Sex Diversity Approach of Spiny Lobster (*Panulirus* spp) to Marine Oil Spill Pollution in Southern Waters of Java

To cite this article: F E D Haryono *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* 116 012008

View the [article online](https://iopscience.iop.org/article/10.1088/1755-1315/116/1/012008) for updates and enhancements.
Sex Diversity Approach of Spiny Lobster (*Panulirus* spp) to Marine Oil Spill Pollution in Southern Waters of Java

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1. **Introduction**

Cilacap waters is known dense of marine ships transportation, at other side, the activity of fisheries fleet have lead more complex of maritime sector. Super marine tanker vessel supplying crude oil to Cilacap oil refinery, barges supplying coal to 3 electric power plants and cement factory. Those
activity have impacted to water quality. Navigation ship channel to Tanjung Intan port have lead a lot of sinking of ships in Cilacap waters. The ships that have sunk were USS Langley on February 27, 1942, Niaga 34 loaded full of asphalt drums, Alisa XVII on November 1989 loading 11.000 drums of asphalt, MT King Fisher loaded full of crude oil on April 2000. The distribution of crude oil and bitumen spill shows toward to northwest when spring tide and to southeast at neap tide [1]. Banana VI and a ship were leak with 5000 tons of airplane oil on January 15, 2010, MT Alisa XVII 18.101 GT aground and leaked, including a lot of fishing boats. Four shipwreck of oil tanker had been accidents during period 2006-2008 [2]. The latter MT HHC were sunk loaded bulk of asphalt and MT Harmony Seven load 33,000 tons of diesel at October 17, 2015. Liquid and solid wastes extremely have polluted in Southern Java waters. Concentration of hydrocarbon in Cilacap sediment with risk levels ranged from low to medium-low and ecological risk for marine organism were obtained a greater impact at some locations [3]. The presence of oil spills has sensitive and very sensitive at coastal areas of Cilacap waters [4]. Concentrations heavy metal Cr, Ni, and Zn in sediments as result of Cilacap refinery site stations. The adverse effect of the conditions may cause more serious harmful effect to a wider range of organisms [5]. At other side, sewage disposal outlets produced a decrease in population density and changes in size spectra [6].

Variability of all organism that life on mainland, marine and aquatic ecosystem is known as diversity. Ecologically with their complexity of all sub part, include diversity of species, inter species and their ecosystem. The condition of diversity stated by [7] as diversity biology or biodiversity. Furthermore, the number and frequency of ecosystems, or genetic system are included the parts of degree of natural diversity [8]. Counting the number of species is done to obtain the diversity, although even more that can be expressed by a real number. Species composition, structure and function tropic ecology of a species is focus aspects of biodiversity [9]. Ecosystems under stress indicates diversity decline [10].

Fishery species under over-exploitation condition for some decade will occur diversity and long period of over exploitation impacted to diversity. The condition impacted to spiny lobster genus Panulirus [11]. Stocks of spiny lobster on some area may be close to collapse, the conditions as result of heavily overexploitation to the species [12]. Management of spiny lobster fisheries for international and regional cooperation is importance to manage to area that have high of degree of connectivity [13].

Phylum of crustaceans consists of 30.000 species, which crab and lobster are large species [14] and important crustacean fishery resource was spiny lobster [15]. The species have supported the global food stocks of fishery production currently around 260,000 tons per year [16]. Tropical spiny lobster consists several species, the species can survive without water for a certain periods. Lobster fisheries production was decrease for some decades and become an important issue in Indonesia now [17].

Biological aspect of spiny lobster, spawning circle starts to spawn that females migrate away from coastal waters to deeper waters, whish range number of egg between 159.000 – 1.925.000. After hatching the species living in the bottom waters for two years and moving to coral for mating and laying eggs [18]. The eggs fertilized externally by the male sperm [19]. Lobster age of 4-5 years old of coral lobster change of colour from red to pink before migrated to offshore [20]. Eggs of lobster found different at a large geographic scale [21]. The eggs hatch into transparent phyllosome larvae and metamorphic into puerulus. The distribution of the larvae follow ocean current for 6-12 months [post larvae]. The transparent pueruli settle on beach substrate as benthic organism and experience the dark pigmentation and moulting with 8-10 days into juvenile. Life a year as benthic organism in depth of 3-15 m, two years grew into adulthood and female migrate to deeper water to spawn [22]. Eggs of lobster hatch and the larva grew to adult of 30 mm total length experiencing 22 times of moulting during a 256 days [23].

Male and female of spiny lobster exhibits dimorphism with clear differences and the key parameter for the management regime were size of sexual maturity. Lobster in Las Perlas found 297 females, 175 (59%) had eggs and ratio of male than female 1.29:1 [24]. [25] observed that in Iran waters obtained 260 of P. homarus which number of female more than male [female 143 and male
Hereinafter referred at monsoon climate obtained 104 mature females and 42 were ovigerous and 36 were moulting. Female CL decline smaller than male and fishery activity impacted the difference of size between the sexes geographically [26]. Larvae with different length classes, sex, moulting condition and presence of eggs in female found at any significant difference between frequency of occurrence of each larvae [27].

Biological information such as size of sexual maturity, size distribution, relationship of CL, BW and sex ratio are important criteria to study the behaviour and characteristic of spiny lobster, significantly estimating size relation to the number taken by the fishery. Sexual maturity of lobster can attain at 6.02 cm of CL for male and 6.59 cm for female [28]. Most female of lobster during reproductive season choose to cohabit with large males and large male tended to cohabit with large female. Mate size of male and female associated freely with no preference [29]. Sexual mature of females can estimate the growth of lobster. The estimated sizes at 50%, physiological and functionally mature are [mean ± SE] CL : 56.46 ± 0.56 mm and CL : 66.63 ± 1.07 mm [30]. The oil spill pollution and high of fisheries activity have pressure extremely to coastal waters quality of the Southern of Java. This study aimed to analyze the influence of marine oil spill pollution to sex diversity of spiny lobster.

2. Method

Coastal waters of Southern Java is known as high of lobster catch area. The study area especially in Central Java Province and Special Region of Yogyakarta waters. Which Central Java waters consist four districts, namely Cilacap, Kebumen, Purworejo and Wonogiri. Special Region of Yogyakarta consist three districts, namely Kulonprogo, Bantul and Gunungkidul.

The study were done from January to July 2015. Spiny lobsters were collected randomly encompassed in coastal waters of the districts. All sampling were performed six times at the location using 1 inch mesh size of gillnet. Captured lobsters were put in a cool box to be identified morphologically and sex in situ based on [31]. Total Length [TL] and Carapace Length [CL] measurement were measured using a caliper to the nearest 0.1 mm, based on [32] method. The wet weight was measured using electric balance to the nearest 0.1 g and data analyzed statistically (α 0.05).

3. Result

Fisherman who catch of spiny lobster as small scale fishery. Totally, 892 fisherman were capture of lobster at study area, using 0.5 ton of fiberglass canoe. The average of lobster net length were 1000 m or 10-20 piece of gillnets. Figure 1 shown the species distribution of spiny lobster was captured from districts. Spiny lobster from Gunungkidul waters were captured as highest percentage, which as much as 37.12%. Wonogiri district waters was not obtained of lobster, at the waters was not present of fisherman. Percentage of spiny lobster from Cilacap district were captured 24.195%. Coastal morphology of Gunungkidul district was limestone cliffs and distance to Cilacap approximately 250 km. Spiny lobster catch activity by Gunungkidul fishermen was more productive than other district and the habitat support the growth of lobster. Gunung kidul and Cilacap were centre of spiny lobster capture activities, although the number of fishermen at Gunung kidul were at least compare with fishermen by other districts, lobster was captured at the district as the most numerous.
Morphologically identify of lobster were obtained six species, namely *P. homarus*, *P. ornatus*, *P. versicolor*, *P. penicillatus*, *P. longipes* and *P. polyphagus*. Diversity morphology of spiny lobster species at districts was dominated by *P. homarus* [64%]. *P. penicillatus* species was captured 23%, *P. ornatus* 6%, *P. versicolor* 4%, *P. longipes* 2% and *P. polyphagus* 1%. Seabed habitat of Gunungkidul and one fifth of Kebumen districts were rocky. Spiny lobster were captured from those distric dominated by *P. penicillatus*. Seabed substrate other those districts was sand or sand muddy. *P. homarus* [scallops spiny lobster] inhabit in sand seabed substrate. Figure 2 shown the percentage of dominant distribution of lobster, which each district was captured *P. homarus*, except Gunungkidul district that dominated by *P. penicillatus*. The different of diversity of species between Gunungkidul and Cilacap districts than other districts were obtained that, at those districts more differ of species lobster. Each districts were obtained five species of spiny lobster, except *P. longipes* at Gunung Kidul and *P. penicillatus* at Cilacap.

Sex diversity of male in Figure 3 bellow shown that *P. homarus* as dominant species [64.01%] and secondly was *P. penicillatus* [22.06%]. Spiny lobster that inhabit in Gunungkidul district waters, which the district is known as most distant from Cilacap, which about 250 km. The Cilacap waters was center of extreme water quality due to result of frequent oil transport vessels that run aground and sunk.

Sex diversity of female spiny lobster species from southern Java waters [Figure 4] were shown that *P. homarus* species as the dominant [63.70%], *P. penicillatus* species were obtained 23.97% and the fewest female was *P. polyphagus* [0.68%].
Gunungkidul, Bantul, Kulonprogo, Purworejo and Kebumen districts directly related to influence of Indonesian ocean waters. The condition differ with Cilacap district waters, which Cilacap district is protected from influence of Indonesian ocean by Nusakambangan island. Bantul and Kulonprogo districts as part of Yogyakarta province were found a lot of river, which springs at Merapi volcano. The seabed substrate at the districts waters was muddy sand and in 2014 the volcano was erupt. A lot of sand sediment as eruption material from the mountain moved into the coast.

![Figure 4. Percentage distribution of female Panulirus species.](image)

The comparison of male to female of each district [Table 1] was acquired lobster from Gunungkidul and Cilacap districts more female than male. Male and female ratio for Gunungkidul spiny lobster were found 0.99 and 0.95 for Cilacap. Coastal waters quality of Gunungkidul was clearer than Cilacap and distance from sources of pollution of oil spill 250 km, thus supporting the existence the spiny lobster. Comparison between male and female lobsters in each district was found the number of male more than female at the two districts. Bantul district with ratio of males to females 1:03 and distance to Cilacap 200 km, and secondly Kulonprogo with ratio 1:4, distance to Cilacap 150 km. We assumed that the eruption of volcano recently and volcano material move into coastal waters have effect to the sex diversity of lobster.

| District    | Percentage | Ratio |
|-------------|------------|-------|
| Cilacap     | 10.4       | 11.0  |
| Kebumen     | 4.4        | 6.9   |
| Purworejo   | 0.3        | 0.9   |
| Kulonprogo  | 2.8        | 2.0   |
| Bantul      | 12.3       | 11.9  |
| Gunungkidul | 18.5       | 18.6  |
| Sum         | 48.7       | 51.3  |

| District    | Male  | Female | Ratio |
|-------------|-------|--------|-------|
| Cilacap     | 10.4  | 11.0   | 0.95  |
| Kebumen     | 4.4   | 6.9    | 0.64  |
| Purworejo   | 0.3   | 0.9    | 0.33  |
| Kulonprogo  | 2.8   | 2.0    | 1.40  |
| Bantul      | 12.3  | 11.9   | 1.03  |
| Gunungkidul | 18.5  | 18.6   | 0.99  |
| Sum         | 48.7  | 51.3   | 0.949 |

Diversity of males and females for the entire district were obtained females [51.3 %] more than males [48.7 %], which the ratio of male compared to female 0.949, these value shown that 9 of male were obtained 10 of female lobsters. Statistically was showed significant differences [$\alpha_{0.05} : 0.741$]. Likewise, comparison of sex diversity of each lobster species which male compared to the female were obtained females more than male, except $P. Versicolor$. Sex diversity of lobster were shown no significant relationships [$\alpha_{0.05} : 0.397$].

Sex diversity condition of marine organism as a result of the pressure fishing activity expressed by [9] that diversity aspects, focus on species composition, community structure and ecological function of species was formed from integration of size diversity between richness of species and size of abundance size. Condition of females more than males allegedly were captured in long period can cause large scale change in stock other than increasing of exploitation.

Table 2 was shown the comparison between females and ovigerous female, that one-eighth of female have eggs, [12 %]. The comparison between female to male is very different from that observed by [24] in Iran waters was found by almost equal ratio, that is half of female have eggs, while for female lobster in Southern waters of Java was obtained only one-sixth from total of lobster females have eggs.
Table 2. Female and ovigerous female ratio of *Panulirus* sp.

| Female [%] | Ovigerous Female [%] |
|------------|---------------------|
| 88         | 12                  |

Climatic conditions at the time of data collection in Southern Java waters was not different from the conditions of the season conducted by [24] research, but we found female have eggs differ of ratio. The shortest carapace length of spiny lobster is 46 mm and weigh 102.8 g, while the longest size was 92 mm with weight 1689 g.

4. Conclusion

Cilacap waters as center of oil spill accumulation was influent existence of spiny lobster. Sex diversity of spiny lobster in the Southern waters of Java was more female of lobster than male and the relationship was significant. Sex distribution ratio in six districts waters was found more male than female in Bantul and Kulonprogo districts. Eruption of Merapi vulcano have accumulate in bantul and Kulonprogo districts waters. Ratio of ovigerous female to non ovigerous female was found 0.12.

Lobster fishery production conditions was resulted that females more than males, and these conditions take place during the period of time, then the future will affect to availability of lobster in the waters and become extinct. Furthermore, conditions of districts waters is interconnected and open to exploitation by any fisherman or common property resources. Under the conditions, important to design the joint management to the fisheries resources as well as joint management of prevention and treatment of water pollution impacts. The aim of management is maintain the availability of fishery resources, particularly lobster stock, those step is importance to the long term lobster fishery.

5. Discussion

Oil spills was very often occurred and as a representative of chronic oil contaminated in Cilacap coastal waters [32], and managed based on ecosystem is importance to help the development of fisheries, especially species of spiny lobster [13]. Linked the condition of fish size and shrimp that mean annual production at Cilacap district for commercially important fish and shrimp were smaller. On the other side the health of water quality can be seen from the biological condition of female and male organism. Average length of species that 90% of the female length mature have egg indicate the water quality is health [33]. While diversity is a whole variability of living organisms from all resources, including the diversity of species, between species and ecosystems. Ecosystems under stress conditions indicating diversity is decrease [10].

Spiny lobster as a large-sized of decapod organism [35] influence of water quality is being limiting of life factor. The relation to oil spill pollution that crude oil settles on seabed and lobster live on seabed, which need ability to survive in order to retain its kind. The existence of lobster at this research is result of a form of adaptation to extreme environmental water quality and fishery pressure. As bottom organism, lobster must survive to adjust oil spill that settles on seabed. Lobster sample were obtained over 1100 species indicated that the species able to survive and proliferate. 51.3 % female from total number of lobster was obtained 12% as ovigerous female.

The grow and mature lobster species which subsequently produce eggs are strongly influenced by the conditions of water quality i.e. availability to feed, water quality, external fertilization. Furthermore, water quality conditions greatly is affect to growth, egg production and fertilization process that external system. Based on the high ratio of non-ovigerous females, we assumed the condition is caused by worse of water quality as direct and long term impact of frequent oil spill that have contaminate in Southern Java waters.

The coast line from Cilacap to Wonogiri districts approximately is 300 km and spiny lobster was captured by 826 fisherman that capture time depend upon to climate season. However, if the lobster were caught dominated by female for long period, the condition will affect to the stock. Problem
solving to the condition that is appropriate the government to do more to manage lobster fishery by limiting of catch, including policies with sanctions appropriate as responsibilities to impact of pollution. Marine oil spill pollution was impacted to water quality and extreme impact to the level of tropic marine organisms, the existence of the fish resources are very urgent to be study with regard to the availability of food, especially the fish resources of high economic value. Study conditions fishery resources and water quality are very dynamic and interrelated. The assessment as the basis for further management and management that have been enacted should be evaluated, as recommended by [36] that economic impact of the policy liabilities seabed ship fleet that landed in Spain that operating in Iberian sea.

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