Population structure and biological aspects of lobster (Panulirus spp.) of the Madura Strait landed in Situbondo of East Java, Indonesia

A Setyanto1,2*, A B Sambah1, D Widhiastika1, Soemarno2, D G R Wiadnya1 and C Prayogo2

1Fishery Resources Utilization Study Program, Faculty of Fisheries and Marine Science, Universitas Brawijaya, Malang, East Java, Indonesia 65145
2Post Graduate Program, Faculty of Agriculture, Universitas Brawijaya, Malang, East Java, Indonesia 65145

*Corresponding author e-mail: asetyanto@ub.ac.id

Abstract. Lobster is an important economic fishery resource in domestic and international trade. The high economic value of lobster due to increasing market demand has led to its intensive exploitation. The enactment of specific regulations on lobster proves the urgency of its management. Madura Strait is one of the unique biogeographical sea regions of East Java. This research was conducted in January-March 2021 at Pasir Hitam Beach, Situbondo. The purpose of this study was to determine the species composition of lobsters, the frequency distribution and the growth form, and the sex ratio. The analysis applied is class distribution of length and weight classes, regression analysis, and chi-square. The lobster catches consist of 4 species, namely Scalloped spiny lobster (Panulirus homarus), Ornate spiny lobster (P. ornatus), Painted spiny lobster (P. versicolor), and Mud spiny lobster (P. polyphagus). P. homarus is the most dominant species. The frequency distribution of carapace length and weight of P. homarus, P. ornatus, and P. versicolor has met the minimum size limits rules. The length and weight relationship of P. Homarus and P. ornatus were negative allometric, while P. versicolor isometric. Lobster sex ratio is in a balanced condition.

1. Introduction
Lobster or spiny lobster is an invertebrate group of crustaceans with hard-skinned body characteristics and filled with spines. Lobster belongs to the family of Palinuridae with 49 species. Six of these species are found in Indonesian waters. Six species, namely Panulirus versicolor, Panulirus ornatus, Panulirus homarus, Panulirus longipes, Panulirus polyphagus, and Panulirus penicillatus were also found around East Java [1][2].

Lobster is an important economic fishery resource in Indonesia. According to FAO, in 2015 Indonesia's lobster exports had ranked third after Canada and the USA. The high economic value of lobster causes intensive utilization of lobster [3]. This has an impact on the exploitation of lobster disregarded its sustainability [4]. Unsuccessful aquaculture efforts put more pressure on wild lobster.

The excessive fishing effort is has caused decrease in stock, imbalance in the sex ratio, and other biological aspects to extinction [5]. In addition, the size of the lobster caught is getting smaller [6]. The crustacean group experienced the highest pressure compared to other fish groups.
With the enactment of several regulations regarding lobster fisheries, it confirms the significance of lobster fisheries management in Indonesia. One of the basic resources for its management is information on the biological aspects. This study provides information on the composition of lobster species, carapace length and weight distribution, length and weight relationship, sex ratio, and lobster fecundity. The information from this study can be used as a basis consideration in management of the Madura Strait lobster fishery.

2. Methods
The research was conducted at Pasir Hitam Beach, hamlet of Selasaan, Seletereng Village, Kapongan District, Situbondo Regency. The coordinates of the study location are -7.703° South Latitude and 114.101° East Longitude.

Statistical analysis used is descriptive analysis including identification of lobster species referring to Carpenter & Niem 1998 (Volume 2) and Holthuis (1991). Analysis of lobster species composition by looking for percentage values. Analysis of the frequency distribution of carapace length and lobster weight with class distribution frequency. Inductive/inferential statistical analysis was used for species composition analysis using the Kruskal Wallis and Mann-Whitney method to determine differences between lobster species. Analysis of the relationship between length and weight using linear regression test and t test. The sex ratio analysis used the chi-square test to determine the ratio of male and female lobsters.

3. Results and Discussion
3.1 Fishing boat and gear
Pasir Hitam Beach fishermen use a traditional 2 GT boat made of fiber with an overall length of 8.5 m, 1.55 m wide, 80 cm high. Diesel engine type diesel fuel with a power of 10 PK. Dong Feng brand boat engine. The number of crew members is 1-2 people with a one-day fishing system. Lobster is a by-catch of gillnet and three-layer gill nets (trammel net) or locally known as “jaring gondrong”. The main catches of those kinds of fishing gear are grouper, swimming crabs, emperor, stingray, sweetlips, rabbit fish, shrimp and scallops.

3.2 Species of lobster
The study found four species of lobster that is lobster pasir (Scalloped spiny lobster, Panulirus homarus), lobster mutiara (Ornate spiny lobster, P. ornatus), lobster bambu (Painted spiny lobster, P. versicolor), and lobster pakistan (Mud spiny lobster, P. polyphagus) see Figure 1.

![Figure 1](a) P. homarus; (b) P. ornatus; (c) P. versicolor; (d) P. polyphagus.)
3.3 Population structure of lobster catches

The composition of lobster catches is dominated by *P. homarus* with a percentage of 52% while the least is *P. polyphagus* with a percentage of 2%, see Table 1.

**Table 1.** Number and percentage of lobster catch.

| No. | Species       | Catch | Number | Percentage |
|-----|---------------|-------|--------|------------|
| 1   | *P. homarus*  |       | 135    | 52%        |
| 2   | *P. ornatus*  |       | 97     | 37%        |
| 3   | *P. versicolor* |     | 24     | 9%         |
| 4   | *P. polyphagus* |     | 5      | 2%         |
|     | **Total**     |       | 261    | 100%       |

Differences in the composition of lobster species are caused by the different habitats of each lobster species [1]. According to Phillips et al. (1979) each lobster species has a different habitat zoning. According to Carpenter & Niem (1998) *P. homarus* and *P. ornatus* are found in shallow sandy, rocky, and slightly murky waters which are habitats for both lobsters. This is in accordance with the conditions of the northern waters of Situbondo which are rocky and sandy, which has coral reefs covering an area of about 4.7 km² found in almost every district/city sea area, namely in Arjasa and Panarukan.

![Figure 2. lobster catch composition.](image)

The result of the Kruskal Wallis test is that there is a significant difference in the composition of each species. Furthermore, further tests were carried out with the Mann-Whitney test to determine the differences between species.

The test showed that *P. homarus* and *P. ornatus* were dominant, followed by *P. versicolor* and *P. polyphagus* (Figure 2). The dominance of different lobster catches is due to differences in the habits of each species [1]. The difference in the dominance of the catch of lobster species is thought to be due to environmental conditions such as temperature, pH, salinity, depth so that it affects the level of lobster catch in a water [5]. In addition, environmental factors that affect the abundance of lobster species are temperature, light intensity, currents, and dissolved oxygen [7]. The dominant catch of lobster species in the Southern Sea of East Java is also *P. homarus* [1,2] while *P. polyphagus* is dominant in the Northern Sea of East Java [3].
3.4 Length and weight frequency distribution of lobster

Analysis of the frequency distribution of carapace length and weight was carried out on *P. homarus* and *P. ornatus* and *P. versicolor*. The number of *P. homarus* was 135 with a carapace length frequency distribution of 48-149 mmCL. The carapace length of *P. homarus* with a size of <60 mmCL was 10 (7%) while the size of 60 mmCL was 125 (93%). At the weight frequency distribution it ranged from 47-556 grams. The weight of *P. homarus* with a size of <150 grams was 28 (21%) while the size of 150 grams was 107 fish (79%), Figure 3(a).

The number of *P. ornatus* and *P. versicolor* was 97 and 24 individuals, respectively. Their carapace length frequency distribution of 46-232 mmCL and 58-138 mmCL. The carapace length of both lobster species with a size of <80 mmCL was 27 individuals (28%) and 5 (21%), while the size of ≥ 80 mmCL was 70 (72%) and 19 (79%). The weight frequency distribution of *P. ornatus* ranges from 97 to 2,512 grams while *P. versicolor* was 104-1,186 grams. The weight of *P. ornatus* and *P. versicolor* with a size of <200 grams was 33 (34%) and 8 (33%) while the size of ≥ 200 gram was 64 (66%) and 16 (67%), see Figure 3(b) and Figure 3(c).

![Figure 3](image-url)
The study found that carapace length and weight of lobster are dominated by sizes which comply with the regulation (PERMEN-KP Number 17 of 2021). Similar result was found in the study done in Kupang of Nusa Tenggara Timur [8]. Interestingly, smaller sizes of *P. homarus* were caught from the Southern Sea of Java i.e., Ayah District of Kebumen Central Java and Prigi Bay Trenggalek of East Java [9], [10]. According to Mochammad (2004) lobsters have reached the gonad maturity phase starting at carapace length of 10.8 cm (male) and 8 cm (female). The first time the gonads mature when the lobster reaches the age of 5-8 years. Lobsters caught at a size of <8 cm are thought to be caught in areas near the coast while sizes >8 cm are thought to be caught in deep waters and far from the coast as spawning and breeding sites [11].

### 3.5 Length and weight relationship of lobster

Analysis of the relationship between carapace length and lobster weight was carried out on *P. homarus*, *P. ornatus* and *P. versicolor*. The results of the analysis of the relationship between length and weight in *P. homarus* produce the equation $W = 0.4041CL^{1.4236}$ and the value $R^2 = 0.4992$ with a value of $b$ (slope) of 1.4236 as seen in Figure 4a. The growth pattern of *P. homarus* was negative allometric ($b<3$) (Figure 4(a)).
Figure 4. Length-weight relationship of (a) *P. homarus*; (b) *P. ornatus*; (c) *P. versicolor*.

Analysis of the relationship between carapace length and weight of *P. ornatus* resulted in the equation $W = 0.0928CL^{1.7456}$ and $R^2 = 0.623$ with a value of $b$ (slope) of $1.7456$ as seen in Figure 4b. The growth pattern of *P. ornatus* was negative allometric ($b<3$) (Figure 4b).

Analysis of the relationship between carapace length and weight of *P. versicolor* resulted in the equation $W = 0.0005CL^{2.9129}$ and $R^2 = 0.8804$ with a value of $b$ (slope) of $2.9128$ as seen in Figure 4c. The growth pattern of *P. versicolor* is isometric ($b = 3$), i.e., the growth of carapace length is more equal to the growth of lobster weight (Figure 4c).

The growth pattern between different species was determined from the value of $b$ in the length-weight relationship equation. The difference in $b$ values is generally due to differences in the area and time of sampling. In addition, there are ecological and biological factors that affect the difference in the value of $b$. Ecological factors are season, water quality, pH, salinity, geographical position and sampling technique. Biological factors are gonadal development, eating habits, sex growth phase. In addition, environmental conditions can affect fish conditions so that the length-weight relationship will deviate from the cubic law [6]. Other factors that influence growth patterns are heredity, sex, age, disease, parasites. Biological parameters that indicate whether water quality can be seen from the number and types of biotas are heredity and sex. External factors that affect growth patterns are food and water temperature [12].

Research in the southern waters of Yogyakarta obtained the results that the female lobster is positive allometric while the male lobster is negative allometric. Female lobsters are fatter than male lobsters. The average length and weight of female lobsters is greater than that of male lobsters, but the largest length and weight are found in male lobsters. It is presumed that adult female lobsters use some of their feed energy for reproduction so that female lobsters are fatter than male lobsters. Moulting activity in lobster causes carapace length to grow faster than its weight [13]. Lobster moulting as much as 20-25 times from hatching to adulthood to grow to be long and heavy but when mature the moulting frequency decreases with age [14].

3.6 Sex ratio
The total number of all male and female lobster species is 261. There were 172 male lobsters and 89 females. Sex ratio between males and females of all species is 1.9: 0.5 or 66% male lobster and 34% female lobster seen in Table 6. In these data, lobster catches are dominated by male, except for *P. polyphagus*. The value of $X^2$ count < $X^2$ table, then accept $H_0$ which means there is no significant difference between the ratio of male and female sexes. It can be interpreted that the male and female sexes are in a balanced state, and it is suspected that there is still a chance for the formation of new individuals (Table 2).
Table 2. Sex ratio of lobster.

| Species          | Distribution | Sex Ratio | Persentase | X2 hitung | X2 tabel |
|------------------|--------------|-----------|------------|-----------|----------|
|                  | Total        | Male      | Female     |           |          |
| P. homarus       | 86           | 49        | 1.8        | 64%       | 0.150    | 3.841    |
| P. ornatus       | 68           | 29        | 2.3        | 70%       | 0.323    | 3.841    |
| P. versicolor    | 16           | 8         | 2.0        | 67%       | 0.222    | 3.841    |
| P. polyphagus    | 2            | 3         | 0.7        | 40%       | 0.080    | 3.841    |
| Total            | 172          | 89        | 1.9        | 66%       | 0.202    | 3.841    |

The difference in the results of different sex ratio studies is thought to be caused by different aquatic environmental conditions so that the growth of lobsters differs [15]. Environmental conditions provide more carrying capacity, ecological factors and minimal coastal pollution make organisms increase in these waters so that production levels increase [12]. The variation in sex ratio is different in each region due to three factors, namely differences in sexual behavior, environmental conditions and fishing locations [16]. A balanced comparison of the number of male and female individuals makes it possible to produce new individuals from the fertilization of eggs and sperm so that the sustainability of a population is maintained. The different proportions of males and females are thought to be due to the unequal pressure of utilization on lobster behavior. Changes in behavior in lobsters, namely the occurrence of molting, reproduction and prey activity [17].

4. Conclusion
The results of research conducted in January-March 2021 at Pasir Hitam Beach; Situbondo Regency can be concluded that: Lobster species composition consists of 4 species, namely Scalloped spiny lobster (Panulirus homarus), Ornate spiny lobster (P. ornatus), Painted spiny lobster (P. versicolor), and Mud spiny lobster (P. polyphagus). The population structure is that the highest dominance is Scalloped spiny lobster and Ornate spiny lobster, the second is Painted spiny lobster, followed by Mud spiny lobster. The frequency distribution of carapace length and weight in the majority meets the criteria of legal-size rules. The relationship between carapace length and weight of scalloped and ornate spiny lobsters were negative allometric while painted lobsters were isometric. The results of the sex ratio analysis of scalloped, ornate, painted, and mud spiny lobster were found to be in a balanced condition. Further studies on biological parameters such as: growth and mortality rate, recruitment, length at first gonad maturity and capture (Lm and Lc) and spawning potential ratio (SPR) need to be done for the effectiveness of lobster management in the Madura Strait.

Acknowledgement
Thanks to the lobster fishery research group (lobster brigade), especially the Situbondo team (Madura Strait). Colleagues Dr. eng. Abu Bakar Sambah, S.Pi., MT in the process of research and writing. Dhita Widhiastika who worked a lot on this study. The fishing communities of Pasir Hitam Beach, Situbondo and lobster collectors for their willingness to share information and experiences.

References
[1] A. Setyanto, N. A. Rachman, and E. S. Yulianto, “Distribusi dan Komposisi Spesies Lobster yang Tertangkap di Perairan Laut Jawa bagian Jawa Timur, Indonesia,” J. Perikan. Univ. Gadjah Mada, vol. 20, no. 2, pp. 49–55, 2018, doi: 10.22146/jfs/.36151
[2] A. Setyanto et al., “Species composition of puerulus spiny lobsters from the South Sea of Pacitan of East Java, Indonesia,” IOP Conf. Ser. Earth Environ. Sci., vol. 493, no. 1, 2020, doi: 10.1088/1755-1315/493/1/012022
[3] D. D. Kembaren, T. Ernawati, and B. Shadotomo, “Analisis Hasil Per Penambahan Baru
Perikanan Lobster Pasir Panulirus homarus (Linnaeus, 1758) Di Perairan Aceh Barat,” *J. Lit. Perikan. Ind.*, vol. 22, no. 2, pp. 61–70, 2016

[4] R. Pratiwi, “Keanekaragaman dan Potensi Lobster (Malacostraca: Palinuridae) di Pantai Pameungpeuk, Garut Selatan, Jawa Barat,” *Biosfera*, vol. 35, no. 1, p. 10, 2018, doi: 10.20884/1.mib.2018.35.1.524

[5] B. Pranata, V. Sabariah, and S. Suhaemi, “Aspek Biologi dan Pemetaan Daerah Penangkapan Lobster (Panulirus spp) di Perairan Kampung Akudomi Distrik Yaur Kabupaten Nabire,” *J. Sumberd. Akuatik Indopasifik*, vol. 1, no. 1, p. 1, 2017, doi: 10.30862/jsai-uniipa.2017.vol.1.no.1.12

[6] I. T. Hargiyatno, F. Satria, and A. P. Prasetyo, “Hubungan Panjang-Berat dan Faktor Kondisi Lobster Pasir (Panulirus homarus) di Perairan Yogyakarta dan Pacitan,” *BAWAL*, vol. 5, no. 1, pp. 41–48, 2013

[7] L. Nugroho, “KelimpahanUdangKarangBerduri (Panulirus spp) di Perairan Pantai Watukarung Pacitan,” Universitas Sebelas Maret, 2007

[8] S. Triharyuni and N. N. Wiadnyana, “Aspek Biologi dan Musim Penangkapan Lobster (Panulirus spp) di Perairan Kupang Nusa Tenggara Timur,” *Juli*, vol. 23, no. September, p. 31, 2017, [Online]. Available: http://ejournal-bali-bangk.kkp.go.id/index.php/jppi

[9] M. Kadafi, R. Widaningroem, and Soeparno, “Biological Aspects ans Maximum Sustainable Yield of Spiny Lobster (Panulirus spp.) in Ayah Coastal Waters Kebumen Regency,” *J. Fish. Sci.*, vol. 8, no. 1, pp. 108–117, 2006

[10] A. Nurfiarini and D. Wijaya, “Estimasi Potensi dan Tingkat Pemanfaatan Sumberdaya Lobster Pasir (Panulirus homarus) di Perairan Prigi Kabupaten Trenggalek,” *J. Penelit. Perikan. Indones.*, vol. 25, no. 3, p. 169, 2019, doi: 10.15578/jppi.25.3.2019.169-178

[11] A. Rahman, D. A. Hedioanto, and D. Wijaya, “Sebaran Ukuran dan Faktor kondisi Lobster Pasir (Panulirus homarus Linnaeus 1758) di Pananjung Pangandaran,” *Widyariset*, vol. 4, no. 2, pp. 205–211, 2018

[12] H. N. Yusuf, A. Suman, T. Hidayat, and A. S. Panggabean, “Parameter Populasi Lobster Bambu (Panulirus versicolor) di Perairan Simeulue,” *BAWAL Widya Ris. Perikan. Tangkap*, vol. 9, no. 3, p. 185, 2018, doi: 10.15578/bawal.9.3.2017.185-195

[13] S. S. Djasmani, Djamanto, and Sukardi, “Pemanfaatan Dan Laju Tangkap Udang Lobster Di Pantai Selatan Daerah Istimewa Yogyakarta,” *J. Perikan. Univ. Gadjah Mada*, vol. 14, no. 1, pp. 20–26, 2012, doi: 10.22146/jfs.9051

[14] J. R. Factor, *Introduction, Anatomy, and Life History American Lobster (Homarus americanus).* 1995

[15] D. D. Kembaren, P. Lestari, and R. Ramadhani, “Parameter Biologi Lobster Pasir (Panulirus homarus) di Perairan Tabanan, Bali,” *BAWAL Widya Ris. Perikan. Tangkap*, vol. 7, no. 1, p. 35, 2015, doi: 10.15578/bawal.7.1.2015.35-42

[16] M. I. Effendi, *Biologi Perikanan.* Yogyakarta: Yayasan Pustaka Nusantara, 2002

[17] U. Chodrijah, A. Priatna, and D. Nugroho, “Distribusi Ukuran Panjang dan Parameter Populasi Lobster Lumpur (Panulirus polyphagus Herbst, 1793) di Perairan Sebatik, Kalimantan Utara (WPPNRI-716),” *J. Penelit. Perikan. Indones.*, vol. 1, no. 1, p. 11, 2018, doi: 10.15578/jppi.1.1.2018.11-23