STOCK AND FISHERY ASSESSMENT REPORT OF BLUE SWIMMING CRAB *PORTUNUS PELAGICUS* (LINNAEUS, 1758) IN KIEN GIANG WATERS, VIET NAM

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1. INTRODUCTION

Overview

The report on stock assessment of Blue Swimming Crab (BSC) *Portunus pelagicus,* Linnaeus 1758, was prepared based on the MOU between WWF Vietnam, VASEP Crab Council, Department of Agricultural and Rural Development of Kien Giang and Research Institute for Marine Fisheries dated 01/10/2012 about the implementation of the activities "Stock assessment of blue swimming crab in Kien Giang waters" within the project "Fisheries Improvement Project for the Blue Swimming Crab in Kien Giang, Vietnam".

BSC fisheries is important to the coastal fishing communities in Southwest waters of Vietnam, especially in Kien Giang Province with more than 3.800 crab fishing boats targeted on BSC and dozen thousand of labors working directly in this fisheries (Sở NN&PTNT Kiên Giang, 2010). Total catch of BSC was estimated about 11.3 thousand tons in 2008 (Thúy, 2010) and showed the signals of the decreasing trend due to the high fishing effort in recent years.

Up to date, there was no study on the biology, fisheries and stock assessment of BSC not only Kien Giang waters but also in the Sea of Vietnam. This activities is considered as the first study on the stock assessment and biological information collection of BSC in Vietnam.

Discription of Blue Swimming Crab

The BSC *Portunus pelagicus,* Linnaeus 1758 belongs to the Phylum Arthropoda, Class Malacostraca, Order Decapoda and Family Portunidae and the local name is "Ghẹ xanh".

Portunus pelagicus has 5 pairs of legs, the body is flat. The first pair of legs was modified to be claws, which are biggest legs, which perform the protection, attach and predation functions. There are spines on the upper part of the 2 claws. The 5th pair of legs are swimming legs was modified to swimming legs with small furs on the egde. The legs 2, 3 and 4 are called crawl legs. The carapace is grey blue with the pear shape. The carapace's surface protrusion from the middle to the edge. On the carapace and on the legs, there are many small bright spots. Next to the two sides of the eye socket are spiky spines, of which the last spines are lengthened,

sharp, and hard. Male crab are bright blue with white spots and featured longe claws. Female crab are brown, green staining and more rounded carapace (Figure 1). These characteristics are used to identify male and female crabs with the view from carapace.

Figure 1. Photos of Blue Swimming Crab: upper: male and lower: female. Taken by Vu Viet Ha in Ham Ninh landing site, Phu Quoc District, Kien Giang Province during the survey on March 2013

BSC is widely distributed in tropical waters. They appear from intertidal zone to the depth of 50m throughout the Indo – West Pacific. They occur in mangrove, sea grass, coral reef habitats and estuaries, on both sandy and muddy bottoms, concentration in the depth range of 5-25m (Williams, 1982, Edgar, 1990, Clarke & Ryan, 2004). In Vietnam, BSC is distributed throughout the coastal waters from North to South and aggregated densely in Kien Giang waters.

Biology

The life cycle of BSC spends five stages throughout (Figure 2), including eggs, zoea larvae, megalopa larvae, juvenile crab and adult crab. Zoea larvae, hatching from eggs, has a length of about 0.04 mm. At this stage, zoea larvae is drifting freely in the surface water layer and can drift away 80 km from the spawning grounds (Williams, 1982). Food is phytoplankton. After 4-5 weeks, zoea develops to megalopa. At this stage, the entity has shape of crab head, shrimp body,

small size, live passive and drifting. Megalopa larvae will undergo 5-7 times of metamorphosis. When reaching the size of 0.4 mm, megalopa larvae begins migrating into the estuaries where there are more nutrients to grow. When megalopa larvae turn to the young crab stage, they move to a higher salinity area. The main food at this stage zooplankton. After about 1 week, the megalopas develop to juvenile crab. At this stage, the crabs live in the mud bottom and migration from the spawning ground in the coast to the sea, living mainly in the seagrass beds. After 12 to 18 months, phase 1 crab grow into adult, sexually mature and enter the spawning stage to create the next generation.

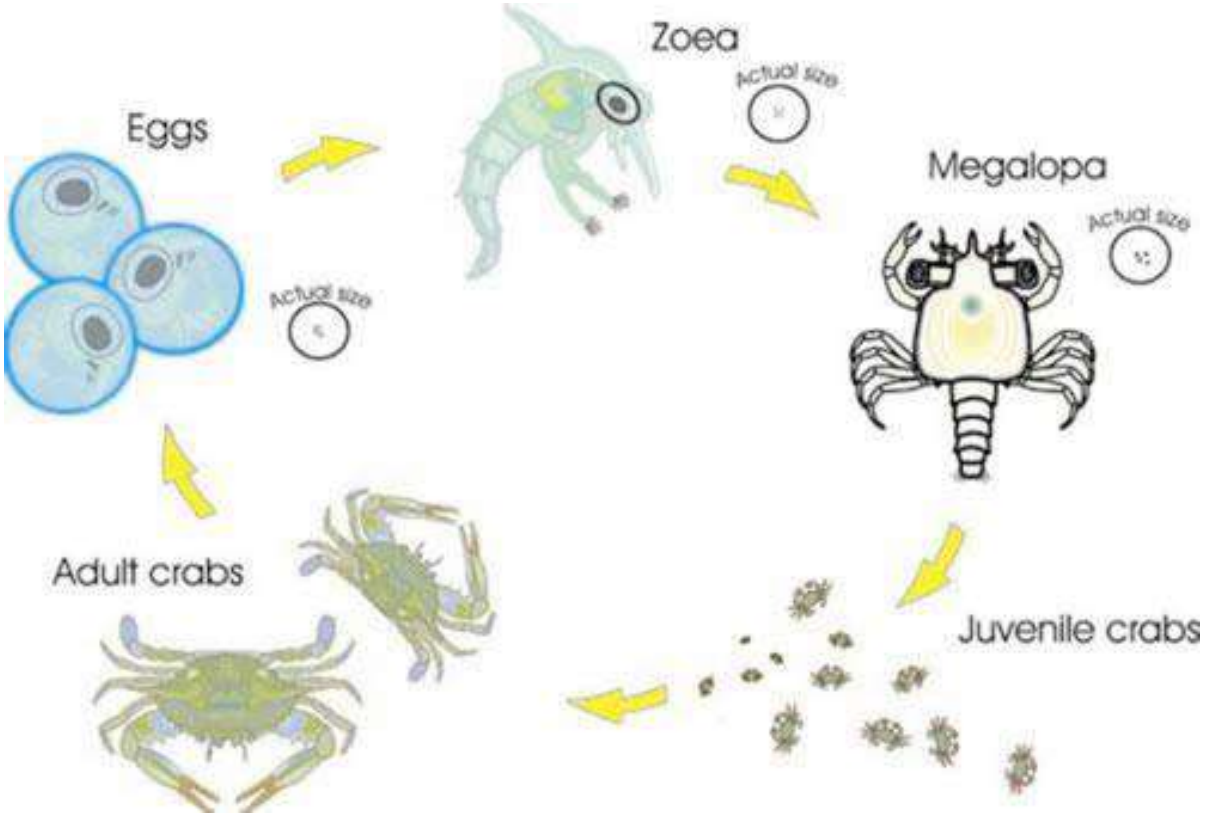


Figure 2. Lifecycle of blue swimming crab *(Portunus pelagicus)*

The BSC population is predominantly comprised of male crab and there are large changes monthly. Kamrani et al. (2010) reported that the sex ratio was 1.2:1 annually and in percentages were 53.9% male and 46.1% female. The variation in the percentage of male: female could be explained by the different in migration of

male and female crabs in each stage of the life cycle. After the spawning season, the small crabs usually habit in the mangrove or seagrass areas. When grown up, the female crabs migrate to the estuary or coastal areas (Kamrani et al., 2010, Weng, 1992, Meagher, 1971). When matured, the BSC move to the deeper waters to release eggs (Potter et al., 1983).

BSC reached adult size in about one year old (Smith, 1982). The growth rate of BSC differs among regions and depends on the temperature (Campbell & Fielder, 1986, Sukumaran & Neelakantan, 1996). The smallest mature size of female crab observed at 89 mm (CW) (Potter & Lestang, 2000) while it is 94mm (CW) in Leschenault Estuary. The size at first maturity (CW_{50}) of male and female BSC in the Peel-Harvey is 84mm and 98 mm (CW), respectively while in the Leschenault Estuaries it is estimated at 88mm (CW) for the male and 97 mm (CW) for the female. In India waters, the ripe size of male and female crabs is in the ranges from 85-90 mm and 80-90mm (CW), respectively (Sukumaran & Neelakantan, 1996).

BSC gets ripe and produce continuously during the year in tropical and sub-tropical waters (Campbell & Fielder, 1986, Potter et al., 1983), whereas in temperate waters, the breeding season is limited to the summer only (Potter et al., 1983, Smith, 1982, Penn, 1977).

Fisheries

The BSC fisheries in the Kien Giang waters is localised to the districts of Ha Tien, Kien Luong, Hon Dat and Phu Quoc Island. Fishers are located in a number of small village communities along the coast, living rely on this fisheries. They use small fishing boats to fish for BSC both day and night. Most of fishing boats engaged in BSC fisheries in Kien Giang are equiped small engine, 20-33HP. According to the statistic figures in 2009, a total of 3.823 fishing boats engaged crab fisheries in Kiengiang (Sở NN&PTNT Kiên Giang, 2010). Gillnet and Trap are main fishing gears targeted in BSC. Fishermen normally use the gillnet of about 10 km long for the boats with engine <20HP and up to 45 km long for the fishing boats equiped bigger engine. The stretched mesh (2a) of gillnet varies from 70-90mm.

The BSC resource in Kien Giang is exploited around the year, with the main season from April to August. The fishing grounds are mainly coastal to 30m depth. BSC accounted for about 90% of total catches.

Stock and fisheries assessments for BSC haven't been conducted previously in Vietnam. The catch of BSC was occationally mentioned in technical reports of the bottom trawl surveys by the Research Institute for Marine Fisheres (RIMF) before. Results from the bottom trawl surveys showed that the BSC distributes widely in the coastal waters of Vietnam, from the Tonkin Gulf, Central waters, Southeast and Southwest waters. However the proportion of BSC in catches is relatively low or negligible since the BSC was the non-target species of this gear.

In 2013, under the financial support from WWF Vietnam, Department of Agriculture and Rural Development of Kien Giang has conducted an frame survey on BSC fisheries. Results indicated that there are 1,718 fishing units registered for BSC fisheries in the whole province with 949 fishing boats equipped with the engine ≤20HP and 769 units motorized the engine >20HP (Sở NN&PTNT Kiên Giang, 2013). There are 1,337 fishing boats engaged with gillnet fisheries and 381 units using the trap fisheries.

Management

Management measures based on stock assessment and referent points have not been applied in any fisheries in Vietnam yet. Currently, fisheries management in Vietnam was made based on the clossing season and size limitations of target species or nets. Circular 02/2006/TT-BTS dated March 20th, 2006 issued by the Ministry of Fisheries, guiding on the implementation of Decree No. 59/2005/ND-CP May 4th, 2005 of the Government on the Production, Trading conditions on some fisheries are one of first writing document in fisheries management in Vietnam. It is mentioned that every year, the fishing activities are banned in the period of 1st April to 30th June on the coastal areas and the minimum size for harvesting of BSC is 100 mm carapace width. The stretched mesh (2a) of the gillnet is not less than 90mm.

Currently, the BSC fishery is heavily exploited (per.com.). An MSC pre-assessment of the BSC fishery identifies its status as medium risk citing the principle issues as:

- Limited knowledge on stock status;
- No harvest strategy
- Limited application of harvest control tools;
- Inadequacy in information systems;
- Uncertainty on bycatch interactions and ecosystem impacts;
- No supporting research implementation;

- Weaknesses in decision making and consultation processes; and
- Limited enforcement.

To protect the BSC resource in Kien Giang waters in the direction of maintaining ecologically sustainable production, WWF Vietnam, VASEP Crab Council, Department of Agriculture and Rural Development of Kien Giang and the Research Institute of Marine Fisheries are cooperating to conduct the project "Assessment of the blue swimming crab resources in Kien Giang, Vietnam" aiming to achieve scientific basis for management, contributing to sustainable development of the blue swimming crab fishery in Kien Giang.

2. MATERIALS AND METHODS

2.1. Data sampling

2.1.1. Landing survey

Information on catch and effort of BSC fisheries is collected monthly by local collaborators in fisheries communities of Ha Tien, Kien Luong, Phu Quoc and Kien Hai districts using sampling in time and space approach (Constantine, 2002). During month, local collaborators go to fisheries communities to interview fishermens about fishing activities as fishing ground, catch of BSC and non-target species, trip duration, number of trip per month, active day per month and information on net/trap used for the fishing trips. Each month, 32 forms will be collected from each fishing fleet. Total number of forms collected monthly will be 128 (2 gears x 2 fleets/gear x 32 forms/fleet = 128 forms). By end of the month, all forms will be sent to RIMF for encoding into the BSC database.

2.1.2. Logbook

Logbook data for crab fishing boats are collected monthly. The logbooks designed by RIMF are sent directly to the local collaborators then the collaborators will distribute to crab fishing boats to record the fishing activities. Captains are guided to record and then be responsible for record all information related to fishing activities including fishing location, fishing time, catches of each species in weight and number and discard at sea. The logbooks are collected monthly by the local collaborators and periodically sent to RIMF for encoding and analysis. Every month, 32 logbooks will be distributed to 32 fishing boats to record the fishing information.

Thus, the total number of logbook distributed and collected back are 64 (2 fishing gears x 32 logbooks/gear = 64 logbooks).

2.1.3. Observer

On board observation of BSC fisheries has been done by RIMF scientists. Observers record all information related to fishing hauls, including fishing location, fishing time, species composition, species catches and sizes. In 2013, 4 observer trips with 10-15 days/trip were conducted in January, April, August and October on the gillnet and trap fishing boats.

2.1.4. Biological sampling

Biological samples of the BSC were collected monthly at Mui Nai (Ha Tien), Binh An (Kien Luong), Bai Bon, Ham Ninh, Hon Thom (Phu Quoc) and Nam Du (Figure 3). Each month, 250 - 300 BSC were randomly bought from the catches of gillnet and trap fishing boats.

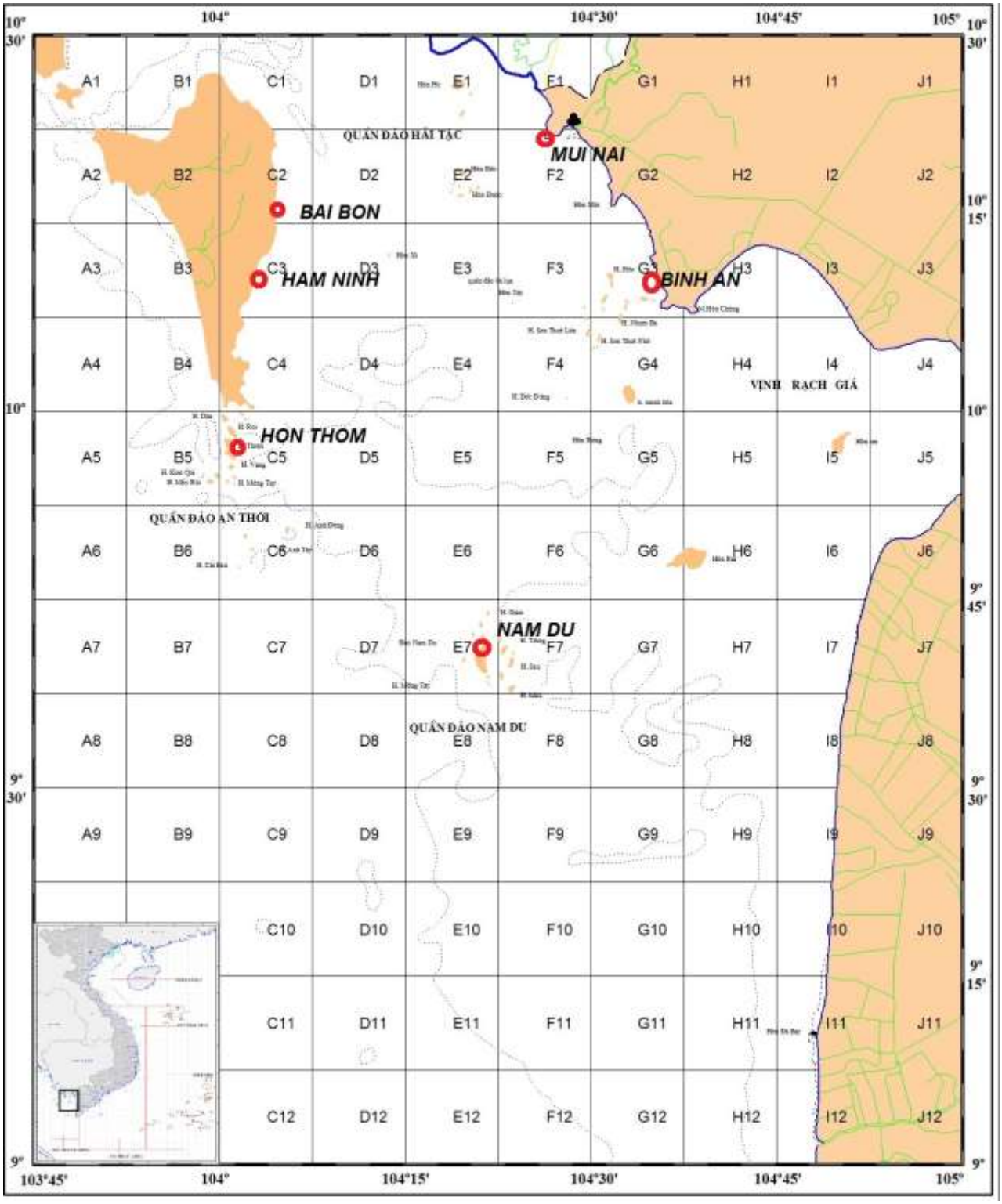


Figure 3. Kien Giang waters and locations of the sampling sites for BSC

BSC samples was analyzed individually for sex, carapace length (CL, mm), carapace width (CW, mm), body weight (W) and gonad weight (W_g). CL and CW were measued to nearest 0.1 mm using Panme ruler (Figure 4). W and W_g were

weighted to 0,01 gram using electric weight scale. Gonad maturity stage was determined using the scale of 5 level as discribed by Sumpton et al (1994).

Figure 4. Panme ruler on the left and electric weight scale on the right used in biological samplings

Stage I: the gonad is underdeveloped and dark

Stage II: the gonad is developing and opaque white

Stage III: the gonad is developed and light yellow

Stage IV: Matured, The gonad is dark yellow and fills the abdominal cavity

Stage V: Matured, eggs are covered in the overalls, eggs when laying have yellow color and switched to dark brown or black.

In 2013, total 3.800 BSC individuals were collected and analyzed (Table 1).

Table 1. Numbers of BSC individuals were analyzed in 2013

Month	Gillnet	Trap	Total
January	128	153	281
February	129	169	298
March	143	129	272
April	146	129	275
May	155	178	333
June	144	226	370

Month	Gillnet	Trap	Total
July	152	201	353
August	185	135	320
September	90	230	320
October	157	150	307
November	233	112	345
December	193	133	326
Total	**1.855**	**1.945**	**3.800**

2.2. Data analysis

2.2.1. Biological data analysis

+ Size distribution

Size distribution of BSC were analyzed by the descriptive statistics method.

+ Growth

The growth parameters of BSC are determined by fitting the von Bertalaffy growth function $CW_t = CW_\infty * (1 - e^{-k(t-t_0)})$ to the length frequency data using ELEFAN I incoporated in FiSAT II (Gayanilo et al., 2002) where CW_t is the carapace width at the time *t*; CW_∞ is the asymptotic carapace width; *k* is growth coefficient; t_o is the theory assumed carapace width at age 0.

+ Size – weight relationship

Length – weight relationship of BSC is fitted using power regression for male and female BSC separately: $W = a.CL^b$ and $W = a.CW^b$ for for the carapace length and carapace width with weight. Where CL is carapace length, CW is carapace width, a is anabonism and b is catabonism. The size – weight relationship of male and felmale is tested using MANCOVA.

+ Size at first maturity

- *Size at first maturity (CW_{m50}) of BSC* is estimated by fitting a logistic curve to the relationship between proportion mature and size class (CW): $P = \frac{1}{1 + e^{[-r(CW - CW_{m50})]}}$ (King, 1995) where P is the proportion mature and r is constant.

+ Sex ratio and Spawning season

The ratio of male/female and the percentage of gonad maturity stages of BSC population was analyzed monthly by descriptive statistics method. Spawning season of BSC is inferred based on the fluctuations of Gonado Somatic Index (GSI) and the proportion of the gonad maturity stages. GSI of BSC is identified as $GSI = \frac{W_g + 1}{W} * 100$ (Sumpton et al., 1994) with W_g is gonad weight and W is body weight.

2.2.2. Catch – Fishing Effort

Status of BSC exploitation in Kien Giang waters is analyzed, evaluated using the fisheries indicators (Constantine, 2002), including: fishing effort (average number of fishing days per month, the number of fishing vessels, Boat Activity Coeffiecient (BAC), fishing time), catch rate, catch components, total catches and fishing grounds.

Catch per Unit Effort (CPUE, kg per day) is analyzed for each fishing fleet as $CPUE_i = \frac{C_i}{D_i}$ *and* $\overline{CPUE_\iota} = \frac{1}{n} * \sum_{i=1}^{n} CPUE_i$, where C_i is the catch (kg) of the fishing trip i and D_i is number of fishing days in the trip i. The mean active day per month per month is estimated as $A_i = \frac{\sum AD_i}{n_i}$ In which, AD_i is number of fishing days in the previous month of the fishing fleet.

Total catch of BSC is sum of the catches of each fleet (Constantine, 2002). The catch of fleet *i (Yi)* is calculated as $Y_i = CPUE_{i*} F_{i*} A_{i*}BAC$. *Where* F_i is number of fishing boats of fleet *i* and A_i is the mean active day per month of the fleet *i* , BAC is the Boat Activity Coefficient.

2.2.3. Biomass estimation

Stock biomass of BSC are estimated by Length Based Cohort Analysis (LCA), based on length frequency data, growth parameters, mortality and total catch of species in a year Jones (1981). First, the length groups (carapace width) are converted to age groups based on the von Bertalanffy function:

$$t(L_1) = t_0 - \frac{1}{K} Ln\left(1 - \frac{L_1}{L_\infty}\right)$$

$$\Delta_t = \frac{1}{K} Ln\left(\frac{L_\infty - L_1}{L_\infty - L_2}\right)$$

$$N_{L_1} = \left(N_{L_1} * T_{L_1,L_2}^{M/2k} + C_{L_1,L_2}\right) * T_{L_1,L_2}^{M/2k}$$

$$C_{L_1,L_2} = \frac{F}{Z} N_{L_1}(1 - e^{-Z\Delta t})$$

Where t(L_1) is age in length group L_1; L_∞, t_o and k are parameters in the von Bertalanffy growth equation; $C_{L1,L2}$ is number of individuals between length L_1 and L_2 that are caught; N_{L1}, N_{L2} are number of individuals that survive to reach length L_1 and L_2, $T_{L1,L2}$ is fraction representative for the time interval at length L_1 and L_2, Z is total mortality estimated as fishing mortality (F) plus natural mortality (M).

Fishing mortality is calculated by $F = M\frac{F/Z}{1-F/Z}$ where F/Z refer to length group. F/Z is derived from catches and stock number: $\frac{F}{Z} = \frac{C_{L_1,L_2}}{N_{L_1} - N_{L_2}}$ and $\overline{N_{L_1,L_2}} = \frac{N_{L_1} - N_{L_2}}{Z * \Delta t}$. Natural mortality of BSC is estimated by Pauly's empirical formula: Log(M) = -0.0066 – 0.279log(L∞) + 0.6543log(K) + 0.4634log(T) with the mean temperature in Kiengiang waters is 28.7°C.

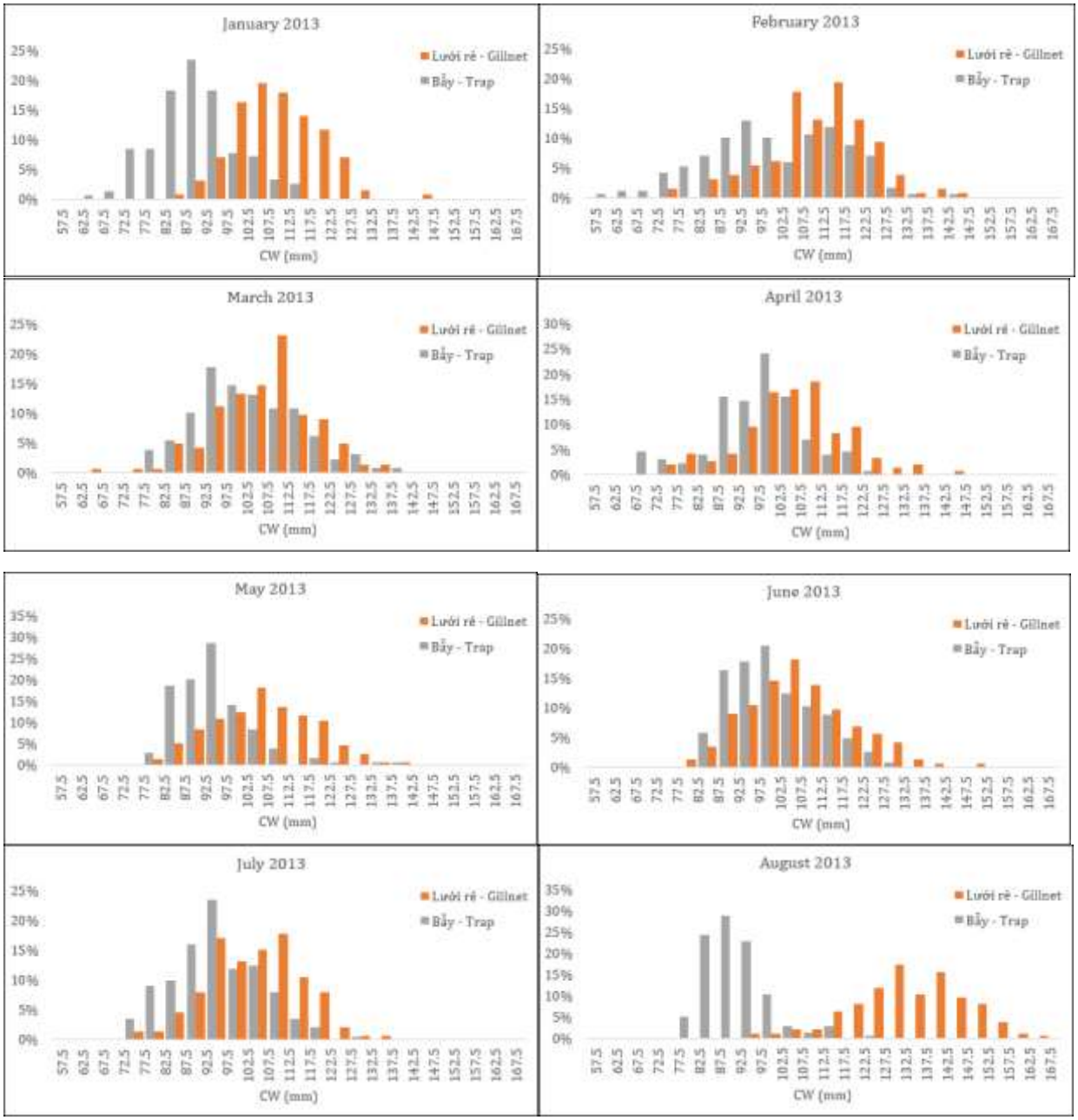
Finally, stock biomass of BSC is estimated as $B = \sum N(L_i, L_{i+1}) * W(L_i, L_{i+1})$. where $N(L_i, L_{i+1})$ is the mean number of individuals in the length group L_i and L_{i+1}, $W(L_i, L_{i+1})$ is mean weight of the length group L_i and L_{i+1}.

3. RESULTS AND DISCUSSION

3.1. Stock assessment

3.1.1. Size distribution

Size distribution (CW, mm) of BSC exploited by gillnets and traps in Kien Giang waters are presented in Figure 5 and average size caught monthly presented in Figure 6. Results showed that the size of BSC caught monthly is high variation and is different between the two types of fishing gear. Gillnet caught BSC bigger in size in comparison to that by trap. The smallest size of BSC caught by gillnets was 63mm in December and the largest size was 193mm caught in August. For traps, the smallest size was 59mm and the biggest size was 143mm caught in February.


January 2013
February 2013
March 2013
April 2013
May 2013
June 2013
July 2013
August 2013
Lưới rê - Gillnet
Bẫy - Trap
CW (mm)

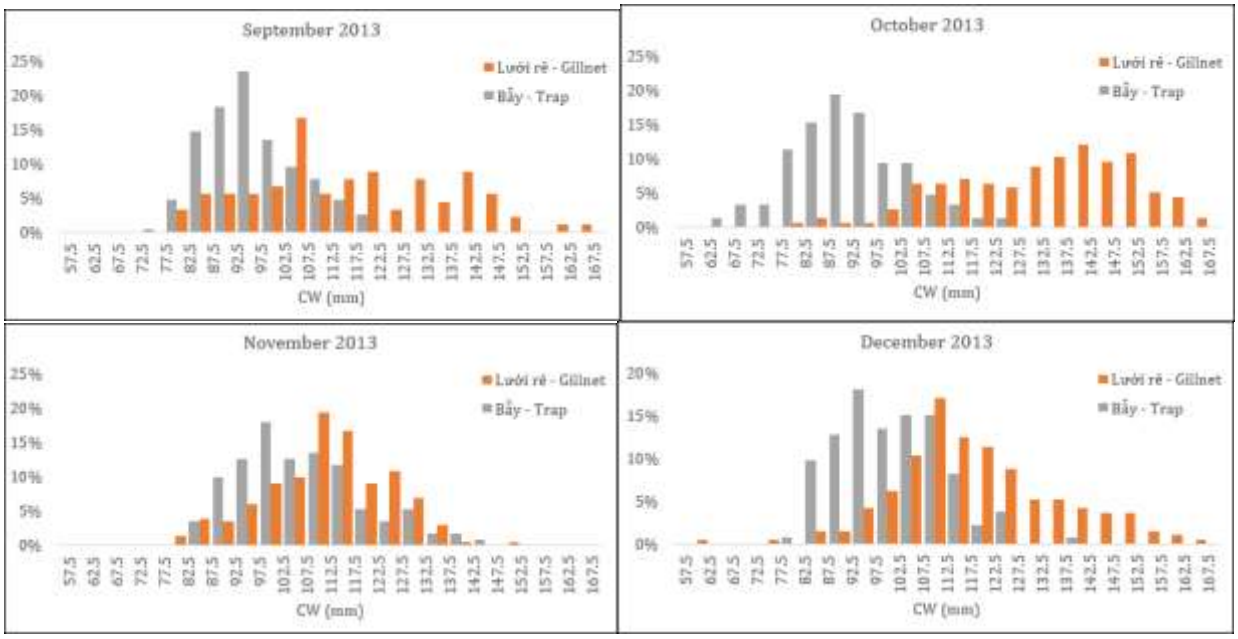


Figure 5. Monthly length (CW) frequency distribution of BSC caught by gillnet and trap in Kiên Giang in 2013

Average size of BSC exploitated by gillnets was quite stable during the period from January to July 2013, mainly in the range of 105 - 115mm. From August, the size of BSC captured was bigger and varied in a large interval. In contrast, catches from traps shows that sizes felt in a stable range without fluctuation between months. The mean size varied in the range of 85 - 100mm.

There was certain difference between the sizes of male and female crabs, especially in gillnets fishery. In the period from January to June , the female crabs are bigger than the male crab. From July to November the male crabs in the catches were larger size. For trap, the difference in sizes was not shown in the period from January to August but from September to December, the female crabs is bigger than the male crabs, on average.

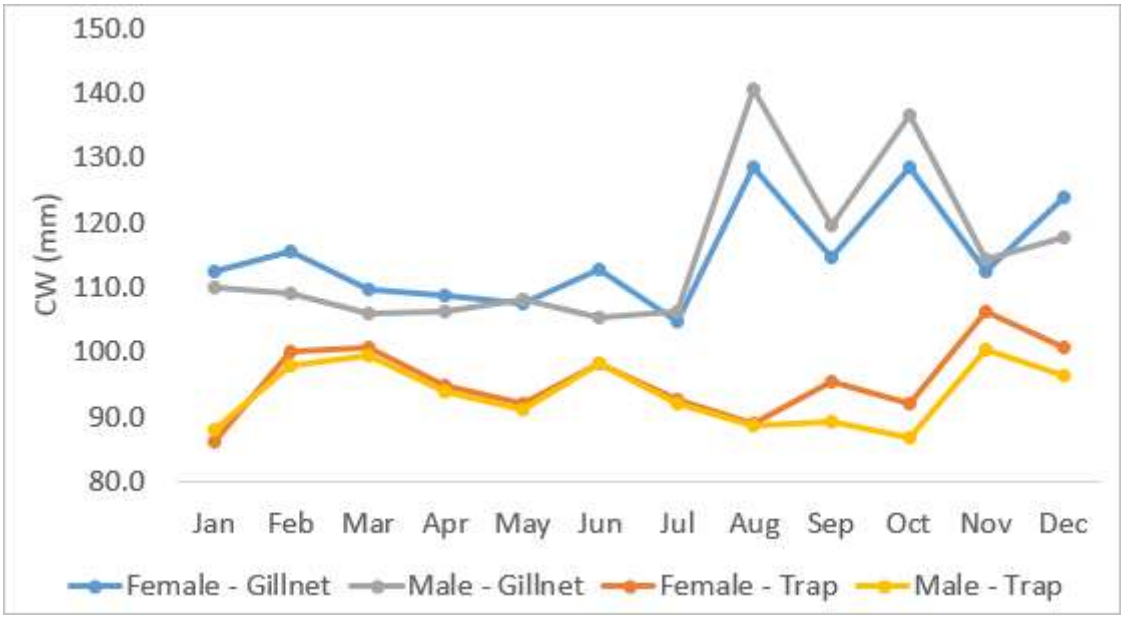


Figure 6. Monthly variation in the mean size of the BSC in Kiên Giang water in 2013

The sizes of BSC fished in different fishing grounds of Kien Giang waters were difference. BSC caught in Kien Luong have the smallest size. Average size of BSC exploited by gillnets was 105.7mm (CW) and by trap was 95.1mm (CW). BSC caught in Bai Bon and Ham Ninh were bigger than that in Kien Luong with average size of 96.0mm for trap and 110.3mm for gillnets (Table 2).

BSC caught around Nam Du and Hon Thom Island is bigger than that captured in other regions since the fishing grounds are more deeper. Average captured size (CW) reached 137.2mm. The biggest size was measured at 142.4mm in December and the smallest size was 134.7mm in August.

In Ha Tien area, BSC were caught mainly by traps. The average size was 95.1mm (CW). In 2013, from the beginning of southwest monsoon season, most crab fishing boats changed to fish jellyfish.

Table 2. Average size (CW, mm) of BSC sampled from catch of crab fishing boats in landing sites along the coast of Kien Giang Province

	Nam Du & Hon Thom	Bai Bon & Ham Ninh		Ha Tien	Kien Luong	
Sampling time	Gillnet	Gillnet	Trap	Trap	Gillnet	Trap
Jan		111.1		87.4		
Feb		112.8		98.8		
Mar		108.1		100.1		
Apr		107.4		94.4		
May		107.9	91.8			

Sampling time	Nam Du & Hon Thom	Bai Bon & Ham Ninh		Ha Tien	Kien Luong	
	Gillnet	Gillnet	Trap	Trap	Gillnet	Trap
Jun		108.5	98.4			
Jul					105.7	92.6
Aug	134.7		88.7			89.0
Sep	136.5	104.1	93.1			
Oct	139.5	107.4				89.4
Nov		113.5	105.2			98.2
Dec	142.4	114.7	98.4			
Average	**137.2**	**110.3**	**96.0**	**95.1**	**105.7**	**91.1**

Using the ELEFAN I method for fitting von Bertalanfy growth function to the length frequency of BSC, the von Bertalanffy growth equation for BSC has the form of $CW_t = 175.88 * (1 - e^{-0.99(t-t_0)})$ and the growth performance index is ø'= 4,486.

For the female, CW_∞ and K in the von Bertalanffy growth equation is CW_∞ = 175.4; K = 0.94/year and for male CW_∞ = 177.9; K = 1.2/year. The results also showed that the growth rate in length of male higher than that of female (male: ø'= 4.570; female ø' = 4.464). Overall growth curve of blue crabs is described in Figure 7, for female in Figure 8 and for male Figure 9.

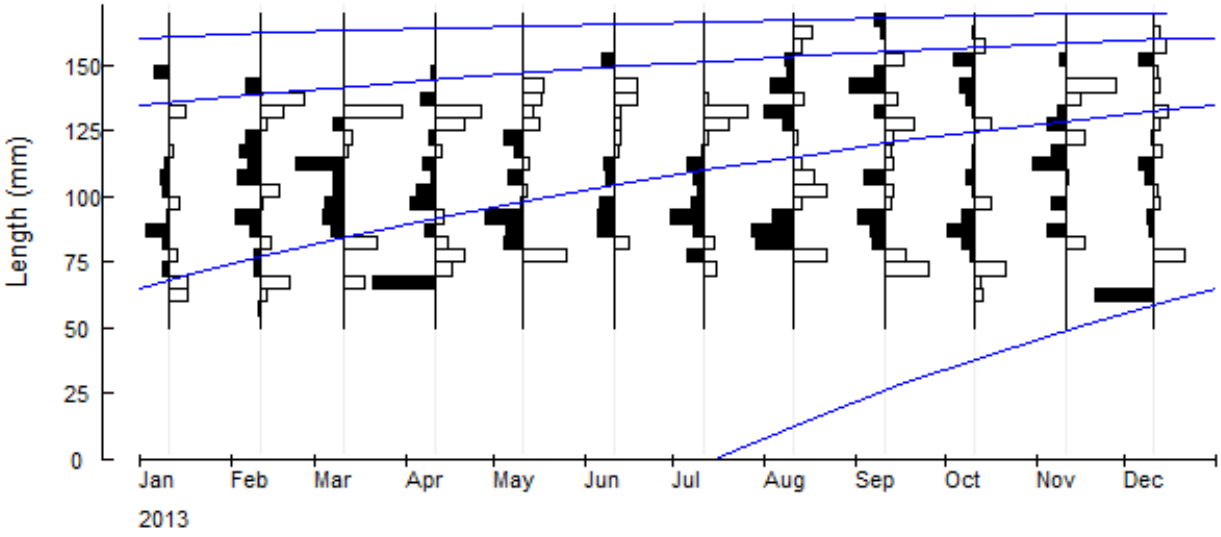


Figure 7. Length (CW) frequency and von Bertalaffy growth curve of BSC in Kien Giang water.

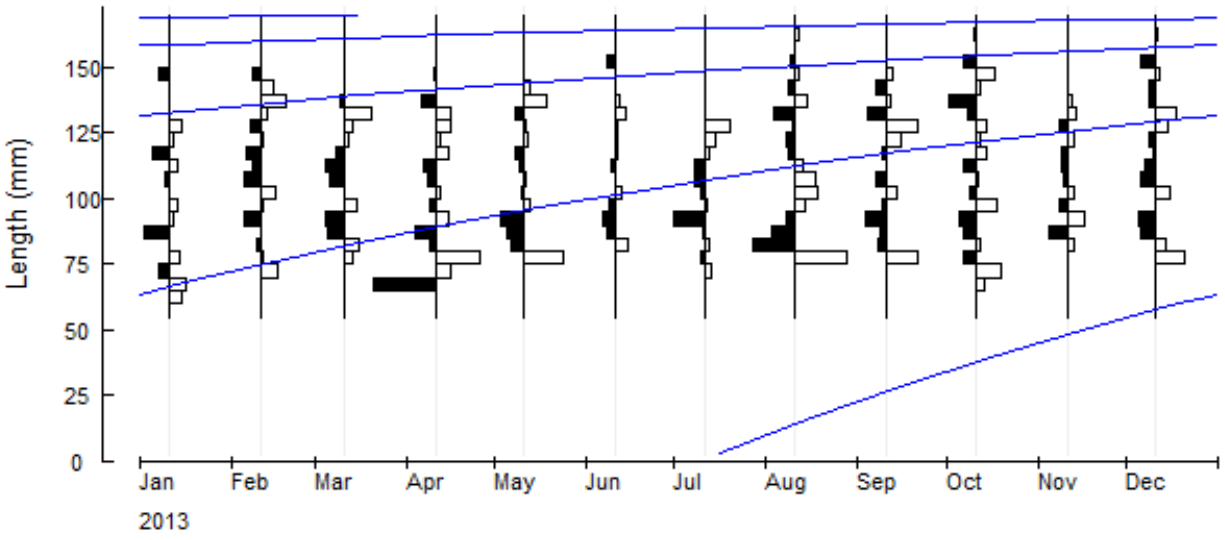


Figure 8. Length (CW) frequency and von Bertalaffy growth curve of female BSC in Kien Giang water.

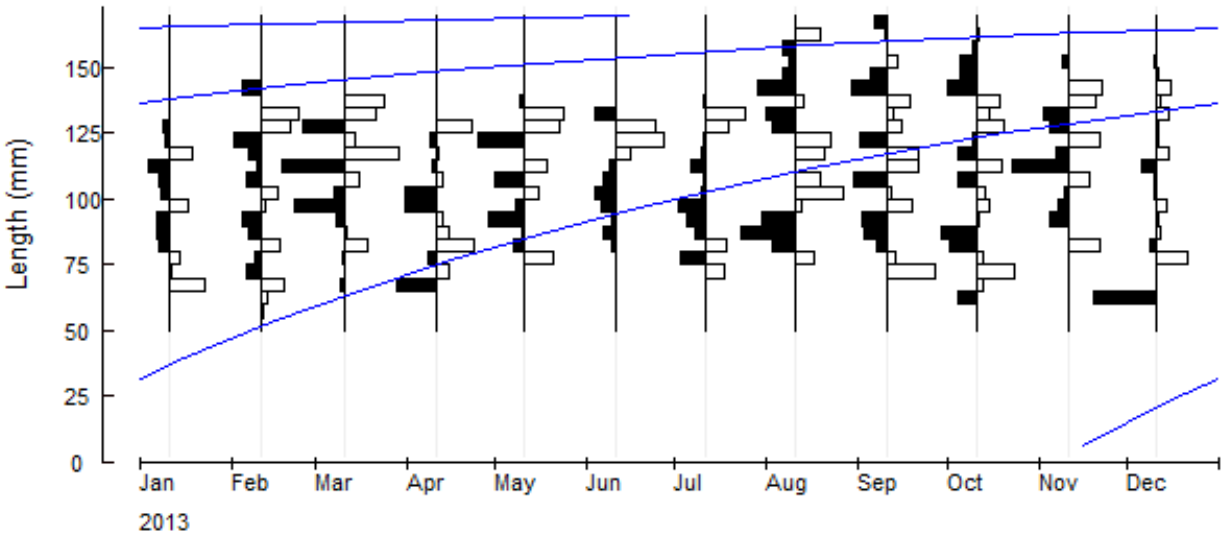


Figure 9. Length (CW) frequency and von Bertalaffy growth curve of male BSC in Kien Giang water.

Comparing the growth rates of blue crabs in the waters of Kien Giang, Vietnam and other waters showed that the growth rate of the blue crab in the waters of Kien Giang is equivalent to the growth rate of the blue crab in the Bandar Abbas, Northern Persian Gulf, Sikao Bay, Trang province, Thailand but lower than that in the coastal waters of Trang province, Thailand (Table 3).

Table 3. Growth parameters of BSC in some regions

Area	Sex	CW∞	K	ø'	Author
Kiên Giang waters	Male	177.90	1.20	4.570	This study
	Female	175.40	0.94	4.464	
	Overal	**175.88**	**0.99**	**4.486**	
Bandar Abbas, Northern Persian Gulf	Male	168.00	1.20	4.530	(Ehsan et al., 2010)
	Female	177.9	1.1	4.542	
	Overal	**172.5**	**0.98**	**4.465**	
Sikao Bay, Trang Province, Thailand	Male	158.0	1.3	4.511	(Songrak & Choopunth, 2006)
	Female	154.0	1.2	4.454	
	Overal	**161.0**	**1.1**	**4.455**	
Coastal Area, Trang Province, Thailand	Male	179.0	1.5	4.682	(Sawusdee & Songrak, 2009)
	Female	171.0	1.6	4.670	
	Overal	**173.0**	**1.5**	**4.652**	

3.1.2. Size – weight relationship

The relationship between carapace length and weight, between carapace width and weight of BSC species in Kien Giang waters is presented in Figure 10 and Figure 11. The results show that both female and male crabs are allometric growth and weight growth rate is faster than length growth rate. Female weight growth rate is slower than that of male (MANCOVA, $p < 0.001$). In the same size group, weigh of male is high than that of female. Carapace width and weight relationship equation is:

Female: Ln(W) = -10,3632+3,1633*Ln(CW)

Male: Ln(W) = -11,296+3,3706*Ln(CW)

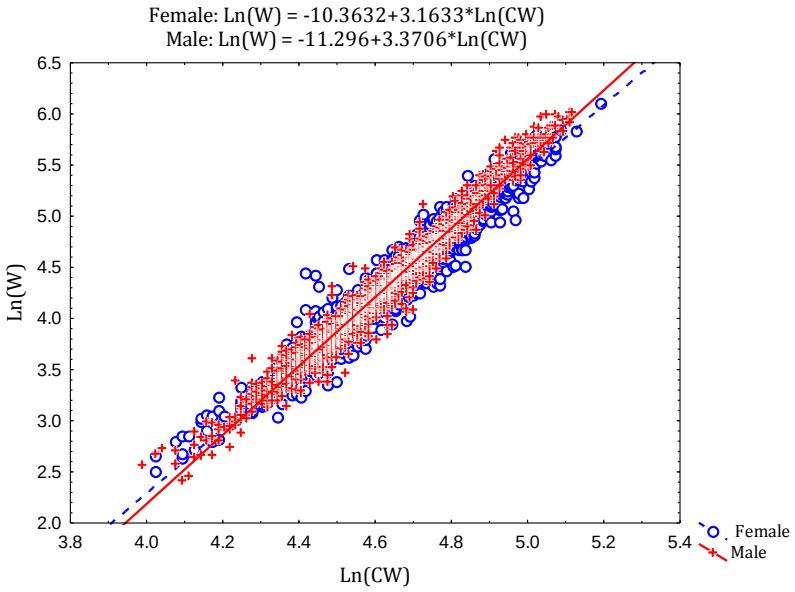


Figure 10. Carapace width and weight relationships of BSC in Kien Giang waters based on the data collected in 2013. Data was logarithsm

The correlation between the carapace length and weight of BSC is presented in **Error! Reference source not found.**. Statistical analysis showed that, in the ame size group, the weigh of the females is heavier than males (MACOVA, p <0.001). The carapace length and weight relationship of BSC is described by the equations:

Female: Ln(W) = -7.7976 + 3.1382*Ln(CL)

Male: Ln(W) = -7.6061 + 3.0838*Ln(CL)

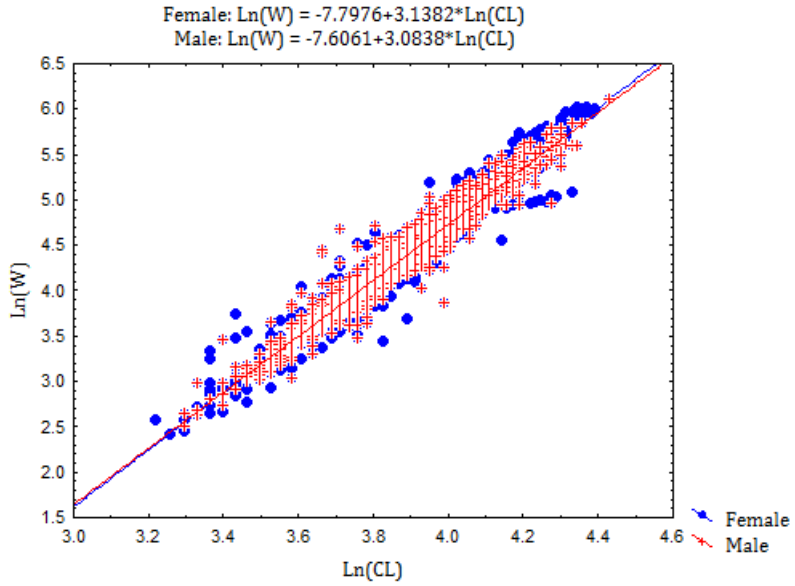


Figure 11. Carapace length and weight relationships of BSC in Kien Giang water sbased on data collected in 2013. Data was logarithsm

The carapace length and carapace width relationship of BSC (Figure 12) showed that the growth rate of carapace width of male crabs was greater than that of female crab (MANCOVA, p <0.001) and expressed as:

Female: Ln(CW) = 0.9654+0.9504*Ln(CL)

Male: Ln(CW) = 1.0092+0.9388*Ln(CL)

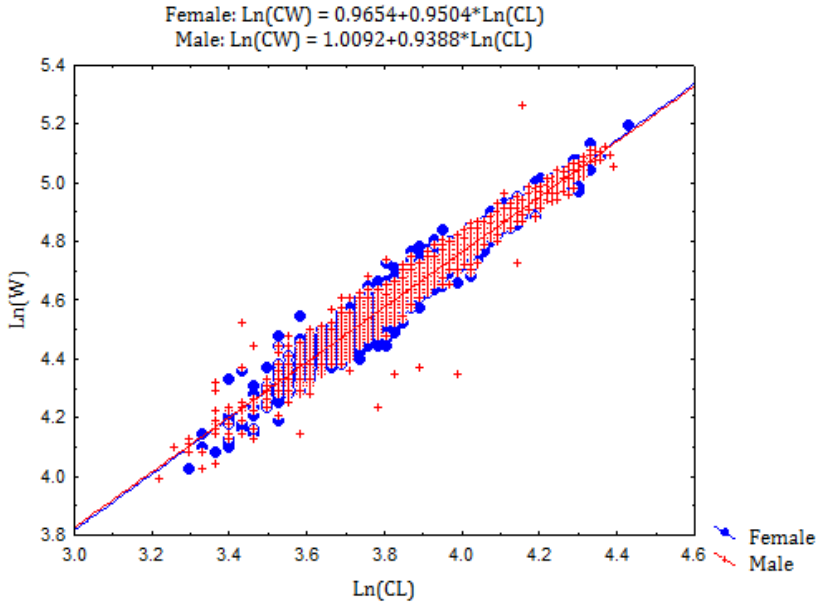


Figure 12. Carapace length and carapace width relationships of BSC in Kien Giang water sbased on data collected in 2013. Data was logarithsm

3.1.3. Biomass estimation

Length-frequencies of BSC collected monthly in 2013 are used in length converted catch curve model to determinine fishing mortality (F=1.91 for all sexes combined; F = 2.05 for female and F = 2.33 for male) and exploitation rate (E=0.64 for all sexes combined; E = 0.66 for female and E = 0.65 for male) since the natural mortality rate (M) is calculated from Pauly's M imperical equation was 1.10 at the mean temperature of 28.7ºC. It is indicated that the fishing pressure on BSC population is at a medium level. The Length converted catch curve of BSC in 2013 is graphically shown in Figure 13.

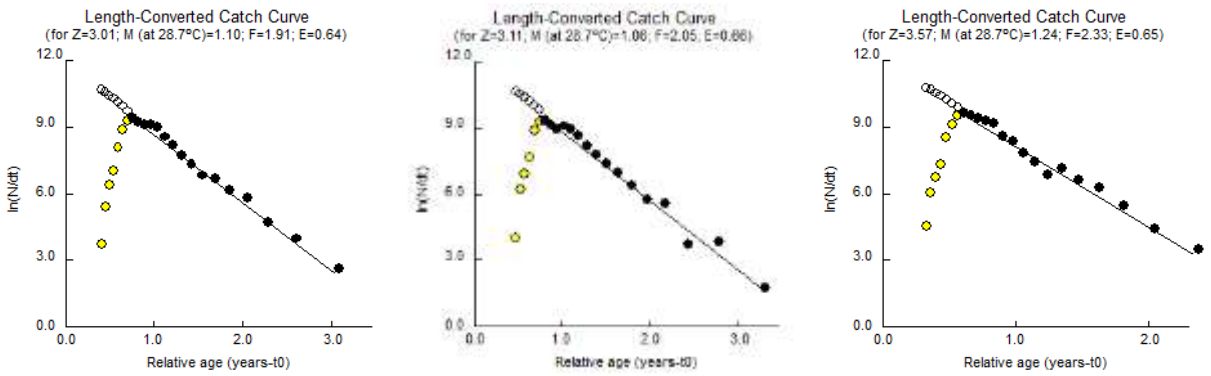


Figure 13. Length converted Catch curve of BSC in Kien Giang waters in 2013 (Left: Both sexes; middle: female; right: male)

Stock biomass of BSC in Kien Giang waters estimated using the Length Base Cohort Analysis method is around 7.13 thousand tons, corresponding to 1.54 x 10^6 individuals (Table 4).

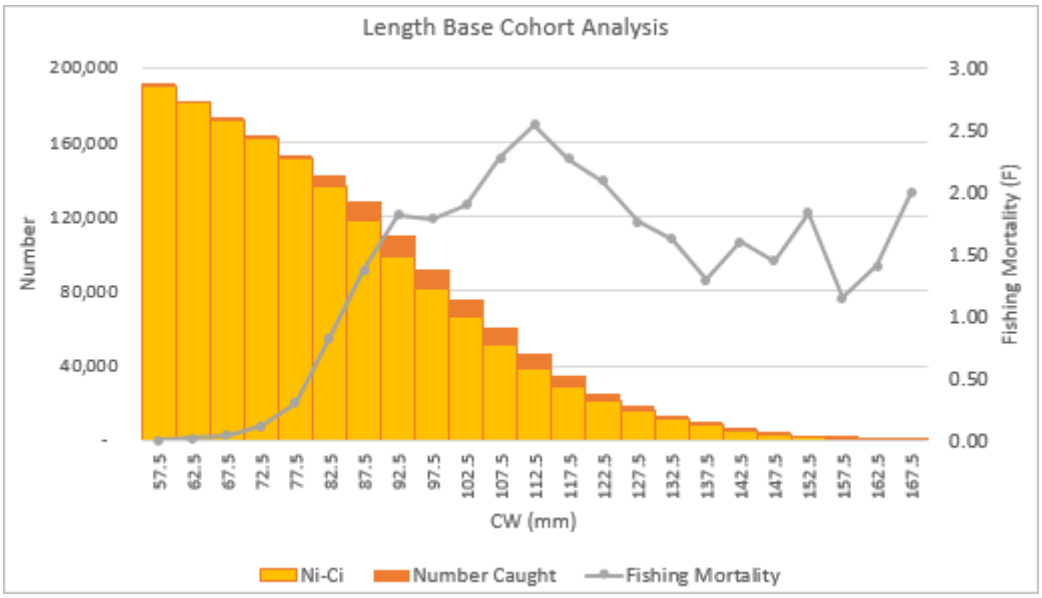


Figure 14. Stock assessment and fishing mortality of BSC in Kien Giang waters in 2013

Prematured blue swimming crabs dominate in BSC stock biomass with 57.74% (4.13 thousand tons), matured BSC accounted for 42.26% of (3.02 thousand tonnes). In terms of stock abundance, prematured BSC accounted for 83.67% (1.29 x 10^6 individuals) and matured BSC accounted for only 16.33% with 0.25 x 10^6 individuals (Table 4).

Table 4. Stock biomass of BSC in Kien Giang waters in 2013

Group	Biomass		Abundance	
	(x10^3 tons)	%	(x10^6 indv.)	%
Premature	4.13	57.74	1.29	83.67
Mature	3.02	42.26	0.25	16.33
Total	**7.13**	**100.00**	**1.54**	**100.00**

The fishing effort at maximum sustainable yeild (F_{MSY}) for BSC populations in waters of Kien Giang modelled by Beverton & Holt Yield per Recruiment model is 0.8 and the fishing effort at the precautionary fisheries management ($F_{0.1}$) is 0.6 (Figure 15). In 2013, the $F_{current}$ was 1.0; which means the current fishing effort exceeds the fishing effort at MSY 20% and exceeds the $F_{0.1}$ 40%.

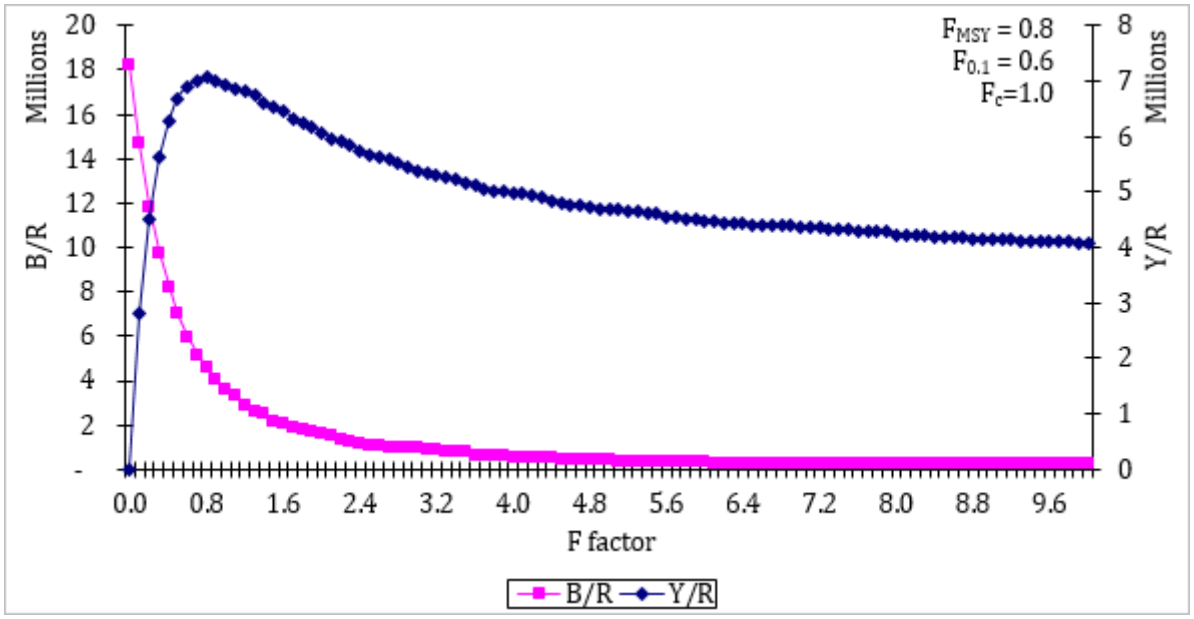


Figure 15. Berverton & Holt Yield per Recruiment model of BSC in Kien Giang waters in 2013

Comparison to stock assessment for BSC in Trang Province, Thailand, it is noted that the fishing pressure on BSC stock in Kien Giang waters is in medium level. As reported by Sawudee & Songrak (2009), the fishing mortality of BSC in Trang Provine is 7.35 for sexes combined; 7.24 and 7.62 for female and male, respectively. The natural mortality is estimated at 1.61 per year and the exploitation rate is 0.82. Sawudee & Songrak (2009) estimated the biomass for BSC in Trang Province at 98.9 thousand tons and the yield statistic in period from September 2006 to August 2007 was 356.2 thousand tons. Using the Thompson & Bell Prediction model in searching for the MSY and F_{MSY}, Sawudee & Songrak (2009) showed the

BSC stock is overexploited with fishing effort of BSC fisheries in 2006-2007 is 40% over the fishing effort at MSY.

In case of BSC stock in Kien Giang waters, the F_{2013}/F_{MSY} >1, indicated that to maintain stock equilibriumly against fishing pressure, it is a need to reduce the fishing effort.

3.2. Reproductive biology

3.2.1. Sex ratio

Variation of sex ratio male/females of BSC populations in Kien Giang waters are presented in Figure 16. Results showed that, the males are dominant in comparison to females. Results from surveys in 2013 indicated that the females only accounted for a higher percentage in May and September. The migration patterns of BSC are differences between males and females before and after the breeding season may affected to monthly fluctuation of the male/female ratio in Kien Giang waters.

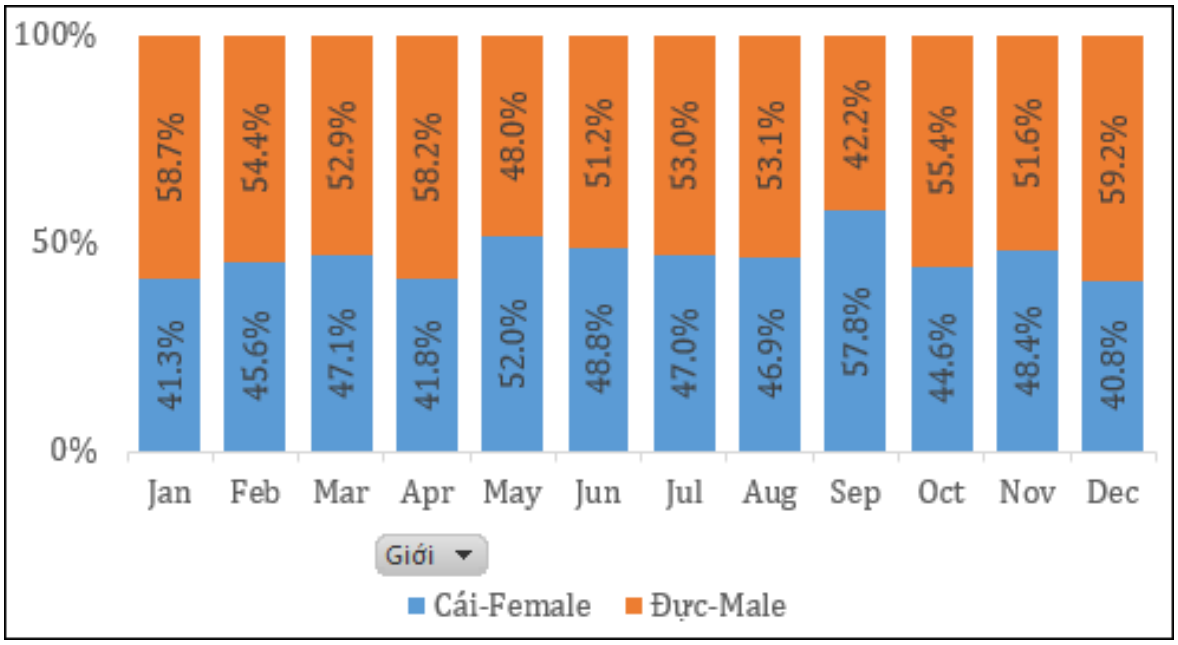


Figure 16. Fluctuation of male/female ratio of the BSC in Kien Giang waters

3.2.2. Size – maturity stage distribution

Figure 17 describes the rate of sexual maturity by size groups (CW) of BSC in Kien Giang waters. The juvenile crabs with the gonadal maturity at stages I, II were observed below 70mm in carapace width. Gonad development at stage III was derived from the size 72 mm. The smalest matured crabs was caught at the length

group of 86mm. The individuals with size from 100mm but gonad development is at phase I or II are those who have been spawning and gonad regeneration begins.

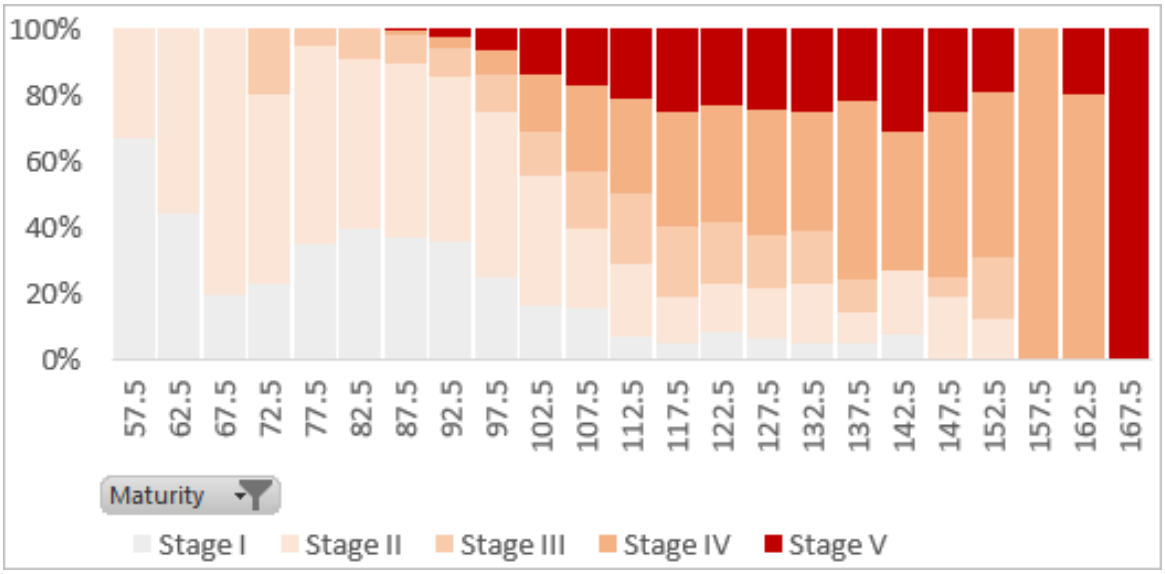


Figure 17. Proportion of gonad maturity stages by length groups of BSC in Kien Giang waters in 2013

The results of analysis gonads monthly showed that blue crab spawning scattered throughout the year that main spawning season is in March and sub spawning season is in August. During the main spawning season, gonad at stage IV and V accounted for high percentages, gonado somatic index (GSI) reaches peak in March and fell sharply after the spawning season, which showed that crabs spawn once in the main spawning season.

From April to July is the period of gonad development after the spawning season. At this time, the gonads of BSC are mainly in phase I and II . Sub spawning season starts in August. During the sub spawning season, BSC spawn many times, each time they will release part of the ovary and spawning season prolonged than in the main spawning season. GSI reaches a peak in August. Batch ovarian remaining will continue to develop and the second phase of the sub spawning season is in October and November.

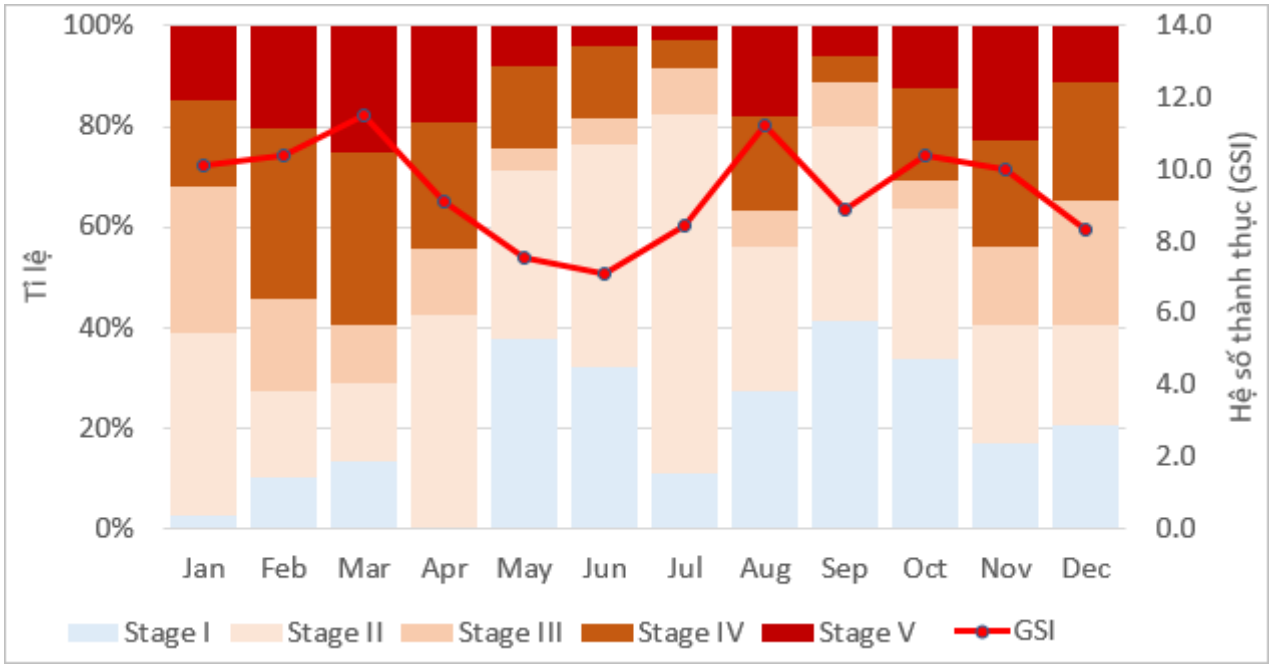


Figure 18. Monthly variation of gonad maturity ratio and gonado somatic index (GSI) of BSC in Kien Giang water s in 2013

The size at first maturity (CW_{50}) of BSC in Kien Giang waters is estimated at 99.28mm. The curve describes the rate of sexual maturity by length group are shown in Figure 19.

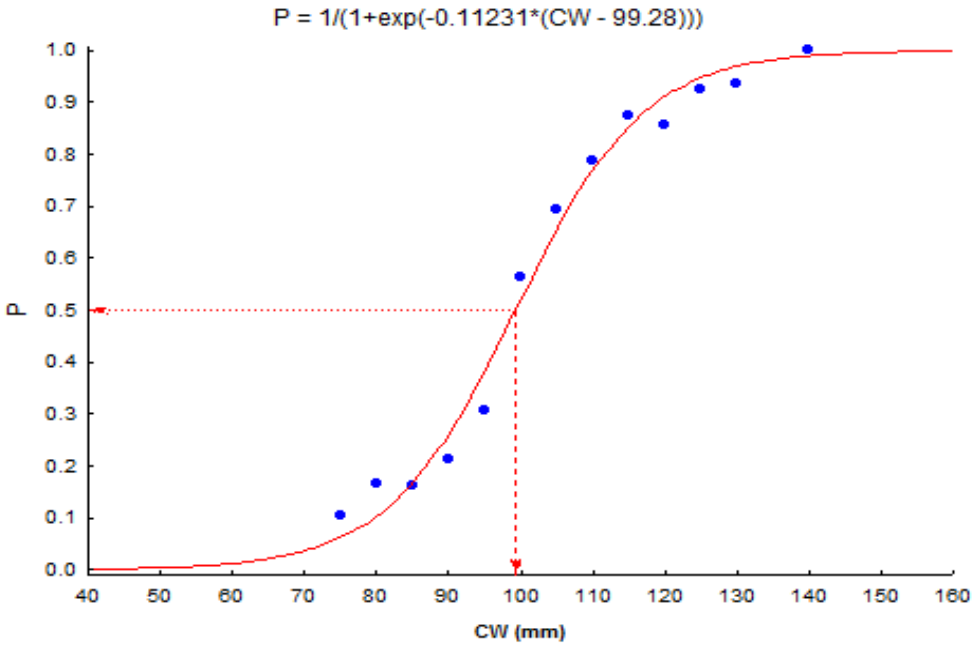


Figure 19. Relationship between percentage of maturity stage and size of BSC in Kien Giang waters in 2013

Compared with the size at first maturity of BSC in other regions, it is shown that the size at first maturity of BSC in Kien Giang waters is equivalent to that in the Peel-Harvey estuary, Leschenault estuary, Australia and larger than that in the Gulf of Koombana, the Cockburn Sound and Shark Bay, Australia (Table 5)

Table 5. Size at first maturity (CW_{50}, mm) of BSC in some regions

Areas	Size at first spawning (CW_{50}; mm)	Author
Cửa sôngPeel-Harvey, Australia	98.00	(Lestang et al., 2003)
Cửa sôngLeschenault, Australia	97.50	(Lestang et al., 2003)
Vịnh Koombana, Australia	86.90	(Lestang et al., 2003)
Vùng Cockburn Sound, Australia	86.40	(Lestang et al., 2003)
Vịnh Cá mập, Australia	92.00	(Lestang et al., 2003)
Kiên Giang, Việt Nam	99.28	This study

3.3. Fisheries

3.3.1. Catches and Fishing Effort

Results of the survey on the number of crab fishing boats in Kien Giang waters, by Kien Giang Department of Agriculture and Rural Development in collaboration with WWF Vietnam, has made a statistic number of 1,718 crab fishing boats (Table 6). Gillnet accounted for 77.8% and traps accounted for 22.2%. Group of small engine capacity below 20HP accounted for 54.5% and above 20HP accounting for 45.5%.

Crab traps mainly concentrated in Kien Hai, Kien Luong and Ha Tien districts. Crab gillnets mainly concentrated in Hon Dat and Phu Quoc districts.

Table 6. Number of crab fishing boats in Kien Giang water in 2013 (Source: DARD Kien Giang, 2013)

HP group	District	Trap	Gillnet	Total no. (boats)	Proportion (%)
<20CV		**179**	**758**	**937**	**54.5**
	An Biên		15	15	0.9
	Châu Thành	1	13	14	0.8
	Hòn Đất		196	196	11.4
	Kiên Hải	32	9	41	2.4
	Kiên Lương	57	24	81	4.7
	Phú Quốc	16	403	419	24.4
	Hà Tiên	73	98	171	10.0

>20CV		**202**	**579**	**781**	**45.5**
	An Biên		17	17	1.0
	An Minh	41	12	53	3.1
	Châu Thành	9	6	15	0.9
	Hòn Đất		215	215	12.5
	Kiên Hải	72	42	114	6.6
	Kiên Lương	55	77	132	7.7
	Phú Quốc	1	183	184	10.7
	Hà Tiên	24	27	51	3.0
Total no.		**381**	**1337**	**1718**	
Proportion (%)		**22.2**	**77.8**	**100.0**	

In 2013, the fishing effort of the BSC fisheries have great variation between months. Analysis of the Boat Activity Coefficent (BAC) of BSC fisheries, it is found that the activity of gillnet fishing boats is stable during a year while the trap fishing boats is seasonly affected monsoon because of limitation in size of the boats.

During year, the BAC of the gillnetter almost ranges between 0.5-0.6. The peak was observed in October (0.78) and dropped to bottom in April (0.45) (Figure 20).

BAC of the trap was highest in November (0.85) and lowest in July (0.36), this is the time the boats changed to target on jellyfish. The fishing cycle of traps rotated with that of gillnet. When the BAC of the trap increases, the BAC of gillnets decreased (Figure 20).

Number of operating days per month of gillnet and trap are low in February and March, it is the lunar new year time (Figure 21, Appendix 2). The mean active day of the trap is lowest in March (11.3 days/month) and highest in November (23.6 days/month). For gillnet, in February the fishing boat is only active 12.5 days on average. It is increasing in the following months and got a peak in October with 23.1 days/month on average.

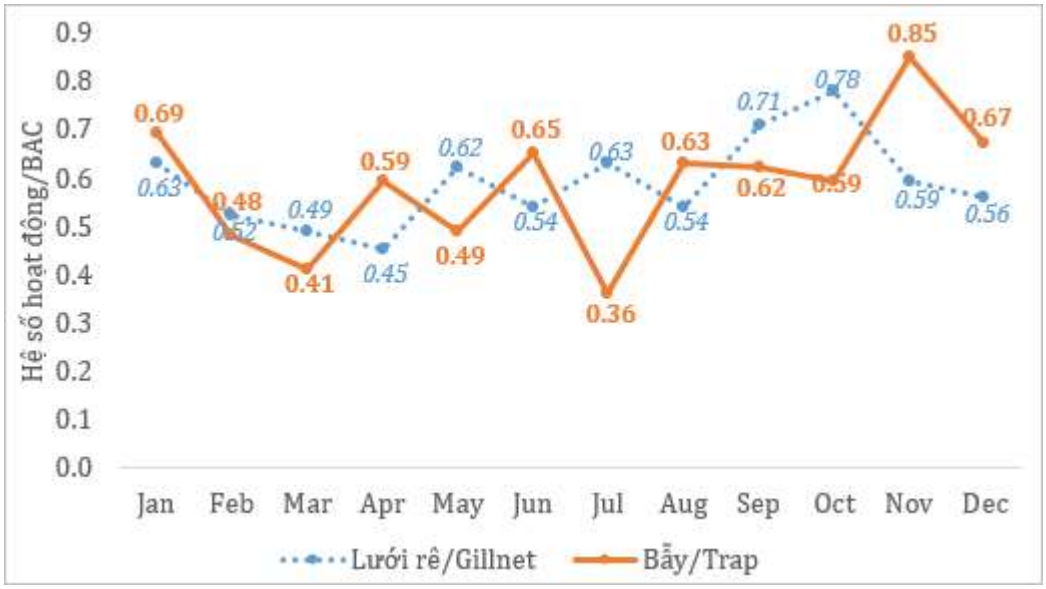


Figure 20. Boat Activity Coefficient (BAC) in BSC fisheries in Kien Giang in 2013

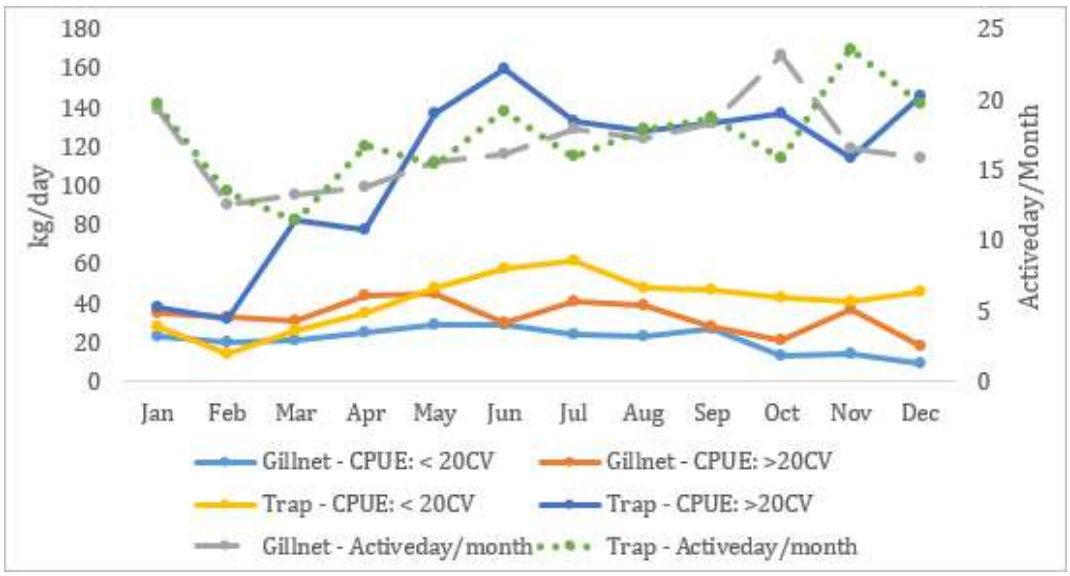


Figure 21. Fluctuation of fishing day/month and monthly catch rate (kg/day) of gillnet and trap fishing fleets in Kien Giang.

The standard catch rate (kg/net panel) in gillnet fishery and ratio of BSC catch in the total catches are presented in Table 7. For fishing fleet <20HP, BSC accounted for primarily proportion of catches with an average of 89.43 %, highest in December (97.64 %) and lowest in February (70.47 %). Averaged catch rate was 0.4 kg/net panel, highest was 0.57 kg/net panel in July and lowest was 0.3 kg/net panel in November.

For fishing fleet > 20HP, proportion of BSC in the total catches was lower in comparison to that in the catches of fishing fleet < 20HP. The ratio of blue crab catches in this fleet was highest at 89.77 % in January and lowest at 62.67 %, average rate was 74.86 %. Average standard catch rate of gillnet fleet > 20HP reaches 0.44 kg/net panel, lowest in December (0.24 kg/net panel) and highest in July (0.53 kg/net panel).

Comparison of the standard catch rates of the fleet <20HP and >20 HP shows the significant difference between catch rates of the two fleets (ANOVA , $p < 0.001$, **Error! Reference source not found.**)

Table 7. Catch proportion of BSC (%) and average standard catch rate (kg/net panel) of gillnet in Kien Giang in 2013

Month	<20HP		>20HP	
	BSC catch/total catch (%)	kg/net panel	BSC catch/total catche (%)	kg/net panel
Jan	92.81	0.56	89.77	0.41
Feb	70.47	0.43	71.86	0.47
Mar	78.41	0.37	78.80	0.33
Apr	89.99	0.36	64.62	0.39
May	90.13	0.36	62.67	0.46
Jun	87.07	0.41	71.19	0.49
Jul	89.43	0.58	70.48	0.53
Aug	89.19	0.36	73.08	0.52
Sep	91.19	0.39	79.43	0.48
Oct	92.03	0.38	78.15	0.32
Nov	88.93	0.30	75.63	0.53
Dec	97.64	0.35	70.06	0.24
Average	**89.43**	**0.40**	**74.86**	**0.44**

For crab traps, average standard catch rate of the fleet <20HP was 4.93 kg/100 traps. Highest catch rate was 7.13 kg/100 traps in May and lowest was 2.7 kg/100 traps in January. Catches of BSC is dominated, mainly in the range 41-48% of the total catch.

For crab Chinese traps, average standard catch rate of the fleet <20HP was lower than that of the fleet >20HP (ANOVA, $p<0.001$), average was 6.12 kg/100 traps for the fleet <20HP and 7.27 kg/100 traps for the fleet >20HP. (Table 8, Figure 22).

Proportion of BSC in the total catches of fleets higher in January, February, March and April with the ratio is above 40% of total catches. From May to

December, the BSC appear at lower proportion, almost below 23% of the total catches (Table 8).

Table 8. Catch proportion of BSC (%) and average standard catch rate (kg/100traps) of the trap fishing fleets in Kien Giang in 2013

Month	Trap <20CV		Chinese trap <20HP		Chinese trap >20HP	
	kg/100 traps	BSC catch/total catch (%)	kg/100 traps	BSC catch/total catch (%)	kg/100 traps	BSC catch/total catch (%)
Jan	2.70	47.42	8.46	65.69	4.64	22.99
Feb	2.58	42.39	5.80	53.71	4.85	20.94
Mar	2.59	43.34	3.14	41.73	5.07	37.49
Apr	4.53	41.30	5.00	42.70	5.58	43.69
May	7.13	40.94	8.21	23.32	9.18	16.92
Jun	6.02	45.37	4.52	16.75	8.86	17.75
Jul	6.75	47.40	6.45	17.83	7.77	18.16
Aug	5.32	47.73	6.64	17.52	6.82	17.39
Sep	5.14	48.25	5.80	20.00	6.89	17.76
Oct	4.92	48.11	5.25	19.99	7.18	18.68
Nov	4.43	48.08	5.34	19.19	7.04	19.06
Dec	4.16	46.10	7.41	18.75	7.83	19.04
Average	**4.93**	**46.08**	**6.12**	**30.29**	**7.27**	**22.49**

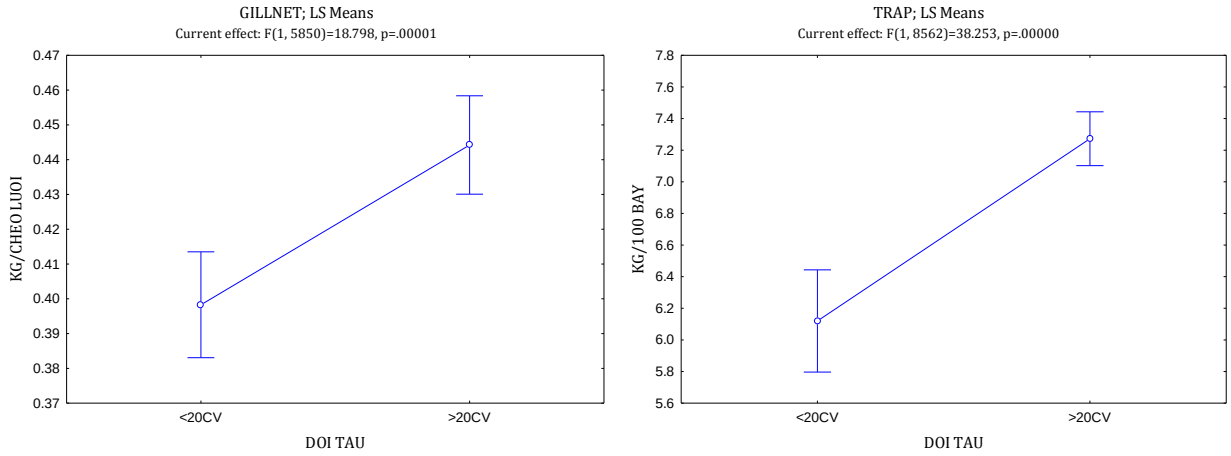


Figure 22. Plots of catch rates of the gillnet fishing fleets <20HP, >20HP and trap <20HP, >20HP in Kien Giang in 2013

Average catch rate per day of the gillnet and trap fleets <20 HP ranged mostly 20-40 kg/day. The catch rate of trap fleet >20 HP was higher. In the period from May to December 2013, the catch rate of the trap fleet >20HP maintained at 120-140 kg/day. Average catch rate was highest in June, reaching 160 kg/day (**Error! eference source not found.**, Appendix 2).

The surveys also showed the fishing coefficient increases, the average number of fishing days of the fleet also increased. In the months BAC was high, the average fishing time was also high and the average catch rates also higher.

Total catch of BSC caught in Kien Giang waters in 2013 is estimated at 7.8 thousand tons, with 53.4% exploitated by gillnet and 46.6% exploited by traps (Table 9).

In terms of the fleet, catches of the fleet > 20 HP accounted for 62.6 % of total catches, whereas catches of the fleets less than 20HP accounts for only 37.4 % .

Table 9. Total catch estimated for BSC in Kien Giang in 2013

Gear	Catch	<20HP	>20HP	Total	Proportion (%)
Gillnet	Catch (tons)	1,917	2,279	4,196	53.4
	Proportion (%)	45.7	54.3	100.0	
Trap	Catch (tons)	1,018	2,641	3,658	46.6
	Proportion (%)	27.8	72.2	100.0	
Total	**Catch (tons)**	**2,935**	**4,920**	**7,855**	
	Proportion (%)	37.4	62.6	100.0	100.0

3.3.2. Fishing Ground

Fishing grounds of crab gill nets and crab traps is presented in Figure 23. Fishing fleet <20HP mainly exploited in the coastal of Kien Luong district, including the rectangle G3 , G4 , F4; Ham Ninh – Bai Bon area, comprising of the rectangle C2, D2 , D3 and southern region of Phu Quoc from An Thoi to the northwest of the Nam Du archipelago.

Fishing fleet >20HP has a wider fishing areas, fishing grounds cover most of the Northmost of Nam Du Island to Hai Tac archipelago, the historical waters Vietnam-Cambodia and western region of Phu Quoc Island. The high catch rates of BSC is observed in the rectangles A2, B2, A4, B4, A5, B5, B6, C2, C5, C6, B5, B6, D5, D6, G3 and J4.

The crab trap mainly operates in the Ham Ninh - Bai Bon area, Kien Luong coast and around Hon Tre island. The high catch rates fishing grounds were obseved in ractangle I3, I5 and C3.

The Chinese trap fleet concentrated in the waters around the Hai Tac archipelago and Hon Tre - Hon Rai spreading to the Hon Thom Island and southern

waters of Rach Gia Bay (**Error! Reference source not found.**). The high cath rates ere in the rectangles C2, G6, H5, H6, H7, I3, I5, I6, I7 and F7.

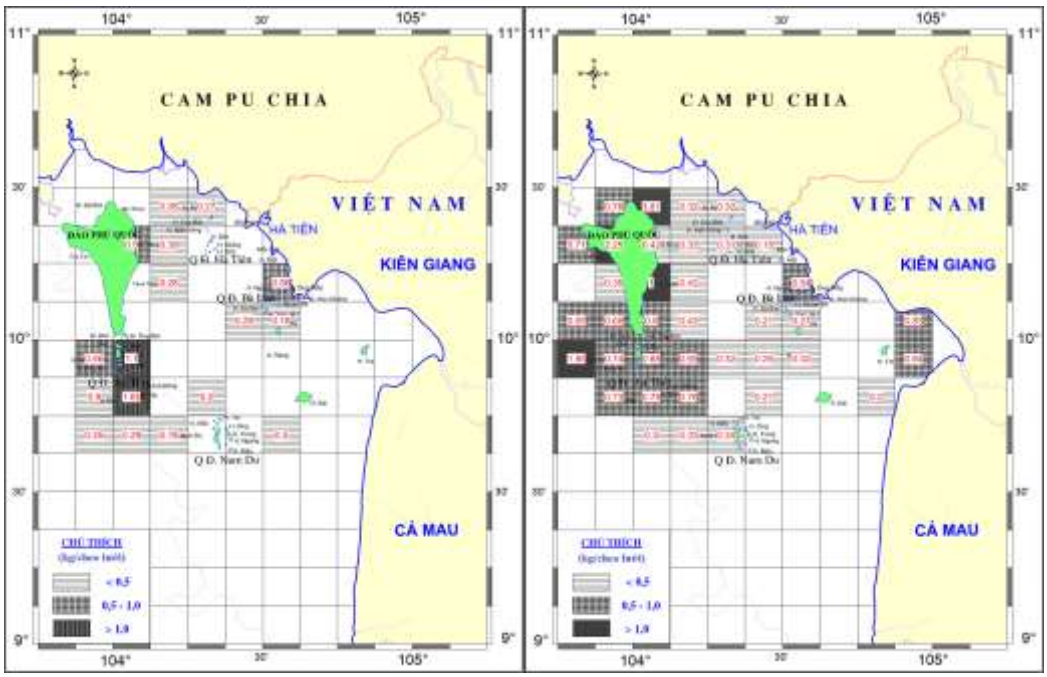


Figure 23. Fishing grounds of crab gillnet fishing fleets in Kien Giang in 2013 (fleet <20CV: left; fleet >20CV: right)

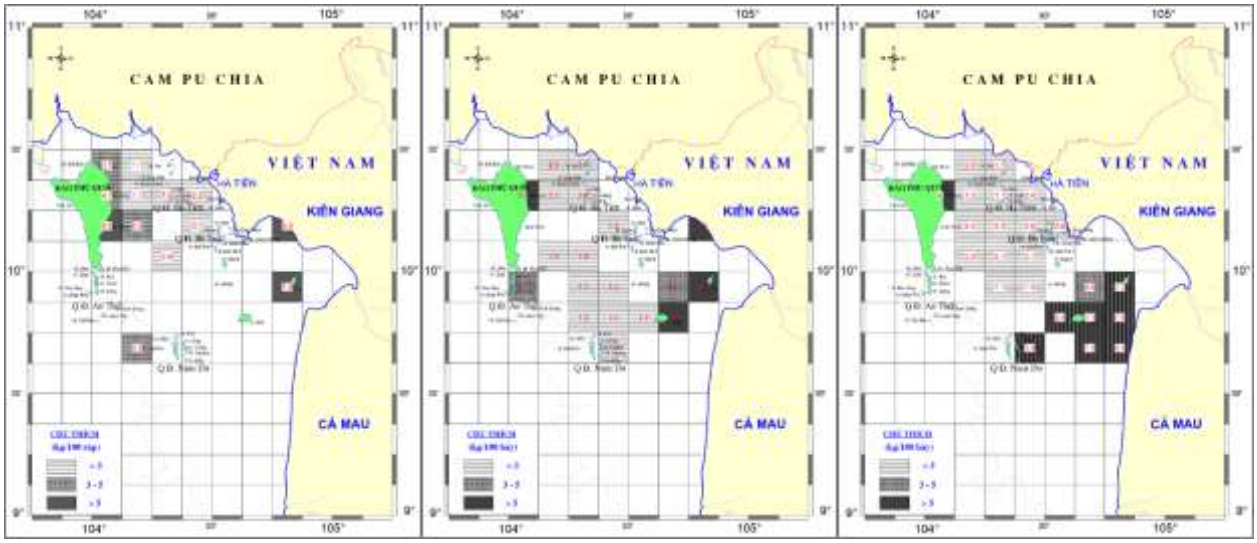


Figure 24. Fishing grounds of trap fishing fleets in Kien Giang in 2013 (trap fleet <20CV: left; Chinese trap fleet <20CV: middle; Chinese trap fleet >20CV: right)

3.3.3. Bycatch

There are 102 species/species group caught in the catches of gillnets and traps of 4 observer trips conducted in January, April, August and October in 2013 (Table 10). Among them, 87 species caught by gillnet and 23 species caught by trap.

The non-targeted species appearing regularly in catches of gillnets include : crab (*Charybdis feriatus, C. voiceover*), shark (*Chiloscyllium punctatum*), stingray (*Dasyatis zugei*), shrimp (*Ibacus novemdentatus*), snail shells (*Cymbiola nobilis*), croaker fish (*Pennahia Anea*), fish (*Terapon theraps*) and fish (*Upeneus tragula*) 23 species recorded in the catches of traps include: crab (*Charybdis affinis*), goby (*Acentrogobius caninus*), crayfish (*Oratosquilla oratoria*) and prawn (*Penaeus semisulcatus*).

The remaining species is occasonally caught in BSC fisheries, even rarely seen in catches of both trap and gillnet.

Table 10. List of species caught in the catch of gillnet and traps based on the observer trips (+: rare seen; ++: not frequently seen; +++: frequently seen)

Species/Species group	Gillnet				Trap			
	Jan-13	Apr-13	Aug-13	Oct-13	Jan-13	Apr-13	Aug-13	Oct-13
Targeted								
Portunus pelagicus	+++	+++	+++	+++	+++	+++	+++	+++
Non-targeted								
Acentrogobius caninus							++	++
Alepes djedaba				+				+
Allenbatrachus grunniens			+	+				
Apogon kiensis								+
Arelia bilineata			+					
Arius sp				+				
Atule mate			+	+				
Calappa lophos				+				
Carangoides armatus				+				
Carangoides chrysophrys			+	+				
Charybdis affinis	+				+++	+++	+++	+++
Charybdis feriatus	+++	+++	++	++				
Charybdis natator			++	++				
Chelmon marginalis				+				
Chiloscyllium punctatum			++	++				
Cymbiola nobilis	+		+++	+++				
Cynoglossus sp				+				

Species/Species group	Gillnet				Trap			
	Jan-13	Apr-13	Aug-13	Oct-13	Jan-13	Apr-13	Aug-13	Oct-13
Dasyatis kuhlii			+	+				
Dasyatis zugei	+++	+++	+++	+++				
Diodon holocanthus			+					
Epinephelus bleekeri				+				
Epinephelus sexfasciatus				+				
Epinephelus trimaculatus				+				
Gerres erythrourus				+				
Gerres japonicus			+	+				
Grammatobothus polyophthalmus			+					
Gymnothorax kidako			+					
Halaelurus buergeri				+				
Himantura imbricata				+				
Hipocamphus trimaculatus			+					
Ibacus ciliatus				+				
Ibacus novemdentatus			++	++				
Inegocia japonica			+	++				
Inimicus cuvieri				+				
Johnius belangerii								+
Lactoria cornutus				+				
Lagocephalus lunaris				+				+
Leiognathus berbis				+				
Leiognathus brevirostris								+
Lethrinus lentjan			+	+				
Lutjanus lutjanus			+	+				
Megalaspis cordyla				+				
Melo melo			+	+				
Metapenaeus intermedius							++	
Monacanthus chinensis				+				
Muraenesox cinereus			+					
Nemipterus furcosus				+				
Octopus sp				+				
Odontodactylus scyllarus				+				
Oratosquilla oratoria	+			++	+++	+++	+++	
Otolithes ruber								++
Paralichthys olivaceus			+					
Parapenaeopsis hungerfordi							+	
Parascolopsis inermis			+					
Pardachirus pavoninus				+				
Penaeus latisulcatus			+					
Penaeus semisulcatus			+	+			++	++

Species/Species group	Gillnet				Trap			
	Jan-13	Apr-13	Aug-13	Oct-13	Jan-13	Apr-13	Aug-13	Oct-13
Pennahia anea			+++	++				+
Pennahia argentata								+
Pentapodus paradiseus				+				
Platycephalus indicus			+					
Plectorhinchus pictus				+				
Plotosus lineatus			+	+				
Plotosus sp				+				
Podophthamus vigil			+	+				
Pomadasys maculatus				+				
Portunus sanguinolentus				+				
Proscyllium venustum			+					
Pseudorhombus dupliciocellatus				+				
Pterois russelii			+	+				
Rachycentron canadum				+				
Rastrelliger brachysoma			+	+				
Sagocentron rubrum			+					
Sardinella sp				+				
Saurida elongata			+	+				
Scatophagus argus								+
Scolopsis taeniopterus			+	+				
Scolopsis vosmeri			+	+				
Secutor ruconius								+
Sepia aculata				+				
Sepia inermis							+	+
Sepia lycidas			+	+				
Siganus canaliculatus				+				
Siganus guttatus			+	+				
Sillago cananiculatus				+				
Sillago maculata				+				
Sillago sihama			+	+				+
Taeniura lymma			+					
Terapon jarbua			+	+				
Terapon theraps			++	++				
Trachinocephalus myops				+				
Upeneus tragula			++	++				
Yongeichthys nebulosus								+
Mực nang	+	+						
Podophthanus vigil	+	+						
Other fishes	+	+						
Other groups							+	

Species/Species group	Gillnet				Trap			
	Jan-13	Apr-13	Aug-13	Oct-13	Jan-13	Apr-13	Aug-13	Oct-13
Trash fish							+	
Mixed fishes							+	
Murex trocheli	+	+						
Harpiosquilla harpax	+							
COUNT	**11**	**7**	**44**	**68**	**3**	**3**	**11**	**17**

CONCLUSION

Total catch of BSC in the Kien Giang waters in 2013 is estimated at 7.8 thousand tons with 53.4% of the gillneter and 46.6% of the trap.

The stock biomass of BSC was estimated at 7.13 thousand tons corresponding to 1.54 x 10^6 individuals, with 3 thousand tonnes of mature crabs and 4.1 thousand tonnes of immature crabs.

The stock assessment using the Berverton and Holt Yield per Recruiment model showed that the BSC resources is heavily exploited (Length Converted Catch Curve: E>0.6; Beverton & Holt Yield per Recruiment Model: $F_{current}>F_{MSY}$; $F_{0.1}<F_{current}$). To manage the BSC fishery, the reduction in fishing effort is required to maintain sustainable BSC resource again the fishing pressure.

BSC begins mature at the size 86mm (CW). Size at first maturity (CW_{50}) is 99.28mm. Size of BSC exploited by traps currently smaller than the size at first maturity. To reduce the risk of fishing on BSC stock, the minimum mesh size corvering the trap need to be increased.

BSC bears egg during year around. The main spawning season of BSC is considered from February to April with peak in March. The sub-spawning season is in August and October-November. During the sub-spawning season, the ovary of BSC is spawning partly and the spawning season prolongs and spawning occurs scattered.

Percentage of crab females in populations is always lower than that of the male crabs. During the year, the ratio of female crabs dominates over the males at the end of the main spawning season and during the first batch of the sub spawning season.

Von Bertalanffy growth equation of blue crabs is $CW_t = 175.88 * (1 - e^{-0.99(t-t_0)})$ and the growth performance index is ø ' = 4,486 . The growth equation for the female is $CW_t = 175.4 * (1 - e^{-0.94(t-t_0)})$ and for the male is $CW_t = 177.9 * (1 - e^{-1.2(t-t_0)})$. Growth rates of male is higher than that of the female.

There were total 102 species/species groups in catches of gillnets and traps. The non-target species appearing regularly in catches of gillnets is red crab (*Charybdis feriatus, C. voiceover*), shark (*Chiloscyllium punctatum*), stingray (*Dasyatis zugei*), shrimp (*Ibacus novemdentatus*), Snail shells (*Cymbiola nobilis*), Croaker fish (*Pennahia anea*), Largescaled terapon (*Terapon theraps*) and Bartail Goatfish (*Upeneus tragula*) and in the catches of the trap is (*Charybdis affinis*), Sand goby (*Acentrogobius caninus*), crayfish (*Oratosquilla oratoria*) and prawn (*Penaeus semisulcatus*).

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APPENDICES

Appendix 1. Discriptive statistics of BSC samples collected from catches of gillnets and traps fisheries in Kien Giang Province

			CW (mm)				CL (mm)				Aver. weight (g)	N
Trip	Gear	Sex	Min	Medium	Std, Dev.	Max	Min	Medium	Std, Dev.	Max		
201301			**60.0**	**98.2**	**15.4**	**145.0**	**28.0**	**45.3**	**8.1**	**97.0**	**68.6**	**281.0**
	Gillnet		**85.0**	**111.1**	**10.0**	**145.0**	**39.0**	**51.3**	**5.0**	**70.0**	**99.1**	**128.0**
		Female	91.0	112.7	10.4	145.0	41.0	52.0	5.4	70.0	102.9	48.0
		Male	85.0	110.1	9.7	129.0	39.0	51.0	4.8	61.0	96.9	80.0
	trap		**60.0**	**87.4**	**10.0**	**114.0**	**28.0**	**40.2**	**6.5**	**97.0**	**43.1**	**153.0**
		Female	60.0	86.4	9.6	108.0	28.0	39.4	4.4	50.0	40.1	68.0
		Male	66.0	88.3	10.2	114.0	29.0	40.9	7.8	97.0	45.5	85.0
201302			**59.0**	**104.8**	**16.2**	**146.0**	**27.0**	**48.5**	**8.0**	**74.0**	**84.7**	**298.0**
	Gillnet		**75.0**	**112.8**	**12.5**	**146.0**	**35.0**	**52.5**	**6.4**	**74.0**	**103.7**	**129.0**
		Female	75.0	115.5	12.8	146.0	35.0	53.9	6.6	74.0	111.6	74.0
		Male	87.0	109.0	11.3	140.0	40.0	50.5	5.6	68.0	93.1	55.0
	Trap		**59.0**	**98.8**	**16.1**	**143.0**	**27.0**	**45.4**	**7.8**	**68.0**	**70.2**	**169.0**
		Female	74.0	100.2	12.7	125.0	33.0	46.1	6.1	58.0	68.1	62.0
		Male	59.0	97.9	17.8	143.0	27.0	45.0	8.7	68.0	71.4	107.0
201303			**69.0**	**104.3**	**12.8**	**137.0**	**34.0**	**48.1**	**6.2**	**65.0**	**82.3**	**272.0**
	Gillnet		**69.0**	**108.1**	**11.8**	**135.0**	**36.0**	**50.1**	**5.4**	**64.0**	**92.4**	**143.0**
		Female	84.0	109.8	11.4	135.0	39.0	50.8	5.4	64.0	96.8	79.0
		Male	69.0	106.0	12.0	131.0	36.0	49.2	5.4	62.0	86.9	64.0
	Trap		**76.0**	**100.1**	**12.5**	**137.0**	**34.0**	**45.9**	**6.2**	**65.0**	**71.2**	**129.0**
		Female	76.0	100.7	12.5	128.0	34.0	46.0	6.1	60.0	70.9	49.0
		Male	77.0	99.7	12.6	137.0	35.0	45.8	6.4	65.0	71.3	80.0
201304			**65.0**	**101.3**	**13.9**	**145.0**	**29.0**	**46.4**	**6.6**	**68.0**	**74.7**	**275.0**
	Gillnet		**75.0**	**107.4**	**12.8**	**145.0**	**34.0**	**49.7**	**6.1**	**68.0**	**90.2**	**146.0**
		Female	81.0	108.9	15.1	145.0	36.0	50.6	7.4	68.0	95.1	57.0
		Male	75.0	106.4	11.0	127.0	34.0	49.1	5.1	58.0	87.1	89.0
	Trap		**65.0**	**94.4**	**11.6**	**121.0**	**29.0**	**42.8**	**5.2**	**54.0**	**57.2**	**129.0**
		Female	65.0	94.9	13.5	121.0	30.0	42.9	6.0	54.0	58.7	58.0
		Male	65.0	94.1	9.9	117.0	29.0	42.7	4.4	52.0	56.0	71.0
201305			**77.0**	**99.3**	**13.3**	**141.0**	**36.0**	**45.6**	**6.2**	**65.0**	**71.8**	**333.0**
	Gillnet		**81.0**	**107.9**	**12.0**	**141.0**	**37.0**	**49.6**	**5.7**	**65.0**	**92.9**	**155.0**

			CW (mm)				CL (mm)				Aver. weight	
Trip	Gear	Sex	Min	Medium	Std, Dev.	Max	Min	Medium	Std, Dev.	Max	(g)	N
		Female	81.0	107.6	13.0	141.0	37.0	49.4	6.1	65.0	90.3	80.0
		Male	87.0	108.3	10.8	135.0	40.0	49.8	5.3	65.0	95.8	75.0
	Trap		**77.0**	**91.8**	**9.2**	**135.0**	**36.0**	**42.2**	**4.4**	**62.0**	**53.4**	**178.0**
		Female	77.0	92.3	10.3	135.0	37.0	42.7	4.7	62.0	54.5	93.0
		Male	79.0	91.2	8.0	118.0	36.0	41.6	3.9	55.0	52.1	85.0
201306			**80.0**	**102.3**	**12.5**	**152.0**	**37.0**	**46.9**	**5.8**	**72.0**	**76.8**	**370.0**
	Gillnet		**80.0**	**108.5**	**12.8**	**152.0**	**37.0**	**49.7**	**6.2**	**72.0**	**93.0**	**144.0**
		Female	88.0	112.9	12.9	152.0	40.0	51.7	6.2	72.0	101.5	59.0
		Male	80.0	105.5	11.9	144.0	37.0	48.2	5.7	66.0	87.2	85.0
	Trap		**80.0**	**98.4**	**10.5**	**129.0**	**37.0**	**45.2**	**4.9**	**60.0**	**66.4**	**226.0**
		Female	81.0	98.4	10.6	129.0	37.0	45.3	4.8	60.0	65.3	122.0
		Male	80.0	98.4	10.5	123.0	37.0	45.1	4.9	57.0	67.6	104.0
201307			**71.0**	**98.2**	**12.6**	**138.0**	**30.0**	**44.6**	**6.5**	**67.0**	**66.6**	**353.0**
	Gillnet		**75.0**	**105.7**	**11.2**	**138.0**	**35.0**	**48.7**	**5.8**	**67.0**	**87.4**	**152.0**
		Female	80.0	104.7	10.6	124.0	38.0	48.6	5.2	60.0	83.4	57.0
		Male	75.0	106.3	11.6	138.0	35.0	48.8	6.2	67.0	89.8	95.0
	Trap		**71.0**	**92.6**	**10.5**	**128.0**	**30.0**	**41.4**	**5.1**	**56.0**	**50.8**	**201.0**
		Female	71.0	92.9	10.8	128.0	30.0	41.8	5.2	56.0	50.7	109.0
		Male	72.0	92.2	10.0	117.0	31.0	41.0	4.9	53.0	51.0	92.0
201308			**76.0**	**115.4**	**25.5**	**193.0**	**33.0**	**52.9**	**13.0**	**76.0**	**128.8**	**320.0**
	Gillnet		**96.0**	**134.7**	**13.8**	**193.0**	**45.0**	**62.9**	**6.8**	**76.0**	**190.6**	**185.0**
		Female	96.0	128.7	13.0	160.0	45.0	60.0	6.7	74.0	165.6	92.0
		Male	116.0	140.7	11.8	193.0	52.0	65.7	5.7	76.0	215.3	93.0
	Trap		**76.0**	**88.9**	**8.0**	**122.0**	**33.0**	**39.3**	**3.5**	**53.0**	**44.1**	**135.0**
		Female	77.0	88.9	8.6	122.0	34.0	39.5	3.8	53.0	43.9	58.0
		Male	76.0	88.8	7.6	112.0	33.0	39.2	3.2	49.0	44.2	77.0
201309			**72.0**	**100.0**	**17.3**	**165.0**	**36.0**	**47.5**	**7.8**	**78.0**	**82.7**	**320.0**
	Gillnet		**80.0**	**117.4**	**20.1**	**165.0**	**36.0**	**54.0**	**10.3**	**78.0**	**141.5**	**90.0**
		Female	80.0	114.9	16.6	145.0	36.0	53.0	8.4	67.0	128.1	41.0
		Male	81.0	119.6	22.5	165.0	36.0	54.9	11.6	78.0	152.7	49.0
	Trap		**72.0**	**93.1**	**9.8**	**119.0**	**36.0**	**44.9**	**4.6**	**58.0**	**59.7**	**230.0**
		Female	79.0	95.5	9.9	119.0	38.0	46.0	4.6	58.0	62.8	144.0
		Male	72.0	89.3	8.3	111.0	36.0	43.2	4.1	54.0	54.4	86.0
201310			**62.0**	**111.9**	**26.9**	**167.0**	**27.0**	**51.2**	**13.7**	**81.0**	**124.9**	**307.0**
	Gillnet		**83.0**	**133.4**	**18.4**	**167.0**	**39.0**	**62.2**	**9.7**	**81.0**	**201.1**	**157.0**
		Female	83.0	128.7	16.3	162.0	40.0	60.0	8.1	78.0	158.8	67.0
		Male	88.0	136.8	19.2	167.0	39.0	63.8	10.5	81.0	232.6	90.0
	Trap		**62.0**	**89.4**	**11.9**	**120.0**	**27.0**	**39.7**	**5.1**	**54.0**	**45.1**	**150.0**
		Female	66.0	92.2	12.3	120.0	30.0	40.9	5.0	53.0	49.3	70.0
		Male	62.0	87.0	11.0	120.0	27.0	38.6	5.0	54.0	41.5	80.0
201311			**80.0**	**110.4**	**13.8**	**150.0**	**37.0**	**50.3**	**6.6**	**70.0**	**100.0**	**345.0**
	Gillnet		**80.0**	**113.5**	**12.9**	**150.0**	**37.0**	**51.9**	**6.1**	**70.0**	**109.3**	**233.0**

			CW (mm)				CL (mm)				Aver. weight	
Trip	**Gear**	**Sex**	**Min**	**Medium**	**Std, Dev.**	**Max**	**Min**	**Medium**	**Std, Dev.**	**Max**	**(g)**	**N**
		Female	80.0	112.4	13.0	138.0	37.0	51.6	6.2	66.0	105.1	103.0
		Male	81.0	114.4	12.8	150.0	37.0	52.2	6.1	70.0	112.6	130.0
	Trap		**82.0**	**103.8**	**13.4**	**141.0**	**38.0**	**46.9**	**6.3**	**67.0**	**80.5**	**112.0**
		Female	83.0	106.3	14.2	138.0	38.0	48.0	6.6	63.0	86.6	64.0
		Male	82.0	100.4	11.6	141.0	38.0	45.4	5.5	67.0	72.2	48.0
201312			**63.0**	**111.3**	**18.6**	**180.0**	**34.0**	**51.2**	**8.9**	**84.0**	**111.0**	**326.0**
	Gillnet		**63.0**	**120.3**	**17.5**	**180.0**	**34.0**	**55.3**	**8.6**	**84.0**	**139.2**	**193.0**
		Female	76.0	123.9	21.9	180.0	34.0	57.0	10.8	84.0	149.1	76.0
		Male	63.0	117.9	13.6	150.0	36.0	54.2	6.5	72.0	132.8	117.0
	Trap		**78.0**	**98.4**	**11.0**	**135.0**	**36.0**	**45.1**	**5.0**	**62.0**	**69.9**	**133.0**
		Female	80.0	100.8	12.4	135.0	36.0	46.2	5.5	62.0	74.3	57.0
		Male	78.0	96.5	9.6	116.0	36.0	44.3	4.4	54.0	66.6	76.0

Appendix 2. Boat Activity Coefficent (BAC), activeday/month, catch per unit effort (CPUE, kg/day) and total catch of BSC in Kien Giang Province in 2013

Month	Gear	BAC	Mean Activeday	CPUE (kg/day)		Total Catch (tons)		
				<20CV	>20CV	<20CV	>20CV	TOTAL
1	Gillnet	0.63	19.3	23.5	35.4	214.6	248.1	462.7
1	Trap	0.69	19.7	28.4	38.1	74.3	96.9	171.2
2	Gillnet	0.52	12.5	20.3	32.9	99.4	123.7	223.1
2	Trap	0.48	13.5	14.2	31.9	17.7	38.9	56.6
3	Gillnet	0.49	13.2	21.5	30.9	104.0	115.0	219.1
3	Trap	0.41	11.4	25.6	82.2	20.0	62.5	82.5
4	Gillnet	0.45	13.8	25.5	44.3	120.1	160.5	280.6
4	Trap	0.59	16.7	35.3	77.9	66.8	143.5	210.3
5	Gillnet	0.62	15.6	28.9	45.2	210.0	252.4	462.4
5	Trap	0.49	15.4	47.6	137.2	69.0	193.6	262.6
6	Gillnet	0.54	16.1	28.9	30.3	189.7	152.6	342.3
6	Trap	0.65	19.2	57.8	160.0	138.8	374.1	512.9
7	Gillnet	0.63	18.0	24.4	41.4	208.3	272.4	480.7
7	Trap	0.36	16.0	62.2	133.2	66.7	139.0	205.7
8	Gillnet	0.54	17.2	23.2	39.5	164.4	214.7	379.1
8	Trap	0.63	17.9	48.1	128.1	103.9	269.4	373.3
9	Gillnet	0.71	18.4	26.7	27.9	262.2	210.8	473.0
9	Trap	0.62	18.7	46.9	131.6	105.4	287.9	393.3
10	Gillnet	0.78	23.1	13.0	21.4	176.0	223.4	399.5
10	Trap	0.59	15.8	43.3	136.5	77.9	239.1	317.0
11	Gillnet	0.59	16.6	14.3	36.7	106.9	210.2	317.0
11	Trap	0.85	23.6	41.4	114.4	161.3	433.8	595.1

Month	Gear	BAC	Mean Activeday	CPUE (kg/day)		Total Catch (tons)		
				<20CV	>20CV	<20CV	>20CV	TOTAL
12	Gillnet	0.56	15.9	9.1	18.6	61.2	95.7	156.9
12	Trap	0.67	19.8	45.6	146.2	115.9	361.9	477.8
TOTAL						**2,934.5**	**4,920.1**	**7,854.7**
	B120					1,916.9	2,279.4	4,196.4
	F201					1,017.6	2,640.7	3,658.3