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Exploitation Levels and Population Dynamics Analysis of Rock Lobster (*Panulirus Ornatus*)

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Abstract: Level of utilization of Rock Lobster **(***Panulirus ornatus***)** resources found in Salemo Island waters, Kab. Pangkep South Sulawesi has not yet reached the Maximum Sustainable Yield level (Hasrun.2002), but if it is managed continuously without control over the use of non-environmentally friendly fishing gear it can result in overfishing. Rock Lobster is a resource that can be recovered, but without serious management it can disrupt the sustainability of the stock. Rock Lobster **(***Panulirus ornatus***)** is a marine biota that is widely used as a consumption commodity, both for the domestic market and for export needs). High market demand has the potential to reduce stocks in nature due to overfishing

This research was conducted on March 1, 2022 – April 30, 2022 on Salemo Island, Kab. Pangkep Province of South Sulawesi. The number of rock lobster measured was all the catches of fishermen. The number of of rock lobster measured was all the catches of the maximum number of fishermen 275. Carapace length (cm) was measured using a vernier caliper with an accuracy of 0.1 cm.. dan Permen Kelautan dan Perikanan No.1 tahun 2015. Carapace length measurement starts from the spine above the eye to the tip of the carapace on the dorsal indentati, (Sparre *et al.,*1999). The weight of the of rock lobster was weighed using a digital scale with a capacity of 5 kg and an accuracy of 1 gram. Data analysis using the method Elefan I (Electronic Lenght Frequencys Assesment Tool) program FISAT II (Fao-Iclarm Fish Stock Assesment Tool).

The results of this study indicate that the population dynamics of pearl rock lobster the first time it is caught is 8.25 cm with maximum carapace length 18.90 cm. Exploitation rate = 0,22/ year with criteria *underfishing* (E < 0,5) with utilization rate 22 % and allow upgrade up to 20 %.

Keywords: Rock Lobster**,** Population Dynamics, Exploitation, Salemo Islan

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1. Introduction

Indonesia is the largest archipelagic country in the world, consisting of oceans and large and small islands. The area of Indonesian sea waters is estimated to reach 5.8 million km2 or about two-thirds of Indonesia's territory, with a coastline length of 81,000 km (Simbolon, 2011) and has the highest biodiversity in the world (mega biodiversity).

South Sulawesi's potential fish resources are in the Fisheries Management Area (WPPI) 713 covering the waters of the Makassar Strait, Bone Bay, Flores Sea and Bali Sea. Meanwhile, the estimated potential for fish resources in WPP 713 is 929,700 tonnes/year (data based on the Decree of the Minister of Marine Affairs and Fisheries). RI Fisheries Number KEP.45/MEN/2011 concerning Estimation of the Potential of Fish Resources in the Fisheries Management Area of the Republic of Indonesia.

Salemo Island Kab. Pangkep South Sulawesi, which is located in the waters of the Makassar Strait, South Sulawesi consists of 120 islands, is one of the areas with a wide distribution of coral as a producer of pearl crayfish (Panulirus ornatus), which is quite large, however, the existence of certain types of crayfish populations is not yet known. been exploited by local fishermen, the number and type of fishing gear in operation and the fishing season, (KKP. 2019). Level of utilization of crayfish (Panulirus spp) resources found in Salemo Island waters, Kab. Pangkep South Sulawesi has not yet reached the Maximum Sustainable Yield level (Hasrun.2002), but if it is managed continuously without supervision and control over the use of fishing gear that is not environmentally friendly it can result in overfishing or over fishing. Even though crayfish are a resource that can recover, without serious management it can cause disruption to the sustainability of the stock (Hasrun, 2002). Pearl crayfish (Panulirus ornatus) is a marine biota that is widely used as a consumption commodity, both for the domestic market and for export needs (Hilal & Fachri 2016). High market demand has the potential to impact on the decline in natural stocks due to overfishing (Kadafi et al. 2006).

Pearl crayfish (P. ornatus) found on Salemo Island, Pangkep Regency, have long been exploited by fishermen, this is due to the combination of beautiful patterns and colors and the selling price is higher than other types. Information on the management of these crayfish and aspects of their population dynamics has not been widely carried out and there are indications that local fishermen catch crayfish using non-selective fishing gear, toxic materials and bombs which can damage pearl crayfish populations and habitat (P. ornatus) so it is feared that it will have an impact on the decline in the population. The utilization of pearl crayfish (P. ornatus) fishery resources needs to be managed in a sustainable manner, meaning that its utilization should not exceed the available sustainable potential, so it is necessary to carry out research on aspects of pearl crayfish (P. ornatus) population dynamics on Salemo Island, Pangkep Regency.

2. Research Methods

Time and Place of Research

This research was conducted on 1 February 2022 – 30 April 2022 on Salemo Island, Pangkep regency, Province of South Sulawesi (Figure 1).

Figure 1. Map of Research Locations

Research Methods

Tools and Materials

The tools used in collecting primary data include stationery, meters, digital cameras, scales. The material used in this study was Pearl Coral Shrimp (Panulirus ornatus).

Research procedure

The number of crayfish measured was all caught by fishermen who were landed, so that each crayfish has the same opportunity to be sampled and at the same time the bias can be reduced. Sampling time was once a week for 3 months. Carapace length (cm) was measured using a caliper with an accuracy of 0.1 cm (Figure 2). The limit for measuring carapace length starts from the spine above the eye to the tip of the carapace on the dorsal indentation, (Sparre et al., 1999) and Maritime Affairs and Fisheries Regulation No. 1 of 2015. The weight of crayfish is weighed using a digital scale with a capacity of 5 kg and accuracy level of 1 gram.

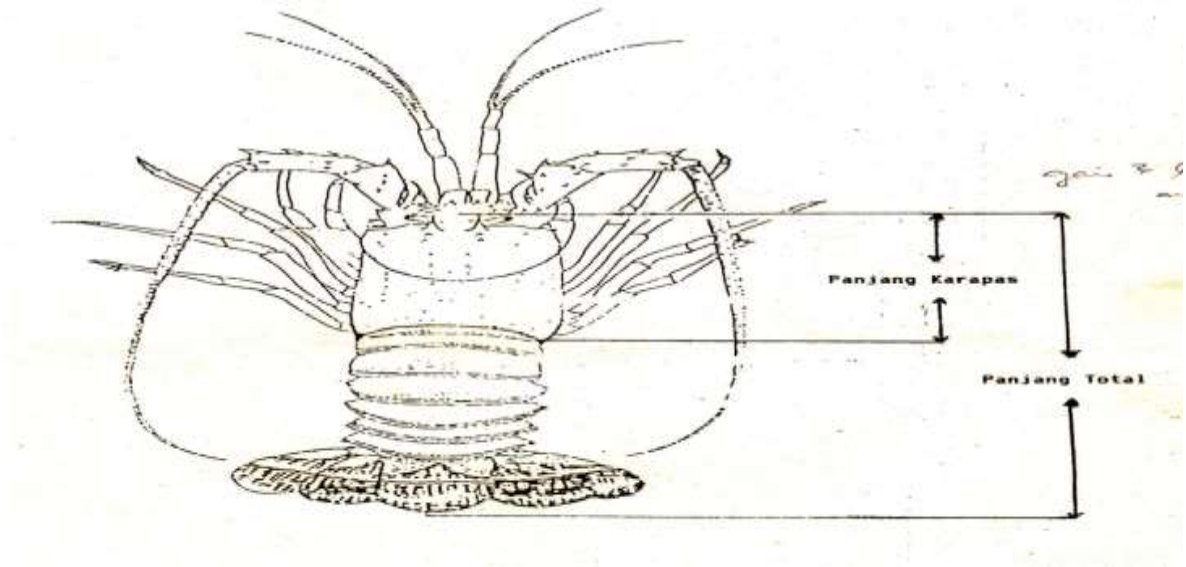


Figure 2. Total Length and Carapace Length of Pearl Coral Shrimp
(*Panulirus ornatus*)

Method of collecting data

Sampling for 3 months. The data used in this study is primary data derived from preliminary research in the form of captured pearl crayfish (P. ornatus). Besides that, other primary data collection is in the form of measurement of length and weight data, and the level of maturity of the gonads. Measurement of length and weight data was carried out by taking pearl crayfish (P. ornatus) caught by fishermen, namely pearl crayfish which were measured for carapace length (cm) and weight (grams). Estimation of population parameters in the form of length first caught (Lc), age group, growth parameters (L∞, K, t0), natural mortality rate (M), fishing mortality rate (F) and exploitation rate (E).

Data Analysis

Length of Crayfish First Caught (Lc)

Estimating the value of Lc can be seen in the carapace length frequency data, which is the result of calculating the highest mode mean value from the class midpoint frequency. Analysis of the long frequency distribution of crayfish was carried out using the normal distribution approach which can be estimated using the equation proposed by Wiadnya, et al (1997) as follows:

$$f_c(L) = \frac{n\ x\ dl}{s\sqrt{2\pi}}\ x\ e^{\left[\frac{L-\bar{L})^2}{2x^2}\right]}$$

Where:

f_c (L) = Frequency of crayfish belonging to the long class

dl = Interval of each long class

π = 2.14

e = 2.72

n = Number of samples in the sampling

L = Middle class long

$\bar{L}$ = Average length of one cohort

s = standard deviation to mean length

Estimating the average standard deviation of crayfish length from each data length, the above equation is transferred into a linear form, namely:

$$\Delta \ln fc\,(z) = a - b\,x\,\left[L + \left(\frac{dl}{2}\right)\right]$$

Where:

Δ ln⟦fc (z)⟧ = Difference between two length classes in ln

z = Symbol for the difference of two length classes

[L+ (dl/2)] = Upper limit of each length class

a, b = Constants

The mean and standard deviation of the length of each cohort is estimated by:

$$\bar{L} = \frac{a}{b} \quad \text{dan,} \quad s^2 = \frac{dl}{b}$$

The average length ($\bar{L}$) can be calculated if the length L' is known (the length where the length of the crayfish at that size is longer than the full catch). L' is the lower bound of the class interval. If the value of L' is known then the average length can be calculated. The value of $\bar{L}$ is always greater than L' and L' is always greater than the length it was first caught (Lc < L' < $\bar{L}$). The average length can be calculated with the following equation (Sparre and Venema, 1999):

$$\bar{L} = \frac{\Sigma C * L}{n}$$

Age Group

The size composition of crayfish was made in the form of carapace length classes and determining the frequency of carapace length measurements using the Sturges method. According to Sturges' rules, there are several steps that need to be taken in determining class categories including:

1. Calculating the amount of data range/range (R)

Range = the largest observation value - the smallest observation value

2. Determine the number of classes (K)

According to Andi Hakim Nasution and Barizi, the number of classes can be determined by: if observations (n) < 250, then the number of classes is 9 and if observations (n) ≥ 250 then the number of classes can be calculated using the formula: 1 + (10/3) log n.

3. Determine the class interval (P), namely the amount of data range divided by the number of observation classes (R/K).

4. Determine class limits, namely the value of the upper class limit and the lower class limit. The lowest and (the lowest – 1 + interval).

Then graphs were created using the Microsoft Excel program.

Estimation of Growth Parameters

Calculation of the growth equation uses the ELEFAN I (electro length frequency analysis) method contained in the FISAT II program package. L∞ can be estimated using Pauly's (1984) formula with the formula:

$$L\infty = Lmaks/0{,}95$$

Where:

Lmax = the highest sample length obtained

In the ELEFAN I program the data used will produce troughs and peaks to estimate the appropriate index (Rn) in the formula:

$$R_n = 10\frac{ESP}{ASP}/10$$

Where:

ASP = Available Sum Peak
ESP = Explained Sum Peak
The Rn value (fit index) is used to estimate the K value (growth coefficient) in the form of a scale from 0.1 to 10.0. Then to get the best estimate of the value of K using the output from the Response surface analysis. Determination of the t0 value according to Saputra (2009) uses Pauly's empirical formula using a multiple regression relationship between the theoretical age at zero fish length (t0) with infinity length (L∞) and K, which are as follows:

$$Log - t0 = -0{,}3952 - 0{,}2752\, Log\, L\infty - 1{,}038\, Log\, K$$

Where:
L∞ = Infinity length (cm)
K = Von Bertalanffy growth coefficient
The growth rate is estimated by the Von Bertalanffy model (Gulland, 1980) with the following formula:

$$Lt = L\infty\,(1 - e^{-k(t-t0)})$$

Where:
Lt = length of fish at age t (cm)
L∞ = Infinity length (cm)
t0 = Theoretical age of fish at 0 length
K = Von Bertalanffy growth coefficient

Level of Exploitation
Mortality Rate Estimation
The calculation of the Z value (total mortality) was obtained using the catch curve method which was converted to length, in the FISAT II program package. The formula for calculating the value of Z is as follows:

$$\mathrm{In}\left(\frac{\mathrm{Ni}}{\Delta \mathrm{ti}}\right) = \mathrm{a} + \mathrm{b} \cdot \mathrm{ti}$$

Where:
Ni = number of fish in class i length
Δti = time needed for fish to grow at class i length
ti = age at the median length of class i
M (natural mortality) is calculated based on Pauly's (1984) empirical formula by entering the parameters K per year, L∞ (mm), and T (average annual water surface temperature in degrees Celsius). Pauly's empirical formula is as follows:

$$Log\, M = -0.0066 - 0.279\, Log\, L\infty + 0{,}6453\, Log\, K + 0{,}4634\, Log\, T$$

Where:
M = Coefficient of natural mortality
L∞ = Infinity length (cm)
K = Von Bertalanffy growth coefficient
T = The average temperature of Indonesian waters is approximately 28°C (Subani 1977 and SST data for September 2012 to January 2013)
Capture mortality (F) can be calculated by subtracting total mortality (Z) from natural mortality (M), with the formula below:

$$Z = F + M, becomes: F = Z - M$$

Based on the estimated value of the mortality rate due to fishing (F) divided by the total mortality rate (Z), the exploitation rate (E) can be estimated by the following formula:

$$E = F/Z$$

If the value of E = 0.5 indicates that the value is optimum (Eopt), this is based on the assumption that a balanced result is optimum when F=M (Gulland 1971 in Pauly 1983).

Exploit Rate (E)

The level of utilization or exploitation (exploitation rate) of fisheries can be known especially for caught bamboo shrimp, so the Beverton and Holt formula can be used:

$$E = \frac{F}{F+M} = \frac{F}{Z}$$

3. Results and Discussion

Research Locations

Pangkajene and Islands Regency is a part of the province of South Sulawesi which is located between 1 10°E and 4°40'S and 8°00'S or is located on the coast of the West Coast of South Sulawesi Province which consists of lowlands and mountains. The lowland area of 73,721 ha, stretching from the west to east coastline, consists of rice fields, swamps and ponds.

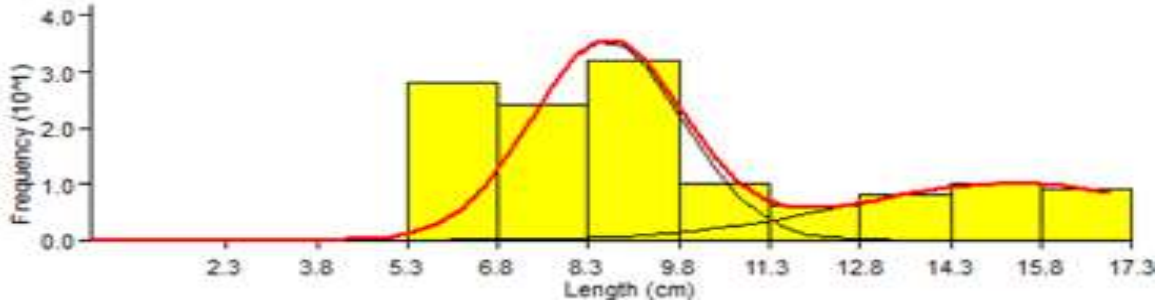
Geographically, Salemo Island is a coastal area located at position 04042'28.8" South Latitude and 119026'56.4 East Longitude, with administrative boundaries; To the north it is bordered by the Makassar Strait, to the east by the Pangkep coast, to the south by Mattiro Kanja Village, and to the west by Mattiro Walie. The area of Mattiro Bombang Village is 2,200 Ha, 6.71 Ha and the Karang area, 2,104.07 Ha.

Length of Crayfish First Caught (Lc)

The first caught length (Lc) of pearl crayfish can be calculated based on carapace length frequency data. The purpose of calculating this Lc is to find out the length where 50% of the pearl crayfish is retained and 50% of it passes through the mesh (Sparre and Venema, 1999). The Lc value obtained from the calculation of crayfish with the equation L_c = (-a)/b and with Paying attention to the fishing gear used to catch crayfish is bottom gill nets, so this Lc value is very influential. The results of an analysis of the size of pearl crayfish caught for the first time in the waters around P. Salemo showed an Lc value of 8.25 cm (Appendix 2). Bakhtiar et al., (2013) explained that crayfish in Cilacap waters are included in the growth-overfishing category because the crayfish caught are dominated by small sizes (Lc 50% = 43.50 mm).

Age Group

The results of the grouping analysis of the carapace length mode of the pearl crayfish found two age groups for each fishing operation, namely there were two age groups for the length of the crayfish. Based on (Figure 3), it shows that the catches that produced each of the two cohorts at the start of the study occurred in March 2022 and April 2022.



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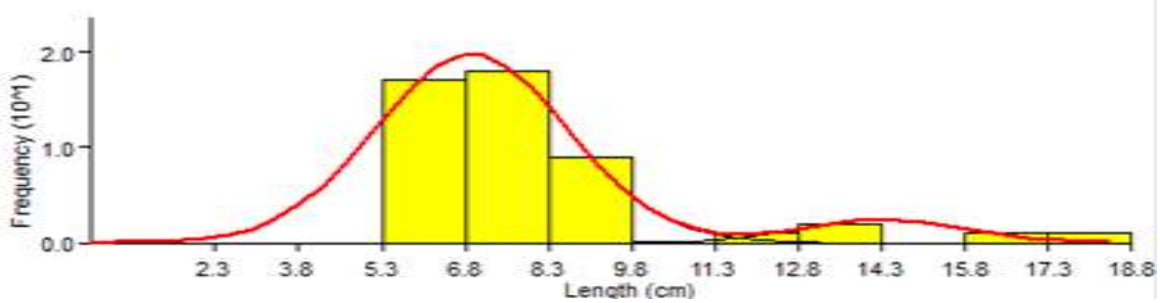

April 2022

Figure 3. Age Group Curve of Pearl Coral Shrimp (P. Ornatus)

The difference in the number of cohorts caught was more due to the recruitment (entry) of new individuals from spawning crayfish that occurred in the previous months so that in the following month two cohorts were found. The mode shift of each carapace length group of crayfish generally occurs in young crayfish, namely in the carapace length range of 6.0 cm – 18.0 cm. This is because young crayfish generally grow faster than older crayfish (Dina, 2008).

Based on Bhatacharya's model analysis which is based on carapace length data during 2 months of crayfish fishing operations, it is obtained that there are 2 cohorts. This shows that it is suspected that the fishing gear used to catch crayfish in the waters of Salemo Island catches all age groups so that it has a low selection rate and it is feared that crayfish that have not had time to regenerate will also be caught.

The data were obtained and processed using the ELEFAN I method found in FISAT and obtained a value of (L∞) = 18.90 cm, K = 0.74 per year and t0 = 0.395. The value of the growth coefficient that has been obtained is then using the VBGF method (von Bertalanffy Growth Formula through FISAT II) and to find out the growth rate by entering that value. The results of calculations using this method can be seen in (Figure 4, Figure 5 and Appendix 3).

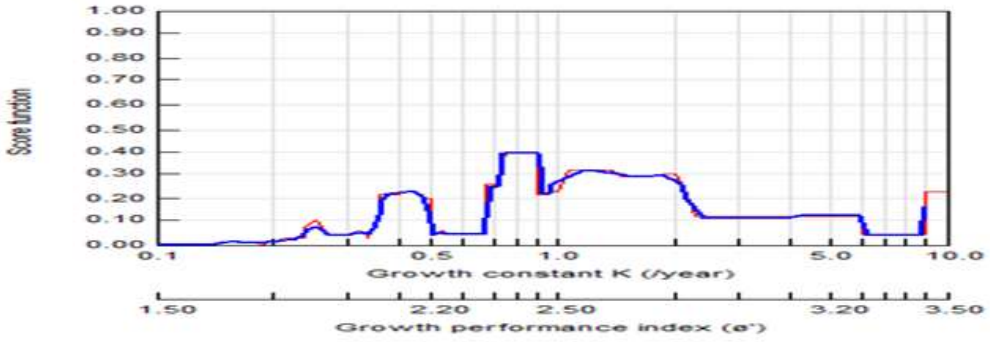

Figure 4. K and L∞ Value Analysis Curve for Pearl Coral Shrimp (P. Ornatus) Elefan I Method on Scanning Of K-Value Physicist Program II

This is usually referred to as the fast and slow growth of a species which is represented by K and R values (Begon et al, 2005). Species that have a large growth coefficient (K) value generally have a shorter lifespan (Dina, 2008). Pearl crayfish growth curve based on the Von Bertalanffy method with plots of crayfish age (months) and theoretical length (cm).

Based on the pearl crayfish growth curve using the Von Bertalanffy method, the equation L∞=18.90 is obtained.

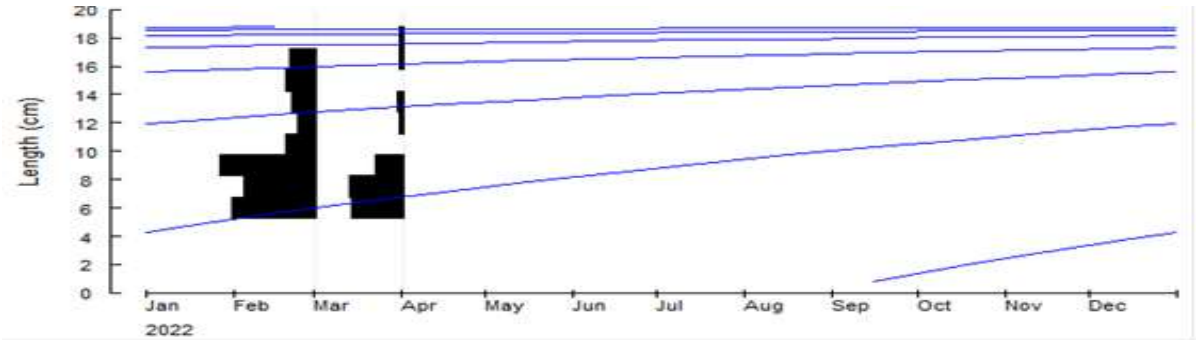

Figure 51. Graph of Pearl Coral Shrimp (P. ornatus) Growth Rate

The large crayfish caught have not reached their maximum carapace length and have a fast growth rate. Mallawa (1996) explained that if the value of K > 0.5 then the growth is relatively fast. Pearl crayfish caught are able to reach a maximum carapace length of 18.90 cm or 180.90 mm after being over 8 years old and if the pearl crayfish has reached its maximum carapace length it is estimated that it will experience natural mortality

so that pearl crayfish are long-lived species. Sparre and Venema (1999) explain that some long-lived species almost reach their maximum carapace length at 5 years and above and have high K values.

Kuthalingham et al. (1980) reported that monthly growth of crayfish was increased between 2-3 mm carapace length (CL). MacDonald (1982) observed that the sexual maturity of female crayfish was 8.2 cm (CL). Frisch (2007) states that it takes 3 years to reach sexual maturity and 10-12 years to reach maximum size. Maximum size can be reached at 40 cm in total length, although the average adult total length is less than 30 cm. Crayfish spawning occurs throughout the year in Palau (MacDonald, 1982). Growth of crayfish Batu Hijau crayfish (P. homarus) is in the medium to fast category, with K males (0.31) and K females (0.26); (Bakhtiar et al., 2013)

Estimation of Mortality Rate and Exploitation Rate (E)

Estimation of the total mortality rate (Z) of pearl crayfish was carried out by estimating the catch curve converted to length (Length-converted catch curve) using FISAT II software version 1.2.2, then inputting the values of L∞ and K. The calculation results obtained Z values is 2.17/year so that it can be explained that the total mortality rate consists of the natural mortality rate and the fishing mortality rate (Table 1).

Table 1. Mortality and Exploitation Rates of Pearl Coral Shrimp (P. Ornatus)

No.	Parameter	Value (Year)
1.	Total mortality (Z)	2.17
2.	Natural mortality (M)	1.70
3.	Catch mortality (F)	0.47
4.	Eksploitation rate (E)	0.22

The natural mortality rate of pearl crayfish is more common in crayfish between 1 and 2 years old (Table 2). This is thought to occur because young pearl crayfish have not been able to adapt to environmental conditions and often experience moulting which causes high cannibalism among pearl crayfish. In addition to natural mortality, mortality due to capture occurs mostly in adult pearl crayfish and young crayfish are also caught, so the higher the natural mortality and fishing mortality, the pearl crayfish population will decrease.

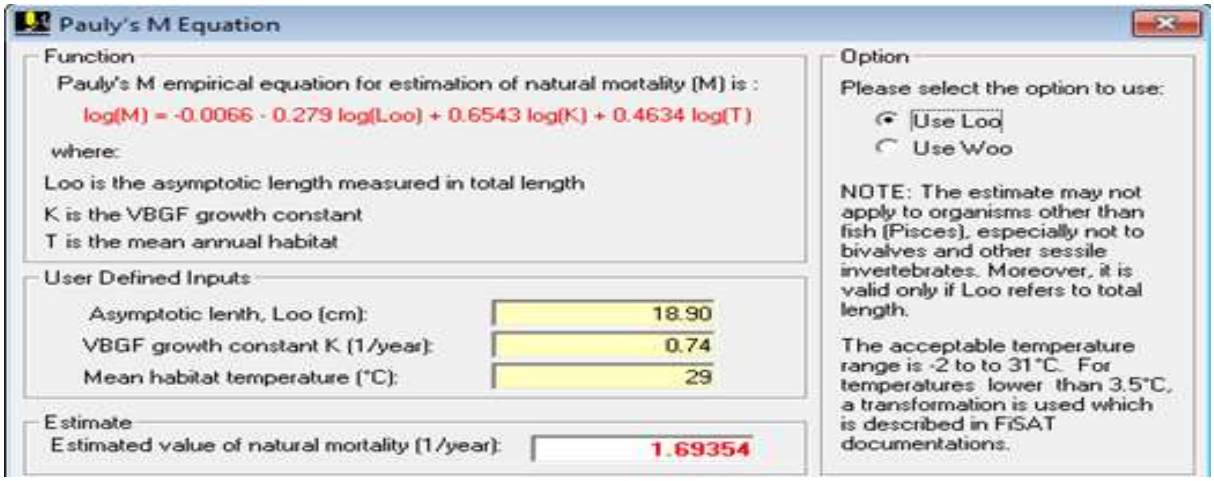

Figure 6. Natural Mortality Calculation Results for Pearl Coral Shrimp (P. ornatus)

Estimation of the natural mortality rate (M) of pearl crayfish using pauly's empirical formula by entering the value of L∞ = 18.90 cm and the value of K = 0.74. the average value of temperature (T) obtained from field measurements is 29oC. the calculation result from FISAT II for natural mortality is 1.69/year (Figure 7).

The natural mortality (M) of crayfish is 1.69/year, which shows that the mortality of pearl crayfish in the waters of P. Salemo is relatively high. Pauly (1984) explained that natural mortality (M) is declared large if the M value reaches 1.5/year. Natural deaths in waters are generally caused by high temperatures, disease, predation (Welcomme, 2001; low pH (Naughton, 1990).

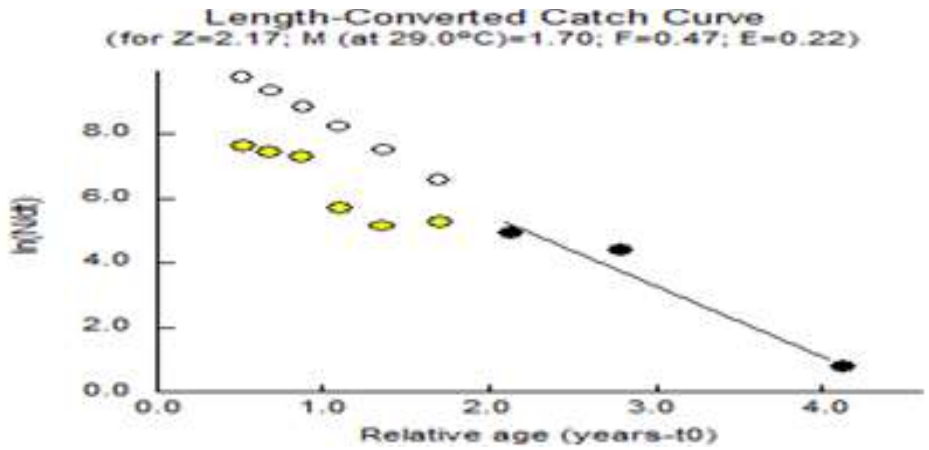

Figure 7. Calculation results of the exploitation rate of Pearl Coral Shrimp (P. ornatus) using the FISAT II vers.1.2 program

Fishing mortality (F) can be obtained from the formula Z = F + M (Sparre and Venema, 1999) and to find the F value, the equation F = Z – M is used. The Z value and M value have been obtained from the FISAT II program so that the F value is calculated.

The F value obtained from these calculations explains that the fishing mortality of pearl crayfish is 0.47/year (Figure 7). Based on this, it is known that the natural mortality rate (M) is much greater than fishing mortality (F) or less intensive, so it can be said that pearl prawns (P. ornatus) caught with gill nets do not experience fishing pressure, because the fishing speed Natural mortality is a parameter that cannot be controlled or observed directly, it is necessary to control the catch, fishing effort and gear used. This indicates that the mortality of crayfish is greater due to natural mortality. Gulland (1969) stated that if the value of M > F, the status of the fishery is still underexploited.

The E value obtained from the calculation indicates that the condition of the pearl crayfish fishery is underfishing with an E value of 0.22/year or provides information that 22% of crayfish mortality is caused by fishing pressure, or less than <0.5.

Based on the concept of the optimum rate developed by Gulland (1969) and Pauly (1984) that the optimum rate of exploitation is reached when the value is equal to 0.5/year (Eopt. = 0.5/year). With reference to the concept of rate optimum exploitation (Gullad., 1969 and Pauly., 1984), the pearl crayfish exploitation rate in the waters of Salemo Island (0.22/year) has not crossed the threshold of the optimum exploitation rate value of 0.22/year (22%) of the Eopt value. = 0.5/year, pearl crayfish fishery is underfishing with 28%. This explanation shows that the number of fishing gear operating in the Salemo Island area is still small and classified as traditional fishing gear so that additional fishing gear units are still expected.

4. Conclusions

1. Population dynamics of pearl crayfish (Panulirus ornatus)

a. Size of first caught pearl crayfish (Lc) = 8.25 cm

b. Maximum carapace length (L∞) = 18.90 cm, growth coefficient (K) = 0.74/year and t0 = -0.39

c. Total mortality rate (Z) = 2.17/year, natural mortality rate (M) = 1.70/year and fishing mortality (F) = 0.47/year

2. Level of exploitation of pearl crayfish (Panulirus ornatus)

a. Exploitation rate (E) = 0.22/year with underfishing criteria (E < 0.5) with an exploitation rate of 22% and allows for an increase of up to 28%.

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