The effect of moon phases upon purse seine pelagic fish catches in fisheries management area

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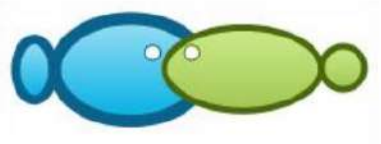

The effect of moon phases upon purse seine pelagic fish catches in fisheries management area (FMA) 716, Indonesia

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Abstract. The purse seine is a fishing tool whose main part is a net whose target catch is pelagic fish. Many factors influence the amount of catch and one of them is the Moon Phases. Changes in the moon phases can identify best times for fishing operations. The purpose of this study was to analyze the effect of the moon phases on the total catch of *K. pelamis*. The data was collected by following the fishing operation directly. The data analysis method used was descriptive to understand how the purse seine operation process and to classify the number of catches based on 4 moon phases. The results of the analysis of differences in the number of catches in each moon phases showed that the highest number of catches occurred in the first crescent cycle 8.575 kg (35%) and the smallest number of catches was during the dark moon phases 1.877 kg (8%). For the results of the analysis of the influence of the moon carried out by the ANOVA test, the value was 0.577>0.05, which means that the moon phases did not have a significant effect on the number of catches.

Key Words: Sulawesi sea, pelagic schooling species, hunter's moon, skipjack tuna.

Introduction. Indonesia is an archipelagic country that has natural wealth and high fishery resources, both in capture fisheries, marine cultivation, public waters and others (KKP 2017). Fishery resources in North Gorontalo Regency are estimated to have the potential for capture fisheries of 590,970 tons consisting of 175,260 tons of large pelagic fish, 384,750 tons of small pelagic fish, and other types of fish of 30,960 tons. Concerning the utilization rate, it is estimated that capture fishery it has only reached 46% of its potential (Department of Marine Affairs and Fisheries 2010). To take advantage of the potential of capture fisheries in North Gorontalo, there are several ways and one of them is using purse seine fishing (Center for Marine and Fisheries Education 2012).

Fishing boats are boats or other floating means that are used for fishing (Fachrussyah 2017). The purse seine boat used for fishing activities in Gorontalo waters uses a "two boat system". The purse seine is a net fishing gear from that is operated by circling a group of fish to a bowl-shaped tool at the end of the fishing process (Salencer 2018). The operation of this fishing gear basically consists of 4 stages of activities which include setting, pursing, hauling and brailling (Santoso & Bawole 2014).

In the operation of a purse seine, there are several factors that affect its operation, one of which is the moon phases. Changes in the moon phases can indicate a good time in fishing operations because there is a difference in light intensity in each moon phases and will affect fish that have positive or negative phototaxis properties of light so that differences in intensity will affect the volume of the catch when fishermen operate (Jatmiko 2015).

The principle of catching fish with a purse seine is to purse a school of fish with a net. After that the lower net is drained like a bowl, so that the fish is collected in the

codend and cannot escape (Syamsuddin et al 2014). The net is operated in the morning starting at 05.00 AM, setting time lasts half an hour. In one trip, the purse seine is operated 1 to 2 times (setting), depending on the catch (Rahmat & Witdiarso 2017).

Fish that are the main purpose of catching from purse seine are fish that are "Pelagic Schooling Species" (Gatut & Sukandar 2011). According to Baskoro et al (2006), fishing operations with purse seine around FADs with small pelagic fish as target species include scad (*Decapterus* spp.), yellowstripe scad (*Selaroides leptolepis*), large pelagic fish such as skipjack tuna (*Katsuwonus pelamis*), frigate tuna (*Auxis rochei*) and baby tuna (*Thunnus* spp.). A fishing ground is where fish that is the target of fishing are caught in maximum amount and fishing gear can be operated economically as well (Nusantara et al 2014).

According to Gatut & Sukandar (2011) the first step in operating this fishing gear is to find a fishing ground. Because the fish that are targeted by the purse seine are clustered fish living in palagics, generally the catching area is in the form of seas in offshore areas with water depths of about 50 meters or more.

The distribution of demersal fish resources in FMA-716 is relatively narrow covering the coastal areas of Tarakan, Belinyu and Nunukan in East Kalimantan and Likupang Bay and around the Sangihe Talaud islands in North Sulawesi (Suman et al 2014).

Fish catches are multispecies in nature comprising demersal and pelagic species. The Indonesian fisheries administration records the catch is divided to eleven statistical areas also called "management areas" (FAO 20128) (Figure 1).

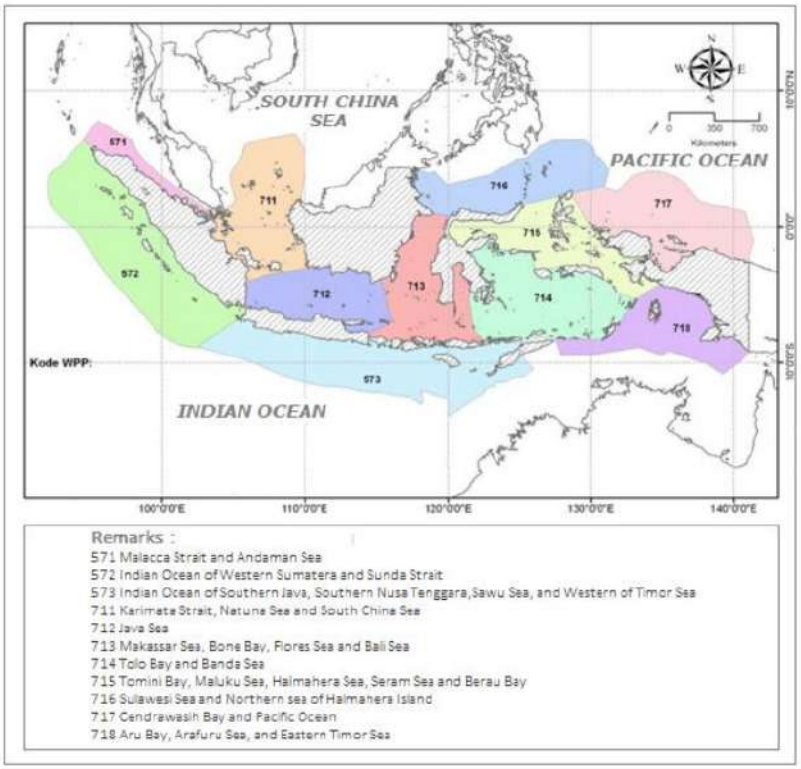

Figure 1. Fisheries management areas (FMA) in Indonesia (FAO 2018).

Moon phases. Optimization of fishing will work well if fishermen can find out the factors that influence it. These factors include suitability in using fishing gear. The fishing gear used should be adjusted to the fishing ground and the type of fish that is the main

target. In addition to the suitability of using fishing gear, fish resources will affect the catch obtained. The factor of the period of the day of the month will indirectly have an impact on the availability of fish resources, so fishermen need to know the changes in each period of the day of the month (Jatmiko 2015).

The catch of fish is strongly influenced by natural factors, one of which is the moon phases. The catch is also affected by changes in the intensity level of the moonlight. Changes in the amount and type of fishermen's catch in each lunar cycle (dark moon, dark to first crescent, first crescent to light moon, bright moon to last crescent) greatly impact the amount of catch and also the income level of fishermen (Nurlindah et al 2017).

The changing conditions of the lunar period are divided into four phases. New or dark moon phase (new moon), moon phase quadrant 1 (first quarter), full moon phase (full moon), and moon phase quadrant 3 (third quarter) (Figure 2). The period of change in the conditions of the month on average occurs every seven days. This division is based on the time or period of the appearance of the month. The condition of a bright moon occurs when the appearance of the moon is more than 8 hours in one day, while the moon bright occurs when the appearance of the moon is between 4 hours-7.5 hours, and the dark moon period occurs when the appearance of the moon only appears between 0 hours - 3.5 hours (Lee 2010).

Figure 2. Moon phases of Gorontalo region (timeanddate.com/moon/phase/).

The use of light as a fishing aid is closely related to the behavior of fish towards light. In the lift net fishing, the light sources are natural and artificial. Natural light sources come from the sun and moon, when the moon is full, the moonlight will spread over the surface of the water so that the fish will also spread on the surface of the water. This makes it very difficult for fishermen to carry out fishing operations with a purse seine, because it is difficult for fishermen to collect fish into one catchable area. The catch of the boat chart is a group of small pelagic fish that are reactive to light. There are patterns of fish arrival around the light source that go directly to the light source and some are only around the light source. The moon phases are an indication for determining fishing time for fishermen (Siahainenia 2017).

Material and Method. The present research was conducted from November 2019 to May 2020 by participating in the fishing operations of the purse seine vessels (Figure 3) operating in North Gorontalo waters.

The tools and materials used in the present research were camera, calculator, laptop, stationery and Moon Phase Calendar application.

Figure 3. The purse seine fishing boat used during the study.

Data collection method. The authors used several methods in data collection, including by way of: observation, interviews and documentation.

1. Primary data were obtained by making direct observations on the ship by participating in ship fishing operations, the data includes; (1) preparation, (2) setting, (3) pursing, (4) hauling, (5) brailing, (6) fish handling, (7) date of each moon phases (Table 1).
2. Secondary data were data from fishing owners or companies. The data collection method used was a survey method.

Table 1

The emergence of moon phases

Third quarter		*New moon*	
Date	Time	Date	Time
20/11/2019	05:10	26/11/2019	23:05
19/12/2019	07:14	26/12/2019	13:13
17/01/2020	20:58	25/01/2020	05:42
First quarter		*Full moon*	
Date	Time	Date	Time
04/12/2019	14:58	12/12/2019	13:02
03/1/2020	12:45	11/1/2020	03:21
02/2/2020	09:41	09/2/2020	15:33

Data processing. The data that have been obtained during the study were grouped and classified using tables. Data for each trip of fishing activities were grouped according to the catch, type of fish captured, income and the moon phases.

Data analysis. Using descriptive analysis that describes the process of operating fishing gear and to determine the composition of the catch related to the moon phases, a quantitative research was carried out. Furthermore, to observe the effect of the moon phases, the composition of the catch was grouped into four moon phases. To find out the percentage comparison of fishing results between the four moon phases, the approach of Susaniati et al (2013) was applied:

$$p = \frac{ni}{n} x\ 100$$

Where:

p = percentage
ni = value of catch per species
n = value of total catch

$$\text{Percentage of dark moons} = \frac{\text{total new moon catch}}{\text{total moon phases catches}} x\ 100$$

$$\text{Percentage of dark moons} = \frac{\text{total first quarter catch}}{\text{total moon phases catches}} x\ 100$$

$$\text{Percentage of dark moons} = \frac{\text{total full moon catch}}{\text{total moon phases catches}} x\ 100$$

$$\text{Percentage of dark moons} = \frac{\text{total third quarter catch}}{\text{total moon phases catches}} x\ 100$$

To find out whether the moon phases affects the number of catches, the authors conducted a One Way Anova test using SPSS 22 software. Before carrying out the One Way Anova test, the normality and homogeneity tests must be passed first. The basis for decision making is as follows:

- Normality test
  If the value is Sig. > 0.05, then the data is normally distributed
  If the value is Sig. <0.05, then the data is not normally distributed
- Homogeneity test
  If the value is Sig. > 0.05, then the data is the same or homogeneous
  If the value is Sig. <0.05, then the data is not the same or not homogeneous
- Anova test
  If the value is Sig. > 0.05, then the average is equal or has no effect
  If the value is Sig. <0.05, then the average is different or influential

Fishing ground. The fishing operation area at the time of the research was in the Fisheries Management Area of the Republic of Indonesia (FMA-RI) 716, namely in the Sulawesi Sea region (Figure 4). The setting (catching) positions were as it is presented in Table 2.

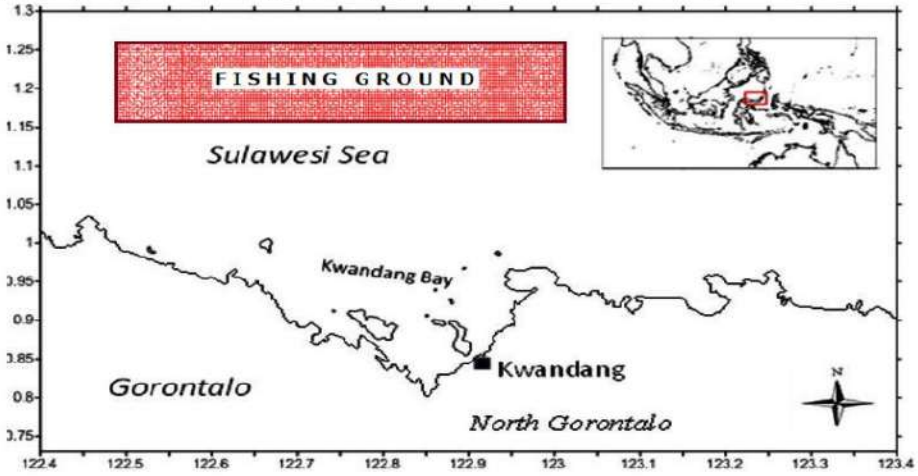

Figure 4. Fishing ground (Noegroho et al 2019).

Table 2

Position at the time of the caching operation

No	*Latitude*	*Longitude*
1	01°19′ 54″ U	123°19′ 36″ T
2	01°15′ 54″ U	122°28′ 18″ T
3	01°11′ 18″ U	122°34′ 36″ T
4	01°22′ 42″ U	122°39′ 12″ T
5	01°21′ 36″ U	122°36′ 00″ T
6	01°15′ 54″ U	122°28′ 18″ T
7	01°21′ 48″ U	122°36′ 42″ T
8	01°20′ 36″ U	122°13′ 54″ T
9	01°12′ 00″ U	122°14′ 30″ T
10	01°12′ 48″ U	122°35′ 48″ T

Results and Discussion

Catched fish. The dominant target fish caught in the waters of North Gorontalo were *K. pelamis*, frigate tuna (*Euthynnus affinis*), yellowfin tuna (*Thunnus albacares*), Indian scad (*Decapterus* sp.).

Amount of fish caught during 16 trips. The moon phases are divided into 4 cycles, namely the *first quarter*, the *new moon*, the *third quarter* and the *full moon*. The grouping of the amount of catches according to the moon cycle is based on the number of trips as many as 16 trips which were then subdivided into 4 moon phases. Figure 5 preents the amount of catch of 16 trips.

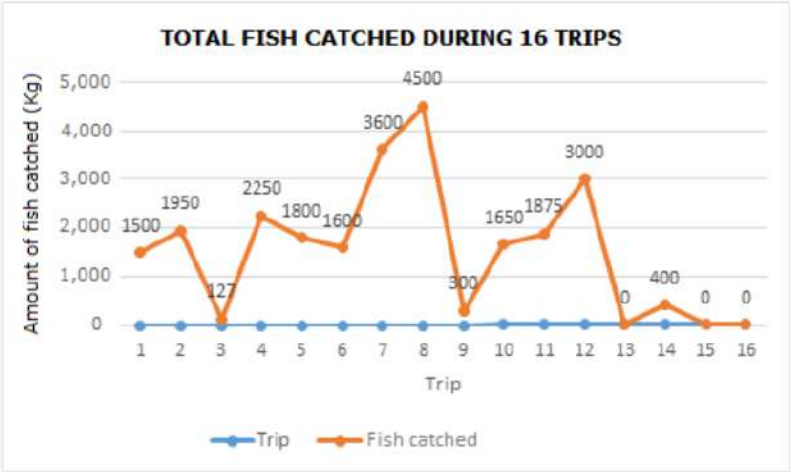

Figure 5. Amount of fish caught during 16 trips.

It can be seen that based on the results of the research, the most fish caught was on the 8th trip with the amount of fish of 4,500 kg consisting of *K. pelamis* with 1,500 kg, *Decapterus* sp. with 2,000 kg and *E. affinis* with 1,000 kg.

The total amount of catches was 24,552 kg, with 10,852 kg of *Decapterus sp.*, *Euthynus affinis* 7,850 kg and *K. pelamis* 5,850 kg. It can be seen that the highest catch consisted of *Decapterus* sp. 44% (10,852 kg) and the lowest was recorded for *K. pelamis* 24% (5,850 kg) (Figure 6).

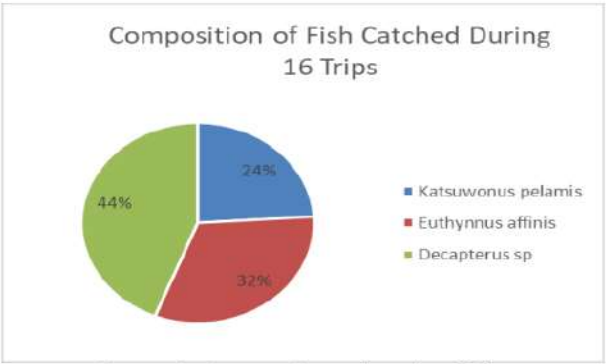

Figure 6. Composition of catched fish.

The total amount of catches according species, based on four moon phases can be seen in the Figure 7.

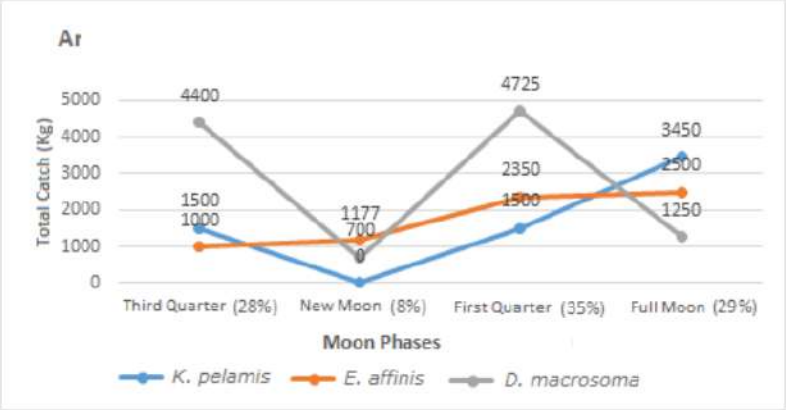

Figure 7. Amont of catch according species based on 4 month cycles.

Effect of the moon phases upon the catches amount. Grouping based on moon phases revealed the best results for the *first quarter* of 35% (8,575 kg) and the weekest results 8% (1,877 kg) in the *new moon* phases as shown in Figure 8.

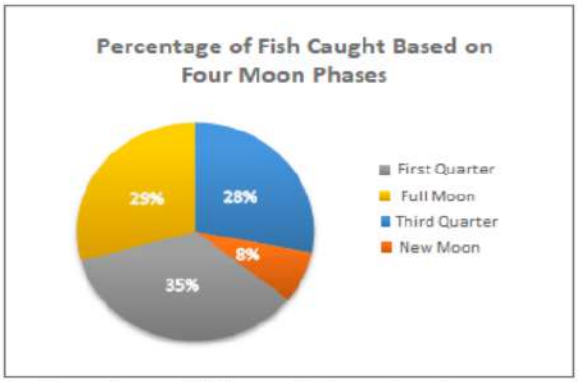

Figure 8. Percentage of fish caught based on four moon phases.

To determine whether or not the moon cycle affects the number of catches SPSS software for the One Way Anova test was used (Tables 3-5).

- Normality test

Table 3

Normality test

Phase	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Third quarter	.224	3	.	.984	3	.759
New moon	.318	3	.	.887	3	.344
First quarter	.268	3	.	.950	3	.571
Full moon	.276	3	.	.942	3	.537

From the normality test above, it can be concluded that the Sig. >0.05 so that the data is normally distributed and can be continued to the homogeneity test

- Homogeneity Test

Table 4

Homogeneity test

Levene statistic	*df1*	*Df2*	*Sig.*
1.093	3	8	.406

For the homogeneity test, the Sig. 0.406>0.05 so that it can be said to be homogeneous and it can be continued to the last stage, namely the anova test.

- Anova test

Table 5

Anova test

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Between groups	8601192.667	3	2867064.222	.701	.577
Within groups	32720469.33	8	4090058.667		
Total	41321662.00	11			

From the ANOVA test results above, it can be seen that the Sig. 0.577>0.05, which means that the lunar cycle has a weak or insignificant effect on the amount of catch.

Jatmiko (2015) reported the total catch was not significantly different accordind different moon phase periods. However, the result of the study showed that catch of seven out of nine species of total catch were significantly influenced by moon cycle. The highest fish catch were found during new moon phase period. Furthermore, comparison of fishermen based on the statistical analysis showed significant differences between moon cycle ($p<0.05$) concerning catches.

According Hutapea et al (2018), the results of observations show that the highest catch was recorded at new moon phase, amounting 43% of the total catch, while the lowest catch was at the full moon phase whith 8% of the total catch. This shows that the phase of the moon with its light intensity greatly affects the volume of the catch so that the productivity of the purse seines increases in the new moon phase while during the full moon phase the productivity decreases.

Conclusions

1. From the results of the study it can be concluded that the total number of fish caught was 24,552 kg with the highest catch consisting in *Decapterus* sp. (10,852 kg).
2. The highest amount of catch was obtained during the *first quarter phase*, namely as much as 8,575 kg (35%).
3. The lowest amount of catch was recorded during the *new moon phases* (1.877 kg; 8%).
4. For the one way ANOVA test results, the Sig. 0.577>0.05, revealed that the moon phases has no significant effect on the amount of catch.

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