The Exploitation Status of The Slender Grouper (*Anyperodon leucogrammicus*) in Arafura Sea, Indonesia

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The Exploitation Status of The Slender Grouper (*Anyperodon leucogrammicus*) in Arafura Sea, Indonesia

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Abstract. Arafura Sea is rich in its resources, e.g. shrimp, pelagic fish, demersal fish, and coral reef fish. Coral reef fish commonly found in Arafura waters are among others brown-marbled grouper, slender grouper, leopard coral grouper, humpback grouper, etc. One of the groupers that has a higher selling price than the other groupers is slender grouper (*Anyperodon leucogrammicus*). The high demand for the fish is in line with the increase in the catch and the exploitation status. Therefore, a study is necessary to analyze the exploitation status of the slender grouper in Arafura Sea. This study was carried out from March to November 2017 by sampling the grouper at its landing site in Dobo, Aru Islands, from the fishing grounds in Arafura Sea, Maluku. The size of the slender grouper was 15–120 cmTL, and its growth pattern was allometric negative. Its growth rate (K) was 0.34 per year and its fishing mortality (F) was higher than the natural mortality (M). The exploitation rate (E) of the fish was 0.52%, meaning the fish was already moderately exploited. Therefore, precautionary managements are necessary to maintain the sustainability of the slender grouper resources in Arafura Sea.

1. Introduction

The Arafura Sea has long become a fishing ground for fishing boats as the area is rich in marine resources such as shrimps, crustaceans, small and large pelagic fish, demersal fish, and coral reef fish. Such richness is supported by the periodic upwellings in the waters [1]. The Arafura Sea also has numerous small islands that become the habitats of the coral reef fish around the Aru Islands. The coral reef areas serve as an association site and provide food, spawning ground, rearing site, and protection for the coral reef fish [2]. The coral reefs around the Aru Islands can be found in Enu, Jin, Barakan, Panambulai, Koba, Lola, Waraba, and Kararai Islands [3]. Based on the satellite imageries, Arafura's coral reefs are situated in the Aru Islands' north, east, and south coastal areas, and in Papua's north coastal area at the edge of the Arafura Sea, particularly in Kaimana and the surrounding areas [4]. The coral reefs are abundant around the Aru Islands because Arafura and Banda Seas have open waters and strong currents [5].

One of the most exploited coral reef fish is grouper as it has a high selling price and is preferred by the consumers [6]. Based on the data from Dobo Supervisory Unit of the Maritime and Fisheries Resources, the Ministry of Maritime Affairs and Fisheries (Satwas SDKP KKP Dobo), the fish production, or the total catch, from various fishing gears in Arafura Sea that landed at Aru (Dobo) Islands in January to October 2017 was 20,765.10 tons. The groupers were mostly caught by bottom longlines (220.955 tons) and gillnets (23.158 tons). On the other hand, based on the statistical data from the Ministry of Maritime Affairs and Fisheries, the production of groupers in Papua kept increasing, i.e. 328 tons in 2010, 2,027 tons in 2014, and 8,296 tons in 2018. However, the fish from the Arafura Sea are not only landed in Dobo, but also in Merauke, Timika, Jakarta, Probolinggo, Indramayu, Pekalongan, Cirebon. As the landing areas are scattered, the data on the groupers caught by fishing boats in the Arafura's fishing grounds are not collected systematically and, therefore, there is no information available on the overall grouper production. However, based on the Regulation of the Ministry

of Maritime Affairs and Fisheries No. 50 Year 2017, the coral reef fish exploitation in Arafura was already 1.07 (overfishing).

Various groupers landed in several locations such as Timika (Papua), Dobo (Maluku), Probolinggo, and Indramayu, are orange-spotted grouper, brown-marbled grouper, etc. There are 36 grouper species traded in Ambon [7]. One of the groupers from Arafura is the genus *Anyperodon* that only has one species, i.e. *A.leucogrammicus*. The species has an elongated body. According to [8, 9,10,11] the species has an elongated body, brownish-gray with brown spots on the head, large mouth, no palatine teeth, and rounded caudal, dorsal, and anal fins. The dorsal fin has XI spines and 14–16 soft rays, while the anal fin has III spines and 8–9 soft rays [12]. The species is widely distributed in the Indo-Pacific Oceans, including West Indo-Pacific and Middle Pacific [13,14], and even in East Africa and the Red Sea [11].

Intensive exploitations change the population structure and decrease the quantity of the resource. Therefore, grouper fisheries management is necessary. In addition to being vulnerable to fishing pressure, groupers also face another challenge because of the degraded condition of the coral reefs [15]. The fish also have slow growth rate and slower gonadal maturation, and is a hermaphrodite species, making it difficult to predict its spawning activity in [16]. The species *A.leucogrammicus* has lower chance to be cultivated in aquaculture [8] than the other grouper species such as humpback, camouflage, orange-spotted, brown-marbled, and leopard coral groupers [17,18]. On the other hand, fisheries managements require scientific information on the population dynamics and the exploitation status of the species. However, such studies are scarce. Studies on groupers in Indonesia are mostly on the grouper aquaculture, not on their exploitation status. Therefore, a study on the exploitation status of the groupers in Arafura Sea is necessary, particularly on the slender grouper (*A.leucogrammicus*), to provide the basis for the government policy in maintaining grouper resources.

2. Material and Methods

2.1 Data Collection

The study was carried out using survey method at one of the landing sites of the fishing boats in Arafura Sea (Figure 1), i.e. Aru Islands (Dobo), from March to November 2017. The data were collected monthly by the researchers and an enumerator. A total of 696 slender groupers were measured. The data collected were fish's total length (TL) (measured using a tape measure) and weight (weighed using 0.1-gram digital scale).

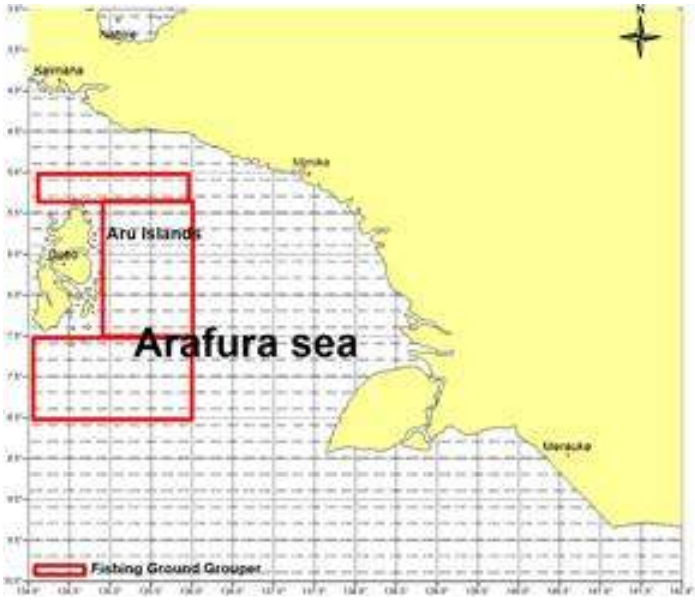

Figure 1. The groupers' fishing grounds in Arafura Sea

2.2 Data Analysis

The slender grouper's total length (TL) was tabulated to determine the dominant size structure of the species and to analyze the length distribution by class interval. The relation between the fish's total length and weight was analyzed using an equation [19]; b = 3 means isometric, and b ≠ 3 means allometric. The length at first capture (Lc) was then analyzed by determining the intersection between 50% cumulative frequency curve and the fish's TL [20].

The estimation of the slender grouper's growth parameters, i.e. asymptotic length (L∞) and growth coefficient (K), were analyzed using the ELEFAN I method of the software FAO ICLARM Fish Stock Assessment Tool (FISAT II). The fish' theoretical age at the length equals to 0 was then determined separately following the empirical formula by Pauly [21].

The natural mortality (M) is related to the growth parameters Von Bertalanffy K and L∞. The fish's natural mortality (M) was estimated following the empirical formula by [22] as follows:

$$\text{Ln M} = -0.152 - (0.279\ \text{Ln}\ L_{\infty}) + (0.6543\ \text{Ln K}) + (0.463\ \text{Ln T})$$

Note:
M = natural mortality
L∞ = asymptotic length
K = growth rate
T = average annual sea surface temperature (°C)

The total mortality (Z) was then estimated using the catch curve linearized by length composition data. The natural mortality (M) was estimated using the empirical formula by in [22] by converting the length data into the age data using the inverted growth equation by Von Bertalanffy. In addition, the fishing mortality (F) was calculated using a simple equation, i.e. F = Z – M. According to [21], the optimum fishing mortality (F), or the optimum exploitation rate, is $F_{optimum}$ = M, and $E_{optimum}$ = 0.5.

3. Results and Discussion

3.1 The size structure and the growth pattern

The size of the slender groupers caught in Arafura Sea was 15–120 cmTL, with 30 cmTL being the dominant size. See Table 1 for the total length (TL) of the grouper caught by month, and Figure 2 for the fish frequency by class interval. The smallest slender grouper was caught in November 2017, and the biggest in May, June, August, and October 2017.

Table 1. The range of the total and the dominant length of the slender grouper (*A. leucogrammicus*) in Arafura sea

Month	Total Length		Dominant (cm)
	Min (cm)	Max (cm)	
Mar	20	65	50
Apr	25	95	30
May	25	120	40
Jun	45	120	90
Jul	20	110	35
Aug	50	120	90
Sep	20	90	65
Oct	20	120	40
Nov	15	100	35
Total	15	120	30

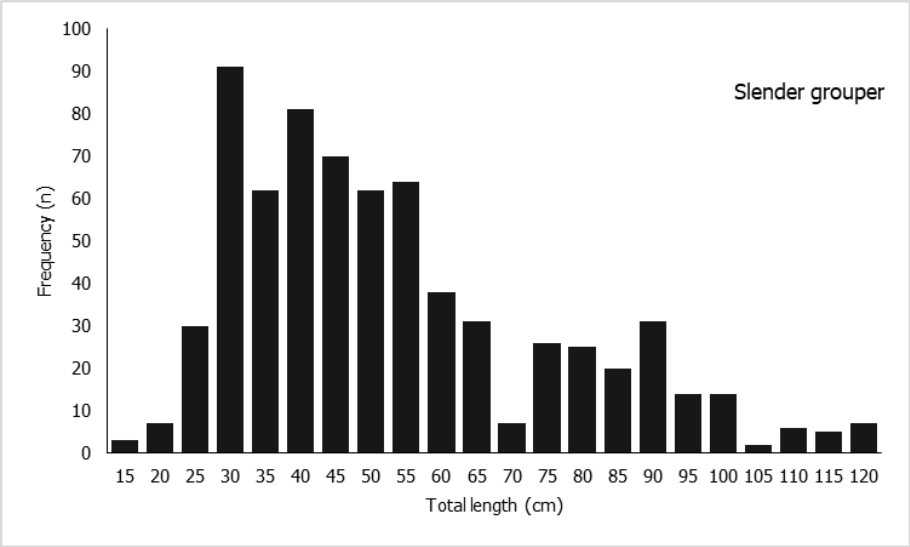

Figure 2. The size structure of the slender groupers (*A. leucogrammicus*) in Arafura Sea

The size was larger than those found in Barru waters (26.5–30.5 cm TL; weight 201.35–288.86 grams) [8]. According to [12], slender groupers are able to grow up to 52 cm TL. The fish size was 28.5 cmTL (23 cm SL) in Andaman Sea, 21.8–34 cm SL in Pohnpei, and 23.8–42.6 cm TL in North Male Atoll, Maldives, and 60 cm TL (50 cm SL) in Kwandang, North Gorontalo, Indonesia[9, 16, 23, 24]. Such different sizes were due to the water fertility and the different locations where they were caught. According to [25], adult groupers are more abundant in deep coral reef waters, while the young ones in shallow coral reef waters. In Hoga Island, Southeast Sulawesi, according to [26], the fish population has a high density in the coral reef slopes and tops, and low in the other parts of the coral reefs.

The results of the analysis on the relation between the total length and the weight of the fish revealed that a = 0.06; b = 2.5878; and R = 0.9566 (Figure 3), indicating that the fish has a negative allometric growth pattern. This means, the fish is faster in increasing its length than in increasing its weight, or, in other words, the fish is slender. Several grouper species, such as *Cephalopholis argus, E. tauvina, E. merra,* and others, in Kenya waters have isometric growth patterns [27]. On the other hand, the brown-marbled grouper (*E. fuscoguttatus*) in Seribu Islands, Jakarta, has a positive allometric growth [28]. Such diverse b values of the fish are due to various determining factors that influence their growth pattern, i.e. the environment, food, sex, gonadal maturation, their gut condition during the capture, etc. According to [29], b value can be different due to the physiological condition, the food, and the growth phase of the fish.

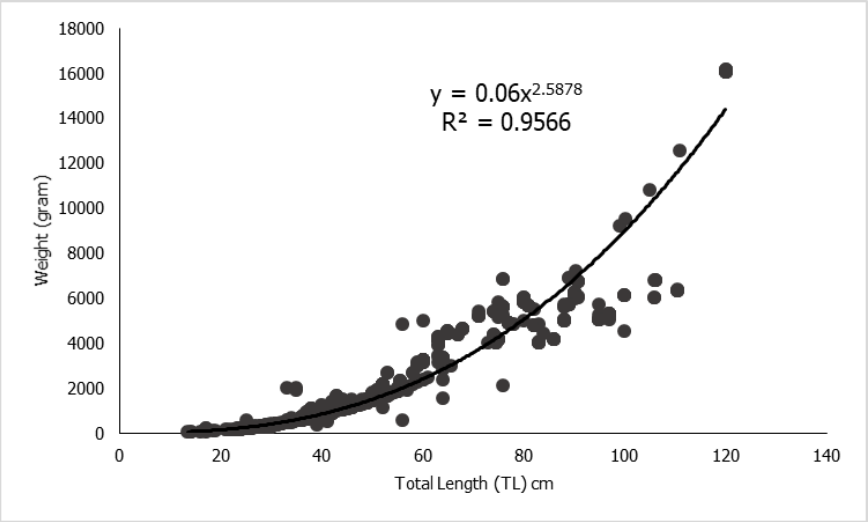

Figure 3. The relation between the length and the weight of the slender grouper (*A. leucogrammicus*) in Arafura Sea

However, in general, the growth patterns are different due to the quantity of the food consumed by the fish and the environmental condition of the waters [30]. According to [26], the groupers are the top predators of fish, crustaceans, and cephalopods, and they are the determining factor of the community structure in the coral reefs. Insufficient food will surely affect their growth. Their food is also highly related to the habitat's environment because well-maintained coral reefs are the home for the small fish and the food for the large ones [2]. Damaged coral reef will lead to the declining food availability that eventually affect the fish growth.

3.2 The Length at First Capture

The slender groupers are mostly caught by the fishers using handlines in coral reef areas around Dobo, Arafura, Maluku. Their length at first capture (Lc) was 52.4 cmTL (Figure 4), and 49.4% of the caught fish were below the Lc. The length of the groupers caught depends on the size of the hooks used by the fishers. The size of the hook affect the weight and the distribution of the caught fish [31]; [32].

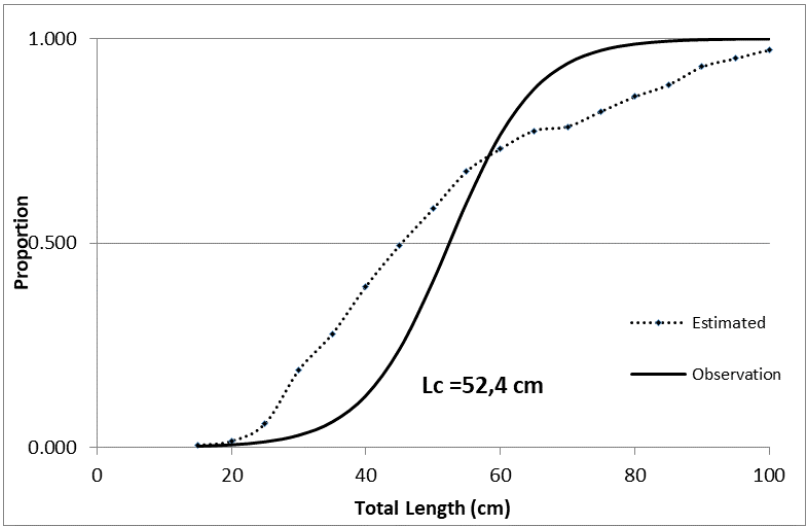

Figure 4. The length at first capture (Lc) of the slender grouper (*A. leucogrammicus*) in Arafura Sea

The slender grouper is one of the rarely caught fish by the fishers. In several locations, only a few of them are caught. Only 1% of all the groupers caught in Kenya [27] and 10% in Seribu Islands, Jakarta, is the slender grouper [33], while in Kotania Gulf, Maluku, the fish is the least caught grouper [6]. The slender groupers live at the bottom of the coral reefs [34], making them rarely caught by the fishers' handlines. According to [12], the fish lives in 5–80 m deep waters, and therefore not all the fishers' handlines are able to catch them. However, in Karimunjawa, Central Java, the fish is caught using *muroami* nets, traps, and nets [35], while in Kotania Gulf, Maluku, groupers are caught using longlines, handlines, nets, traps, bottom gillnets, spears, and harpoons [6]. The most selective fishing gear to catch groupers is handline as its hook size can be adjusted according to the size of the mouth opening of the target fish.

3.3 The population dynamics and the exploitation status

The growth rate of a species is related to the time required for the species to reach its asymptotic length (L∞) [36]. Based on the results of the analysis, the growth rate (K) of the slender grouper in Arafura Sea was 0.34 per year and its asymptotic length (L∞) was 129 cmTL. The equation was **Lt=129 [1-e $^{-0.34(t - 0.32605)}$]**. See Figure 5 for the length distribution. The growth rate of the species to reach its asymptotic length was of slow growth category as the K was below 0.5. Most groupers have slow growth rate, such as *E. guttatus* in Puerto Rico and St. Thomas [37], *P. aerolatus, P. leopardus, P.maculatus, P. oligacanthus,* and *Cephalopholis cyanostigma* in Karimunjaya, Central Java, and brown-marbled grouper in Seribu Islands, Jakarta [38, 39, 28].

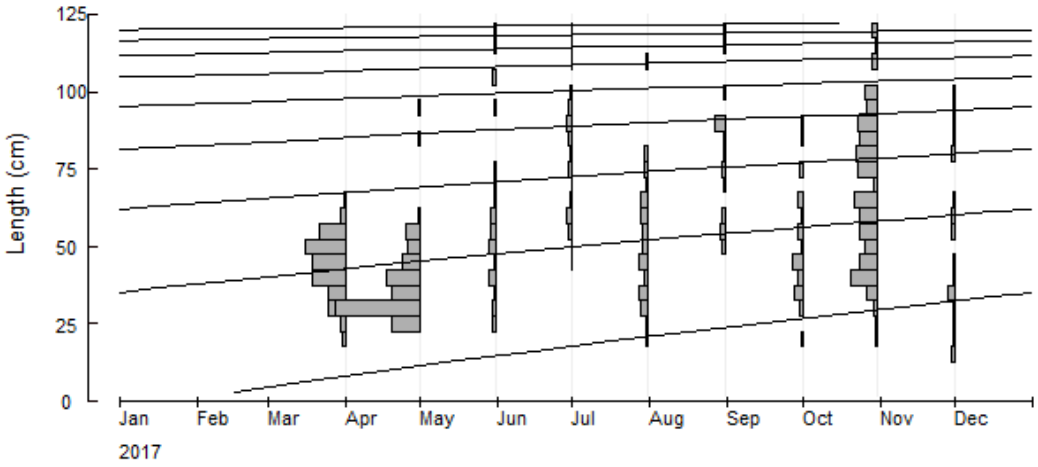

Figure 5. The total length (TL) frequency distribution of the slender grouper (*A. leucogrammicus*) in Arafura Sea

Based on the growth rate and the asymptotic length, the slender grouper's age at the first capture (Lc = 52.4 cmTL) was 1.2-year old, or approximately 14.5 months (Figure 6). The species' age to reach its asymptotic length (L∞ = 129 cmTL) was 23 years old. The species was faster in reaching its asymptotic length than the other groupers such as *C. cyanostigma* in Karimunjaya, Central Java (approximately 30 years) [39], *P. areolatus, P. leopardus,* and *P. maculatus* (approximately 27 years) [38].

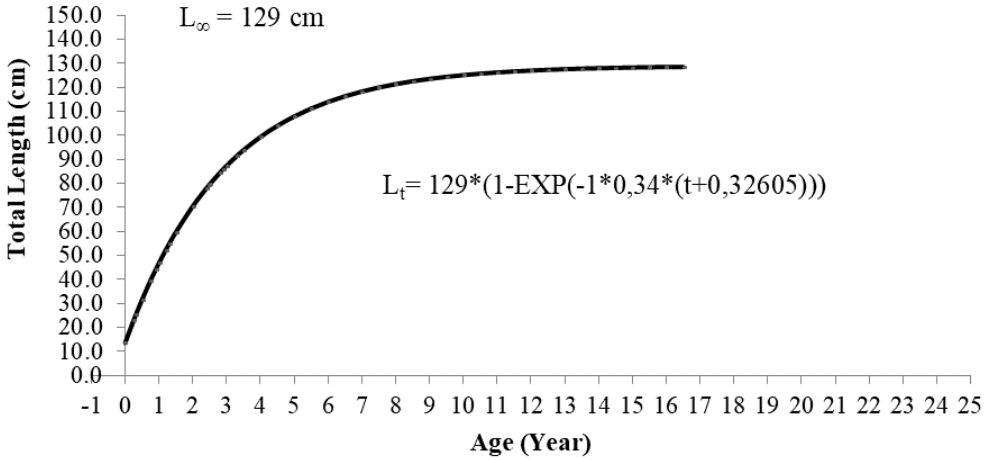

Figure 6. The growth curve of the slender grouper (*A. leucogrammicus*) in Arafura Sea

Despite having a slow growth rate, groupers live longer than the other fish species. However, the recruitment of the slender grouper should be paid a close attention to allow them reproduce and increase their population, and the number of the juveniles growing into adult fish should also be counted [40]. Based on the results, it was estimated that the slender grouper has two (2) recruitment peaks, i.e. January–March and September–November (Figure 7). For the first peak, the recruitment was 26.67% in January, decreasing to 21.98% in February, and to 15.49% in March (Table 2). While for the second peak, the recruitment was 5.53% in September, decreasing in the following months to 3.17% in November. This recruitment process is highly related to the fish reproduction and spawning activities. The spawning activity is one of the determining factors of the population and the exploitation status of the fish species. The slender groupers live in tropical waters [12], characterized by its partial spawner trait, i.e. laying eggs gradually during the spawning process [41], meaning that the fish spawns all year long but the peak of the recruitment occurs when the fish in gonadal maturation IV are the most abundant [42].

As groupers are protogynous hermaphrodite fish, meaning they change their sex from female to male, scientific studies are required to determine the fish length during the gonadal maturation. Their sex change depends on their size, age, and species [42]. The length of the other grouper species in Hongkong during gonadal maturation is 20–30 cm TL [40]. In slender groupers, such length is reached when they are 3–6 months. Based on the above data, 95% slender groupers had already passed their gonadal maturation period and contributed to the waters by increasing their populations. However, according to [26], slender groupers are slow in their gonadal maturation and have low reproduction.

The reproduction of the slender groupers in Pohnpei is in February [16], while the other species in April and June (*P. areolatus*), May and October (*P. leopardus*), April and August (*P. maculatus*), April and October (*P. oligacanthus*) [38], and October (*E. sexfasciatus*) [42]. The reproduction process is related to the water temperature. Grouper *E. striatus* spawns at 25–25.5°C [43]. As the water temperature of the Arafura Sea is 24–27°C [44], the waters are still able to support the fish spawning process.

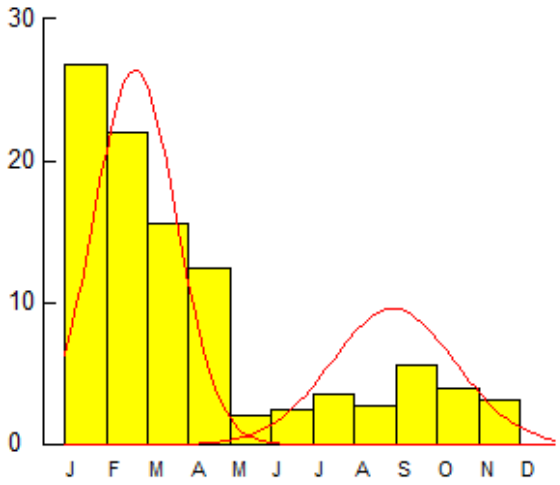

Figure 7. The recruitment pattern of the slender grouper (*A. leucogrammicus*) in Arafura Sea

The slender grouper's fishing mortality (F = 0.55 per year) was higher than its natural mortality (M = 0.51 per year). Fast-growing fish has higher natural mortality, and slow-growing fish has lower natural mortality. Natural mortality is closely related to L∞ because fish with greater body length have fewer predators than the smaller fish. in [22], there are environmental factors influencing the natural mortality, i.e. average water temperature, maximum length (L∞), and growth rate (K). In addition, damaged coral reefs due to the pollutions from the land can cause the natural mortality of coral reef fish, including groupers.

Table 2. The recruitment of the slender grouper (*A. leucogrammicus*) in Arafura Sea

Month	Recruitment (%)
January	26.67
February	21.98
March	15.49
April	12.41
May	1.90
June	2.46
July	3.73
August	2.71
September	5.53
October	3.86
November	3.17

Fishing mortality is the mortality caused by fishing activities [22]. Fishing mortality being higher than the natural mortality means the fish mortality is mostly due to exploitations. Based on the data analysis, the slender grouper's exploitation rate (E) was 0.52 %, meaning the fish was already moderately exploited. Precautions should be taken in managing the fish to maintain the population. High exploitation rate will change the resource stock of the waters. Intensive fishing activity is one of the driving factors for the decreasing grouper population [7]. Based on the IUCN Red List of Threatened Species, slender grouper belongs to the least concern category, meaning precautionary management is required as the species is already under concern.

Damaged coral reefs due to excessive and destructive fishing activities, sedimentation, and pollutions change the population of the coral reef fish [45]. The coral reefs in Aru Islands are already severely damaged by excessive and destructive fishing activities, while the coral reefs in Papua are only less damaged in [4, 5]. To maintain the ecosystem sustainability, coral restoration activities can be carried out in the area.

There are several measures that can be taken to ensure the sustainability of the groupers, particularly the slender grouper. First, regulations should be set in place on the allowable size to catch and to trade, and the regulations should be prioritized to allow young fish to increase the population. The allowable size to catch is related to the size of the hooks used to capture the coral reef fish. Second, the coral reef areas in Arafura Sea are designated as conservation areas to disallow excessive and destructive fishing activities in the areas. Finally, the government involves the fishers to work together in monitoring the area to maintain the sustainability of the resources.

4. Conclusion

The size of the slender groupers caught in Arafura Sea was 15–120 cm TL, with 30 cm TL being the dominant size. The fish had a negative allometric growth pattern with the length at first capture (Lc) 52.4 cm TL. Its growth rate (K) was 0.34 per year with asymptotic length (L∞) 129 cm TL. Its fishing mortality (F) was higher than the natural mortality (M), driving the exploitation rate (E) high (E = 0.52%). As the fish was already moderately exploited, precautions should be taken in its management. Several measures that should be taken in its management are among others to set the regulations on the allowable size to catch and to trade, and to designate the coral reef areas in Arafura Sea as conservations areas to maintain the habitats of the groupers and to disallow the destructive fishing activities in the area.

Acknowledgement

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