

Grouper and snapper fisheries dynamics in Sumbawa Waters - Indonesia as a database for sustainable fisheries management

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Abstract. The lack of information regarding the conditions of grouper and snapper fishing activities in Sumbawa waters is one of the reasons for local government difficulties in making policies related to grouper and snapper fisheries management. This data is very important for decisions that need to be implemented at community level. In making this decision, the West Nusa Tenggara (NTB) provincial government needs information on catch composition and productivity in grouper and snapper fishing units, fishing grounds, and the fishing season for grouper and snapper in Sumbawa waters. Sumbawa waters are the largest production contributor to grouper and snapper fisheries in NTB Province. The dominant species of grouper and snapper caught in Sumbawa waters are *Lutjanus argentimaculatus*, *Lutjanus malabaricus*, *Plectropomus leopardus*, and *Epinephelus coioides*. These four species are also caught by fishermen under their sexual maturity length in Sumbawa waters. Grouper and snapper fishing units used by fishermen in Sumbawa waters have a productivity between 5.42 – 22.28 kg/trip. The grouper fishing seasons in Sumbawa waters are in March-April, June, August-September, and November, while the snapper fishing season in Sumbawa waters is in January-March, May-June, and September.

Key Words: CPUE, fishing season index, FMA 573, FMA 713, limited data fisheries, small-scale fisheries.

Introduction. West Nusa Tenggara (NTB) Province is one of Indonesia's regions with a significant potential for fisheries resources, including coral reefs, lobster, and tuna fisheries (Yulianto et al 2016). Reef fisheries production in NTB Province is dominated by grouper and snapper species. Sumbawa waters in NTB Province are waters that contribute to the production of grouper and snapper in large numbers compared to other waters. Data from the Department of Marine Affairs and Fisheries of the NTB Province in 2016 showed that around 93.39% of the total grouper production and 88.59% of the total snapper production in the NTB Province originated from Sumbawa waters.

The high production of grouper and snapper in Sumbawa waters indicates a lot of fishing for grouper and snapper in Sumbawa waters. This condition is concerned to causes problems for the sustainability of the grouper and snapper fishery resources. Sadovy de Mitcheson (2016) states that overexploitation of reef fish resources causes a rapid decline in fish stocks, and can even lead to the extinction of local ecology. In addition, high fishing pressure in coastal waters can also determine overfishing (Usman et al 2014).

However, information regarding the current condition of grouper and snapper fishing activities in Sumbawa waters is still very minimal. In fact, this information is necessary for carrying out proper fisheries management (Sumiono et al 2010). The lack of available data, either in the form of unavailability of data, unsystematic data, or unsustainability of data, may result in inaccurate data regarding the utilization of fish resources, which ultimately results in a lack of information for management plans (Ramirez et al 2017; Houk et al 2017). The lack of information regarding the current condition of grouper and snapper fisheries causes difficulties for the local government of the NTB Province in carrying out management activities for grouper and snapper fisheries in

Sumbawa waters. Pennino et al (2016) stated that the lack of availability of fishery data can hinder fisheries management activities, and even can make fisheries management activities ineffective. For fisheries management activities in an area with minimal fishery data to be carried out, the most viable solution is resource knowledge at the ecosystem level and identifying fishing activities (Previero & Gasalla 2018). Fishery management is essential for local and central governments because through fisheries management an effort can be made to control fishing activities (Prisantoso 2010) so that fisheries sustainability can be maintained.

Several studies on grouper and snapper fisheries in Indonesia have been carried out. Research related to biological parameters was carried out on the six-bar grouper (*Epinephelus sexfasciatus*) in the Glondonggede waters of Tuban (Mariskha & Abdulgani 2012), the squaretail coral grouper (*Plectropomus areolatus*) in the Kapota – Wakatobi waters (Alamsyah et al 2013), the grouper (*Epinephelus* sp.) in the Wakatobi National Park waters (Tadjuddah et al 2013), the areolate grouper (*Epinephelus areolatus*) in the Galesong Kota Village waters, Takalar (Sitepu 2014), the barramundi (*Lates calcarifer*) in inner canal waters of Sembilang Pesisir National Park area – Banyuasin (Ridho & Patriono 2016), and the brownstripe red snapper (*Lutjanus vitta*) in Jakarta Bay and its surroundings (Oktaviyani & Kurniawan 2017). In addition, there is research on the dynamics of grouper fisheries in Karimunjawa National Park (Yulianto et al 2013). A study of the population parameters of Malabar blood snapper (*Lutjanus malabaricus*) in the East Java Sea was conducted by Wahyuningsih et al (2013). In fact, there are also several studies regarding the sustainable potential estimation of grouper and snapper in Indonesia, including the sustainable potential estimation of the red snapper (*Lutjanus malabaricus*) landed on the South Coast of Tasikmalaya – West Java (Sriati 2011), grouper in Makassar Strait waters (Rochmady & Susiana 2014), snapper in the Sambas Regency waters (Baharudin 2013), and grouper in Kwandang Bay, North Gorontalo Regency (Achmad et al 2018). The research related to grouper and snapper fisheries in NTB Province that have been carried out includes the biological aspects of red snapper (*Lutjanus malabaricus*) in the Sape waters (Andamari et al 2004) as well as estimation of sustainable potential and utilization status of Northern red snapper (*Lutjanus campechanus*) and grouper (*Epinephelus* sp.) in the Alas Strait (Santoso 2016).

This research provided information about grouper and snapper fisheries in Sumbawa waters, NTB Province such as catch composition and productivity per fishing unit, fishing area, and the fishing season for grouper and snapper in Sumbawa waters. This research is expected to be an input for the local government of NTB Province in managing grouper and snapper fisheries in Sumbawa waters.

Material and Method

Description of the study sites. This research was conducted in Sumbawa waters which is the center of grouper and snapper fishing activities on Sumbawa Island – NTB Province – Indonesia. The Sumbawa waters are the focus of this research area in the north-eastern part of Sumbawa Island which is part of the Fisheries Management Area (FMA) 713, as well as in the southern and eastern parts of Sumbawa Island which are part of FMA 573. Grouper and snapper fishing activities in the northern part of Sumbawa Island are in Saleh Bay. Meanwhile, grouper and snapper fishing activities in the southern part of Sumbawa Island are located in Cempi Bay and Waworada Bay. The waters to the east of Sumbawa Island which are the location for grouper and snapper fishing are Sape waters. The depth of the four bays is about 2-200 meters.

Data collection for this study was carried out at fish landing sites spread across four bays in the Sumbawa waters area which are the locations for grouper and snapper fishing. The six main landing sites that are the focus of this research are the fish landing sites in Labuan Sumbawa Village (Labuan Badas District – Sumbawa Regency), Labuan Kuris Village (Lape District – Sumbawa Regency), Labuan Jambu Village (Tarano District – Sumbawa Regency), Hu'u Village (Hu'u District - Dompu Regency), Rompo Village (Langgudu District – Bima Regency), and Bugis Village (Sape District – Bima Regency). The six landing sites represent grouper and snapper fishing activities based on the diversity

of fishing gear types operating in the Sumbawa waters. Figure 1 shows the positions of the six fish landing sites in question.

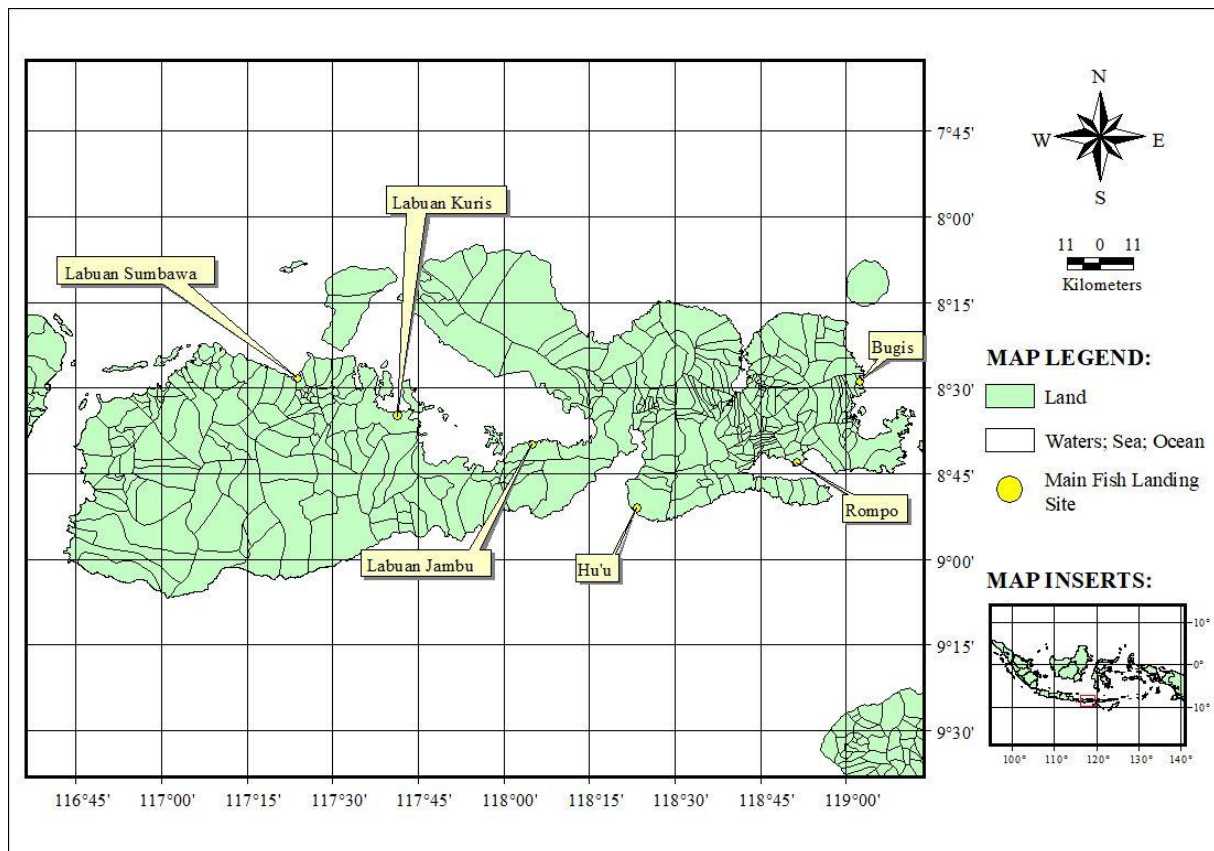


Figure 1. Fish landing sites of grouper and snapper in Sumbawa waters (map generated using ArcView GIS 3.3).

Data collection. Data collection on grouper and snapper catches in Sumbawa waters was carried out from April 2016 to December 2019. The data collection was carried out using the sampling method. Data sampling was collected for 7 to 15 days each month at six fish landing sites which were the focus of data collection. The catch data collected in this study consisted of fish species, the number of catches, the catch weight, and the fork length of the caught fish. Fish length measurement activity is carried out directly using a measuring board or ruler and then recorded on the length data entry sheet. Besides that, in this study, the measurement of lengths was carried out using the photo method, in which the enumerator documents the fish caught by fishermen and uploads them to the database. After obtaining fork length data, a comparison was made with the length at first maturity for each type of fish. This comparison is important to identify that the fishing activity has been carried out in a responsible fishery. In this study, the length at first maturity for each type of fish was obtained from several literature studies.

Data analysis. This study conducted several data analyses to answer the research objectives. The data analysis are:

(a) *Catch composition:* Analysis of catch composition was carried out on each fishing unit of grouper and snapper. Through this analysis, the percentage of catch per grouper and snapper species will be identified in each fishing unit. The formula used to calculate the percentage of catch composition is:

$$\% \text{ catch composition} = \frac{\text{catch species } i}{\text{total catch}} \times 100\%$$

- (b) *Length frequency analysis*: Length frequency analysis was conducted to identify the length distribution of grouper and snapper caught by fishermen. The length measure used is the total length (TL). This analysis was carried out using the Microsoft Excel program application for histogram data processing.
- (c) *Productivity of fishing units*: Productivity analysis of fishing units was carried out to determine the effectiveness of each grouper and snapper fishing unit. In this study, identification of the productivity of each grouper and snapper fishing unit was carried out every month during the period April 2016 to December 2019. The formula used to determine productivity (CPUE) is:

$$\text{CPUE (kg/trip)} = \frac{\text{catch production (kg)}}{\text{effort (trip)}}$$

- (d) *Fishing season pattern*: In this study, the analysis of fishing season patterns uses the moving average method from Dajan (1983) and the formula modified by Wiyono (2001). The criteria used in the analysis of the fishing season pattern is the value of the fishing season index (FSI). If the FSI value in a particular month is above 100%, it can be said that month is the best fishing season for grouper and snapper. Meanwhile, if the FSI value in a particular month is below 100%, it can be said that the month is not the best fishing season for grouper and snapper.

Result and Discussion

Fishing unit. Grouper and snapper in Sumbawa waters are caught by fishermen using several types of fishing gear, including boat lift net, traps, drift gillnet, set gillnet, speargun, troll line, handline, and bottom longline. However, the main fishing gears for catching grouper and snapper are speargun, handlines, and bottom longlines. Meanwhile, other fishing gear catches grouper and snapper as by-catch. In general, grouper and snapper in other parts of Indonesia are caught using hand lines, bottom longlines, folding traps, spears, explosives, and toxic chemicals such as potassium cyanide (Sari & Nababan 2009; Riyanto et al 2011). However, according to the Regulation of the Minister of Maritime Affairs and Fisheries Number 18 (2021) concerning the Placement of Fishing Equipment and Fishing Auxiliary Equipment in the Fisheries Management Area of the Republic of Indonesia and the High Seas and the Arrangement of Andon Fishing, the use of explosives and chemicals as fishing methods is categorized as illegal fishing, thus strict law enforcement is required against this acts.

The fishing fleet used by fishermen in Sumbawa waters to catch grouper and snapper is between 2-10 gross tonnage (GT). This shows that grouper and snapper fishing is carried out with small-scale fishing units (Kandula et al 2015). The number of fishermen who carry out fishing activities in one grouper and snapper fishing unit is between 1-10 people, adjusted to the size of the vessel used. In general, grouper and snapper fishermen in Sumbawa waters go to sea in the morning and return to the fishing base one day later in the morning or afternoon, and there are even fishermen who return the next night. The fishing trip duration is determined by how far is the fishing ground that fishermen can reach and the number of catches they managed to catch.

The speargun, handline, and bottom longline fishing units operated by grouper and snapper fishermen in Sumbawa waters have different productivity. It is suited to the statement by Frisch et al (2012), that fishing gear has different fishing productivity. The analysis results showed that the average productivity of each grouper and snapper fishing unit for speargun, handline, and bottom longline respectively was 8.85 kg/trip, 22.28 kg/trip, and 5.42 kg/trip.

Figure 2 show the productivity trend of the speargun, hand line, and bottom longline fishing units that catch grouper and snapper in Sumbawa waters. In general, the three

fishing methods had an increasing trend during the period from April 2016 to December 2019. However, if we look back from April 2016 to December 2018, the productivity of the three grouper and snapper fishing units experienced a downward trend. The productivity trend has decreased because of the great effort made by fishermen in the three fishing units, but the catches produced are not increasing or even decreasing. According to Rahmawati et al (2013) and Budiasih and Dewi (2015), increased efforts have an effect on decreasing productivity because continuous efforts will reduce fish resource production. The utilization of fish resources can be said is sustainable if the relationship between catch and effort has a linear relationship (Petrere et al 2010). In addition, Yovitner et al (2020) state that high fishing production if followed by low fishing productivity indicates an excess of effort in catching the fish.

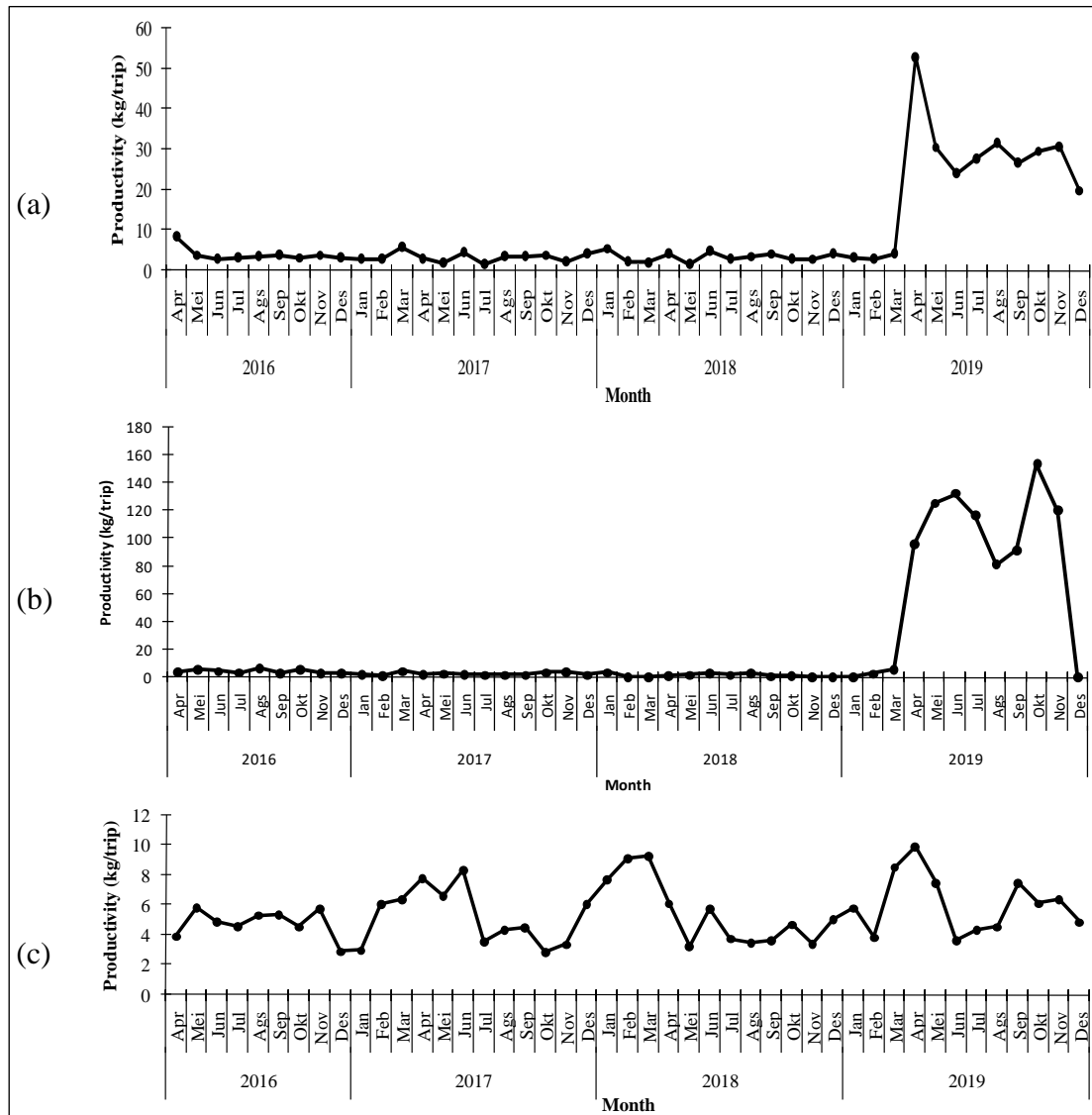


Figure 2. Productivity of (a) speargun, (b) hand line, and (c) bottom longline fishing units.

From January to December 2019, the trend of fishing unit's productivity of speargun, hand line, and bottom longline in grouper and snapper fisheries in Sumbawa waters has increased. This happened because of the control of grouper and snapper fishing efforts carried out by the NTB Provincial Government, in this case, the Marine and Fisheries Department of NTB Province. According to Monroy et al (2010), controlling the fishing effort in a fishing ground can contribute to reducing the impact of overfishing on these fish resources. Therefore, controlling fishing efforts carried out by the NTB provincial government is appropriate because overcoming the decline in the productivity of fishing

units can have an impact on the return of declining fish resource production so that fish resource stocks return. Hilborn et al (2020) state that areas with uncontrolled fishing activities will have an impact on high levels of fish production and an impact on the poor condition of fish stocks.

Grouper and snapper fish resources. Sumbawa waters in NTB Province are waters that have a high diversity of groupers and snappers. It is because the conditions of coral reefs in Sumbawa waters are ideal for the life of reef fish. Coral reefs in Sumbawa waters have a combination of fringing, both sloping and steep, and the enormous influence of Arindo and the Flores Sea provides larval intake, nutrition, and freshwater circulation (Yulianto et al 2016). Sondita et al (2011) and Huliselan et al (2017) stated that grouper and snapper are fish species that live in bottom waters and are generally associated with coral reefs. Therefore, the determination of the fishing ground for grouper and snapper is based on the condition of coral reefs in the waters. Coral reefs that experience degradation or damage cause these coral reefs to have fewer fish resources (Wilson et al 2012) and low biodiversity (Newman et al 2015). On the other hand, healthy coral reefs with high coral cover will have abundant fish resources and high biodiversity (Panggabean & Setyadji 2009).

In this study, there were about 45 species of grouper and 40 species of snapper caught by fishermen in Sumbawa waters from April 2016 to December 2019. Fishermen who use speargun fishing gear catch dominant species of *Plectropomus leopardus* (23.19%) and *Epinephelus coioides* (19.51%). Meanwhile, fishermen who use handline dominantly catch *Lutjanus malabaricus* (36.52%) and *Plectropomus leopardus* (16.77%). The dominant species of grouper and snapper caught using the bottom longline are *Epinephelus coioides* (37.39%) and *Lutjanus malabaricus* (32.13%). Based on the information on the catch composition, grouper is the dominant fish caught by fishermen in Sumbawa waters compared to snapper.

The dominant species caught by fishermen in the fishing activities of grouper and snapper in Sumbawa waters are *Epinephelus coioides* and *Plectropomus leopardus*, while the dominant species of snapper caught are *Lutjanus malabaricus* and *Lutjanus argentimaculatus*. The length of the species caught varies. Figure 3 shows the number of the four species caught by fishermen in Sumbawa waters by length group.

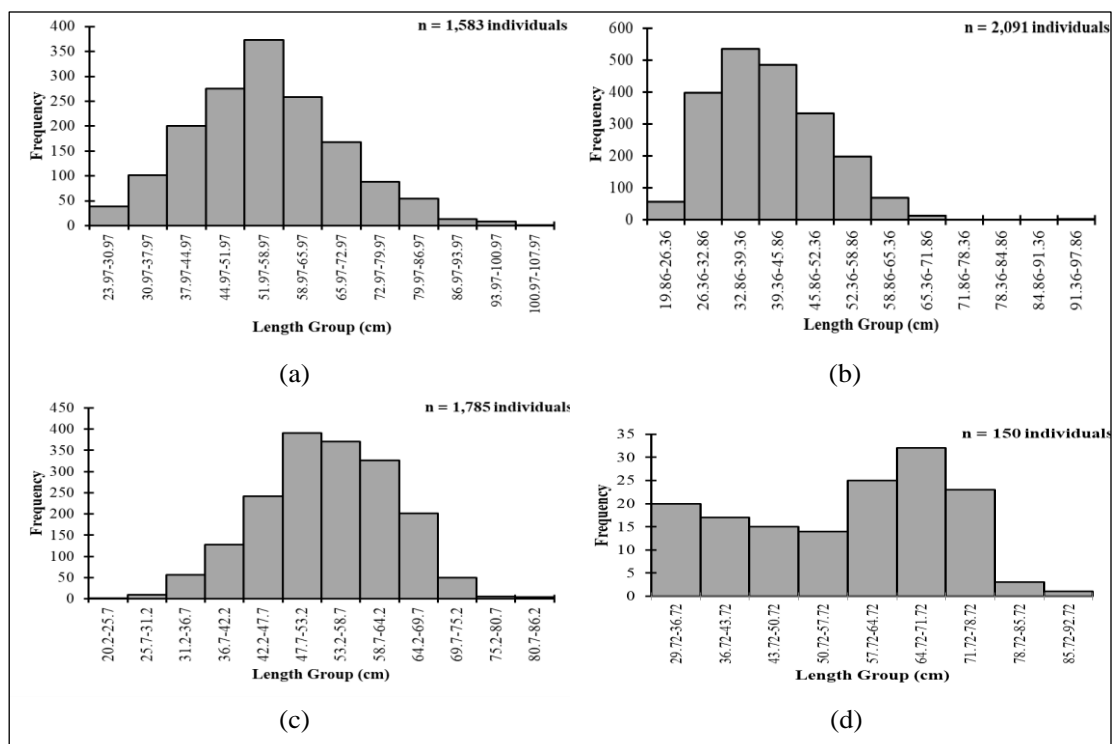


Figure 3. Length frequency of (a) *Epinephelus coioides*, (b) *Plectropomus leopardus*, (c) *Lutjanus malabaricus*, (d) *Lutjanus argentimaculatus* caught in Sumbawa waters from April 2016 to December 2019.

Based on Figure 3, it is shown that grouper and snapper have been caught at smaller lengths than the length at first maturity (Lm). Lm is described as the mean length of fish when they become sexually mature for the first time. Catching fish under the Lm can lead to population depletion as a consequence. Sequentially, the Lm for *Epinephelus coioides*, *Plectropomus leopardus*, *Lutjanus malabaricus*, and *Lutjanus argentimaculatus* was 48.3 cm (Fishbase 2018a), 52.06 cm (WCS 2018), 57.6 cm (Fishbase 2018b), and 57 cm (Fishbase 2018c). Based on this information, it can be stated that 28.93% of *Epinephelus coioides*, 85.99% of *Plectropomus leopardus*, 63.14% of *Lutjanus malabaricus* and 42.67% of *Lutjanus argentimaculatus* caught by fishermen in Sumbawa waters between April 2016 and December 2019 were under Lm. Therefore, it is necessary to control the size of grouper and snapper caught by fishermen.

Catching fish that have a length below Lm will affect the sustainability of these fish resources. Continuous fishing of fish less than Lm will cause changes in the size distribution of the fish caught, the evolution of smaller mature gonadal fish, and the extinction of these fish (Lappalainen et al 2016). Therefore, Lm is often used as a very important key parameter in fisheries management, especially regarding the exploitation of fish resources available in the waters (Tsikliras & Stergiou 2014).

Controlling the size caught is very important for the fish resources sustainability and the economic activities sustainability for the catch. The form of control that can be implemented to the catch size is limiting the size of grouper and snapper caught, as well as breaking the marketing chain for grouper and snapper that are smaller than Lm.

Grouper and snapper fishing season. Indications that are generally used to determine the fishing season are the number of catches and the ability of the fishing gear used. The analysis results using the moving average method show that the grouper fishing seasons in Sumbawa waters are March-April, June, August-September, and November (Figure 4a). Meanwhile, the snapper fishing seasons in Sumbawa waters are in January-March, May-June, and September (Figure 4b). Other studies have shown that the grouper fishing seasons in Bengkulu are January, March-June, and August-December (Andriyeni & Zulkhasyni 2015). In addition, other studies have found that the snapper fishing seasons in Brondong Archipelago Fishing Port (PPN Brondong) are March-April, and July-December (Azkia et al 2015).

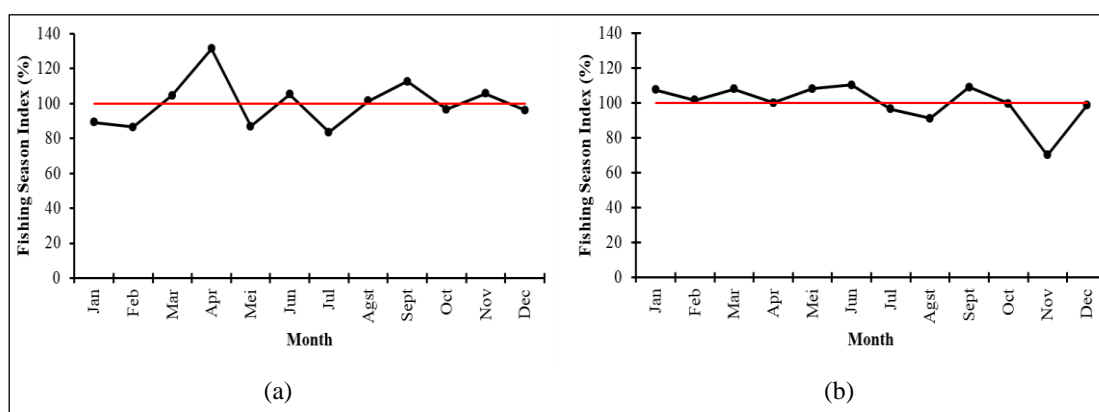


Figure 4. Fishing season index for (a) grouper and (b) snapper in Sumbawa waters.

Information on fishing seasons is necessary as a basis for determining the exact time when fishing activities should not be carried out every year. This information will assist the government in managing fisheries activities to support the recovery of newly indicated or over-exploited species. Meanwhile, for fish species in underexploited conditions, optimal utilization is necessary to be considered. In general, *Plectropomus leopardus* and *Lutjanus malabaricus* in the Saleh Bay are moderately-exploited, while *Epinephelus coioides* in the Saleh Bay is over-exploited (FIP2B NTB 2021).

Conclusions. Grouper and snapper fishing activities in Sumbawa waters are carried out in Saleh Bay, Cempi Bay, Waworada Bay, and Saleh Waters. The dominant species of grouper and snapper caught in Sumbawa waters are *Epinephelus coioides*, *Plectropomus leopardus*, *Lutjanus malabaricus*, and *Lutjanus argentimaculatus*. Specimens of these four species which have immature gonads were also caught by fishermen in Sumbawa waters. Grouper and snapper fishing units used by fishermen in Sumbawa waters have productivity between 5.42 – 22.28 kg/trip. Based on the productivity, it is known that the most productive grouper fishing season in Sumbawa waters is in March-April, June, August-September, and November, while the most productive snapper fishing seasons in Sumbawa waters are in January-March, May-June, and September.

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

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