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Research Article

Lobster Population Parameter in Bumbang Bay, Central Lombok

Parameter Populasi Lobster Perairan Teluk Bumbang, Lombok Tengah

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Abstract

Bumbang bay is one of the lobster fishing areas in Central Lombok District, where fishing is carried out at all times and has the potential to disrupt the sustainability of the population in the future. Data is collected from the stock of lobster stocks that are still in fishing cages. Potential risks and fishing pressure could be assessed through length and weight, growth, structure size and potential recruitment analysis. The results of the study found 6 species of lobsters, of which are 2 dominant species were pearl lobster (45.5%) and sand lobster (44.5%) of the total catch. The Length and weight relationship have a negative allometric pattern which is (pearls lobster b = 2.04 and sand lobster = 1.2). The growth rate is relatively slow with a growth rate coefficient of 0.2-0.49 per year. Therefore, recruitment per biomass from the population is also low and exploitation rate about 0.6. The population growth and recruitment relatively low and increasing the exploitation rate, potential to unsustainable of the lobster population in the future.

Abstrak

Perairan Teluk Bumbang adalah salah satu pusat perikanan lobster di Lombok Tengah, dimana penangkapan dilakukan setiap waktu dan berpotensi mengganggu keberlanjutan populasi dimasa yang akan datang. Potensi risiko dan tekanan penangkapan dapat dikaji melalui analisis panjang dan bobot, pertumbuhan, struktur ukuran dan potensi *recruitment*. Hasil penelitian ditemukan sebanyak 6 jenis lobster, dimana 2 jenis dominan yaitu lobster mutiara (45,5%) dan lobter pasir 44,5% dari total tangkapan. Hubungan panjang dan berat memiliki pola allometrik negatif (lobster mutiara b=2,04 dan lobster pasir =1,2). Pertumbuhan tergolong lambat dengan koefisien laju pertumbuhan 0,2-0,49 per tahun. Begitu juga *recruitment per biomass* dari populasi juga rendah dan eksploitasi tergolong tinggi yaitu 0,6. Kemampuan tumbuh yang lambat dengan *recruitment* yang rendah serta eksploitasi tinggi, potensial menganggu keberlanjutan populasi lobster dimasa yang akan datang.

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1. Introduction

Bumbang Bay is one of the lobster producers in Lombok Island. There are 500 fishermen in total including the nursery fishermen, merchant, and 300 heads of the family of catch fishermen. This condition shows a high amount of fishing activity and demands the need to control these activities to prevent overexploitation. To ensure the fishing stays sustainable, there needs to be an indicator of how many are left for reserve and how many are available for fishing.

The population parameters related to stock that have been found are catch composition, size structure, growth, exploitation rate, and recruitment capability. Other than fishing, another factor affecting the stock is competition, e.g. against another species such as green crab (Goldstein *et al*., 2017) where 33% of all lobsters with carapace size larger than 80 mm are preyed upon by said green crabs.

The growth rates of spiny lobsters are 11.2±0.32 mm per month for its length and 1.81±0.19 grams to 2.28±0.21 grams/month (Syafrizal *et al*., 2018). Species *Panulirus elephans* also have a relatively slow growth rate of 1.9 mm a year whether in the wild are in a marine protected area (MPA). Moreover, it has been recorded that the maximum asymptotic length for female lobsters is 116 mm and 185 mm for male lobsters. Meanwhile, the mortality rate (naturally occurring) inside the MPA is 0.41 a year, while outside the MPA is 0.78 a year. Furthermore, the mortality rate by fishing is 0.43 from the total population (Bevacqua *et al*., 2010).

Lobster growth is also determined by density, food availability, extreme environment changes, and also depth. The lobster variant called southern rock lobster in Tasmania is proven to grow slowly in deep waters. Lobster species *Jasus edwardsii* reached 110 mm of asymptotic carapace length for its male and 105 cm for its female (Chandrapavan *et al*., 2010). From both examples above, it seems that lobster growths generally are relatively slow.

Tropical lobster management is highly dependent on temperature indicator, food, and competition between aquatic biota, so to sustain stock availability and mitigate overfishing, there needs to be a proper scoring of population indicator. Another important note on lobster management aside from population parameters, there are also thresholds of size, growth, and mortality, and also yield per recruitment potency to ensure sustainability.

Researches about variant availability, size structure of lobster population catches, growth rate, and yield per recruit capability need to be done, therefore relevant information could be obtained and serves as stock sustainability parameter. Next, protection of the fishing area is crucial in keeping mortality rate in check, because naturally occurring mortality is already high. Policies needed to ensure all things mentioned above are concerning the environment condition, population status, size, and intensity of external pressure to ensure the management of lobster aquaculture stays optimal in the future.

2. Material and Method

2.1 Research Time and Location

The research was done at Bumbang Bay, Middle Lombok in June 2017. The research location includes lobster larvae catching area at Bumbang Bay and also its fishermen as shown on the map below (Figure 1).

2.2 Data Collection Procedure

Data are collected from all lobster catching and collecting sites. Because of the lobster catching prohibition, data are collected from the stock obtained by fishermen's lobster traps. All the variants and apparent sizes are observed to obtain needed data. Data obtained are total carapace length (mm), lobster weight (grams), aquatic environment conditions, and much other documentation. No samples were sorting as the sample itself was limited.

2.3 Data Analysis

Data obtained among the research sites are lobster variants caught by fishermen, dimensional data such as length, and weight, catching area and sites, prices, and other interview data relevant to business system done by fishermen.

Analysis done within the research are length analysis to determine growth, length, and weight correlation, and lobster recruitment. Data analyses were done using a descriptive statistical approach; determining the mean and standard of deviation (Wallpole, 1993). Length-weight correlation analysis was done using a cubic law approach; $W=aL^b$, where W is the fish mass in grams, L is the total length in mm, and *a* and *b* serve as constant acquired through regression.

Group distribution and determination are done using separate normal distribution approach. The normal distribution obtained presents an age group. Steps taken were: 1) Acquired carapace length data were grouped into classes based on length to determine lobster distribution frequency. 2) Frequency distribution data was analyzed with Battacharya's method of size separation principle. 3) Next, the normal distribution count was analyzed to find the population structure (age class). Normal curve approach principle was determined by the following function: $\ln(N_{i+1}) - \ln(N_i) = a_j + b_j \cdot L_i$, where

Figure 1. Lobster Research Site Bumbang Bay, Central Lombok

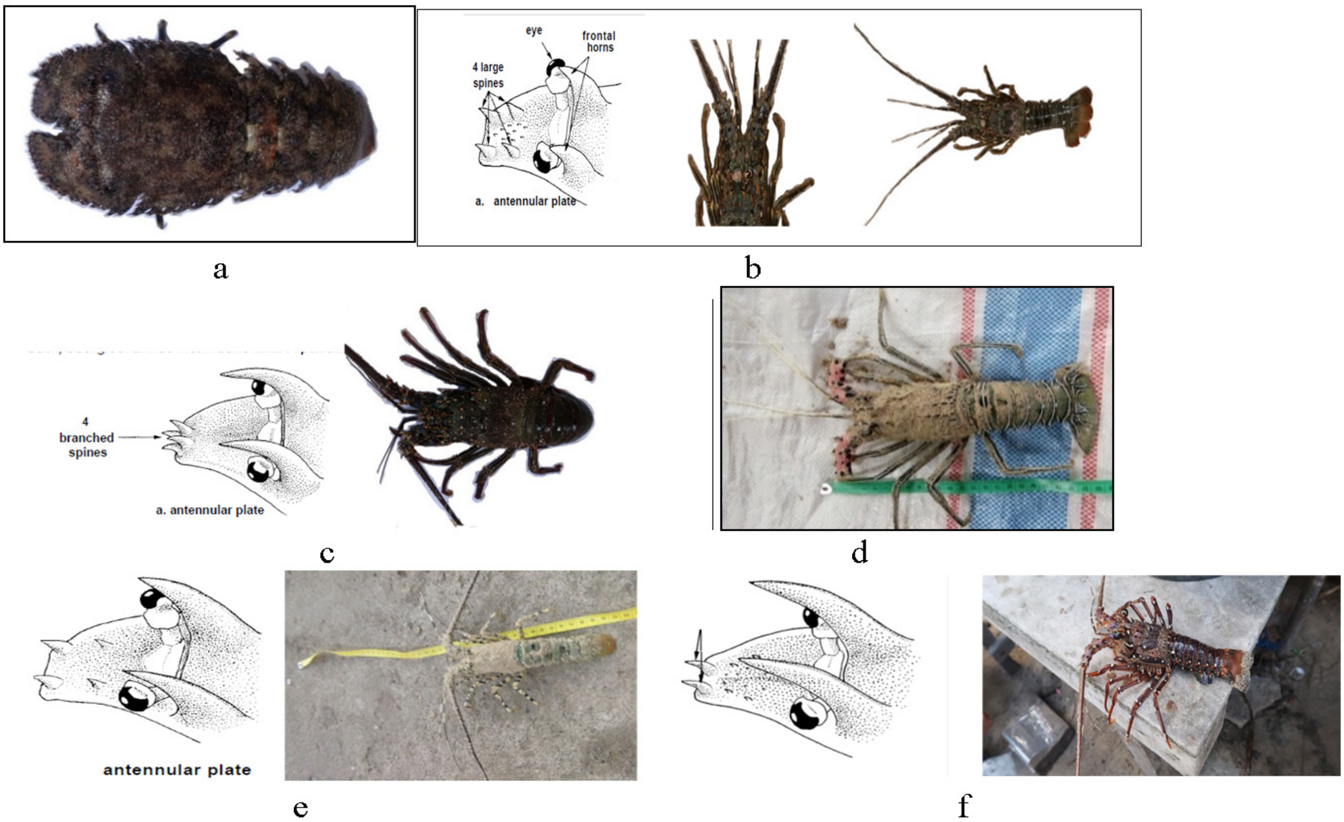

Figure 2. Slipper Lobster (*Parrabicus antarticus*) a; Spiny Lobster (*Panulirus homarus*) b; Pronghorn spiny Lobster (*Panulirus penicillatus*) c; Rock Lobster *Panulirus versicolor* d; Ornate spiny Lobster *Panulirus ornatus* e; Western Rock lobster *Panulirus longipes longipes* f.

N_i and N_{i+1} are the same sequential components from lobster groups from the sample (e.g., member of j age group) and L_i is the upper limit of the class N_i. From here, the mean of normal distribution is **Lj=-aj/bj** and the standard of deviation is **(j) = $(-\Delta L/b_j)^{1/2}$**, where ΔL is a constant from the age group, then the index of separation (SI) is calculated with **SI=ΔLj/(-ΔL)**. Growth analysis was done using Sheperd's approach, which is: $\mathbf{S = (s_A{}^2 + s_B{}^2)^{1/2}}$, where S_A and S_B are goodness-of-fit scores (Stz) acquired from Von Bartalanfy Growth Plot (VBGF) analysis of time (t_z) from 0 to 0.25.

3. Results and Discussion

3.1 Lobster Variant at Bumbang Bay

There are 6 species of lobster variants at Bumbang Bay. Those caught lobsters were dominated by lobsters from *Palinuridae* family, *Panulirus* genus, which includes 5 species, and one variant from the family *Scyllaridae* and *Parribacus* genus. Local names of these lobsters are fan lobster, sand lobster, bamboo lobster, stone lobster, *batik* lobster, and pearl lobster. The description of found variants is as follows.

3.2 Catch Composition

The composition is commonly related to adaptation and species conservation. Species with great adaptability, whether in exploitation zone or no-take zone (NTZ), usually shows high availability. From 6 recorded variants, 312 lobsters were obtained. Catch composition consists of 44.5% sand lobster, 45.5% pearl lobster, and the other 4 variants. Both of these variants are the main catch in Bumbang Bay. Catch composition is shown as follows in Figure 3.

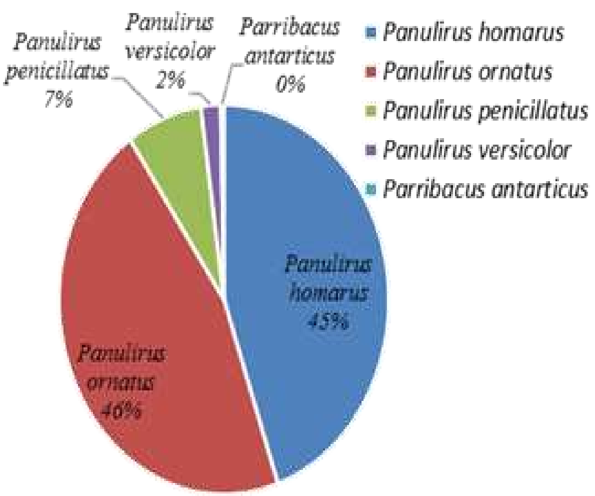

Figure 3. Lobster Catch Composition

Lobster population composition and amount serve as a population indicator in an ecosystem. Lobsters in no-take zones (NTZ) in a conservation area will be abundant (Buglass, 2018). However, an abundance of the population isn't without risk, because it serves as prey to predators such as reef fishes and other carnivorous fish. A higher composition of one variant than the other may be caused by a different dominant fishing technique on certain variants (Driscoll *et al*., 2015). So the amount of population, other than because of fishing, must be observed simultaneously with other competing or associating species.

3.3 Weight-Length Correlation

According to the result of length and weight calculation, it was found that the growth pattern of sand lobster and pearl lobster caught in Bumbang Bay are negative allometric, meaning that it grows in length quicker than it is in weight (Figure 4). Meanwhile, the analysis of the other variants was not performed.

T-test result came up as 95% true from value b towards value 3 for both lobsters, it was also acquired that > t_{tabel} and shows negative allometric. Value b shows low value because of ecological and biological factors (Manik, 2009). Ecological factors include weather, water quality, temperature, pH, salinity, geographic position, and sampling technique (Zargar *et al*., 2012; Jenning *et al*., 2001). Biological factor includes gonad development, feeding habit, growth phase, and gender (Froese, 2006; Tarkan *et al*., 2006).

3.4 Size Structure

For the smallest sand lobster obtained was 18.22 mm (carapace length) and the longest was 101.88 mm (carapace length). Meanwhile, the smallest pearl lobster obtained was 11.55 mm (carapace length) and the longest was 101.92 mm (carapace length). Lobsters from both variants were taken each day and the mode obtained for sand lobster was 55.72 mm (carapace length) with total caught 22 lobsters, and for pearl lobster mode 60.55 mm with total caught 38 lobsters.

From all lobsters recorded, the longest was *P. penicilatus* with 260.mm with mean 177.4 ± 5.77 mm. While variant with the shortest length (smallest) recorded was *Parribacus antarcticus* with 110.3 mm, other results are as follows (Table 1).

The length-frequency distribution of both lobsters is shown in Figure 5. According to Figure 5, it is known that length-frequency distribution for sand lobster ranges from 18.22 mm – 101.88 mm, with the highest class interval frequency on interval 54.22 – 57.22 mm. Length frequency distribution of sand lobster ranges from 11.55 to 101.92 mm, with the highest class interval frequency on interval 56.55 – 64.55 mm. Length frequency distribution and group size distribution are shown in Figure 5.

Table 1. Caught Lobster Length Range

Lobster Variant	Local Name	N	Total Length (mm)		
			max	min	Mean± sd
Panulirus homarus	Sand Lobster	139	197,1	32,3	113,0±4,02
Panulirus ornatus	Pearl Lobster	142	202,6	53,2	144,1±2,84
Panulirus penicillatus	Stone Lobster	23	260,6	53,6	177,4±5,77
Panulirus versicolor	Bamboo Lobster	6	196,9	36,9	171,2±3,69
Parribacus antarticus	Fan Lobster	1	110,3	-	-

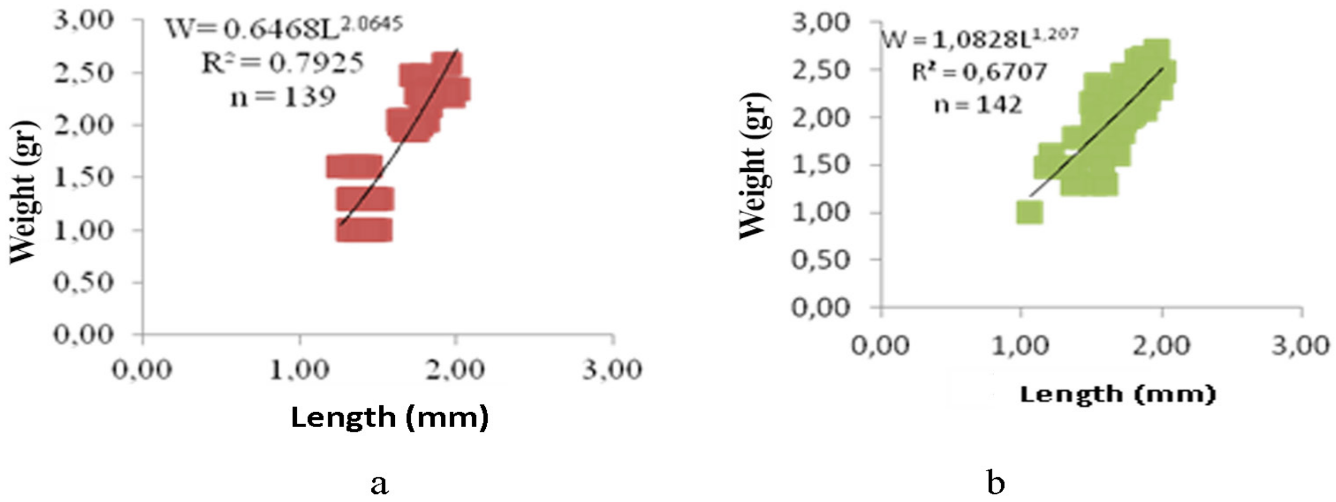

Figure 4. Length and Weight Relation of Spiny lobster and Ornate Spiny Lobster

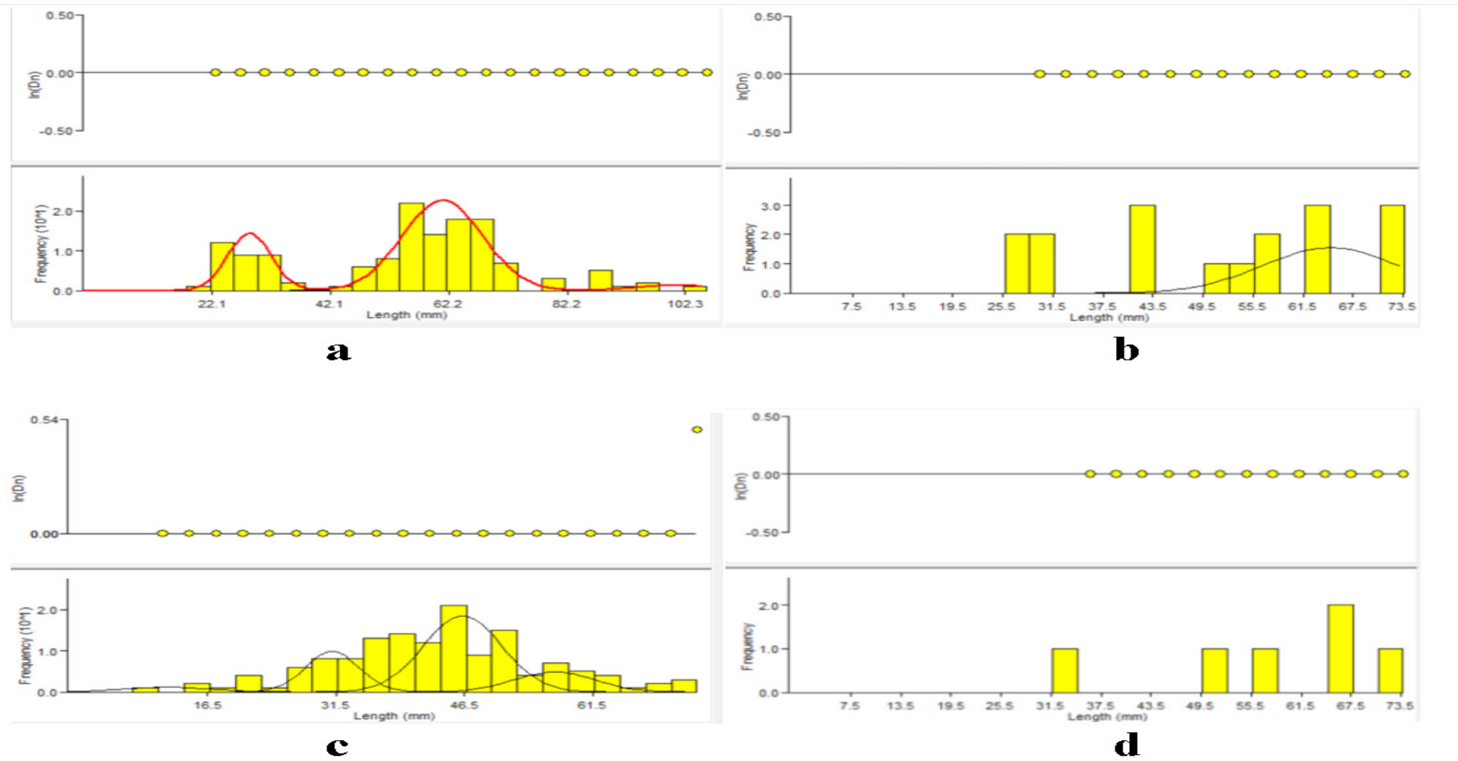

Figure 5. Length Frequency Distribution (a) Spiny Lobster (*P. homarus*) and (b) Pronghorn Spiny Lobster (*P. penicillatus*) c) Ornate Spiny Lobster (*P. ornatus*) and Rock Lobster (*P. versicolor*)

Generally, size varies for each lobster variant caught. Sand lobster has three size groups, stone lobster has one size group, pearl lobster has four size groups, bamboo lobster one size group, and so does fan lobster. The biggest catch result from each variant varies from 46.30-61.09 mm with a total population reaching 39.54% from the total population. These data show that lobster sizes are distributed to different classes. Distributed means of size groups observed from the whole population are as follows (Table 2).

Caught sand lobsters have a relatively small size and dominantly sized below 17 cm. This size period indicates that this lobster has a slow growth rate (k=0.14/year) and with breeding frequency twice a year or more, it means with said frequency and high fecundity it is presumed that the stock will suffice for 7 times (of harvesting) a year (Alborés, 2019). Growth could also be faster if food is sufficient because a more mature population tend to be opportunistic in their feeding habit (Blamey *et al.*, 2018) and warmer temperature supports longevity (Harrington *et al.*, 2019).

Table 2. Distribution of population size groups

Lobster Variant	Mean(mm)	Deviation(mm)	Population	Separation Index
Sand Lobster	28,33	3,710	33,48	n,a
	61,09	6,860	97,03	3,380
	100,59	6,810	5,77	2,760
Stone Lobster	64,72	8,060	10,4	Na
Pearl Lobster	11,72	5,100	4,83	Na
	31,03	3,120	25,59	3,320
	46,30	4,580	70,51	2,440
	57,02	4,670	18,91	2,060
Bamboo Lobster	71,75	18,515	6	n,a
Fan Lobster	110,3	-	-	Na

The generic lobster variant has an average growth rate and slower on growing infinite length ($L\infty$). According to Table 3, sand lobster and pearl lobster have the same relative growth rate, while the fan lobster was slower. According to Saputra *et al.*, (2008), the average size of caught lobsters or the size of the first catch are ideally not less than half of infinite length ($L\infty$). *Homarus americouldus* variant falls under one of the faster lobsters in developing their gonad fertility, affected by warm temperature (Bris *et al.*, 2016). This correlation may as well serve as an indicator that there is a correlation between climate change to the gonad fertility scale of a fish.The result of the length analysis could be acquired from the carapace length. Gardner *et al.*, (2015) states that the highest recruitment occurs at a size range between 60 to 64 mm for stone lobster. The catch chance is 50% of the total population (Lc_{50} or Lc). Lc could be used as first caught lobster average size indicator.

Obtained data of first catch size (Lc) of lobster in Bumbang Bay are 57.05 mm for sand lobster and 58.25 mm for pearl lobster. According to mode size (55.72 mm) and Lc before, lobster size caught in Bumbang Bay waters are categorized as small, and so it could be hypothesized that the reproduction chance couldn't be guaranteed to suffice, and from utilization aspect it is categorized as overexploitation (growth overfishing) because it was dominated by smaller lobster. This condition may also indicate recruitment overfishing because the chance for reproduction is getting thinner. The same result was also found in research in Kebumen waters conducted by Saputra (2008), where Lc acquired was 56 mm while the Lc_{50} is 67 mm, indicating a catch size less than ideal.

Catch chance will increase as length also increases, reaching maximum or close to the maximum from all catch size. The analysis result shows that the cumulative catch chance will increase with size greater than 70 mm. Meaning the larger the size, the easier it is to catch, whether it's caused by maturity or a change in yield potency change. The presumptions of changes in catch chance are as follows (Figure. 7).

Yield per recruit potency or biomass per recruit or substantially high. At maximum exploitation rate, maximum yield potency decreases, as well as biomass per

Table 3. Lobster and its growth rate

Lobster Variant	k	L∞ (mm)	To
Sand Lobster	0,42	110,75	-0,00035
Stone Lobster	0,45	137,07	-0,00206
Pearl Lobster	0,42	107,6	-0,00062
Bamboo Lobster	0,49	98,126	-0,00060
Fan Lobster	0,24	68,65	-0,00060

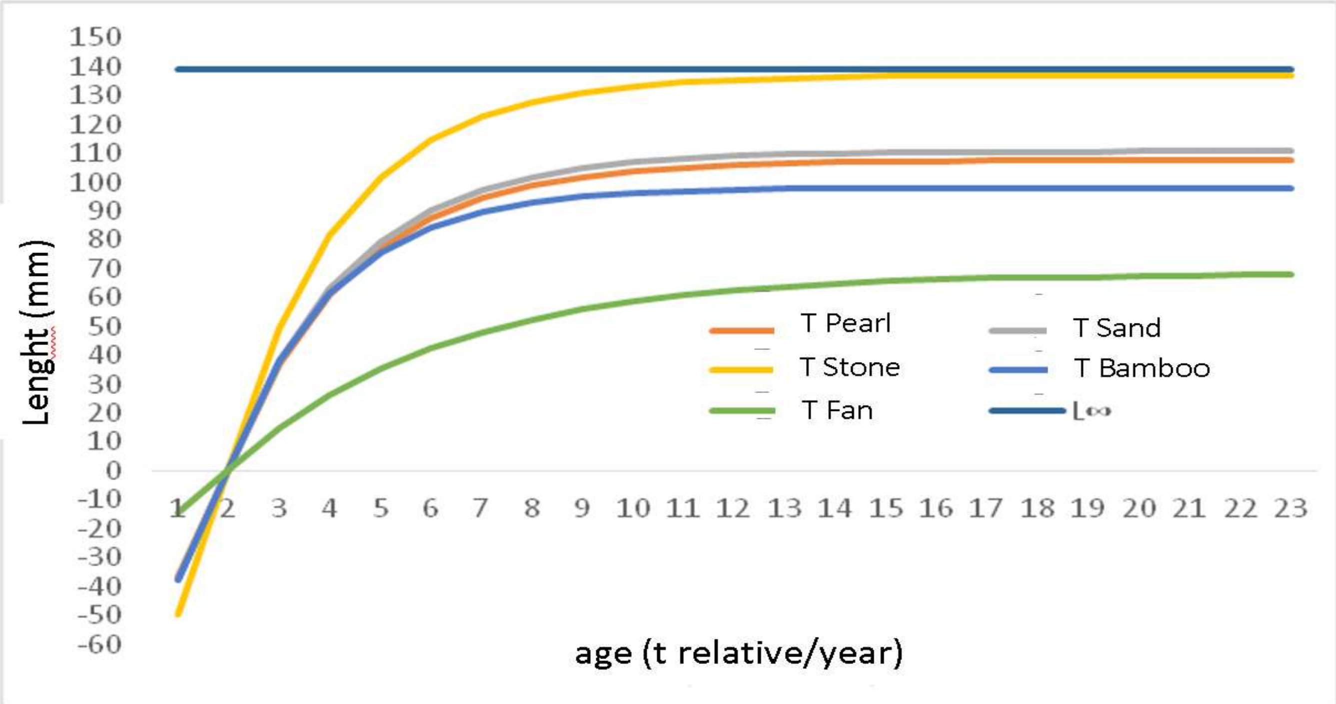

Figure 6. Growth rate and development of Lobsters

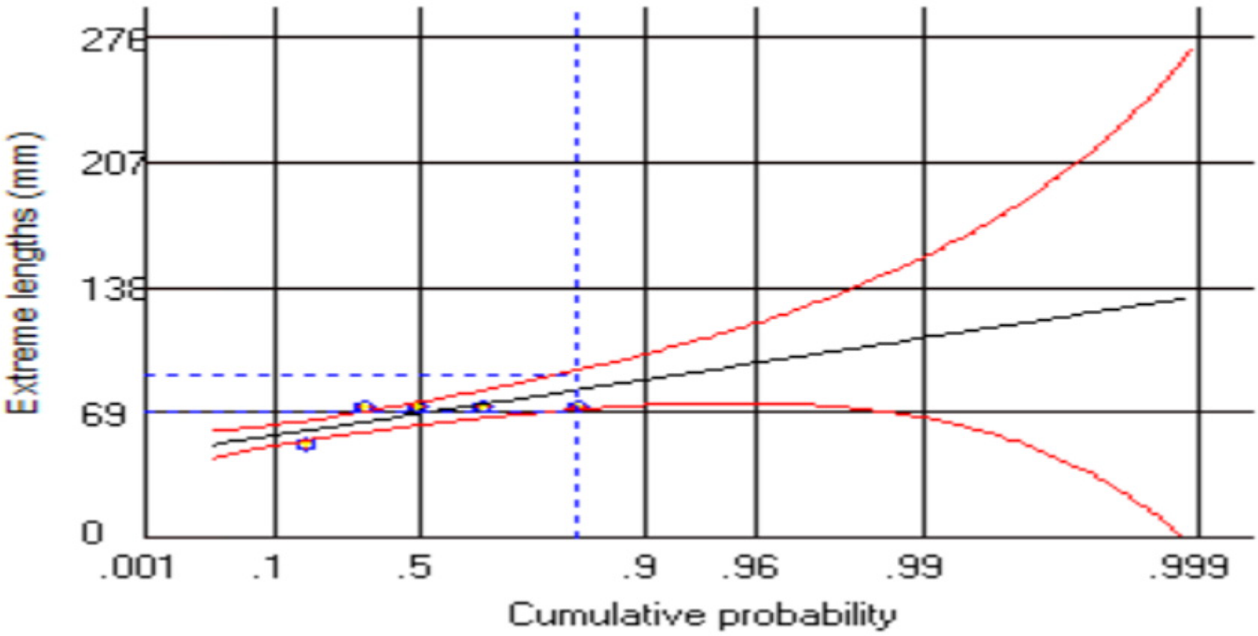

Figure 7. Cumulative Probability Catch of Total Lobster

recruit. From Figure 8, it is shown that with an estimated ratio of catch size against infinity length reaching 109.12 mm, the ratio of yield per recruit is less than 50% as well as biomass per recruit. It could be seen that there is a vulnerable phase of a lobster, if there were no fishing, the population will still decline as naturally occurring mortality still persists. The translocation process of catch size is necessary to improve the quality of catch size.

Lobster fishing in actual conditions that result in a smaller size than the length infinity (L_∞) is defined as overfishing, so are mature gonad size that is larger than the average catch size. The high frequency of juveniles caught may incur three things, 1) high population of juveniles in the water, 2) Indiscriminate fishing tool (as in small mesh size, etc.), and 3) declining population of mature fish. Optimal management design would be the development of aquaculture and nursery, management and regulation of fishing tool size to catch juvenile fishes.

The amount and size of a new population in the waters are related to the ability in recruiting stock. Biomass recruit and catch stock potential are crucial as a base in determining catch allocation to keep lobster exploitation as sustainable (Caputi *et al*., 2018). The recruitment process shows larvae and juvenile attachment to the surface pattern to be relevant with catch size as the behavior of the population tends to group up in early days (Priyambodo *et al*., 2016).

The available stock should be utilized when it's still in its juvenile state to be prepared for when it's a mature stock. Because it will undergo an increase in mortality rate caused by predation, competition, or natural mortality.

Average lobster size caught in Walis Sand State Beach, Rye, with standard fishing equipment is 61.98±0.61 mm. Fishing without a separation pouch on the equipment yields an average of 62.38±0.12 mm and the average size of lobster caught with scuba gear is 48.06±0.90 mm measured from its carapace (Clark *et al*., 2015). The amount of catch is highly dependent on lobster density (Clark *et al*., 2015). Goldstein *et al*., (2017) found that the lobster distribution in Great Bay Estuary is higher than areas further from the estuary, although there is an abundance of another Crustacea such as crabs in the estuary.

The average size of lobster is used as an indicator in developing harvest strategy (Klaer *et al*., 2012). In many practices of lobster processing, it is known that the complexity and connectivity between social systems and lobster habitat as an ecological system are inseparable (Partelow and Boda, 2015).

Lobsters in conservation sites tend to be different than the ones outside conservation sites, in regards to its mortality rate. *Panulirus elephas* has a mortality rate of 0.41 per year in situ and 0.78 ex-situ, including natural causes and catching (Bevacqua *et al*., 2010). Other than

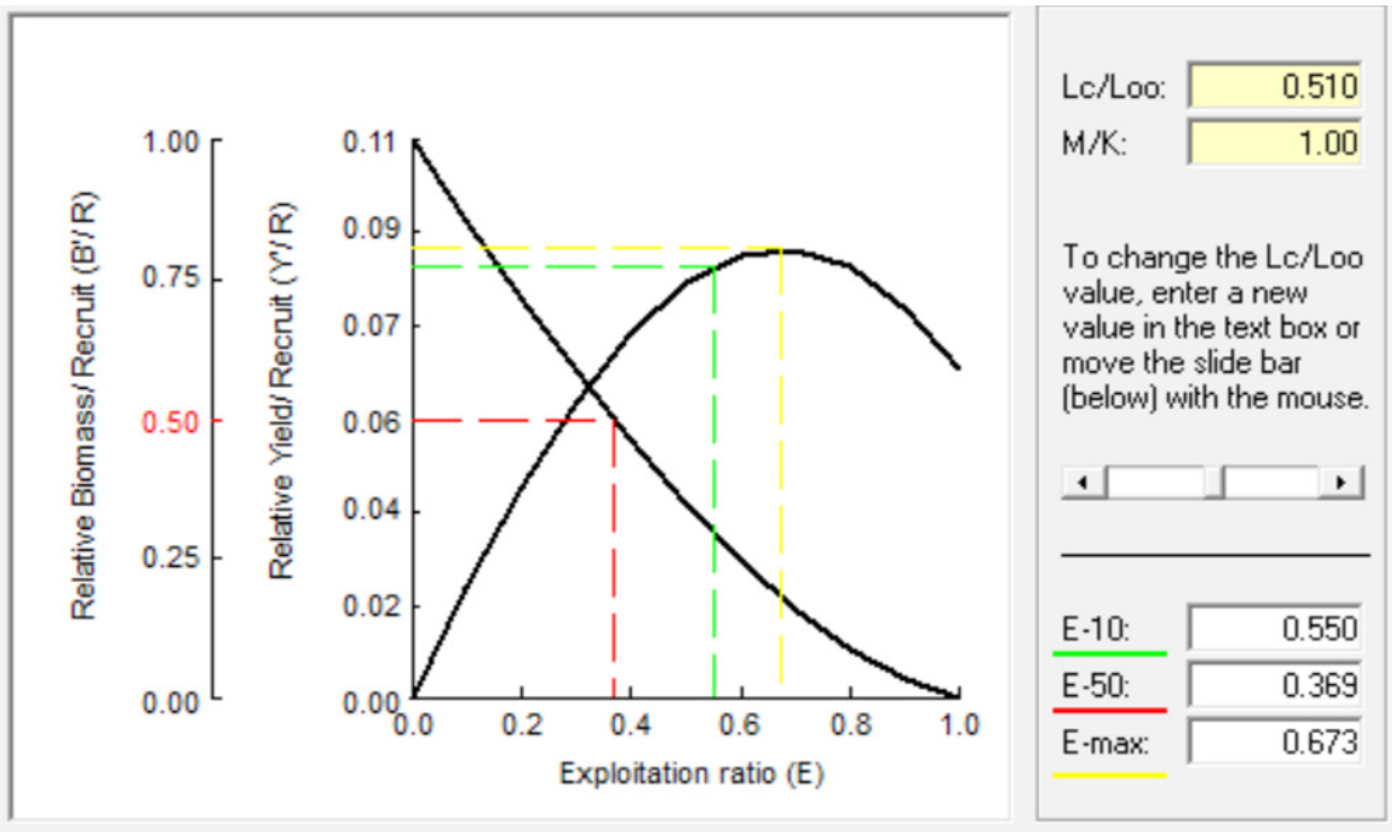

Figure 8. Biomass per recruit relative potency. It shows a certain phase relevant to the current catch result.

that, the adaptability to current speed and oxygen are also relevant (Halswell *et al*., 2018).

The adaptive management strategy of the lobster population from the determined Total Allowable Catch (TAC) is to consider growth speed and biomass accumulating ability as a basis to determine TAC (Buglass *et al*., 2018). To ensure an increase in lobster biomass, it is necessary to monitor the catch closing program effectivity. According to Montez *et al.,* (2012) in West Australia, the closed area does not guarantee an abundance, as natural predator persists and may also increase.

Jesus edwardsii lobster shows faster growth in shallow water than in deep water. Not only water movement and oxygen availability, food availability also caused a high amount of lobster larvae Bumbang Bay (Chandrapavan *et al*., 2010).

There exist five dominant lobster variants caught in Bumbang waters by fishermen, or in total there is 71% of the main variant found in Bumbang, meaning it classifies as the prime commodity in Bumbang and Lombok. Caught lobsters are usually juvenile lobsters with a length of no more than 10 cm and weigh less than 250 grams. Meanwhile, mature lobsters caught with size above Lc are 6-7% of all population (of caught lobsters). This means the juvenile lobster population dominates. Lobster has a slow growth rate, high fecundity, and maximum breeding frequency estimate every mature lobster is twice a year. Therefore, there needs to be a great timing in lobster utilization, With high exploitation rate (0.6 per year), rapidly decreasing yield per recruit level, as well as biomass per recruit.

4. Conclusion

The higher the ratios of lobster catch size against the maximum allowed catch length, the higher the exploitation rate and lower the recruitment potency. Meaning there needs to be a utilization scenario on a certain time so that the lobster stock could be utilized in other ventures. The fishing activity should pay attention to critical phrases and the population of juvenile lobsters. To further increase the benefit, lobster seed utilization for aquaculture should be taken into account. There needs to be monitoring towards various competitor biota and predators, especially in larvae or juvenile stadiums of the lobster population.

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Author's Contributions

All authors discussed the results and contributed to from the start to final manuscript; Yon: Conduct research on population and export population biology teams, Zul: The research team coordinator and coordinate the team and are responsible for the social ecology system material, Su: As a research team for the fishing gear / lobster, Ben: As a lobster economic valuation research team, Fran: Survey Team that carries out field data collection, Sef: Survey Team that carries out field data collection, Rif: Survey Team that carries out field data collection

Conflict of Interest

The authors declare that they have no competing interests

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