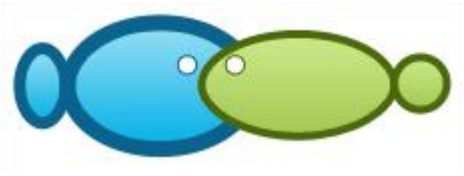

Reproductive biology of blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) in Lasongko Bay, Southeast Sulawesi-Indonesia

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Abstract. Information about reproductive biology is significantly needed in management of blue swimming crab (*Portunus pelagicus*) fishery. This research informs spatial and temporal sex ratio, gonadal development, gonado somatic index (GSI) and first size sexual maturity of male and female crab, as well as crab spawning season in Lasongko Bay, Southeast Sulawesi. Crab collection were conducted with gillnet in five different types of habitat. Gonadal development of crab was examined by their color and morphological characters. Sex ratio was analyzed of χ^2 test, and gonadal development proportion of male and female crabs were described. Gonado somatic index (GSI) among stations were analyzed by one-way ANOVA and followed by Tukey's test. Sex ratio of crabs spatially and temporally of generally did not differ significantly from 1:1. Gonad developments of male and female crab were varied spatially and temporally. GSI at every gonad development stage of male and female crabs generally was not significantly different among stations. GSI of male crab was smaller than the female crab. The first sexual maturity size of male and female crabs were 109.8 mm carapace width (CW) and 115.7 mm CW, respectively. The crab spawned in Lasongko Bay the whole year, and three peaks of spawning season were detected.

Key Words: fishery management, gonad maturation, Portunidae, sex ratio, sexual maturity, spawning season.

Introduction. Indonesia is considered as the hotspot in marine biodiversity including crustaceans. Some of the marine crustaceans of Indonesia have economic value in fishery market, such as mantis shrimp, lobsters, hippoid crabs, mud crab, blue swimming crab, etc. Hence, many of current researches were focused on fishery-resources crustaceans. The topic of the current researches on crustaceans were relatively broad, covering several biological aspects such as habitat of certain crustaceans (Sarong & Wardiatno 2013; Wardiatno et al 2014; Tahmid et al 2015a), morphological characters (Wardiatno & Mashar 2013), growth and allometric relationships (Mashar & Wardiatno 2013a, b; Muzammil et al 2015), distribution, population and abundance dynamics (Wardiatno & Mashar 2011; Mashar et al 2014; Zairion et al 2014a, b; Hamid & Wardiatno 2015; Ambarsari et al 2016; Tahmid et al 2015b), reproduction (Wardiatno & Mashar 2010; Zairion et al 2015a, b; Hamid et al 2016; Edritanti et al 2016), burrowing behavior (Wardiatno et al 2016a) as well as their biochemical composition for human nutrition (Wardiatno et al 2012; Santoso et al 2015). Some of them were about reports of their occurrence as first record in Indonesia or diversity assessment (Mashar et al 2014; Ardika et al 2015; Mashar et al 2015; Wardiatno et al 2015a, b; Wardiatno et al 2016b, c). The blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) is an important economic fishery resource with high demand for export, but the production is solely produced from catches in the wild. Blue swimming crab fishery in Indonesia has been intensively conducted and some researches showed state of overfishing (Kembaren et al 2012; Ernawati 2013; Ihsan et al 2014; Hamid & Wardiatno 2015), hence it is necessary to implement sustainable management. It is proved that reproductive biology is needed

for the crab sustainable management (Arshad et al 2006; Kamrani et al 2010; Ikhwanuddin et al 2012a).

There are numerous studies of the blue swimming crab in reproductive biology point of view (Ingles & Braum 1989; Sumpton et al 1994; Sukumaran 1995; Poter & de Lestang 2000; de Lestang et al 2003; Arshad et al 2006; Abdel-Razek et al 2006; Dineshbabu et al 2008; Ikhwanuddin et al 2009, 2011, 2012a; Johnson et al 2010; Kamrani et al 2010; Jazayeri et al 2011; Hosseini et al 2012; Kembaren et al 2012; Sunarto 2012; Ernawati 2013; Josileen 2013; Efrizal et al 2015; Kunsook et al 2014; Liu et al 2014; Songrak et al 2014; Hamid et al 2015a, b; Zairion et al 2015a, b). Results from these studies indicated that the biological parameters of crab reproduction varied among locations.

Several studies on the reproductive biology of female crab were reported from Indonesian waters, such as in the north coast of Central Java (Sunarto 2012; Ernawati 2013), Pangkep coast-South Sulawesi (Ihsan et al 2014), and East Lampung coast (Zairion et al 2014, 2015a, b). The location of these studies were open marine waters, and study in in a relatively semi-closed waters such as in a bay is lacking. In Thailand, a report of sort of study was written by Kunsook et al (2014).

Lasongko Bay is a potential for crab fishing located in the region of Central Buton Regency, Muna island. Some biological aspects of the crab were reported from the bay, i.e. fishery (Hamid 2011), population dynamics (Hamid & Wardiatno 2015), changes in of proximate and fatty acid of the eggs crab during embryonic development (Hamid et al 2015a), as well as fecundity and gonad maturity stages ovigerous female crabs (Hamid et al 2015b). The aim of this study is to elucidate some reproductive biological aspects including sex ratio, gonad development stages, gonado somatic index (GSI) and size at first sexual maturity of male and female, and spawing season in Lasongko Bay for *P. pelagicus*.

Material and Method

Research site. The research was conducted in Lasongko Bay, Southeast Sulawesi, Indonesia from April 2013 to March 2014. Lasongko Bay is located at latitude 05°15' to 05°27'S and Longitude 122°27' to 122°33' E (Figure 1). Crabs were collected at seven stations. Stations 1 to 5 were characterised by sand and sand clay substrates and some of the stations were partially covered with sea grass. While the substrates of stations 6 and 7 were composed by clay loam and clay, respectively (Hamid et al 2016).

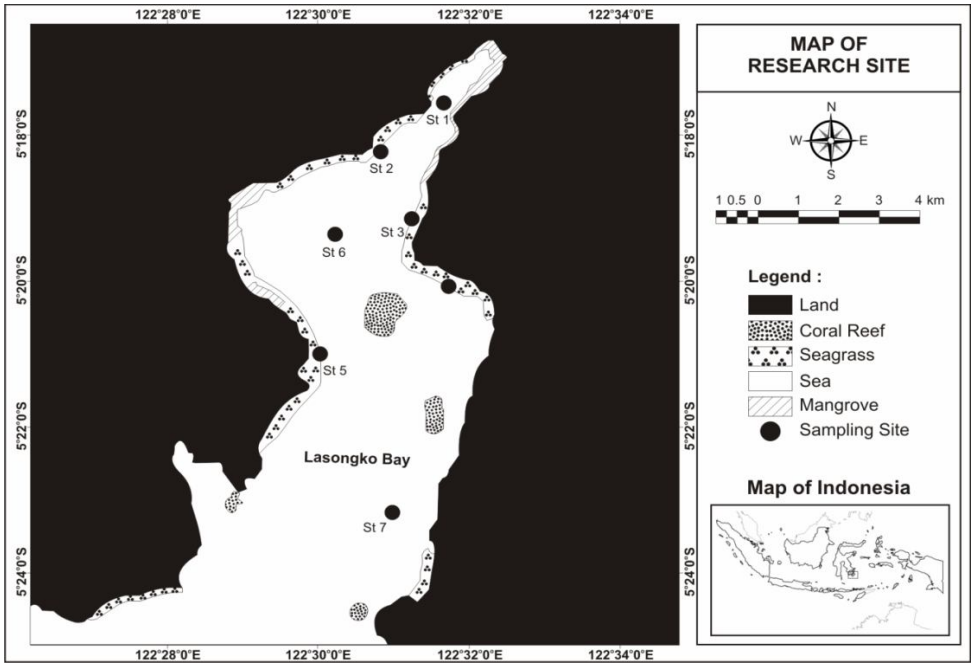

Figure 1. Map showing the location of the study site in Lasongko Bay, southest Sulawesi - Indonesia. Black dots indicate sampling sites (adapted from Hamid et al 2016).

Sampling and measurement of crab. Crab collections were made monthly by bottom gillnets with mesh sizes of 1.5, 2.5, and 3.5 inches. Gillnets were set at each location around 17.00 until 17:45 and hauled in the morning next day at 06:15 until 08:45.

All collected crabs were separated and counted by sex, and the occurrence of ovigerous female were noted. The weight of each crab was measured by a digital scale (Xon Med FC) with accuracy of 0.01 g. The carapace of crabs was opened to observe gonadal development, and the weight of gonad were measured laso by a digital scale with accuracy of 0.01 g. Gonadal development in female was divided into four stages (following de Lestang et al 2003; Kamrani et al 2010; Ikhwanuddin et al 2012a) based on changes in morphology, color and distribution of ovarian occupying the hepatic space, while for in male crab it was divided into three stages (following Sukumaran 1995; de Lestang et al 2003) based on changes in morphology, color, distribution testes and vas deferens (Table 1). Gonado somatic index (GSI) of male and female was calculated based on the ratio of gonad wet weight to total body wet weight of crab (Sukumaran 1995; Jazayeri et al 2011).

Table 1

Characteristics of the appearance macroscopically of each gonad development stage of female and male blue swimming crab (*Portunus pelagicus*)

Stage	*Female*	*Category*
I	Ovary small or thin and colorless or transparent	Immature
II	Ovary grows, changes color to cream or light yellow, but not occupying hepatic area	
III	Ovary increasingly large, dark yellow or ivory, about 1/3 to 1/4 of the area occupied hepatic	Mature
IV	Ovary occupies most of the hepatic region, the lobes, ovary orange or reddish orange.	
Stage	*Male*	*Category*
I	Testes and vas deferens not clearly distinguishable: a thin tube translucent vas deferens	Immature
II	Testes and vas deferens well developed, tube of testes large coiled spreads laterally and posteriorly to the stomach. Vas deferent opaque or white mass rolled hepatic extends to both sides.	
III	Testes very large, vas deferens thick and milky white mass extending to fill a large part of the body cavity.	Mature

The spawning season was estimated based on the distribution of the average monthly GSI of female crab, and is supported by the distribution of the presence of ovigerous female crabs in each month during the study as reported by Hamid et al (2015b). For estimating first size at 50% maturity, mature crabs (Stage III in males and Stages III and IV in females) the carapace width (CW) were measured by digital calliper with accuracy of 0.05 mm.The first size at 50% sexual maturity were calculated with logistic curve.

Data analysis. Sex ratio was determined by chi-square test (χ^2) at p = 0.05 (Steel & Torrie 1980). The distribution of the gonad stage proportion of male and female crab between stations and sampling periods were analyzed descriptively and presented in tables and graphs. The difference in GSI of male and female crabs among locations were analyzed by one-way ANOVA test followed by Tukey test at p = 0.05. Prior to the tests, GSI data crab were firstly tested for the normality with Kolmogorov-Smirnov test at p = 0.05 (Steel & Torrie 1980). Since the results were not in normal distribution, the data were transformed to log 10.

Results

Sex ratio. In total the number of male and female crabs collected from all stations were 606 and 570, respectively. Sex ratio of the population was 1.06:1. The results χ^2 test showed that sex was generally unbalance between the males and females crab, except at station 4 and the total population (Table 2). While monthly sex ratio in the crab population is seen in Figure 2.

Table 2

Number and sex ratio of male to female crab at each station in Lasongko Bay, Southeast Sulawesi – Indonesia

Station	Number (crab)		Proportion (%)		Sex ratio male:female	X^2_{hit}	p value
	Male	Female	Male	Female			
1	138	103	57.26	42.74	1.34:1	5.75	ns at p = 0.05
2	139	129	51.87	48.13	1.08:1	11.99	ns at p = 0.05
3	70	62	53.03	46.97	1.13:1	7.18	ns at p = 0.05
4	78	71	52.35	47.65	1.10:1	21.61	*p < 0.05
5	75	61	55.15	44.85	1.23:1	17.74	ns at p = 0.05
6	54	60	47.37	52.63	0.90:1	6.24	ns at p = 0.05
7	52	84	38.24	61.76	0.62:1	9.49	ns at p = 0.05
Total	606	570	51.53	48.47	1.06:1	14.47	*p < 0.05

* significantly different; ns - not significant.

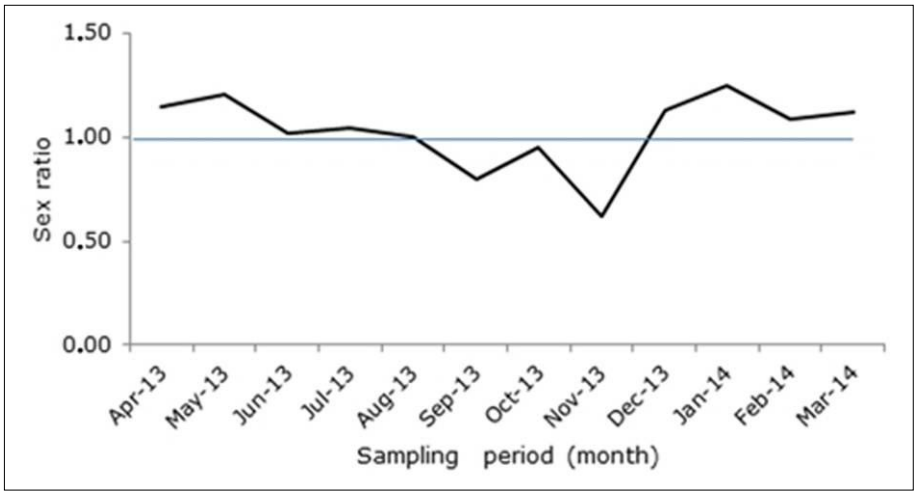

Figure 2. The sex ratio of male to female crab at each sampling period in Lasongko Bay, Southeast Sulawesi – Indonesia.

Gonad gevelopment. The proportion of male crabs at each station with undeveloped gonads ranged from 2.22 to 34.51%, immature gonads (stages I and II) ranged from 33.96 to 56.41%, and mature gonads (stage III) ranged from 27.42 to 44.44% (Table 3). In female the proportion of undeveloped gonads female ranged from 11.67 to 52.94 %, immature gonads (stages I and II) ranged from16.67 to 40.00%, and mature gonads (stages III and IV) ranged from 15.13 to 71.67% (Table 3).

In temporal point of view male crab at each sampling period was generally dominated by immature gonads (stages I and II), except in the months of September, October and February (dominated by mature gonads). The proportion of immature gonads of male crab at each sampling period ranged from35.14 to 87.23%; the lowest in October and the highest in June, while mature gonad ranged from 12.77 to 64.86% (Figure 3). Proportion of mature gonad of male crab in September, October and February was higher than that in other eight months.

Table 3

Conditions gonad development of female and male crabs at each station in Lasongko Bay, Southeast Sulawesi – Indonesia

Station	Undeveloped (%)		Immature (%)		Mature (%)		Number (crab)	
	Male	Female	Male	Female	Male	Female	Male	Female
1	22.58	52.94	50.00	22.35	27.42	24.71	124	85
2	34.51	47.90	40.85	36.97	24.65	15.13	142	119
3	17.14	19.23	37.14	19.23	45.71	61.54	70	52
4	14.10	22.39	48.72	32.84	37.18	44.78	78	67
5	10.26	23.64	56.41	40.00	33.33	36.36	78	55
6	28.30	14.29	33.96	30.61	37.74	55.10	53	49
7	2.22	11.67	46.67	16.67	44.44	71.67	45	60

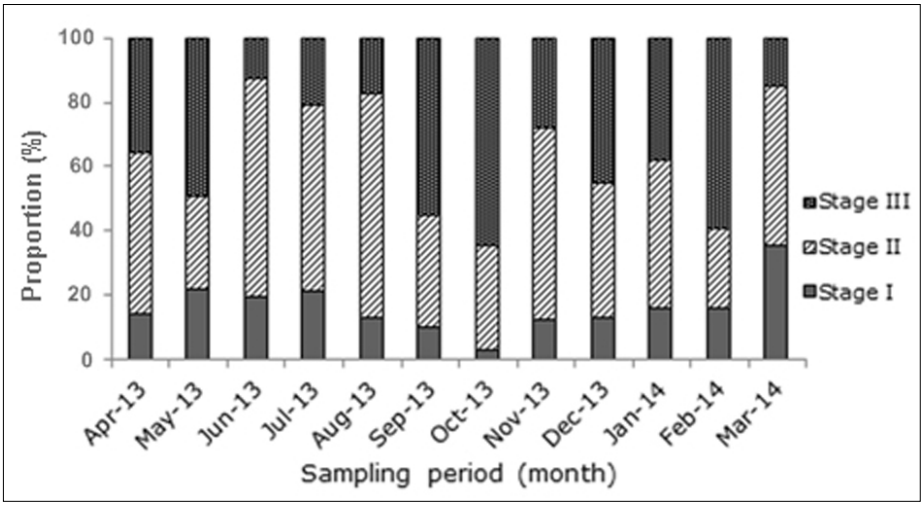

Figure 3. The proportion of gonads stage of male crab at each sampling period in Lasongko Bay, Southeast Sulawesi – Indonesia.

Female crabs caught in April, July, September, January and March were dominated by immature gonads, while those caught in May, June, August, October, November, December and February were dominated by mature gonads. The proportion of immature gonads female crab at each sampling period ranged from 25.00 to 68.42%, with the lowest in June and the highest in September. The proportion of mature gonad of female crabs at each sampling ranged from 31.58 to 75.00%, with the highest in June and the lowest in September (Figure 4).

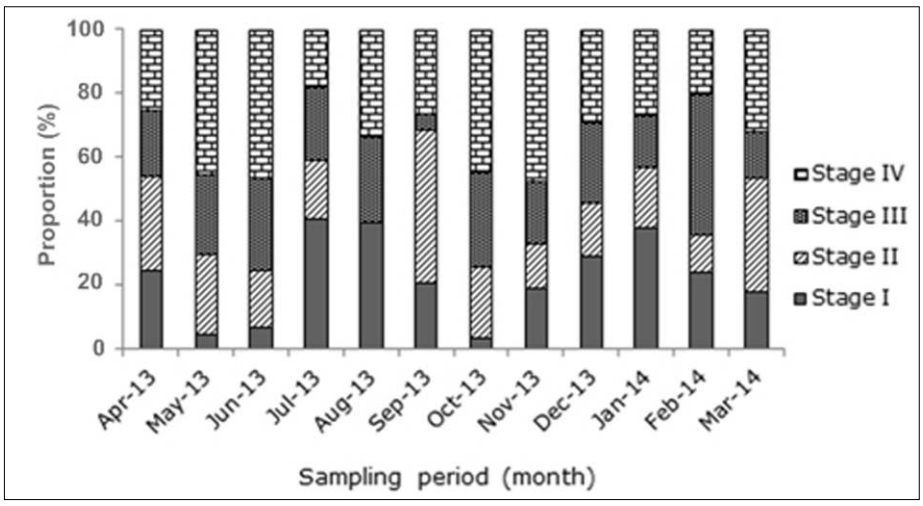

Figure 4. The proportion of gonads stage of female crab at each sampling period in Lasongko Bay, Southeast Sulawesi – Indonesia.

Gonado somatic index (GSI) and spawning season. GSI of male and female crab at stages I and II are likely to be similar, while GSI of female crabs at stage III is bigger than the GSI of male crab (Table 4). GSI of male crab at stages I and II tended to vary among stations, but ANOVA test showed that GSI of male crab on both stages were not significantly different ($p > 0.05$) among stations. Mean of values of GSI in male crabs at stage III ranged from 1.07 to 1.99, and they were significantly different ($p < 0.05$ among stations, with the largest GSI found at station 6, and the smallest at station 1 (Table 4).

The mean values of GSI in female crab stage I to IV at each station ranged from 0.23 to 6.91 (Table 4). GSI of female crab at the same stage tended to vary among stations, but one-way ANOVA test showed that most of them were not significantly different ($p > 0.05$) among stations, and only the stage II showed a significant difference ($p < 0.05$) among stations (Table 4). The largest GSI in female crab stage II was found at the station 2 and the smallest at station 3.

Table 4

GSI of female and male blue swimming crab (*Portunus pelagicus*) in each stage and station collected from Lasongko Bay, Southeast Sulawesi – Indonesia

Station	GSI per stages of male crab			GSI per stages of female crab			
	I	II	III	I	II	III	IV
1	0.31 ± 0.16^{a}	0.78 ± 0.17^{a}	1.07 ± 0.27^{b}	0.29 ± 0.18^{a}	0.78 ± 0.41^{ab}	3.64 ± 1.36^{a}	6.41 ± 1.65^{a}
2	0.37 ± 0.19^{a}	0.79 ± 0.26^{a}	1.30 ± 0.50^{b}	0.23 ± 0.13^{a}	1.13 ± 0.61^{a}	3.13 ± 0.39^{a}	6.16 ± 1.59^{a}
3	0.29 ± 0.07^{a}	0.65 ± 0.13^{a}	1.65 ± 1.13^{a}	0.45 ± 0.08^{a}	0.61 ± 0.19^{b}	3.03 ± 1.50^{a}	6.22 ± 1.78^{a}
4	0.46 ± 0.32^{a}	0.78 ± 0.37^{a}	1.50 ± 0.55^{ab}	0.33 ± 0.28^{a}	0.86 ± 0.13^{ab}	3.02 ± 1.78^{a}	6.07 ± 2.16^{a}
5	0.31 ± 0.16^{a}	0.68 ± 0.18^{a}	1.22 ± 0.68^{b}	0.30 ± 0.25^{a}	0.86 ± 0.50^{ab}	2.56 ± 0.52^{a}	6.48 ± 2.23^{a}
6	0.29 ± 0.12^{a}	0.63 ± 0.15^{a}	1.99 ± 1.39^{a}	0.30 ± 0.12^{a}	0.66 ± 0.25^{b}	3.25 ± 1.13^{a}	6.91 ± 1.45^{a}
7	0.24 ± 0.06^{a}	0.76 ± 0.24^{a}	1.08 ± 0.27^{b}	0.41 ± 0.10^{a}	0.85 ± 0.19^{ab}	2.58 ± 0.99^{a}	6.73 ± 2.17^{a}

Note: Column and the item with the same letter indicate non significantly different at $p = 0.05$.

GSI mean values monthly in male crabs were smaller those in female crabs; in male crab GSI ranged from 0.73 to 1.35, while in female crab they ranged from 1.80 to 4.55 (Figure 5). The highest of GSI mean value monthly in male crab was found in May and the lowest in November; while in female crabs the highest was in October and lowest in September (Figure 5).

Spawning season of the crab in Lasongko Bay occurred throughout the year based on the presence of mature gonad in female and ovigerous females. Based on the distribution of GSI mean values monthly in female crab and the proportion of the ovigerous female, the peak spawning season of crab in Lasongko Bay occurred in May, June, August, and October (Figure 5).

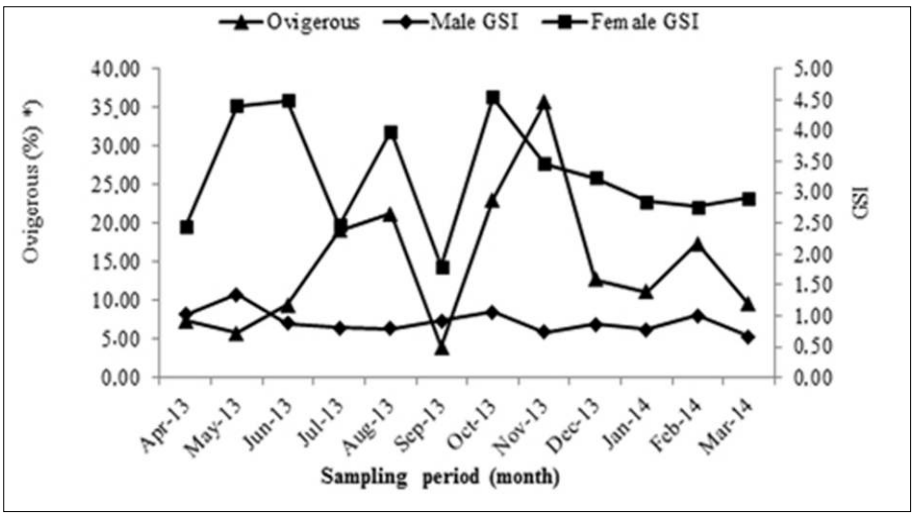

Figure 5. GSI mean monthly of males and females crab, and ovigerous female crab proportion each sampling period in Lasongko Bay, Southeast Sulawesi – Indonesia ($^{*)}$ proportion of ovigerous female each month was taken from Hamid et al (2015b)).

First size* sexual *maturity. First size at 50% sexual maturity (CW50%) of male crab in Lasongko Bay was found smaller than that of female crab. The CW50% of male crab was 109.83 mm-CW, while of female crab was 115.71 mm-CW (Figure 6). Smallest size of gonad mature (stage III) male crab in Lasongko Bay was 83.7 mm-CW, while in female crab the smallest sizes of stages III and IV were 82.2 mm and 91.8 mm–CW, respectively.

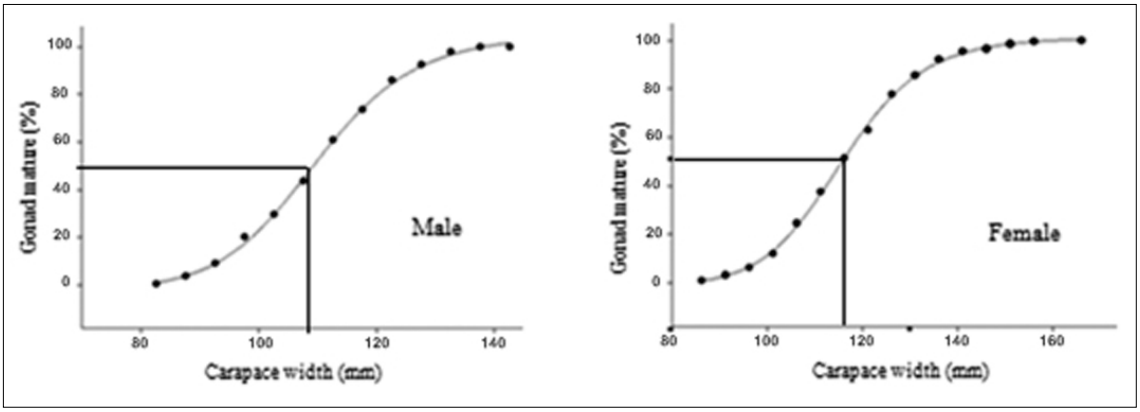

Figure 6. Logistic curve estimating first size at 50% sexual maturity of male and female crab in Lasongko Bay, Southeast Sulawesi – Indonesia.

Discussion

Sex ratio. Sex ratio of the blue swimming crab in Lasongko Bay, southeast Sulawesi was found to vary spatially and temporally. In some stations the number of male were higher than female, however, the results of χ^2 test showed the sex ratio of the blue swimming crab population is equal between male and female (Table 2). It means that varies in habitat condition seems not to affect the sex proportion for the whole population. Balanced sex ratio in the population would increase the success of mating event in these waters. The number of female were higher in most cases collected from the deeper part of the bay (i.e. stations 6 and 7), which is presumably related with migration. It is proved that female was more likely to migrate to the deeper waters to spawn (Ikhwanuddin et al 2012b; Kunsook et al 2014), and to some extent this phenomenon may affect sex ratio of population (Potter & de Lestang 2000; de Lestang et al 2003). Total sex ratio of crab population in Lasongko Bay was still within the range reported in previous studies (Dhawan et al 1976; Sukumaran 1995; Potter & de Lestang 2000; Potter et al 2001; Xiao & Kumar 2004; Dineshbabu et al 2008; Ikhwanuddin et al 2009; Kamrani et al 2010; Jazayeri et al 2011; Hosseini et al 2012; Kembaren et al 2012; Sunarto 2012; Ernawati 2013; Nitiratsuwan et al 2013; Safaie et al 2013; Ihsan et al 2014; Kunsook et al 2014). Previous studies showed that sex ratio in blue swimming crab population varied by location. The variation of sex ratio was believed to be related to the behavior of crab, environmental conditions and collection methods (Sukumaran 1995). The composition of crab size and type of fishing gear may also affect sex ratio (Potter & de Lestang 2000; Kunsook et al 2014).

Gonad development. The proportion of famale with matured gonad was higher in the deeper stations, i.e. in the middle part and the outer part (mouth) of the bay. In the inner part with shallow waters female with undeveloped gonad was dominant (Table 3). It strongly indicates that matured females tended to migrate for spawning into the deeper waters to get clear water conditions with high oxygen and salinity (Sumpton et al 1994; de Lestang et al 2003). The inner part of Lasongko Bay is relatively shallow, turbid with lower salinity, whereas in the middle and the mouth of the bay is relatively deeper, clear with higher salinity (unpublished data).

Gonad maturation and GSI in both sexes showed three peaks in the year (Figures 3, 4 and 5). The increase of GSI was in line with gonad development, hence GSI is a

good indicator to determine the development of gonad on crabs and other crustaceans (Liu et al 2014). Three peaks in a year as the pattern in gonad maturation of the blue swimming crab population were also found in Bone Gulf, Indonesia (Kembaren et al 2012), Pati coast, Indonesia (Ernawati 2013), and the northern coast of the Persian Gulf, Iran (Kamrani et al 2010), but the period was not the same for each location. However, gonad maturation pattern in female blue swimming crab of Brebes coast, Indonesia (Sunarto 2012), KhungKrabaen Bay, Thailand (Kunsook et al 2014), Persian Gulf and Sea of Oman, Iran (Safaie et al 2013) and Beibu Gulf, China (Liu et al 2014) was detected to have only two peaks in a year.

The proportion of gonad development and GSI of males and females crab also varied among studies. The proportion of female with matured gonad in this study based of sampling period was lower than that in Pati coast, Indonesia (Ernawati 2013) and Beibu Gulf, China (Liu et al 2014), but is higher than that found in the Gulf of Bone, Indonesia (Kembaren et al 2012). The GSI of male crab found in this study is greater compared to previous studies (Pillay & Nair 1971; Sumpton et al 1994; Jazayeri et al 2011), but is lower than those found by Soundarapandian et al (2013) and Songrak et al (2014). The GSI mean values monthly of female crab in Lasongko Bay is lower than previously reported (Pillay & Nair 1971; Sukumaran 1995; Sukumaran & Neelakantan 1997; Potter & de Lestang 2000; Potter et al 2001; Kunsook et al 2014; Liu et al 2014; Songrak et al 2014), but is higher than those found in the northern coast of the Persian Gulf, Iran (Kamrani et al 2010) and Leschenault Estuarine, Austalia (Potter et al 2001). GSI of ovigerous female crabs were lower than GSI of non-ovigerous female crabs (Pillay & Nair 1971; Hamid et al 2015b).

The variation of the proportion of gonad development and GSI of blue swimming crab among different locations is probably related to habitat conditions, seawater condition, body size and weight of crabs. Gonad development in female were strongly affected by water temperature and salinity (Potter & de Lestang 2001; de Lestang et al 2003; Kamrani et al 2010; Safaie et al 2013; Green et al 2014; Kunsook et al 2014; Liu et al 2014). Temperature as the main factor behind the variation in the reproduction cycle of crab were reported (Potter & de Lestang 2000; Kamrani et al 2010; Green et al 2014; Liu et al 2014).

Spawning season and first size at sexual maturity. Spawning season in Lasongko Bay took place throughout the year; it is characterized by the occurrence of females with matured gonad and ovigerous female every month during the study (Figures 4 and 5). As mentioned above the peak of spawning season in the bay was three times a year. Comparison of spawning season of the blue swimming crab from different location of the world is summarized in Table 5.

Many studies showed that spawning season of blue swimming crab was correlated with variation of temperature, salinity, food availability, rainfall and photoperiod (Pillay & Nair 1971; Cobo & Fransozo 2003; Soundarapandian et al 2013). Temperature, light intensity and photoperiod vary seasonally among locations where the crab lives, so these three environmental components might play important role in determining the gonad maturation of crustaceans (Li et al 2011) and consequently would determine the peak of spawning season as well. A number of researchers reported how temperature was one of factors behind the variation of peak spawning season in blue swimming crab population (Pillay & Nair 1971; Kangas 2000; Potter & de Lestang 2000; de Lestang et al 2003; Kamrani et al 2010; Safaie et al 2013; Liu et al 2014).

First size at sexual maturity in a population is usually defined as approximately 50% of individuals in the population have sexually matured (King 1995). Some previous research showed that first size at 50% sexual maturity of male and female crabs varied between locations waters (Table 5). First size at 50% sexual maturity of male crabs in this study was still within the range found in several locations in the world, ranged from 74.9 to 115 mm-CW, while in female crab was larger than the results of previous studies, ranged from 71.63 to 113.0 mm-CW (Table 5).

Many factors may affect the size at sexual maturity in a crab population. The availability of food, predation, density of crabs (de Lestang et al 2003; Johnson et al

2010; Kunsook et al 2014; Liu et al 2014), as well as differences in the duration and the proportion of molting crab (Soundarapandian et al 2013) were some biological factors affecting the size at sexual maturity. While environmental aspects include differences in temperature and salinity (Potter & de Lestang 2000; de Lestang et al 2003; Soundarapandian et al 2013; Green et al 2014; Liu et al 2014). In technical point of view, factors such as fishing pressure, type of fishing gear used during sampling, sampling location, and method of determining the first size sexual maturity crabs (Songrak et al 2013; Soundarapandian et al 2013; Kunsook et al 2014; Liu et al 2014) would make the differrence of size at sexual maturity among habitat.

For sustainable use of the crab in the bay it is important to recommend a legal size and the closure of season based on size at 50% sexual maturity and spawninng season. Based on the two parameters, it is recommended for legal size of male crab in Lasongko Bay is ≥ 109.8 mm-CW and female is ≥ 115.7 mm-CW, and closing season is suggested to be in in May and June, August, and October.

Table 5

The peak of spawning season and the presence of ovigerous females as well as first size sexual maturity (FSSM) crab in several waters locations

Location	*Season peak (month)*		*FSSM (mm)*		*Source*
	Spawning	*Ovigerous*	*Minimum*	*CW50%*	
Persia Gulf & Adjacent	Jul-Aug, Dec	Jul-Sep, Dec	32	96.0 F	Kamrani et al (2010)
Bandar Abas Coast, Persia Gulf					
East Coast, Persia Gulf, Iran	Mar-Apr	-	-	95 M	Jazayeri et al (2011)
		-	82	88 F	
Bardawil Lagoon, Eiypt	Feb-May	Jun-Oct	85	96 F	Abdel-Razek et al (2006)
Persia Gulf and Oman Sea	Oct & Sep	Sep-Oct	93	113 F	Safaie et al (2013)
South Asia	Mar, Aug, Dec-Jan	Aug-Apr	-	95 F	Pillay & Nair (1971)
Cochin, India					
South west Karnataka Coast, India	Jan-Feb, Sep	Aug-Feb	81.1 80.0	105 M 99 F	Sukumaran (1995)
South Karnataka Coast, India	Feb-Mar	Feb-Mar	-	96 F	Dineshbabu et al (2008)
Beibu Gulf, China	Feb-May	Feb-May	78.5	108.2 F	Liu et al (2014)
Australia	Mar,	Mar,		79 F	Shields & Wood (1993);
Moreton Bay, Queensland	May-Jun, Aug	Aug-Oct		81 M	Sumpton et al (1994)
Cockburn Sound	Oct-Nov	Oct-Dec	72.1[a]	96.8 M 86.2 F	Potter et al (1983); Potter & de Lestang (2000);
Shark Bay	-	Jun-Aug, Dec-Jan	76.2[a] 61	115.1 M 92.4 F	Potter et al (2001); de Lestang et al (2003);
Kombana Bay	Sep-Nov, Jan	Oct-Jan		86.9 F	Johnston et al (2011)
Leschenault Estuary	Sep-Nov	Dec-Jan	94	98.0 F	
Peel-Harvey Estuary	Oct-Dec	Nov-Feb	61	97.5 F	
Willis Estuary	Nov-Dec	Nov-Jan	38	46 CL F	Johnson et al (2010)
Southeast Asia					
Ragay Bay, Luzon-Philippines	Feb-Apr, Jul-Oct	-	-	105.6 M 96.4 F	Ingles & Braum (1989)
Trang Coast, South Thailand	Dec-Feb	Mar-Apr, Aug-Sep	64.5	78 M 74.9 M	Nitiratsuwan et al (2010, 2013); Songrak et al (2013, 2014)
Khung Krabaen Bay, Thailand	Dec, Mar, Jul-Aug	Dec, Feb-Mar, Sep	58.2	106.2 F	Kunsook et al (2014)
Brebes Coast, Indonesia	Apr, Sep	Jun-Aug, Jan-Mar		101 F 128 M	Sunarto (2012)
Bone Gulf, Indonesia	May, Dec	-	69.36	71.63 F	Kembaren et al (2012)
Pati Coast, Indonesia	Sep-Nov, Feb	-	-	107 F	Ernawati (2013)
Pangkep Coast, Indonesia	Jul, Aug, Sep, Oct	-	- 85	95.5 M 106 F	Ihsan et al (2014)
East Lampung, Indonesia	Mar-Jun, Sep-Nov	Apr-Jun, Oct-Nov	-	98 M 103 F	Zairion et al (2015b)
Lasongko Bay, Indonesia	May-Jun, Aug, Oct-Nov	Jul-Aug, Nov-Oct, Feb*)	83.7 82.2	109.8 M 115.7 F	This study

M - male; F - female; CL - carapace length; *) source: Hamid et al (2015b).

Conclusions. Sex ratio in some stations showed male biased, but for the entire population it is equal between male and female. According to patterns in gonad maturation and gonado somatic index as well as the occurrence of matured and ovigerous females, three peaks were detected in spawning season, i.e. in May-June, August, and in October-November. The development of gonad maturity between male and female crab spatially and termporally tended not to be concomitant. The size at sexual maturity of male and female crab is 109.83 mm-CW and 115.71 mm-CW, respectively. These findings could be used to support the implementation of policy for blue swimming crab's sustainable fishery in the bay.

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