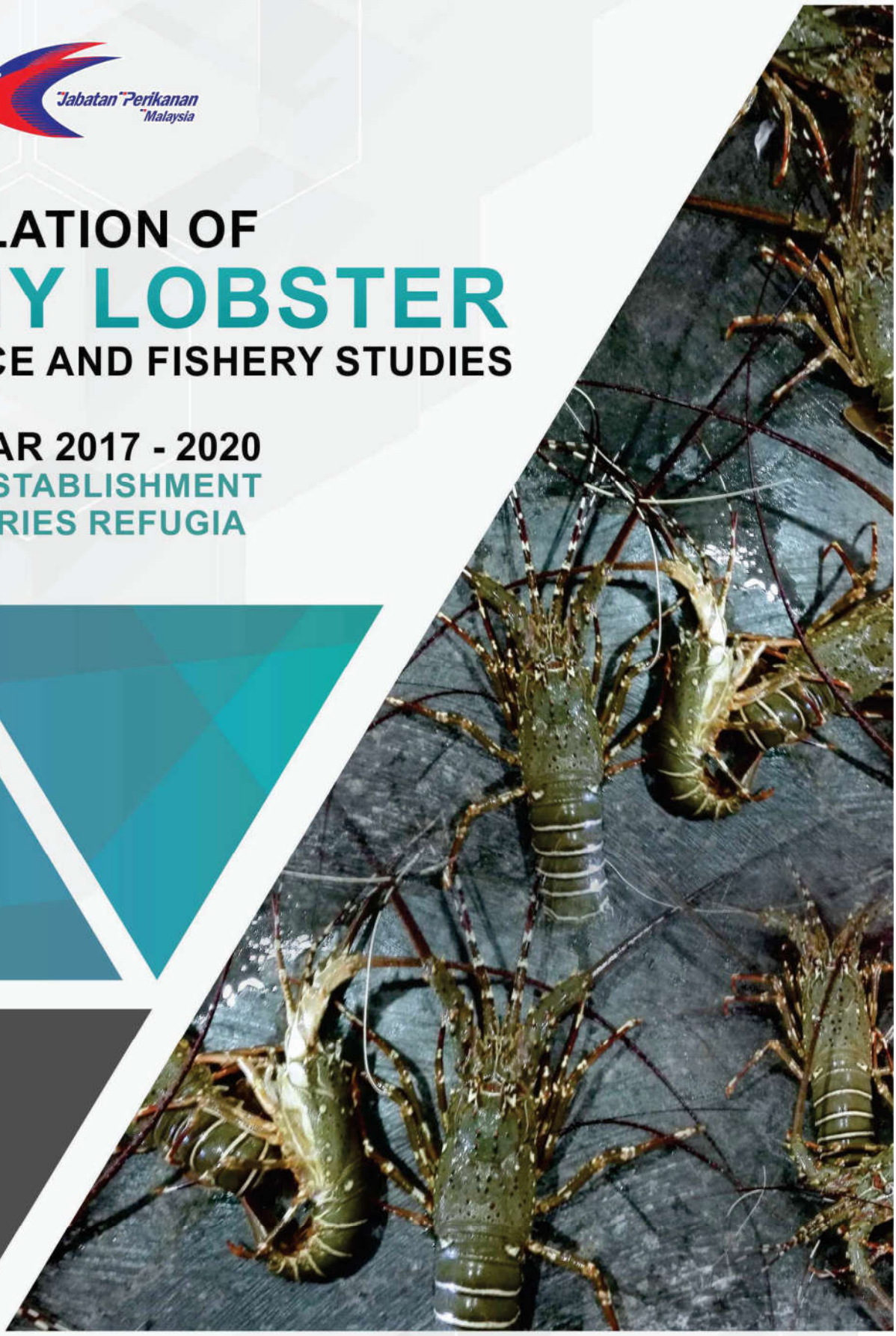
COMPILATION OF
SPINY LOBSTER
RESOURCE AND FISHERY STUDIES

FROM YEAR 2017 - 2020
FOR THE ESTABLISHMENT OF A FISHERIES REFUGIA



Editors:
Ryon Siow • Nur Hidayah Asgnari • Sallehudin Jamon
FRI KAMPUNG ACHEH

SEAFDEC/UNEP/GEF Fisheries *Refugia* Project

"Establishment and Operation of a Regional System of Fisheries* Refugia *in the South China Sea and Gulf of Thailand"

COMPILATION OF SPINY LOBSTER RESOURCE AND FISHERY STUDIES FROM YEAR 2017-2020 FOR THE ESTABLISHMENT OF A FISHERIES REFUGIA

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2021

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Acknowledgement

I would like to express my appreciation to the researchers and supporting staff of the Department of Fisheries Malaysia who have involved in these studies, especially the staff of Fisheries Research Institute Kampung Acheh, the Johor and Pahang State Fisheries Offices and all the stakeholders involved in this SEAFDEC/UNEP/GEF Establishment and Operation Project of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand.

These scientific studies concerning the biology, resources and socio-economic aspects of the spiny lobster fishery in East Johor and southern Pahang were conducted from year 2017 to 2020. From the study, it is suggested that area in Tg. Leman, Johor waters be recommended as a refugia site for spiny lobster. The findings were presented in a series of seminars and meetings held locally and abroad.

A documentary entitled *Udang Kara: Khazanah Negara* (Lobster: A National Treasure) was aired by the national television station *Rancangan Televisyen Malaysia* (RTM) in December 2018. This was a great achievement where the Fisheries Research Institute was able to expose our research activities and indirectly promote the conservation of spiny lobster resources to all Malaysians. The knowledge obtained from these studies will be incorporated in the management decisions and establishment of a fisheries refugia for the spiny lobster in the waters especially in East Johor and southern Pahang. Congratulations!

Regards,

DR. HAJI ZAINODDIN BIN HAJI JAMARI
Senior Research Director
Fisheries Research Institute (FRI) Batu Maung
Penang

Foreword

This compilation of reports is intended for an easy and comprehensive source of reference for other researchers, fisheries managers and policy makers especially from the Department of Fisheries Malaysia to manage the fisheries stock of the spiny lobster in Malaysia.

Our scientists have conducted significant studies on the spiny lobster resource and biology aspects in East Johor waters as well as southern Pahang. I would like to congratulate all people involved in this study for the very outstanding effort, especially the officer and staff of FRI Kampung Acheh, the captain and crew of KK SENANGIN II as well as all who have participated in the research. Thank you for the corporation and never-ending support.

In this regard, I hope the Capture Fisheries Research Division through FRI Kampung Acheh will continue to excel in producing world-class research results and become a reference point for others in the field of spiny lobster resource studies. I also hope that the findings and recommendations in this book will improve our management strategies to ensure sustainable exploitation of these valuable spiny lobster resources.

SALLEHUDIN BIN JAMON
Director
Capture Fisheries Research Division,
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Preface

The Fisheries Research Institute (FRI) Kampung Acheh, Perak was given the task to provide scientific knowledge concerning the spiny lobster biology and resources for the project entitled SEAFDEC/UNEP/GEF Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand. This book is the outcome of at least four years (2017-2020) of comprehensive studies of spiny lobster East Johor and southern Pahang.

The studies involved comprises of subjects such as the spiny lobster resources in the waters off East Johor and southern Pahang, the spiny lobster fishery, the distribution of spiny lobster larvae and the socio-economic aspects which were conducted by the researchers from FRI Kampung Acheh, Perak and FRI Batu Maung, Penang. The findings and recommendations from these studies can be used as a baseline and references by the management of the Department of Fisheries Malaysia to ensure the proper management and sustainability of the spiny lobster resources and fishery in Malaysia.

We would like to acknowledge the work and assistance provided by all the staff of FRI Kampung Acheh, FRI Batu Maung, Johor State Fisheries Office, Pahang State Fisheries Office and the Marine Park and Resource Management Division, Putrajaya.

Thank you.

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Lobster Resource Survey at East Johor Waters in Year 2016-2017

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Abstract: This study was conducted to evaluate the current resource status of spiny lobsters (*Panulirus* spp.) and slipper lobster (*Thenus orientalis*) in the East Johor waters. The objectives of this study were to obtain information pertaining to the distribution and density of spiny lobsters and slipper lobsters in the East Johor waters. The study covered the Zone B and Zone C fishing areas in East Johor. Samplings were conducted using bottom trawl nets onboard a fisherman trawler boat in August 2016 and onboard the KK Senangin II vessel in August 2017 in the same fishing area. The samples from the surveys were analyzed to gather information such as length and weight according to species and the egg maturity level of lobsters caught. The results from the surveys indicated that the average catch rate (kg.hour^{-1}) of slipper lobster in the year 2016 was 0.19 ± 0.09 S.E. kg.hour^{-1} while in the year 2017, the average catch rate (kg.hour^{-1}) of both spiny lobster and slipper lobster (combined) was 0.21 ± 0.12 S.E. kg.hour^{-1}. There was no *Panulirus* spp. lobster sample during the year 2016 survey. The average density (kg.km^{-2}) for slipper lobster in the year 2016 and 2017 were 1.52 ± 0.71 S.E. kg.km^{-2} and 0.32 ± 0.13 S.E. kg.km^{-2} respectively. The average density (kg.km^{-2}) for spiny lobster in the year 2017 was 7.26 ± 3.09 kg.km^{-2}. The results from the surveys indicated that the distribution of *Panulirus* spp. lobsters during the August period was very sparse in the zone B and zone C areas as compared to the slipper lobsters. However, several adult size mud spiny lobsters (*Panulirus polyphagus*) were successfully caught at two deep water (>30m) locations at Zone C and were found to be bearing eggs. The establishment of a lobster refugium is proposed as a fishery management measure to protect the lobster resource in the study area.

Keywords: *Panulirus* spp., *Thenus orientalis,* East Johor, fishery resources, lobster

Abstrak: Kajian ini bertujuan menentukan status sumber terkini udang karang (*Panulirus* spp.) dan udang lobok (*Thenus orientalis*) yang ada di kawasan perairan Johor Timur. Objektif kajian adalah untuk mendapatkan maklumat taburan dan kepadatan udang karang dan udang lobok di kawasan perairan Johor Timur. Skop kawasan kajian adalah di perairan perikanan zon B dan zon C di Johor Timur. Persampelan telah dijalankan menggunakan alat pukat tunda di atas bot nelayan pada Ogos 2016 dan kapal KK Senangin II pada Ogos 2017 di kawasan tangkapan yang sama. Hasil tangkapan dianalisa untuk mendapatkan maklumat panjang dan berat mengikut spesies serta tahap kematangan telur udang karang. Keputusan survei mendapati purata kadar tangkapan (kg.jam^{-1}) udang lobok pada tahun 2016 ialah 0.19 ± 0.09 S.E. kg.jam^{-1} manakala pada tahun 2017 pula, purata kadar tangkapan (kg.jam^{-1}) udang karang dan udang lobok ialah 0.21 ± 0.12 S.E. kg.jam^{-1}. Tiada udang karang *Panulirus* spp. berjaya disampel pada survei tahun 2016. Purata kepadatan (kg.km^{-2}) bagi udang lobok pada tahun 2016 dan 2017 ialah 1.52 ± 0.71 S.E. kg.km^{-2} dan 0.32 ± 0.13 S.E. kg.km^{-2} masing-masing. Purata kepadatan udang karang pada tahun 2017 pula ialah 7.26 ± 3.09 kg.km^{-2}. Keputusan survei mendapati taburan udang karang *Panulirus* spp. pada bulan Ogos amat kurang di kawasan laut zon B dan zon C berbanding spesies udang lobok. Namun begitu, beberapa ekor udang karang hijau (*Panulirus polyphagus*) bersaiz dewasa telah berjaya ditangkap di dua lokasi air dalam (>30m) di zon C dan didapati ia membawa telur. Penubuhan sebuah refugia udang karang dicadangkan sebagai satu langkah pengurusan perikanan bagi melindungi sumber udang karang di kawasan kajian.

Introduction

Lobsters are one of the much sought-after commercial marine species in Malaysia and elsewhere in the world. In the East Coast of Peninsular Malaysia, there are at least five main species of spiny lobsters, namely *Panulirus polyphagus*, *P. versicolor, P. homarus homarus, P. longipes longipes* and *P. ornatus* (Alias *et al.*, 2000). However, among these five species, *P. polyphagus* is the most dominant commercial species and can be found in abundance in East Johor waters. The Palinurid spiny lobsters are different from the true lobsters (such as *Homarus* spp.)

usually found in the Atlantic Ocean, in that they lack the large chelae (claw) usually associated with true lobsters. However, the spiny lobsters are taxonomically more related to the slipper lobster (Scyllaridae) such as *Thenus orientalis*, and both *P. polyphagus* and *T. orientalis* can be found in abundance in East Johor waters.

For the spiny lobster *P. polyphagus*, the juvenile lobsters are usually found along the shallow coastal habitat while the adult lobsters are usually found in the deeper sea bed of East Johor waters. Thus, the adult lobsters are often caught by bottom net trawlers while traditional fisherfolk such as traps and drift nets operators target the juvenile lobsters. Every year, the newly grown adult spiny lobsters will embark on a migration to deeper sea from their coastal habitat for breeding and spawning purposes (Alias *et al.,* 2000). A previous study by Alias *et al.* (2000) has indicated that the breeding and migration season begins in July and berried females were high in August. During this critical moment, the spiny lobster population is susceptible to overfishing due to the high aggregation of lobsters at any one time and the risk of capture by the fisherfolk.

Currently, the lobsters resources throughout the world are already either fully exploited or over-exploited (FAO, 2011). The Caribbean Spiny Lobster (*Panulirus argus*) fishery in Western Central Atlantic, the Cape Rock Lobster (*Jasus lalandii*) fishery in Southeast Atlantic and the palinurid spiny lobster (Palinurus spp.) fishery in Eastern Central Atlantic were all reported to be overfished (FAO, 2011). However, the state of the lobster fishery in Malaysia is still unknown but the recent trend of decreasing landings (DOFM, 2018) is of great concern to the local lobster fishery industry and management.

Thus, the aim of this study was to evaluate the current resource status of spiny lobsters (*Panulirus* spp.) and slipper lobster (*Thenus orientalis*) in the East Johor waters. The objectives of this study were to obtain information pertaining to the distribution and density of spiny lobsters and slipper lobsters in the study area.

Materials and Methods

Sampling Area and Design

The study area was located at the trawler's fishing ground in East Johor, Peninsular Malaysia. Based on the Malaysian marine fishery zoning system, the study area covered both the zone B and zone C area. Two surveys were conducted in the same area during similar periods, on the 24-27 August 2016 and 21-24 August 2017. The first survey was conducted using a chartered commercial fish trawler while the second survey was conducted onboard a Department of Fisheries Malaysia research vessel, KK Senangin II. A total of 17 locations were sampled in year 2016 survey, covering an estimated study area of 1177.16 square kilometer while in the subsequent year, 18 locations were sampled in an estimated study area of 1812.30 square kilometer (Figure 1). Initially, the sampling locations were predetermined systematically but some adjustments were made during the actual sampling to adapt to local condition and suitability.

Sampling was conducted using bottom trawl nets with an average trawling operation speed of about 6.3 $km.h^{-1}$ and trawling duration of about 60 minutes. The coordinates of the starting and ending positions of each trawling operation were recorded along with other information such as water depth and trawling direction. After each haul, the catch was sorted, identified to the species level and measured onboard the study vessels.

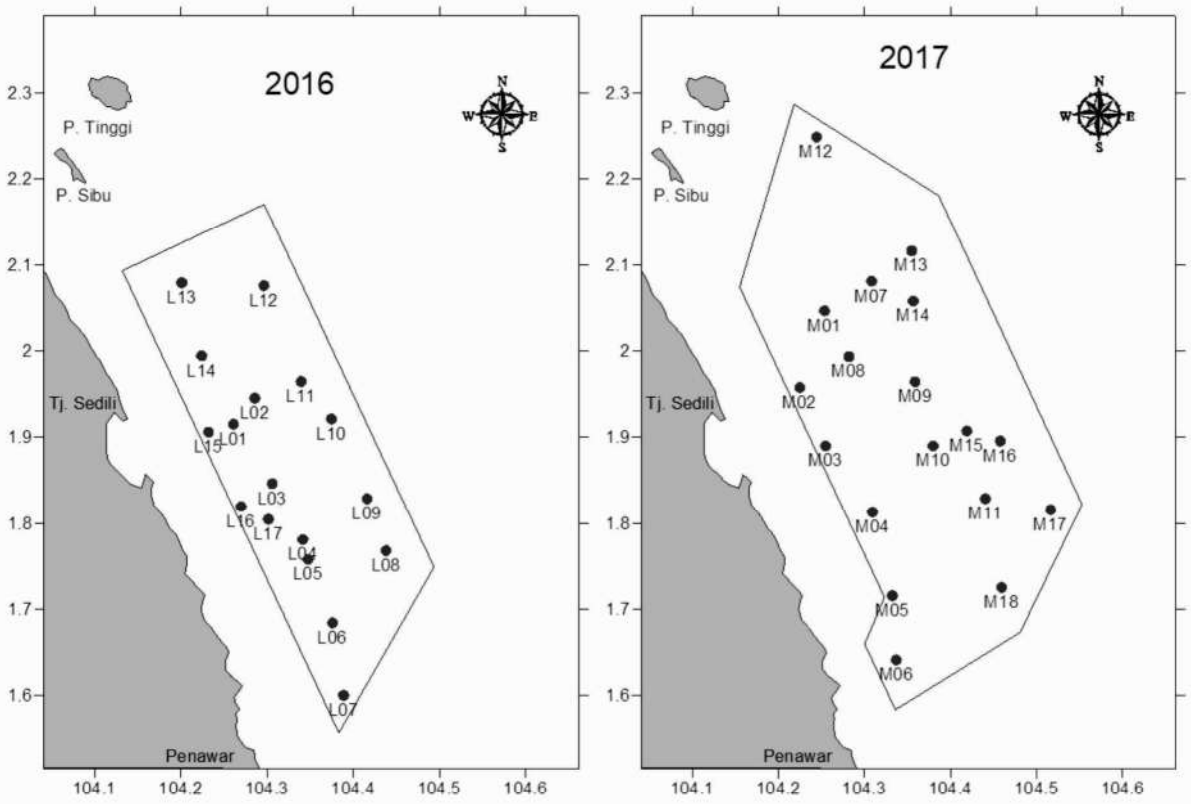

Figure 1: Maps showing the sampling locations in the survey area in East Johor in year 2016 (left) and 2017 (right). The estimated study area in year 2016 was 1177.16 square kilometer while in year 2017 was 1812.30 square kilometer

Data analysis

The density of the fish sampled in the survey were calculated using the "swept area method" (Sparre and Venema, 1998). The swept area, a, was estimated using the following equation:

$$a = D * h * x \quad \text{.....(Equation 1)}$$

$$\text{Where } D = V * t \quad \text{..... (Equation 2)}$$

Where V is the average speed ($km.hr^{-1}$) of the trawling operation, t is the trawling duration (in hours), h is the length of the trawl net headrope and x is the fraction of the headrope which equal to the width of the path swept by the trawl net (FRI, 2017). In this study, the value of x used was 0.5 (Sparre and Venema,1998).

Assuming that the weight of the catch of each haul is Cw, then the catch per hour is described as Cw/t. Also, if "a" is the area swept by the trawl net during each operation, then a/t represent the area swept per hour. Therefore, the equation for the weight of catch per unit area is as follow:

$$(Cw/t) / (a/t) = Cw/a \quad \text{..... (Equation 3)}$$

The mean weight of catch per unit area (Cw/a) divided by the catchability coefficient, q will gives the mean biomass per unit area. For this study, the value of q = 0.5 was used as recommended for trawlers in Southeast Asia (Sparre and Venema,1998). The biomass, B of the study area, A was calculated with the following equation:

$$B = (Cw/a) / q * A \quad \text{..... (Equation 4)}$$

The potential yield of the exploited stock (in metric ton) was calculated using the following equation:

$$\text{Potential Yield, MSY} = 0.5 * (Y + M * Bc) \quad \text{..... (Equation 5)}$$

Where Y is the current yield (in metric ton),

M is the natural mortality coefficient, and

Bc is the current biomass, obtained from the swept area method

Finally, the Exploitation Rate, E was calculated using the following equation:

$$E = (Y / Bc) / ((Y / Bc) + M) \quad \text{..... (Equation 6)}$$

All the calculations and equations were referred from Sparre and Venema (1998), and FRI (2017).

Estimation of Maximum Sustainable Yield (MSY) of lobsters in the study area using surplus production model (Schaefer Model) were also carried out using data from the annual landing and effort statistic obtained from the Department of Fisheries Malaysia (DOFM, 2018). The calculations involved were referred from Sparre and Venema, (1998).

Results

Catch Rates

The average catch rate for the year 2016 survey was 65.52 ± 12.14 kg.hr^{-1}, comprising of significant number of low value fishes (average catch rate of 34.27 ± 9.35 kg.hr^{-1}), followed by commercial fishes (average catch rate of 29.44 ± 6.65 kg.hr^{-1}), squids (average catch rate of 5.33 ± 0.75 kg.hr^{-1}), crabs (average catch rate of 0.53 ± 0.12 kg.hr^{-1}), slipper lobsters (average catch rate of 0.19 ± 0.09 kg.hr^{-1}) and shrimps (including mantis shrimps) (average catch rate of 0.12 ± 0.05 kg.hr^{-1}) (Table 1). Slipper lobsters were only caught at 3 sampling locations (haul 11, 13 and 14) with the catch rates ranging from 0.05 to 0.35 kg.hr^{-1}. No spiny lobster was present in catch during the entire duration of the year 2016 survey.

In the subsequent survey in the year 2017, the average catch rate for the survey was 60.12 ± 22.15 kg.hr^{-1}, comprising of even higher number of low value fishes (average catch rate of 40.93 ± 21.80 kg.hr^{-1}), followed by commercial fishes (average catch rate of 13.81 ± 1.83 kg.hr^{-1}), squids (average catch rate of 4.75 ± 0.88 kg.hr^{-1}), shrimps (average catch rate of 0.69 ± 0.58 kg.hr^{-1}), crabs (average catch rate of 0.46 ± 0.11 kg.hr^{-1}) and lobsters (spiny and slipper lobsters) (average catch rate of 0.21 ± 0.12 kg.hr^{-1}) (Table 2). Spiny lobsters were caught at 2 location (station 11 and 16) while slipper lobsters were caught at 8 other sampling locations. The catch rates of spiny lobster at station 11 and 16 were 1.24 and 0.50 kg.hr^{-1} respectively while the catch rates of slipper lobsters ranged from 0.02 to 0.14 kg.hr^{-1}.

Table 1: Catch rates (kg.hr^{-1}) of major group of fishes in the year 2016 survey

Haul	Fish	Squid	Slipper Lobster	Crab	Shrimp and Squilla	Low Value Fish	Total
	Catch rate (kg.hr^{-1})						
1	48.20	5.90		0.20		30.00	84.30
2	12.40	5.00		0.80		22.00	40.20
3	61.70	7.10				120.00	188.80
4	14.18	2.50		0.20		115.00	131.88
5	53.80	4.40				40.00	98.20
6	5.75	4.50		0.20		20.00	30.45
7	7.60	14.38		0.30		40.00	62.28
8	31.56	2.08		0.20	0.40	10.00	44.24
9	2.39	1.96		0.58	0.10	5.00	10.03
10	5.68	3.46		0.50			9.64
11	8.31	3.50	0.05	0.22		6.00	18.08
12	4.02	5.35		0.39	0.09	3.00	12.85
13	12.52	9.43	0.16	0.40	0.10	8.00	30.61
14	74.24	7.75	0.35	0.65		40.00	122.99
15	20.39	5.10		0.90	0.05	30.00	56.44
16	51.20	5.60			0.02	25.00	81.82
17	86.48	2.63		1.88	0.07		91.06
Average	**29.44**	**5.33**	**0.19**	**0.53**	**0.12**	**34.27**	**65.52**
Std. Error	**6.65**	**0.75**	**0.09**	**0.12**	**0.05**	**9.35**	**12.14**

Table 2: Catch rates (kg.hr^{-1}) of major group of fishes in the year 2017 survey

Station	Fish	Squid	Lobster	Crab	Shrimp	Others	Low Value Fish	Total
	Catch rate (kg.hr^{-1})							
1	9.91	2.00	0.04			0.54	12.10	24.59
2	29.90	3.00	0.03	0.18	0.06		5.30	38.46
3	15.78	3.18	0.03				11.70	30.69
4	22.75	1.54				0.32	398.00	422.61
5	5.73	3.13		0.15	0.15		50.00	59.16
6	11.00	3.47			1.86		110.00	126.33
7	19.53	10.00	0.06	0.40			26.00	55.99
8	23.98	2.00				0.38	17.00	43.36
9	8.18	2.64	0.05				9.84	20.71
10	20.57	3.20		0.35		0.83	15.28	40.23
11	8.17	5.24	1.24	0.78			12.70	28.13
12	18.79	17.33	0.03			0.20	16.00	52.35
13	2.79	6.10	0.02	0.22			8.00	17.13
14	3.53	5.29		1.23		0.04	5.13	15.22
15	4.54	5.02		0.60		0.05	8.40	18.60
16	15.57	4.60	0.50	0.50			11.94	33.10

17	12.86	5.70	0.14	0.15			13.00	31.85
18	15.09	2.10					6.40	23.59
Average	**13.81**	**4.75**	**0.21**	**0.46**	**0.69**	**0.34**	**40.93**	**60.12**
Std. Error	**1.83**	**0.88**	**0.12**	**0.11**	**0.58**	**0.11**	**21.80**	**22.15**

Density

The average catch density for the year 2016 survey was 558 ± 105 kg.km^{-2} and catch density ranged from 84 kg.km^{-2} (haul 10) to 1644 kg.km^{-2} (haul 3) (Figure 2). For commercial fishes, the average density for the year 2016 survey was 301 ± 56 kg.km^{-2} and ranged from 44 kg.km^{-2} (haul 9) to 768 kg.km^{-2} (haul 17). The average density for low value fishes in the year 2016 survey was 292 ± 81 kg.km^{-2} and ranged from 27 kg.km^{-2} (haul 12) to 1045 kg.km^{-2} (haul 3). Fish density was generally higher in area closer to the shoreline (haul 1-7, 13-17) compared to further sea locations (haul 8 – 12).

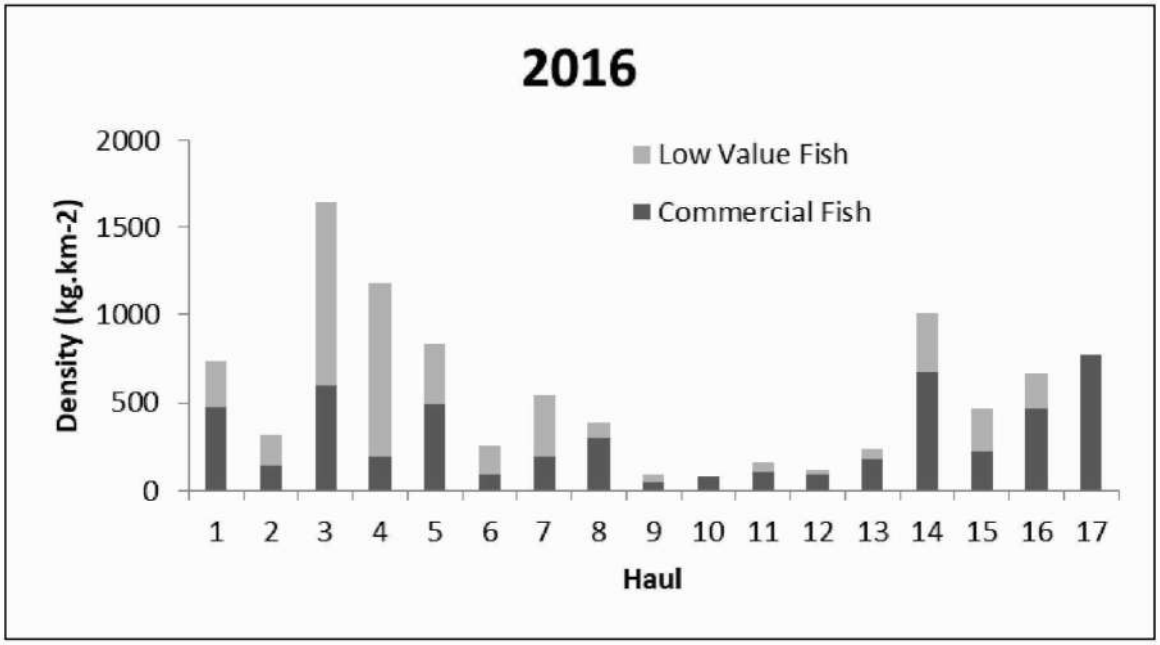

Figure 2: Fish density (kg.km^{-2}) according to haul from the 2016 survey

In the year 2017, the average catch density from the survey was 465 ± 207 kg.km^{-2} and catch density ranged from 76 kg.km^{-2} (station 13) to 3855 kg.km^{-2} (station 4) (Figure 3). For commercial fishes, the average density for the year 2017 survey was

123 ± 12 kg.km^{-2} and ranged from 41 kg.km^{-2} (station 9) to 224 kg.km^{-2} (station 4). The average density for low value fishes in the year 2017 survey was 342 ± 200 kg.km^{-2} and ranged from 24 kg.km^{-2} (station 2) to 3630 kg.km^{-2} (station 4).

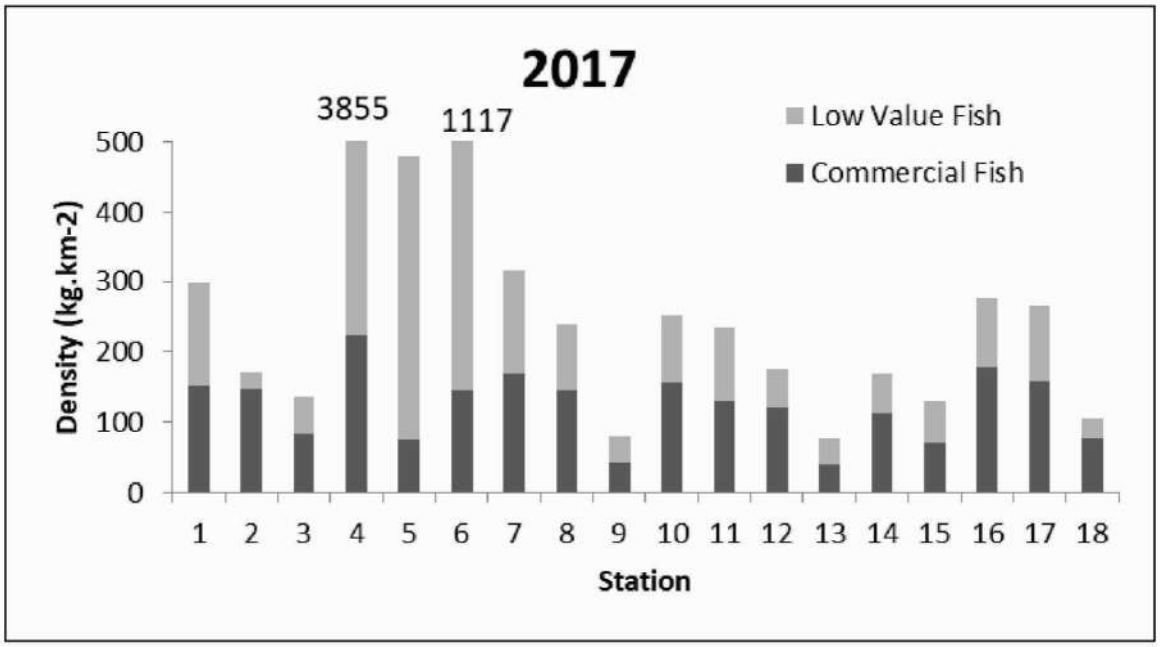

Figure 3: Fish density (kg.km^{-2}) according to haul from the 2017 survey

In the year 2016, only slipper lobsters were successfully caught during the survey and were found in haul 11 (0.45 kg.km^{-2}), haul 13 (1.23 kg.km^{-2}) and haul 14 (2.86 kg.km^{-2}) (Table 3, Figure 4). However, no spiny lobster were caught during that survey. In the following year, more samples of slipper lobsters were successfully sampled and the density ranged from 0.09 to 1.17 kg.km^{-2} (Table 4). The 2017 survey also was able to obtain 3 spiny lobster samples from two locations and the density was estimated to be 10.34 kg.km^{-2} at station 11 and 1.17 kg.km^{-2} at station 17. There was no occurrence of slipper lobster at station 11 and 17 during the year 2017 survey.

Table 3: Density (kg.km^{-2}) of slipper lobster (*T. orientalis*) from the 2016 survey

Haul	Species	Density (kg.km^{-2})
11	*T. orientalis*	0.45
13	*T. orientalis*	1.23
14	*T. orientalis*	2.86

Table 4: Density (kg.km^{-2}) of slipper lobster (*T. orientalis*) and spiny lobster (*P. polyphagus*) from the 2017 survey

Station	Species	Density (kg.km^{-2})
1	*T. orientalis*	0.43
2	*T. orientalis*	0.11
3	*T. orientalis*	0.13
7	*T. orientalis*	0.34
9	*T. orientalis*	0.18
11	*P. polyphagus*	10.34
12	*T. orientalis*	0.09
13	*T. orientalis*	0.09
16	*P. polyphagus*	4.17
17	*T. orientalis*	1.17

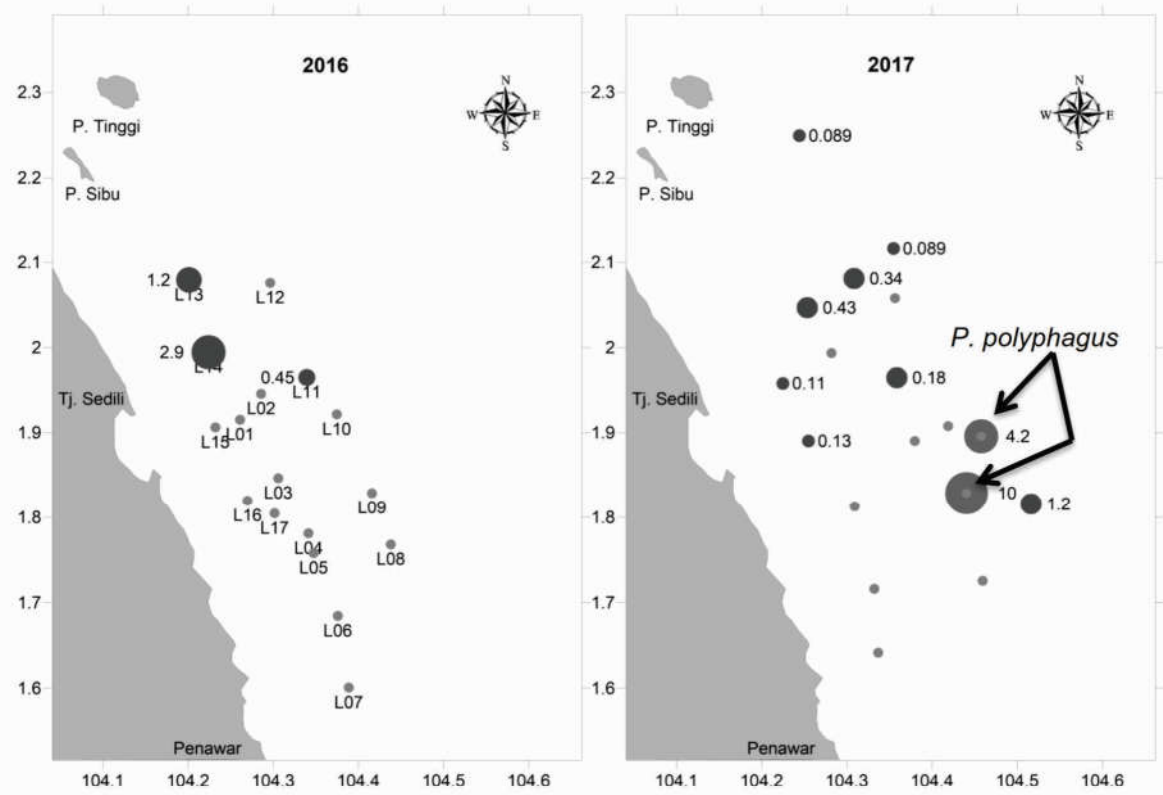

Figure 4: Maps showing the distribution and density (kg.km^{-2}) of slipper lobster (*T. orientalis*) and spiny lobster (*P. polyphagus*) in the survey area in year 2016 (left) and 2017 (right)

MSY and Exploitation Rate

From the year 2016 survey, the potential yield (MSY) of fish resources in East Johor waters was estimated to be in the range of 10,810 to 12,125 metric ton (Table 5). These values were calculated based on the natural mortality coefficient, M value of 1.6 derived from previous demersal surveys of the area (FRI, 2017). Similarly, the potential yield estimates from the year 2017 ranged from 11,696 to 12,997 metric ton. The exploitation rate, E (year^{-1}) for both years were estimated to be at 0.9 and considered very high.

Table 5: The potential yield (metric ton) and exploitation rate (year^{-1}) (M = 1.6) of fish resources in the East Johor waters from the year 2016 and 2017 surveys

Year	2016	2017
Area, a (km^2)	1,177	1,812
Density, D (kg.km^{-2})	558	465
Biomass, Bc (metric ton)	1,314	1,686
Landing, Y (metri ton)	19,517 – 22,147	20,695 - 23,297
Mortality, M	1.6	1.6
Potential Yield, MSY (metric ton)	10,810 - 12,125	11,696 - 12,997
Exploitation Rate, E (year^{-1})	0.9	0.9

* Mortality, M value derived from 2014-2016 Demersal Survey data (DOF Malaysia)
** Landing data derived 2 datasets: 0-70 GRT Trawler and Total Landing of Traps, Drift Nets and Trawlers

As for the spiny lobster resources, the potential yield (MSY) of spiny lobster in East Johor waters from the year 2017 survey was estimated to be in the range of 8 to 62 metric ton (Table 6). These values were calculated based on the natural mortality coefficient, M value of 0.45 derived from other previous studies (Kagwade, 1994; Radhakrishnan *et al*., 2005). The exploitation rate, E (year^{-1}) for was estimated to be at the range of 0.2 to 0.9 (based on the range of landing, Y values).

Likewise for the slipper lobster resources, the potential yield (MSY) of slipper lobster in East Johor waters from the year 2016 and 2017 surveys were estimated to be in the 17 and 19 metric ton respectively (Table 7). These values were calculated based on the natural mortality coefficient, M value of 0.918 derived from other previous studies

(Courtney, 1997; 2002). The exploitation rate, E (year^{-1}) were estimated to be at 0.90 in year 2016 and 0.97 in year 2017 and were considered very high for both years.

Table 6: The potential yield (metric ton) and exploitation rate (year^{-1}) (M = 0.45) of spiny lobster in the East Johor waters from the year 2017 survey

Year	2016	2017
Area, a (km^2)		1,812
Density, D (kg.km^{-2})	Not Available	7.26
Biomass, Bc (metric ton)		26.3
Landing, Y (metri ton)		4 – 113
Mortality, M		0.45
Potential Yield, MSY (metric ton)		8 – 62
Exploitation Rate, E (year^{-1})		0.2 – 0.9

* Mortality, M value derived from Kagwade, 1994 and Radhakrishnan *et al.*, 2005
**Landing data derived 2 datasets: 0-70 GRT Trawler and Total Landing of Traps, Drift Nets and Trawlers

Table 7: The potential yield (metric ton) and exploitation rate (year^{-1}) (M = 0.918) of slipper lobster in the East Johor waters from the year 2016 and 2017 surveys

Year	2016	2017
Area, a (km^2)	1,177	1,812
Density, D (kg.km^{-2})	1.52	0.32
Biomass, Bc (metric ton)	3.57	1.15
Landing, Y (metric ton)	30	37
Mortality, M	0.918	0.918
Potential Yield, MSY (metric ton)	17	19
Exploitation Rate, E (year^{-1})	0.90	0.97

* Mortality, M value derived from Courtney, 1997; 2002
**Landing data derived from 25 - >70 GRT Trawlers landings

Catch and effort of lobster fisheries

As a comparison, the analysis of Maximum Sustainable Yield (MSY) of spiny lobsters in the East Johor waters using the statistical catch and effort data (Schaefer Model) produce a higher MSY value of 124 metric ton, with the fMSY of 49,599 boat trips per year (standardized effort based on the effort of drift nets) (Figure 5). This value is double of the estimated value of 62 metric ton using the survey data and calculation using the Cadima's equation.

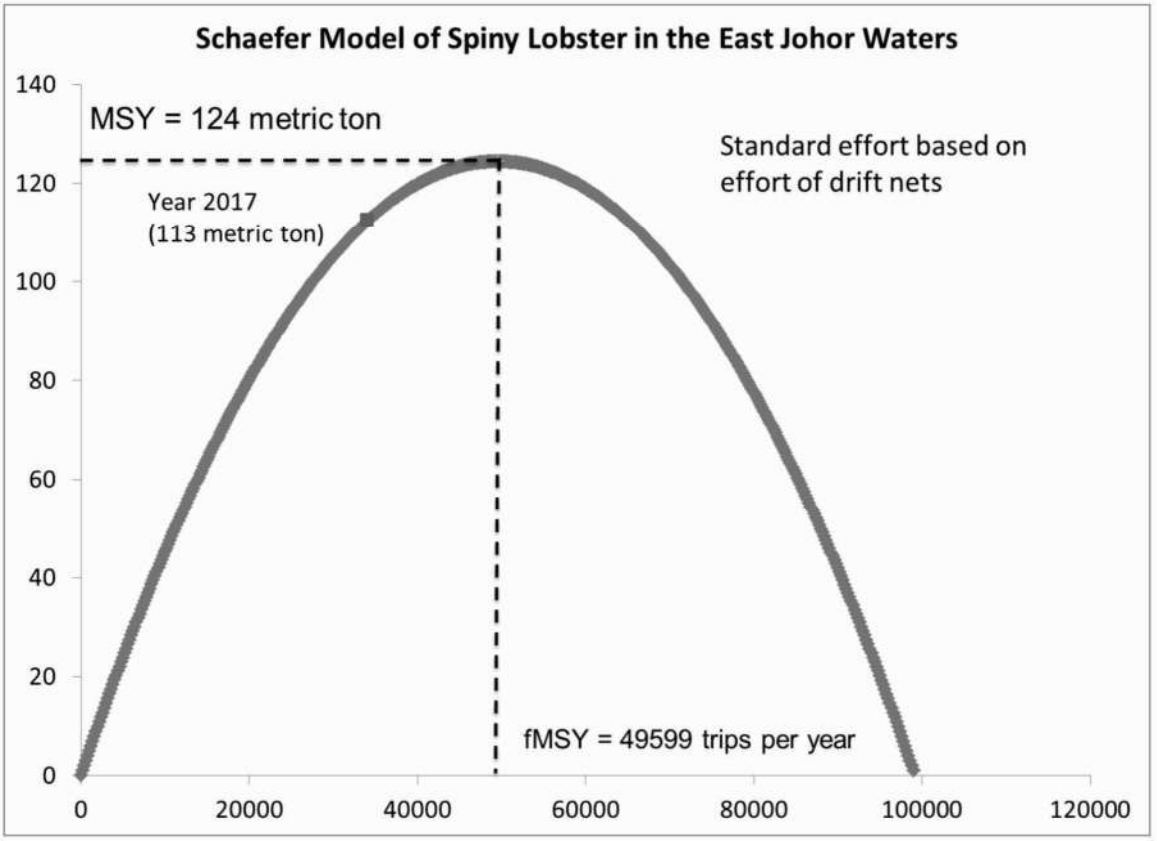

Figure 5: Schaefer Model of the spiny lobster resource in the East Johor waters. MYS was estimated to be about 124 metric ton with fMSY = 49,599 trips per year (drift nets)

A further analysis of the statistical catch and effort data covering the East Coast of Peninsular Malaysia produce a spiny lobster MSY value of 199 metric ton, with the fMSY of 427,211 boat trips per year (standardized effort based on the effort of drift nets) (Figure 6). This MSY value is 160% higher than the MSY value of spiny lobster in the East Johor waters alone.

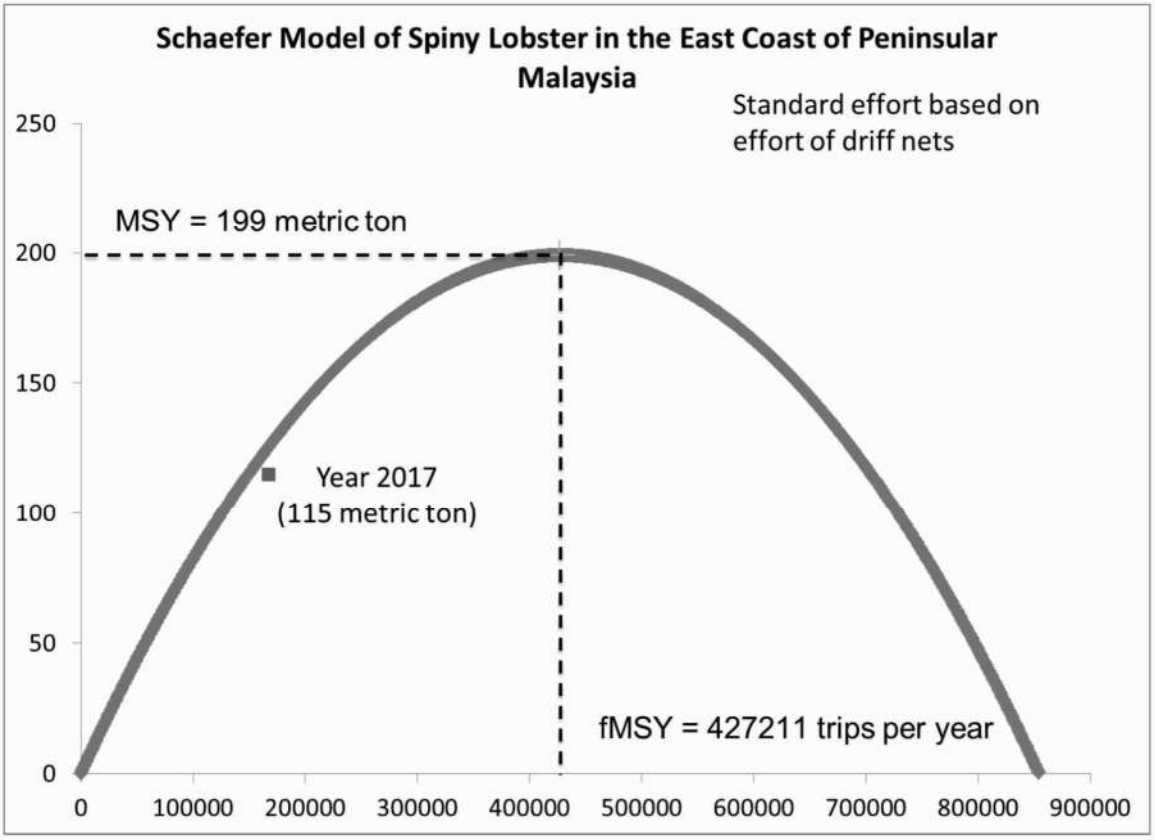

Figure 6: Schaefer Model of the spiny lobster resource in the East Coast of Peninsular Malaysia. MYS was estimated to be about 199 metric ton with fMSY = 427,211 trips per year (drift nets)

Likewise for the slipper lobster fishery in the East Johor waters, the analysis of Maximum Sustainable Yield (MSY) using the statistical catch and effort data (Schaefer Model) produce a MSY value of 172 metric ton, with the fMSY of 115,736 boat trips per year (standardized effort based on the effort of 10-24.9 GRT trawlers) (Figure 7). This value is 905% higher than the estimated value of 19 metric ton using the survey data and calculation using the Cadima's equation.

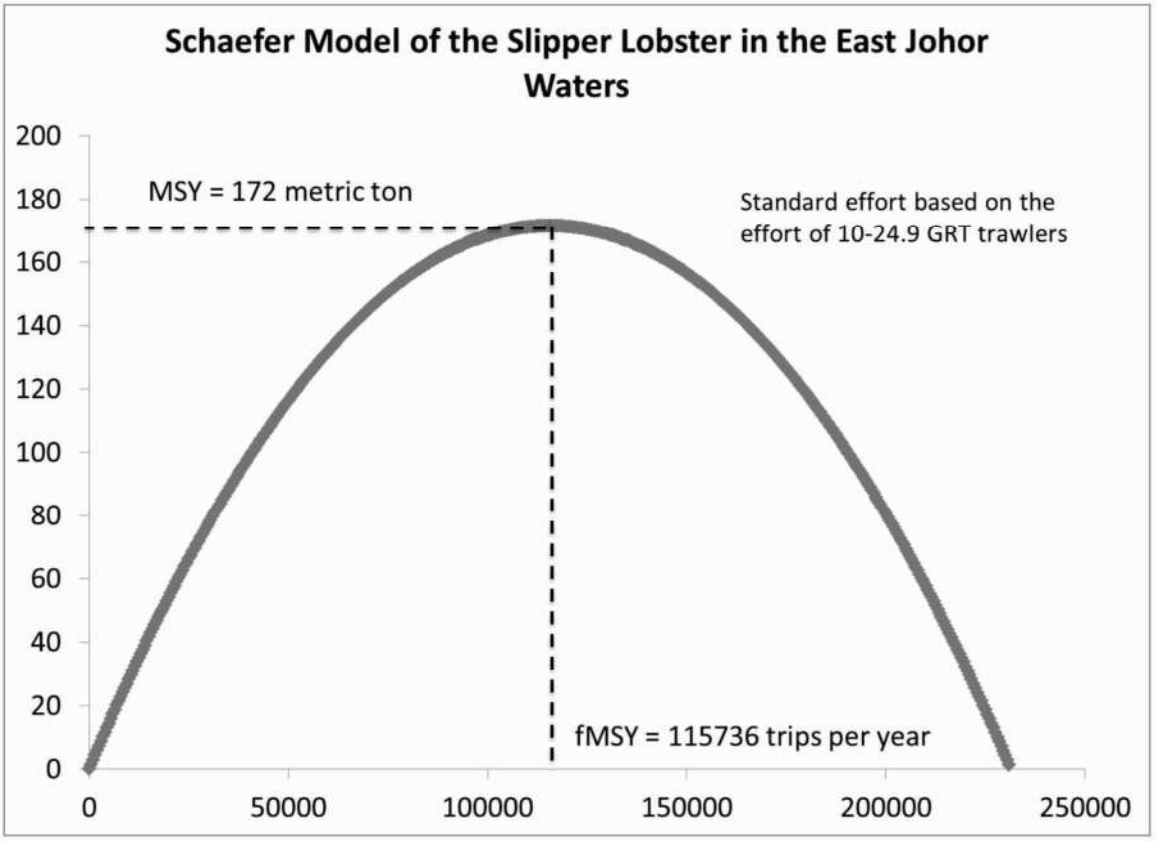

Figure 7: Schaefer Model of the slipper lobster resource in the East Johor waters. MYS was estimated to be about 172 metric ton with fMSY = 115,736 trips per year (10-24.9 GRT trawlers)

A further analysis of the statistical catch and effort data covering the East Coast of Peninsular Malaysia produce a slipper lobster MSY value of 348 metric ton, with the fMSY of 30,036 boat trips per year (standardized effort based on the effort of 25-39.9 GRT trawlers) (Figure 8). This MSY value is 202% higher than the MSY value of slipper lobster in the East Johor waters alone.

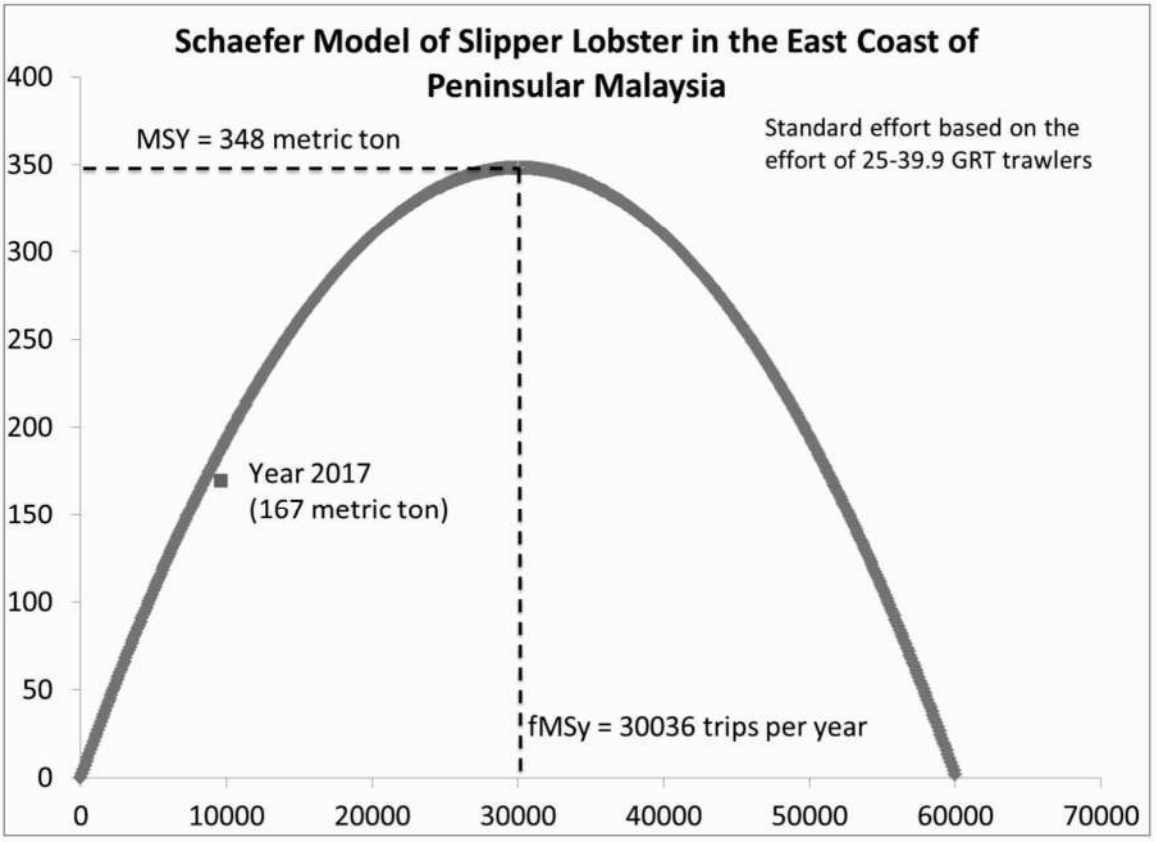

Figure 8: Schaefer Model of the slipper lobster resource in the East Coast of Peninsular Malaysia. MYS was estimated to be about 348 metric ton with fMSY = 30036 trips per year (25-39.9 GRT trawlers)

Discussion

Lobsters resource in East Johor

In this study, two scientific surveys were conducted annually at about the same period (end of August 2016 and 2017) but using two type of vessels, namely a fisherman trawler in year 2016 and a research vessel KK Senangin II in year 2017. During the course of these two surveys, the catch rate of spiny and slipper lobsters were low and in sparse locations. Slipper lobsters were only caught at 3 sampling locations (haul 11, 13 and 14) in year 2016 with the catch rates ranging from 0.05 to 0.35 $kg.hr^{-1}$ but occurred in 8 sampling locations in year 2017 with the catch rates ranging from 0.02 to 0.14 $kg.hr^{-1}$. Likewise, the density of slipper lobsters ranges from 0.45 to 2.86 $kg.km^{-2}$ in year 2016 and 0.09 to 1.17 $kg.km^{-2}$ in year 2017. The occurrence of *Panulirus* lobsters were even rarer in the surveys as they were only

found at two locations in the 2017 survey, at station 11 and 16 with catch rates of 1.24 and 0.50 kg.hr^{-1} respectively and density of 10.34 and 4.17 kg.km^{-2} respectively.

According to a previous study conducted by Alias *et al.* (2000) in the same area, the breeding and migration season of spiny lobster begins in July and the numbers of berried females should be high by August. However, the surveys conducted in this study were not able to collect higher number of spiny lobsters and only 3 adult sized lobsters were caught in two locations. This may indicate a severe drop in spiny lobster resource in the study area since the last study by Alias *et al.* (2000). The spiny lobsters caught in the 2017 survey were also carrying eggs thus the breeding season was still in effect in August.

As such, the potential yield (MSY) of spiny lobster in East Johor waters derived from the year 2017 survey was estimated to be in the range of 8 to 62 metric ton. This high disparity in range was due to the selection of spiny lobster landing dataset. The lower potential yield value was calculated using trawlers landing dataset while the higher potential yield value (62 metric ton) took into account landings from all related gears, namely trawlers, drift nets and traps. Similarly, the high disparity in landing values also affected the exploitation rate, E (year^{-1}) which were estimated to be in the range of 0.2 to 0.9. Based on the precautionary principle (FAO, 1996; Cadima, 2003), this study suggest to use the higher value of potential yield (62 metric ton) and the exploitation rate, E of 0.9 per year as it represent a broader scope of the spiny lobster fishery in East Johor. Subsequently, the spiny lobster fishery in East Johor can be considered as over-exploited as the year 2017 landing already exceeded the potential yield (MSY) value and the current stock biomass is less than 40% of the estimated unfished stock size (Ye, 2011).

For the slipper lobster resource in East Johor waters, the potential yield (MSY) calculated from the data of the year 2016 and 2017 surveys were quite similar (17 and 19 metric ton respectively). However, the estimated exploitation rate, E (year^{-1}) were for this species were very high (0.90 in year 2016 and 0.97 in year 2017). Thus, the

slipper lobster fishery in East Johor is also considered to be over-exploited with similar reasoning as the spiny lobster fishery. Slipper lobsters are mainly caught by trawler boats plying the East Johor waters (DOFM, 2018). Any management measures concerning slipper lobsters will need to focus on the fishing effort of the trawlers there.

Statistical catch and effort data

The analysis of Maximum Sustainable Yield (MSY) of spiny and slipper lobsters in the East Johor waters using the statistical catch and effort data (Schaefer Model) produce significantly higher MSY values than the estimates from the surveys and calculation based on the Cadima's equation. For the spiny lobster resource, the MSY value was double the estimated value from the surveys while for the slipper lobster resource, the MSY value was nine fold (905%) higher than the value derived from the surveys and calculation using Cadima's equation. The disparity between the values from the statistical catch and effort data with the results from the surveys were influenced by several factors, such as the success rate of lobster capture during the surveys, seasonality during the surveys, frequency of surveys and the accuracy of statistical data collections. However, scientific surveys are costly to undertake and both methods have their own advantages and weaknesses (Garcia *et al*., 1989).

A comparison of the MSY values of spiny lobster resources between East Johor and the entire East Coast of Peninsular Malaysia waters indicated that the East Johor has about 62% of the total East Coast of Peninsular Malaysia spiny lobsters resources. Likewise for the slipper lobster resources, East Johor has about 49% of the total East Coast of Peninsular Malaysia slipper lobsters resources. These high representation of lobster resources in East Johor warrant special management attention to conserve and protect the two lobster resources from further over-exploitations.

Role of Fishery Refugia

The spiny and slipper lobster fisheries in East Johor are high value and important fisheries and involved the livelihood of more that 550 fisherfolks (DOFM, 2018). However, the lobster resources are getting lesser and being over-exploited as indicated from the surveys of this study. As a step to promote better fishery management and to help recover the lobster resources, a fishery refugia is proposed to be established for the lobster fisheries in East Johor waters. The fishery refugia concept is unlike a fully closed marine protected area (MPA), but differ in that it only closes a certain part of the habitat area critical to the life cycle of the intended species (such as during breeding, spawning or migration season) and at a certain period of the year (UNEP, 2007).

Such move can help the recovery of lobster stocks, especially during critical stages of their life cycle such as during migration and spawning periods. The breeding season for spiny lobster begins in July and peaks in late August and the adult lobsters will migrate to deeper offshore water to spawn (Alias *et al.*, 2000). However, not much information is available about the details of the location of the spawning area and migration route and further studies and surveys are needed to obtain this information. Also, the practice of releasing berried female lobsters caught by the fisherfolk back to the sea should also be encouraged and promoted by the fishery management as the current practice of taking nearly all sizes of lobster (>100g per individual) as catch is unsustainable (personal observation). Unless some evident management actions are implemented, the spiny and slipper lobsters resources will continue to be depleted by over-exploitation.

Conclusion

This study indicated that the catch rate of spiny and slipper lobsters were low and in sparse locations. Both the spiny lobster and slipper lobster fisheries in East Johor can be considered as over-exploited as the current stock biomass is less than

40% of the estimated unfished stock size. This situation is worrying since East Johor has about 62% of the total spiny lobsters resources and about 49% of the total slipper lobsters resources in the East Coast of Peninsular Malaysia water. Unless some evident management actions are implemented, the spiny and slipper lobsters resources will continue to be depleted by over-exploitation. A fishery refugium is proposed as a management measure to protect the current lobster populations in East Johor water.

Acknowledgement

We would like to thank the all the staff of Johor State Fisheries Office and the crew of KK Senangin II who have assisted us during the course of this study. This study was funded through the developmental grants P21-30701011-22501-040 and P21-30701011-23300-069.

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Lobster Resources Survey at the Surrounding Waters Off East Johor and Southern Pahang in Year 2018

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Abstract: This study was a continuance of previous years' work and was conducted to evaluate the current resource status of spiny lobster (*Panulirus* spp.) and slipper lobster (*Thenus orientalis*) in East Johor and southern Pahang waters for the purpose of establishing a fisheries refugia. The objectives of this study were to obtain information pertaining to the distribution and density of lobsters in East Johor and southern Pahang waters. A sea survey was conducted onboard the KK Senangin II vessel using a bottom trawl net in the surrounding waters of Tioman Island and Tanjung Leman in the month of October 2018. The results from this survey indicated the presence of slipper lobsters at eight sampling stations with the average density of 1.29 ± 0.42 kg.km^{-2}. The slipper lobster densities ranged from 0.43 to 4.12 kg.km^{-2} and can be found in the waters between the islands of Pulau Tinggi, Pulau Besar, Pulau Seri Buat and Pulau Tioman. However, no spiny lobster was found in the samples during the course of the survey. Further surveys were required in order to determine the breeding location of the spiny lobsters.

Keywords: fishery resources, spiny lobster, slipper lobster, Tioman Island, East Johor

Abstrak: Kajian ini adalah lanjutan daripada kerja tahun-tahun sebelumnya dan bertujuan menentukan status sumber udang karang (*Panulirus* spp.) dan udang lobok (*Thenus orientalis*) yang ada di kawasan perairan Johor Timur dan selatan Pahang bagi tujuan penubuhan sebuah refugia perikanan. Objektif kajian adalah untuk mendapatkan maklumat taburan dan kepadatan udang karang di kawasan perairan Johor Timur dan selatan Pahang. Satu survei laut telah dijalankan di perairan Pulau Tioman dan Tanjung Leman menggunakan kapal KK Senangin II dan alat pukat tunda

dasar pada bulan Oktober 2018. Hasil survei laut mendapati kehadiran udang lobok di lapan stesen kajian dengan kepadatan purata 1.29 ± 0.42 kg.km^{-2}. Julat kepadatan udang lobok di antara 0.43 sehingga 4.12 kg.km^{-2} dan boleh didapati di perairan di antara pulau-pulau seperti Pulau Tinggi, Pulau Besar, Pulau Seri Buat dan Pulau Tioman. Namun, udang karang tidak ditemui dalam sampel semasa survei dijalankan. Survei lanjutan perlu dijalankan bagi menentukan kawasan pembiakan udang karang.

Introduction

The spiny lobster fishery in East Johor and southern Pahang is considered an important and high valued activity. The fishing gears involved in this fisheries consist of traps and drift nets which were operated in the coastal area while spiny lobsters are also landed as bycatch from fish trawlers operating in deeper waters in zone B and C of the Malaysian sea area. There are at least 5 known spiny lobster species (*Panulirus polyphagus, P. versicolor, P. homarus homarus, P. longipes longipes* dan *P. ornatus*) documented in the waters of East Coast of Peninsular Malaysia (Alias *et al.*,2000). However, the mud spiny lobster (*P. polyphagus*) is the most common species found the East Johor and southern Pahang waters. There is also another type of lobster commonly found in the East Johor and southern Pahang waters, namely the slipper lobster or locally know as *udang lobok* (*Thenus orientalis*). The slipper lobster can be found in deeper waters beyond the coastal shore and often caught by trawler boats as bycatch.

As with many other marine fisheries, the populations of spiny lobsters as well as slipper lobsters in the South China Sea are facing high fishing pressure and the natural resources are on the decline. From the year 2014 to 2017, the annual landings trend of spiny lobsters suffered a decline of 17% while the annual landings of slipper lobsters dropped as much as 78% (DOFM, 2018). Realizing the enormity of the current situation, the fishery management decided to establish a fishery refugia for the conservation of lobster resources especially during critical life stages such as during migration and spawning seasons (UNEP, 2007).

This study was a continuation of previous surveys conducted in the surrounding waters and was intended to determine the status of spiny lobster (*Panulirus* spp.) and slipper lobster (*T. orientalis*) resources. The information derived from this study will be incorporated in the planning and establishment of the new fishery refugia. Therefore, the specific objectives of this study were to determine the distribution and density of lobster resources in the waters of East Johor and southern Pahang. The survey was conducted onboard the research vessel KK Senangin II in October 2018.

Materials and Method

The spiny lobster survey was conducted in the waters off Tanjung Leman, Johor and Tioman Island, Pahang onboard the research vessel KK Senangin II using a bottom trawl net with a cod-end mesh size of 38mm. The sampling was conducted from 24 to 28th October 2018. Each session of the bottom trawling activity was conducted for the duration of about 60 minutes and the coordinates for the start and end of the trawling operation were recorded.

Other information collected during the trawling operation included the speed of the vessel, the water depth and direction of the trawling. After the end of the trawling operation, the catch from each haul was sorted and the fishes were measured and identified to the species level. The data collected from the sampling were analyzed to obtain the density information of spiny lobsters in the study area. A total of 13 locations were sampled during the study, covering an estimated area of 6294 square kilometer.

Results and Discussion

The average density of fish in the study area was 476 ± 135 kg.km^2 (±S.E.) and a total of 112 fishes, 11 crustaceans, 9 cephalopods and two bivalves species were recorded from this survey. In addition, the results from this survey indicated the presence of slipper lobsters (*T. orientalis*) at eight sampling stations with the average density of 1.29 ± 0.42 kg.km^{-2} (Figure 1). The slipper lobster densities ranged from 0.43 to 4.12 kg.km^{-2} and can be found in the waters between the islands of Pulau Tinggi, Pulau Besar, Pulau Seri Buat and Pulau Tioman (Figure 2). The results from this survey was consistent with the results from previous studies conducted in the

surrounding waters. As comparison, the results from the surveys in the waters of East Johor in year 2016 and 2017 both indicated the average densities of slipper lobsters in the area at 1.52 ± 0.71 kg.km^{-2} and 0.32 ± 0.13 kg.km^{-2} respectively.

However, there was no spiny lobster (*P. polyphagus*) caught during the 2018 survey. The study area in the surrounding the Tioman archipelago and deep sea area was assumed to be a suitable habitat for the adult spiny lobsters but this survey was unsuccessful in obtaining any samples. The possible factors explaining the absence of the spiny lobsters in this area may be due to the season when the sampling was conducted (at the end of October), where the lobsters may have migrated elsewhere to their spawning ground. The presence of illegal foreign trawlers conducting pair trawling activities nearby also may have impacted the results of this study since excessive trawling activities (using illegal gears) can greatly reduce the bottom fish resources in the study area.

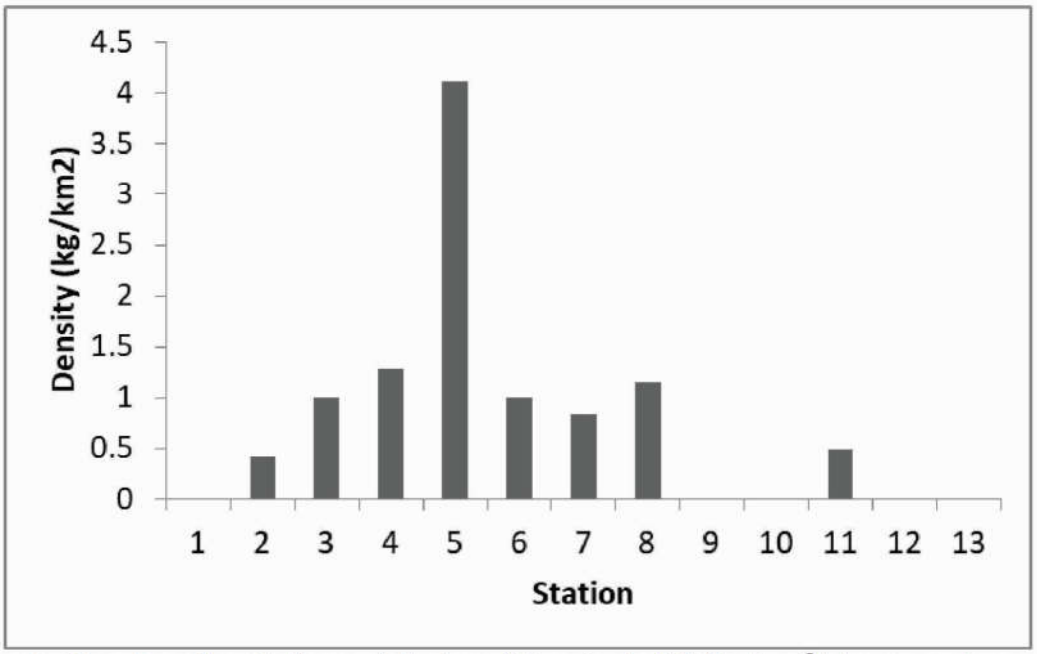

Figure 1: The density of slipper lobsters (*T. orientalis*) (kg.km^{-2}) from each sampling station in the waters off Tioman Island and Tanjung Leman. The survey was conducted in October 2018

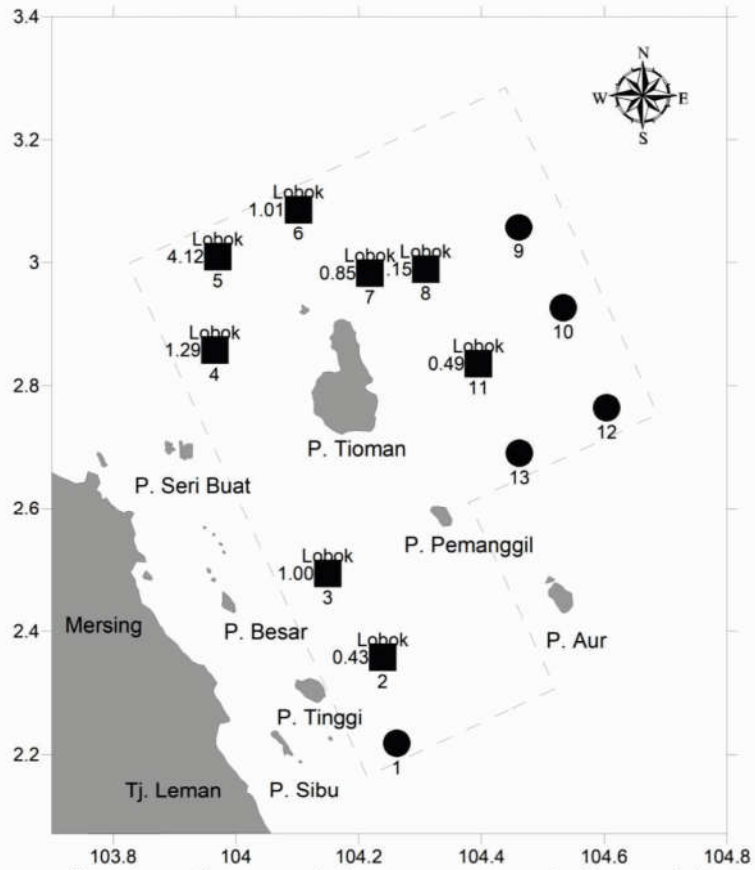

Figure 2: The sampling locations and the presence of slipper lobsters (*T. orientalis*) are marked in black square symbols and their densities are indicated at left side (kg.km^{-2}). The study area covered an estimated area of 6294 km^2 (dashed line)

Conclusion

This survey has indicated that the distribution of slipper lobsters can be found around the islands of Pulau Tinggi, Pulau Besar, Pulau Seri Buat and Pulau Tioman. Their densities ranged from 0.43 to 4.12 kg.km^{-2} and the average density was 1.29 ± 0.42 kg.km^{-2}. There was no spiny lobster (*P. polyphagus*) caught during the 2018 survey even if the study area in the surrounding the Tioman archipelago and deep sea area was assumed to be a suitable habitat for the adult spiny lobsters. The possible factors explaining the absence of the spiny lobsters in this area may be due to the season when the sampling was conducted (at the end of October), where the lobsters may have migrated elsewhere to their spawning ground. Further surveys were needed to determine the spawning ground of spiny lobsters for the establishment of a fisheries refugia site and protection of the spiny lobster resources.

Acknowledgement

We would like to thank the all the staff of the Department of Fisheries Malaysia, Fisheries Research Institute Kampung Acheh and the crew of KK Senangin II whom have assisted us during the course of this study. This study was funded through the developmental grants P21-30701011-22501-040 and P21-30701011-23300-069. This study was also partially funded by the SEAFDEC-UN Environment-GEF Fisheries Refugia Project Fund.

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Appendices

Appendix 1: Sorting of fish catch conducted onboard the KK Senangin II ship after each bottom trawling session

Appendix 2: During this survey, there was also a filming session (by the local television) documenting the fisheries refugia project in Malaysia

Appendix 3: The crew of KK Senangin II, the research team and the RTM documentary filming team involved in the survey of spiny lobster resources in the waters off Tioman Island

The Study of Mud Spiny Lobster (*Panulirus polyphagus*) Distribution and Density in East Johor-South Pahang Waters: Observer-On-Board Survey 2019

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Abstract: In an effort to create a lobster refugia in the East Johor-South Pahang waters, several scientific surveys were carried out in previous years to determine the resource level and distribution of mud spiny lobsters in the East Johor-South Pahang waters. This study was a continuance of such surveys and aimed to the determine the location where high concentration of mud spiny lobsters can be found in the East Johor-South Pahang waters. A total of six sampling trips were carried out onboard four fish trawler vessels (3 zone B vessels and one zone C vessel) between September to November 2019. This study was conducted using the *Observer-On-Board* method, where the location and duration of each fishing operation was at the discretion of the vessel's operator. During each sampling trip, two DOFM personnel were assigned onboard each fish trawler vessel and were tasked to record the landing of lobsters in every haul. From the data collected, the density of the lobsters were calculated using the Swept Area Method. A total of 195 hauls were recorded from six fishing trips. The total number of *P. polyphagus* caught during the duration of the entire survey was 49 tails. However, the majority (80%) of the mud spiny lobsters were caught at the fishing ground south of Pulau Aur, Johor. The average density of mud spiny lobsters at the south of Pulau Aur area were higher (0.87 - 1.17 $kg.km^{-2}$). This area can be further focused as the proposed site for the lobster refugia but the exact size and location of the lobster refugia will require further discussions with various stakeholders.

Keywords: *Panulirus polyphagus*, lobster, East Johor, refugia, fisheries resource

Abstrak: Dalam usaha mewujudkan satu refugia perikanan bagi udang karang di perairan Johor Timur-Pahang Selatan, beberapa survei saintifik telah dijalankan sejak beberapa tahun dahulu bagi menentukan tahap sumber dan taburan udang karang di perairan Johor Timur-Pahang Selatan. Kajian ini merupakan sambungan daripada survei-survei tersebut dan bertujuan mengenal pasti lokasi di mana terdapat kepadatan udang karang yang tinggi di perairan Johor Timur-Pahang Selatan. Sebanyak enam trip persampelan telah dijalankan di atas empat buah bot pukat tunda ikan (3 bot zon B dan sebuah bot zon C) semasa tempoh September sehingga November 2019. Kajian ini telah dijalankan berdasarkan kaedah *Pemerhati-Atas-Bot,* di mana lokasi dan tempoh operasi tangkapan ikan adalah ditentukan oleh operator bot. Semasa setiap trip kajian, dua anggota kakitangan DOFM telah menaiki bot nelayan tunda dan ditugaskan untuk merekodkan tangkapan udang karang pada setiap operasi tunda ikan. Daripada maklumat yang dikumpulkan, kepadatan udang karang dapat dihitung berdasarkan kaedah *Swept Area*. Sejumlah 195 operasi tangkapan ikan telah direkodkan sepanjang enam trip persampelan tersebut. Jumlah udang karang *P. polyphagus* yang berjaya ditangkap semasa survei ini adalah 49 ekor. Namun, majoriti (80%) tangkapan udang karang adalah di kawasan perikanan di selatan Pulau Aur, Johor. Kepadatan purata udang karang di kawasan selatan Pulau Aur juga adalah lebih tinggi (0.87 - 1.17 kg.km^{-2}). Kawasan ini boleh diberi tumpuan khusus sebagai tapak cadangan bagi penubuhan refugia perikanan udang karang tetapi saiz dan lokasi sebenar refugia perikanan tersebut perlu melalui perbincangan lanjutan bersama pemegang-pemegang taruh.

Introduction

The mud spiny lobsters (*Panulirus polyphagus*) is a prized seafood commodity in Malaysia. Due to its high demand and high price, the related lobster fishery is very active and has thus created high pressure to the lobster's natural resources and the sustainability of the lobster fishery. In an effort to mitigate this decline in lobster resources, a proposal to create a lobster refugia in the East Johor-South Pahang

waters is underway and spearheaded by the Department of Fisheries Malaysia. The fisheries refugia the context of the UNEP/GEF South China Sea Project are defined as:

"Spatially and geographically defined, marine or coastal areas in which specific management measures are applied to sustain important species [fisheries resources] during critical stages of their life cycle, for their sustainable use"

Source: *UNEP, 2005*

Several scientific surveys were carried out in previous years to determine the resource level and distribution of mud spiny lobsters in the East Johor-South Pahang waters. This information is vital for the determination of the lobster aggregation and spawning site to be designated as a proposed lobster refugia site in Malaysia. Thus, the aim of this survey was the determine the location where high concentration of mud spiny lobsters can be found in the East Johor-South Pahang waters and subsequently a proposed area for the establishment of a lobster refugia in East Johor-South Pahang waters.

Materials and Methods

The lobster survey was conducted in the fishing ground in East Johor-South Pahang waters. A total of six sampling trips were carried out onboard four fish trawler vessels (3 zone B vessels and one zone C vessel). The sampling periods were between September to November 2019. For each sampling trip, two DOFM personnel were assigned onboard a fish trawler vessel for the entire duration of the fishing trip (one to two weeks). Their task were to record the landing of lobsters for every haul. Some of the information recorded were location of the fishing operation (GPS coordinates), weight and length of individual lobsters caught and presence of berried lobsters. Standardized forms were prepared for the DOFM personnel to fill. The completed forms were brought back to FRI for analysis. As this study is based on the

Observer-On-Board method, the location and duration of each fishing operation was solely at the discretion of the vessel's operator.

The density of the lobsters were calculated using the Swept Area Method as prescribed by FAO (Sparre and Venema,1998).

The swept area, a, was estimated using the following equation:

$$a = D * h * x \quad \text{.....(Equation 1)}$$

$$\text{Where } D = V * t \quad \text{..... (Equation 2)}$$

where V is the average speed ($km.hr^{-1}$) of the trawling operation, t is the trawling duration (in hours), h is the length of the trawl net headrope and x is the fraction of the headrope which equal to the width of the path swept by the trawl net (FRI, 2017). In this study, the value of x used was 0.5 (Sparre and Venema, 1998).

Assuming that the weight of the catch of each haul is Cw, then the catch per hour is described as Cw/t. Also, if "a" is the area swept by the trawl net during each operation, then a/t represent the area swept per hour. Therefore, the equation for the weight of catch per unit area is as follow:

$$(Cw/t) / (a/t) = Cw/a \quad \text{..... (Equation 3)}$$

Results

A total of 195 hauls were recorded from six fishing trips. The number of hauls for each trip was dependent on specification of individual trawler vessel and the location of their fishing ground. A summary of the fishing trips from the four fish trawler vessels is shown in Table 1. The total number of *P. polyphagus* caught during the duration of the entire survey was 49 tails. However, the majority (80%) of the mud spiny lobsters were caught at the fishing ground south of Pulau Aur, Johor.

Table 1: A summary of the fishing trips during the study from September – November 2019

Trip No.	Vessel Reg. Number	No. of Hauls	Fishing Area	No. of Lobsters Caught	Ave. Depth (m)
1	JHF5222T	35	Zone B, P. Sibu to Desaru	3	N.A
2	PAF4623	20	Desaru, P. Seri Buat to P. Tinggi	2	26.9
3	JHF3388T	34	South of P. Aur	12	47.3
4	JHF5222T	38	Zone B, P. Sibu to Desaru	4	N.A
5	JHF3388T	41	South of P. Aur	27	44.2
6	JHF1255T	27	P. Sibu to P. Besar	1	20.1
	Total	**195**		**49**	

* N.A : depth data not available

During the duration of the survey, three berried lobsters (female with eggs) were caught. All three individuals were from the fishing area south of Pulau Aur. The size range of the berried lobsters were from 7.5 – 11.7 cm (CL) or weighted from 470 – 810 gram. The eggs were at the intermediate stage of development (based on the reddish color of the eggs), indicating spawning season for the spiny lobster in the area was still ongoing in October 2019. There were no other berried female lobsters caught elsewhere during the survey.

The distribution and density of mud spiny lobsters in the East Johor-South Pahang waters area are shown in Figure 1. Generally, the lobsters can be found in three areas, namely south of Pulau Aur, coastal area of Bandar Penawar and north-east of Pulau Besar. However, large concentration of mud spiny lobsters have been recorded in zone C region south of Pulau Aur. The overall average density of mud spiny lobsters was 0.95 $kg.km^{-2}$ and ranged from 0.31 to 2.62 $kg.km^{-2}$ (Table 2). However, the average density of mud spiny lobsters at the south of Pulau Aur area were higher (0.87 and 1.17 $kg.km^{-2}$) than other areas and the chances of catching the lobster species there were higher as well.

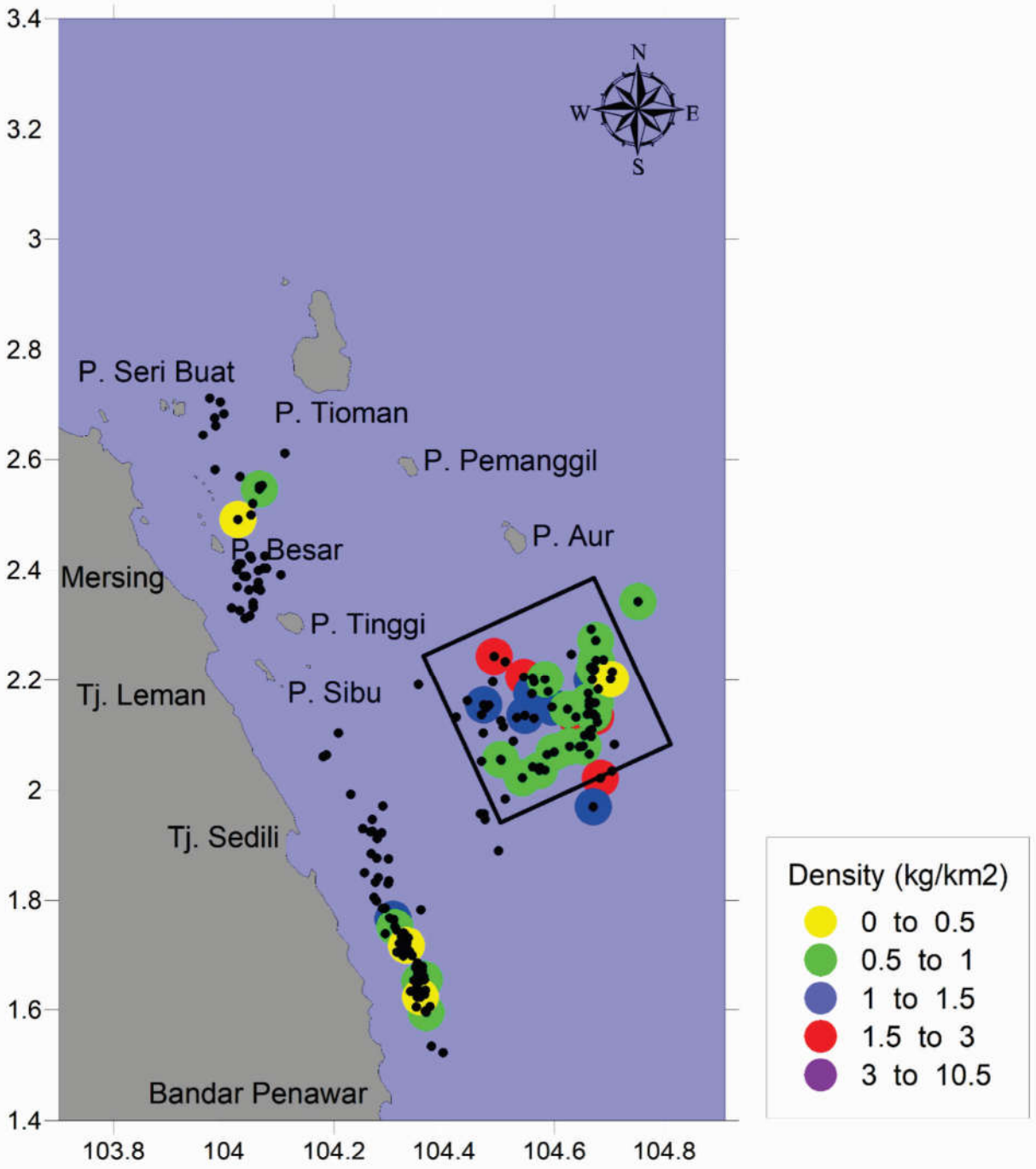

Figure 1: The density of *P. polyphagus* lobster (kg.km^{-2}) from the Observer-On-Board surveys conducted during the September – November 2019 period. The sampling stations are indicated by the black dots while the area with the presence of lobsters are colored according to the their density ranges (refer to legend). The proposed area of focus for the lobster refugia is indicated by the black box.

Table 2: Average density (kg.km^{-2}) and range of density of *P. polyphagus* lobster for each trip during the survey

Trip No.	Vessel Reg. Number	Average	Min	Max
		(kg.km^{-2})		
1	JHF5222T	0.73	0.43	1.02
2	PAF4623	0.81	0.76	0.85
3	JHF3388T	0.87	0.46	1.57
4	JHF5222T	0.59	0.31	0.73
5	JHF3388T	1.17	0.53	2.62
6	JHF1255T	0.40	0.40	0.40
	Overall	**0.95**	**0.31**	**2.62**

Discussion

The results from this survey have indicated a high concentration of mud spiny lobsters in the zone C fishing ground south of Pulau Aur, Johor. This area has a higher density of lobsters, has spawning females and can be further focused as the proposed site for the lobster refugia site (Figure 1). The exact size and location of the lobster refugia will require further discussions with various stakeholders as the area is a fishing ground for zone C trawler vessels (Table 3).

Table 3: The coordinates for the proposed site for the lobster refugia at south of Pulau Aur, Johor

Position	Latitude	Longitude
Point 1	N 2° 14.670'	E 104° 21.753'
Point 2	N 2° 23.146'	E 104° 40.334'
Point 3	N 2° 04.972'	E 104° 48.686'
Point 4	N 1° 56.441'	E 104° 30.137'

However, during the survey at the south of Pulau Aur, we have also recorded multiple sightings of illegal pair trawling activities. Many of these vessels are known to be operated by foreign fishermen and this issue should be taken up during the stakeholders meetings and discussions. The effect of illegal fishing activities such as pair trawling can have a big impact on the local fish resources and the proposed refugia area.

Conclusion

A total of 195 hauls were recorded from six fishing trips. The total number of *P. polyphagus* caught during the duration of the entire survey was 49 tails. However, the majority (80%) of the mud spiny lobsters were caught at the fishing ground south of Pulau Aur, Johor. The average density of mud spiny lobsters at the south of Pulau Aur area were higher (0.87 - 1.17 $kg.km^{-2}$). This area can be further focused as the proposed site for the lobster refugia but the exact size and location of the lobster refugia will require further discussions with various stakeholders.

Acknowledgement

I would like to thank the crew of KK Senangin II from the Fisheries Research Institute Kampung Acheh and the staff of Department of Fisheries Malaysia who have participated or contributed in this survey. A special thanks to Mr. Lau Kim Lee from Lian Hin Fishery and all his fishing crew for their kind cooperation in participating in this Observer-On-Board survey. This study was funded through the developmental grants P21-30701011-22501-040 and P21-30701011-23300-069 and the SEAFDEC/UNEP/GEF Fisheries Refugia Project Grant.

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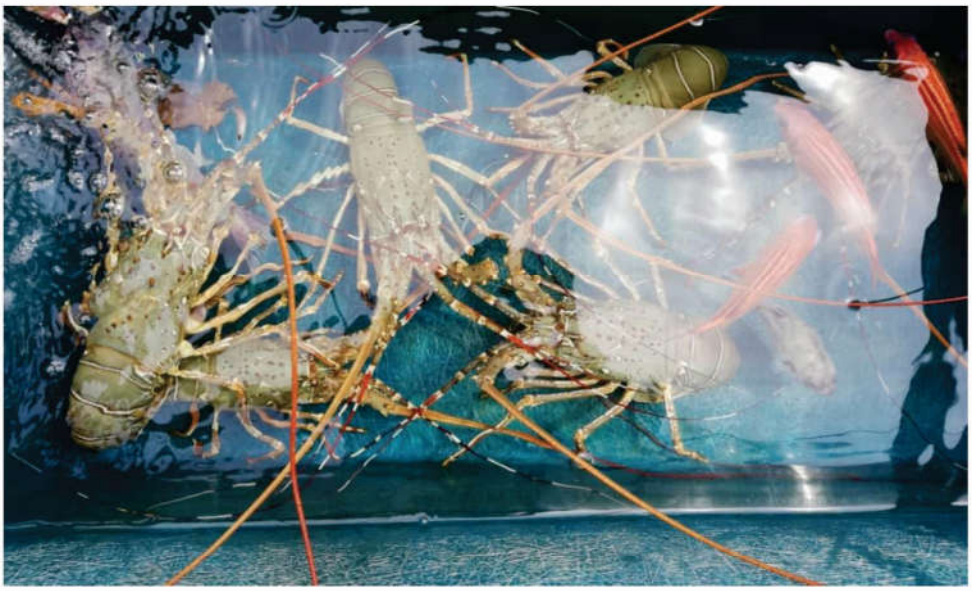
Appendices



Appendix 1: Lobster caught at the south of Pulau Aur waters (on third trip onboard JHF3388T)

Appendix 2: Lobster caught at the south of Pulau Aur waters (on fifth trip onboard JHF3388T)

Appendix 3: Lobster caught at the Pulau Sibu to Desaru waters (on forth trip onboard JHF5222T)

Distribution and Density of Phyllosoma Lobster in East Johor and Pahang Waters of Peninsular Malaysia

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Abstract: This study was conducted to determine the distribution and density of phyllosoma in East Johor and Pahang waters of Peninsular Malaysia. Sampling was conducted twice at the sampling site in August 2017 and October 2018 using a larvae net with 500 µm mesh size through horizontal towing on the subsurface. Samples were observed under stereomicroscopy and identified to genus level. Phyllosoma samples were observed and differentiated into Panulirid and Scyllarid phyllosoma. Density of phyllosoma was calculated by using the number of phyllosoma and volume of water filtered. Density was standardized to 1000 m^3 and the distribution was digitally mapped. This study showed that the phyllosoma of *Panulirus* spp. occurred along Tanjung Sedili waters and more distributed in August 2017 compared to October 2018. Phyllosoma of *Thenus orientalis* showed the highest density in October 2018 and distributed near island waters of Pulau Sibu, Pulau Tinggi, Pulau Pemanggil and Pulau Tioman. This indicated that August is one of the spawning seasons of Panulirid lobster in East Johor. The factors that contribute to the occurrence of phyllosoma on east Johor waters were also discussed.

Keywords: Phyllosoma, *Panulirus* spp., *Thenus orientalis*, distribution, density

Abstrak: Kajian ini dilakukan untuk mengetahui kepadatan dan taburan filosoma di perairan Johor Timur dan Pahang, Semenanjung Malaysia. Persampelan dilakukan dua kali iaitu pada bulan Ogos 2017 dan Oktober 2018 menggunakan jaring larva dengan saiz mata pukat 500 µm dan tundaan secara horizontal di sub-permukaan air. Sampel diasingkan dan dikenalpasti untuk filosoma dengan menggunakan stereomikroskop sehingga ke peringkat genus. Sampel filosoma diperhatikan dan dibezakan antara filosoma panulirid dan scyllarid. Kepadatan

filosoma dikira dengan menggunakan jumlah filosoma dan isipadu air yang ditapis masuk melalui jaring larva. Kepadatan filosoma diseragamkan kepada 1000 m^3 dan taburannya dipetakan secara digital. Kajian ini menunjukkan bahawa filosoma *Panulirus* spp. terdapat di sepanjang perairan Tanjung Sedili dengan taburan yang lebih meluas pada bulan Ogos 2017 berbanding Oktober 2018. Filosoma *Thenus orientalis* menunjukkan kepadatan tertinggi pada Oktober 2018 dan taburannya terdapat di perairan pulau Pulau Sibu, Pulau Tinggi, Pulau Pemanggil dan Pulau Tioman. Ini menunjukkan bahawa bulan Ogos merupakan antara musim bertelur udang karang Panulirid di Johor Timur. Faktor-faktor yang menyumbang kepada terdapatnya filosoma di perairan Johor Timur juga dibincangkan.

Introduction

Lobsters are one of the expensive fishery commodities in Malaysia's market. This resource is mainly landed in Sabah, Sarawak and East Johor in Peninsular Malaysia. Sabah recorded the highest landing of spiny lobster, *Panulirus* spp. in Malaysia with an average of 47.1% followed by East Johor (33.9%) and Sarawak (9.8%). Landing of slipper lobster, *Thenus* spp. was also dominated by Sabah (42.9%) followed by Terengganu (16.3%), Sarawak (16.1%) and East Johor (12.1%) (DOFM, 2020).

Both spiny lobster and slipper lobster accounted for 0.05 % of Malaysia's total marine landings. Landings of spiny lobster increased from 299 tonnes in 2015 to 427 tonnes in 2019 while landings of slipper lobster fluctuated between 255 tonnes to 344 tonnes during the same period. Most of the spiny lobster landed on the East Coast of Peninsular Malaysia were caught by trawl net (52.9%), drift net (27.2%) and trap (19.2%), while slipper lobster was mostly caught by trawl net (94.0%) and drift net (5.7%) (DOFM, 2020). A study by Ibrahim *et al*. (2000) also found that 80% of lobsters caught by trawl net were slipper lobster and only comprised 20% of spiny lobster.

According to Alias *et al.* (2000) at least five species of spiny lobsters can be found on the East Coast of Peninsular Malaysia which are *Panulirus ornatus, P. versicolor, P. homarus homarus, P. longipes and P. polyphagus.* Species of *Panulirus polyphagus* (Mud Spiny Lobster) is the most dominant and can be found mainly in East Johor waters.

Studies on the life cycle of marine lobster in their natural habitat in Malaysia especially during larval stages or phyllosoma is still scanty. Information during early life history is important to protect the resource for sustainability. This is in line with the concept of refugia to protect important species during critical stages of their life cycle such as during migration and spawning seasons (UNEP, 2007). Refugia is specific management of geographical and spatial, marine or coastal areas for maintaining an important species of fisheries that are at a critical stage of life to ensure its sustainability (UNEP, 2005) where it was developed as a new approach to identifying and set areas to integrate fisheries and habitat management.

Phyllosoma is the larval stage for Palinurid and Scyllarid lobsters (Family Palinuridae and Scyllaridae). Phyllosoma and matured adults are critical stages in the lobster life cycle. Phyllosoma has a planktotrophic phase with long duration and highly complex pelagic periods (Matsuda *et al*., 2006). The morphology of lobster larvae or phyllosoma are transparent, leaf-like, long-legged and dorsally (dorso-ventrally compressed) in which it acts hydrodynamically, easily rotates and moves long distances along the waterfront of the ocean (Bradford *et al*., 2005).

There are four phyllosoma life stages and one nisto stage for *T. orientalis* compared with *Panulirus* spp. (Barnett *et al*., 1984). The life stage of the phyllosoma of *Panulirus* spp. is divided into 10 stages and one puerulus stage (Matsuda and Yamakawa, 2000). Phyllosoma of *Panulirus* spp. and *T. orientalis* are different in terms of size and shape of the cephalic shield and the length of the antennule and antenna as mentioned by Innoue *et al*. (2001). Cephalic shield for species of *Panulirus* spp. slightly oval compared to *T. orientalis* that is slightly wider. The Antennule length and antenna of *Panulirus* spp. is longer than *T. orientalis*.

The migration pattern of matured adults of Palinurid lobster for spawning has been mentioned by many researchers. Matured adult migrates to the deep sea for spawning, the phyllosoma grows in the deep sea to puerulus stage before back to the coast (Matsuda dan Yamakawa, 2000). Alias *et al*. (2000) suggested that mature adults, usually larger than 400g spawn in deep waters and the planktonic larvae drift back to shore to complete the life cycle. The objective of this study was to determine the density and distribution of phyllosoma in East Johor and Pahang waters as one of the information needed in establishing fisheries refugia for lobsters.

Materials and Methods

Samplings were conducted in East Johor waters on 21st to 24th August 2017 and 24th to 27th October 2018 with a research vessel of KK SENANGIN II. A total of 17 stations were sampled in 2017 and 13 stations in 2018 (Figure 1 and Figure 2).

Samples of phyllosoma were taken by using larva net with a 1-meter diameter frame and 500 μm for net mesh size (Figure 3). A flowmeter was attached at the mouth of the larva net to record the volume of water passed through. Larva net was towed by horizontal at sub-surface of seawater for 10 minutes and vessel speed at 2 knots. Samples were immediately preserved at 10% with formalin after each towing. Sorting of samples and identification of phyllosoma was done at the laboratory. Dino-Eye Eyepiece Camera was used for identification and measurement of phyllosoma size.

Morphology and life cycle of panulirid phyllosoma was identified based on Matsuda and Yamakawa (2000) while for phyllosoma of *Thenus orientalis* was based on Mikami dan Greenwood (1997). Density (No./ 1000 m^3) and distribution of phyllosoma was calculated by using the formula below:

$$\text{Density per 1000 m}^3 = \left(\frac{1000}{Water\ Volume\ filtered}\right) \times \text{No. of phyllosoma}$$

Where,

Water volume filtered = R x 0.3 m/rpm x mouth area of larva net

R = different of flowmeter reading

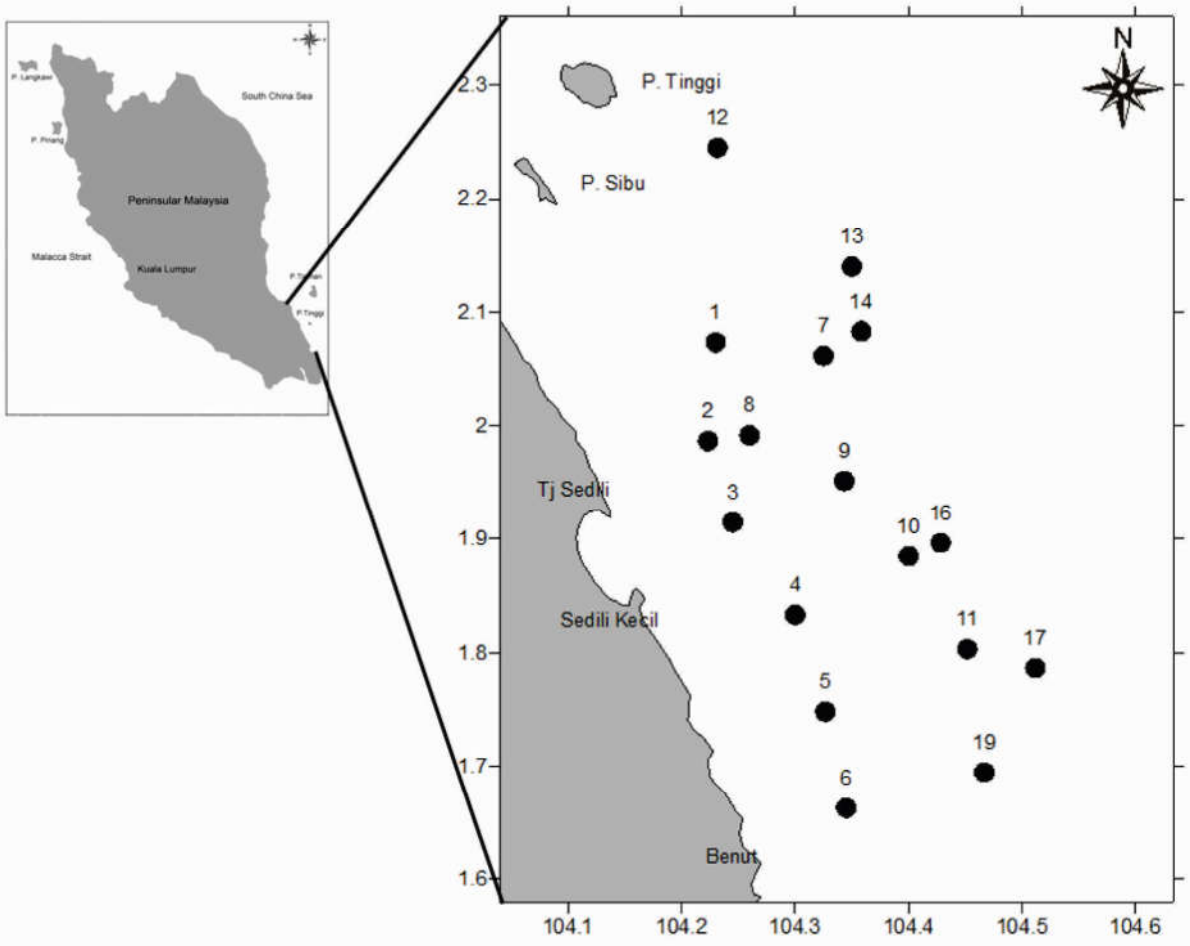

Figure 1: Sampling stations in 2017

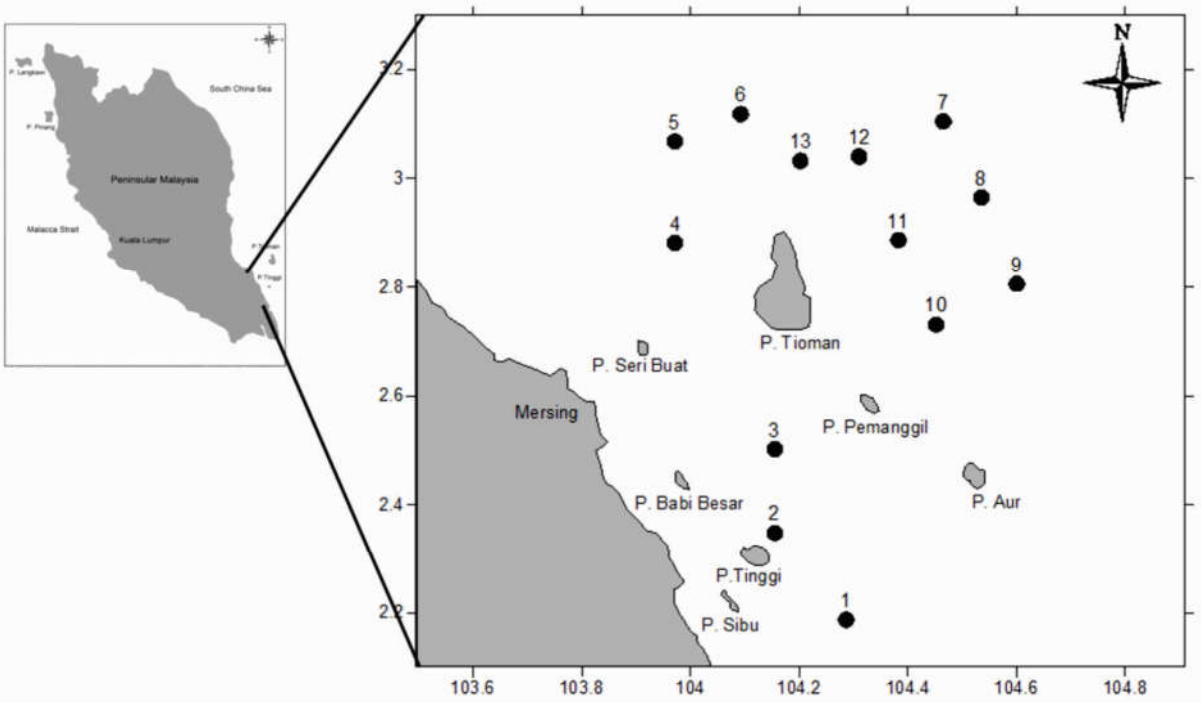

Figure 2: Sampling stations in 2018

Figure 3: Towing of larva net

Results and Discussion

The number of phyllosoma for Panulirus spp. dan Thenus orientalis by stations

Figure 4 showed the number of phyllosoma for *Panulirus* spp. and *T. orientalis* by the station in August 2017. Only 59 phyllosomas have been identified from 17 stations consisting of 48 species of *Panulirus* spp. and 11 species of *T. orientalis*. The highest number of *Panulirus* spp. and *T. orientalis* were found at Station 1 with 17 and 7 phyllosomas respectively. In Station 1, *Panulirus* spp. were also recorded at Station 3 (seven phyllosomas), Station 4 and 9 (six phyllosomas). Meanwhile, less than four phyllosomas were found at Station 2,6,10 and 16. Phyllosoma of *T. orientalis* was found at Station 12 (three phyllosomas) and Station 16 (one phyllosoma).

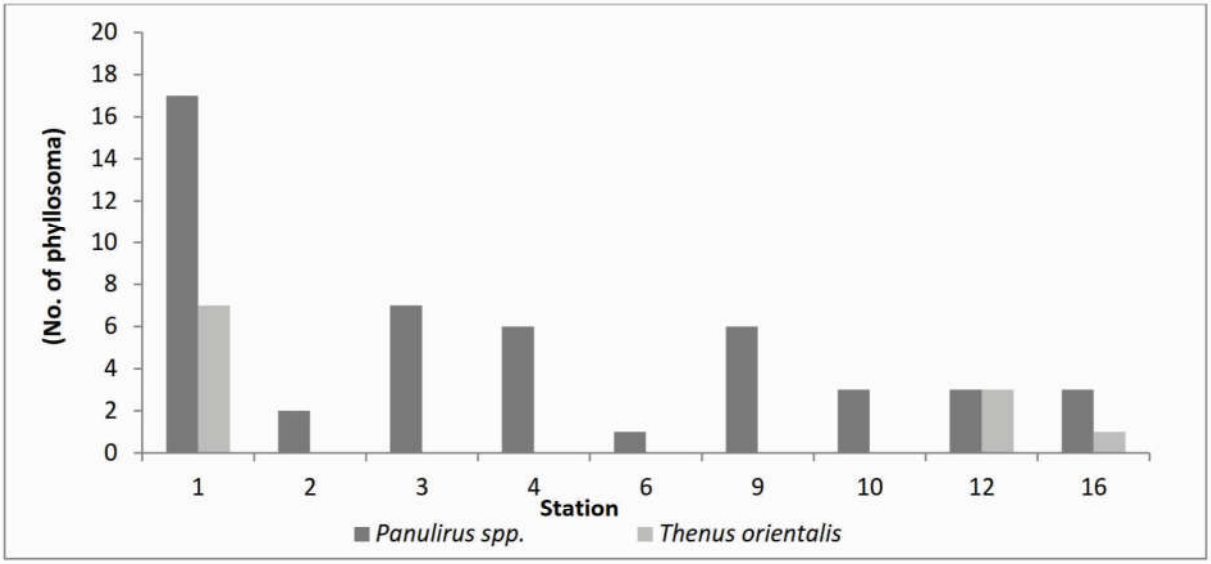

Figure 4: Number of phyllosoma for *Panulirus* spp. and *Thenus orientalis* by stations in August 2017

A total of 165 phyllosomas were recorded during sampling conducted in October 2018 for both genera (Figure 5). Phyllosoma of *Panulirus* spp. only occurred at two stations that were station 1 (13 phyllosomas) and station 5 (18 phyllosomas). Phyllosoma of *T. orientalis* was the highest at station 1 that was 100 phyllosoma, followed by station 5 (17 phyllosomas) and station 2 (14 phyllosomas). Station 11 and station 3 recorded two phyllosomas and one phyllosoma respectively.

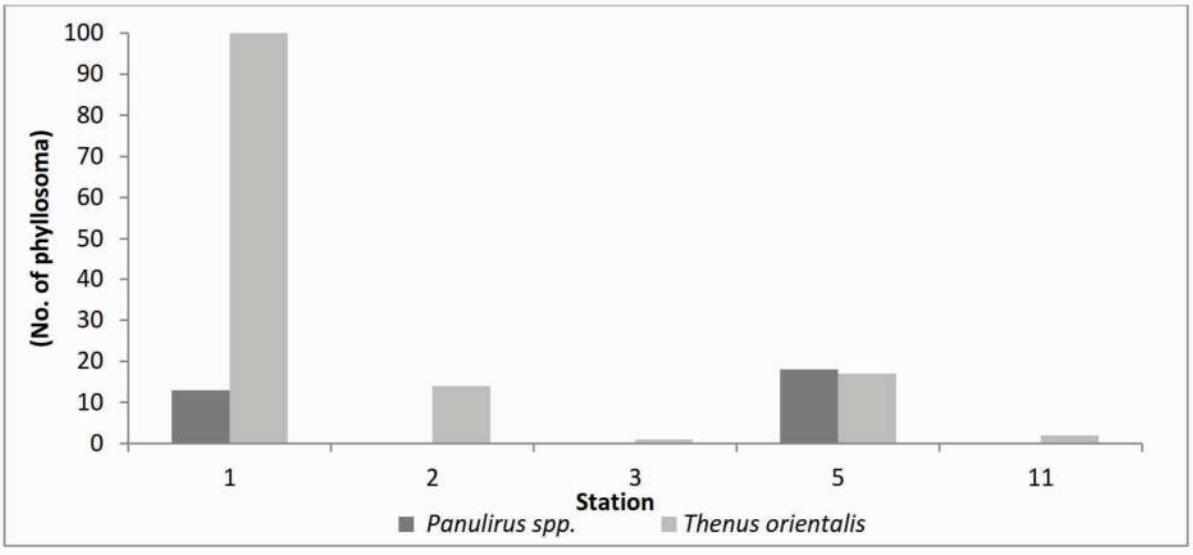

Figure 5: Number of phyllosoma for *Panulirus* spp. and *Thenus orientalis* by stations in October 2018

Phyllosoma of *Panulirus* spp. sampled in 2017 were at stage I to stage VI (Table 1 and Figure 6), while for *T. orientalis* were at stage I to IV. The average size of phyllosoma of *Panulirus* spp. was 0.96 mm to 4.24 mm, and for *T. orientalis* was 2.00 mm to 11.46 mm. Several phyllosomas were mostly at stage I (38 phyllosomas), three phyllosomas at stage III and IV and two phyllosomas recorded at stage V and VI respectively.

Table 1: Number of phyllosomas by stages and size (mm)

Year	Species	Stages	Avg. ±Std. BL	No. of ind.
2017	*Panulirus* spp.	I	0.96 ± 0.08	38
		III	1.33	3
		IV	2.17	3
		V	2.58	2
		VI	4.24	2
	Thenus orientalis	I	2.00	5
		II	5.87	4
		III	9.35	1
		IV	11.46	1
2018	*Panulirus* spp.	I	0.99 ± 0.18	31
	Thenus orientalis	I	1.62 ± 0.48	125
		II	6.01	6
		III	9.29	1

*Note:BL is Body Length in mm

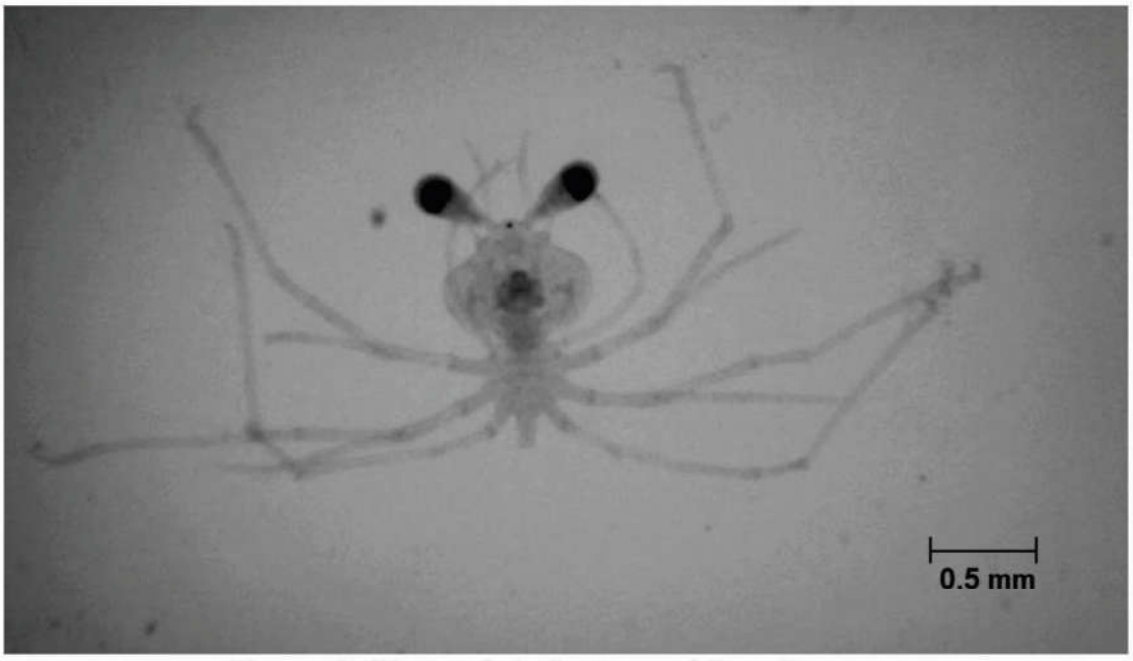

Figure 6: Photo of phyllosoma of *Panulirus* spp.

A total of thirty-one phyllosomas of *Panulirus* spp. sampled in 2018 were at stage I with average body length at 0.99 mm. The average size for phyllosoma of *T. orientalis* was between 1.62 mm to 9.29 mm and most of the phyllosoma were at stage I (125 phyllosomas). In general, most phyllosomas sampled in 2017 and 2018 were at the early stage (I to III).

Distribution and Density of Phyllosoma

Phyllosoma of *Panulirus* spp. was distributed in the southeast of Pulau Tinggi and along the coast of Tanjung Sedili and Sedili Kecil. Nine stations recorded the occurrence of phyllosoma (Figure 7a). Phyllosoma was also found in the waters of Benut that was station 6. There were only three stations that recorded the occurrence of phyllosoma of *T. orientalis* between Pulau Tinggi and Sedili Kecil waters (Figure 7b). Sukarno (1994) stated that the spawning season of *T. orientalis* occurs throughout the year with the peak in December to February. All the stations are located in water depth between 17.1 to 36.3 meters.

The density of phyllosoma of *Panulirus* spp. ranged between 0.1/1000 m^3 to 2.5/1000 m^3. Station 1 recorded the highest density (2.5/1000 m^3) followed by station 3 (1 /1000 m^3), station 9 and station 4 at 0.9 /1000 m^3 respectively and station 6 with the lowest density at 0.1 /1000 m^3. Other station (2, 10,12 and 16) recorded at 0.3/1000 m^3 and 0.4/1000 m^3 (Figure 7a). The density of phyllosoma of *T. orientalis* at the three stations was 1/1000 m^3 (station 1) followed by 0.4 /1000 m^3 (station 12) and 0.1 /1000 m^3 (station 16) (Figure 7b).

Phyllosoma of *Panulirus* spp. only occurred at two stations located north of Pulau Tioman and east of Pulau Sibu during sampling in 2018 (Figure 8a). Distribution for phyllosoma of *Thenus orientalis* occurred at five stations located in waters of Pulau Tioman, Pulau Pemanggil, Pulau Tinggi and Pulau Sibu (Figure 8b). All the stations are located in water depth between 25 to 57 m.

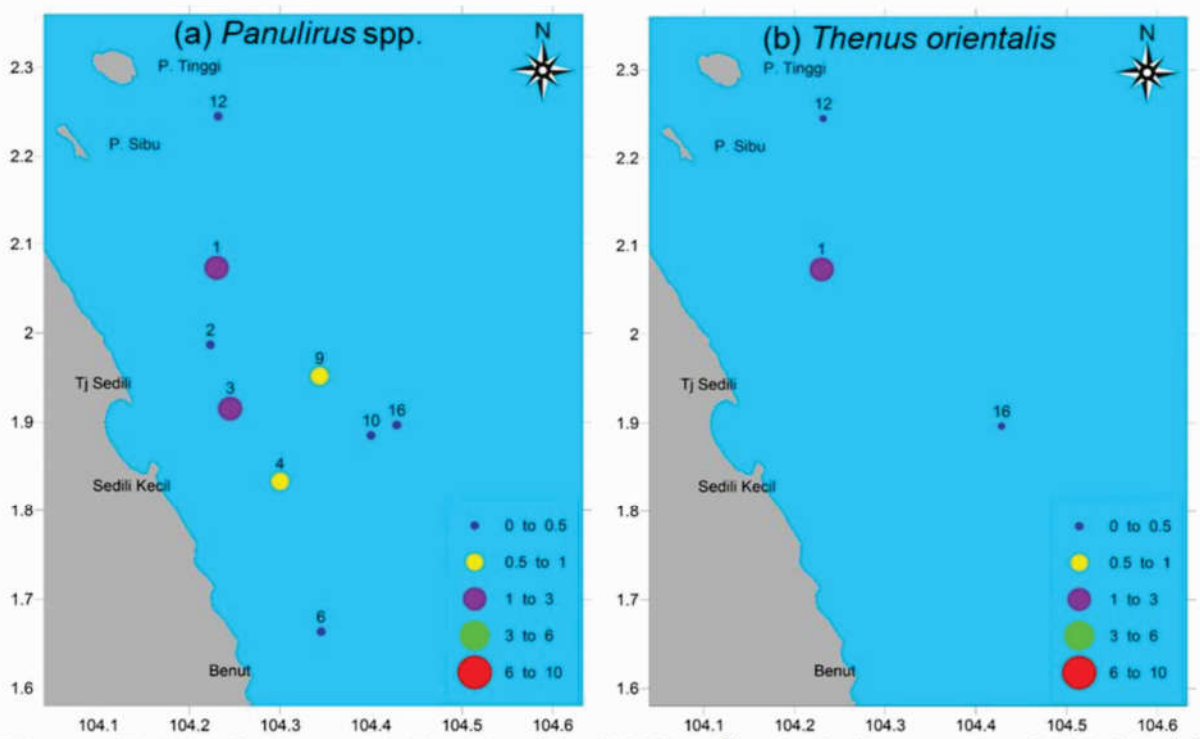

Figure 7: Distribution and Density (No./1000 m^3) of phyllosoma in 2017 for (a) *Panulirus* spp. and (b) *Thenus orientalis*

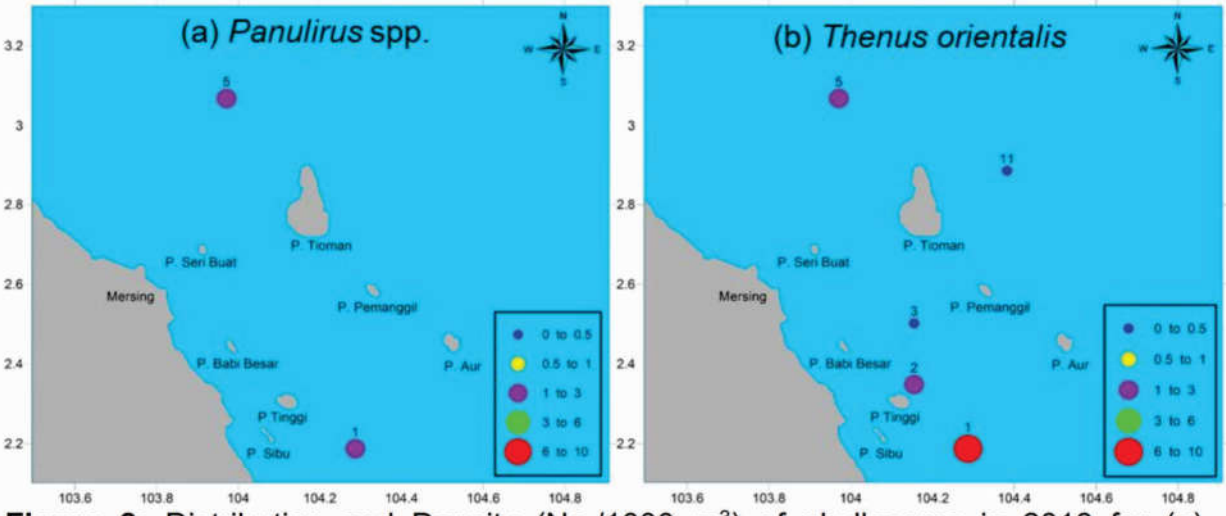

Figure 8: Distribution and Density (No./1000 m^3) of phyllosoma in 2018 for (a) *Panulirus* spp. and (b) *Thenus orientalis*

Phyllosoma density of *T. orientalis* was higher compared to density phyllosoma of *Panulirus* spp. The highest density of *T. orientalis* was 10/1000 m^3 (station 1) followed by 2.1/1000 m^3 (station 5) and 1.5/1000 m^3 (station 2). Station 3 and station 11 recorded less than 1/1000 m^3 (Figure 8b). Density for phyllosoma of *Panulirus* spp. were 1.3/1000 m^3(station 1) and 2.3/1000 m^3 (station 5) (Figure 8a).

The density of phyllosoma of *Panulirus* spp. in August 2017 is higher than in October 2018. This may be due to the spawning season that may occur in August. Abd Haris Hilmi *et al.* (2005) reported the abundance of phyllosoma in the coastal waters of southeast Johor off Sungai Musuh in May with the density up to 22 phyllosoma/100m^3. Alias *et al.* (2000) found that the breeding and migration season starts in July and berried females were high in August.

Phyllosoma density and distribution may be influenced by the high zooplankton density since the phyllosoma is carnivorous (Khvorov *et al*., 2012). Abdulaziz *et al*. (2008) stated that the onset of breeding of Scalloped Spiny Lobster *Panulirus homarus* along the coast of Oman in May/June coincides with the onset of the southwest monsoon conditions in the Arabian Sea region. Drop in water temperature and occurrence of upwelling generated nutrient rich coastal waters. Thus, increased primary productivity and zooplankton biomass.

This phenomenon also occurs in the Southern South China Sea. According to Mohd Fadzil (2012), during the southwest monsoon, the current along the Malaysia coast flows northward while during the northeast monsoon the current flows southward with a maximum speed of 0.4 m/s and 1 m/s respectively. The cooler water from the north is transported to the south and this leads to a temperature reduction in the central of the South China Sea. The convergence of the two opposite currents direction occurs in May at latitude 2°N which leads to upwelling. East Johor is located between latitude 1.3°N and 2.6°N.

The high density of phyllosoma in the waters of Tanjung Sedili is likely due to sampling stations located near the artificial reef of Pulau Tinggi that were deployed in 2008 by the Department of Fisheries Malaysia. The study by Ahmad *et al*. (2012) found adult lobsters in the area of an artificial reef in Terengganu and Johor waters. In Johor waters, 40 artificial reefs were deployed.

Most of the early stages of *Panulirus* spp. (stage I to III) and *T. orientalis* (stage I and II) has been found near coastal stations while for the late stage of *Panulirus* spp. (stage IV to VI) and *T. orientalis* (stage II and III) found at station near Pulau Tinggi. Inoue *et al.* (2001) also found that early stage of *Panulirus* was retained within northeastern Taiwan waters while the later stage is flush out to elsewhere as they lived at deeper depths. Other reports showed a few Panulirid phyllosomas and an abundance of Scyllarid phyllosoma found in coastal waters (Braine *et al.*, 1979; Phillips *et al.*, 1981; Sekiguchi, 1986; Inoue *et al.,* 2000).

In Peninsular Malaysia, the east coast area was more abundant in lobster resources due to the rocky, reef and sandy-mud bottom that are preferred by these families. Depth of water and time (day and night) influence the density of the phyllosoma (Ashanti *et al*., 2016). Water depth was shallower during sampling in August 2017 compared to October 2018. This may result from the more occurrence of phyllosoma in many stations during sampling in 2017. The present study findings were also supported by a study of Ashanti *et al*. (2016) where the early-stage (I-III) phyllosoma was found to be in the water depths of 0 to 50 m during the day and night. Thus, it can be conclude that the spawning area for spiny lobster near the shore with shallow water.

Conclusion

Phyllosoma of *Panulirus* spp. in East Johor waters was high density in August, especially off Tanjung Sedili waters. The high density of phyllosoma may be influenced by the occurrence of upwelling and by artificial reefs located in the waters of Tanjung Sedili and Pulau Tinggi, Johor. This information could be used in establishing a refugia fishery of lobster on the East Coast of Johor and Pahang waters.

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Spiny Lobster (*Panulirus* spp.) Larvae Study in the Coastal Waters (Zone A) Off East Johor, Peninsular Malaysia

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Abstract: In an effort to create a lobster refugia in the East Johor-South Pahang waters, vital information about the life cycle of the mud spiny lobster (*Panulirus polyphagus*) is required for effective management of lobster resources. The aims of this study were to determine the distribution and density of lobster larvae, or also known as phyllosoma in the waters of East Johor. The study was conducted along the coastal area of Zone A (less than 5 nautical miles from the shoreline), spanning from Sedili to Sungai Rengit, East Johor. Sampling activity was carried out onboard a chartered vessel throughout the period from 15-22 November 2020. A total of 29 sampling stations were successfully sampled and the samples were brought back to the laboratory for further analysis. The results from this study showed that the lobster phyllosoma were found in four study locations with the average density of 0.27±0.05 individual/1000m^3 (±S.E). The distribution of lobster phyllosoma were more concentrated around the southeast Johor area near Sungai Rengit. However, there was also one location at Sedili which had the presence of the lobster phyllosoma. All lobster phyllosoma found in this study were still in the stage I (the first stage after hatching from egg) of development. The results from this study indicated that the planktonic larvae (phyllosoma) of lobsters were carried by the sea surface current southward and to the coastal area during the northeast monsoon season.

Keywords: spiny lobster, phyllosoma, density, distribution, refugia, life cycle

Abstrak: Dalam usaha mewujudkan sebuah refugia udang karang di perairan Johor Timur-Pahang Selatan, maklumat penting berkenaan kitar hidup udang karang lumpur, (*Panulirus polyphagus*) amat diperlukan bagi pengurusan sumber udang karang yang berkesan. Matlamat kajian ini adalah bagi menentukan taburan dan kepadatan larvae udang karang, atau juga dikenali sebagai filosoma di perairan Johor Timur. Kajian ini telah dijalankan di sepanjang perairan Zon A (kurang daripada 5 batu nautika daripada pantai), bermula daripada Sedili sehingga ke Sungai Rengit, Johor Timur. Aktiviti persampelan telah dijalankan di atas bot sewa sepanjang tempoh 15-22 November 2020. Sebanyak 29 stesen persampelan telah berjaya dikaji dan sampel yang diperolehi telah dibawa pulang ke makmal bagi analisis lanjutan. Keputusan kajian ini mendapati filosoma udang karang boleh dijumpai di empat kawasan kajian dengan kepadatan purata sebanyak 0.27±0.05 individu/1000m^3 (±S.E). Taburan filosoma udang karang lebih tertumpu di kawasan tenggara Johor berhampiran Sungai Rengit. Namun, terdapat satu lokasi di Sedili yang menunjukkan kehadiran filosoma udang karang. Semua filosoma udang karang yang dijumpai semasa kajian ini masih di peringkat I (peringkat pertama selepas menetas daripada telur) perkembangan. Keputusan daripada kajian ini menunjukkan bahawa larva (filosoma) udang karang yang bersifat planktonik telah dibawa oleh arus permukaan laut ke arah selatan dan menghampiri kawasan persisiran pantai semasa musim monsun timur laut.

Introduction

The spiny lobster (*Panulirus polyphagus*) is a prized and exotic seafood species in Malaysia and mostly caught in the waters off East Johor, Peninsular Malaysia (Alias *et al.,* 2000). Due to its high price and demand, the lobster natural resources is in decline over the recent years (DOFM, 2019). The spiny lobsters are targeted and caught by nearshore fishermen using traditional gears such as drift nets and lobster traps while fish trawlers which operate further out to the sea often caught the adult spiny lobsters as bycatches in their trawl nets. As such, both the adult and juvenile stages of the spiny lobsters are commercially fished in East Johor.

In order to restore the spiny lobster resource to a better sustainable level, a new fisheries management approach which focus on protecting the critical life stages of the targeted species (such as during migration, spawning and juvenile period) is being introduced by the Department of Fisheries Malaysia. This new management approach, or known as the fisheries refugia concept, hopes to protect the targeted species population during its important life stages at specific time period and location in order to give a better chance for the reproduction and replenishment of the targeted stock (SEAFDEC, 2014).

In order to implement the fisheries refugia for the spiny lobster population in East Johor, vital information concerning the life cycle and biology of the spiny lobster is needed. The spiny lobster larvae or known as phyllosoma is in the planktonic stage and their distribution are greatly influenced by the sea surface current movement. Several studies concerning the resource and larvae distribution of the spiny lobster in East Johor have been conducted in the past, particularly in the fishing area where trawl nets operate (above 5 nautical miles from the shoreline).

However, the waters near the shoreline (less than 5 nautical miles) or known as the Zone A area (under the fishing zoning system practiced in Malaysia) have not yet been studied and this study is intended to close the gap in the information available. Thus, the objectives of this study was to evaluate the density and distribution of the spiny lobster larvae (phyllosoma) in the waters off East Johor, Peninsular Malaysia.

Materials and Method

The phyllosoma sampling was conducted in the nearshore waters off East Johor, Peninsular Malaysia. The study area ranged from Sedili to Sungai Rengit, Johor. The sampling area focused at the shoreline area (less than 5 nautical miles

from the land) in the Zone A waters. Sampling was conducted onboard a chartered boat and a total of 29 sampling stations were sampled (Figure 1). The sampling period was between 15 - 22 November 2020. The average depth from the sampling locations was 11.62±0.76 (±S.E) meter.

To sample the phyllosoma, a larvae net with a one meter diameter circular frame and 500 micron mesh net was used (Figure 2). A flowmeter was attached at the opening of the larvae net to record the volume of water passed through. The initial flowmeter reading was recorded before the larvae net was deployed into the sea. The larvae net was then towed horizontally at sub-surface depth for 10 minutes and the towing speed was maintained at about 2 knots. The flowmeter reading was then recorded again after the larvae net was retrieved to calculate the volume of water passed through the net. Samples collected were immediately preserved at 10% with formalin after each towing. The samples were then brought back to the laboratory for sorting and identification.

The density (No./ 1000 m^3) of phyllosoma was calculated by using the formula below:

$$\text{Phyllosoma density per 1000 } m^3 = \left(\frac{1000}{Water\ Volume\ filtered}\right) \times \text{No. of phyllosoma}$$

Where;

Water volume filtered = R x 0.3 m/rpm x mouth area of larva net

and

R = difference in flowmeter reading

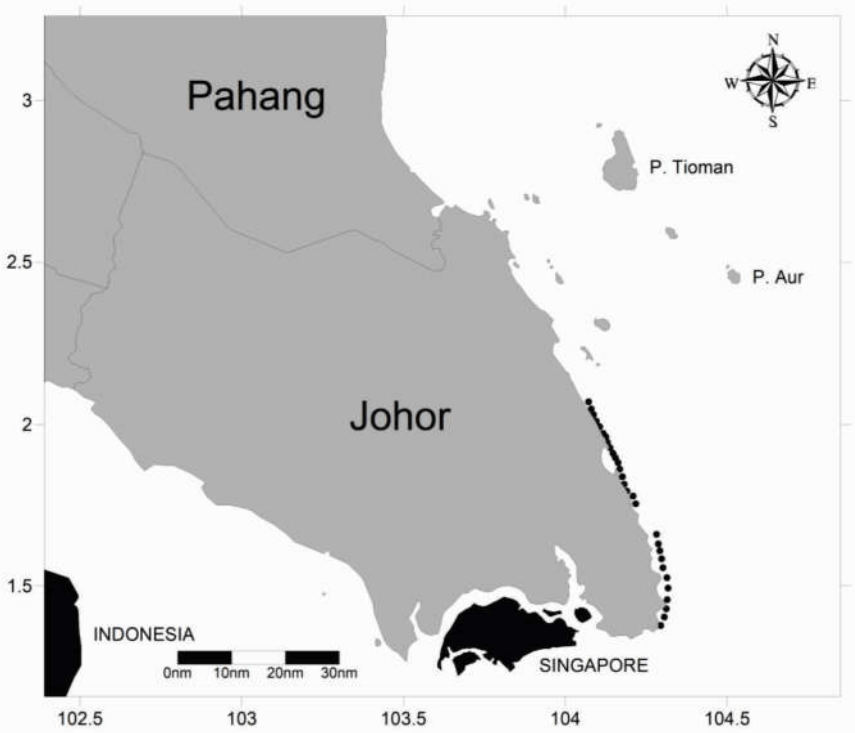

Figure 1: The sampling stations for the spiny lobster larvae are marked with black dots. A total of 29 stations were sampled during the 16-20 November 2020 period

Figure 2: A larvae net with a one meter diameter circular frame and 500 micron mesh net was used to sample the spiny lobster phyllosoma

Results

A total of 29 stations along the coastline from Sedili to Sungai Rengit, Johor were sampled during the November 2020 period. The sampling period also coincided with the northeast monsoon which brought rainy weather and strong wind blowing to the south. The results from this study indicated the presence of spiny lobster phyllosoma at four locations, namely station 2004, 2021, 2028 and 2030. The average density of spiny lobster phyllosoma was 0.27±0.05 individual/1000m^3 (±S.E) and ranged from 0.2 to 0.4 individual/1000m^3. Except for station 2004 (which was located north of Sedili), the other three stations were located at the south east region of Johor between Benut and Sungai Rengit (Figure 3).

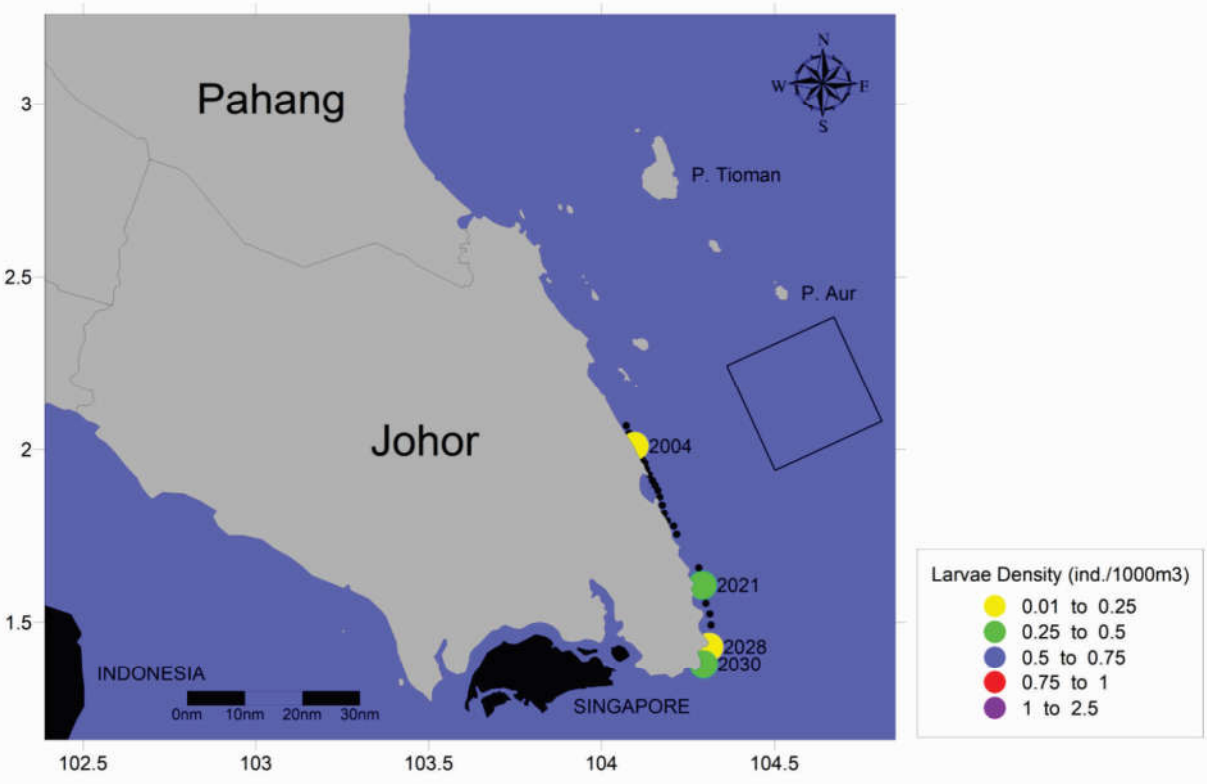

Figure 3: The density of spiny lobster phyllosoma (individuals/1000m^3) ranged from 0.2 to 0.4 individual/1000m^3. The proposed refugia area is marked with a square line and is located south of Pulau Aur

Further analysis of the larvae samples indicated that all lobster phyllosoma found in this study were still in the stage I (the first stage after hatching from egg) of

development (Figure 4). The average body length of *Panulirus* spp. phyllosoma found was 1.107±0.07 mm and ranged between 0947 to 1.288 mm (Table 1).

Figure 4: An example of the lobster phyllosoma found during this study. All lobster phyllosoma found in this study were still in the stage I (the first stage after hatching from egg) of development.

Table 1: The body length and developmental stages of *Panulirus* spp. phyllosoma found in this study

Station	Development Stage	Body length (mm)	Number of individual
2004	I	1.107	1
2021	I	0.947	1
2028	I	1.085	1
2030	I	1.288	1
	Average	**1.107±0.07**	

Discussion

The sampling was conducted in November 2020, during the northeast monsoon, which brought rainy weather and strong wind blowing from the north-east toward the south (Mohd Fadzil, 2012). It is hypothesized that the spiny lobster phyllosoma which were planktonic in nature, were carried by the ocean surface current

from their spawning and hatching ground southward and towards the coastal area. From previous surveys, it was determined that the spiny lobster spawning ground was located south of Pulau Aur and covered an area about 20 by 20 nautical miles.

However, the densities of the spiny lobster phyllosoma from this study was low, ranging from 0.2 to 0.4 individuals/1000m^3. The phyllosoma found in this study were also still in the early developmental stage I, signifying short lapse of time after hatching. A spiny lobster phyllosoma study conducted in August 2017 indicated higher densities of phyllosoma (ranged between 0.1 to 2.5 individuals/1000 m^3) in the zone B waters (5 to 12 nautical miles from the shoreline) near Sedili (Abd Haris Hilmi *et al.* 2020). In that study, most of the phyllosoma found were also in the stage I of development. Therefore, we could conclude that the breeding season for spiny lobsters may still occur in November but in low intensity as compared to earlier months.

Conclusion

A total of 29 sampling stations were successfully sampled in the coastal waters of zone A, East Johor and the results from this study showed that the lobster phyllosoma were found in four study locations with the average density of 0.27±0.05 individual/1000m^3 (±S.E). The distribution of lobster phyllosoma were more concentrated around the southeast Johor area near Sungai Rengit. All lobster phyllosoma found in this study were still in the stage I (the first stage after hatching from egg) of development.

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The Study of Spiny Lobsters Landings in East Johor-South Pahang Waters for the Establishment of a Fisheries Refugia Site

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Abstract: The spiny lobster is a high value fishery commodity and its natural resource can be found in the waters of East Johor and South Pahang. However, the level of this resource is in decline due to over exploitation. One new approach taken by the Department of Fisheries Malaysia to overcome this issue is to establish a fisheries refugia conservation zone. The main objective of this spiny lobster resource study was to identify the location of the spawning ground in the waters of East Johor-South Pahang for the purpose of the establishment of a fisheries refugia. The landing data of spiny lobster were collected at selected jetties at Sedili, Tanjung Leman and Endau. The results from this study indicated that the average weight of spiny lobsters peaked around November to January at Sedili, October to November at Tanjung Leman and July at Endau. The average weight of spiny lobsters landed at Sedili was 248.6 g and ranged from 153.1 – 354.4 g. Likewise, the average weight of spiny lobsters landed at Tanjung Leman was 283.7 g and ranged from 180.3 – 422.1 g. Meanwhile the average weight of spiny lobsters landed at Endau was 433.9 g and ranged from 374.2 – 522.2 g. The average carapace length of mud spiny lobsters at Sedili was 6.74±0.09 cm (±S.E.) for female and 6.68±0.09 cm (±S.E.) for male. While the average carapace length of mud spiny lobsters at Tanjung Leman was 7.56±0.10 cm (±S.E.) for female and 6.81±0.15 cm (±S.E.) for male. At Endau, the average carapace length of mud spiny lobsters was 8.51±0.13 cm (±S.E.) for female and 7.98±0.09 cm (±S.E.) for male.

Keywords: spiny lobster, refugia, sustainable fishery resource, landings

Abstrak: Udang karang merupakan suatu komoditi perikanan yang bernilai tinggi dan sumber semulajadi udang karang ini boleh didapati di kawasan perairan Johor Timur dan Pahang Selatan. Namun, tahap sumber udang karang semakin berkurangan kerana eksploitasi berlebihan. Satu pendekatan baharu yang diambil oleh Jabatan Perikanan Malaysia bagi mengatasi isu ini adalah bagi menubuhkan sebuah zon konservasi refugia perikanan. Objektif utama kajian sumber udang karang ini adalah untuk mengenalpasti lokasi pembiakan udang karang di kawasan perairan Johor Timur-Pahang Selatan bagi penubuhan refugia perikanan. Maklumat pendaratan udang karang telah dikutip di jeti-jeti terpilih di Sedili, Tanjung Leman dan Endau. Keputusan daripada kajian ini menunjukkan berat purata udang karang mencapai nilai tertinggi di sekitar bulan November sehingga Januari di Sedili, Oktober sehingga November di Tanjung Leman dan Julai di Endau. Berat purata udang karang yang didaratkan di Sedili bernilai 248.6 g dan berjulat antara 153.1 – 354.4 g. Manakala berat purata udang karang yang didaratkan di Tanjung Leman pula bernilai 283.7 g dan berjulat antara 180.3 – 422.1 g. Di samping itu, berat purata udang karang yang didaratkan di Endau bernilai 433.9 g dan berjulat antara 374.2 – 522.2 g. Panjang purata karapas udang karang di Sedili pula ialah 6.74±0.09 cm (±S.E.) bagi betina dan 6.68±0.09 cm (±S.E.) bagi jantan. Manakala panjang purata karapas udang karang di Tanjung Leman ialah 7.56±0.10 cm (±S.E.) bagi betina dan 6.81±0.15 cm (±S.E.) bagi jantan. Di Endau, panjang purata karapas udang karang ialah 8.51±0.13 cm (±S.E.) bagi betina dan 7.98±0.09 cm (±S.E.) bagi jantan.

Introduction

The spiny lobster is a high value fishery commodity and its natural resource can be found in the waters of East Johor and South Pahang. There are five recorded species of spiny lobsters from the genus *Panulirus* in the Malaysian waters but *Panulirus polyphagus* is the most dominant species to be found in that area (Alias *et al.,* 2000). However, the current spiny lobster resource is on the decline due to over exploitation (DOFM, 2019). The Department of Fisheries Malaysia has taken note of the current resource situation and intends to improve the spiny lobster resource status.

One of the new management approach taken by the Department of Fisheries Malaysia is to establish a marine conservation area known as the fisheries refugia conservation zone. The fisheries refugia concept focused on the resource protection of selected fish species (such as the spiny lobster) during critical periods of its life cycle such as during breeding and migration seasons or during its juvenile stage (SEAFDEC, 2014). A particular fisheries refugia will have a specific closing time period and spatial area for the protection of the critical life stage period(s).

In order to support the development of a spiny lobster fisheries refugia site, vital background information such as the breeding area location, spawning period and season as well as the status of the current spiny lobster resource is required. The spiny lobster landings study was carried out since year 2017 to 2020 to identify the landing patterns of spiny lobsters and to gather biological information such as the breeding season. The main objective of this study was to gather landing data of spiny lobsters at selected jetties for the establishment of a fisheries refugia.

Materials and Method

Spiny lobsters landing data collection was carried out at selected fisherman jetties (Sedili, Tanjung Leman and Endau) throughout the year 2017-2020. At each jetty, enumerators appointed by FRI Kampung Acheh would collect daily landing data of all spiny lobsters. The information collected include the type of spiny lobsters species, weight, sex status, the presence of eggs (indicator of breeding season) and other information. All data collected would then be compiled and sent to FRI Kampung Acheh via email for further analyses. The spiny lobster landings data collection was carried out since July 2017 and ended in March 2020. In addition, landing data of spiny lobsters derived from the Annual Fisheries Statistics (DOFM, 2021) were analyzed to obtain additional information about the spiny lobster fishery in East Johor.

Results

Average weight of spiny lobsters

The results from the spiny lobster landing data collected from the three jetties (Sedili, Tanjung Leman and Endau) indicated that the average size of spiny lobsters peaked around November to January at Sedili (Figure 1), October to November at Tanjung Leman (Figure 2) and July at Endau (Figure 3). The average weight of spiny lobsters landed at Sedili was 248.6±8.5 g (±S.E.) and ranged from 153.1 – 354.4 g. Likewise, the average weight of spiny lobsters landed at Tanjung Leman was 283.7±13.1 g (±S.E.) and ranged from 180.3 – 422.1 g. Meanwhile the average weight of spiny lobsters landed at Endau was 433.9±10.5 g (±S.E.) and ranged from 374.2 – 522.2 g.

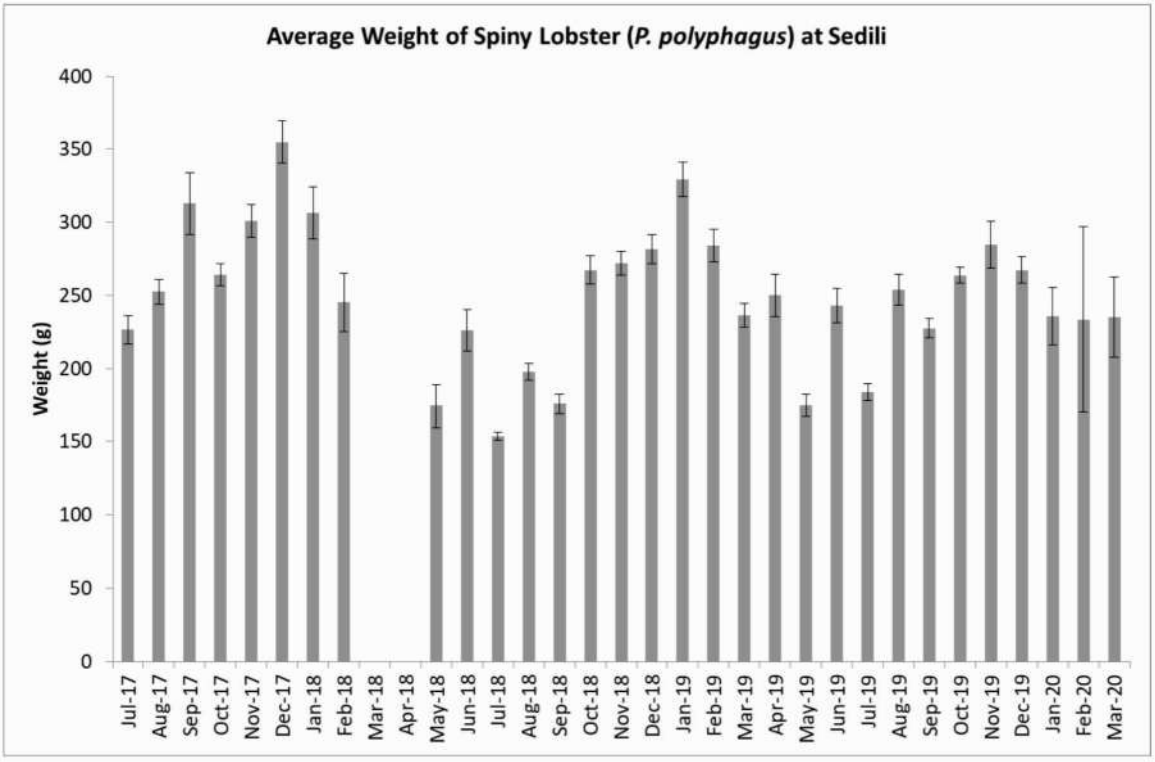

Figure 1: Average weight of spiny lobster (*P. polyphagus*) at Sedili (with S.E. bar)

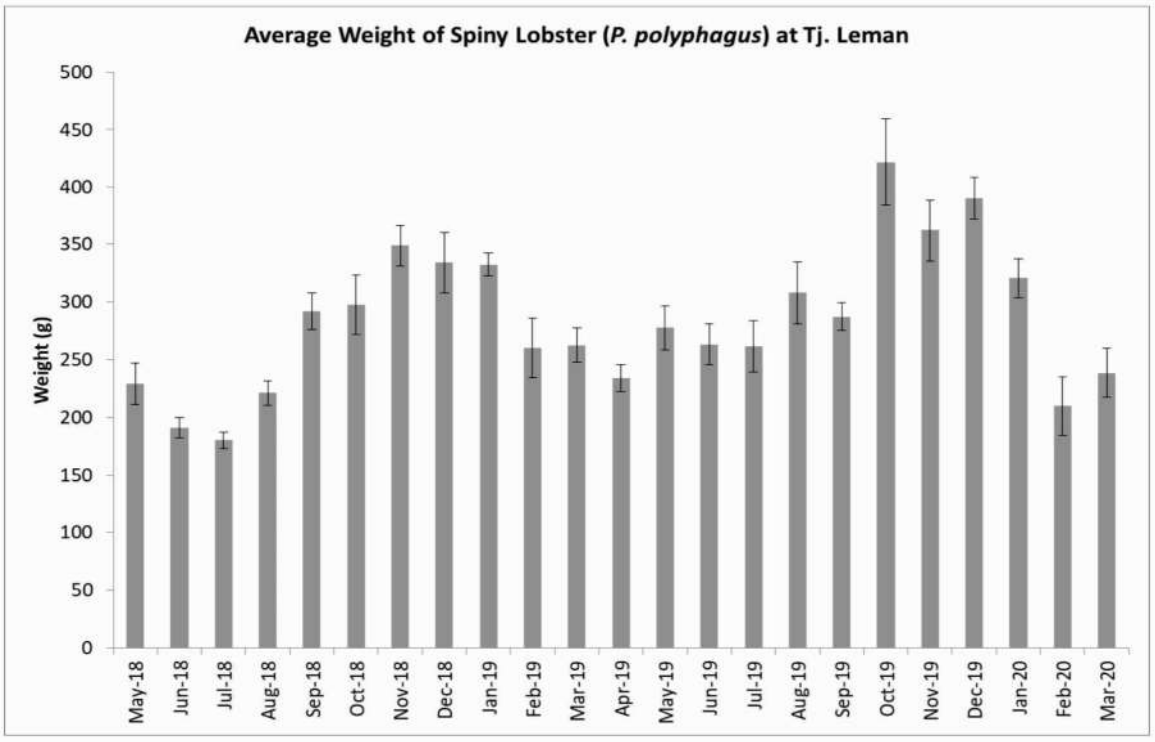

Figure 2: Average weight of spiny lobster (*P. polyphagus*) at Tanjung Leman (with S.E. bar)

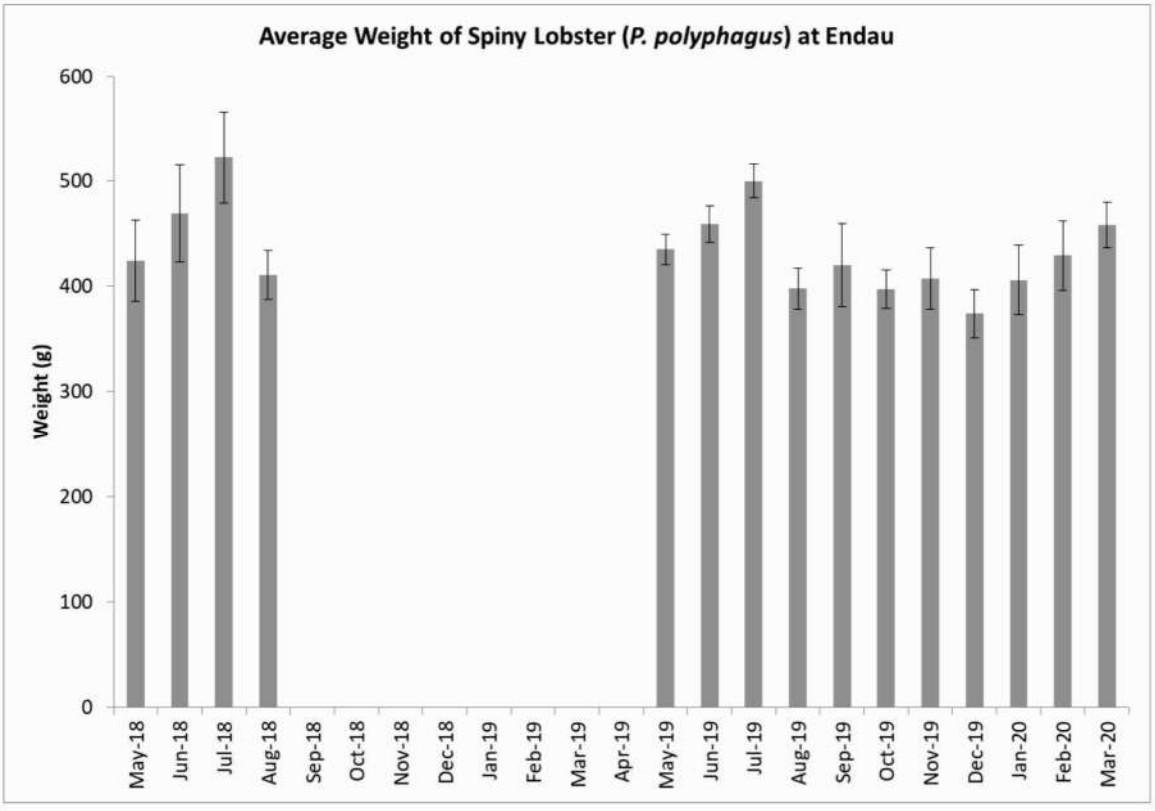

Figure 3: Average weight of spiny lobster (*P. polyphagus*) at Endau (with S.E. bar)

Average carapace length (CL) of spiny lobsters

In term of carapace length (CL), the results from the Sedili jetties indicated that the average size of spiny lobsters peaked around December 2017, June 2018, April 2019 and October 2019 for female and December 2017, January 2019 and November 2019 for male at Sedili (Figure 4). As for Tanjung Leman, the average size (in term of carapace length, CL) of spiny lobsters peaked around June 2018, November 2018 and November 2019 for female and November 2018 and October 2019 for male at Sedili (Figure 5). Meanwhile at Endau, the average size (in term of carapace length, CL) of spiny lobsters peaked around May 2018, Jun 2019 and March 2020 for female and July 2018 and September 2019 for male (Figure 6).

The average carapace length of mud spiny lobsters at Sedili was 6.74±0.09 cm (±S.E.) for female and 6.68±0.09 cm (±S.E.) for male. While the average carapace length of mud spiny lobsters at Tanjung Leman was 7.56±0.10 cm (±S.E.) for female and 6.81±0.15 cm (±S.E.) for male. At Endau, the average carapace length of mud spiny lobsters was 8.51±0.13 cm (±S.E.) for female and 7.98±0.09 cm (±S.E.) for male.

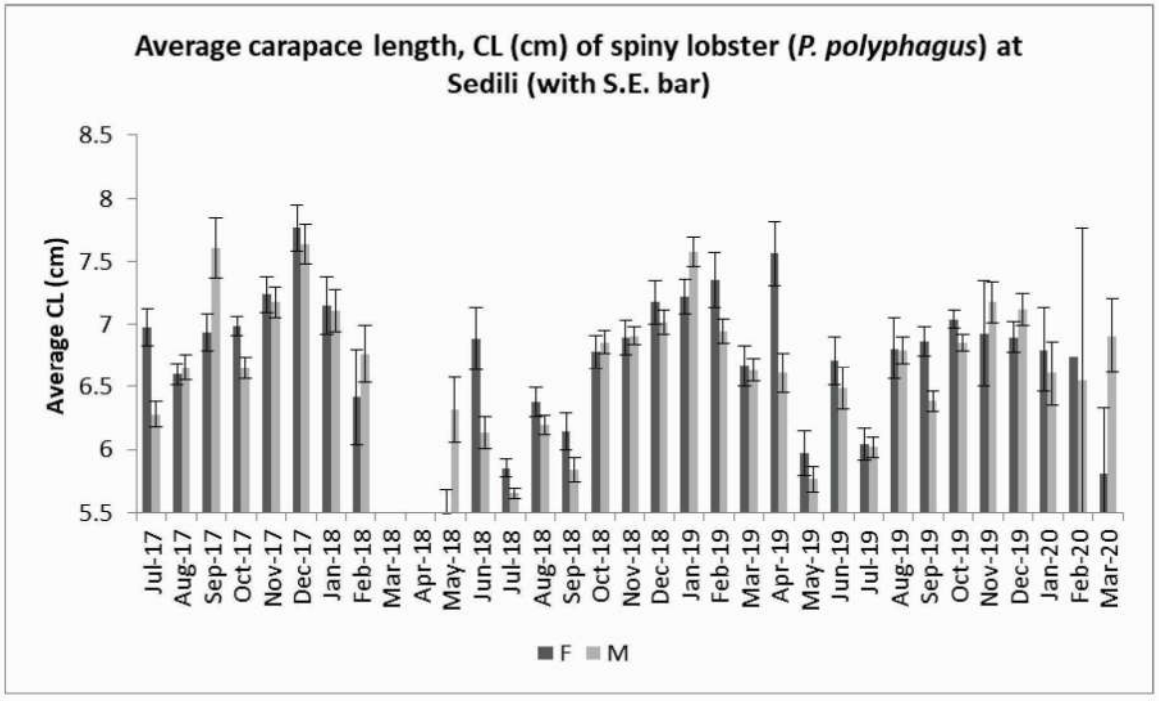

Figure 4: Average carapace length, CL (cm) of spiny lobster (*P. polyphagus*) at Sedili (with S.E. bar)

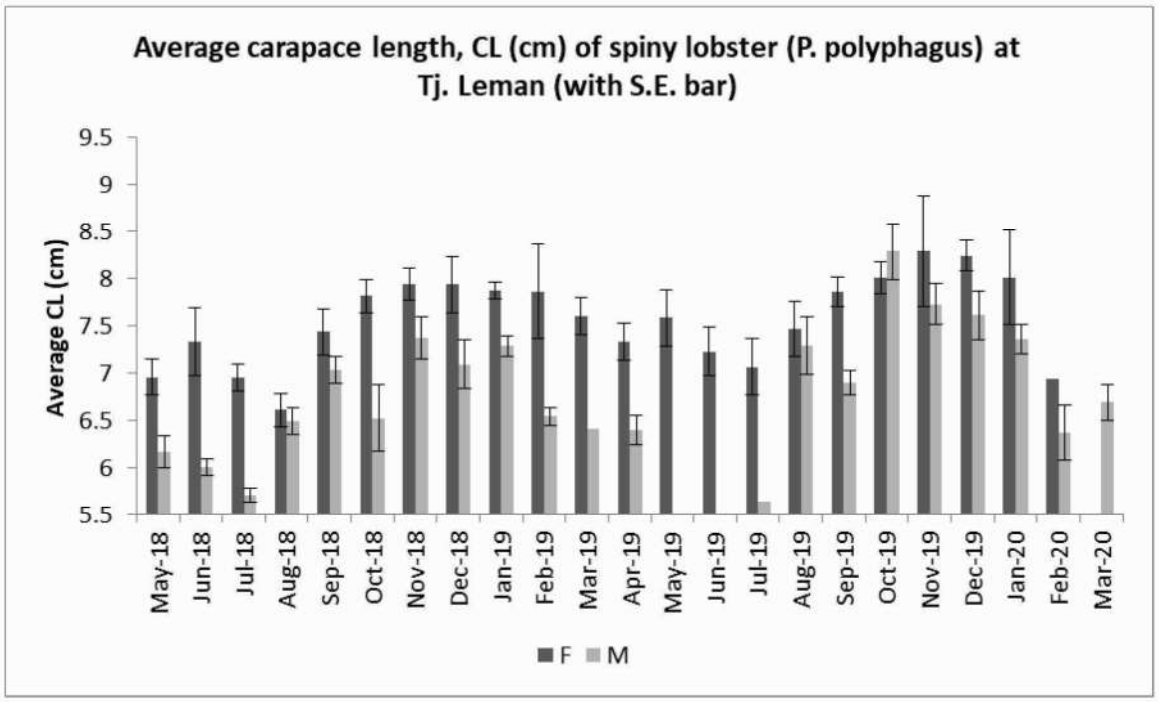

Figure 5: Average carapace length, CL (cm) of spiny lobster (*P. polyphagus*) at Tanjung Leman (with S.E. bar)

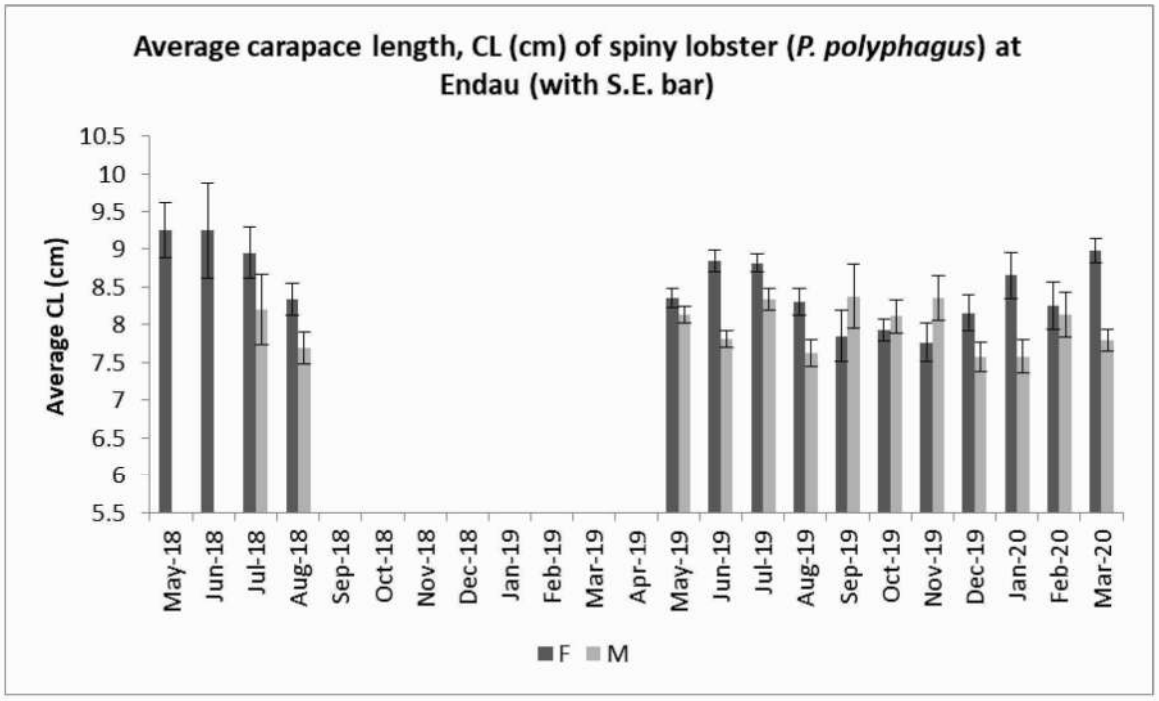

Figure 6: Average carapace length, CL (cm) of spiny lobster (*P. polyphagus*) at Endau (with S.E. bar)

Ratio of female to male spiny lobsters

As for the ratio of female to male spiny lobster landed at each location, generally there were more male lobsters landed compared to females, especially at the coastal area. The average ratios of females to males spiny lobsters landed was 0.50±0.04 at Sedili, 0.48±0.07 at Tanjung Leman and 1.08±0.06 at Endau. However, the results from the Sedili jetties also indicated that higher number of female lobsters were landed in the months of October 2017, May 2018, January 2019, June 2019 and October 2019 (Figure 7). As for Tanjung Leman, more female lobsters were landed in the months of December 2018, March 2019 and December 2019 while May-June 2019 recorded only females lobsters (Figure 8). At Endau, slightly more female lobsters were landed in the months of July 2019 and October 2019 while May-June 2018 recorded only females lobsters (Figure 9).

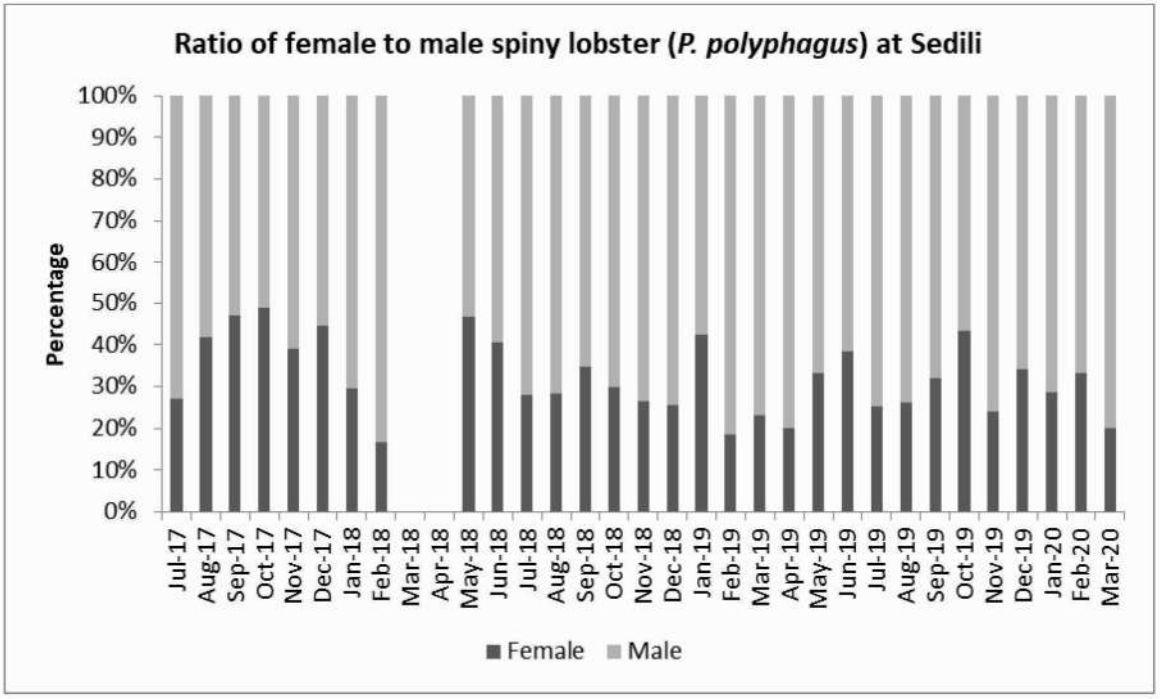

Figure 7: Ratio of female to male spiny lobster (*P. polyphagus*) at Sedili

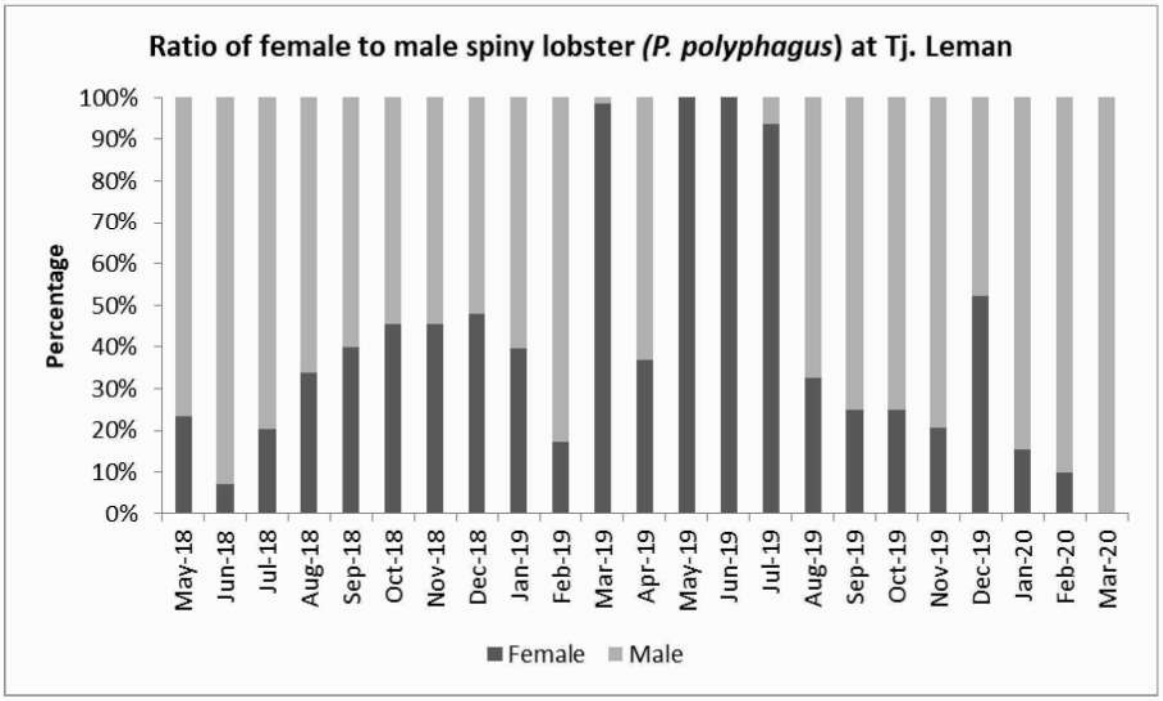

Figure 8: Ratio of female to male spiny lobster (*P. polyphagus*) at Tanjung Leman

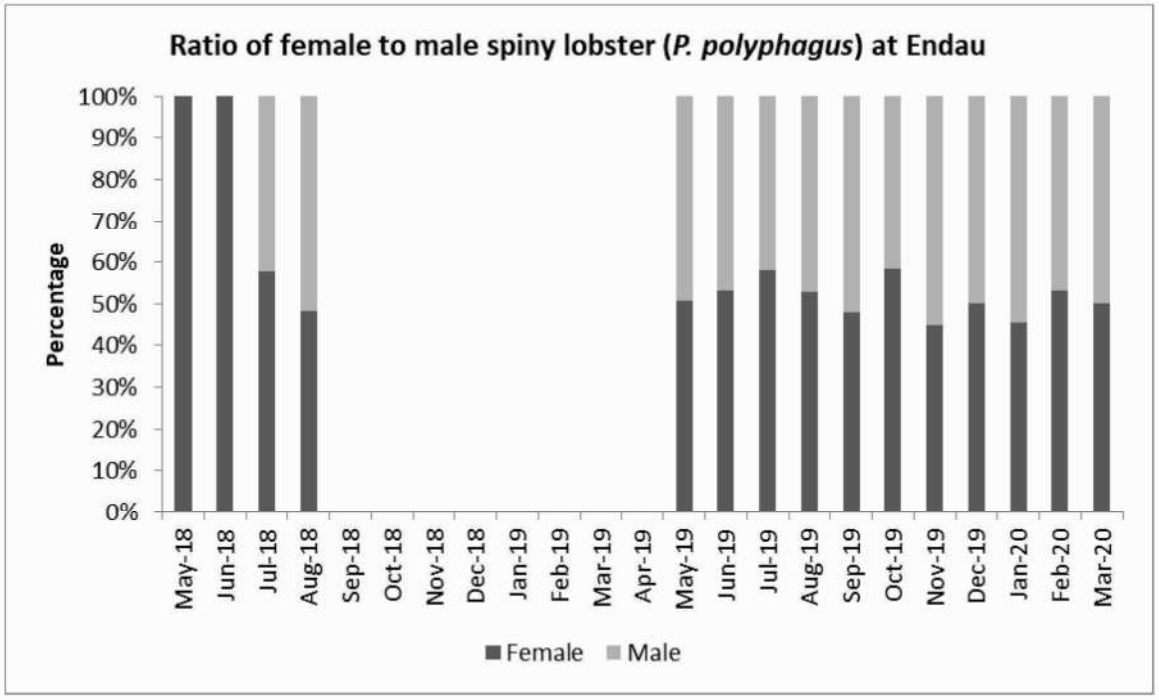

Figure 9: Ratio of female to male spiny lobster (*P. polyphagus*) at Endau

This study also recorded the observation of berried spiny lobsters at the three study sites. The most number of berried females were landed at Endau (91%) compared to Sedili or Tanjung Leman. The average carapace length of berried spiny lobsters

recorded at the three sites was 9.32±0.15 cm (±S.E.) and ranged from 5.52 cm to 11.84 cm. The average weight of berried spiny lobsters recorded was 632.46±0.03 cm (±S.E.) and ranged from 135g to 1200g. At Endau, berried spiny lobsters were landed by fishermen in May to August 2018 and from December 2019 to March 2020. The highest percentage of berried females were recorded in the month of July 2018 where 39.5% of total spiny lobsters landed in Endau were berried females. However, the general trend for the availability of berried females in Endau was not able to be determined as there were insufficient data for other period from September 2018 to November 2019.

Discussion

Landing of undersized spiny lobsters

Based on a previous spiny lobster study by Ikhwanuddin *et al.* (2014) in East Johor, the size at maturity for the spiny lobster (*P. polyphagus*) were stated to be about 6.02 cm CL for male and 6.59 cm CL for female. Comparing these two values with the average landing sizes of spiny lobsters in Sedili (Figure 4), Tanjung Leman (Figure 5) and Endau (Figure 6), it is discovered that spiny lobsters below the size at maturity were frequently landed in Sedili and sometime in Tanjung Leman. The average size of female spiny lobsters landed in Sedili were below the size at maturity in the months of February, May, July, August and September of 2018, May and July of 2019 as well as March 2020.

Likewise, the average size of male spiny lobsters landed in Sedili were below the size at maturity in the months of July and September 2018 and May and July of 2019. Meanwhile at Tanjung Leman, the average size of male spiny lobsters landed were below the size at maturity in the months of Jun and July of 2018 and July 2019 while all female lobsters were landed above the size at maturity. Likewise, spiny lobsters landed at Endau were all above the size at maturity stated.

The uncontrolled harvesting of undersized spiny lobsters at Sedili and Tanjung Leman may consequently leads to growth overfishing, where young lobsters were caught before they can reach maturity size and able to reproduce (Radhakrishnan *et al*., 2005). As of now, there is no regulation governing the size of spiny lobsters allowed to be caught in Malaysia but future management actions such as setting a minimum size and/or catch limit are required and should be considered for the spiny lobster fishery in Malaysia.

Factors influencing the spiny lobster catch

The results from this study showed marked differences in spiny lobster size landed at each jetties in Sedili, Tanjung Leman and Endau. The size of spiny lobsters caught was highly related to the fishing location and the type of gear used. The lobster fishermen from Sedili and Tanjung Leman areas operated mainly traditional gears such as drift nets at nearshore area to catch the spiny lobsters. In contrast, the spiny lobsters landed at Endau were mainly bycatch from commercial fish trawlers which ply their trade at fishing area further out at sea. Thus, the size of spiny lobsters caught by the fish trawlers were much bigger than the catch of nearshore traditional fishermen. The traditional fishermen at Sedili and Tanjung Leman mainly caught the juvenile and young adults stages of the spiny lobsters which seek refuge among the rocks at the near shore area.

In term of seasonality, bigger spiny lobsters were caught near the end of the year especially at Sedili and Tanjung Leman, which coincide with the northeast monsoon and generally rough weather at the sea around East Johor. The increased current strength, wave action and drop in water temperature during the rainy season may prompt bigger spiny lobsters to come out of their burrows or crevices in search of food or perform other activities.

Monthly landing of spiny lobsters in East Johor

The effect of the northeast monsoon on the overall spiny lobster landings in East Johor was evident as shown in the statistics collected periodically by the Department of Fisheries Malaysia (DOFM. 2021). An analysis of the spiny lobster landing throughout a five years period from 2015-2019 indicated increasing landing of spiny lobsters as the year ends and the northeast monsoon began (Figure 10). Throughout the period, spiny lobster landings in East Johor peaked around March 2015, November 2015, September 2016, October 2017, December 2018 and November 2019. The fishing activities during the northeast monsoon season would likely be hampered by constant bad weather but in the same time the likelihood of catching more spiny lobsters was higher.

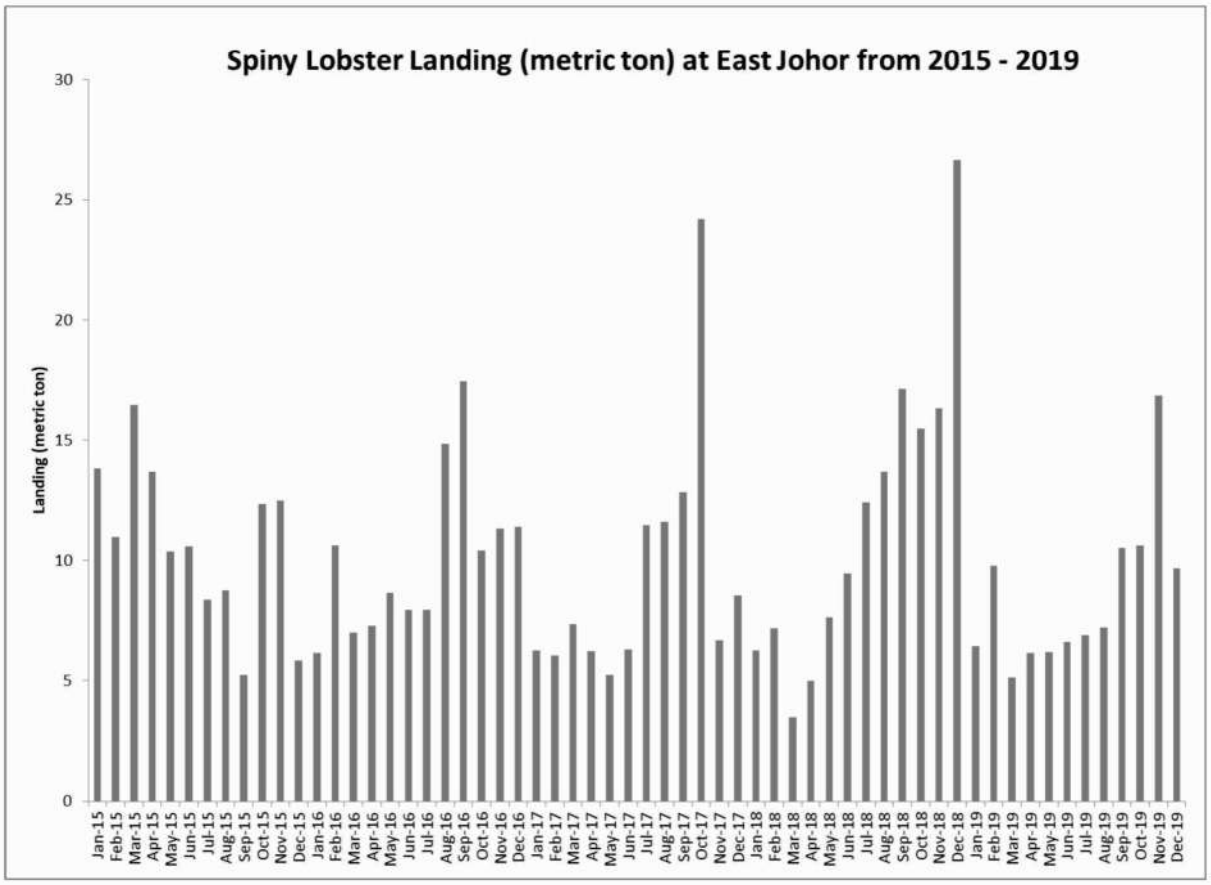

Figure 10: Monthly landing of spiny lobsters from East Johor for year 2015-2019 (Source: Annual Fisheries Statistics, 2015-2019)

Calculation of Maximum Sustainable Yield (MSY)

Using the landing and effort data from the Malaysia Annual Fisheries Statistics (DOFM, 2021), the calculation of Maximum Sustainable Yield (MSY) for the spiny lobster resources in East Johor waters was carried out based on the Schaefer Model and the Fox Model (Sparre and Venema, 1998). The results from the Schaefer Model analysis showed that the MSY level of the spiny lobsters in East Johor waters was at 129 metric ton with fMSY at the level of 8283 units per year (effort was standardized based on the effort of drift nets) (Figure 11).

However, the results from the Fox Model analysis showed lesser values, where the MSY level of the spiny lobsters in East Johor waters was calculated at 110 metric ton with fMSY at the level of 5830 units per year (effort was standardized based on the effort of drift nets) (Figure 12). The MSY and fMSY values from the Fox Model were 14.7% and 29.6% less than the values derived from the Schaefer Model.

For reference, the annual spiny lobster landing in East Johor for the year 2019 was 102 metric ton. For the sustainable management of spiny lobster resource, the annual spiny lobster landing in East Johor area should not exceed the MSY value of 129 metric ton if based on the Schaefer Model or 110 metric ton if based on the Fox Model. Therefore, the reduction in effort as well as conservation effort such as the fisheries refugia management will help in this matter.

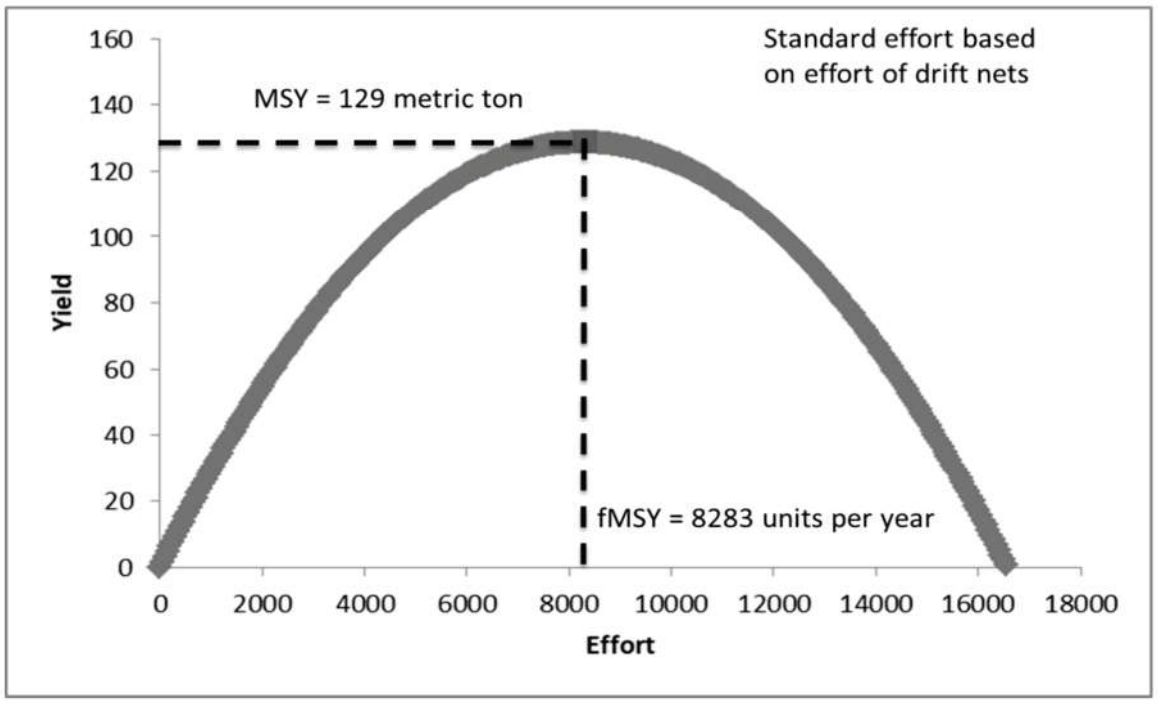

Figure 11: Schaefer Model of the spiny lobster resource in the East Johor waters. MYS was estimated to be about 129 metric ton with fMSY = 8283 units per year (effort was standardized based on the effort of drift nets)

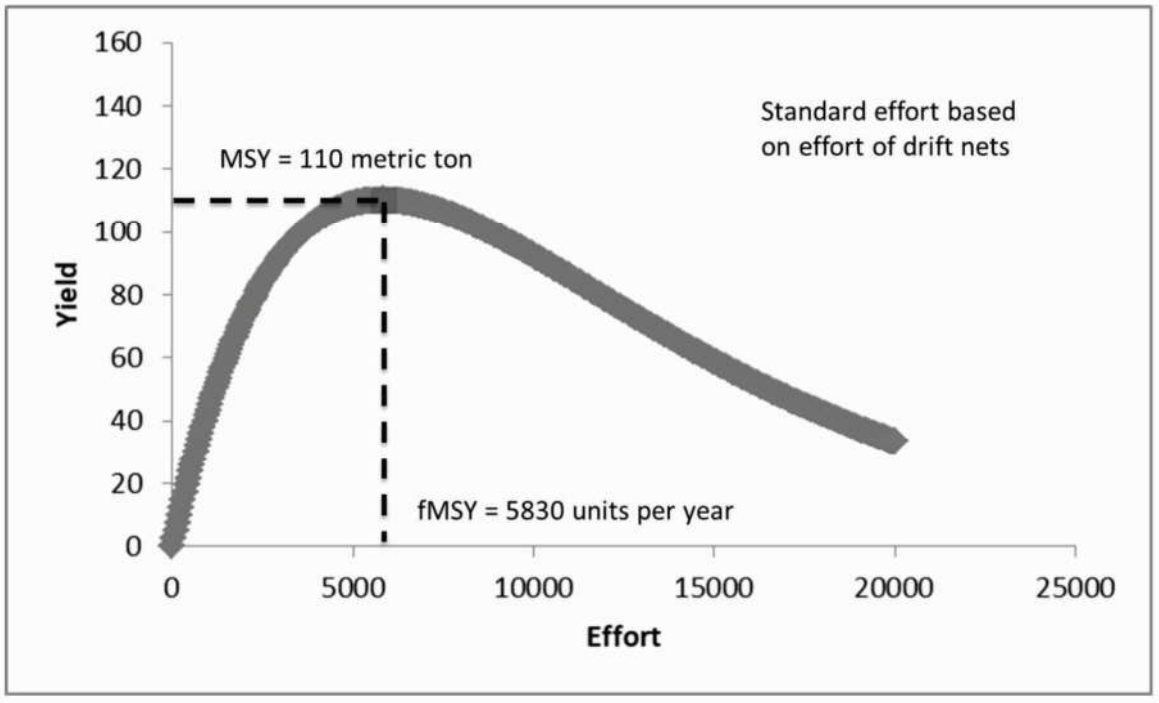

Figure 12: Fox Model of the spiny lobster resource in the East Johor waters. MYS was estimated to be about 110 metric ton with fMSY = 5830 units per year (effort was standardized based on the effort of drift nets)

Acknowledgement

I would like to thank the appointed enumerators and the staff of Department of Fisheries Malaysia who have participated or contributed in this study. A special thanks to the lobster jetties owners in Sedili, Tanjung Leman and Endau for their kind cooperation in participating in this study. The lengths of spiny lobsters were calculated based on an equation from a set of length-weight data from a previous study at East Johor in 2015 (Zulkifli Talib, unpublished). This study was funded through the developmental grants P21-30701011-22501-040 and P21-30701011-23300-069 and the SEAFDEC/UNEP/GEF Fisheries Refugia Project Grant.

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Appendices

Appendix 1: Daily landing data collection and lobster weight measurement undertaken by an appointed enumerator at Tanjung Leman jetty

The Pre-Effect Analysis on the Pre-Establishment of Lobster Refugia towards the Socio-economy of Fishers in South Pahang to East Johor 2018 - 2019

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Abstract: This study aimed to gain insights into artisanal fishers whose directly and indirectly involved in lobster fishery in the waters of South Pahang to East Johor. The concept of 'refugia' may be somewhat foreign to our fishers, compared to 'closed season' or prohibition of fishing in certain areas, or seasons which are easier to grasp and comprehend. This was acknowledged by 60% of respondents (n=165) who did not fully understand the concept of refugia, while almost 30% of the respondents did not have a clue on the meaning of refugia itself. However, the Department of Fisheries' plans to establish lobsters' refugia in the waters of Tanjung Leman, Johor have been well received by nearly 80% of the respondents interviewed over the past two years (2018-2019). The Cronbach's Alpha scores obtained from the Reliability Test conducted on respondents' responses on perceptions (0.819) showed consistent results and interpreted as ''GOOD". In other words, respondents along the coast of South of Pahang to the East of Johor agreed with the establishment of refugia for lobster. Results from this study may have direct implications for the decision-makers of the Department, however, they also may serve as a baseline for future social and economic studies of the mud spiny lobster fishery in the East Coast of Peninsular Malaysia.

Keywords : lobster fishery, refugia, Tanjung Leman, Reliability Test

Abstrak: Kajian ini bertujuan mendapatkan pandangan nelayan tradisional yang terlibat secara langsung dan tidak langsung dalam perikanan udang karang di perairan selatan Pahang sehingga ke Johor Timur. Konsep 'refugia' mungkin agak asing bagi nelayan tempatan, berbanding 'musim tertutup' atau larangan tangkapan ikan di kawasan tertentu, atau musim tertentu di mana ia lebih mudah difahami. Kenyataan ini telah dipersetujui oleh 60% daripada responden (n=165) yang tidak begitu memahami konsep refugia sepenuhnya, manakala hampir 30% daripada responden langsung tidak mengenal istilah refugia itu sendiri. Namun begitu, rancangan Jabatan Perikanan Malaysia untuk menubuhkan refugia perikanan udang karang di perairan Tanjung Leman, Johor telah diterima baik oleh hampir 80% responden yang ditemubual dalam tempoh dua tahun (2018-2019). Skor Alfa Cronbach yang diperolehi daripada Ujian Kebolehpercayaan yang dijalankan ke atas maklumbalas responden terhadap persepsi (0.819) menunjukkan keputusan yang konsisten dan dikira "BAIK". Dengan kata lain, responden di sekitar persisiran pantai di Pahang Selatan hingga ke Johor Timur bersetuju dengan penubuhan refugia udang karang. Keputusan daripada kajian ini boleh membantu dalam membuat dasar pengurusan yang sewajarnya oleh Jabatan Perikanan Malaysia di samping menjadi asas bagi kajian-kajian sosial dan ekonomi perikanan udang karang di Pantai Timur Semenanjung Malaysia pada masa hadapan.

Introduction

Coral shrimp or lobster is one of the most valuable fisheries resources for most countries in the Southeast Asia. Due to the high market value, the lobster resources have been severely harvested and curtailed. In these kind of exploitation, it poses threat to the survival of lobster stock sustainability in the ocean.

In Vietnam, lobster farming began in the mid-1990s with an industry worth USD50 – 60 million a year. However, the farming relied heavily on the supply of wild and juvenile lobster, that had to be reared for 15-18 months to reach marketable size. Indirectly, the consumption of these wild fry interferes with the natural recruitment of lobster in the oceans. In near future, the lobster farming industry will be severely affected by the

extinction of adult lobster. Efficient and sustainable management of lobster resources is an immediate action that must be taken promptly to ensure the survival of the wild lobster population, as well as the wealth generated from these resources.

The spiny lobster is a sedentary species, exhibiting well-defined migratory patterns and within a geographical restricted range (South Pahang – East Johor). Because of its inactive nature, management is bound to be easy to facilitate for this species resources, in comparison with other species.

The concept of fisheries refugia has been defined by United Nations Environment Programme (UNEP) as :-

"*Spatially and geographically marine or coastal areas in which specific management measures are applied to sustain important species (fisheries resources) during critical stages of their life cycle, for their sustainable use*"

and is being developed as a new approach to identify key areas for integrated habitat management and fisheries.

In Malaysia, consultations have been conducted to identify potential areas for fisheries refugia. The consultancy comprises representatives of local government bodies, research institutions, institutions of higher learning (universities), law enforcement agencies, fisheries associations and non-governmental organizations. The two selected refugia locations are Tanjung Leman, Johor (lobster) and Kuala Baram, Sarawak (tiger shrimp).

The lobster resources are heavily concentrated in the East Coast of Peninsular Malaysia (ECPM) due to its sandy, rocky, sandy bottom that is the perfect habitat for two species of lobsters, namely the slipper lobster (*Thenus orientalis*) and the mud spiny lobster (*Panulirus polyphagus*).

The focal mud spiny lobster fishery in the ECPM is based in the South of Pahang until East of Johor. The major fishing grounds of *Panulirus polyphagus* are concentrated at

the waters of Kuala Rompin, Endau and Tioman Island in Pahang State; and Mersing, Tanjung Sedili, Pengerang and Sungai Rengit in Johor.

According to the National Fisheries Statistics, central landings of lobster took place at South Pahang and East Johor in the ECPM, as shown in Table 1. High demand for lobsters has created a lucrative market, but harvesting them from the wild may deplete the lobster population. The mean ex-vessel price for the lobster increased from RM25.90 per kilogram in 2006, to RM46.99 in 2016 (also refer to Table 1).

The objective of this study was to provide a social and economic characterization of the ECPM lobster fishers. In doing so, variables pertaining to the following were assessed in aggregate for all respondents as follows:

i. to evaluate the socio-economic impact on the fishers of the South of Pahang to East of Johor before the establishment of lobster's refugia at Tanjung Leman
ii. to determine the status of lobster fishery in the ECPM from South of Pahang – East of Johor
iii. to determine the exploitation status of lobster fishery in the ECPM such as the number of fishers, gears, vessels, catch rate per trip, etc.
iv. to determine the economics of the lobster fishery in respect of expenditure and revenue; and
v. to verify the acceptance of fishers towards lobster refugia to be proposed at Tanjung Leman, Johor for lobsters.

The scope of the study is to study the profile of lobsters' fishers in order to obtain information on:

i. the respondents' background such as place of origin, marital status, ethnicity, level of education, residence, basic facilities and property ownership,
ii. lobster catch operations such as fishing gears, fishing areas, duration, operational costs, catch and species composition,
iii. the marketing and distribution of lobsters,
iv. respondents' main occupation and additional incomes,
v. income distribution, household income and expenditures; and
vi. other related information.

Table 1 : Lobster landing statistics in the East Coast of Peninsular Malaysia

Year	Pahang	East Johor	Total landing (tonnes)	Mean ex-vessel price (RM/kg)	Value (RM)
2006	27	83	110	25.90	2,849,000.00
2007	23	65	88	n.a.	n.a.
2008	66	51	117	32.82	3,839,940.00
2009	87	37	124	34.39	4,264,360.00
2010	66	51	117	32.90	3,849,300.00
2011	29	40	69	32.90	2,270,100.00
2012	64	35	99	34.85	3,450,150.00
2013	36	80	116	n.a.	n.a.
2014	23	136	159	42.76	6,798,840.00
2015	n.a.	n.a.	n.a.	n.a.	n.a.
2016	n.a.	121	121	46.99	5,685,790.00

n.a. : Data not available
Source : Statistics of Department of Fisheries 2016
USD1 ~ RM4.03 (April, 2021)

In order to assess the interactions in economy and social system, the component in lobster fishery could be identified from the production stage (catches and landings), to distributions and sales, and finally to the consumers.

By implementing this study, the number of lobsters' fishers in the ECPM, starting from the South of Pahang to the East of Johor could be verified. Other than that, the market, cost and returns of lobster fishery shall be determined so as issues and obstacles in the lobster fishery could be addressed. The overall goal was to determine the dependence of the fisher and his/her household on fishing in general and on lobster fishing in particular.

Materials and Method

The primary goal of this study was to obtain the social and economic information about lobster fishery in the ECPM. Therefore, the methods for conducting the study were questionnaires, focus group discussions and key informant interviews.

Questionnaire development and design

A structured questionnaire was developed to collect social and economic information from artisanal lobster fishers mostly comprised of owners and owner-operators. Majority of the questions were close-ended and collected quantitative data. However, open-ended questions provided respondents the chance to comment on contentions issues.

The questionnaire was divided into six sections :

i. the project information,
ii. the respondents' profile,
iii. fishers' household income,
iv. fishing operations in general ; and
v. lobster capture operations.

Questions pertaining to aspect of fishers' level of awareness on the proposed refugia at Tanjung Leman were also asked, including the benefits of refugia, and social and environmental protection offered by refugia.

Research design

Information on the number of lobsters' fishers and their respective vessels were acquired from Pahang and Johor State Department of Fisheries. This included the statistical data of catch and landings of lobsters in the East Coast of Peninsular Malaysia.

The Fisheries District Offices planned and came up with the interview appointments with the fishers/respondents by setting up the date, time and venue (usually at the landing piers, coffee shops and/or community halls). At the designated date and time,

the project leader with a group of enumerators will be at the location, accompanied by the Fisheries District staff to conduct face-to-face interview. The enumerators would then jot down the answers from the respondents in the questionnaires.

The process took about 10 – 15 minutes per questionnaire, based on the information given by the respondents. Small tokens were awarded to the respondents as appreciation for the co-operation given. Data were keyed-in the Microsoft Excel which were then transported to SPSS for analysis.

Formal and informal key informant interviews and focus group discussions provided the opportunity to obtain additional in-depth information on the fishery. They permitted respondents to clarify statements or to further elaborate on brief comments. Samplings of the catch by fishers were also conducted to determine the species compositions of various artisanal gears.

Questionnaire responses were coded and entered into data tables. Data were then analyzed using SPSS for Windows. Secondary data sources consisted mainly of records and reports, ranging from fisheries statistics to registration records to the reports of similar studies and consultations. The information from these sources were included int the results and discussions.

Locations

A total of 11 locations (three fishing bases in Tioman Island) were selected for this study. In Pahang, the study site began at Kuala Rompin, Rompin Lama, Endau and Tioman Island (Appendix 1). Three interview locations in Tioman Island include Kampung Tekek, Kampung Juara and Kampung Mukut. In the state of Johor, the study areas covered Tanjung Leman, Tanjung Sedili, Sedili Besar, Sedili Kecil and Sungai Musoh.

Results

This section presents the results from the fishers ; the respondents' questionnaire examines the basic of the lobster fishery such as information on the boats, local knowledge of lobster, gear used and fishing effort. Income, operating costs, boat maintenance and marketing were also examined. The respondents' attitudes and perceptions with respect to the resource, its management and the lobster refugia proposal were examined as well.

Lobster fishery overview

The real scenario of fishers in Malaysia are divided into two categories ; commercial fishers or artisanal fishers. The fishers in question are further divided into fishing gears used by them such as trawl, purse-seine, drift nets, etc. Accordingly, artisanal fishers will catch variety of fish, squids, prawns and other marine species. Therefore, fishers are not referred to as lobster fishers (for instance). Because the waters of South Pahang up to East Johor are rich in lobster resources, they will indirectly target lobsters as their primary catch. However, the capture of other marine species is as important as lobsters and will not be simply discarded.

Fishing gears

The average boat length used by artisanal respondents is 20.84 ft and empowered with of 40.94 engine. The fishing gears used by the respondents comprises of drift net (p*ukat hanyut*), trap or pots (*bubu*), hooks and line (p*ancing*), longlines (*rawai*) ; and other drift nets such as *pukat tangs*i, *jaring tahan*, *pukat cerut* and *tagan*.

Catch and effort

The average overall catch of the artisanal respondents (including lobster) was 20.248 kg per trip with an operational cost of RM80.76 per trip (Table 2). The composition of lobster comprises 29.79% of the total catch (kg) per trip. The respondents engaged in the fishing activities approximately 19.5 days monthly.

Table 2 : The information on the fishing activities in South of Pahang – East Johor

Site	Catch weight (kg trip^{-1})	% of lobster from overall catch	Operational cost (RM trip^{-1})	Operational days per month
Kuala Rompin	29.222	4.68	144.88	16.7
Rompin Lama	18.000		85.55	20.0
Endau	47.500	30.00	89.00	12.0
Kampung Tekek	11.571		85.36	17.0
Kampung Mukut	17.917	10.00	88.88	15.0
Kampung Juara	15.250	7.50	101.69	16.5
Tanjung Leman	20.361	43.33	65.24	23.6
Tanjung Sedili	59.607	24.33	68.67	19.8
Sedili Besar	20.361	17.00	75.84	17.4
Sedili Kecil	9.056	23.00	62.64	22.9
Sungai Musoh	5.130	58.65	75.72	24.4
Overall weighted average	***20.248***	***29.79***	***80.76***	***19.5***

USD1 ~ RM4.03 (April, 2021)

Distance and depth of fishing areas

From interviews, respondents reported that they operated approximately 3.17 nautical miles from shoreline, which was 2.00 nautical miles for Tioman Island respondents and 3.24 nautical miles for mainland respondents. Lobstermen and hooks and line fishers of Tioman Island operated in the sea not more than two nautical miles. On the hand, the mainland respondents were fishing within the range between 2.00 to 5.00 nautical miles as shown in Figure 1.

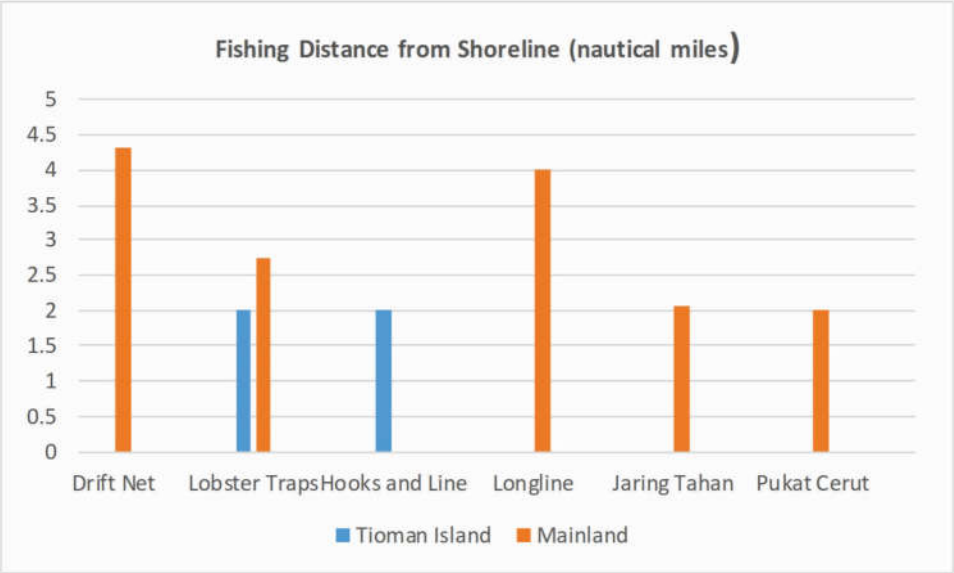

Figure 1: Distance of fishing by respondents along the South of Pahang – East Johor

The average depth of the fishing areas by Tioman Island respondents and the mainland respondents was averagely 27.98 meters. Once again, respondents at Tioman Island operated at a depth of 20.000 meters, while mainland respondents operated within a depth of 12.000 to 45.000 meters as indicated in Figure 2.

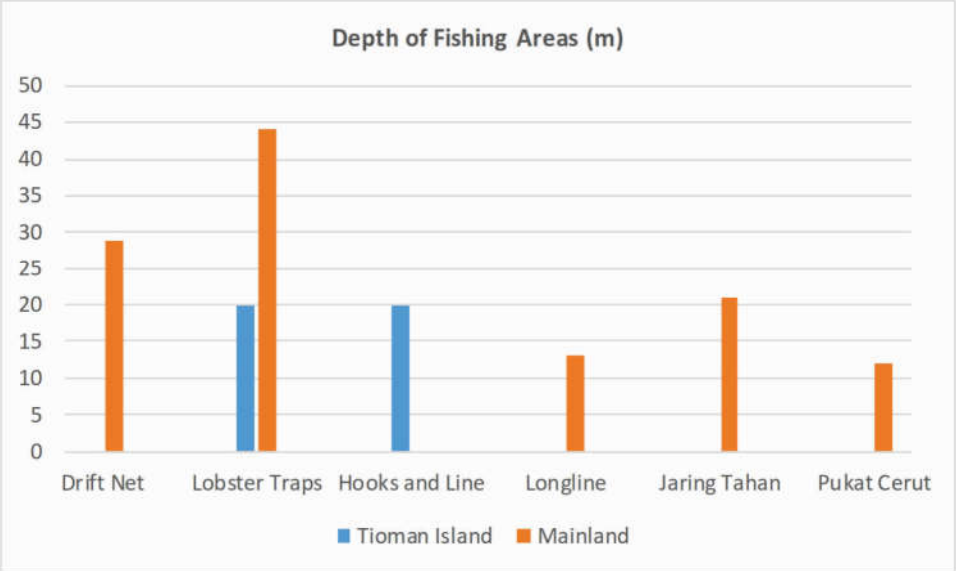

Figure 2: Depth of fishing by respondents along the South of Pahang – East Johor

Demographic characteristics of respondents and households

Respondents were mostly dominated by males, who represented 98.8% of the survey population. The interviewed female respondents assisted their spouses in fishing operations only. The percentages of age groups under 20 were 0.6%, 20 to 39 years (23.2%), 40 to 59 years (50.0%) and over 60 years old (26.2%).

In order of prominence, the highest level of education attained by respondents were university degree (0.6%), diploma holder (23.2%), Secondary 5 (15.9%), Secondary 3 (38.4%), Primary 6 (16.5%), no formal education (5.5%). Generally, it indicated that the literacy rates among the respondents were high ; and fishers are able to read and write reasonably well.

A total of 81.2% of respondents were native to Pahang and Johor. The rest came from other states who emigrated because of job opportunities and / or married the local women.

Majority of respondents were married with a coverage of 87.9%, followed by single respondents (9.7%) and single parent (2.4%). 91.0% of respondents were head of the family while the rest of the family were headed by father (8.4%) and elder brother (0.6%).

The type of built-up of the respondents' residences is also an indicator of the household economic status. The percentage distribution of brick residential homes was 64.6%, wooden house (9.8%) and partially brick house (25.6%). 69.1% of respondents were the possessor of their residences. All respondents' homes were supplied with tap water and electricity.

The use of the latrine system is one of the indicators of hygiene, especially in the rural areas. The absence of proper toilets means that the practice of disposal of sewage into the river or sea can cause water pollution and impede the health status in the fishing villages.

The well-being of respondents' household could be measured by observing the home appliances and vehicles. Vehicle ownership indicated that motorcycle was the most owned vehicle at 84.2% followed by car (61.8%). In terms of home appliances, 95.8% of respondents owned a refrigerator, followed by washing machine (92.7%) and television (90.2%). The percentage of respondents owing mobile telephone was 92.1%, making it the main communication tool used for work and personal matters.

Respondents' household in the South of Pahang to the East Johor spent an average of RM1,174.30 month^{-1}. The highest expenditure of a respondent's household was foodstuff (RM642.78 month^{-1}), followed by vehicle installments (RM582.81 month^{-1}), home installment payment (RM322.63 month^{-1}), Other expenses (RM287.50 month^{-1}), school children's education expenses (RM280.45 month^{-1}), house rental payment (RM2733.82 month^{-1}) and utility bills (RM222.07 month^{-1}). Cigarettes was the lowest expenditure for a respondent's household in the study areas at RM163.36 month^{-1}.

Economic profile of fishers in the South of Pahang – East Johor

Nearly all respondents (81.8%) along the waters of South Pahang to East Johor regarded fishing as the major source of income. In addition, household expenditures were also supported by the income of their working wives and children as well. The Monthly Fisheries Subsistence Allowances of RM300.00 provides additional household income to respondents. 60.0% of all respondents regarded lobster fishing as their most important type of fishing. However, respondents using drift nets (62.6%) and lobster traps (31.1%) were significantly more inclined to rate lobster fishing as their most important fishing type than any other gears. The lobster catching season runs actively from March to November. According to respondents, the lobster distribution along the waters of Pahang to Johor was influence by Southeast Wind (*Angin Tenggara*).

Capital investment

Most of the respondents have made a significant investment in the fishery and are highly dependent on it for personal income. The majority respondents of artisanal fishers interviewed were owner-operators and only a small number were crews. The mean estimated current market value of boat, engine and fishing gears was RM14,270.93 as shown in Table 3.

Table 3: Start-up capital for the acquisition of boat, engine and fishing gears

Major Fishing Gear	Boat (RM)	Engine	Major Gear	Secondary Gear	Mean Capital
Drift net Type 1 *(Pukat Tangsi)*	5,333.33	6,666.67	1,100.00	1,500.00	13,233.33
Drift net	6,385.51	8,488.00	2,202.34	1,862.19	15,899.84
Lobster traps	6,284.21	7,989.47	2,511.11	1,418.75	15,637.76
Hooks and line	4,047.83	6,078.26	519.58	750.00	9,278.78
Crab traps	6,500.00				6,500.00
Longlines	6,500.00	5,850.00	5,000.00		14,850.00
Barrier net *(Jaring tahan)*	6,243.53	7,535.29	1,735.00	853.00	13,764.84
Overall Average	***5,953.73***	***7,802.69***	***1,858.86***	***1,645.79***	***14,270.93***

USD1 ~ RM4.0345 (April, 2021)

Operational cost

From Table 2, the mean total operating cost of fishers in their respecting fishing based was RM80.76 trip^{-1}. In addition, other costs such as lubricant oil, ice, bait and food supplies were also part of the expenses. In this regard, the fishing gear which recorded the highest operating expenses was hooks and line at RM96.44 trip^{-1}. It was followed by longline (RM80.50 trip^{-1}), lobster trap (RM79.88 trip^{-1}), crab traps (RM79.00 trip^{-1}), drift net (RM70.93 trip^{-1}), barrier net (RM67.06 trip^{-1}), *pukat cerut* (RM60.00 trip^{-1}) and *pukat tangsi* (RM52.50 trip^{-1}). Operating expenses incurred by *tagan* operator was the lowest at RM38.00 trip^{-1} (Table 4).

Table 4 : The operational costs borne by respondents according to fishing gears

Major fishing gear	Petrol	Lubricant oil	Ice	Bait	Food	Others	Mean total
Drift net type 1 *(Pukat tangsi)*	47.50		10.00				52.50
Drift net	57.23	11.33	5.88		19.25	15.00	70.93
Lobster traps	56.76	7.38	4.08	11.53	21.50	22.00	79.88
Hooks & line	50.88	9.49	12.20	22.93	13.33	27.50	96.44
Crab traps	44.00	20.00	10.00	5.00			79.00
Longline	60.00	12.00	4.00	12.50			80.50

Tagan	35.00		3.00				38.00
Barrier net *(Jaring tahan)*	58.70	7.85	5.91		50.00		67.06
Drift net type 2 *(Pukat Cerut)*	50.00		10.00				60.00
Overall average	***55.65***	***10.24***	***6.47***	***17.11***	***18.73***	***23.00***	***75.78***

USD1 ~ RM4.0345 (April, 2021)

A total of 93.2% respondents also reported that operating costs incurred in catching fish also inclusive of lobster fishing. Only a small percentage of respondents carried out normal fishing and lobster fishing separately with their own operating costs.

Maintenance costs

Respondents carried out maintenance and repair on their respective boats at least once a year. However, for engines and fishing gears will be maintained, repaired or ultimately replaced depending on the needs and the extend of the damage. It is vital to ensure the smooth fishing operations in the ocean. Hence, respondents allocated an average of RM2,203.86 annually. Barrier net (*jaring tahan*) operators recorded the highest maintenance cost at RM3,352.63 year^{-1}, followed by longlines (RM2,500.00 year^{-1}). *pukat tangsi* (RM2,100.00 year^{-1}), drift net (RM2,022.12 year^{-1}), hooks & line (RM2,020.77 year^{-1}), lobster traps (RM1,986.75 year^{-1}), and crab traps and *tagan* (both at RM1,500 year^{-1}). *Pukat cerut* was reported as the lowest maintenance fishing gear at only RM1,000.00 year^{-1}.

Revenue

A large proportion of the respondents had no other income, and therefore depended on fishing as their sole livelihood. Most respondents especially at Sedili Besar, Sedili Kecil and Sungai Musoh targeted both fish and lobsters.

The average weighted monthly income of respondents from fishing activities alone was RM2,160.46; in which respondents using Lobster Traps recorded the highest revenue of RM3,061.30 per month. However, the total income earned by respondents was RM2,714.25 per month (Table 5).

From fishing alone, 81.4% of the operations had estimated gross earnings below RM2,500.00 per month, 11.2% had gross earnings between RM2,501.00 – RM5,000.00 per month, 6.2% had gross earnings between RM5,001.00 – RM7,500.00 per month; and another 1.2% had gross earnings between RM7,501.00 – RM10,000.00 per month.

The comparison of lobster catches from 2016 to 2019 indicated that 82.4% of respondents interviewed reported significant declines. Among the contributing factors were (i) pollution due to reclamation works, (ii) oil spill contaminations, (iii) water current and weather changes, (iv) constructions, (v) the sea was getting shallower; and (vi) the over-whelming number of fishers. On the other hand, 9.1% of respondents informed that the catches of lobster were increasing due to factors such as (i) fishers were more experienced, (ii) improved seasons and weather conditions, (iii) more efficient fishing equipment, (iv) bigger engine horsepower; and (v) operating areas were nearer to the area of artificial reef.

Table 5: Average income earned by respondents of South Pahang – East Johor

Major fishing gear	Mean Income form fishing	Mean side income	Subsistence allowance	Soacial welfare allowance	Other sources of income	Mean total of income
Drift net type 1 *(Pukat Tangsi)*	1,000.00		300.00			1,633.33
Drift net	1,966.81	1,416.92	300.00	300.00	1,150.00	2,520.81
Lobster traps	3,061.30	1,333.33	283.33		1,500.00	3,448.26
Hooks & line	1,725.00	1,314.00	250.00		1,287.50	2,449.64
Crab traps	1,300.00		300.00			1,600.00
Longline	2,000.00		300.00			2,150.00
Tagan	1,500.00	1,300.00				2,800.00
Barrier net *(Jaring Tahan)*	2,910.00	1,500.00				3,285.00
Drift net type 2 *(Pukat Cerut)*	1,200.00	1,500.00	300.00			2,700.00
Overall average	***2,160.46***	***1,378.67***	***293.88***	***300.00***	***1,278.57***	***2,714.25***

USD1 ~ RM4.0345 (April, 2021)

Marketing arrangements

Fish catch (including lobsters) were sold to fish wholesalers (87.7%) as compared to direct selling to consumers (7.9%). However, only 4.4% of respondents indicated that catch was supplied directly to seafood restaurants around the coast. For non-local markets such as Penang, Kuala Lumpur or Singapore, live lobsters will be put into holding tanks or cement ponds. The lobsters will then be transported and distributed live to markets and/or consumers. There is a difference in price and size for lobster market in both states. In Pahang, lobster reaches a market price of RM80.00 per kg (USD19.29) with marketable size of 400g per piece. In Johor however, the ex-vessel price of lobster can reach up to RM140.00 per kg (USD33.75) with desirable size of 200g per piece.

Opinions and perceptions on fisheries management

In order to obtain respondents' perspective on the proposed lobster refugia at Tanjung Leman, several related questions were also asked. The series of questions were categorized into three sections, i.e. (i) the level of awareness, (ii) the benefits of refugia, and (iii) social and environmental protection.

Level of awareness

Respondents were asked whether they knew and understood the concept of 'refugia' as opposed to similar concept such as 'marine protection areas (MPA)' or 'non-fishing zone', etc. A total of 60.0% of the respondents did not fully understand the concept of refugia and 29.7% respondents had totally had no idea on the meaning and the concept of refugia was all about (Figure 3).

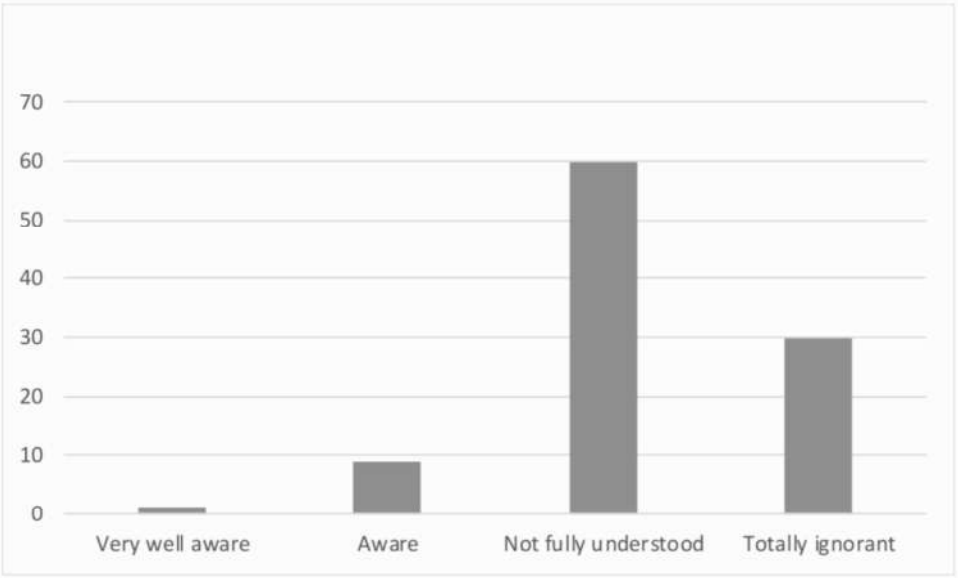

Figure 3: Understanding the meaning and concept of 'refugia' (unit :%)

Under the *"Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and Gulf of Thailand",* the Department of Fisheries Malaysia intends to establish a refugia for lobster in the East Coast of Peninsular Malaysia. Hence, Tanjung Leman of Johor is identified as the site of choice for refugia. Therefore, 54.3% respondents noted that they were not well aware of the plan (Figure 4).

From the interviews, at least 80.0% of the respondents (Figure 5) agreed with the proposed location. However, there was suggestion of establishing the refugia for lobster at the waters of Sedili, as lobsters' landings are the among the highest in the coast of South of Pahang to the East of Johor.

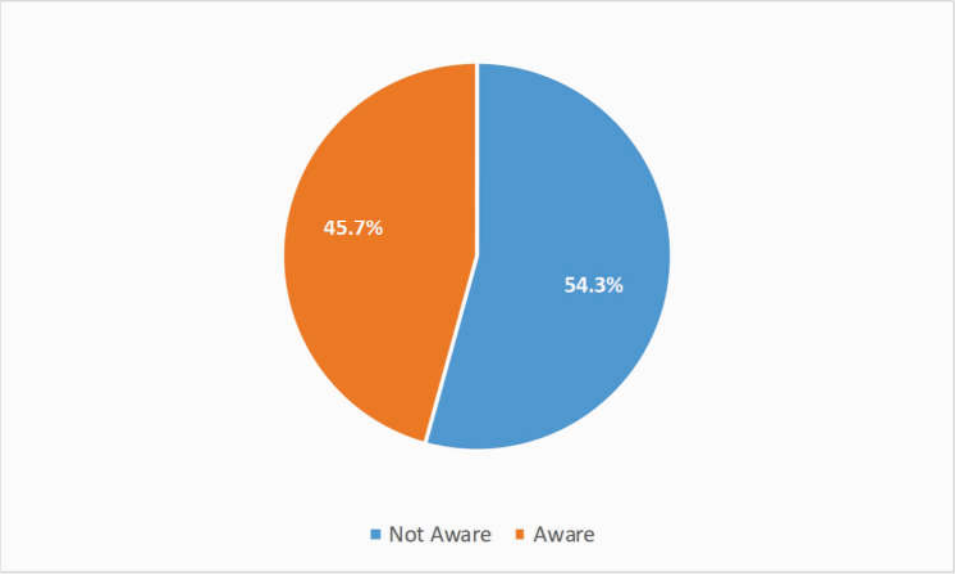

Figure 4: Proposed establishment of lobster refugia at Tanjung Leman, Johor

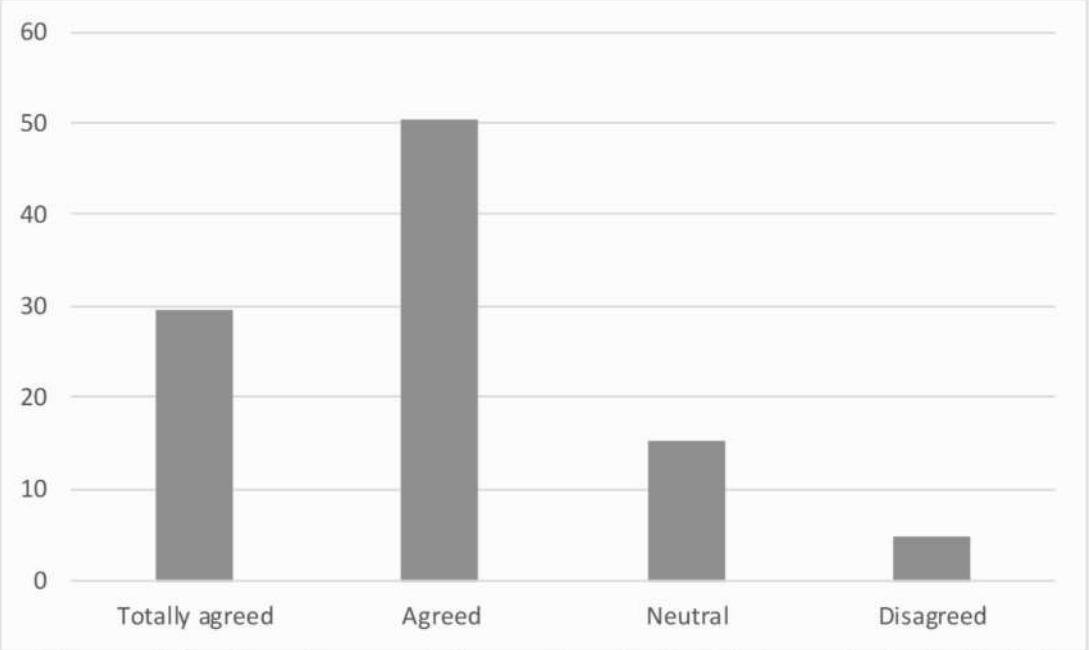

Figure 5: Tanjung Leman, Johor as the site for lobster refugia (unit : %)

A total of 72.1% respondents agreed with the proposal to enforce a ban on lobster capture during their breeding season. Respectively, 13.9% respondents disagreed as well as 13.9% respondents remained neutral on this matter (Figure 6).

To ensure the success of this program, fishers' co-operation is very important. In this regard, the Department of Fisheries Malaysia would like to propose that fishers in the vicinity of Tanjung Leman to be held accountable for maintaining the refugia, once after they are formally established. The fisheries authority has limited capacity to

manage the lobsters' refugia. Therefore, 74.5% respondents agreed to jointly-maintained the refugia as opposed by 12.1% of the respondents (Figure 7).

With regards to the prohibition of fishing in the areas that would be gazette as lobster refugia, nearly 75% of respondents believed that it should be enforced. However, respondents opposed to the proposal and remained neutral were 12.7% respectively (Figure 8).

The respondents had expressed the view that the fisheries authority / government should have presented these issues to the stakeholders and consulted with them before any fishery-related programs could be implemented. The opinion was keenly expressed by 87.3% of respondents from the interview (Figure 9).

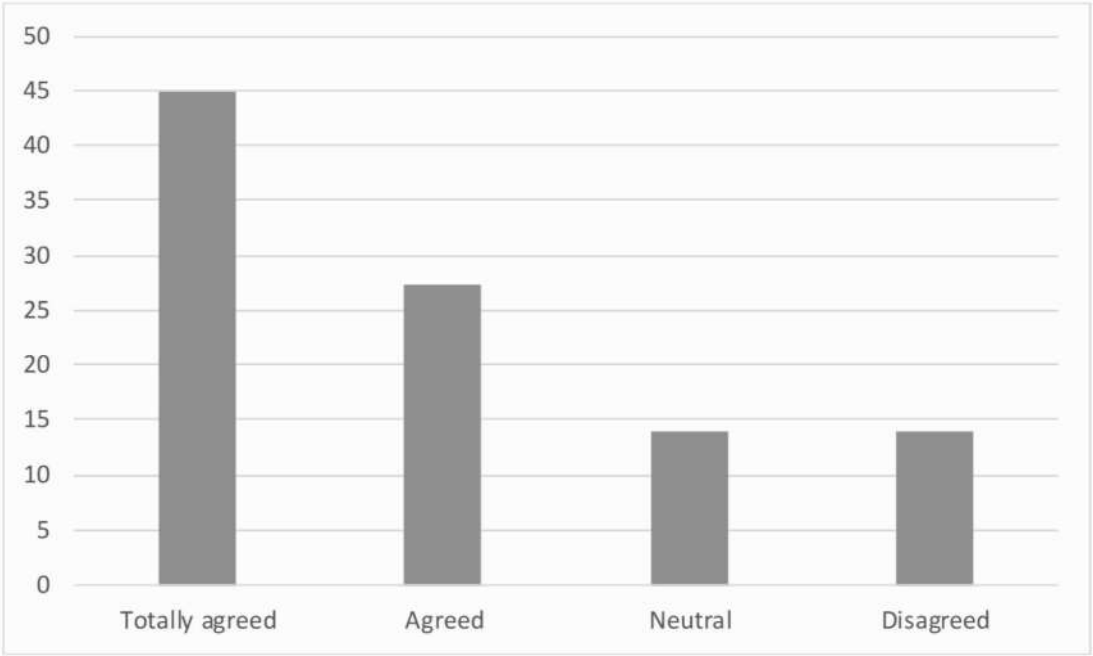

Figure 6: Prohibition of lobster fishery during the breeding season (unit : %)

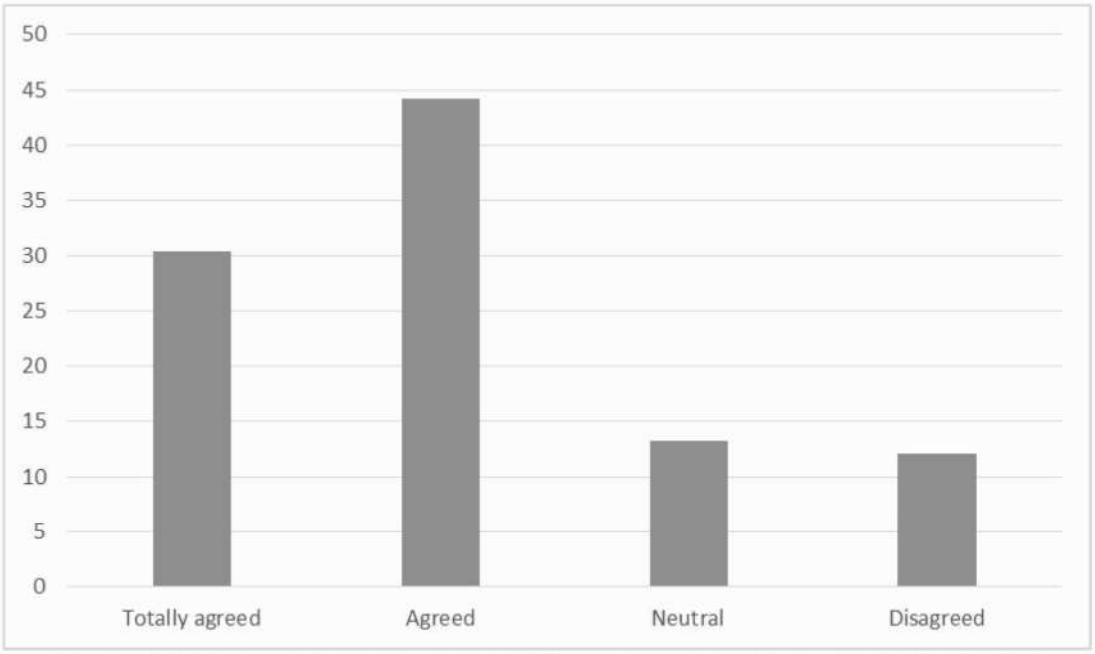

Figure 7: Respondents' responsibility to maintain the refugia (unit : %)

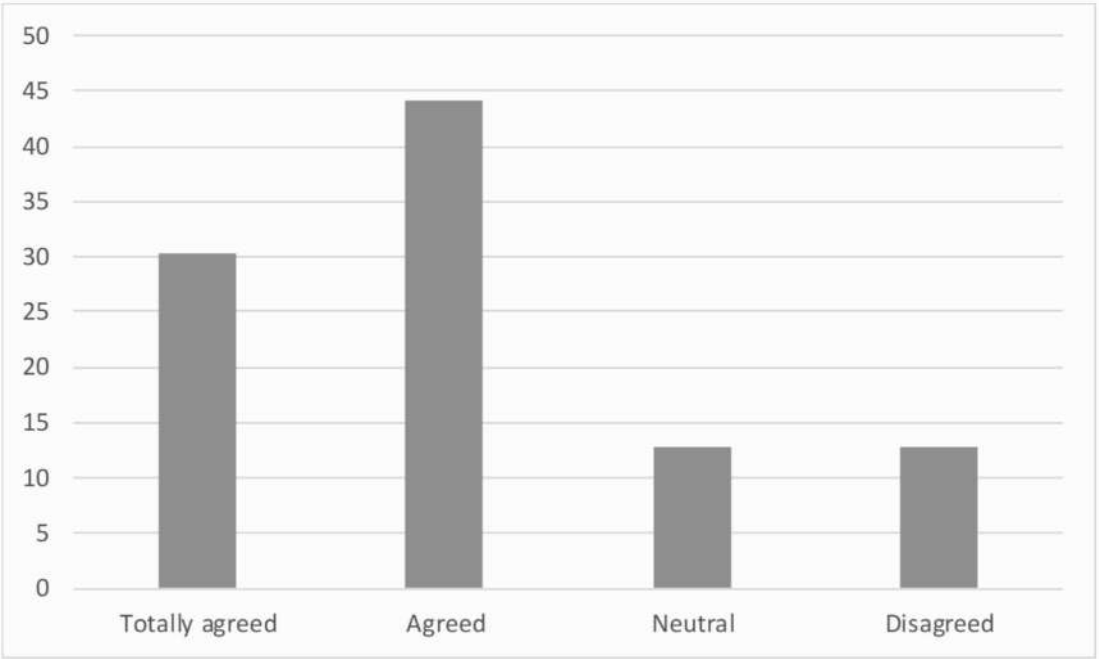

Figure 8: The site of the refugia should be 'no-fishing zone' (unit : %)

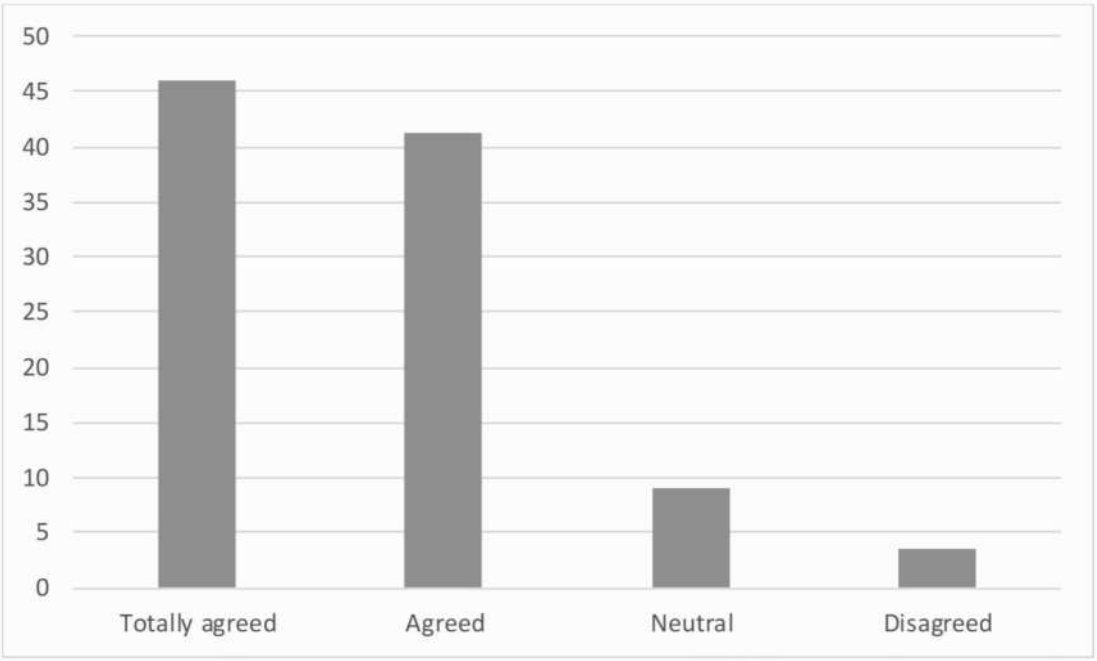

Figure 9: Need for discussion / consultation between DoFM and fishers regarding the establishment of lobster refugia

The benefits of refugia

As many as 81.2% of respondents agreed that the establishment of refugia can help increase fisher's income. Only a small percentage of respondents (3.6%) disagreed with the statement as indicated in Figure 10.

Although almost half of the respondents did not fully understand the meaning and concept of refugia, 75.2% of respondents agreed that artisanal fishers along the coast of the South of Pahang to the East of Johor would benefit from the establishment of refugia. However, 23.0% of the respondents remained mum on this matter while less than 2.0% of the respondents were being skeptical of the statement (Figure 11).

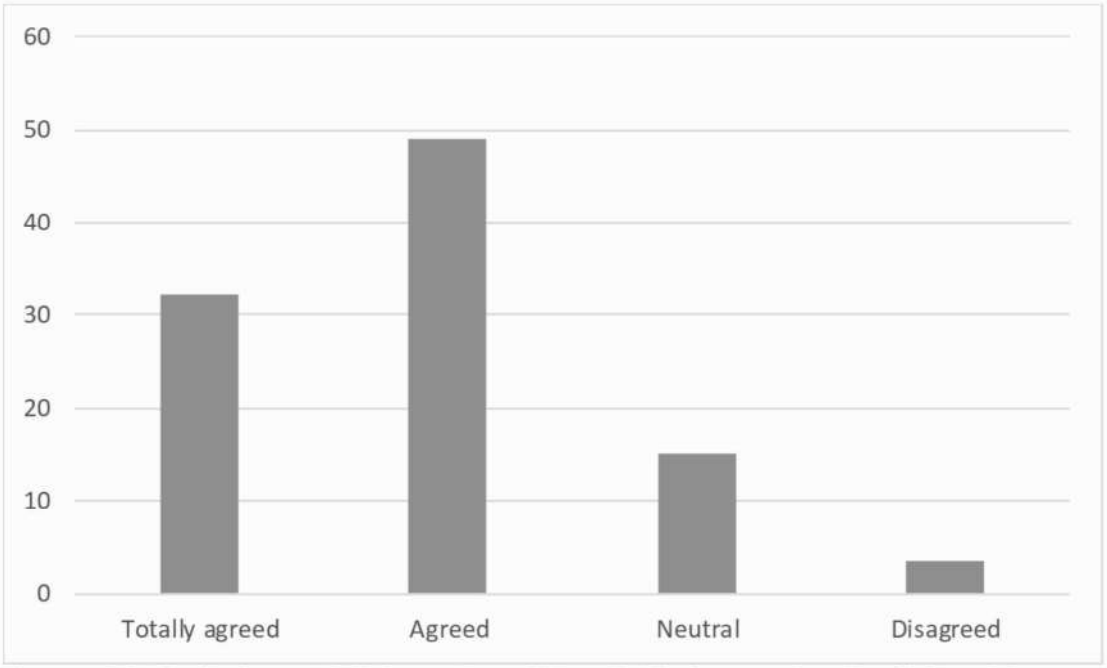

Figure 10: Refugia establishment could assist in increasing the fishers' income (unit : %)

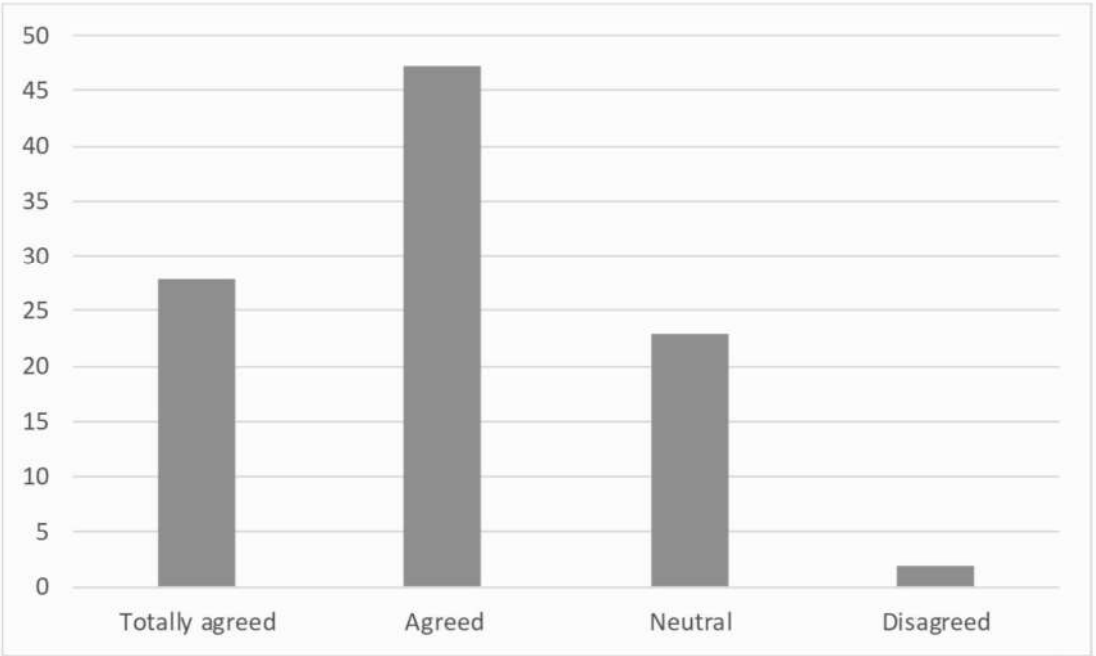

Figure 11: Artisanal fishers will benefit from the establishment of refugia (unit : %)

A total of 73.95% of the respondents interviewed agreed that the establishment of the refugia will bestow useful knowledge to artisanal fishers operating in the surrounding areas (Figure 12).

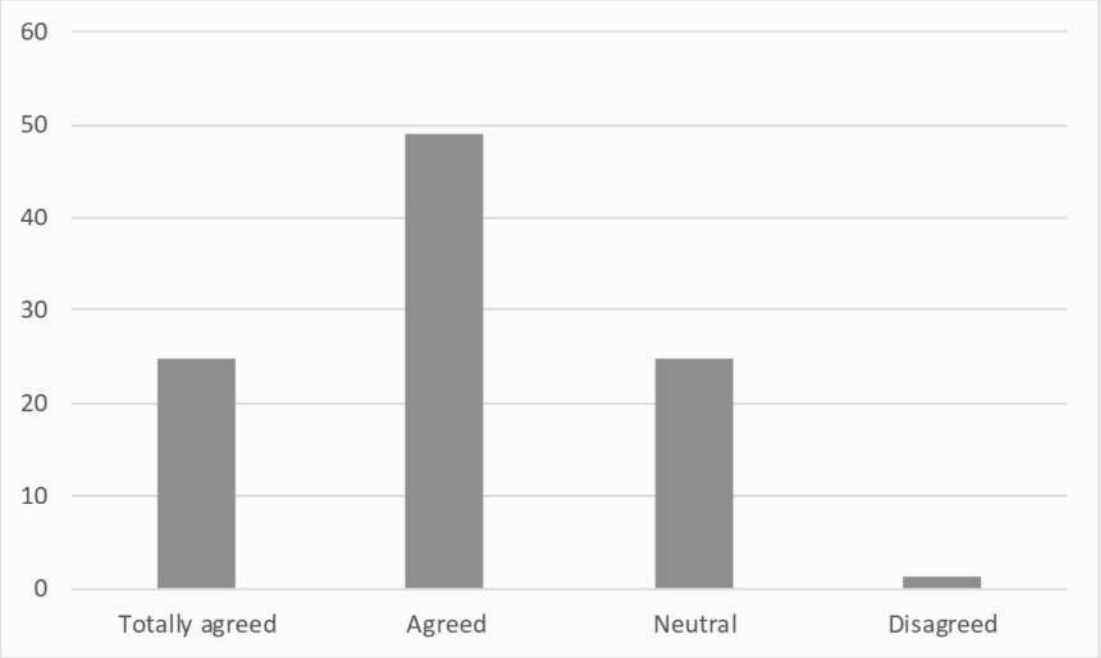

Figure 12: Refugia provide useful knowledge to artisanal fishers (unit : %)

A total of 72.1% of the respondents were optimistic that the number of lobsters would eventually increase after the establishment of the refugia. However, this view was not enthusiastically shared by 6.1% of the respondents while 21.8% of the respondents remained neutral on this statement (Figure 13).

Nearly 70% of the respondents believed that the quality of lobsters will be improved (bigger size) due to the establishment of refugia in the waters of South Pahang to East of Johor as indicated in Figure 14.

A total of 67.9% of the respondents welcomed the establishment of more refugia along the coast of Pahang to East Johor in the future as it would boost the lobster resources and thus, increasing the income of artisanal fishers. However, 10.3% respondents expressed their disagreement on the statement while 21.8% of respondents remained neutral (Figure 15).

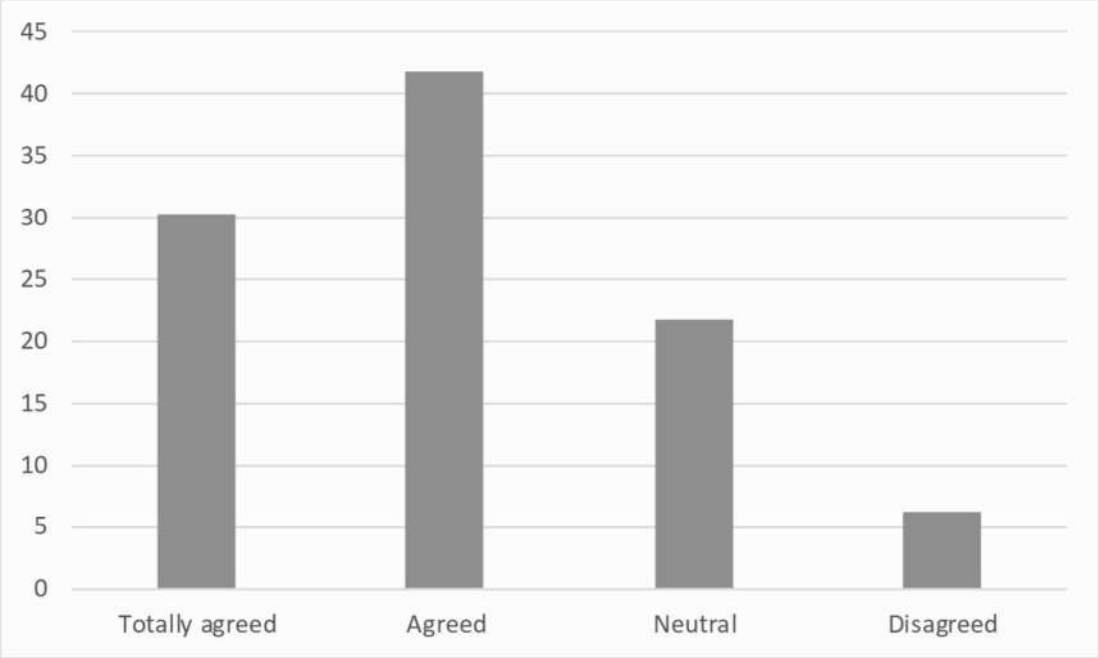

Figure 13: Refugia will increase the number of lobsters (unit : %)

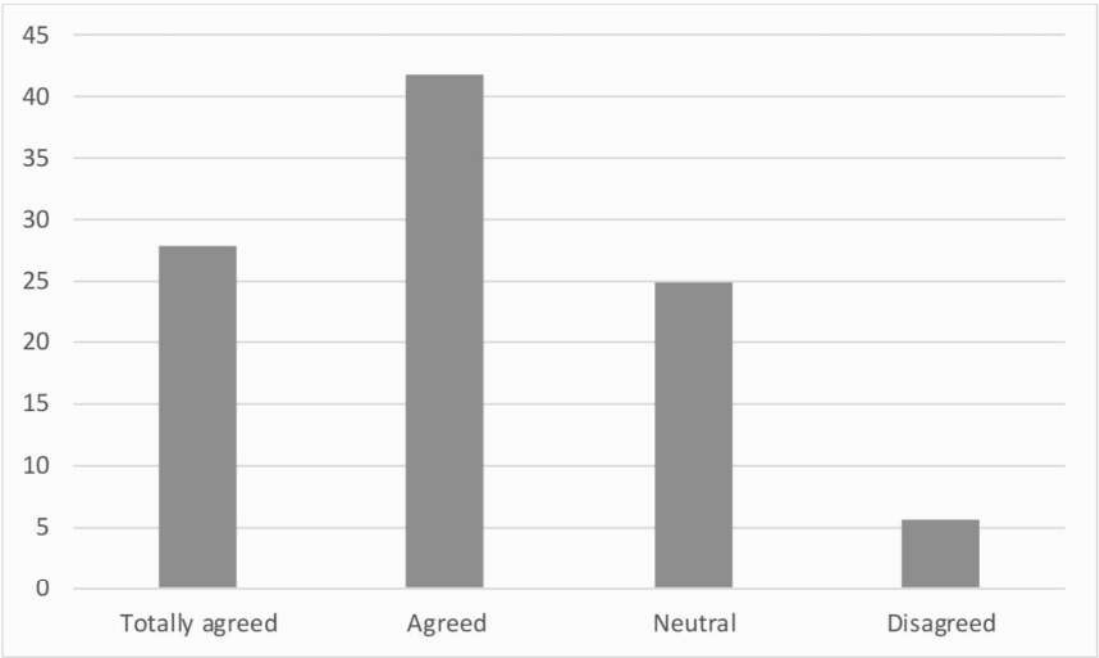

Figure 14: The quality of lobsters will be improved (unit : %)

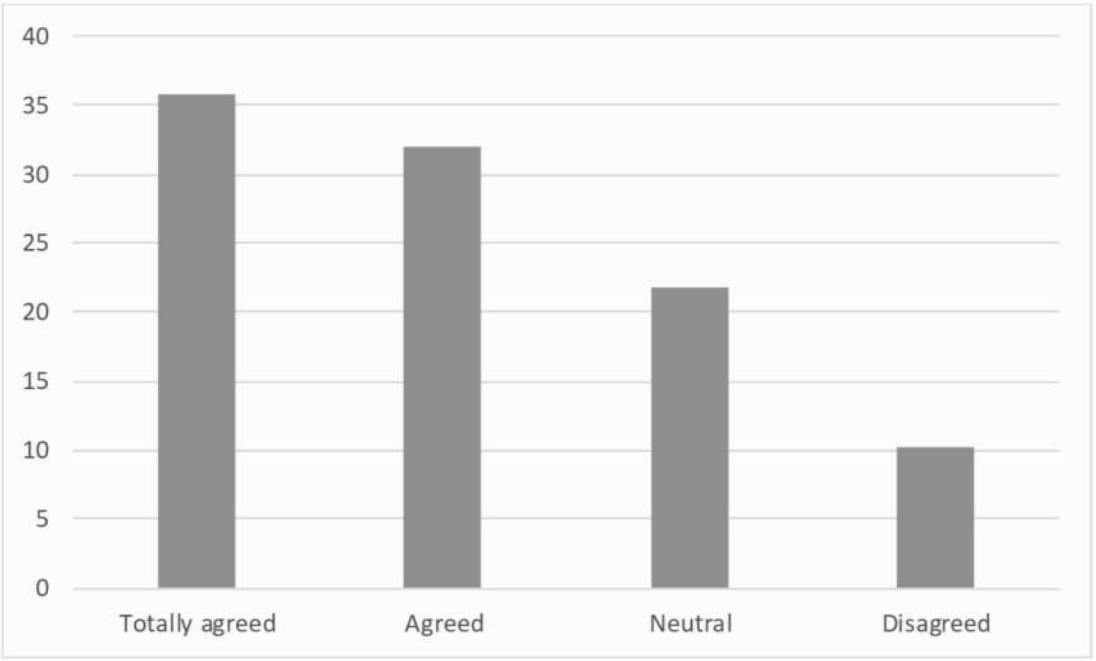

Figure 15: More refugia need to be built/established (unit : %)

Social and environmental protection

The establishment of lobster's refugia will affect human rights such as dignity, culture and uniqueness of the fishing community were strongly opposed by more than half (55.2%) of the respondents interviewed. While 30.3% of the respondents remained neutral while 15.5% respondents agreed with the statement (Figure 16).

The establishment of lobster's refugia causes social conflict over fishers' access to fishery resources were shared equally by both the dissenting (42.4%) and the neutral respondents (40.0%) as shown in Figure 17.

A total of 44.8% of respondents felt that the establishment of lobster's refugia will change the utilization of land, sea and fishery resources. However, this statement was supported by 12.7% respondents while 42.4% respondents remained silent (Figure 18).

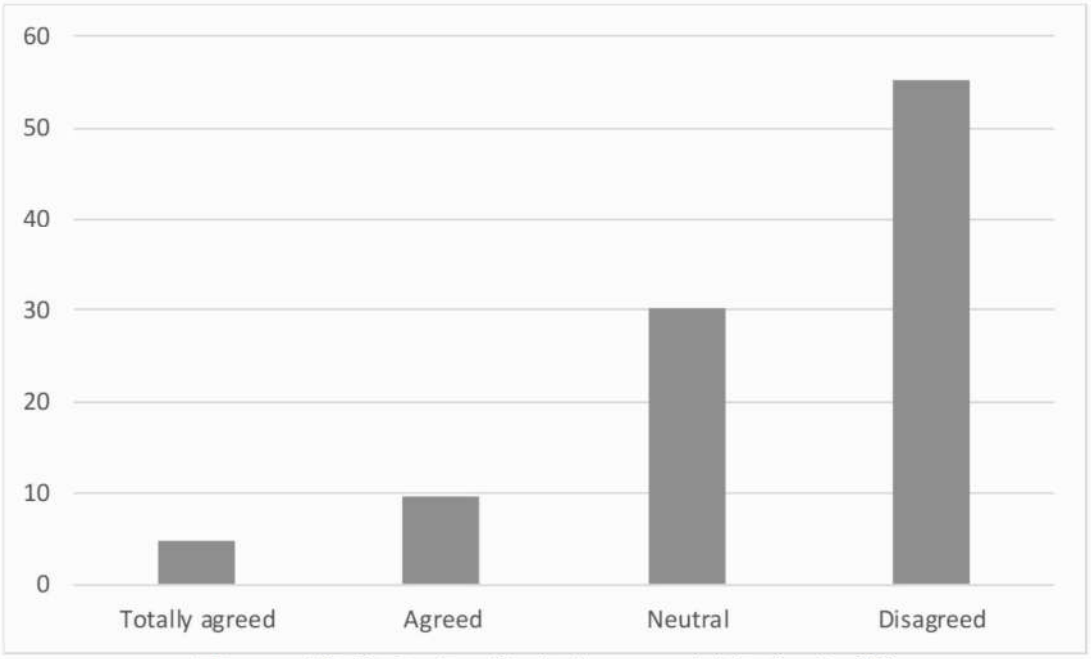

Figure 16: Refugia affects human rights (unit : %)

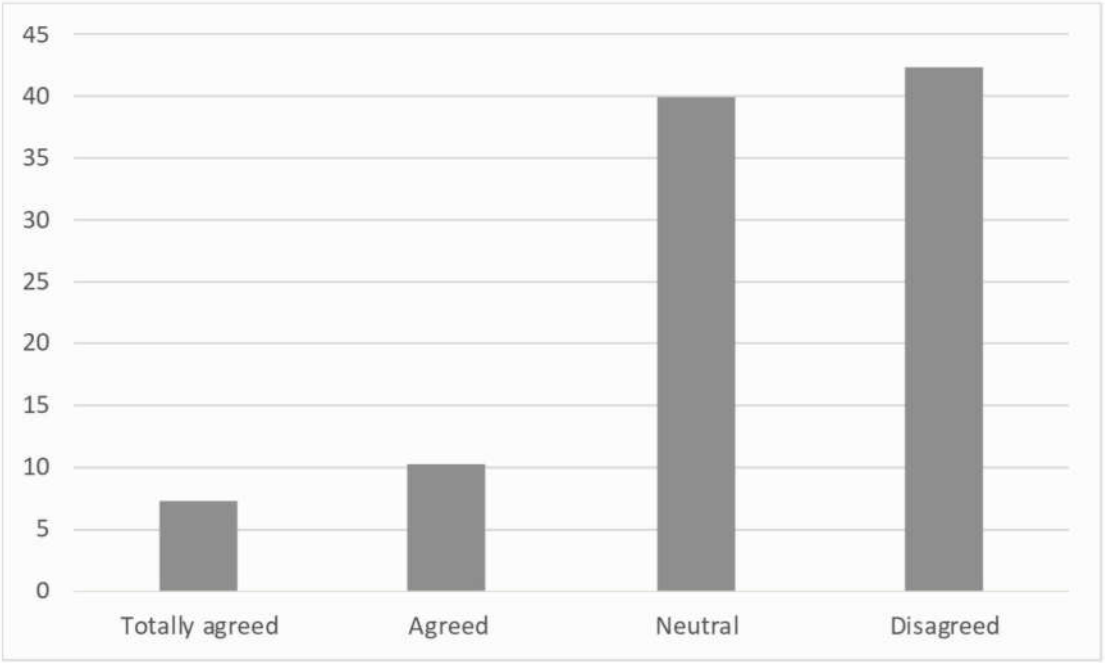

Figure 17: Refugia causes social conflict on fishers' access to fishery resources (unit : %)

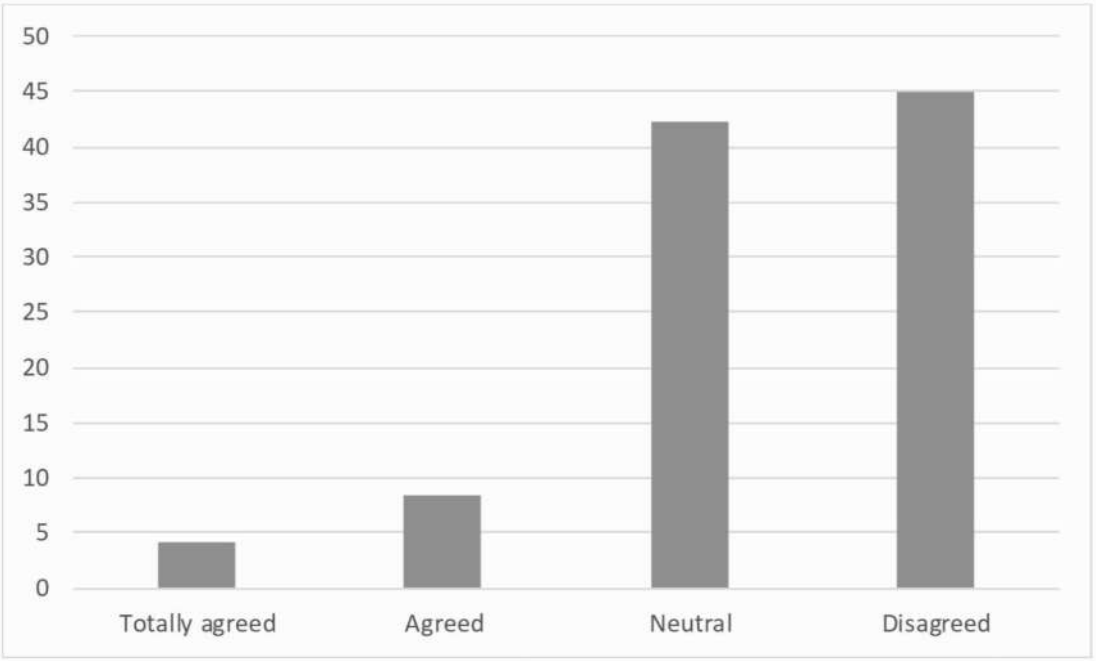

Figure 18: Refugia changes the use of land, sea and fishery resources (unit : %)

More than 50% of the respondents disagreed on the establishment of refugia will cause displacement of local communities to other areas. 40% of the respondents remained neutral, while the rest of the respondent agreed with the statement (Figure 19).

A total of 71.0% of the respondents did not consider that the establishment of refugia will cause the dwindling number of fishers, or fishers will lose their jobs, thus affecting their livelihood. On the contrary, less than 10% of respondents believed that refugia will reduce the number of fishers (Figure 20).

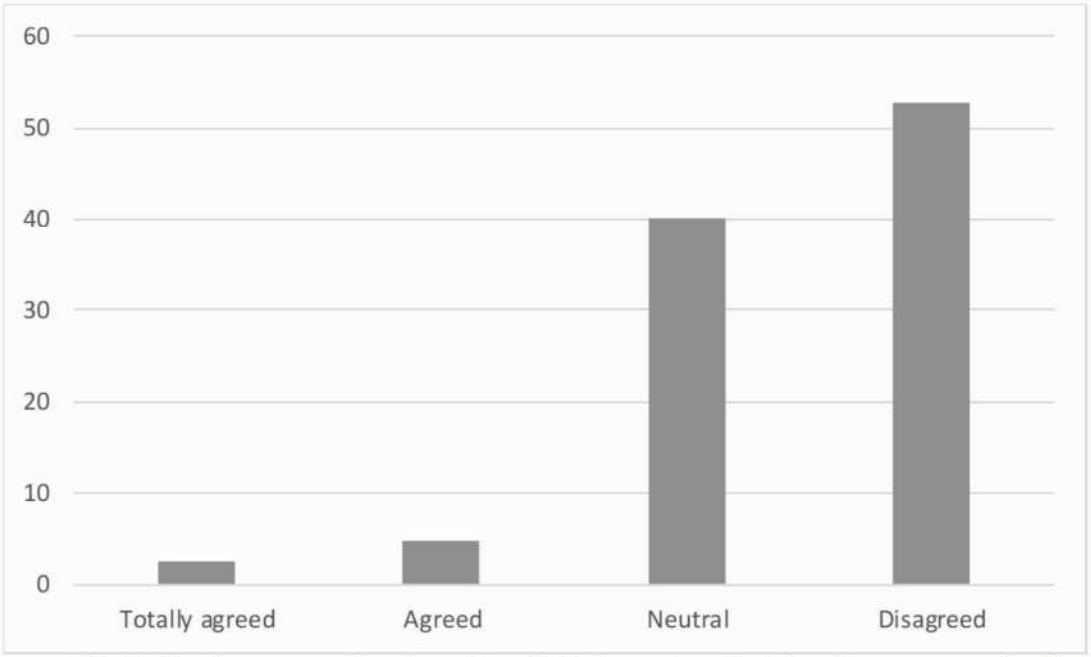

Figure 19: Refugia causes local residents to be relocated to other areas (unit : %)

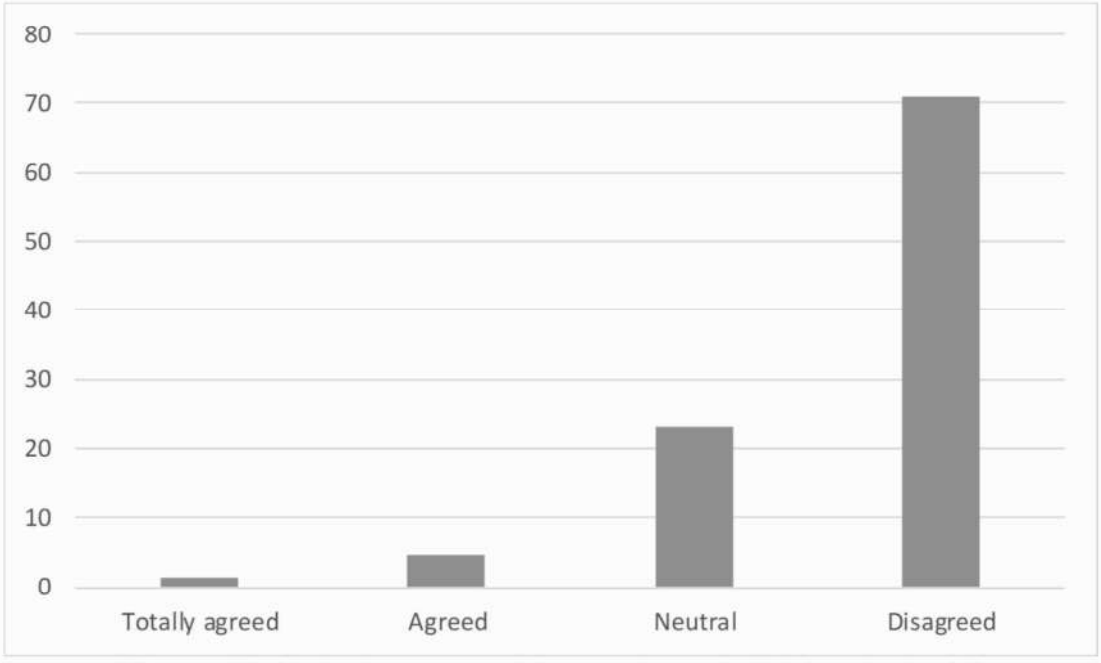

Figure 20: Refugia causes fishers to lose their jobs (unit : %)

The establishment of lobster's refugia proposed by the Department of Fisheries was not considered by respondents (71.6%) to cause a decline in eco-tourism and recreational fisheries. Only 6.4% of respondents insisted that it would upset the eco-tourism as well as recreational fishing (Figure 21).

Only 4.8% of the respondents believed that the refugia will lead to a deterioration on the livelihood of the fishers as well as the local communities. This statement was strongly rejected by 70.4% of respondents while the rest of the respondents had no comment / opinion on this matter (Figure 22).

A total of 71.0% of respondents disagreed that the establishment of the refugia will have a disproportionate impact on women, the disabled and the poor as indicated in Figure 23.

A total of 74.0% of the respondents were reluctant to agree with the statement that refugia would affect the cultural heritage of the local communities along the south of Pahang to the east of Johor, while 4.2% of the respondents thought otherwise. 21.8% of the respondents remained neutral (Figure 24).

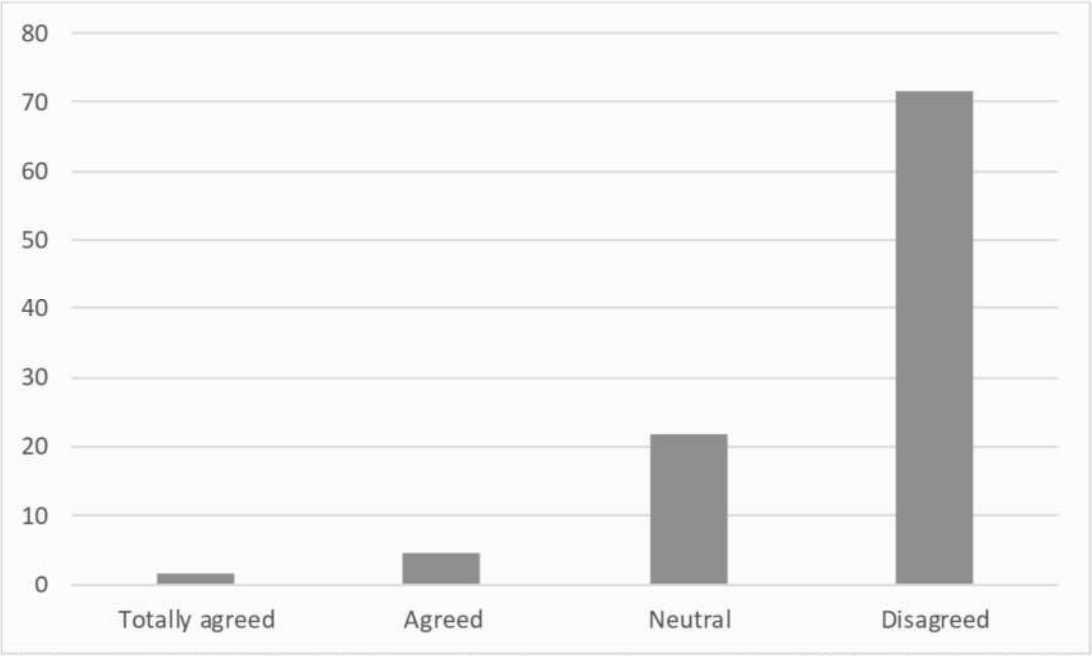

Figure 21: Refugia affects eco-tourism and recreational fisheries (unit : %)

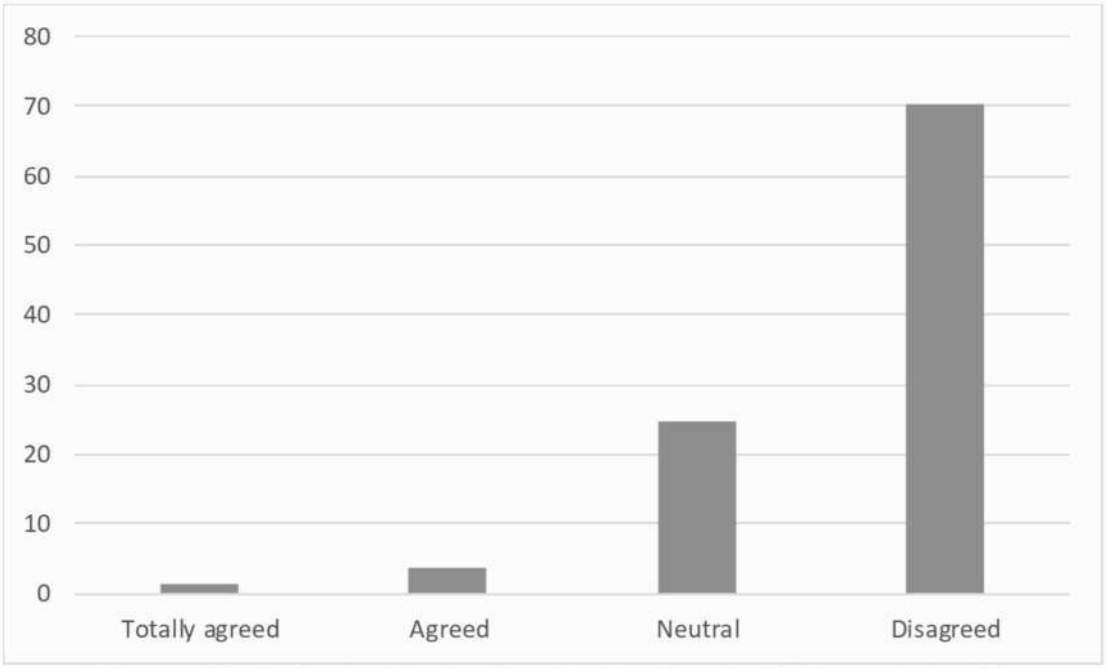

Figure 22: Refugia deteriorates the livelihood of fishers (unit : %)

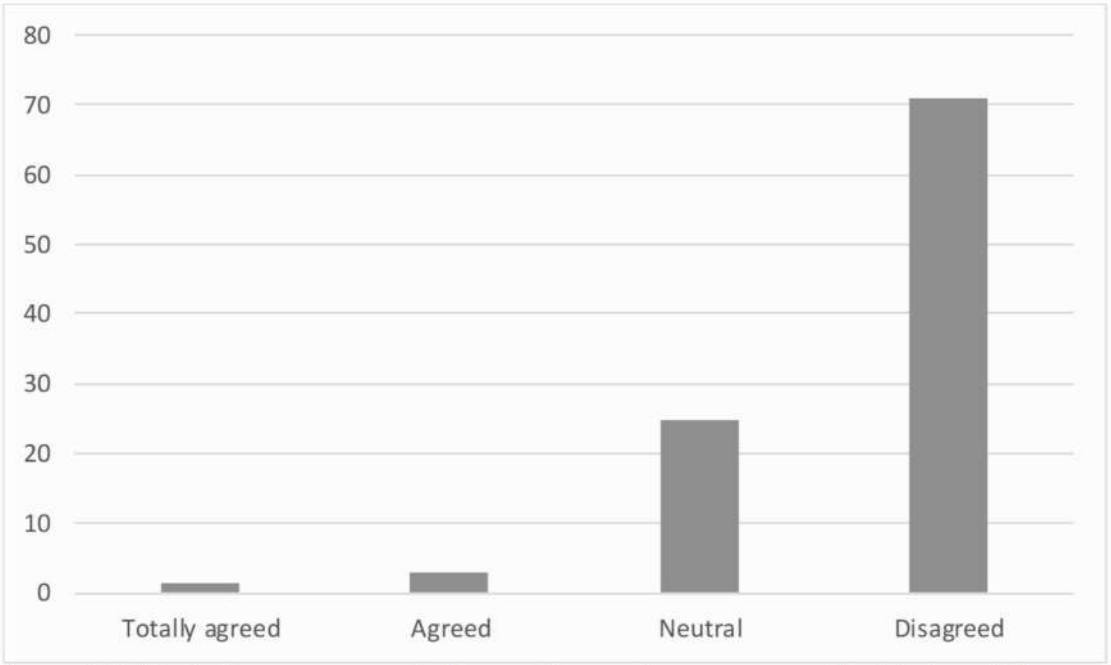

Figure 23: Refugia causes unbalanced impact on women, disabled and the poor (unit : %)

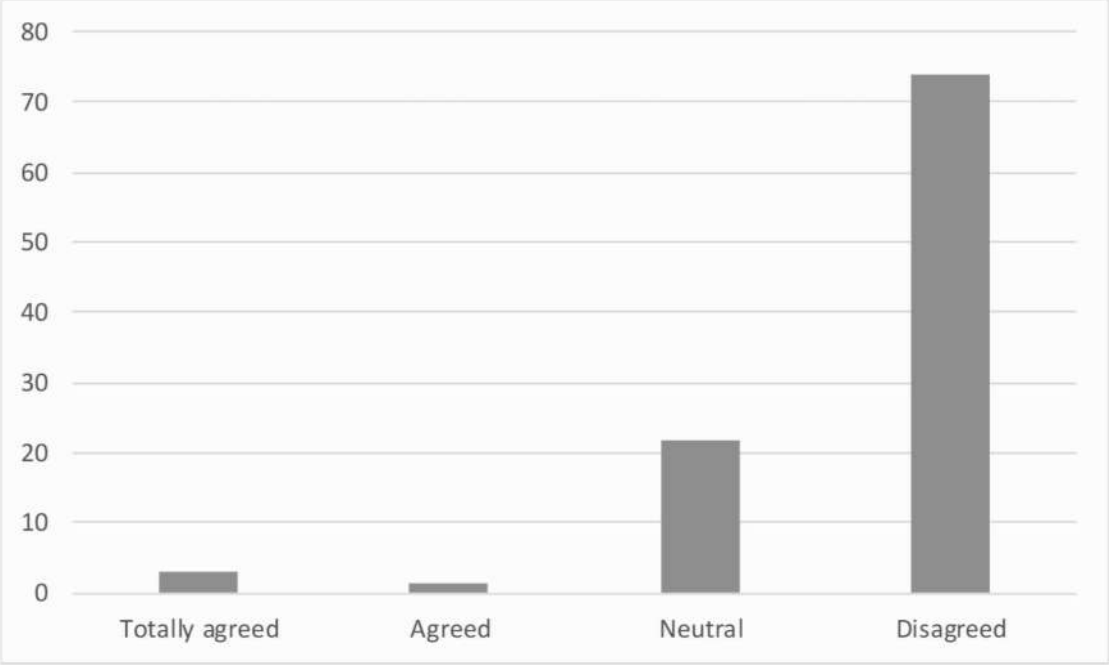

Figure 24: Refugia affects the cultural heritage of local communities (unit : %)

Reliability Test

Descriptive analyses were used to obtain the demographic profile. Since the questionnaires on the perceptions on issues regarding the establishment of lobster's refugia consisted of Likert Scale (1 = Strong Agree, 2 = Agree, 3 = Neutral and 4 = Disagree), Cronbach's Alpha for each variable should be counted in order to measure the internal consistency of the questionnaires. According to Cronbach (1951), the thumb of rule for the interpretation of Reliability Test is indicated in Table 6. The reliability of 0.7 or higher are required and the Table 7 indicated the score of the reliability rest for each variable.

Table 6: Cronbach's Alpha score guide

Cronbach's Alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Table 7: Reliable Statistics for Variables

Variable		Scale Mean If Item Deleted	Scale Variance If Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha
Keyword	Item				
Concept	Fig. 3	50.04	69.431	-0.001	**0.826**
Site	Fig. 4	51.75	68.898	0.063	**0.823**
Agree site	Fig. 5	51.27	64.907	0.330	**0.814**
Prohibit	Fig. 6	51.25	61.020	0.456	**0.808**
Maintan	Fig. 7	51.15	62.410	0.428	**0.809**
No_fishing	Fig. 8	51.15	61.418	0.492	**0.806**
Discuss	Fig. 9	51.52	63.385	0.467	**0.808**
Income	Fig. 10	51.32	61.024	0.669	**0.799**
Benefit	Fig. 11	51.24	60.401	0.743	**0.796**
Knowledge	Fig. 12	51.20	62.271	0.599	**0.803**
Increase	Fig. 13	51.15	59.710	0.703	**0.795**
Quality	Fig. 14	51.19	58.434	0.793	**0.790**
More_refugia	Fig. 15	51.16	58.792	0.703	**0.796**
Human_rights	Fig. 16	51.19	58.434	0.793	**0.790**
Social_conflict	Fig. 17	51.15	59.710	-0.703	**0.795**
Change	Fig. 18	51.16	58.792	-0.658	**0.796**
Relocate	Fig. 19	49.87	70.421	-0.093	**0.834**
Lose_jobs	Fig. 20	50.05	71.620	-0.172	**0.838**
Eco_tourism	Fig. 21	49.95	70.601	0.106	**0.833**
Livelihood	Fig. 22	49.79	70.469	-0.097	**0.831**
Impact	Fig. 23	49.59	69.305	0.011	**0.826**
Culture	Fig. 24	49.59	70.194	-0.073	**0.829**

Based on Table 7, the Reliability Test of Cronbach's Alpha for each variable are greater than 0.7, thus, the overall for the Reliability test for the variables can be further shown in Table 8.

Table 8: The overall for the Reliability test for the variables

Cronbach's Alpha	Cronbach's Alpha based on Standardized Item	No of Item
0.819	0.799	22

The results indicated that the Cronbach's Alpha is 0.819 which is good, based on the rule of thumb for interpreted Reliability Test.

Discussion

According to Fisheries Statistics, the catch and landings of lobster from 2016 to 2018 showed a significant decline. Among the contributing factors are (i) pollution due to land reclamation activities, (ii) pollution due to oil spills by commercial ships,

(iii) sea current and weather changes, (iv) construction of new ports, (v) shallow sea levels; and (vi) the increasing number of fishers.

However, the increasing income from fishing activities is influenced by other contributing factors such as (i) fishers are experienced and wiser, (ii) efficiency of fishing gear, (iii) bigger horsepower of the engine and (iv) operating near the artificial reef.

Marine Protected Area (MPA) is an ecosystem-based management tool established to protect sensitive habitats, fauna and related ecosystem services. MPA is established to create an area or location where biodiversity and abundance of marine can be restored and preserved. In other cases, MPA is established based on the requirements of fisheries management, as protection to nursery and breeding areas so that fisheries resources are biologically protected.

Compared to refugia, as outlined by *SEAFDEC/UNEP / GEF Project : Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and Gulf of Thailand*, a refugia is geographically and spatially defined area, where specific management measures are used to maintain important species (fishery resources) during the critical stages of its life cycle, for the sustainability of the species.

Lobster is one the fish resources caught along the coast of South Pahang to the East of Johor. In addition, the lobster has become a commodity that generates among the highest income for artisanal fishers. In this regard, fishers have made significant investments in the lobster fishery through purchasing of vessel and suitable fishing gears. Lobster that are caught are sold directly to tourism sector; seafood restaurants and hotels, the real economic drivers that depends heavily on artisanal fishers for the continuous supply of lobsters.

Mud spiny lobsters in these watersheds are relatively sedentary, exhibiting clear migration patterns and limited only in restricted geographical environments. These lobsters make it easier for the Department of Fisheries to manage this resource compared to other species.

Fishers can actually guess the season or month in which lobsters carrying egg sacs. However, majority of fishers are not as sure or interested in other biological phenomena as the formation of tar spot during sperm formation, skin shedding (molting) or differences in proportions between male to female lobsters. This is because the information was not important for fishers. However, for researchers and decision-makers, such information is crucial in verifying the appropriate location and season before refugia can finally be gazetted. Lobsters usually require extra protection during mating or breeding season to provide opportunities to reproduce and maintain the stock. However, socio-economic arguments may influence the timing and location of lobster. Quoting fishers at Sedili Besar and Sedili Kecil, refugia is best established in their areas, compared to the recommended Tanjung Leman waters. More landings of lobsters are recorded in Sedili Besar and Sedili Kecil as compared to Tanjung Leman.

The fishers along the waters of South Pahang to East Johor are very clear about the needs and benefits of refugia as the number of lobsters are declining at an alarming rate. They also realized that their income will increase if and only if they complied with the refugia requirements. In this regard, fishers recognized the need for change and come to an understanding with the Department of Fisheries Malaysia's measures in protecting fisheries resources, especially mud spiny lobsters for the future. The awareness of these change is reluctantly acknowledged by some fishers who insist in maintain their fishing methods or targeted species.

The fisheries stakeholders also provided some suggestions to help boost the lobster fishing industry. Fishers proposed that there is a need for alternative for fishing; in terms of species, fishing gears, fishing techniques and fishing areas as measures of compliance with the establishment of refugia that would be influenced by the current lobster fishing. Fishers, especially young fishers need to be trained in mastering the various fishing techniques in to further developing this industry. Fishers no longer have to rely on the hereditary experience taught by their father or grandfather in human capital development and personal skills.

The results from the discussions with the respondents also suggested that fishers and the Department of Fisheries Malaysia are also concerned about the negative potential of the socio-economic impact of refugia establishment. This is because the Department of Fisheries Malaysia has limited capacity in managing the refugia (staff and finance). In this regard, the involvement of fishers in refugia management is critical and urgently obligatory. It is also noted that high level of trust and understanding between the Department of Fisheries Malaysia and the members of the fishing community was observed from this study. This linkage should be strengthened and extended throughout the Department of Fisheries Malaysia so that fishers can rest assured that the Department of Fisheries Malaysia is truly committed in ensuring the sustainability of fisheries resources and safeguarding the interests of fishers as well as future generations.

In return, fishers should be prepared at all time and encouraged to supply and share data of catch and effort voluntarily with the Department of Fisheries Malaysia so that the resource of lobsters can be evaluated more accurately. Information on the status of the resources can be passed back to fishers for feedback, and allows both parties to make precise decisions on which fishers agree to comply with is as the authority agrees to enforce it.

Active participation of fishers and fishers' communities is critical for the sustainable utilization of fisheries resources. It will create a transition towards co-management where bot resource users (fishers) and government agencies (Department of Fisheries Malaysia) can work together to address management issues and share decision-making responsibilities before any actions can be taken.

The Department of Fisheries Malaysia has also designed and implemented several educational programs for fishers and the public on the importance of working together to safeguard fisheries resources and livelihood. Such programs can raise awareness of environmental issues, especially fisheries and thus, strengthen beneficial relationships.

Socio-economic information is essential for long-term monitoring and is used to determine the status of resources and how management measures can influence the

stakeholders. Assuming the establishment of refugia is the best for conservation of lobsters, the impact on the stakeholders should be monitored periodically while mitigation measures are in place. This is the essence of adaptive management whereby the results of this socio-economic information can be used to reinforce the decisions made by top management. On-going monitoring of the economics of fisheries as these refugia are fully implemented is to look at the development and its impact on fishers, resources and the environment.

In refuting the allegation that the Department of Fisheries Malaysia does not take fishers' support seriously, it may be time for fishers to begin keeping records of the catch and landing so that it can be shared with the Department of Fisheries Malaysia; so that the Government of Malaysia can better appreciate the economic importance that fishers contributed to the national fisheries production.

Future research and management direction

The scope of the study to be extended on (i) the distribution, ecology and biology of spiny lobsters and (ii) stock assessment and population dynamics.

Lobster fishery in Malaysia is enforced under the Fisheries Act 1985. National Action Plan of Lobster Fishery shall be (drafted) with regards to :

i. Usage of specific fishing gears such as crab traps or hooks and line (for instance)
ii. Other specific fishing methods such as collection by hand or diving
iii. Identify and gazette reef areas as fisheries sanctuaries, marine protection areas or no-take zone for spiny lobsters.
iv. Control of live spiny lobsters' exports (regulated by minimum carapace length, for instance).
v. To determine the export quota (any specific metric tonnes) with export season restricted to any specific months.
vi. To enforce all berried individual lobsters to be released immediately upon capture.
vii. To prepare and implement other relevant regulations leading to sustainable management from time to time.

viii. For aquaculture, emphasis will be on the artificial seed propagation and development of suitable culture technologies and systems.

Continuous monitoring on the economics of lobster fishery would be obligatory when refugia is completely implemented to see what effect it is having. This should be done to provide data within a year of two after it has come completely into effect.

Acknowledgement

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Appendices

Appendix 1: Study locations in the South of Pahang – East of Johor

CAPTURE FISHERIES RESEARCH DIVISION
FRI KAMPUNG ACHEH
DEPARTMENT OF FISHERIES MALAYSIA
32000 SITIAWAN, PERAK.

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