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Kepada: Eni Kovacs

Jum, 20 Agu 2021 jam 17.54

Dear Dr. Eni
Here I send a manuscript journal with tittle is Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia.

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Erick Nugraha

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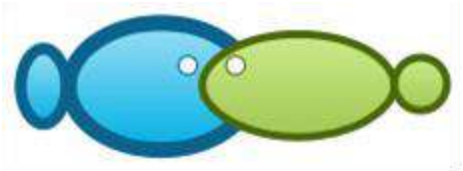

Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. Parameters observed were species composition (*Sc*), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by blue swimming crab (*Portunus pelagicus*) at 25.64%. The index value of the diversity of fish species caught was 2.191 kg and the dominance index value of the caught fish species was 0.169. In this study, the results of the moderate diversity index and low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has good selectivity but is not environmentally friendly.

Keywords: *Naso hexacanthus*, *Portunus pelagicus,* Crustaceans, selective fishing gear.

Introduction. The fisheries and marine sector are one of the leading programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by coastal communities is still dominated by coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is bottom gill net (Syamsuddin et al 2021). Factors that influence the success of fishing are knowledge of the fishing ground, fish behavior, fishing methods and techniques, and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even though the analysis used is less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others, the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020), and the last is the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014), efficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnet are nets that are installed perpendicular to the water (Pondaag et al 2018) which have efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the fish caught with gillnet are only fish whose body size allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net so that they can develop

well and become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the size distribution of fish populations because gillnets have high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh. So that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

Seeing these conditions, it is necessary to conduct research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity as a contribution to fisheries management in Kulu waters, North Minahasa Regency.

Material and Method

This research was conducted in the waters of Kulu, North Minahasa Regency for 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while case studies are studying specific cases on limited objects (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material is made of polyamide (PA) with a span of 30 m in length and 3 m in width for each 1 piece of net.

The caught fish are then identified, separated by type, weighed and measured, and recorded. Data analysis using Microsoft Excel software which includes species composition (*Sc*), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets at a location with the following equation:

1) Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{\text{xi}}{\text{X}} \text{ x } 100\%$$

Where :
Sc = Species composition (%)
xi = number of individual species-i
X = total number of individuals of all species

2) Diversity index (H') using the Shannon-Wiener (Krebs, 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where :
H' = diversity index
ni = number of fish for species i
N = total individual fish for all species

3) Dominance index (C) using the simson formula (Adelusi et al 2018; Odum 1993) :

$$C = \sum (\text{ni}/\text{N})^2$$

Where :
C = dominance index
ni = number of individual species-i
N = total number of individuals of all species

Results and Discussions

Fishing activities using bottom gillnets were carried out as many as 15 trips with 117 fish caught at the fishing ground as shown in the figure 1 below:

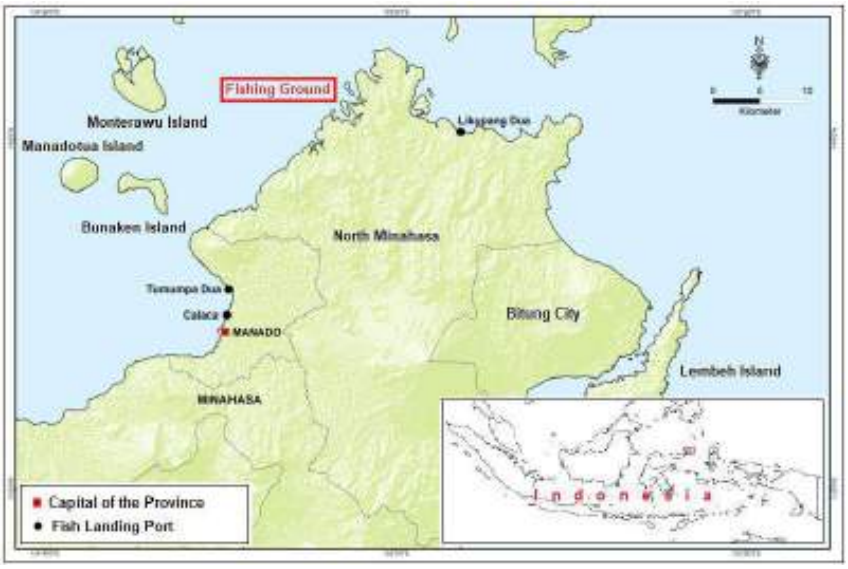

Figure 1. Map of fishing grounds in the Kulu waters. (WCS Indonesia)

Based on the data in table 1 below, it can be seen the composition of the number of fish caught consists of fish species and crustacean species:

Table 1

Species composition (Sc) of fish caught

No	Scientific Name of Fish	Catching Trip															Total Catching (Fish)	Composition (%)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	*Naso hexacanthus*	3	4	2		3	9	1	3				2	6	1		34	29.06
2	*Portunus pelagicus*		2		3	5		5	2	2	5	1	1	1	3		30	25.64
3	*Scarus psittacus*				5					1	1		1				8	6.84
4	*Upeneus sulphureus*							1		1					3	1	6	5.13
5	*Euristhmus microceps*	1				1						1			1	2	6	5.13
6	*Carangoides gymnostethus*											1		2	1	1	5	4.27
7	*Lethrinus harak*	2						1	1				1				5	4.27
8	*Torquigener brevipinnis*			5													5	4.27
9	*Lutjanus carponotatus*	2	2														4	3.42
10	*Sargocentron rubrum*															4	4	3.42
11	*Siganus margaritiferus*	2															2	1.71

12	*Cypselurus sp.*		2														2	1.71
13	*Cynoglossus lingua*								1						1		2	1.71
14	*Heniochus acuminatus*					2											2	1.71
15	*Lactoria pentacantha*	1															1	0.85
16	*Toxotes jaculatrix*				1												1	0.85
Amount Catch (Fish) per trip		11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100
Amount of fish (idv.)		6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		
Catch Rate (trip/fish)																	7.8	

Then in Figure 2, it can be seen that the most caught type of fish is sleek unicornfish (*Naso hexacanthus*) as much as 29.06%, followed by crustaceans, namely blue swimming crab (*Portunus pelagicus*) as much as 25.64%.

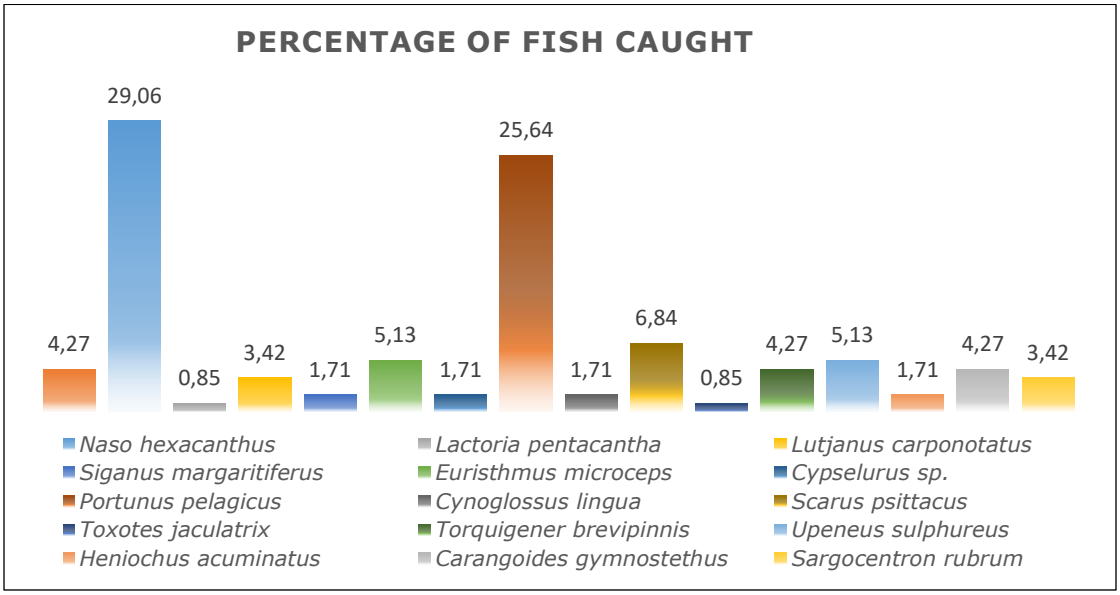

Figure 2. Percentage of fish caught by bottom gillnet.

The following is a picture of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa:

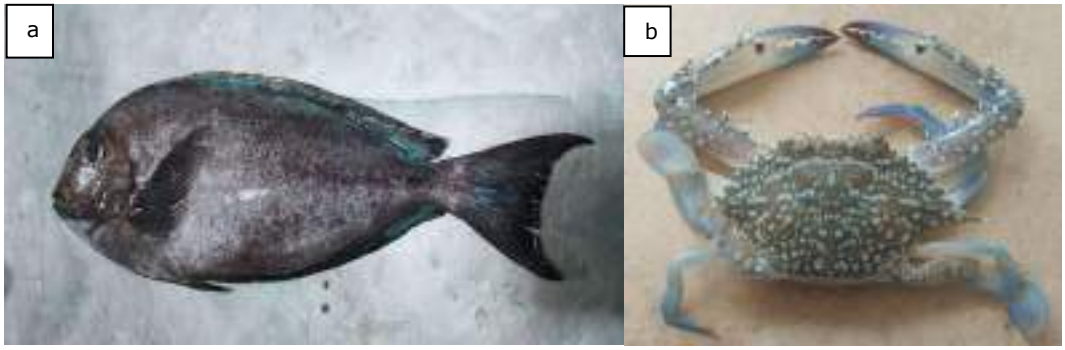

Figure 3. a) *Naso hexacanthus, b) Portunus pelagicus*

The number of fish caught with bottom gillnets was 117 fish from 16 types of fish. The average number of catches and the number of fish species were 7.8 and 3.5. The type of fish that was caught the most were *N. hexacanthus* as many as 34 fish (29.06 %), followed by *P. pelagicus* as many as 30 fish (25.64 %). The abundance of *N. hexacanthus* is due to around the Kulu waters being a good habitat where the abundance of food is quite a lot. In addition, the bottom of the water is sandy. The composition of the type of fish caught is presented in table 1 below.

Table 2

Composition of weight (Kb) of caught fish

Scientific Name	Catching trips															Amount (Kg)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus Sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

In table 2 above, it can be seen that the total weight of the fish caught was *P. pelagicus* at 7.53 kg (33.55%) and *N. hexacanthus* was followed by 4.21 kg (18.77). From the species composition, *N. hexacanthus* showed the most caught, but from the weight composition, *P. pelagicus* showed the most dominant.

Table 3

Diversity and dominance index results

No	Scientific name	H' (Diversity)	C (dominance index)
1	*Lethrinus harak*	0.135	0.002
2	*Naso hexacanthus*	0.359	0.084
3	*Lactoria pentacantha*	0.041	0.000
4	*Lutjanus carponotatus*	0.115	0.001
5	*Siganus margaritiferus*	0.070	0.000
6	*Euristhmus microceps*	0.152	0.003
7	*Cypselurus sp.*	0.070	0.000
8	*Portunus pelagicus*	0.349	0.066
9	*Cynoglossus lingua*	0.070	0.000
10	*Scarus psittacus*	0.183	0.005
11	*Toxotes jaculatrix*	0.041	0.000
12	*Torquigener brevipinnis*	0.135	0.002
13	*Upeneus sulphureus*	0.152	0.003
14	*Heniochus acuminatus*	0.070	0.000
15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

The total value of the diversity index (Table 3) for the types of fish caught is 2,191. Based on the diversity index criteria presented in table 4 (Shanon Wiener index criteria), these results indicate moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe, 2010)

Index	Value	Category
Diversity	$H' \leq 2,0$	Low
	$2,0 < H' \leq 3,0$	Moderate
	$H' \geq 3,0$	High

Based on the dominance index, table 5 (Rappe, 2010) states that the dominance index value ranges from 0-1, where: index 1 indicates dominance by one species is very high (there is only one species at one station). While the index 0 indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe, 2010)

Index	Value	Category
Dominance	$0,0 < C \leq 0,5$	Low
	$0,5 > C \leq 0,75$	Moderate
	$0,75 < C \leq 1$	High

In Figure 4 it can be seen that the highest species diversity index is *N. hexacanthus* with an index value of 0.359 and the lowest there are two species that have the same index value (0.041) namely *Lactoria pentacantha* and *Toxotes jaculantrix.*

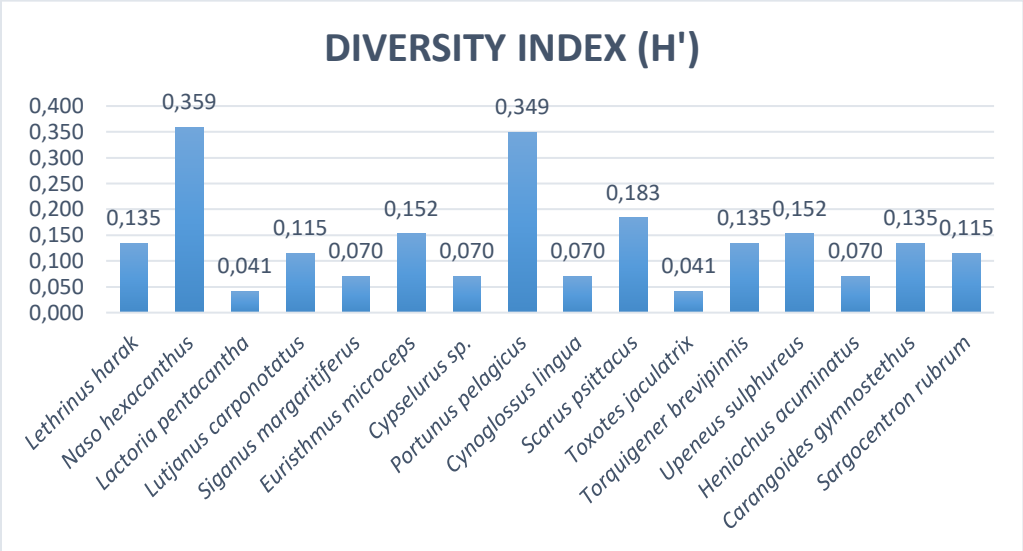

Figure 4. Value of diversity in each type of fish

The total value of the dominance index (Table 3), the type of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore, based on the overall fish species caught, the largest dominance value in general was the *N. hexacanthus* species obtained at the time of capture with a dominance value of 0.084 (Figure 5).

Figure 5. The value of the dominance index for each type of fish

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. In this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely *Lactoria*

pentacantha, Siganus margaritiferus, Cypselurus sp., Cynoglossus lingua, Toxotes jaculatrix and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value where this species has relatively more individuals than other species. *Lactoria pentacantha, Siganus margaritiferus, Cypselurus sp., Cynoglossus lingua, Toxotes jaculatrix* and *Heniochus acuminatus* had the lowest dominance values because these six species had the least number of individuals compared to other species.

In accordance with the opinion (Nugroho et al 2015; Mardhan et al 2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of fishing gear is low and not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in a waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has high selectivity, because it has caught certain fish. Vice versa, if the diversity index value is high, the fishing gear used has low selectivity, because it obtains many types of catch (Nugroho et al 2015; Hakim & Nurhasanah 2017).

In this study, the results of the moderate diversity index and low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has good selectivity but is not environmentally friendly.

Conclussions. The composition of fish species caught with bottom gillnets in Kulu waters was 117 fish consisting of 15 species from the fish group and 1 species from the crustacean group. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows moderate diversity. The index value of the dominance of fish species caught at the research location in Kulu waters is 0.169. This shows that the dominance is low.

Conflict of interest. The authors declare no conflict of interest.

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**** WCS Indonesia. (www.data-ikan.org)

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Submission letter

Article title:

Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

Hereby I would like to submit the manuscript entitled “Analysis of Specific Shallow Water Current for Endemic Fish Conservation at Natuna Islands, Indonesia” to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarised text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve of this submission.

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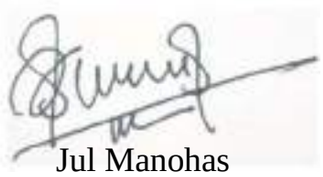

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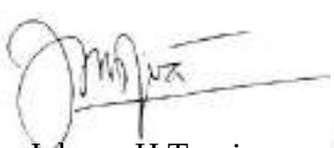

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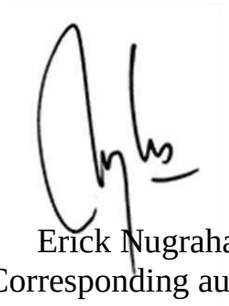

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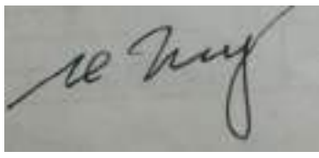

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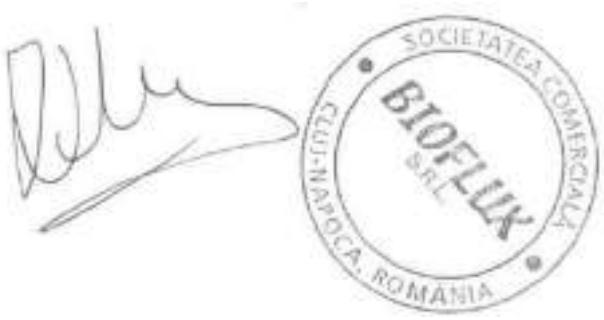

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--
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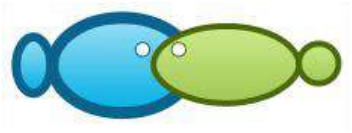

Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. The Pparameters observed were the species composition (Sc), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was the sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by the blue swimming crab (Portunus pelagicus) at 25.64%. The diversity index value of the ~~diversity of~~ fish species caught was 2.191 ~~kg a~~nd the dominance index value of the caught fish species was 0.169. In this study, the ~~results of the~~ moderate diversity index and low dominance index value indicate ~~, it can be concluded~~ that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly.
Key Words: *Naso hexacanthus*, *Portunus pelagicus*, Crustaceans, selective fishing gear.

Introduction. The fisheries and marine sector has a~~are one of the~~ leading contribution to the programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by the coastal communities is still dominated by the coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is the bottom gill net (Syamsuddin et al 2021). Factors that influence the success of fishing are the knowledge of the fishing ground and of the~~,~~ fish behavior, the fishing methods and techniques~~,~~ and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even thou~~g~~h its~~the~~ analysis ~~used is~~was less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others~~,~~ : the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020)~~,~~ and ~~the last is~~ the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014~~),~~). E~~e~~fficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnet~~s~~ ~~are nets that~~ are installed perpendicular~~ly~~ to the water (Pondaag et al 2018) which increases the~~have~~ efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the ~~fish caught with gillnet are only fish whose~~ body size of the fish caught allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net, so that they can develop ~~well and~~ to become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the distribution ~~size distribution~~ of the fish populations'

size, because gillnets have a high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh, ~~.~~ ~~So~~ so that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

~~Seeing these conditions~~In the light of the presentation above, it ~~is~~ appears necessary to conduct a deeper research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity, as a contribution to the fisheries management in Kulu waters, North Minahasa Regency.

Material and Method. ~~The This~~ The present research was conducted in the waters of Kulu, North Minahasa Regency ~~for~~ during 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while the case studies are ~~studying specific cases~~focusing on a limited ~~objects~~ scope (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material ~~is~~ was made of polyamide (PA) with a span of 30 m in length and 3 m in width for each ~~1~~ piece of net.

The caught fish ~~are~~ were then identified, separated by type, weighed, ~~and~~ measured~~,~~ and recorded. Data analysis, using Microsoft Excel software, ~~which includes~~ included the species composition (Sc), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets, ~~at a location~~ with the following equation:

1) Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{xi}{X} \times 100$$

Where:
Sc - species composition (%);
xi - number of individual species-i;
X - total number of individuals of all species.

2) Diversity index (H') using the Shannon-Wiener (Krebs~~,~~ 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where:
H' - diversity index;
ni - number of fish for species i;
N - total individual fish for all species.

3) Dominance index (C) using the simson formula (Adelusi et al 2018; Odum 1993) :

$$C = \sum (ni/N)^2$$

Where:
C - dominance index;
ni - number of individual species-i;
N - total number of individuals of all species.

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Results and Discussion. Fishing activities using the bottom gillnets were carried ~~out as many as~~during 15 trips, with 117 fish caught at the fishing ground, as shown in Figure 1.

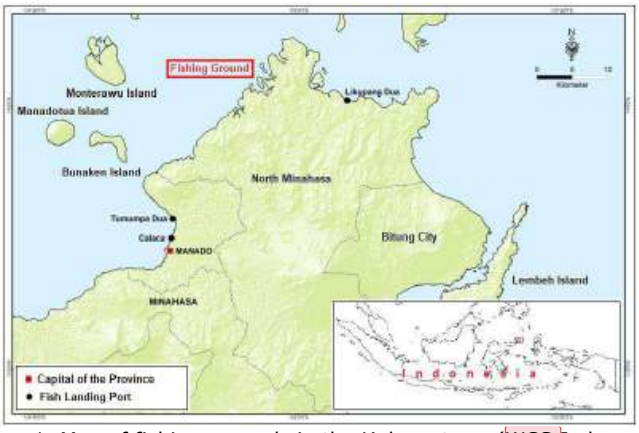

Figure 1. Map of fishing grounds in the Kulu waters ~~-~~ (WCS Indonesia).

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Based on the data in Table 1, it can be seen that the composition of the ~~number of fish~~ caught consists of fish ~~species~~ and crustacean species.

Table 1

Species composition (Sc) of fish caught

No	Scientific name of fish	Catching Trip															Total catching (fFish number)	Composition (%)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	*Naso hexacanthus*	3	4	2		3	9	1	3				2	6	1		34	29.06
2	*Portunus pelagicus*		2		3	5		5	2	2	5	1	1	1	3		30	25.64
3	*Scarus psittacus*				5					1	1		1				8	6.84
4	*Upeneus sulphureus*							1		1					3	1	6	5.13
5	*Euristhmus microceps*	1				1						1			1	2	6	5.13
6	*Carangoides gymnostethus*											1		2	1	1	5	4.27
7	*Lethrinus harak*	2						1	1				1				5	4.27
8	*Torquigener brevipinnis*			5													5	4.27
9	*Lutjanus carponotatus*	2	2														4	3.42
10	*Sargocentron rubrum*															4	4	3.42
11	*Siganus margaritiferus*	2															2	1.71
12	*Cypselurus sp.*		2														2	1.71
13	*Cynoglossus lingua*								1						1		2	1.71
14	*Heniochus acuminatus*					2											2	1.71
15	*Lactoria pentacantha*	1															1	0.85
16	*Toxotes jaculatrix*				1												1	0.85

~~Amount Catch~~ Caught (~~f~~Fish number~~)~~ per trip	11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100
Amount of fish (individuals~~dv.~~)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		
Avg. Catch Rate (fish number trip~~-1/fish~~t)																7.8	

~~Then i~~In Figure 2, it can be seen that the most caught type of fish is sleek unicornfish (*Naso hexacanthus*) as much as 29.06%, followed by crustaceans, namely blue swimming crab (*Portunus pelagicus*) as much as 25.64%.

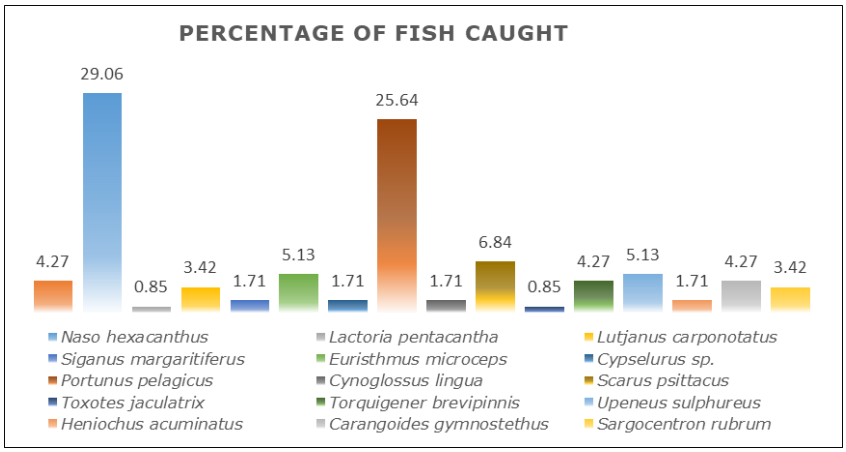

Figure 2. Percentage of fish caught by bottom gillnet.

The following ~~is a~~are pictures of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa:

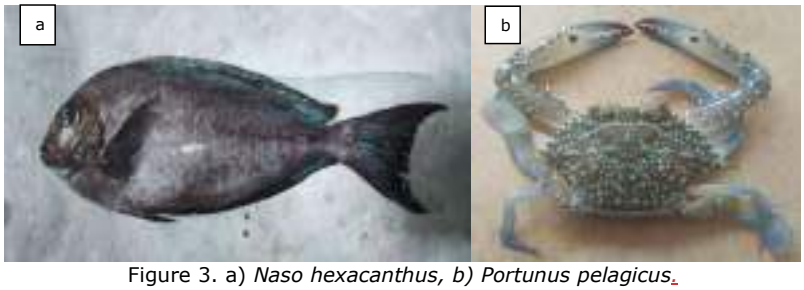

Figure 3. a) *Naso hexacanthus, b) Portunus pelagicus*.

The number of fish caught with bottom gillnets was 117 ~~fish from~~ individuals of 16 ~~types~~ species~~of fish~~. The average numbers of catches and ~~the number~~ of fish species were 7.8 and 3.5, respectively. The type of fish that was caught the most were *N. hexacanthus*~~,~~ ~~as many as~~ 34 individuals~~fish~~ (29.06~~–~~%), followed by *P. pelagicus*, ~~as many as~~ 30 individuals~~fish~~ (25.64~~–~~%). The abundance of *N. hexacanthus* is due to ~~around~~ the Kulu waters, which are ~~being~~ a good habitat where ~~the abundance of~~ food is abundant~~quite a lot~~. In addition, the bottom of the water is sandy. The catch weight composition ~~of the~~by type of fish caught is presented in table ~~1~~ 2 below.

Table 2

Composition of weight (~~Kb~~Kg) of caught fish

Scientific Name	Catching trips															Amount (Kg)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus Sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

In Table 2 above, it can be seen that ~~the total weight of the fish caught was~~ *P. pelagicus* contributed with ~~at~~ 7.53 kg (33.55%) and *N. hexacanthus* ~~was followed by~~with 4.21 kg (18.77)~~.~~ to the total weight of the fish caught. ~~From the~~In the species composition, *N. hexacanthus* was dominant ~~showed (~~the most often caught), but ~~from the~~in the weight composition, *P. pelagicus* ~~showed the most~~was dominant.
The total value of the diversity index (Table 3) for the types of fish caught is 2.191.

Table 3

Diversity and dominance index results

No	*Scientific name*	*H' (Diversity)*	*C (Dominance index)*
1	*Lethrinus harak*	0.135	0.002
2	*Naso hexacanthus*	0.359	0.084
3	*Lactoria pentacantha*	0.041	0.000
4	*Lutjanus carponotatus*	0.115	0.001
5	*Siganus margaritiferus*	0.070	0.000
6	*Euristhmus microceps*	0.152	0.003
7	*Cypselurus sp.*	0.070	0.000
8	*Portunus pelagicus*	0.349	0.066
9	*Cynoglossus lingua*	0.070	0.000
10	*Scarus psittacus*	0.183	0.005

11	*Toxotes jaculatrix*	0.041	0.000
12	*Torquigener brevipinnis*	0.135	0.002
13	*Upeneus sulphureus*	0.152	0.003
14	*Heniochus acuminatus*	0.070	0.000
15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

~~The total value of the diversity index (Table 3) for the types of fish caught is 2,191.~~ Based on the diversity index criteria presented in table 4 (Shanon Wiener index criteria), these results indicate a moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe, 2010)

Index	Value	Category
Diversity	H' ≤ 2.0	Low
	2.0 < H' ≤ 3.0	Moderate
	H' ≥ 3.0	High

~~Based on I~~the dominance index criteria in~~,~~ table 5 (Rappe, 2010) state~~s~~ that when the dominance index ~~value ranges~~ (ranging from 0~~-~~ to 1)~~,~~ has the value~~where: index~~ 1, it indicates a very high dominance by one species ~~is very high~~ (~~there is~~ only one species at one station)~~.~~ ~~-~~ w~~W~~hile when the index is 0, this indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe~~,~~ 2010)

Index	Value	Category
Dominance	0.0 < C ≤ 0.5	Low
	0.5 > C ≤ 0.75	Moderate
	0.75 < C ≤ 1	High

In Figure 4 it can be seen that the highest species diversity index value is reached by *N. hexacanthus* ~~-,with an index value of~~ 0.359, and the lowest ~~there~~ value (0.041) is reached by~~are~~ two species ~~that have the same index value (0.041)~~ , namely *Lactoria pentacantha* and *Toxotes jacula~~n~~trix.*

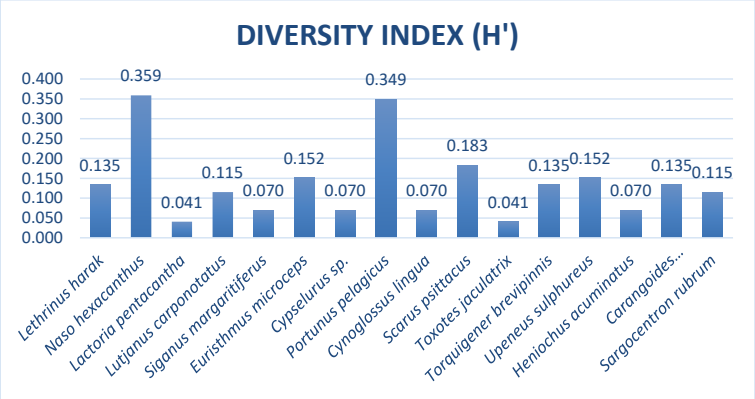

Figure 4. Value of diversity index in each type of fish.

The total value of the dominance index (Table 3~~),~~) for all species ~~the type~~ of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore, based on the overall caught fish species composition ~~caught~~, the largest dominance value (0.084) ~~in general~~ was reached by the *N. hexacanthus* species ~~obtained at the time of capture with a dominance value of 0.084~~ (Figure 5).

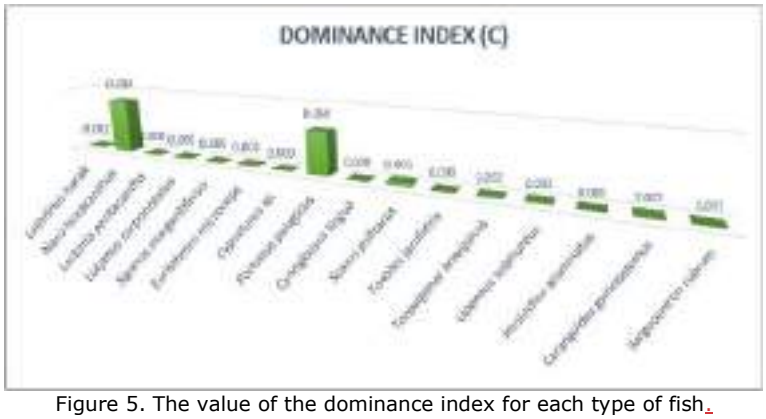

Figure 5. The value of the dominance index for each type of fish.

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. ~~In~~ At this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely *Lactoria pentacantha*, *Siganus margaritiferus*, *Cypselurus* sp., *Cynoglossus lingua*, *Toxotes jaculatrix* and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value, which means that ~~where~~ this species ~~has~~ had relatively more individuals caught than other species. ~~*Lactoria*~~ *L. pentacantha*, ~~*Siganus*~~ *S. margaritiferus*, *Cypselurus* sp., ~~*Cynoglossus*~~ *C. lingua*, ~~*Toxotes*~~ *T. jaculatrix* and ~~*Heniochus*~~ *H. acuminatus* had the lowest dominance values because these six species had the ~~least~~ lowest number of individuals compared to other species.

In accordance with ~~the opinion (~~Nugroho et al (2015) and~~;~~ Mardhan et al (2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of the fishing gear is low and therefore it is not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in the ~~a~~ waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has a high selectivity, because it ~~has~~ can ~~caught~~ catch ~~certain~~ a targeted fish. Vice versa, if the diversity index value is high, the fishing gear used has a low selectivity, because it ~~obtains~~ catches many ~~types of catch~~species (Nugroho et al 2015; Hakim & Nurhasanah 2017).

~~In this study, the results of the moderate diversity index and low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has good selectivity but is not environmentally friendly.~~

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Conclusions. The composition of the fish species caught with bottom gillnets in Kulu waters was 117 ~~fish~~ individuals, consisting of 15 species of ~~from the~~ fish ~~group~~ and 1 species of ~~from the~~ crustaceans ~~group~~. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows a moderate diversity. The dominance index value ~~of the dominance~~ of fish species caught at the research location in Kulu waters wa~~i~~s 0.169. This shows that the dominance is low. In this study, due to a moderate diversity index and a low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly

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Conflict of interest. The authors declare no conflict of interest.

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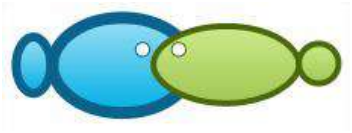

Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. The parameters observed were the species composition (Sc), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was the sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by the blue swimming crab (Portunus pelagicus) at 25.64%. The diversity index value of the fish species caught was 2.191 nd the dominance index value of the caught fish species was 0.169. In this study, the moderate diversity index and low dominance index value indicate that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly.
Key Words: *Naso hexacanthus*, *Portunus pelagicus*, Crustaceans, selective fishing gear.

Introduction. The fisheries and marine sector has a leading contribution to the programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by the coastal communities is still dominated by the coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is the bottom gillnet (Syamsuddin et al 2021). Factors that influence the success of fishing are the knowledge of the fishing ground and of the fish behavior, the fishing methods and techniques and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even though its analysis was less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others: the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020) and the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014). Efficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnets are installed perpendicularly to the water (Pondaag et al 2018) which increases the efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the body size of the fish caught allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net, so that they can develop to become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the distribution of the fish populations size, because gillnets have a high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh, so that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

In the light of the presentation above, it appears necessary to conduct a deeper research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity, as a contribution to the fisheries management in Kulu waters, North Minahasa Regency.

Material and Method. The present research was conducted in the waters of Kulu, North Minahasa Regency during 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while the case studies are focusing on a limited scope (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material was made of polyamide (PA) with a span of 30 m in length and 3 m in width for each piece of net.

The caught fish were then identified, separated by type, weighed, measured and recorded. Data analysis, using Microsoft Excel software, included the species composition (Sc), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets, with the following equation:

1) Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{xi}{X} \times 100$$

Where:
Sc - species composition (%);
xi - number of individual species-i;
X - total number of individuals of all species.

2) Diversity index (H') using the Shannon-Wiener (Krebs 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where:
H' - diversity index;
ni - number of fish for species i;
N - total individual fish for all species.

3) Dominance index (C) using the simson formula (Adelusi et al 2018; Odum 19~~93~~71) :

$$C = \sum (ni/N)^2$$

Where:
C - dominance index;
ni - number of individual species-i;
N - total number of individuals of all species.

Results and Discussion. Fishing activities using the bottom gillnets were carried during 15 trips, with 117 fish caught at the fishing ground, as shown in Figure 1.

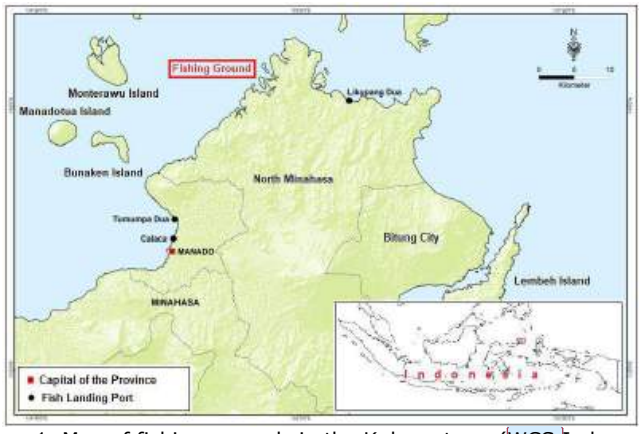

Figure 1. Map of fishing grounds in the Kulu waters (WCS Indonesia).

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Based on the data in Table 1, it can be seen that the composition of the caught consists of fish and crustacean species.

Table 1

Species composition (Sc) of fish caught

No	Scientific name of fish	Catching Trip															Total catching (fish number)	Composition (%)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	*Naso hexacanthus*	3	4	2		3	9	1	3				2	6	1		34	29.06
2	*Portunus pelagicus*		2		3	5		5	2	2	5	1	1	1	3		30	25.64
3	*Scarus psittacus*				5					1	1		1				8	6.84
4	*Upeneus sulphureus*							1		1					3	1	6	5.13
5	*Euristhmus microceps*	1				1						1			1	2	6	5.13
6	*Carangoides gymnostethus*											1		2	1	1	5	4.27
7	*Lethrinus harak*	2						1	1				1				5	4.27
8	*Torquigener brevipinnis*			5													5	4.27
9	*Lutjanus carponotatus*	2	2														4	3.42
10	*Sargocentron rubrum*															4	4	3.42
11	*Siganus margaritiferus*	2															2	1.71
12	*Cypselurus sp.*		2														2	1.71
13	*Cynoglossus lingua*								1						1		2	1.71
14	*Heniochus acuminatus*					2											2	1.71
15	*Lactoria pentacantha*	1															1	0.85
16	*Toxotes jaculatrix*				1												1	0.85
Caught fish number		11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100

per trip															
Amount of fish (individuals)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4
Avg. Catch Rate (fish number trip^{-1}t)															7.8

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In Figure 2, it can be seen that the most caught type of fish is sleek unicornfish (~~*Naso*~~ *N. hexacanthus*) as much as 29.06%, followed by crustaceans, namely blue swimming crab (~~*Portunus*~~ *P. pelagicus*) as much as 25.64%.

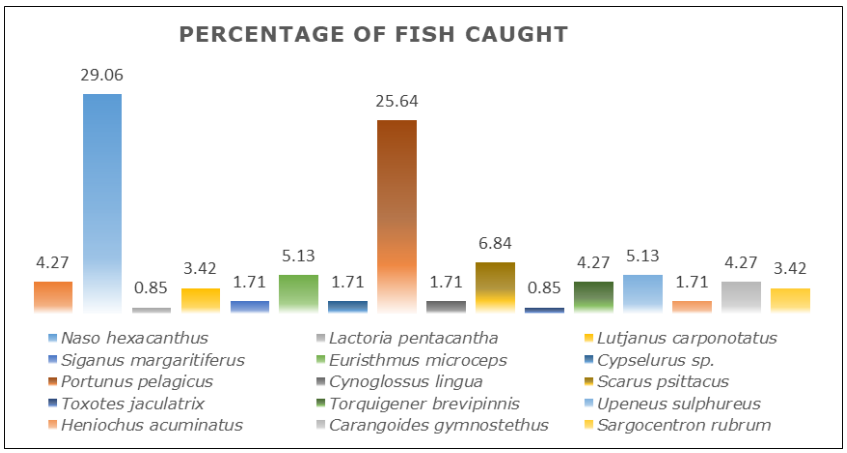

Figure 2. Percentage of fish caught by bottom gillnet.

The following are pictures of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa:

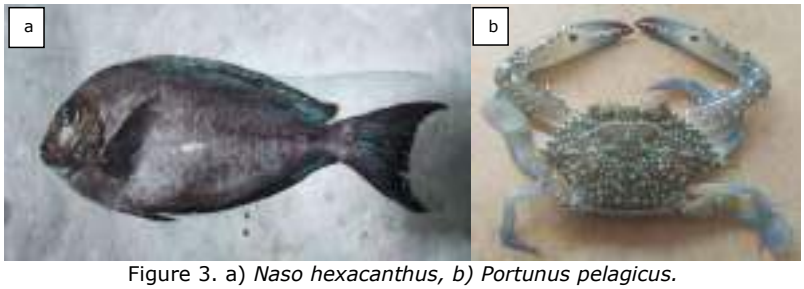

Figure 3. a) *Naso hexacanthus, b) Portunus pelagicus.*

The number of fish caught with bottom gillnets was 117 individuals of 16 species. The average numbers of catches and of fish species were 7.8 and 3.5, respectively. The type of fish that was caught the most were *N. hexacanthus*, 34 individuals (29.06%), followed by *P. pelagicus,* 30 individuals (25.64%). The abundance of *N. hexacanthus* is due to the Kulu waters, which are a good habitat where food is abundant. In addition, the bottom of the water is sandy. The catch weight composition by type of fish caught is presented in table 2 below.

Table 2

Composition of weight (Kg) of caught fish

Scientific Name	Catching trips															Amount (Kg)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus Sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

In Table 2 above, it can be seen that *P. pelagicus* contributed with 7.53 kg (33.55%) and *N. hexacanthus* with 4.21 kg (18.77) to the total weight of the fish caught. In the species composition, *N. hexacanthus* was dominant (the most often caught), but in the weight composition, *P. pelagicus* was dominant.
The total value of the diversity index (Table 3) for the types of fish caught is 2.191.

Table 3

Diversity and dominance index results

No	*Scientific name*	*H' (Diversity)*	*C (Dominance index)*
1	*Lethrinus harak*	0.135	0.002
2	*Naso hexacanthus*	0.359	0.084
3	*Lactoria pentacantha*	0.041	0.000
4	*Lutjanus carponotatus*	0.115	0.001
5	*Siganus margaritiferus*	0.070	0.000
6	*Euristhmus microceps*	0.152	0.003
7	*Cypselurus sp.*	0.070	0.000
8	*Portunus pelagicus*	0.349	0.066
9	*Cynoglossus lingua*	0.070	0.000
10	*Scarus psittacus*	0.183	0.005
11	*Toxotes jaculatrix*	0.041	0.000
12	*Torquigener brevipinnis*	0.135	0.002
13	*Upeneus sulphureus*	0.152	0.003

14	*Heniochus acuminatus*	0.070	0.000
15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

Based on the diversity index criteria presented in table 4 (Shanon Wiener index criteria), these results indicate a moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe, 2010)

Index	Value	Category
Diversity	$H' \leq 2.0$	Low
	$2.0 < H' \leq 3.0$	Moderate
	$H' \geq 3.0$	High

The dominance index criteria in table 5 (Rappe 2010) state that when the dominance index (ranging from 0 to 1) has the value 1, it indicates a very high dominance by one species (only one species at one station), while when the index is 0, this indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe 2010)

Index	Value	Category
Dominance	$0.0 < C \leq 0.5$	Low
	$0.5 > C \leq 0.75$	Moderate
	$0.75 < C \leq 1$	High

In Figure 4 it can be seen that the highest species diversity index value is reached by *N. hexacanthus*, 0.359, and the lowest value (0.041) is reached by two species, namely ~~*Lactoria*~~ *L. pentacantha* and ~~*Toxotes*~~ *T. jaculatrix.*

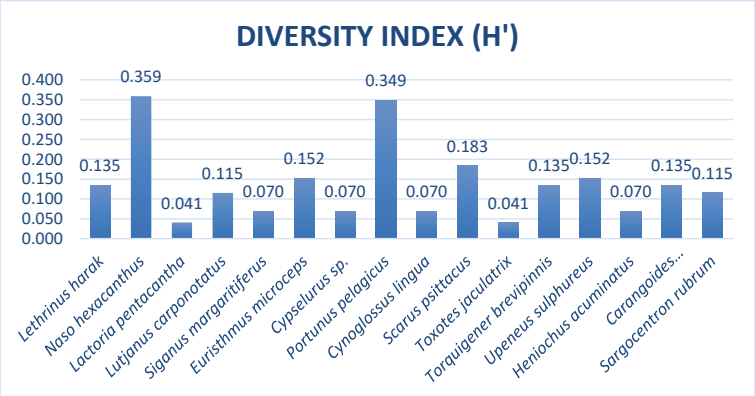

Figure 4. Value of diversity index in each type of fish.

The total value of the dominance index (Table 3) for all species of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore,

based on the overall caught fish species composition, the largest dominance value (0.084) was reached by the *N. hexacanthus* species (Figure 5).

Figure 5. The value of the dominance index for each type of fish.

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. At this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely ~~*Lactoria*~~ *L. pentacantha*, ~~*Siganus*~~ *S. margaritiferus*, *Cypselurus* sp., ~~*Cynoglossus*~~ *C. lingua*, *Toxotes jaculatrix* and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value, which means that this species had relatively more individuals caught than other species. *L.pentacantha*, *S. margaritiferus*, *Cypselurus* sp., *C. lingua*, *T. jaculatrix* and *H. acuminatus* had the lowest dominance values because these six species had the lowest number of individuals compared to other species.

In accordance with Nugroho et al (2015) and Mardhan et al (2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of the fishing gear is low and therefore it is not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in the waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has a high selectivity, because it can catch a targeted fish. Vice versa, if the diversity index value is high, the fishing gear used has a low selectivity, because it catches many species (Nugroho et al 2015; Hakim & Nurhasanah 2017).

Conclusions. The composition of the fish species caught with bottom gillnets in Kulu waters was 117 individuals, consisting of 15 species of fish and 1 species of crustaceans. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows a moderate diversity. The dominance index value of fish species caught at the research location in Kulu waters was 0.169. This shows that the dominance is low. In this study, due to a moderate diversity index and a low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly.

Conflict of interest. The authors declare no conflict of interest.

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*** Wildlife Conservation Society (WCS) Indonesia www.data-ikan.org

Commented [WU8]: No abbreviations.

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Questions

Eni Kovacs <ek.bioflux@gmail.com>
Kepada: erick nugraha

Rab, 22 Sep 2021 jam 03.42

Dear Dr. Nugraha,

Apologies, but we have some questions related to the article before publishing, please find the comments in the manuscript.

Thank you.

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Kind regards,
Editor AACL Bioflux
Eniko Kovacs

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Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. The parameters observed were the species composition (Sc), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was the sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by the blue swimming crab (*Portunus pelagicus*) at 25.64%. The diversity index value of the fish species caught was 2.191 nd the dominance index value of the caught fish species was 0.169. In this study, the moderate diversity index and low dominance index value indicate that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly.
Key Words: *Naso hexacanthus*, *Portunus pelagicus*, crustaceans, selective fishing gear.

Introduction. The fisheries and marine sector has a leading contribution to the programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by the coastal communities is still dominated by the coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is the bottom gill net (Syamsuddin et al 2021). Factors that influence the success of fishing are the knowledge of the fishing ground and of the fish behavior, the fishing methods and techniques and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even though its analysis was less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others: the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020) and the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014). Efficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnets are installed perpendicularly to the water (Pondaag et al 2018) which increases the efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the body size of the fish caught allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net, so that they can develop to become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the distribution of the fish populations' size, because gillnets have a high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh, so that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

In the light of the presentation above, it appears necessary to conduct a deeper research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity, as a contribution to the fisheries management in Kulu waters, North Minahasa Regency.

Material and Method. The present research was conducted in the waters of Kulu, North Minahasa Regency during 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while the case studies are focusing on a limited scope (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material was made of polyamide (PA) with a span of 30 m in length and 3 m in width for each piece of net.

The caught fish were then identified, separated by type, weighed, measured and recorded. Data analysis, using Microsoft Excel software, included the species composition (Sc), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets, with the following equation:

1) Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{xi}{X} \times 100$$

Where:
Sc - species composition (%);
xi - number of individual species-i;
X - total number of individuals of all species.

2) Diversity index (H') using the Shannon-Wiener formula (Krebs 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where:
H'- diversity index;
ni - number of fish for species i;
N - total individual fish for all species.

3) Dominance index (C) using the Simson formula (Adelusi et al 2018; Odum 1971):

$$C = \sum (ni/N)^2$$

Where:
C - dominance index;
ni - number of individual species-i;
N - total number of individuals of all species.

Results and Discussion. Fishing activities using the bottom gillnets were carried during 15 trips, with 117 fish caught at the fishing ground, as shown in Figure 1.

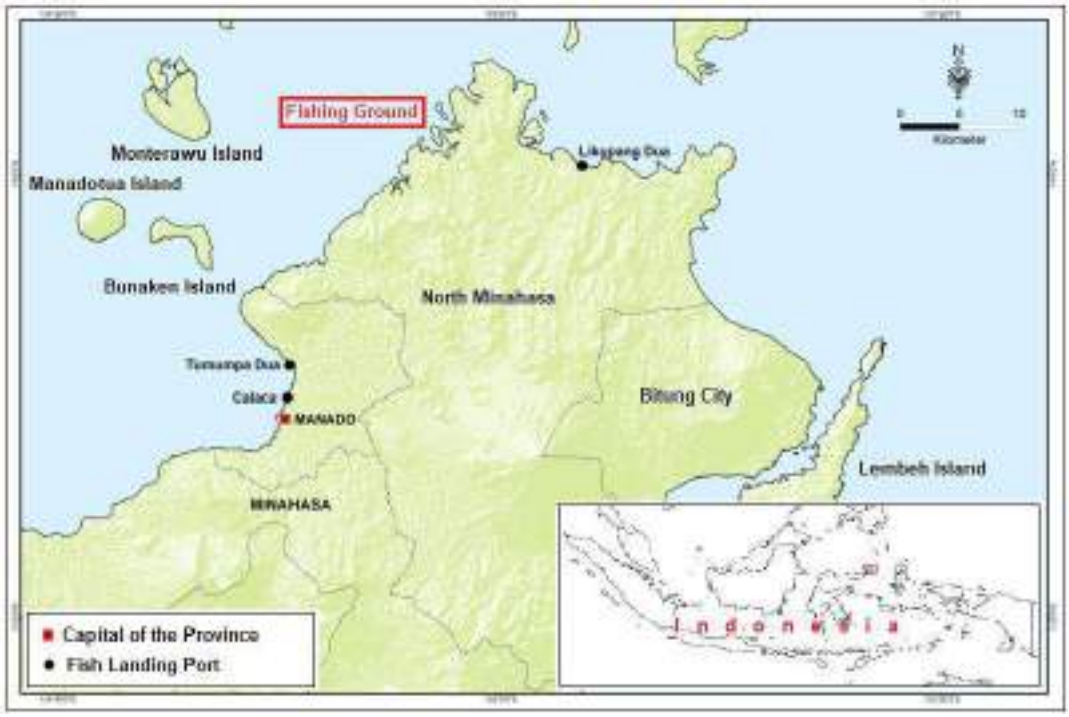

Figure 1. Map of fishing grounds in the Kulu waters (Wildlife Conservation Society Indonesia).

In Figure 2, it can be seen that the most caught type of fish was sleek unicornfish (*Naso hexacanthus*), as much as 29.06%, followed by crustaceans, namely blue swimming crab (*Portunus pelagicus*) as much as 25.64%.

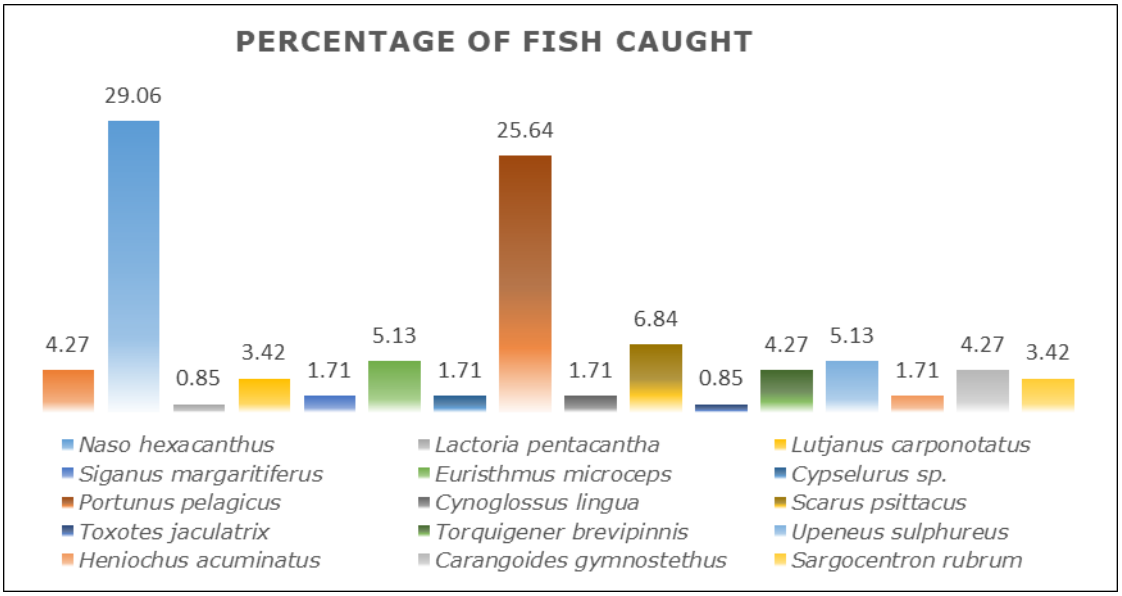

Figure 2. Percentage of fish caught by bottom gillnet.

The following are pictures of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa (Figure 3).

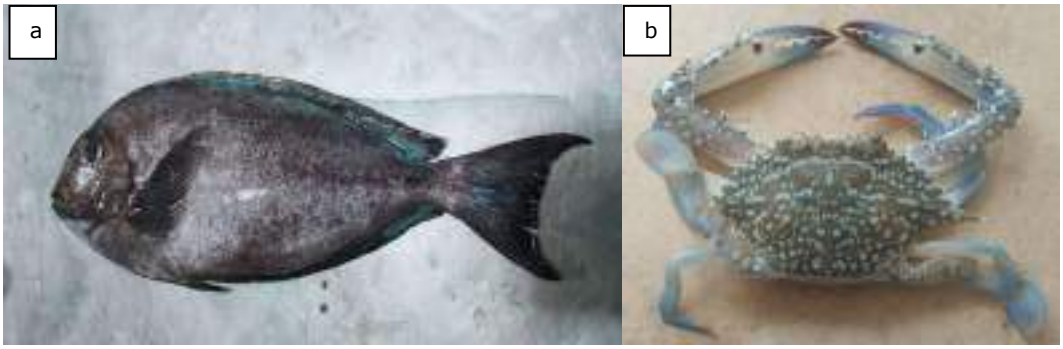

Figure 3. a) *Naso hexacanthus*, *b) Portunus pelagicus.*

Based on the data in Table 1, it can be seen that the composition of the caught consists of fish and crustacean species.

The number of fish caught with bottom gillnets was 117 individuals of 16 species. The average numbers of catches and of fish species were 7.8 and 3.5, respectively. The type of fish that was caught the most were *N. hexacanthus*, 34 individuals (29.06%), followed by *P. pelagicus*, 30 individuals (25.64%). The abundance of *N. hexacanthus* is due to the Kulu waters, which are a good habitat where food is abundant. In addition, the bottom of the water is sandy. The catch weight composition by type of fish caught is presented in Table 2.

In Table 2, it can be seen that *P. pelagicus* contributed with 7.53 kg (33.55%) and *N. hexacanthus* with 4.21 kg (18.77) to the total weight of the fish caught. In the species composition, *N. hexacanthus* was dominant (the most often caught), but in the weight composition, *P. pelagicus* was dominant.

The total value of the diversity index (Table 3) for the types of fish caught is 2.191.

Table 3

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No	*Scientific name*	*H' (Diversity)*	*C (Dominance index)*
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15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

Table 1

Species composition (Sc) of fish caught

Scientific name of fish	Catching trip															Total catching (fish number)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	3	4	2		3	9	1	3				2	6	1		34	29.06
Portunus pelagicus		2		3	5		5	2	2	5	1	1	1	3		30	25.64
Scarus psittacus				5					1	1		1				8	6.84
Upeneus sulphureus							1		1					3	1	6	5.13
Euristhmus microceps	1				1						1			1	2	6	5.13
Carangoides gymnostethus											1		2	1	1	5	4.27
Lethrinus harak	2						1	1				1				5	4.27
Torquigener brevipinnis			5													5	4.27
Lutjanus carponotatus	2	2														4	3.42
Sargocentron rubrum															4	4	3.42
Siganus margaritiferus	2															2	1.71
Cypselurus sp.		2														2	1.71
Cynoglossus lingua								1						1		2	1.71
Heniochus acuminatus					2											2	1.71
Lactoria pentacantha	1															1	0.85
Toxotes jaculatrix				1												1	0.85
Caught fish number trip^{-1}	11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100
Amount of fish (individuals)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		
Avg. catch rate (fish number trip^{-1})																7.8	

Table 2

Composition of weight (kg) of caught fish

Scientific name	Catching trips															Amount	Composition
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(kg)	(%)
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

Based on the diversity index criteria presented in Table 4 (Shanon Wiener index criteria), these results indicate a moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe 2010)

Index	Value	Category
Diversity	H′ ≤ 2.0	Low
	2.0 < H′ ≤ 3.0	Moderate
	H′ ≥ 3.0	High

The dominance index criteria in Table 5 (Rappe 2010) state that when the dominance index (ranging from 0 to 1) has the value 1, it indicates a very high dominance by one species (only one species at one station), while when the index is 0, this indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe 2010)

Index	Value	Category
Dominance	0.0 < C ≤ 0.5	Low
	0.5 > C ≤ 0.75	Moderate
	0.75 < C ≤ 1	High

In Figure 4 it can be seen that the highest species diversity index value is reached by *N. hexacanthus*, 0.359, and the lowest value (0.041) is reached by two species, namely *Lactoria pentacantha* and *Toxotes jaculatrix.*

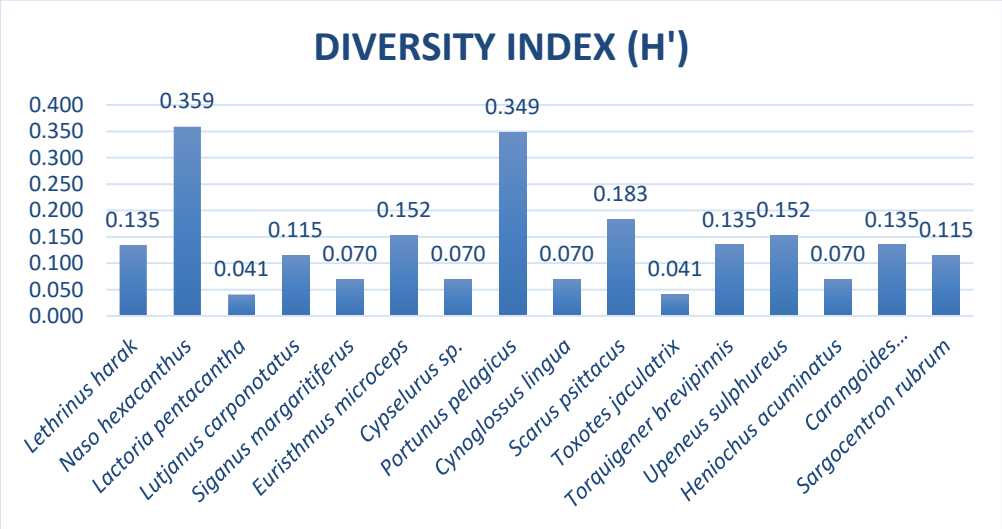

Figure 4. Value of diversity index in each type of fish.

The total value of the dominance index (Table 3) for all species of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore, based on the overall caught fish species composition, the largest dominance value (0.084) was reached by the *N. hexacanthus* species (Figure 5).

Figure 5. The value of the dominance index for each type of fish.

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. At this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely *L. pentacantha*, *Siganus margaritiferus*, *Cypselurus* sp., *Cynoglossus lingua*, *T. jaculatrix* and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value, which means that this species had relatively more individuals caught than other species. *L. pentacantha*, *S. margaritiferus*, *Cypselurus* sp., *C. lingua*, *T. jaculatrix* and *H. acuminatus* had the lowest dominance values because these six species had the lowest number of individuals compared to other species.

In accordance with Nugroho et al (2015) and Mardhan et al (2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of the fishing gear is low and therefore it is not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in the waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has a high selectivity, because it can catch a targeted fish. Vice versa, if the diversity index value is high, the fishing gear used has a low selectivity, because it catches many species (Nugroho et al 2015; Hakim & Nurhasanah 2017).

Conclusions. The composition of the fish species caught with bottom gillnets in Kulu waters was 117 individuals, consisting of 15 species of fish and 1 species of crustaceans. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows a moderate diversity. The dominance index value of fish species caught at the research location in Kulu waters was 0.169. This shows that the dominance is low. In this study, due to a moderate diversity index and a low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly

Conflict of interest. The authors declare no conflict of interest.

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Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. The parameters observed were the species composition (Sc), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was the sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by the blue swimming crab (*Portunus pelagicus*) at 25.64%. The diversity index value of the fish species caught was 2.191 nd the dominance index value of the caught fish species was 0.169. In this study, the moderate diversity index and low dominance index value indicate that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly.
Key Words: *Naso hexacanthus*, *Portunus pelagicus*, crustaceans, selective fishing gear.

Introduction. The fisheries and marine sector has a leading contribution to the programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by the coastal communities is still dominated by the coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is the bottom gill net (Syamsuddin et al 2021). Factors that influence the success of fishing are the knowledge of the fishing ground and of the fish behavior, the fishing methods and techniques and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even though its analysis was less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others: the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020) and the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014). Efficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnets are installed perpendicularly to the water (Pondaag et al 2018) which increases the efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the body size of the fish caught allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net, so that they can develop to become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the distribution of the fish populations' size, because gillnets have a high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh, so that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

In the light of the presentation above, it appears necessary to conduct a deeper research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity, as a contribution to the fisheries management in Kulu waters, North Minahasa Regency.

Material and Method. The present research was conducted in the waters of Kulu, North Minahasa Regency during 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while the case studies are focusing on a limited scope (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material was made of polyamide (PA) with a span of 30 m in length and 3 m in width for each piece of net.

The caught fish were then identified, separated by type, weighed, measured and recorded. Data analysis, using Microsoft Excel software, included the species composition (Sc), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets, with the following equation:

1) Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{xi}{X} \times 100$$

Where:
Sc - species composition (%);
xi - number of individual species-i;
X - total number of individuals of all species.

2) Diversity index (H') using the Shannon-Wiener formula (Krebs 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where:
H'- diversity index;
ni - number of fish for species i;
N - total individual fish for all species.

3) Dominance index (C) using the Simson formula (Adelusi et al 2018; Odum 1971):

$$C = \sum (ni/N)^2$$

Where:
C - dominance index;
ni - number of individual species-i;
N - total number of individuals of all species.

Results and Discussion. Fishing activities using the bottom gillnets were carried during 15 trips, with 117 fish caught at the fishing ground, as shown in Figure 1.

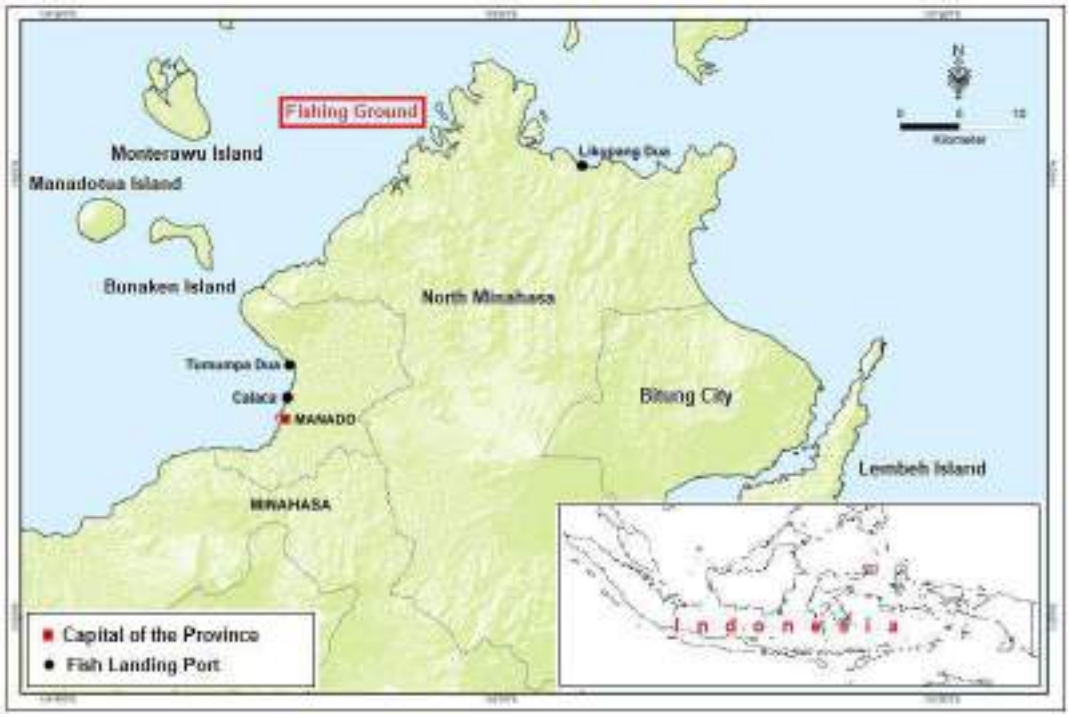

Figure 1. Map of fishing grounds in the Kulu waters (Wildlife Conservation Society Indonesia).

In Figure 2, it can be seen that the most caught type of fish was sleek unicornfish (*Naso hexacanthus*), as much as 29.06%, followed by crustaceans, namely blue swimming crab (*Portunus pelagicus*) as much as 25.64%.

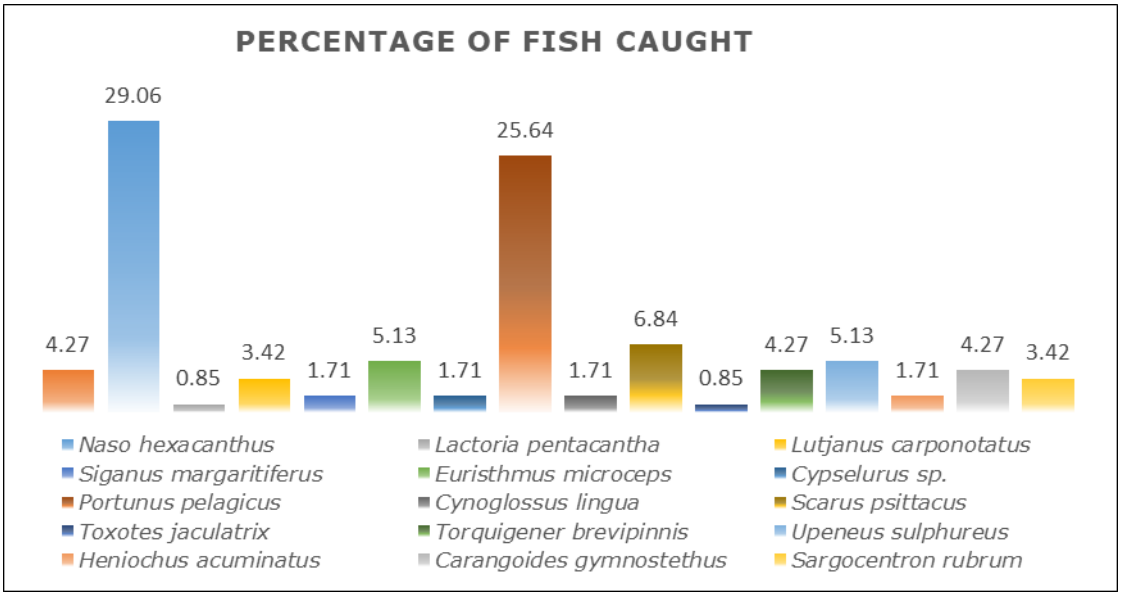

Figure 2. Percentage of fish caught by bottom gillnet.

The following are pictures of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa (Figure 3).

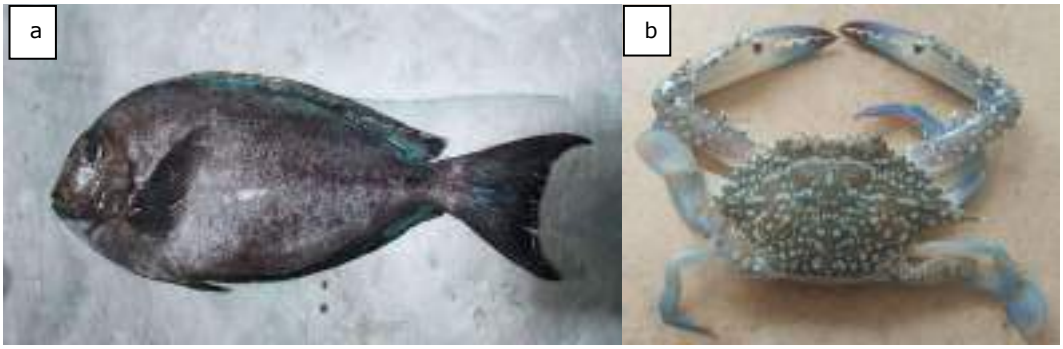

Figure 3. a) *Naso hexacanthus*, *b) Portunus pelagicus.*

Based on the data in Table 1, it can be seen that the composition of the caught consists of fish and crustacean species.

The number of fish caught with bottom gillnets was 117 individuals of 16 species. The average numbers of catches and of fish species were 7.8 and 3.5, respectively. The type of fish that was caught the most were *N. hexacanthus*, 34 individuals (29.06%), followed by *P. pelagicus*, 30 individuals (25.64%). The abundance of *N. hexacanthus* is due to the Kulu waters, which are a good habitat where food is abundant. In addition, the bottom of the water is sandy. The catch weight composition by type of fish caught is presented in Table 2.

In Table 2, it can be seen that *P. pelagicus* contributed with 7.53 kg (33.55%) and *N. hexacanthus* with 4.21 kg (18.77) to the total weight of the fish caught. In the species composition, *N. hexacanthus* was dominant (the most often caught), but in the weight composition, *P. pelagicus* was dominant.

The total value of the diversity index (Table 3) for the types of fish caught is 2.191.

Table 3

Diversity and dominance index results

No	*Scientific name*	*H' (Diversity)*	*C (Dominance index)*
1	*Lethrinus harak*	0.135	0.002
2	*Naso hexacanthus*	0.359	0.084
3	*Lactoria pentacantha*	0.041	0.000
4	*Lutjanus carponotatus*	0.115	0.001
5	*Siganus margaritiferus*	0.070	0.000
6	*Euristhmus microceps*	0.152	0.003
7	*Cypselurus* sp.	0.070	0.000
8	*Portunus pelagicus*	0.349	0.066
9	*Cynoglossus lingua*	0.070	0.000
10	*Scarus psittacus*	0.183	0.005
11	*Toxotes jaculatrix*	0.041	0.000
12	*Torquigener brevipinnis*	0.135	0.002
13	*Upeneus sulphureus*	0.152	0.003
14	*Heniochus acuminatus*	0.070	0.000
15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

Table 1

Species composition (Sc) of fish caught

Scientific name of fish	Catching trip															Total catching (fish number)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	3	4	2		3	9	1	3				2	6	1		34	29.06
Portunus pelagicus		2		3	5		5	2	2	5	1	1	1	3		30	25.64
Scarus psittacus				5					1	1		1				8	6.84
Upeneus sulphureus							1		1					3	1	6	5.13
Euristhmus microceps	1				1						1			1	2	6	5.13
Carangoides gymnostethus											1		2	1	1	5	4.27
Lethrinus harak	2						1	1				1				5	4.27
Torquigener brevipinnis			5													5	4.27
Lutjanus carponotatus	2	2														4	3.42
Sargocentron rubrum															4	4	3.42
Siganus margaritiferus	2															2	1.71
Cypselurus sp.		2														2	1.71
Cynoglossus lingua								1						1		2	1.71
Heniochus acuminatus					2											2	1.71
Lactoria pentacantha	1															1	0.85
Toxotes jaculatrix				1												1	0.85
Caught fish number trip^{-1}	11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100
Amount of fish (individuals)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		
Avg. catch rate (fish number trip^{-1})																7.8	

Table 2

Composition of weight (kg) of caught fish

Scientific name	Catching trips															Amount	Composition
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(kg)	(%)
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

Based on the diversity index criteria presented in Table 4 (Shanon Wiener index criteria), these results indicate a moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe 2010)

Index	Value	Category
Diversity	H′ ≤ 2.0	Low
	2.0 < H′ ≤ 3.0	Moderate
	H′ ≥ 3.0	High

The dominance index criteria in Table 5 (Rappe 2010) state that when the dominance index (ranging from 0 to 1) has the value 1, it indicates a very high dominance by one species (only one species at one station), while when the index is 0, this indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe 2010)

Index	Value	Category
Dominance	0.0 < C ≤ 0.5	Low
	0.5 > C ≤ 0.75	Moderate
	0.75 < C ≤ 1	High

In Figure 4 it can be seen that the highest species diversity index value is reached by *N. hexacanthus*, 0.359, and the lowest value (0.041) is reached by two species, namely *Lactoria pentacantha* and *Toxotes jaculatrix.*

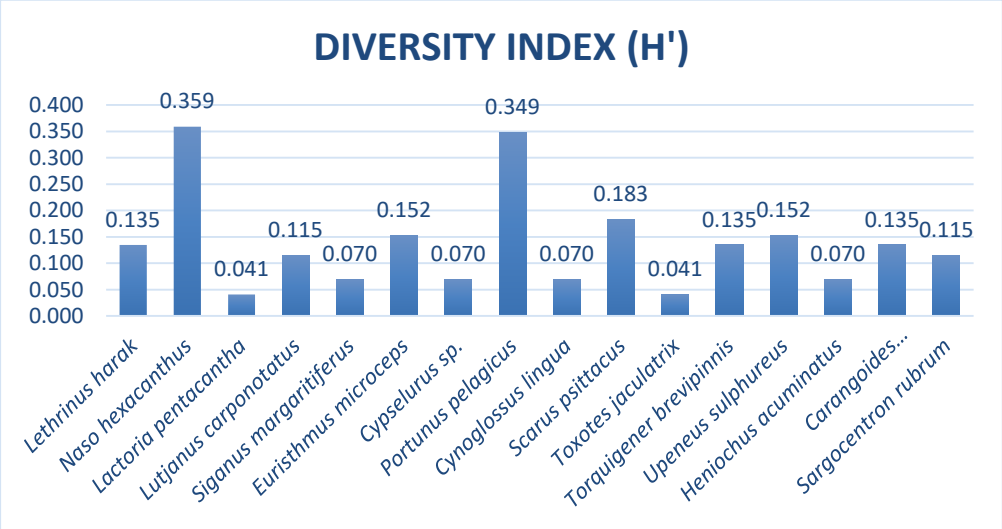

Figure 4. Value of diversity index in each type of fish.

The total value of the dominance index (Table 3) for all species of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore, based on the overall caught fish species composition, the largest dominance value (0.084) was reached by the *N. hexacanthus* species (Figure 5).

Figure 5. The value of the dominance index for each type of fish.

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. At this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely *L. pentacantha*, *Siganus margaritiferus*, *Cypselurus* sp., *Cynoglossus lingua*, *T. jaculatrix* and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value, which means that this species had relatively more individuals caught than other species. *L. pentacantha*, *S. margaritiferus*, *Cypselurus* sp., *C. lingua*, *T. jaculatrix* and *H. acuminatus* had the lowest dominance values because these six species had the lowest number of individuals compared to other species.

In accordance with Nugroho et al (2015) and Mardhan et al (2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of the fishing gear is low and therefore it is not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in the waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has a high selectivity, because it can catch a targeted fish. Vice versa, if the diversity index value is high, the fishing gear used has a low selectivity, because it catches many species (Nugroho et al 2015; Hakim & Nurhasanah 2017).

Conclusions. The composition of the fish species caught with bottom gillnets in Kulu waters was 117 individuals, consisting of 15 species of fish and 1 species of crustaceans. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows a moderate diversity. The dominance index value of fish species caught at the research location in Kulu waters was 0.169. This shows that the dominance is low. In this study, due to a moderate diversity index and a low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly

Conflict of interest. The authors declare no conflict of interest.

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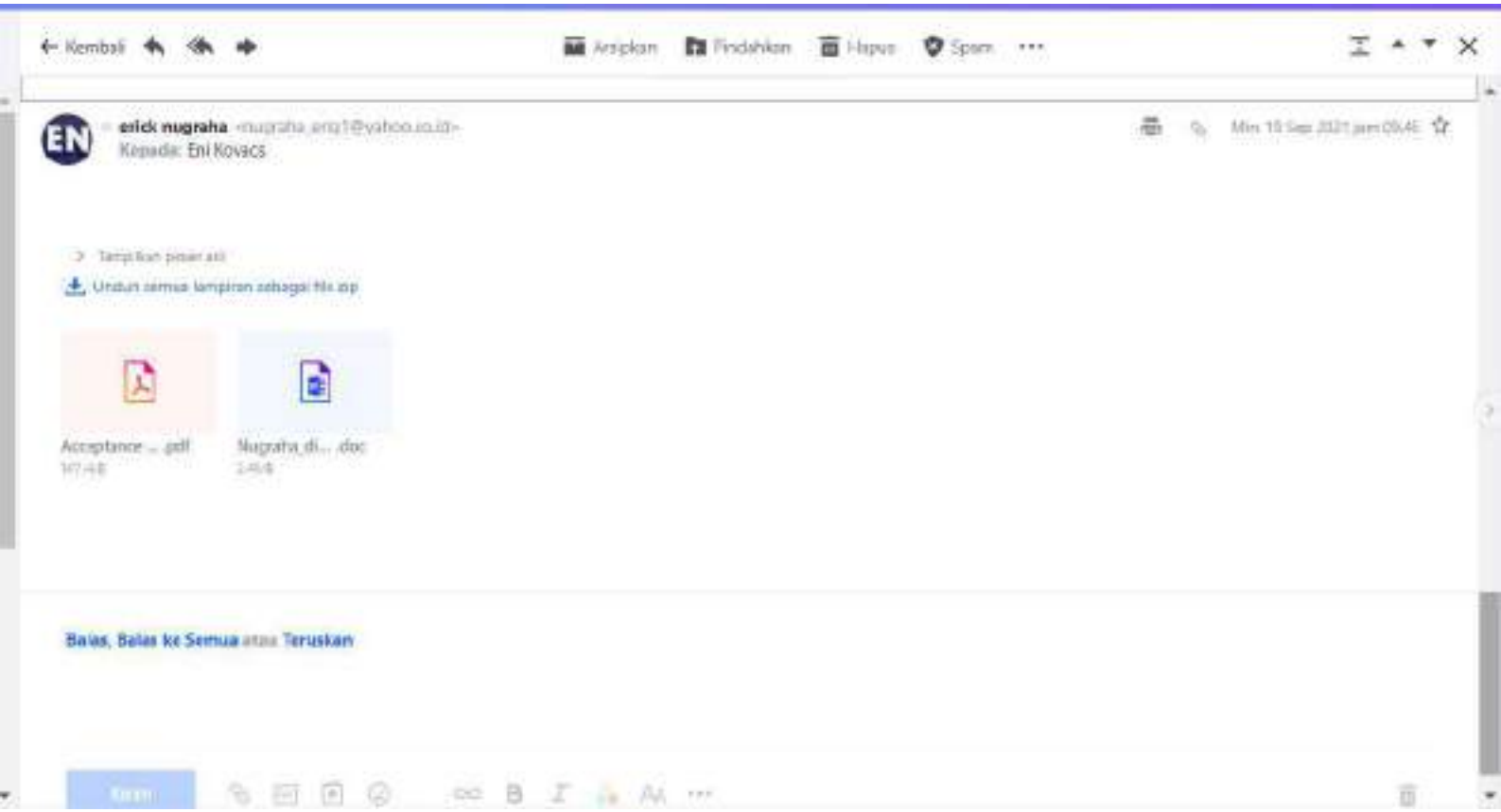
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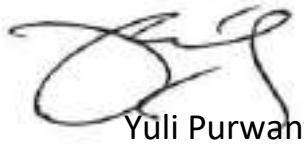
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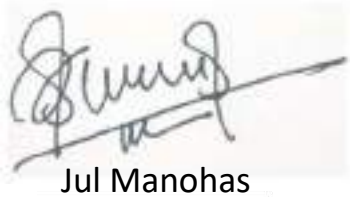
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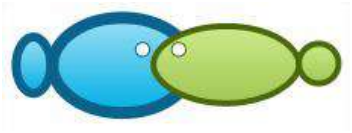

Analysis of the diversity index and dominance of bottom gillnet catches in Kulu waters, North Minahasa Regency, Indonesia

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Abstract. The purpose of this study was to determine the composition of the type of catch, the level of diversity and the dominance index. This research was carried out in the Kulu waters, North Minahasa Regency, from November to December 2020. The fishing gear used was a bottom gillnet with a mesh size of 3 inches. The parameters observed were the species composition (Sc), diversity index (H') and dominance index (C). The results showed that the composition of the dominant fish species caught was the sleek unicornfish (*Naso hexacanthus*) which was 29.06%, followed by the blue swimming crab (*Portunus pelagicus*) at 25.64%. The diversity index value of the fish species caught was 2.191 and the dominance index value of the caught fish species was 0.169. In this study, the moderate diversity index and low dominance index value indicate that the bottom gillnet in Kulu waters has a good selectivity, but it is not environmentally friendly.
Key Words: *Naso hexacanthus*, *Portunus pelagicus*, crustaceans, selective fishing gear.

Introduction. The fisheries and the marine sector has a leading contribution to the programs for economic development in North Sulawesi (Tatali et al 2013). The utilization of fishery resources by the coastal communities is still dominated by the coastal fisheries (Dahuri 2001). One type of fishing gear that is widely used by fishermen is the bottom gillnet (Syamsuddin et al 2021). Factors that influence the success of fishing are the knowledge of the fishing ground and of the fish behavior, the fishing methods and techniques and the fishing gear used (Matsuoka 1995; Lubis 1985; Mvula 2009). The problem of environmentally friendly fishing technology has received attention for a long time even though its analysis was less detailed (Anggraini et al 2018).

The selection of fishing gear includes several criteria, among others: the species of fish to be caught, the economic value of the fish, the depth of the waters, the characteristics of the bottom of the waters (if the fishing gear is operated at the bottom of the water) (FAO 2020) and the selectivity of the fishing gear (to avoid bycatch or endangered species) (Carles et al 2014). Efficient and selective fishing methods can also reduce the current over fishing (Putri et al 2018).

Gillnets are installed perpendicularly to the water (Pondaag et al 2018) which increases the efficiency and selectivity, because they are rectangular in shape and tend to have a certain mesh size (King 1995). Gillnet is a selective fishing gear because the body size of the fish caught allows them to be entangled in the mesh size. Fish that are smaller than the mesh size gillnet will escape from the net, so that they can develop to become adults (Making et al 2014; Hantardi et al 2013; Emmanuel et al 2008). Gillnets are also used as a sampling tool in estimating the distribution of the fish populations' size, because gillnets have a high catch selectivity (Henderson & Nepszy 1992; Faife & Einarsson 2003; Hickford et al 2010).

This fishing gear is widely used by fishermen in Kulu village, North Minahasa Regency because it has several advantages, including being easy to operate and relatively inexpensive (Rifai et al 2019). The mesh size used in gillnets is generally adjusted to the size of the fish being the target of catching (Fitri et al 2021; Subani & Barus 1989). Thus, the catch is expected to be dominated by fish whose size corresponds to the size of the mesh, so that the sustainability of fish resources will be maintained (Zamil 2007; Sutriyono et al 2017).

In the light of the presentation above, it appears necessary to conduct a deeper research on fish catches with bottom gillnets to provide scientific information about the types of catches and fish diversity, as a contribution to the fisheries management in Kulu waters, North Minahasa Regency.

Material and Method. The present research was conducted in the waters of Kulu, North Minahasa Regency during 15 fishing trips starting from November to December 2020. This research was carried out by following a descriptive method based on case studies and using experimental fishing methods, while the case studies are focusing on a limited scope (Nazir 1985). The data collection technique was carried out by operating a bottom gillnet with a mesh size of 3 inches. The net material was made of polyamide (PA) with a span of 30 m in length and 3 m in width for each piece of net.

The caught fish were then identified, separated by type, weighed, measured and recorded. Data analysis, using Microsoft Excel software, included the species composition (Sc), Diversity index (H') and dominance index. Furthermore, the catch data were analyzed for composition based on the type and weight of the catch with basic gillnets, with the following equation:

1. Species composition (Sc) is the number of i-species per the total number of individuals caught, with the following formula (Greenstreet et al 2007; Samitra & Rozi 2018):

$$Sc = \frac{xi}{X} \times 100$$

Where:
Sc - species composition (%);
xi - number of individual species-i;
X - total number of individuals of all species.

2. Diversity index (H') using the Shannon-Wiener formula (Krebs 1989; Speelerberg & Fedor 2003).

$$H' = - [(ni/N) / Ln (ni/N)]$$

Where:
H'- diversity index;
ni - number of fish for species i;
N - total individual fish for all species.

3. Dominance index (C) using the Simson formula (Adelusi et al 2018; Odum 1971):

$$C = \sum (ni/N)^2$$

Where:
C - dominance index;
ni - number of individual species-i;
N - total number of individuals of all species.

Results and Discussion. Fishing activities using the bottom gillnets were carried during 15 trips, with 117 fish caught at the fishing ground, as shown in Figure 1.

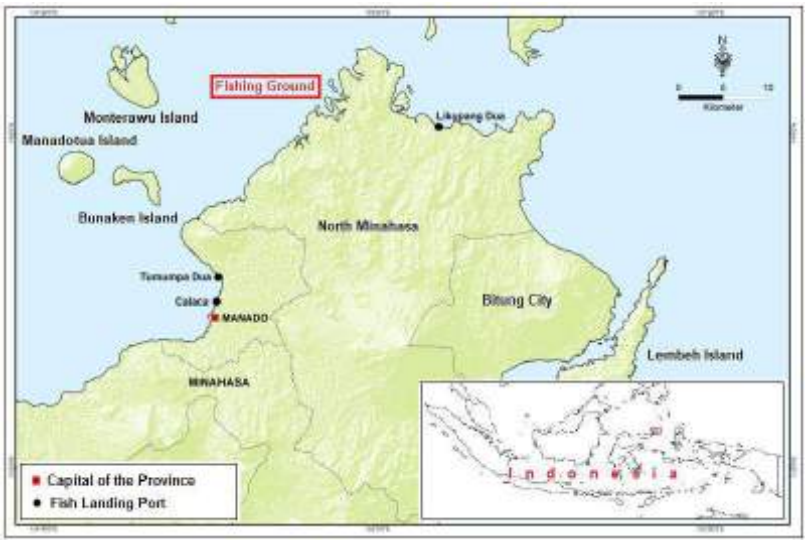

Figure 1. Map of fishing grounds in the Kulu waters (Wildlife Conservation Society Indonesia).

In Figure 2, it can be seen that the most caught type of fish was sleek unicornfish (*Naso hexacanthus*), as much as 29.06%, followed by crustaceans, namely blue swimming crab (*Portunus pelagicus*) as much as 25.64%.

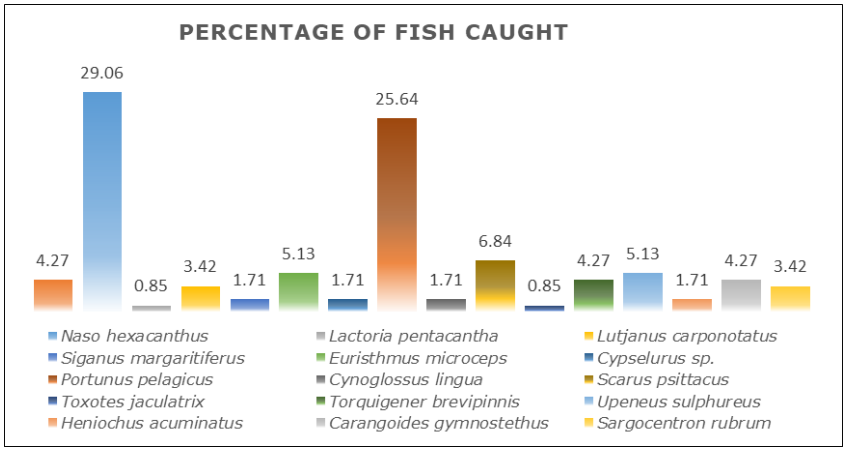

Figure 2. Percentage of fish caught by bottom gillnet.

The following are pictures of the dominant types of fish and crustaceans caught in the Kulu waters, North Minahasa (Figure 3).

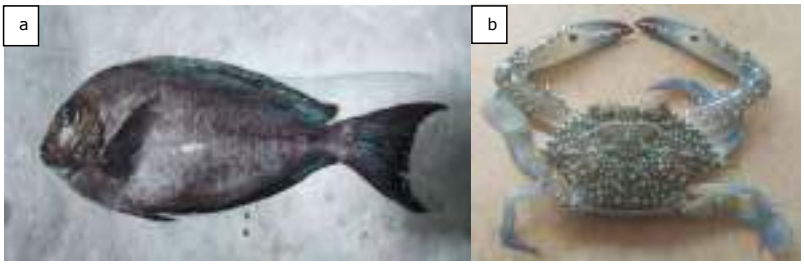

Figure 3. a) *Naso hexacanthus*, *b) Portunus pelagicus.*

The total value of the diversity index (Table 1) for the types of fish caught is 2.191.

Table 1

Diversity and dominance index results

No	*Scientific name*	*H' (Diversity)*	*C (Dominance index)*
1	*Lethrinus harak*	0.135	0.002
2	*Naso hexacanthus*	0.359	0.084
3	*Lactoria pentacantha*	0.041	0.000
4	*Lutjanus carponotatus*	0.115	0.001
5	*Siganus margaritiferus*	0.070	0.000
6	*Euristhmus microceps*	0.152	0.003
7	*Cypselurus* sp.	0.070	0.000
8	*Portunus pelagicus*	0.349	0.066
9	*Cynoglossus lingua*	0.070	0.000
10	*Scarus psittacus*	0.183	0.005
11	*Toxotes jaculatrix*	0.041	0.000
12	*Torquigener brevipinnis*	0.135	0.002
13	*Upeneus sulphureus*	0.152	0.003
14	*Heniochus acuminatus*	0.070	0.000
15	*Carangoides gymnostethus*	0.135	0.002
16	*Sargocentron rubrum*	0.115	0.001
	TOTAL	2.191	0.169

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Do you agree?

Based on the data in Table 2, it can be seen that the composition of the caught consists of fish and crustacean species.

The number of fish caught with bottom gillnets was 117 individuals of 16 species. The average numbers of catches and of fish species were 7.8 and 3.5, respectively. The type of fish that was caught the most were *N. hexacanthus*, 34 individuals (29.06%), followed by *P. pelagicus*, 30 individuals (25.64%). The abundance of *N. hexacanthus* is due to the Kulu waters, which are a good habitat where food is abundant. In addition, the bottom of the water is sandy. The catch weight composition by type of fish caught is presented in Table 3.

In Table 3, it can be seen that *P. pelagicus* contributed with 7.53 kg (33.55%) and *N. hexacanthus* with 4.21 kg (18.77) to the total weight of the fish caught. In the species composition, *N. hexacanthus* was dominant (the most often caught), but in the weight composition, *P. pelagicus* was dominant.

Table 2

Species composition (Sc) of fish caught

Scientific name of fish	Catching trip															Total catching (fish number)	Composition (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Naso hexacanthus	3	4	2		3	9	1	3				2	6	1		34	29.06
Portunus pelagicus		2		3	5		5	2	2	5	1	1	1	3		30	25.64
Scarus psittacus				5					1	1		1				8	6.84
Upeneus sulphureus							1		1					3	1	6	5.13
Euristhmus microceps	1				1						1			1	2	6	5.13
Carangoides gymnostethus											1		2	1	1	5	4.27
Lethrinus harak	2						1	1				1				5	4.27
Torquigener brevipinnis			5													5	4.27
Lutjanus carponotatus	2	2														4	3.42
Sargocentron rubrum															4	4	3.42
Siganus margaritiferus	2															2	1.71
Cypselurus sp.		2														2	1.71
Cynoglossus lingua								1						1		2	1.71
Heniochus acuminatus					2											2	1.71
Lactoria pentacantha	1															1	0.85
Toxotes jaculatrix				1												1	0.85
Caught fish number trip^{-1}	11	10	7	9	11	9	8	7	4	6	3	5	9	10	8	117	100
Amount of fish (individuals)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		
Avg. catch rate (fish number trip^{-1})																7.8	

Table 3

Composition of weight (kg) of caught fish

Scientific name	Catching trips															Amount	Composition
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	(kg)	(%)
Naso hexacanthus	0.37	0.5	0.25		0.38	1.11	0.13	0.37				0.25	0.74	0.12		4.21	18.77
Portunus pelagicus		0.5		0.77	1.26		1.26	0.51	0.25	1.78	0.25	0.26	0.13	0.55		7.53	33.55
Scarus psittacus				0.75					0.13	0.15		0.13				1.15	5.13
Upeneus sulphureus							0.12		0.12					0.43	0.12	0.80	3.55
Euristhmus microceps	0.5				0.13						0.16			0.13	0.25	1.16	5.16
Carangoides gymnostethus											0.15		0.62	0.24	0.23	1.24	5.55
Lethrinus harak	0.25						0.25	0.25				0.13				0.88	3.92
Torquigener brevipinnis			1.16													1.16	5.15
Lutjanus carponotatus	0.38	0.51														0.88	3.94
Sargocentron rubrum															0.5	0.50	2.21
Siganus margaritiferus	0.25															0.25	1.11
Cypselurus sp.		0.38														0.38	1.71
Cynoglossus lingua								0.13						0.05		0.17	0.77
Heniochus acuminatus					0.25											0.25	1.11
Lactoria pentacantha	0.13															0.13	0.56
Toxotes jaculatrix				1.76												1.76	7.83
Amount (kg)	1.87	1.89	1.4	3.28	2.01	1.11	1.76	1.26	0.5	1.93	0.56	0.76	1.49	1.51	1.1	22.43	100
Amount of fish (idv.)	6	4	2	3	4	1	4	4	3	2	3	4	3	6	4		

Based on the diversity index criteria presented in Table 4 (Shanon Wiener index criteria), these results indicate a moderate diversity, because the value of H' is greater than 2 and less than 3.

Table 4

Criteria for diversity index (Rappe 2010)

Index	Value	Category
Diversity	H' ≤ 2.0	Low
	2.0 < H' ≤ 3.0	Moderate
	H' ≥ 3.0	High

The dominance index criteria in Table 5 (Rappe 2010) state that when the dominance index (ranging from 0 to 1) has the value 1, it indicates a very high dominance by one species (only one species at one station), while when the index is 0, this indicates that among the species found there is no dominance.

Table 5

Dominance index criteria (Rappe 2010)

Index	Value	Category
Dominance	0.0 < C ≤ 0.5	Low
	0.5 > C ≤ 0.75	Moderate
	0.75 < C ≤ 1	High

In Figure 4 it can be seen that the highest species diversity index value is reached by *N. hexacanthus*, 0.359, and the lowest value (0.041) is reached by two species, namely *Lactoria pentacantha* and *Toxotes jaculatrix.*

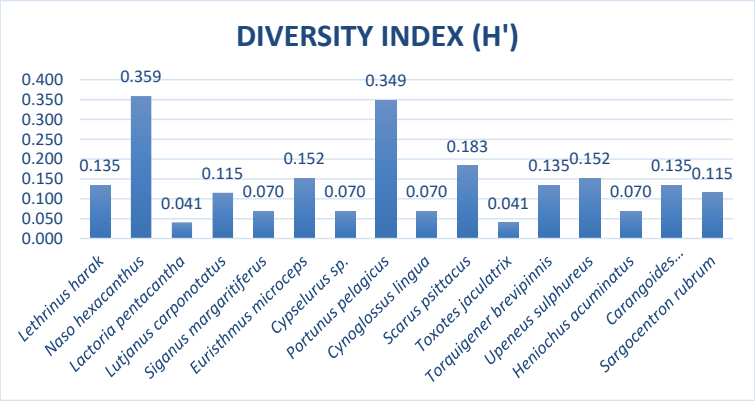

Figure 4. Value of diversity index in each type of fish.

The total value of the dominance index (Table 3) for all species of fish caught was 0.169. This shows that among the types of fish caught the dominance is low. Furthermore, based on the overall caught fish species composition, the largest dominance value (0.084) was reached by the *N. hexacanthus* species (Figure 5).

Figure 5. The value of the dominance index for each type of fish.

Based on Figure 5, the value of species dominance varies between 0.000 to 0.084. At this research location, the species that has a relatively high dominance index value is *N. hexacanthus* (0.084). The lowest species dominance was found in 6 species, namely *L. pentacantha*, *Siganus margaritiferus*, *Cypselurus* sp., *Cynoglossus lingua*, *T. jaculatrix* and *Heniochus acuminatus* (Figure 5).

N. hexacanthus has the highest dominance index value, which means that this species had relatively more individuals caught than other species. *L. pentacantha*, *S. margaritiferus*, *Cypselurus* sp., *C. lingua*, *T. jaculatrix* and *H. acuminatus* had the lowest dominance values because these six species had the lowest number of individuals compared to other species.

In accordance with Nugroho et al (2015) and Mardhan et al (2019), if the diversity index value is high, the dominance index value is low, and vice versa. This indicates that the selectivity of the fishing gear is low and therefore it is not environmentally friendly.

The diversity index value will be high or low depending on the variety of species caught (Okpiliya 2012). If the catch and variety of species are high, the level of fish diversity in the waters will be high, but if the catch and variety of species are low, the level of fish diversity will be low (Wahyu et al 2013).

If the diversity index value is low, it indicates that the fishing gear used has a high selectivity, because it can catch a targeted fish. Vice versa, if the diversity index value is high, the fishing gear used has a low selectivity, because it catches many species (Nugroho et al 2015; Hakim & Nurhasanah 2017).

Conclusions. The composition of the fish species caught with bottom gillnets in Kulu waters was 117 individuals, consisting of 15 species of fish and 1 species of crustaceans. The value of the diversity of fish species caught during the study in Kulu waters was 2,191. This shows a moderate diversity. The dominance index value of fish species caught at the research location in Kulu waters was 0.169. This shows that the dominance is low. In this study, due to a moderate diversity index and a low dominance index value, it can be concluded that the bottom gillnet in Kulu waters has a good selectivity but it is not environmentally friendly

Conflict of interest. The authors declare no conflict of interest.

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