The Shadow Blue Economy: Optimizing non-target Catch of the Blue Swimming Crab Fisheries in North Coast of Central Java, Indonesia

Zairion Zairion[123*], *Akhmad* Nurhijayat[2], *Luky* Adrianto[123]

[1]Center for Coastal and Marine Resources Studies, IPB University, Bogor City16127, Indonesia
[2]Coastal and Marine Resources Management Study Program, IPB University, Dramaga, Bogor 16680, Indonesia
[3]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Dramaga, Bogor 16680, Indonesia

Abstract. Blue Economy is the concept of sustainable use and management of resources, including small-scale blue swimming crab (BSC) fisheries. The coastal area of Pati District is one of the BSC landing bases on the north coast of Central Java (part of Indonesian Fisheries Management Area/IFMA 712). However, there has been no study of non-target composistion as a complement to exploratory analysis to better understand the complexity of the social-ecological systems in the BSC fisheries in this region. The purpose of this study is to identify of economically non-target species, Correlation between economically non-target with target species and trend of their proportions, optimizing non-target catch value during Covid-19 pandemic. The biological data was collected from the daily logbooks of BSC middleman, which included catches from 368 individual fishers from January 2019 - March 2021. The socio-economic data was obtained by structured interviews and group discussion. The analytical methods were used such as identification, correlation and trend analysis, and descriptive analysis. The economically non-target species found include *Scylla serrata*, *Charybdis feriatus*, squid and cuttlefish (cephalopods), *Charybdis affinis*, *Podopthalmus vigil*, *Portunus sanguinolentus*, and *Babylonia spirata* (mollusc). Significant correlation between BSC catches decreased, while the catch of *Scylla serrata* and *Charybdis feriatus* are increased. The trend of economically non-target BSC fisheries decreased for sale during the Covid-19 pandemic and shadow economic occurred with the changed of fishermen behaviour who were previously commercial fishers to be subsistence fishers. The other shadow blue economy also occurred since mud crab were frequently caught as the non-target species.

* Corresponding author: zairion@apps.ipb.ac.id

1 Introduction

Sustainable use and management of resources, including in marine fisheries is part of the concept of blue economy. Among the marine fisheries sector, the small-scale fisheries are dominant in Indonesia, while the small-scale of the blue swimming crab (BSC) fisheries have significant potential and contribution to economic growth and reduction of unemployment on a national scale. The BSC fisheries are also one of the fisheries sectors that have economic value and high demand in the international market. One of the potential areas for small-scale BSC fishing activities in northern Central Java is Pati District, including one of the landing places for BSC catches from Indonesian Fisheries Management Area (IFMA) 712.

In marine capture fisheries as well as blue swimming crab (BSC) fisheries have non-target catch or bycatch. The non-target catch has the potential to reduce the abundance and diversity of aquatic biota types, thereby having a negative impact on the sustainability of aquatic biota diversity [1, 2]. The BSC non-target catch is generally divided into two groups, namely retained species and discarded catch or wasted species. Retained species have economic value and other vauable that they are used by fishermen, while species that do not have economic value are discarded or not used [3, 4]. However, those fishermen's catches are also categorized into main catch, bycatch and discarded catch worthless or wasted, and those with economic value or retained [5,6].

The study of economically non-target species in the context of capture fisheries is relevant for sustainable management of fisheries resources. Studies on non-target fish species may include aspects of assessing potential and resource utilization as well as marketing non-target species. The BSC fishery, especially gill-net fishery produces non-target species (NTS) including fish, crustaceans, mollusks and various other types of aquatic biota [4, 7, 8].

The COVID-19 pandemic has had a significant impact on the fisheries sector. This impact covers various aspects, from production to trade in fishery products. The direct impact of the pandemic is a decrease in demand for fish and fishery products. The pandemic has changed people's consumption patterns. In this case, studying economically non-target species is very important to identify the potential and encourage diversification of fishery products. However, it can be hoped that a more holistic policy can be created in an effort to manage sustainable capture fisheries resources [9]. This is also the basis for the need to conduct a study regarding the identification of economically non-targets and production trends during the COVID-19 pandemic on the coast of Pati District. Apart from that, this information can be a scientific basis for managing fisheries resources on the Pati District Coastal waters.

2 Methods

2.1 Time and Place of Research

This research was conducted in December 2020 to March 2021 with data collection carried out on the coastal area of Alasdowo Village, Dukuhseti Sub-district, Pati District, North coast of Central Java Province (**Fig. 1**). The blue swimming crab (BSC) as target species and other non-target catch using bottom gill-net in part of Java Sea or part of Indonesian Fisheries Management Area (IFMA) 712 were landed at coastal fishing port of Alasdowo village and surrounding area. All BSC and economically non-target species are generally bought by the midleman.

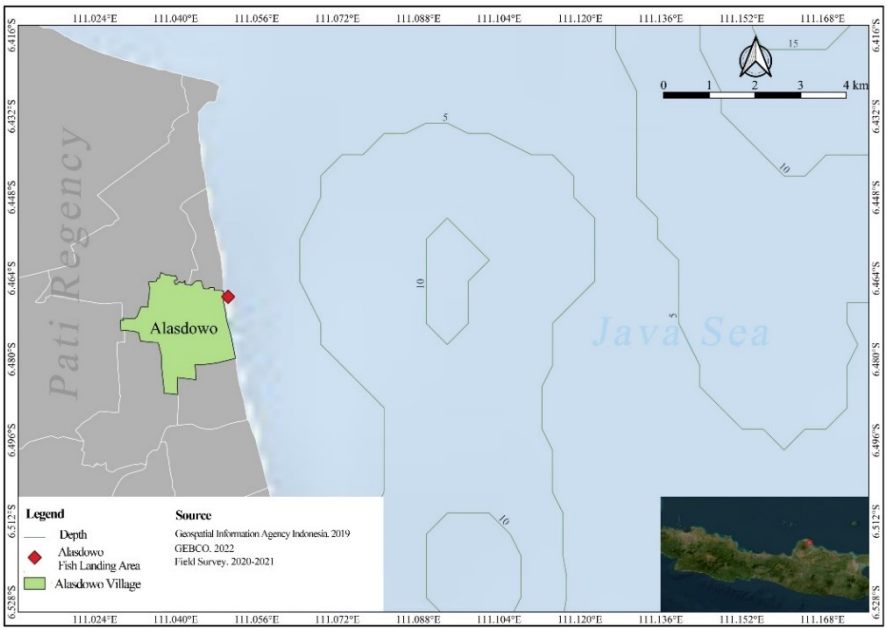

Fig. 1. Research location.

2.2 Data collection

The type of data used in this research was secundary and primary data. The secundari data is textual data on catches (landing report) from five middleman, which included catches of 368 fishers. Data collection was also carried out using the participatory method through interviews with 65 fishermen as respondents who were guided using a list of questions (questionnaire). The questionnaire does not cover aspects of personal human rights, so it does not require ethics screening. The selection of respondent fishermen was conducted using purposive methods. The criteria for selecting respondents in purposive sampling was including : (1) the BSC fishermen who have been running their fishing business for more than five years, (2) owner fishermen (who own their own boats, engines and fishing gear) or captains who only own fishing gear and run the fishing business from the boat that owned by the builder or supplier, (3) fishermen who carry out fishing activities at the study location.

2.3 Data analysis

Analysis of non-target catches was carried out descriptively. This analysis was carried out based on the crab catch. Descriptive analysis was carried out using R software and some additional packages [10]. The analysis was including (1) identification of economically non-target species, (2) correlation analysis of non-targets with target species, (3) descriptive analysis to determine non-target production trends.

Identification of non-target species was carried out based on catch data from crab fishermen periodically (time series). Non-target relationships with target species were carried out using correlation analysis. Correlation analysis was visualized in matrix form which shows the significance of correlation and/or uncorrelation (multicollinearity) in each relationship, namely the relationship between non-target and target species [11, 12]. Descriptive analysis was carried out based on observations of non-target catch data periodically (monthly period) [13, 14].

3 Results and discussion

3.1 Identification of economically valuable non-target species or commodity

There are seven economically valuable non-target commodities, including *Charybdis feriatus, Charybdis affinis, Portunus sanguinolentus, Podophthalmus vigil*, squid and cuttlefish (chephalopod), *Babylonia spirata* (mollusc), and *Scylla serrata*. The diversity of economically valuable bycatch commodities in BSC fisheries in the coastal waters of Pati District is lower than in the coast of East Lampung [4], Kendari Bay and Lasongko Bay, Southeast Sulawesi [7, 8]. This condition occurs due to different ecosystem characteristics between the coastal waters of Pati District, and this condition is identical to that reported by [4] and [15]. The diversity of non-target species in BSC fisheries is also influenced by season as well as the method and type of fishing gear used [15].

Each fresh commodity has a different price and depend on market. The price of *C. feriatus* was about IDR 40,000-60,000 per kilogram, while *C. affinis* and *P. vigil* around IDR 3,000-10,000 per kilogram. The commodity of *P. sanguinolentus* has price around IDR 10,00-30,000 per kilogram, squid and cuttlefish (chephalopod) around IDR 15,000-25,000, while *B. spirata* (mollusc) was around IDR 20,000-25,000 per kilogram. The *Scylla serrata* commodity has variety in the price based on size and category. The *S. serrata* with a size of more than 200 grams per individual (SSsA), the price can reach IDR 60,000-100,000 per kilogram. Meanwhile, *S. serrata* within mature egg condition (SSsB) was around IDR 80,000-125,000 per kilogram, while for under-sized *S. serrata* (LSs) was around IDR 20,000-40,000 per kilogram and *S. serrata* in moulting condition (MSs) was around IDR 50,000-80,000 per kilogram. In general, non-target catches with economic value are sold to the middleman in helping the fishermen's household needs.

3.2 Correlation between economically non-target and target species

Correlation analysis was performed to estimate the relationship of non-targets to target species. Non-target correlations can show significance and/or are not correlated (multi-collinearity) with the target species (BSC), presented in the correlation matrix (**Fig. 2**). The results of the correlation matrix analysis show that BSC and *B. spirata* (BSC|molluscs) have a positive and significant correlation value of 0.0689. This shows that the acquisition of BSC catches as the main commodity tends to be accompanied by the acquisition of *B. spirata* catches. Meanwhile, the correlation between BSC and mud crabs (*S. serrata*) with a size of more than 200 g was also positive and significant (BSC|SSsA), namely 0.002, while BSC and female mud crabs in mature gonad condition (BSC|SSsB) have a correlation value of 0.0433. This shows that the acquisition of BSC catches tends to be also accompanied by the acquisition of mangrove crab catches. However, it is suspected that BSC fishing grounds are also the habitat and distribution of mud crabs. Mud crabs (*S. serrata*) and several species of crab from the Portunidae family are types of crab that can be consumed (edible crab) and have economic value. Generally, BSC fisheries have by-catch which is utilized by fishermen (useful) such as mangrove crabs and several other types of crustaceans [16].

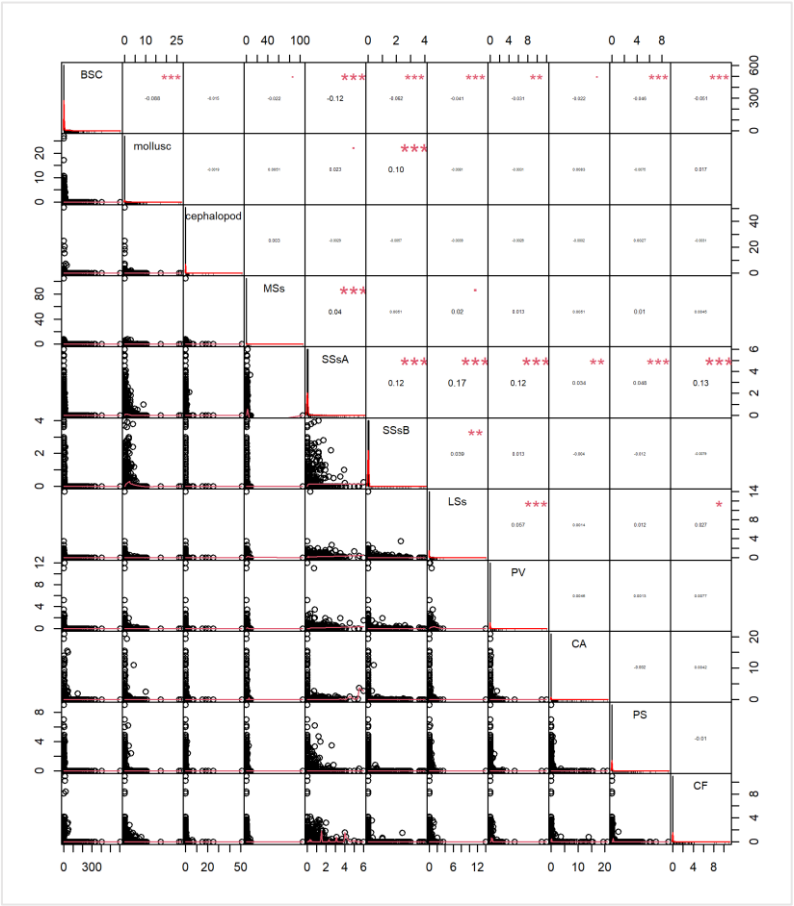

Fig 2. Non-target correlation matrix to the target species: crab (BSC)

*Note: The correlation value is scaled based on the magnitude of the value; one star indicates significance <0.01 at α 0.05. (CF = *Charybdis feriatus*; cephalopods = squid and cuttlefish; CA = *Charybdis affinis*; SSsA= mud crab with size > 200 gr; LSs= small/juvenile mud crab; PV= *Podophthalmus vigil*; SSsB= mud crab in spawning condition; PS = *Portunus sanguinolentus*; Mollusc= *Babylonia spirata*; MSs= mangrove crab in molting phase).

Another positive and significant correlation result was between BSC and *C. feriatus* (BSC|CF) with a correlation value of 0.002. Both species are classified as portunid crabs, apart from having the same distribution and habitat, there is also an indication of the influence of the fishing gear used, namely the type of trap and/or nets (gill-nets). In general, fishermen sell non-target catches because they are commodities that have economic value. Meanwhile, when the volume of non-target catch is small or only a few individuals, it is used for consumption by fishermen's households [17, 18].

The composition of non-target resources that have economic value during the observation period shows different amounts or volumes. However, it is influenced by several factors including season, habitat and geographical area [15]. The discussion of the non-target economy of crab fisheries provides an understanding of the spatio-temporal characteristics of the resource, which can be seen based on the volume of catch or heterogeneity of abundance [11, 19, 20].

Based on the description above, the non-target comodities that have economic value shows different volumes. This can be influenced by several factors including season, habitat

and geographical area [15]. The discussion of the economically non-target catch of crab fisheries provides an understanding of the spatio-temporal characteristics of the resource, which can be seen based on the volume of catch or heterogeneity of abundance [11, 19, 20].

According to [21], there are several species of marine crab that are often caught in BSC fisheries, including *Charybdis* spp. and *P. sanguinolentus*. The results of research conducted by [4] also found that that the economically non-target species of BSC fishery were crustaceans, including shrimp and types of crab such as *Charybdis* spp., *P. sanguinolentus,* and *P. vigil* as well as other crabs species. The *Babylonia spirata* (mollusk) species is a non-target crab fishery which is mostly used as a food/consumer ingredient, while its shells are used for craft jewelry in the home industry [22].

3.3 Trend in proportion of non-target population captured

The number of species populations can be an indicator of the stability of a community in an ecosystem [14]. The volume or number of economically valuable non-target populations caught has fluctuating tendency (**Fig 3**). The same variation was also found in the composition of non-economic target commodities during regular observation periods (time series) (**Fig 4**). In 2019, the proportion of catches consisted of *B. spirata* (mollusk) (33%), squid and cuttlefish (cephalopods) (6%), *C. affinis* (CA) (11%) and *C. feriatus* (CF) (8%). Meanwhile, in 2020 the proportion of catches consisted of *B. spirata* (molluscs) (20%), squid and cuttlefish (cephalopods) (14%), *C. affinis* (CA) (49%) and *C. feriatus* (CF) (4%). Meanwhile, in 2021 the proportion of catches consisted of *B. spirata* (molluscs) (72%), squid and cuttlefish (cephalopods) (11%), *C. affinis* (CA) (2%) and *C. feriatus* (CF) (47%). According to [15], the discovery of crustaceans and molluscs in high numbers indicates a connection with the crab's natural food source and/or the presence of competing organisms.

Based on the results of interviews, the number of non-target populations caught could be caused by the similarity of ecological space as a habitat for organisms and/or influenced by the physical conditions of the waters such as the direction and pattern of currents in the sea. According to [4], this can also be influenced by the specifications of the type of BSC fishing gear that is operated at the bottom of the waters and is permanent, so that it can also catch sedentary organisms including demersal fish, crustaceans and molluscs. Another influencing factor is the availability of food. All of non-targets identified in this research have economic value and to be sold to the midleman and/or used for consumption by fishermen's households [4, 22]. Thus, this can be preliminary information in overall estimating whether the BSC fishing activities provide profits to fishing households or vice versa [20, 23, 24].

The results of this descriptive analysis are also supported by data on the number or proportion of BSC as target species and non-target catches (**Fig 5a-5c**). The non-target species were the dominant catch for sale in June-October 2019, while during Covid-19 Pandemic was vise versa (especially in June-October 2020). Based on regular catch data, in general the proportion of crab dominates more than non-target, except in June-October 2019. This is an indication of the influence of the season. The results of research conducted by [25] show that the number or proportion of non-target (NTS) and target species (BSC) is influenced by the fishing season, where the number of catches of target species (BSC) is dynamic and still dominates. Meanwhile, in 2020, in general, the number or proportion of non-targets (NTS) was much less than in 2019. This was caused by the majority or most fishermen using non-targets for household consumption. There was a Covid-19 pandemic in 2020, which has an impact on the market or markets for non-target commodities. However, these factors cause fishermen to be more likely to use non-targets to meet household consumption needs.

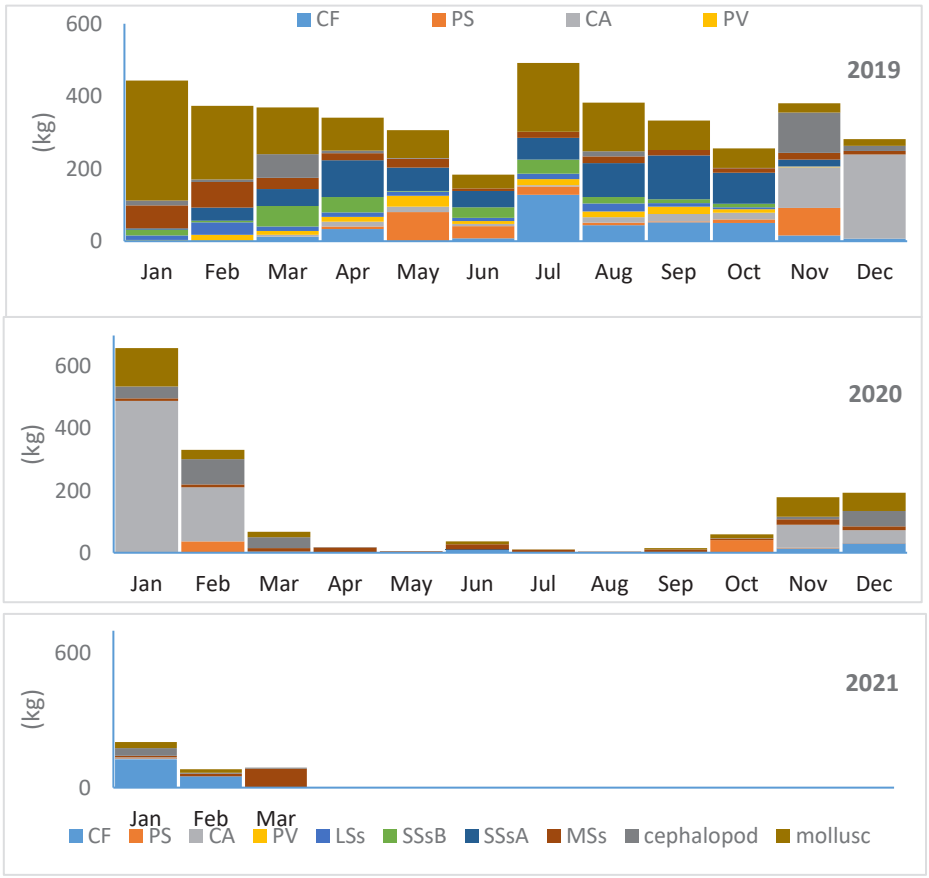

Fig 3. Volume of non-target populations captured in each month from January 2019 to March 2021. Note: CF = *Charybdis feriatus*; PS = *Portunus sanguinolentus*; CA = *Charybdis affinis*; PV= *Podophthalmus vigil*; LSs= small/juvenile mud crab; SSsB= mud crab in spawning condition; SSsA= mud crab with size > 200 gr; MSs= mangrove crab in molting phase; cephalopods = squid and cuttlefish; Mollusc= *Babylonia spirata*.

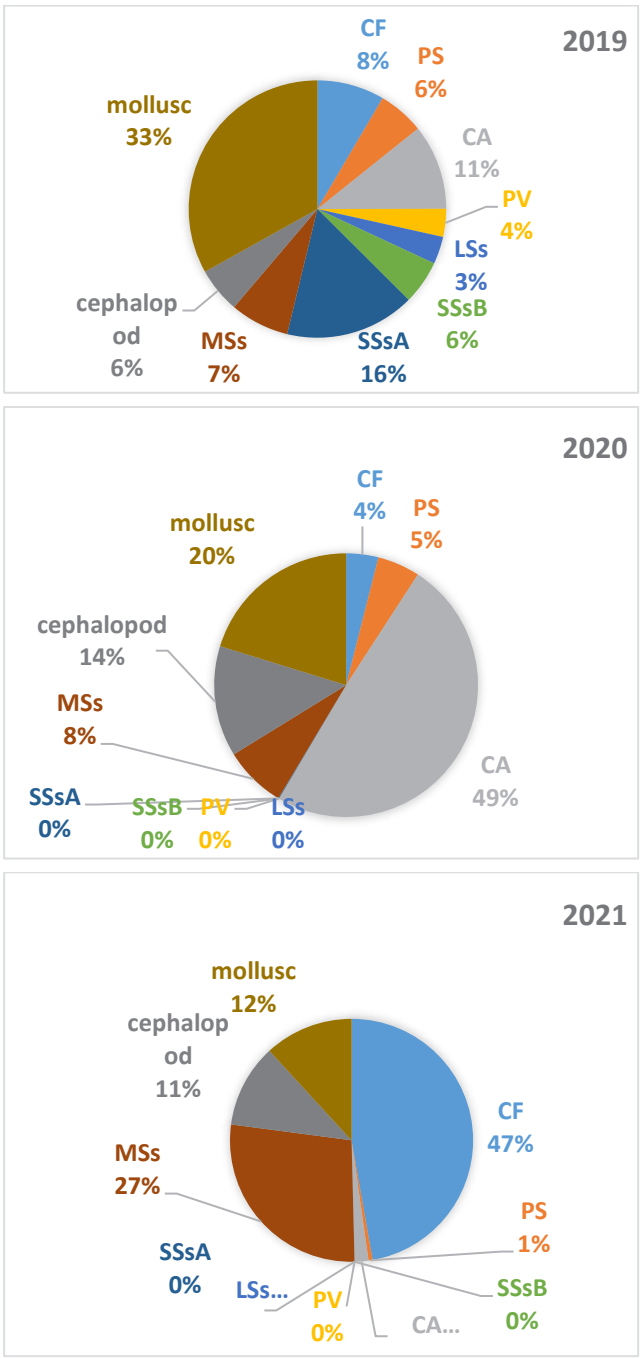

Fig 4. Composition of economically non-targets species in BSC fisheries January 2019 to March 2021. Note: CF = *Charybdis feriatus*; PS = *Portunus sanguinolentus*; CA = *Charybdis affinis*; PV= *Podophthalmus vigil*; LSs= small/juvenile mud crab; SSsB= mud crab in spawning condition; SSsA= mud crab with size > 200 gr; MSs= mangrove crab in molting phase; cephalopods = squid and cuttlefish; Mollusc= *Babylonia spirata*.

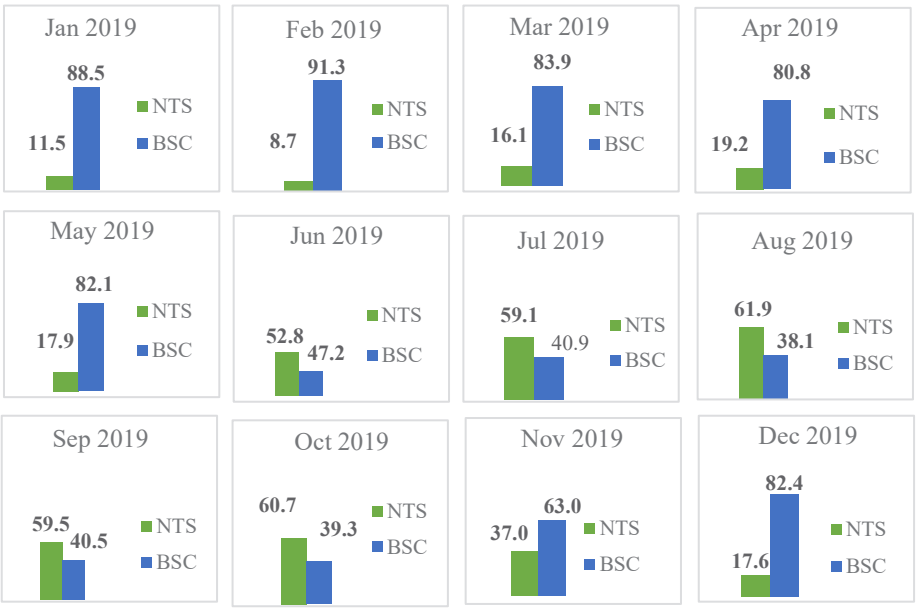

Fig 5a. Proportion (%) of the blue Swimming crab (BSC) and non-target species (NTS) in 2019.

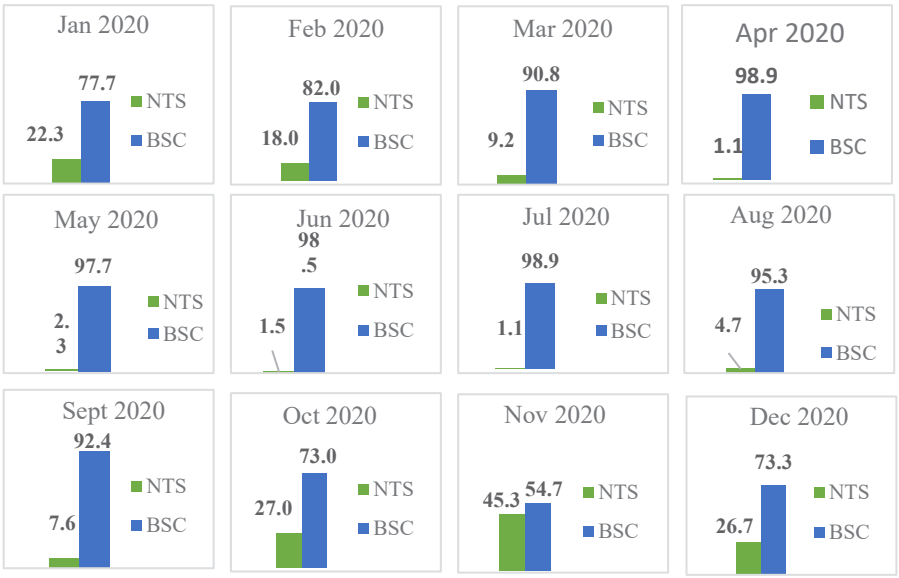

Fig 5b. Proportion (%) of the blue Swimming crab (BSC) and non-target species (NTS) in 2020.

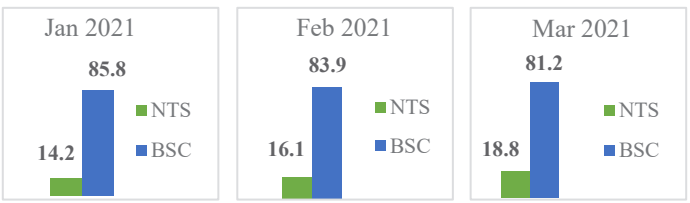

Fig 5c. Proportion (%) of the blue Swimming crab (BSC) and non-target species (NTS) in 2021

In recent years, it has been indicated that BSC fisheries productivity is more dynamic and fluctuating [20, 26]. Such conditions can affect the sustainability of BSC fisheries business activities, so that the output from non-target studies with economic value can become useful basic scientific information and act as a substitute for capture fisheries businesses if target species are minimally available [27]. This further supports the opinion that the composition of economically valuable non-targets in BSC fisheries can be basic and complementary information in monitoring the feasibility of BSC fisheries businesses [11]. However, by-catch or non-target species which have a proportion of each species greater than 2% of the total catch need to be carefully managed to maintain ecological balance in the target species' habitat.

4 Conclusions

There are seven commodities as non-economic target species. The mud crab (*S. serrata*), crucifix crab (*C. feriatus*), and spiral babylon snail/molluscs have a significant correlation with BSC catches. The trend of economically non-target species decline for sale during the Covid-19 pandemic and shadow economics occurred with changes in the behavior of fishermen from previously commercial fishers to subsistence fishers. In general, fishermen also obtain economic by-catch in the form of mud crabs in addition to BSC catches as a shadow blue economy species.

References

1. C. Kunsook, P. Dumrongrojwatthana. Trop. Life Sci. Res. **28**, 1 (2017)
2. R. Samanta, S.K. Chakraborty, L. Sheroy, T.S. Nagesh, S. Behera, T.S Bhoumik. Reg. Studies in Mar. Sci. **17** (2018)
3. European Commission. COM (2002)
4. I. P. Sari, Z. Zairion, Y. Wardiatno. Jurnal Biol. Trop. **19,** 1 (2019)
5. D. L. Alverson, S.E. Hughes. *Rev.* Fish Biol. and Fish. **6** (1996)
6. I. M. Hasbi, R.D. Risa, R. Djaffar. Octopus: Jurnal ilmu perikanan. **9** (2020)
7. A. Hamid, S. Kamri. Mar. Fish. **10** (2019)
8. A. Hamid, S. Kamri, N. Irawati, Y. Wardiatno. AACL Bioflux **13**, 2 (2020)
9. M. Mendoza-carranza, E. Ejarque, L.A.J. Nagelkerke. P. ONE, May 21 (2018)
10. M. Crawley. The R Book. Second Edition (2013)
11. Zairion. PhD Dissertation (IPB University, Indonesia, 2015)
12. A. Zulfikar. PhD Dissertation (IPB University, Indonesia, 2020)
13. I. N. Radiarta, Hasnawi, A. Mustafa. J. Ris. Akua. **8**, 2 (2013)
14. L. S. Pillai, S. J. Kizhakudan, E.V. Radhakrishnan, P. Thirumilu. Indian J. Fish. **61**, 2 (2014)
15. H. Fazrul, S. Hajisamae, M. Ikhwanuddin, S. Pradit. Turkish J. of Fish. and Aqu. Sci. **15** (2015)
16. N. T. Mardhan, La Sara, Asriyana. J. Biol. Trop. **19**, 2 (2019)
17. M. I Batista, M.T. Celia, N.C. Henrique. Fish. Res. **100** (2009)
18. J. M. S. Goncalves, K. I. Stergiou, J. A. Hernando, E. Puent, D. K. Moutopoulos, L. Arregi, M. C. Soriguer, C. Vilas, R. Coelho, K. Erzini. Fish. Res. **88** (2007)

19. S. J. Seijo. Spatial bioeconomic dynamics of marine fisheries Fish. and Aqua. V. EOLSS, Mexico (2010)
20. A. K. Ekawati AK. Master tesis (IPB University, Indoesia, 2019)
21. M. M. Bhosale, R. A. Pawar, M. S. Sawant, A.S. Pawase. J. of fish. and life sci. **2**, 1 (2017)
22. R. Faizah. BAWAL **1**, 4 (2007)
23. A. Damora A. Master tesis (IPB University, Indonesia, 2016)
24. D. S. Efendi PhD Dissertation (IPB University, Indonesia, 2021)
25. T. Ernawati. *Master tesis* (IPB University Indonesia, 2013)
26. L. Adrianto, D. Apriliyanti, R.M. Sitohang, I. Nurokhmah. IOP Conf. Ser.: Earth Environ (2020)
27. S. Kusumo, L. Adrianto, M. Boer, Suharsono. AACL Bioflux. **13**, 2 (2020)