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.

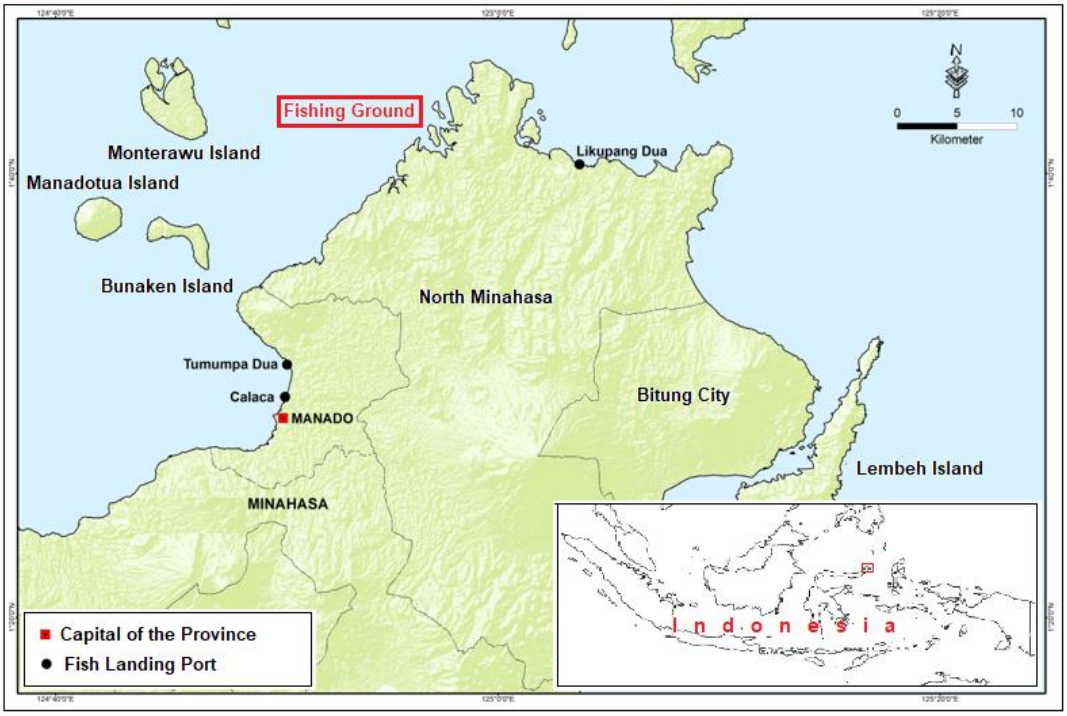

Figure 1. Map of fishing grounds in the Kulu waters (Wildlife Conservation Society Indonesia).

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%.

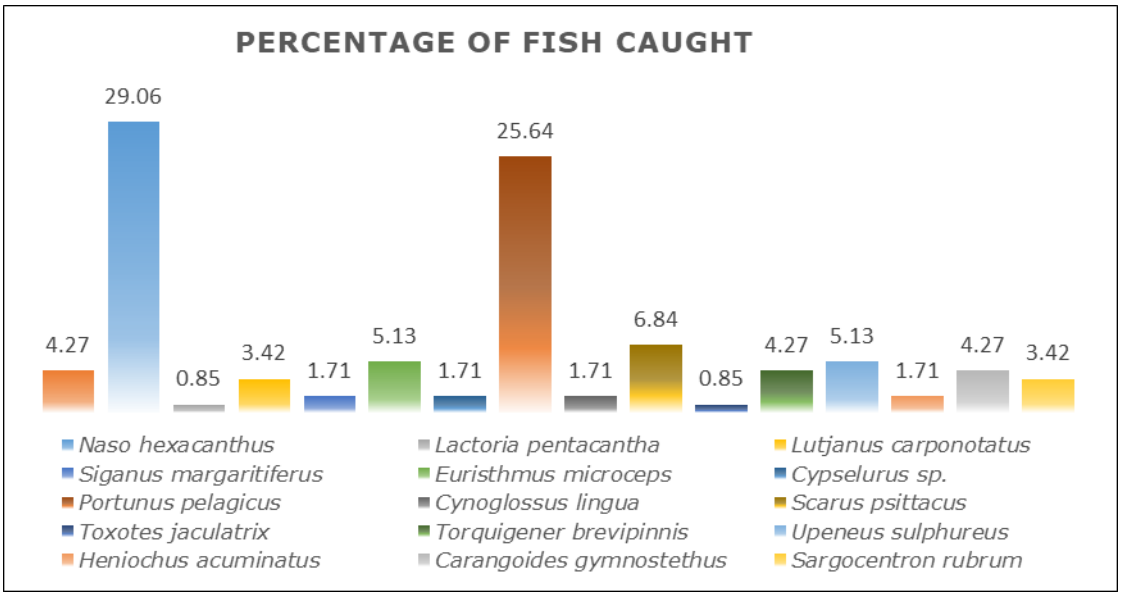

Figure 2. Percentage of fish caught by bottom gillnet.

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

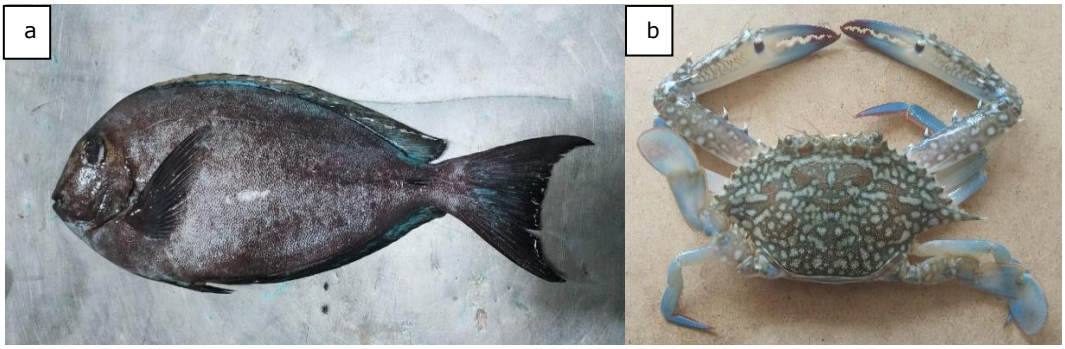

Figure 3. a) *Naso hexacanthus*, *b) Portunus pelagicus.*

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

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.*

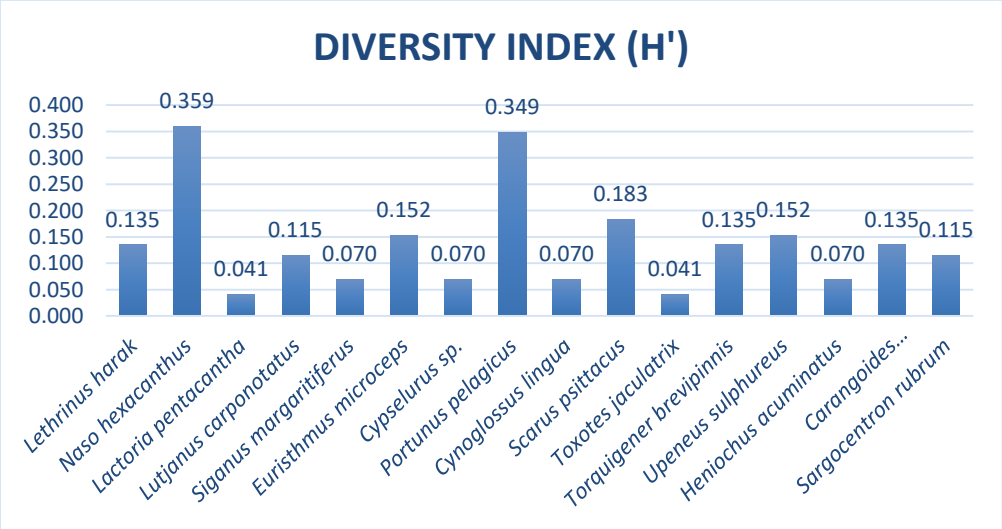

Figure 4. Value of diversity index in each type of fish.

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).

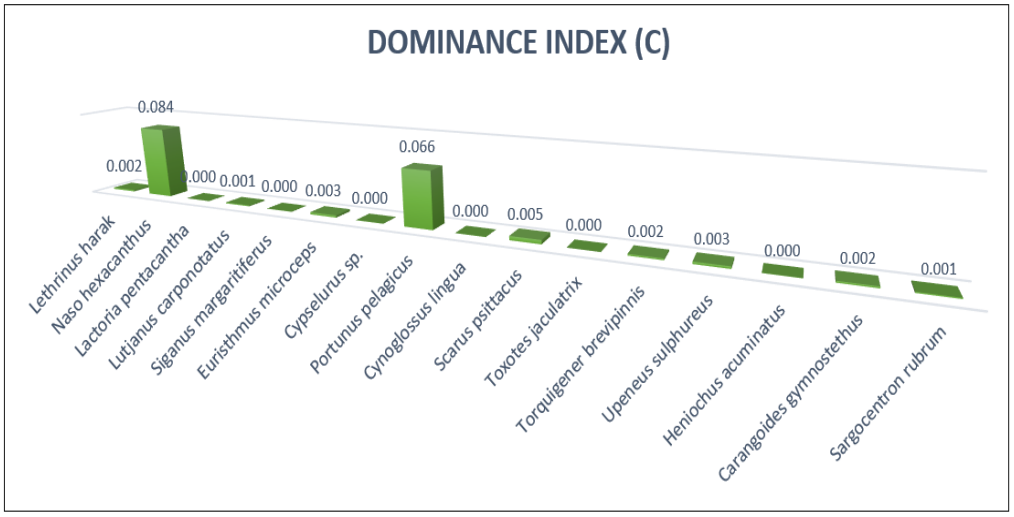

Figure 5. The value of the dominance index for each type of fish.

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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