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Bycatch Composition and Ecological Status of Trap and Gillnet Blue Swimming Crab Fisheries in Bone Gulf, Southeast Sulawesi, Indonesia

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ABSTRACT

In Indonesia, bycatch is currently among the problems of crab fisheries apart from overfishing due to limited data. Therefore, this study aimed to determine the species composition, proportion and ecological status of the bycatch fishery of trap and crabs gillnet in the southeastern Bone Gulf. The sampling was monthly carried out, and the samples obtained were grouped into four; namely, fish, crustaceans, molluscs and echinoderms. The composition of the bycatch of trap and gillnet crab fisheries was dominated by crustacean groups. Based on the Mann Whitney test, the proportion of crab trap and gillnet bycatch was significantly different (P<0.05). Furthermore, the species composition of the crab trap fisheries bycatch consisted of 29 and 31 species of old and new traps, respectively, as well as 52 species of gillnet fishery bycatch. The ecological status of the bycatch diversity of the trap fishery is low, while the crab gillnet fishery is moderate. This showed that crab gillnets have lower ecological stress than crab traps.

INTRODUCTION

Bycatch is one of the problems faced by large and small-scale capture fisheries in the world **(Shester & Micheli, 2011; Page *et al*., 2013; Squires *et al*., 2021; Saber *et al*., 2022)**, with a proportion of 40% **(Scales *et al*., 2018)**. It has become a serious threat to protected marine animals such as turtles, sharks and rays, seabirds and mammals **(Shester & Micheli, 2011; Zainudin *et al*., 2017; Squires *et al*., 2021)**, creating ecological pressure and threatening the sustainability of marine life **(FAO, 2019)**. Gemerally, the blue swimming crab (*Portunus pelagicus*) fisheries bycatch consists of groups of fish, crustaceans, molluscs and echinoderms **(Pillai *et al*., 2014; Fazrul *et al*., 2015; Samanta *et al*., 2018)**, while their composition and abundance depend on the species and fishing gear design **(Shester & Micheli, 2011; Leland *et al*., 2013; Broadhurst *et al*., 2014; Kalayci & Yeşilçiçek, 2014)**.

In Indonesia, the blue swimming crab fisheries is still classified as a small-scale fishery; these fisheries are managed by local fishermen using traps and gillnets **(Maduppa *et al*., 2016)**. This crab species is one of the Indonesia's main fishery export commodities **(Kembaren *et al*., 2018; Rahman *et al*., 2021)**, which comes from capture fisheries. Since the demand for crab consumption is continuously increasing, the intensity of crabs fishing becomes higher, leading to the overfishing of the majority of crab stocks **(Tirtadanu & Chodrijah, 2019)** including the Southeast Sulawesi **(Hamid & Wardiatno, 2015)**. In addition, bycatch is one of the problems in the management of crab fisheries in Indonesia due to the limited available data **(Hamid & Kamri, 2021)**. Therefore, bycatch data are needed in ecosystem-based crab fisheries management in the country **(Shester & Micheli, 2011; Kalayci & Yeşilçiçek, 2014; Fazrul *et al*., 2015)** to assess crab fisheries certification **(Hamid *et al*., 2020; Hamid & Kamri, 2021)**.

Globally, several bycatch studies on crab gillnet fisheries have been carried out including those of **Kumar *et al*. (2013)**, **Page *et al*. (2013)** and **Fazrul *et al*. (2015)**. Similarly, bycatch studies on crab trap fisheries have been carried out by **Leland *et al*. (2013)**, **Chavez *et al*. (2017)** and **Kunsook and Dumrongrojwatthana (2017)**. In Indonesia, studies have been conducted on the bycatch of gillnet crab fisheries; for example, **Hamid and Wardiatno (2018**), **Mardhan *et al*. (2019)** and **Sari *et al*.(2019)**, as well as on trap- crab fisheries **(Hamid *et al*., 2020; Hamid & Kamri, 2021)**. Although a bycatch study on traps in crap fisheries that are equipped with escape vent has recently been carried out by **Rotherham *et al*. (2013)** and **Broadhurst *et al*. (2017, 2019)**, it has no study has been conducted in Indonesia.

The southeastern waters of Bone Gulf are part of the Kolaka Regency, Southeast Sulawesi, which are crabs fishing ground for local fishermen. Studies on gillnet crabs fisheries in these waters have been carried out **(Syahrir, 2011),** however, the bycatch data for crab trap fisheries is still not yet available. Therefore, this study aims to determine the species composition, proportion, and ecological status such as Shannon-Wiener diversity index, evenness index, and Simpson dominance index of the bycatch fisheries of trap and gillnet crabs in the southeastern Bone Gulf, Southeast Sulawesi, Indonesia.

MATERIALS AND METHODS

Location and Period of Study

This study was conducted in five crab fishing areas, namely Kolakasi, Tahoa (Kali Merah), Towua I, Dawi-Dawi-Pomalaa, and Tambea, Kolaka Regency, Southeast Sulawesi, Indonesia (Fig. 1). In these locations, crab fishing is carried out by small-scale fishermen using traps and gillnets, which are popularly called crab trap fisheries and crab gillnet fisheries. The fishing ground is the southeastern waters of Bone Gulf, from the intertidal area to a depth of 30 meters. Meanwhile, bycatch sampling was carried out from March to October 2021.

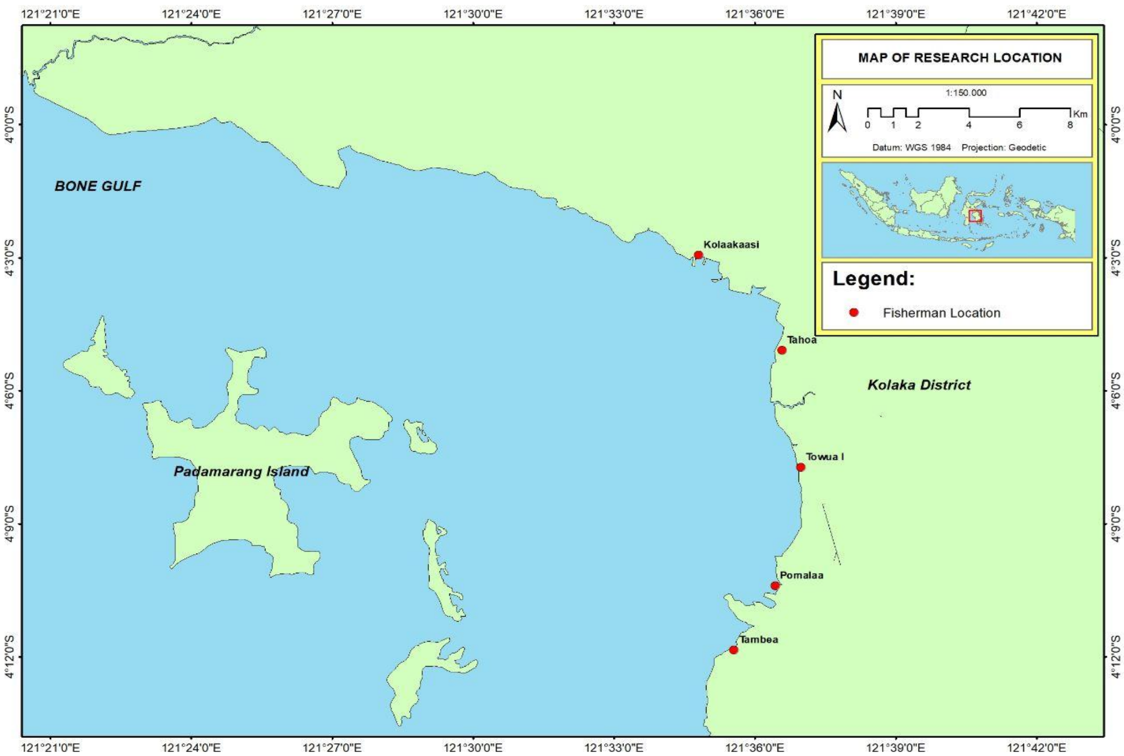

Fig. 1. Map of study and location of the fisherman of blue swimming crab fisheries (black circles) in Southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Sampling Protocols

The byctach sampling at each location was carried out once a month. Meanwhile, the two types of traps used were butterfly-type traps commonly used by local fishermen (old traps), and butterfly-type traps equipped with two escape vents with a size of 3.5 x 5.0 cm (new traps). The gillnet crab with a mesh size of 4 inches (10.16 cm) was also used, while the crab traps and gillnets were installed in the afternoon and were removed in the morning for the catch to be taken. Subsequently, the number of bycatch catches in each sampling period was counted and separated into four groups, namely fish, crustaceans, molluscs, and echinoderms for each type of fishing gear. Bycatch fish samples were identified based on on **Kuiter & Tonozuko (2001)** and **White *et al*. (2013)**, samples of bycatch crustaceans were identified using **Wee & Ng (1995), Carpenter & Niem (1998), Ng *et al*. (2008)** and **Khvorov (2012)**, and mollusc were identified by **Wilson & Gillet (1979)**.

Data Analysis

Data for each group of bycatch were analyzed and presented according to the type of fishing gear. The status of each group of bycatch traps and gillnet crabs fisheries was determined from the perceptions of local fishermen **(Alverson *et al.*, 1994)**, and divided into two categories, namely retained (economic value) and discarded (not valuable). The ecological status of the bycatch of trap and gillnet fisheries was determined by the

Shannon-Wiener diversity, evenness, and Simpson dominance indexes **(Brower *et al*., 1990)**. Furthermore, the proportion of bycatch of crustaceans to crab catches was analyzed according to **FAO (2019),** while the difference in the proportion of bycatch between types of fishing gear was determined using the Mann Whitney test at a significance level of 0.05

RESULTS AND DISCUSSION

1. Bycatch Composition in General

In this study, the composition of bycatch trap fisheries discovered only consisted of fish, crustaceans, and mollusc groups, while echinoderms were only as gillnet crab with the three bycatch groups as stated above (Table 1). The bycatch of the trap and gillnet crab fisheries was dominated by crustacean groups, identical to the bycatch of the lobster trap fisheries in the Irish Sea, Turkey (**Ondes *et al*., 2017**), and the crab fishery in Kendari Bay, Indonesia. However, in Lasongko Bay, the country is dominated by echinoderm groups (**Hamid & Kamri, 2019**). The proportion of crustaceans bycatch in crab old traps fisheries was 91.99%, while new traps were 83.12% and gillnets has 68.20% (Table 1). These results were higher than 43.99% found in Lasongko Bay and 65.75% in Kendari Bay (**Hamid & Kamri, 2019**).

Table 1. The proportion of each bycatch crab trap and gillnet fisheries group based on the abundance in southeastern Bone Gulf, Southeast Sulawesi, Indonesia

Bycatch group	Bycatch proportion per fishing gear (%)		
	Old trap	New trap	Gillnet
Fish	7.58	16.08	21.84
Crustaceans	91.99	83.12	68.20
Molluscs	0.43	0.80	9.20
Echinoderms	0	0	0.77
Total (%)	100	100	100

The proportion of bycatch crustacean weight to the crab catch showed a significant difference ($p<0.05$) between the types of fishing gear. The proportion of bycatch crustaceans between the two types of crab traps was not significantly different ($p>0.05$), while there were differences ($p<0.05$) between with the proportion of crab gillnet bycatch (Table 2). Furthermore, the proportion of the number and weight of crustaceans bycatch in the old trap was lower than in the new trap. This indicated that the escape vent in the new trap was less effective in reducing the number of bycatch crustaceans. Bycatch crustaceans are assumed to be more attracted to the bait in the crab trap than passing through the escape gate in the crab trap, which serves as an entry place for the bycatch. The proportion of the number and weight of bycatch crustaceans of crab gillnet fisheries was lower than the crab trap fisheries (Table 2). Based on these data, crab gillnets are more selective than crab traps, which is similar to the results of **Fazrul *et al*. (2015)** and **Kunsook & Dumrongrojwatthana (2017)**. In this study, the proportion of bycatch crustaceans in the crab trap fisheries obtained was higher than the Kung Krabaen Bay, Thailand, which was 49.0% (**Kunsook & Dumrongrojwatthana, 2017)**.

Table 2. The proportion of bycatch crustaceans to crab catches based on fishing gear southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Fishing gear	Bycatch number proportion (%)		Bycatch weight proportion (%)	
	Mean	Range	Mean	Range
Old trap	36.92a	13.21 - 59.86	20.57a	1.59 - 31.97
New trap	50.91a	28.99 - 66.99	30.95b	7.12 - 39.95
Gillnet	18.18b	15.38 - 41.18	13.72c	6.64 - 22.40

Note: Columns with unequal letter items show significantly different ($p<0.05$).

2. Bycatch Fish Composition

The total composition of the bycatch of trap and gillnet crab fisheries found in the southeastern of Bone Gulf was 31 species from 20 families with an abundance of 227 individuals. The species composition of the bycatch of the gillnet cran fisheries was higher than trap fisheries, which is similar to Lasongko and Kendari Bays **(Hamid & Kamri, 2019)**. Furthermore, the species composition of old trap bycatch fish found 11 species, new trap 12 species and gillnet has 21, with the highest abundance caught with new trap (Table 3). In this study, the species composition and abundance of the crab trap and gillnet fisheries were lower than those in Lasongko and Kendari Bays **(Hamid & Kamri, 2019)**, as well as in Kolono Bay **(Hamid & Kamri, 2021),** but higher than those discovered by **Syahrir (2011),** namely 2 species (Table 4).

Moreover, the composition of the bycatch fish of crab trap and gillnet fisheries that had discarded status (no economic value) was lower than the retained status (economic value), which were 7 species (22.58%) and 24 species (77.42%), respectively. The protected fish, shark (*Carcharoides* sp.) as bycatch of crab gillnet, and 2 species of poisonous fish, namely *Atothron manilensis* and *Chelonodon patoca* (Table 3) were found. The abundance of these poisonous fish was lower than those in Lasongko and Kendari Bays **(Hamid & Kamri, 2019)**, and Kolono Bay **(Hamid & Kamri, 2021)**.

In this study, 7 species of bycatch fish with high economic value were found, namely *Lethrinus lentjan*, *Lutjanus erythropterus*, *L. malabaricus*, and *Epinephelus malabaricus* as bycatch of crab trap and gillnet fisheries, while *Siganus gutatus* and *S. vermiculatus* were bycatch of crab gillnet (Table 3). The five species of bycatch fish are still classified as juveniles and not yet suitable for trading and were identical to crab gillnet fisheries in Pattani Coast and Bay, Thailand **(Fazrul *et al*., 2015)**, Lasongko Bay, and Kendari, Indonesia **(Hamid & Kamri, 2019)**, and crab trap bycatch in Kolono Bay **Hamid & Kamri, 2021)**. Meanwhile, the species composition of bycatch fish of high economic value found in the southeastern Bone Gulf was lower than those in Lasongko and Kendari Bays **(Hamid & Kamri, 2019)** and Kolono Bay **(Hamid & Kamri, 2021)**, which was relatively the same as those in Pattani Coast and Bay, Thailand **(Fazrul *et al*., 2015)**.

Table 3. The species composition of fish bycatch in the crab trap and gillnet fisheries in southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Family	Species	Abundance (ind.) per gear			Category
		Old Trap	New Trap	Gillnet	
Balistidae	*Balistoides viridescens*			1	D
Carangidae	*Atule mate*			1	R
Centrogenyidae	*Centrogenys vaigiensis*	1	1		D
Chanidae	*Chanos chanos*			3	R
Dasyatidae	*Neotrygon kuhlii*		1	9	R
Drepaneidae	*Drepane longimana*			2	R
	Drepane punctata			2	R
Gerreidae	*Gerres shima*			2	R
Holocentridae	*Sargocentron rubrum*			1	R
Leiognathidae	*Leiognathus equulus*			2	R
	Equulites leuciscus		1		R
	Nuchequula gerreoides	1			R
Lethrinidae	*Lethrinus lentjan*	1		1	R
Lutjanidae	*Lutjanus erythropterus*		1		R
	L. malabaricus	1			R
Odontaspididae	*Carcharoides* sp.			1	R
Monacanthidae	*Acreichthys tomentosus*	1	3	2	D
Muraenidae	*Gymnothorax* sp.		1		D
Nemipteridae	*Nemipterus* sp.A	49	53		R
	Pentapodus bifasciatus	2	8		R
Pomacentridae	*Dischistodus fasciatus*			1	D
Serranidae	*Cephalopholis argus*	9	22	1	R
	Epinephelus malabaricus		2	3	R
Siganidae	*Siganus canaliculatus*			4	R
	S. gutatus			4	R
	S. vermiculatus			3	R
Soleidae	*Brachirus* sp. A			8	R
Soleidae	*Pardachirus pavoninus*			3	R
Tentraodontidae	*Atothron manilensis*	1		2	D
	Chelonodon patoca		2		D
Terapontidae	*Terapon theraps*	4	6		R
Number of species (taxa)		11	12	21	
Abundance (individual)		70	100	56	

Remarks: R= retained (valuable economic) D= discarded (non-valuable)

The species composition of fish and crustaceans bycatch of crab trap and gillnets fisheries found varies between locations globally. The composition of the bycatch of crab trap fisheries showed 8-27 fish species and 15-37 crustacean species, while for crab gillnet fisheries, the bycatch found were 2-61 species of fish and 6-38 species of crustacean (Table 4). Meanwhile, various species compositions of bycatch fish and crustacean were assumed due to differences in aquatic habitat conditions (**Fazrul *et al*., 2015; Hamid & Kamri, 2019; 2021)**, season, fishing gear, design **(Shester & Micheli, 2011; Page *et al*., 2013; Fazrul *et al*., 2015)**, area, and frequency of sampling between water locations **(Hamid *et al*., 2020).**

Table 4. Species composition of fish and crustaceans bycatch of crab trap and gillnets fisheries in globally waters

Location	Bycatch number of species			Source
	Fish	Crustaseans	Molluscs	
Trap				
Wallis Lake, Australia	8	-	-	**Leland *et al*. (2013)**
Kung Kren Bay, Thailand	-	17	-	**Kunsook & Dumrongrojwatthana (2017)**
Georgia, USA*	26	15	-	**Page *et al*. (2013)**
Lasongko Bay, Indonesia	17	-	-	**Hamid & Kamri (2019)**
Kendari Bay, Indonesia	23	37	-	**Hamid & Kamri (2019); Hamid *et al.* (*2020*)**
Kolono Bay, Indonesia	27	20	7	**Hamid & Kamri (2021)**
, Indonesia	11	18	1	**Current study**
Gillnet				
Pattani Bay, Thailand	61	26	8	**Fazrul *et al*. (2015)**
Pattani Coast, Thailand	33	29	25	
Thoothukudi Coast, India	7	6	3	**Kumar *et al*. (2013)**
Lasongko Bay, Indonesia	27	38	-	**Hamid & Wardiatno (2018)**
Kendari Bay, Indonesia	31	-	-	**Hamid & Kamri (2019)**
, Indonesia	2	6	1	**Syahrir (2011)**
, Indonesia	21	25	5	**Current study**

Remarks: * *Calinectes sapidu*

3. Bycatch Crustaceans Composition

The total composition of bycatch crustaceans of crab trap and gillnets fisheries in the southeastern of consisted of 33 species from 16 families with 1543 individuals. Meanwhile, the species composition of crustaceans bycatch in the crab old trap and traps consisted of 18 species each, while the crabs' gillnet was 25 species (Table 5). The abundance of crustaceans bycatch in the crab old trap fisheries was higher compared to the crab new trap and crab gillnet of bycatch (Table 5).

Table 5. The species composition of crustaceans bycatch in the crab trap and gillnet fisheries in the southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Family	Species	Abundance (ind.) per gear			Category
		Old Trap	New Trap	Gillnet	
Calappidae	*Calappa hepatica*			2	D
	Calappa philargius			2	R
Diogenidae	*Dardanus* sp.	11	12	4	D
Dromiidae	*Dromia* sp.			2	D
Eriphiidae	*Myomenippe hardwickii*		1	1	R
Euryplacidae	*Eucrate* sp..		5	4	D
Grapsidae	*Grapsus albolineatus*			3	D
Inachidae	*Camposcia retusa*			1	D
Majidae	*Schyzophys aspera*			4	D
Matutidae	*Ashtoret lunaris*	2	1	14	D
Parthenopidae	*Daldorfia horrida*			1	D
Pilumnidae	*Pilumnus* sp.			5	D
Portunidae	*Charybdis anisodon*	430	276		R
	C. helleri	60	58		R
	C. truncata	1			R
	C. feriatus		2		R
	Gonioinfradens sp.	1			R
	Podophthalmus vigil	102	62	35	R
	Portunus sanguinolentus	98	19	24	R
	Scylla serrata	2		7	R
	Thalamita admete			1	R
	T. danae	6	1	2	R
	T. crenata	76	46	14	R
	T. sima	16	20	18	R
	T. spinimana	29	7		R
Squillidae	*Harpiosquilla raphidea*	5	2		R
Scyllaridae	*Thenus orientalis*			1	R
Varunidae	*Varuna* sp.	7	3	4	D
Xanthidae	*Atergatis integerrimus*	4	2	3	D
	Atergatis floridus			1	D
	Etitus utilus			19	D
	Demania sp.	1	1		D
	Lophozozymus pictor	2	4	4	D
Number of species (taxa)		18	18	25	
Abundance (individual)		850	517	176	

Remarks: R= retained (valuable economic) D= discarded (non-valuable)

In this study, the species composition and abundance of bycatch crustaceans in a crab trap and gillnets fisheries were lower compared to those in Lasongko Bay **(Hamid &Wardiatno, 2018)**, Kendari Bay (**Hamid *et al*., 2020)**, and Kolono Bay **(Hamid & Kamri, 2021)**, but higher than that reported by **Syahrir (2011)**, namely 6 species (Table 5) and bycatch crustaceans in the *Cainectes sadipus* trap fisheries in Georgia, USA

(Page *et al*., 2013). Furthermore, the crustaceans bycatch of crab trap and gillnet fisheries with discarded status (not economic value) were 16 species (48.49%), while retained status (economic value) were 17 species (51.51%). These results were lower than those found in Lasongko Bay **(Hamid & Wardiatno, 2018)**, Kendari Bay **(Hamid *et al*., 2020)**, and Kolono Bay (**Hamid & Kamri, 2021)**, but higher than the values reported by **Syahrir (2011)**, namely 6 species (Table 5), and bycatch crustaceans in the *C. sadipus* trap fisheries in Georgia, USA **(Page *et al*., 2013).**

In this study, only 2 individuals of *Scylla serrata* were found as bycatch crustaceans in crab trap fisheries with high economic value and were similar to those found in Kolono Bay **(Hamid & Kamri, 2021)**. In Kendari Bay, 5 species of bycatch crustaceans were found with high economic value, which consists of 1-11 individuals per species **(Hamid *et al*., 2020).** Meanwhile, 2 species of bycatch crustaceans, namely *S. serrata* with 7 individuals and 1 individual of *Thenus orientalis*, with high economic value were found in the crab gillnet fisheries (Table 5), while in Lasongko Bay 5 species were found **(Hamid & Wardiatno, 2018)**.

4. Bycatch Composition Echinoderms and Molluscs

Only 2 individuals of *Protoreaster nodosus* species of echinoderm bycatch in the crab gillnet fisheries were found (Table 6) and is identical to that in Kolono Bay, but as a crab trap bycatch **(Hamid & Kamri, 2021)**. Meanwhile, molluscs bycatch in crab trap fisheries only found one species, namely *Tritia* sp. with 4 individuals for the old trap and 5 individuals for the new trap. Similarly, *Tritia* sp. was also found in Kolono Bay as bycatch of crab trap fisheries with an abundance of 1-256 individuals, which were mostly caught in seagrass beds **(Hamid & Kamri, 2021)**.

Table 6. Species composition of molluscs and echinoderms bycatch in the crab trap and gillnet fisheries in southeastern of Bone Gulf, Southeast Sulawesi, Indonesia.

Group	Family	Species	Abundance (ind.) per gear			Category
			Old Trap	New Trap	Gillnet	
Moluscs	Muricidae	*Murex trapa*			2	D
	Nassariidae	*Tritia* sp.	4	5	10	R
	Tonnidae	*Tonna* sp.			1	R
	Trombidae	*Lambis lambis*			10	R
	Valutidae	*Cymbiola* sp.			1	R
Abundance (ind.)			4	5	24	
Echinodems	Oreasteridae	*Protoreaster nodosus*			2	D

Remarks: R= retained (valuable economic) D= discarded (non-valuable)

In this study, the composition of the bycatch molluscs of crab gillnet fisheries found were 5 species with 24 individuals, and 4 of these species were retained (Table 6). The species number of mollusc bycatch of crab gillnet was higher than the results of

Syahir (2011), and **Kumar *et al*. (2013)**, but lower than those reported by **Fazrul *et al*. (2015)**.

5. Temporally Composition of Bycatch

The species composition of the crab trap and gillnet fisheries was temporally a combination of the four groups of bycatch, which varied between the sampling periods. Temporally, the species composition of the bycatch of the crab old trap fisheries were 5-15 species with 48-185 individuals, while the crab new trap bycatch was 11-21 species with 75-171 individuals in each sampling (Table 7). The species composition of the crab old trap bycatch was lower than those in Kolono Bay **(Hamid & Kamri, 2021)**. Furthermore, the species composition of the bycatch of the crab gillnet fisheries temporally were 2-20 species with 8-57 individuals in each sampling (Table 7).

Table 7. The temporally composition and abundance of bycatch in the crab trap and gillnet fisheries in the southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Sampling Period (Month)	Old Trap		New Trap		Gillnet	
	Species number	Abundance (ind.)	Species number	Abundance (ind.)	Species number	Abundance (ind.)
March	6	93	-	-	2	8
April	5	53	-	-	20	57
May	11	98	-	-	14	28
June	15	185	11	171	18	47
July	10	138	11	75	19	40
August	13	165	12	134	14	25
September	14	145	18	115	15	29
October	14	48	21	128	7	28
Species number		29		31		52
Abundance (individual)		925		623		262

Remarks: - Sampling without using new trap

6. Ecological Status of Bycatch

The diversity index value of fish, crustacean and the combined groups of bycatch of crab trap fisheries were <1 for both types of traps of crab, while it was >1 for crab gillnet bycatch (Table 8). Furthermore, the value of diversity and evenness index of fish, crustaceans, and the combined group of crab gillnet fisheries bycatch was higher than the crab trap fisheries bycatch, while the value of dominance index of the crab gillnet fisheries bycatch was lower than the crab trap fisheries bycatch (Table 8). The diversity index value of fish and the combined group bycatch of the crab old trap was lower than the new trap, while the crustacean diversity index value of the crab old trap bycatch was relatively higher than the new trap bycatch.

Table 8. The value of the ecological index of each bycatch group of crab fisheries based on fishing gear in the southeastern of Bone Gulf, Southeast Sulawesi, Indonesia

Bycatch group	Ecologcal index	Value of ecological index per gear		
		Old trap	New trap	Gillnet
Fish	Diversity index (H')	0.6226	0.6655	1.2096
	Evenness index (E)	0.5985	0.6166	0.9148
	Dominance index (D)	0.5273	0.3347	0.0614
Crustacean	Diversity index (H')	0.7357	0.7244	1.1496
	Evenness index (E)	0.5861	0.5771	0.8224
	Dominance index (D)	0.2976	0.3224	0.0940
Bycatch group combined	Diversity index (H')	0.8061	0.8555	1.6033
	Evenness index (E)	0.5570	0.6119	0.9298
	Dominance index (D)	0.2718	0.2602	0.1026

Based on the analysis of the ecological index (Table 8), the ecological status of fish, crustaceans, and the combined bycatch of crab trap fisheries was low in diversity with unstable communities. Furthermore, it experienced high ecology pressure due to crab trap fisheries, the distribution of the abundance of each species of fish and crustaceans was uneven, and there were dominant species of fish and crustacean groups (Tables 3 and 4). Meanwhile, the ecological status of the bycatch of the crab gillnet fishery was moderate with stable communities, experienced balanced ecology stress due to the crab gillnet fisheries, the abundance of each species of fish, and crustaceans is evenly distribute. However, there are no dominant species of fish or crustacean of bycatch crabs gillnet (Tables 3 and 4).

The dominant fish group as bycatch of crab trap fisheries found in the southeastern of Bone Gulf is *Nemipterus* A sp. (Table 3), while the crustacean group bycatch consisted of *Charybdis anisodon*, *Portunus sanguinolentus*, and *Podophthalmus vigil* (Table 4). The proportion of *Nemipterus* A. sp. as the bycatch of crab traps fisheries were 70% (old traps) and 54% (new traps), respectively. Meanwhile, the proportion of *C. anisodon* was 50.59% (old traps) and 53.38% (new traps), respectively of the total bycatch of fish and crustaceans group.

In the southeastern of Bone Gulf, *C. anisodon* was caught with crab traps at a depth of >10 m, and not with crab gillnets, because the fishing grounds for gillnets were only spread in intertidal areas and seagrass beds at a depth of <10 m. However, *C. anisodon* in Lasongko Bay was caught with crab gillnets in the seagrass area at a depth of 30 m **(Hamid & Wardiatno, 2018)**, while in Kolono Bay, it was caught with crab traps in the estuaries, seagrass beds at a depth of 27 m **(Hamid & Kamri, 2021).** In this study, the abundance of *P. sanguinolentus* and *P. vigil* was higher than that found in Kendari Bay **(Hamid *et al.*, 2020)** and Kolono Bay **(Hamid & Kamri, 2021)**, however, *P. sanguinolentus* was not found in Lasongko Bay **(Hamid & Wardiatno, 2018)**.

The diversity index value of bycatch fish in the crab trap fisheries obtained in this study was relatively the same as that found in Kolono Bay, which was 0.552-0.768 **(Hamid & Kamri, 2021)**. However, it was lower compared to those in Lasongko and Kendari Bays, which were 1.1858 and 1.2882 **(Hamid & Kamri, 2019)**, and also in the bycatch of the lobster trap fisheries in the Irish Sea, Turkey, ranging from 0.6896 to 1.4058 **(Ondes *et al*., 2017)**. The bycatch crustacean diversity index value of crab trap fisheries obtained was higher than that found in Kolono Bay, 0.471-0.648 **(Hamid & Kamri, 2021)**, while the value of the crab gillnet fisheries obtained was higher the 0.812-0.893 in Lasongko Bay **(Hamid & Wardiatno, 2018)**. Furthermore, the combined value of the crab gillnet fisheries obtained was lower than the 2.84-3.47 bycatch value in the Bay and Coast Pattani, Thailand **(Fazrul *et al.*, 2015)**. The differences in ecological index values are due to variation in the number of species and the distribution of each species of fish and crustacean bycatch between the types of fishing gear in crab fisheries, and differences in fishing intensity **(Brower *et al.*, 1990; Hamid *et al.*, 2020).**

CONCLUSION

The composition of the bycatch of trap and gillnet crab fisheries in the southeatern of Bone Gulf is dominated by crustaceans groups. Furthermore, the proportion of bycatch crustaceans in new trap fisheries was greater than the old crab traps. Based on the species composition, crab trap fisheries bycatch consisted of 29 species of old trap, 31 of new trap, and 52 species of crab gillnet fisheries bycatch. The ecological status of the bycatch of the crab trap fisheries has low diversity, unstable community, and a dominant species. Meanwhile the crab gillnet fisheries bycatch is classified as medium diversity, the community is stable, and there are no dominant species. Therefore, crab gillnet is have lover ecological stress compared to crab trap.

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