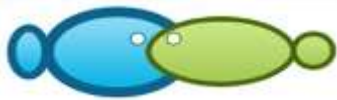


**Usulan Awal Naskah  
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# Mapping of Fishing Areas and the Effect of Moon Phase on Trap Net Catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing area in the waters of the Sigeri District, Pangkep Regency, was available in several places and was ideal for operating trap nets. The effect of the moon phase (tidal) on fish catches on the operation of trap net fishing gear, it is better in the full moon and dead moon phases to get more catches because in this lunar phase high tides occur compared to other moon phases. Tidal height affects the amount of catch, and only a small part is influenced by several external factors during the study. For every 1% increase in sea level at high tide, the catch value increases by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

**Keyword:** Mapping; Arrest Area; Catch; net traps; Moon Phase

## INTRODUCTION.

To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process is that fish are trapped during high tides every day and are operated parallel to the shoreline.

Tides are a phenomenon of the movement of rising and falling sea levels caused by a combination of gravity and the attractive force of astronomical objects, especially by the sun, earth, and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high or low tides and low tides, and high or low tides will affect the movement of fish migrating/closer to the shore for the purpose of foraging, spawning and rearing various types of fish. Furthermore, high and low tides will affect the trap net fishing area.

Tides are nothing but ocean currents, where the tides move towards the coast, and the tides move away from the land. These two things are closely related to each other because the determination of bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 meters from the shoreline. Because the shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan, 2018).

The catch of fishermen using erratic trap net fishing gear is sometimes abundant and sometimes very lacking. Factors that influence the problem are the lack of information on suitable fishing grounds, lack of information about the right time to catch. According to Aulia (2018), the composition of trap net catches in the Sigeri area is 27 species with the production of trap net catches for 13 fishing trips, both operated in the afternoon and at night but has not explained its relation to the moon phase so that it can

streamline fishermen's working time. With this problem in mind, I will conduct a study entitled the effect of the moon phase on the catch of trap net fishing gear in the coastal waters of Sigeri, Pangkep Regency with the aim of providing information to fishermen on fishing grounds, suitable fishing times, and dominant catches that have high value. high economical. This study aims to determine the map of the trap net fishing area and determine the production of trap net catches based on the moon phase in the waters of Pangkep Regency.

## RESEARCH AND METHOD

This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location map is presented in Figure 1.



Figure 1. Location of the research

In this study, the object of research is fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used in this study was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip. data on the existing condition of coastal waters, oceanographic data on coastal waters. Participate in fishing operations to conduct direct observations in the field and conduct interviews using a questionnaire related to the operation of trap net fishing gear. In this study used descriptive qualitative data analysis for and quantitative. For mapping using the GIS method with criteria, the admiral method for measuring tides and regression analysis to determine the relationship between the number of catches (kg) of each moon phase related to tides in the waters of Sigeri District, Pangkep Regency.

Ihsan (2015) said that in this study, the determination of the appropriate fishing area was carried out by analyzing bathymetric data, tidal data and tidal data other existing. Bathymetric analysis was obtained after tracking with S and Z patterns using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated, with the aim of producing a map of the depth class of the research location and more specifically a map of the location of the operating area for trap net fishing gear. Tidal analysis uses the Admiralty Method, which is a tidal analysis method used to calculate two harmonic constants, namely amplitude and phase delay. After obtaining the tidal components, namely the amplitude and the price of the phase delay, then it is calculated:

- Average Water Level (Mean Sea Level)  $MSL = A(S_0)$
- Lowest Low Water Level  
 $LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$
- Highest High Water Level  
 $HHWL = A(S_0) + (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

- Pair type (F) =  $A(K1) + A(O1) / A(M2) + A(S2)$

The type of tide can be determined by using the following formula:

$$F = \left( \frac{K_1 + O_1}{M_2 + S_2} \right)$$

Where:

F : Formzahl number.

K1: Amplitude of the affected daily tidal wave cub by the declination of the sun and moon.

O1: Amplitude of the affected single daily tidal wave by the sun's declination.

M2: Amplitude of the average double daily tidal wave influenced by the moon.

S2: Amplitude of the average double daily tidal wave influenced by the sun.

According to Triatmodjo, (1999) in (Asri et al., 2014), there are 4 classifications of tidal types based on tidal constants:

$0 < F < 0.25$  = Pure Double daily tidal type

$0.25 < F < 1.50$  = Mixed Tidal Type Double Inclined Daily

$1.50 < F < 3.0$  = Single Daily Inclined Mixed Tidal Type

$F > 3.0$  = Pure Single Daily Tidal Type

For mapping the fishing area for trap net fishing gear, it is also analyzed using a geographic information system (GIS), the overlay method using ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then unionized with the mean sea level (MSL) data on tidal measurements and then given point manually at a suitable location for the placement of the trap net fishing gear. Ihsan (2018) said that the factors that affect the trap net fishing area use the following criteria:

**a. Tides:** The location of fishing is influenced by tides, it is suspected that the lower the tide, the easier it is to operate the trap net. The maximum and minimum tidal heights, analyzed the mean sea level (MSL) and looked for the types of tides found at the trap net operating location.

**b. Mangrove vegetation:** The fishing location is influenced by the distance from the mangrove vegetation, it is suspected that the closer and better the mangrove vegetation is, the better the trap net installation.

**c. Salinity:** The location of fishing is influenced by the salinity of the waters, because the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

**d. Seawater temperature:** The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

**e. Substrate:** The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

**f. Water depth:** The depth of the water is one of the most important things in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as mangrove vegetation conditions, salinity, sea water temperature, substrate, water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the Independent factors that can affect the catch (Dependent) of the Trap net fishing gear in order to see a straight line relationship, a simple linear regression formula is used:

$$Y = \alpha + \beta x$$

Where:

- Y = Catch (dependent)
- = constant
- = Regression coefficient of independent variable
- x = High tide (full moon phase, early moon phase, moon phase dark and moon phase end

## RESULTS

### 1. Physical and Chemical Aspects of Coastal Oceanography

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 (four) phases of the moon, obtained the values for tidal height and sea level, as presented in Table 1.

Table 1. The results of the analysis of the value of tidal height and sea level (MSL)

| No | Type of moon phase               | high tide (cm) Variable X | Value of low tide (cm) | MSL (cm) |
|----|----------------------------------|---------------------------|------------------------|----------|
| 1  | Dead moon phase                  | 162                       | 59                     | 110.5    |
| 2  | Phases of the early quarter moon | 115                       | 23                     | 69       |
| 3  | Full moon phases                 | 185                       | 42                     | 113.5    |
| 4  | Phases of the late quarter moon  | 149                       | 40                     | 94.5     |

The results of temperature and salinity measurements for 3 treatments at the research location were found to be optimal for the growth and development of the caught fish. the data are presented in Table 2.

Table 2. Results of temperature and salinity measurements during the study

| No | Physical and chemical aspects of oceanography | Value     |
|----|-----------------------------------------------|-----------|
| 1  | Temperature                                   | 31 - 34°C |
| 2  | Salinity                                      | 30-36 ppt |

### 2. Mapping of trap net fishing areas

Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency as presented in Table 3. .

Table 3. The results of the analysis of the development of fishing locations using the bathymetry (depth) approach of the waters

| Trap net capture location | Coordinate point location of trap net fishing gear | Depth (m)   |
|---------------------------|----------------------------------------------------|-------------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S              | 0,18 - 0,31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S              | 0,31 - 0,45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S               | 0,45 - 0,59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S              | 0,18 - 0,31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S               | 0,73 - 0,87 |

Based on bathymetric measurements at the research site, to determine the location for trap net catching with the following criteria: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) dense mangrove vegetation and 4) the existing trap net operation location is done by fishermen. For shallow waters, it must be based on the type of tidal sea water according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

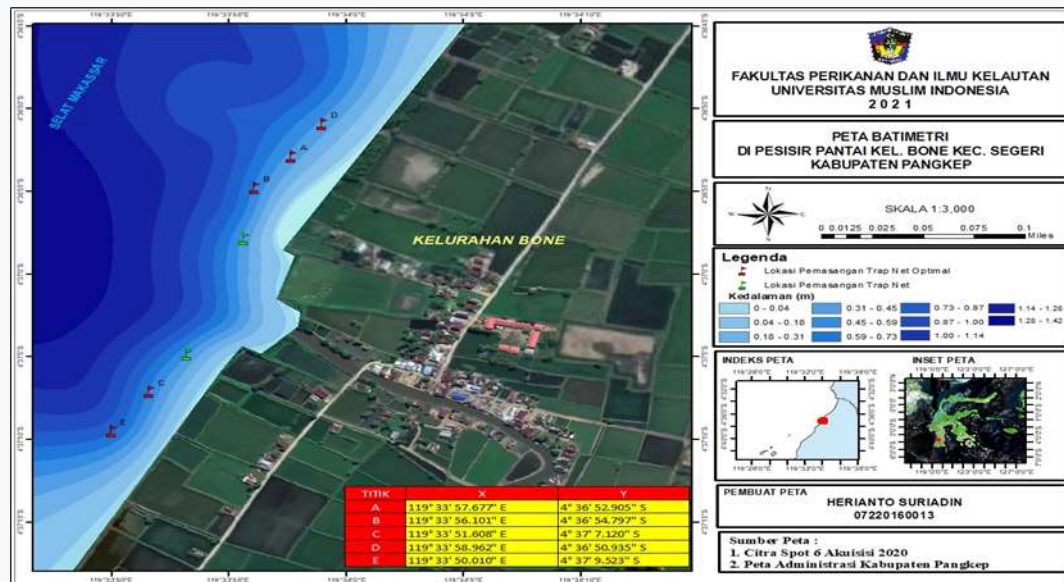


Figure 2. The mapping results (Ihsan, 2021)

### 3. Relationship between production of trap net catch and moon phase

The relationship between the number of production catches (kg) trap net based on the moon phase, shows that in the high tide phase the highest production value was obtained during the study, as presented in Table 4.

Table 4. Total production of catch (kg) trap net by moon phase

| No | Type of moon phase               | Catch Production (Kg) Variable Y |
|----|----------------------------------|----------------------------------|
| 1  | Dead moon phase                  | 97,060                           |
| 2  | Phases of the early quarter moon | 47,925                           |
| 3  | Full moon phases                 | 142,835                          |
| 4  | Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch has a close effect with the equation  $Y = -111.950 + 1.329x$  where the constant is -111.950, the regression coefficient (x) of 1.329 states that every 1% addition of sea level at high tide, the value of the catch increases by 1.329. more complete is presented in Table 5.

Table 5. The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup> |            |                             |            |                           |        |      |
|---------------------------|------------|-----------------------------|------------|---------------------------|--------|------|
| Model                     |            | Unstandardized Coefficients |            | Standardized Coefficients | t      | Sig. |
|                           |            | B                           | Std. Error | Beta                      |        |      |
| 1                         | (Constant) | -111.950                    | 35.005     |                           | -3.198 | .085 |
|                           | Tide high  | 1.329                       | .226       | .972                      | 5.879  | .028 |

| a. Dependent Variable: Catch      |                   |          |                   |                            |
|-----------------------------------|-------------------|----------|-------------------|----------------------------|
| Model Summary                     |                   |          |                   |                            |
| Model                             | R                 | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1                                 | .972 <sup>a</sup> | .945     | .918              | 11.44936                   |
| Predictors: (Constant), High tide |                   |          |                   |                            |

## DISCUSSION

### 1. Physical and chemical aspects of coastal oceanography

#### a. ups and down

The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest low tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon and occurrence every day at sea, and affect the movement of fish. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) said that the relationship between fish abundance and currents at high tide was 0.126 which was included in a very low correlation. Meanwhile, the relationship between fish abundance and currents at low tide is 0.896 which is included in a very strong correlation. The lower the current value, the higher the fish abundance because not all fish can adapt to high current speeds.

Several types of trap net catches are caught because they are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study (Manan, 2011) that the catches caught were 8 genera, namely *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*. Fish larvae caught at high and low tide based on the moon phase, both new moon phase, early moon phase, full moon phase and late moon phase were dominated by *stolephorus* and *ambassis*. Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide to move towards the coast in line with the current at high tide.

In this regard, the currents and tides greatly affect the migration of eels from larvae to adults. Larvae carried by currents to the coast became glass eels and elvers, then migrated to the mouth of the river and so on upstream affected by changes in water flow and tides. Changes in water level in river waters are determined by the high and low tides in the estuary, as well as by the high and low rainfall that falls in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims on the surface of the water at high tide and hides at the bottom at low tide. Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast in line with the current at high tide.

In this connection, the currents and tides greatly affect the migration of eels from larvae to adults. Larvae carried by currents to the coast became glass eels and elvers, then migrated to the mouth of the river and so on upstream affected by changes in water flow and tides. Changes in water level in river waters are determined by the high and low tides in the estuary, as well as by the high and low rainfall that falls in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims on the surface of the water at high tide and hides at the bottom at low tide. Maturbongs et al., (2019) said that as many as 98 fish caught which were divided into 45 fish in the dark moon phase and 53 fish in the bright moon phase, 14 fish species from 14 genera were collected. 2. Species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity in the dark moon

phase is in the uneven category, in the bright moon phase it is in the less uniform category.

### **b. Temperature**

Based on Table 2, that the temperature of the waters along the coast obtained values ranging from 31 - 34°C by measuring 3 repetitions of each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning one type of catch is white snapper (*Lates calcarifer*). According to (Cheong & Yeng. 1986), that the optimal temperature for white snapper spawning generally ranges from 27-33°C.

The temperature of a waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus, 2004). While Latuconsina et al., (2012) that the optimal temperature range for fish life in tropical waters is between 28°C - 32°C. Where the water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish.

### **c. Salinity**

Based on Table 2, the value of salinity (salt content) of waters along coastal waters is obtained in the range of 30-36 ppt by measuring 3 repetitions at each observation point. This value indicates that the salinity level in these waters is low because it is near the estuary (estuary) where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities or levels of salt, one of which is caught in the trap net, namely mullet. According to Aulia., (2018), adult and young mullets (length from 4 – 7 cm) have a fairly wide tolerance for salt content (0 - 35 ppt).

Fish that have origins of life in brackish waters also have a strong immune level because they can survive with different levels of salinity ranging from larval size to adult size, one of which is white snapper. According to Mulyono (2011), white snapper spawning is in areas with a salinity ranging from 30-32 ppt, the eggs that have been released will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then with increasing size the larvae migrate to the water. brackish until adulthood will live in waters with a salinity of 30-32 ppt. The relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the relationship between fish abundance and salinity at high tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels. According to Silalahi et al., (2017) which states that the variation in salinity values is caused by the influence of water supply. Salinity decreases due to incoming fresh water and also due to the occurrence of tides in these waters.

## **2. Trap Net Fishing Area**

Based on the results of bathymetry measurements in Table 3, in coastal waters using a roller meter and echosounder mapping in the coastal waters of the Segeri District, Pangkep Regency, it shows that the depth of the coastal waters is very shallow and sloping with a distance of 100 m to the sea from the shoreline. Based on bathymetric mapping, it can be seen that the depth on the coast. The depth of the waters varies from a depth of 0.4 to 1.19 m with the shape of sloping coastal waters up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The results of the measurement of the depth of the location points for the operation of the trap net fishing gear which so far have been at an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height is 50 m from the shoreline.

Aulia et al., (2018) said that one of the requirements for the location of the operation of trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest low tide it is easier to capture fish caught in the trap net area when the sea water recedes to the lowest tide.

Risnawati et al., (2018) said that the bathymetry map of 4 sub-districts in Pangkep Regency which includes the Districts of Bungoro, Labakkang, Ma'rang, and Segeri. The map is also overlaid along with water bathymetry, showing various depth variations ranging from 0 to -50 meters. For the distribution of fishing gear to be studied, the waters that have a depth ranging from 0 Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

### **3. Relationship between production of trap net catch and moon phase**

To find out the relationship between the phases of the moon which consists of the early moon phase, full moon phase, dead moon phase and late moon phase, which are related to tides and trap net catches in this study, it was based on the weight of the catch and the height of the tides obtained. obtained from the results of measurements at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty Method for the 4 (four) phases of the moon, obtained the value of tidal height and sea level against the trap net catches in Table 1, for testing the relationship between the phases of the moon, in this case related to with tides on trap net catches from the results of tidal analysis, using the Admiralty Method, the value of high tide (cm), as an independent variable (Independent), and the amount of production of trap net catches for the 4 phases of the moon which is the test in this study In this case, the weight of the catch (Y) is the dependent variable.

To test the effect of the moon phase on the trap net catch, the value, based on the results of recording the weight of the catch (Y) as the dependent variable and observations of tidal height (X) as the independent variable (Independent) of each moon phase can be seen through the equation simple linear regression. Based on the results of simple linear regression analysis using the SPSS 25.0 application, the results are as follows.

Based on Table 5, the results of the analysis above show that the effect of the moon phase (tidal height) on the catch has a close influence with the equation  $Y = -111.950 + 1.329x$  where the constant is -111.950, the regression coefficient (x) of 1.329 states that each addition 1% of sea level at high tide, then the value of the catch increases by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

The value (R) explains the magnitude of the correlation (relationship) between tidal height and the catch obtained, namely  $R = 0.972$ . The value of R Square (coefficient of determination or  $R^2$  which explains how much the catch variable can be explained by the tidal height variable so that the value of  $R^2 = 0.945$  is obtained which.

This means that 94.5% of tidal height affects the number of catches, while the remaining 5.5% is influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area. net, or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which is included in a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which is included in a strong correlation.

Based on this, it shows that the full moon phase has a high tide of 185 cm with a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm with a catch of 97,060 kg, this is related to the daily migration of fish more there are many during the moon phase where at that time the tides are high, so the fish that

carry out daily migration/migration further enter coastal waters and rivers because the sea water is higher or deeper on the coast.

Subiyanto et al., (2009), said that the abundance of plankton in the estuary and the strong currents at high tide, and increased food abundance and decreased predation rates. The number of fish larvae caught was 904 individuals, at high tide 472 individuals were caught (52.21%) and at low tide 432 individuals were caught (47.79%). Abdul Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns that occur in each phase. The difference in catches both at high and low tide is due to differences in the direction of currents and the strength of the tides that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters. Where the tidal pattern is closely related to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength that occurs in the Spring Tide is greater than the tidal strength that occurs in the Neap Tide so that it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) said that the moon phase affected the migration of eels. Haraldstad, (1985), said that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have brackish salinity, because each pair of sea water flows deep into the river. This also causes the distribution and distribution of several types of marine fish such as titan and mullet found very far from the sea. Higher tides, such as occurs during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Likewise, the natural movement of several types of fish and non-fish such as prawns and crabs, although spawning off the coast and in the deep sea, still arrives at the beach where they are reared, reared, looking for food and protection more quickly because of the tidal currents that occur every day.

Abdul Manan (2011) explained that the difference in catches both at high and low tide was due to differences in the direction of currents and the strength of the tides that carried fish larvae in and out of the river mouth. This is due to the movement of the body of the fish larvae which is not so strong that it can be carried away by the current. In contrast to low tide. At low tide, fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

So the tidal conditions affect the abundance of fish larvae in the waters. The strength of the current at high tide makes fish larvae carried to the estuary area and prefer to stay at low tide because the estuary area has an abundance of food sources for fish larvae and adult fish. According to Subiyanto, et al., (2009) There is a difference in abundance at high and low tide because at high tide many fish larvae are carried to the estuary by tidal currents and avoid low tides by being on the side of the estuarine waters because in the estuarine area they find a place to live. suitable for growth. This is reinforced by Subiyanto et al., (2009), that the larvae are moved by the current where the current flows towards the mouth of the estuary during the flood tide, and the fish larvae that are distributed to the mouth of the estuarine are young larvae and young fish.

## **CONCLUSION.**

1. The trap net fishing area in the waters of the Sigeri District, Pangkep Regency, is available in several places and is ideal for operating a trap net with a large number of catches.
2. The effect of the moon phase (tidal) on fish catches on the operation of the Trap net fishing gear, it is better in the full moon and dead moon phases by getting more catches because in this lunar phase high tides occur compared to other moon phases. Tidal height affects the amount of catch, and only a small part is influenced by several external factors during the study.

**Conflict of interest.** The authors declare no conflict of interest.

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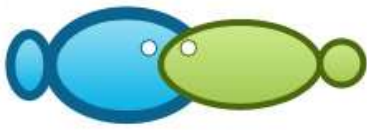
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# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing ~~area grounds~~ in the waters of the Sigeri District, Pangkep Regency, ~~was/were~~ available in several places and ~~were~~ ideal for operating trap nets. ~~There was observed a significant~~ effect of the moon phase (tidal) on fish catches ~~during~~ the operation of trap net fishing gear, ~~it is better especially~~ in the full moon and dead moon phases ~~to get more catches because in this lunar phase, due to the~~ high tides ~~occur compared to other moon phases~~. Tidal height ~~affects~~ ~~affected most of~~ the amount of catch, and only a small part ~~is/was~~ influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value ~~increases/increased~~ by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

**Key Words:** mapping, arrest area, catch, net traps, moon phase.

Comment [A1]: Please reformulate

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process ~~is that consist of trapping fish are trapped~~ during high tides ~~every day~~ and ~~which~~ are operated ~~parallel~~ to the shoreline.

Tides are ~~the a phenomenon of the movement of rising and falling~~ sea levels ~~fluctuations~~, caused by a combination of gravity and the attractive force ~~of between~~ astronomical objects, especially ~~by~~ the sun, earth, and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high ~~or low tides~~ and low tides, ~~and high or low tides which~~ will affect the ~~movement of fish migrating/migrations~~ closer to the shore ~~for the purpose of while~~ foraging, spawning and rearing ~~various types of fish~~. Furthermore, high and low tides will affect the trap net fishing area.

Comment [A2]: Please clarify

Tides are nothing but ocean currents, ~~where the tides move moving~~ towards the coast, and ~~the tides move back~~ away from the land. ~~The These two things are closely related to each other because the determination of~~ bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 meters from the shoreline. ~~Because~~ ~~The~~ shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan, 2018).

Comment [WU3]: Citation?

The catch of fishermen using erratic trap net fishing gear is ~~sometimes abundant and sometimes very lacking~~ ~~extremely fluctuating~~. Factors that influence the problem are ~~the lack of depending on the~~ information on ~~the~~ suitability of ~~the~~ fishing grounds ~~and on the right timing, lack of information about the right time to catch~~. According to Aulia

(2018), the composition of trap net catches in the Sigeri area is of 27 species ~~with the production of trap net catches for~~ captured during an average of 13 fishing trips, ~~both~~ operated ~~both~~ in the afternoon and at night. ~~but has not explained The catch its~~ relation to the moon phase ~~has not yet been explained, so that it can in order to optimize streamline~~ fishermen's working time. ~~The present~~ ~~With this problem in mind, I will conduct a study entitled the~~ aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, ~~with the aim of in order to providing-provide~~ information to the fishermen on fishing grounds, suitable fishing times, and dominant catches that have high economical value. ~~high economical.~~ ~~Therefore, this study aims to determines~~ the map of the trap net fishing area and ~~determine~~ the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.



Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used ~~in this study~~ was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; ~~(4) data on the existing condition of coastal waters,~~ oceanographic data on coastal waters. ~~Participate~~ ~~The authors participated~~ in fishing operations to conduct direct observations in the field and ~~conduct~~ interviews using a questionnaire related to the operation of trap net fishing gear. In this study used ~~descriptive qualitative data analysis for and quantitative.~~ For mapping ~~using~~ the GIS method was used with criteria, ~~the~~ ~~The Admiralty~~ ~~admiral~~ method was used for measuring tides, ~~and~~ ~~The~~ regression analysis was used to determine the relationship between the number of catch volumes (kg) ~~of each moon phase related to and the tides,~~ during each moon phase, in the waters of Sigeri District, Pangkep Regency.

Ihsan (2015) said that in this study, the determination of the appropriate fishing area was carried out by analyzing bathymetric data, tidal data and tidal data other existing. Bathymetric analysis was obtained ~~after by~~ tracking with S and Z patterns using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated, with the aim of producing a map of the depth class of the research location and, more specifically, ~~a map~~ of the location of the operating area for the trap net fishing gear. Tidal analysis uses the Admiralty ~~m~~Method, ~~for which is a tidal analysis method used to calculate-calculating~~ two harmonic component~~s~~constants, namely amplitude and phase delay. After obtaining the

**Comment [WU4]:** When was the research conducted?

**Comment [WU5]:** The legend should be in English.  
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**Comment [A6]:** reformulate

**Comment [A7]:** Please reformulate

**Comment [A8]:** ?

tidal components, ~~namely the amplitude and the price of the phase delay, then it is the following can be~~ calculated (L...):

Comment [WU9]: Sources of the formulas.

Average Water Level (Mean Sea Level)  
 $MSL = A(S_0)$

Lowest Low Water Level  
 $LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

Highest High Water Level  
 $HHWL = A(S_0) + (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

Pair type (F) =  $A(K_1) + A(O_1) / A(M_2) + A(S_2)$

Comment [A10]: signification of the variable symbols, please.

The type of tide can be determined by using the following formula:

$$F = \left( \frac{K_1 + O_1}{M_2 + S_2} \right)$$

Where:

F - Formzahl number;

$K_1$  - Amplitude of the affected daily tidal wave cub by the declination of the sun and moon;

$O_1$  - Amplitude of the affected single daily tidal wave by the sun's declination;

$M_2$  - Amplitude of the average double daily tidal wave influenced by the moon;

$S_2$  - Amplitude of the average double daily tidal wave influenced by the sun.

Comment [A11]: Signification?

According to Triatmodjo (1999) in (Asri et al., al 2014), there are 4 ~~classifications of~~ tidal types based on ~~tidal constants~~:

Comment [A12]: Please clarify

$0 < F < 0.25$  = ~~Pure-pure Double-double~~ daily tidal type

$0.25 < F < 1.50$  = ~~Mixed-mixed Tidal Type Double-double Inclined-inclined Dailydaily tidal type~~

$1.50 < F < 3.0$  = ~~Single-single Daily-mixed inclined daily Inclined-Mixed-Tidal Typetype~~

$F > 3.0$  = ~~Pure-pure Single-single Daily-daily~~ Tidal Type

~~For mapping the~~ The fishing area (for trap net fishing gear) ~~mapping, it is also analyzed using with a~~ geographic information system (GIS), ~~using the overlay method using of the~~ ArcGIS 10.3 software, where the processed bathymetric data that has been interpolated is then ~~unionized-correlated~~ with the mean sea level (MSL) data ~~on from the~~ tidal measurements and then ~~given point~~ manually ~~assigned at~~ a suitable location for the placement of the trap net fishing gear. Ihsan (2018) ~~said-stated~~ that the factors that affect the trap net fishing area ~~use are~~ the following ~~criteria~~:

a. Tides: ~~The location of fishing is influenced by tides,~~ it is ~~suspected-assumed~~ that the lower the tide, the easier ~~it is to operate~~ the trap net ~~operating~~. The maximum and minimum tidal heights, analyzed the mean sea level (MSL) and looked for the types of tides found at the trap net operating location.

Comment [A13]: The semantics of this phrase not correct! Please reformulate

b. Mangrove vegetation: ~~The fishing location is influenced by the distance from the mangrove vegetation,~~ it is ~~suspected-assumed~~ that the closer ~~and better~~ the mangrove vegetation ~~is~~, the better the trap net installation.

Comment [A14]: Please find a scientific explanation

c. Salinity: ~~The location of fishing is influenced by the salinity of the waters, because due to~~ the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water is one of the most important things in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate, ~~and~~ water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship independent between these independent factors that can affect and the catch volumes (dependent variable) of the ~~Trap-trap~~ net fishing gear in order ~~to see a straight line relationship, a simple linear regression formula is used (...)~~:

$$Y = \alpha + \beta x$$

Where:

$Y$  = ~~Catch-catch volume~~(dependent)

$\alpha$  = constant

$\beta$  = ~~Regression-regression~~ coefficient of independent variable

$x$  = ~~High-high~~ tide water level (full moon phase, early moon phase, moon phase dark and moon phase end

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, ~~obtained the values for tidal height and sea level, as, are~~ presented in Table 1.

Table 1  
The results ~~of the analysis~~ of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements ~~for 3 treatments~~ at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish. ~~the data are presented in Table 2.~~

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the ~~operation of~~ trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

**Comment [A15]:** Please avoid arguments like "the better the trap net installation" and avoid reusing / repeating whole parts of phrases ("The location of fishing is influenced by") like in the selected paragraph. Please reformulate the selected paragraph and use a scientific argumentation

**Comment [WU16]:** Citation needed

**Comment [A17]:** Which treatments? Please clarify

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach ~~of the waters~~

| Trap net capture location | Coordinate points <del>for the</del><br>location of trap net fishing gear | Depth (m) |
|---------------------------|---------------------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                                     | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                                     | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                                      | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                                     | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                                      | 0.73–0.87 |

Based on bathymetric measurements at the research site, ~~the following criteria were used~~ to determine the location for trap net catching ~~with the following criteria~~: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) ~~dense-the~~ mangrove vegetation ~~must be dense~~ and 4) ~~the existing trap net operation location is done by fishermen~~. For shallow waters, ~~it-the choice~~ must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

**Comment [A18]:** Location is done by fishermen. Please reformulate the phrase

**Comment [WU19]:** Please use English in the description, legend etc

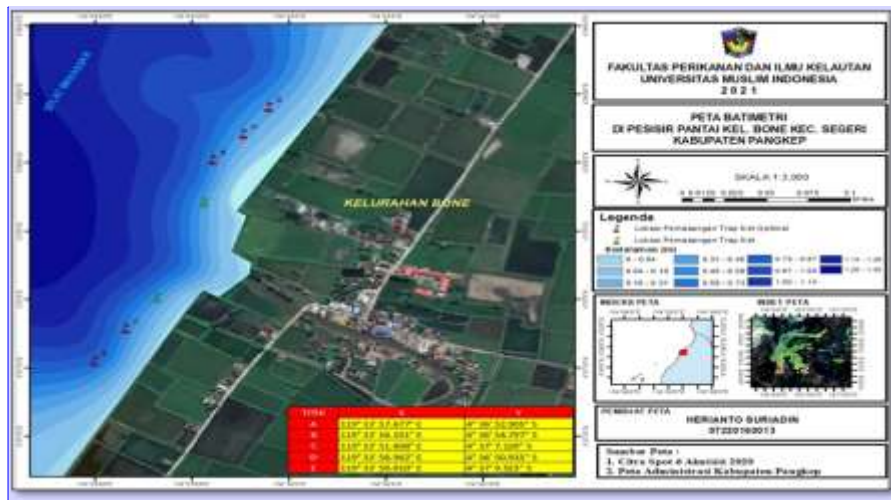


Figure 2. The mapping results (Ihsan, 2021).

**Comment [A20]:** Not in the reference list.

**Relationship between production of trap net catch and moon phase.** The relationship between the ~~trap net number of catch~~ production ~~volumes catches~~ (kg) ~~trap net-based on~~ and the moon phase, shows that ~~the highest production value was obtained in-for~~ the high tide phase ~~the highest production value was obtained during the study~~, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch Production (Kg) Variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch ~~has a close effect with~~ can be approximated by the equation  $Y = -111.950 + 1.329x$ , where with the a constant is of -111.950, and a the regression coefficient (x) of 1.329, meaning states that for every sea level marginal increase of 1% addition of sea level at the high tide, the value of the catch increases by 1.329, more complete is as presented in Table 5.

Table 5  
The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>         |            |                             |            |                           |                            |      |
|-----------------------------------|------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             |            | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   |            | B                           | Std. error | Beta                      |                            |      |
| 1                                 | (Constant) | -111.950                    | 35.005     |                           | -3.198                     | .085 |
|                                   | Tide high  | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch      |            |                             |            |                           |                            |      |
| Model summary                     |            |                             |            |                           |                            |      |
| Model                             |            | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 |            | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |            |                             |            |                           |                            |      |

Comment [WU21]: Please respect the AACL tables formatting

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest low tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon and occurrence occurring every day on a daily basis at sea, and affecting the fish movement of migrations fish. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) said-stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which was included in shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows is included in a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several types-species caught of by trap net catches are caught because they are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan, (2011) that the which mentions catches caught were the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. Fish-The frequency of fish larvae caught at high and low tide, based on the moon phase, (both new moon phase, early moon phase, full moon phase and late moon phase) were-was dominated by *stolephorus* and *ambassis*. Dwiponggo (1972) suggests that certain types of fish will move with the high tide current at high tide to move towards the coast in line with the current at high tide.

In this regard, the currents and tides greatly affect the migration of eels, both from larvae to and adults. Larvae are carried by currents to the coast, became-becoming glass eels and elvers, then they migrated to the mouth of the river and so on-upstream, being affected by changes in the water flow and tides. Changes in the river's water level

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~~in river waters~~ are determined by the high and low tides in the estuary, as well as by the high and low rainfalls ~~that falls occurring~~ in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims ~~on-at~~ the surface of the water, ~~at-during the~~ high tide, and hides at the bottom, ~~at-during the~~ low tide.

Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, ~~in-line along~~ with the current, at high tide.

~~In this connection, the currents and tides greatly affect the migration of eels from larvae to adults. Larvae carried by currents to the coast became glass eels and elvers, then migrated to the mouth of the river and so on upstream affected by changes in water flow and tides. Changes in water level in river waters are determined by the high and low tides in the estuary, as well as by the high and low rainfall that falls in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims on the surface of the water at high tide and hides at the bottom at low tide.~~

Maturbongs et al., al (2019) ~~said-found~~ that as many as among the 98 fish caught, ~~which were divided into of which~~ 45 fish specimens were captured in the dark moon phase and 53 fish specimens were captured in the bright moon phase, ~~there were identified~~ 14 fish species from 14 genera ~~were collected~~. 2. Species-The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity ~~in-during~~ the dark moon phase is in the uneven category, ~~while in-during~~ the bright moon phase it is in the less uniform category.

**Comment [A22]:** This is exactly the previous paragraph, repeated.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast ~~reach-obtained~~ values ranging from 31- ~~to~~ 34°C ~~CoC by-(measurements wereing 3 repeateditions 3 times forof~~ each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning. ~~one type of catch is white snapper (Lates calcarifer). According to (Cheong & Yeng. 1986), that the optimal temperature for white snapper spawning generally ranges from 27-33°C.~~

The temperature of ~~a-~~waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28-30 °C (Barus, 2004). ~~While According to Cheong & Yeng (1986) the optimal temperature for the spawning of the white snapper (Lates calcarifer) generally ranges from 27 to 33°C.~~ Latuconsina et al., al (2012) ~~found~~ that the optimal temperature range for fish life in tropical waters is between 28- ~~and~~ 32°C. ~~Where the-The~~ water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish. (11)

**Comment [WU23]:** Own research?

**c. Salinity.** Based on Table 2, the value of ~~the~~ salinity (salt content) of waters along ~~the~~ coast ~~at waters~~ is obtained in the range of 30-36 ppt ~~by-measuring(-3 measurement repetitions at each observation point)~~. This value indicates that the salinity level in these waters is low because it is near the estuary, ~~(estuary)~~ where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities, ~~-or levels of salt, one of which is caught in the trap net, namely mullet. According to Aulia., (2018), adult and young mullets (length from 4-7 cm) have a fairly wide tolerance for salt content (0-35 ppt).~~

Fish ~~(from larval size to adult size) that have origins of life originating from the in~~ brackish waters also have a strong immune level because they can survive with different levels of salinity, ~~ranging from larval size to adult size, one of which is white snapper. For instance, according to Aulia (2018), adult and young mullets (4-7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt).~~ According to Mulyono (2011), white snapper spawning ~~is-occurs~~ in areas with a salinity ranging from 30- ~~to~~ 32 ppt, ~~the-The released~~ eggs ~~that have been released~~ will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, ~~in later stages, with increasing size the larvae they migrate to the water, to~~ brackish ~~waters with a salinity of 30-32 ppt, where they will~~

live until their adulthood will live in waters with a salinity of 30-32 ppt. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at high-low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels. According to Silalahi et al., al (2017) which states that the variation in salinity values is caused by the influence of water supply. Salinity decreases due to incoming fresh water and also due to the occurrence of tides in these waters.

**Comment [A24]:** The authors have the abundance and two independent variables (salinity and sea level), which is a multiple regression. Is it your result or is it a citation (authors?)? What formula did you use, if it is yours?

**Comment [A25]:** Not a satisfactory interpretation. Please develop the scientific argumentation

**Comment [A26]:** Logically, if tides are current from the sea to the coast, they bring sea water, whose salinity is higher. Exactly the contrary is stated. Please explain the statement.

**Trap net fishing area.** The mapping Based-based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements in (Table 3), in-performed coastal waters using a roller meter and echosounder, mapping in the coastal waters of the Segeri District, Pangkep Regency, it shows that the depth of the coastal waters is very shallow and sloping with over a distance of 100 m to the sea from the shoreline. Based on bathymetric mapping, it can be seen that the depth on the coast. The depth of the waters varies from a depth of 0.4 to 1.19 m with the bottom shape of or sloping coastal waters, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The results of the measurement of the depth of the location points for the operation of the trap net fishing gear which so far have been at an had an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height is being at 50 m from the shoreline.

Aulia et al., (2018) said that one of the requirements for the location of the operation of trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest low-tide it is easier to capture fish caught in the trap net area when the sea water recedes to the lowest tide.

**Comment [A27]:** Unique author in the reference list.

Risnawati et al., al (2018) said elaborated that the bathymetry map of 4 sub-districts in Pangkep Regency: which includes the Districts of Bungoro, Labakkang, Ma'rang, and Segeri. The map is also overlaid along with water bathymetry, showing various depth variations ranging from 0 to -50 meters. For the distribution of fishing gear to be studied, the waters that have a depth ranging from 0 Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

**Comment [A28]:** Please reformulate, these phrases are not intelligible

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), which are related to tides, and the trap net catches in this study, it was based on, the weight of the catch and the height of the tides obtained. obtained from the results of were measurements measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty Method-method for the 4 (four) phases of the moon, obtained the value of tidal height and sea level against the trap net catches (reported in Table 1), were used for testing the regression relationship between the phases of the moon, in this case related to with tides on trap net catches from the results of tidal analysis, using the Admiralty Method, the value of high tide (cm), as an independent variable (Independent), and the amount of production of trap net catches for the 4 phases of the moon which is the test in this study In this case, the weight of the catch (Y) is the dependent variable.

**Comment [A29]:** This phrase is not intelligible

To test the effect of the moon phase on the trap net catch, the value, based on the results of recording the weight of the catch (Y) as the dependent variable and observations of tidal height (X) as the independent variable (Independent) of each moon phase can be seen through the equation simple linear regression. Based on the results of

**Comment [A30]:** Redundant. Please see the previous paragraph

simple linear regression analysis using the SPSS 25.0 application, the results are as follows.

Based on Table 5, the results of the analysis show that the effect of the moon phase (tidal height) on the catch has a close influence with the equation  $Y = 111.950 + 1.329x$  where the constant is 111.950, the regression coefficient (x) of 1.329 states that each addition 1% of sea level at high tide, then the value of the catch increases by 1,329. The regression coefficient is positive, so it can be said that the direction of the showing a positive influence of the tidal height variable on the catch is positive (very influential) volumes.

**Comment [A31]:** Already mentioned at the results section

The value (R) explains the magnitude of the correlation coefficient (relationship) (R) between tidal height and the catch obtained, namely  $R = 0.972$ , show a strong correlation. The value of R-Square (the coefficient of determination or  $R^2$ ), namely  $R^2 = 0.945$ , which explains how much the catch variable can be explained by the shows a strong explanatory power of the tidal height variable, related to the catch production, so that the value of  $R^2 = 0.945$  is obtained which. This means that 94.5% of the catch volumes are due to the tidal height affects the number of catches, while the remaining 5.5% is are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area net, or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which is included in denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which is also denotes included in a strong correlation.

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Based on this, it shows that the full moon phase has a high tide of 185 cm with and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm with and a catch of 97,060 kg, which this is related to the daily migration of fish more there are many during the moon phase where at that time the tides are high, so the fish that carry out daily migration/migration further entering the coastal waters and towards the rivers because the sea water is due to higher sea level (or deeper on the coastal waters).

Subiyanto et al., al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, and increased food abundance and decreased predation rates. The reporting a number of caught fish larvae caught was of 904 individuals, of which 472 individuals (52.21%) at high tide 472 individuals were caught and (52.21%) and 432 individuals at low tide 432 individuals were caught (47.79%). Abdul Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns that occurs specific to in each phase. The difference in catches during both at high and low tide is due to differences in changes of the currents direction of currents and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation. Where the tidal pattern is closely related to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength that occurs in of the Spring Tide is greater than the tidal strength that occurs in of the Neap Tide, therefore so that it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) said stated that the moon phase affected the migration of eels. Haraldstad, (1985), said affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, because each pair of the sea water flows flowing deep into the river, during high tides. This also causes the distribution dispersion and distribution of several types of marine fish such as titan and mullet found very far from the sea. Higher tides, such as occurings during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Likewise, the natural movement of several types of fish and non-fish, such as prawns and crabs, although spawning off the

coast and in the deep sea, still arrives at the beach where they are reared, reared, looking for food and protection more quickly because of the tidal currents that occur every day.

Abdul Manan (2011) explained that the difference in catches both at high and low tide was due to differences in the direction of currents and the strength of the tides that carried fish larvae in and out of the river mouth. This is due to the movement of Also, the weaker body of the fish larvae make them susceptible to be which is not so strong that it can be carried away by the current. In contrast to low tide. Conversely, at low tide, fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that So the tidal conditions affect the abundance of fish larvae in the waters. The strength strong of the current at high tide makes carry the fish larvae carried to the estuary area, where and they prefer to stay remain at low tide because due to the estuary area has an abundance of food sources for fish larvae and adult fish. According to as observed by Subiyanto, et al., al (2009). There is a difference in abundance at high and low tide because at high tide many fish larvae are carried to the estuary by tidal currents and avoid low tides by being on the side of the estuarine waters because in the estuarine area they find a place to live. suitable for growth. This is reinforced by Subiyanto et al., (2009), that the larvae are moved by the current where the current flows towards the mouth of the estuary during the flood tide, and the fish larvae that are distributed to the mouth of the estuarine are young larvae and young fish.

**Conclusions.** The trap net fishing area grounds in the waters of the Sigeri District, Pangkep Regency, is are available in several places and is are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on fish catches on the operation of the Trap net fishing gear, it is better in the full moon and dead moon phases by getting more catches because in this lunar phase high tides occur compared to other moon phases. Tidal height affects affected the amount of catch during the study, and only a small part is was influenced by several external factors during the study.

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**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [A32]:** Please reformulate clearly

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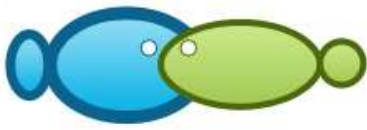
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# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

**Key Words:** mapping, arrest area, catch, net traps, moon phase.

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**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the shorelinecoastaline.

Manan (211), Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area.

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Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 meters from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan, 2018).

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The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Aulia-Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.



Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. In this study used descriptive qualitative data analysis for and quantitative. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

Ihsan (2015) said that in this study, the determination of the appropriate fishing area was carried out by analyzing bathymetric data, tidal data and tidal data other existing. To knowing of the bathymetry data will make it easier to determine in fishing area. Bathymetric analysis was obtained by tracking with Z patterns using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated, with the aim of producing a map of the depth class of the research location and, more specifically, of the location of the operating area for the trap net fishing gear. Tidal analysis uses the Admiralty method, for calculating two harmonic components, namely amplitude and phase delay. After obtaining the tidal components, the following can be calculated (Admiralty, 1921):

Average Water Level (Mean Sea Level)  
 $MSL = A(S_0)$

Lowest Low Water Level  
 $LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

Highest High Water Level  
 $HHWL = A(S_0) + (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

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Pair type (F) =  $A(K1) + A(O1) / A(M2) + A(S2)$

#### Bilangan Formzahl

Penentuan tipe pasang surut air laut dari perhitungan menggunakan metode Admiralty dengan melihat nilai bilangan Formzahl yang dihasilkan.

The type of tide can be determined by using the following formula:

$$F = \left( \frac{K_1 + O_1}{M_2 + S_2} \right)$$

Where:

F = Formzahl Number

M2 = Constant (influenced by moon position)

O1 = Constant (influenced by the declination of the moon)

S2 = Constant (influenced by the position of the sun)

K1 = Constant (influenced by the declination of the moon and sun)

▲ If the value of F > 3, then the tidal type is diurnal, if F < 0.25 the tidal type is semidiurnal, if the F value is between 0.25 – 1.25 then the tidal type is a mixture with a semidiurnal tendency and if the F value is between 1.25 - 3.0, then the tidal type is mixed, with diurnal tendencies (Triatmodjo 2009).

Where:

F = Formzahl number;

K<sub>1</sub> = Amplitude of the affected daily tidal wave cub by the declination of the sun and moon;

O<sub>1</sub> = Amplitude of the affected single daily tidal wave by the sun's declination;

M<sub>2</sub> = Amplitude of the average double daily tidal wave influenced by the moon;

S<sub>2</sub> = Amplitude of the average double daily tidal wave influenced by the sun.

▲ Or the According to Triatmodjo (1999) in (Asri et al 2014), there are 4 tidal types based on tidal constants:

0 < F < 0.25 = pure double daily tidal type

0.25 < F < 1.50 = mixed double inclined daily tidal type

1.50 < F < 3.0 = single mixed inclined daily tidal type

F > 3.0 = pure single daily Tidal Type

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the baseline factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum tidal heights, analyzed the mean sea level (MSL) and looked for the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a manner sustainable.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets.

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**Comment [A12]:** Please find a scientific explanation

Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water is one of the most important things in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in order is (Walpole, R. E. 1995):

$$Y = \alpha + \beta x$$

Where:

Y = catch volume

$\alpha$  = constant

$\beta$  = regression coefficient of independent variable

x = high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1  
The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements for 3 time treatments at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Comment [A13]:** Please avoid arguments like "the better the trap net installation" and avoid reusing / repeating whole parts of phrases ("The location of fishing is influenced by") like in the selected paragraph. Please reformulate the select paragraph and use a scientific argumentation

**Comment [sa14R13]:** This naration is base o trap net fishing area

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**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is done by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

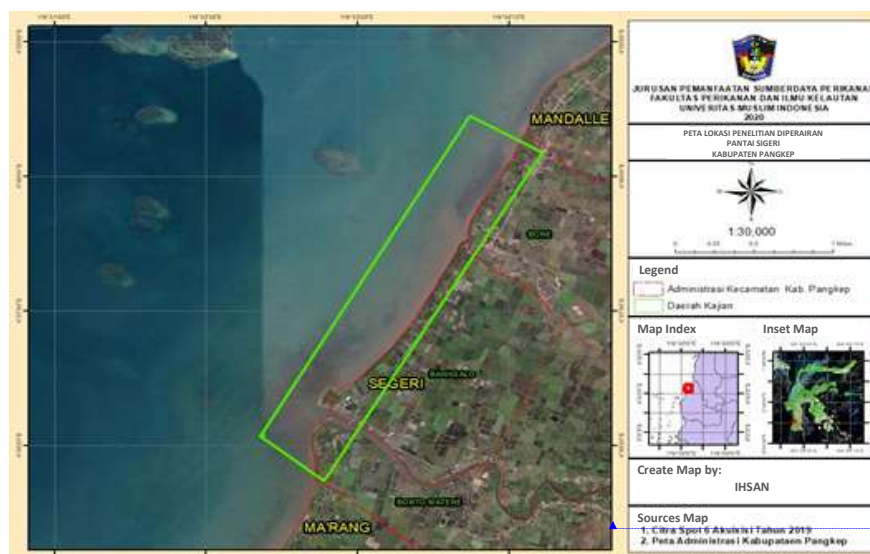


Figure 2. The mapping results (Ihsan, 2021).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

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Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch Production (Kg) Variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>         |            |                             |            |                           |                            |      |
|-----------------------------------|------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             |            | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   |            | B                           | Std. error | Beta                      |                            |      |
| 1                                 | (Constant) | -111.950                    | 35.005     |                           | -3.198                     | .085 |
|                                   | Tide high  | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch      |            |                             |            |                           |                            |      |
| Model summary                     |            |                             |            |                           |                            |      |
| Model                             |            | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 |            | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |            |                             |            |                           |                            |      |

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## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase)

was dominated by *Stolephorus* and *Ambassis*. Dwiponggo (1972) suggests that certain types of fish will move with the high tide current towards the coast.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide.

Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, along with the current, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point). Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus, 2004). According to Cheong & Yeng (1986) the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish.

**c. Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30–36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0–35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels. Silalahi et al (2017) state that the variation in salinity values is caused by the influence of water supply. Salinity decreases due to incoming fresh water and also due to the occurrence of tides in these waters.

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**Comment [WU23]:** Own research?

**Comment [sa24R23]:** Citation by (Barus, 2004)

**Comment [A25]:** The authors have the abundance and two independent variables (salinity and sea level), which is a multiple regression. Is it your result or is it a citation (authors?)? What formula did you use, if it is yours?

**Comment [sa26R25]:** Description by (Mulyono, 2011)

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**Comment [A28]:** Logically, if tides are current from the sea to the coast, they bring sea water, whose salinity is higher. Exactly the contrary is stated. Please explain the statement.

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

The one of requirements for location of operation trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. Aulia (2018) said that one of the requirements for the location of the operation of trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. For the distribution of fishing gear to be studied, the waters that have a depth ranging from 0 Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency. Risnawati et al., (2018) said that the bathymetric map of 4 sub-districts in Pangkep Regency which includes the Districts of Bungoro, Labakkang, Ma'rang, and Segeri. The map is also overlaid along with water bathymetry, showing various depth variations ranging from 0 to -50 cm. For the operation of trap net fishing gear at a depth of 0 meters (during low tide conditions). For a depth of 0 meters, it is generally spread along coastal waters, covering 4 coastal districts which are the research locations. Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

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**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of tidal height analysis, which was carried out using Admiralty Method for the 4 (four) phases of moon, obtained value of tidal height and sea level against of trap net catches in Table 1, for testing the relationship between the phases of moon, in this case related to with tides on trap net catches from results of tidal analysis, using the value of high tide (cm), as an independent variable (Independent), and the amount of production of trap net catches for the 4 phases of the moon being tested in this study, weight catch (Y) as dependent variable (Dependent).

To test the effect of the moon phase on the trap net catch, the value, based on the results of recording the weight of the catch (Y) as the dependent variable and observations of tidal height (X) as the independent variable (Independent) of each moon phase can be seen through the equation simple linear regression. Based on the results of simple linear regression analysis using the SPSS 25.0 application (statistic application), the results are as follows.

The results of analysis showon that the effect of moon phase (tidal height) on the catch has a close influence with the equation  $Y = -111.950 + 1.329x$  where the constant is -111.950, the regression coefficient (x) of 1.329 states that each addition 1% of sea

level at high tide, then the value of the catch increases by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

The value (R) explains the magnitude of the correlation (relationship) between tidal height and the catch obtained, namely  $R = 0.972$ . The value of R Square (coefficient of determination or  $R^2$  which explains how much the catch variable can be explained by the tidal height variable so that the  $R^2 = 0.945$  value is obtained, which means that 94.5% tidal height affects the number of catches, while the remaining 5.5% is influenced by several factors outside of the research, for example the ability and patience of fishermen to comb repeatedly until it is considered that no more fish have entered the trap net trap area, or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which indicates included in a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which is included in a strong correlation. The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (reported in Table 1), were used for testing the regression relationship:

The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R = 0.972$ , shows a strong correlation. The value of the coefficient of determination, namely  $R^2 = 0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Abdul Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Likewise, the natural movement of several types of fish and non-fish, such as prawns and crabs, although spawning off the

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coast and in the deep sea, still arrives at the beach where they are reared, reared, looking for food and protection more quickly because of the tidal currents that occur every day.

~~Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.~~

~~It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto, et al (2009).~~

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on fish catches on the operation of the Trap net fishing gear, it is better in the full moon and dead moon phases by getting more catches because in this lunar phase high tides occur compared to other moon phases. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

**Acknowledgements.** The authors would like to thank the Directorate of Research and Community Service, Directorate General of Research and Development of the Ministry of Education and Research and Technology who has funded this research through the leading university applied research (PTUPT) scheme. We also thank fellow researchers for their significant contributions to this journal.

**Conflict of interest.** The authors declare no conflict of interest.

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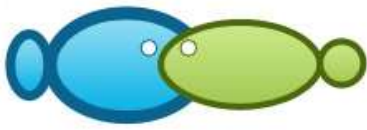
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diajukan kembali ke Jurnal Bioflux**



# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high

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economical value. Therefore, this study determines the map of the trap net fishing area and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi from March to May 2021 (Figure 1)

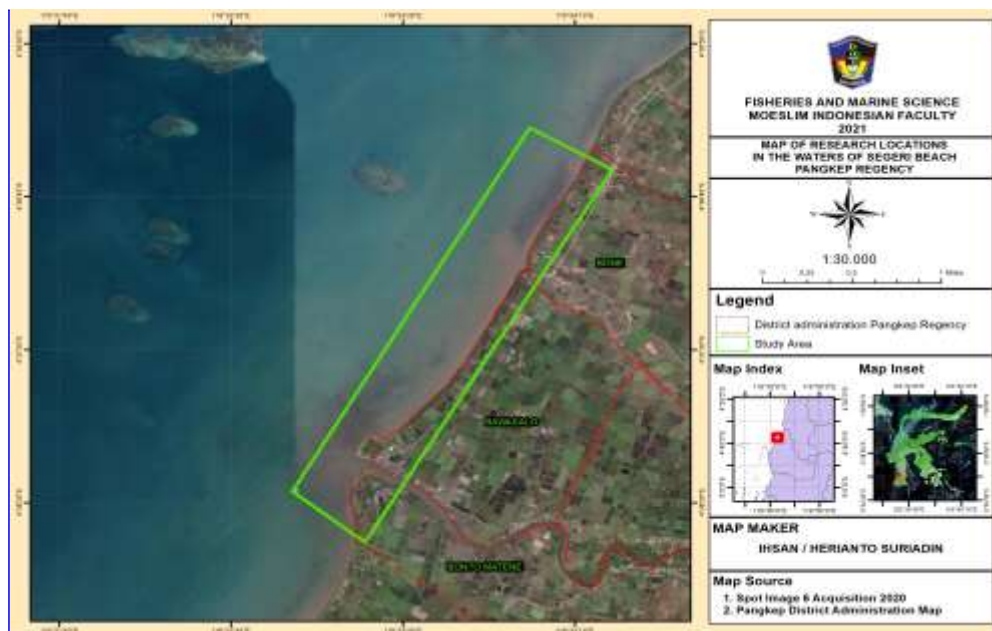


Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because knowing bathymetry and tidal data would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated (Ihsan, 2015).

Sea Level Mean Elevation MSL = A(S0)

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When was the research conducted?

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#### Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

#### Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

#### Formzahl Numbers

Determination of the type of tidal sea water from calculations using the method Admiralty by looking at the resulting Formzahl number value.

The type of tide can be determined by using the following formula:

$$F = \left( \frac{K_1 + O_1}{M_2 + S_2} \right)$$

Where: rumus tidak boleh cetak tebal pak

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

If the value of  $F > 3$ , then the tidal type is a pure single daily tide, if  $F < 0.25$  then the tidal type is a pure double daily tide, if the F value is between 0.25-1.50 then the tidal type is a daily tide. mixed double sloping and if the F value is between 1.50-3.0, then the daily tidal type is single mixed sloping (Triatmodjo 2009). According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The Maximum and minimum high and low tides, analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

**Comment [A5]:** signification of the variable symbols, please.

**Comment [WU6]:** Please unbold the formula.

**Comment [WU7]:** This information is not in line with the below information:

$0 < F < 0.25$  = pure double daily tidal type  
 $0.25 < F < 1.50$  = mixed double inclined daily tidal type  
 $1.50 < F < 3.0$  = single mixed inclined daily tidal type  
 $F > 3.0$  = pure single daily Tidal Type

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The semantics of this phrase is not correct! Please reformulate

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1

The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2

Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18-0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31-0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45-0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18-0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73-0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the operation of the trap net is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

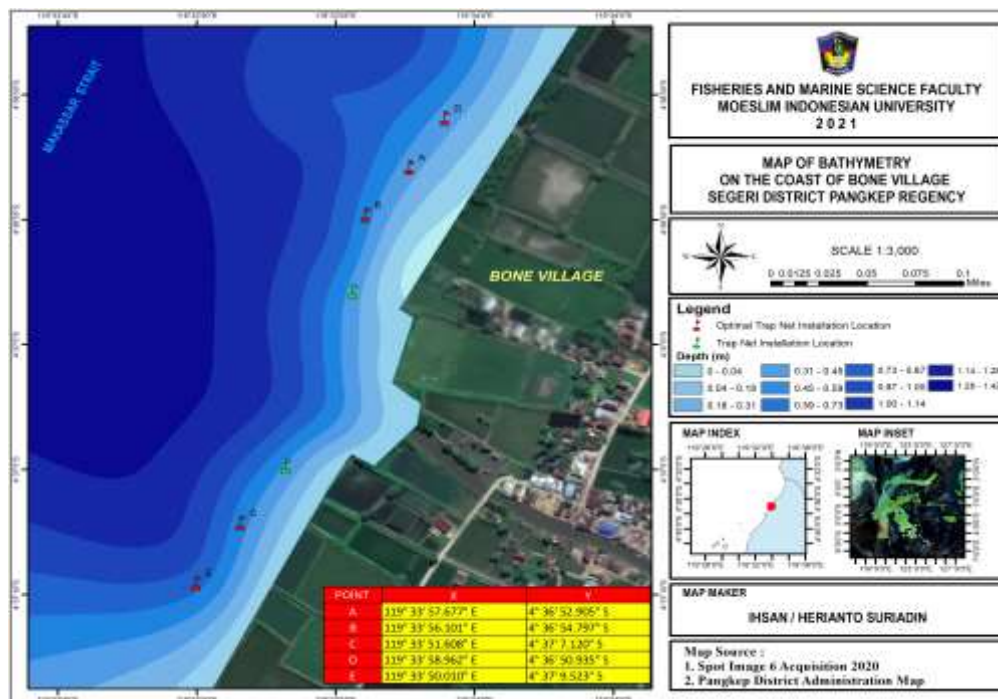


Figure 2. The mapping results (Ihsan, 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4 Total production of catch (kg) trap net by moon phase

| Type of moon phase | Catch production (Kg) variable Y |
|--------------------|----------------------------------|
| Dead moon phase    | 97,060                           |

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And make the text readable.

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|                                  |         |
|----------------------------------|---------|
| Phases of the early quarter moon | 47,925  |
| Full moon phases                 | 142,835 |
| Phases of the final quarter moon | 76,401  |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5 The results of simple regression analysis of the effect of the moon phase on the catch **jangan banyak garis/kolom**

| Coefficients <sup>a</sup>         |            |                             |            |                           |                            |      |
|-----------------------------------|------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             |            | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   |            | B                           | Std. error | Beta                      |                            |      |
| 1                                 | (Constant) | -111.950                    | 35.005     |                           | -3.198                     | .085 |
|                                   | Tide high  | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch      |            |                             |            |                           |                            |      |
| Model summary                     |            |                             |            |                           |                            |      |
| Model                             |            | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 |            | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |            |                             |            |                           |                            |      |

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Please respect the AACL tables formatting

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in

the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, along with the current, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**c. Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30–36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0–35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31 - 0.73 m, especially

when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

The one of requirements for location of operation trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. For the operation of trap net fishing gear at a depth of 0 m (during low tide conditions). For a depth of 0 meters, it is generally spread along coastal waters, covering 4 coastal districts which are the research locations. Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

**Comment [WU13]:** Please reformulate using scientific English language.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

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Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [WU15]:** The references still do not respect the AACL Bioflux Journal's formatting requirements. We have made adjustments, but more information is needed. See the comments below.

**Comment [WU16]:** The source/link of this reference is needed, as the formatting is incorrect

**Comment [WU17]:** The source/link of this reference is needed, as the formatting is incorrect

**Comment [WU18]:** MSc thesis? PhD thesis?

**Comment [WU19]:** No of pages

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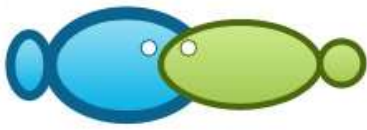
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# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high

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economical value. Therefore, this study determines the map of the trap net fishing area and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi from March to May 2021 (Figure 1)

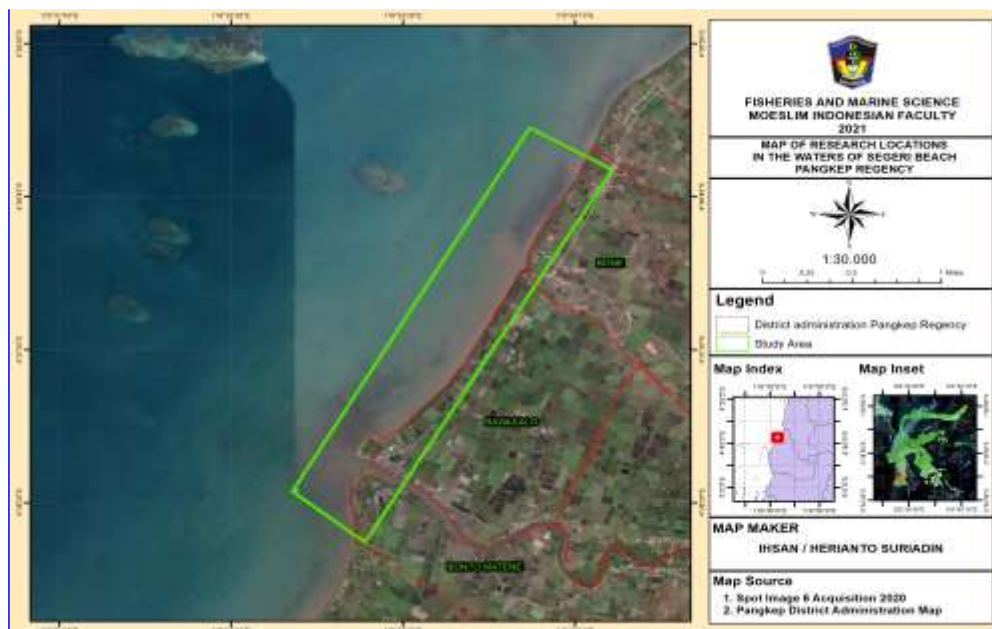


Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because knowing bathymetry and tidal data would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated (Ihsan, 2015).

**Comment [WU2]:** As requested before:

When was the research conducted?

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Administrasi.....etc

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Sea Level Mean Elevation MSL = A(S0)

Lowest Low Water Level

LLWL = A(S0) - (M2 + S2 + K1 + O1 + P1 + K2)

Highest High Water Level

HHWL = A(S0) + (M2 + S2 + K1 + O1 + P1 + K2)

Pair type (F) = A(K1) + A(O1) / A(M2) + A(S2)

Formzahl Numbers

Determination of the type of tidal sea water from calculations using the method

Admiralty by looking at the resulting Formzahl number value.

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

If the value of  $F > 3$ , then the tidal type is a pure single daily tide, if  $F < 0.25$  then the tidal type is a pure double daily tide, if the F value is between 0.25-1.50 then the tidal type is a daily tide. mixed double sloping and if the F value is between 1.50-3.0, then the daily tidal type is single mixed sloping (Triatmodjo 2009). According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The Maximum and minimum high and low tides, analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net.

**Comment [A5]:** signification of the variable symbols, please.

**Comment [WU6]:** This information is not in line with the below information:

$0 < F < 0.25$  = pure double daily tidal type  
 $0.25 < F < 1.50$  = mixed double inclined daily tidal type  
 $1.50 < F < 3.0$  = single mixed inclined daily tidal type  
 $F > 3.0$  = pure single daily Tidal Type

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The semantics of this phrase is not correct! Please reformulate

Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1 The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2 Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3 The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18-0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31-0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45-0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18-0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73-0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the operation of the trap net is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

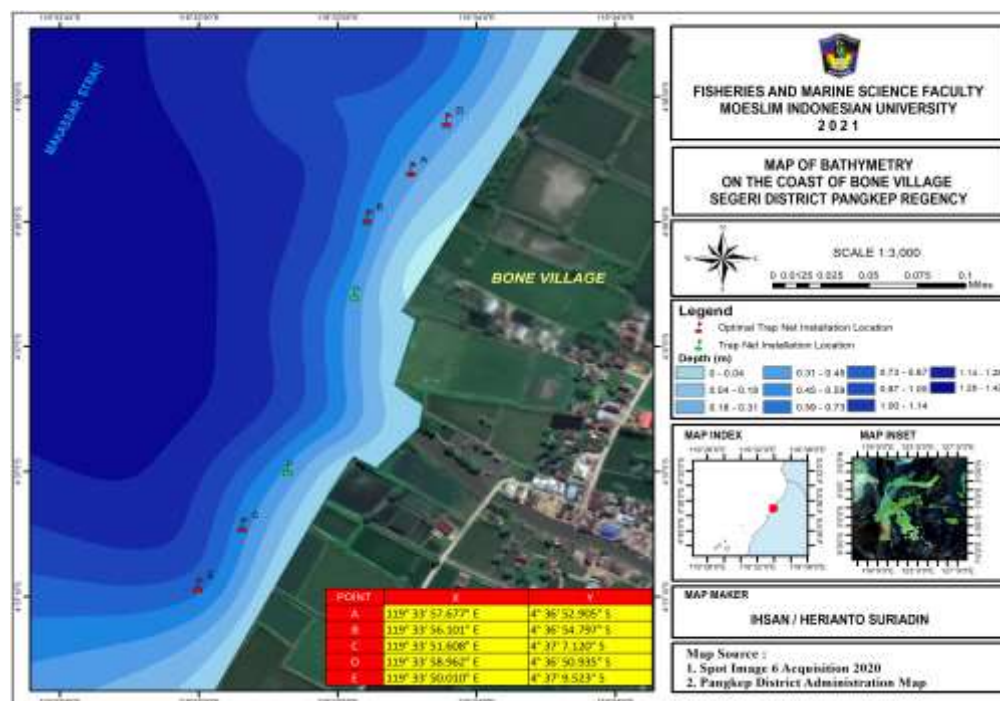


Figure 2. The mapping results (Ihsan, 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

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Locationis done by fishermen? Please reformulate the phrase

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Please use English in the legend  
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Table 4 Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (Kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5 The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>         |                             |            |                           |                            |      |
|-----------------------------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   | B                           | Std. error | Beta                      |                            |      |
| 1 (Constant)                      | -111.950                    | 35.005     |                           | -3.198                     | .085 |
| Tide high                         | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch      |                             |            |                           |                            |      |
| Model summary                     |                             |            |                           |                            |      |
| Model                             | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |                             |            |                           |                            |      |

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Please respect the AACL tables formatting

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the

moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, along with the current, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**c. Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30-32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the

waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

The one of requirements for location of operation trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. For the operation of trap net fishing gear at a depth of 0 m (during low tide conditions). For a depth of 0 meters, it is generally spread along coastal waters, covering 4 coastal districts which are the research locations. Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

**Comment [WU12]:** Please reformulate using scientific English language.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of

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the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [WU14]:** The references still do not respect the AACL Bioflux Journal's formatting requirements. We have made adjustments, but more information is needed. See the comments below.

**Comment [WU15]:** The source/link of this reference is needed, as the formatting is incorrect.

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Comment [WU19]: pages

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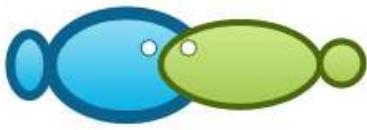
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diajukan kembali ke Jurnal Bioflux**



## Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.

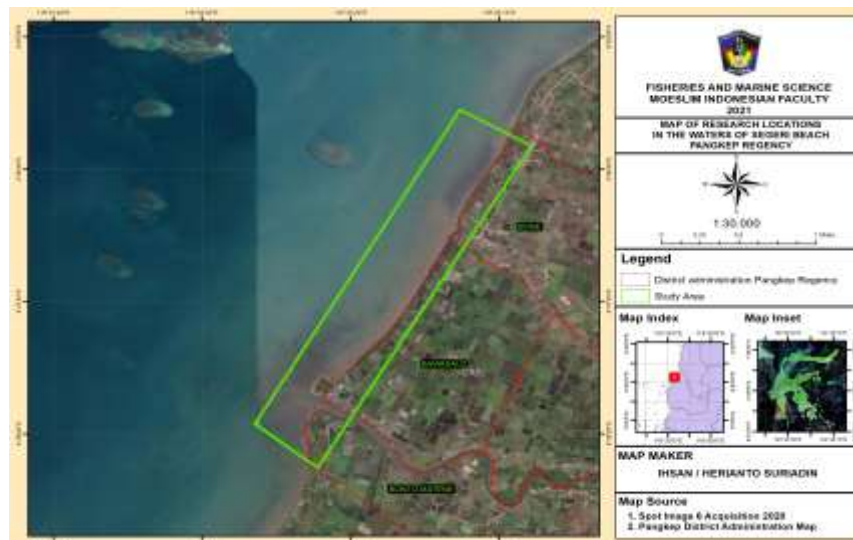


Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(So)$$

Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - Amplitude of the tidal harmonic component

So - Average sea level

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

P1 - Constants affected by the sun's declination

K2 - Constants that are affected by changes in distance, due to the elliptical path of the sun

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the

more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1. The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2. Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3. The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

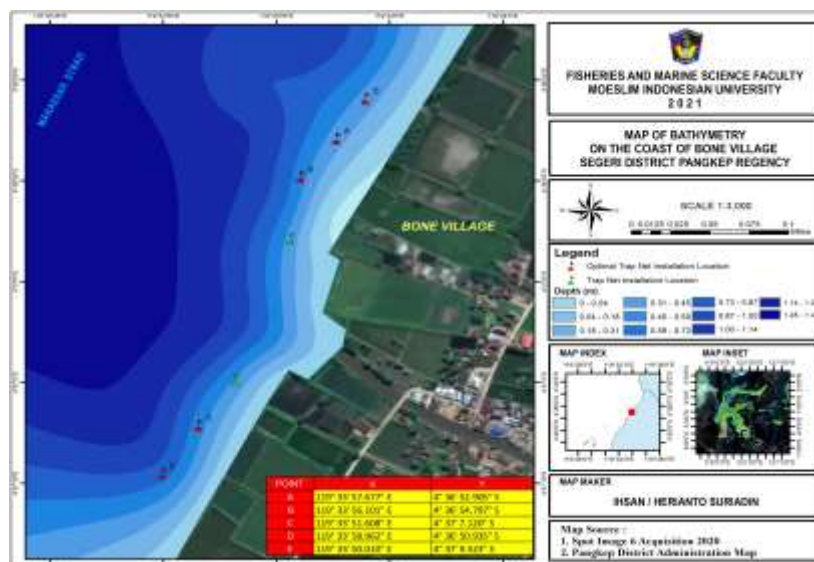


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4 Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (Kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and

a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5 The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>    |                             |            |                           |                            |      |
|------------------------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                        | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                              | B                           | Std. error | Beta                      |                            |      |
| (Constant)                   | -111.950                    | 35.005     |                           | -3.198                     | .085 |
| Tide high                    | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch |                             |            |                           |                            |      |
| Model summary                |                             |            |                           |                            |      |
| Model                        | R                           | R square   | Adjusted R square         | Std. error of the estimate |      |
| 1                            | .972 <sup>a</sup>           | .945       | .918                      | 11.44936                   |      |

<sup>a</sup> - Predictors: (Konstant), High tide

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the

bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30–36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0–35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31–0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

Based on the observations during the research, it is known that one of the requirements in the operation of the trap net fishing gear must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

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Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. The operation of trap nets at low tide (0 meters) is generally spread along coastal waters in 4 districts. Based on the bathymetry map and the distribution of water depths as well as external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

**Comment [WU2]:** As requested before:

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Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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**Conflict of interest.** The authors declare no conflict of interest.

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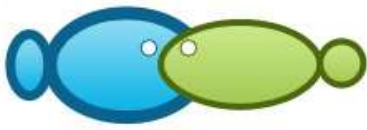
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diajukan kembali ke Jurnal Bioflux**



# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

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**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.

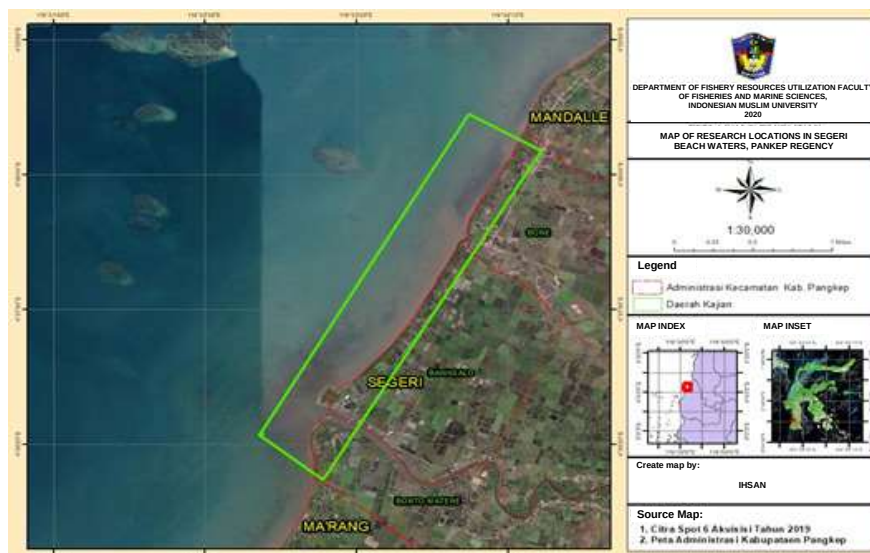


Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. In this study used descriptive qualitative data analysis for and quantitative. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

Ihsan (2015) said that in this study, the determination of the appropriate fishing area was carried out by analyzing bathymetric data, tidal data and tidal data other existing. To knowing of the bathymetry data will make it easier to determine in fishing area. Bathymetric analysis was obtained by tracking with Z patterns using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated, with the aim of producing a map of the depth class of the research location and, more specifically, of the location of the operating area for the trap net fishing gear. Tidal analysis uses the Admiralty method, for calculating two harmonic components, namely amplitude and phase delay. After obtaining the tidal components, the following can be calculated (...):

Average Water Level (Mean Sea Level)

$$MSL = A(S_0)$$

Lowest Low Water Level

$$LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$$

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When was the research conducted?

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Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Bilangan Formzahl

Penentuan tipe pasang surut air laut dari perhitungan menggunakan metode Admiralty dengan melihat nilai bilangan Formzahl yang dihasilkan.

Where:

...

The type of tide can be determined by using the following formula:

$$F = \frac{(K_1 + O_1)}{(M_2 + S_2)}$$

Where:

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

If the value of  $F > 3$ , then the tidal type is diurnal, if  $F < 0.25$  the tidal type is semidiurnal, if the  $F$  value is between 0.25-1.25 then the tidal type is a mixture with a semidiurnal tendency and if the  $F$  value is between 1.25-3.0, then the tidal type is mixed, with diurnal tendencies (Triatmodjo 2009).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum tidal heights, analyzed the mean sea level (MSL) and looked for the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net.

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$0 < F < 0.25$  = pure double daily tidal type  
 $0.25 < F < 1.50$  = mixed double inclined daily tidal type  
 $1.50 < F < 3.0$  = single mixed inclined daily tidal type  
 $F > 3.0$  = pure single daily Tidal Type

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Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1

The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2

Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is done by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

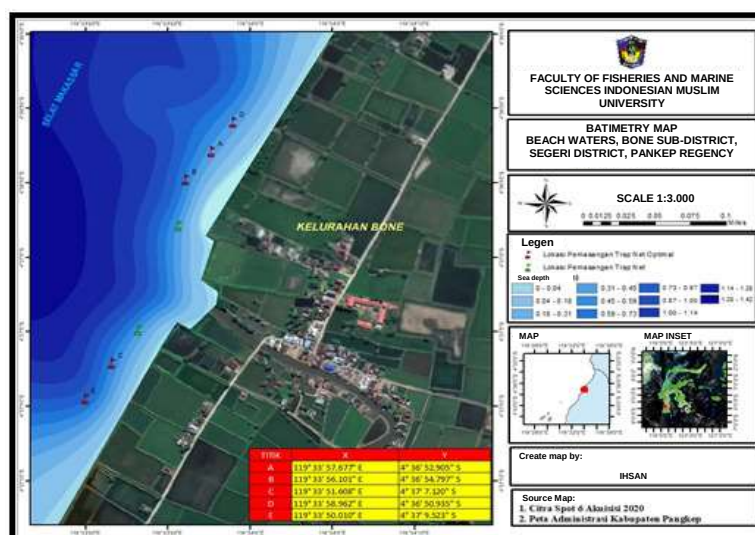


Figure 2. The mapping results (Ihsan, 2021).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (Kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

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Location is done by fishermen? Please reformulate the phrase

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The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>         |                             |            |                           |                            |      |
|-----------------------------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   | B                           | Std. error | Beta                      |                            |      |
| 1                                 | (Constant)                  | -111.950   | 35.005                    | -3.198                     | .085 |
|                                   | Tide high                   | 1.329      | .226                      | .972                       | .028 |
| a. Dependent Variable: Catch      |                             |            |                           |                            |      |
| Model summary                     |                             |            |                           |                            |      |
| Model                             | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |                             |            |                           |                            |      |

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## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, along with the current, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**c. Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

The one of requirements for location of operation trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or

**Comment [WU20]:** Please reformulate using scientific English language.

installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. For the operation of trap net fishing gear at a depth of 0 m (during low tide conditions). For a depth of 0 meters, it is generally spread along coastal waters, covering 4 coastal districts which are the research locations. Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

**Comment [WU21]:** Please reformulate, these phrases are not intelligible

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns

and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

**Acknowledgements.** The authors would like to thank the Directorate of Research and Community Service, Directorate General of Research and Development of the Ministry of Education and Research and Technology who has funded this research through the leading university applied research (PTUPT) scheme. We also thank fellow researchers for their significant contributions to this journal.

**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [WU22]:** The references still do not respect the AACL Bioflux Journal's formatting requirements. We have made adjustments, but more information is needed. See the comments below.

**Comment [WU23]:** pages

**Comment [WU24]:** The source/link of this reference is needed, as the formatting is incorrect

**Comment [WU25]:** The source/link of this reference is needed, as the formatting is incorrect

**Comment [WU26]:** pages

**Comment [WU27]:** MSc thesis? PhD thesis?

**Comment [WU28]:** No of pages

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**Comment [WU31]:** page range

- Maro River at different moon phases of transitional seasons I. *Journal of Fisheries Agribusiness* 12(1):162-173.
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Comment [WU33]: volume, issue, pages

Comment [WU34]: page range

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Comment [WU36]: pages

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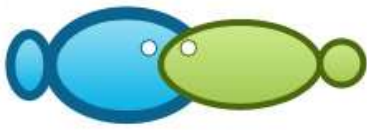
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diajukan kembali ke Jurnal Bioflux**



# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing area grounds in the waters of the Sigeri District, Pangkep Regency, was were available in several places and were as ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during on the operation of trap net fishing gear, it is better especially in the full moon and dead moon phases to get more catches because in this lunar phase, due to the high tides occur compared to other moon phases. Tidal height affects affected most of the amount of catch, and only a small part is was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increases increased by 1,329. The regression coefficient is positive, so it can be said that the direction of the influence of the tidal height variable on the catch is positive (very influential).

**Key Words:** mapping, arrest area, catch, net traps, moon phase.

Comment [A1]: Please reformulate

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process is that consist of trapping fish are trapped during high tides every day and which are operated parallel to the shoreline.

Tides are the a phenomenon of the movement of rising and falling sea levels fluctuations, caused by a combination of gravity and the attractive force of between astronomical objects, especially by the sun, earth, and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high or low tides and low tides, and high or low tides which will affect the movement of fish migrating migrations closer to the shore for the purpose of while foraging, spawning and rearing various types of fish. Furthermore, high and low tides will affect the trap net fishing area.

Comment [A2]: Please clarify

Tides are nothing but ocean currents, where the tides move moving towards the coast, and the tides move back, away from the land. The These two things are closely related to each other because the determination of bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 meters from the shoreline. Because the shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan, 2018).

Comment [WU3]: Citation?

The catch of fishermen using erratic trap net fishing gear is sometimes abundant and sometimes very lacking extremely fluctuating. Factors that influence the problem are the lack of depending on the information on the suitability of the fishing grounds and on the right timing, lack of information about the right time to catch. According to Aulia

(2018), the composition of trap net catches in the Sigeri area is of 27 species ~~with the production of trap net catches for captured during an average of 13 fishing trips, both operated both in the afternoon and at night, but has not explained The catch its relation to the moon phase has not yet been explained, so that it can in order to optimize streamline fishermen's working time. The present~~ With this problem in mind, I will conduct a study entitled the aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, with the aim of in order to providing-provide information to the fishermen on fishing grounds, suitable fishing times, and dominant catches that have high economical value. high economical. ~~Therefore, this study aims to determines the map of the trap net fishing area and determine the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.~~

**Material and Method.** This research was conducted in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.



Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used ~~in this study~~ was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; ~~(4) data on the existing condition of coastal waters,~~ oceanographic data on coastal waters. ~~Participate~~ The authors participated in fishing operations to conduct direct observations in the field and ~~conduct~~ interviews using a questionnaire related to the operation of trap net fishing gear. In this study used descriptive qualitative data analysis for and quantitative. For mapping ~~using~~ the GIS method was used with criteria, ~~the The Admiralty~~ admiral method was used for measuring tides, ~~and The~~ regression analysis was used to determine the relationship between the number of catch volumes (kg) ~~of each moon phase related to and the tides, during each moon phase,~~ in the waters of Sigeri District, Pangkep Regency.

Ihsan (2015) said that in this study, the determination of the appropriate fishing area was carried out by analyzing bathymetric data, tidal data and tidal data other existing. Bathymetric analysis was obtained ~~after by~~ tracking with S and Z patterns using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated, with the aim of producing a map of the depth class of the research location and, more specifically, ~~a map~~ of the location of the operating area for the trap net fishing gear. Tidal analysis uses the Admiralty ~~m~~Method, ~~for which is a tidal analysis method used to calculate calculating~~ two harmonic component constants, namely amplitude and phase delay. After obtaining the

**Comment [WU4]:** When was the research conducted?

**Comment [WU5]:** The legend should be in English.  
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**Comment [A6]:** reformulate

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**Comment [A8]:** ?

tidal components, ~~namely the amplitude and the price of the phase delay, then it is the following can be~~ calculated (L...):

**Comment [WU9]:** Sources of the formulas.

Average Water Level (Mean Sea Level)  
 $MSL = A(S_0)$

Lowest Low Water Level  
 $LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

Highest High Water Level  
 $HHWL = A(S_0) + (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$

Pair type (F) =  $A(K_1) + A(O_1) / A(M_2) + A(S_2)$

**Comment [A10]:** signification of the variable symbols, please.

The type of tide can be determined by using the following formula:

$$F = \left( \frac{K_1 + O_1}{M_2 + S_2} \right)$$

Where:

F - Formzahl number;

$K_1$  - Amplitude of the affected daily tidal wave cub by the declination of the sun and moon;

$O_1$  - Amplitude of the affected single daily tidal wave by the sun's declination;

$M_2$  - Amplitude of the average double daily tidal wave influenced by the moon;

$S_2$  - Amplitude of the average double daily tidal wave influenced by the sun.

**Comment [A11]:** Signification?

According to Triatmodjo (1999) in (Asri et al., al 2014), there are 4 ~~classifications of~~ tidal types based on ~~tidal constants~~:

$0 < F < 0.25$  = ~~Pure-pure Double-double~~ daily tidal type

$0.25 < F < 1.50$  = ~~Mixed-mixed Tidal Type Double-double Inclined-inclined Dailydaily tidal type~~

$1.50 < F < 3.0$  = ~~Single-single Daily-mixed inclined daily Inclined-Mixed-Tidal Typetype~~

$F > 3.0$  = ~~Pure-pure Single-single Daily-daily~~ Tidal Type

**Comment [A12]:** Please clarify

~~For mapping the~~ The fishing area (for trap net fishing gear) ~~mapping, it~~ is also analyzed ~~using with~~ a geographic information system (GIS), ~~using~~ the overlay method ~~using of the~~ ArcGIS 10.3 software, where the processed bathymetric data that has been interpolated is then ~~unionized-correlated~~ with the mean sea level (MSL) data ~~on from the~~ tidal measurements and then ~~given point~~ manually ~~assigned at~~ a suitable location for the placement of the trap net fishing gear. Ihsan (2018) ~~said-stated~~ that the factors that affect the trap net fishing area ~~use are~~ the following ~~criteria~~:

a. Tides: ~~The location of fishing is influenced by tides,~~ it is ~~suspected-assumed~~ that the lower the tide, the easier ~~it is to operate~~ the trap net ~~operating~~. The maximum and minimum tidal heights, analyzed the mean sea level (MSL) and looked for the types of tides found at the trap net operating location.

**Comment [A13]:** The semantics of this phrase not correct! Please reformulate

b. Mangrove vegetation: ~~The fishing location is influenced by the distance from the mangrove vegetation,~~ it is ~~suspected-assumed~~ that the closer ~~and better~~ the mangrove vegetation ~~is~~, the better the trap net installation.

**Comment [A14]:** Please find a scientific explanation

c. Salinity: ~~The location of fishing is influenced by the salinity of the waters, because due to~~ the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water is one of the most important things in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate, ~~and~~ water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship Independent between these independent factors that can affect and the catch volumes (dependent variable) of the ~~Trap-trap~~ net fishing gear in order ~~to see a straight line relationship, a simple linear regression formula is used (.)~~:

$$Y = \alpha + \beta x$$

Where:

Y = ~~Catch-catch volume~~(dependent)

~~-a~~ = constant

~~-β~~ = ~~Regression-regression~~ coefficient of independent variable

x = ~~High-high~~ tide ~~water level~~ (full moon phase, early moon phase, moon phase dark and moon phase end

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, ~~obtained the values for tidal height and sea level, as, are~~ presented in Table 1.

Table 1  
The results ~~of the analysis~~ of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements for 3 treatments at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish. ~~the data are presented in Table 2.~~

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the ~~operation of~~ trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

**Comment [A15]:** Please avoid arguments like "the better the trap net installation" and avoid reusing / repeating whole parts of phrases ("The location of fishing is influenced by") like in the selected paragraph. Please reformulate the select paragraph and use a scientific argumentation

**Comment [WU16]:** Citation needed

**Comment [A17]:** Which tratments? Please cla

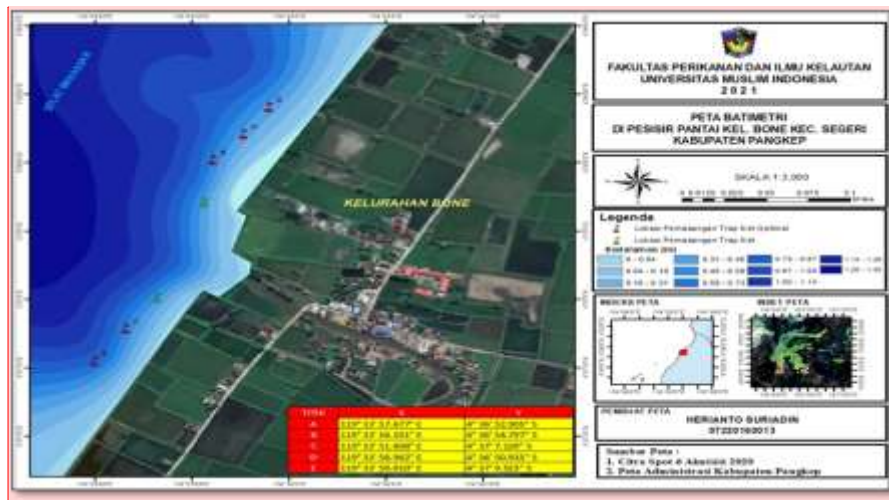
Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach ~~of the waters~~

| Trap net capture location | Coordinate points <del>for the</del><br>location of trap net fishing gear | Depth (m) |
|---------------------------|---------------------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                                     | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                                     | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                                      | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                                     | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                                      | 0.73–0.87 |

Based on bathymetric measurements at the research site, ~~the following criteria were used~~ to determine the location for trap net catching ~~with the following criteria~~: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) ~~dense-the~~ mangrove vegetation ~~must be dense~~ and 4) ~~the~~ existing trap net operation location is done by fishermen. For shallow waters, ~~it-the choice~~ must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

**Comment [A18]:** Location is done by fishermen. Please reformulate the phrase



**Comment [WU19]:** Please use English in the description, legend etc

Figure 2. The mapping results (Ihsan, 2021).

**Comment [A20]:** Not in the reference list.

**Relationship between production of trap net catch and moon phase.** The relationship between the ~~trap net number of catch~~ production ~~volumes catches~~ (kg) ~~trap net based on and~~ the moon phase, shows that ~~the highest production value was obtained in-for~~ the high tide phase ~~the highest production value was obtained during the study~~, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch Production (Kg) Variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch ~~has a close effect with~~ can be approximated by the equation  $Y = -111.950 + 1.329x$ , where with the a constant is of -111.950, and a the regression coefficient (x) of 1.329, meaning states that for every sea level marginal increase of 1% addition of sea level at the high tide, the value of the catch increases by 1.329, more complete is as presented in Table 5.

Table 5  
The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>         |            |                             |            |                           |                            |      |
|-----------------------------------|------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                             |            | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                                   |            | B                           | Std. error | Beta                      |                            |      |
| 1                                 | (Constant) | -111.950                    | 35.005     |                           | -3.198                     | .085 |
|                                   | Tide high  | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch      |            |                             |            |                           |                            |      |
| Model summary                     |            |                             |            |                           |                            |      |
| Model                             |            | R                           | R Square   | Adjusted R square         | Std. error of the estimate |      |
| 1                                 |            | .972a                       | .945       | .918                      | 11.44936                   |      |
| Predictors: (Constant), High tide |            |                             |            |                           |                            |      |

Comment [WU21]: Please respect the AACL tables formatting

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**a. Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest low tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon and occurrence occurring every day on a daily basis at sea, and affecting the fish movement of migrations fish. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) said-stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which was included in shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows is included in a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several types-species caught of by trap net catches are caught because they are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan, (2011) that the which mentions catches caught were the presence of 8 genera, namely: Stolephorus, Ambassis, Periophthalmus, Gerres, Leiognathus, Terapon, Atherinomorus and Chanos, in the analyzed catches. Fish-The frequency of fish larvae caught at high and low tide, based on the moon phase, (both new moon phase, early moon phase, full moon phase and late moon phase) were-was dominated by stolephorus and ambassis. Dwiponggo (1972) suggests that certain types of fish will move with the high tide current at high tide to move towards the coast in line with the current at high tide.

In this regard, the currents and tides greatly affect the migration of eels, both from larvae to and adults. Larvae are carried by currents to the coast, became-becoming glass eels and elvers, then they migrated to the mouth of the river and so on-upstream, being affected by changes in the water flow and tides. Changes in the river's water level

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~~in river waters~~ are determined by the high and low tides in the estuary, as well as by the high and low rainfalls ~~that falls occurring~~ in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims ~~on-at~~ the surface of the water, ~~at during the~~ high tide, and hides at the bottom, ~~at during the~~ low tide.

Dwiponggo (1972) suggests that certain types of fish will move with the current at high tide towards the coast, ~~in-line along~~ with the current, at high tide.

~~In this connection, the currents and tides greatly affect the migration of eels from larvae to adults. Larvae carried by currents to the coast became glass eels and elvers, then migrated to the mouth of the river and so on upstream affected by changes in water flow and tides. Changes in water level in river waters are determined by the high and low tides in the estuary, as well as by the high and low rainfall that falls in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims on the surface of the water at high tide and hides at the bottom at low tide.~~

Maturbongs et al., al (2019) ~~said found~~ that ~~as many as among the~~ 98 fish caught, ~~which were divided into of which~~ 45 fish specimens were captured in the dark moon phase and 53 fish specimens were captured in the bright moon phase, ~~there were identified~~ 14 fish species from 14 genera ~~were collected~~. 2. Species-The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity ~~in during~~ the dark moon phase is in the uneven category, ~~while in during~~ the bright moon phase it is in the less uniform category.

Comment [A22]: This is exactly the previous paragraph, repeated.

**b. Temperature.** Based on Table 2, that the temperature of the waters along the coast ~~reach obtained~~ values ranging from 31- ~~to~~ 34°C ~~by (measurements wereing 3 repeateditions 3 times for of~~ each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning. ~~one type of catch is white snapper (Lates calcarifer). According to (Cheong & Yeng. 1986), that the optimal temperature for white snapper spawning generally ranges from 27-33°C.~~

The temperature of ~~a-~~waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28-30 °C (Barus, 2004). ~~While According to Cheong & Yeng (1986) the optimal temperature for the spawning of the white snapper (Lates calcarifer) generally ranges from 27 to 33°C.~~ Latuconsina et al., al (2012) ~~found~~ that the optimal temperature range for fish life in tropical waters is between 28- ~~and~~ 32°C. ~~Where the-The~~ water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish. (11)

Comment [WU23]: Own research?

**c. Salinity.** Based on Table 2, the value of ~~the~~ salinity (salt content) of waters along ~~the~~ coast ~~at waters~~ is obtained in the range of 30-36 ppt ~~by measuring (-3 measurement repetitions at each observation point)~~. This value indicates that the salinity level in these waters is low because it is near the estuary, ~~(estuary)~~ where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities, ~~or levels of salt, one of which is caught in the trap net, namely mullet. According to Aulia., (2018), adult and young mullets (length from 4-7 cm) have a fairly wide tolerance for salt content (0-35 ppt).~~

Fish ~~(from larval size to adult size) that have origins of life originating from the in~~ brackish waters also have a strong immune level because they can survive with different levels of salinity, ~~ranging from larval size to adult size, one of which is white snapper. For instance, according to Aulia (2018), adult and young mullets (4-7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt).~~ According to Mulyono (2011), white snapper spawning ~~is occurs~~ in areas with a salinity ranging from 30- ~~to~~ 32 ppt, ~~the-The released~~ eggs ~~that have been released~~ will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, ~~in later stages, with increasing size the larvae they migrate to the water, to~~ brackish ~~waters with a salinity of 30-32 ppt, where they will~~

live until their adulthood will live in waters with a salinity of 30-32 ppt. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at high-low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels. According to Silalahi et al., al (2017) which states that the variation in salinity values is caused by the influence of water supply. Salinity decreases due to incoming fresh water and also due to the occurrence of tides in these waters.

**Comment [A24]:** The authors have the abundance and two independent variables (salinity and sea level), which is a multiple regression. Is it your result or is it a citation (authors?)? What formula did you use, if it is yours?

**Comment [A25]:** Not a satisfactory interpretation. Please develop the scientific argumentation

**Comment [A26]:** Logically, if tides are current from the sea to the coast, they bring sea water, whose salinity is higher. Exactly the contrary is stated. Please explain the statement.

**Trap net fishing area.** The mapping Based-based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements in (Table 3), in-performed coastal waters using a roller meter and echosounder, mapping in the coastal waters of the Segeri District, Pangkep Regency, it shows that the depth of the coastal waters is very shallow and sloping with over a distance of 100 m to the sea from the shoreline. Based on bathymetric mapping, it can be seen that the depth on the coast. The depth of the waters varies from a depth of 0.4 to 1.19 m with the bottom shape of or sloping coastal waters, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The results of the measurement of the depth of the location points for the operation of the trap net fishing gear which so far have been at an had an average depth of 0.31 - 0.73 m, especially when the sea water conditions are at high tide, the maximum height is being at 50 m from the shoreline.

Aulia et al., (2018) said that one of the requirements for the location of the operation of trap net fishing gear according to observations during the study was to be in a shallow area, to facilitate fishing. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest low-tide it is easier to capture fish caught in the trap net area when the sea water recedes to the lowest tide.

**Comment [A27]:** Unique author in the reference list.

Risnawati et al., al (2018) said elaborated that the bathymetry map of 4 sub-districts in Pangkep Regency: which includes the Districts of Bungoro, Labakkang, Ma'rang, and Segeri. The map is also overlaid along with water bathymetry, showing various depth variations ranging from 0 to -50 meters. For the distribution of fishing gear to be studied, the waters that have a depth ranging from 0 Based on the bathymetry map, and the distribution of water depths, as well as external factors around coastal waters as a requirement in determining the location of the operation of trap net fishing gear in the waters of Sigeri District, Pangkep Regency.

**Comment [A28]:** Please reformulate, these phrases are not intelligible

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), which are related to tides, and the trap net catches in this study, it was based on, the weight of the catch and the height of the tides obtained. obtained from the results of were measurements measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty Method-method for the 4 (four) phases of the moon, obtained the value of tidal height and sea level against the trap net catches (reported in Table 1), were used for testing the regression relationship between the phases of the moon, in this case related to with tides on trap net catches from the results of tidal analysis, using the Admiralty Method, the value of high tide (cm), as an independent variable (Independent), and the amount of production of trap net catches for the 4 phases of the moon which is the test in this study In this case, the weight of the catch (Y) is the dependent variable.

**Comment [A29]:** This phrase is not intelligible

To test the effect of the moon phase on the trap net catch, the value, based on the results of recording the weight of the catch (Y) as the dependent variable and observations of tidal height (X) as the independent variable (Independent) of each moon phase can be seen through the equation simple linear regression. Based on the results of

**Comment [A30]:** Redundant. Please see the previous paragraph

simple linear regression analysis using the SPSS 25.0 application, the results are as follows:

Based on Table 5, the results of the analysis show that the effect of the moon phase (tidal height) on the catch has a close influence with the equation  $Y = 111.950 + 1.329x$  where the constant is 111.950, the regression coefficient (x) of 1.329 states that each addition 1% of sea level at high tide, then the value of the catch increases by 1.329. The regression coefficient is positive, so it can be said that the direction of the showing a positive influence of the tidal height variable on the catch is positive (very influential) volumes.

**Comment [A31]:** Already mentioned at the results section

The value (R) explains the magnitude of the correlation coefficient (relationship) (R) between tidal height and the catch obtained, namely  $R = 0.972$ , show a strong correlation. The value of R-Square (the coefficient of determination or  $R^2$ ), namely  $R^2 = 0.945$ , which explains how much the catch variable can be explained by the shows a strong explanatory power of the tidal height variable, related to the catch production, so that the value of  $R^2 = 0.945$  is obtained which. This means that 94.5% of the catch volumes are due to the tidal height affects the number of catches, while the remaining 5.5% is are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area net, or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which is included in denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which is also denotes included in a strong correlation.

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Based on this, it shows that the full moon phase has a high tide of 185 cm with and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm with and a catch of 97,060 kg, which this is related to the daily migration of fish more there are many during the moon phase where at that time the tides are high, so the fish that carry out daily migration/migration further entering the coastal waters and towards the rivers because the sea water is due to higher sea level (or deeper on the coastal waters).

Subiyanto et al., al (2009), said that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, and increased food abundance and decreased predation rates. The reporting a number of caught fish larvae caught was of 904 individuals, of which 472 individuals (52.21%) at high tide 472 individuals were caught and (52.21%) and 432 individuals at low tide 432 individuals were caught (47.79%). Abdul Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns that occurs specific to in each phase. The difference in catches during both at high and low tide is due to differences in changes of the currents direction of currents and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation. Where the tidal pattern is closely related to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength that occurs in of the Spring Tide is greater than the tidal strength that occurs in of the Neap Tide, therefore so that it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) said-stated that the moon phase affected the migration of eels. Haraldstad, (1985), said-affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, because each pair of the sea water flows-flowing deep into the river, during high tides. This also causes the distribution-dispersion and distribution of several types of marine fish such as titan and mullet found very far from the sea. Higher tides, such as occurings during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Likewise, the natural movement of several types of fish and non-fish, such as prawns and crabs, although spawning off the

coast and in the deep sea, still arrives at the beach where they are reared, reared, looking for food and protection more quickly because of the tidal currents that occur every day.

Abdul Manan (2011) explained that the difference in catches both at high and low tide was due to differences in the direction of currents and the strength of the tides that carried fish larvae in and out of the river mouth. This is due to the movement of Also, the weaker body of the fish larvae make them susceptible to be which is not so strong that it can be carried away by the current. In contrast to low tide. Conversely, at low tide, fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that So the tidal conditions affect the abundance of fish larvae in the waters. The strength strong of the current at high tide makes carry the fish larvae carried to the estuary area, where and they prefer to stay remain at low tide because due to the estuary area has an abundance of food sources for fish larvae and adult fish. According to as observed by Subiyanto, et al., al (2009). There is a difference in abundance at high and low tide because at high tide many fish larvae are carried to the estuary by tidal currents and avoid low tides by being on the side of the estuarine waters because in the estuarine area they find a place to live. suitable for growth. This is reinforced by Subiyanto et al., (2009), that the larvae are moved by the current where the current flows towards the mouth of the estuary during the flood tide, and the fish larvae that are distributed to the mouth of the estuarine are young larvae and young fish.

**Conclusions.** The trap net fishing area grounds in the waters of the Sigeri District, Pangkep Regency, is are available in several places and is are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on fish catches on the operation of the Trap net fishing gear, it is better in the full moon and dead moon phases by getting more catches because in this lunar phase high tides occur compared to other moon phases. Tidal height affects affected the amount of catch during the study, and only a small part is was influenced by several external factors during the study.

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**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [A32]:** Please reformulate clearly

**Comment [A33]:** Repeated.

**Comment [A34]:** Redundant. The same idea is repeated.

**Comment [A35]:** Please reformulate clearly

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**Comment [WU37]:** What kind of thesis? PhD?Msc?

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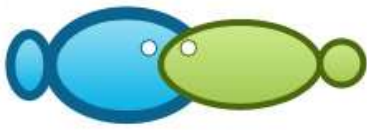
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## Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.

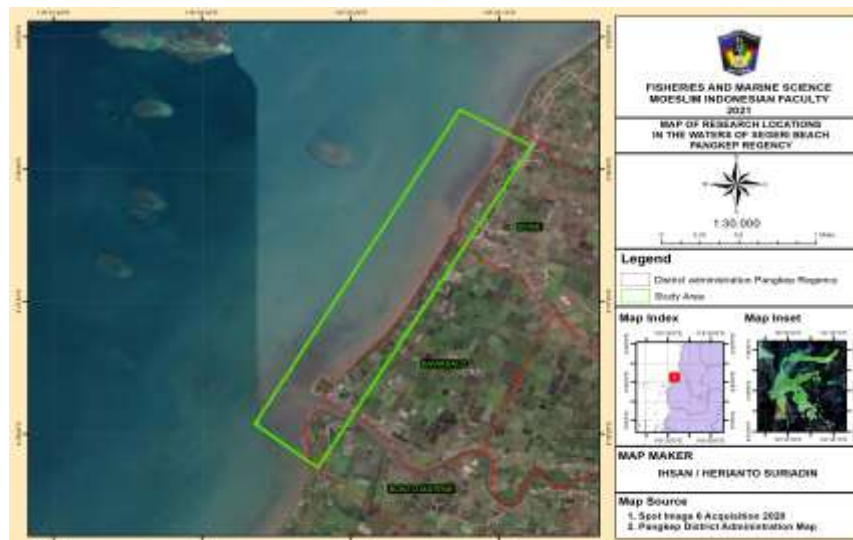


Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(So)$$

Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - Amplitude of the tidal harmonic component

So - Average sea level

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

P1 - Constants affected by the sun's declination

K2 - Constants that are affected by changes in distance, due to the elliptical path of the sun

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the

more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1  
The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a

requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

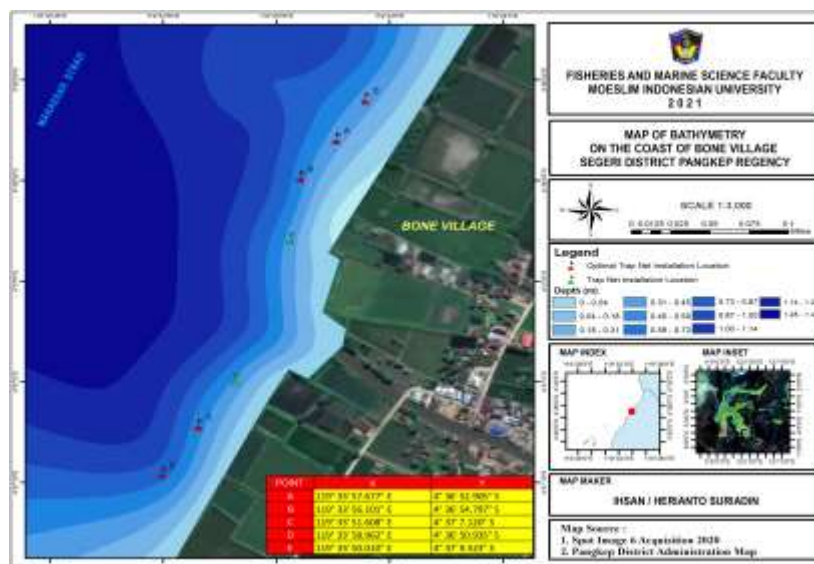


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (Kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5 The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>    |                             |            |                           |                            |      |
|------------------------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                        | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                              | B                           | Std. error | Beta                      |                            |      |
| (Constant)                   | -111.950                    | 35.005     |                           | -3.198                     | .085 |
| Tide high                    | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent Variable: Catch |                             |            |                           |                            |      |
| Model summary                |                             |            |                           |                            |      |
| Model                        | R                           | R square   | Adjusted R square         | Std. error of the estimate |      |
| 1                            | .972 <sup>a</sup>           | .945       | .918                      | 11.44936                   |      |

<sup>a</sup> - Predictors: (Konstant), High tide

## Discussion

### Physical and chemical aspects of the coastal oceanography.

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at

the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30-32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31-0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

Based on the observations during the research, it is known that one of the requirements in the operation of the trap net fishing gear must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes. Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. The operation of trap nets at low tide (0 meters) is generally spread along coastal waters in 4 districts. Based on the bathymetry map and the distribution of water depths as well as external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Comment [WU1]:** As requested before:

Please reformulate using scientific English language.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

**Comment [WU2]:** As requested before:

Please reformulate, these phrases are not intelligible.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising

that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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**Conflict of interest.** The authors declare no conflict of interest.

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**Comment [WU3]:** As requested before:

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**Comment [WU4]:** As requested before:

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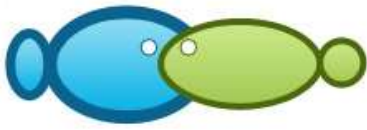
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## Mapping of fishing areas and the effect of the moon phase on trap net catches in Pangkep District Waters, Indonesia

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329 grams. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

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**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, the location is presented in Figure 1.



Figure 1. Research location.

In this study, the object of research was the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(So)$$

Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - amplitude of the tidal harmonic component;

So - average sea level;

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun);

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

P1 - constants affected by the sun's declination;

K2 - constants that are affected by changes in distance, due to the elliptical path of the sun.

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - formzahl number;

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net.

Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1  
The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm) variable X | Value of low tide (cm) | MSL (cm) |
|----------------------------------|---------------------------|------------------------|----------|
| Dead moon phase                  | 162                       | 59                     | 110.5    |
| Phases of the early quarter moon | 115                       | 23                     | 69       |
| Full moon phases                 | 185                       | 42                     | 113.5    |
| Phases of the late quarter moon  | 149                       | 40                     | 94.5     |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34°C   |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18-0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31-0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45-0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18-0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73-0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

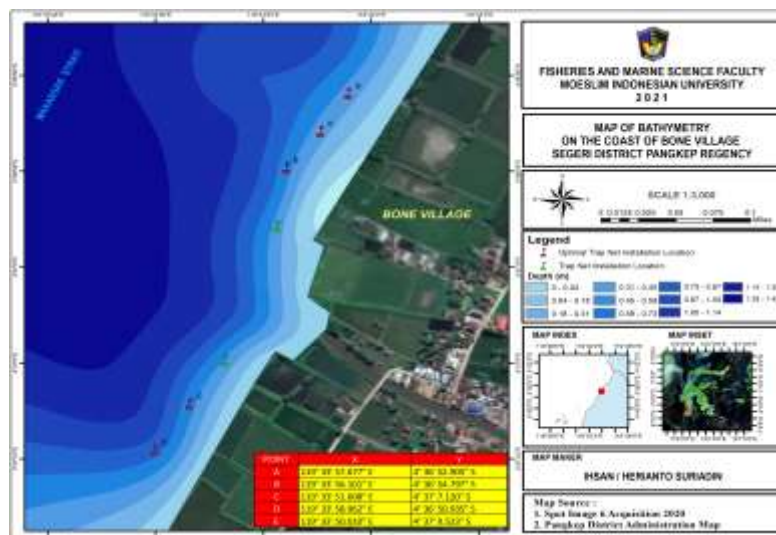


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329 grams, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Model                        | Coefficients <sup>a</sup>        |                    | t                 | Sig.                       |
|------------------------------|----------------------------------|--------------------|-------------------|----------------------------|
|                              | Unstandardized coefficients<br>B | Std. error<br>Beta |                   |                            |
| (Constant)                   | -111.950                         | 35.005             | -3.198            | .085                       |
| Tide high                    | 1.329                            | .226               | 5.879             | .028                       |
| a. Dependent variable: Catch |                                  |                    |                   |                            |
| Model summary                |                                  |                    |                   |                            |
| Model                        | R                                | R square           | Adjusted R square | Std. error of the estimate |
| 1                            | .972 <sup>a</sup>                | .945               | .918              | 11.44936                   |

<sup>a</sup>-Predictors: Constant, High tide.

## Discussion

### **Physical and chemical aspects of the coastal oceanography.**

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inriika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30°C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31-0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline. Based on the observations during the research, one of the requirements in the operation of the trap net fishing gear is that it must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the

better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 m. The operation of trap nets at low tide (0 m) is generally spread along coastal waters in the four districts. Based on the bathymetry map and on the distribution of water depths, as well as on external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon. The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , showed a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , showed a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation. The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due

to the tidal currents that occur every day. Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place. It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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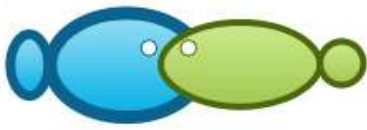
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## Mapping of fishing areas and the effect of the moon phase on trap net catches in Pangkep District Waters, Indonesia

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329 grams. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

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**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, the location is presented in Figure 1.



Figure 1. Research location.

In this study, the object of research was the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(S_0)$$

Lowest Low Water Level

$$LLWL = A(S_0) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - amplitude of the tidal harmonic component;

So - average sea level;

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun);

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

P1 - constants affected by the sun's declination;

K2 - constants that are affected by changes in distance, due to the elliptical path of the sun.

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - formzahl number;

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net.

Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1  
The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm) variable X | Value of low tide (cm) | MSL (cm) |
|----------------------------------|---------------------------|------------------------|----------|
| Dead moon phase                  | 162                       | 59                     | 110.5    |
| Phases of the early quarter moon | 115                       | 23                     | 69       |
| Full moon phases                 | 185                       | 42                     | 113.5    |
| Phases of the late quarter moon  | 149                       | 40                     | 94.5     |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34°C   |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

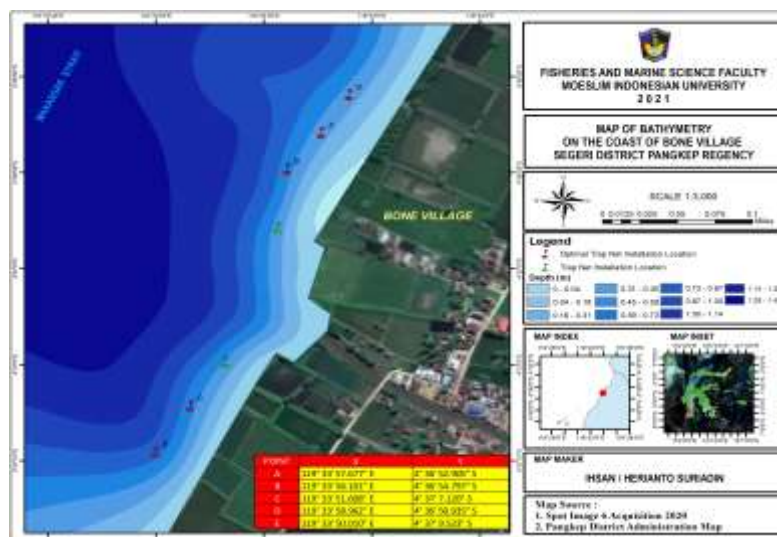


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329 grams, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Model                        | Coefficients <sup>a</sup>        |                    | t                 | Sig.                       |
|------------------------------|----------------------------------|--------------------|-------------------|----------------------------|
|                              | Unstandardized coefficients<br>B | Std. error<br>Beta |                   |                            |
| (Constant)                   | -111.950                         | 35.005             | -3.198            | .085                       |
| Tide high                    | 1.329                            | .226               | 5.879             | .028                       |
| a. Dependent variable: Catch |                                  |                    |                   |                            |
| Model summary                |                                  |                    |                   |                            |
| Model                        | R                                | R square           | Adjusted R square | Std. error of the estimate |
| 1                            | .972 <sup>a</sup>                | .945               | .918              | 11.44936                   |

<sup>a</sup>-Predictors: Constant, High tide.

## Discussion

### **Physical and chemical aspects of the coastal oceanography.**

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30°C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30-32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31-0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline. Based on the observations during the research, one of the requirements in the operation of the trap net fishing gear is that it must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the

better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 m. The operation of trap nets at low tide (0 m) is generally spread along coastal waters in the four districts. Based on the bathymetry map and on the distribution of water depths, as well as on external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon. The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient ( $R$ ) between tidal height and the catch, namely  $R=0.972$ , showed a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , showed a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation. The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due

to the tidal currents that occur every day. Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place. It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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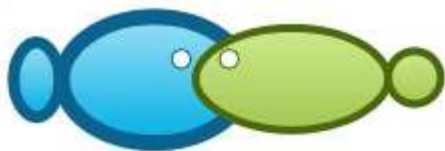
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# Mapping of fishing areas and the effect of moon phase on trap net catches in Pangkep District Waters

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline.

Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011).

Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018).

The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area

and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, and the location is presented in Figure 1.



Figure 1. Location of the research.

In this study, the object of research is the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(So)$$

Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - Amplitude of the tidal harmonic component

So - Average sea level

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

P1 - Constants affected by the sun's declination

K2 - Constants that are affected by changes in distance, due to the elliptical path of the sun

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - Formzahl number;

K1 - Constant (influenced by the declination of the moon and sun);

O1 - Constant (influenced by the declination of the moon);

M2 - Constant (influenced by moon position);

S2 - Constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the

more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1 The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm)<br>variable X | Value of low tide<br>(cm) | MSL<br>(cm) |
|----------------------------------|------------------------------|---------------------------|-------------|
| Dead moon phase                  | 162                          | 59                        | 110.5       |
| Phases of the early quarter moon | 115                          | 23                        | 69          |
| Full moon phases                 | 185                          | 42                        | 113.5       |
| Phases of the late quarter moon  | 149                          | 40                        | 94.5        |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2 Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34 °C  |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3 The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

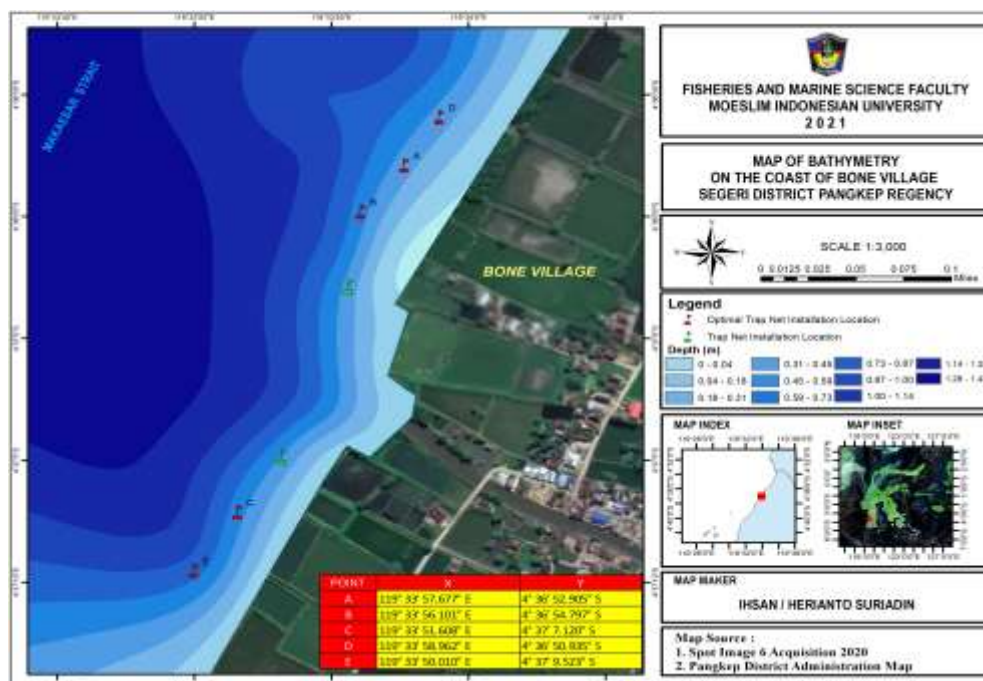


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (Kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5 The results of simple regression analysis of the effect of the moon phase on the catch

| <i>Coefficients<sup>a</sup></i> |                                    |                   |                                  |                                   |             |
|---------------------------------|------------------------------------|-------------------|----------------------------------|-----------------------------------|-------------|
| <i>Model</i>                    | <i>Unstandardized coefficients</i> |                   | <i>Standardized coefficients</i> | <i>t</i>                          | <i>Sig.</i> |
|                                 | <i>B</i>                           | <i>Std. error</i> | <i>Beta</i>                      |                                   |             |
| (Constant)                      | -111.950                           | 35.005            |                                  | -3.198                            | .085        |
| Tide high                       | 1.329                              | .226              | .972                             | 5.879                             | .028        |
| a. Dependent Variable: Catch    |                                    |                   |                                  |                                   |             |
| <i>Model summary</i>            |                                    |                   |                                  |                                   |             |
| <i>Model</i>                    | <i>R</i>                           | <i>R square</i>   | <i>Adjusted R square</i>         | <i>Std. error of the estimate</i> |             |
| 1                               | .972 <sup>a</sup>                  | .945              | .918                             | 11.44936                          |             |

<sup>a</sup> - Predictors: (Konstant), High tide

## Discussion

### **Physical and chemical aspects of the coastal oceanography.**

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning.

The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30 °C (Barus 2004). According to Cheong & Yeng (1986), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities.

Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30-32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea.

The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31-0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline.

Based on the observations during the research, it is known that one of the requirements in the operation of the trap net fishing gear must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the better the

placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 meters. The operation of trap nets at low tide (0 meters) is generally spread along coastal waters in 4 districts. Based on the bathymetry map and the distribution of water depths as well as external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon.

The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes.

The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , show a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , shows a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation.

The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators.

Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural

movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day.

Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the waters with not so great abundance and did not gather in one place.

It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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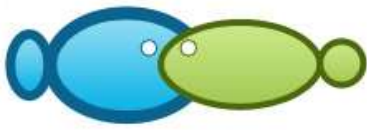
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## Mapping of fishing areas and the effect of the moon phase on trap net catches in Pangkep District Waters, Indonesia

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329 g. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline. Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011). Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018). The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, the location is presented in Figure 1.



Figure 1. Research location.

In the current study, the object of research was the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(So)$$

Lowest Low Water Level

$$LLWL = A(So) - (M2 + S2 + K1 + O1 + P1 + K2)$$

Highest High Water Level

$$HHWL = A(So) + (M2 + S2 + K1 + O1 + P1 + K2)$$

$$\text{Pair type (F)} = A(K1) + A(O1) / A(M2) + A(S2)$$

Where:

A - amplitude of the tidal harmonic component;

So - average sea level;

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun);

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

P1 - constants affected by the sun's declination;

K2 - constants that are affected by changes in distance, due to the elliptical path of the sun.

The type of tide can be determined by using the following formula:

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - formzahl number;

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

0 < F < 0.25 = pure double daily tidal type;

0.25 < F < 1.50 = mixed double inclined daily tidal type;

1.50 < F < 3.0 = single mixed inclined daily tidal type;

F > 3.0 = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

**Comment [WU1]:** Please provide citation, who developed the formula. Thank you.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1  
The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm) variable X | Value of low tide (cm) | MSL (cm) |
|----------------------------------|---------------------------|------------------------|----------|
| Dead moon phase                  | 162                       | 59                     | 110.5    |
| Phases of the early quarter moon | 115                       | 23                     | 69       |
| Full moon phases                 | 185                       | 42                     | 113.5    |
| Phases of the late quarter moon  | 149                       | 40                     | 94.5     |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2  
Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34°C   |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

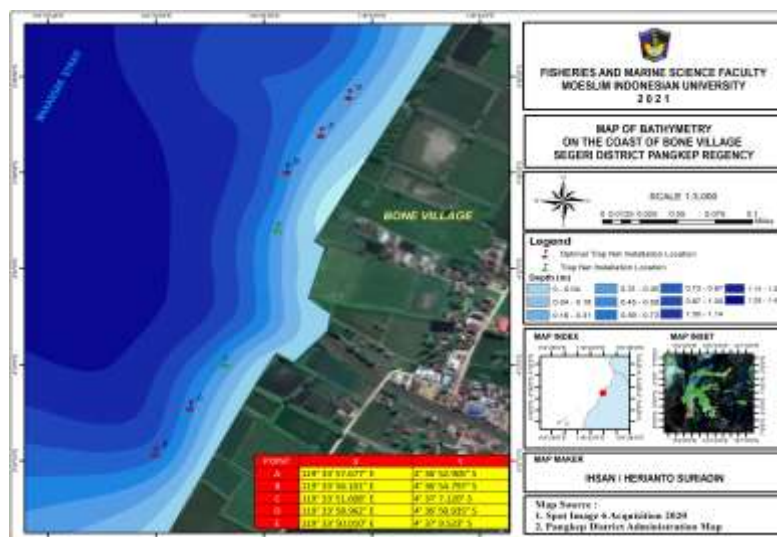


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Model                        | Coefficients <sup>a</sup>        |                    | t                 | Sig.                       |
|------------------------------|----------------------------------|--------------------|-------------------|----------------------------|
|                              | Unstandardized coefficients<br>B | Std. error<br>Beta |                   |                            |
| (Constant)                   | -111.950                         | 35.005             | -3.198            | .085                       |
| Tide high                    | 1.329                            | .226               | 5.879             | .028                       |
| a. Dependent variable: Catch |                                  |                    |                   |                            |
| Model summary                |                                  |                    |                   |                            |
| Model                        | R                                | R square           | Adjusted R square | Std. error of the estimate |
| 1                            | .972 <sup>a</sup>                | .945               | .918              | 11.44936                   |

<sup>a</sup>-Predictors: Constant, High tide.

## Discussion

### **Physical and chemical aspects of the coastal oceanography.**

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning. The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30°C (Barus 2004). According to Cheong (1989), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30–36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities. Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0–35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29–30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30–32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea. The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31–0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline. Based on the observations during the research, one of the requirements in the operation of the trap net fishing gear is that it must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 m. The operation of trap nets at low tide (0 m) is generally spread along coastal waters in the four districts. Based on the bathymetry map and on the distribution of water depths, as well as on external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

**Relationship between production of trap net catch and moon phase.** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon. The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes. The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , showed a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , showed a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation. The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators. Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day. Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the

waters with not so great abundance and did not gather in one place. It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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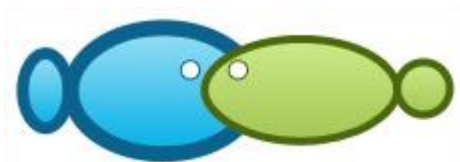
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# Mapping of fishing areas and the effect of the moon phase on trap net catches in Pangkep District Waters, Indonesia

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**Abstract.** Utilization of abundant resources in coastal areas is carried out by fishermen using various types of fishing gear, both traditional and modern. The study used a survey method, the data collected consisted of primary data and secondary data. Data were analyzed using geographic information system methods and ordinary statistical regression methods. The results showed that the trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, were available in several places and were ideal for operating trap nets. There was observed a significant effect of the moon phase (tidal) on fish catches during the operation of trap net fishing gear, especially in the full moon and dead moon phases, due to the high tides. Tidal height affected most of the amount of catch and only a small part was influenced by several external factors, during the study. For every 1% increase in sea level at high tide, the catch value increased by 1,329 g. The regression coefficient shows a positive value, meaning that the tidal height variable affects the catch.

**Key Words:** mapping, arrest area, catch, net traps, tidal height.

**Introduction.** To take advantage of the abundant resources in the coastal area, fishermen use various types of fishing gear, both traditional and modern. One of them is a trap net where the fishing process consist of trapping fish during high tides and which are operated parallel to the coastline. Tides are the sea levels fluctuations, caused by a combination of gravity and the attractive force between astronomical objects, especially the sun, earth and moon. The phases of the moon in question are the full moon phase, the early moon phase, the dark moon phase (dead moon) and the late moon phase. Each phase of the moon is very influential on the high and low tides, which will affect the fish migrations closer to the shore while foraging, spawning and rearing. Furthermore, high and low tides will affect the trap net fishing area (Manan 2011). Tides are nothing but ocean currents moving towards the coast and back, away from the land. The bathymetry is strongly influenced by the mean sea level (MSL) or the average sea level at high tide. In placing the fishing gear, the trap net is installed at a distance of 50 m from the shoreline. The shallower the coastal waters, the better the placement or installation of trap net fishing gear (Ihsan 2018). The catch of fishermen using erratic trap net fishing gear is extremely fluctuating, depending on the information on the suitability of the fishing grounds and on the right timing. According to Ihsan (2018), the composition of trap net catches in the Sigeri area is of 27 species captured during an average of 13 fishing trips, operated both in the afternoon and at night. The catch relation to the moon phase has not yet been explained, in order to optimize fishermen's working time. The present study aims at assessing the effect of the moon phase on the catch of the trap net fishing gear, in the coastal waters of Sigeri, Pangkep Regency, in order to provide information to the fishermen on fishing grounds, suitable fishing times and dominant catches that have high economical value. Therefore, this study determines the map of the trap net fishing area and the production of the trap net catches, based on the moon phase in the waters of Pangkep Regency.

**Material and Method.** The present research was conducted from March to May 2021 in the coastal waters of Sigeri District, Pangkep Regency, South Sulawesi, the location is presented in Figure 1.

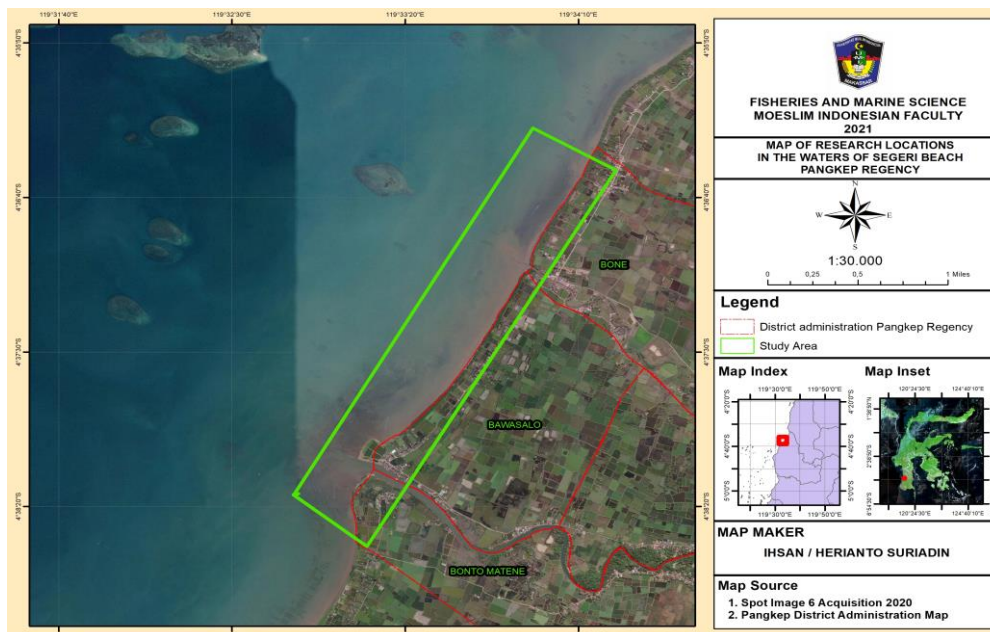


Figure 1. Research location.

In the current study, the object of research was the fish caught by trap net fishing gear operated by fishermen in Sigeri District. The equipment used was a fishing rod, camera, office stationery, global position system, digital scales, hand rectometer, echosounder, tide gauge stick (TPP) and trap net fishing gear.

The data collected includes: (1) tidal observation data; (2) bathymetry data for coastal waters; (3) catch data (kg) per trip; (4) oceanographic data on coastal waters. The authors participated in fishing operations to conduct direct observations in the field and interviews using a questionnaire related to the operation of trap net fishing gear. This study uses qualitative and quantitative descriptive data analysis. For mapping the GIS method was used with criteria. The Admiralty method was used for measuring tides. The regression analysis was used to determine the relationship between the of catch volumes (kg) and the tides, during each moon phase, in the waters of Sigeri District, Pangkep Regency.

The determination of fishing areas was carried out by analyzing bathymetric data and tidal data because these would facilitate the determination of fishing areas. Bathymetric analysis was obtained by tracking, using an echosounder mapping tool. The values stored or recorded in the echosounder mapping are inputted into the ArcGis 10.3 software and then interpolated with the aim of producing a map of the depth class of the location and operating area for trap net fishing gear. Tidal analysis uses the Admiralty method to calculate two harmonic components, namely amplitude and phase delay. After getting the components, the tides can be calculated as follows (Ihsan et al 2015):

Average Water Level (Mean Sea Level)

$$MSL = A(S_o)$$

Lowest Low Water Level

$$LLWL = A(S_o) - (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$$

Highest High Water Level

$$HHWL = A(S_o) + (M_2 + S_2 + K_1 + O_1 + P_1 + K_2)$$

$$\text{Pair type (F)} = A(K_1) + A(O_1) / A(M_2) + A(S_2)$$

Where:

A - amplitude of the tidal harmonic component;

So - average sea level;

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun);

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

P1 - constants affected by the sun's declination;

K2 - constants that are affected by changes in distance, due to the elliptical path of the sun.

The type of tide can be determined by using the following formula (Triatmodjo 2009):

$$F = \left\{ \frac{K_1 + O_1}{M_2 + S_2} \right\}$$

Where:

F - formzahl number;

K1 - constant (influenced by the declination of the moon and sun);

O1 - constant (influenced by the declination of the moon);

M2 - constant (influenced by moon position);

S2 - constant (influenced by the position of the sun).

According to Triatmodjo (2009) there are 4 tidal types based on tidal constants:

$0 < F < 0.25$  = pure double daily tidal type;

$0.25 < F < 1.50$  = mixed double inclined daily tidal type;

$1.50 < F < 3.0$  = single mixed inclined daily tidal type;

$F > 3.0$  = pure single daily tidal type.

The fishing area (for trap net fishing gear) mapping, is also analyzed with a geographic information system (GIS) using the overlay method of the ArcGis 10.3 software, where the processed bathymetric data that has been interpolated is then correlated with the mean sea level (MSL) data from the tidal measurements and then manually assigned a suitable location for the placement of the trap net fishing gear. Ihsan (2018) stated that the factors that affect the trap net fishing area are the following:

a. Tides: it is assumed that the lower the tide, the easier the trap net operating. The maximum and minimum high and low tides analyze the mean sea level (MSL) and determine the types of tides found at the trap net operating location.

b. Mangrove vegetation: it is assumed that the closer the mangrove vegetation, the better the trap net installation. The benefits of the mangrove forest area are that it is the most suitable place for breeding fish, shrimp and various other potential marine habitats. Mangrove forest areas have helped maintain the availability of fish resources in the sea in a sustainable manner.

c. Salinity: due to the conditions around the location are rivers, it is suspected that the more brackish the condition of the waters is, the better the installation of trap nets. Measurements of salinity values were carried out at the operating location of the trap net.

d. Seawater temperature: The location of fishing is affected by the optimal temperature. Conditions around the fishing location are rivers, so the optimal temperature is taken from the optimal temperature benchmark for brackish waters. It is suspected that the more optimal the water temperature, the better the installation of the trap net. Measurement of the water temperature at the location of the operation of the trap net tool.

e. Substrate: The location of fishing is influenced by the condition of the substrate, because around the location there are rivers, and mangrove vegetation and not far from

pond activities, the location is muddy, both in anchoring trap nets. Observation of the type of substrate, and the shape of the beach at the location of the trap net installation.

f. Water depth: The depth of the water plays an important role in the operation of trap net fishing gear, making it easier to catch catch using a seser. The shallower the water, the faster the fishing process in trap net operations.

Measurement data of external factors in determining the trap net fishing area, such as: mangrove vegetation conditions, salinity, sea water temperature, substrate and water depth were analyzed using a qualitative descriptive analysis approach.

To analyze the relationship between the phases of the moon and the number of catches of trap net fishing gear, ordinary regression analysis was used. In testing the a simple linear regression formula was used to identify a linear relationship between these independent factors and the catch volumes (dependent variable) of the trap net fishing gear in orderis (Walpole 1995):

$$Y = \alpha + \beta x$$

Where:

Y - catch volume;

$\alpha$  - constant;

$\beta$  - regression coefficient of independent variable;

x - high tide water level (full moon phase, early moon phase, moon phase dark and moon phase end.

## Results

**Physical and chemical aspects of coastal oceanography.** The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, are presented in Table 1.

Table 1

The results of the value of tidal height analysis and sea level (MSL)

| Type of moon phase               | High tide (cm) variable X | Value of low tide (cm) | MSL (cm) |
|----------------------------------|---------------------------|------------------------|----------|
| Dead moon phase                  | 162                       | 59                     | 110.5    |
| Phases of the early quarter moon | 115                       | 23                     | 69       |
| Full moon phases                 | 185                       | 42                     | 113.5    |
| Phases of the late quarter moon  | 149                       | 40                     | 94.5     |

The results of temperature and salinity measurements at the research location, as presented in Table 2, were found to be optimal for the growth and development of the caught fish.

Table 2

Results of temperature and salinity measurements during the study

| Physical and chemical aspects of oceanography | Value     |
|-----------------------------------------------|-----------|
| Temperature                                   | 31-34°C   |
| Salinity                                      | 30-36 ppt |

**Mapping of trap net fishing areas.** Based on the bathymetry map, the distribution of water depths, as well as external factors around coastal waters, were considered as a requirement in determining the operating location of the trap net fishing gear in the waters of Sigeri District, Pangkep Regency, as presented in Table 3.

Table 3

The results of the analysis of the development of fishing locations using the bathymetry (depth) approach

| Trap net capture location | Coordinate points for the location of trap net fishing gear | Depth (m) |
|---------------------------|-------------------------------------------------------------|-----------|
| A                         | 119° 33' 57.677" E - 4° 36' 52.905" S                       | 0.18–0.31 |
| B                         | 119° 33' 56.101" E - 4° 36' 54.797" S                       | 0.31–0.45 |
| C                         | 119° 33' 51.608" E - 4° 37' 7.120" S                        | 0.45–0.59 |
| D                         | 119° 33' 58.962" E - 4° 36' 50.935" S                       | 0.18–0.31 |
| E                         | 119° 33' 50.010" E - 4° 37' 9.523" S                        | 0.73–0.87 |

Based on bathymetric measurements at the research site, the following criteria were used to determine the location for trap net catching: 1) the waters must be shallow, 2) the physical and chemical aspects of the waters are in accordance with the optimum conditions required by fish, 3) the mangrove vegetation must be dense and 4) the existing trap net operation location is carried out by fishermen. For shallow waters, the choice must be based on the type of tidal sea water, according to measurements in the field and other criteria carried out visually. The mapping results are presented in Figure 2.

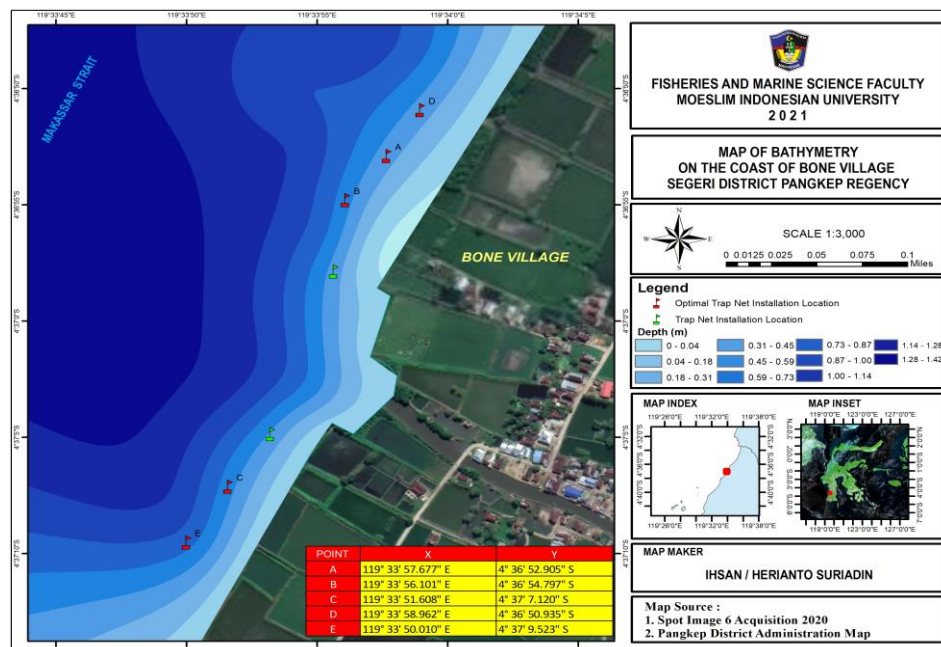


Figure 2. The mapping results (Ihsan 2018).

**Relationship between production of trap net catch and moon phase.** The relationship between the trap net catch production volumes (kg) and the moon phase shows that the highest production value was obtained for the high tide phase, as presented in Table 4.

Table 4

Total production of catch (kg) trap net by moon phase

| Type of moon phase               | Catch production (kg) variable Y |
|----------------------------------|----------------------------------|
| Dead moon phase                  | 97,060                           |
| Phases of the early quarter moon | 47,925                           |
| Full moon phases                 | 142,835                          |
| Phases of the final quarter moon | 76,401                           |

The results of the analysis show that the effect of the moon phase (tidal height) on the catch can be approximated by the equation  $Y = -111.950 + 1.329x$ , with a constant of -111.950 and a regression coefficient (x) of 1.329, meaning that for every sea level marginal increase of 1% at the high tide, the value of the catch increases by 1.329, as presented in Table 5.

Table 5

The results of simple regression analysis of the effect of the moon phase on the catch

| Coefficients <sup>a</sup>    |                             |            |                           |                            |      |
|------------------------------|-----------------------------|------------|---------------------------|----------------------------|------|
| Model                        | Unstandardized coefficients |            | Standardized coefficients | t                          | Sig. |
|                              | B                           | Std. error | Beta                      |                            |      |
| (Constant)                   | -111.950                    | 35.005     |                           | -3.198                     | .085 |
| Tide high                    | 1.329                       | .226       | .972                      | 5.879                      | .028 |
| a. Dependent variable: Catch |                             |            |                           |                            |      |
| Model summary                |                             |            |                           |                            |      |
| Model                        | R                           | R square   | Adjusted R square         | Std. error of the estimate |      |
| 1                            | .972 <sup>a</sup>           | .945       | .918                      | 11.44936                   |      |

<sup>a</sup>-Predictors: Constant, High tide.

## Discussion

### **Physical and chemical aspects of the coastal oceanography**

**Ups and downs.** The results of the tidal analysis in Table 1 were carried out using the Admiralty Method to calculate the height of the tides that occurred in the 4 phases of the moon defined in the study. In the dead moon phase, the highest tide is 162 cm and the lowest is 59 cm, so the mean sea level is 110.5 cm. The early moon phase experienced the highest tide with a value of 115 cm and the lowest tide with a value of 23 cm so that the mean sea level was 69 cm. The full moon phase experiences the highest tide of 185 cm and the lowest low of 42 cm, with an average sea level (mean sea level) of 113.5 cm. The final moon phase experienced the highest high tide of 149 cm and the lowest low tide of 40 cm, with an average sea level of 94.5 cm.

Tides are a natural phenomenon occurring on a daily basis at sea and affecting the fish migrations. High tide is a current moving towards the coast, while low tide is a current moving away from the coast. Inrika (2018) stated that the correlation coefficient in the relationship between fish abundance and currents at high tide was of only 0.126, which shows a very low correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and currents at low tide was of 0.896, which shows a very strong correlation. The lower the current value, the higher the fish abundance, because not all fish can adapt to high current speeds.

Several species caught by trap net catches are influenced by tides, one of which is cotton-cotton fish (*Gerres punctatus*). This is corroborated by the results of the study of Manan (2011) which mentions the presence of 8 genera, namely: *Stolephorus*, *Ambassis*, *Periophthalmus*, *Gerres*, *Leiognathus*, *Terapon*, *Atherinomorus* and *Chanos*, in the analyzed catches. The frequency of fish larvae caught at high and low tide, based on the moon phase (new moon phase, early moon phase, full moon phase and late moon phase) was dominated by *stolephorus* and *ambassis*.

In this regard, the currents and tides greatly affect the migration of eels, both larvae and adults. Larvae are carried by currents to the coast, becoming glass eels and elvers, then they migrate to the mouth of the river and upstream, being affected by changes in the water flow and tides. Changes in the river's water level are determined by the high and low tides in the estuary, as well as by the high and low rainfalls occurring in the upstream area. Tidal conditions also affect the behavior of the elver. Deelder (1984) found that the elver swims at the surface of the water, during the high tide, and hides at the bottom, during the low tide. Dwiponggo (1972) suggested that certain types of fish will move with the current at high tide towards the coast, at high tide.

Maturbongs et al (2019) found that among the 98 fish caught, of which 45 specimens were captured in the dark moon phase and 53 specimens were captured in the bright moon phase, there were identified 14 fish species from 14 genera. The species diversity of demersal fish in the dark and light moon phases is in the low category and the level of species uniformity during the dark moon phase is in the uneven category, while during the bright moon phase it is in the less uniform category.

**Temperature.** Based on Table 2, that the temperature of the waters along the coast reached values ranging from 31 to 34°C (measurements were repeated 3 times for each observation point. Observations were made randomly at 5 different points in the afternoon. Temperature is very influential on the development and survival of fish and at the time of spawning. The temperature of waters is influenced by season, latitude, altitude above sea level, time of day, air circulation, cloud cover and water depth. Aquatic organisms have a certain range that is preferred for their growth. Aquatic environmental conditions are suitable for fish growth in tropical waters with seawater temperatures of 28–30°C (Barus 2004). According to Cheong (1989), the optimal temperature for the spawning of the white snapper (*Lates calcarifer*) generally ranges from 27 to 33°C. Latuconsina et al (2012) found that the optimal temperature range for fish life in tropical waters is between 28 and 32°C. The water temperature affects the metabolic activity of fish and is closely related to dissolved oxygen and oxygen consumption by fish (Barus 2014).

**Salinity.** Based on Table 2, the value of the salinity (salt content) of waters along the coast is obtained in the range of 30-36 ppt (3 measurement repetitions at each observation point). This value indicates that the salinity level in these waters is low because it is near the estuary, where seawater and fresh water meet. The adaptation of fish to changes in salinity indicates that their body resistance is very strong because they can live in different salinities. Fish (from larval size to adult size) originating from the brackish waters also have a strong immune level because they can survive with different levels of salinity, ranging. For instance, according to Aulia (2018), adult and young mullets (4–7 cm of length) have a fairly wide tolerance for the salt content (0-35 ppt). According to Mulyono (2011), white snapper spawning occurs in areas with a salinity ranging from 30 to 32 ppt. The released eggs will go to the beach and the larvae will live in waters with a salinity of 29-30 ppt, then, in later stages, they migrate to brackish waters with a salinity of 30-32 ppt, where they will live until their adulthood. The correlation coefficient in the relationship between fish abundance and salinity at high tide is 0.832 which is classified as a very strong correlation. Meanwhile, the correlation coefficient in the relationship between fish abundance and salinity at low tide is -0.064 which is classified as a very weak correlation. The higher the salinity, the higher the abundance of fish that tolerate salt levels (Mulyono 2011).

**Trap net fishing area.** The mapping based on the results of coastal waters (Segeri District, Pangkep Regency) bathymetry measurements (Table 3), performed using a roller meter and echosounder, shows that the depth of the coastal waters is very shallow and sloping over a distance of 100 m to the sea from the shoreline. The depth of the waters varies from 0.4 to 1.19 m with the bottom shape or sloping, up to several hundred meters towards the sea. The silting process occurs due to a lot of sedimentation of the mud substrate that settles from the delivery of rivers in the coastal area. The upstream part is generally a pond cultivation area which produces a lot of mud every year. The location points for the operation of the trap net fishing gear had an average depth of 0.31-0.73 m, especially when the sea water conditions are at high tide, the maximum height being at 50 m from the shoreline. Based on the observations during the research, one of the requirements in the operation of the trap net fishing gear is that it must be in a shallow area to facilitate fishing operations. According to Ihsan (2018), the shallower the coastal waters, the better the placement or installation of trap net fishing gear, because at the lowest tide it is easier to capture fish caught in the trap net area when the sea water recedes.

Risnawati et al (2018) elaborated the bathymetry map of 4 sub-districts in Pangkep Regency: Bungoro, Labakkang, Ma'rang and Segeri, showing depth variations ranging from 0 to -50 m. The operation of trap nets at low tide (0 m) is generally spread along coastal waters in the four districts. Based on the bathymetry map and on the distribution of water depths, as well as on external factors around coastal waters, it is an important requirement in the operation of trap net fishing gear in Sigeri District, Pangkep Regency.

***Relationship between production of trap net catch and moon phase.*** To find out the relationship between the phases of the moon (which consists of the early moon phase, full moon phase, dead moon phase and late moon phase), related to tides, and the trap net catches, the weight of the catch and the height of the tides were measured at each phase of the moon. The results of the tidal height analysis, which was carried out using the Admiralty method for the 4 phases of the moon, against the trap net catches (Table 1), were used for testing the regression relationship. The regression coefficient is positive, showing a positive influence of the tidal height variable on the catch volumes. The value of the correlation coefficient (R) between tidal height and the catch, namely  $R=0.972$ , showed a strong correlation. The value of the coefficient of determination, namely  $R^2=0.945$ , showed a strong explanatory power of the tidal height variable, related to the catch production. This means that 94.5% of the catch volumes are due to the tidal height, while the remaining 5.5% are influenced by several factors outside of the study, for example the ability and patience of fishermen to do sweeping repeatedly until fish are considered no longer in the trap area or all fish have been caught. The relationship between fish abundance and pH at high tide has a value of 0.605 which denotes a strong correlation. The relationship between fish abundance and pH at low tide has a value of 0.675 which also denotes a strong correlation. The full moon phase has a high tide of 185 cm and a larger catch of 142,835 kg, followed by a dead moon phase (dark moon) with a high tide of 162 cm and a catch of 97,060 kg, which is related to the daily migration of fish entering the coastal waters towards the rivers due to higher sea level (or deeper coastal waters).

Subiyanto et al (2009) stated that the abundance of plankton in the estuary and the decreased predation rates are also related to the strong currents at high tide, reporting a number of caught fish larvae of 904 individuals, of which 472 individuals (52.21%) at high tide and 432 individuals at low tide (47.79%). Manan (2011) explained that the abundance of fish larvae always changes related to the tide patterns specific to each phase. The difference in catches during both high and low tide is due to changes of the currents direction and to the strength of the tides, that carry fish larvae in and out of the river mouth. Tidal patterns that occur in estuary waters greatly determine the distribution and abundance of fish larvae in these waters, in a close relation to the phase of the moon. The spring tide pattern occurs in the new and full moon phases, while the neap tide pattern occurs in the quarter and three quarter moon phases. The tidal strength of the Spring Tide is greater than the tidal strength of the Neap Tide, therefore it is able to bring larger fish larvae into the estuary waters.

Dwiponggo (1972) stated that the moon phase affected the migration of eels. Haraldstad et al (1985) affirmed that eels do not migrate during the full moon. Furthermore, it was suggested that the phase of the full moon has something to do with the light intensity and behavior to avoid predators. Along the coast of the research location, there are several rivers that have a brackish salinity, the sea water flowing deep into the river, during high tides. This also causes the dispersion of several types of marine fish such as titan and mullet found very far from the sea. Higher tides occurring during the full moon phase and dark moon phases affect the movement of fish up to the shore and deep into the river, so it is not surprising that many types of marine fish are found in the river. Fish and non-fish, such as prawns and crabs, although spawning off the coast and in the deep sea, have a natural movement, still arriving at the beach, looking for food and protection, more quickly due to the tidal currents that occur every day. Also, the weaker body of the fish larvae make them susceptible to be carried away by the current. Conversely, at low tide fish larvae were found to be spread evenly in the

waters with not so great abundance and did not gather in one place. It was demonstrated that the tidal conditions affect the abundance of fish larvae in the waters. The strong current at high tide carry the fish larvae to the estuary area, where they prefer to remain at low tide due to the abundance of food sources for fish larvae and adult fish, as observed by Subiyanto et al (2009).

**Conclusions.** Trap net fishing grounds in the waters of the Sigeri District, Pangkep Regency, are available in several places and are ideal for operating a trap net with a large number of catches. The effect of the moon phase (tidal) on the fish catches is better in the full moon and dead moon phases due to the high tides. Tidal height affected the amount of catch during the study and only a small part was influenced by several external factors.

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**Conflict of interest.** The authors declare no conflict of interest.

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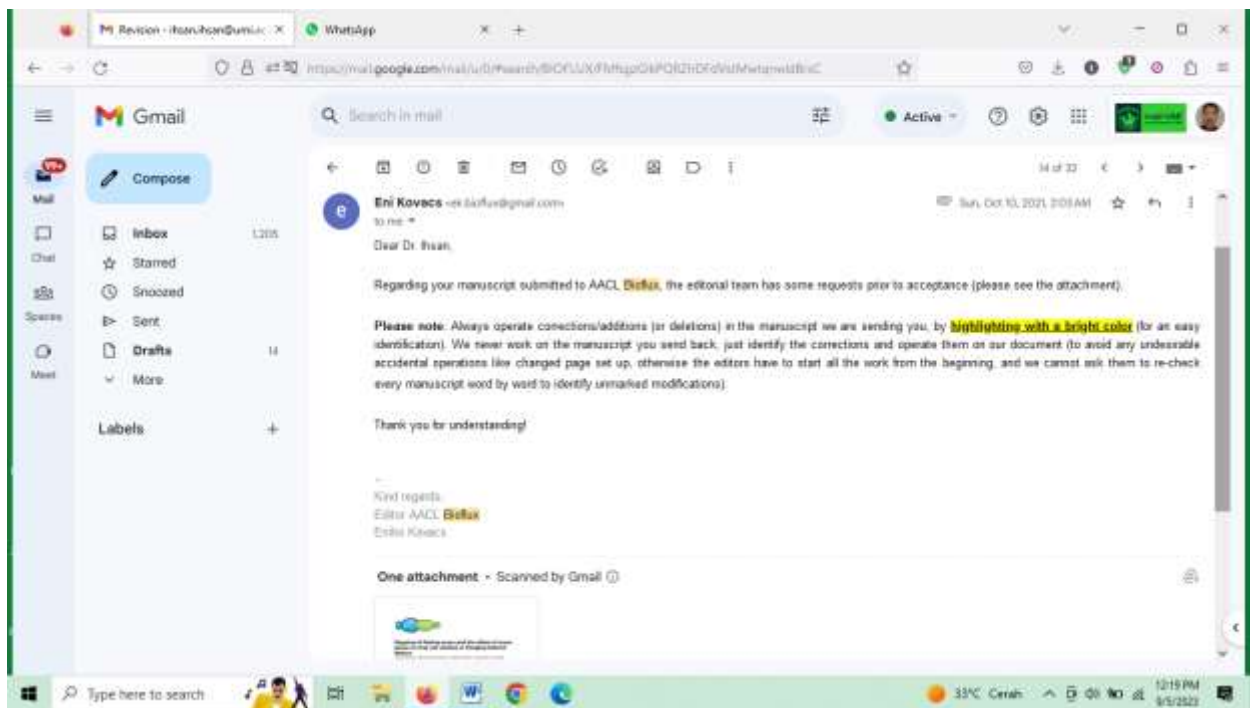
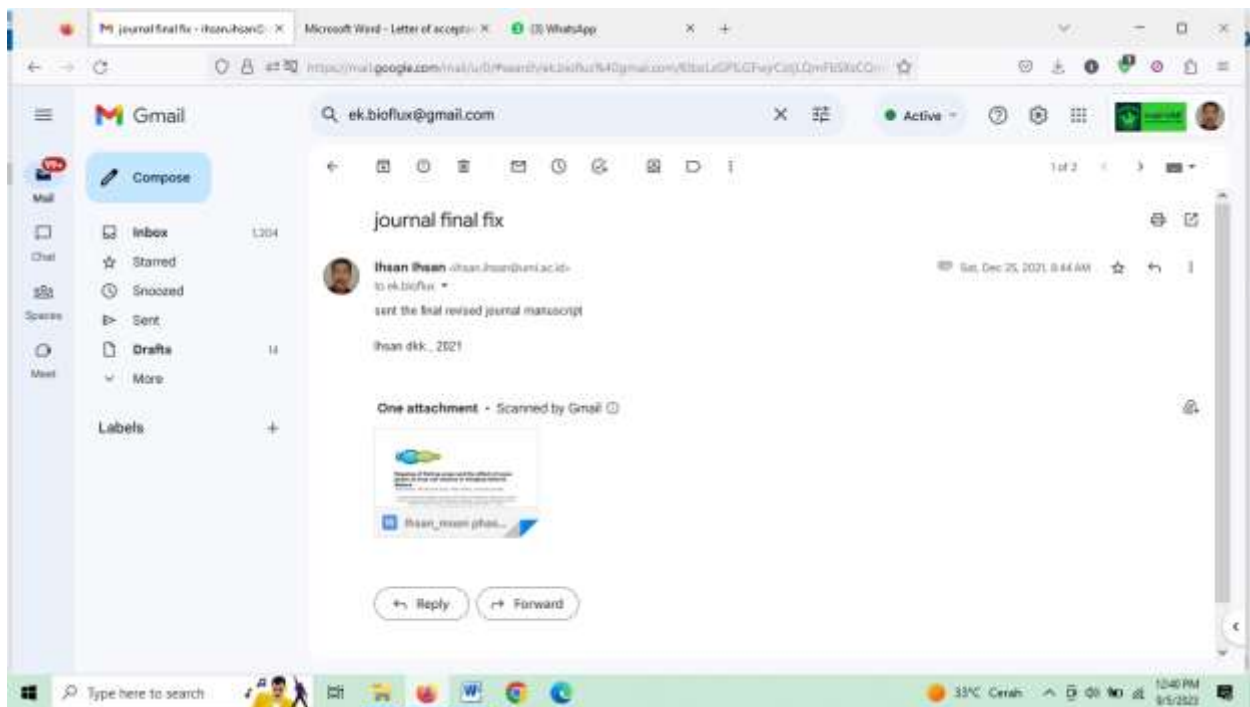
Herianto Suriadin, Student of FPIK-UMI Makassar Resource Utilization Study Program, Faculty of Fisheries and Marine Sciences, Department of Fisheries Resources Utilization, Jl. Urip Sumoharjo KM 5, 90231 Makassar, Indonesia, e-mail: heriantosuriadin@gmail.com

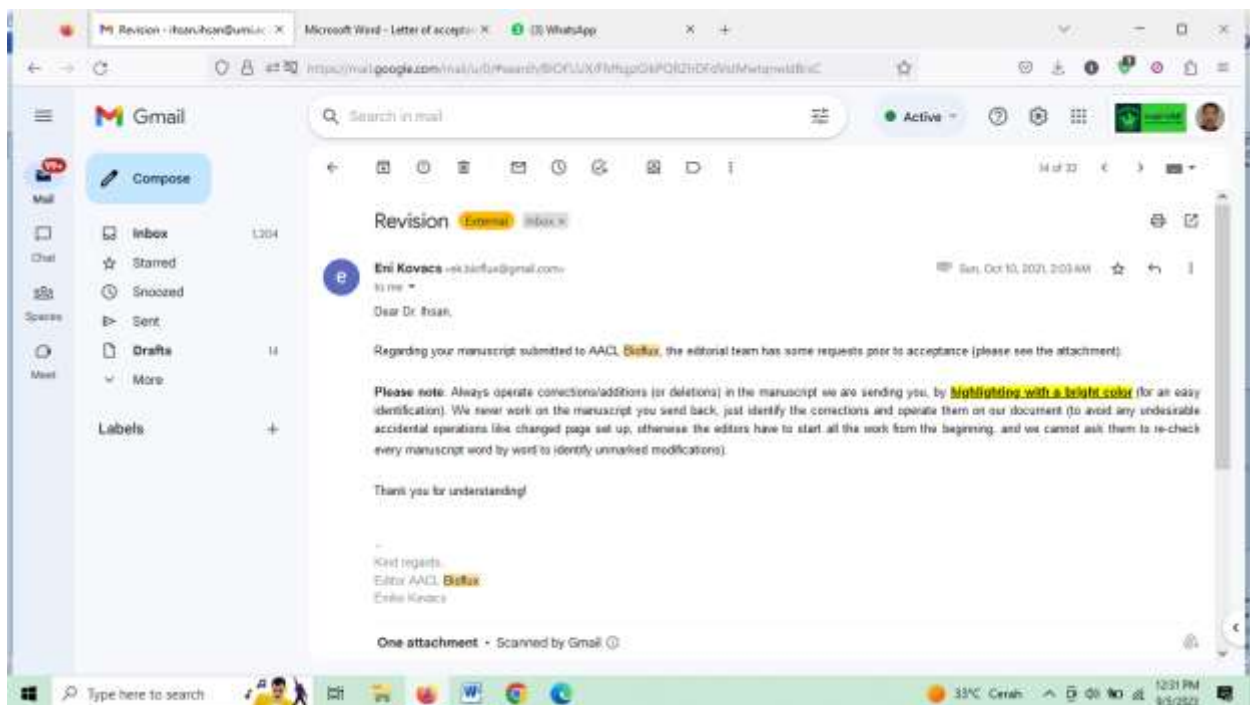
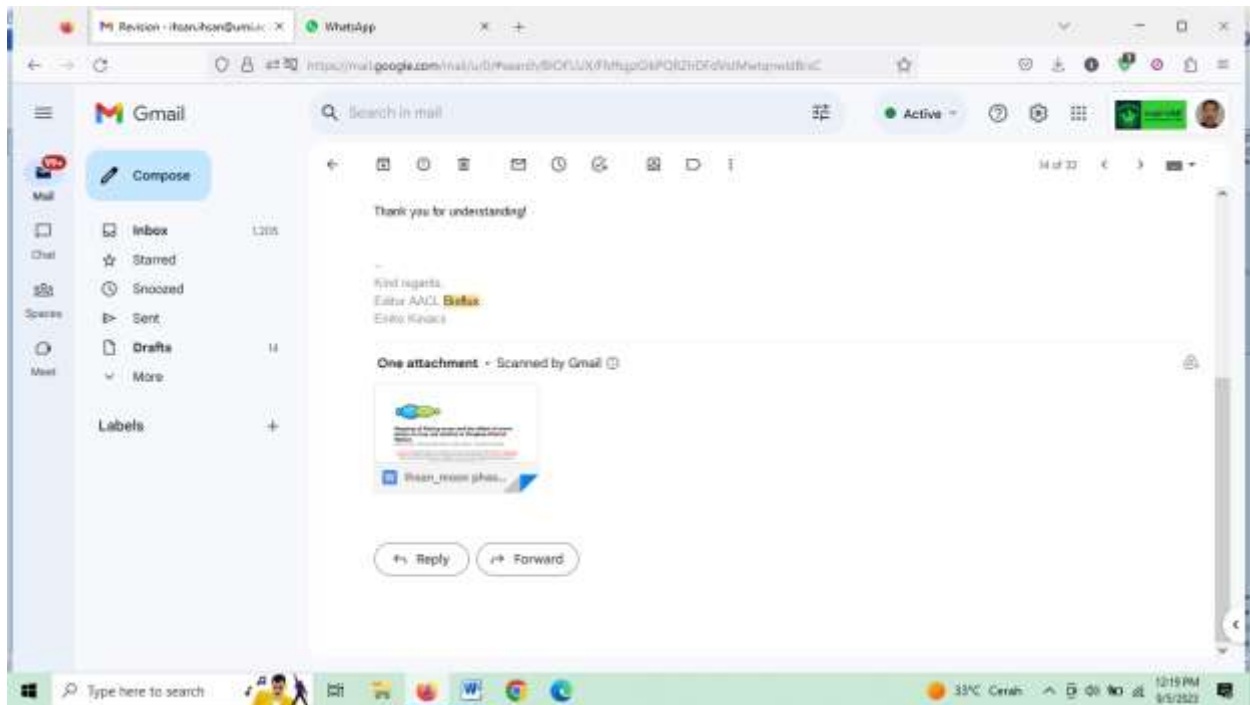
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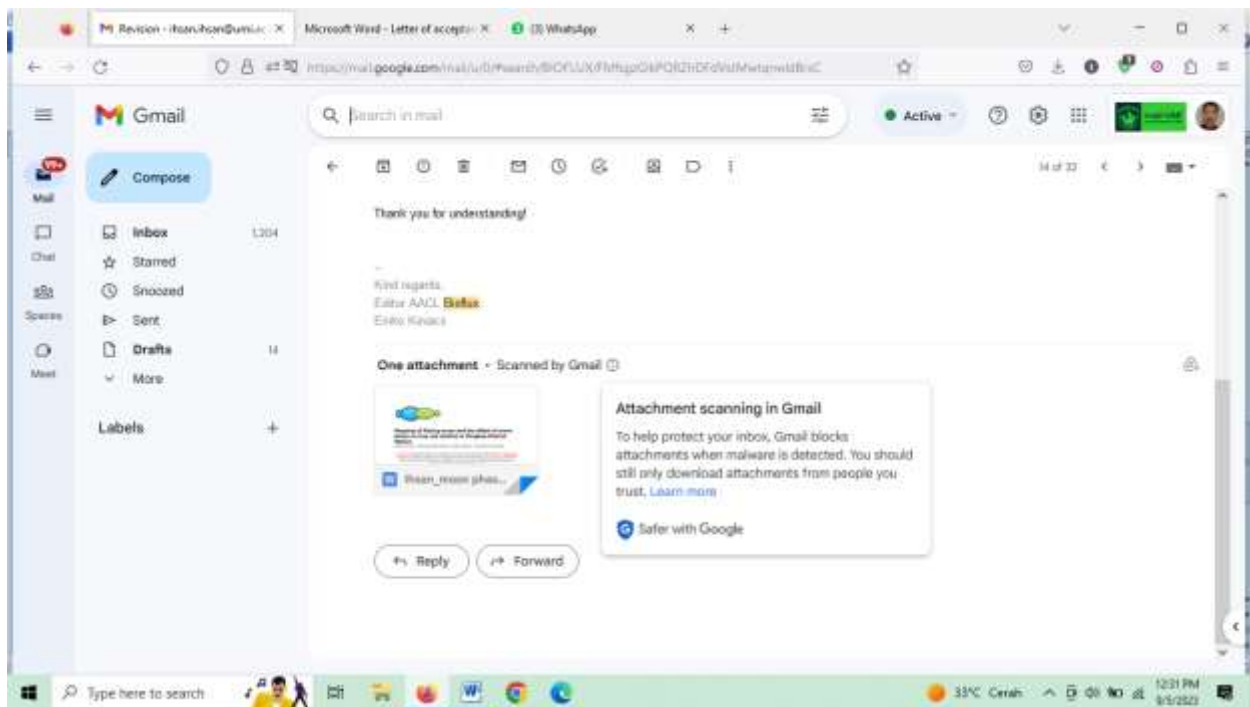
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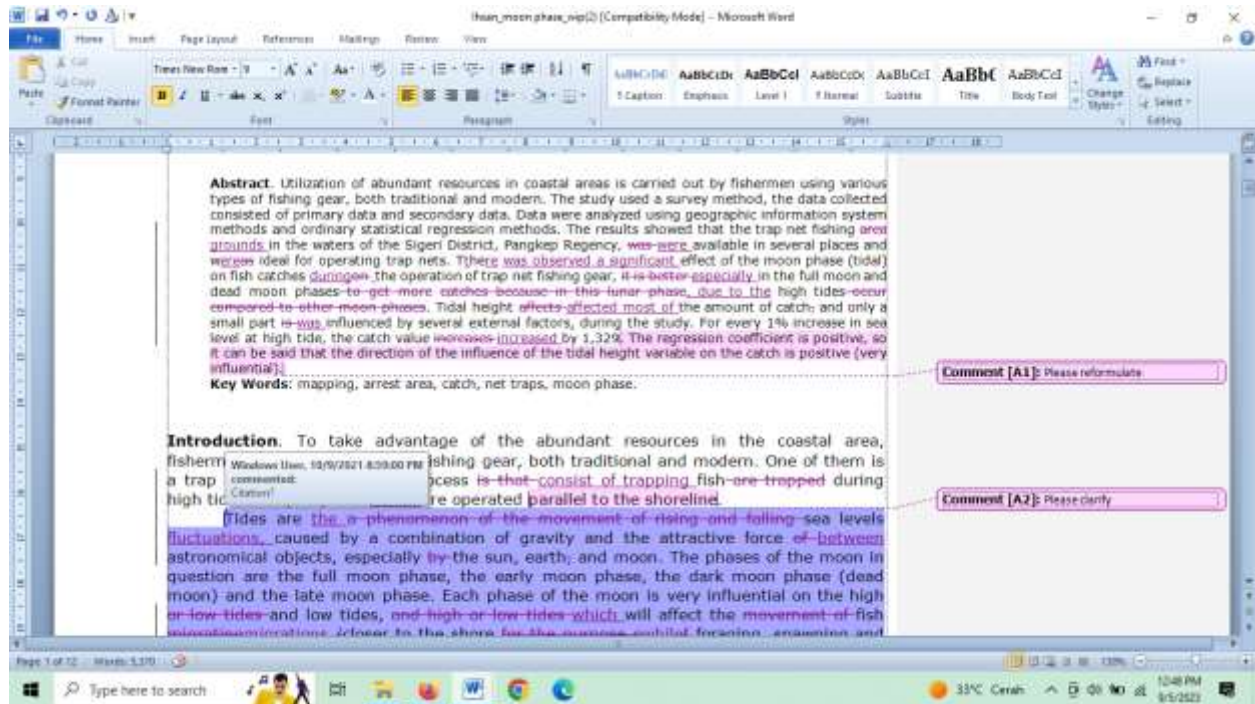
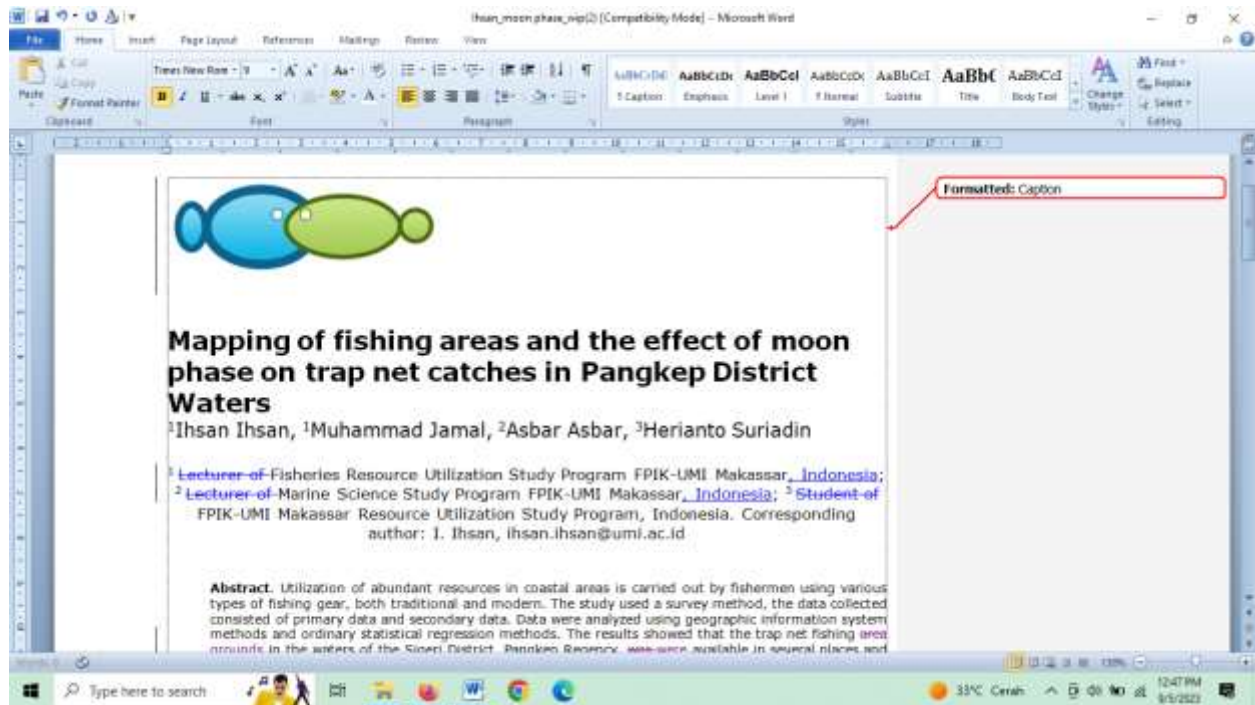
Ihsan I., Jamal M., Asbar A., Suriadin H., 2022 Mapping of fishing areas and the effect of the moon phase on trap net catches in Pangkep District Waters, Indonesia. *AACL Bioflux* 15(1):272-281.

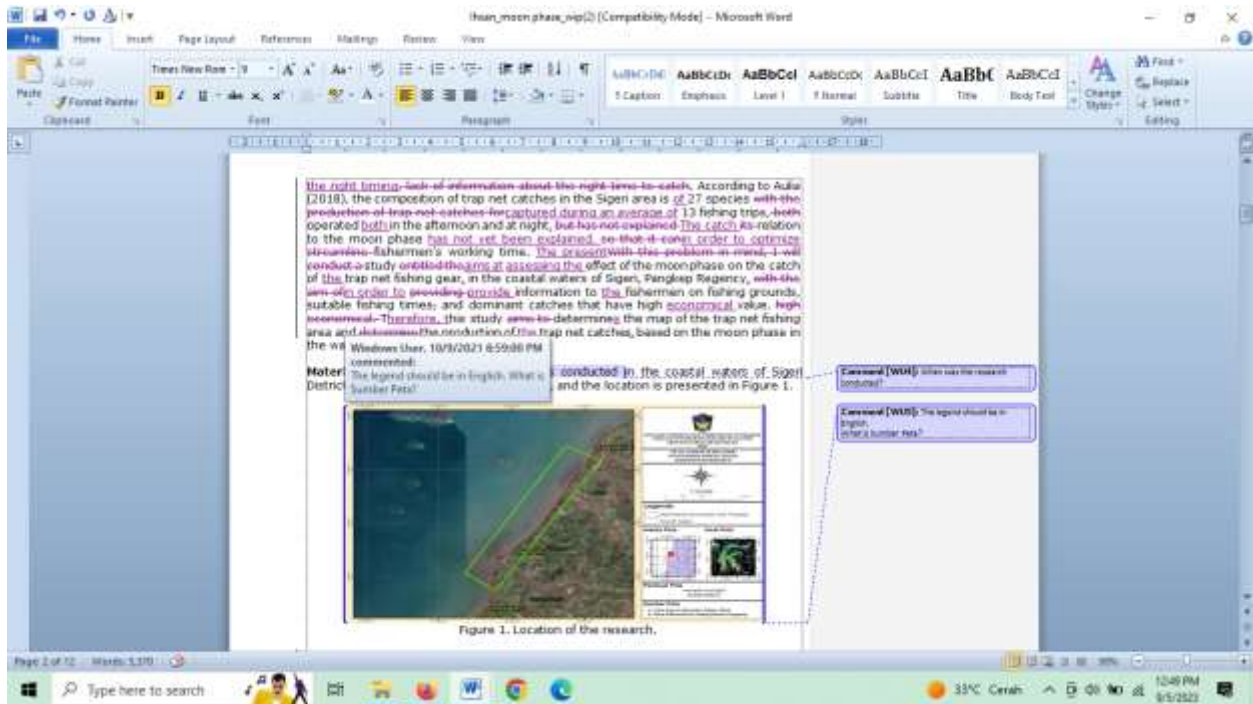
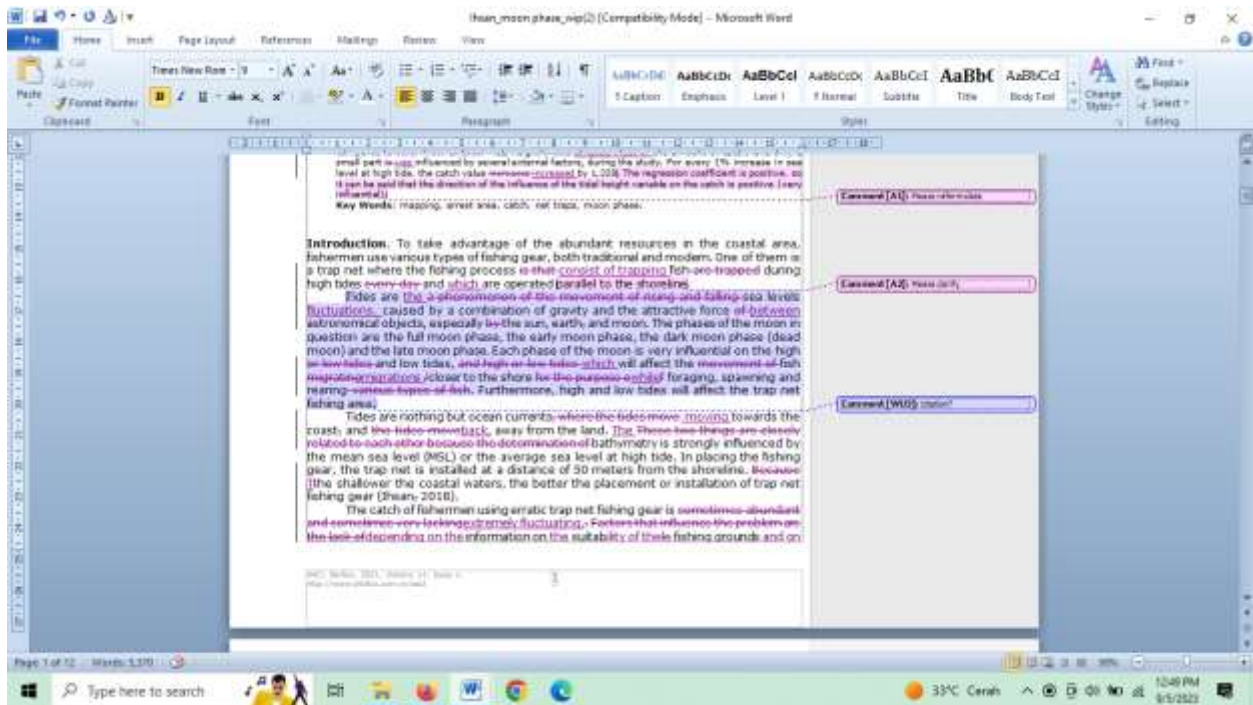
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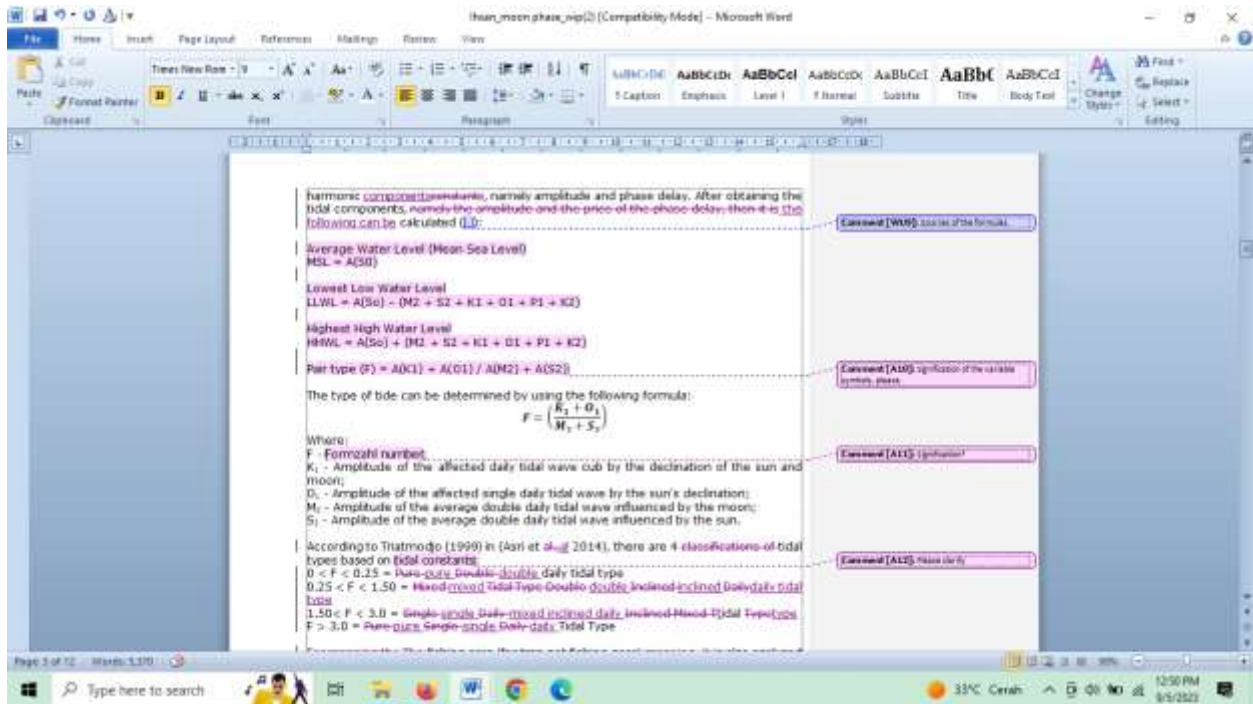
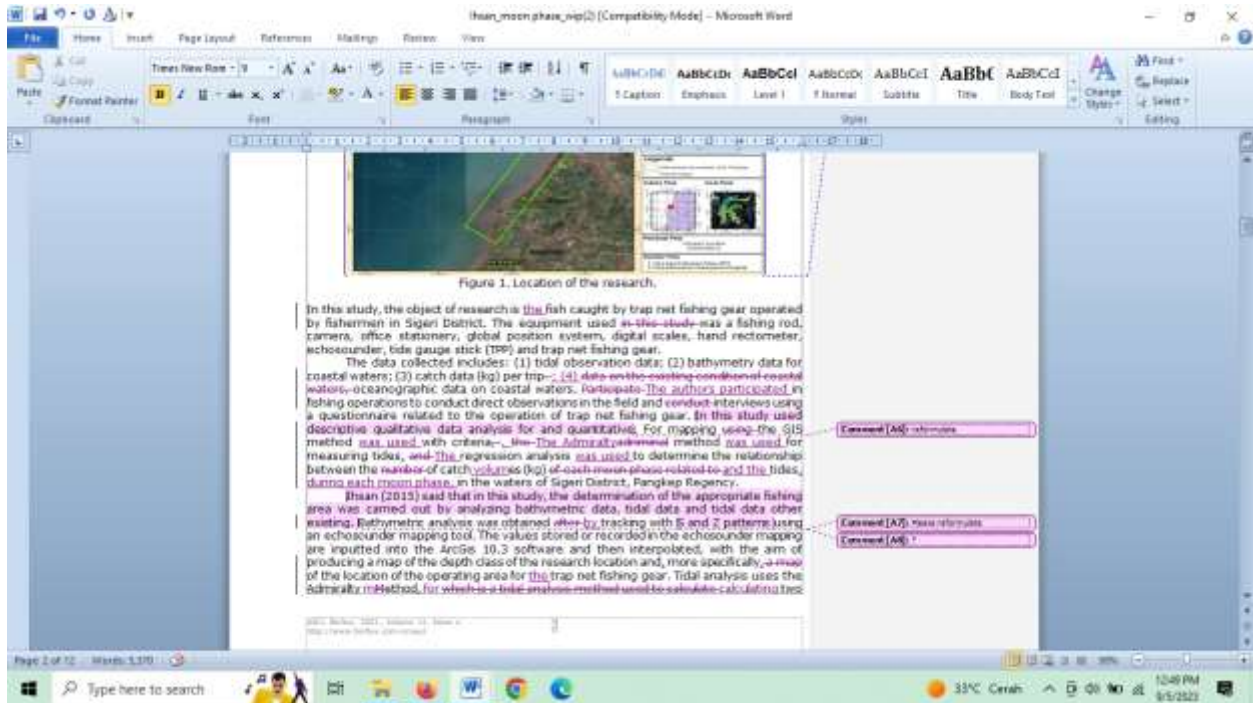


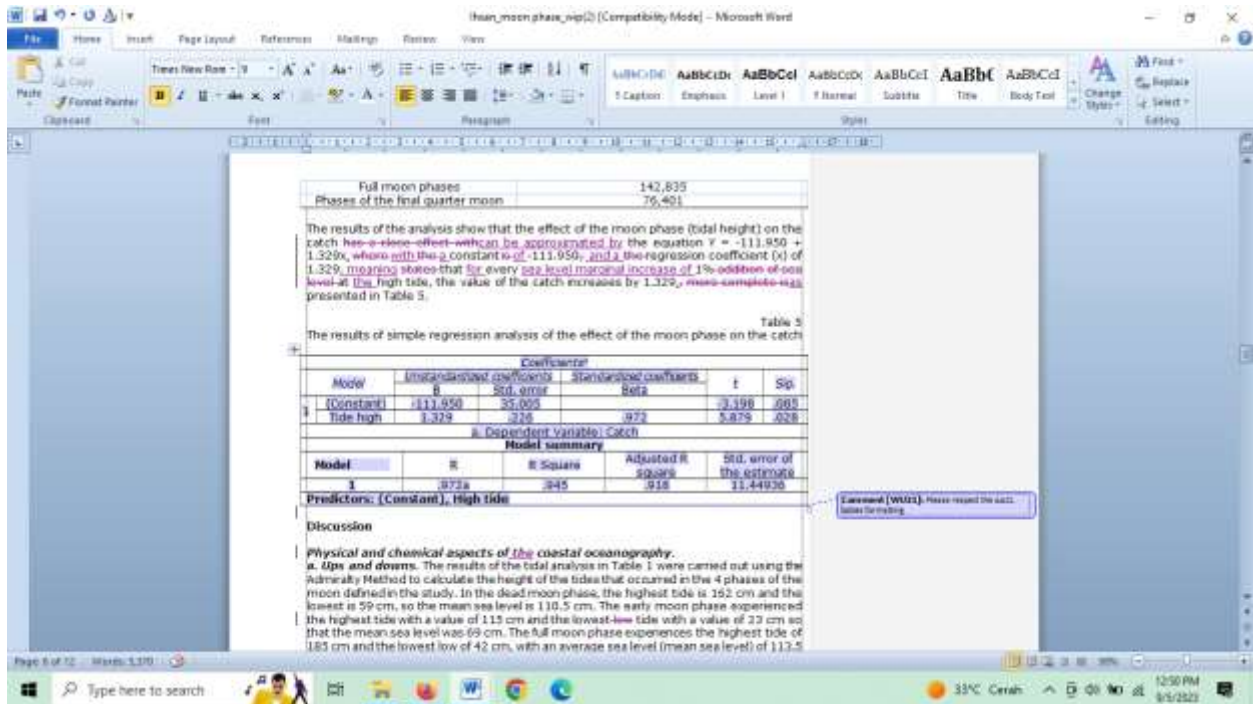
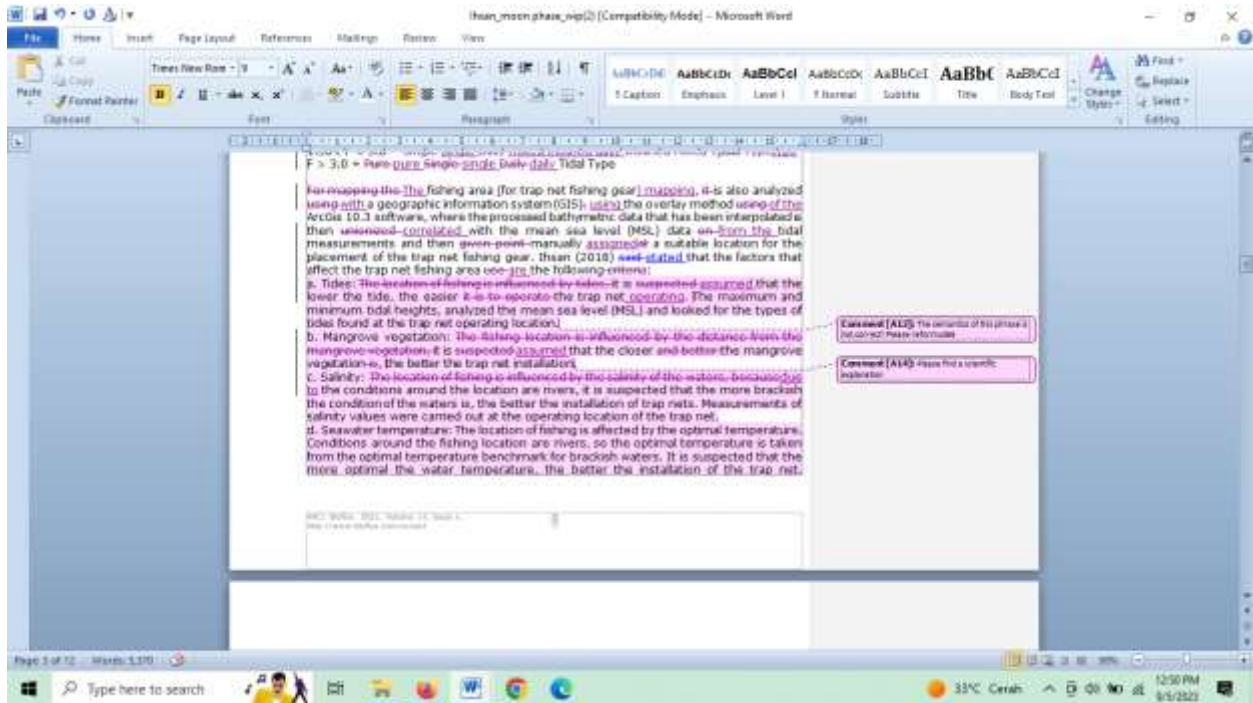


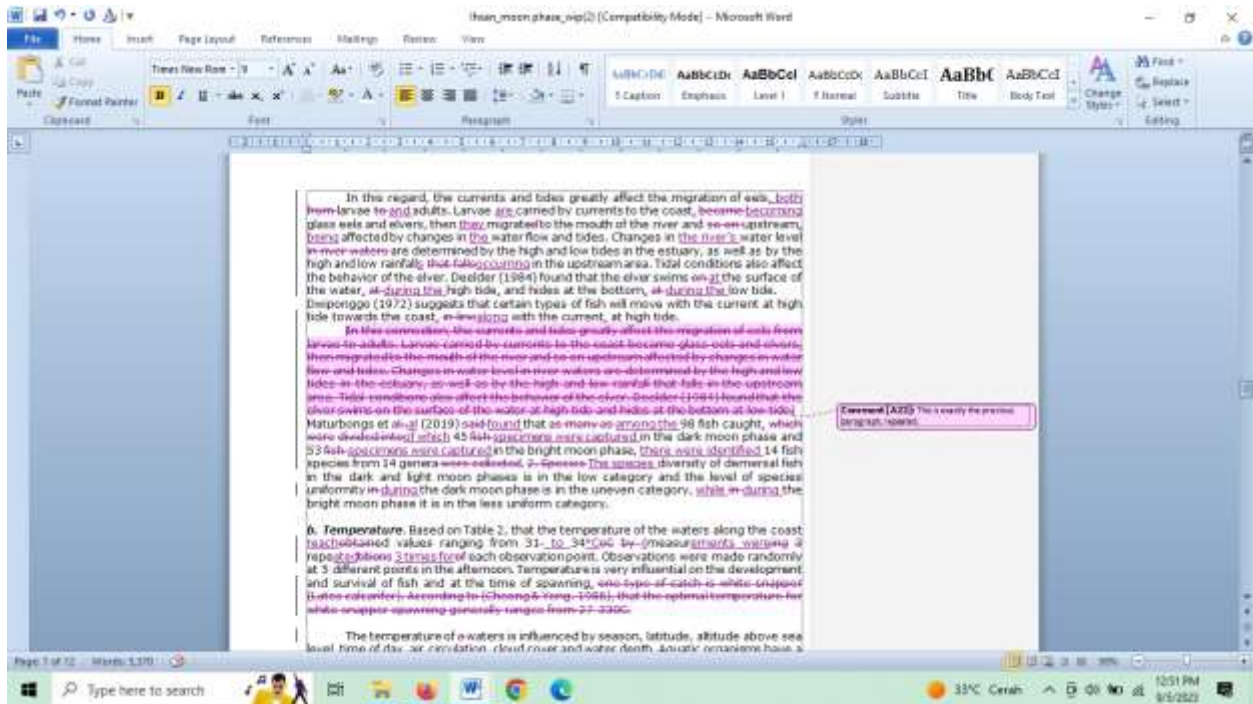
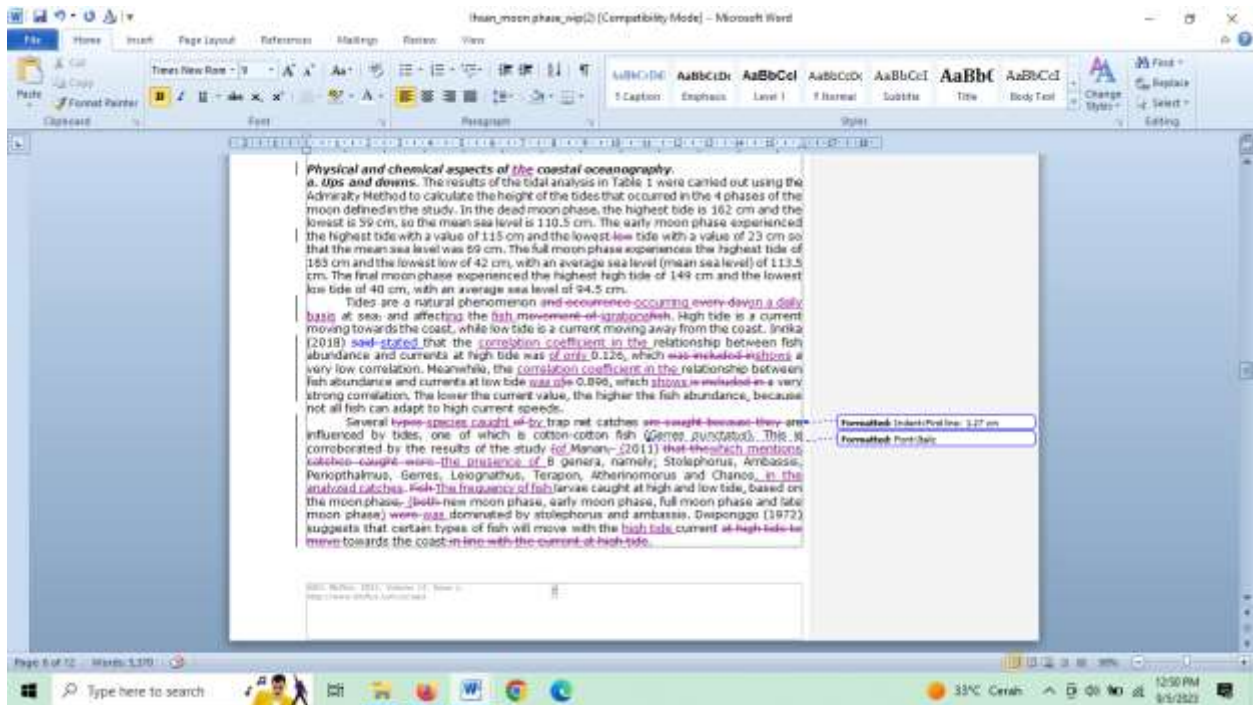


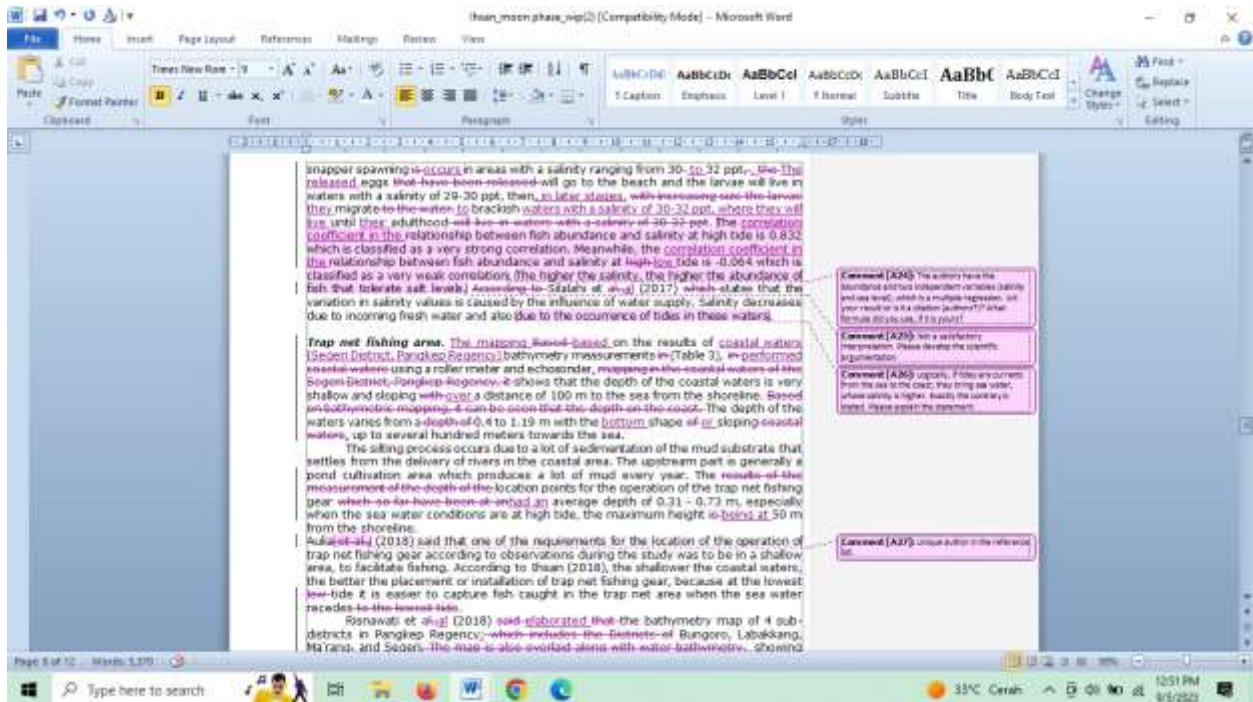
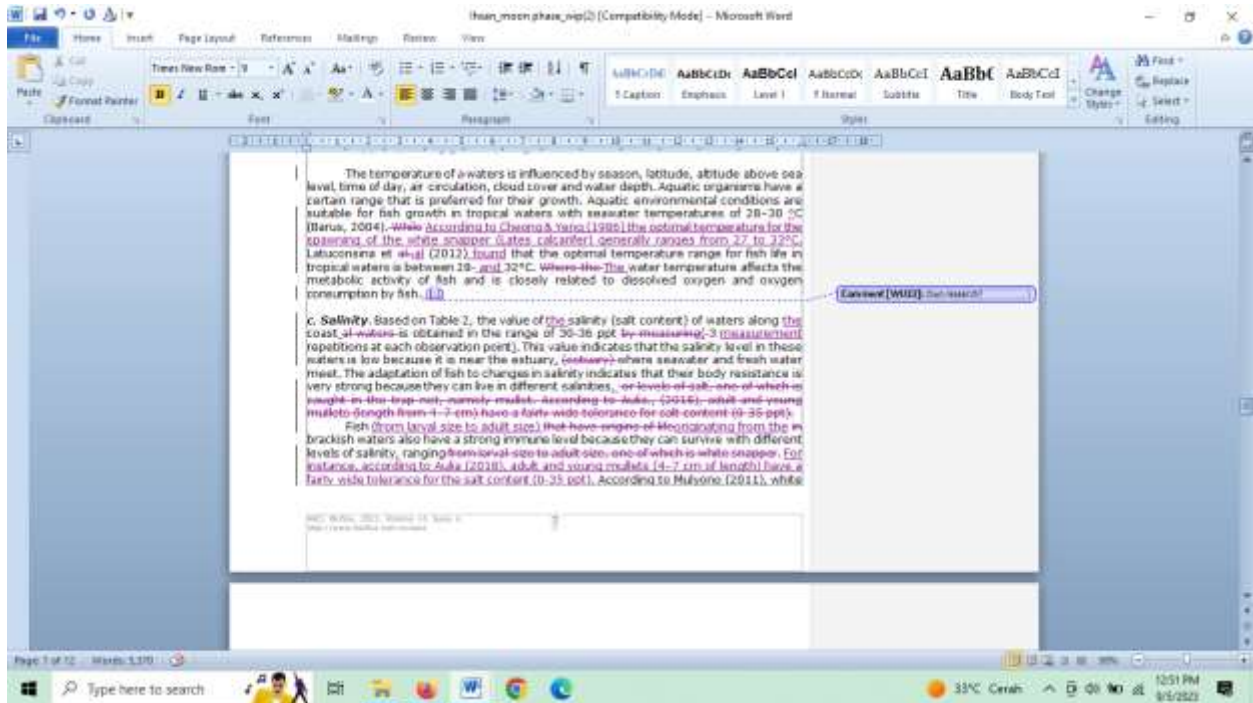




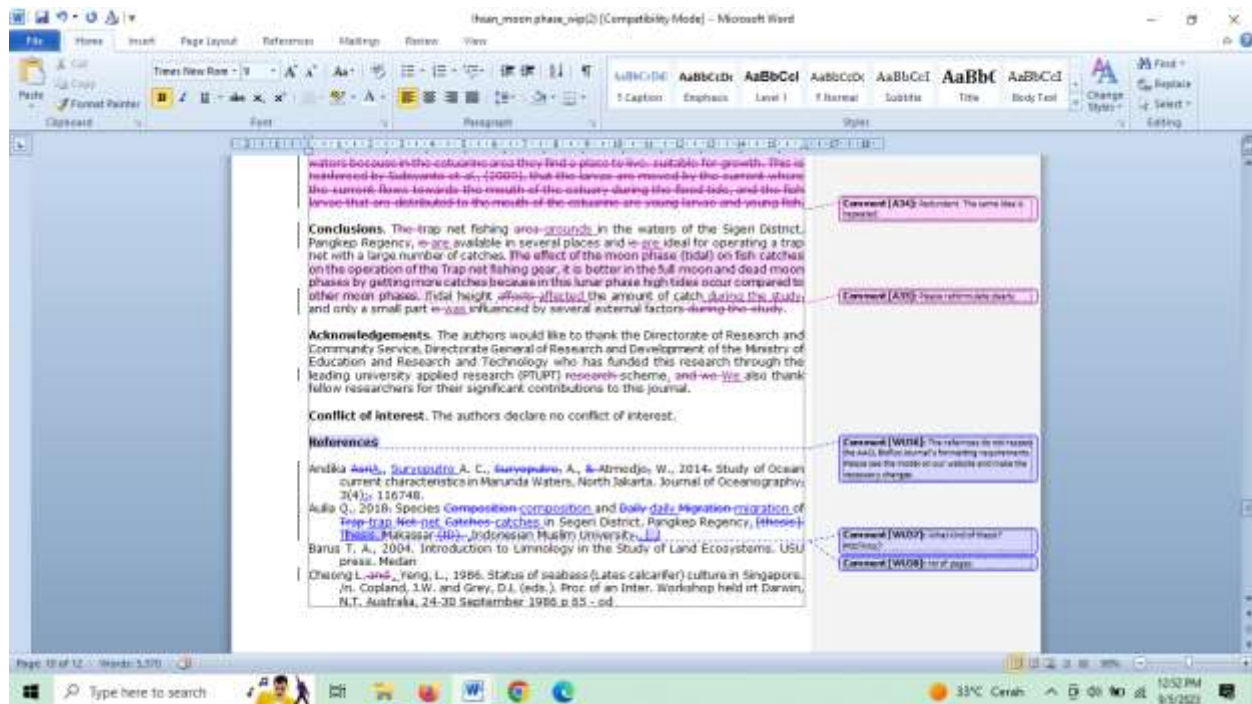
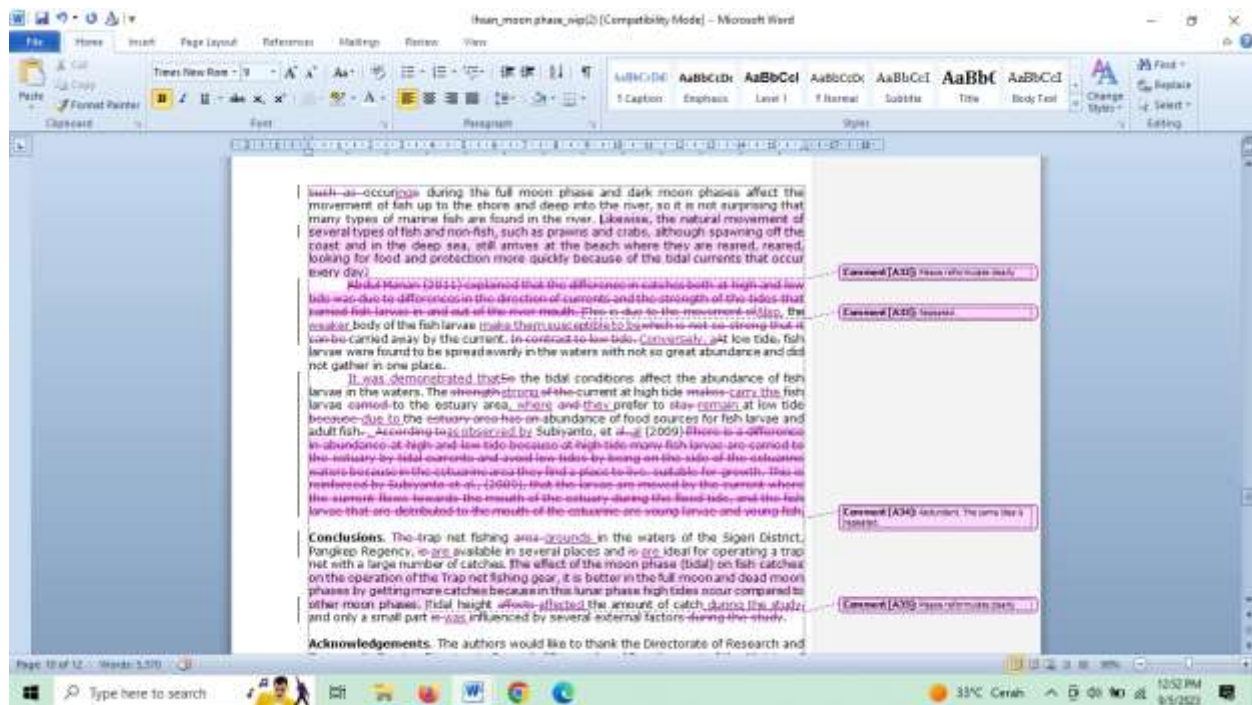




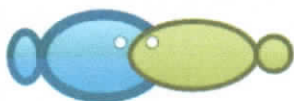








**Usulan ke-15. Submission letter sebelum jurnal diterbitkan pada volume 15  
Issue 1 di Jurnal Bioflux**



## Submission letter

**Article title: Mapping of Fishing Areas and the Effect of Moon Phase on Trap Net Catches in Pangkep District Waters**

Name of the authors: Ihsan, Muhammad Jamal, Asbar, Herianto Suryadin

Here by I would like to submit the manuscript entitled “**Mapping of Fishing Areas and the Effect of Moon Phase on Trap Net Catches in Pangkep District Waters**” to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarised text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve of this submission.

Author

Ihsan

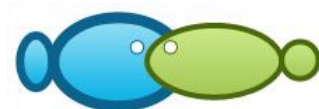
Muhammad Jamal

Asbar

Herianto Suryadin

\*First author: [ihsan.ihsan@umi.ac.id](mailto:ihsan.ihsan@umi.ac.id)

**Usulan ke-17. mendapatkan Certificate/Letter of preliminary acceptance dari  
Editor Jurnal Bioflux atas diterbitkannya naskah kami  
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Authors:

**Ihsan Ihsan, Muhammad Jamal, Asbar Asbar, Herianto Suriadin**

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of the scientific/academic journal: Aquaculture, Aquarium, Conservation & Legislation –  
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