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The dynamic of landing blue swimming crab (*Portunus pelagicus*) catches in Pangkajene Kepulauan, South Sulawesi, Indonesia

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Abstract. Based on numerous research and landing trends, blue swimming crab (*Portunus pelagicus*) in Indonesia are presently under considerable pressure, as the volume and sizes of catches are decreasing. However, the management strategy for blue swimming crab still lacks crucial information. For this reason, a study in relation to the dynamics of the catch landing characteristics of blue swimming crab is important. Therefore, the objectives of this study are to analyse the dynamic of blue swimming crab catches. The study was conducted in Pangkajene Kepulauan, South Sulawesi Indonesia one of the focal points for landing blue swimming crab in Indonesia. The catches, both in total weight and morphometrics were compared between the monsoon season (month) and the phases of the moon. The results of this study concluded that the greatest landings of crab catches in Pangkajene Kepulauan occurred in the dry season (June) during the new moon. A comparison of the morphometrics of gear also concluded a similar result, where the width, length and weight also achieved the highest value during the dry season (June).
Key Words: blue swimming crab, Indonesia, morphometrics, lunar phase, Pangkajene Kepulauan.

Introduction. The pressure on available fish stocks in the small-scale coastal fisheries of Indonesia has dramatically increased in recent years (Wiyono & Hufiadi 2014). As other developing countries, the increases in the type, number, size and efficiency of gears in the multigear-multispecies small-scale coastal fisheries of Indonesia are believed to be the main factors causing the degradation of fish stocks (Berkes et al 2001; Silvestre & Pauly 1997). Although several management approaches have been introduced with the aim of reducing excessive fishing, the Indonesian fisheries have ongoing issues with overcapacity and the reduction of excessive fishing (Nikijuluw 2002).

One particular fisheries resource that requires more attention is the blue swimming crab (*Portunus pelagicus*). Due to a rise in demand, the capture of the blue swimming crab in Indonesian waters has rapidly increased. The blue swimming crab has grown as an important commercial catch, and the number being caught year on year has risen substantially. From 2001 to 2011, production increased on average, by about 9.64% per year; in 2001, the blue swimming crab catch was about 22.040 tonnes, which increased to approximately 42.411 tonnes by 2011 (Ministry of Marine Affair and Fisheries, Indonesia 2011). The export value of the blue swimming crab reached USD 329,724 and was the third largest fisheries export product (excluding other fish) in total value in Indonesia, in 2012 (Ministry of Marine Affair and Fisheries, Indonesia 2012).

Despite the commercial value of the blue swimming crab, there is no specific management to regulate this particular segment of the fishing industry. There are a number of indications that overfishing of blue swimming crab has occurred in some regions, for instance, catch per trip has decreased and the size of a catch has a tendency to be smaller (Kembaren et al 2012). Besides fishing activity, the reduction in catches is

believed to have been caused by the limited fisheries management. Thus, the size of a catch is smaller, with fishing grounds a longer distance from fishing bases.

In order to help resource managers to better understand fisheries resources, information with regards to the dynamics of fisheries, including catches is significant. Information on spatial distribution of crab resources are needed as basis data for management, included sex composition, size distribution, abundance and biomass related to the issue of resource allocation (Kangas 2000). In addition to the monsoon season, the lunar phases are believed to influence the distribution of fish resources. Moreover, lunar phases influence zooplankton migration and generate an abundance of fish (Gliwicz 1986). The cycles of the moon firstly affect the maturation process of molting and sex, in particular in decapod crustaceans (Nascimento et al 1991) and finally, influence the fish catch (Akyol 2013; Akyol & Ceyhan 2012). For this reason, an understanding of the effect of the monsoon and lunar phases on the dynamics of catches and fishermen's fishing strategies in adapting to the changes in dynamics needs to be understood. The aim of this study is to analyse the dynamics of the blue swimming crab (in catch volume and morphometrics) between the monsoon season (month) and lunar phases.

Material and Method. This research was conducted along the coast of Pangkajene Kepulauan (Pangkep) district, South Sulawesi from January 2013 to July 2014. Data in relation to the blue swimming crab were collected from the recorded catches of three collectors; who caught the crabs using 76 gillnetter, 13 trapper and 15 mini trawlers. The fishing gear was a one day fishing trip operated in similar fishing grounds around the Pangkajene Kepulauan coast (Figure 1).

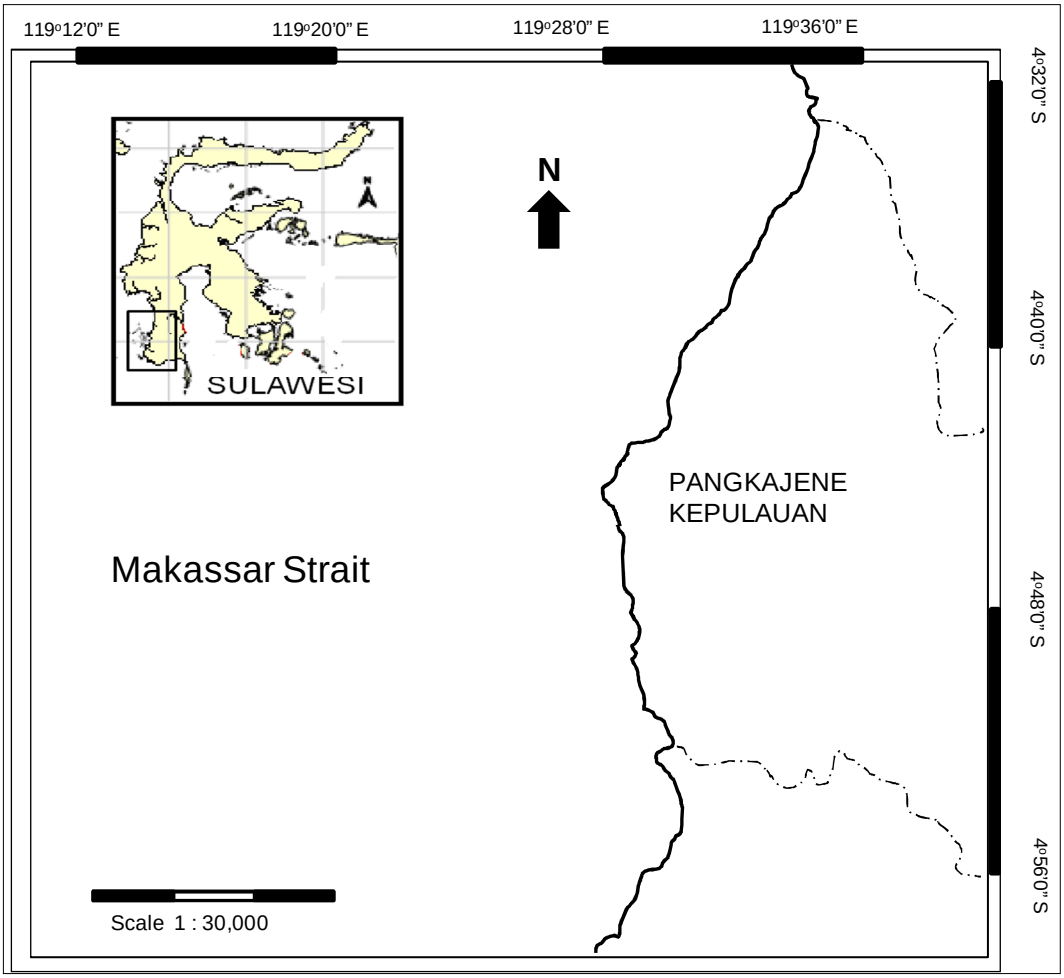

Figure 1. Map of Pangkajene Kepulauan, South Sulawesi Indonesia (redrawn from a map of the earth provided by Geospatial Information Agency of Indonesia 2015).

The arrival of the vessel and data on catches were used as a basis for the data. Besides the volume of catch data (kg), the morphometrics of the blue swimming crab, i.e the width (cm), length (cm) and weight (kg) of crab were also measured. Approximately 1,526 crab samples (an average sample per month of 305) were calculated to ascertain the morphological data. Moreover, data was collected from the fisherman every day, and subsequently aggregated into total catch per day. Furthermore, based on the total catch per day, data was aggregated to a monthly (in BC) and lunar phase. In the case of the lunar phase data, the date of the arrival of the vessel was converted using the following criteria below:

- a) new moon (from the 27th of the previous month to the 4th of the next month);
- b) the first quarter (from the 5th until the 11th of the month);
- c) full moon (from the 12th to the 19th of the current month);
- d) last quarter (the 20th until the 26th of the current month).

To analyse the dynamic of a catch, data were compared between the monsoon season (month) and the lunar phase using ANOVA analysis.

Results and Discussion. The fishing season for the blue swimming crab in Pangkajene Kepulauan generally begins around December/January and finishes in July/August. Other than those particular months, the blue swimming crab is rarely caught by fishermen. The results of the survey showed that the majority of fishing boats operated by fishermen in Pangkajene Kepulauan are the gillnetter (74%). Other fishing boats used are the trapper (12%) and mini trawler (14%). The gillnetter and mini trawler boats usually operate only one unit of fishing gear; however, trapper fishing boats operate approximately 250 units of traps (Figure 2). The number of traps per month increased from January to June. Similar to the traps, the trappers and mini trawlers also showed a similar pattern.

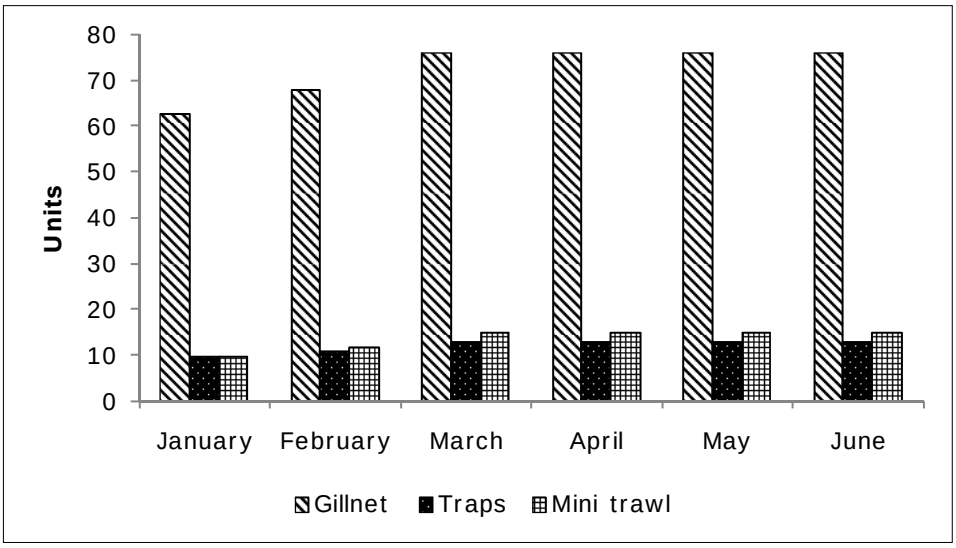

Figure 2. Fishing boats operated in Pangkajene Kepulauan from January and June.

Although it starts from December/January, the primary fishing season for blue swimming crab in Pangkajene Kepulauan is around May–July (Table 1), coinciding with the beginning of the dry season. The fishing season begins in January (93.13 kg day^{-1}) and reaches its peak in June (193.99 kg day^{-1}). After June, when the fishing grounds experience the rainy season, catches decrease, and from August fishing for the blue swimming crab enters the low season.

Table 1

Blue swimming crab catches during the fishing season

Month	*Mean (kg day^{-1})*	*Std. Deviation*	*Minimum*	*Maximum*
January	93.13	61.98	0.00	219.90
February	123.92	52.29	23.90	286.40
March	70.55	36.83	25.40	171.40
April	64.10	20.54	19.00	126.80
May	156.90	74.82	73.80	289.20
June	193.99	54.53	93.00	301.50
July	139.54	31.86	76.20	210.96

Results of the ANOVA analysis (Table 2) demonstrated that in general the catches were significantly different between months ($p < 0.05$). Moreover, advanced analysis (multiple comparisons of catches between months by using Least Significant Difference, LSD) showed that the catches landed from January to June were different when compared with other months, whereas catches landed during July and February, July and May and also March and April are reasonably similar.

Table 2

Anova analysis of blue swimming crab catches (kg) between months

Sources of variance	*Sum of squares*	*Degrees of freedom*	*Mean square*	*F-statistic*	*p-value*
Between groups	409,908.248	6	68,318.041	26,654	0.000
Within groups	522,885.578	204	2,563.165		
Total	932,793.825	210			

The results of measuring the morphometrics of the blue swimming crab explain that during the period from January–May, the width of blue swimming crab catches increased. If the average width in January was approximately 10.97 cm, it increased by May to 12.01 cm. The weight of the crab also showed a similar trend, and increased from January–May. If the average weight of the crab in January is roughly 80.61 grams, it had increased to 112.02 grams by May. In addition, the length of the crab did not demonstrate an increasing trend from January to April (Table 3).

Table 3

Morphometrics of blue swimming crabs

Morphometrics	*Month*	*Mean*	*Std. deviation*	*Minimum*	*Maximum*
Width (cm)	January	10.97	1.85	7.30	15.50
	February	11.18	1.43	6.50	15.50
	March	11.68	1.66	7.00	16.30
	April	12.02	1.78	8.00	18.00
	May	12.01	1.47	4.00	17.00
Length (cm)	January	5.66	4.14	3.20	50.00
	February	5.39	3.41	3.50	56.00
	March	5.02	0.79	2.30	7.50
	April	5.32	0.82	3.20	8.30
	May	5.41	0.77	2.50	9.00
Weight (cm)	January	80.61	47.92	10.00	240.00
	February	86.39	33.12	30.00	210.00
	March	92.54	35.87	6.50	230.00
	April	109.74	47.20	6.50	300.00
	May	118.02	50.51	30.00	390.00

A comparison of performance of morphometrics between the months (Table 4) showed that all were significanly different ($p < 0.05$). However, multiple comparisons of morphometrics between months by using Least Significant Difference (LSD) illustrated that the width of the crabs were different in March compared with the other months. Similar results were established in length, although a comparison of weight showed that the weight of the crabs in April and May were different to other months.

Table 4

A comparison of the morphometrics of the blue swimming crab between months

Sources of variance		*Sum of squares*	*Degrees of freedom*	*Mean square*	*F-statistic*	*p-value*
Width	Between groups	246.84	4	61.71	23.53	0.000
	Within groups	3,988.44	1,521	2.62		
	Total	4,235.28	1,525			
Length	Between groups	53.13	4	13.28	2.99	0.018
	Within groups	6,744.31	1,521	4.43		
	Total	6,797.45	1,525			
Weight	Between groups	318,228.92	4	79.557.23	40.05	0.000
	Within groups	3,021,038.74	1,521	1,986.21		
	Total	3,339,267.69	1,525			

Furthermore, the analysis of the dynamics of catches based on the lunar phase (Table 5) confirmed that the highest average catch occured during the full moon (153.67 kg). The minimum catch during the full moon was 55.68 kg and a maximum catch of approximately 289,20 kg was achieved, with the lowest catch established during the last quarter (102.42 kg).

Table 5

Catches between lunar phases

	Mean	*Std. deviation*	*Std. error*	*Minimum*	*Maximum*
New moon	114.68	73.57	10.62	23.90	301.50
First quarter	121.63	61.06	8.81	25.40	260.10
Full moon	153.67	68.88	9.94	55.68	289.20
Last quarter	102.42	49.04	7.08	0.00	211.20

The results of the ANOVA analysis (Table 6) explained that crab catches were significantly different ($p < 0.05$); however, advanced analysis (multiple comparisons of catches between lunar phase by using Least Significant Difference, LSD) demonstrated that crab catches were similar during the first and last quarters of the new moon. Only catches landed during the full moon where different to other lunar phases.

Table 6

Anova analysis of blue swimming crab catches (kg) between lunar phases

Sources of variance	*Sum of squares*	*Degrees of freedom*	*Mean square*	*F-statistic*	*p-value*
Between groups	68,899.15	3	22,966,38	5.64	0.001
Within groups	765,328.89	188	4,070,89		
Total	834,228.05	191			

The results of this analysis showed that the fishing season in Pangkajene Kepulauan starts in the rainy season, during the west monsoon season (December/January) and finishes in July/August, which coincides with the last of the east monsoon (last dry season). Thus, in order to increase catches, fishermen increased their fishing trips. This

result was similar to the results established on the south Karnataka coast, India; Dineshbabu et al (2008) reported that the trawling season for blue swimming crab on the south Karnataka coast, India is from September to June, and reaches a peak from December to June. In addition, the fluctuation in catches correlates with the salinity (Romano & Zeng 2006; Potter et al 1983, 1998). Moreover, Juwana et al (2002) reported that blue swimming crab live in salinity of 11-53 ppt. Furthermore, it has also believed that the monsoon season influences blue swimming crab catches. During the rainy season when the salinity in the coastal water decreases the crabs migrate to the open ocean. Consequently, this causes the activity of fishermen who operate small scale fishing boat can experience challenges and the catches reduce in number. Conversely, during the dry season when the salinity of the coastal waters returns to normal and the crabs migrate to the coastal zone, fishermen generally witness an increase in crab numbers in their hauls.

Other results from this study explain that blue swimming crab catches were influenced by the lunar phase, and crab hauls achieve their highest volume during the full moon. Hence, this is different to fish, where the catches landed attain the highest volume during the new moon (Lee 2010; Di Natale & Mangano 1995; Akyol 2013; Akyol & Ceyhan 2012). These results are similar to a study conducted in the waters of Cirebon, in the Java Sea (Wiyono 2007). The research demonstrated that the lunar phases are believed to have a significant effect on the behaviour of the crabs and the increasing intensity of moon light during the full moon is believed to encourage the crabs to migrate over a wide area. During the full moon phase, the crabs actively migrate more and reach coastal areas, which means that they are more easily caught by fishermen. Conversely, during the phases of the new moon, when light from the moon entering the water is relatively low, the crab reduced their migration activity and thus, capturing the crabs becomes more difficult.

The lunar phase also affects tidal conditions by having an influence on light during the night (Hilder 1999; Kordi 1997). Changes in sea level eventually affect the availability of food, especially plankton (Dewar et al 2008). Babcock et al (1986) revealed that in addition to affecting the light and tidal conditions (tidal amplitude) the lunar phase is also an important factor in determining reproduction time.

The results of this research and several other studies indicate that the lunar phase has a direct effect on the earth's tides and the light in the waters. Furthermore, these conditions will affect the existence of living resources on the planet, including plankton and fish. Fish will directly use the phase of the moon to determine self-protection strategies and life cycles. Based on this phenomena, fishers can use the lunar phase to determine a fishing strategy, especially for blue swimming crab, where resources require more attention. As a consequence, the intensity of fishing during the fishing season should be managed to avoid over capacity. In addition to managing fishing gears, attention should also focus on the number and the size of a catch based on their dynamics caused by the monsoon season and the lunar phase.

Conclusions. The blue swimming crab is an important commodity within the Indonesian export fisheries. However, as is similar with other countries, the increasing demand for crab in international trade has increased the pressure on the fishing industry. In addition, the use of fishing gear has risen sharply and caused degradation in resources, a reduction in the volume of catches and the size of the crab to become smaller. In order to help resource managers to better understand fish resources, basic information included catch dynamics is required. For this reason, a study pertaining to the dynamics of landing catches has been conducted in Pangkajene Kepulauan, South Sulawesi, Indonesia. The results of the analysis demonstrate that both the monsoon and lunar phase influenced the landing of crabs. The crab fishing season starts from December/January and finishes in July/August with the highest catch volume attained in June. Furthermore, the highest catch of the blue swimming crab is during the full moon, which is different to the fishing season. Similar to the volume of catch, the morphometrics of the crab are also influenced by the monsoon season. Based on the

analysis of the results, fisheries managers can use the information to manage the time of fishing operations.

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