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Discarded Species in Artisanal Fisheries South Sumatra, Indonesia: Case Study on Crab Gill Nets

(Spesies Buangan dalam Perikanan Manual Sumatera Selatan, Indonesia: Kajian Kes Jaring Insang Ketam)

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ABSTRACT

This study identified the discard species generated by the crab gillnet for targeting the blue swimming crab *Portunus pelagicus* (Linnaeus 1758) in the Banyuasin estuarine of South Sumatra, Indonesia. The fishing gear yielded the discarded catch about 12% (25.68 kg) of the total catch in weight (212.68 kg). For the discarded catch, 703 individuals represented 18 species from 3 phyla (Arthropoda, Chordata, and Mollusca). The crustaceans *Charybdis helleri* (Milne-Edwards 1867), *Clibanarius* spp., *Matuta planipes* (Fabricius 1798), and *Libinia dubia* (Milne Edwards 1834) were the majority components of these discards accounted for 90% of the total discards. Results of ecological classification rare, i.e., *Chiloscyllium indicum* (Gmelin 1789), and occasional, i.e., *Chiloscyllium punctatum* (Müller & Henle 1838), and *Maculabatis macrura* (Bleeker 1852) included in the International Union for Conservation of Nature (IUCN) red list as Vulnerable (*C. indicum*), Near Threatened (*C. punctatum*), and Endangered (*M. macrura*) category. Based on the IUCN status, two species of crustaceans i.e., *Carcinoscorpius rotundicauda* (Latreille 1802) and *Tachypleus gigas* (Müller 1785) listed as 'Data Deficient'. Discarded on crab gillnet fishing in Banyuasin waters is a challenge for species that need to be conserved (shark, ray, and horseshoe crabs). Species with IUCN red list status ranging from Data Deficient to Endangered were found dead, except for horseshoe crabs. Mitigation options offered include captive breeding of horseshoe crabs, the release of protected species when caught, and fishing gear modification. These findings can help design suitable mitigations for discarding crab gill nets.

Keywords: Conservation; crab gillnet; discard; ecological classification; IUCN status

ABSTRAK

Kajian ini mengenal pasti spesies buangan yang dijana oleh pukat ketam untuk menyasarkan ketam renang biru *Portunus pelagicus* (Linnaeus 1758) di muara Banyuasin, Sumatera Selatan, Indonesia. Peralatan tangkapan ikan ini menghasilkan tangkapan buang sekitar 12% (25.68 kg) daripada jumlah berat tangkapan (212.68 kg). Daripada tangkapan yang dibuang, terdapat 703 individu mewakili 18 spesies daripada 3 filum (Arthropoda, Chordata, dan Mollusca). Krustasea *Charybdis helleri* (Milne-Edwards 1867), *Clibanarius* spp., *Matuta planipes* (Fabricius 1798) dan *Libinia dubia* (Milne Edwards 1834) merupakan komponen majoriti dalam tangkapan buang yang menyumbang kepada 90% daripada jumlah buangan. Keputusan pengelasan ekologi langka menunjukkan *Chiloscyllium indicum* (Gmelin 1789) dan sekali-sekala, iaitu *Chiloscyllium punctatum* (Müller & Henle 1838) dan *Maculabatis macrura* (Bleeker 1852) termasuk dalam senarai merah *International Union for Conservation of Nature* (IUCN) sebagai kategori rentan (*C. indicum*), hampir terancam (*C. punctatum*) dan Terancam (*M. macrura*). Berdasarkan status IUCN, dua spesies krustasea iaitu *Carcinoscorpius rotundicauda* (Latreille 1802) dan *Tachypleus gigas* (Müller 1785) telah disenaraikan sebagai 'Kekurangan Data'. Tangkapan buang pada pukat ketam di perairan Banyuasin merupakan cabaran bagi spesies yang perlu dipelihara (jerung, pari dan belangkas). Spesies dalam status senarai merah IUCN daripada Kekurangan Data hingga Terancam ditemui mati, kecuali belangkas. Pilihan mitigasi yang ditawarkan termasuk pembiakan kurungan belangkas, pembebasan spesies yang dilindungi apabila ditangkap dan pengubahsuaian peralatan menangkap ikan. Penemuan ini dapat membantu mereka bentuk kaedah mitigasi yang sesuai untuk pukat ketam terbuang.

Kata kunci: Buang; pemuliharaan; pengelasan ekologi; pukat ketam; status IUCN

INTRODUCTION

A discarded catch or called 'discards' is commonly practised by many fishing gears in most fisheries worldwide due to the reasons of damaged fish, undersized, below minimum landing sizes (MLS), or unmarketable (Alverson et al. 1994; Rochet et al. 2002; Sánchez et al. 2004). It is considered to be a waste or the use of suboptimal fisheries resources and affects community structure and biodiversity. In commercial fisheries, the discard practices are inevitable due to variations in the size selectivity of fishing gear, the level of species deficiency, and the multispecies fisheries situations (Borges et al. 2006, 2001; Gonçalves et al. 2007). Hence, the discards relative importance depends on the fishing gear type (active or passive gear), fishing gear characteristics (hanging ratios, mesh size, selectivity), fishing strategies, legislation (fishing quota, legal MLS), marketing constraints, and capacity constraints of storage space on the fishing vessel (Catchpole et al. 2014; Hall 1996; Rochet et al. 2002).

An essential first step to reduce the discards is qualifying the discard composition, identifying the discarded species, when, by whom, and why the discarding practices occur (Catchpole et al. 2014; Morandeau et al. 2014). These steps are crucial to suggest new strategies for minimizing their impact (Urra et al. 2017). The discard estimation is considered a priority related to the pilot surveys or stocks assessment (Sánchez et al. 2004). The discard composition is also necessary to provide scientific advice for mitigation methods and implement adequate fisheries management policies (Catanese et al. 2018).

In the Banyuasin estuarine of South Sumatra (Indonesia), the bottom-set gillnet or the crab gillnet is the most critical gear for targeting the blue swimming crab (*Portunus pelagicus*). These crab gillnets are one of the artisanal fisheries operating around these waters. Even though fish is the majority of discards on the gillnet fishery, most studies in years addressed issues about the impact on marine mammals, turtles, and seabirds (Brownell et al. 2019; Pechham et al. 2007; Žydelis et al. 2013). A common characteristic of the crab gillnet is the discarding practice for unmarketable harvesting bycatch (Fazrul et al. 2015). In terms of traditional belief, small-scale gillnet fishing has a low ecological impact on the marine ecosystem compared to large-scale fisheries (Díaz-uribe et al. 2007; Fazrul et al. 2015), even though gillnet fishing on both small-scale and large-scale fisheries hold equal capability concerning the bycatch and discarded catch (Díaz-uribe et al. 2007; Kumar et al. 2019).

To the best of our knowledge, there has been no comprehensive research on discard for the artisanal fisheries in the Banyuasin estuarine. Research on the trammel net discard in these waters, has been reported in the previous work (Fauziyah et al. 2018a). Still, the discarded catch information from the crab gillnets is a poor-data area. Consequently, it is always necessary to better understand the discarded characteristics and their ecological impact. This research details the discard characteristics generated by the bottom-set gillnet for targeting the blue swimming crab (*P. pelagicus*) in the Banyuasin estuarine of South Sumatra, Indonesia.

MATERIALS AND METHODS

STUDY AREA

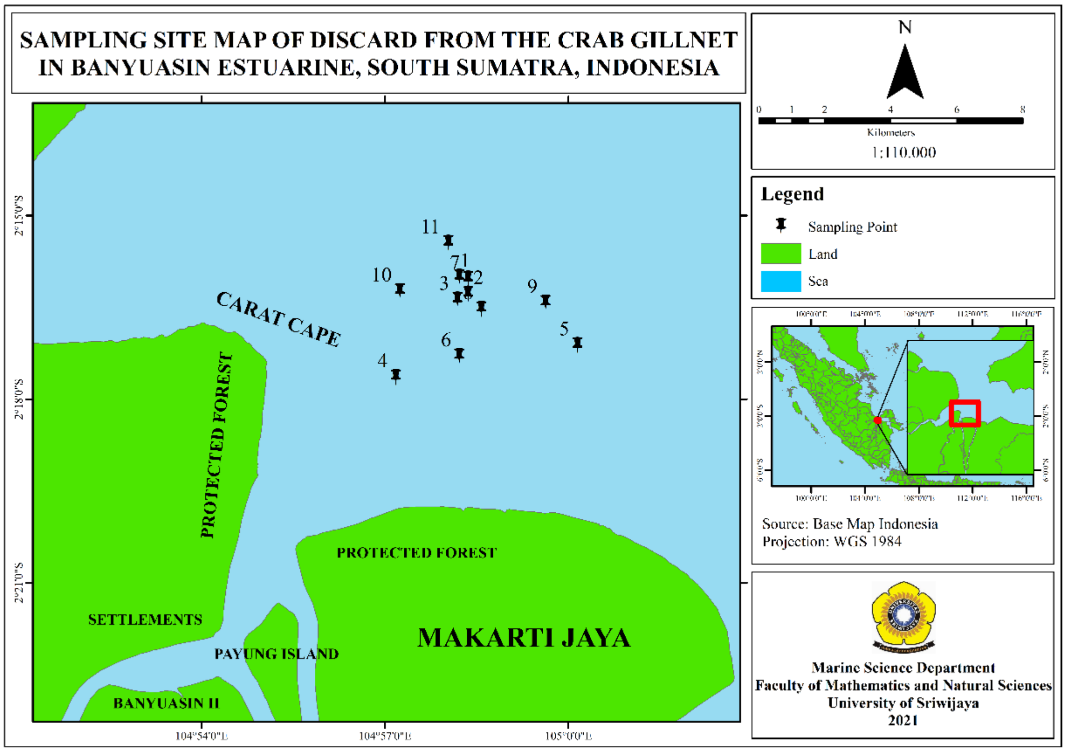
This research focused on experimental fishing using the crab gillnet operating off the Banyuasin estuarine of South Sumatra, Indonesia (Figure 1). These estuarine waters were characterized by a diurnal tide (Hadi et al. 2018). In addition, the primary productivity for these estuarine is significantly influenced by the Musi River inflows that carry the organic matter, nutrients, carbon, and sediment (Fauziyah et al. 2019a). Then, the survey was conducted for 11 days in November 2019.

SAMPLING

Sampling locations and fishing strategies (fishing grounds, soak time, and setting time) were determined by the fishing boat skipper (local fishermen) based on their fishing practices for targeting the blue swimming crab (*P. pelagicus*). Fishing activities were conducted one day per trip in the proximity of the fishing base.

The fishing boat with 11 m long and 3 gross tonnages equipped with an engine power 6 HP was used to operate the crab gillnet (900 m in length) daily trips. The mesh size of the crab gillnet was 3-3.5 inch. This fishing gear was operating during the night (soaking time at night). In other words, these gears were set before sunset and hauled before sunrise (8 h for soaking time).

All discards data include number, length, and weight by species collected during 11 trips (11 samplings). In this survey, discard was a part of the total catch thrown to the sea whole in consequence of personal, legal, or economic considerations (Anderson 2004; Carbonell & Martínez 2012; Catchpole et al. 2014). The discard samples were sorted by species and then measured their total length and body weight. All measurements were recorded at the fishing base. The total length of each discard species was measured to the nearest 1 mm, whereas weight was measured to 1 g accuracy.



Sampling locations and fishing strategies (e.g. fishing grounds, soak time, and setting time) were determined by the local fishermen based on the fishing ground of the blue swimming crab

FIGURE 1. Map of the Banyuasin estuarine showing the sampling boundary and locations of 11 sampling efforts using the crab gillnet

DATA ANALYSIS

Species composition, relative frequency, occurrence frequency, species status for conservation, and discard per unit effort (DPUE) were applied to the discard analysis (Depestele et al. 2011; Diadhiou et al. 2018; Hamid et al. 2020). Discard compositions were analyzed in per cent both by number and weight (Chanchiem et al. 2015). The DPUE formulations of discard from the crab gillnet (Supadminingsih et al. 2019; Wang et al. 2010) were calculated as equation (1):

$$\boldsymbol{X_i = \frac{D_i}{\frac{t_i}{t_s} x \frac{L_i}{L_s} x E_i}} \quad (1)$$

where X_i is the DPUE of species i; D_i is the number individual of discard species i; t_i is the actual soaking time from the crab gillnet per trip (hours); t_s is the standardized soaking time from the crab gillnet (12 h); L_i is the actual net length from the crab gillnet (km); L_s is the standardized net length from the crab gillnet (1 km); and E_i is the total effort (trips).

The species abundance in this study was represented by occurrence frequency and relative abundance (Diadhiou et al. 2018; Fauziyah et al. 2019b, 2018a; Rilov & Benayahu 2000) calculated as in equations (2), (3) dan (4):

$$RA_{ij} = \frac{D_{ij}}{D_{tj}} x100\% \quad (2)$$

$$RAm_i = \frac{1}{n}\sum_{i=1}^{n} RA_{ij} \quad (3)$$

$$OF_i = \frac{F_i}{F_t} x100\% \quad (4)$$

where RAm_i is the mean relative abundance of discard species i; RA_i is the relative abundance of discard species i on the j trip; n is the number of trips; OF_i: is the occurrence frequency of discard species i; D_{ij} is the number individual of discard species i on the j trip; D_{tj}

is the total individuals number of all discard species on the j trip; F_i is the number of discard censuses (a single count of captured discard species along fishing trip) where the i species was found, and F_t is the total number of discard censuses.

Based on the *OF* and *RAm* values, characterizing the discards community could be described using an ecological classification method for determining whether the discards species were dominant, common, occasional, or rare members of the discards community (Harris et al. 2018; Silver et al. 2017). This classification was based on the 25th, 50th, and 75th percentile values for both axis values. For each discard species, overall *RAm* data were log (RAm +1) transformed and plotted against their OF data (Harris et al. 2018).

All discard species were identified by their species status for conservation based on the IUCN red list categories, namely NE (Not Evaluated) to EX (Extinct). Data Deficient (DD), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR) species are respected to be threatened with extinction (IUCN Standards and Petitions Committee 2019).

The Kruskal-Wallis and post-hoc tests were used to determine whether there were statistically significant differences between the multiple datasets. The distributions of discards diversities were examined for the most index and tested for sampling sites effects using the non-parametric One-Sample Wilcoxon Signed Rank Test. All tests were carried out using SPSS 21 software.

Results and Discussion

Species Composition

From the 11 trips of crab gillnet carried out in the Banyuasin estuarine Figure 2, the target species (*P. pelagicus*) accounted for about 88% (187 kg) of the total catch in weight (212.68 kg). The remaining 12% was discarded. There were 703 specimens (total weight of 25.68 kg) of 18 discards species representing 16 families from 3 phyla (Arthropoda, Chordata, and Mollusca) presented in Table 1. The Arthropoda was the most occurring phylum in the discarded catch, consisting of 677 specimens (96%) from 9 species belonging to 8 families. While the Chordata was the second most occurring phylum in the discarded catch, it consists of 22 specimens (3%) from 7 species belonging to 6 families. The Mollusca was the most rarely occurring phylum in the discarded catch, consisting of 4 specimens (1%) from 1 species only. Each discard species represented variation in DPUE. This DPUE values ranged between 0.002-1.014 $kg.km^{-1}.h^{-1}.trip^{-1}$. Their specimen numbers by the recorded species ranged between 1-279 specimens with weighting ranging between 0.002-1.014 kg. One of the highlights in this result is that Spiny Hands (*Charybdis helleri*) from the Arthropoda was the most abundant in terms of DPUE, specimen measured, and the percentage values of weight and number (Table 1 & Figure 3). Statistically significant differences among the discarded species were indicated by the Kruskal-Wallis test (p = <0.0001), and the post hoc tests (Dunn's pairwise tests) showed that the DPUE values for *C. helleri* were significantly higher than other discarded species, except the DPUE values for *Matuta planipes, Libinia dubia, Carcinoscorpius rotundicauda, Tachypleus gigas,* and *Clibanarius* spp. Mangrove Horseshoe Crab (*C. rotundicauda*), Coastal Horseshoe Crab (*T. gigas*), Hermit Crab (*Clibanarius* spp.), and Longnose Spider Crab (*L. dubia*) from the phylum Arthropoda were the second, third, fourth, and fifth most commonly discard species referring to their weight and DPUE values, representing 16, 11, 11, and 10% of all discard sampled. The exceptional noteworthy of this phylum that Spiny Hands (*C. helleri*), Hermit Crab (*Clibanarius* spp.), Flower Moon Crab (*Matuta planipes*), Longnose Spider Crab (*L. dubia*), and Mangrove Horseshoe Crab (*C. rotundicauda*) were the five most common species (crustacean) from discarded catch with a total of 279, 214, 92, 45, and 26 specimens, respectively, representing 40, 30, 13, 6, and 4% of overall discards sampled (Figure 3).

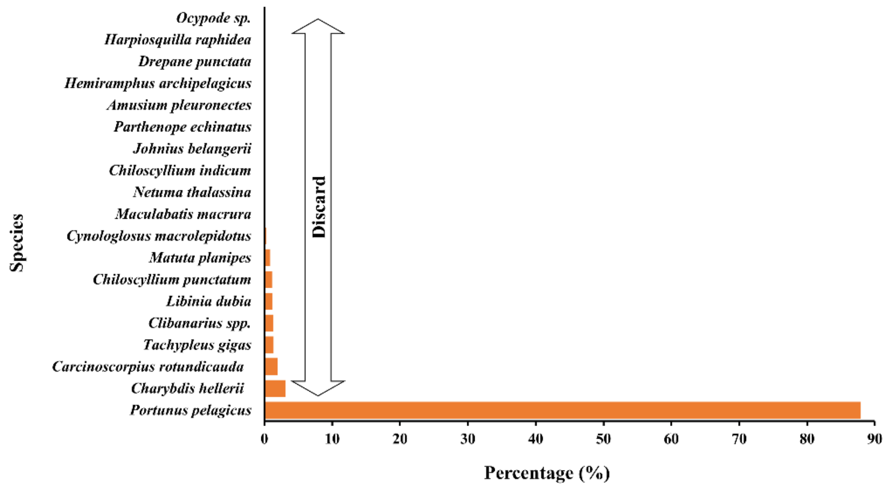
Ecological Classification of All Discard Species

The discards species in this study were ecologically classified within four categories (Figure 4), including Rare, represented by five species (*Ocypode* sp., *C. indicum*, *N. thalassina*, *H. archipelagicus,* and *D. punctata*); Occasional represented by four species (*H. raphidea*, *C. punctatum*, *A. pleuronectes*, and *M. macrura*); Common, represented by five species (*J. belangerii*, *C. macrolepidotus*, *P. echinatus*, *T. gigas*, and *C. rotundicauda*), and Dominant, represented by four species (*L. dubia*, *M. planipes*, *Clibanarius* spp., and *C. helleri*). The Kruskal-Wallis test provided strong evidence of a difference (p=0.001 < 0.05) between the mean relative abundance of at least one pair of Ecological Classification categories. According to the post-hoc tests, there was strong evidence of a difference between the rare and common categories (adjusted p=0.042 < 0.05). The mean relative abundance for discarded species in the dominant category was only significantly higher than the rare category (adjusted p=0.001 < 0.05).

TABLE 1. Discard per unit effort (DPUE), IUCN red list status, length range (mm), and species measured of the crab gillnet from Banyuasin estuarine

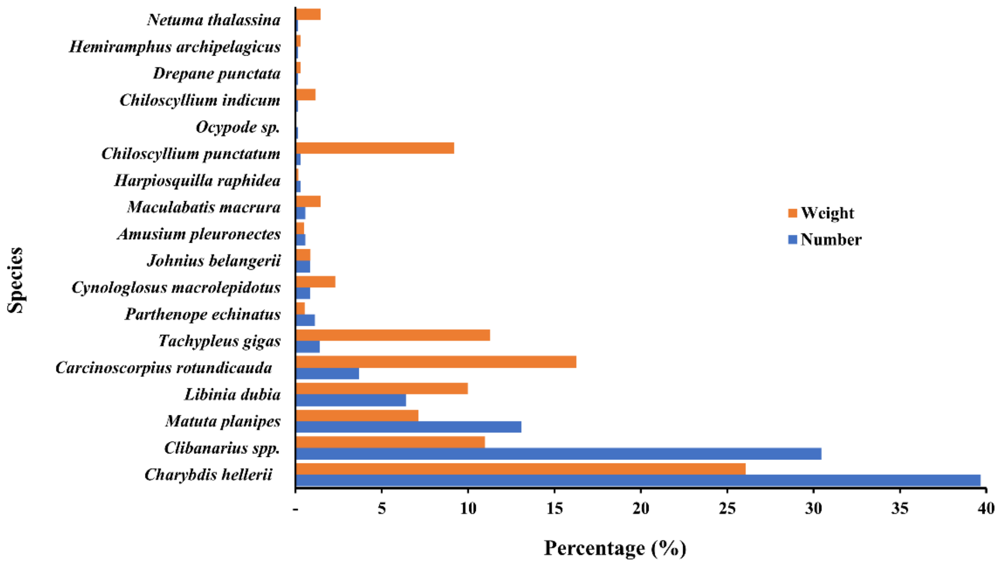
Phylum/ family	English name (Scientific name)	DPUE	IUCN red list status	Length (mm)		Species measured	
				Range	Mean	Count	Weight (kg)
Arthropoda							
Portunidae	Spiny hands *Charybdis helleri*	1.01	NE	23-80	55	279	6.69
Calappidae	Flower moon crab *Matuta planipes*	0.28	NE	25-67	51	92	1.83
Epialtidae	Longnose spider crab *Libinia dubia*	0.39	NE	36-66	50	45	2.56
Parthenopidae	Elbow crabs *Parthenope echinatus*	0.02	NE	33-53	40	8	0.14
Ocypodidae	Ghost crab *Ocypode* sp.	0.00	NE	31-31	31	1	0.01
Limulidae	Mangrove horseshoe crab *Carcinoscorpius rotundicauda*	0.63	DD	176-340	279	26	4.18
Limulidae	Coastal horseshoe crab *Tachypleus gigas*	0.44	DD	198-413	320	10	2.90
Squillidae	Giant harpiosquillid mantis shrimp *Harpiosquilla raphidea*	0.01	NE	115-120	118	2	0.04
Diogenidae	Hermit crab *Clibanarius* spp.	0.43	NE	20-57	32	214	2.82
Mollusca:							
Pectinidae	Asian moon scallop *Amusium pleuronectes*	0.02	NE	66-78	71	4	0.13
Chordata:							
Dasyatidae	Sharpnose whipray *Maculabatis macrura*	0.06	EN	86-160	121	4	0.37
Cynoglossidae	Indian Tongue-sole *Cynologlosus macrolepidotus*	0.09	NE	115-348	205	6	0.59
Hemiscylliidae	Slender bambooshark *Chiloscyllium indicum*	0.05	VU	494-494	494	1	0.30
Hemiscylliidae	Grey carpetshark *Chiloscyllium punctatum*	0.36	NT	673-690	682	2	2.36
Sciaenidae	Belanger's croaker *Johnius belangerii*	0.03	NE	116-160	131	6	0.23
Drepaneidae	Spotted sicklefish *Drepane punctata*	0.01	NE	119-119	119	1	0.08
Hemiramphidae	Jumping halfbeak *Hemiramphus archipelagicus*	0.01	NE	412-412	412	1	0.08
Ariidae	Giant catfish *Netuma thalassina*	0.06	NE	294-294	294	1	0.37
	Total					703	25.68

NE, Not Evaluated; DD, Data Deficient; NT, Near Threatened; VU, Vulnerable; EN, Endangered. The Catch Per Unit Effort (CPUE) for the target species (*P. Pelagicus*) during the survey was 28.33



The 11 trips of crab gillnet conducted yielded about 12% of the total catch in weight

FIGURE 2. Catch composition in weight percentage of the crab gillnet for targeting the blue swimming crab (*Portunus pelagicus*) in the Banyuasin estuarine



Spiny Hands (*Charybdis helleri*) was the most discard species referring to their percentage values of weight and number

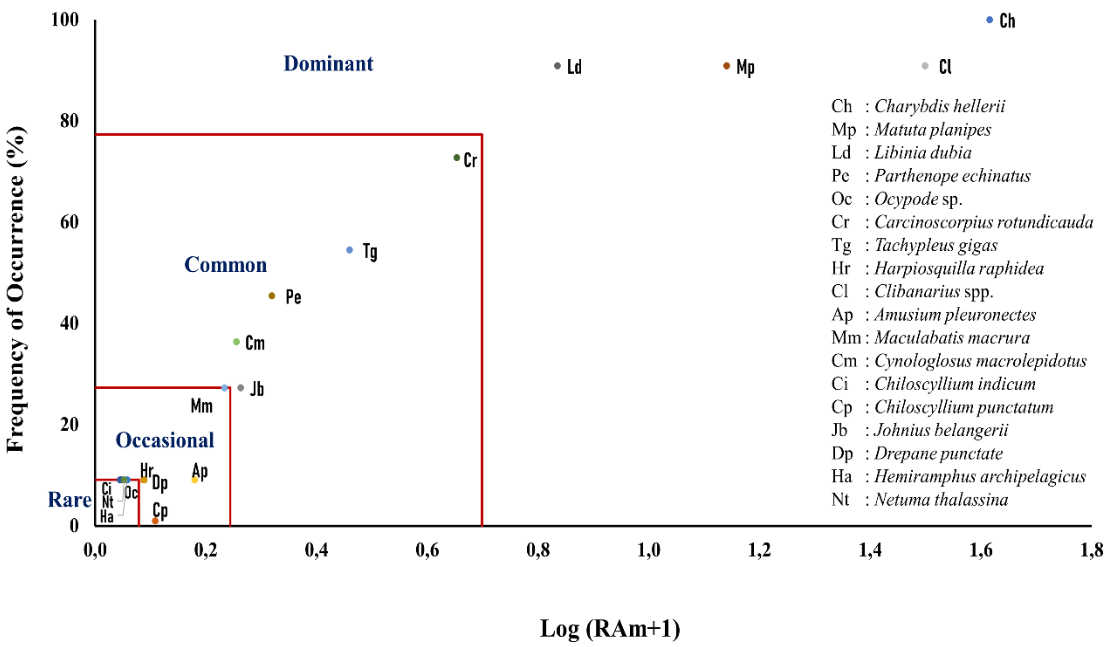
FIGURE 3. Discard species percentage of the crab gillnet from Banyuasin estuarine

CONSERVATION STATUS OF DISCARDS

In this study, all discard species were classified within five categories from nine categories of the IUCN red list, such as Not Evaluated, Data Deficient, Near Threatened, Vulnerable and Endangered. There were two species of crustaceans (*C. rotundicauda* and *T. gigas*) listed as 'Data Deficient', three species of fish (*C. punctatum*, *C. indicum,* and *M. macrura*) listed as 'Near Threatened, Vulnerable and Endangered'. In contrast, other species were listed as 'Not Evaluated' (Table 1).

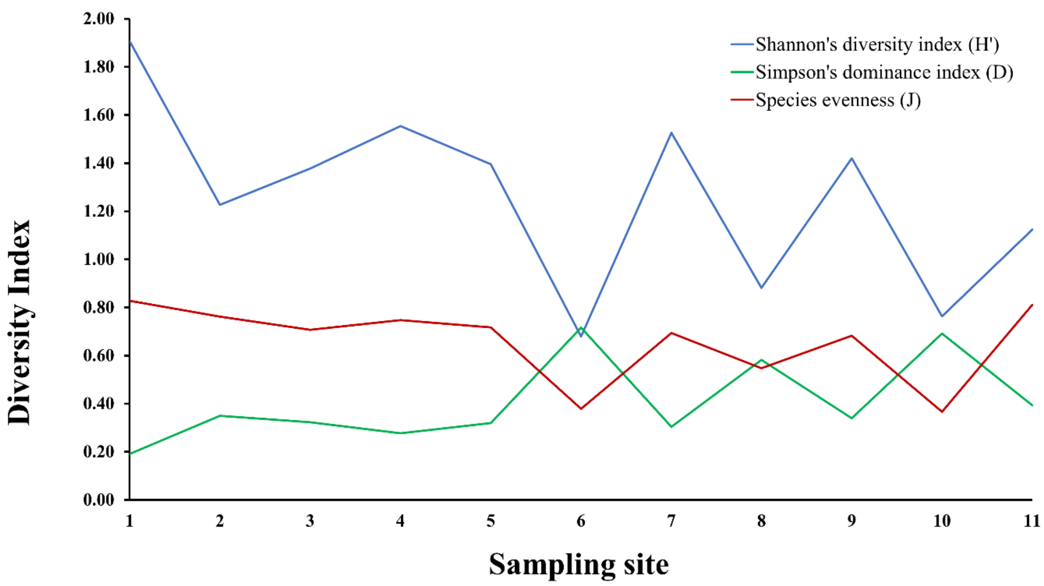
Two species of horseshoe crabs (*C. rotundicauda* and *T. gigas*) were caught during 11 fishing trips. Both species ranged in size from 176-340 and 198-413 mm, respectively. All horseshoe crab were released alive with either minor injuries or in good condition.

Four sharpnose whipray (*M. macrura*), one Slender bamboshark (*C. indicum*), and two grey carpetshark (*C. punctatum*) were caught and discarded in dead condition. Sharpnose whipray ranged in size from 86-160 mm, grey carpetshark went in size from 673-690 mm, and slender bamboshark measured 494 mm.



This classification (rare, occasional, common, or dominant) was based on the 25th, 50th, and 75th percentile values for mean RA and OF. Overall RA data was log (RA+1) transformed and plotted against overall OF data. Of the 18 total species, 4 species were classified as rare, 5 species were occasional, 5 species were common, and 4 species were dominant

FIGURE 4. The ecological classification of each discard species was collected from the crab gillnet in Banyuasin estuarine



Station 1 performed the highest values in Species evenness (J) and Shannon diversity index (H’)

FIGURE 5. The discards diversity from the crab gillnet in Banyuasin estuarine

DIVERSITY INDEX

The highest Shannon's diversity index (One-Sample Wilcoxon Signed Rank Test, $P < 0.003$) and species evenness index (One-Sample Wilcoxon Signed Rank Test, $P < 0.004$) were observed in Station 1 (Figure 5). On the contrary, Station 1 performed the lowest value in the Simpson's dominance index (One-Sample Wilcoxon Signed Rank Test, $P < 0.003$).

DISCUSSION

This study explored the discard species from the crab gillnet fishery operating in the Banyuasin estuarine of South Sumatra, Indonesia. These discards were found in the fishing ground of the blue swimming crab (*P. pelagicus*) from these waters. The substantial in this study was high discards crustacean in the crab gillnet fisheries, especially bottom-set gillnets. These top four discards of crustaceans (*C. hellerii*, *Clibanarius* spp., *M. planipes*, and *L. dubia*) accounted for 90% of the total discards in numbers. During the study, the crustacean predominated the discarded catch of the bottom-set gillnet, similar to observed in Kendari Bay of Southeast Sulawesi, Indonesia (Hamid et al. 2020). The discard species of *C. hellerii* were the greatest value in DPUE, weight, and number. These species were numerically accounting for 40% of total discard in numbers. Besides being vulnerable to discard practices, this species was vulnerable to its predators (Ferry et al. 2017). It is similar to constant/resident organisms and characterized by high tolerance towards environmental variability (González-Acosta et al. 2005). The discard species of *M. planipes* numerically accounted for 13% of total discard in numbers. Discarding *L. dubia* is commonly used as octopus bait for the octopus fishery in Cuba and Mexico, so its local populations might be threatened (Carmona-Osalde & Rodríguez-serna 2012). Nevertheless, *C. helleri* was not commercially crab, and it is similar to observed in Venezuela Martinique (Ferry et al. 2017) and other types of crab. Discarding the commercial species (*N. thalassina*) occurred during this study because this species was still juvenile and thus not marketable.

A market-driven (i.e., preventing the sale for certain bycatch or size classes) and policy (i.e., the legal landings sizes or catch quota) was the main factor that led to discarded catch (Batsleer et al. 2015; Depestele et al. 2011). In this work, the main factors in discarded catch are that the species has no economic value, cannot be utilized, has a small size that makes it impossible to sell it, and that the species is protected. In general, discarding practices had an indirect and direct impact on the community, population, and ecosystem levels even though when the juveniles of marketable species were discarded in large numbers, it's representing a production loss and might have an effect significantly on species recruitment into the fishery.

Based on ecological classification (Figure 4) related to the red list IUCN Table 1, it was said that species with the ecological classification rare, i.e. *C. indicum*, and occasional, i.e. *C. punctatum* and *M. macrura*, included in the IUCN red list category were Vulnerable (*C. indicum*), Near Threatened (*C. punctatum)*, and Endangered (*M. macrura*). This indicates that the species is already hard to find. For horseshoe crabs (*C. rotundicauda* dan *T. gigas*) with ecological classification common including the 'Data Deficient' category has occurred when information required for a risk assessment on extinction species was insufficient (Espinoza et al. 2018). Still, the National Conservation Status (NCS) and the Ministry of Environment and Forestry of Republic Indonesia Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018 states that the two species are included in the Protected Marine Biota (PMB). Discarding the horseshoe crabs (*C. rotundicauda* and *T.gigas*) from the crab gillnets were also occurring in Mayangan waters of West Java, Indonesia (Supadminingsih et al. 2019), in Banyuasin waters using trammel nets, and using trawls (Prianto & Aprianti 2012). Discards obtained from crab gillnets are dead except for horseshoe crabs. For fishers, horseshoe crabs are harmful because their body shape causes damage to the net when caught.

For endangered and protected species, their mortality might be a critical factor for assessing population stability. Even though discarding non-valuable species might represent a loss in economic opportunities, these species could be used as fish meals, fish pastes, fish oils, and other products (Borges et al. 2001). This study has shown that discarding can reduce the survival of protected species (horseshoe crabs and sharks) in the Banyuasin Coastal Waters of South Sumatra as a protected forest area. Efforts to improve the conservation of protected species are to fill gaps in biological and ecological information. Essential steps are taken starting from species identification, the population status of protected species, fishing locations, types of fishing gear used, and seasons. It aims to determine growth parameters, species distribution, spawning locations, captive locations, and seasonal patterns. In addition, conservation is projected to depend heavily on the successful development of DNA techniques to help locate the remaining endangered populations.

It seems that targeting individual species (*P. pelagicus*) effectively at commercial gillnet fishing might not be easy without incurring a discarded catch (Hickford et al. 1997). The substantial discovery in this study was discarded from crab gillnet fishing gear in Banyuasin waters with species ranging from categories Data Deficient to Endangered. Other fishing gears operating in Banyuasin waters are drift gillnet, trammel net, longline drift, trawl, and tidal trap (Fauziyah et al. 2018b) and 'belat'/ estuary barrier trap (Wahyudin et al. 2019). Belat fishing gear is categorized as sensitive in the Environmental Sensitivity Index (ESI) for capturing fisheries (Wahyudin et al. 2019) because it has a tiny mesh size of 0.8 inches. The operation is carried out by trapping fish in tidal conditions around the mangrove ecosystem. This will reduce the population and threaten endangered marine life. Thus, it is very likely that the amount of discard in the Banyuasin waters of South Sumatra will continue to increase because it has never been reported. Therefore, the loss of protected species remains undetected. For this reason, it is imperative to develop ideas for mitigating discarded catches (discarded) together with fishers.

Future actions should include discussions with fishers about discard catch and trial options for breeding or captive horseshoe crabs and releasing protected species when caught. Although according to Wilson et al. (2014), capture and release will impact spawning changes or failure to lay eggs, this is still better than an increasingly endangered population. Another mitigation that we offer in this case is modifying the crab gill net fishing gear by expanding the mesh size of the webbing of the fishing gear above 0.5 inch. A slight expansion in the mesh size did not affect the main catch but did affect the size of the fish caught (Tambunan et al. 2010). Species mortality increased in young adults than in adults when more small-mesh nets were used (Kelkar & Dey 2020). We considered that this option might be acceptable to fishers in the study area because it is easy to implement and inexpensive. Discard from catches can certainly be diminished if passive or sedentary traps are applied consistently (Kelkar & 2020). However, to maintain the quality of the crabs and keep the crabs caught alive, introducing a folding crab trap as the choice of fishing gear is the most appropriate. This last option was the most supportive of conservation measures. Because in addition to fish that were not the target of catch, the possibility of horseshoe crab being caught was also reduced (Nuraini et al. 2009).

Some fishermen still use trawling in artisanal fisheries in the coastal waters of Banyuasin (Fauziyah et al. 2018b), so that strict law enforcement efforts are needed against this prohibition. The negative impact of the rapid decline in the population of species is to be expected, both for economic species and protected species. Consequently, the need for public and local government support to protect protected habitats and species from human activity stressors is critical in developing strategies for marine conservation of threatened species. Close cooperation between fishers, managers, and scientists was also needed for developing practical regulations and solutions without needlessly strict rules (Hall et al. 2000).

Conclusion

Discarding catch on the crab gillnet in the Banyuasin estuarine was dominated by crustaceans (*C. hellerii, Clibanarius* spp.*, M. planipes,* and *L. dubia*). These species accounted for about 90% of the total discards in numbers and about 12% of the total catch in weight. Based on the IUCN status, three species of elasmobranchii i.e. *C. indicum, C. punctatum,* and *M. macrura* listed as 'Vulnerable', 'Near Threatened' and 'Endangered'. The two species of horseshoe crabs i.e., *C. rotundicauda* and *T. gigas* listed as 'Data Deficient'. In Indonesia, this horseshoe crab is included in the Protected Marine Biota. This study has shown that discard can reduce the survival of protected species, especially horseshoe crabs, sharks, and rays, in the Banyuasin Coastal Waters of South Sumatra as a protected forest area. It is essential to develop ideas for the mitigation of discarded catches for discussion with fishers. Mitigation options offered include captive trials of horseshoe crabs, the release of protected species when caught, and fishing gear modification.

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