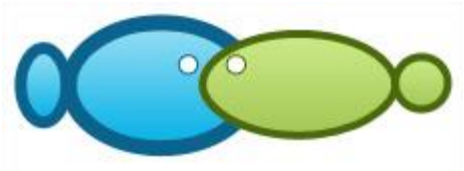

Catch structures, growth patterns and condition factor of grouper fish (Serranidae) caught in the waters near Wayaban, Misool, Raja Ampat

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Abstract. Misool Marine Protected Area (MPA) has a large coral area and a high potential for reef fish biomass. This makes Misool waters important for biodiversity and a source of livelihood for the community around this MPA. This study aims to determine the composition of types and sizes, growth patterns and growth conditions of groupers based on the catch of fishermen in the waters of Wayaban Misool, Raja Ampat Regency, Indonesia. The data collection used in the research was carried out by direct observation and measurement of the catch of handline fishermen who landed their catches at the fish collecting base. The data was analysed descriptively to determine the species and size composition, the relationship between fish length and weight, and condition factors. The results showed that the groupers caught by fishermen in Wayaban waters could be grouped in 15 species, dominated by *Cephalopholis miniata*, *Cephalopholis sexmaculata* and *Plectropumus oligacanthus*. In general, the total length of the grouper caught by fishermen was larger than the length at first spawning (Lm). The results of the analysis of the relationship between length and weight indicated that the growth patterns of groupers studied were different for different species. In general, grouper caught by the fishermen has a good condition (K>1), although for small sizes the growth conditions tends to decline.

Key Words: condition factor, fish size, length and weight relationship, Misool Raja Ampat MPA, Serranidae.

Introduction. Misool is the largest Regional Marine Protected Area (MPA). It is located in the southernmost part of the Raja Ampat MPA Network, which is in the Coral Triangle area, a center of marine biodiversity. According to Prasetya et al (2014), reef fish in South Misool waters consist of 19 fish families and 196 fish species and are categorized as target reef fish for fisheries. Reef fish from the Serranidae family (groupers) are intensively fished by local fishermen and fishermen from outside the Raja Ampat area, because they have important economic value. This family has subfamilies such as Anthiinae (anthias), Epinephelinae (Grammistinae soap fish) and Pseudogrammitinae (podges) (Allen 1997). These fish are solitary (rarely found in pairs), usually hiding in caves or beneath corals.

The exploitation pressure on coral reef ecosystems due to live grouper fishing has been suspected to lead to the degradation of spawning aggregations (SPAGs) of grouper in the Misool KKPD (Muhajir et al 2012). This decline in stock can be related to the use of environmentally unfriendly fishing gear and overfishing by fishermen from outside Misool such as from Sorong, Seram, Madura and even Buton (Muhajir et al 2012).

An understanding of the species composition and size composition of fish caught by fishermen is important to help formulate a right management model for economically

important fish resources, for example controlling illegal fish size in the fisherman catches. Legal size fish is defined as fish that has a total length greater than the length at first maturity (Lm) and has the opportunity to spawn before being caught. The study of growth patterns is useful for understanding fish population dynamics, including in responding to the dynamics of the oceanographic environment in their habitat. Richter (2007) stated that the measurement of length and weight of fish is useful for identifying certain variations in individual weight and length, which can be used as an indication of fish obesity, health, productivity and fish physiological conditions. Furthermore, understanding biology aspects of fish, such as length-weight relationships, condition factor, growth, recruitment and mortality, is useful for the management of fishery resources (Jamal et al 2011).

The description above illustrates the importance of the waters around Misool in supporting the conservation of biodiversity in the coral triangle area. However, until now, there has been very little research regarding the condition of fish resources in terms of biology and ecology in the area. Several related studies focused, for example, on the monitoring of fish resources in the waters of the Misool area marine conservation area (Muhajir et al 2012), on the ecological status of reef fish (Sala et al 2020) and on biomass carrying capacity of reef fish (Prasetya et al 2014). Therefore, the present study is one of the efforts made to contribute to providing information about the biology of fish resources. Specifically, the aims of this study were to determine the species and size composition, the relationship between length and weight of fish and condition factor, especially for groupers caught by fishermen in Wayaban Misool waters, Raja Ampat Regency.

Material and Method

Data collection methods. Collection of data collection was carried out for ten days in January 2019 by direct observation and measurement of the landing catch from hand line fishermen who fished around Wayaban, South Misool and landed their catches at the fish collection base close to the fishing area. The location of the fishing grounds and fish collection base is presented in Figure 1. Collected data consisted of grouper species, quantity of each grouper species, total length and weight of individual groupers. In addition, interviews were conducted with fishermen to find out fishing techniques, fishing gear construction and information on fishing grounds. Indentification of grouper species was based on More & Colas (2016) and fishbase.org.

Method of data analyses. Data for the individual number, total body length and body weight were analyzed using Microsoft Excel 2010. Data on the relationship of length and weight of fish were analyzed using a simple linear model to calculate the coefficients a and b with the following equation (De Robertis & Williams 2008):

$W = aL^b$

Where: W - body weight of fish (g); L - total body length of fish (cm); a and b - regression coefficients. The equation is transformed into a linear equation by means of a logarithm (Suruwaky & Gunaisah 2013). Determination of the growth pattern was based on regression parameter value b, which was then tested statistically using the t-test. The b value from the results of the length-weight relationship analysis illustrates the distribution of length growth and body weight growth of fish. The value of $b=3$ shows isometric growth, which means that the increase in length and weight is balanced. A value of $b<3$ indicates a negative allometric growth form, which means that the length growth is faster than the weight growth. A value of $b>3$ indicates a positive allometric growth, which means that the weight growth is faster than the length growth (Jisr et al 2018).

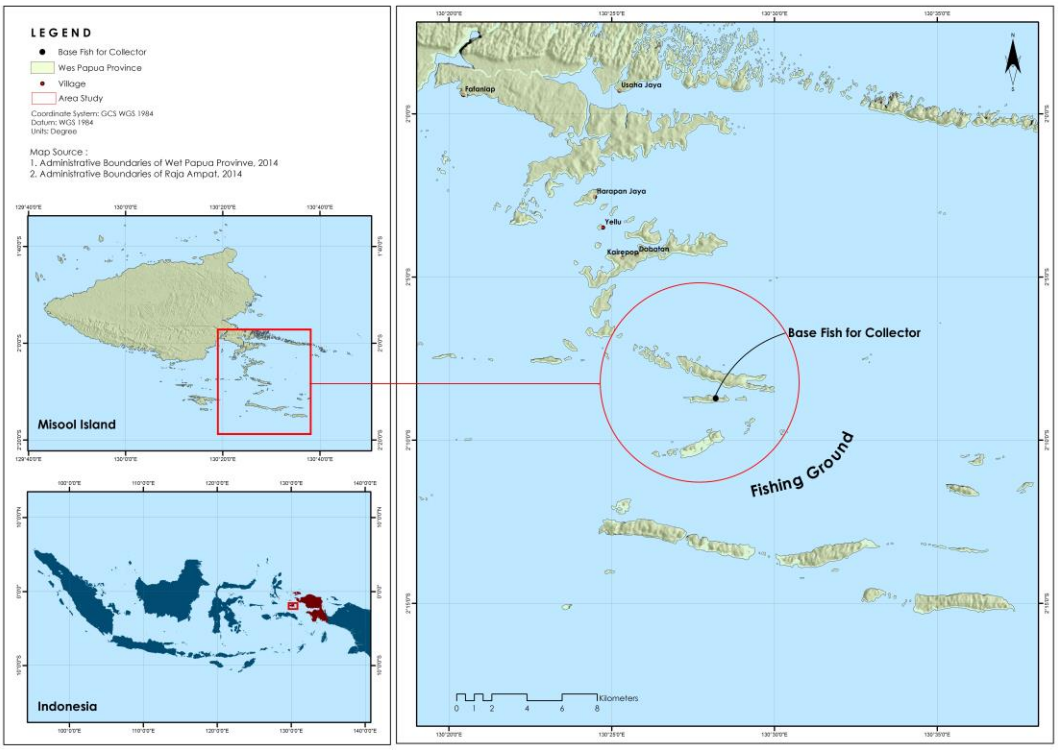

Figure 1. Map of research location in Wayaban waters.

The calculation of the t statistical value was carried out using the method proposed by Weaver & Wuensch (2013), with the following formula:

$$t_{calculated} = \left|\frac{b - b*}{S_b}\right|$$

Where: b - the regression coefficient obtained from simple regression analysis; b*=3; S_b - standard error for b. The criteria for decision making are based on Jisr et al (2018), namely: if $t_{calculated} < t_{table\ 0.05\ (nm-1)}$; b=3, which means the growth is isometric; if $T_{calculated} > t_{table\ 0.05\ (n-m-1)}$, b≠3, which means the growth is allometric. 'm' is the number of predictor variables and 'n' is the number of data pairs.

Calculation of the condition factor uses fish length and weight data and the results of the analysis of the relationship between length and weight of fish. Referring to Effendie (2002) and Jisr et al (2018), the calculation of the condition factor coefficient (K) uses the formula:

$$K = \frac{W}{W*}$$

Where: W - fish weight (g); W* - fish weight calculated based on the LWR model (g); L - length of fish (cm). Fish have good growth conditions if the value of K≥1. If K<1, then the fish are in poor growth conditions (Jisr et al 2018).

Results and Discussion

Composition of each grouper species. Grouper fish in Wayaban, Misool waters, are the primary target species for handline fishermen. 15 grouper species were caught by fishermen in Wayaban. The species with the highest number of individuals was *Cephalopholis miniata*, followed by *Cephalopholis sexmaculata* and *Plectropomus oligacanthus.* The composition of grouper species can be seen in Figure 2.

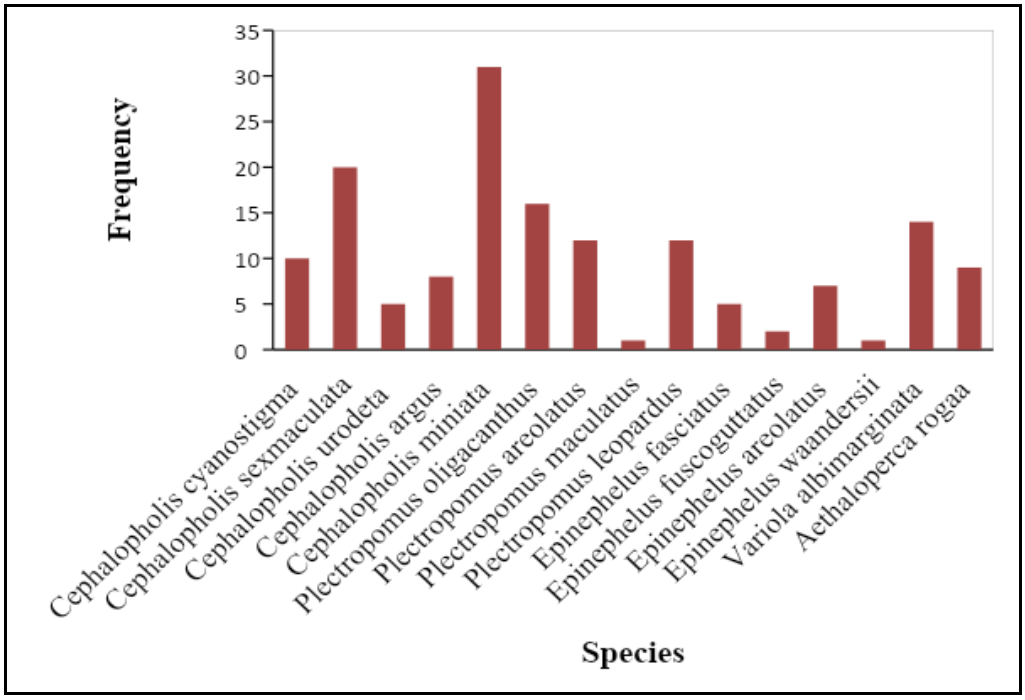

Figure 2. Composition of grouper species captured by fishermen in Wayaban waters.

Based on the list of groupers commonly exported from Indonesia (Khasanah et al 2020), several species of grouper collected from Wayaban water were categorized as highly economic species, traded as live fish, thus known as live reef food fish (Erdmann & Pet-Soede 1997). Some of these species are *Plectropomus areolatus*, *Plectropomus leopardus, Plectropomus maculatus* and *Epinephelus fuscoguttatus*. Due to its high economic value as export commodity, it could lead to an increase in fishing intensity (Khasanah et al 2020). Based on information from fishermen, there was a tendency of decrease in the number of groupers caught by fishermen in the waters near Wayaban. Therefore, monitoring and controlling fishing activities, including monitoring and controlling catches should be done in order to sustain the grouper population.

Composition of grouper sizes. Each species of grouper in Wayaban water had different individual lengths and weights. The composition of length and weight of fish can be seen in Figures 3 and 4. The largest size belonged to *Plectropomus oligacanthus* with lengths ranging from 33-77 cm and weights ranging from 1000-5000 g. The second largest was *Epinephelus fuscoguttatus*, with length ranging between 53-58 cm and weight ranging from 300 to 3900 g, followed by *Epinephelus fasciatus* with sizes ranging from 20 to 27 cm and weighing 113-336 g. In general, the size of the grouper caught by fishermen in Wayaban waters included them in the adult fish category, only a few being of small size (illegal size catches). The sizes of the target fish are presented in Table 1.

Table 1

Length of fish from the Serranidae family from Wayaban Misool water

Family	*Species*	*Length ranges (cm)*	*Mean (cm)*	*Lm (cm)*
Serranidae	*Cephalopholis cyanostigma*	16-28	26	-
	C. sexmaculata	24-35	29.2	-
	C. urodeta	27 -40	31.2	17[b]
	C. argus	25-35	30.2	22[b]
	C. miniata	22-30	26	26[b]
	Plectropomus oligacanthus	37-77	57	39.78[a]
	P. areolatus	30-59	44.3	40.6[a]
	P. maculatus	65	65	39.87[a]
	P. leopardus	29-49	38	42.98[a]
	Epinephelus fasciatus	20-27	24	16[b]
	E. fuscoguttatus	53-58	56	59.41[a]
	E. areolatus	25-30	27,4	20[b]
	E. waandersii	24	24	-
	Variola albimarginata	20-36	27.2	-
	Aethaloperca rogaa	25-39	33	34[b]

Note: a - Khasanah et al (2020); b - Fishbase.org.

Jamal et al (2011) stated that legal catch size should be larger than the length at first maturity (Lm). Based on the Lm value data available at the Fishbase.org and Khasanah et al (2020), compared with the length of grouper captured in Wayaban waters (Table 1), there were 7 species of groupers that had sizes larger than Lm, namely: *C. urodeta*, *C. argus*, *C. miniata*, *P. oligacanthus*, *P. areolatus, E. fasciatus*, and *E. areolatus*. The dominance of legal size groupers in the catches is also reported in traditional fishermen catches of species *P. maculatus* and *P. oligochantus* in the Cenderawasih Bay Marine National Park (Mudjirahayu et al 2017).

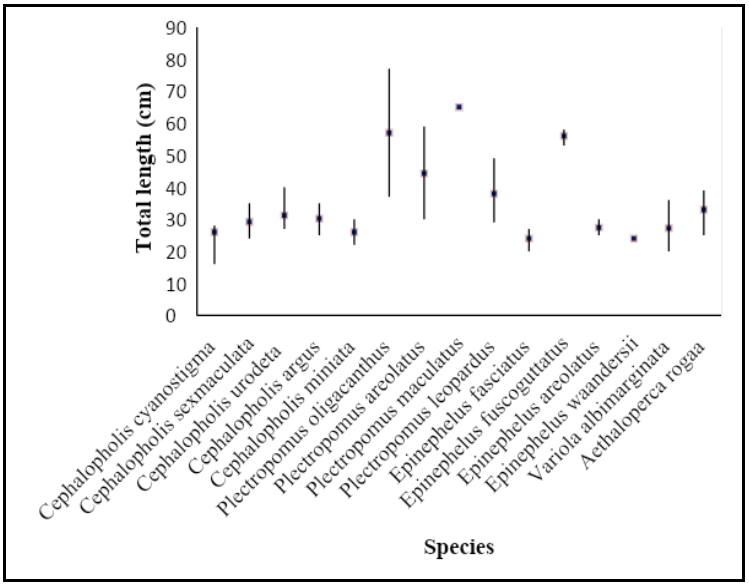

Figure 3. Composition diagram of fish average length.

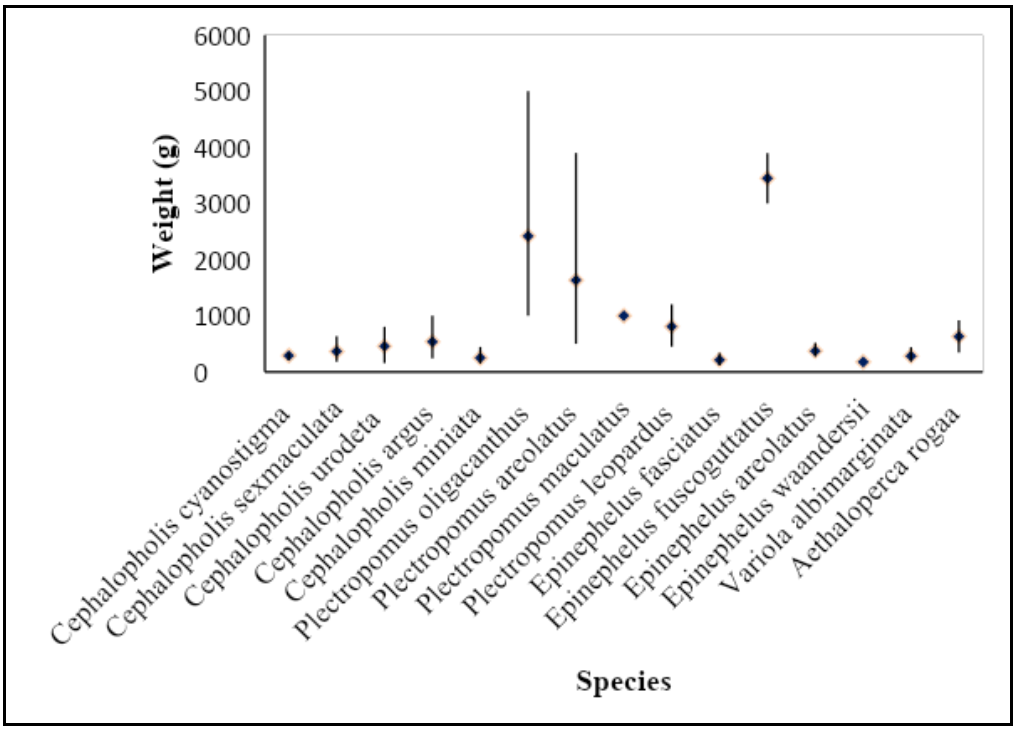

Figure 4. Composition diagram of grouper average weight.

Nevertheless, monitoring of the fish caught by fishermen in the Misool conservation area must continue, considering that there were still catches with small sizes, for example, some catches of *P. leopardus*, *E. fuscoguttatus* and *A. rogaa*. Fishing illegal sizes of groupers was also reported in the Cenderawasih Bay National Park for *P. leopardus* (Bawole et al 2017). If the fishermen continue to catch illegal size fish in the waters of Wayaban Misool, Raja Ampat Regency, and several places in West Papua waters, it can cause a decrease in the stock population of the important economic fish in these areas. It is encouraging that grouper fishing uses handline fishing gear, which is classified as environmentally friendly fishing gear (Sala et al 2018). The use of handlines, apart from not destroying the habitat of the grouper (coral reef), can easily increase its selectivity by only adjusting the size of the hook, to avoid illegal sized catches.

Length and weight relationship (LWR) of grouper fish. LWR analysis using simple linear regression was only carried out on 8 out of 15 species of grouper caught by fishermen in the waters around Wayaban. The selection of the 8 species was based on the number of individuals present for each species. Only species with a total of more than 7 individuals were analyzed. The results of the calculations of the regression coefficients (the coefficients a and b), the coefficient of determination (R^2) and the pattern of fish growth are presented in Table 2.

Table 2

The coefficients of linear regressions for the length-weight relationships of groupers

Species	*Location of studies*	*a*	*b*	R^2	*Growth form*	*Source*
Cephalopholis sexmaculata	Misool, Indonesia	0.53	2.10	0.39	Isometric	Present study
	Lihir Island group (seamount), Papua New Guinea	0.0268	3.00			(Fry et al 2006)
Plectropomus oligacanthus	Misool, Indonesia	0.82	2.38	0.83	Negative allometric	Present study
	Chuuk lagoon, Micronesia	0.0155	2.972			(Cuetos-Bueno & Hernandez-Ortiz 2017)
Variola albimarginata	Misool, Indonesia	0.72	1.20	0.42	Negative allometric	Present study
	Davao Gulf, Philippines	0.0212	3.122			(Gumanao et al 2016)
Plectropomus areolatus	Misool, Indonesia	1.8699	3.05	0.98	Positive allometrics	Present study
	Wakatobi, Indonesia	-1.279	2.639			(Alamsyah et al 2013)
Aethaloperca rogaa	Misool, Indonesia	0.2187	1.9838	0.84	Negative allometric	Present study
	Lihir Island group (seamount), Papua New Guinea	0.0299	3.00			(Fry et al 2006)
Cephalopholis argus	Misool, Indonesia	0,038	3.867	0.66	Isometric	Present study
	Palawan, Philippines	0.0130	3.06			(Palla et al 2018)
Plectropomus leopardus	Misool, Indonesia	0.65	2.24	0.76	Isometric	Present study
	Davao Gulf, Philippines	0.023	3.046	0.98		(Gumanao et al 2016)
	Sarappo Islands, Indonesia	0.22	2.23	0.77	Negative allometric	(Ernaningsih et al 2019)
Cephalopholis miniata	Misool, Indonesia	0.94	2.36	0.61	Negative allometric	Present study
	Davao Gulf, Philippines	0.028	2.85	0.93		(Gumanao et al 2016)

The coefficient b shows the shape of the growth of the fish based on the LWR, where the b value varies among grouper species caught by fishermen in Wayaban Misool. The results of the t-test on the value of b showed that several species of grouper caught in Misool waters had different growth patterns. Referring to the criteria quoted from Jisr et al (2018), *C. sexmaculata*, *C. argus*, and *P. leopardus* had a value of b=3, showing isometric growth, with a length growth proportional to the weight growth. However, species *P. areolatus* had a value of b>3 or a positive allometric growth (which shows a faster growth in length compared to its weight) and the species *P. oligacanthus*, *A. rogaa*, *V. albimarginata*, *C. miniata* had value of b<3 or negative allometric growth, where the length growth is slower than weight gain. Apart from differences among grouper species, several studies reported different b coefficients and growth patterns for the same grouper species (Fry et al 2006; Gumanao et al 2016; Cuetos-Bueno & Hernandez-Ortiz 2017; Ernaningsih et al 2019).

Several studies noted that the value of the b coefficient of the LWR regression associated with fish growth patterns is influenced by many factors, such as aquatic environmental factors, geography, season, sex, age, food availability and disease (Türkmen et al 2002; Ecoutin et al 2005; Jisr et al 2018). In other words, certain fish groups that inhabit one location in certain aquatic environmental conditions will have certain growth patterns. Therefore, it is very important to suggest that studies of these growth patterns in various environmental conditions throughout the year may show different results.

Condition factor. The results of the analyses of the fish condition factor (K) showed relatively different values between the eight grouper species studied (Figure 5). In general, the average K value was greater than 1, which indicated that the fish were in good growth conditions (Jisr et al 2018). However, there was a tendency for fish groups with small sizes to have a K value of less than 1, which indicates poor growth. For example, the species that had a K<1 included *C. sexmaculata* for sizes less than 260 g, *P. oliganthus* for sizes smaller than 2500 g, *V. albimarginata* for sizes smaller than 260 g, and *P. leopradus* for sizes smaller than 100 g. This result is in line with the results of studies which found that the same species at a larger size had a larger K (Rahardjo & Simanjuntak 2008; Gani et al 2020).

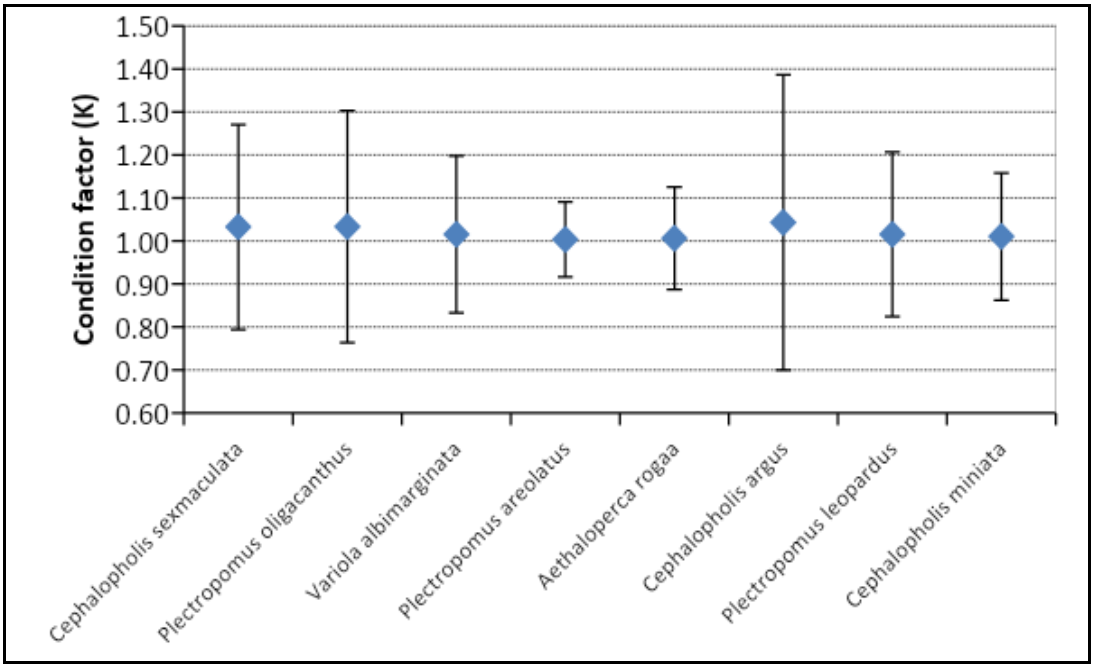

Figure 5. Value of condition factor (K) (with standard deviation) for grouper fish caught from Misool waters, Raja Ampat.

Apart from being influenced by size, the K value is also influenced by other factors, namely aquatic environmental factors, food availability (Jisr et al 2018), and the weight of food in the digestive tract (Ibrahim et al 2017) and level of gonad maturity (Rahardjo & Simanjuntak 2008). Rahardjo & Simanjuntak (2008) stated that the fish at sexual maturity in the first three stages tend to experience a decline in growth, but in the fourth gonad maturity phase the growth will increase.

Conclusions. Grouper fish caught by fishermen in Wayaban waters consisted of 15 species. The species with the highest number of individuals was *Cephalopholis miniata*, followed by *Cephalopholis sexmaculata* and *Plectropumus oligacanthus*. In general, the sizes of groupers caught by fishermen were greater than the length at the first maturity (Lm). Different species of groupers had different growth patterns. The groupers caught had good condition factors (K>1), although the condition factor tended to decrease for smaller sizes.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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