Aquaculture management of blue swimming crab (*Portunus pelagicus*) using integrated submerged net cage in Pangkep Regency waters, South Sulawesi, Indonesia

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Abstract. The present study aimed to determine the cultivation area suitability and submerged net cage model of blue swimming crab integrated with other aquaculture activity. This study was conducted from April to November 2017. Primary and secondary data were collected and analyzed for water suitability and land utilization using mapping and geographic information system analysis (GIS). The water quality parameters suggested different results: dissolved oxygen 5.1-10.7 mg L^{-1}, salinity 7-35 ‰, temperature 32-34.4°C, and pH 7–8 respectively. The findings suggested two large clustering aquaculture management area; cluster 1 (the area of 26,342 ha) which is located close to the shoreline and cluster 2 (172,953 ha) which is located far from the coastal line. The management of crab cultivation was integrated with other utilization using submerged net cage with seaweed farming. The suitable submerged net cage model for integrated crab cultivation are rectangular cage with 2 different sizes: (1) large size cages of 150 cm length, 100 cm of height and 100 cm width. The net used was made from nylon (PE Number 12), the material of the main pillar was threaded iron of number 12 and the width of number 7. The net applied was made from nylon Polyethylene (PE) number 12 with mesh size of 1.0 cm. All parts of the submerged net-cage materials were built from the same materials like the large size net-cages. Management of submerged net cage can be integrated with other aquaculture activity, such as seaweed cultivation, and other finfish floating net cage cultures.
Key Words: cultivation, cluster, farming, fishermen, production.

Introduction. Blue swimming crab (*Portunus pelagicus*) is a sought-after aquaculture commodity contributing significantly to local people and the national income of Indonesia. *P. pelagicus* is one of the major commodities for export with regards to the Indonesian fisheries sector (Wiyono & Ihsan 2018). The increase in market prices of *P. pelagicus* also has been attributed in part to increasing volumes of exports and domestic demands. The value of Indonesian swimming crab and crab exports in 2012-2017 increased each year by 0.67% and 6.06% (MMAF 2019). Many restaurants and hotels serve *P. pelagicus* as its seafood dish for their costumer. As a result, it attracts the attention of local fishermen to start catching crabs and farming crabs as a source of income. However, improper utilization management of crabs resources, as well as land utilization, has been the major issue of the *P. pelagicus* stock depletion and land utilization conflicts. Several studies related to the excessive catching of *P. pelagicus* in Indonesia were revealed by (Hamid & Wardiatno 2015; Hamid et al 2016; Sara et al 2019; Wagiyo et al 2019).

In order to enhance severely depleted stocks of *P. pelagicus*, a proper utilization marine-based culture management is required. The deficits may be minimized through conditioning strategies leading to enhance crab production (Young et al 2008). It can be done using a composite culture of crabs with other cultured commodities such as finfish and seaweed. It may prevent the conflicts of spatial use in the coastal areas of Pangkep Regency.

Aquaculture management of blue swimming crab using integrated submerged net cage is one of the management strategies that may increase the production of blue swimming crab as well as maintaining the stock of crab and the crab supply for the market. These management system changes have increased in recent years. The advantages of this management are easy control, efficiency, fast monitoring, and the possibility of incorporating several forms of automation (Tavares et al 2017).

The management of the crab cultivation is expected to be carried out in an integrated manner with other land utilization such as seaweed farming and other finfish aquaculture. Therefore, it is able to solve the conflicts of space utilization for the crab cultivation. The most important aspect of the management of integrated crab cultivation is the submerged net cages models. In line with this, the research objective consisted of: 1) Determining the management of crab cultivation in an integrated manner with other spatial utilization activities in the waters of Pangkep Regency; 2) Assessing the use of submerged net cage model for crab cultivation.

Material and Method

Description of the study sites. The present study was conducted at Pangkep waters from April to November 2017 (Figure 1).

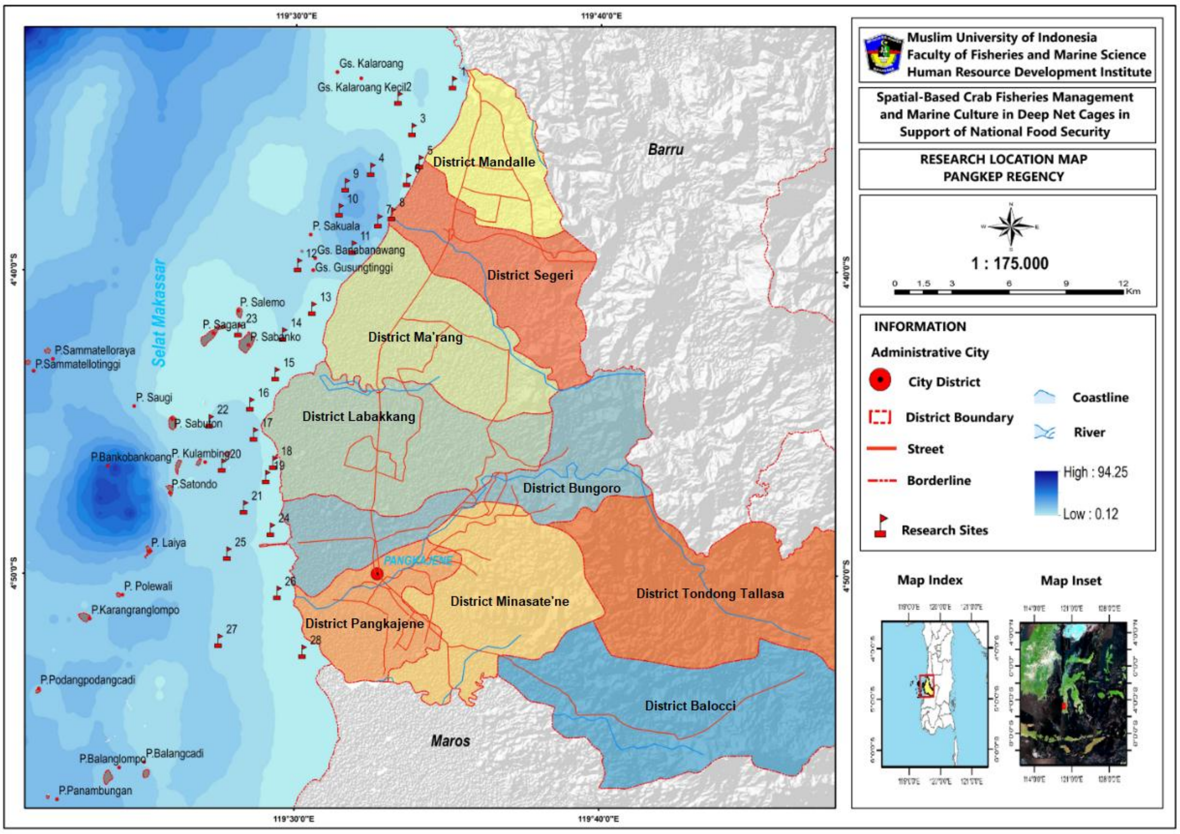

Figure 1. The location of Pangkep waters, South Sulawesi, Indonesia.

Data collection. Materials and equipment used during the period of study included *P. pelagicus* larvae, submerged net cage, current meter, hand refractometer, dissolved oxygen (DO) meter, underwater camera, thermometer, global positioning system, label, stationery, cold-boxes, Secchi disk, check-list form. Data consisted of primary and secondary data. Primary data was obtained in situ observation to determine the clustering aquaculture area for crab cultivation based on the aspects of physics and chemistry of oceanography. Twenty eight of sampling sites were used for data collection. The Global Positioning System (GPS) was used to determine the observation location or station. The secondary data was obtained from relevant agencies with the present study. Matrix and conformity criteria were applied for management suitability analysis, according to Ihsan (2015), (Tables 1-3).

Table 1

Criteria for determining the suitability of an area

X0 (= score value) – X1 (= X0 + Ci)	Unsuitable (N)
X1 – X2 (= X1 + Ci)	Acceptable (S2)
X2 – X3 (= max value)	Suitable (S1)

X0 - lower limit of assessment scale; X1 - limit between unsuitable and acceptable class; X2 - limit between acceptable and suitable class; X3 - upper limit of assessment scale.

Table 2

Suitability matrix for adult *Portunus pelagicus*

Parameters	*Suitable category*				*Unsuitable category*		
	Weigh	*Description of suitable parameters*	*Score*	*Total Score*	*Description of unsuitable parameters*	*Score*	*Total Score*
Temperature	0.40	28-31°C	2	0.80	<28 or >31°C	1	0.40
Salinity	0.30	31-36‰	2	0.60	< 31 or 36‰>	1	0.30
Dissolved oxygen	0.20	4-6 ppm	2	0.40	<4 ppm or >6 ppm	1	0.20
pH	0.10	6.78 – 8.0	2	0.20	<6.78 or >8.0	1	0.10
	1.00	Total maximum score		2.00	Total minimum score		1.00

Table 3

Determination of area suitability category

Interval class	*Category*
1.00–1.33	Not suitable (N)
1.34–1.67	Fairly suitable (S2)
1.68-2.00	Suitable (S1)

Data analysis. Data were descriptively and quantitatively analyzed including the suitability data of the aquatic environment. The geographic information systems (GIS) with ArcView method was applied.

Results

Integrated management of P. pelagicus farming. The management of *P. pelagicus* farming using submerged net cage in an integrated manner in the waters of Pangkep Regency has been recognized as aquaculture region. Due to efficiency and effectiveness in crab farming with submerged net cage, it is necessary to determine the suitability of the crab aquaculture in Pangkep waters based on location of crab cultivation. The object of observation can be grouped based on the characteristics possessed by the object of observation. Grouping observational objects was performed by considering the homogeneity level of the observation object in one cluster while maximizing heterogeneity between clusters (Yuniati & Rachman 2016). Clustering the location of aquaculture region and marine space management wss based on the efficiency and the effectiveness of *P. pelagicus* using submerged net cage with consideration of distance of location from coastal line or islands (Table 1).

The results showed that the clustering aquaculture area can be divided into two large clusters, namely cluster 1 (the area of 26,342 ha) which the location of crab cultivation is integrated with the location of seaweed cultivation, located close to the shoreline (Figure 2). Most methods of seaweed farming in the waters of Pangkep Regency included long line method. The aquaculture method is integrated where on the surface of the water seaweed farming and crab cultivation is resided in the bottom of the waters of seaweed cultivation. Meanwhile, cluster 2 (172,953 ha) where the location of crab cultivation integrated with the location of seaweed cultivation, located far from the coastal line (Figure 2). It leads to an increase in the operational cost for monitoring and feeding. Nonetheless, the crab cultivation using a submerged net cage does not need much operational cost because the fishermen can do both monitoring and fishing at the same time. The cluster area 2 was not influenced significantly by water quality changes particularly, declining of temperature and salinity. There are no much pollution inputs from upper land such as river, sedimentation, and effluent waste.

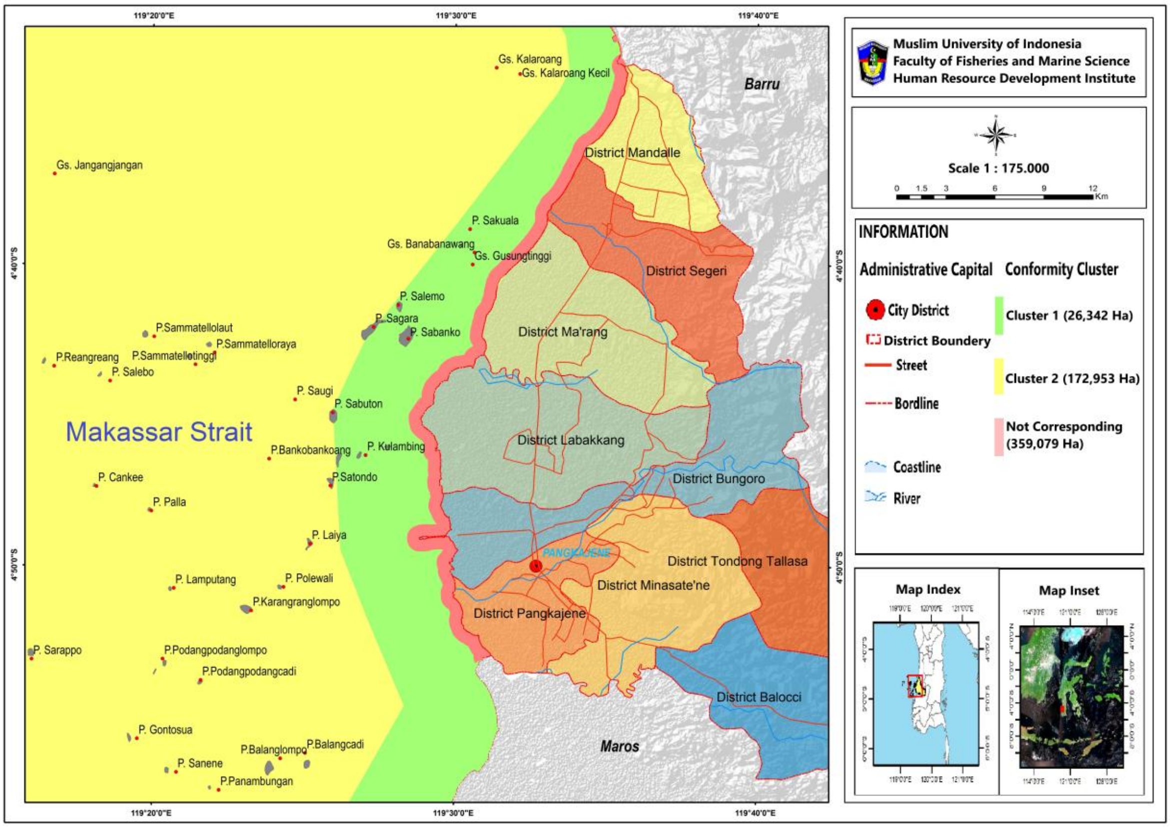

Figure 2. Suitable area for blue swimming crab farming using submerged net cage in Pangkep Regency.

In addition, the coordinate points of the suitability of the crab cultivation land after clustering in the waters of Pangkep Regency is presented in Table 4.

In the present study, the unsuitable area of 3,590.74 ha for crab farming is considered. This location is directly adjacent to the shoreline leading to poor water quality due to freshwater input from rivers and sedimentations. The water at this location is also very shallow. It is not suitable for submerged net cage. The depth requirements of the location of crab cultivation for submerged net cage should be 1.5-2 times of the size of submerged net cage (Ihsan et al 2017).

Integrated management of aquaculture is intended to prevent the conflicts interest concerning the use of area for aquaculture and other purposes. Not only seaweed cultivation can be integrated with crab farming but also other finfish aquaculture using floating net cages can also be performed. The map of integration of crab cultivation using submerged net cage with other activities is presented in Figure 3.

Table 4
The coordinates of the location of the suitability of the crab cultivation land after clustering in the waters of Pangkep Regency

Coordinates		*Criteria*
X	*Y*	
119° 35' 14.662" E	4° 34' 37.872" S	Not suitable
119° 33' 36.552" E	4° 37' 9.734" S	
119° 31' 25.095" E	4° 40' 16.154" S	
119° 29' 1.241" E	4° 45' 39.504" S	
119° 28' 40.538" E	4° 49' 7.916" S	
119° 30' 6.122" E	4° 51' 57.196" S	
119° 28' 49.413" E	4° 52' 25.889" S	Cluster 1
119° 27' 36.596" E	4° 49' 6.426" S	
119° 27' 25.498" E	4° 45' 22.629" S	
119° 30' 24.496" E	4° 39' 45.164" S	
119° 32' 38.749" E	4° 36' 39.597" S	
119° 34' 16.040" E	4° 34' 17.208" S	
119° 23' 1.902" E	4° 34' 44.186" S	Cluster 2
119° 20' 55.266" E	4° 45' 4.512" S	
119° 20' 42.457" E	4° 55' 45.986" S	

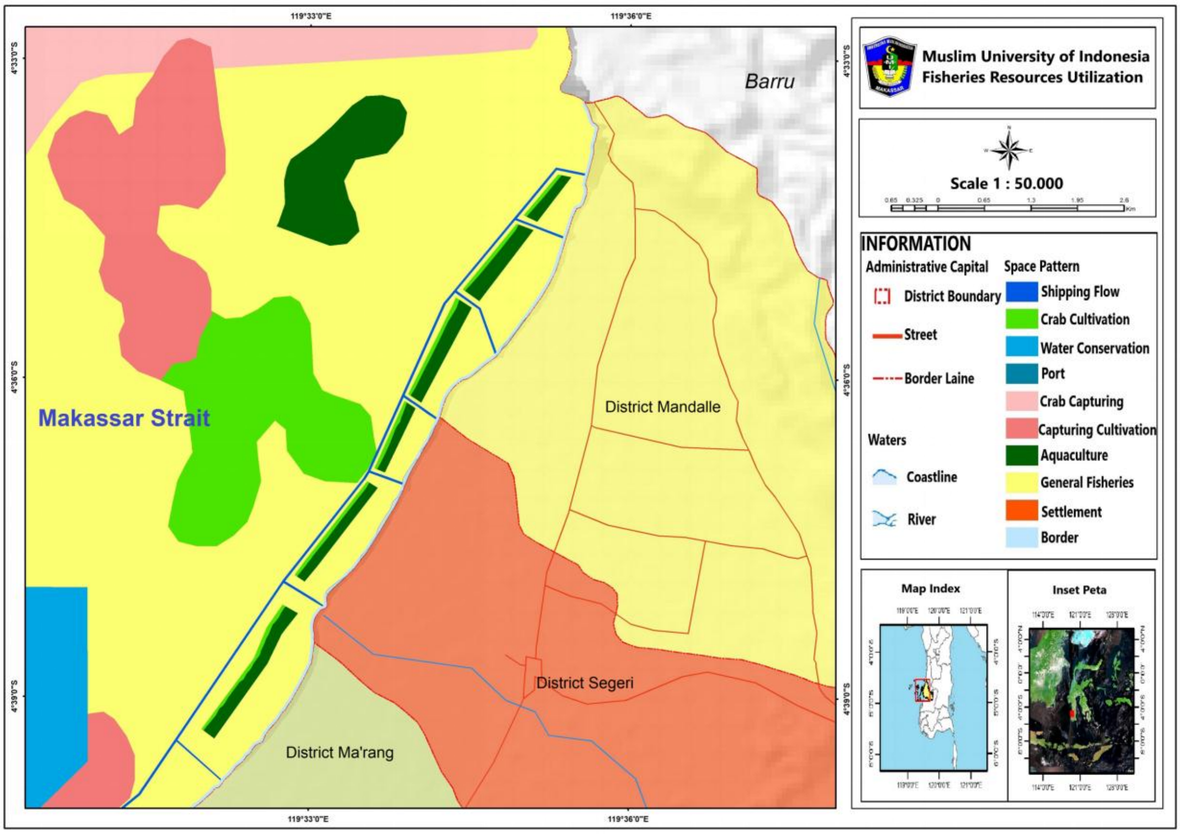

Figure 3. Map of management of crab cultivation in submerged floating net cages integrated in the waters of Pangkep Regency.

Water quality measurement. For the suitability determination of clusters 1 and cluster 2 for crab cultivation was done using the physical and chemical oceanographic aspects. The results of water quality measurements at 28 stations during survey period revealed: temperature of 27-34°C, salinity of 28-34 ppt, and pH of 6.50-8.00. The optimal water pH for fish and shrimp life is 6.5-8 (neutral) (Wardhany et al 2018). This pH level promotes optimal balance between oxygen and carbon dioxide which inhibits the growth of various harmful microorganisms in the water. The optimal pH water for crab cultivation is 6.5 and 8.5 (Juwana 1993). Furthermore at pH 9.5-11.0 and 4.0-6.0 lead to low production and lower than 4.0 or higher 11.0 have detrimental effect on aquatic organisms causing high mortality.

DO measurements revealed a concentration range of 5.17-7.97 mg L^{-1}. DO-dissolved oxygen content is an important limiting factor for biota, and the range of values is 5.1-9.2 mg L^{-1} which is considered optimal and supports the life of marine biota (ME 2004). The optimal water temperature for crab cultivation is 26-32°C (Adiwijaya et al 2002). However, the crabs are very tolerant concerning water temperatures ranging between 17 and 37°C (Perkins 1974). Study on crab cultivation in ponds in Laikang Village revealed the following parameters: salinity 30-43 ppt, DO 4-10 mg L^{-1}, pH 4-8 and temperatures of 27-34°C.

Submerged net cage model for P. pelagicus farming. A rectangular model of submerged net cage was used: 1) submerged net cage size was 150 cm length and 100 cm width and 100 cm height; 2) small submerged net cage size was 75 cm length, 50 cm width and 50 cm height using a net made of nylon (PE No. 12). For the net cage framework wrapping net was used and tied properly. The use of wood as a framework for making submerged net cage is much durable compared to iron which much prone to be corrosive.

The cultivation of *P. pelagicus* can be done in the earthen pond with one log pond and two grow-out ponds. The crablets were reared for 1-2 months until the sexual dimorphism was evident. Furthermore, the grow-out of crab was carried out by applying a floating cage system or a net installed near the beach. The rearing ponds size was 50 x 100 m. Ponds of this size can accommodate up to 10,000 crabs. The submerged net cage model used is presented in Figure 4.

Figure 4. Submerged net cage model for *Portunus pelagicus* farming. (A) Large submerged net cage of 150 cm length, 100 cm main pole and small submerged net cage of 75 cm length, height 50 cm of threaded steel number 12; (B) Large submerged net crab of 100 cm width of main pole and a small cage of 50 cm steel size 7 (normal); (C) Nets (nylon) PE / 12 mesh size 1.0 cm; (D) submerged net cage door size 30 x 50 cm (E) submerged net cage door leaf size 30 x 50, frame made of steel and use a PA / 12 size net; (F) Plastic strap No PE/7 mm, submerged net cage hangers.

To simplify the submerged and lift process, a plastic PE no 7 mm was used. The length of the plastic strap depends on the depth of the water. The length of plastic rope used during the study was 5-10 m. Besides that, it is expected that the depth of the water with the length of the rope must be different. If the water depth is 7 meters, the length of the rope was approximately 10 m. So that, during tide, the submerged net cage was visible from the surface of the water.

Conclusions. Management of submerged net cage can be integrated with other aquaculture activity, such as seaweed cultivation, and other finfish floating net cages. The submerged net cage system is considered suitable for integrated crab cultivation with a rectangular model; 1) large size cages, 2) small size cages, with the same size and models.

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