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Composition, Catch Rate, and Stock Density of Snapper (Lutjanidae) in Aru and the Arafura Sea

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ABSTRACT

The exploitation of snappers in Aru and the Arafura Sea occurs without any clear rules and controls. This situation could exacerbate the stock and eventually threaten the sustainability of snapper's fishery. This study analyzed the catch composition, catch rate, stock density, and biomass estimation of the Aru and the Arafura Sea snappers. The study was conducted from October 20 to November 20, 2018, using the RV Bawal Putih 03 as part of the Fisheries Management Area (FMA) 718 stock assessment research. The swept area method was used to estimate the red snappers' catch rate, composition, and density. Nine snapper species were found inhabiting the areas that consist of two genera, *Lutjanus* and *Pristipomoides*. The catch composition consists of 52.3% *L. johnii*, 33.1% of *L. malabaricus*, 8.7% of *L. vitta*, while the *L. lutjanus* has the lowest proportion of 0.24%. The red snappers' catch rates vary from 0.2 to 340 kg/hour, and the highest catch rates occur in-depth strata 31 - 40 meters in the north of the Aru Islands and the south of Timika waters. The average density of snapper stock in the Arafura Sea is 448.1kg/ km^2, with a total biomass estimation about 428,760.7 tons.

INTRODUCTION

The Aru and the Arafura Sea are well known as the dominant fishing grounds of large commercial fishing vessels since the areas have considerable stock of demersal fish and shrimp. **FAO (2001)** reported that demersal fishing in the Arafura Sea had met challenges such as lack of awareness of the existing fisheries regulations, monitoring and controlling of the imposed regulations, increasing fishing effort, and the very high discard rates of bycatch. Geographically, Aru Islands and the Arafura Sea are shallow waters (predominantly with 50m to 80m in depth) bordered with northern Australian waters in the southern part **(Sulistiyo *et al*., 2013)**. Before the trawl ban imposed in 2015, the areas were well-known as the primary fishing ground for the demersal-shrimp fishery, famously called the golden fishing ground of shrimp and demersal fish **(Sulistyo *et al*., 2013)**. According to Ministerial Decree No 50 2017 regarding the stock estimation and total allowable catch, the Arafura Sea, as a part of Indonesian Fisheries Management Area 718, has a total allowable catch estimation of 876,722 tons.

Snappers are among the high potential stocks of demersal fish in the Arafura Sea. These groups of species are grouped in the family Lutjanidae and inhabit the shallow to deep water, with depths ranges between 50 & 180m. Snappers are targeted by the bottom longline and trawl **(Sadhotomo & Suprapto, 2013)**. According to **Fry and Milton (2009)** and **Sriati (2011)**, snappers are highly vulnerable due to their low movement and narrow migration area, long lifespan, and small schooling. In addition, **Newman *et al.* (2020)** reported that snappers have a lifespan of up to 20 years to reproduce eggs in a long time.

Blaber *et al*. (1994) suggested that biological information such as species composition, spatial distribution, and stock density of the demersal fishing is critical to achieving the targeted species' sustainable management. Meanwhile, **Suman *et al*. (2007)** pointed out that fishery resource utilization based on stock management approach is necessary for implementing proper management measures. Therefore, this research aimed to analyze and provide information on the species composition, catch rate (kg/hour), and stock density of some demersal fish species caught by the experimental trawl in the Arafura Sea as it can be used in management measures.

MATERIALS AND METHODS

The research survey was conducted within a month, starting from October 20 to November 20, 2018, using an experimental trawl fishing Bawal Putih 03 vessel in the Arafura Sea, known as the Fishery Management Area (FMA 718). The sampling station consisted of 50 trawling stations as presented in Fig. (1). A stratified random sampling method was used to determine the fishing sampling plot stratified in different depths (10-20, 21-30, 31-40, 41-50, 51-60 and 61-70 meters) by considering the bottom substrate type for each station. The trawl net was swept once in each trawling spot. All catch was sorted, recorded, and scaled according to the species to get the information on the species composition. The total catch per hour (in kilogram) was used as the catch rate and accounted for estimating the stock density.

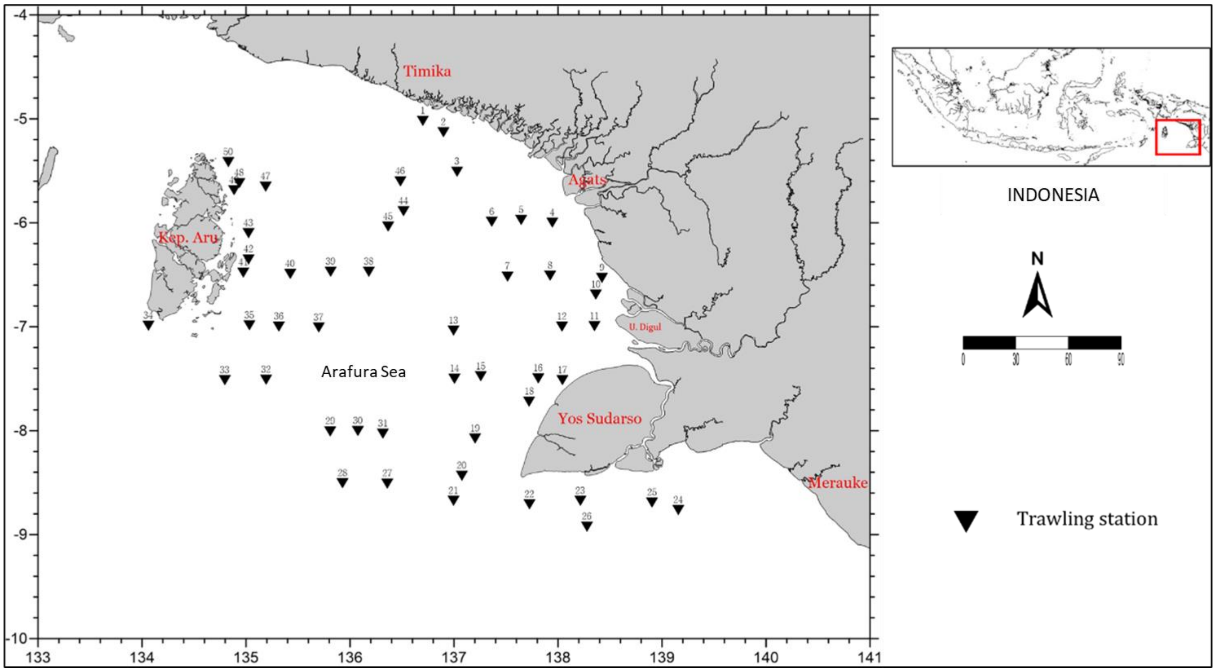

Fig. 1. Trawling stations in Aru and Arafura Sea

The trawl net design has been categorized as a four-layer consisting of the top, left-side, and bottom layers. In detail, the trawl net specification can be described as follows; the head rope length is 36m; the ground rope is 40m; the body is made of PE with mesh size 1.5 to 4.0 inches. The cod end has a 6m length with a mesh size of up to 1.5 inches. **Fischer and Whitehead (1974), Gloerfelt-Tarp and Kailola (1985)**, **Carpenter and Niem (1999)**, **Allen *et al.* (2000)** and **Nakabo (2000)** were used as the guidance of species identification, while table and histogram were used to visualize the composition.

Data analysis

Species composition of the snappers

The species composition was then analyzed as the comparison (in percentage) among the species caught from the trawling. The catch from each species was then tabulated and displayed in a graph to show the variances. It was assumed that the catch rate is proportional to the snapper biomass, so that value has been used as the index of relative abundance that to be used to estimate the stock abundance.

The catch rate

The catch rate of a trawl net is a function of its catch (kg) within a time unit (hour) that was calculated from **Sparre and Venema (1999)** formulation as follows:

$$C/R = \left(\frac{Cw}{t}\right) \text{ kg/hour}$$

where:

- C/R = the catch rate.
- C_w = total catch (kg).
- t = hauling duration (hour)

The stock density

In terms of the stock density estimation, the swept area should be known and calculated first by using the below formula:

$$a = S \times E_1$$

Where,

- S = $v \times t \times 1.852 \times 10^{-3}$.
- a = the swept area size per hour (km^2).
- E_1 = the opened-mouth size of the net (m) = ($f_2 \times h$).
- S = the distance among other swap (km)
- v = the vessel speed during the hauling = knot (miles/hour).
- t = the hauling duration (hour).
- 1.852 = a constant conversion from miles to kilometer.
- 10^{-3} = a constant converstion from meter to kilometer.
- f_2 = empiric fraction.
- h = head rope length (m).

The stock density was calculated using the formula as follows:

$$D = \frac{Cw/a}{ef} \text{ kg/km}^2$$

Where,

- D = stock density
- C_w = amount of catch (kg)
- A = the size of the swept area (km^2)
- ef = fishing power factor, where 0.5 Shindo (1973) is commonly used in Southeast Asia
-

RESULTS

Catch composition

The data analysis includes 31 sampling spots from the total 50 sampling stations representing the snappers' evidence. The trawling spots have depths from 10 to 65 meters in depth, where mud and sand dominate the bottom substrate. The results show the total catch of snappers is 659.4kg, consisting of nine species and two genera belonging to family Lutjanidae, as shown in Table (1).

Table 1. The total catch of snappers using trawl swept method according to the depth levels

No	Species	depth (meter)						Total (kg)
		10-20	21-30	31-40	41-50	51-60	61-70	
1	*Lutjanus carponotatus*	-	-	7	-	-	-	7
2	*Lutjanus johni*	3.6	-	340	12.5	-	-	356.1
3	*Lutjanus lutjanus*	-	-	-	0.2	-	-	0.2
4	*Lutjanus malabaricus*	0.2	3.6	116	47.2	39.6	1.1	207.7
5	*Lutjanus russelli*	0.2	1.4	5.5	0.3	6.1	0.8	14.2
6	*Lutjanus sebae*	-	-	2.4	5.2	-	-	7.6
7	*Lutjanus vitta*	-	1.3	26.4	27.3	3.6	0.4	59
8	*Pristipomoides multidens*	-	-	-	-	-	2.4	2.4
9	*Pristipomoides typus*	-	-	-	-	4.7		4.7
	Grand Total	4	6.3	497.3	92.8	54	5.1	659.4

The trawling experiment caught the genus *Lutjanus* in almost all levels of depth. Meanwhile, the genus *Pristipomoides* was recorded predominantly at 51 to 60 meters and 61 to 70 meters. In addition, the majority of snappers were found at the depth levels of 31 to 40 meters and 41 to 50 meters in the eastern part of the Arafura and Aru fishing ground, as shown in Fig. (4).

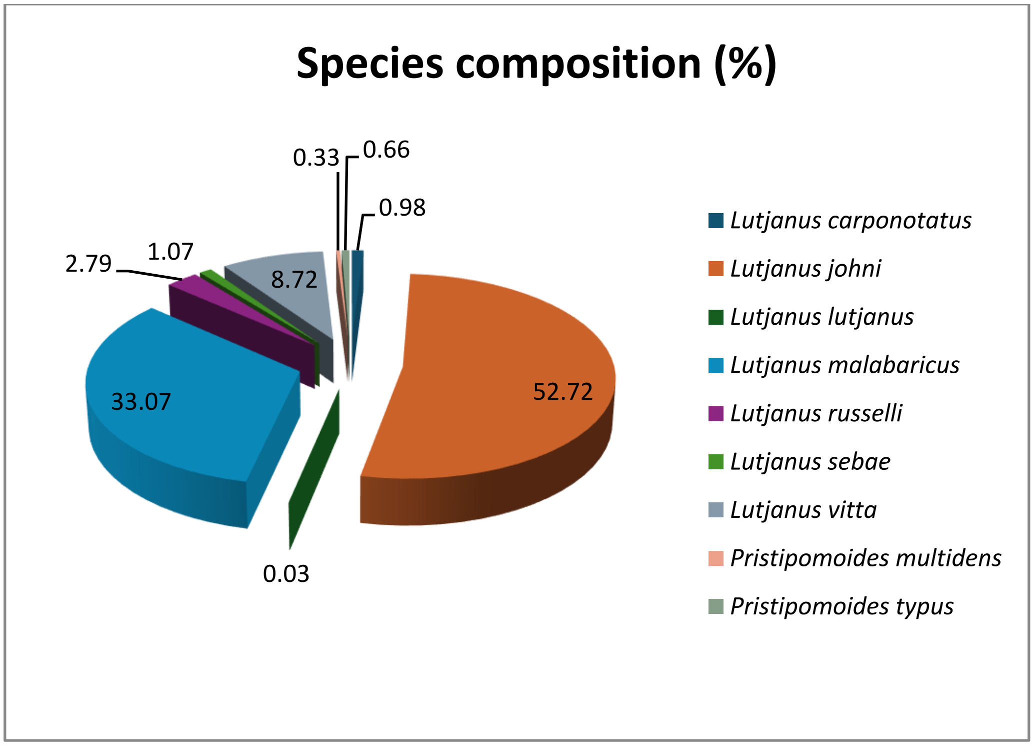

Fig. 2. Species composition (%) of snapper caught by the trawl net in the Arafura Sea

The amount of catch and the variety of snappers caught were different at each sampling station. Fig. (2) shows that *Lutjanus johnii* dominated the catch, with 356.1kg (52.3% of the total catch) recorded at the eastern part of the Aru Islands fishing ground, at a depth of 10 to 20, 31 to 40, and 41 to 50 meters, respectively. The second dominant species was recorded to be *Lutjanus malabaricus*, with a total catch of 207.7kg (33.1 % out of the total) at almost all depth levels. This latter species is commonly found in 31 to 40 meters depth in Teluk Pisang waters (western part of Timika waters), the southern tip of Wamaro River mouth in western Papua waters, and the eastern area of Aru Island.

Table 2. The species composition of snappers in the Arafura Sea from several trawling surveys

No	Species	Snappers species composition (%)		
		RV Baruna Jaya 8 (Suprapto *et al.*, 2010)	RV Baruna Jaya 4 (Taufik *et al.*, 2016)	RV Bawal Putih 3 (this research survey)
1	*Lutjanus areolatus*	0.34	-	-
2	*Lutjanus carponotatus*	-	1.61	4.86

3	*Lutjanus fulviflammus*	43.88	-	-
4	*Lutjanus johni*	12.02	8.16	85.08
5	*Lutjanus lentjan*	-	6.58	0.17
6	*Lutjanus lutjanus*	-	0.75	-
7	*Lutjanus malabaricus*	37.22	28.01	3.46
8	*Lutjanus monostigma*	-	0.53	-
9	*Lutjanus ruselli*	-	40.92	0.86
10	*Lutjanus sebae*	0.57	7.17	1.74
11	*Lutjanus vitta*	5.96	4.55	1.37
12	*Pristipomoides multidens*	-	1.71	0.82
13	*Pristipomoides typus*	-	-	1.63

Table (2) shows the dynamic of species composition of the snappers, indicating changes in the composition over the last decade in the Aru and the Arafura Sea. A species such as *L. johnii* dominated the catch during this survey, compared to the survey conducted in the previous year, where *L. fulviflammus* and *L. ruselli* dominated the species in 2010 and 2016, respectively.

The catch rate and spatial distribution of the snappers

The catch rate of snappers all over the sampling station varies from 0.2 to 340kg/ hour. The highest catch rate was recorded at a depth of 38 meters, with 340kg/ hour at station 50, located in the northern tip of Aru Islands. The second-highest catch rate of 25 kg/hour was recorded at station 1 at a depth of 41 to 50 meters in the western part of Timika waters (Fig. 3). In comparison, the highest catch rate of snappers (Lutjanidae), ever recorded in the Arafura Sea, was 783.95 kg/hour during November and December, as reported by **Budihardjo *et al.* (1992)**. Fig. (3) represents the catch rate based on depth level. The highest catch rate found at a depth of 31 to 40 meters was 60.8kg/ hour, recorded at eight sampling stations, namely the 5th, 13th, 35th, 36th, 37th, 39th, 48th, and 50th stations, covering the area of the western waters of Agats, the southeastern, eastern, and northern parts of Aru Islands. The second-highest catch rate was recorded at the depth of 41 to 50 meters, with 5.9kg/ hour at seven sampling stations, namely the 1st, 2nd, 3rd, 33rd, 38th, 45th, and 46th, in the southern part of Arafura (Timika waters), as well as in the eastern, southeast, and northern parts of the Aru Islands. The depth level of 10 to 20 meters recorded the lowest catch rate, with 1kg/ hour at four stations, namely the 11th, 20th, 41th, and 49th. Surprisingly, some stations recorded no catch of snappers, particularly those located in the eastern part of the Arafura Sea.

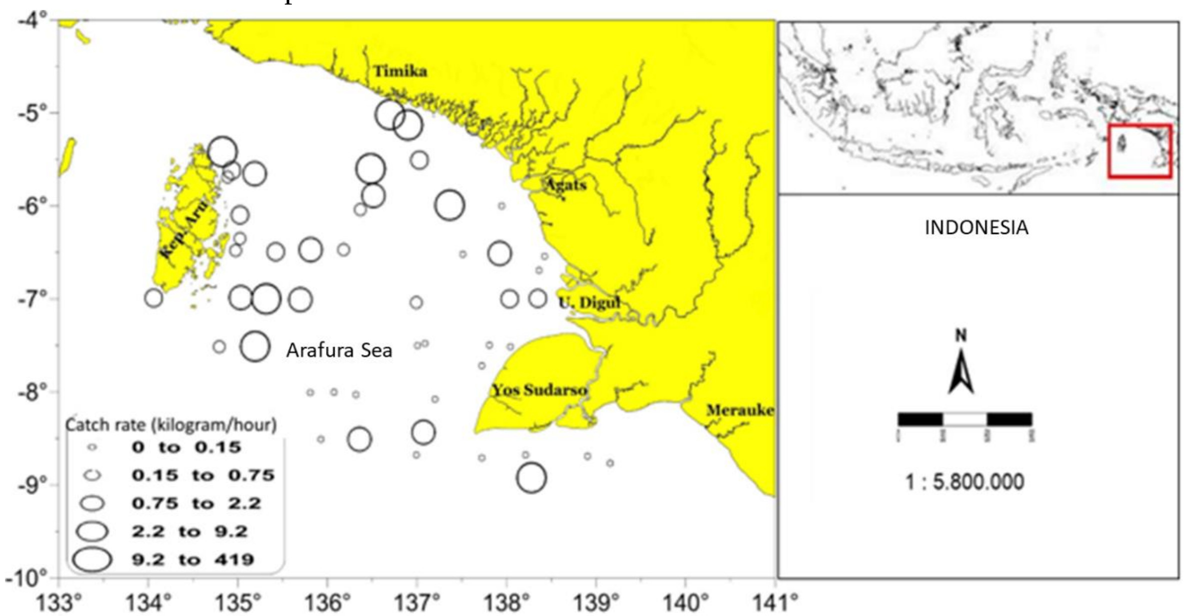

Fig. 3. Catch rate distribution of snappers in the Arafura Sea based on depth level

Stock density

The results show that the average stock density of snappers is 448.1kg/ km^2. The *Lutjanus johnii* species was recorded with the highest value, 231.5kg/ km^2, followed by *Lutjanus malabaricus* with 154.7kg/ km^2, and *Lutjanus lutjanus* with 0.1kg/ km^2 (Fig. 3).

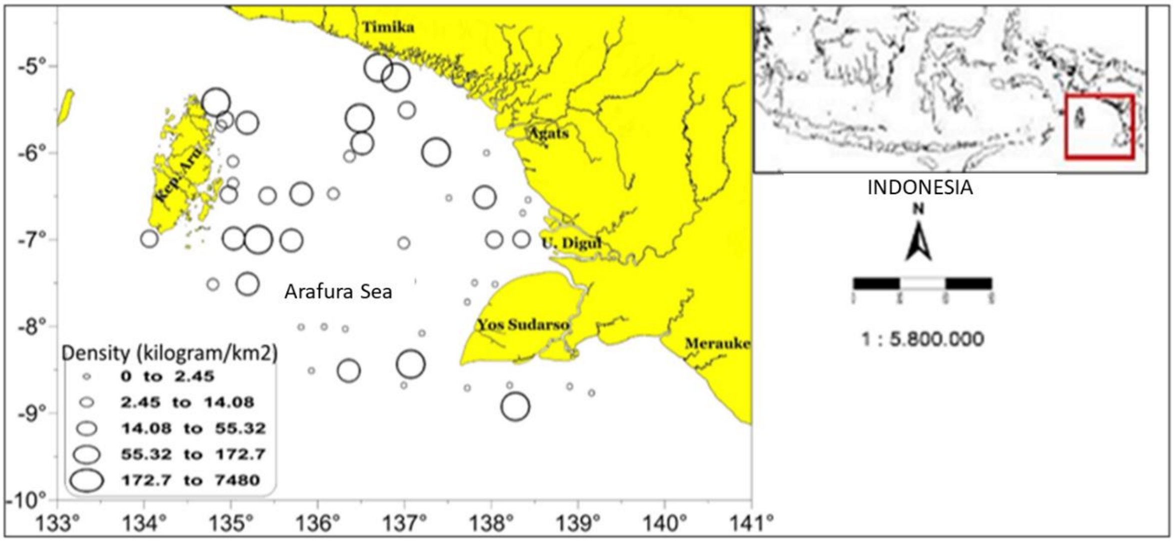

Fig. 4. Stock density distribution of snappers caught in the Arafura Sea based on sampling point location

The Arafura Sea size is estimated to be 956,863km. sq, with the total biomass of about 428,760.7 tons. The result shows *Lutjanus johnii*, locally known as Jenaha, has the densest biomass among other snappers species, with 221,513.8 tons, followed by *Lutjanus malabaricus* (48,026.7 tons), and *Lutjanus vitta* (35,882.4 tons). In contrast, *Lutjanus lutjanus* (as seen in Table 3) was recorded with the lowest biomass, 95,7 tons.

The total allowable catch is estimated according to the total mortality (Z) 1.4 per year, natural mortality (M) 0.66, and fishing mortality (F) 0.74 per year, respectively **(Suman *et al.* 2018)**. Thus, the total allowable catch can be estimated with all the parameters, resulting in the TAC of snappers in the Arafura Sea being about 300,132.5 tons per year. As stated previously, Jenaha (*L. johnii*) has the highest potential standing stock, as many as 155,059.6 tons/year, succeeded by *L. malabaricus* with 103,618.7 tons. In contrast, *L. lutjanus* has the lowest standing stock with 66.9 tons/year.

DISCUSSION

Catch composition

Interestingly, this research indicates a shift in the snappers' catch composition in Aru and the Arafura Sea over the decade. As reported by **Suprapto *et al.* (2010)**, *L. fulviflammus* and *L. malabaricus* were two dominant species that have been caught in Aru and the Arafura Sea, while a survey conducted by **Taufik *et al.* (2016)** reported that *L.*

russelli and *L. malbaricus* formed the majority of the catches. ComparED to the current results, where *L. johnii* was the major catch during the trawling experiment.

Within the decades, Aru Islands and the Arafura Sea are the two golden fishing grounds of many commercial fishing gears such as shrimp trawlers and bottom gillnet, although the shrimp trawl has been banned since 2005 **(Sadhotomo *et al.*, 2002)**. The massive shrimp fishing in the previous regime might impact the catch composition of the demersal fish, particularly on the species composition of the snappers since the shrimp trawl could also catch the snappers as a bycatch. **Gallaway *et al.* (2020)** stated that snappers are subject to high natural mortality rates since they are bycatch of shrimp trawls, naturally recording 86% mortality in the first year of life and 70% in the second year of life. **Evans and Wahju (1996)** also reported a substantial discarded bycatch of shrimp trawls in the Arafura Sea; most of them are finfish (including demersal fish such as snappers), and some invertebrates. Unfortunately, there is no information regarding the size of discarded-finfish of the shrimp trawls in Aru and the Arafura Sea, according to the report of **Evans and Wahju (1996)**.

As a comparison, **FAO (2001)** also reported that 43 species of fish from 14 genera had been identified in the Arafura Sea; all of them are bycatch of shrimp trawls. In 1991, according to **FAO (2001)**, trawl fishing mainly caught croakers and jewfish. In contrast with a recent trawl survey, Jenaha (*L. johnii*) dominates the catch of this trawling experiment. The high biomass record of Jenaha (*L. johnii*) in the Arafura Sea during the trawling experiment indicates that this species has high adaptability to environmental changes like the fishing pressure compared to other snappers' species. **Purba (1994)** stated that Jenaha fish (*L. johnii*) is one of the snapper species that has a wide range of adaptability.

The catch rate and spatial distribution of the snappers

Since the catch varies from the lowest 0.2 kg/hour to the highest 340 kg/hour, it seems that the habitat type and depth affect the abundance of the snappers. **Taufik *et al.* (2016)** reported that the previous sampling experiment using trawl recorded that snappers were mostly caught with bottom-drift gill net at a depth of 41 to 50 and 31 to 40 meters. Another investigation conducted by **Suprapto *et al.* (2010)** reported that snappers in the Arafura Sea were mostly caught during night fishing at a depth of 21 to 30 meters, meaning the fish is active for searching the food during the night, as mentioned by **Octaviyani (2018)**.

We recorded that those sampling stations with zero and low catch rates have similar habitat types where muddy substrate dominates the seabed. This zero and meager catch might be related to the very low salinity and muddy bottom-substrate at those sites, so that area is unsuitable for snappers. In contrast, the highest catch rate in the waters near Aru Islands in the southern waters of Timika is attributed to the sandy-coral habitat of the areas and that is suitable for the snappers inhabit the areas. **Gallaway et al. (2020)** mentioned that younger fish and older fish of snappers are spatially segregated, where the young fish settle to the bottom closer to the shore and inhabit low-relief habitats. On the other hand, as the fish grow, they move to higher-relief habitats (including rocky outcrops and reefs) where natural mortality rates are much lower and become reproductively mature.

The Vessel Monitoring System tool (VMS tool) has been deployed on the fisher' bottom gillnet vessel that landed in Probolinggo landing base where fishing has been performed in the Arafura Sea. In addition, VMS tool shows the massive coral habitat in the area near Aru Islands and the Timika waters. Such a habitat becomes a perfect spot for the demersal fish. **Sumiono *et al.* (2011)** reported that demersal fish tend to be schooling in a particular habitat, such as coral and sandy-bottom substrate.

Stock density

Suman *et al*. (2016) stated that snappers are one of the highest commercial fish targeted by the fishers in the Aru and the Arafura Sea and suggested that the utilization of snappers should not exceed their total allowable catch (TAC). The Ministry of Marine Affairs and Fisheries (MMAF) - the government of Indonesia, has issued ministerial decree No 50/2017 regarding the potential estimation and TAC of several commercial fish groups. In this regulation, the government limits the TAC of the demersal fish up to 876,722 tons in the Fishing Management Area 718 (FMA 718), where Aru and the Arafura Sea are the predominant parts of that FMA. This TAC number is much higher than the result of this survey, where the TAC is estimated to be 300,132.5 tons per year, meaning that there is a substantial decrease in the potential stock of the snappers in the Aru the Arafura Sea within the last decade.

Muawanah *et al.* (2021) reported that a massive shifting of fishing gear occurred in the Aru and the Arafura Sea since the shrimp trawl had effectively been prohibited in 2015. The bottom longline and oceanic gillnet have become the significant fishing gears that replaced shrimp trawls since the prohibition, and those gears targeted demersal fish, including the snappers.

CONCLUSION

In this study, nine predominant species were found in the Aru Islands and the Arafura Sea consisting of two genera, namely *Lutjanus* and *Pristipomoides* belonging to the family Lutjanidae. Jenaha *(L. johnii)* dominates about 52.3 % of the total catch. The catch rate varies between 0.3kg/hour and 340kg/ hour, while the highest catch rate is recorded at a depth level of 31 to 40 meters in the northern tip of the Aru Islands and southern Timika waters. The average stock density of snappers in the Arafura Sea is 448.2kg/ km2 with a biomass estimation of about 428.760,7 tons, indicating the lower biomass estimation ever recorded. We suggest setting back the TAC of the snappers to ensure the sustainability of the fishery.

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