Biodiversity of Lobster (*Panulirus*) from Eastern Indian Ocean of Indonesia Waters

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Abstract. Lobster fisheries play a very important role in the development of Indonesian fisheries management. Lobster fishing for Indonesian people plays a role in the economic, social and political fields. The key reason for this important role is because lobster fisheries are dominated by small-scale fishermen. Lobster also has ecological functions that play a key role in a benthic aquatic ecosystem. Tropical lobsters in the *Panulirus* group in Indonesian waters (Eastern Indian Ocean) are the most species and have high endemic levels. It is reasonable if the Indonesian government makes lobster fisheries as one of the fisheries groups that need to be considered in its territorial fisheries management (FMARI: Fisheries Management Area of the Republic of Indonesia). Each management area has different ecological characteristics. Differences in ecological conditions will cause differences in the composition of lobster species. For the sake of lobster fisheries management in each region, it is necessary to specify indicator species on the spatial and temporal scale. This study aims to identify lobster species of the genus *Panulirus* in the FMARI 573 eastern part of Indonesian waters. Data retrieval is done by taking samples from lobster fishermen. Sampling locations include Kebumen, Trenggalek, Blitar, Lumajang, Jember, and Sumenep. The sampling time was carried out in August-September 2018. Data was analyzed descriptively by identifying morphologically and recording the number of individuals per species. Identification of samples is carried out at the study site and also in the laboratory. The study found six lobster species, namely: *Panulirus ornatus* (Udang mutiara), *P. homarus* (U. pasir), *P. penicillatus* (U. batu), *P. versicolor* (U. bambu), *P. longipes* (U. batik) and *P. polyphagus* (U. pakistan) with the type of sand most often found among the study sites. Further research needs to be done to look at the distribution and connectivity of lobster populations by analyzing species variation in each life phase (larvae / puerullus, juvenile, adult) at a certain space and time scale.

Keywords: biodiversity, Indonesia, larvae, lobster, fisheries management, Indian Ocean.

1. Introduction
Indonesia is geographically classified into the East Asian marine region where its lobster species are known to have high levels of diversity and endemicity [1]. There are 19 species of lobster known in the world in the genus of *Panulirus* which have tropical habitats and are of high commercial value...
among other fisheries production categories [2, 3], six species including: *Panulirus ornatus*, *P. pennicillatus*, *P. versicolor*, *P. polyphagus*, *P. homarus* and *P. longipes* are found almost in all Indonesian waters including the South Sea of Java. Each species may have the same distribution area and may also be different. Within the territorial sea of Indonesia, the Indian Ocean covers the territorial waters of West Sumatra, South Java and South Bali and Nusa Tenggara.

The six lobster species were reportedly caught and landed by fishermen in several regions such as: Lombok, West Nusa Tenggara [4], South Bali, Bali [5, 6], Pangandaran, West Java [7], to West Aceh, Aceh [8]. While information from some unpublished literature on lobster species was caught by fishermen in all districts along the southern coast of Java, namely: Jember, East Java; Pacitan, East Java; Gunung Kidul, Yogyakarta; Kebumen, Central Java; Cilacap, Central Java; and Pangandaran, West Java. Therefore, there is a very strong argument that the waters of South East Java are also a habitat for the six species of lobsters. Like most lobsters they inhabit the substrate in the form of holes, coral cracks, and the bottom of a rocky beach. Vertically spread between just below the surface of the water to a depth of more than 100 meters. The home range of these lobsters is from the coastline to the continental shelf boundary [9].

Java South Sea Biogeography is included in the classification among 232 eco-regions proposed in the global system for coastal areas and exposure known as the Marine Eco-regions of the World / MEOW. Eco-region of the Java Sea Region is included in the Central Indo-Pacific marine realm and Java transitional provinces [10]. The transition area of Java includes the South Java Sea, South Nusa Tenggara Sea, Sawu Sea, and West of Timor Sea. The length of the South Java sea coast is around 1500.12 km which stretches from the tip of Ujung Kulan (Pandeglang, Banten Province) to the west up to semanjung Blambangan (Banyuwangi, East Java Province) in the east. Lobster fisheries in South Java are dominated by small-scale fisheries. And they generally are classified as a type of multi-gear and multi-species fisheries. That is because lobster fishermen also catch other types of fisheries such as pomfret, cod, and octopus with fishing gear that are different from one target to another target.

Although it is dominated by small-scale fisheries, the contribution to national fisheries production is very large. Even though the national production volume of lobster is very low, the quality (rupiah) is very high, even the second highest compared to other fishery commodities. This is because lobster is a fishery product for export. Lobsters from the family of *Palinuridae* inhabit all tropical and sub-tropical marine waters where lobster becomes very important in ecology and economy [11].

Most fish species and coastal decapods have pelagic and diffuse larval phases which then end in settlement in suitable coastal habitats. Recent studies show that these larvae are actively looking for suitable habitat using swimming abilities [12], and censorship [13]. This lobster life cycle includes the transition from the planktonic (phyllosome) larval phase which then metamorphoses to the next stage into the phase nekton (puerulus) post-larvae which moves towards the coast to settle in shallow coastal waters. Which will then experience molting to become small lobsters that are benthic and sedentary [14].

The lobster larval phase is relatively very long, that is, up to almost 18 months in some species which usually includes 7-13 phyllosome phase different from each stage marked with one or more cocoon (instars) period [15]. The initial phyllosome growth stage experienced after hatching from eggs is having very limited swimming ability. That results in them being spread widely to offshore waters by waves [15, 16]. So that at the phyllosome phase at most palinurid species are often found in oceanic waters outside the continental boundary as far as approximately 1500 km from the coast [17].

The location and trigger of metamorphosis from the final phyllosoma phase to the puerulus phase is uncertain because of difficulties in obtaining evidence of an observation or experiment. At the end of the phyllosoma phase metamorphosed into puerulus, a mechanism by which they move towards the coast into shallow water to stay is also unclear. However, the possibility of this involves a combination of the ability to swim actively towards the coast and the use of natural processes on the beach or passive processes such as surface currents caused by wind [18].

Although on the one hand the actual evidence of active movement towards the coast is very weak because the evidence is obtained from the measurement of very short swimming power and the energy...
consumption released is also very small [19]. Then on the other hand evidence of passive movement towards the coast is derived from the correlation between the time at puerulus which settles/settles with natural phenomena such as coastal wind, rain, and current patterns [20-22].

The distribution of puerulus in some offshore surveys indicates that their movement is towards the coast compared to movements that spread randomly [18]. They are found at shallower waters from offshore waters more than 50 km away [23].

From the above explanation it can be concluded that lobster fisheries are very important for the Indonesian economy. However, the actions of lobster fisheries management to protect and maintain the sustainability of lobster resources are relatively neglected. Therefore, the purpose of this activity is to develop formulations to protect ecosystems and conserve lobster resources. For this reason, this activity will contribute to the availability of information on lobster population biodiversity through identification of adult lobsters from fishermen. This information needs to be carried out further studies on lobster biodiversity in the larval phase (puerulus and juvenile). Merging these two topics will be used to describe the dynamics of lobster populations, namely the distribution and connectivity of lobster species on certain time and space scales. This information will be beneficial for lobster management, for example in the case of designs of marine protected area.

2. Method
The sampling location covers the provinces of Central Java in Kebumen and East Java which include: Trenggalek, Blitar, Lumajang, Jember, and Sumenep. Sampling time is carried out in August-September 2018.

Data collected is from the catch of lobsters’ fishers. Each lobster species encountered was sampled to be identified directly at the sampling location. The sample is then calculated by the number per individual per species in each location. Representative documentation of species is carried out at locations which are then repeated when samples are identified in detail in the laboratory.

The lobster was identified by looking at its physical characteristics as a reference in determining the type of species sorted from the special character (character) of Family Palinuridae, the special character of the genus and the specific character of each individual lobster. Then it will be matched using identification references according to Carpenter and Niem (1999) in the Marine Lobster of the Word “FAO Species Catalog Vol. 13”. Documentation when presented with a representative sample of each lobster species will be used as supporting data for species identification. Some samples of lobster will be stored at the Hydrobiology Laboratory of Brawijaya University to be used as specimens. The data will then be processed and descriptive analysis will be carried out.

3. Result and Discussion
Spiny lobster or rock lobsters belong to the same group of genera Palinuridae. They inhabit ubiquitously in tropical and temperate seas. But in the tropics the most species and abundance of spiny lobsters are found. Their habitat is ranging from intertidal down to the deep, almost 3000 m deep sea [2]. The Palinuridae, which is important for commercial purposes, does not overlap each other's spatially as a function of depth and latitude [24].

The lobster group in the study was from the Palinuridae which was different from the other groups. In addition to its spiny body the distinctive difference is the presence of a pair of antennae whose length exceeds the length of his body. Another distinguishing feature is the absence of a pair of claws on one the walking leg [2, 25]. The overall study found six lobster species, namely: Panulirus ornatus, P. homarus, P. versicolor, P. pennicilatus, P. longipes, and P. polyphagus. The distribution of lobster species is not evenly distributed in each sampling location (Table 1). This is possible because the sampling time is short and does not represent all time (months) of the year. Certain sampling sites also do not represent any different habitat conditions that are possible to become lobster habitats of different types. The species of lobster is highly related to oceanographic conditions (physics, chemistry, biology) and its existence is often at a certain space and time.
Table 1. Panulirus species and location found.

| No | Latin, international and local name | Picture | Location |
|----|-----------------------------------|---------|----------|
| 1  | *P. ornatus* Ornate spiny lobster Mutiara/kentangan/cemara | ![Picture](image1) | Blitar, Jember, Lumajang |
| 2  | *P. Homarus* Green sand lobster, scalloped spiny lobster Udang pasir/pantung/bireng | ![Picture](image2) | Kebumen, Trenggalek, Blitar, Lumajang, Jember |
| 3  | *P. versicolor* Green lobster Udang bambu/metalik/Kendal | ![Picture](image3) | Kebumen, Trenggalek, Blitar, Jember, Sumenep |
| 4  | *P. penicillatus* Pronghorn spiny lobster Udang batu/jaka | ![Picture](image4) | Kebumen, Blitar, Lumajang, Sumenep |
| 5  | *P. longipes* Flower lobster, long legged spiny lobster Udang batik/bintik seribu/bunga/berasan | ![Picture](image5) | Jember, Sumenep |
| 6  | *P. polyphagus* Mud spiny lobster Udang Pakistan/coklat/jarak | ![Picture](image6) | Cilacap, Gunungkidul, Pacitan |

The results of this study are in accordance with previous studies where the six lobster species were reported caught and landed by fishers in several territorial waters of the Eastern Indian Ocean such as: Lombok, West Nusa Tenggara [4], South Bali, Bali [5, 6], Gunungkidul, Pacitan [26, 27], Yogyakarta
[28], Kebumen [29], Pangandaran, West Java [7], to West Aceh, Aceh [8]. While information from some unpublished literature on lobster species was caught by fishers in districts along the southern coast of Java such as: Jember, Pacitan, Gunung Kidul, Kebumen, in Central Java; Cilacap, and Pangandaran in West Java.

From a review of juvenile and adult ecology, Panulirus lobsters are widespread and numerous, particularly on rocky and coral substrates. Though some members of the genus are found on the soft muddy bottom they remain hidden during the day and active to forage in dark time. So they are nocturnal which like to hunt their prey in night time as to avoid their predators. All members of the genus are non-specialist feeders. They are foraging on a wide range of food items. Just few of Panulirus species, the juveniles are found solitary in the small holes or dens that they choose in shallower inshore waters [14, 30], than those of the adult population are usually caught and found. Spiny lobsters are solitary when they are in larval stage and become gregarious as they grow [31, 32] that is considered an effective anti-predator strategy [14]. Natural mortality rates of juvenile lobsters are extremely high which is estimated to be 80–96% [33] and 96–99% [18] in the first year after settlement. For several species substantial migrations is undertaken as they approach or reach sexual maturity (e.g. P. argus, [34]; P. cygnus, [35]; P. ornatus, [36]). Once they have settled in their dens, spiny lobsters can stay for long periods of time occupying holes within their home range [37]. The dynamic of the lobster species according to space and time in each phase of their life is interesting to study. Such population dynamics are important for understanding the distribution and connectivity of lobster populations as one of the important information in the management of lobster fisheries.

4. Conclusion
Based on the results of this study it can be concluded that in this study we found six lobster species, namely: Panulirus ornatus (Udang mutiara), P. homarus (U. pasir), P. penicillatus (U. batu), P. versicolor (U. bamboo), P. longipes (U. batik) and P. polyphagus (U. pakistan) with the type of sand most often found among the study sites.

Further research needs to be done to look at the distribution and connectivity of lobster populations by analyzing species variations in each life phase (Larvae / puerullus, juvenile, adult) on a certain scale of space and time.

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