

# FRI

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R&D @ South China Sea

# NEWSLETTER



Cover picture: R&D on artificial reefs @ Mukah, Sarawak waters

# Message from the Editor

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## Dear Readers

I am delighted to bring you this year Fisheries Research Institute - FRI Newsletter, Volume 25 (2022), focussing on the R&D @ South China Sea (SCS) within Malaysian border. As widely known, the SCS is a region of tremendous economic and geostrategic importance. One-third of the world's maritime shipping passes through this area, carrying over US\$3 trillion in trade each year. Furthermore huge oil and natural gas reserves are believed to lie beneath its seabed. It also contains lucrative fisheries, which are crucial for the food security of millions in Southeast Asia. The SCS is also famous as a home to some of the world's richest reef systems and over 3,000 indigenous and migratory fish. This makes the SCS the richest in biodiversity resources, including marine fish from all over the world. Hence, this issue is dedicated to present various information on the R&D conducted in this area by the FRI.

The editorial team is continuously striving to improve the newsletter, thus, any comments or feedback would be gratefully appreciated. I can be reached via e-mail at [norhana@dof.gov.my](mailto:norhana@dof.gov.my) or [wannorhana@yahoo.com](mailto:wannorhana@yahoo.com). I look forward to continuous contributions of articles, suggestions on themes and other valuable inputs from all FRI researchers. We wish all of you a productive reading.

**Wan Norhana Md Noordin**

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# Features

## Research and Development of Artificial Reefs (ARs) on the East Coast of Peninsular Malaysia

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Artificial reefs (ARs) refer to artificial structures deployed on the seabed to provide shelter, habitat, or breeding areas, while hindering destructive fishing activities in coastal areas (Department of Fisheries (DOF), 2008). Artificial reefs are one of the well-known fishery management tools to mitigate the declining fishery resources in coastal areas. The idea for ARs arose from the natural tendency of fish to attracted solid materials or be drawn towards underwater objects, also known as thigmotaxis (Saharudin et al., 2012). Traditionally local fishers deploy wrecked wooden boats and plant as ARs (Wong, 1991).

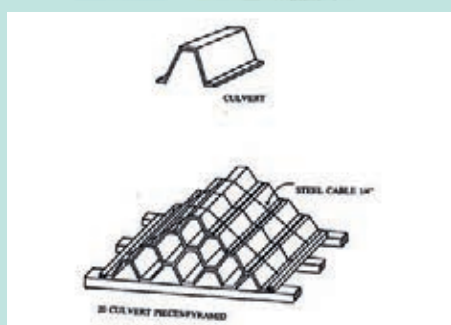
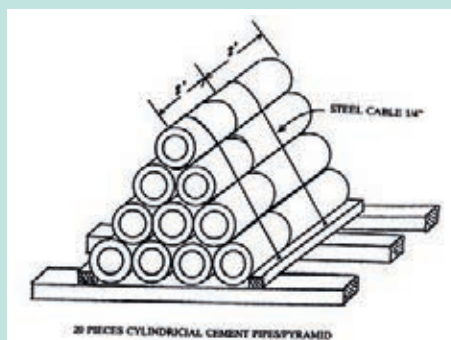
The first structured ARs on the east coast of Peninsular Malaysia was set up in June 1979, using 2,031 used tyres as the building blocks, near Pulau Ekor Tebu, Terengganu. Based on the surveillance conducted by the DOF using underwater videos and photos, the surface of tyre reefs was overgrown and covered by various marine flora and fauna. These observations have prompted the DOF to expand the construction of tyre reefs in other states in Malaysia. Later, more tyre reefs were set up, with Terengganu leading the record with 11 sites and a total number of 378,573 tyres, followed by Pahang with 10 sites and 348,222 tyres, and east Johor with 10 sites and 289,037 tyres. However, since 1996, the use of tyre for ARs has been declining. The DOF has eventually prohibited the use of tyres due to the potential release of chemicals that might affect the environment. Moreover, the surveillance conducted between 2007 and 2008 using side-scan sonar in Terengganu waters found strong water currents destroying ARs tyres in the open sea, especially during monsoon seasons. As a result, the ropes that were used to secure the tyres deteriorated, and the scouring process loosened tyres on seafloors.



Tyre Reef

Besides tyres, derelict and confiscated wooden vessels were also used as reefing materials. Reefing of wooden vessels occurred ad hoc at selected locations using the readily available vessels along shores or jetties. Hence, no standard measurement or specification was determined (Jothy, 1986). The first vessel reef on the east coast was constructed using seven vessels on 18 Mac 1984 in Pulau Kapas, Terengganu. The project was then expanded to Kuala Besar, Kelantan, on 25 August 1984 using 14 vessels. Before reefing, vessels were thoroughly cleaned of all debris, hydrocarbons, and loose parts. Water and fuel tanks were opened or punctured to facilitate the vessel's sinking (Wong, 1991). The DOF has sunk more than 1,000 fishing vessels and Vietnamese refugee boats since 1984 in Terengganu waters.

After tyre reefs were banned, concrete and PVC pipe reef are introduced. There were two types of concrete ARs designed: a cylindrical concrete culvert (0.6 m length x 0.6 m diameter) and a V-shaped concrete culvert (0.6 m length x 0.6 m height). The concrete culverts were arranged into a pyramid on a hard wooden platform and tied with a steel cable. The first concrete ARs deployed on the east coast of Peninsular Malaysia was in Kuala Ibai dan Kuala Setiu, Terengganu, in 1987. However, the design was not popular because of the high logistical and construction costs (Wong, 1991).



Cylinder and V-shape concrete culvert arranged in pyramid to form an ARs module

Meanwhile, in 1991, the Asia Development Bank (ADB) funded the first PVC pipe reefs near Pulau Perhentian Marine Park. At a depth of 18 meters, one hundred pieces of X-shaped modules measuring two-meter height and width were deployed. Each module's bottom half had a unique hole in the middle for anchor attachment to prevent the module from drifting away during monsoon seasons. The construction encompassed 1,860 m<sup>2</sup>, which was intended to serve as the foundation for a marine ranching project like those seen in Japan. All pipes were vented with five-centimeter diameter holes that acted as entrances inside the pipes for juvenile fish to hide.

Beginning 1990, the construction of concrete ARs also took a new direction to attract specific commercial species. Initially, squid and lobster were the two main target species in the reef construction. The first lobster reef was deployed near Pulau Redang in 1990. Its first ARs module consisted of six rectangular blocks stacked on top of one another, each with two apertures pointing in opposite directions. The second module was called Igloo. This module's structure consisted of two arcs and a spherical aperture with just one entrance that acted as a hiding place for lobsters.



Rectangular block and igloo lobster ARs modules

In June 1992, Pulau Redang received its first ceramic reefs devoted to lobsters (Che Omar & Sukarno, 1994; Sukarno et al., 1994). The primary material used in constructing the ceramic reef was two sizes of ceramic cylinder pipes. Two cylinder pipes made up each tier, with two large, 0.4 meter, diameter ceramics used as its foundation. The intermediate and upper levels had smaller (0.25 meter) diameter cylinder pipes and on top of the upper cylinder pipe was a flat concrete slab. However, lobsters were never found in or around the module during surveillance, suggesting that the ARs failed to meet its objectives. At last, nearly 40 per cent of the module sunk to the seabed, and the DOF has no longer used this material since 1993.

Aside from lobster ARs, concrete squid ARs were built to attract squids, particularly Sepia pharaonis, to aggregate, mate, and deposit their eggs. Its first ARs was constructed near Jambu Bongkok, Terengganu in 1992 (Che Omar & Sukarno, 1994; Sukarno et al., 1994). However, the prototype was not strong to endure strong water currents during monsoon seasons. The structures scattered over the bottom were then most likely destroyed by illegal trawlers.

In 1993, ADB supported the installation of concrete ARs for recreational fishing in Pulau Tioman, Pahang. Eighty reinforced concrete reefs (1.2 m x 1.2 m x 1.2 m) were constructed

from grade 30 cement comprising a larger module of nine pieces, six at the bottom, two in the middle, and one on the top. The outcome was not particularly successful because the site chosen was too deep for the sunlight to penetrate, and thus inhibited the growth of marine fouling, sessile, and encrusting organisms (Mohamed Pauzi et al., 1995).

In 1995, the second recreational concrete reef design (approximately 1 m x 1 m x 1 m) was constructed and deployed near Pulau Rhu in Terengganu. The concretes were piled up into a module consisting of 29 units arranged with 16 units at the bottom, (9) units in the middle, and four (4) units on the top. The structure was tied together with a polyethylene rope. However, this project also did not do well due to construction failure.



Twenty nine unit recreational concrete ARs deployed in Pulau Rhu, Terengganu

In 2000, the Southeast Asian Fisheries Development Center (SEAFDEC) sponsored short-term R&D on ARs and fish aggregating devices to improve the design and construction of traditional fish aggregating devices and ARs. A new Artificial Reefs Fish Aggregating Devices (ARFADs) was designed and implemented in Pulau Kapas, Terengganu, in 2002. The ARFADs were made up of plastic stripes to aggregate pelagic fish and 3.2 metric tonnes of concrete ARs as an anchor to attract demersal fish. Since then, ARFADs had been a favourite destination for recreational anglers and divers because they offered handy locations with high concentrations of pelagic and demersal species and a diverse array of marine life similar to that found in coral reefs. The project was initially successful however, later the plastic stripes became very heavy after fouling with sessile and encrusted organisms, resulting in the whole structure sinking to the seabed (Ahmad et al., 2004).

Since 2006, the design and construction of ARs continue to shift. The main goal is to design and construct big-sized reinforced concrete ARs suitable for hard and soft bottom seabeds. Reinforced concrete ARs are proven to be more successful in aggregating demersal fish and can last longer, if manufactured according to marine construction standards (Grove and Sonu, 1985; Grove et al., 1991). The smallest size of reinforced concrete ARs measured 1.65 x 1.65 x 1.66 m and the biggest is 3.4 x 3.4 x 3.6 m, with the weight of a single module ranging from 6 to 35 metric tonnes. The first reinforced concrete ARs, known as tetrapod, were built in Cherating, Pahang, and Ma' Daerah, Terengganu, in 2007. The design was further enhanced in 2007 to make it more durable and able to survive impacts during free-fall deployment procedures. This new form, known as Tetrapod II, was first used in Terengganu and Pahang on Malaysia's east coast. Tetrapod ARs, installed near Ma' Daerah turtle nesting beach in 2006, became a safe resting area for green turtles throughout inter-nesting seasons. In July 2010, an adult green turtle, *Chelonia mydas*,

was found resting near the AR. This area has been classified as a temporary safe habitat for turtles to protect them from trawling activities. Other than tetrapod, more than 12 ARs are constructed and deployed on the

east coast of Peninsular Malaysia. Table 1 summarises the innovation in the reinforced concrete of ARs design and construction on the east coast of Peninsular Malaysia from 2006 to 2017.

ARs module	Year of deployment	Location
Tetrapod	2006	Pahang (Cherating); Terengganu (Ma' Daerah, Pulau Bidong); Kelantan (Pasir Putih)
Tetrapod II	2007	Pahang (Cherating, Sg. Miang, Cherok Paloh); Terengganu (Ma' Daerah, Rantau Abang, Dungun)
Cuboid	2007	Terengganu (Setiu, Kuala Terengganu, Marang, Dungun)
Recreational	2007	Terengganu (Teluk Ketapang)
Soft Bottom II	2008	Terengganu (Besut)
Soft Bottom III	2009	Terengganu (Besut); Kelantan (Tumpat, Kuala Besar, Kuala Sabak, Kuala Kemasin, Bachok)
Recreational II	2009	Pahang (Pekan)
Cube	2009	Terengganu (Ma' Daerah, Kuala Terengganu, Jambu Bongkok, Marang, Setiu); Pahang (Pulau Tioman)
Soft Bottom Anti-trawl	2010	Kelantan (Kuala Tumpat, Kuala Besar)
Cuboid Bioactive	2010	Terengganu (Pulau Bidong)
Cube Juvenile	2010	Pahang (Nenasi)
Cube Juvenile Anti-trawl	2012	Terengganu (Kuala Dungun, Rantau Abang)
Steel	2014	Terengganu (Pulau Bidong, Marang)
Oil rig platform	2017	Terengganu (Pulau Kapas)

Table 1: The chronology of ARs innovation on the east coast of Peninsular Malaysia (2006–2017)

In 2019, the Southeast Asian Marine Fishery Resource Institute (ISMAT) conducted underwater monitoring on selected ARs on the east coast of Malaysia to investigate fish assemblages and biomass near ARs. The findings estimated that 4.7 metric tonnes of fish biomass with a value of RM 66,618.00 was recorded at Cube ARs deployed in Kijal, Terengganu, while 3.1 metric tonnes of fish biomass worth around RM 49,876.20 at Cube ARs in Merchang, Terengganu (Muhammad Amirullah et al., 2020). It is assumed that pooling adult fishes near ARs enhances catchability, and therefore increases fishing mortality and reduces spawning stock biomass. In Malaysia, the goal of restoring depleting fish stock in coastal areas has not been fully achieved by the deployment of ARs. Resource surveys within the coastal areas still demonstrate a steady decline in catch rates. However ARs do improve the catch and income of some traditional fishers and at the same time deter illegal trawling in coastal waters (Saharudin et al., 2012).



In conclusion, ARs may be a practical tool to improve coastal marine environments and enhance fish biomass and abundance when adequately managed. Proper management before and after deployment, and the use of suitable material, as well as proper site selection, construction, deployment, monitoring, and assessment, are the crucial factors in determine ARs' efficiency in enhancing fish resources. ARs may also aggregate juvenile fish, making them more vulnerable to capture and thus contributing to overfishing.

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## The Use of Stock-Production Model Incorporating Covariates (ASPIC) for Stock Assessment of Selected Fish Species in the South China Sea and Sulu Sulawesi Sea

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### Materials and Methods

A total of twelve analyses were carried out in the SCS and SSS based on catch and fishing effort (number of vessels) data and ten fish species were selected in the analysis, as in Figure 1.

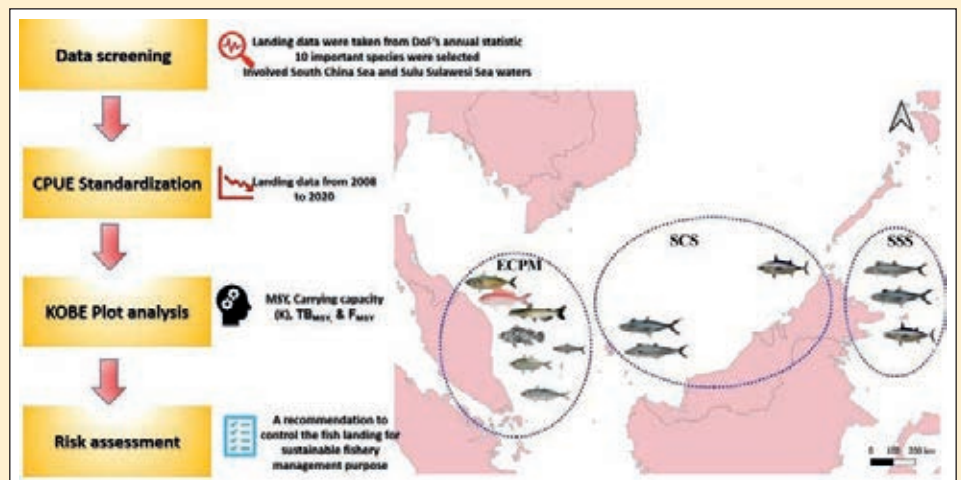


Fig. 1: The flowchart of material and methods used to analyse 10 selected species from the South China Sea (SCS) and Sulu Sulawesi Sea (SSS).

### Introduction

The South China Sea (SCS) homes several world's richest reef systems and over 3000 indigenous and migratory fish. This makes the SCS one of the richest in biodiversity. Without proper fish stock assessment in SCS waters, fisheries resources could potentially collapse and might be in serious jeopardy.

Fish stock assessment involves numerous statistical and mathematical calculations and methods (Hilborn et al., 1992; Jacobson et al., 2002). The common method uses the standardized catch rate or catch per unit effort (CPUE) as the proxy for stock abundance (Maunder & Punt, 2004), which is then predicted into current stock abundance and maximum sustainable yield (MSY) (Methot & Wetzel, 2013) of targeted fish. The present analysis use the application of the stock-production model incorporating covariates (ASPIC) using CPUE data (Prager, 1994) approach.

ASPIC is used to investigate the stock status of selected fishes. The concept of the biomass dynamic assessment is the same as the surplus model, whereby the standardized CPUE is used as the proxy for the abundance of the population being exploited in the targeted area (Prasetyo et al., 2018). This analysis aims to estimate the recommended MSY value as a harvest boundary to minimize stock collapse (Quinn & Collie, 2005). The early methods of fish stock assessment models assumed that fish stocks were at an equilibrium state (Maunder et al., 2006; Prager, 1994; Walters & Parma, 1996). However, due to changes in biotic and abiotic conditions (Razzaq et al., 2019), a non-equilibrium state of fish stock is also considered for MSY estimation level (Prasetyo et al., 2018). The ASPIC model could also address the issues of the earlier described methods, based on data availability, by applying the surplus-calculation approach for stock assessment analysis.

Therefore, this study aimed to investigate the stock status of selected fish species in the SCS and Sulu Sulawesi Sea (SSS) using the ASPIC model.

### Results and Discussion

To determine the stock status in the SCS and SSS, the twelve (12) analyses on ten (10) selected species were conducted using ASPIC. The results and the Kobe plots were as in Figure 2 and Table 1. Figure 2 presents the estimates of current stock size (TB) and current fishing mortality (F) in relation to optimal spawning stock size and optimal fishing mortality. The four phases to represent stock status are the orange (starting phase), green (safe zone), yellow (recovery zone), and red zones (overfished). The Kobe plots, reveal that two (2) out of ten (10) species in the stock status which were demersal (*Nemipterus* sp. and Groupers) and pelagic (*Rastrelliger kanagurta*) fishes on the east coast of Peninsular Malaysia were in the red quadrant, indicating that the species were overfished. The other species which were in the green quadrant were in a safe zone.

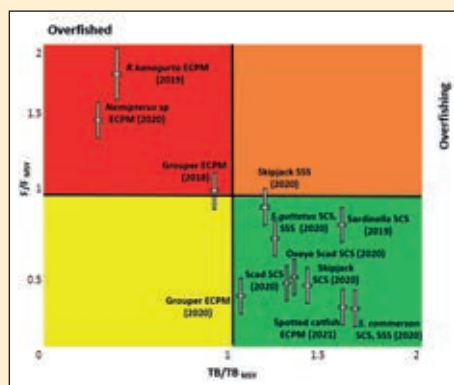


Fig. 2: The combined Kobe plot for 10 selected species in the South China Sea SCS and Sulu Sulawesi Sea SSS.

The Kobe II management strategy matrices (K2MSM) shows specific management measures that could achieve the intended management target within three to ten years. Fisheries managers would then be able to decide on management strategies based on the risk level and time frame, which are appropriate for fisheries. The summary of probabilities (%) infringing or violating TBMSY and FMSY within three years and ten years for all selected species is shown in Table 1.

### Case study of *Nemipterus* sp.

The *Nemipterus* sp. was selected as one of the case studies used for this analysis. The stock status of this species was in the red zone (overfished) in 2020. The Kobe II management strategy matrices (K2MSM) was conducted in that year, and the output showed that the catch of *Nemipterus* sp. was the average catch in the past three years (2018–2020), which was 17,427 tonnes, exceeding the maximum limit of sustainable yield (MSY) of 16,060 tonnes. For the stock to be below the MSY limit, the catch must be reduced by 30 to 40 per cent from the current catch to make sure that within three to ten years, the catch would be less than 50 per cent of the MSY level. The summary of the risk assessment is presented in Table 1.

### Case study of Grouper species

The number of the catch of Grouper species exceeded the maximum limit of MSY in 2018, indicating that the stock was overexploited and experiencing overfishing according to TB/TBMSY and F/FMSY. However, the catch recorded in the ECPM in 2020 was in the safe zone (green zone). If the current catch is maintained at 1,949 tonnes, it is anticipated that the catch will remain at a safe level (green zone) for the next 10 years, with 2 per cent of TB/TBMSY and 0 per cent of F/FMSY to violate the MSY limit.

### Case study of Indian mackerel

The current catch of Indian mackerel (*R. kanagurta*) in the ECPM area was still below the MSY level. However, the percentage of F mortality at the FMSY level was above 89 per cent and the total biomass (TB) of the TBMSY (TB/TBMSY) was only 36 per cent. Therefore, it is advised to decrease the current catch to 20 per cent within the next three years and 30 per cent in the next ten years to ensure the status of the catch will be at least at the recovery zone (orange zone).

### Case study of Skipjack in SSS

Skipjack in the SSS has the potential to cross the overfishing zone (orange zone), which was 51 per cent compared to the green zone at 49 per cent. Following this situation, the fisheries management must take precautions to ensure that this species does not enter an

overfished zone (red zone) in the coming years. Other species in the green zone could still be explored as they were in the safe stock.

In conclusion, the stocks that were in the green zone are considered safe and could still be explored. However, the management needs to ensure that the stock will still be in the green zone for the next ten years to ensure adequate fish supply in the future. For species in the red zone, the management must plan a strategy to return the stock status to the safe level to ensure sustainable fishery resources by emphasizing conservation efforts.

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**Table 1: Summary of ASPIC analysis on 10 selected species in South China Sea SCS and SSS, including management recommendations for red zone species.**

No.	Year	Area	English Name	Malay Name	Scientific Name	Group	Current Catch (Tonnes)	Msy (Tonnes)	FMSY	TBMSY	F/ FMSY	TB/ TBMSY	Status	Recommendations	
														3 years	10 years
1.	2019	ECPM	Indian Mackerel	Kembong Borek	Rastrelliger Kanagurta	Pelagic	19,363	27,410	0.2885	95,000	1.892	0.3682	94%	To reduce the current catch to 30%	To reduce the current catch to 30%
2.	2020	ECPM	Threadfin bream	Kerisi	Nemipterus spp.	Demersal	17,427	16,060	0.247	65,000	1.577	0.6964	86%	To reduce the current catch to 40%	To reduce the current catch to 30%
3.	2020	ECPM	Oxeye scad	Selar	Selar boops	Pelagic	9,137	17,180	0.1637	105,000	0.3703	1.386	77%		
4.	2020	ECPM	Scad	Selayang	Decapterus spp.	Pelagic	27,472	45,710	0.3108	147,000	0.377	1.433	64%		
5.	2019	SCS	Sardinella	Tamban	Sardinella spp.	Pelagic	7,143	9,231	0.577	16,000	0.6381	1.421	99%		
6.	2020	SCS & SSS	Indo Pacific King Mackerel	Tenggiri Papan	Scomberomorus Guttatus	Pelagic Pelagic	6,955 6,955	7,756 7,756	0.4082 0.4082	19,000 19,000	0.6918 0.6918	1.228 1.228	100% 100%		
7.	2020	SCS&SSS	Narrow Barred Spanish Mackerel	Tenggiri Batang	Scomberomorus Commerson	Pelagic Pelagic	1,866 1,866	3,981 3,981	0.5308 0.5308	7,500 7,500	0.2394 0.2394	1,742 1,742	99% 99%		
8.	2020	SSS	Skipjack	Tuna jalur	Katsuwonus Pelamis	Oceanic Tuna	4,548	4,458	0.0541	7,725	0.974	1.282	49%		
9.	2020	SCS	Skipjack	Tuna jalur	Katsuwonus Pelamis	Oceanic Tuna	8,696	9,119	0.48	19,000	0.466	1.479	86%		
10.	2021	ECPM	Spotted catfish	Duri/Otek	Arius maculatus	Demersal	1,439	2,781	0.4279	6,500	0.3388	1.687	100%	Maintain/reduce the current catch	
11.	2018	ECPM	Grouper	Kerapu	Epinephelinae	Demersal	1,612	2,484	0.656	15,000	1.309	0.504	80%		
12.	2020	ECPM	Grouper	Kerapu	Epinephelinae	Demersal	1,949	2,959	0.2573	11,500	0.486	1.07	53%		

## The Establishment of the Giant Tiger Prawn (*Penaeus monodon*) Refugia in the South China Sea at Kuala Baram, Miri, Sarawak

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### Introduction

The South China Sea (SCS) is a marginal sea surrounded by several countries including Malaysia, Indonesia, the Philippines, Taiwan, and Vietnam. To meet the challenges of unsustainable exploitation and irreversible damage to the SCS, collaboration and cooperation between countries are needed to establish legal frameworks that cover the area of mutual interest. Therefore, the initiative 'Establishment and Operation of a Regional System of Fisheries Refugia in the South China Sea and the Gulf of Thailand' was developed by SEAFDEC/UNEP/GEF to meet this need via the fisheries component of the Strategic Action Programme for the South China Sea. This initiative has been initiated and funded by SEAFDEC-UNEP-GEF with participation from six member countries, namely Malaysia, Cambodia, Thailand, Vietnam, Indonesia, and the Philippines. In Malaysia, Kuala Baram in Miri, Sarawak has been chosen as one of the sites for the establishment of refugia for candidate species, the Giant Tiger Prawn

(*Penaeus monodon* Fabricius), as part of a mitigation measure. The offshore area of Kuala Baram in Miri, Sarawak, which sloops into deep water (as close as 4 nautical miles) facing the SCS was indicated as the last frontier for tiger prawn in Malaysia (Hadil and Albert, 2001; Hadil, 2004; Hadil, 2007; Hadil, 2014). The objective of the study was to obtain information on the current distribution, density and biomass of tiger prawn spawners in the proposed refugia area.

### Materials and Methods

The study was conducted using both primary and secondary data. The first approach involved a resource survey on Giant Tiger Prawn at the proposed 370 km<sup>2</sup> refugia in Kuala Baram waters, Miri, Sarawak. An out-rigged trawler, SF3-221, was deployed to do the task. The sampling commenced on 24 until 26 August 2019. Figure 1 presents a map of the stations of the Giant Tiger Prawn. In 2014, Stations 7 to 10 were the stations for the study of tiger prawn spawners, whereas stations 1 to 6 were the stations in 2019.



Fig 1: Map showing stations 1 to 10

Samples were collected using the swept area method, particularly the bottom trawl, to determine the density of tiger prawn per square nautical mile. In the current study, the trawl sweeps or paths are called the 'swept area' or the 'effective path swept'. The trawling duration ranged from 2.0 to 2.25 hours, with an average speed of 2.0 knots. The trawling duration and speed varied because of the limited area to maneuver, since a big portion of the coastal waters of Kuala Baram were oilfields. The swept area was estimated using the equation as follows:

$$a = D \cdot h \cdot x, D = V \cdot t,$$

where V is the velocity of the trawl over the ground during trawling, t is the time spent trawling, h is the length of the headrope, and x is that fraction of the headrope which is equal to the width of the path swept by the trawl. For South East Asia, the x-values suggested are from 0.4 to 0.66 (Shindo 1973, SCSP 1978). However, Pauly (1980) suggests 0.5 as the best compromise x-value for tropical waters. In this study, the value of 0.5 was adopted.

The water depth and quality (including temperature, pH, dissolved oxygen, and salinity) were recorded. Once the catch was brought aboard, large-sized fish and prawns, as well as dangerous and poisonous specimens were separated. All commercial species, regardless of size, were weighed and recorded. The caught tiger prawns were weighed and measured to the nearest millimeter in terms of total and carapace lengths.

The density of the tiger prawn was calculated from the catch rates recorded in kg/hour from this survey. If the weight of catch per haul was Cw, then Cw/t was the catch per hour when t, was the duration of the trawl haul. If 'a' is the area swept by the trawl haul, the a/t represented the area swept per hour. In this survey, an hour of trawling with a trawl net which headrope measured 24.8 m in length, covering the swept area. For SF3-221, two nets were used simultaneously, resulting in the total headrope used for the calculation of biomass being 49.6 m. With one nautical mile equals 1852 meters, the equation for the weight of catch per unit area was:

$$(Cw/t) / (a/t) = Cw/a \text{ kg per sq. nm}$$

The mean weight of catch per unit area (Cw/a) was divided by q (catchability coefficient) equated to the average biomass per unit area. The catchability coefficient represented the amount of the tiger prawn caught by the trawl relative to the amount that escaped capture. In the events when q = 1.0, all the prawns in the path of the trawl were assumed to have been caught. Thus, the biomass, B, of the entire study area, A, was:

$$B = (Cw/a) / q \cdot A$$

The second approach used a stock assessment tool using the Surplus Production Model. This model is among the simplest, yet most widely

used in the stock assessment to estimate maximum sustainable yield (MSY) and the corresponding optimum fishing effort (Singh, 2011). This model could be computed with fewer input data unlike analytic models. To operate this model, catch and effort data are needed as input data. Moreover, the Schaefer model is the most commonly used among SPMs (known also as Biomass Dynamic Models) (Schaefer, 1954). This model is based exactly on the logistic population growth model.

The catch per effort or yield per unit of effort is designated as Y/f. The Y/f is a function of effort, 'f'. MSY could be computed from equation (1) in the Schaefer model:

$$Y(f)/f(i) = a + b \cdot x \cdot f(i)$$

The slope 'b' is negative if the catch per unit effort y/f decreases for increasing effort. This model implies that one effort level for which the y/f value obtained just after the first boat fishes on the stock for the first time corresponds to one y/f value. Hence, the intercept value is positive. Thus, -a/b is positive, and y/f is zero for f = -a/b as the negative value of catch per unit effort, y/f is will not be a reality, this model applies to f values lower than '-a/b'.

$$MSY = -0.25a^2/b$$

$$FMSY = -0.5 \cdot a/b$$

## Results and Discussion

### Density and biomass of *P. monodon*

A total of six hauls were recorded from six different locations. Location, water depth, and water quality were presented in Table 1. *P. monodon* was caught in locations 1, 2, and 3, with the highest concentration in location 3. These three locations from the tip of Kuala Baram were in the range of 8.27–10.67 km (4.47–5.76 nm). A total of 95 tails (9,027.2 g) of *P. monodon* were caught within a 10-meter water depth. The catch included 51 male and 44 female tiger prawns. The total length of male prawns caught was 196–234 mm, and weighed 53.4–116.8 g. Whereas for female prawns, the total length ranged from 221 to 284 mm, and weighed 87.4–189.8 g. In addition, a majority (45 %) of the spawners shed eggs, while 16 per cent of them were ready to spawn.

The carapace length ranged from 45 to 59 mm for males, whereas females ranged from 54 to 72 mm. According to Motoh (1981), the minimum size at maturity was 37 mm carapace length for males and 47 mm carapace length for females. The estimated average density of *P. monodon* on the proposed site was 13.92 kg/km<sup>2</sup> and its biomass was estimated at 10.3 tonnes. The findings of the current study revealed that the proposed refugia site has a high density of tiger prawns with spawning females, which is in line with a previous study by Hadil (2014).

However, the biomass of *P. monodon* resources in the current study was observed over a limited time. Better estimated biomass could be achieved using the average results from a series of studies to provide a better actual landing stock.

### Landing and CPUE trend

The annual landing of tiger prawn in Kuala Baram during a ten-year period (2011–2020) was derived from the Annual Fisheries Statistics (Department of Fisheries Malaysia, 2020) and elucidated in Figure 2. In general, the landing trend fluctuated, with an increasing trend from 2011–2015, which peaked in 2015 (22,245.20 kg), followed by a downward trend in 2016 and another ascending trend from 2018 to 2020 (12,092.70 kg). The catch per unit effort also showed a similar fluctuation trend to the landing data.



Fig. 2: Landing and CPUE of *Penaeus monodon* in Kuala Baram, Miri, Sarawak (2011–2020)

### Surplus Production Model

The stock and risk assessment of the Giant Tiger Prawn species using the Surplus Production Model (Schaefer, 1989) showed that the status of this species in Kuala Baram was 127, 96.66 kg, which was within the maximum sustainable yield (MSY). However, in 2015 and 2016, the number exceeded the MSY (see Figure 3) due to more capture effort of the species around that period as the landing of all species was high (Fisheries Statistics, DOF, 2015; 2016).

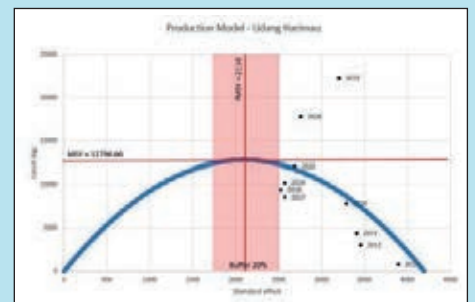


Fig. 3: Surplus Production Model for *Penaeus monodon* (2011–2020)

Starting from 2017, the MSY level decreased until 2020 due to the establishment of refugia in SCS, which began in 2017. The refugia programme included a series of consultations with fishermen who caught this species. A series of socioeconomic surveys were also carried out in the refugia to assess the community acceptance of the refugia concept for fisheries management in their respective areas. For instance, in 2016, the Sarawak State Fisheries Office assisted a local university in Sarawak (UiTM) to conduct a socioeconomic survey of fishermen in four areas in Miri (JPLS).

## Conclusion

In conclusion, annual experimental surveys and monitoring of commercial fishing boat performances should be carried out to confirm the status of known fisheries and to assess the efficacy of management measures such as refugia. The current study discovered that the Giant Tiger Prawn resources in this designated refugia area should be maintained at their current levels, but with a precautionary approach to fishing. New and additional information should also be made available for the development of new products and the refinement of existing ones.

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Table 1. A species checklist of four ARs in Mukah waters, Sarawak

FAMILY / SPECIES	COMMON NAME	Number Of Individuals Observed (n)		
		CUBOID	PROKA	REEFBALL
<b>Family Apogonidae</b>				
1. <i>Apogonichthysoides sialis</i>	Twinbar Cardinalfish	10	-	-
2. <i>Ostorhinchus neotes</i>	Mini Cardinalfish	29	-	30
3. <i>Ostorhinchus</i> sp.	-	-	-	22
<b>Family Caesionidae</b>				
4. <i>Caesio cunning</i>	Redbelly Yellowtail Fusilier	-	60	40
5. <i>Pterocaesio chrysozona</i>	Goldband Fusilier	200	-	-
<b>Family Carangidae</b>				
6. <i>Alectis indica</i>	Diamond Trevally	1	-	5
7. <i>Atule mate</i>	Yellowtail Scad	1	-	-
8. <i>Carangoides malabaricus</i>	Malabar Trevally	-	-	5
9. <i>Caranx sexfasciatus</i>	Bigeye Trevally	4	-	34
10. <i>Gnathanodon speciosus</i>	Golden Trevally	7	-	-
11. <i>Selaroides leptolepis</i>	Yellowstripe Scad	-	-	240
12. <i>Selaroides</i> sp.	-	1	-	-
<b>Family Chaetodontidae</b>				
13. <i>Chelmon rostratus</i>	Copperbanded Butterflyfish	1	4	-
14. <i>Heniochus diphreutes</i>	Schooling Bannerfish	2	1	-
<b>Family Dasyatidae</b>				
15. <i>Himantura leoparda</i>	Leopard Whipray	1	-	-
16. <i>Taeniura lymma</i>	Bluespotted Ribbontail Ray	-	-	1
<b>Family Echeneidae</b>				
17. <i>Echeneis naucrates</i>	Live Sharksucker	-	-	1
<b>Family Ehippiidae</b>				
18. <i>Platax teira</i>	Spotbelly Batfish	1	4	-
<b>Family Haemulidae</b>				
19. <i>Diagramma pictum</i>	Painted Sweetlips	3	-	1
<b>Family Leiognathidae</b>				
20. <i>Gazza minuta</i>	Toothed Ponyfish	100	-	-
<b>Family Lethrinidae</b>				
21. <i>Lethrinus lentjan</i>	Redspot Emperor	-	16	-
<b>Family Lophiidae</b>				
22. <i>Lophiomus setigerus</i>	Striped Angler	-	-	1
<b>Family Lutjanidae</b>				
23. <i>Lutjanus gibbus</i>	Humpback Red Snapper	3	-	-
24. <i>Lutjanus johnii</i>	John's Snapper	73	2	3
25. <i>Lutjanus lutjanus</i>	Bigeye Snapper	1002	2	161
26. <i>Lutjanus madras</i>	Indian Snapper	4	-	-
27. <i>Lutjanus russellii</i>	Russell's Snapper	1	2	15
28. <i>Lutjanus vitta</i>	Brownstripe Snapper	451	2	8
<b>Family Muraenidae</b>				
29. <i>Gymnothorax reevesii</i>	Reeve's Moray	-	-	2
<b>Family Nemipteridae</b>				
30. <i>Scolopsis vosmeri</i>	Whitecheek Monocle Bream	-	2	8
<b>Family Pomacanthidae</b>				
31. <i>Pomacanthus annularis</i>	Blueringed Angelfish	1	6	2
<b>Family Pomacentridae</b>				
32. <i>Chromis chromis</i>	Damselfish	2	-	20
33. <i>Chromis</i> sp.	-	2	-	-
34. <i>Chrysiptera parasema</i>	Yellowtail Damselfish	46	2	30
35. <i>Chrysiptera rollandi</i>	Rolland's Demoiselle	-	-	9
36. <i>Dascyllus</i> sp.	-	-	-	8
<b>Family Scombridae</b>				
37. <i>Scomberomorus commerson</i>	Narrowbarred Mackerel	1	-	-
<b>Family Serranidae</b>				
38. <i>Cephalopolis boenak</i>	Brownbarred Rockcod	9	16	16
39. <i>Diploprion bifasciatum</i>	Barred Soapfish	1	2	-
40. <i>Epinephelus erythrurus</i>	Cloudy Grouper	-	-	1
41. <i>Epinephelus fuscoguttatus</i>	Brownmarbled Grouper	1	-	-
42. <i>Epinephelus maculatus</i>	Highfin Grouper	-	1	-
43. <i>Plectropomus leopardus</i>	Leopard Coralgrouper	2	1	-
<b>Family Sphyraenidae</b>				
44. <i>Sphyraena jello</i>	Pickhandle Barracuda	101	-	-
<b>NUMBER OF INDIVIDUALS</b>		<b>2,061</b>	<b>663</b>	
<b>NUMBER OF SPECIES</b>		<b>30</b>	<b>24</b>	
<b>NUMBER OF FAMILIES</b>		<b>14</b>	<b>13</b>	

## Artificial Reef Fish Communities in Mukah, Sarawak, Malaysia

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The diversity and community structure of fish in water bodies are important to characterise the development of adequate conservation strategies (Pino-Del-Carpio et al., 2014). With the worries about the declining number of reef fish and fish stock in Malaysia, artificial reefs (ARs) are introduced as alternatives in the rehabilitation of fish populations. In Sarawak, ARs deployments started in 1984. Since then, there are a total of 25 ARs sites deployed. This article provides information on fish communities of four ARs in Sarawak waters.

A total of twenty units of reef balls, six units of cuboid ARs, and eight units of coral propagation ARs were surveyed in Mukah waters in April and May 2021. The ARs were first deployed by Jabatan Perikanan Laut Sarawak (JPLS) in 2006. A fish community survey was conducted by first using fishing method for an hour, and then scuba diving for a visual survey. Mainly, baited fishing and seven eyes rigs were utilised for sample capturing. Species identification was done on each captured individual and recorded. For the visual survey, scuba divers went underwater for a period of one to three hours and observed all the individual fish surrounding the ARs. Every observed species was then identified and recorded according to their respective species.

The results from the survey of three different sites documented a total of 44 fish species. The highest number of species was found at the cuboid ARs (30 species), followed by reef balls (24 species), and coral propagation ARs (16 species) (see Table 1). The number of individuals recorded was the highest at cuboid ARs (n = 2061), followed by reef ball (n = 663), and coral propagation ARs (n = 123). Based on Shannon's diversity analysis conducted on all the sites, reef balls yielded the highest species diversity with  $H' = 2.12$ , followed by coral propagation ARs ( $H' = 1.84$ ) and cuboid ARs ( $H' = 1.65$ ).

The most dominant family observed in cuboid ARs was Lutjanidae (74 %). This could be due to the high density of small-prey species that serves as the main diet for predator species such as snapper (*Lutjanus* sp.). The high density of snappers may also be the result of schooling behaviour for juveniles and sub-adult snappers, which tend to aggregate at feeding sites and serve as a protective mechanism against larger predators.

The visual survey identified higher individuals and species compared to the fishing method. The use of unsuitable baits and rigs might affect the fishing method as certain baits and rigs only targeted specific fish species.

Thus for the future survey, it is recommended to adopt a visual underwater survey. Nevertheless, different baits and rigs could also be utilised to increase the range of fish captured. Also, species from the Family Chaetodontidae are commonly found in the reef surroundings. As a result, it is deduced that butterflyfish could act as a biological indicator for reef health (Reese, 1981). However, during this survey, a minimal count of butterflyfish was recorded at the sampling sites. The survey will be continued in the year 2022 to obtain more evidence of the effectiveness of each type of ARs.



A = Fishing survey being conducted pre-diving



B = An individual *Lutjanus johnii* (John's Snapper) recorded at an artificial reef



C = Survey at one of the cuboid artificial reefs

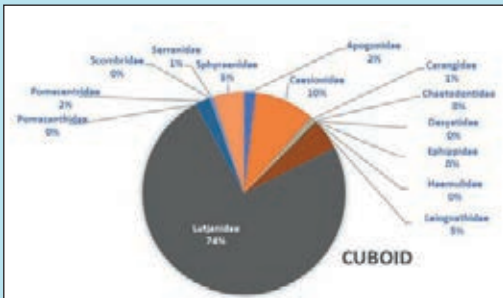


Fig. 3: Fish families and their percentage (%) for cuboid ARs

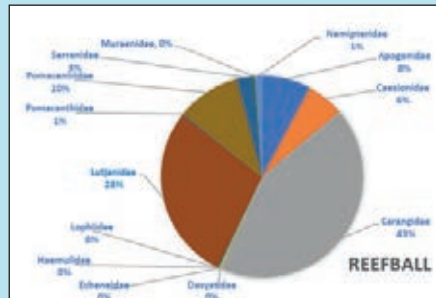


Fig. 4: Fish families and their percentage (%) for reef ball

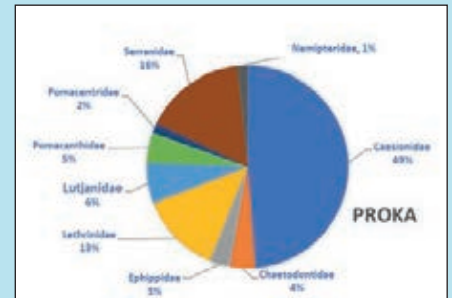


Fig. 5: Fish families and their percentage (%) for coral propagation (PROKA) ARs

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# Research Update

## Fish Landing by Zone and Species Composition in Kuching, Sarawak

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Capture fisheries has been the main livelihood of fishermen in Malaysia, contributing to the nation's economy. The Fisheries Research Institute Bintawa, Sarawak conducted a study on the Oceanic Fisheries Resources and Capture Fisheries Bio-Socioeconomic study from 2021 to 2024 as part of the Twelve Malaysia Plan (RMK-12) in order to gain a comprehensive understanding of Sarawak's capture fisheries.

This article presents a bio-socioeconomy study conducted in Sarawak waters, which are connected to the South China Sea (SCS), the main surrounding ocean. The objectives of the study were: 1. to determine the resource status based on MSY, MEY, and optimal catch capacity for oceanic tuna resources and capture fisheries; 2. to determine the living status and dependence of fishermen on fishing activities; 3. to evaluate the cost and returns from all types of fishing activities conducted. The samples selected were based on common commercially landed fish species actively caught by local fishermen, the main fishing gears used, and the active and prominent operating fish landing sites in Sarawak.

A total of 18 fish species were observed in this study (Table 1). The respondents were active operators of fishing zone A to zone C2 in three regions: Region 1 (Kuching, Sematan, Santubong, Sadong Jaya, Sebuyau, and Kabong); Region 2 (Sibu, Mukah, Sarikei, Belawai, Daro, and Tanjung Manis); and

Region 3 (Miri, Bintulu, Limbang, and Lawas). A total of six landing sites were chosen as the main locations for sampling. For Region 1, the Malaysian Fisheries Development Authority (LKIM) fish landing jetty at Tanjung Bako and the Sampadi fish landing jetty in Lundu.

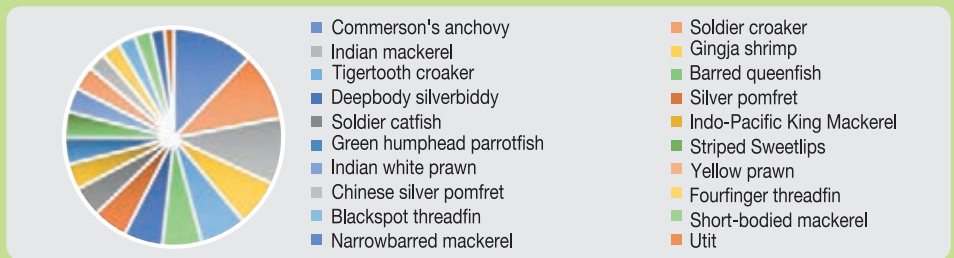


Fig 1: Species in Zone A of Kuching region

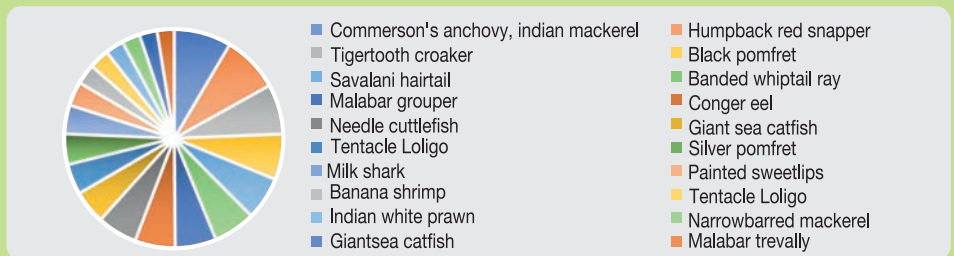


Fig 2: Species in Zone C of Kuching region

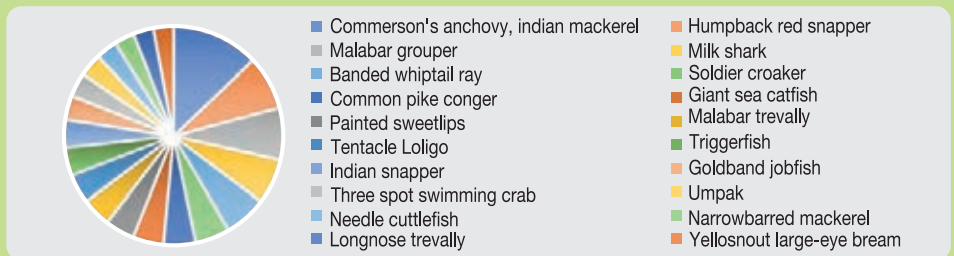


Fig 2: Species in Zone C2 of Kuching region

Figure 1 shows Zone A was dominated by anchovies, Indian mackerels, and soldier croakers. The least species captured from this zone was Utit, followed by Indian mackerel, short-bodied mackerel, and fourfinger threadfin. The species caught within this zone were pelagic fishes and its small by catches were demersal fishes. As in Figure 2, more demersal species, such as grouper, needle cuttlefish, and milk shark, contributed to increased captured landing weight. These demersal species are slightly expensive on the market, generating

more income for local fishermen. On the other hand, more expensive species were captured in Zone C2 compared to Zone A and C. Zone C2 generated higher landing records for species like milk shark, common pike conger, red snapper, banded whiptail ray, longnose trevally, and other highly-priced demersal species (Figure 3). However, the species composition may differ from other regions, including Sibuluan and Miri, as the geographical areas of each region are different. Some regions have deeper or shallower waters suitable for high-priced

demersal or pelagic species, depending on the fishing gear used in the operation.

Based on the results obtained in the current study, Kuching still has a high biodiversity of fish species as its maximum sustainable yield (MSY) and maximum economic yield (MEY) are still in safe zones. However, more consistent studies are still needed to ensure that the status of fish diversity and fish stock in Sarawak waters are still under control and well exploited according to the stock assessment tools used.

## Microplastics pollution in the South China Sea: To what extent?

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Marine plastic pollution has been a heated topic discussed among scientists, activists, and even civilians in recent years. A study conducted by the University of Plymouth asserts that plastic contamination in the marine environment has been increasing consequentially since the 1990s with the discovery of larger plastic items such as bags, ropes, and fishing nets in the North Atlantic. Due to the consistent demand for plastic globally over the past decades among consumers, owing to its durability, lightweight, and cost effectiveness, plastic has rapidly grown as the municipal waste stream between 1950 and 2003.

Pollution of plastic does not only perturb developing countries, but also advanced European countries. Plastic botching on the terrestrial area would then flow through rivers and estuaries, before finally arriving at the ocean. According to a study in the Science journal, scientists estimated that in 2016 between 19 to 23 metric tonnes (MT) of plastic had found its way into rivers and oceans. Another preceding study from the journal Science estimates about 8.5 MT of plastic ends up in the oceans yearly. This is ascertained by a study in 2014 that estimated about 250,000 tonnes of plastic were floating on the ocean surface. Upon entering the ocean, plastics are exposed to ultraviolet light (UV) and constantly low temperature, causing them to break down, becoming brittle and soon defragmented into smaller fragments, referred to as microplastics.

Microplastics can be defined as tiny plastic particles with sizes less than 5 millimeters (mm) and are ubiquitous in marine waters. There are two sources of microplastics, primary and secondary sources. The primary sources can be defined as small plastics that are purposely manufactured for industrial applications such as toothpaste and facial scrubs. Secondary sources are plastics discarded into oceans and disintegrate under ultraviolet radiation or mechanical wearing.

## Microplastics in the South China Sea: Malaysia region

The South China Sea (SCS) is circumscribed by a few countries including China, the Philippines, Indonesia, Malaysia, Thailand, and Vietnam, which are estimated as the top ten countries contributing plastic waste from land to sea. Microplastics studies in the SCS region of Malaysia were first published in 2018, comprising of Terengganu and Pahang states, yet most microplastics studies were centered in Terengganu, the east coast of Peninsular Malaysia.

In 2020, Universiti Malaysia Terengganu (UMT) discovered an average of 1 plastic particle in 130 individuals in microplastic ingestion by

zooplankton in Terengganu coastal waters. The study also discovered that the average abundance of the occurrence of microplastics on seawater surfaces was 3.3 particles/L, with fibers being the dominant type. Interestingly, the polyamide fibers, generally utilised in ropes, gears, and fishing lines, were ingested by zooplankton, highly correlating with the total concentration of microplastics in seawater. The results are aligned with a recent study in Terengganu offshore waters in 2021 that finds fibers to be the most presiding types of microplastics in the seawater, along with other zooplankton species. Another study documented the occurrence of microplastics in the gastrointestinal tract (GIT) of *Thunnus tonggol*, with an average ingestion rate of 23.7 particles/individual (Photo 1).

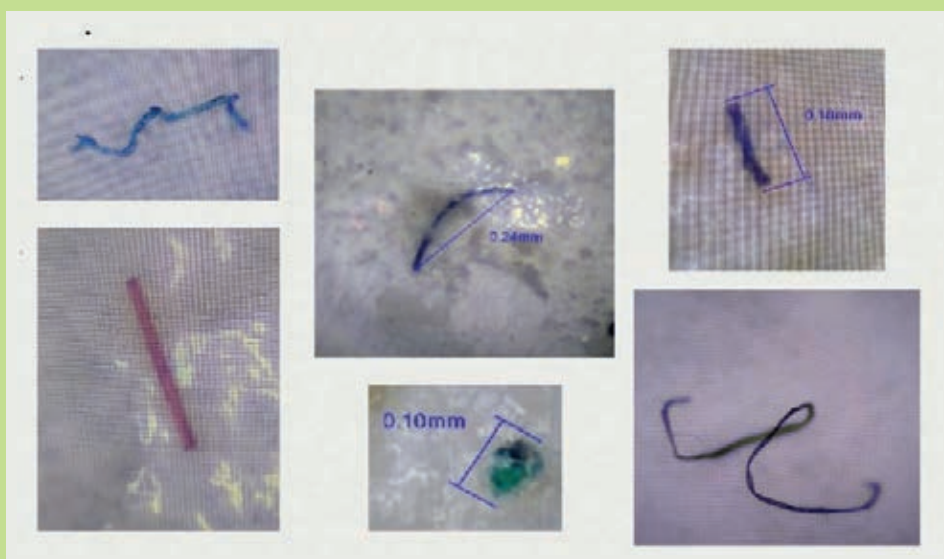


Photo 1: Microplastic fibers that were found in GIT of *Thunnus tonggol* captured from Terengganu

The baseline study found microplastics in all stations, with a mean abundance ranging from 0.13 to 0.69 particles/L. The polymers identified in this study included polyester, polystyrene, polyamide, polyvinyl chloride, and polyethylene (PET). The mentioned polymers are widely used by humans, especially PET and polystyrene, which are mostly manufactured as food and drink packaging.

## Microplastics in the South China Sea: China region

In comparison, the China region of SCS records a higher abundance of microplastics in its surface water. Microplastic pollution is recorded in the sea waters at Meiji Reef, Chigua Reef, and Huayang Reef with a total abundance of 18.6, 0.5, and 1.0 particles/L, respectively. Abundance of microplastics was also recorded in biota collected from sea areas that were close to China. Results indicated that microplastic abundance was at 1 to 5 particles/individual from soft tissue and GIT of different marine species. The abundance may be influenced by factors such as monsoon, hydrodynamic features, and possibly a feasible 'hotspot' of microplastic accumulation.

Contrary to Malaysia, microplastic shapes that were found the most in the China region were films, followed by fibers. This may signal different sources of microplastic pollution between these two areas. The main composition of microplastics was the secondary source of microplastics: polyolefins, which is usually produced as grocery bags, and food wrappers, as well as heavily used in the agricultural sector in certain coastal areas.

## Impacts on marine organisms

Microplastic pollution is not only impacting the environment but also affecting organisms inhabiting the coastal area. Based on the results presented above, the mean value of microplastics in the surface water of SCS is higher than what is estimated for the world's ocean. The results show that fishes have been ingesting microplastics and evidence is found in their GIT. Other marine organisms such as mollusks, crustaceans (Photo 2), gastropods, and corals (Photo 3) are found with microplastics in their tissues. Even though the negative effects of microplastic ingestion are still controversial, laboratory studies show that exposure to microplastics increases stress response in organisms, some even impacting their behaviour, delaying growth, and causing reproductive impairment. Since few organisms are consumed as a whole by humans, the fatalistic effects of microplastics on aquatic organisms and human health should be studied in detail to avoid further serious problems.

As a preliminary conclusion, it is discovered that there is a large distribution of microplastic contamination along the South China Sea. Characteristics of polymers found indicate multiple sources of microplastics which are likely from land-based sources around the sea, due to improper management of plastics waste which is discarded into the ocean. An extensive solution is needed to combat the surge of ocean pollution. Solutions such as reducing plastic pollution through joint efforts of provinces surrounding the South China Sea to restrict plastic bag usage in all or part of their jurisdictions, which is currently performed by China, Indonesia, Malaysia, Vietnam, and the Philippines, should be continued and applauded. Continuous plastic waste monitoring while tackling the problem at the source is also vital for a sustainable future and to prevent the South China Sea from becoming a garbage patch, as the Great Pacific Garbage Patch in the central North Pacific Ocean has.

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Photo 2: Visible microplastic fibers under larval lobster's carapace. Courtesy: Madelyn Woods



Photo 3: Corals with microplastics in its tissue. Courtesy: Boston University

# Short Communication

## Is the Sea Cucumber Species in the Pulau Perhentian Marine Park of The South China Sea Protected and Flourished?

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The condition of coral reef habitats is reflected by the diversity of associated species, especially those that are considered indicator organisms (Skewes & Persson, 2017). Sea cucumbers are one of the bioindicator organisms to the health of coral reefs. They rely on their habitat for food and protection. In exchange, sea cucumbers contribute to the sea bottom cleaning by eating waste and detritus from the sea bottom (Aminur Rahman et al., 2015). This activity reorganises the bottom sediment and induces bioturbation on the benthic layers. As a result, the extirpation of holothurians has resulted in the hardening of the sea floor, thereby threatening the potential habitats for other benthic organisms (Bruckner et al., 2003).

However, the frequency of sea cucumber landings has declined since 2016, for instance in the State of Pahang (Department of Fisheries, Malaysia, Annual Statistics, 2011–2018). The loss of resources was reported due to foreign fishermen's encroachment into Malaysian waters (Bernama, 2015; Mohd Farhan, 2017; Nur Fazlizai, 2020; Hazelen, 2021). In May 2017, the Malaysian Maritime Enforcement Agency (MMEA) and DOFM confiscated three vessels transporting sea cucumbers, worth MYR 5 million near Pulau Tinggi, Johor. In July 2020 and July 2021, MMEA detained a few foreign fishing boats carrying 100 kg of sea cucumbers in Kemaman, Terengganu, and 200 kg of catch in Tok Bali, Kelantan, respectively.

Kamaruddin et al. (2009) reported a total of nineteen sea cucumber species in the Terengganu Marine Park Islands, with eight of the species unidentified. Later, Zaidnuddin and Forbes (2001) report observation of twelve species in the coral reef of Pulau Perhentian which are *Stichopus chloronotus*, *Stichopus vastus*, *Holothuria atra*, *Holothuria edulis*, *Bohadschia marmorata*, *Bohadschia argus*, *Actinophyga lecanora*, *A. miliaris*, *Synaptula lamperti*, *Pearsonothuria graeffei*, *Stichopus ocellatus* and *S. hermannii*.

A short study was carried out to determine the sea cucumber species distribution and the number of species in Pulau Perhentian Marine Park in August 2020. A free-roaming dive search was conducted to observe sea cucumber at selected six sampling sites in Pulau Perhentian Marine Park, Terengganu, three at Pulau Perhentian Kecil and three sites at the Pulau Perhentian Besar (Schmitt et al., 2002). All survey areas were at 5 m deep and each dive search was carried out for approximately 30 minutes. Sea cucumber species were determined using 'A taxonomic key and Field Guide to Sea Cucumber of Malaysia' (Forbes et al., 1999). The species, number, and length of sighted sea cucumbers were recorded.



Free roaming dive survey

Even though free-roaming dive search covered a wide search area along the reefs, only a few species were observed. We observed eight sea cucumber species which were *Stichopus chloronotus*, *Stichopus vastus*, *Holothuria atra*, *Holothuria edulis*, *Bohadschia marmorata*, *Bohadschia argus*, *Synaptula lamperti*, and *Pearsonothuria graeffei*. These species were of low commercial values in the sea cucumber trading. Also, the study found that most of the reefs were dominated by boulder coral from the Porites species, which formed forms small patches of fringing reefs.

*Actinophyga lecanora*, *A. miliaris*, *Stichopus ocellatus* and *Stichopus hermanni* were not observed during the survey. These four undiscovered species of sea cucumbers are large-sized species that are the targets of sea cucumber fishers. These species are important in the sea cucumber market and can normally be found at commercial size. Their breeding and nursery sites have yet to be discovered and the replacement rate from the juvenile stage is still undetermined.



*Actinophyga lecanora*



*Stichopus hermanni*



*Stichopus ocellatus*

The number of sea cucumber species found during this survey is lower than the species observed in the past. The previously common species such as *Stichopus ocellatus* and *S. hermanni* are not found during this survey. In the past, these species were easily found on the reef between the coral boulders and sand substrates due to their large size, and therefore could easily be distinguishable from the surrounding.

From our observation, we assume that the sea cucumber has not been properly protected in the park areas. We observe a lesser number of valuable species during this survey, hence are concerned with the sea cucumber population. The absence of the most sought-after sea cucumbers may indicate poaching activities in this area, supporting reports of confiscation by the local authority. Furthermore, the decline in the breeding population, habitat alteration, or climate change may also have impacted the population. This requires further observation and communication consultation with the local's communities to ascertain the relevant condition.

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# Short Communication

## Distribution of Heavy Metals in Fish from Selected Landing Sites in Pahang, Terengganu and Kelantan.

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Heavy metal contamination is considered persistent due to its toxicity property (Ansari et al. (2004). The presence of heavy metals in the aquatic environment may disrupt aquatic ecosystems through bioaccumulation and biomagnification. For instance, the exposure of marine organisms to excessive levels of heavy metals may cause organism growth inhibition, tissue and DNA damage, and the inability to generate new tissue (Gagan et al., 2016). The commonly found heavy metals in wastewaters include Arsenic (As), Cadmium (Cd), Chromium (Cr), Cuprum (Cu), Plumbum (Pb), Nickel (Ni), and Zinc (Zn). These metals enter the aquatic ecosystems by direct discharge through human activities such as domestic sewage, agriculture, mining, and metal-based industrial operations. This study is conducted to assess heavy metal contaminants in pelagic and demersal fishes from selected landing sites in three states facing the South China Sea: Pahang, Terengganu, and Kelantan.

Fish sampling was carried out from March 2017 to March 2018 at landing jetties in Kuantan, Pahang, Tok Bali, Kelantan, and Kuala Besut, Terengganu (see Table 1). The fishes were washed with deionized water and placed in a polyethylene bag and kept frozen (-20°C) until the analysis. A total of 0.5 g of fish tissue was measured and digested using a microwave digester for about an hour until its fully digested and then allowed to cool to room temperature. The solutions were diluted in 50 ml ultrapure water. Sample preparation for metal analysis was carried out as described in the EPA Method 200.8 (1994) and 6020 (CLP-M) (1998). The concentration of metals was determined using the Inductive Coupled Plasma Mass Spectrometer (ICP-MS) CX7500. Six metals were measured: Zn, Cu, As, Cd, Hg (Mercury), and Pb. A standard solution was used for calibration and the tuning of the ICP-MS was procured from Agilent Technologies. Metals concentrations were then presented in mg/kg.

Table 1: Sampling details					
No.	Species Name	Quantity (samples)	Weight (gram)	Length (cm)	Location
<b>Pelagic Fish</b>					
	<i>Rastrelliger kanagurta</i>	40	110 – 138	21.9 – 24.3	Kelantan
	<i>Rastrelliger brachysoma</i>	15	39 – 50	15.3 – 16.5	Terengganu
		10	39 – 50	15.3 – 16.5	Kuantan
	<i>Decapterus kuroides</i>	26	86 – 120	21.1 – 22.7	Terengganu
		12	8 – 120	20.7-21.8	Kuantan
	<i>Decapterus russelli</i>	46	60 – 89	18.7 – 21.1	Kelantan
<b>Demersal Fish</b>					
	<i>Nemipterus furcosus</i>	73	132 – 149	22.0 – 22.8	Kelantan
		4	209 – 220	24.0 – 27.6	Terengganu
		10	209 – 218	24.0 – 27.5	Kuantan
	<i>Pennahia anea</i>	5	55 – 80	15.5 – 18.7	Kelantan
	<i>Pennahia pawak</i>	13	102 – 180	12.8 – 19.6	Terengganu
		10	110 – 125	20.4 – 22.5	Kuantan
		34	100 – 130	20.3 – 23.3	Kelantan
<b>TOTAL</b>		<b>298</b>			

**Table 2** shows the metal concentration recorded in the current study. The total concentration of As, Cd, Hg, and Pb in pelagic fish was below the recommended levels stated in the Malaysia Food Act (MFA) (1983). However, the Hg level was found higher in demersal fish samples from Kuala Besut (1.40 mg/kg), whereas the level was observed to be close to the MFA standard in demersal fish samples from Kelantan and Pahang with 0.98 mg/kg and 0.88 mg/kg, respectively. As a result, the high Hg level in demersal fish from Terengganu, Kelantan, and Pahang warrant close monitoring and the source of contamination should be further investigated.

Table 2: Metal concentrations in fish tissues (mg/kg)						
Location	Type	No. of specimens	Elements			
			As	Cd	Hg	Pb
Pahang	Pelagic	22	1.19	0.04	0.01	0.16
	Demersal	20	1.27	0.03	<b>0.88</b>	0.19
Kelantan	Pelagic	86	0.81	0.03	0.07	0.16
	Demersal	112	4.67	0.01	<b>0.98</b>	0.19
Terengganu	Pelagic	41	2.86	0.04	0.11	0.16
	Demersal	17	3.27	0.08	<b>1.4</b>	0.76
MFA (1983)	NA	NA	1	1	1	1
FAO (1983)	30	30	NA	NA	NA	0.5
FAO/WHO (1989)	40	30	NA	0.5	NA	0.5

MFA: Malaysian Food Act; FAO: Food and Agriculture Organisation; WHO: World Health Organisation

This study also demonstrates a difference in metal concentration between the pelagic and demersal fishes, with higher Hg concentration in demersal fish. This observation supports Storelli and Barone (2013) who suggest that demersal fish has a higher ability to absorb metals. Though some studies state that among fish tissues, fish muscles were shown to harbour the lowest concentration of metals (Fathi & Esmail, 2015), the fish muscles in the current study recorded a high concentration of metal. Fish muscles may be a poor indicator for other metals (Jeziarska & Witeska, 2001), but Hg shows a higher affinity to muscles in comparison to other metals.

This finding is worrying because muscles are consumed by men. Khaja et al. (2015) report that the consumption of fish contaminated by As and Hg may cause several negative health effects on the skin, liver, gastrointestinal, and respiratory tracts, as well as cardiovascular, hematopoietic, and nervous systems.

In conclusion, Hg level exceeding the MFA standards was recorded in fish samples from Kelantan, Terengganu, and Pahang, with demersal fish containing a higher concentration of heavy metals than pelagic fish. It is recommended that further studies are carried out to identify the sources of pollution.

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# Short Communication

## Bio-Socio-Economic Study of Capture Fisheries in Sarawak

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The main objective of the current study is to determine the socioeconomic status of the fishermen operating in Zone A to Zone C2 in Sarawak. This study also focuses on the basic information of capture fisheries in Sarawak, such as its operating costs, returns by active boats to the sea, and the views of fishermen related to the issues and challenges of the capture fisheries industry in Sarawak. For this study, the determination of samples or study specimens was based on commercial fish species commonly landed, the main fishing gear used, and the main fish landing jetties in Sarawak. Eighteen fish species were targeted in this study, as illustrated in Figure 1. The respondents were the fishermen operating from Zone A to Zone C2 in three regions: Region 1 (Kuching, Sematan, Santubong, Sadong Jaya, Sebuyau, and Kabong); Region 2 (Sibu, Mukah, Sarikei, Belawai, Daro, and Tanjung Manis); and Region 3 (Miri, Bintulu, Limbang, and Lawas).

The resource status of the current study was based on the determination of maximum sustainable yield (MSY), maximum economic yield (MEY), and the optimal catch capacity for oceanic tuna resources and capture fisheries to establish the living status and dependency of fishermen on fishing activities and to evaluate the cost and returns of all types of fishing activities.

The project implementation was based on the following methods:

- Determination of distribution, density, biology, genetics, and oceanography for tuna oceanic for four years.
- A biological study of the landing composition according to the species and type of trawl used each month for four years.
- Determination of effort for each piece of equipment used.
- Collecting biological data including length-weight relationships and gonadal studies for oceanic and bio-socioeconomics tuna.
- Determination of the socioeconomics for oceanic tuna resources and fishery catches.

This study was conducted from March 2021 to February 2022, in collaboration with the State Marine Fisheries Department, Sarawak, Malaysian Fish Development Authority, Sri Muara Fishermen's Association, and other agencies. A preliminary analysis via FAO-ICLARM Fish Stock Assessment Tools (FiSAT) was conducted on 10 out of 14 selected dominant species in the waters of Region I, Kuching, Sarawak (see Table 1).

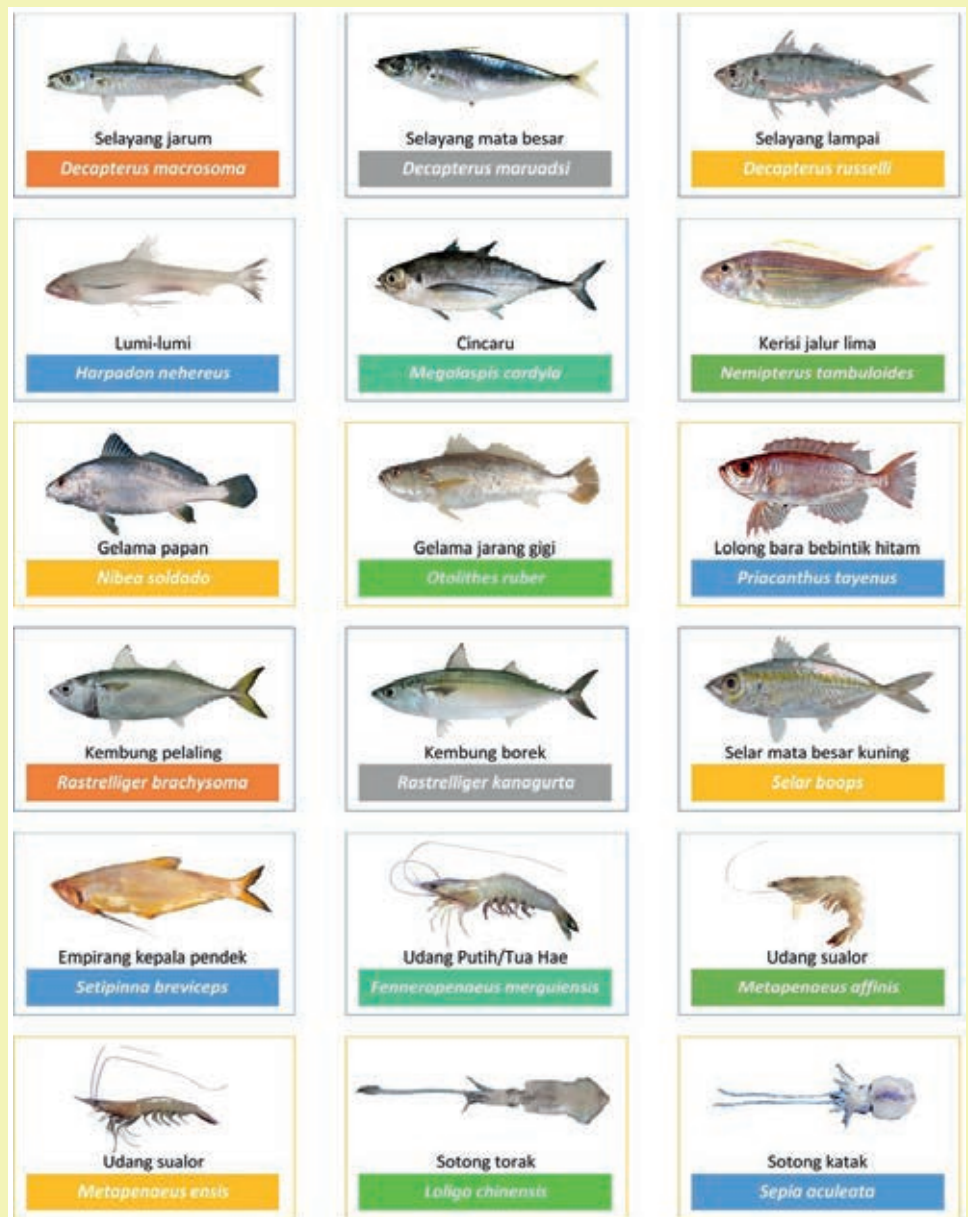


Figure 1: Targeted fish species in the Bio-Socio-Economic study of Capture Fisheries in Sarawak

The exploitation rate (E) was high ( $> 0.5$ ) for four species namely *Megalaspis cordyla*, *Nemipterus tambuloides*, *Rastrelliger kanagurta*, and *Setipinna breviceps*. These four species showed mortality due to fishing gear (F) being higher than natural mortality (M). The fishing capacity categorised in Quadrant D indicates that small-sized fish were caught with high fishing capacity.

The exploitation rate  $\epsilon$  was low ( $< 0.5$ ) for six species namely *Decapterus macrosoma*, *Decapterus maruadsi*, *Harpodon nehereus*, *Nibea soldado*, *Otolithes ruber*, and *Priacanthus*

*tayenus*. The results of the analysis also found that the natural mortality (M) for these six species was higher than the mortality due to fishing gear (F). The catching capacity of the five species categorised in quadrant A indicates large-sized fish caught with low catching capacity. On the other hand, only one species, *Nibea soldado*, was discovered in Quadrant B, indicating small-sized fish caught with low catching capacity. However, the results of this analysis are only preliminary analysis, and the study is still undergoing to collect more comprehensive data in order to obtain accurate and precise results.

**Table 1:** Results of FISAT preliminary analysis of 10 fish species in the waters of Region 1, Kuching, Sarawak

Species	L	K	Z	M	F	E	Quadrant
<i>Decapterus macrosomia</i>	23.63	0.30	1.32	0.90	0.42	0.32	A
<i>Decapterus maraud</i>	26.78	0.79	3.05	1.63	1.42	0.47	A
<i>Hargadon nehereus</i>	32.03	1.30	3.27	2.15	1.13	0.34	A
<i>Megalaspis cordyla</i>	36.63	0.53	2.67	1.15	1.52	0.57	D
<i>Nemipterus tambuloides</i>	34.98	0.42	2.79	1.00	1.79	0.64	D
<i>Nibeas soldado</i>	30.23	1.10	2.87	1.96	0.92	0.32	B
<i>Otolithes ruber</i>	30.03	0.27	0.94	0.78	0.16	0.17	A
<i>Priacanthus tayenus</i>	37.68	0.81	1.73	1.51	0.22	0.13	A
<i>Rastrelliger kanagurta</i>	21.13	0.89	3.95	1.88	2.07	0.52	D
<i>Setipinna breviceps</i>	35.28	0.51	3.34	1.13	2.21	0.66	D

# According to Pauly & Soriano (1986)

A - Large-sized fish are caught with low catching capacity.

B - Small-sized fish are caught with low catching capacity.

C - Large-sized fish are caught with high catching capacity.

D - Small-sized fish are caught with high catching capacity.

In conclusion, the information from the preliminary results of the current study can be utilised by the top management of the Fisheries Department for the next four years to initiate potential programmes that can improve the livelihood of local marine fishermen, who probably belong to the B40 category. The results of this study are also expected to improve the livelihood of traditional marine fishermen as marketing agents and agri-entrepreneurs by marketing their catch (individuals, associations, or cooperatives) and reducing the role of middlemen in the capture fisheries business chain.

## The Application of Turtle Excluder Device (TED) to the Monsoon Shrimp Trawl Net in Kemaman, Terengganu

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On the east coast of Peninsular Malaysia facing the South China Sea, one of the main causes of turtles' death is due to being trapped in the codend of monsoon shrimp trawl nets (PTMT). Accordingly, the Turtle Excluder Device (TED) is a device designed to fit into the codend of a shrimp trawl net to prevent turtles from being trapped. Thus, the installation of TED is necessary.

In 2011, a pilot study on the use of TED with a metal grid size of 4 inches, named Georgia (refer to Photo1), was conducted in Geliga, Kemaman, Terengganu by FRI Rantau Abang, Department of Fisheries Malaysia (DOF). This study utilised one shrimp trawler. Its performance in selectively removing sea turtles was monitored using an underwater camera (refer to Photo 2). The camera managed to capture two (2) adult sea turtles entering the net and exiting through the valve of TED. The results prove that TED could prevent turtles from being trapped in a shrimp trawl net which can cause the death of sea turtles.



Photo 1: TED (Model Georgia)



Photo 3: The Super Shooter



Photo 2: Underwater camera fitted to TED



Photo 4: TED with grid size of more than 4 inches

Another study was conducted in 2012, involving six (6) PTMTs, also in Kemaman, Terengganu. The focus was to promote the use of a TED model called 'Super Shooter' (refer to Photos 3 & 4) with a grid size of more than 4 inches. Later, this study compared the quality of yield and catch of shrimp trawlers with and without the use of TED. Another study was carried out to observe the placement of valves at the bottom of the net. The results of this study showed that three (3) turtles were found trapped in the trawl codend without TED.

In 2013, FRI researchers developed S-TED, a modification of the prior TED. The modification was done at the bottom of the TED by designing a metal grid size of 4 inches to include rays in the catch as they are of high value (refer to Figure 6). The field testing results using PTMT in Malaysia were approved by the NOAA, United States. The used TED was modified from its original shape of the S-TED. The size was modified depending on the GRT of the boats. This modification was important to fit different sizes of shrimp trawl nets. A total of six (6) series of TED modifications were built according to the capacity of boats and shrimp trawl nets.



Photo 5: Model S-TED

In 2014, there was a continuation in improving TED, particularly in removing trash fish, jellyfish, and garbage caught in the codend. This caught the attention of fishermen as manual isolation of the catches was time consuming. Through cooperation with the State Fisheries Department, the use of TED continues to expand in other states such as Kelantan, Pahang, Johor, and Sarawak, and has shown to be promising. Several studies on the effectiveness of using TED have been conducted in these states. However, no turtles were found trapped in the codend of shrimp trawl nets.

In 2015, the DOF provided complimentary 200 units of TED to PTMT fishermen on the east coast. In 2016, FRI registered S-TED as intellectual property and was granted in 2021 (MY-177152-A). Based on the benefits of TED are to prevent deaths of turtles, decrease trash fish (30 %), jellyfish (25 %), and garbage (20 %), save diesel consumption (15 %), and produce quality catches, the DOF decided to make it compulsory in 2017.

In 2018, NOAA United States made an official visit to Malaysia to assist PTMT fishermen in improving TED based on the specifications adopted by the US. In 2019 and 2020, another visit was made to conduct an inspection, along with FRI Rantau Abang and DOF officers, on the use of TED by PTMT boats. This is important for NOAA to approve and recognise the utilisation of TED by PTMT. The recognition is helpful for Malaysia to export prawn to the US, which has already imposed an embargo on countries that wants to export prawn using TED on shrimp trawl net.

# Moments @ FRI

## 11<sup>th</sup> DAA Symposium Report (23-26 August 2022)

After almost 5 years of planning and shifting mode of event from physical to online, back to physical and lastly hybrid, finally the 11th Diseases in Asian Aquaculture Symposium was successfully launched on the 23rd of Aug 2022 in a glorious ceremony. The event was held at the Borneo Convention Centre Kuching (BCCK), Sarawak and officiated by the The Right Honourable, Datuk Patinggi Tan Sri (Dr) Abang Haji Abdul Rahman Zohari bin Tun Datuk Abang Haji Openg, Premier of Sarawak. The welcome remark was delivered by Datuk Seri Dr. Ronald Kiandee, Minister of Agriculture and Food Industries (MAFI). Before that Dr Eduardo Leano gave the introductory remark on behalf of the Fish Health Section of the Asian Fisheries Society. This event was held for 4 days and ended on the 26th of Aug 2022.



## 11<sup>th</sup> Symposium On Diseases in Asian Aquaculture (DAA 11) 2022



FRI technologies exhibited during Farmers Day, DAA11



MAHA (Malaysia Agriculture and Horticulture Exposition) 2020, Serdang, Selangor (8-14 Aug, 2022)



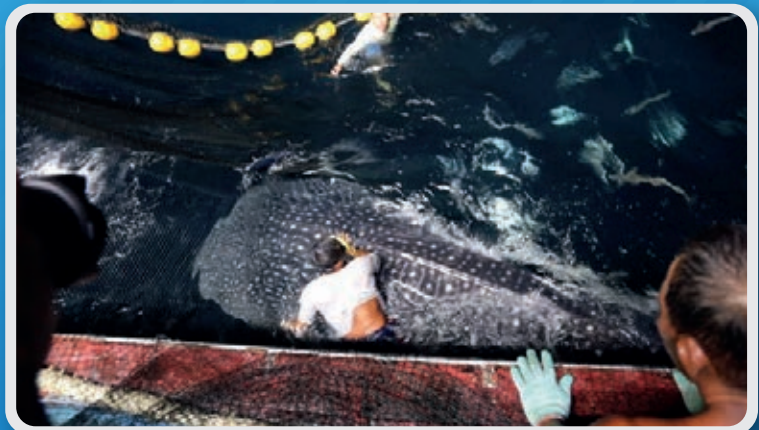


**Tok Nan Open Sea Fishing Competition by  
Lundu District Council at  
Sematan Waters, 10-11th June 2022  
with FRI Bintawa researchers joined as judges.**



**Tuna FSI Application  
Advancement Programme,  
8 Aug 2022,  
Kuching, Sarawak**

**Whale shark (*Rhincodon typus*)  
trapped in purse seine off  
Santubong waters  
during FSI Tuna verification study  
being released by FRI researcher.**



**Interview with Mr Daud Awang,  
Researcher from FRI Bintawa  
on R&D at Pulau Layang-Layang  
for national TV show,  
RTM 360 Degree**



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