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Message from the Editor

Dear Readers,

I am honoured to share the latest issue of the FRI Newsletter (Volume 23) which highlights the capture fisheries research activities carried out by the Fisheries Research Institute (FRI).

The stagnation or decline in the capture fisheries production in many parts of the world underscores the importance of fisheries policy. However, the current state of stocks can at least be partially attributed to the difficulties in regulating fisheries resources and preventing their overexploitation. Even with improvements in regulations, pressures on capture fisheries will remain, due to continued population growth. R & D Capture Fisheries is one of the important scopes of research being carried out by the FRI. Information obtained from the R&D is expected to assist the fisheries manager to better manage our fish resources to sustain the industry.

Last but not least, I would like to thank the contributors who submitted technical reports, short communications, updates and photos for this newsletter. The success of this newsletter depends on your response. I look forward to continued contributions of articles, suggestions on themes and other valuable inputs for the upcoming volumes from all FRI researchers. My team is continuously striving to improve our newsletter, thus, any comments and feedback would be gratefully appreciated and I can be reached via e-mail at norhana@dof.gov.my or wannorhana@yahoo.com.

Wan Norhana Noordin

What's insides

Regional Action Plan for Management of Transboundary Species: Indo Pacific Mackerel in the Gulf of Thailand Sub Region

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Introduction

Mackerels (Family Scombridae), particularly the Indo-Pacific mackerel *(Rastrelliger brachysoma),* also known as the short-necked mackerel, are among the most economically important small pelagic fishes in the Southeast Asian region, contributing approximately 38% of the region's total small pelagic fisheries production or 11% of the total capture fisheries production in 2010. Comparing several Mackerel species, in 2016 the Indo-Pacific mackerel contributed about 78% of the total Mackerel production at an average value of 1,492 USD/MT, which is a decrease from the production reported in 2015 (SEAFDEC, 2018).

On the production of Indo-Pacific mackerel by countries, Indonesia was the major producer in the region, reporting the highest production at 283,106 MT in 2016, followed by Philippines at 38,339 MT (SEAFDEC, 2018). As for Thailand, the Mackerel production was not segregated by species, but the total production of all mackerel species was reported to be 81,017 MT. Nevertheless, it could be observed that the country's total mackerel production in 2016 had drastically reduced as compared to the production of 194,845 MT in 2012. Similar to Thailand, Philippines also reported the declining trend in its Mackerel production through the same period (SEAFDEC, 2018).

The Gulf of Thailand Sub-region (GoT) is one of the most important ecosystems for Indo-Pacific mackerel, where the peak of highest catch using purse seine and falling net was reported in 1996 at 328,955 MT; while low catch was reported during 3 periods, in 1999, 2005 and 2010 at 289,285 MT, 283,984 MT and 259,354.56 MT, respectively, and the catch had never reached 300,000 MT as recorded in 1996 (SEAFDEC, 2018).

Generally, the species was caught by various types of fishing gears in the GoT; and the three major types recorded in 2008 were purse seines (45%), driftnets (31%) and trawls (18%). The landings showed declining trends indicating that the mackerel stocks in the South China Sea and GoT were already overexploited. For instance, in 2016, Thailand reported (SEAFDEC, 2018) the catch production of Indo-Pacific mackerel using 3 main fishing gears; purse seine (3,008 MT), trap (691.6 MT) and trawl (630.3 MT).

Stock status of Indo Pacific Mackerel

The Indo-Pacific mackerel is considered inexpensive but contains high protein, making the species popular for consumption in the Southeast Asian countries such as Cambodia, Indonesia, Thailand, Malaysia, etc. However, with the drastic increase in the production of canned mackerels to replace the decreasing sardines, the catch of Indo-Pacific mackerel has recently been declining as a result of overfishing and unregulated fishing operations in several countries. Such situation has become a great concern for countries in the Southeast Asian region.

A number of fish species including mackerels were reported to be in the overexploitation state in the GoT (Puthy, 2007). In his study using the Schaefer and Fox models, the results indicated that mackerel stocks were both biologically and economically overexploited, but there were opportunities to increase the mackerel stocks by reducing fishing efforts which would allow the stocks to recover.

Thailand also reported that the species was in an overexploitation state throughout the past years. The species also had changing population patterns, which could be due to the environmental impacts. Furthermore, distribution of fish larvae could also be influenced by changes in phytoplankton, water current, and temperature (SEAFDEC, 2017).

In Indonesian waters, over-exploitation of pelagic fishery resources, including the Indo-Pacific mackerel had been highlighted in the Java Sea and other Indonesian waters. However, the recent population dynamic study by Zamroni & Ernawati (2019) showed that the Indo-Pacific mackerels in the Northern Coast of Java off Indonesia waters was still being fully exploited, and the recruitment process had not been disturbed. Although the species had yet to reach the heavily exploitation state, suggestion was made that fishing efforts should be reduced; while fishing permits, such as number of units, size of fishing fleet, fishing gear dimensions, and fishing technology pressure, should also be controlled. Nevertheless, due to the limited biological information of the Indo-Pacific mackerel, studies on the genetic diversity of the species including off Java Island was conducted (Indaryanto *et al.* 2015).

Meanwhile, the declining Indo-Pacific mackerel due to changes in environmental condition and water quality, and modification and loss of critical habitats, had been documented in several countries and reported by the media.

Issues, Knowledge Gaps, and Challenges

Based on the reviews and inputs from six Southeast Asian countries, namely Cambodia, Indonesia, Malaysia, Philippines, Thailand, and Vietnam, in response to the SEAFDEC questionnaires in September 2019, the issues, knowledge gaps and challenges for sustainable utilization of Indo-Pacific mackerel could be summarized as follows:

Data and Information

- Insufficient landing and biological data collection for population and abundance study
- No current information of migratory patterns, spawning grounds and season for a whole life cycle
- No regular monitoring on capture fishery production

Understanding the Status of Fish Stock

- Lack of knowledge on stock structure (need DNA study)
- Insufficient stock status of *R. brachysoma* (distribution and abundance)
- Insufficient information on population dynamics (Growth parameters, mortalities and relationship with other regional stock)
- No actual efforts to exploit the resources
- Trans-boundary distributions
- Lack of knowledge on how to deploy Multi-fishing gears to harvest

Management Responses

- No Fisheries Management Plan
- No information on existing and effectiveness of regulations
- No co-management schemes/ arrangements
- No trans boundary management mechanism/plan
- No information on effects/loss to IUU fishing
- No database or software for assessment
- No traceability system using electronic logbook
- Support the sustainable management concept, co-management, and EAFM

Awareness Building

- Educate people and students in fisheries communities
- Distribute brochures or any media to promote of fisheries management
- Raise awareness of both small-scale fishers and commercial fishers
- Sharing findings at both policy management level and fishermen
- Develop consultation among researchers, managers and stakeholders (EAFM)
- To support the sustainable management concept, co-management, and EAFM

Strengthen Regional Cooperation

- Standardization on data collection for regional stock assessment
- Data sharing
- Lack of management body
- Develop the trans boundary management mechanism/plan

Study the Environment Impact

- Temporary disappearance of short mackerel in the Gulf of Thailand
- Impact of climate change to fish migration route

Enhance Capacity Building

- Inadequate knowledge on research works as follows:
  - Species identification of small size (juvenile) and larval fishes
  - Otolith study (to know age of fish)
  - Data collection at landing sites: catch and biological data
  - Data analysis
  - Stock Assessment and modelling
- Fishing gear technology

Required Regional Cooperation for Transboundary Species

Since 1953, Thailand undertook several management actions for the Indo-Pacific mackerel stock. From 1953 to 2015, several studies were conducted, and 13 Notifications were released in relation to closure of fishing area in the Gulf of Thailand with the objective of conserving the spawning grounds and nursery stages of aquatic resources (Saikliang 2016). Thailand also undertook several studies to enhance knowledge on migration patterns of the Indo-Pacific mackerel within the country's EEZ in the Gulf of Thailand. The country's efforts for effective fisheries management of the Indo-Pacific mackerel were continued up to the present.

Information on migration patterns of the Indo-Pacific mackerel within the country's EEZ in Gulf of Thailand sub-region is already available for almost 30 years. However, the recent results from genetic analysis of the Indo-Pacific mackerel using individual assignment and mixed-stock analysis showed contradictory migratory behaviour of the species between the stock in the inner Gulf of Thailand and the stock in the eastern part of the Gulf of Thailand (Kongseng et al., 2020). Additionally, the population from Pattani Province may also have migrated across the eastern Gulf of Thailand through the southern part of Vietnam and Cambodian waters. Such results indicated that the Indo-Pacific mackerel is a transboundary species and joint management cooperation at the regional or sub-regional levels among countries that harvested the Indo-Pacific mackerel is necessary for sustainable management of the species.

Provisions of The Regional Action Plan for The Management of Transboundary Indo-Pacific Mackerel

There are several international instruments aiming at conservation and management of marine resources, *e.g.* the 1982 United Nations Convention on the Law of the Sea (UNCLOS), the United Nations Fish Stock Agreement (UNFSA), and the UN Sustainable Development Goal (SDG) 14. These instruments also support initiatives in combating illegal fishing towards sustainable use of seas and marine resources, as well as to enhance the environmental, economic and social well-being of coastal fishers and communities. At the regional level, the ASEAN-SEAFDEC Resolution and the Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region adopted by the ASEAN-SEAFDEC Member Countries in 2001 and 2011 also specified the importance of establishing and implementing effective fisheries management through ecosystems approach by integrating habitat and fisheries resources and increasing social and economic benefit to all stakeholders, and applying knowledge/science-based development and management of fisheries.

Recognizing the needs to strengthen cooperative efforts among countries towards sustainable utilization of the marine resources, particularly the Indo-Pacific mackerel that is important trans boundary resource in the Gulf of Thailand, SEAFDEC with the funding support from the Government of Sweden through the SEAFDEC-Sweden Project on "Fisheries and Habitat Management, Climate Change and Social Well-being in Southeast Asia" and the SEAFDEC/UNEP/GEF Project on "Establishment and Operation of a Regional System of Fisheries *Refugia* in the South China Sea and Gulf of Thailand (Fisheries *Refugia*)" thereby facilitating discussion among the Gulf of Thailand countries to develop the Regional Action Plan (RAP) for the Management of the Indo-Pacific mackerel. The RAP contains five Sections, namely:

Section 1 : Introduction;
Section 2 : Stock Status of Indo-Pacific mackerel;
Section 3 : Issues, Knowledge Gaps and Challenges;
Section 4 : Required Regional Cooperation for Management of Trans boundary Species; and
Section 5 : Provisions of the RAP including goals, outcomes, objectives and actions.

The Provisions of RAP were categorized into 5 dimensions, which are: 1) Governance; 2) Social; 3) Economic, 4) Ecosystem; and 5) Climate Change; and these were aligned with the concept of the Ecosystem Approach to Fisheries Management (EAFM).

This RAP for Management of the Indo-Pacific mackerel is a non-legal binding document that is meant to serve as a foundation to identify practices and processes that support the implementation of the relevant ASEAN-SEAFDEC Resolution and Plan of Action. It marks an evolutionary step towards concerted regional approach to support countries' efforts to manage this transboundary fish stock in the Gulf of Thailand.

The Goal of Regional Action Plan

This RAP is intended to serve as a guide for the concerned countries in implementing actions to achieve the goal of ***"Sustainable Indo-Pacific mackerel fisheries in the Gulf of Thailand sub-region through science-based management for shared benefit to other ASEAN Member States by 2030."***

Expected Outcomes

i. Healthy Indo-Pacific mackerel resources through the implementation of fishery management plan in the Gulf of Thailand
ii. Accurate and comprehensive information on the Indo-Pacific mackerel in the Gulf of Thailand
iii. Model for development of management plan for the Indo-Pacific mackerel that could be applicable to other sub-regions

Required Actions

All participating member countries surrounding the Gulf of Thailand sub region need to work together as a strong and effective team to proceed with management strategies and follow-up actions covering the aspects of governance, social, economic, ecosystem and climate change dimensions.

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Kembung Borek (Indian Mackerel, *Rastrelliger kanagurta*): Towards Sustainable Management in Malaysia

Suggestion: Towards Sustainable Management of the Indian Mackerel (Rastrelliger kanagurta) in Malaysia

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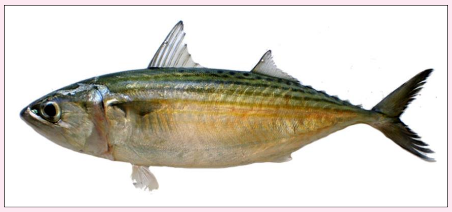
Introduction

Kembung Borek (English name: The Indian mackerel, Scientific name: *Rastrelliger kanagurta)* (Figure 1) is one of the economically important epipelagic fish species in Malaysia. An epipelagic fish inhabits the epipelagic zone i.e. water from the surface of the sea down to 200 metres. It is also referred to as the surface waters or the sunlit zone. The Indian mackerel belongs to the Scombrid family of Perciformes Order. This species is commonly found distributed across the Indo-West Pacific from South Africa, the Seychelles and the Red Sea, east of Indonesia and northern Melanesia, Micronesia, Samoa, China and Ryukyu Islands of southern Japan (Akib *et al.,* 2015).

The Indian mackerel is abundant across the waters off north-west and east of Peninsular Malaysia, Sabah and Sarawak. It is a highly migratory species, with a fusiform body that is streamlined that make them fast swimmers. In Malaysia, the Indian mackerel contributed about 3.45% of the total marine fish landings in 2019. It was also the second highest pelagic species (about 9% of total pelagic species landing) after the short mackerel. Table 1 shows the landings of important pelagic species according to the fishing areas.

Fig. 1: The Indian mackerel, *Rastrelliger kanagurta*



The aim of fishery management is to ensure sustainability in harvesting fish stocks and to avoid depletion of the resources (SEAFDEC, 2017). A successful or accurate stock assessment is very important so that fishery management for certain species can be developed depending on the estimation on quota and allowable catch regulation. This is applicable to all fish including the Indian mackerel. The resources should be managed at the optimum level since it is an important commercial fish especially for the middle-income group.

Table 1: The landings of important pelagic species (tonnes) by fishing areas in 2019

Local name	West Coast Peninsular Malaysia	East Coast Peninsular Malaysia	Sarawak and Labuan FT	Sabah	Total
Cencaru / Torpedo Scad	24,499	3,054	4,954	170	32,677
Selar / Yellowtail scad	6,175	7,217	2,656	2,687	18,737
Pelata / Blackfin scad	4,742	986	579	73	6,381
Selar Kuning / Finlet scad	1,230	6,322	530	1,380	9,463
Selayang / Scads	25,643	24,736	6,039	13,447	69,866
Aya hitam / Longtail tuna	5,233	31,638	1,020	5.018	42,910
Aya kurik / Eastern little tuna / Kawakawa	11,264	12,897	606	762	25,531
Tenggiri / Spanish mackerel	7,703	2,048	4,451	2,745	16,949
The Indian mackerel	29.395	9,876	4,893	6,173	50,338
Pelaling / Temenong / Short mackerel / Short-bodied mackerel	92,908	557	429	326	94,221

The fishing waters of Malaysia can be mainly divided into four zones: (i) West Coast of Peninsular Malaysia (WCPM); (ii) East Coast of Peninsular Malaysia (ECPM); (iii) Sabah and (iv) Sarawak. The WCPM covers the Strait of Malacca that embraces the north of the Andaman Sea and Indian Ocean, meanwhile the ECPM, Sabah and Sarawak face the South China Sea waters. The main fishing gears that were commonly used to catch the Indian mackerel are purse seine and trawl net. There are possible use of other tools by the purse seiners such as fish aggregating devices (FADs) or light to lure the fish into the net.

There are various methods used for stock assessment depending on the types of data, knowledge used and degree of age-structured population dynamics in the model (Cadrin & Collas, 2015). One of the methods, Kobe or phase Plot analysis had been introduced to evaluate the status of tuna stock based on the fishing mortality (F) and biomass (B) associated with Maximum Sustainable Yield (MSY; *i.e.* FMSY and BMSY) (Maunder and Aires-de-Silva, 2011). This method was introduced by the Tuna Regional Fisheries Management Organizations (RFMOs), held in Kobe, Japan in January 2007. This study aims to determine the current stock status of the Indian mackerel in the WCPM and ECPM using the Kobe Plot analysis. It is hoped that the information provided through the biology and stock assessment may be used by the fisheries managers to formulate the best strategy to ensure the sustainable management of this valuable resource in Malaysia.

Materials and Methods

The study was conducted in two phase. The first phase involved the gonad maturation study which was conducted from year 2016 to 2019. Samples of the Indian mackerel were collected monthly from the commercial purse seiners at Kuala Perlis, West Coast of Peninsular Malaysia landing site from April 2016 to December 2019. In total, 8,100 Indian mackerel samples were collected and measured for gonado-somatic estimation (GSI). The GSI is a metric that represents the relative weight of the gonad to the fish weight. Secondary data was obtained from the Department of Fisheries, Malaysia and published catch data from the Food and Agriculture Organization (FAO) from 2008-2017 was also compiled to elucidate the catch and landing trend of the Indian mackerel in Malaysia.

The second phase was the stock assessment study of the Indian mackerel using the Kobe Plot Analysis. There are two main visualization tools used in the Kobe Framework; a phase plot and strategy matrix. The phase plot visualized the current stock status and exploitation rate according to the targeting points such as BMSY and FMSY of the Indian mackerel. On the other hand, the strategy matrix represents the probability of catch according to the management objective such as the total allowable catch (TAC). This will be translated according to colours stated such as green (safe zone), yellow (recovery), and red (overfished).

Results and Discussion

Gonad maturation study

Based on the gonad maturity study, the spawning season for the Indian mackerel in WCPM were estimated to be in Dec to Mar, which had the highest value of gonado-somatic indices for both sexes (value ranged between 2.4 – 4.5) (Figure 2). The maximum spawning activity occurred in March with the male and female GSI at 4.5 and 4.29 respectively. The size at first maturity was estimated to be 19.6 cm for male and 20.4 cm for female. The fecundity of fish ranged between 25,144 -151,256 eggs.

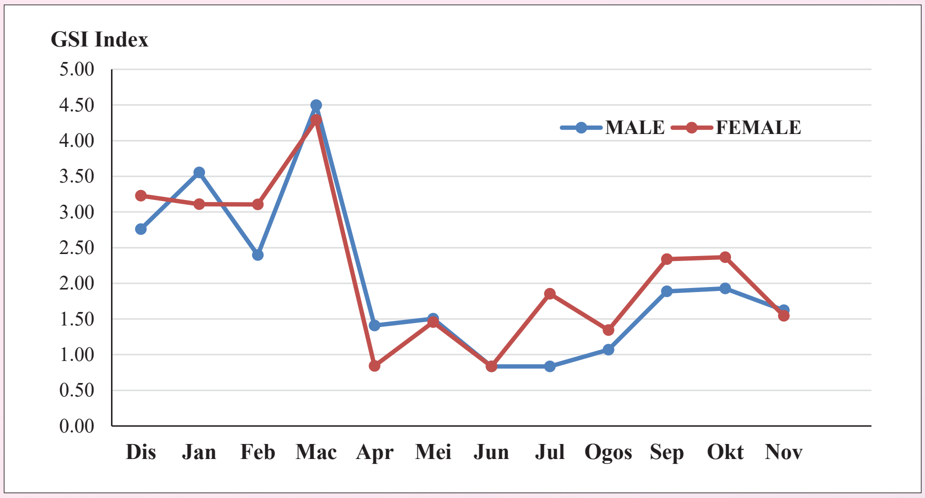


Fig. 2: Average gonado-somatic index of the Indian mackerel in the West Coast Peninsular Malaysia, 2016-2019.

Stock assessment of the Indian mackerel

Catch and landing trend

Catch data from 2008 to 2017 extracted from the annual fisheries statistic by the Department of Fisheries, Malaysia and published catch data from FAO (FAO, 2018) were used to generate Figure 3 which illustrates catch trends for the Indian mackerel in WCPM from 2008 to 2017. In general, the catch trend shows a gradual increase in catch from 2008 (20,540 tonnes) to 2012 (40,229 tonnes) before dropping slightly in 2013 with catches at 29,000 tonnes with an ascending trend again in 2014 with the highest catch recorded at 44,400 tonnes. The catch however gradually decreased from 2014 to 2017. The Catch Per Unit Effort (CPUE) also showed similar trends as the catch data.

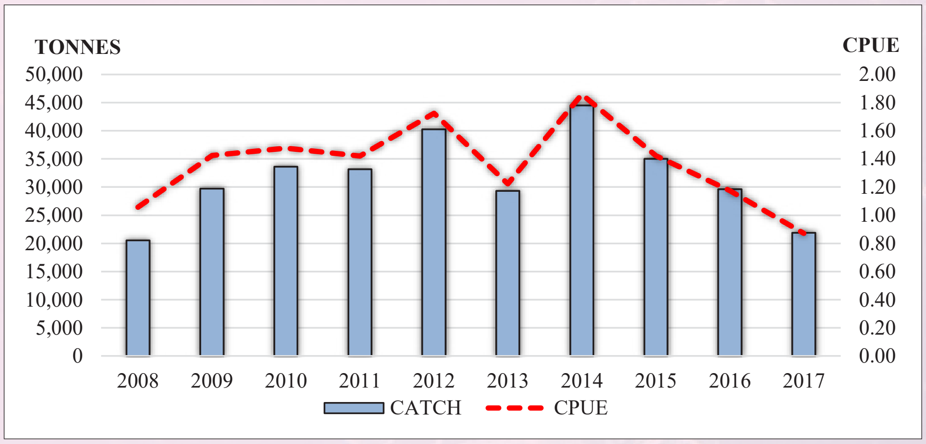


Fig. 3: Catch and CPUE of the Indian mackerel in the West Coast Peninsular Malaysia, 2008 to 2017

East Coast of Peninsular Malaysia

Figure 4 shows the catch trends for the Indian mackerel in the ECPM from 2008 to 2017. There are no specific trends in the catches of the Indian mackerel in the ECPM within the study period with decrease and increase of catch recorded alternately. The CPUE showed a stable trend from 2008 to 2012 followed by an increasing trend after 2012 until 2017. The CPUE standardization was based on the landing data by year with number of unit's effort.

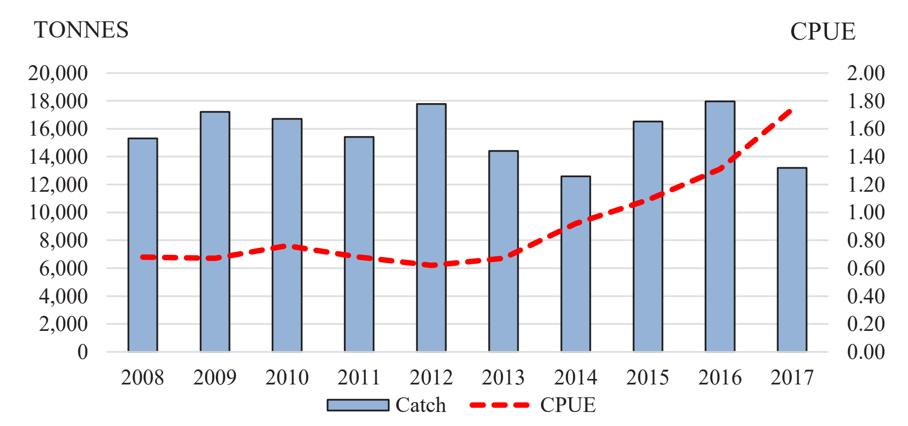
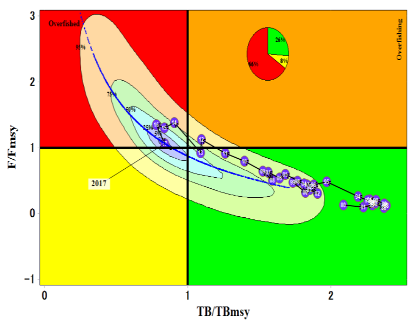


Fig. 4: Catch and CPUE of the Indian mackerel in the East Coast Peninsular Malaysia, 2008 to 2017

The Indian mackerel (West Coast Peninsular Malaysia)

Red zone (56%) and Green zone (26%)
Maximum Sustainable Yield: 43,100 tonnes
Current Catch : 52,878 tonnes
TB/TBmsy = 0.81 and F/Fmsy = 1.12
Current catch level (Ave. 2008-2017): 52, 878 tonnes*
Advice: TAC < 10,000 t (20% reduction from *)



The Indian mackerel (East Coast Peninsular Malaysia)

Green zone (59%) and Red zone (33%)
Maximum Sustainable Yield: 17,030 tonnes
Current Catch : 15, 896 tonnes
TB/TBmsy=1.27 and F/Fmsy=0.62 (close to MSY)
Current catch level (Ave. 2008-2017): 15, 896 tons*
Advice: TAC < 2,000 t (10% reduction from *)

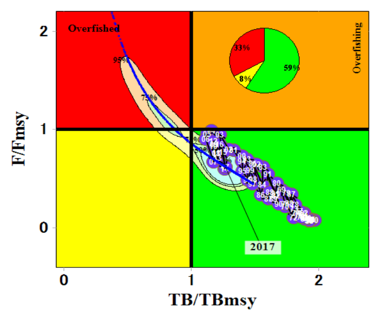


Fig. 5: Stock status (2017) and management advices (Total Allowable Catch/TAC) based on stock assessment by KOBE Plot Analysis

Based from the stock and risk assessment of the Indian mackerel using KOBE plot analysis showed that the status of this species in WCPM was in the red zone that implied that it was overexploited (Fig. 5). The catch in the West Coast was 52, 878 tonnes which was over the limit of maximum sustainable yield (MSY) of 43 100 tonnes. In order for the stock to be in the green zone (safe zone), the catch needed to be reduced by 20% from the current catch to sustain the stock in the long run.

Meanwhile, the stock status of the Indian mackerel in the ECPM as of 2017, was in the green zone implying that the stock was **still safe** to be harvested (Fig. 5). However, for the current catch level at 15,896 metric tonnes, the risk of violating the TBMSY and FMSY was less than 7%. Thus, the total catch of the Indian mackerel in the ECPM should be less than MSY level, i.e. 17,030 metric tonnes to ensure that the stock of the Indian mackerel in the ECPM was within the safe zone (green) to be sustained for the next 10 years.

As an epipelagic species, the behaviour such as being migratory cannot be avoided. Thus, joint trade promotions should be established together with neighbouring countries such as Thailand and Indonesia. Through the establishment of Technical Working Group; activities such as information exchange should be developed. Skills development through capacity building or training program can be developed and upgraded. The control of IUU fishing also needs to be strengthened by carrying the surveillance activities and enforcement, control of importation and landing of transhipment. A cooperation between scientist and managers also could be facilitated so the development of information, education and communication programs on sustainable use of resources can be supported thus management measures to control fishing effort and capacity at national or even regional level can be established.

Conclusion

The stock status of the Indian mackerel in Malaysia as of 2017, being in the green zone implies that the stock is still safe to be harvested. However, based on the current catch level for both areas, a proper management should be considered to ensure that the stock of the Indian mackerel lies within its safe zone (green) or can be sustained for the next 10 years. The collaboration with neighbouring countries such as Thailand and Indonesia should also be in the picture due to the epipelagic nature of this species.

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ASPIC: A Key Tool for Capture Fisheries Management Strategies

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Introduction

Fisheries stock assessments are important scientific tools used to evaluate the health of fish populations. A stock assessment is the process of collecting, analysing, and reporting demographic information to determine changes in the abundance of fishery stocks in response to fishing and, to an extent possible, predict future trends of stock abundance. The information from fish stock assessment enables the managers to formulate management strategies to sustain fish populations, ecosystems, and the socioeconomic viability of commercial and recreational fisheries.

Counting fish in the ocean is an inexact science, hence stock assessment exercise tends to produce results with varying degrees of uncertainty. Generally available assessment methods are based on two types of mathematical models: (1) a model of the dynamics of the fish population under consideration, coupled with (2) a model of the relationship of observations to actual attributes of the entire fish population. These models are placed in a statistical framework for estimation of abundance and associated parameters, including assumptions on the kinds of errors that occur in each model. No single assessment method provides the best answer for all stocks. For that reason, different types of assessment models have been developed. One of the reliable methods is a Stock-Production Model Incorporating Covariates (ASPIC). This paper presents the information on ASPIC.

A Stock-Production Model Incorporating Covariates (ASPIC)

ASPIC is a computer program for fisheries stock assessment work. Building on earlier work by Graham, Schaefer, Pella, Tomlinson, Fletcher, and others, ASPIC program implements methods described by Prager (1994) and Prager *et al.* (1996) to fit a nonequilibrium surplus-production model for data on fish catch and relative abundance. ASPIC is a combination of classical methods used on stock and risk assessments and has become a key tool in providing scientific advice for capture fisheries management strategies. Scientific advice for management of fisheries is based on the common KOBE framework.

Summary probabilities

The levels of biomass greater than fishing mortality, that can support maximum sustainable yield (MSY) for a range of capture fisheries management options. This requires estimates of current status relative to reference points and projections for the different management options. The KOBE package can read results from a variety of stock assessment packages and summarize them in KOBE format.

Brief history of the KOBE Plot Analysis

The joint tuna Regional Fisheries Management Organization (RFMO) process, also known as the 'KOBE process', is sought to harmonize the activities of the five tuna-RFMOs. (First Organization (RFMO) process, also known as the 'KOBE process', is sought to harmonize the activities of the five tuna-RFMOs). First meeting was held in Kobe, Japan in January 2007 and 'Phase Plots' were introduced to produced recommendations to standardize the presentation of stock assessment results and management advice (Fig 1). The results were presented in four quadrants: red-orange-yellow-green format. Later in April 2009, the second joint meeting of tuna-RFMOs, known as Kobe II, held in San Sebastian, Spain introduced the Decision Matrices. In July 2011, the third joint meeting of tuna-RFMOs, known as Kobe III, was held in La Jolla, California in the United States.

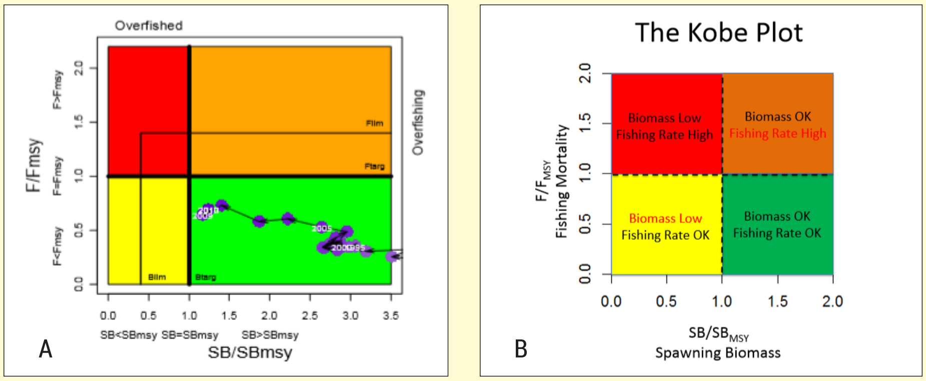

Fig. 1: (A) Kobe (phase) plot of the time series of estimates of stock size and fishing mortality relative to their MSY reference points and (B) Coloring plot showing representing a phase: Red- Overfished, Orange- Overfishing, Yellow-Recovery and Green-Good condition.

Prior to applying the ASPIC model as a tool for fisheries stock status in Malaysia, most researchers used the classical production surplus model which was carried out with the assumption that the resource status is in a balanced condition, although in reality the fish stocks were generally in an unstable or non-equilibrium condition. The instability is the characteristic of trying to make the population adaptive to changes in natural death caused by fluctuations and changes in the surrounding environment (Hilborn & Walters, 1992). One effort to approach instability was by Prager (1994) was to develop an approach to changes in biomass over the utilization period, which was relatively long assuming non-equilibrium biomass using the ASPIC. This approach is considered an improvement to the approach that enables scientists to track and detect various biomass and exploitation based levels of the dynamics of fisheries at certain times. However, Quetglas *et al.* (2013) stated that the role of environmental factors and utilization pressures greatly affected the dynamics of fish populations that are to be used. Whereas, Botsford *et al.* (2014) stated that the occurrence of fluctuations in abundant population in a fishery is not yet fully understood and still required environmental data coherent decadal time.

The ASPIC which originally was developed to look at the tuna stocks status has now been expanded to other fish species. This application had been used in fisheries stock assessment in several countries including the North Atlantic waters (Prager & Shertzer, 2010); assessment of Redfish *(Sebastes mentella and Sebastes fasciatus)* stock in the Southwest Atlantic waters (Avila de Melo *et al.*, 2012); sardine fisheries in the Moroccan waters (Gascoigne, 2016) and nomei fish *(Harpodon neherus)* in the Pakistani waters (Kalhoro *et al.*, 2013). The status estimation utilization of small pelagic fish in the waters of the Middle Sea was done with the same model which indicated the need for utilization restrictions due to the status of the stock being in a state of over-exploitation (Cardinale *et al.*, 2009). At the regional level of management, (Chassot *et al.*, 2009) used the same model to evaluate tuna longline fisheries against big eye tuna *(Thunnus obesus)* in the waters of the Indian Ocean.

In Malaysia, the ASPIC model was used by the local researchers in determining the stock status of several fish species. For instance, the determination of large pelagic transboundary fish stock (neritic tuna and seer fish species) with the cooperation of SEAFDEC (Sallehudin *et. al* 2018). Besides that, ASPIC analysis on the demersal. Threadfin Bream in Peninsular Malaysia (Sallehudin. Jamon, unpublished data) and *Decapterus* spp. (Noorul Azliana Jamaludin, unpublished data) had also been studied.

ASPIC analysis

The ASPIC analysis process requires at least 10 years landing data series and effort. A normal CPUE (Catch per Unite Efforts) must be obtained first and Standardization-CPUE will be used later in the analysis of the stock assessment by ASPIC. To determine the best nominal CPUE, a number of calculations are required depending on the number of units, trips, days and hours. The best nominal CPUE value is selected based on the relationship between the total catch and the nominal CPUE and should have a strong negative correlation of CPUE standardization.

Biasness can be in the nominal CPUE due to effects of year, season, area and boat (crew) size, therefore nominal CPUE need to be standardized to reduce such biasness. There are various multivariate statistical methods in CPUE standardization such as the General Linear Model (GLM), negative binominal model, regression tree, Tweedie model etc. (Shono, 2004). GLM was used as the standard approach to evaluate if GLM is the appropriate model in each CPUE standardization process. If GLM is not suitable, other statistically valid methods will be used. In general, the usage of GLM model depended on the situation of missing data;

Log (CPUE+c) = (mean) + [Y] + [Q] + [R] + [INT] + [crew] + (error)

where, c: 10% of average overall nominal CPUE

Y: effect of year
Q: effect of quarter (season)
A: effect of region

In ASPIC, there are a few options for the basic production model to be applied such as the Fox and Schaefer model. In the Schaefer model, 4 parameters (K: carrying capacity, B0/K where B0 is the total biomass at the start of fisheries, q: catchability and MSY) need to be estimated. Meanwhile in the Fox model, five parameters need to be estimated. In theory, the Fox model produces less biased results but there are often some difficulties to get conversions (solutions) due to more parameters that need to be estimated than in the Schaefer's model.

In conducting ASPIC, assumption is that B0 = K, as it is quite often difficult to get conversions when there is a longer time series for catch and much less for CPUE series. In a such case, B0 =K assumption will be effective to get more realistic results. If it is not able to obtain any convergences, K value needs to be fixed and ASPIC explored by varying plausible K values (scenarios). The best result is obtained using R2 and MSE (mean squared errors), i.e., the scenario with highest R2 and lowest MSE are selected.

There are five softwares required in the ASPIC model, where 4 of them are used in performing the data analysis while 1 software is for generating diagrams of the Kobe Plot and Risk Assessment (Fig 3). The first software is a CPUE standardization program. This software analyzes the nominal CPUE to standardize the CPUE. The second software is the ASPIC Batch Job, which is used to analyze data to obtain the optimum MSY, Total Biomass (TB) and Fishing mortality (F). The third software is the Command Promt, which analyzes data and produces input population trajectory data (Non-Bootstrapped) and to generate Biomass Relative (brel) and Fishing Relative (frel) data to be used to generate Kobe plots. The fourth software is the Kobe II Risk matrix that will generate the Kobe matrix table and Stock projection figure. The final process is Kobe Plot software which is used to produce Kobe Plot and Stock Assessment diagram. Fig 4 below shows the flowchart of methods in assessing data for stock assessment using A Stock-Production Model Incorporating Covariates (ASPIC).

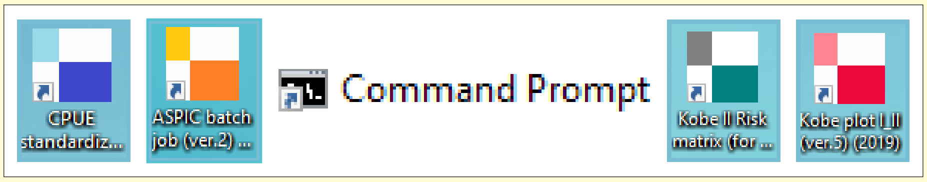

Fig. 2: Five softwares used for performing the Kobe Plot and Stock Assessment Diagram

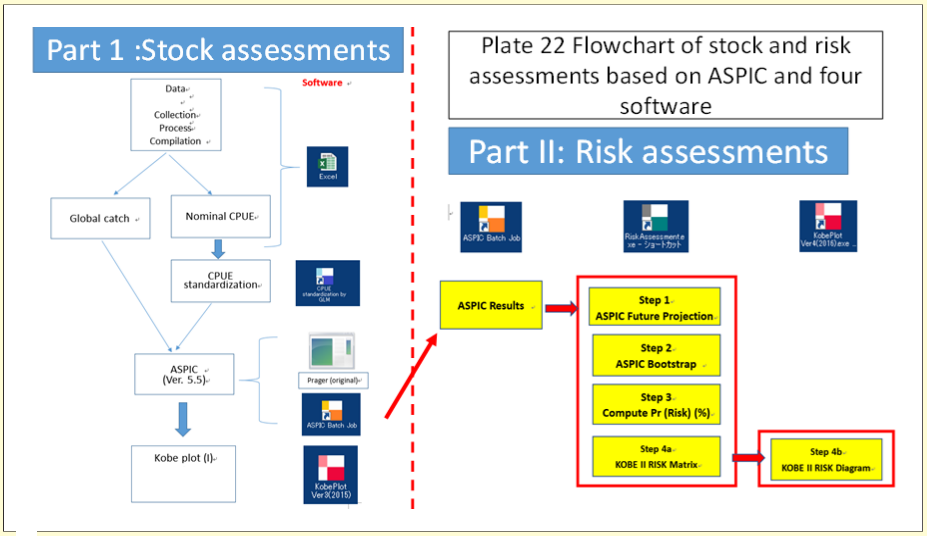

Fig. 3: Flowchart of stock and risk assessments methodology based on ASPIC

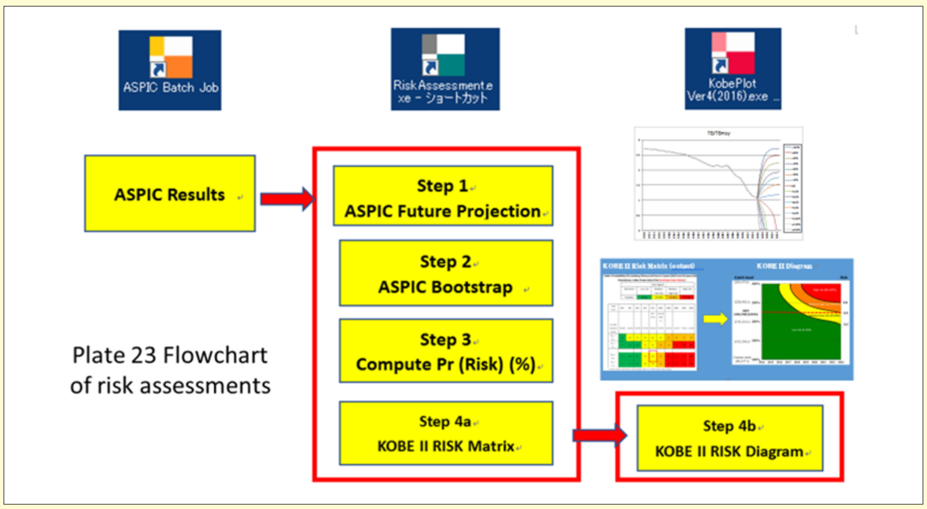

Fig. 4: Flowchart of stock and risk assessment based on ASPIC and 4 software

KOBE Plot

The first output from ASPIC analysis is the KOBE plot diagram. The KOBE plot illustrate the present status of a stock based on fishing mortality (F) and biomass (B) associated with the maximum sustainable yield (MSY); i.e. fishing mortality maximum sustainable yield (FMSY) and biomass maximum sustainable yield (BMSY). If the current fishing mortality (F) is above the FMSY, overfishing is suggested to be occurring; if the current biomass (B; or some measure of spawning output) is below the BMSY, the stock is determined as overfished. In the KOBE plot diagram, the B/BMSY is on the x-axis while the F/FMSY is on the y-axis (Fig 1). The vertical and horizontal lines at 1.0, splits the plot into four sections with the upper left representing a phase which is not desirable: overfishing and an overfished stock; and the lower right representing a healthy stock: overfishing not occurring and an under fished stock. The trajectory of the stock over time is plotted so that the historical status of the stock can be seen.

To explain further, an example of KOBE Plot analysis, results of the Threadfin Bream in the West Coast of Peninsular Malaysia as in Fig. 5 (Sallehudin J. 2020 (unpublished) is used. From Fig 5, it could be seen that typically, a stock starts in the lower right. As the fishery develops, the stock moves into the upper left as the population becomes overexploited because of inappropriate management. There is substantial uncertainty in the quantities used to generate the KOBE plot, and therefore the uncertainty in the current status is often included in the plot.

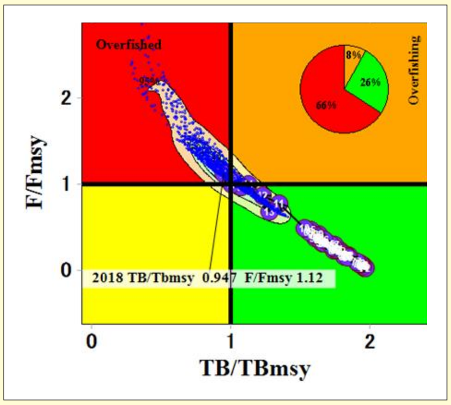

Fig. 5: Kobe Plot: Threadfin Bream (West Coast of Peninsular Malaysia) that the current stock status (2018) is in the overfished (red) zone where TB/TBmsy = 0.947 and F/Fmsy = 1.12. Probability status of threadfin bream fish in 2018 fits 66% in the overfished zone, 26% in the save zone and 8% in overfishing zone.

KOBE matrix and stock assessment

The KOBE Strategy Matrix presents the specific management measures that would achieve the intended management target with a certain probability within a certain time period. In the case of fisheries managed under a system of Total Allowable Catches (TACs), the outputs would be the various TACs that would achieve a given result. In the case of fisheries managed by effort limitations, the outputs would be expressed as, for example, fishing effort levels or time/area closures. It would also indicate where there are additional levels of uncertainty associated with data gaps. Managers would then be able to base management decisions upon the level of risk and the time frame they determine which is appropriate for that fishery.

Table 1 provides examples when the management target is to end overfishing, rebuild a depleted stock, or maintain a sustainable fishery. In this case, current catch was 6% above the MSY level. Management can make decision to decrease the catch until below MSY level to ensure the stock is rebuilt in the next coming 10 years.

Fig. 6 shows the future projection of total biomass (TB) and fishing mortality (F) in each situation and one (1) is a reference limit for TB and F. The condition of TB value is considered as good when the present level is above the reference limit, while for the F value it must be below 1. Management can choose to either add or reduce the levels of TB and F according to the percentage level.

The management could make an easier and more accurate decision when the risk assessment figure is developed (Fig. 7). The risk assessment figure comprises of four irregular shaped sections which are generated to determine the present fish stock condition which are at High Risk (75-100%), Medium High Risk (50-75%), Medium Low Risk (25-50%) and Low Risk (< 25%). The MSY line acts as a guide to ensure action is taken to increase or decrease the catch level in order not to violate the MSY line.

Table 1: Kobe II management strategy matrices (K2MSM) show the Probabilities (%) infringing or violating the TBmsy and Fmsy in 3 years (2021) and 10 years (2028) for the Threadfin Bream species (Sallehudin J, 2020 unpublished)

Color Legend				
Risk levels	Low risk	Medium low risk	Medium high risk	High risk
Probably	0 - 25%	25 - 50%	50 - 75%	75 - 100

	60%	70%	80%	90%	94% MSY	100% Current catch (*)	110%	120%	130%	140%
10 catch scenarios (ton)	11,178	13,041	14,904	16,767	17,510	18,630	20,493	22,356	24,219	26,082
TB2021 < TBmsy	46	51	54	58	59	62	66	69	72	75
TB2021 > F msy	13	25	43	56	61	68	76	82	85	89
TB2028 < TBmsy	24	32	45	64	71	82	90	95	98	99
TB2028 > F msy	12	18	36	63	72	84	92	96	98	99

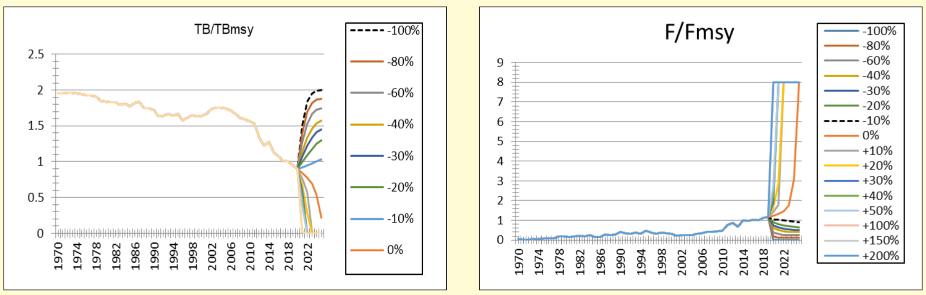

Fig. 6: Future projection of total biomass and fishing mortality with different percentages after 2018 for the Threadfin Bream species (Sallehudin J, 2020 unpublished).

Catch level TBMSY Risk Catch level FMSY Risk

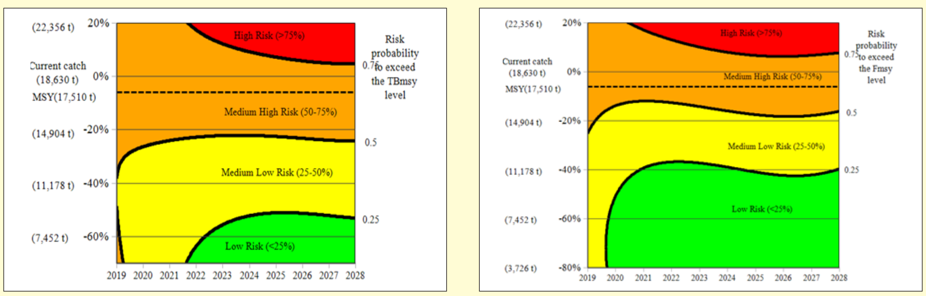

Fig. 7: Risk level (probability %) violating TBmsy (left) and Fmsy (right) for the next 10 years (2018-2028) by different catch levels of the Threadfin Bream species (Sallehudin J, 2020 unpublished)

Why are Kobe Plots and K2MSM important for policy makers?

a. For stocks whose assessed status is in the lower right (green) quadrant of the Kobe Plot, aimed at maintaining the stocks within this quadrant with a high probability.
b. For stocks whose assessed status is in the lower left (yellow) quadrant of the Kobe plot, aimed at rebuilding these stocks in as short a period as possible.
c. For stocks whose assessed status is in the upper right (orange) quadrant of the Kobe Plot, aimed at ending overfishing with high probability in as short a period as possible.
d. For stocks whose assessed status is in the upper left quadrant (red), aimed at ending

overfishing with a high probability and at rebuilding the biomass of these stocks in as short a period as possible.

Conclusions

Application of the ASPIC model clarifies the status utilization and dynamics of fish resource stocks based on the level of the biomass ratio (BMSY) and fishing mortality (FMSY). In addition, the phenomenon of overfishing can be overcome with the proposal to prevent the collapse of the fishing industry. The results obtained through the Kobe Plot diagram, Table Matrix, Future Projection and Risk Assessment diagram will facilitate the managers to make decisions in fisheries management.

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Resource and Biology of Four Finger Threadfin (*Eleuteronema tetradactylum, Shaw,* 1804) from Perak waters

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The four-finger threadfin, *Eleuteronema tetradactylum* is also known as Senangin Rambu Empat locally. This fish belongs to the family Polynemidae. Other species in this family are *Eleuteronema tridactylum* (Three finger threadfin/Senangin rambu tiga), *Polydactylus sextarius* (Senangin Buih Tanda/ Blackspot threadfin), *Leptomelanosoma indicum* (Indian threadfin/Mancong), *Filimanus xanthonema* (Yellowthread threadfin/Lelauh kuning) and *Polynemus melanochir melanochir* (Blackhand paradise fish/Senangin-bulu sirip hitam). Senangin Rambu Empat (referred as senangin in the text) is a pelagic fish. It has silver colour head and body with big eyes and silvery iris. The important features are the pectoral fin with four white filaments (Photo 1). The objective of this study is to get an information on landings of senangin, size composition, maturity stages, types of fishing gears used to catch them, the fishing ground and nursery area.

The district of Larut Matang, Taiping landed the highest catches of senangin as compared to other districts in Perak. The monthly landings ranged between 46.6 - 154.5 MT in the year 2018. (Fig 1). The landing increased from August to October and decrease in November. Drift net, trawl net, barrier net, longline and push net are used to catch the fish. Small boats operating drift net goes out to the fishing ground in the early morning and comes back late in the evening, but the bigger boats may stay overnight at sea. Fishing operation by drift net is generally 14 days in each month during spring tide. Catch per unit effort (CPUE) for drift net ranged between 2.8-93.0 kg/boat/trip. Fishing ground of drift net is located around three nautical miles from the shoreline, whereas the juvenile and larvae inhabit the river mouth which is their nursery ground (Fig 2 and Fig 3).

Senangin caught by drift nets are normally larger as compared to those caught by push net (Table 1). Most of fish caught by push net were at juvenile stage. Large size of fish was mostly sold at local market at RM 28.00 per kilogram. This species exhibits hermaphrodite's protandry i.e changes sex from male to female during fish growth. This study observed that the sex changing behavior might occur when the fish size is around 315 mm in total length. Senangin is one of the commercially important fish. Their habitat is localized and refugia could be considered for fisheries management purpose. However, many information is still scanty, thus study will be continued in the 12th Malaysia Plan with more focus on their habitat and life cycle.

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Photo 1: Senangin Rambu Empat *(Eleuteronema tetradactylum)*

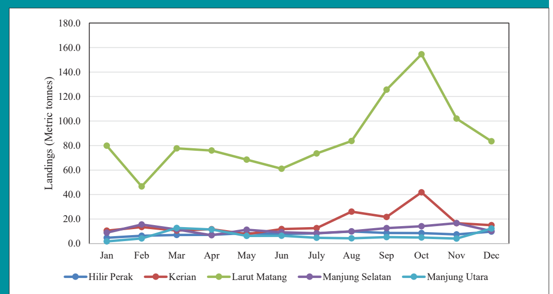

Fig. 2: Landings of Senangin by districts in Perak in the year 2018

Table 1: Size of Senangin caught by drift nets and push nets at Larut Matang, Taiping Perak

Fishing Gear Types	Minimum (mm)	Maximum (mm)	Average ± S.D (mm)	N (No. of fish)
Drift Nets	175	618	379.37 ± 94.85	199
Push Nets	85	202	147.36 ± 25.10	277

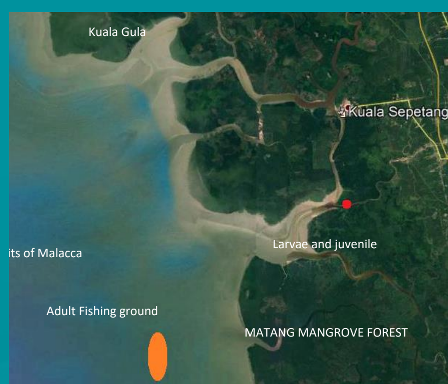

Fig 3: Map showing one of the fishing grounds for catching threadfin by drift net and nursery area in Larut Matang waters

Fig 4: Sampling for fish larvae of threadfin using larval net at river mouth in Larut Matang waters

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Importance of Fecundity in Analysis Determining the Reproductive Potential Analysis of Marine Fishes

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Fecundity is one of the most important aspects of reproductive biology of fish species which provides information on the number of eggs in the ovary prior to the spawning season (Adebiyi, 2012). A clear knowledge of fecundity plays a significant role to evaluate the commercial potentials of fish stock and to assess the abundance and reproductive potential of the spawning stock (Bhendarkar *et al.,* 2018).

Fecundity studies are also relevant in fish population dynamics and productivity studies. Fecundity-length relationships for many exploited fish stocks are often poorly understood due to small sample sizes and high levels of intrinsic variability among individuals. Female fish retain their oocytes internally, therefore maximum reproductive output will be subjected to body cavity constraints. Limitation of maximum reproductive capability due to size of the body cavity explains the strong correlation of fecundity and body size of fish (Wooton, 1992). The large influence of size towards fecundity is clearly demonstrated by the general use of relationships between fecundity and female size (usually expressed as length or weight) to describe variations in the fecundity of marine fish species.

Regression analysis between fecundity and the size of fish was determined using the formula

Fecundity (F=) Ax^b,
X = Standard length of fish (cm) or weight of fish (g),
a = regression constant
b= regression coefficient.

The relationship was transformed into a straight-line using logarithm, as

Log Y= a + b Log X (Adebiyi, 2012)

Besides body cavity, another constraint that influences reproduction of the fish is the size of egg. Larger egg volume may result in the decreasing number of eggs that could be produced. The egg number is inversely proportionate to egg size. Another factor which may influence fecundity is age and reproductive experience. Previous study on Atlantic cod revealed that the first time spawners had lower annual fecundity (number of eggs released per female in a year) as compared to the repeated spawners of similar size (Trippel, 1998).

Fecundity can vary widely between individuals of the same population and between years, populations and species. These variations play important role in stock assessment and fisheries management. Absence of monitoring of fecundity in stock assessment exercise could be due to time consuming factors using gravimetric or volumetric methods. Although these methods are simple, inexpensive and provide reliable results, the work is time-consuming and tedious (Thorsen and Kjesbu, 2001). However, emerging new methods may help. For example, a new method by Thorsen Kjesbu (2001) has successfully reduced time and labour during fecundity measurement. This method uses image analysis system to automatically determine mean oocyte diameter of a gonad sample and the oocyte density via a calibration curve.

Due to the importance of fecundity assay, the FRI Kg. Acheh had conducted fecundity assay for several indicator species including hilsa shad, Indian mackerel, short mackerel and kawakawa. Only ripe ovaries (maturity stage IV) were collected for fecundity assay and was performed thrice using different parts of the eggs; anterior, posterior and the middle part. Fig 1 shows the steps in fecundity assay using volumetric method.

Fig 1: Steps in fecundity assay of Hilsa shad, *Tenualosa ilisha*

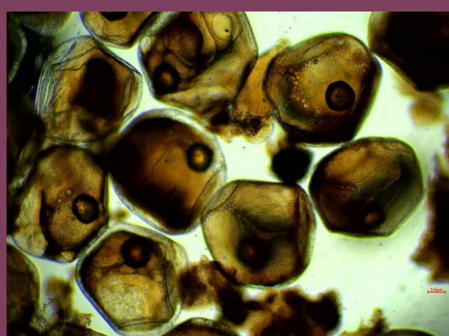

Fig 2: Microscopic image of matured ova of *Tenualosa ilisha* (4X magnification)

The logarithmic relations between fecundity and total length, body weight and ovary weight were linear suggesting that the fecundity of indicator species generally increased with the increase of length, weight and ovary weight. This information is crucial for fishery management plan of these species to ensure the sustainability of these resources in Malaysian waters.

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The Sea-Trial of Mid Water Trawl in Malaysia

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In Malaysia, Mid Water Trawl (MWT) had been tested since the 70's, however most of the trials were not properly and fully documented. Some of the reports suggested that MWT was not very effective to be operated locally. Trials carried out in other South East Asian countries also yielded similar outcome (Miyata, 1978). In 2018, the DOF Malaysia had shown interest in introducing MWT as an alternative to bottom trawling. In view of this, several studies and sea-trials had been conducted to determine the feasibility of MWT in Malaysia in the year 2019.

This paper describes one of the sea-trials of MWT that was carried out by the DOF Malaysia with the expertise of SEAFDEC Training Department (SEAFDEC/TD) deploying its vessel, MV SEAFDEC 2 (MVS 2), off Miri waters, Sarawak. The study was undertaken from 10-24th September 2019 and was jointly participated by several researchers from FRI Kg Acheh (Perak), FRI Bintawa (Sarawak), FRI Rantau Abang (Terengganu), SEAFDEC/MFRDMD (Terengganu), representatives from DOFM's engineering division, APM (Terengganu) and also from the Labuan Fisheries Office. The objectives of the study were to determine the viability of MWT operations in Malaysian waters and to learn more on how to operate the MWT.

In acquiring knowledge on operating the Japanese-made MWT, 15 stations were pre-determined within 6,377 NM^2 off Miri waters and a blind trawl was conducted at each of the stations. The depth ranged between 50-100 meters. For the viability study of the MWT, if there was any sighting of a big school of pelagic fish, the MWT would be engaged to catch it.

The mid-water trawl net used for the sea trial on-board M.V. SEAFDEC was constructed by four (4) net seams with a head rope and a fishing rope (or ground line) of 42.3 m in length. Length from the wing net to the cod-end part was approximately 88 m. The cod end part, made of Polyethylene was 360mm in diameter with a mesh size of 60 mm, and double layered.

The otter board of the mid-water trawl of the M.V. SEAFDEC 2 is classified as 'Biplane' a standard design of Japanese mid-water trawl. The dimensions are 1,650 mm in height and 750 mm in length with double vertical boards. The weight of the otter board body in air is 402.5 kg and weight in water is 350 kg. There are six (6) iron plates, assembled as additional weight with each plate being 25 kg. In this Sea Trial, two (2) iron plates (50 kg) were additionally fixed on the right otter board to maintain the balance.

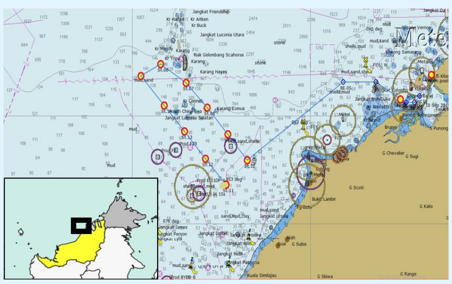
There were a few devices used to monitor the operation and to ensure that the net was functioning properly. On-board the MVS 2, an echo-sounder and a scanning SONAR were used simultaneously to locate fish schools both underneath the vessel and around and to obtain essential information e.g. depths, fish school, current speed and direction. The scanning sonar was also used to detect the performance of the mid-water trawl and otter boards which is necessary for the fishing master to manoeuvre the vessel speed in accordance to the desired depths and the characteristics of the mid-water trawl. To monitor the net depth at real time, during the operations, a SCANMAR depth sensor (Model SS4-P-VTL, SCANMAR AS, Norway) was secured at the ground rope of the mid-water trawl. To obtain the net depth (sea surface to the net), two (2) depth recorders (Model ATD-HR, S/N 232 and S/N 234, Alec Co., Ltd., Japan) were attached at the head rope and ground rope of the net to record depths where the net was submerged, while for the net spread determination, measurements of the towing warp and distance between the towing warps were taken to calculate the net spread.

The MVS2 managed to do 10 blind trawls at 10 stations, out of 15 planned stations in Miri waters, to expose DOFM staff on the operations of the MWT sets and the use of devices in monitoring the MWT. However, for the blind trawls, there were no catches of any commercial fish or other aquatic species, except for some small larval fish probably sticking to the net when hauling. The larvae were generally identified as eel larvae *(Leptocephalus sp.)*, trigger fish larvae and *Gempylus sp.* (snake mackerel) fish larvae (SEAFDEC/TD, 2019).

The SONAR and scientific echo-sounder were used to the fullest capacity to find fish, within 3,000m in radius of the vessel. However, no large or dense school of fish was detected in any strata of the sea, in order to demonstrate a proper operation of the MWT to catch a school of fish.

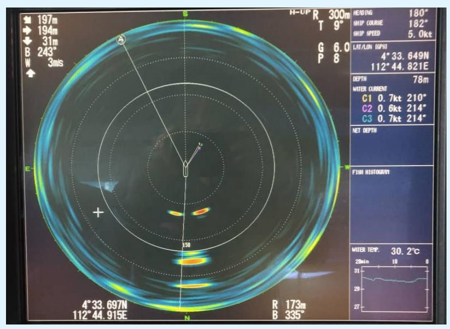
In terms of the operations of the MWT (the shooting of the net and maintaining it at the desired depths and ended with the hauling of the sets of MWT), it was successfully done by MVS2 ship crew and the DOFM staff were able to observe and learn as well. However, for the inability in finding school of fish could be linked to many other factors concerned e.g. fishing season, environmental conditions, climate change, weather conditions and movement of the fish schools in the sea trial areas.

Considering that MWT is a non-destructive fishing gear which targets pelagic fishes and this technology has not been in use in Malaysian waters, future studies should be undertaken to see the fullest potential of this gear in our fishing industry.

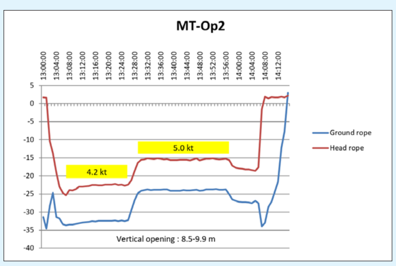


Study area in Miri waters, with 10 blind trawl stations

The "Bi-plane" type otter-board used by MV SEAFDEC 2



The SONAR's digital display of the sets of midwater trawl in action, and can be seen in the lower part of the display



Data analysis from the net recorder from an-hour blind trawl operation, showed that the speed of vessel could determine the depth of the midwater trawl net

Participants from the DOF Malaysia with the expert and crew of MV SEAFDEC 2 involved in the project

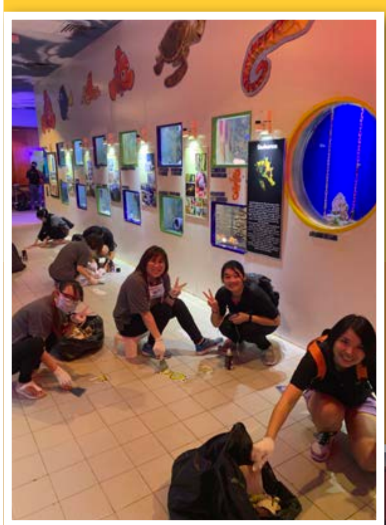
Moments in FRI

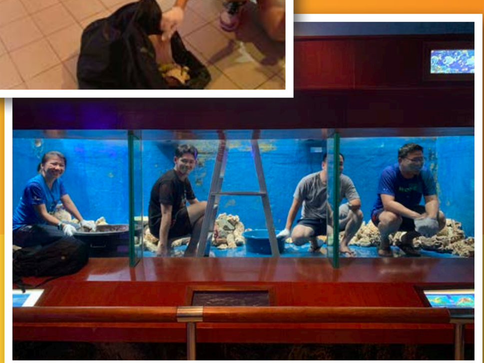
Visit by the Minister of Agriculture and Food Industry, Datuk Seri Dr. Ronald Kiandee to #myDOF Tuna Gallery @FRI Batu Maung (19 Jun 2020)

Fish kill event at Krian, Perak and investigation by the FRI team in May 2020

Course on Red Tilapia Breeding and Management at FRI Glami Lemi involving 13 farmers and Terengganu State Fisheries Staff (4 - 5 Feb 2020)

Training course on freshwater prawn broodstocks management at the FRI Pulau Sayak, 23-26 September 2019



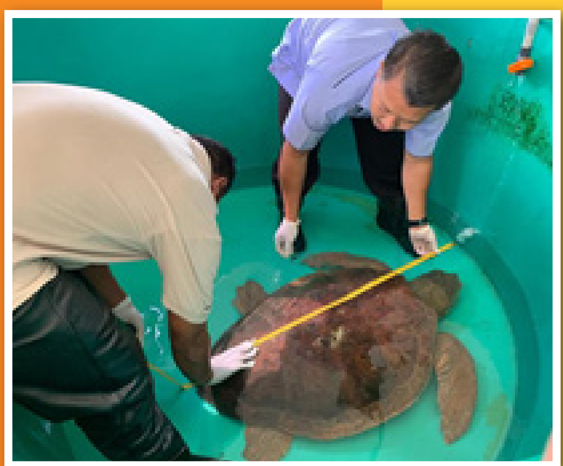


Corporate social responsibility (CSR) programs by DELL Malaysia at Aquarium Tunku Abdul Rahman, Batu Maung, 10 January & 12 April 2019

Visit by local feed miller (Dindings Soya & Multifeeds Sdn Bhd) to FRI Glami Lemi (7 Feb 2020)

Cockles Culture Management Workshop co-organised by Japan International Research Center for Agricultural Sciences (JIRCAS) and FRI, Department of Fisheries Malaysia in Gelang Patah, Johor (18-20 Feb 2020)

Post mortem on Whale Shark stranded at Parit Jawa, Muar, Johor by FRI Rantau Abang team



A stranded loggerhead turtle (Caretta caretta) has been rescued by fishermen and treated at Aquarium Tunku Abdul Rahman, Batu Maung, 7 September – 24 October 2019

Researcher from FRI Gelang Patah, won silver award in the Malaysia Technology Expo (20 - 22 Feb 2020) for her invention of Hydro Cockle Sorter

Lobster *(Panulirus polyphagus)* Fishery Refugia in Malaysia

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The mud spiny lobsters *(Panulirus polyphagus)* is a highly valued seafood commodity in Malaysia. However, the fishing pressure for this fishery is intense due to the high demand and lucrative price. Eventually, the natural mud spiny lobsters' resources are on the decline and active management efforts are required to rehabilitate the lobster population. A fisheries refugia is proposed by the Department of Fisheries Malaysia as a management measure to mitigate this decline in lobster resources and this initiative is part of the regional South China Sea Fisheries Refugia Project by UNEP/GEF/SEAFDEC. The roles of research in this refugia project are to provide vital scientific information pertaining to the biology and ecology of the mud spiny lobster population in the East Johor-South Pahang waters and subsequently to identify a suitable area for the establishment of a mud spiny lobster refugia.

In order to achieve these roles, two main research activities were carried out namely the collection of mud spiny lobster landing data at selected jetties around East Johor (Sedili, Tanjung Leman and Endau) and resource surveys conducted at sea. For the landing data collection, appointed enumerators would collect daily lobster landing data (weight) as well as associated data such as sex and presence of eggs. This study had been implemented since year 2017 and ended in March 2020. Likewise, resource surveys using bottom trawl net were conducted at sea to determine the location and concentration of mud spiny lobsters around the East Johor-South Pahang waters.

The results from the spiny lobster landing data collected at three selected jetties (Sedili, Tanjung Leman and Endau) indicated a rising trend in the size of lobsters caught at Sedili from July to November 2019 (Fig 1), September to October at Tanjung Leman (Fig 2) and May to July at Endau (Fig 3). The average weight of spiny lobsters at Sedili was 243.6±2.0 g ranging from 10.0 to 940.0 g. Likewise, the average weight of spiny lobsters at Tanjung Leman was 271.4±4.2 g ranging from 60.0 to 1600.0 g, and the average weight of spiny lobsters at Endau was 444.1±6.5 g and ranging from 143.0 to 1360.0 g.

The frequency of berried female (lobsters with eggs) mud spiny lobsters landed at the jetties around East Johor waters indicated a peak around May to July period and coincided with the increase in the size of adult lobsters caught by bottom trawlers (Fig 3 & 4). This observation may also give an indication that the breeding period for mud spiny lobsters in East Johor is also between the May to August period. However, more data is needed from the landing sites to confirm this observation.

Fig 1: Average weight of *P. polyphagus* at Sedili, Johor from May 2018 to February 2020

Fig 2: Average weight of *P. polyphagus* at Tanjung Leman, Johor from May 2018 to February 2020

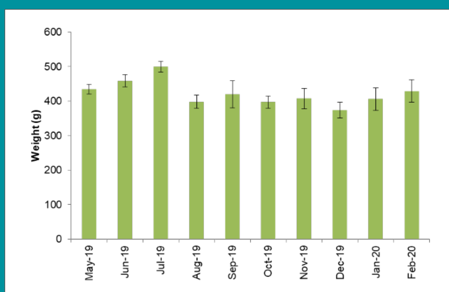

Fig 3: Average weight of *P. polyphagus* at Endau, Johor from May 2019 to February 2020

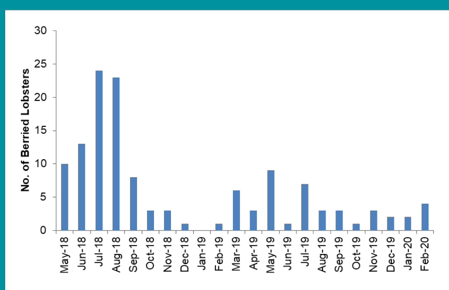

Fig 4: Frequency of berried *P. polyphagus* landed in East Johor waters from May 2018 to February 2020

The results from the spiny lobster landing data indicated a clear difference in size among the three landing sites (Sedili, Tanjung Leman and Endau). The size of lobsters is influenced by the fishing location and the type of gear used. Lobsters landed at Sedili and Tanjung Leman are mostly by artisanal fishermen using drift nets near the shoreline area. In contrast, the fishermen from Endau mostly operate commercial trawlers and bottom trawl nets further out at sea. Thus, the size of spiny lobsters landed by the trawlers were usually bigger than the lobsters caught by artisanal fishermen.

A comprehensive lobster resource survey was undertaken in year 2019. A total of 195 hauls were recorded from six fishing trips onboard commercial trawlers. The total number of *P. polyphagus* caught during the survey was 49 lobsters. The majority (80%) of *P. polyphagus* were caught south of Pulau Aur, Johor (Fig 5) with an average density of around 1.05±0.10 kg.km^{-2}(±S.E.) with presence of berried lobsters among the catches. Therefore, a new *P. polyphagus* refugia was proposed within this area that covered an area of about 20 by 20 nautical miles (Fig 5). The estimated *P. polyphagus* biomass (B) in this proposed refugia was 2.94 metric ton (during the October 2019 period). This refugia area is located in the zone C fishing area and further discussion with the stakeholders is required to finalize this proposed site.

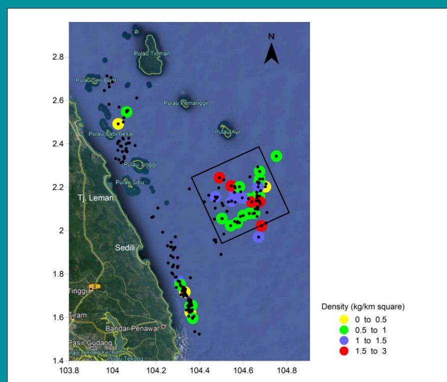

Fig 5: The density of lobsters from the survey conducted onboard commercial trawlers in year 2019

Fig 6: Mud spiny lobster caught during the survey onboard the commercial trawlers

Fig 7: Berried female lobster (lobster with eggs) caught during the survey

The Hand-Thrown Cast Net with Light in Kedah Waters: Its Application and Impact to the Fisheries Resources

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The traditional fishermen in Kedah used modified hand-thrown cast nets with lights to attract and catch squid. The gear was named "Pukat Tebar Berlampu", locally is modified to draw the bottom end to encircle the squid and uses light to attract squid. At present, the hand-thrown cast net does not require a license to operate because it is not considered as fishing gear under the Fisheries Act 1985. The use of this gear has become popular among the fishermen because of its efficiency in catching squid at night. Hence, there is a need to investigate this gear so that it will not over exploit the fisheries resources. A study was conducted for 3 years (2017-2019) in the coastal waters of Kedah (Kuala Kedah and Kuala Sala) and Pulau Langkawi in order to determine the specifications of the gear, fishing season, catch composition, biological aspects of the catches and the impact to the resources.

The study found that this gear was used all year-round in Pulau Langkawi waters and only from Nov- Mar in Kedah. Although squids are found all year round in Langkawi, the landing trend is higher during 2 months at the end and starting of the year. This gear was operated by coastal fishermen using small fiberglass boats attached with an outboard engine. Almost all the cast nets are made of monofilament with an overall length of 2.7-4.0 m, mesh size of 1 in and operated manually. All boats have at least a petrol-powered generator to light up the light-luring metal halide bulbs. Operations usually started from 7 pm to 7 am almost every night except during full moon, where they cease operation. The fishermen prefer to anchor their boats but if the current is strong, they will use the drift nets to slow down the drifting of the boat. Usually three types of bulbs (green, red and yellow) were used with intensity ranging from 250W to 15000W. The fisherman will start lighting up the green bulb first to lure the squid until a significant number of squids had aggregated at the surface of the water. The green bulb will be turned off and red bulb turned on before throwing in the cast nets. The red light is believed to make the squid stagnant and easier to catch. This process will be repeated until before sunrise.

More than 80% of the catch composition consisted of squid with the most dominant squid caught being *Loligo duvauceli*. The squid's mantle length (ML) measured between 45 - 220 mm (Male); 35 - 155 mm (Female), and the average weight being 36.8 g for male and 31.9 g for female. Nearly all samples of Loligo spp showed maturity of more than 50% and only samples from Bukit Malut, Langkawi recorded more immature *Loligo* spp. The study established that the use of this gear during off season in Kuala Sala, could catch a small number of fishes, more than squid. However, it is not economical for the fisherman to just catch small commercial fish to cover the cost of going out to fish. Thus, it is assumed that this gear will only be used during the squid season.

The catch using this gear was decent and could go up to more than 100 kg of squids per night, thus, it is expected that the use of this gear will increase in the future.

The analysis of cephalopod stock status in the Straits of Malacca for 10 years (2009-2018) indicated that the level was over exploited. Besides, recently in 2019, the intensity of the light bulbs used has been increased from 1000W to 2000W. Due to these factors, this gear usage should be controlled. This study has outlined some recommendations for the management of this gear and among them is the need to license the gear as additional equipment to licensed traditional boats/ vessels only.

Light bulbs that were used to attract squids before the net was thrown to catch it

The hand-thrown cast net that is being used by the fishermen in Kedah

Main catch from the hand-thrown cast net; Indian squid, *Loligo duvaucelli.*

Morphometric Relationship and Population Dynamics of the Black Pomfret *(Parastromateus niger)* in Mukah, Sarawak

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The study on the biology of the black pomfret *(Parastromateus niger)* had been conducted since 2018 in Mukah, Sarawak. This study is important for the sustainable exploitation of *P. niger* so that it could positively impact the economy of Mukah traditional fishermen. A total of 1,886 black pomfrets were caught via Panau. The length and weight of *P. niger* were recorded (Figure 1) and the data was further analysed using FiSAT II. Table 1 shows the morphometric relationship where $W = 0.0569L^{2.6801}$, $r^2 = 0.6$ with the TL ranging from 12.3 – 40.5 cm. The asymptotic length ($L\infty$) was estimated at 42.53 cm, while the von Bertalanffy growth function (K) was 1.50 yr^{-1}. Total (Z), natural (M) and fishing (F) mortalities were calculated as 3.84 yr^{-1}, 2.18 yr^{-1} and 1.66 yr^{-1} respectively. The exploitation rate (E = 0.43) obtained indicated that the black pomfret was not overexploited in the waters of Mukah. The maturation and spawning seasons were determined through the examination of ovary (Figure 2). The female attained first sexual maturity at the size of 30.0 cm and the gonadosomatic index analysis revealed that July was the spawning month.

Fig. 1: Taking measurements on length and weight of *P. niger*

Fig. 2: Ovary examination

Table 1: Length-weight relationship and growth parameters of *P. niger*

TL Range (cm)	Equation	L yr^{-1}	K yr^{-1}	F yr^{-1}	M yr^{-1}	Z yr^{-1}	E
12.3 – 40.5	$W = 0.0569\ L^{2.6801}$	42.53	1.50	1.66	2.18	3.84	0.43

Morphometric Relationship and Population Dynamics of Jellyfish *(Rhopilema esculentum)* in Bruit Island, Mukah, Sarawak

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The research on jellyfish was carried out from February 2018 throughout the year. In total of 1,632 jellyfishes *(Rhopilema esculentum)* were caught by using the jellyfish net. The length and weight of *R. esculentum* were recorded (Figure 2) and analysed using the FiSATII software. Data analysis from FiSAT II (Table 1) showed that the morphometric relationship was expressed by $W = 0.01866L^{1.412}$ and $r^2 = 0.7$. The TL range from 13 – 49 cm. The asymptotic length (L∞) was estimated at 49.55 cm, while the von Bertalanffy growth function (K) was 2.30 yr^{-1}. Total (Z), natural (M) and fishing (F) mortalities were calculated as 4.61 yr-1, 2.77 yr^{-1} and 1.85 yr^{-1}, respectively. The current exploitation rate (E = 0.40) indicated that there was a good potential for the presence of R. esculentum stock in the waters of Bruit Island, Mukah. Jellyfish has become one of the major fisheries exports to other countries in Southeast Asia, triggering a market competition between jellyfish fishermen, including Sarawak Therefore, information from this research is important for the sustainable exploitation of the resource by controlling the fishing effort level.

Jellyfish fishing operation

Recording of length and weight of *R. esculentum*

Table 1: Length-weight relationship and growth parameters of *R. esculentum*

Range (cm)	Equation	L	K	F	M	Z	E
13 – 49	$W = 0.01866\ L^{1.412}$	49.55	2.30	1.85	2.77	4.61	0.40

Improvement of The Manual Bottom Longline into an Automated System (Automatic Baiting Longline - ABLL)

Longline in Malaysia is called as Rawai and is very popular among the fishermen in Bintulu. This gear involves a hooking procedure, which is manually operated, however dangerous and could lead to injuries and laborious (Figure 1). Thus, in 2019, FRI Bintawa has produced ABLL to replace the manual bottom longline. ABLL is an automatic, labour efficiency and safe. The preliminary results of the ABLL test run showed that it can operate 3 times faster than the manual bottom longline. Within 1 km of operation, the manual bottom longline took about 30 minutes with 3 fishermen to operate, while the ABLL was only 10 minutes with only one fisherman operating it. This had indicated a good early discovery to help improve the productivity of deep-sea fishermen in the future.

Fig. 1: Left: Manually-operated bottom longline; Right: Automatic Baiting Longline (ABLL)