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Characteristics of coral reef fisheries in the Wakatobi islands

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Abstract. Wakatobi National Park has a diverse fish population, and its conservation potential for reef fish resources is quite large. As a result, to be sustainable, the exploitation of these resources must be properly managed. This study aims to look into the characteristics of reef fish fisheries, such as species composition, catch, fishing ground, and fish length. The outcomes are hoped to be beneficial in monitoring the management of the resources. This research was conducted in April–November 2018 in Wakatobi, Indonesia. Analytical methods process the data. The results showed that gold spotted rabbitfish (*Siganus punctatus*), parrotfish (*Hipposcarus longiceps*), emperor (*Lethrinus lentjan*), grouper (*Epinephelus* sp), and trevallies (*Caranx* sp) dominated the total catch from muroami, speargun, and hand line. Muroami boats have a higher average CPUE (212 kg/trip/month) than speargun (29.0 kg/trip/month) and handlines (13.0 kg/trip/ship). Some of the reef fish caught in Wakatobi National Park is small and immature. Muroami net, speargun, and handline fishing are mostly done in the southern part of the Wakatobi National Park area, around Binongko Island. One of the management actions undertaken by Wakatobi fishermen is fishing inside the management zone that has been established, namely the local use zone.

Keywords: Composition, catch, fishing ground, CPUE, reef fish, Wakatobi

1. Introduction

As an archipelagic country, Indonesia plays an essential role in developing the fishing industry. The Wakatobi Sea is one of these areas, which has been designated as Wakatobi National Park (WNP) by the Minister of Forestry since 2002 through the Decree of the Ministry of Forestry of the Republic of Indonesia No 765/KPTS.II/2002. Wakatobi waters are part of the Coral Triangle Center, which includes Indonesia, the Philippines, and the Solomon Islands. The Coral Triangle Center includes 590 species of reef fish, the world's longest atoll, and 50,000 hectares of coral reefs with a living coral cover percentage ranging from 36.51 to 52.86% [1,2,3]. Furthermore, Wakatobi waters have been designated a biosphere reserve [4] for the rich diversity of fish species and coral reefs, allowing people to benefit from reef fish resources while remaining sustainable.

Reef fish are fish that spend the majority of their lives in coral reef ecosystems. The more living coral cover there is, the more fish there are. Their movement is not too far, activity is low, and schools are not too large, resulting in a relatively even distribution compared to pelagic fish [5,6,7]. The use of various fishing gear to catch reef fish must be done under environmentally friendly fishing principles [8]. FishiSmall-scale



and traditional fisheries dominate fishing activities in WNP fishing gear used includes gill nets, traps, muroami, handlines, snares, and spearguns, but the most effective and widely used are the muroami nets, handlines and spearguns [9].

Continuous human activities in the field of capture fisheries will compromise the productivity, diversity, and survival of fish resources, resulting in an increased need to understand and manage coastal zones [10]. [11] added that fishing activities affect biodiversity and productivity, population structure, and habitat, particularly when using inappropriate fishing gear, both passive and active. Muroami nets and spearguns are active fishing equipment, whereas handlines are passive fishing equipment. Handline fishing gear is one of the simple fishing methods used by many traditional fishermen. Thus, fishing activities play an important role in the country's economy. Fishing activities have not only a direct impact on the target species and by-catch but also the marine ecosystem as a whole.

The catch per unit effort (CPUE) can estimate the abundance of fish populations in a particular area in commercial and recreational fisheries [12]. Because of the limitations of fishing gear and boat technology used by local Wakatobi fishermen, the potential of existing marine fisheries cannot be fully utilized. The purpose of this study was to examine species composition per fishing gear, reef fish catches per unit of effort (CPUE), length of several reef fish species, and fishing grounds.

2. Material and methods

2.1. Data collection

In Wakatobi waters, research on the characteristics of reef fish fisheries was conducted from April to November 2018, the Banda Sea with the main landing site on Wangi-Wangi Island, Southeast Sulawesi (Figure 1). The catch composition data was obtained by observing the catch from muroami fishing gear, hand line, and arrow every month for 8 months. Fish sampling results were obtained, sorted, weighed, and identified based on identification books [13.14.15]. Researchers and enumerators collected biological data on the length of several dominant reef fish while collecting data on catches per unit effort (CPUE) of respected fishing gears. The CPUE calculation requires the production/total catch as well as the number of trips. Data and information on fishing grounds were obtained through interviews and discussions with the ship's captain and crew, specifically by displaying the fishing location on a map adjusted for latitude, longitude, and grid number. Moreover, data on fishing aspects collected included ship specifications, fishing gear dimensions, fishing operations, and dominant fish species. The data collection was carried out by researchers and enumerators, using the e-BRPL data collection system by filling out forms designed to record catch data, the fishing boat's operational information, the fish length, and reproduction biology in landing sites.

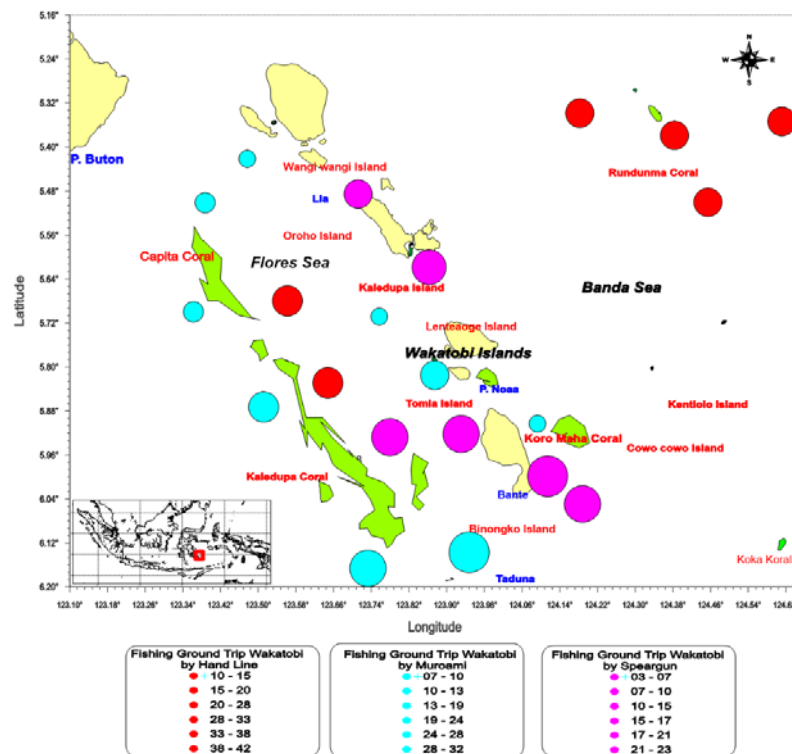


Figure 1. Map of the research area and reef fish fishing ground

2.2. Data analysis

Analysis of catch composition includes fish species from all catches with the formula [16]:

$$\text{composition of fish species} = \frac{n_i}{N_i} \times 100\%$$

n_i is the number of individuals from species i and N_i is the total number of all individuals.

Catch per unit effort (CPUE) was analyzed to determine the fish resource abundance by tabulating the landing/catch data and the fishing effort (trip) equation used for CPUE analyses is from [17]:

$$CPUE_t = \frac{Catch_t}{Effort_t}$$

$CPUE_t$ is the catch per unit effort at t-month; $Catch_t$ is the catch in month t dan $Effort_t$ is a fishing effort at year t. Standard fishing gear is the fishing gear with the highest productivity for a certain kind of fish or having the highest CPUE average fishing power index equal to one. In this study, muroami net is used as the standard fishing gear.

The average size of the first fish caught (L_c) calculation is conducted by calculating the value of $L_{50\%}$. In L_c calculation, 50% is considered the optimum level of fish exploitation, whereas for 100% of the fish in the sea, the optimum is only 50% that can be caught and the other half must be released. The average value for the first time caught is calculated by the following equation [18]:

$$S_L = \frac{1}{1 + \exp(S1 - S2 * L)} \quad \text{Ln} \left[\frac{1}{S_L} - 1 \right] = S1 - S2 * L \quad L50\% = \frac{S1}{S2}$$

S_L is a logistic curve with $S1$ and $S2$ being constant in the logistic curve formula.

3. Results and discussion

3.1. Fishing gear design, fleet, and fishing operational

3.1.1 Muroami net. Muroami's boat fleet is made of wood and measures 8.0 m long, 1.3 m wide, and 0.8 m deep, weighing 1 GT. The boat engine has a capacity of 24-30 PK, and the crew consists of 5-6 people. Muroami boat operations use 2 ships, one as propulsion and the other for herding fish, equipped with a rope that has been installed with wood as a shocker, operated for 1-2 days with several settings 2 times/trip. The main material of the net is made of 0.2 PE string with an inch mesh on the pocket and 2½ inches on the wings and body. The length of the net reaches 85 m. The ballast material uses sea snails with a hole in the middle. Fishermen install the gear at a depth of 1.5-3.0 m (Figure 2).

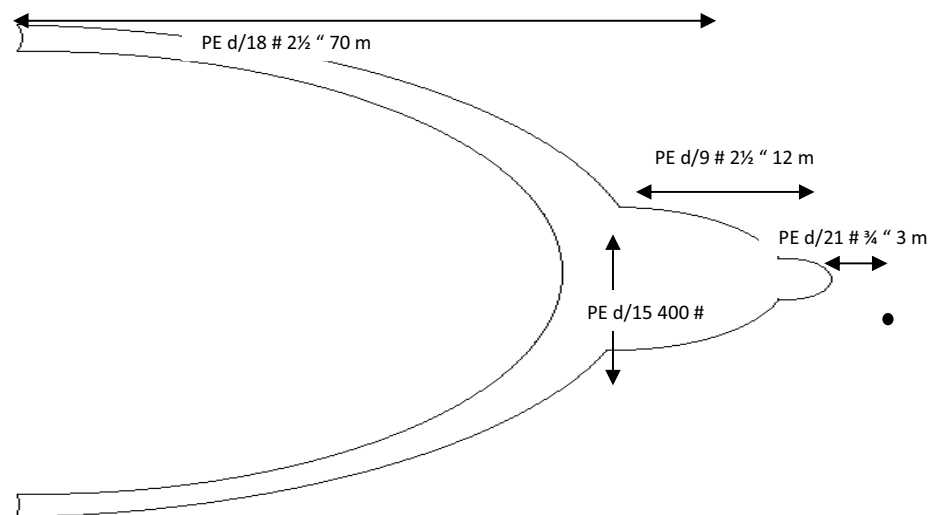


Figure 2. Muroami net specification and design.

3.1.2 Handline. The handline fishing fleet is made of wood with dimensions of 10.0 m long, 1.3 m wide, and 0.8 m deep and the weight of the ship is 1 GT. The boat's engine capacity is 7-30 PK and the crew members are 6-7 people. The materials used for the line are quite simple: rope, ballast, swivel, and fishing rods. Hand line and arrow gears are often found in one muroami fleet. The main targets of this gear are reef fish and demersal fish. Handline fishing gear employs fish flesh and artificial bait made of plastic and silk cloth in the shape of a fish. The smallest hook used is number 7; each trip lasts 1-2 days and the operating depth is 5-10 m (Figure 3).

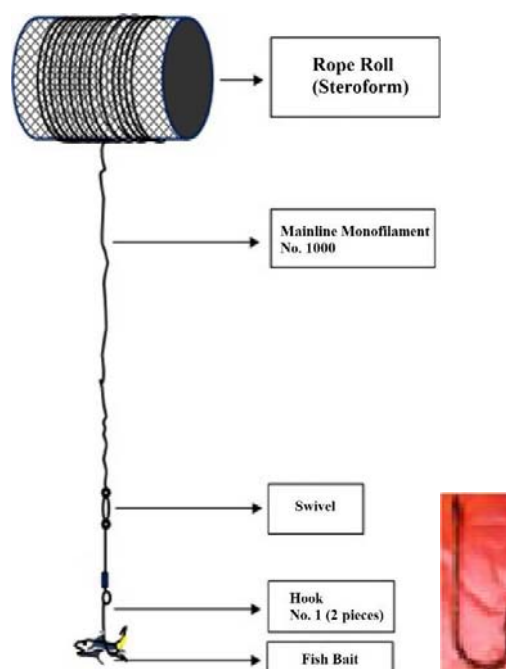


Figure 3. Handline fishing gear specification and design.

3.1.3 Speargun. Fishermen in WNP use speargun as fishing gear. The fleet of this gear is made of wood with dimensions of 9.0 m long, 1.3 m wide, and 0.8 m deep, and the weight of the ship is 1 GT. The engine capacity is 5-26 PK and the crew members are 1-4 people. The speargun comprises several parts, including a gun barrel with a length not more than 100 cm, stainless steel arrow with a length not more than 130 cm, a rubber thrower, an arrow hook, and a trigger (Figure 4). The gear's main targets are reef fish living around coral reefs and seagrass. Speargun operations are carried out by diving without using tools such as compressors and doing so manually for 60 to 180 minutes in a single dive. Each fisherman makes two dives, with a 60-120 minute interval between them. The depth of the dive ranges from 2 to 30 meters. This fishing gear is used not only when following fishing operations with boats, but also in the waters around the coast.

Arrows

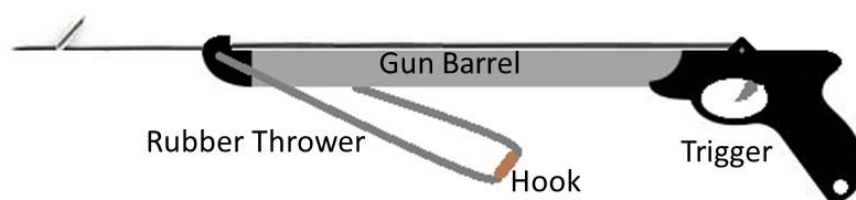


Figure 4. Speargun specification and design used by fisherman in Wakatobi National Park.

3.2. Catch composition

Muroami catches in Wakatobi waters have been identified as belonging to 47 genera and 16 families. The species composition of fish caught in muroami nets was dominated by Goldspotted rabbitfish (*Siganus punctatus*) 38%, Pacific longnose parrotfish (*Hipposcarus longiceps*) 9%, Pink ear Emperor (*Lethrinus*

lentjan), and Highfin coral grouper (*Plectropomus oligocanthus*) each 7%, *Epinephelus ongus* and *Scarus psittacus* each are 5% respectively, then *Siganus puellus*, *Siganus canaliculatus* and *Scarus rivulatus* at 4%, 3%, and 3%. Based on the month of observation, *S. punctatus* dominated the catch of muroami. Observation of July, the catch composition was dominated by *S. punctatus* (30.58%), *H. longiceps* (9.97%) and *L. lentjan* (8.64%). August, dominated by *S. argenteus* (37.91%), *H. lociceps* (8.62%) and *P. oligocanthus* (7.08%). September was dominated by *S. argenteus* (30.58%), *L. ornatus* (6.09%), *Lethrinus sp* (5.37%) and October was dominated by *S. argenteus* (64.85%), *T. acus melanotus* (4.71%) and *S. virgatus* (3.77%) (Table 1, Appendix 1).

The family composition of fish caught by muroami is dominated by Siganidae (64.79%), Lethrinidae (10.07%), Scaridae (7.28%), Serranidae (4.46%), Mullidae (2.56%), Balistidae (1.60%), Belonidae (1.6%), Labridae (1.58%), Acanthuridae (1.12%), and Ostraciidae 1.04% (Figure 4). This contrasts with the findings of Hartati et al. (2010), who discovered that the composition of muroami net catches in the Seribu Islands, Indonesia, is dominated by Goldband fusilier (*Pterocaesio chrysozona*), Redbelly yellowtail fusilier (*Caesio cuning*), both from Caesionade family and Yellowstripe scad (*Selaroides leptolepis*) from Carangidae. Furthermore, the families Acanthuridae, Lutjanidae, Scaridae, Siganidae, Labridae, and Lethrinidae dominate the diversity of reef fish in Banda Sea waters [19]. WNP is dominated by Acanthuridae (Surgeonfishes), Scaridae (parrotfishes), and Serranidae (groupers) [20], and Staring Bay, Southeast Sulawesi are dominated by Acanthuridae, Caesionidae, Haemulidae, Labridae and Lutjanidae [21]). Baronang (local name for rabbitfish) dominance is related to their habitat, where they inhabit coral reefs and seagrass ecosystems as a nursery and rearing area [22,23].

Table 1. Muorami net catch composition in Wakatobi National Park, Indonesia.

No	Genus	Family	Composition (%)				Total
			July	August	September	October	
1	<i>Siganus punctatus</i>	Siganidae	30.58	37.91	58.24	64.86	52.46
2	<i>Siganus argenteus</i>	Siganidae	0.00	0.00	4.30	0.94	1.98
3	<i>Siganus puellus</i>	Siganidae	3.32	4.46	0.00	0.00	1.12
4	<i>Siganus canaliculatus</i>	Siganidae	4.65	2.71	1.43	2.36	2.51
5	<i>Siganus virgatus</i>	Siganidae	0.00	0.00	4.66	3.77	2.97
6	<i>Scarus ghoban</i>	Scaridae	0.00	0.00	1.08	0.00	0.42
7	<i>Scarus rubroviolaceus</i>	Scaridae	0.00	0.77	0.00	0.00	0.07
8	<i>Scarus rivulatus</i>	Scaridae	3.32	3.47	0.00	0.00	1.03
9	<i>Scarus psittacus</i>	Scaridae	5.32	5.28	0.00	0.00	1.62
10	<i>Scarus rubroviolaceus</i>	Scaridae	0.66	0.00	0.00	0.00	0.14
11	<i>Scarus longiceps</i>	Scaridae	0.00	0.00	0.00	2.83	0.85
12	<i>Scarus fasciatus</i>	Scaridae	0.00	0.00	0.00	2.59	1.20
13	<i>Hipposcarus longiceps</i>	Scaridae	9.97	8.62	1.43	0.00	3.49
14	<i>Lethrinus lentjan</i>	Lethrinidae	8.64	6.53	3.58	2.36	4.57
15	<i>Lethrinus sp</i>	Lethrinidae	0.00	0.00	5.38	0.00	2.12
16	<i>Lethrinus semicinctus</i>	Lethrinidae	3.32	2.17	0.00	0.00	0.91
17	<i>Lethrinus ornatus</i>	Lethrinidae	0.00	0.00	6.09	0.94	2.69
18	<i>Monotaxis granduculis</i>	Lethrinidae	1.33	1.23	0.00	0.00	0.40

No	Genus	Family	Composition (%)				Total
			July	August	September	October	
19	<i>Gnathodentex aurolineatus</i>	Lethrinidae	1.33	0.52	0.00	0.00	0.33
20	<i>Plectropomus oligocanthus</i>	Serranidae	7.98	7.09	0.00	1.42	2.78
21	<i>Plectropomus areolatus</i>	Serranidae	0.23	0.53	0.00	0.00	0.10
22	<i>Epinephelus ongus</i>	Serranidae	5.32	5.02	0.00	0.00	1.60
23	<i>Epinephelus fasciatus</i>	Serranidae	1.33	1.00	0.00	0.00	0.38
24	<i>Epinephelus melanostigma</i>	Serranidae	0.36	0.83	0.00	0.00	0.15
25	<i>Epinephelus quoyanus</i>	Serranidae	0.66	0.56	0.00	0.00	0.19
26	<i>Epinephelus undulosus</i>	Serranidae	1.33	0.77	0.00	0.00	0.35
27	<i>Cephalopholis argus</i>	Serranidae	1.33	1.94	0.00	0.00	0.46
28	<i>Cephalopholis miniata</i>	Serranidae	0.00	0.00	0.54	0.00	0.21
29	<i>Lutjanus lemniscatus</i>	Lutjanidae	1.33	2.20	0.00	0.00	0.49
30	<i>Lutjanus carponotatus</i>	Lutjanidae	0.66	1.09	0.00	0.00	0.24
31	<i>Symphorichthys spilurus</i>	Lutjanidae	0.35	0.81	0.00	0.00	0.15
32	<i>Kwee (Carangoides sp)</i>	Carangidae	0.00	0.00	0.00	2.36	0.71
33	<i>Parupeneus barberinus</i>	Mullidae	2.66	1.39	1.79	1.42	1.83
34	<i>Parupeneus chrysopleuron</i>	Mullidae	1.99	0.88	0.00	0.00	0.51
35	<i>Upeneus sulphureus</i>	Mullidae	0.00	0.00	0.00	2.36	0.71
36	<i>Himantura bleekeri</i>	Dasyatidae	0.00	0.00	1.79	0.00	0.71
37	<i>Tylosurus acus melanotus</i>	Belonidae	0.00	0.00	0.00	4.72	1.41
38	<i>Balistoides viridescens</i>	Balistidae	0.00	0.00	2.51	1.42	1.41
39	<i>Plectorichthys chaetodonoides</i>	Haemulidae	0.66	0.78	0.00	0.00	0.21
40	<i>Chaerodon anchorago</i>	Labridae	0.66	0.54	1.43	1.89	1.32
41	<i>Hemigymnus melapterus</i>	Labridae	0.66	0.90	0.00	0.00	0.22
42	<i>Lactoria diaphama</i>	Ostraciidae	0.00	0.00	0.72	0.00	0.28
43	<i>Ostracion cubicus</i>	Ostraciidae	0.00	0.00	0.18	1.89	0.64
44	<i>Arothron hispidus</i>	Tetraodontidae	0.00	0.00	1.43	0.00	0.57
45	<i>Cyclichthys spilostylus</i>	Diodontidae	0.00	0.00	1.25	0.00	0.50
46	<i>Acanthurus mata</i>	Acanthuridae	0.00	0.00	1.08	0.00	0.42
47	<i>Acanthurus nigricauda</i>	Acanthuridae	0.00	0.00	0.00	1.89	0.57
Total			100.00	100.00	100.00	100.00	100.00

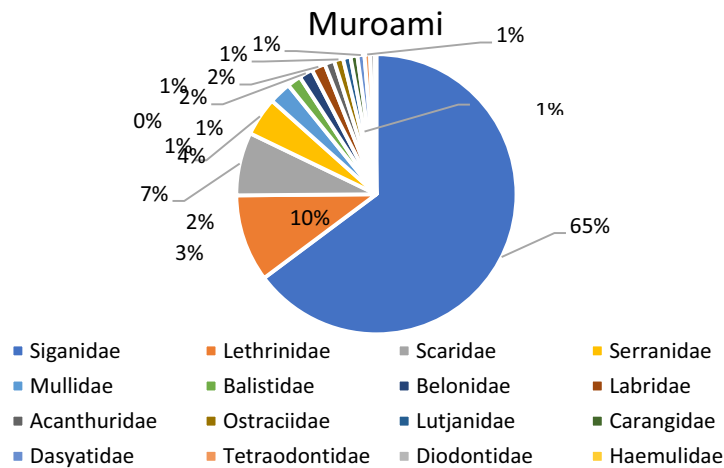


Figure 5. Muroami net catch composition based on Family.

More than 50% of speargun catches were dominated by Emperor fishes (*Lethrinus* sp) 66.94%, other types of fish were parrotfish (*Scarus* sp) 29.19%, grouper (*Epinephelus* sp) 1.88%, *Tylosurus acus* (1.53%), *Cephalopholis argus* (0.21%), *Carangoides* sp (0.14%) and *Cephalopholis miniata* (0.09%). The composition of speargun catches from June to August was dominated by Emperor fish (*Lethrinus* sp.) and parrotfish (*Scarus* sp) (Table 2). Unlike the findings of [24,25], the Caesionidae family dominates the composition of the gear catches in the waters of Gorontalo and Karimunjawa (Central Java).

Table 2. Speargun catch composition in Wakatobi National Park, Indonesia.

No	Genus	Family	Composition (%)					Total
			April	May	June	July	August	
1	<i>Carangoides</i> sp	Carangidae	0.96	0.00	0.00	0.00	0.00	0.14
2	<i>Tylosurus acus</i> sp.	Belonidae	0.96	0.00	1.94	0.88	1.63	1.53
3	<i>Scarus</i> sp.	Scaridae	43.09	41.33	20.45	43.36	32.34	29.19
4	<i>Epinephelus</i> sp.	Serranidae	2.57	3.33	0.25	5.60	4.08	1.89
5	<i>Cephalopholis miniata</i>	Serranidae	0.16	0.00	0.00	0.44	0.00	0.09
6	<i>Cephalopholis argus</i>	Serranidae	1.45	0.00	0.00	0.00	0.00	0.21
7	<i>Lethrinus</i> sp	Lethrinidae	50.80	55.33	77.37	49.71	61.96	66.94
Total			100.00	100.00	100.00	100.00	100.00	100.00

The composition of the fish species caught by handline was dominated by Sunu grouper (*Plectropomus* sp) from Serranidae and Kwee fish (*Caranx* sp) from the family Carangidae. Serranidae is found almost every month (Table 3). In contrast to the results of [26] in Puerto Princesa Bay, Palawan, Philippines, the composition of the fish caught from the same gear is dominated by The Lattice monocle bream (*Scolopsis taenioptera*) from the Nemipteridae family. The composition of fish species caught by this gear in Wakatobi (Indonesia) and Palawan (Philippines) differs due to habitat. Because the habitat of Wakatobi waters is coral

reefs, the dominant fish caught are grouper (Serranidae) and kwee (Carangidae), whereas the habitat of Palawan (Philippines) is sandy mud, so Lattice monocle bream is the dominant fish caught (Nemipteridae).

Table 3. Handline catch composition in Wakatobi National Park, Indonesia.

No	Species	Family	Composition (%)					Total
			April	May	June	July	August	
1	<i>Epinephelus sp</i>	Serranidae	3.51	-	-	6.42	-	3.67
2	<i>Plectropomus sp</i>	Serranidae	96.49	97.06	97.06	48.79	83.43	68.65
3	<i>Lethrinus sp</i>	Lethrinidae	-	2.94	2.94	3.42	16.57	5.00
4	<i>Caranx sp</i>	Carangidae	-	-	-	41.37	-	22.67
Total			100	100	100	100	100	100

Thus, reef fish caught in Wakatobi National Park by muroami, handlines, and speargun, such as the Baronang (Siganidae), Emperor/lencam (Lethrinidae), grouper (Serranidae), parrotfish (Scaridae), trevallies (Carangidae), Goatfishes (Mullidae), Triggerfishes (Balistidae), Labridae, A 74 species of fish were caught in the same waters, namely on Kaledupa Island (Wakatobi National Park), including 63 species of reef fish and 11 species of pelagic and demersal fish. The families Siganidae, Lethrinidae, Mullidae, and Scaridae have the most dominant and overexploited species. [27].

3.3. Size distribution of reef fish

The length distribution of several reef fish species caught by muroami and speargun is presented in Figure 6. The length of baronang fish (*S. punctatus*) caught by arrows ranges from 14.3 – 39.8 cmFL (Fork Length) with an average of 25.37 cmFL while *S. muroami's punctatus* catch ranged from 11.2-30.1 cmFL with an average of 23.25 cmFL. The length of *S. punctatus* caught by speargun was larger than that of muroami. This is because arrow fishing gear is a productive and selective fishing gear because fishermen only catch fish that are allowed to be caught and of the suitable size to catch.

The length distribution of lencam fish (*L. atkinsoni*) from muroami catches ranged from 12.0 to 37.7 cmFL with an average of 27.7 cmFL. The length distribution of grouper (*P. areolatus*) from arrow catches ranged from 16.6-45.0 cmTL (Total Length) with an average of 25.38 cmTL. The length distribution of parrotfish (*H. longiceps*) from arrow catches ranged from 16.0 to 39.8 cmTL with an average of 25.3 cmTL.

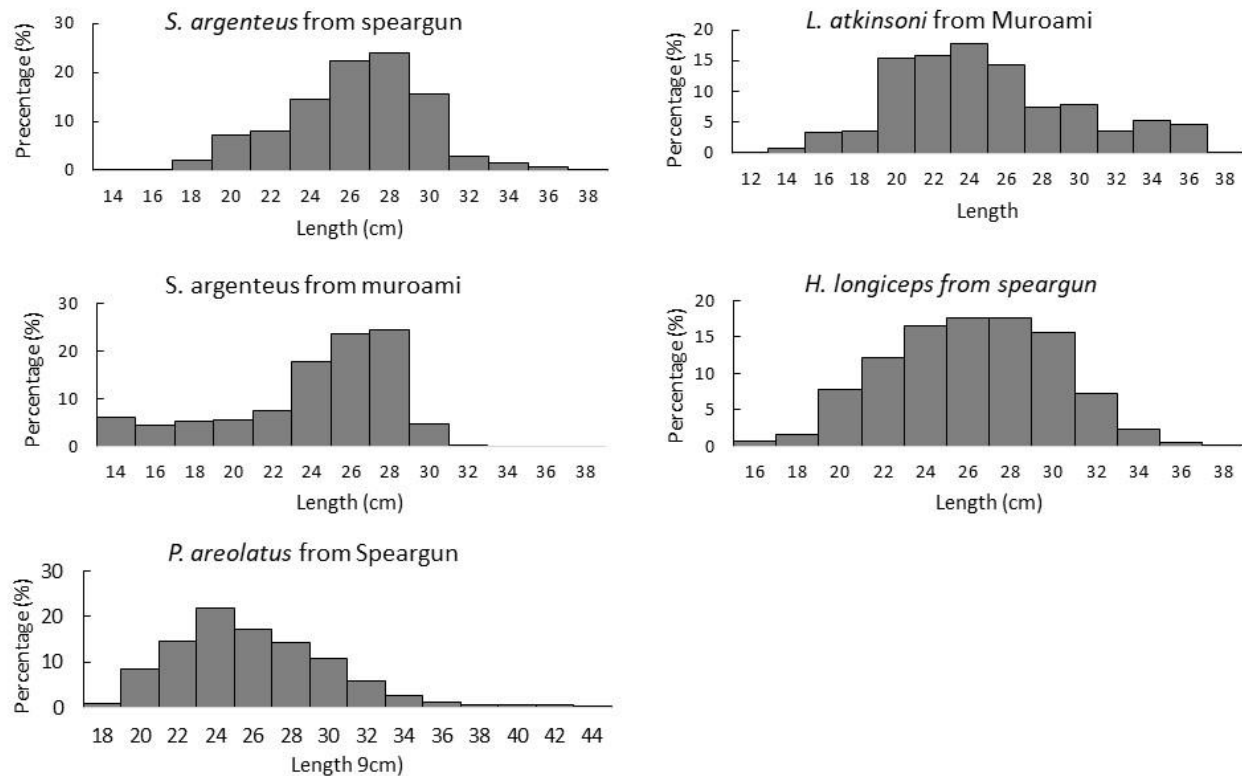


Figure 6. Length distribution of *S. argenteus*, *L. atkinsoni*, *P. areolatus* and *H. longiceps* from muroami net Speargun in Wakatobi National Park, Indonesia.

The estimated length average (L_c) of *S. punctatus* caught by muroami was 25.20 cm, and from speargun was 24.84 cm, L_c *L. atkinsoni* from muroami net was 24.06 cm, L_c *P. areolatus* from arrow fishing gear was 24.97 cm and L_c *H. longiceps* from arrow fishing gear was 25.51 cm (Figure 7). The size of the reef fish was the size of an immature fish. This was because the average length at first capture of fish caught was smaller than the average size at first maturity of 36.95 cm for *P. areolatus* and 32.9 cm for *H. longiceps*, respectively [28,29].

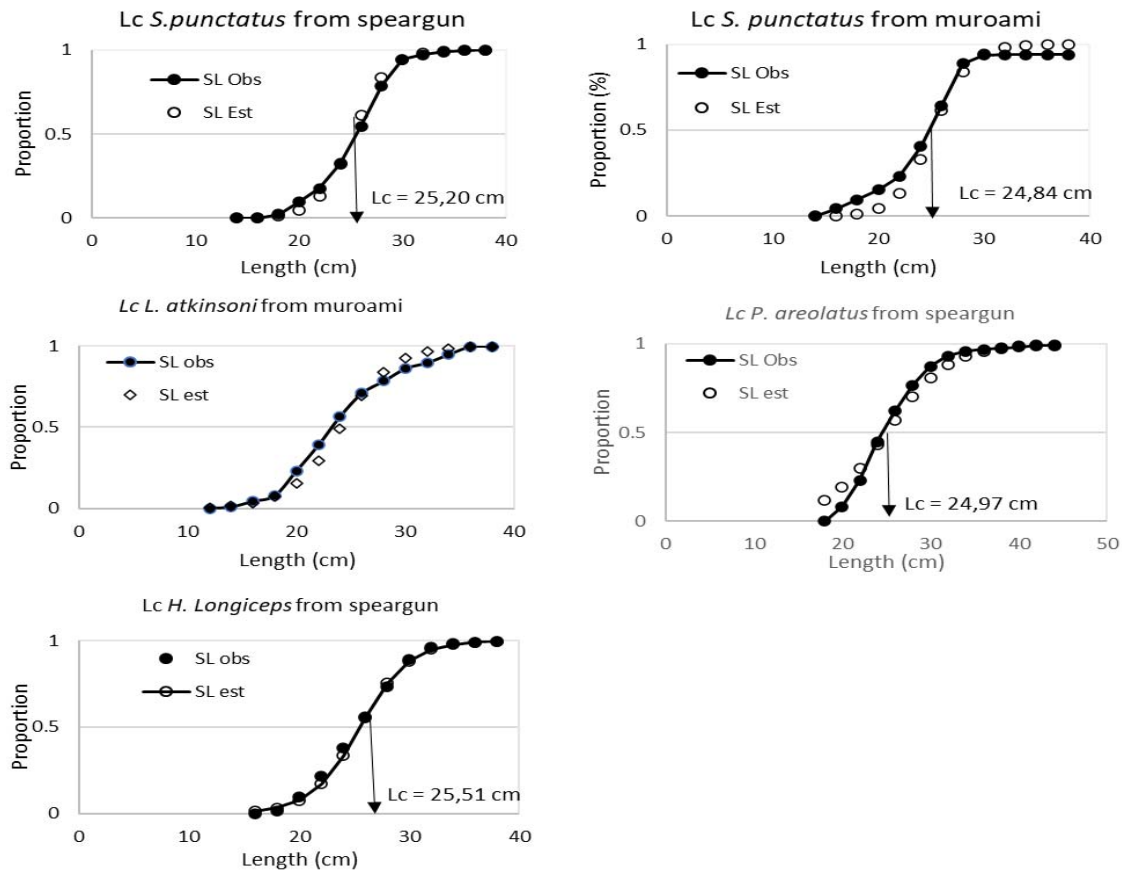


Figure 7. The average length at first caught (L_c) of *S. argenteus*, *L. atkinsoni*, *P. areolatus* and *H. longiceps* from muroami net and Speargun in Wakatobi National Park, Indonesia.

3.4. Catch Per Unit of Effort (CPUE)

Muroami catches from Wakatobi waters that landed on Wangi-wangi Island ranged from 1,550 – 6,398 kg with the number of the trips ranging from 10-25 trips so that the catch per unit of effort (CPUE) of this gear boat ranged from 155 -297 kg/trip/month with an average 212 kg/trip/month. The lowest CPUE was in November (155 kg/trip/month) and the highest was in September (297 kg/trip/month) (Table 4). The CPUE of muroami ships in the Seribu Islands, Jakarta, varies from 40-364 kg/ship [30]. Speargun catches ranged from 500 – 4,313 kg/month with the number of trips fluctuating each month ranging from 14-232 trips/month so that the CPUE of reef fish from speargun catches ranged from 10.0-65.0 kg/trip/month with an average of 29, 0 kg/trip/month. The lowest CPUE was in June and July and the highest was in October (Table 5). Handline catches ranged from 383 – 745 kg/month with the number of trips ranging from 10-17 trips/month so the CPUE of the gear catches ranged from 10.0-17.0 kg/trip/month with an average of 13.0 kg/trip/ship. The lowest CPUE was in July and the highest was in April (Table 6). The CPUE of muroami, handline and speargun varies monthly depending on weather conditions [26].

Based on these results, the average CPUE of muroami boats (212 kg/trip/month) is greater than the CPUE of speargun boats (29.0 kg/trip/month) and hand line. (13.0 kg/trip/ship). This is because muroami boats catch more types and quantities and all sizes of fish are caught, both the smallest to the largest with more by-catch. Muroami boats use nets with a mesh size of 1 inch on the bag and 2½ inches on the wings

and body. Furthermore, during operation, the fishing boat uses auxiliary vessels to herd fish into nets, causing damage to fish habitats such as coral reefs and seagrass. The CPUE of the speargun and handline is smaller than the muroami. This is because these fishing gear is more selective on the size of the fish caught than the net. The Handline uses the smallest hook number 7. In addition, handline and speargun fishing gear apply the concept of a code of conduct for responsible fisheries (CCRF) so that fishing technology can be responsible, low by-catch, and environmentally friendly [25, 31, 8]. Fishing activities impact on diversity, target fish, by-products, and habitat damage, so it is necessary to promote more environmentally friendly fishing methods and use more selective nets [32].

Table 4. Catch, Effort and catch per unit of effort of Muroami

Month	Catch (Kg)	Effort (Trip)	CPUE (Kg/trip)
April	6,398	25	256
May	3,751	20	188
June	3,818	20	191
July	4,960	25	198
August	5,010	24	209
September	6,241	21	297
October	5,020	25	201
November	1,550	10	155

Table 5. Catch, Effort and catch per unit of effort of speargun

Month	Catch (Kg)	Effort (Trip)	CPUE (Kg/trip)
April	1,097	85	12.90
May	4,313	232	18.59
June	564	55	10.26
July	500	48	10.43
August	1,063	23	46.20
September	1,088	19	57.24
October	904	14	64.57
November	1,079	90	11.99

Table 6. Catch, Effort and catch per unit of effort of handline

Month	Catch (Kg)	Effort (Trip)	CPUE (Kg/trip)
April	745	43	17.33
May	383	34	11.27
June	610	44	13.85
July	413	41	10.08
August	724	64	11.31
September	687	56	12.26
October	703	52	13.52
November	450	29	15.52

3.5. Reef fish fishing ground location

The distribution of fishing ground from handline boats in Wakatobi National Park is mainly around the West and Northeast of Binongko Island as many as 38-42 trips, North of Kaledupa Island, south and northeast of Karang Kaledupa, North and south of Karang Koro Maha as many as 33-38 trips; North and south of Kaledupa Coral, and Rundunma Coral for 28-33 trips, east for Wangi-wangi Island and North for Tomia Island for 20-28 trips, North and south for Karang Kapata for 15-20 trips; West P. Wangi and P. Kadelupa as much as 10-15 trip. The fishing area of the handline boat is farther than that of the other two gears, namely Karang Rundunma. The distribution of fishing ground from muroami boats is highest on Binongko Island with 28-32 trips and Kaledupa reef (24-28 trips) and the least areas on Capita reef (10-13 trips) and Wangi-wangi Island (7-10 trips). The distribution of fishing ground for speargun boats is highest on Binongko Island (21-23 trips), Tomia Island (17-21 trips), and Kaledupa Island (15-17 trips) while the least fishing areas are on Wangi-wangi Island (3-7 trips) (Figure 1).

The fishing ground for these three fishing gears is mostly carried out in the southern part of the WNP area, around Binongko Island. The fishing location for many kinds of fishing gear in Wakatobi is relatively the same, around the coral atoll which is on the south side of Wakatobi National Park. According to South Mola Village fishermen, the best places to catch groupers and other reef fish are at Kamponaone Coral, Kaledupa Coral, Tomia Coral, Runduma Coral, Koko Coral, Koromaho Coral, and Kapota Coral [33]. According to the findings of this study, fishermen in WNP fish in local utilization zones. According to decree number SK.149/IV-KK/2007, WNP management is based on a zoning system consisting of (1) core zone, (2) marine protection zone, (3) local utilization zone, (4) zone general use, (5) tourism zones, and (6) land/special zones [34,35]. In addition, [36] recommend conservation zones for coral reef ecosystems in the northern and eastern parts of WNP (sustainable fisheries zones), while economic zones and aquaculture fisheries activities in the western and southern parts of WNP.

4. Conclusion

There were 47 genera and 16 families of fish caught in the waters of Wakatobi National Park. Gold spotted rabbitfish (*Siganus punctatus*), parrotfish (*Hipposcarus longiceps*), emperor (*Lethrinus lentjam*), grouper (*Epinephelus* sp), and trevallies (*Caranx* sp) dominated the total catch from muroami, speargun, and hand line. *S. punctatus* length from speargun was greater than that of muroami. Some of the reef fish caught in Wakatobi National Park are small and immature. Muroami boats have a higher average CPUE (212 kg/trip/month) than speargun boats (29.0 kg/trip/month) and handlines (13.0 kg/trip/ship), although speargun and handlines are more selective on the size of the fish caught and are more environmentally friendly (does not damage coral reef habitat). Muroami net, speargun, and handline fishing is mostly done in the southern part of the Wakatobi National Park area, around Binongko Island. One of the management actions undertaken by Wakatobi fishermen is fishing reef fish inside the management zone that has been established, namely the local use zone.

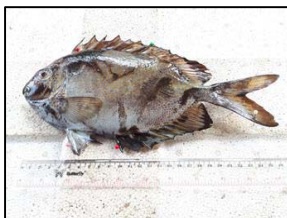
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Appendix. Types of reef fish caught by fishermen in WNP using muroami, speargun and handline fishing gear.



Siganus fuscescens



Siganus punctatus



Siganus guttatus



Hipposcarus longiceps



Scarus fasciatus



Scarus rivulatus



Scarus psittacus



Scarus prasiognathus



Caesio lunaris



Parupeneus barberinus



Parupeneus chrysopleuron



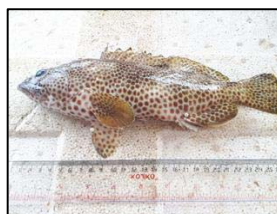
Lutjanus decussatus



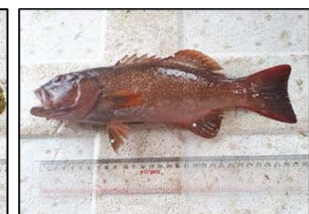
Lethrinus lentjan



Anyperodon leucogrammicus



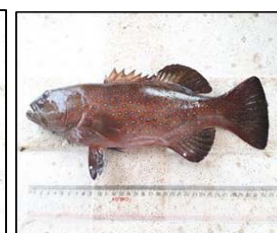
Epinephelus faveatus



Plectropomus leopardus



Cephalopholis argus



Plectropomus areolatus



Cephalopholis miniata



Variola louti

6. References

- [1] Turak E 2003 *Coral reef surveys during TNC SEACMPA RAP of Wakatobi National Park, Southeast Sulawesi, Indonesia* p 33-52
- [2] Firmansyah F, A Mustofa, Estradivari, A Damora, C Handayani, G Ahmadi, J Harris, Amkietela, KJ Teule, Sugiyanta, V Santiadji, A Wijonarno and M Yusuf 2017 *Coast. And Oce. J.* **1** 2 147-156
- [3] Pet-Soede L and Erdmann M V 2003 *Rapid Ecological Assessment Wakatobi National Park WWF/TNC* (Bali: Joint Publication Denpasar Bali)
- [4] UNESCO 2012 Ecological Sciences for Sustainable Development. Wakatobi. Retrieved from <http://www.unesco.org/new/en/naturalsciences/environment/ecologicalsciences/biosphere-reserves/asiaand-thepacific/indonesia/wakatobi/>
- [5] Choat J H and D R Bellwood 1991 *The Ecology of Fishes on Coral Reefs. Reef Fishes: Their history and evolution* (Durham: Department of Zoology University of New Hampshire Durham)
- [6] Sale P F 1991 Reef fish communities: open nonequilibrium systems. The ecology of fishes on coral reefs, 564-598. <http://www.vliz.be/en/imis?refid=9169>
- [7] Komyakova V, P L Munday and G P Jones 2013 *PloS one* **8** 12 p.e83178
- [8] Tupamahu A, Haruna, B G Hutubessy, S R Siahainenia, A C Nanlohy and K Hehanusa 2021 *J. Agri. Per.* **14** 1 p 44-54
- [9] Heland P V and J Clifton 2015 *Conserv. and Soc.* **13** 2 p 154-165
- [10] Jackson J C, Kirby M X, Berger W H, Bjorndal K A, Bourque B J, Bradbury R H 2001 *Sci.* **293** 629-639
- [11] Goñi R 1998 *Oce. and Coastal Manag.* **40** 3764
- [12] Punt A and Hilborn R 1997 *Fish Bio. and Fish.* **7** 35-65
- [13] Tarp G T, and Kailola P J 1984 *Trawled Fishes of Southern Indonesia and Northwestern Australia.* (Australia: Australian Development Assistance Bureau)
- [14] Allen G 1999 *A Field Guide for Anglers and Divers : Marine Fishes of South-East Asia* (Singapore: Periplus Editions)
- [15] White W T, Last P R, Dharmadi, Faizah R, Chodriyah U, Prisantoso B I, Pogonoski J J, Puckridge M, and Blader S J M 2013 *Market fishes of Indonesia Species of fish in Indonesia ACIAR Monograph N0 55* (Indoensia: ACIAR)
- [16] Krebs CJ 1989 *Ecological Methodology. Second Edition* (New York: An Imprint of the Addition Wesley Longman)
- [17] Noiija D, S Martasuganda, B Murdiyanto and A A Taurusman 2014 *J. Tekn. Per. dan Kel.* **5** 1 55-64
- [18] Sparre P, Venema S 1998 *Introduction to tropical fish stock assessment. Part I: Manual. FAO Fisheries Technical Paper* (Rome: FAO)
- [19] Wouthuyzen S, F D Hukom, P Makatipu and D Pelasula 2018 *IOP Conf. Series: Earth and Env. Sci.* **184** 012009 21pp
- [20] Edrus I N, R S Utama, T A Hadi, S R Suharti and Y Tuti 2021 *J. Lit. Perikan. Ind.* **27** 1 43-55
- [21] Nadia L A R, M Ramli, L M H Nadia, M F Purnama and I Male 2021 *AACL Bioflux* **14** 2 931-941
- [22] Latuconsina H, R Affandi, M M Kamal and N A Butet 2020 *J. Ilmu dan Tek. Kel. Trop.* **12** 1 89-106
- [23] Hyndes G A, A J Kendrick, L D MacArthur and E Stewart 2003 *Mar. Bio.* **142** 1195-1206
- [24] Nihe M, A Salam and A S R Baruadi 2017 *Nikè: J. Ilmiah Per. dan Kel.* **5** 1 8-13
- [25] Mubarak, S H Wisudo and B H Iskandar 2012 *Marine Fish.* **3** 2 115-122
- [26] Gonzales J B 2019 *Intern. J. of Fish. and Aqu. Studies* **7** 4 166-171
- [27] Yuliana E, A Winata, H E Adimu, Y T Hewindati and W A Djatmiko 2021 *HAYATI J. Biosci.* **29** 2 245-252
- [28] Taylor B M and E Cruz 2017 *PeerJ*, DOI10.7717/peerj.4079.

- [29] Khasanah M, N N Kadir and J Jompa 2019 *Animals* **9** 9 643
- [30] Hartati S T, K Wagiyo and Prihatiningsih 2011 *J. Lit. Perikan. Ind.* **17** 2 83-94
- [31] Kour F and Y Hibata 2019 *Jurnal Agribisnis Perikanan* 12(2) 232-242
- [32] Arimoto T 2001 *Proc. of Satellite Workshop on Fishing Impact-Evaluation, Sol. and Policy* 6 – 7 October 2001 at Tokyo University of Fisheries: 1-1
- [33] Alamsyah A S, La Sara and A Mustafa 2013 *J. Mina Laut Indo.* **1** 1 73-83
- [34] Adimu H E, M Boer, F Yulianda and A Damar 2018 *IOP Conf. Series: Earth and Env. Sci.* **176** 012035 1-9
- [35] Haniru LO 2017 *Jurnal Hukum Volkgeist* 2(1) 71-81
- [36] Chandra H, D Simbolon, B Wiryawan, B H Iskandar and A A Taurusman 2017 *AES Bioflux* **9** 2 148-157