Potential fishing grounds for Portunus pelagicus

by Abdul Ghofar

Potential fishing grounds for *Portunus pelagicus* based on oceanographic factors of the Tukak Sadai waters, Bangka Belitung, Indonesia

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Abstract. The increasing demand for blue swimming crab (*Portunus pelagicus*) in Indonesia encourages fishermen to look for new fishing grounds. The presence of *P. pelagicus* in waters is predicted from oceanographic factors, including temperature, salinity, depth and currents. The purpose of this study is to predict the potential fishing grounds of *P. pelagicus* based on oceanographic factors in the Tukak Sadai waters, Bangka Belitung, Indonesia. Physical parameter data was obtained from a total of 20 fishing ground stations from March to May 2019. Polynomial regression was used to analyze the relationship between catches and physical parameters. In contrast, the spatial distribution of *P. pelagicus* fishing grounds used the kriging method to determine the suitability class. The results showed that the oceanographic characteristics of the fishing grounds were: 27.7-32.7‰ salinity, 29.5-31.8^{0}C temperature, 2-7 m depth and 0.34-0.4 m s^{-1} current velocity. The water depth factor has a high correlation with *P. pelagicus* catches (0.78), followed by temperature, current and salinity. Very potential fishing grounds of *P. pelagicus* in Tukak Sadai waters based on oceanographic conditions and the carapace width legal size (>100 mm) is located at a distance of 2 miles from the coast.

Key Words: blue swimming crab, depth, physical parameters, Tukak Sadai.

Introduction. In Indonesia, blue swimming crab (*Portunus pelagicus*) is an export commodity with high economic value. Its demand increases yearly; for example, in 2017 and 2018, approximately 15867 and 16300 tons were sold, respectively (Indonesian Crab Management Association 2019). The nation relies on 65% of fishery products to fulfil its productive requirements (Central Bureau of Statistics 2018).

P. pelagicus has an extensive fishing ground encompassing the western coast of Sumatra, the northern coast of Java, the southern and eastern coast of Kalimantan, southern part of Sulawesi and the western region of Papua (Sumiono 1997; La Sara & Astuti 2015; Kembaren et al 2018; La Sara et al 2019). This resource is greatly exploited in Riau Islands, located in the northern and southern coast of Sumatra (La Sara et al 2016), East Lampung (Zairion et al 2014) and Bangka Island, particularly in Tukak Sadai waters. According to the regulation of the Minister of Maritime Affairs and Fisheries of Indonesia number 71 of 2016, the fishing grounds are located on the fishing lane IA (from sea level at the lowest ebb to 2 nautical miles), IB (comprises coastal waters extending from 2 to 4 nautical miles), and II (waters outside fishing lane I extending to 12 nautical miles) and the commonly used fishing gear is a trap (folding trap).

Presently, the determination of fishing grounds by the fishermen in Tukak Sadai is carried out by traditional means without regard for the life cycle of *P. pelagicus*. Furthermore, fishing activities are focused on a particular area, and various sizes of the blue swimming crab are captured. However, when carried out continuously, it inhibits the growth rate of this specie in nature (Hamid et al 2017).

The act of determining potential fishing grounds is also an essential factor involved in maintaining the sustainability of these resources. Some of these considerations include the ontogenetic migration properties of *P. pelagicus*, which involve the development in the life phases, starting from when the egg is released into the waters to the larvae, juveniles and adult crabs (Kangas 2000). The existence of *P. pelagicus* in the waters is predicted by possessing knowledge of the environmental conditions in accordance with their lifestyle, such as temperature, salinity (Potter & de Lestang 2000; Jazayeri et al 2011; Ikhwanuddin et al 2016), depth (Zairion et al 2014; Kembaren et al 2018) and water current (Ihsan 2015; Ihsan & Saenong 2018). In the tropics, temperature and salinity affect the existence of blue swimming crab in the waters (Kamrani et al 2010). Furthermore, the natural distribution depends on salinity (de Lestang et al 2003), and Ikhwanuddin et al (2012) reported that the larvae undergo complete metamorphosis into first juvenile crabs at a temperature of 30^{0}C and salinity of 30 ppt. The depth of the water determines the distribution of *P. pelagicus* depending on carapace width. For example, an average carapace width size of 108.57 mm was discovered at a depth of 5 m, while at a depth of approximately 10 m, the average carapace width was 145.45 mm (Zairion et al 2014). Water currents play an essential role in the life cycle of *P. pelagicus* and in the migrations for foraging and spawning (Ihsan & Saenong 2018).

Based on the description above, it is necessary to research the oceanographic factors of Tukak Sadai waters, located at Bangka Belitung, Indonesia, to obtain a potential fishing ground and a catch size in accordance with the Regulation of the Minister of Maritime Affairs and Fisheries of Indonesia Number 12 of 2020. Data, information and spatial analysis of the suitability of the fishing ground is important. Therefore, this study is expected to be used as a reference in determining the catch size of *P. pelagicus* and its fishing ground based on oceanographic conditions, while maintaining the sustainability of the resources.

Material and Method

Description of the research location. The research was conducted in 20 fishing stations, situated in Tukak Sadai waters, South Bangka Regency, Bangka Belitung Province, from March to May 2019 (Figure 1).

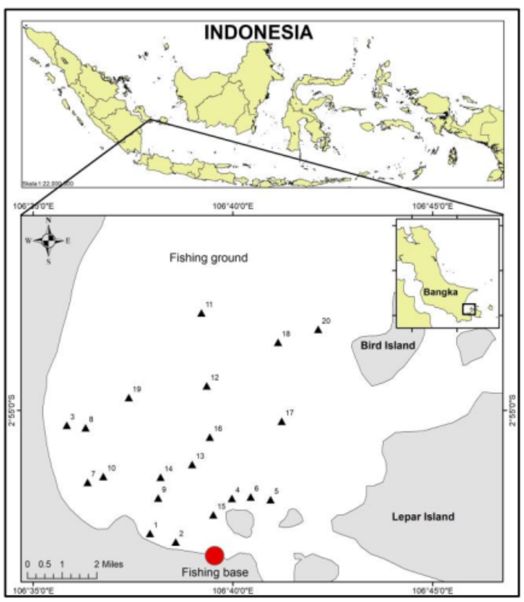

Figure 1. Research location in Tukak Sadai Village, Bangka Belitung Islands, Indonesia.

Description of fishing gear. The specifications of the folding traps include the framework made of iron (Ø 0.4 cm), as presented in Figure 2. A polyethene multifilament net with a mesh size of 2.7 cm was utilized. The traps were 48 cm long (L), 30 cm wide (W), and 17 cm high (H). There were 25 cm (F) wide funnels on both sides of the folding traps and an iron hook at the center with bait for pepetek fish (Leiognathidae), which further attracted crabs. The operating mechanism of the traps applied the longline system (Figure 3). Therefore, it required the main and the branch rope to have a length of 3000 m and 1.5 m, respectively. The ropes were fabricated with polyethene multifilament material, with Ø 0.7 cm and Ø 0.4 cm. 300 traps were used with a distance of 10 m between them.

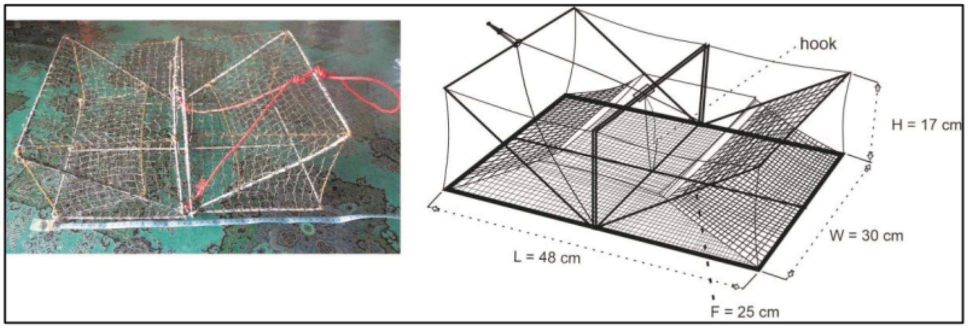

Figure 2. Dimensions of the folding traps.

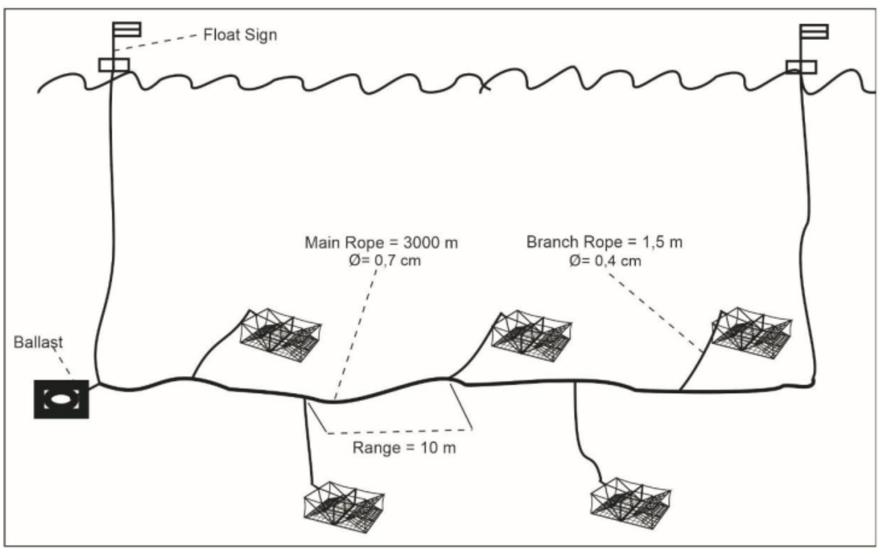

Figure 3. Operation of folding traps.

Data collection. The measurement of the physical and biological parameters of the blue swimming crab were carried out *in situ*. Temperature, salinity, depth, and currents were measured using a DO-5510 oxygen meter, PE 07 salinity meters, scaled ropes, and data from OSCAR (Ocean Surface Currents Analyzes Real-time), respectively. The coordinates of the fishing stations were determined from Garmin's Global Positioning System (GPS) data. Information relating to the carapace width (CW) were obtained using a vernier caliper to measure the distance between the 9^{th} anterolateral spines and recorded to the nearest 0.1 cm (Ikhwanuddin et al 2009; Hosseini et al 2012; Zairion et al 2014).

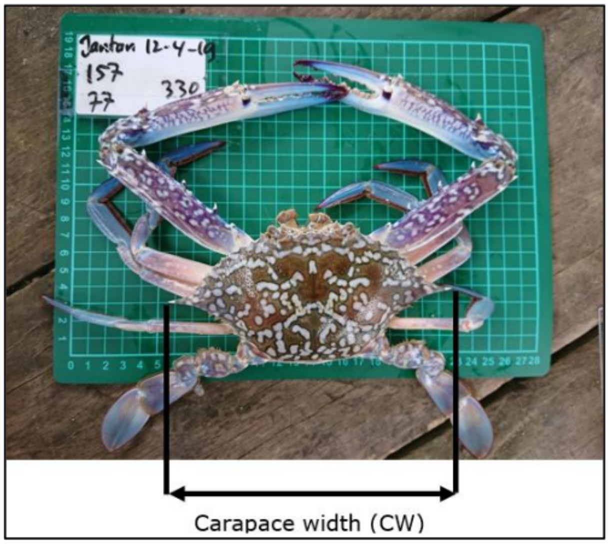

Figure 4. Measurement of carapace length of *Portunus pelagicus*. Source: Regulation of the Minister of Maritime Affairs and Fisheries of Indonesia Number 12 of 2020.

Data analysis. The Kolmogorov-Smirnov normality test was performed on all data. Furthermore, a quadratic polynomial regression test was carried out to determine the relationship between the physical parameters (x, y) and catches using quadratic equations. Generally, the polynomial regression model is as follows (Malensang et al 2012):

$$y = \beta_0 + \beta_1 x + \beta_0 x^2$$

Where: y - dependent variable (crab catch variable); β_0 - regression constants/intercept parameters; $B_{1,2}$ - regression coefficient/coefficient parameter; x - independent variables (temperature, salinity, depth, current).

Data analysis was carried out on spatial modelling in accordance with geostatistical gridding referred to as the kriging method (Hartoko & Kangkan 2009). Coordinate data transformation was carried out by geodetic computing information (degree; minute; second) into a single numerical formula (Hartoko & Helmi 2004):

Numeric Value (Lat; Long) = Degree + [Minute + (Second/60)]/60

The subsequent step was the analysis of the suitability of the fishing ground based on the spatial score matrix, as well as total catch, carapace width of *P. pelagicus*, and oceanographic parameters; this was based on an understanding of their specific functions in the ecosystem. These variables are modeled by the Inverse Distance Weighted (IDW) technique using the Raster calculator to interpolate the reclassified data (Indarto & Faisol 2012). Scoring weight was achieved when the total catch was 20%, carapace width 35%, the temperature 10%, salinity 10%, depth 15%, and current 10%.

The suitability level of the fishing ground is divided into 4 classes as reported by Hartoko & Widowati (2008), namely S1 - very potential (85-100%); S2 - potential (75-84%); S3 - potential enough (65-74%); N - less potential (<65%). The purpose of the spatial model is to ensure that the fishing ground is in accordance with the ideal size of 100 mm as stipulated by the Regulation of the Minister of Maritime Affairs and Fisheries of Indonesia Number 12 of 2020. Therefore, a special consideration during its assessment is the distribution of *P. pelagicus* carapace size.

Results and Discussion

Water quality. Tukak Sadai is a semi-open water protected from ocean waves on the eastern side of Lepar and Burung Islands. According to Table 1, the results from the measurements conducted on the quality of waters show that the temperature ranges between 29.5-31.8^{0}C, with an average of 30.39±0.76^{0}C and is higher than offshore. Salinity values range from 27.7 to 32.7‰, with an average of 31.36‰±1.47. On the contrary, the salinity offshore is higher than in the southwest, approximately 27.71‰. This condition is influenced by the mass of freshwater from the river. The depth of the water ranges from 2 to 3 m in the southwest and extends to 7 m in the northeast region. The direction of water current is from west to east and ranges between 0.34-0.40 m s^{-1}. All oceanographic profiles are presented in Figure 5.

Table 1

Physical qualities of water

Parameter	*Unit*	*Average*	*Range*
Temperature	^{0}C	30.39±0.76	29.5-31.8
Salinity	‰	31.36±1.47	27.7-32.7
Depth	M	4.34±1.52	2-7
Current	m s^{-1}	0.37±0.01	0.34-0.4

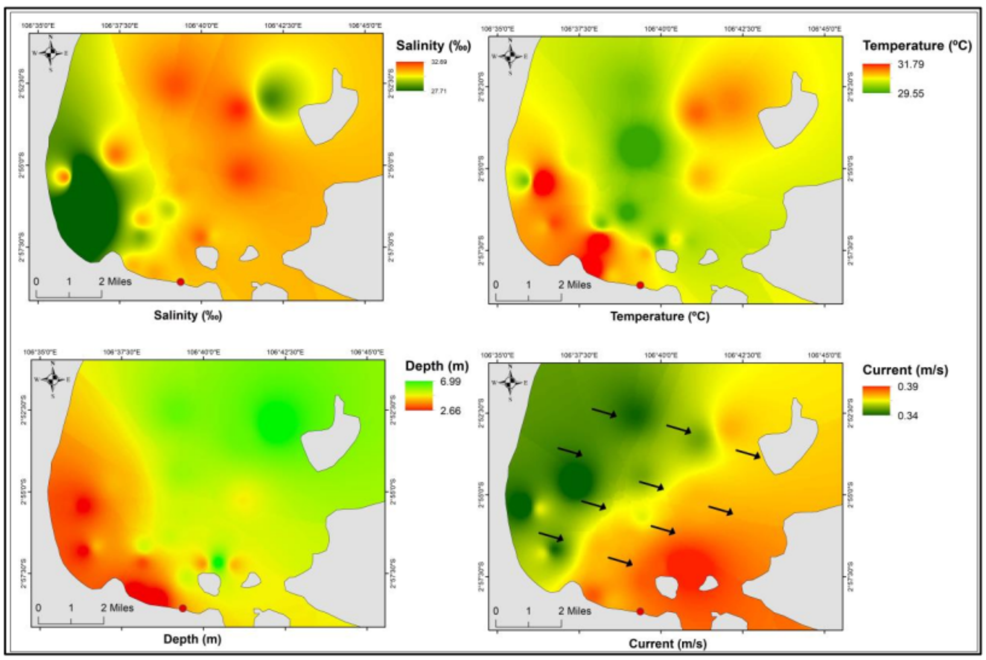

Figure 5. Oceanographic profile of the Tukak Sadai waters, Indonesia.

Relationship between physical conditions and catches. The results from the Kolmogorov-Smirnov normality test are as follows: asym.p sig temperature of 0.990>0.05, asym.p sig salinity of 0.534>0.05, asym.p sig depth of 0.442>0.05 and asym.p sig of the current of 0.679>0.05. Therefore, the data is normally distributed. According to Polynomial regression analysis, a relationship exists between physical conditions and catches, as presented in Table 2. For example, a very significant relationship exists between depth and catch. This is in accordance with the values of the correlation coefficient r-value of 0.786 and the coefficient of determination R^2 of 0.617, which shows that 61.7% of the catches is dependent on the depth variable. However, parameters such as salinity, temperature, and current have a less significant relationship, with r-values below 0.4. The relationship between physical conditions and catches is presented in Figure 6.

Table 2

Relationship between physical conditions and catches

Regression	*Polynomial formula*	*Correlation coefficient (r)*	*Coefficient of determination (R^2)*
Temperature with catches	$y=0.1313x^2-7.0763x+97.391$	0.396	0.157
Salinity with catches	y=-0.1365x2+7.9134x-109.96	0.318	0.101
Depth with catches	$y=0.5136x^2-5.067x+14.859$	0.786	0.617
Currents with catches	$y=-213.23x^2+191.81x-38.124$	0.352	0.124

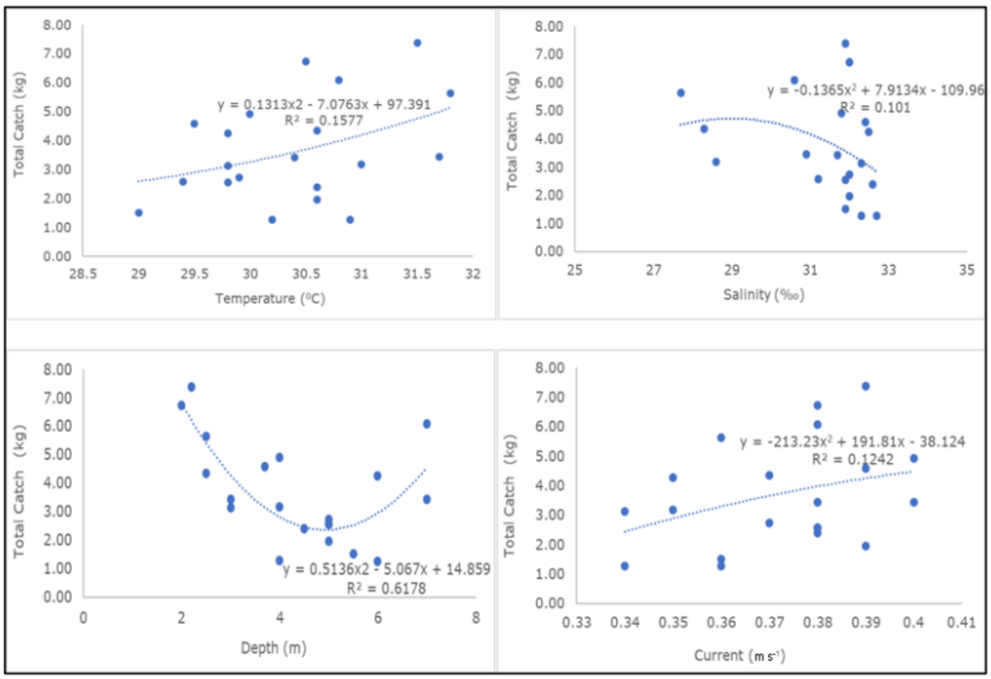

Figure 6. Relationship between physical conditions and catches.

Potential fishing ground of P. pelagicus. The total catches of *P. Pelagicus* from 20 stations were 73.31 kg. The lowest catch of 1.26 kg was discovered at station 18, while the highest catches of 7.38 kg and 6.72 kg at stations 1 and 2, respectively, as presented in Figure 7.

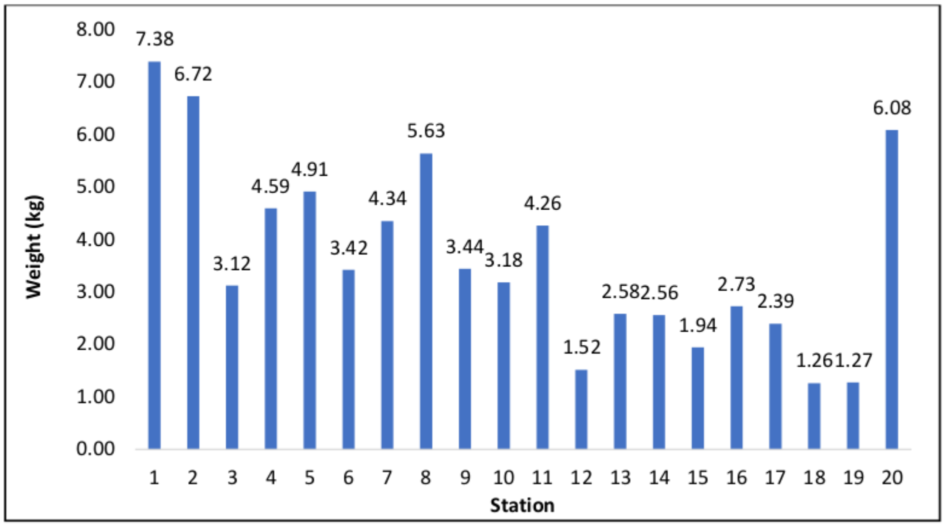

Figure 7. *Portunus pelagicus* productivity in the 20 stations.

The carapace size of *P. pelagicus* caught ranged between 67-165 mm. The width is used to determine whether the catch has the authorized size of 100 mm, as approved by the Minister of Maritime Affairs and Fisheries Number 12 of 2020. Therefore, the total legalized catches in this study are 58.84%, while 41.16% of *P. pelagicus* caught were under the legal limit.

The highest percentage of catches with legal size, 100%, 96%, 94%, 93%, and 92% were discovered at stations 5, 16, 6, 20, and 14, respectively. Meanwhile, the lowest percentages of legal size were 72%, 60%, 58%, 57%, and 46%, at stations 1, 19, 2, 10, and 16, respectively (Figure 8).

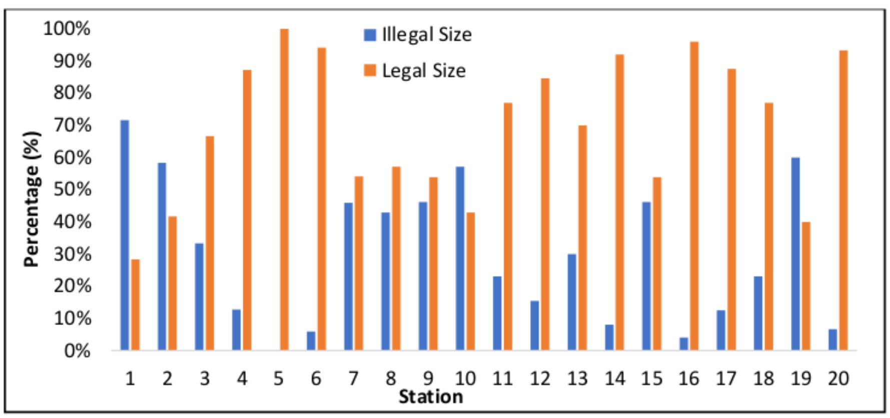

Figure 8. Percentage of undersized *Portunus pelagicus* in the 20 stations.

According to the results from the spatial analysis, fishing grounds grouped in 4 categories, very potential, potential, potential enough and less potential were determined (Figure 9). Very potential fishing grounds based on oceanographic factors and catches with legal size were discovered at stations 4, 5, 6, 17 and 20, with an average catch of 4.278 kg, ranging between 2.39 and 6.08 kg. Furthermore, based on the width of the carapace, approximately 92.4% of the catch has a legal size according to Minister of Maritime Affairs and Fisheries Regulation Number 12 of 2020. The less potential fishing grounds are discovered at stations 3, 8, 19, 1 and 2, with an average catch of 4.824 kg, between 1.27 and 7.38 kg. The legal catch percentage in the less potential fishing grounds was 46.8%, while 53.2% of crabs had a carapace width below 100 mm.

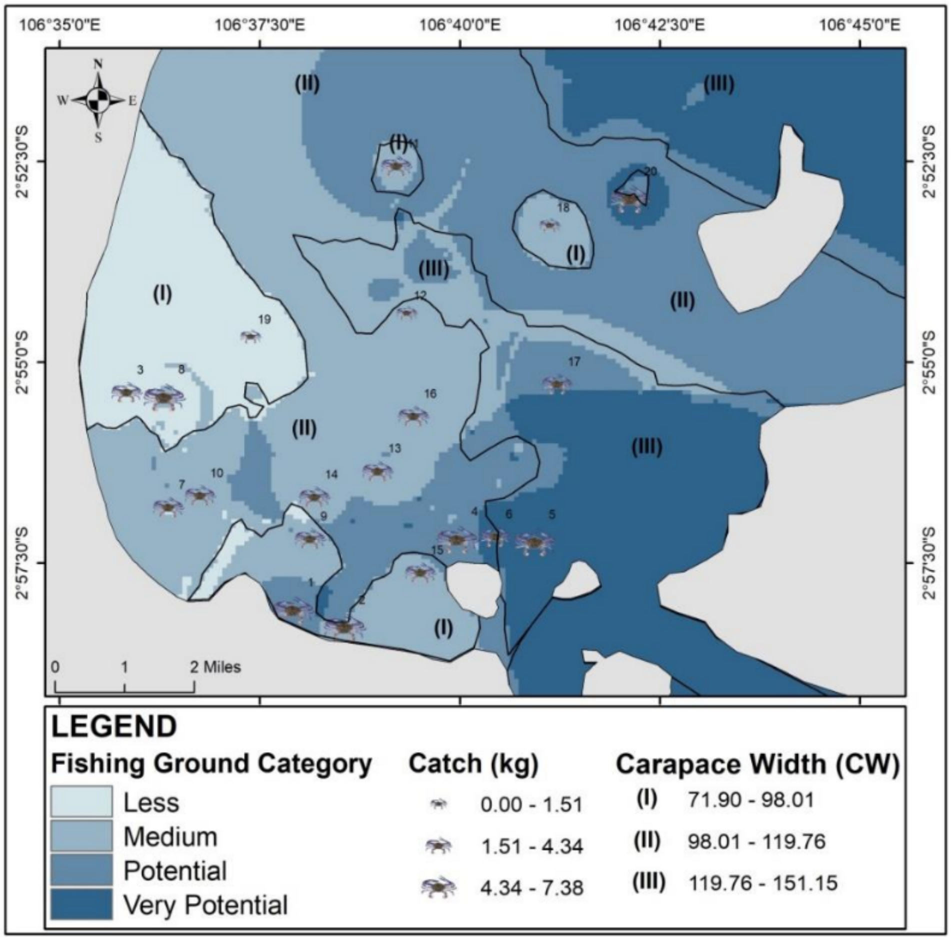

Figure 9. The distribution of *Portunus pelagicus* potential fishing ground in Tukak Sadai.

The effect of temperature on the number of *P. pelagicus* catches is 15% with a correlation coefficient (r) of 0.39, which shows that these variables are in low correlation. These results are similar to the research conducted in the Lasongko Bay waters by Hamid (2015), who state that the relationship between temperature and the number of crabs caught has a relative small correlation coefficient (r) of 0.26. According to Setyawan & Wirasatriya (2017), the number of catches in Tegal waters is 67.43% influenced by temperature, with a correlation coefficient of 0.82, showing a strong relationship. Potter & de Lestang (2000) reported an abundance of adult *P. pelagicus* in the Leschenault estuary, southwestern Australia, during spring and summer and a drastic decrease during winter and early spring.

The temperature distribution in the fishing grounds of *P. pelagicus* ranged from 29 to 31.8^{0}C. The highest catches (7.38 kg) were obtained at a temperature of 31.5^{0}C, while the lowest catch (1.26 kg) was discovered at 30.9^{0}C. According to Kunsook et al (2014), temperature is an ecological factor that controls the distribution of *P. pelagicus*. Kangas

(2000) further stated that temperature affects its movement. In southwestern Australia, *P. pelagicus* is active and easily caught during summer. However, it is inactive during winter.

Salinity affects the number of catches with 10%, with a correlation coefficient (r) of 0.31, which shows that the relationship between these variables is included in the low correlation. These results contradict the studies conducted in Tegal by Setyawan & Wirasatriya (2017), where catches were dependent on the salinity (52.23%) at a coefficient of 0.73 and a strong correlation was reported. Hamid (2015) stated that there was a significant correlation between salinity and the total population of *P. pelagicus* caught in Lasongko Bay waters. However, these variables had a negative correlation.

P. pelagicus is dominantly found in fishing grounds with salinity between 30.6 and 32.7 ppt. The highest number of catches is 7.38 kg at a salinity of 31.9 ppt, while the lowest is 1.26 kg at a salinity of 32.7 ppt. According to Potter & de Lestang (2000), *P. pelagicus* is usually found in fishing grounds with a salinity of 20-35 ppt. Furthermore, Kunsook et al (2014) stated that the relationship between its abundance and ecological factors shows that salinity is the primary ecological factor that controls the distribution of *P. pelagicus*. Blue swimming crab has the ability to regulate osmotic pressure in its body by altering hyposalin to hypersalin waters to suit the environmental conditions. Therefore, it tends to survive within a wide salinity range (11-53 ppt) for a long time (Kangas 2000). During the rainy season, there is an increase in surface runoff, and this causes a decrease in salinity as well as the migration of *P. pelagicus* to open waters, thereby causing low catches for small scale fishermen. Conversely, during the dry season, there is a decrease in surface runoff from the mainland, which causes normal salinity in the coastal waters and the migration of *P. pelagicus* to this zone, providing opportunities for fishermen (Wiyono & Ihsan 2018).

The depth of Tukak Sadai waters appropriate for the survival of *P. pelagicus* ranges from 2 to 7 m. The effect of depth on the number of catches was 61.7%, with a correlation coefficient (r) of 0.78, which shows that the relationship between these variables is included in the strong correlation. Hamid (2015) stated that the correlation coefficient between the total population of *P. pelagicus* caught and water depth is -0.375, which is classified as low correlation. The research conducted by Setyawan & Wirasatriya (2017) in the Tegal waters shows that the catches are influenced by depth (18.48%) with a correlation coefficient of 0.43, a relatively strong relationship.

The depth of the waters is closely related to the distribution and migration of *P. pelagicus*. Sunarto (2012) reported that they generally migrate towards the deeper waters when spawning. This shows that depth affects the size distribution (Chande & Mgaya 2003; Ernawati et al 2015). Furthermore, according to Batoy et al (1988), the spatial distribution of *P. pelagicus* is related to its size, the larger crabs (50 mm carapace length) being usually caught at a depth above 5 m, while juveniles (carapace length of 30 mm) are found in shallower waters or near the coast.

The current of the water in the fishing ground ranged from 0.34 to 0.40 m s^{-1}. In the west, it was as low as 0.34 m s^{-1} and, further eastward, its speed increased to 0.4 m s^{-1}. The effect of current on the number of catches was 12%, with a correlation coefficient (r) of 0.35, showing that the relationship between these variables is included in the low correlation. These results contradict the study conducted in Tegal waters (Setyawan & Wirasatriya 2017), which shows that 81.84% of catches are dependent on the current. In addition, it also affects the life cycle of *P. pelagicus* by aiding migration in order to find food and for spawning. Tidal and seasonal currents play an important role in the life cycle of *P. pelagicus*. According to Ihsan & Saenong (2018), tidal currents hugely affect the horizontal distribution of zoea, megalopa, young and adult crabs before and after the spawning period to ease their movement from the coast to offshore and vice versa.

Suitable potential fishing grounds in accordance with oceanographic conditions and catches above the legal carapace width of 100 mm were discovered at stations 4, 5, 2, 6, 17 and 20, which are within 2 miles of the coast. According to Adam et al (2006), the fishing ground of catchable *P. pelagicus* in the waters of Pangkajene Regency is located at a minimum distance of 3.7 nautical miles from the coast to the open waters. This shows that there are abundant resources in Tukak Sadai. Therefore, the purpose of catches with a size above 100 mm is to ensure sustainability of the activity, because that is the size of the first gonad maturity. The blue swimming crabs in Pati waters have an average width of the carapace at first gonad maturity of 107 mm (Ernawati et al 2014), while in East Lampung waters they have an average width of the carapace at first gonad maturity of 103 mm (Zairion et al 2014). Therefore, based on the Regulation of the Minister of Maritime Affairs and Fisheries of Indonesia Number 12 in 2020, the legal size of the carapace width needs to be above 100 mm. The minimum size in Indonesia is less than the stipulated size in Australia. In South Australian waters, *P. pelagicus* attains a minimum legal size (110 mm) at the age of 14-18 months, being sexually mature. Additionally, female crabs produce at least two bags of eggs in one season (Kumar et al 2003).

Conclusions. There is a strong relationship between aquatic depth and the catches of *P. pelagicus* in Tukak Sadai waters, Bangka Belitung, Indonesia. Meanwhile, oceanographic factors such as temperature, salinity, and current have a low relationship with the catches. The distribution of very potential fishing grounds based on oceanographic conditions and the catch size at stations 4, 5, 6, 17 and 20, within a distance of 2 miles from the coast, with a legal catch percentage of 92.4%.

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