The establishment of fisheries refugia as a new approach to sustainable management of fisheries in Malaysian waters

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Abstract: The marine fisheries resources worldwide are facing depletion but traditional management methods may not be adequate to overcome this problem. A new fishery management approach which focuses on protecting the critical stages in the life cycle of the selected marine species is presented in this paper. The fisheries refugia concept focuses on temporal and a spatially defined marine or coastal area in which specific management measures are implemented to sustain the targeted species. This concept was initiated by SEAFDEC-UNEP-GEF in the South East Asia region and are participated by six member countries namely Malaysia, Cambodia, Thailand, Vietnam, Indonesia and the Philippines. In Malaysia, two sites were selected for this project which is the lobster refugia (\textit{Panulirus} spp. and \textit{Thenus orientalis}) in Tanjung Leman, Johor and the tiger prawn (\textit{Penaeus monodon}) refugia at Kuala Baram, Miri, Sarawak. This paper discusses the activities carried out to establish these two refugia. These activities include resource surveys of lobsters and tiger prawns at different life stages (larvae, juvenile and adult) and socio-economic profiling of fishers communities at both sites. Several stakeholder consultation sessions were also held with fishers and local agencies to promote the refugia concept and gather feedbacks on the implementation of the new management approach. Two information centers were set up at Tanjung Leman and Kuala Baram, Miri with the objectives of disseminating information regarding the fisheries refugia project and its benefits to the stakeholders. Likewise, in collaboration with the local television station RTM, two fisheries refugia documentaries were produced and broadcast nationwide. The targeted outcome of this project is to have these two sites gazetted as fisheries refugia so that the wild resources of lobsters and tiger prawns are sustainably managed through spatial and seasonal closure during the critical stages of their life cycle.

Keywords: lobster; tiger prawn; fisheries refugia; new management approach; Malaysia.

1. Introduction

The states of marine fisheries worldwide face a common outlook which is either in decline or facing depletion [1]. Most fisheries have the twin problems of over-capacity and over-exploitation, in addition to the uses of destructive/unsustainable fishing gears and practices [2, 3]. Marine habitats such as coral reef, mangrove and seagrass which promote and protect the fish population face severe threats from destruction due to destructive fishing gears, widespread pollution and unrestrictive human
development activities [4]. The decadal rates of marine habitat loss in the South China Sea and Gulf of Thailand from seagrass, mangrove and coral reefs are estimate to be about 30%, 16% and 16% respectively [5]. Traditional fishery management methods such as fishing effort control, prohibited gears, vessel size and engine capacity limits may not be adequate to overcome the declining of the fish resources in Malaysia [2,4]. A new fishery management approach which focuses on protecting the critical stages in the life cycle of the selected marine species is initiated by SEAFDEC-UNEP-GEF in the South East Asia region and are participated by six member countries namely Malaysia, Cambodia, Thailand, Vietnam, Indonesia and the Philippines. The fisheries refugia concept focuses on temporal and a spatially defined marine or coastal area in which specific management measures are implemented to sustain the targeted species.

The fisheries refugia concept focuses on temporal and a spatially defined marine or coastal area in which specific management measures are implemented to sustain the targeted species. This concept was initiated by SEAFDEC-UNEP-GEF in the South East Asia region and are participated by six member countries namely Malaysia, Cambodia, Thailand, Vietnam, Indonesia and the Philippines. The project officially began in Malaysia in year 2017 and is spearheaded by the Department of Fisheries Malaysia and with participation from local agencies and communities. SEAFDEC-UNEP-GEF also assisted in terms of technical advices and co-financing.

The fisheries refugia concept adopted by Malaysia followed closely the SEAFDEC-UNEP-GEF definition, which state that the fisheries refugia are “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” [6]. Therefore, the fisheries refugia focuses on the nature of the particular habitat and its critical significance to the life-history of the targeted species.

2. The fisheries refugia concept
The fisheries refugia are specific areas of significance to the life-cycle of fish species. These areas may be known breeding or spawning grounds, or the migration routes of the fish species to the breeding grounds and also the nursery grounds of juveniles. The fisheries refugia may also involves several areas during different periods of targeted fish species life cycle, as the movement of eggs, larvae, juveniles and adults may cover a large area of the sea and it would be impractical to limit fishing activities to all areas of concern at one particular period. Thus, the fisheries refugia should also be defined in time and space, according to the particular life stages of the fish species which require protection. For many fish species, the most critical life stages which necessitate some form of protection from fishing activities are during their migration, breeding and spawning periods. During these periods, the fish species are most likely to aggregate in large numbers and any fishing activities which target the fish population during these times will likely to affect the future population of the fish species.

However, the fisheries refugia should not be no-take zones and are different from the traditional marine parks found in Malaysia. The period of closure to fishing in the fisheries refugia are temporary and depend on the period of life stages of the targeted species which require protection, and may cover traditional fishing areas and places outside the fishing grounds such as mangrove and seagrass habitats. On the contrary, marine parks in Malaysia are permanent no-take zones, which aims to protect all marine species within a fixed area and intended at achieving goals and objectives of biodiversity conservation. The fisheries refugia are more intended to safeguard the spawning aggregations, nursery grounds, and migration routes of the targeted fish species. The ultimate aim of the fish refugia is to ensure that the fishery resources are exploited sustainably through protection of critical stages of their life cycle. In Malaysia, two sites were selected for this project which is the lobster refugia (Panulirus spp. and Thenus orientalis) in Tanjung Leman, Johor and the tiger prawn (Penaeus monodon) refugia at Kuala Baram, Miri, Sarawak (Figure 1).
Figure 1. The locations of the proposed Lobster Refugia at Tanjung Leman, Johor and Tiger Prawn Refugia at Kuala Baram, Sarawak.

2.1. Fisheries refugia implementation in Malaysia

Under the fisheries refugia project in Malaysia, the national coordination mechanism consisted of 3 levels, namely the National Fisheries Refugia Committee, the National Scientific and Technical Committee and two site based Fisheries Refugia Committees at Tanjung Leman and Kuala Baram (Figure 2). The Focal Person for the National Fisheries Refugia Committee is the Deputy Director General of Fisheries Malaysia while the Focal Person for the National Scientific and Technical Committee is the Deputy Director of the Fisheries Research Institute. The refugia project also receives technical and financial inputs from the Regional Refugia Project Steering Committee based in Bangkok, Thailand.

The membership in the National Fisheries Refugia Committee consisted of stakeholders from various agencies such as the Ministry of Agriculture and Agro-Based Industry, Department of Fisheries Malaysia, State Planning Unit Sarawak, Johor and Pahang State Economy Development Units (UPEN), Fisheries Research Institutes, Johor, Pahang and Sarawak States Fisheries Departments, Malaysia Maritime Enforcement Agency (MMEA) and others. The main task of the National Fisheries Refugia Committee is to focus on matters relating to the planning and operational management of priority refugia sites. These stakeholders will assist with the identification of proposed measures for the fisheries sector’s sustainable use of fish habitats and biodiversity for incorporation in Malaysia’s national fisheries policy [3].

Likewise, the membership in the National Scientific and Technical Committee consisted of Fisheries Research Institutes, Marine Park Division (DOFM), Johor, Pahang and Sarawak States Fisheries Departments, environment based NGOs, Johor Corporation and selected experts from local universities. The main task of the National Scientific and Technical Committee is to enhance access to information relating to the status and trends of related fisheries and their habitats and to improve national-level management and sharing of information and data on fish early life history and biology.

At the two refugia sites in Kuala Baram and Tanjung Leman, the membership of each local Fisheries Refugia Committees consisted of representatives from the Fisheries District Offices, local Fisherman Associations, District Fisheries Development Authority (LKIM), District Office, local enforcement authorities and trawler associations. Their main tasks are to delineate boundaries and planning of the formal designation of fisheries refugia sites, developing community-based management plans and the day-to-day planning and management of their respective refugia sites [3].
The activities in the fisheries refugia project in Malaysia are outlined in four main components. The first component is the identification and management of fisheries and critical habitat linkages at priority fisheries refugia. In this component, activities such as scientific data gathering and surveys are undertaken, drafting community-based management plans for the refugia, and conducting practical capacity building programs for management volunteers. Management teams for the Refugia sites are also established with members appointed from the local agencies and fishers’ community. Some community-based projects related to refugia can also be carried out to alleviate the livelihood impact from the periodical closure of fishing grounds or to promote better balanced gender participation in the refugia project.

The second component of the fisheries refugia project is the improvement of management of critical habitats for fish stocks of transboundary significance via national and regional actions to strengthen the enabling environment and knowledge-base for fisheries refugia management. In this component, activities related to fisheries policy and legal framework are set in place. These activities may include defining the policy and legal basis for formal designation and establishment of fisheries refugia, development of national guidelines and fine-tuning the national policy, legal and planning frameworks for demarcating boundaries and managing refugia. Other activities such as information sharing related to status and trends in fish stocks and their habitats in Malaysia waters are also included.

The third component is the management and dissemination of information in support of national and regional-level implementation of the fisheries refugia. Activities in this component include documentation of activities and best practices in fisheries management and conservation, public awareness programs, publication of refugia materials and websites. Lastly, the fourth component is the cooperation and coordination exercises at the national and regional levels for management of integrated fish stock and critical habitat. Activities in this component include cross-sectoral coordination between agencies, scientific experts inputs and consultations and catalyzing the local community action via establishment and operation of site-based management boards.

Highlight of the four components of the refugia project in Malaysia [3]:

Figure 2. The national coordination mechanism for the execution of the SEAFDEC/UNEP/GEF Fisheries Refugia Project in Malaysia.
Component 1: Identification and management of fisheries and critical habitat linkages at priority fisheries refugia in the South China Sea.

Component 2: Improving the management of critical habitats for fish stocks of transboundary significance via national and regional actions to strengthen the enabling environment and knowledge-base for fisheries refugia management in the South China Sea.

Component 3: Information Management and Dissemination in support of national and regional-level implementation of the fisheries refugia concept in the South China Sea and Gulf of Thailand.

Component 4: National and regional cooperation and coordination for integrated fish stock and critical habitat management in the South China Sea and Gulf of Thailand.

2.2. Lobster Refugia at East Johor-South Pahang

The lobster fishery in the East Coast of Peninsular Malaysia focused mainly at the waters of East Johor and southern part of Pahang state. Fishers at these areas use traditional gears such as traps and seine nets to catch lobsters at the shoreline area while commercial trawlers sometime capture adult lobsters as bycatches in their bottom trawl nets at deeper water. The lobsters caught were preferably kept alive and sold to collectors at jetties in Sungai Rengit, Sedili, Tanjung Leman, Mersing and Endau in Johor and Rompin in Pahang. Previous study by Alias et al. [7] recorded at least five types of spiny lobsters available in the area (P. polyphagus, P. versicolor, P. ornatus, P. homarus and P. longipes). However, P. polyphagus or mud spiny lobster is the dominant catch species and thus the subsequent establishment of lobster refugia in the area is based on the biology and life cycle of the P. polyphagus lobster. As an addition, the project also include the slipper lobster (Thenus orientalis) fishery as well. Live lobsters fetch significantly higher price as they are sold to nearby seafood restaurants and even exported to Singapore. The pricing of lobsters varies according to size and also seasonality. The jetty price may range from RM100 to RM160 per kilogram of lobster but may change according to supply and seasonality. The market demand for lobster is strong even if the price is comparatively expensive to other seafood as it is traditionally considered a luxury food item.

The landing trend of spiny lobsters from the east coast of Peninsular Malaysia has been on a decline since the early 2000’s (Figure 3). Intense fishing pressure, changes to the marine habitats, pollution and severe weather anomalies (such as prolonged El Nino and rising sea temperature) have impacted the spiny lobster population and fishery in the region. Rapid coastal development especially at the southern tip of East Johor in recent years has further affected the shallow muddy habitat which juvenile spiny lobsters thrives. In order to mitigate the decline in lobster resources, a new fishery management method is required to overcome the multiple threats to the lobster fishery in the east coast of Peninsular Malaysia.

There were past studies concerning the resource and life cycle of P. polyphagus in the East Johor area [7-9] but the migration route and spawning ground have yet to be determined clearly. However, scientists studying the Panulirus lobsters have indicated that the spiny lobster will undertake a mass migration to their spawning ground before releasing their eggs into deeper sea [10, 11]. From the previous landing data collected, it is observed that egg-bearing lobsters are usually found during the months of July-September and this coincide with a previous study by Alias et al. [7], which state that the peak breeding season is in August.

The scientific studies to support the formation of the Lobster Refugia in Tanjung Leman, Johor focused mainly on four main activities which were the collection of lobster landing data from jetties, lobster eggs and maturation observation from the landing jetties, lobster resource and larvae surveys in the fishing ground at East Johor. For example, the monthly average weight of mud spiny lobster (P. polyphagus) landed by fishers at Tanjung Leman, was 269 gram and ranged from 180 to 349 gram (Figure 4). From the landing data, the size of mud spiny lobster increased and peaked during the rainy season which coincide with the North-East monsoon. Bigger sized lobsters may be induced to come out from their burrows due to the influx of freshwater from the land during the rainy season and
subsequently caught by the fishers (personal comm. with Prof. M. Ikhwanuddin, Universiti Malaysia Terengganu).

The Fisheries Research Institute has conducted several lobster resource and larvae surveys in the East Johor-South Pahang waters in the year 2016 to 2018. The surveys were carried out using bottom trawl net gear and covered the normal fish trawling grounds. Likewise, lobster larvae samplings were also undertaken during the resource survey to gauge the density and distribution of the lobster larvae. The results of the surveys were then mapped out to determine the best location for the formation of the lobster refugia (Figure 5) [13].

2.3. Tiger Prawn Refugia at Kuala Baram, Miri
The wild tiger prawn (*P. monodon*) population in Miri, Sarawak is the few remaining healthy tiger prawn populations in Malaysia. Due to unhindered coastal development in the past, declining...
mangrove habitats and other fisheries related factors, the tiger prawn resources have decreased drastically and is reflected in the fisheries landing (figure 6). During the last 10-years period from 2008 to 2018, the total landing of tiger prawn in Malaysia has shown a 30% decrease in landing [12].

To mitigate this declining condition, a tiger prawn refugia is proposed at the river mouth of Kuala Baram in Miri, Sarawak and the refugia site has been roughly identified based on past and current research findings [14,15,16,17,18]. The proposed site for the tiger prawn refugia is located near a mangrove forest with an adjoining river mouth. The offshore area slopes into deeper depth as the area is adjacent to the continental slope. In the vicinity of the refugia area is the Miri-Sibuti Coral Reefs National Park.

The scientific studies to support the formation of the Tiger Prawn Refugia in Kuala Baram, Miri, Sarawak focused mainly on three main activities which were tiger prawn (\textit{P. monodon}) landing data collection, maturation stage observation and identification of nursery areas for juvenile prawn in the
Baram River area. Kuala Baram is located at the mouth of the Baram River in Miri and has a sizeable mangrove habitat essential for the tiger prawn life cycle.

In the life cycle of the tiger prawn, the adult tiger prawn would copulate and spawn in the deep water off Kuala Baram before the larvae make its way back to the mangrove habitat and grow into post-larvae and juveniles. During several phases of the life cycle, there are various threats that may affect the population thus the formation of a tiger prawn refugia will greatly aid in the preservation of the prawn stock (Table 1). The catch rate, density, biomass and maximum sustainable yield of tiger prawn resource at Miri have been determined from previous study and is given in table 2 [18].

**Table 1.** The life history phase, known habitat and possible threat analysis for the tiger prawn in Kuala Baram, Sarawak.

| Life history phase | Known habitat/ critical area | Threat                                        |
|--------------------|------------------------------|-----------------------------------------------|
| Early-life history | Ocean water up to 130 m (muddy/sandy/rocky) | Filtering, predator (whale, manta-ray)         |
| Juvenile          | Seagrass/ mangrove/ estuary | Deforestation                                 |
| Pre-recruit       | Seagrass – salty water (25-30 ppt) | Shrimp push net and bag net                    |
| Adult             | Deepwater (20-50 m)         | Trawl net                                     |
| Spawning          | Oceanic water               | Trawl net                                     |

**Table 2.** The catch rate, density, biomass and maximum sustainable yield (MSY) of tiger prawn resource at Miri.

| Area Size (NM²) | Catch Rate (kg.hr⁻¹) | Standard Deviation | Density (kg.NM⁻²) | Biomass (metric ton) | MSY (metric ton) |
|----------------|----------------------|--------------------|-------------------|---------------------|------------------|
| 296            | 1.99                 | 0.523             | 52.44             | 15.52               | 23.00            |

Source: [18].

**Figure 7.** Stages of gonad development (Stage I – V) of female tiger prawn caught during the survey according to month (stage = st).

Gonad studies were undertaken to determine the breeding season of tiger prawn at Kuala Baram and the results indicated peak breeding season during the July-August period when the percentage of
stage-IV gonad was the highest (Figure 7). This information is vital to the determination of the closing season of the tiger prawn refugia which enable the protection of tiger prawn during their spawning period.

2.4. Socio-economic surveys of the refugia sites

A series of socio-economic surveys were conducted at the tiger prawn and lobster refugia to gauge the communities acceptance of the refugia concept of fisheries management in their areas. The socio-economic survey of fishers covering four areas in Miri was carried out in the year 2016 by a local university in Sarawak (UiTM) and was assisted by the Sarawak State Fisheries Office (JPLS). A total of 231 respondents took part in this survey. The findings from the survey indicated that 47.3% of respondents agreed not to conduct fishing operation of lobster during its breeding season after the establishment of refugia and 50.3% of respondents are willing to be involved in the management process of the refugia site [19].

Similarly, the baseline socio-economic survey of fishers covering eight fishing areas in Pahang-Johor was undertaken during March to August 2018. A total of 138 respondents took part in this survey. The findings showed that 88.2% of respondents agreed with the establishment of refugia as proposed by the Department of Fisheries Malaysia, while 85.3% of respondents agreed not to conduct fishing operation of lobster during its breeding season after the establishment of refugia and a further 97.1% of respondents agreed that the Department of Fisheries Malaysia should discuss with the fishers and fishers’ community regarding the proposal of the establishment of lobster refugia [20].

2.5. Stakeholder consultation with local communities and agencies

A series of stakeholder consultations were conducted at the two fisheries refugia sites in East Johor-South Pahang and Kuala Baram, Sarawak (Table 3). During the consultations, the participants were given briefings about the fisheries refugia concept, results from related scientific studies and management measures concerning the targeted fisheries. After the briefing, participants (fishers and local agencies alike) were given the opportunities to ask questions and feedbacks were gathered from the participants to be incorporated in the formation of the two fisheries refugia.

Table 3. List of stakeholder consultation sessions conducted in Malaysia for the Fisheries Refugia Project for year 2017-2018.

| No. | Type of stakeholder consultation            | Location         | No. of participants | Date       |
|-----|---------------------------------------------|------------------|---------------------|------------|
| 1.  | Fishers Consultation Session                | Miri, Sarawak    | 55                  | 18th July 2017 |
| 2.  | Fishers (Artisanal) Consultation Session    | Sedili, Johor    | 130                 | 20th Aug 2017 |
| 3.  | Local Agencies and Fishers Consultation Session | Kuala Rompin, Pahang | 41              | 10th Oct 2017  |
| 4.  | Fishers (Trawlers) Consultation Session     | Endau, Johor     | 30                  | 30th July 2018 |
| 5.  | Fishers (Trawlers) Consultation Session     | Sedili, Johor    | 18                  | 31st July 2018 |
| 6.  | Fishers Consultation Session                | Kuala Rompin, Pahang | 75              | 29th Aug 2018 |

2.6. Public awareness and dissemination of refugia related information

In order to promote the fisheries refugia concept to the general public, the Department of Fisheries Malaysia has set up two Refugia Information Centers (RIC) at the Tanjung Leman Ferry Jetty and Miri Fisheries District Office. The purpose of these Refugia Information Centers is to create public awareness and disseminate information about the fisheries refugia concept to the public. The Refugia Information Center at the Tanjung Leman Ferry Jetty was officiated by the Director General of Fisheries Malaysia on the 20th of November 2017 and attended by local fishers and representatives
from the local agencies. After the success and positive response given to the RIC at Tanjung Leman, another RIC was established at the Miri Fisheries District Office for the tiger prawn refugia in year 2019. In the Refugia Information Centers, various information about the targeted fisheries are on displayed and visitors can seek further information about the refugia project from the staff on duty.

To further promote the fisheries refugia in Malaysia, the Department of Fisheries Malaysia in collaboration with Radio Televisyen Malaysia (RTM) has produced two 30-minutes documentaries about the lobster and tiger prawn refugia at East Johor-South Pahang and Kuala Baram respectively. The documentaries were broadcasted through national television in the Simfoni Alam program on the 4th and 25th of December 2018. Such use of mass media to promote the fisheries refugia enable further outreach of the audience groups and stimulate wider public support for the fisheries refugia projects. The public support is important since the fisheries refugia entails significant involvement of the local communities in the site-based management of the refugia activities and the compliance to the seasonal closure periods.

2.7. Effectiveness of fisheries refugia

The effectiveness of the fisheries refugia concept to manage the fisheries depends on several factors during the inception and execution of the project. During the inception process, the choice of species to be selected and protected under this management scheme is very important. The fisheries refugia concept may be more effective for species which aggregate during spawning season and has sufficient scientific information which already define the locations required for the seasonal closure [21-23]. Since the fisheries refugia concept works on protecting the fish population during specific time and space of their life cycle, the complete scientific information of the fish life stages must be obtained.

Seasonal closure as a form of fisheries management has already been implemented in many other countries varying degree of successes but must be accompanied with other forms of management measures such as gear, effort, capacity restrictions and catch quotas [24-26]. In relation to that, increase in fishing activities after closure period must be managed to avoid sudden fishing pressure to the protected fish stock [27-29]. The implementation of the fisheries refugia project in Malaysia is still ongoing and cooperation from various groups of stakeholders is vital to ensure the effectiveness of the fisheries refugia.

3. Conclusion

The fisheries refugia is a new initiative to conserve high value fishery resources in Malaysia. It is not a no take zone area such as the marine parks but aims to protect the targeted fish population during the critical stages of their life cycle. The fisheries refugia can be considered as a type of Ecosystem Approach to Fisheries Management (EAFM). National level coordination between various agencies is very much needed to implement this initiative. Fishers cooperation is vital and the fishery resource concerned will be manage by the fishers community through the EAFM approach. The targeted outcome of this project is to have these two sites established as fisheries refugia so that the wild resources of lobsters and tiger prawns are sustainably managed through spatial and seasonal closure during the critical stages of their life cycle.

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