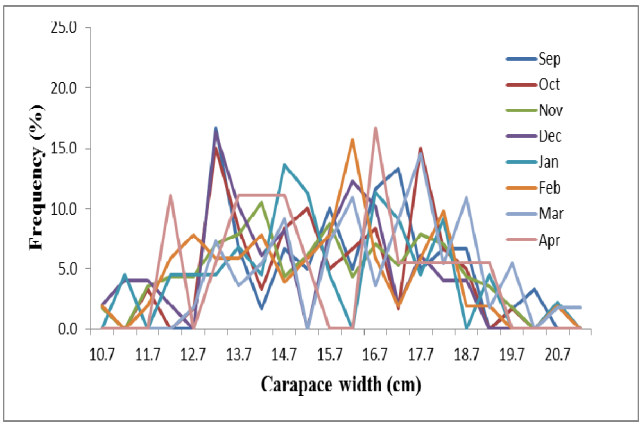

Fig 6: Polygon frequency of carapace width *S. serrata* based on sampling period

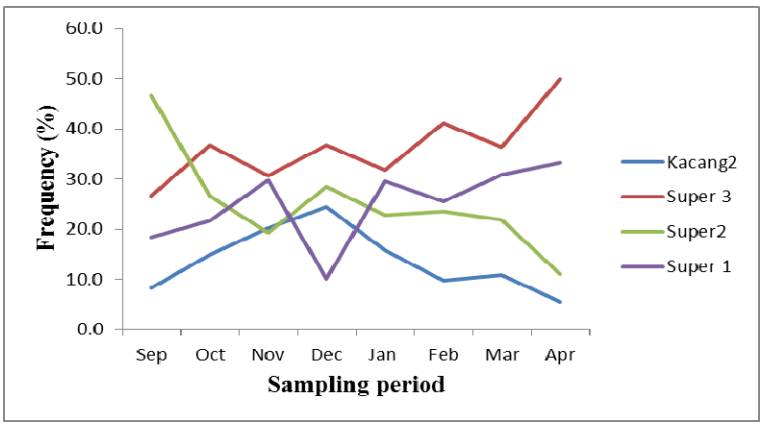

Fig 7: Polygon frequency of weight category *S. serrata* based on sampling period

The results of analysis summarized in Table 3 show that minimum value of carapace width is found in November, whilst maximum and largest average values are found in March. In terms of weight, minimum value belongs to October to December and in January, while maximum and the largest average values occur in March.

Table 3: Sizes of *S. serrata* based on sampling period

Period	n	Carapace width (cm)				Weight (g)			
		Min	Max	Mean	SD	Min	Max	Mean	SD
September	60	13.0	20.4	16.03	2.00	225	1550	785.8	290.40
October	60	11.5	19.5	15.58	1.99	200	1500	713.3	325.78
November	114	10.5	19.6	15.40	2.25	200	1800	765.0	427.99
December	49	10.9	18.9	14.94	2.10	200	1500	647.1	320.10
January	44	11.0	20.6	15.51	2.23	250	1600	771.6	362.79
February	51	10.9	20.6	15.38	2.22	200	1775	751.5	338.62
March	55	12.5	21.3	16.58	2.12	225	2200	852.7	512.37
April	58	12.0	19.1	15.52	2.20	300	1750	786.1	426.96

3.2. Growth pattern

Growth pattern of mangrove crabs is determined based on the values of b in length (width)-weight relationship of 451 individuals from four locations and 8 sampling periods. Length (width)-weight relationship for pooled data is presented in Figure 8 while for locations and sampling periods are summarized in Table 4 and Table 5, respectively.

It can be seen in Table 4 and Table 5 that correlation coefficients (r) which describe degree of association between the two variables ranging from 0.760 - 0.891 and those values are larger than r_{table} (critical values of r at p = 0.01). Thus, there is highly significant correlation between the two variables analysed [10] and contribution of length (carapace width) to weight which are shown by determination coefficients (R^2) ranging from 57.8 - 79.4% in which for pooled data is 68.6% (Figure 8).

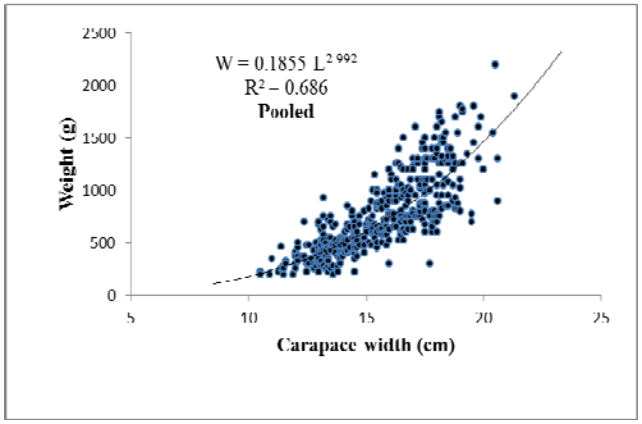

Fig 8: Carapace width-weight relationship of *S. serrata* in Western Seram

Table 4: Summary of length-weight relationship of *Scylla serrata* based on location

Location	W = a L ^{b}	r	t $_{calc.}$	t $_{table}$	Range of b at p = 0.05
Wael	W = 0.148 L $^{3.082}$	0.845	0.48	1.98	2.745 - 3.420
Kasuari	W = 0.036 L $^{3.549}$	0.837	1.25	2.05	2.639 - 4.459
Manipa	W = 0.151 L $^{3.067}$	0.838	0.14	1.96	2.720 - 3.241
Masika Jaya	W = 0.458 L $^{2.653}$	0.818	1.23	2.01	2.086 - 3.220
Pooled	W = 0.186 L $^{2.992}$	0.828	0.08	1.96	2.804 - 3.179

Table 5: Summary of length-weight relationship of *Scylla serrata* based on sampling period

Period	W = a L ^{b}	r	t $_{calc.}$	t $_{table}$	range of b at p = 0.05
September 2013	W = 0.853 L $^{2.240}$	0.760	**2.05***	2.00	1.893 - 2.988
October	W = 0.153 L $^{3.044}$	0.799	0.15	2.00	2.443 - 3.646
November	W = 0.043 L $^{3.538}$	0.891	**3.32***	1.98	3.021 - 3.875
December	W = 0.184 L $^{2.986}$	0.843	0.05	2.01	2.428 - 3.544
January 2014	W = 0.223 L $^{2.942}$	0.876	0.23	2.02	2.438 - 3.446
February	W = 0.505 L $^{2.646}$	0.830	1.39	2.01	2.135 - 3.156
March	W = 0.086 L $^{3.237}$	0.782	1.17	2.01	2.527 - 3.948
April	W = 0.153 L $^{3.081}$	0.853	0.17	2.00	2.082 - 4.080

* significantly different at p=0.05

The results of length (carapace width) - weight relationship of mangrove crabs based on pooled data, locations and sampling periods presented in Table 4 and Table 5 show that the values of b ranging from 2,240 - 3,549. The results of test by using't-Student' show that the values of calculated t are smaller than t $_{table}$ (p=0.05; df=n-2) except for the periods of September and November. Subsequent analysis by using the values of b at 95% confidence interval show the same results, in which the value of 3.0 is included in all values of b interval except for those two periods. These results indicated that mangrove crabs in all locations and sampling periods except for September and November have isometric growth pattern (b=3) in which length (carapace width) increment is proportional to weight increment. In contrast, mangrove crabs in September have negative allometric growth pattern (b<3) i.e. length increment is faster than weight and those in November have positive allometric growth (b>3), weight increment is faster than length (carapace width) increment [10, 11, 15].

Some studies on length-weight relationship of mangrove crab also showed similar results as the present study in which some mangrove crab had isometric growth and some had allometric growth. Ali *et al*. (2004) [2] have reported isometric growth for male and negative allometric for female mangrove crabs from Khulna, Bangladesh. On the contrary, Sentosa and Syam (2011) [13] have reported negative allometric growth pattern for male and female mangrove crabs from Mayangan, Subang. Furthermore, Syam *et al*. (2011) [16] have found negative allometric growth for combined sex of mangrove crab in Mayangan, Subang. Meanwhile, Wijaya *et al*. (2010) [18] have reported negative allometric and positive allometric growth for female and male mangrove crabs, respectively in Kutai National Park.

Length weight relationship is important in fishery biology because it can be used as conversion factor to convert length to weight and *vice versa* [4]. Furthermore, Froese (1998) [6] had stated that if data of size frequency is available then length data can be converted to weight in order to estimate biomass. Effendie (1997) [4] had also stated that length-weight relationship can be used to determine condition factor which describes relative fatness or well-being of organisms.

3.3. Condition factor

Condition factor used in this analysis is relative condition factor i.e. comparison between observed weight and predicted weight based on length (width) -weight relationship of each individual for location, sampling period and pooled samples. The results of condition factor analysis are presented in Table 6 and Table 7.

Table 6: Condition factor of *Scylla serrata* based on sampling site

Location	Condition factor		
	Range	Mean	SD
Wael	0,40 - 1,74	1,04	0,29
Kasuari	0,56 - 1,95	1,04	0,28
Manipa	0,30 - 2,24	1,04	0,29
Masika Jaya	0,64 - 1,92	1,03	0,27
Pooled	0,30 - 2,21	1,03	0,29

Table 7: Condition factor of *Scylla serrata* based on sampling period

Period	Condition factor		
	Range	Mean	SD
September 2013	0,44 - 1,85	1,03	0,27
October	0,31 - 1,62	1,04	0,27
November	0,41 - 1,66	1,02	0,26
December	1,60 - 1,75	1,04	0,28
January 2014	0,58 - 1,45	1,03	0,23
February	0,59 - 1,64	1,03	0,27
March	0,60 - 1,77	1,03	0,33
April	0,64 - 1,96	1,03	0,30

It can be seen in Table 6 and Table 7 that condition factor for each individual varies and it is ranging from 0.3 - 2.24. However, average values of condition factor for mangrove crabs based on location and sampling period are almost identical and closed to unity. These results are not surprising because most mangrove crab in four locations and eight sampling periods have isometric growth pattern in length (width)-weight relationship. Effendie (1997) [4] had stated that ideal condition of organism will be achieved if relative condition factor is unity (CF=1) or closed to unity i.e. when weight increment is proportional to length (width) increment or weight increment is equal to the cubic of length/width (isometric growth). As wide range of condition factor of organisms is determined by location, season, maturity and food availability [8], identical values which are closed to unity of condition factor found in this study indicated that mangrove crab *S. serrata* in Western Seram can grow and reproduce well all year round.

4. Conclusion

It can be concluded that most *S. serrata* caught in mangrove area of Western Seram consist of adult individuals and have spawned at least once. Mangrove crabs in the area have isometric growth for all sampling periods except for the periods of September and November which show negative allometric and positive allometric growth pattern, respectively with the condition factor closed to unity.

To ensure sustainability, further study is needed particularly on reproduction and population dynamic of mangrove crab in the area.

5. Acknowledgement

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