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Acronyms

AFMA	Australian Fisheries Management Authority
AMFRHRD	Agency for Marine and Fisheries Research and Human Resources Development (Badan Riset dan Pengembangan Sumber Daya Manusia Kelautan dan Perikanan)
AP2HI	Asosiasi Perikanan Pole & Line dan Handline Indonesia (Indonesian Pole & Line and Handline Fisheries Association)
BET	Bigeye tuna
BRIN	Badan Riset dan Inovasi Nasional (National Agency for Research and Innovation)
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CFR	Centre for Fisheries Research (Badan Riset dan Inovasi Nasional)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWR	Department of Agriculture and Water Resources
DGCF	Directorate General for Capture Fisheries (Direktorat Jenderal Perikanan Tangkap)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAD	Fish Aggregation Device
FMA	Fisheries Management Area
GDP	gross domestic product
GEF	Global Environment Facility
IATTC	Inter-American Tropical Tuna Commission
IO	Indian Ocean
IORA	Indian Ocean Rim Association
IOTC	Indian Ocean Tuna Commission
IUU fishing	Illegal, Unregulated and Unreported fishing
IPNLF	International Pole and Line Foundation
MDPI	Masyarakat Dan Perikanan Indonesia
MMAF	Ministry for Marine Affairs and Fisheries (Kementerian Kelautan dan Perikanan)
MSC	Marine Stewardship Council
MSE	Management Strategy Evaluation
NGO	Non-governmental organisation
NTMP	National Tuna Management Plan (Rencana Pengelolaan Tuna Nasional)
RFMO	Regional Fisheries Management Organisation
RITF	Research Institute for Tuna Fisheries (Loka Riset Perikanan Tuna)
RIMF	Research Institute for Marine Fisheries (Balai Riset Perikanan Laut)
SFP	Sustainable Fisheries Partnership
SKJ	Skipjack tuna

SPC	Pacific Community
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	Western Central Pacific Ocean
WPEA	Western Pacific and East Asia monitoring program
WWF	World Wildlife Fund
WFF	Walton Family Foundation
YFT	Yellowfin tuna

2 Executive summary

Indonesia is the second largest producer of fisheries products in the world and the largest producer of tuna, contributing some 15% of global production. Its tuna fishing fleets are large and diverse, spanning the eastern Indian Ocean to the Western and Central Pacific Ocean via the Archipelagic Waters of the Java and Banda Seas. Its geographic location and the importance of tuna and tuna-like species for economic development, livelihoods and food security makes Indonesia a central member of three tuna Regional Fisheries Management Organisations (RFMOs). While much progress has been made in the development of fisheries management, monitoring and research capability required to effectively manage these important domestic and international resources, substantial challenges remain. There is currently limited capacity for operational management of these important resources to maximise benefits and minimise risks of overfishing. Importantly, Indonesia also lacks the operational management tools and aspects of the regulatory framework required to manage its tuna fisheries to meet its domestic needs and obligations to the RFMOs.

The overall aim of the project was to enable Indonesian fisheries scientists, industry, non-governmental organisations (NGOs) and managers to improve the effectiveness of monitoring and management systems for Indonesian tuna fisheries and, by doing so, contribute to the longer-term goal of improving the economic and social benefits, while reducing the conservation risks to the tuna stocks. The project involved four main components: i) development of operational harvest strategies and associated institutional arrangements, ii) population biology, iii) review of socio-economics (S-E) and, iv) broader capacity building in tuna fisheries research and management. The primary focus for each component was the three tropical tuna species (skipjack, yellowfin and bigeye tuna) in Indonesian Archipelagic Waters (IAW). The highly migratory and international nature of tuna and tuna fisheries meant there was a strong focus on connectivity with the Western Central Pacific Ocean and Indonesian engagement in the WCP Fisheries Commission (WCPFC).

The project team successfully led the development and adoption by the Indonesian Government of a formal harvest strategy (HS) framework for the management of tuna fisheries in IAW. The Interim HS Framework, launched in 2018, specified the forms of HS for tropical tuna, the monitoring programs required to implement them and a coordinated 5-year action plan to focus activities by government, industry and NGOs. The action plan included the recommendations of the S-E review, which initiated a heightened focus on S-E and a series of projects at the national scale. The Interim HS Framework and technical and advisory support provided by this project were central to maintaining momentum and focus of stakeholders and leveraging investment for further development and implementation of the HS. It directly resulted in multi-million-dollar investments to expand the monitoring programs, increase coverage of industry fisheries' improvement plans (FIPs) and engagement in the HS process. The annual technical and stakeholder workshops became the primary national forum for review of the IAW fishery, progress with the action plan and consideration of management measures for implementation in IAW. This resulted in management measures to limit the number of FADs, a spatial and temporal closure in Banda Sea and a precautionary catch reduction being adopted as part of the implementation of the HS, which was launched by the Minister for Marine Affairs and Fisheries in June 2023.

In parallel, a two-year biological sampling program was established across the archipelago to collect monthly samples between 2019 and 2021. The program collected ~16,500 samples, which represents one of the most comprehensive collections for tropical tuna for population biology. It also involved a range of capacity building activities in fisheries science. COVID-19 related impacts and institutional restructure in Indonesia meant it was not possible to complete the analysis of these samples in the current project. This remains an urgent priority as they will make a major contribution to reducing the

current uncertainty in population parameters that are central to estimating the status and productivity of these nationally and regionally important stocks.

The knowledge and technical and institutional capability developed through this project will be important to continued implementation of the harvest strategy, in particular, the incorporation of catch-based management measures, following the recently announced Measurable Fishing Policy (*Penangkapan Ikan Terukur*, PIT).

3 Background

Indonesian tropical tuna fisheries

Indonesia is the second largest producer of fisheries products in the world and the largest producer of tuna, contributing some 15% of global production (FAO 2019). The tropical tuna stocks and the fisheries that harvest them are central to food security, employment, regional economic development and national terms of trade. Tropical tuna species represent approximately 11% of Indonesian fisheries production by weight (Anon. 2022, MMAF 2022a). Tuna exports are also central to the economies in Indonesia, with the export value of tuna value around US$565 million in 2022 (Selina Wamucii 2023).

Indonesian tropical tuna fishing fleets are large and diverse, with their geographic range of operations spanning from the eastern Indian Ocean to the Western and Central Pacific Ocean via the Java and Banda Seas, and in recent years extending into the Southern Ocean. They include both commercial (industrial scale) and artisanal/small-scale sectors. The tuna fisheries are multi-gear including longline, purse seine, pole and line, gillnet and handline/troll-line, and, although illegal by current Indonesian law, some vessels will carry and use multi-gears on one fishing trip. The number of tuna fishing vessels in Indonesia is extremely large (estimated to be at least 300,000), consisting of both motorised and non-motorised vessels, ranging in size from less than 1 gross tonnage (GT) to as large as 198 GT (Purse Seiner) (MMAF and OFP-SPC 2021).

A large proportion of the fishing vessels are smaller than 30 GT, placing them under provincial and regency jurisdictions for licensing purposes. Those >30 GT are licensed under national jurisdiction by the central government. As in many countries, jurisdictions are also defined by fishing zones; 0 – -4 nautical miles (nm) is under regency jurisdiction (until 2014), 4-12 nm is under provincial jurisdiction, and 12- –200 nm is under national jurisdiction. These vessels and zone-based jurisdictions add to the complexities of designing, monitoring and implementing effective fisheries management.

Catches by Indonesia's tuna fishing vessels are, in general, multi-species, including skipjack tuna, *Katsuwonus pelamis*, yellowfin tuna, *Thunnus albacares*, bigeye tuna, *T. obesus*, albacore tuna, *T. alalunga*, andmany tuna-like species such as marlins, swordfish, spearfish, mackerels (*'tongkol'*), pelagic sharks, and dolphin fish (*Coryphena hippurus*), but obviously highly dependent on the gear and also region of fishing operations. Previous studies, including that of our previous ACIAR project (FIS/2009/059) have shown the proportion of juvenile yellowfin tuna and juvenile bigeye tuna in the catches of purse-seine, pole and line, and handline/troll-line vessels to be very substantial (Widodo et al. 2016a, 2016b).

Deepwater anchored Fish Aggregation Devises (FADs) have been an integral part of Indonesia's tuna fisheries since the 1970s. Although it has proved difficult to estimate the total number of tuna FADs across the Indonesian archipelago, the number is thought to be in the several thousands (Widodo et al. 2016a). Since 2014, Indonesia has a suite of fisheries regulations related to installation and operation of FADs, but the implementation and enforcement of these regulations has to date been ineffective. The FADs are used by purse-seine, pole and line and handline/troll-line gears, and conflicts between the fishers using those gears are commonplace. A key output from the previous ACIAR project (FIS/2009/059) was a suite of recommendations on how to improve management of the FADs.

Knowledge gaps

The tuna fisheries in the Pacific Ocean waters of Indonesia, the Philippines and Vietnam represent around 30% of the annual catches of key tuna species in the Western Central Pacific Ocean (WCPO) (McDonald 2021). The lack of accurate data on catch, effort and the composition of catches in these waters has been highlighted as a key uncertainty in WCPO stock assessments at WCPFC for a number of years (McDonald 2021). In an effort to improve understanding of these fisheries and increase the accuracy of data available for stock assessments, a series of projects have been implemented since 2000 to support data collection in Indonesia, the Philippines and more recently Vietnam (McDonald 2021). These projects have included the Indonesia and Philippines Data Collection Project (IPDCP), the West Pacific East Asia Oceanic Fisheries Management Project (WPEA-OFM), and the Sustainable Management of Highly Migratory Fish Stocks in the West Pacific and East Asian Seas (WPEA-SM). The WPEA-SM project, implemented by the WCPFC Secretariat and national project coordinators in the three countries, terminated on 27 April 2019.

The information underpinning stock assessments of tuna species in Indonesian waters remains quite limited (Herrera 2002, Proctor et al. 2003, Anon. 2015), resulting in high levels of uncertainty in current stock status and productivity and, hence, the sustainability of the current yields. For instance, life history traits of fish are vital inputs to stock assessments and for setting reference points for sustainable fishery management (McBride 2014). Crucially, accurate information on life history parameters such as longevity, length/age at maturity, asymptotic length and growth rates are not available for tropical tunas in Indonesian waters, or indeed for much of the Indian Ocean. A previous daily ageing study in the western Indian Ocean estimated growth parameters for yellowfin tuna in the area (Sardenne et al. 2015), but found that counts of 'daily' increments in otoliths underestimated the age of large bigeye tuna, and that otoliths were not useful for ageing skipjack. An earlier study in the eastern Indian Ocean found that bigeye tuna can live up to 16 years based on counts of annual increments (Farley et al. 2006). There have been no comprehensive studies of tropical tuna reproductive dynamics or maturity in Indonesian waters. Several studies, however, have shown that growth and maturity-at-length in tunas can vary within and between ocean basins (Farley et al. 2006; Farley et al. 2014; Williams et al. 2012). Although life-history data are available for some tuna species in other oceans, they should not be used in place of locally obtained parameters from the Indonesian region. Thus, to meet the long-term sustainability requirements of Indonesia's fisheries, there is a pressing need for targeted life-history research at archipelagic and regional scales.

Capacity gaps

Its geographic location and the importance of tuna and tuna-like species for economic development, livelihoods and food security makes Indonesia a central member of three tuna Regional Fisheries Management Organisations (RFMOs): the Western and Central Pacific Fisheries Commission (WCPFC), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). Indonesia is also a Cooperating Non-Member of the Inter-American Tropical Tuna Commission (IATTC). Tuna RFMOs determine research, monitoring and reporting requirements that members are obliged to meet. While there has been substantial progress in Indonesia's participation in tuna RFMOs and meeting its monitoring and reporting responsibilities, there has been limited capacity for operational management of these important resources to maximise benefits and minimise risks of overfishing. This situation has the potential to generate substantial short- and long-term economic losses, reduced food security and associated social impacts for Indonesia. Given the highly migratory nature of these fishery resources, there are likely to be commensurate impacts for developing economies in the adjacent Pacific and Indian oceans (Haward and Bergin 2016).

Indonesia achieved its first Marine Stewardship Council (MSC) certification for a tuna fishery in November 2018 (MSC 2018). The MSC certification, however, is conditional on the adoption of harvest strategies (MSC 2014). A harvest strategy is the process of setting harvest limits for a fished species and is generally considered to comprise three elements: a monitoring strategy, a method for assessing stock status, and a decision process (Smith et al. 2008; Miller et al. 2018). Harvest strategies must contain pre-agreed rules that determine the intensity of fishing that can take place, based on indicators of the targeted stock's status, termed harvest control rules (HCRs). The adoption and implementation of harvest strategies is therefore considered central to obtain and/or maintain MSC certifications for tuna.

Recognising the importance of effective management of tuna resources, Indonesia's Ministry for Marine Affairs and Fisheries (MMAF), supported by stakeholder groups, initiated discussions on the potential to develop formal harvest strategies for the management of Indonesia's tuna resources with reference points, HCRs and the precautionary approach at a workshop in Bogor in October 2014 (Anon. 2015). The workshop recommended the formation of a collaboration among Indonesian fisheries managers, scientists, industry, fishing associations and NGOs to establish a work program to further advance the development of harvest strategies. Subsequently, a draft work plan was created in which it was agreed that case studies for Indonesian archipelagic waters be developed and used to evaluate the likely performance of alternative forms of harvest strategies.

The initial technical work and stakeholder consultation to develop case studies of harvest strategies are supported by the West Pacific and East Asia (WPEA) program of WCPFC (Hoshino et al. 2018). This project leverages the substantial investment from ACIAR, CSIRO and partners outlined above.

4 Objectives

Research Questions

The project was designed to address seven research questions central to improving a) our understanding of the productivity of tropical tuna stocks and b) the design of harvest strategies to monitor and manage the complex range of fisheries that harvest them. Outputs from a) will also inform the design of harvest strategies under b).

Productivity of skipjack, yellowfin and bigeye tuna in Indonesia

i) Do the fundamental growth and reproductive biology parameters of tropical tuna vary significantly among regions of Indonesia and the wider Indo-Pacific Oceans?
ii) What are the seasonal and inter-annual variation in the reproductive biology of tropical tuna in Indonesia?
iii) Can fin spines or other “hard parts” be used to accurately age skipjack tuna?

Harvest Strategies

iv) What are the most cost-effective designs for catch and effort monitoring to meet Indonesia’s requirements for domestic fisheries management and meeting their responsibilities and obligations to tuna RFMOs?
v) What are the likely social and economic impacts associated with different forms of fisheries management measures and how do they vary among sectors of the tuna fisheries?
vi) What form of harvest strategy is both feasible to implement and most likely to meet the objectives of the National Tuna Management Plan, given the current situation of Indonesian tropical tuna fisheries, management and research?
vii) What are the likely trade-offs in catch performance and stock conservation risk between single-species and multi-species harvest strategies for tropical tuna in complex, multi-gear fisheries?

Aim and Objectives

The overall aim of the project was to enable Indonesian fisheries scientists, industry and managers to improve the effectiveness of monitoring and management systems for Indonesian tuna fisheries. The objective was to contribute to the longer-term goal of improving economic and social benefits, while reducing conservation risks to these regionally important stocks.

The specific objectives were to:

(i) Facilitate policy and technical consultative processes for the development of the Harvest Strategy Framework for the tropical tuna fisheries in Indonesia.

(ii) Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction).

(iii) Examine the potential social and economic impacts of alternative management measures through surveys and bio-economic modelling.

(iv) Evaluate operational harvest strategies for tropical tuna in Indonesia’s Fisheries Management Areas 713–715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies.

(v) Develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant tuna RFMOs.

5 Methodology

5.1 Facilitate policy and technical consultative processes for the development of the Harvest Strategy Framework for the tropical tuna fisheries in Indonesia

The foundation for this component of the project had been created through the multi-stakeholder consultative process for development of the harvest strategy for IAW in the two years leading up to the commencement of this project (see Attachment 1, Appendix 1, Satria and Sadiyah 2018; Hoshino et al. 2020). The project team led the design and establishment of this process, which was formalised by the appointment of the Harvest Strategy Technical Working Group and Harvest Strategy Steering Committee under the Director General Capture Fisheries, MMAF, to direct the process. This included the schedule and requirements for annual data exchange by MMAF agencies and NGOs and annual Technical and Stakeholder workshops for transparent review of progress and wide consultation on the further development and refinement of the harvest strategy framework. It was expected that this framework for the harvest strategy would form the basis of a Ministerial Decree or regulation under the National Tuna Management Plan and be accompanied by a 3–5-year work plan for design and implementation of operational harvest strategies for FMAs 713 – 715.

This consultative and technical review process provided the forum for input to the review of suitable monitoring series, the design and capacity building on harvest strategies, the importance of population biology for defining aspects of harvest strategies and management measures, and the role of stock assessment and management strategy evaluation in tuna fisheries management and consultation and agreement on objectives, reference points and management measures for the harvest strategy framework (MMAF 2018).

In addition to the formal harvest strategy process, dedicated workshops were convened at CSIRO (Hobart) and in Indonesia where Indonesian scientists and DGCF staff were given briefings and hands-on training on: Commonwealth Harvest Strategy Policy and guidelines, the Fisheries Management Act and the separation of policy and operational management between DAFF and AFMA, and harvest strategies implementation in Commonwealth fisheries (i.e. how the concepts of harvest strategies can be translated into active fisheries management). These workshops were designed to highlight the common issues and the substantial differences in policy and management between Australian and Indonesian fisheries management and the range of issues that need to be considered in development of harvest strategies that are appropriate to the Indonesian context and likely to be most practical and effective. In 2018, and again in 2023, these workshops included advice and support in the preparation of the harvest strategy documentation and briefings and planning for the next stage of implementation.

5.2 Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction).

5.2.1 Sampling design and protocol

A biological sampling program was developed to obtain sufficient samples of bigeye (BET), yellowfin (YFT) and skipjack (SKJ) tuna from three regions (east, central and west) across the Indonesian archipelago to enable statistically robust analysis of the population biology between the sampling regions. The sampling program was developed and refined during three planning workshops in Bali in March, July, and September 2019. The aim was to include as best representation as possible of the populations of tuna based on the stock structure results of project FIS/2009/059. Genetic analyses in Project FIS/2009/059 suggested at least two or three main genetic groups of BET and YFT, with clines of genetic variation across the range sampled (Proctor et al. 2019).

Four fishing ports were selected for sampling based on their location, the size range of each species landed, and the availability of enumerators for sampling. The ports selected were Bitung (east), Kendari (central), and Palabuhanratu and Cilacap (west) (Figure 5.2.1). The aim of the program was to collect gonads, otoliths, tissue and fin spines using a staged approach:

- **In Year 1,** sample 100 fish (sexes combined) of each species each month in the three sampling regions.
- **In Year 2**, sample 50 fish (females only) of each species each month in the three sampling regions.

Adequate sampling of the whole length range of fish was required to obtain robust estimates of growth and maturity parameters. Hence, a combination of random and length-stratified sampling was used. Specifically, an initial period of random sampling was conducted each month, followed by length-stratified sampling to “fill in” gaps for length classes not adequately represented in the random sample.

The sampling protocol included measuring fish length, removing and storing otoliths, gonads and fin spines, determining sex, and weighing, subsampling and classifying gonads macroscopically. A sampling protocol was drafted and used as the guideline for training the sampling teams. Training of scientists from Indonesia’s fisheries research institutes (RIMF, CFR and RITF) was conducted over several workshops in Bali, using “Train the Trainer” methods. This was possible because many of the Indonesian Team were researchers / senior scientists that had participated in previous ACIAR and IOTC projects and hence were familiar with the collection protocols (Proctor 2016; Davies et al. 2020).

Following the completion of training, the scientists travelled to three of the four fishing ports (Palabuhanratu, Kendari, Bitung) in September/October 2019 to train local field enumerators and commence sampling. Sampling at the fourth port (Cilacap) commenced in August 2020 with the aim of increasing the number of large BET sampled in the western region. Sampling continued monthly until September-December 2021, including over the COVID-19 shutdown period where COVID-19 safe work procedures were applied in the ports. The sampling teams used social media applications (apps) to provide real-time feedback among enumerators and the project team on progress, which was very helpful, particularly when COVID impacted on movement. Appendix 2 provides a summary report of the enumeration and sample collection in each port.

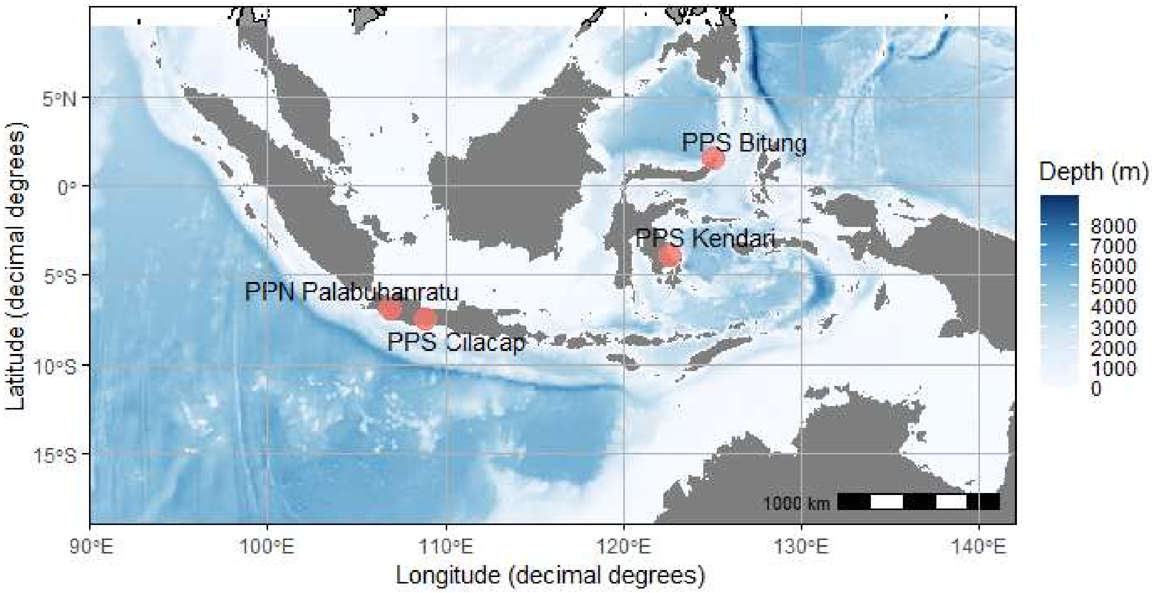

Figure 5.2.1 Map showing the locations of the four fishing ports where sampling was conducted for BET, YFT and SKJ.

5.2.2 Sample database

I Gede Bayu Sedana of CFR created a dual app system for this project. The initial component was an app for online data entry developed with PHP and MySQL. Prior to using the application, each enumerator was required to log in. Once logged in, access was limited to their own data (Figure 5.2.2). Data were entered by the enumerators and available to the project in real time. The second component of the app was developed for dissemination of data. An online dashboard application was created using the shiny package in R (Chang et al. 2023). Interactive visualization of data based on one or more parameters is possible through this app (Figure 5.2.3).

The ability to access a “live” representation of the sample collection as it was populated, using the sample database, allowed the sample teams to identify any potential data gaps in the collection and respond through strategic allocation of project resources and deployment of enumerators.

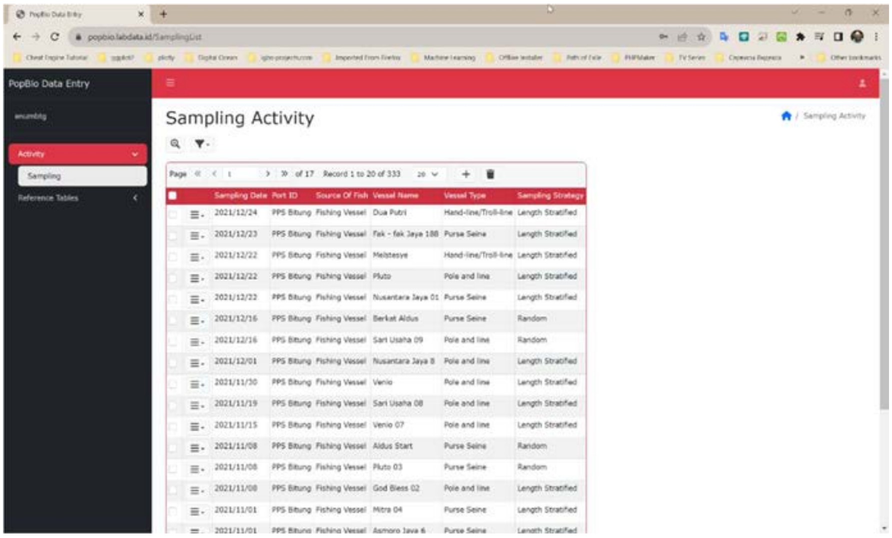

Figure 5.2.2. Online data entry application (https://popbio.labdata.id) developed for the project.

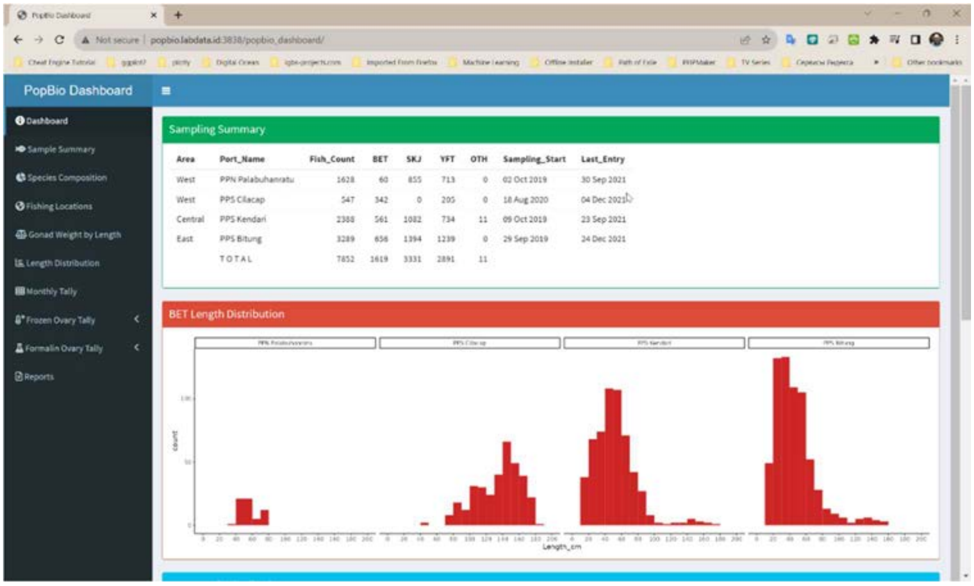

Figure 5.2.3. An example data summary and figures available via the online dashboard application (http://popbio.labdata.id:3838/popbio_dashboard)

5.2.3 Sample collection

The straight fork length (FL) of all fish was measured to the nearest lower half centimetre and weight (W) to at least the nearest 0.1 gram. Gonads were removed and weighed to the nearest gram, unless they were too small to weigh (i.e., the fish was very small/immature). Sex was identified and reproductive phase determined macroscopically (i.e., visually) following the images and descriptions in Diaha et al. (2015), which were adapted to the standardised terminology of Brown-Peterson et al. (2011) (Table 5.2.1). Fish in stage 1 or 2 were considered immature and fish in stages 3 to 5 were considered mature. Females in a regenerating phase (resting after spawning) were not identified as this can only be done accurately through histological analysis of ovaries. Fish with gonads that were too small to determine the sex were classed as indeterminate, and fish landed gutted were classed as unknown. Further detail on enumeration methods and sample collection is included in the Appendix 2 (Summary Report of enumeration and sample collection) and a selection of projected related photos in Appendix 11.

Table 5.2.1 Macroscopic reproductive phases of tuna from Diaha et al. (2015) and Brown-Peterson et al. (2011)

Stage	Diaha et al, (2015)	Brown-Peterson et al. (2011) & current study
1	Immature	Immature
2	Early maturing	Early developing
3	Late maturing	Late developing
4	Ripe	Spawning capable/actively spawning
5	Spawned/spent	Regressing

Only gonads from females above a certain minimum sampling size (i.e., 80 cm FL for BET, 60 cm FL for YFT and 30 cm FL for SKJ) based on maturity studies in other regions were subsampled and fixed in formalin for histological analysis. Histological analysis of ovaries of smaller fish was not necessary as all were immature. A 1.0 cm wide cross section from the middle of the larger ovary lobe was taken and placed in a pre-filled and labelled vial of 10% formalin. All ovaries classed as actively spawning (stage 4 females with large translucent hydrated oocytes that are easily dislodged from the ovary material) were retained for potential batch fecundity estimation. The ovaries were placed in a labelled plastic bag and frozen. Otoliths were removed from each fish using either the “lift the lid” or the “drilling” method (see Appendix 3; Sampling protocol). The otoliths were cleaned and dried and placed in a labelled vial. The first spine of the first dorsal fin was removed whole from the base and was placed in a labelled zip lock bag and frozen for future analysis.

5.2.4 Sample analysis

Unfortunately, a substantial institutional restructure in Indonesia (MMAF-BRIN) during the project impacted the ability of the Indonesian team to participate in the sample processing and analysis for the population biology component of the project. The restructure left the project in a position where the laboratory identified to undertake processing of biological samples (the Research Institute for Tuna Fisheries in Bali (RITF)) was no longer available. Further, the absence of a new MoU between ACIAR and BRIN and CSIRO-BRIN meant that funding could not be transferred to BRIN to complete the laboratory work.

The intention of the project was to prepare histological sections of gonad samples and sections of otolith and fin spine samples at RITF. The histological sections were then to be assessed to determine gonad phase, reproductive cycle and maturity status. The aim was to have the histology sections read by multiple readers to assess and quantify reader differences before a consensus classification was determined. These results were to be compared with results from the macroscopic (visual) classification of gonads to determine error rates. Furthermore, spawning periodicity, spawning fraction, batch fecundity and potential annual fecundity were to be estimated based on the histological analysis and oocyte count data. Finally, otolith and fin spine sections were to be read to estimate age and growth parameter for each species.

In addition to the RITF lab being unavailable for sample processing and analysis, the COVID-19 pandemic restricted travel to Indonesia for in-person training on reproductive biology and age estimation. However, online training was conducted in November 2021 and preliminary data analysis was undertaken in August 2022 (See Appendix 6).

In-person inspections of four labs were undertaken in Indonesia when COVID-19 travel restrictions were lifted to assess their suitability for processing biological samples for the project and for training in fish ageing and reproductive biology (see Appendix 4). The Laterio Lab in Ancol (Jakarta) has the required instruments for otolith analysis available, except for a handle tool, which will need to be sourced. The Genomic Lab (Cibinong) is only available for genetic analysis; there are no histology or otolith preparation labs present. The Serpong Lab (Tangerang) has instruments for histological analysis available (e.g., a microtome), however, the required chemicals and the other instruments are not available. Furthermore, there are very limited personnel available to conduct the lab work. The Histopatologi lab in Gondol (Bali) has a substantial lab with most equipment required for histological analyses. Unfortunately, the automatic tissue processor no longer works well, so it needs to be run manually. The integrated camera microscope is also very old and slow. These two main instruments are required to be upgraded. The maximum capacity for histology slides that can be produced in one run is between 25-50 slides per day. In summary, the reproductive analysis for tuna (histology) can be conducted at this lab using the current available instruments, but there is no lab available for analysing otolith or spine samples.

5.2.5 Consolidation of sample collection

The samples for the population biology component of the project were stored in freezers across Indonesia awaiting retrieval up until May 2023. Due to concerns about ongoing port storage options in Sulawesi, the tissue samples from Bitung and Kendari needed to be secured and consolidated in BRIN "Laterio" facilities in Ancol, North Jakarta and Gondol (Bululeng NW Bali) before the end of June 30, 2023. Facilities at these two BRIN laboratories will ensure ongoing secure storage of these tissues, prior to processing and analysis, for what will become a unique and valuable dataset. The sample consolidation from Sulawesi required two teams to visit Bitung and Kendari, liaise with port officials, enumerators, assess tissue collection, package and arrange appropriate air transport. In both locations it was important for the teams to not simply locate the samples, pack them and leave. The success of this section of the project, and the resultant tissue collection was heavily dependent on the DGCF enumerator and fishing port staff. The strong relationships that the Indonesian in-country project leaders had nurtured with fishing port officials, over years, was found to be invaluable in the context of the major disruptions to this project from the COVID-19 pandemic and the restructuring of the science and resource management sector.

The storage arrangements for the samples collected from Javanese ports, Cilicap and Palabuhanratu, had been assessed as more secure, so the timeline for their consolidation to BRIN facilities was less urgent. A road-based solution, using a single team and a refrigerated transport was arranged to move them to secure storage space within the BRIN research facilities in Ancol, or Cibinong.

5.2.6 Preliminary data analysis

Despite the setbacks described in section 5.2.4, some preliminary data analyses were completed, including analysis of length-weight relationships (LWR), evaluation of spawning periodicity, and estimation of maturity ogives using macroscopic classification of gonads conducted in the field.

The LWR was estimated using a power function of the form $W = aFL^b$, where a is the coefficient of the power function and b is the exponent indicating isometric growth when equal to 3. Gonad index (GI) was calculated as: $GI = W/FL^3 \times 10^4$ (Ramon and Bailey, 1996). The proportion of mature females, p, was modelled as a function of length using logistic regression:

$$log\left(\frac{p}{1-p}\right) = \alpha + \beta FL$$

The models were fit using the glm function in R (R Core Team 2021).

5.3 Examine the potential social and economic impacts of alternative management measures through surveys and bio-economic modelling

5.3.1 Review of previous socio-economic studies and data

A desktop review and field visits to gather information from government, industry group, and NGO personnel were conducted between September 2018 and October 2019. The objectives were (i) to create a consolidated database of the recent and ongoing social and economic studies and data collected for fisheries and communities linked to tuna fisheries in Indonesia, and (ii) to identify potential social and economic data sources that could be used for the development and implementation of tropical tuna harvest strategies in Indonesia. The study resulted in a technical report (Appendix 5) which identified at least 21 data sources and their summary descriptions. The review also identified data gaps and proposed potential social and economic performance measures, or indicators, that can be incorporated into the simulation evaluation framework (Management Strategy Evaluation) in the future. This review has resulted in 3 separate projects being funded during the life of the current project: one led by Eriko Hoshino (funded by the Walton Family Foundation, WFF); one led by the University of Technology Sydney (funded by ACIAR SRA); one led by NGOs and industry members of the Tuna Consortium (funded by WFF) (see the Results section for more details).

5.3.2 Bioeconomic modelling

The original aim was to develop bioeconomic models for the Indonesian tuna fisheries with age-structured, quarterly time-step, multi-fleet, and multi-gear specifications, if the required data to construct such models were available. Bioeconomic models typically require detailed information on the biology of the species, technical interactions between fishing gears and catches, cost structure of the fishing fleet and market conditions, as well as information on prices. The biological parameters (e.g. natural mortality, growth) and fleet parameters (e.g. selectivity) could be taken from literature, the WCPFC stock assessment models outputs, and Indonesian port-based sampling data. However, based on the initial socio-economic review study above, it became apparent that the available effort data remains insufficient to establish a functional relationship between fishing effort, catch and biomass (i.e. production function). It is necessary to have time-series data of sufficient length on fishing effort at a finer scale (e.g. number of hooks, number of sets) than is currently available to be able to estimate production function parameters. Hence, this activity was not pursued further at this time; rather, effort was focussed on securing resources and coordinating efforts to improve the collection of the required data.

5.3.3 Developing socio-economic response models

The original plan was to develop socio-economic response models that allowed: i) an evaluation of trade-offs in meeting conflicting objectives (social, economic and stock conservation objectives) of various harvest strategies in a simulation setting prior to implementation, and ii) an exploration of harvest strategies that would maximise/maintain social and economic benefits while minimising the negative impacts on the stocks. Again, the limited quantitative socio-economic data available did not allow us to develop such response models. Instead, the focus was shifted to improve the availability of quantitative socio-economic data and to lay the groundwork to establish more systematic socio-economic data collection. The review study has also proposed targeted research, including a country-wide characterization of the tropical tuna fisheries, and a study to estimate cascading economic impacts (known as multiplier effects) of the tropical tuna fisheries based on surveys of business and household expenditures and available Input-Output table in Indonesia. As noted, this has led to a separate project funded by the Walton Family Foundation and CSIRO (see the Results section for more details).

5.3.4 Coordination with partners

To coordinate activities by partner institutions, provide expert advice and assist MMAF/BRIN to initiate wider socio-economic research plans and data collection activities (more details in the Results section).

5.4 Evaluate operational harvest strategies for tropical tuna in Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies

5.4.1 Identifying key monitoring series

The original exploratory analysis was conducted in July 2015 in Hobart by scientists from the CFR of MMAF and CSIRO to identify potential monitoring series that could be used as inputs to a harvest strategy for FMAs 713-715 as part of the early scoping stages of the HS process. Of the eleven data series identified, three were selected as candidates based on (i) area coverage (i.e., data series must cover at least one, if not all, of FMAs 713-715), (ii) availability of effort data at high frequency (i.e. daily); and (iii) continuity (i.e., data collection must be ongoing) (Hoshino et al. 2020). These data series were improved and updated every year between 2016 and 2022. These key data series were used to estimate selectivity parameters for the Indonesian tuna fleet (e.g. Ernawati et al. 2021), and to derive indices of local stock abundance within Indonesia (e.g. standardized CPUE) (Sadiyah et al. 2021). Both are also used as key inputs in the Operating Model parameterisation and Management Strategy Evaluation (see below).

5.4.2 Developing prototype Operating Models

In the first instance, prototype Operating Models (OMs) were developed to evaluate example harvest strategies for skipjack tuna and yellowfin tuna in Indonesian archipelagic waters. OMs provide a mathematical representation of the system to be managed and contain the biological components of the system, the fishery that operates on the modelled population, how data are collected from the managed system and how they relate to the modelled population (Punt et al. 2016). The population dynamics of the prototype OMs follow very closely to those used in the WCPO stock assessment models, but consider only one spatial region per species relevant to Indonesia (i.e. region 7 for yellowfin tuna, region 5 for skipjack tuna), while accounting for the movement of fish between those regions and the others in the wider WCPO (Hoshino et al. 2020).

5.4.3 Evaluation of example harvest strategies

Using extended versions of the prototype OMs developed in this initial stage, example harvest strategies based on adaptive effort control for the large-scale Indonesian fleet (>30 Gt) were developed. Their performance in meeting specific management objectives was compared against constant effort/catch strategies (status quo) in a simulation evaluation framework, known as Management Strategy Evaluation (MSE) (Punt et al. 2016), using empirical harvest strategies in an approach, similar to that used for the Australian tropical tuna longline fisheries (Davies et al. 2007) and a general form of empirical HCR from Curruthers et al. (2016). The simple empirical HCRs were based on fisheries indicators from the domestic fleet (e.g. CPUE or average size). Using these models, it was possible to evaluate the impacts of different qualities of data and/or indicators on monitoring and management outcomes. In doing so, it provided a basis for fisheries scientists and managers to evaluate and refine cost-effective fishery monitoring strategies. This approach is particularly pertinent to many small-scale fisheries for which more complex and expensive scientific monitoring methods is often cost prohibitive.

The initial results were presented in Hoshino et al. 2020, and the updated model development (after the regional stock assessment results were updated by SPC) and results were presented at annual technical working group meetings and stakeholder meetings in 2021 (for skipjack tuna) and 2022 (for yellowfin tuna). The summary of models and results, as well as key assumptions and uncertainties identified are provided in the respective technical reports (Appendices 4-5).

5.4.4 Stakeholder engagement and consultation

The stakeholder consultation workshops were used as the primary platform for stakeholder engagement in the harvest strategy process, with a focus on review of results and consultation on management objectives and management measures suitable for implementation of the harvest strategies. They were convened by the Directorate General for Capture Fisheries (DGCF) of MMAF and CSIRO team members attended as invited experts. In addition to participants from DGCF and the AMAFRHR/BRIN project team, participants included representatives from the tuna industry, fishing associations, Indonesian and international fisheries scientists, NGOs, heads of local (regency and provincial) port authorities and representatives from the relevant tuna RFMOs. The purpose of stakeholder consultation was to establish a common understanding within MMAF, Indonesian tuna fishing industry and NGOs of the interaction between national and international fisheries management regimes, role and purpose of stock assessment and harvest strategies in fisheries management, and the steps and considerations involved in the development and testing of harvest strategies.

In parallel to the stakeholder engagement, the Technical Working Group (TWG), led by the Indonesian scientists of the MMAF institutes CFR and RIMF (later merged into Centre for Fishery Research in BRIN) and supported by CSIRO experts, conducted a series of technical workshops to analyse available time series data and to identify the uncertainties and data gaps, and the actions required for testing and implementing harvest strategies. The TWG identified priorities which were subsequently adopted by the Ministry (MMAF 2018) and also developed prototype simulation models for conducting demonstration MSE for case study fisheries (see 5.4.3 and Hoshino et al. 2020).

A total of seven Stakeholder Workshops and four Technical Workshops were held between October 2014 and November 2018 in this development phase of the Harvest Strategy Framework, and an additional five Stakeholder Workshops and four Technical Workshops during the refinement phase between 2019 and 2022, leading up to adoption of the full Harvest Strategy Framework in 2023.

5.4.5 Capacity building activities

Capacity building workshops involving key personnel from DGCF (Ms Putuh Suwadela, Mr I Gede Bayu Sedana, Ms Lia Novita) and CFR/RIMF (Dr Fayakun Satria, Dr Lilis Sadiyah, Ms Tri Ernawati) were undertaken in July 2016, May 2018, March 2020, and February 2023. The workshops were designed to provide participants with a deeper understanding of concepts of harvest strategies, MSE, operational fisheries management tools and modern scientific advancement in fisheries management used in Australia and globally. Participants were also given tutorial with hands on experience in conducting exploratory data analyses of key monitoring data for use in the empirical harvest strategies, and in simulation testing of example harvest strategies using R to develop a stronger understanding of concepts, such as feedback control and observation and estimation error.

In addition, a separate capacity building workshop was held in September 2020 online, targeting the NGO members of the Walton Family Foundation (WFF) Tuna Consortium. The aim of the workshop was to achieve consistency in terminology and technical processes across NGOs, industry groups, government and scientific communities, and thereby facilitate harmonization of the process for developing operational harvest strategies among stakeholders. Recent innovative methods (e.g. use of new genetic methods to estimate population size and connectivity) to improve scientific knowledge for better management of fisheries resources, including tuna, were also presented to stimulate discussions among donor communities/advocacy groups and identify potential future areas of investment.

In addition to the workshops above, a substantial in-kind contribution was provided by team members (Eriko Hoshino, Campbell Davies, Craig Proctor) and CSIRO experts from outside of the direct project team (Ingrid van Putten, Jeff Dambacher) to the UTS team of social scientists to gain familiarity about the concepts of harvest strategies, the development and consultation process and their quantitative data requirements. The support included direct contributions to the proposal of the UTS-led ACIAR SRA project (FIS/2020/109) on socio-economic indicators for tuna fisheries, technical advice on how their outcomes may be used in the harvest strategy process, participation in two informal workshops on qualitative and semi-quantitative modelling in support of harvest strategies in 2019 organised by Nick McLean, and contributions to the mid-term review project report.

5.5 Develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant tuna RFMOs

The project team provided technical and financial support for a number of activities identified as priority in the ACIAR-Indonesia Strategic Plan and development opportunities associated with the three relevant tuna RFMOs' Commissions and Scientific Committees (i.e., WCPFC, IOTC and CCSBT). These included support for two Indonesian scientists to pursue a PhD in Australia, support for two John Dillon fellowship recipients, and scientific training and financial support for the key government scientists to attend tuna RFMO technical meetings and training workshops. This support and activities spanned the three components of the project (HS and MSE, population biology and socio-economics), two of the three RFMOs (WCPFC, CCSBT) and extended the scope of the biology component from tropical tuna to a PhD study on Kawakawa (*Euthynnus affinis*), a priority neritic tuna species for Indonesia.

Maintaining the momentum of the harvest strategy process and consolidation of the wider collaboration was facilitated by regular in-country visits and online engagement between senior scientific (Dr Fayakun Satria) and policy (Dr Tony Ruchimat, Saut Tampubolon, Mr Trian Yunanda and Ms Putuh Saudela) project team members and chairs of the TWG and Stakeholder meetings, respectively. Regular interaction with senior NGO champions of the harvest strategy process and other major donors (e.g., WFF, US-Aid, Packard Foundation) through in-country workshop attendance and regular online engagements was essential to maintaining support for the harvest strategy process and, also, effectively influencing investments in research, monitoring and capacity building, beyond the direct activities of this project.

6 Achievements against activities and outputs/milestones

Objective 1: To facilitate policy and technical consultative processes for the development of the Harvest Strategy Framework for the tropical tuna fisheries in Indonesia.

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Provide expert advice and support for completion of the Tuna Harvest Strategy Case Study for FMAs 713 – 715. *(PC, A)*	Presentation to Steering Committee of WPEA project. (Hoshino et al. 2018).	May 2018	Eriko Hoshino presented summary of prototype MSE models to Steering Committee of the WPEA project, which includes the Scientific Director of the WCPFC. The WPEA had supported the development of the prototype models that were used to demonstrate the potential for developing empirical HS for tuna in IAW.
		Framework for Harvest Strategies for Tropical Tuna in Archipelagic Waters of Indonesia (MMAF 2018)	May 2018	Keynote address by Campbell Davies on HS development process at Bali Tuna Conference and formal MMAF framework for harvest strategies for skipjack, yellowfin and bigeye tuna launched by Director General of Capture Fisheries (DGCF) at Bali Tuna Conference in May 2018. Framework provides the policy context and multi-agency/stakeholder action plan for further development and implementation of harvest strategies for IAW 2018-2023.
		Indonesian Peer Review paper on process (Satria and Sadiyah 2018)	Oct 2018	Summary paper on HS development process published by two Indonesian research scientists from Center for Fisheries Research (CFR) who lead the Technical Working Group and analysis of catch and effort data.
		4th Technical Workshop, Bogor	November 2018	Fayakun Satria (RIMF) presented ongoing tuna monitoring programs, issues identified and recommendations. Lilis Sadiyah (CFR) and Tri Ernawati (RINF) presented an update of selectivity estimation and CPUE standardization, which shows declining trends. Eriko Hoshino (CSIRO) presented preliminary results of MSE testing for example harvest strategies for skipjack tuna.
		1st Stakeholder Implementation Workshop, Bogor	November 2018	Stakeholders agreed on 5 general management measures: (1) restrictions on use of FADs, (2) closure of certain fishing areas. (3) restrictions on fishing operations days (4) restrictions on the number of vessels, and (5) limitations on catches. Agreement on limiting the number of additional fishing permits for industrial vessels over 30GT.

		5th Technical Workshop, Bogor	October 2019	Lilis Sadiyah (CFR) and Tri Ernawati (RINF) presented an update of selectivity estimation and CPUE standardization. Eriko Hoshino (CSIRO) provided an update of OM/MSE model development and ongoing socio-economic study.
		2nd Stakeholder Implementation Workshop	November 2019	Maintain the agreement limiting the number of additional fishing permits for vessels over 30GT
		6th Technical Workshop, Bogor and Online	February 2021	Eriko Hoshino (CSIRO) and Campbell Davies (CSRIO) presented the updates on OM/MSE model development, regional stock status and implications for Indonesia
		3rd Stakeholder Implementation Workshop	March 2021	Maintain the agreement limiting the number of additional fishing permits for vessels over 30GT
		8th Technical Workshop, Bogor, Online	November 2022	Lilis Sadiyah (CFR) and Tri Ernawati (RINF) presented an update of selectivity estimation and CPUE standardization. Eriko Hoshino (CSIRO) presented preliminary results of MSE testing for example harvest strategies for yellowfin tuna Based on the results above and recent stock assessment of SPC, TWG recommended a precautionary catch reduction plan of up to 10%.
		5th Stakeholder Implementation workshop, Bogor, Online	November 2022	Agreement on precautionary catch reduction plan of up to 10% over the next 3 years for all vessels catching tuna.
		Indonesia Tuna Conference, Bali	May 2023	Fayakun Satria (BRIN) and Campbell Davies (CSIRO) provided keynote speech on harvest strategy for tuna
		World Oceans Day conference	June 2023	Framework for Harvest Strategy officially adopted by Minister
1.2	Conduct policy, management and research training workshops on harvest strategy development and implementation with Department of Agriculture (DA), Australian Fisheries Management Authority (AFMA) and CSIRO. *(PC, A)*	Training workshop for CFR Scientists and DGCF staff, at CSIRO Marine Laboratories, Hobart.	7 – 18 May 2018	Training visit for three scientists (Fayakun Satria (RIMF), Lilis Sadiyah (CFR), Bayu Sedana (CFR)) and two fisheries managers (Lia Novita and Putuh Saduela (DGCF)) on harvest strategies and MSE and operational fisheries management, policy and governance.
		Training workshop and visit to AFMA and DA for senior DGCF fisheries managers.	AFMA, DAWE visit originally rescheduled for 1st - 2nd Quarters of 2020.	Not completed, due to COVID-19 travel restrictions and institutional uncertainty in 2021-22.

PC = partner country, A = Australia

Objective 2: To determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction).

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Complete biological sampling *(PC, A)*	Scoping trip to select and confirm sampling locations	Nov 2018	Scoping trip to 5 fishing ports in Nov 2018, as preliminary to commencement of the biological sampling program. Ports visited were Muara Padang and Bungus in West Sumatera; Palabuhanratu in West Java; Bitung in North Sulawesi; and Ambon in Maluku.
		Detailed sampling design for biological sampling.	Sep 2019	Planning workshop for the biological sampling program held in Bali, 4 – 5 March 2019. 17 participants. Full training workshop and finalisation of SOP completed in September 2019.
		Monthly sampling of otoliths and gonads for growth and reproductive biology	***Dec 2021***	**Completed**. Commenced in October 2019 following completion of training. Monthly sampling by trained field enumerators and led by RIMF, CFR and RITF scientists at four ports (4th port added in Mar 2020) over a 29-month period. Sampling objectives largely achieved safely for all three species for both otoliths and gonads under extenuating circumstances by Indonesian team. The samples collected and associated data (length, sex, gonad weight etc) were reviewed in a project workshop in Nov 2021. This clearly demonstrated that success of the sample collection phase. The samples represent one of the most comprehensive biological sampling programs for age, growth and reproduction for tropical tuna and is a credit to the project team.
2.2	Conduct training workshops for Indonesian scientists to build capacity in contemporary population biology laboratory and analysis methods. *(PC, A)*	Project Planning workshop for biological sampling and initial training for key staff.	March 2019	Planning for biological sampling. First stage of sampling training delivered, held in Sanur, Bali.
		Draft Standard Operating Procedure (SOP) developed for the biological sampling program. Appendix 3.	June 2019	SOP for biological sampling progressed. Key elements of the SOP were delivered at the previous March 2019 planning workshop in Bali. Follow-up delivery planned for July 2019 planning workshop and with hands-on training at the Sept 2019 training workshop (both to be held in Bali).
		Project Planning workshop for biological sampling	July 2019	Biological Sampling Planning Workshop, held the Harris Hotel, Kuta, Bali.
		Follow-up training in biological sampling for key staff	September 2019	Biological sampling hands-on training delivered, held at the RITF, Bali.

		Population Biology Training Workshop (hybrid) Appendix 6	November 2021	Population Biology Training Workshop (hybrid), held at the RITF, Bali and at CSIRO, Hobart. This workshop included an introduction to population dynamics and stock assessment; fish ageing methods; reproductive biology methods; and using data from age and growth estimates and reproductive biology for stock assessment .
		BRIN-CSIRO Indonesian Tuna Research Workshop for examining and summarising biological sampling data Appendix 6	August 2022	Data from biological sampling, stored in PopBio Dashboard database, was examined, cleaned and summarised. Held at CSIRO, Hobart.
2.3	Analyse biological samples and model the resulting data to estimate life-history parameters. *(PC, A)*	1. Maturity ogive (cumulative frequency graph) for yellowfin, bigeye and skipjack tuna; 2. Fecundity and spawning frequency estimates by fish size/age for the species; 3. Assessments of spatial and temporal variation in reproductive parameters of the species across the Indonesian archipelago; 4. Population parameter inputs for reference points in harvest strategy decision rules; 5. Indonesian fisheries scientists with well-developed skills in tuna reproductive biology; skills that can be readily applied to other pelagic and non-pelagic fish species.	June 2023	An initial online training workshop held in November 2021 on (i) reproductive/maturity classification, batch fecundity, spawning frequency, (ii) annual and daily ageing methods, and (iii) estimating maturity ogives, decimal ages, and growth curves. Preliminary analysis of the sampling data was completed in August 2022 during in-person training workshop in Hobart. This included examining the sample data and checking for missing data or errors and selecting samples for ageing and histology. Also examining length -weight and gonad weight-length relationship by species. **Incomplete** Unable to commence sample processing due to extended administrative delay due to BRIN restructure, which resulted in ACIAR decision to close project. Samples collated and secured at BRIN and MMAF facilities, with intention to process as soon as resources are available and current administrative issues are resolved. HS process confirmed the priority and value of these data for Indonesian specific population parameters for Harvest Strategy and wider WCPFC stock assessments.

PC = partner country, A = Australia

Objective 3: To examine the potential social and economic impacts of alternative management measures through surveys and bioeconomic modelling

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Socio-economic analyses and/or bioeconomic modelling of tuna fisheries sectors and relevant communities. *(PC, A)*	Consolidated database of social and economic studies and data collected for fisheries and communities linked to tuna fisheries.	Dec 2019	Based on the desktop review (July 2018-June 2019) and in person interviews (March 2019) the project identified at least 21 programs / studies related to the socio-economic aspects of tuna fisheries in Indonesia. This summary was presented for information and review to the 5th Technical HS Workshop in late 2019. Detail can be found in the technical report in Appendix 5
3.2	Propose potential social and economic performance measures or indicators that can be incorporated into the simulation evaluation framework (Management Strategy Evaluation). *(PC, A)*	Set of plausible social and economic response models (indicators) for inclusion in Management Strategy Evaluation.	Dec 2019	A desktop review on available approaches to derive socio-economic performance indicators was presented at the Technical and Stakeholder Workshops in October 2019.
3.3	Examine the potential trade-offs among social, economic and stock conservation objectives of various harvest strategies			**Not completed.** The activity was discontinued following the completion of the data review, as there was insufficient data available at that time (see above). Targeted research proposed by the review study resulted in 2 separate projects being funded to increase the availability of socio-economic data which will allow evaluation of trave-offs among social, economic and stock conservation objectives as part of future work.

PC = partner country, A = Australia

Objective 4: To evaluate operational harvest strategies for tropical tuna in Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Review existing fisheries monitoring programs and conduct a design study for harvest strategy refinement and implementation. *(PC, A)*	Consistent monitoring protocols and sampling designs across different monitoring programs for catch monitoring as part of implementation of harvest strategies.	Nov 2018	Technical Harvest Strategy (HS) process reviewed existing government, industry and NGO programs for the tuna fisheries. A greater consistency in catch monitoring and observer protocols across these programs has been the result; The regular Technical HS Workshops have included review and analysis of data submissions (CPUE standardisation and selectivity) by MMAF and stakeholders. These have been instrumental in maintaining engagement and driving incremental improvement in the monitoring programs
		Formal data submission process established.	April 2019	A HS Data Submission process has been formalised between DGCF, CFR and the NGOs, and with Industry bodies engaged in the HS process. The data specifications, quality control and data management systems are being refined by CFR following review at the 4th Technical HS Workshop (Nov 2018) and the 1st submission process (Mar 2019). This formal data submission process has continued, despite the disruption caused by COVID-19 and the MMAF-BRIN transition and is central to the ongoing development and implementation of the HS, and also to fisheries science and management capacity building across the public and private sectors (See 7.1.1).

4.2	Provide expert advice to DGCF and CFR on the development and selection of operation harvest strategies, consistent with the National Tuna Harvest Strategy Framework. *(PC, A)*	Set of candidate harvest strategies for operational management of tropical tuna in Indonesia.	**December 2021**	**Complete.** See Anon., 2018 Launch of Interim HS Framework Technical work on MSE modelling continued in collaboration with DGCF and BRIN staff. The simulation models for the MSE (known as Operating Models) have been: i) extended to include more realistic range of scenarios for population dynamics, fisheries and connectivity with the wider Pacific Ocean; and are ii) being updated (statistically conditioned) with the outputs of the most recent regional stock assessments from the SPC to ensure the evaluation phase will be as up to date as possible. The preliminary modelling results for skipjack tuna were presented at the Stakeholder meeting in February 2021. Work for yellowfin tuna was presented at the November 2021 workshops. CFR (now BRIN) staff are being directly involved in this process, including provision of data and parameter inputs and developing an understanding of the details of the models. A significant review of the progress of HS implementation was completed at the Technical and Stakeholder workshops hosted by DGCF in November 2022.
4.3	Test the likely performance of candidate harvest strategies using Management Strategy Evaluation			**Completed (see Hoshino et al 2020, and technical reports TR1-4.** The results of the MSE modelling and consultation has been a central input to the management decisions to further limit entry of large vessels into the tuna fishery in IAW and the proposed precautionary catch reduction proposed at the 2022 Stakeholder workshop and included in the 2023 Harvest Strategy Framework launched by the Minister for Fisheries on World Oceans Day, 2023 (MMAF 2023)

PC = partner country, A = Australia

Objective 5: To develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant tuna RFMOs.

No.	Activity	Outputs/ milestones	Completion date	Comments
5.1	Review of current and proposed tuna research and monitoring activities and staff capabilities across CFR/RIMF/RITF and DGCF, where appropriate, and institutional mechanisms for scientific advice and engagement in tuna RFMOs. *(PC, A)*	Alignment of major NGO/Industry tuna monitoring and fishery improvement plans.	Original June 2019 with commencement of the Walton Family Foundation funded Tuna Consortium.	**Partially complete.** The CSIRO project team, key CFR researchers (Satria, Wudianto, Sadiyah) and DGCF managers (Yunanda, Suadela) have successfully built partnerships with Indonesian and international NGOs who are now formally collaborating through the Walton Family Foundation "Tuna Consortium" of, led by The Nature Conservancy and including, MDPI, AP2HI, IPLNF, SFP, PT, Marine Change and LINI. CSIRO operated as an independent advisor to the consortium and WFF providing strategic advice on priorities for WFF and the Tuna Consortium and technical review of project outputs. The combination of COVID-19 (budget impact) and, in particular, the BRIN-MMAF institutional restructure (roles, responsibilities and administrative delays) seriously disrupted the completion of this activity through 2022-23. It has implications for continuation of the monitoring programs established over the last decade. It has directly impacted on the data availability for the harvest strategy for IAW, other monitoring programs in the Indian Ocean and Indonesia's ability to meet its international reporting requirements to tuna RFMOs. Davies has spent a considerable time working with DGCF and BRIN colleagues to assist in addressing the issues raised by the transition. While some progress had been made prior to the close of this project (June 2023), substantial issues remain unresolved.

5.2	Develop a 5-10 year capability plan for tuna research and management and tuna RFMO engagement		2018 & 2023 for Harvest Strategy action plan.	**Partially complete.** The timing of the MMAF-BRIN transition meant that there was not time to complete a comprehensive plan. However, the Harvest Strategy Framework provides a revised set of priorities and action plan for monitoring and management of tuna in the IAW. In addition, the establishment of the WFF Tuna consortium and the formal and informal collaborative mechanisms that have been formed around it provide considerably more coordination among researchers, NGOs, MMAF and BRIN than existed previously.
5.3	Provide targeted support for individual participation in formal and informal tuna RFMO technical meetings, for example through small grant proposals for capacity development funding from CCSBT		2019-2023 2021 2019 & 2023 2023 2023	Supervision and operating support for PhD in population Biology. (Jatmiko, UTAS) Train-the-trainer for Population Biology x 3 (Sulistyaningsih, Hartaty, Tri Hargiyatno) Support for 2 x John Dillon Fellows (Tri Ernawati and Sulistyaningsih) Stock Assessment training workshop x 2 (Satria and Sadiyah) CCSBT OMMP Technical meeting (Satria and Sadiyah)

PC = partner country, A = Australia

7 Key results and discussion

7.1 Facilitate policy and technical consultative processes for the development of the Harvest Strategy Framework for the tropical tuna fisheries in Indonesia

7.1.1 Overview

The policy and technical process for the development of the harvest strategy framework is illustrated in Figure 7.1.1. As noted above, the process was initiated before the inception of this project, however, the project team were directly involved in the initial design of the process from the outset, with participation in the earlier stages supported by NGOs, WCPFC-WPEA project and CSIRO. The figure includes the policy context for the harvest strategy (commitment in the National Tuna Management plan, formal notification to WCPFC), substantive decisions on key elements (objectives and candidate management measures) and specific decisions to limit access to the fishery by some sectors in response to information from the technical process. The lower panel summarises the main stages of the technical development and MSE process, as well as the timing and focus of the dedicated capacity building workshops. The final framework was launched by the Minister for Marine Affairs and Fisheries, Mr Sakti Wahyu Trenggono, on World Oceans Day 2023.

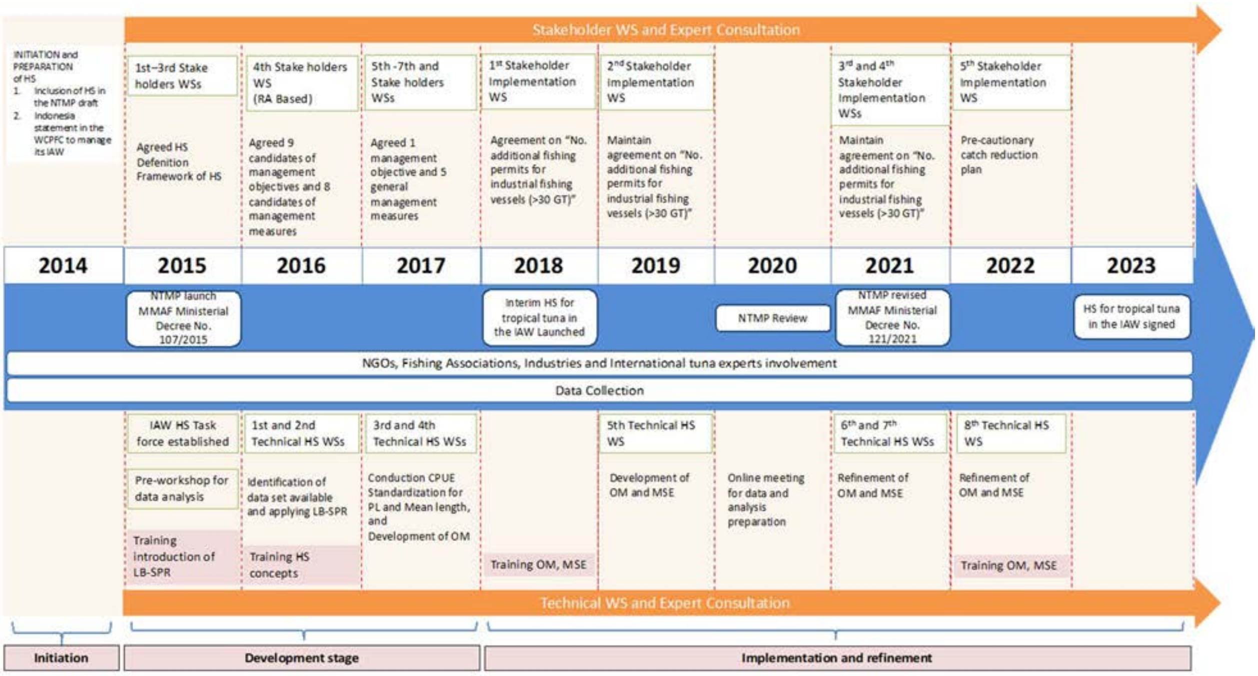

Figure 7.1.1. Summary of stakeholder consultation and technical activities and timelines for the development of the harvest strategy framework for tropical tuna in Indonesian archipelagic waters. Updated from Satria and Sadiyah (2018).

7.1.2 Scope of the Harvest Strategy

The tropical tuna stocks in IAW are considered part of the WCPO tuna stocks, with stronger connectivity between the archipelagic waters and the adjacent WCPO and limited exchange with the Indian Ocean (Proctor et al. 2018; Davies et al. 2020; Lewis and Davies 2021). As such, they are assessed as part of the regional stock assessments conducted by SPC (e.g., Vincent et al. 2019, 2020; Jordan et al. 2022) for the WCPFC. Figure 7.1.2 summarises the release and recapture points for skipjack tuna from the large-scale conventional tagging programs that have been undertaken by SPC since the early 1990s. This demonstrates the scale of movement by these highly migratory species (see Vincent et al. 2020 for YFT) and the level of connectivity between different regions of the WCPO. More details of the regional connectivity and studies on population structure can be found in Lewis and Davies (2021), Moore et al. (2020) and Proctor et al. (2019). The key point, in terms of the scope and design of the harvest strategy for IAW, is that it could not be developed in isolation from the connectivity with fish and fisheries impacts from the fleets in the wider WCPO fishery.

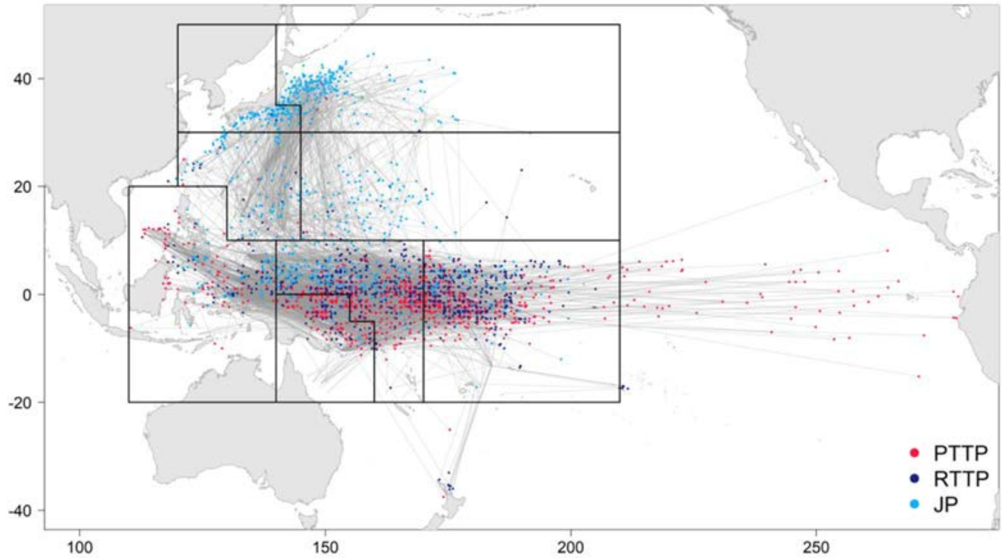

Figure 7.1.2: Summary of distribution of skipjack tuna tag movements where release and recapture locations from regional tagging programs were further than 1000 nautical miles apart. Source: Vincent et al., 2019.

Figures 7.1.3 and 7.1.4 summarise the distribution of the catches of skipjack and yellowfin tuna (the primary focus of the HS) across the Pacific Ocean. They highlight the scale of catches taken in Indonesia and the surrounding waters, as a proportion of the WCPFC fisheries, and the fact that a large proportion of the catches are taken by “other” gears. This reflects the wide range of gears that are used by the Indonesian fleet for tuna and by small-scale fishers, in particular.

In the initial development stage of the harvest strategy process, given the important role of tuna and small-scale fishers in food security and employment, the primary focus for the development of management measures was to control the level of fishing by large-scale industrial and commercial sectors of the fishery. At this time, the advice from stakeholders and experts was that different forms of effort control, or spatial/temporal closures, would be the most likely form of management measure to be used in the harvest strategy. At that time, quota management was not considered a viable approach, given the high uncertainty in the estimates of total catch and the difficulty in accurately monitoring catch levels within-season across such a geographically complex and diverse fishery. As a result, the initial set of operating models developed to evaluate alternative harvest strategies were based on control of the effort of the large-scale (>30Gt) component of the fleet (Hoshino et al. 2020). However, as the quality and detail of the catch reporting improved and knowledge of the fleets response to regulatory interventions and market shocks improved, it became clear that it would not be possible to achieve the objectives of the harvest strategy without including consideration of the level of fishing by the small-scale sector (Hoshino et al. 2021c, Appendix 5).

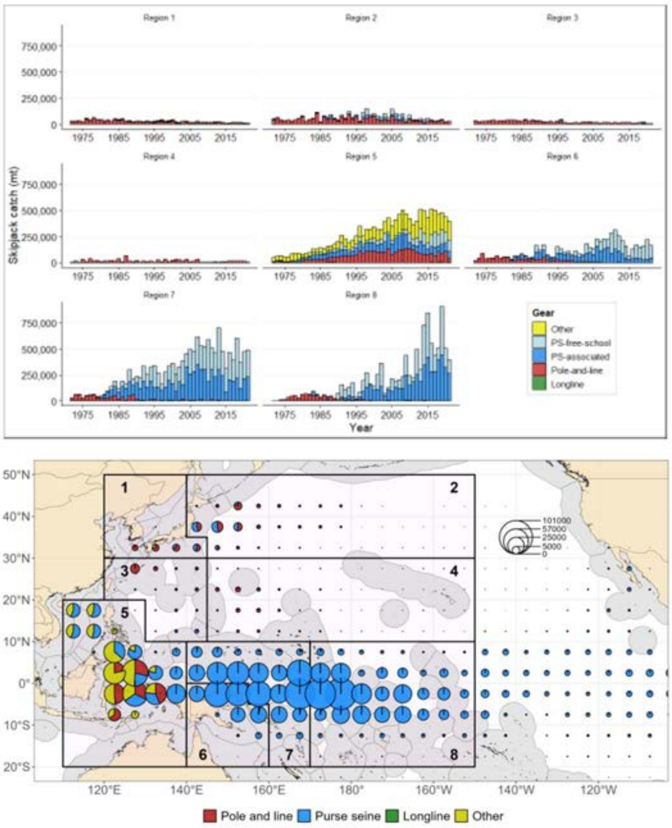

Figure 7.1.3: Summary of distribution of catch by gear for skipjack tuna in the western central Pacific Ocean and eastern Pacific Ocean. The black lines denote the areas of competency of the Western Central Pacific Fisheries Commission (western side) and the Inter-American Tropical Tuna Commission (eastern). Note the scale of catches by "Other" gears in Indonesia and SE-Asia. This reflects the large proportion of catch taken by a variety of other gears and small-scale fishers in this region. (Source: Jordan et al. 2022).

7.1.3 Complementarity and consistency with regional science and management

Under the archipelagic waters provisions of the United Nations Convention on the Law of the Sea, national exclusive economic zones are subject to conservation and management measures agreed by RFMOs, such as the WCPFC. Archipelagic waters are considered internal waters and are not subject to the decisions of RFMOs. However, members of RFMOs are obliged to manage their internal fisheries in archipelagic waters in a way that is consistent with, or does not undermine, conservation and management measures adopted by adjacent RFMOs. In the case of the harvest strategy development, Indonesia's stated intent (Anon. 2016) in developing the harvest strategy for tropical tuna in IAW (Figure 7.1.5) is part of meeting this obligation to manage its domestic tuna fisheries in a way that is consistent with, or does not undermine, decisions of the WCPFC, of which it is a member.

Given this policy and governance context, the harvest strategy framework was designed to be appropriate to the Indonesian context, practically implementable and likely to meet the domestic objectives of the Indonesian government and stakeholders, while being consistent with and complementing existing and likely future decisions of the WCPFC.

This was achieved by designing and implementing stakeholder engagement and technical processes to:

- Specify management objectives and reference points for the tuna fisheries in IAW.
- Identify, improve and expand Indonesian tuna fisheries monitoring data that could be suitably used to develop indicator series for empirical harvest strategies in the medium term.
- Develop a simulation modelling platform for testing empirical harvest strategies based on Indonesian monitoring series that was conditioned[1] to be consistent with the relevant stock assessments for the WCPFC.
- Facilitate capacity building at the individual and institutional level in harvest strategies, stock assessment and MSE for internationally managed tuna stocks.
- Support the MMAF in leading the development and implementation of the harvest strategy framework through the provision of technical and expert advice to the managers, scientists and stakeholders.

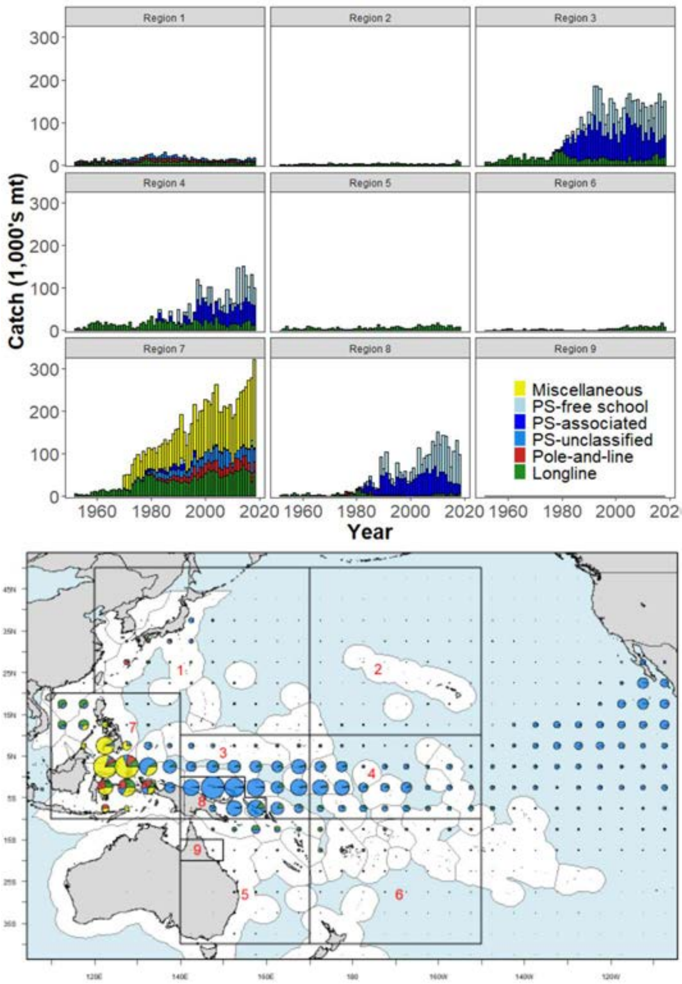

Figure 7.1.4: Summary of distribution of catch by gear for yellowfin tuna in the western central Pacific Ocean and eastern Pacific Ocean. The black lines denote the areas of competency of the Western Central Pacific Fisheries Commission (western side) and the Inter-American Tropical Tuna Commission (eastern). Note the scale of catches by "Other" (labelled "Miscellaneous") gears in Indonesia and SE-Asia. This reflects the large proportion of catch taken by a variety of other gears and small-scale fishers in this region. (Source: Vincent et al. 2020)

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[1] Conditioning is the process of statistically fitting the operating models to the outputs from the current stock assessment and available data from Indonesia, so they are as consistent as possible. It can be thought of as "calibrating" the models, so they are as consistent with the current WCPFC stock assessment as possible. This is done to ensure, to the extent possible, that the conditions for the simulation testing of the alternative harvest strategies is similar/appropriate to the current best understanding of the stock and fishery, as represented by the most recent stock assessment.

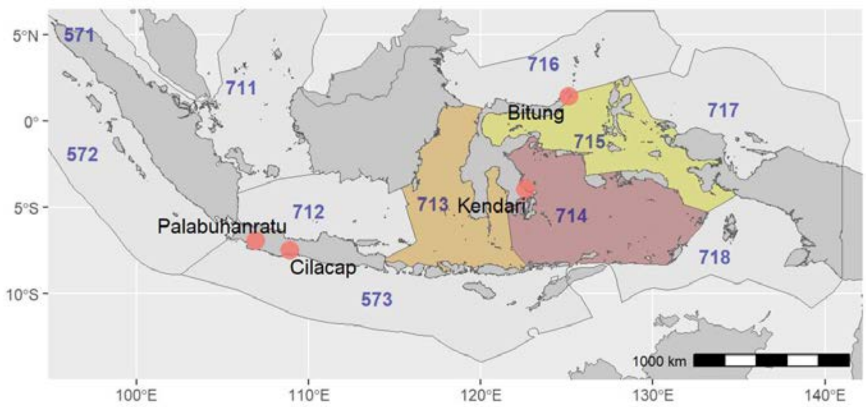

Figure 7.1.5. Map of Fisheries Management Areas (FMAs) across the Indonesian territorial, archipelagic and EEZ waters, with the three archipelagic FMAs included in the harvest strategy (713, 714, 715) in colour; 716 and 717 are in EEZ, territorial and archipelagic waters. FMA 713-717 fall within the statistical area of the WCPFC. FMA 571, 572 and 573 are in Indonesia's EEZ, territorial and archipelagic waters and fall within the statistical area of the IOTC.

7.1.4 Coordination and expansion of catch monitoring programs

One of the first activities completed in the development of the harvest strategy process was a review of available catch monitoring series to determine if there were series of sufficient quality and duration that they could be candidates for indicator series to be used in empirical harvest strategies (Anon. 2015b; Satria and Sediyah 2018; Hoshino et al. 2018). This review identified three series as potential candidates (pole and line for skipjack, handline and longline for yellowfin) and a number of others that may have potential, if their quality and duration were improved.

The geographic coverage of these series is shown in Figure 7.1.6 and the characteristics of each series are summarised in Table 7.1.1. Figure 7.1.7 illustrates the progress over the period of the project, with the WPEA program being the longest running program (2010-2021). This clearly demonstrates the increased participation by NGO participants and extended coverage of ports and sectors of the tuna fleet since the launch of the Interim Harvest Strategy framework in 2018, which had a focus on increasing the coverage and consistency of the monitoring programs as part of the action plan (Anon. 2018). It also reflects the inception of the Walton Family Foundation Tuna Consortium, which also had a strong emphasis on improving the quality of monitoring data and supporting fisheries improvement plans (FIPs) for small-scale fishers for potential MSC certification. While the diversity of contributions to the overall monitoring program provides some resilience to peaks and troughs in funding, the lack of a stable source of funding remains a weakness and a risk to the longer-term implementation of the harvest strategy (Hoshino et al. 2019b).

The standardisation and expansion of the catch monitoring programs across stakeholders substantially increased the coverage and quality of the data available for use as input series for the harvest strategy framework (for CPUE and size-based indicators) and to provide local estimates of selectivity for inclusion in the operating models for the MSE testing of candidate harvest strategies.

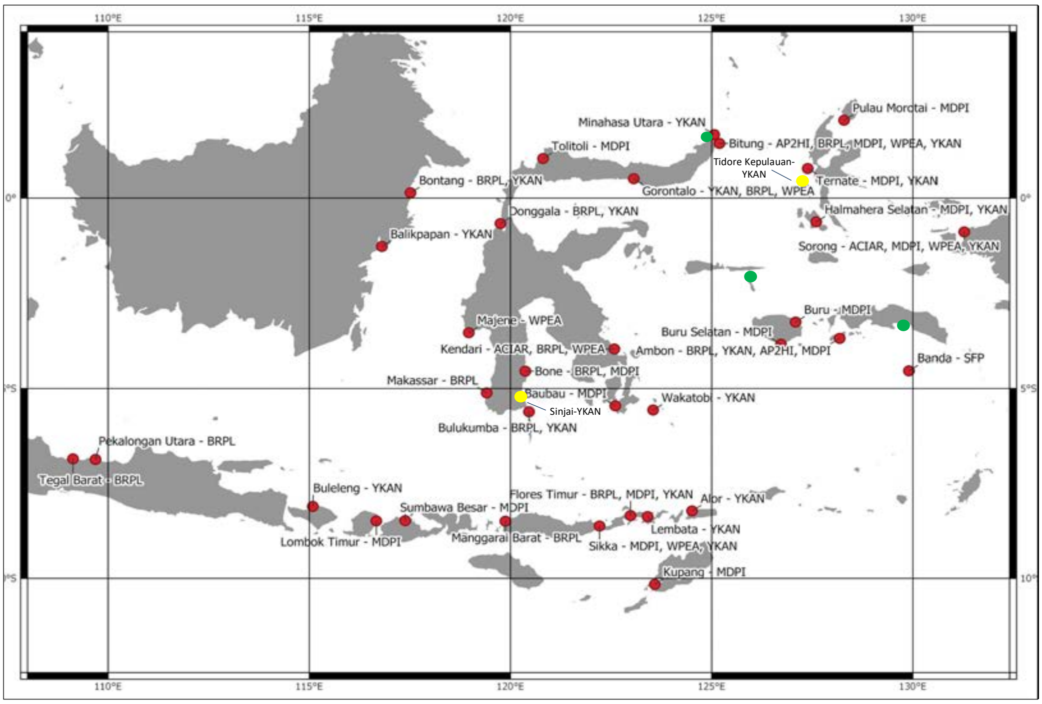

Figure 7.1.6: Location of the port monitoring sites by the MMAF, WPEA and NGO programs across the Indonesian archipelago. See Table 7.1.4 for details of sectors covered by each program.

Table 7.1.1. Summary of data submitted by MMAF and NGO monitoring programs in 2022.

Data series name/source	Sampling period	Sampling freq.	FMA coverage	Fishing gear	Source of effort/catch data	Rel. abundance?	Size indices?	On going?
Pusriskan - WPEA (Port Sampling)	2010 – 2021	Daily	713 - 715	LL, HL, PS, PL, GL, TL, TLH	Effort(gt, days at sea, fishing days), Catch(per landing per species)	BET, SKY, YFT, OTH	√	√
Pusriskan - ACIAR (Port Sampling)	2013 – 2015	Daily	713 - 715	HL, PL	Effort (days at sea), Catch (per landing per species)	BET, SKY, YFT, OTH	√	X
BRPL (Port Sampling)	2018 – 2020	Daily	713 - 715	PS, TL, HL, PL, LL	Effort(days at sea, fishing days, setting per trip, hooks), Catch(per landing per species)	BET, SKY, YFT, OTH	N/A	√
MDPI (Port Sampling)	2012 – 2021	Daily	713 - 715	HL, PL	Effort(gt, days at sea, fishing days), Catch(per landing per species)	BET, SKY, YFT, OTH	√	√
AP2HI (Port Sampling)	2018 – 2021	Daily	713 - 715	HL, PL	Effort(gt, days at sea, fishing days), Catch(per landing per species)	BET, SKY, YFT, OTH	√	√
SFP (Port Sampling)	2015 – 2021	Daily	713 - 715	HL	Effort(gt, days at sea, fishing days), Catch(per landing per species)	BET, SKY, YFT, OTH	√	√
YKAN (Port Sampling)	2019 – 2021	Daily	713 - 715	PL, HL, TL, PS, GL	Effort(gt, days at sea, fishing days, setting per trip), Catch(per landing per species)	BET, SKY, YFT, OTH	√	√
DJPT (Observer)	2016 – 2021	Setting	713 - 715	HL, PS, PL, LL, TL	Effort(gt, fishing days, hooks), Catch(per setting per species)	BET, SKY, YFT, OTH	√	√
MDPI (Observer)	2019 – 2021	Setting	713 - 715	TL, HL	Effort(gt, fishing days), Catch(per setting per species)	BET, SKY, YFT, OTH	√	√
AP2HI (Observer)	2017 – 2021	Setting	713 - 715	PL	Effort(gt, fishing days, hooks), Catch(per setting per species)	BET, SKY, YFT, OTH	√	√
DJPT (Logbook)	2015 – 2021	Setting	713 - 715	PS, PL, HL, TL, LL	Effort(gt, fishing days, hooks), Catch(per setting per species)	BET, SKY, YFT, OTH	√	√
YKAN (Logbook/CODRS)	2021	Setting	713-715	LL	Effort(gt, fishing days, hooks), Catch(per setting per species)	BET, SKY, YFT, OTH	√	√

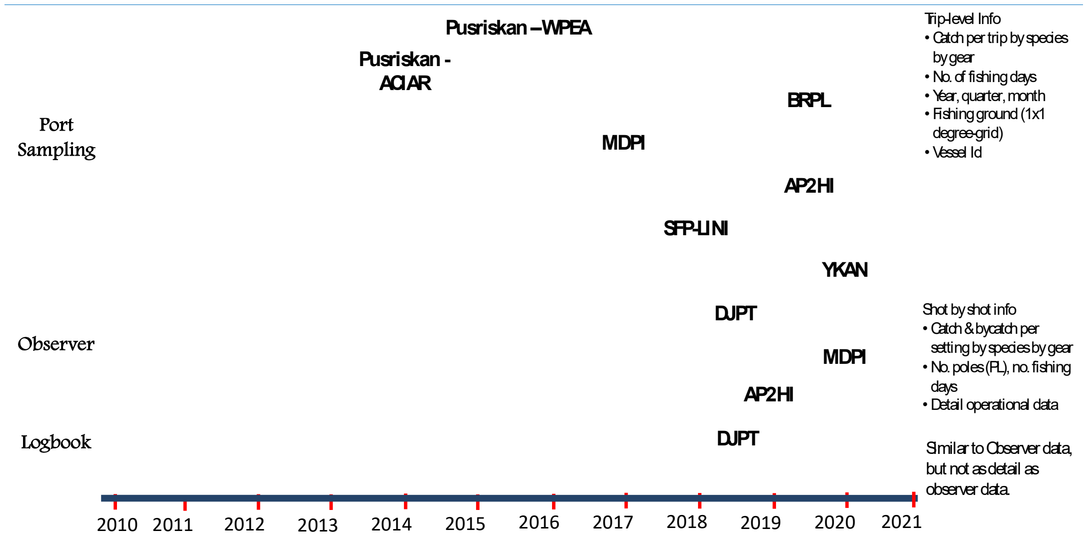

Figure 7.1.7 Period of data collected by various types of data collection program by each data provider from 2010-2021.

7.1.5 Monitoring series for use in harvest strategy

As noted, three catch monitoring data sources were identified for use as input data series in the harvest strategy: i) pole and line for skipjack (Figure 7.1.8) and ii) handline (Figure 7.1.9) and iii) longline (Figure 7.1.10) for yellowfin tuna. The pole and line and handline monitoring had the widest and most consistent coverage, having been supported for the longest period by a series of the WPEA projects and the earliest systematic initiatives focussed on small-scale fisheries by Indonesian NGOs, such as MDPI (Figure 7.1.8 and 7.1.9). The longline data source was initially identified to provide a complementary data stream to the predominantly small fish taken in the handline fishery at that time, given that the longline fleet predominantly caught larger, adult yellowfin tuna. The quality of the data available for the longline fleet has steadily improved since the implementation of the logbook system and, in particular, the more recent introduction of the e-logbook system. However, the level of activity in the fleet was also heavily impacted by the introduction of the foreign fishing vessel ban, which resulted in much of the larger longliners being inactive in the fishery through 2017-2018 (Figure 7.1.10) (F. Satria, pers comm).

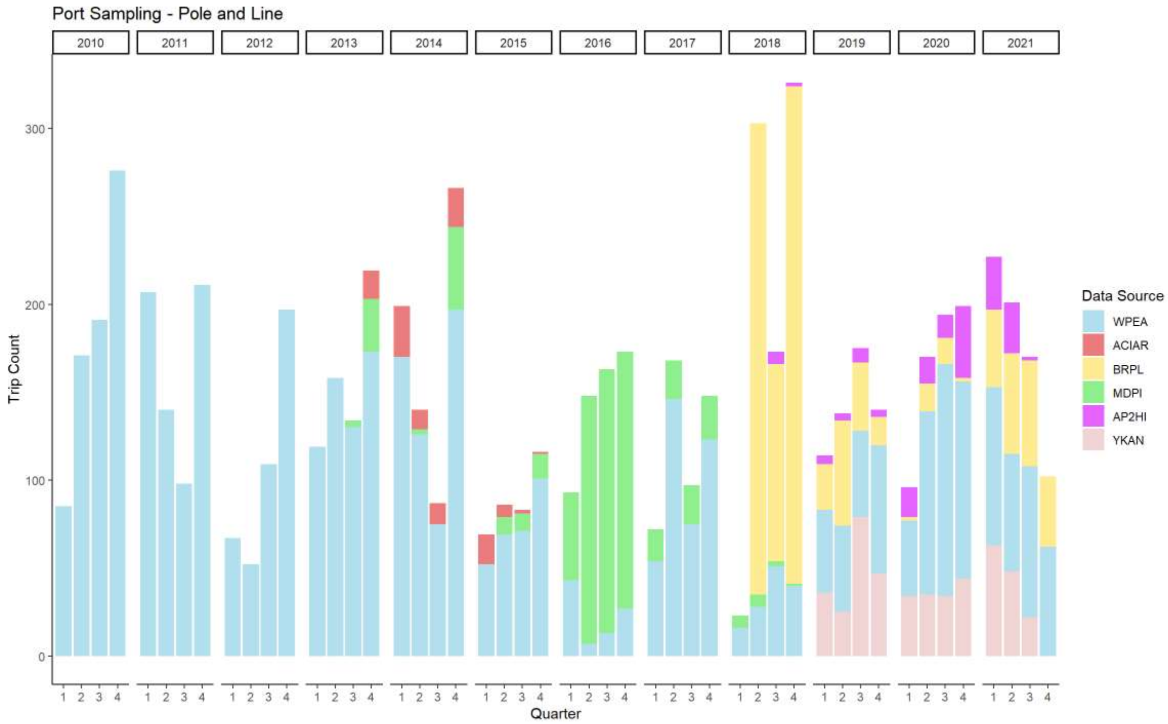

Figure 7.1.8. Number of trips recorded by port sampling program from pole and line vessels by data sources by quarter.

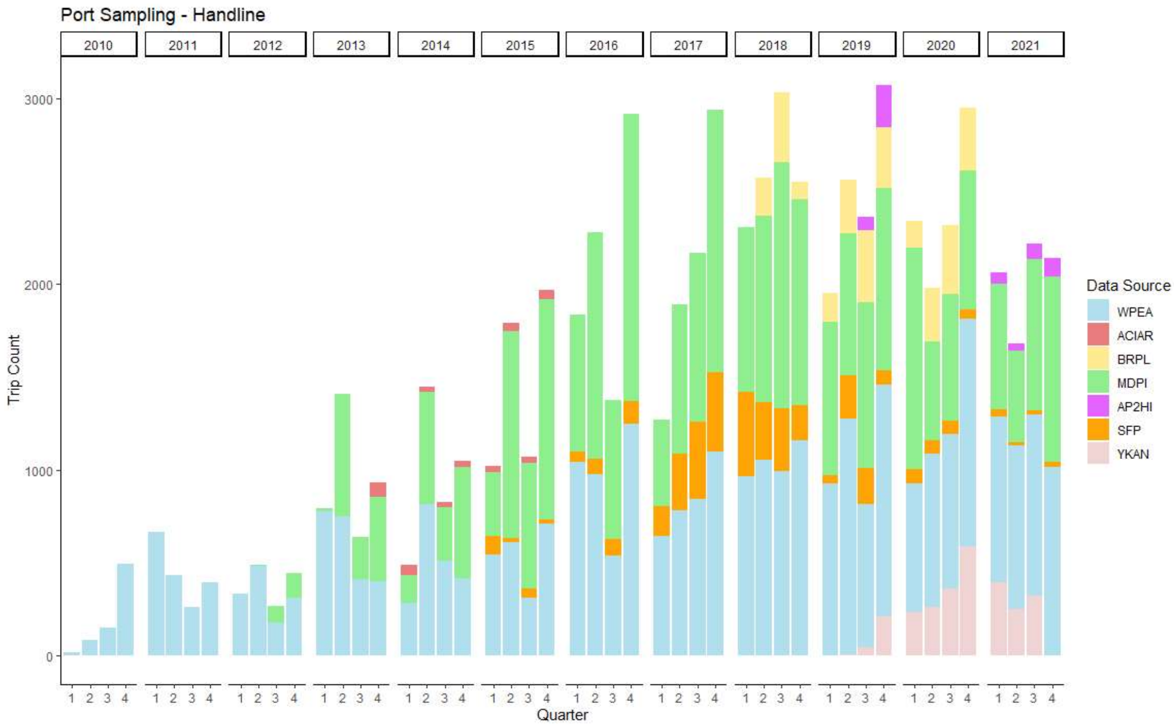

Figure 7.1.9. Number of trips recorded by port sampling program from handline vessels by data sources by quarter.

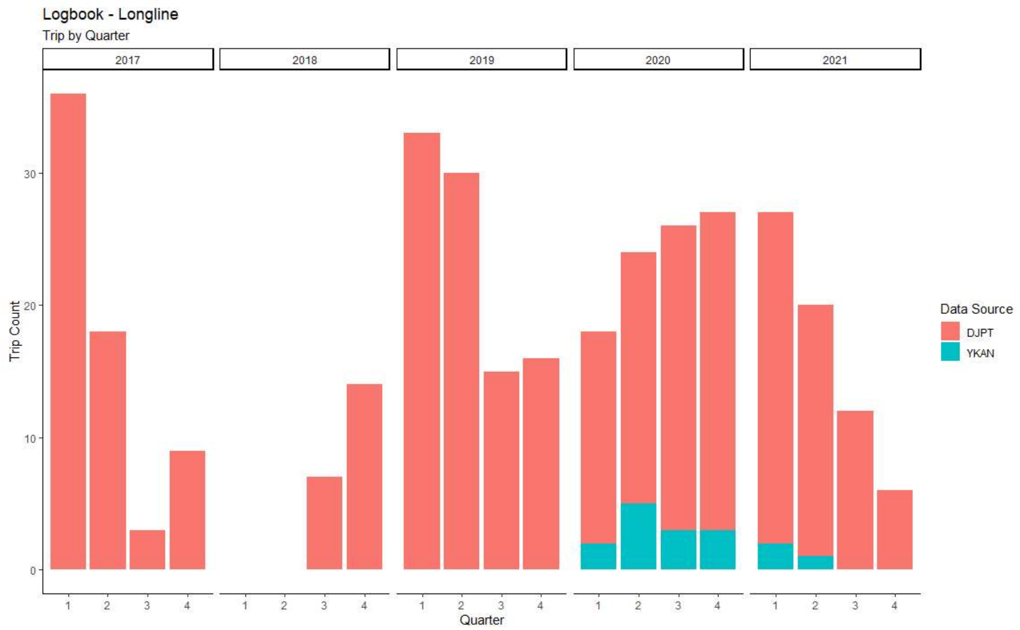

Figure 7.1.10. Number of trips recorded by logbook program from longline vessels by data sources by quarter.

7.1.6 Indicator series for empirical harvest strategies

Two types of indicators of stock status were identified for development of candidate harvest strategies: i) standardised catch per unit effort (CPUE) as an index of abundance, and ii) average size of fish in the catch as a composite index of fishing mortality. At the initiation of the process, none of the data series were of sufficient length, or quality and resolution to fit statistically significant generalised linear or additive models (Sadiyah et al. 2018). This provided motivation for the MMAF and NGOs involved in the process to focus on maintaining and expanding the programs and filling the identified gaps in the monitoring series. Table 7.1.2 demonstrates the progressive improvement in the three sources of pole and line data for skipjack (port sampling, observers and logbooks) through until 2022, such that it is now possible to obtain a statistically significant standardisation of the CPUE data from port sampling (Figure 7.1.11). While this is not yet possible for the other two data sources, there has been improvements in key operation characteristics that are required for the standardisation process, which remains a priority for the logbook and observer programs run by the Ministry and is assisted by the regular review of these data through the formalised data exchange process.

Table 7.1.2 Progress of the CPUE standardisation for SKJ from pole and line vessels

	Port Sampling	Observer	Logbook
No. of recorded trips/sets	7293 [4822]	....	.....
Data source	WPEA, ACIAR, BRPL, *MDPI*, AP2HI, YKAN	AP2HI, DJPT	DJPT
Effort data	✓ Number of fishing days	✓ Number of poles	✗ Number of poles unavailable
Catch Data	✓ Catch in kg	✓ Catch in kg	✓ Catch in kg
Temporal Coverage	✓	✓	✓
Spatial coverage		✓	✓
CPUE indices	✓ Deviance explained 68.1%	✓ Deviance explained 26.8%	✗

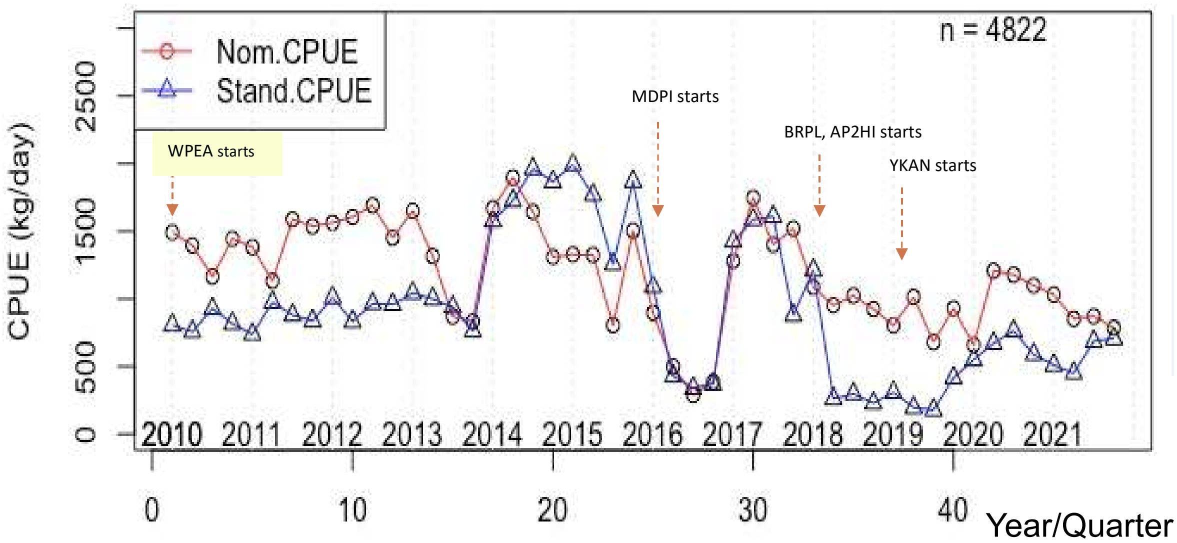

Figure 7.1.11. Example of CPUE standardisation for SKJ from pole and line port monitoring data from across Indonesian archipelagic waters, including commencement points of the different monitoring programs (see Figure 7.1.6 for locations of monitoring sites for each program).

Table 7.1.3 Progress of the CPUE standardisation for YFT from handline vessels

	Port Sampling	Observer	Logbook
No. of recorded trips/sets	73776 [26272; 16889 dHL]	4267	38429
Data source	WPEA, ACIAR, BRPL, MDPI, AP2HI, SFP, YKAN	DJPT, MDPI	DJPT
Effort data	✓ Number of fishing days	✗ ?	✗ ?
Catch Data	✓ Catch in kg	✓ Catch in kg	✓ Catch in kg
Temporal Coverage	✓	✗ less than 3 years for quarterly data	✓
Spatial coverage			
CPUE indices	✓ Deviance explained 87.3% & 86.1%	✗	✗

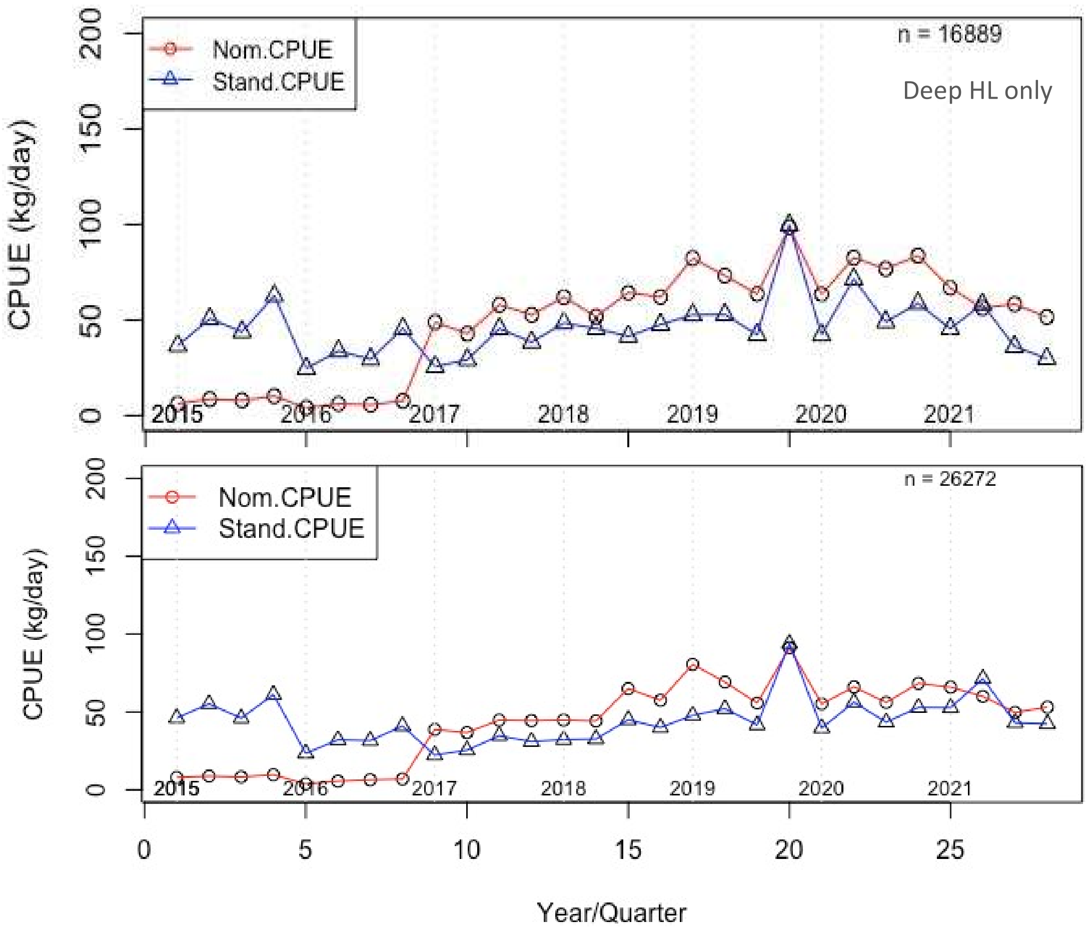

Figure 7.1.12. Example of CPUE standardisation for YFT from handline (deep HL only, top; all data, bottom) port monitoring data from across Indonesian archipelagic waters (see Figure 7.1.6 for locations of monitoring sites for each program).

Similarly for yellowfin tuna handline data, while it was not possible to obtain a statistically significant standardisation of CPUE earlier in the process, the improvements in the port monitoring data series have been such that the current standardisation for the handline data explains 86-87% of the deviance (Table 7.1.3, Figure 7.1.12). The small-scale nature of much of the handline fleet means it is more challenging to make improvements in the other two sources, particularly observer coverage.

In the case of the longline fishery for yellowfin, there have been improvements in the logbook data from the logbook program (Table 7.1.4). It is now possible to fit a standardisation model, however, the series is still relatively short in duration and the standardisation is explaining only 30 percent of the deviance (Figure 7.1.13). Hence, continuing to extend and improve the data series for the longline fleet is considered a high priority.

Table 7.1.4 Progress of the CPUE standardisation for YFT from longline vessels

	Port Sampling	Observer	Logbook
No. of recorded trips/sets			4469 [4345]
Data source			DJPT, YKAN
Effort data			✓ Number of hooks
Catch Data			✓ Catch in kg
Temporal Coverage	✗	✗	✓
Spatial coverage	✗ Mostly outside IAW		✓
CPUE indices	✗	✗	✓ Deviance explained 30.9%

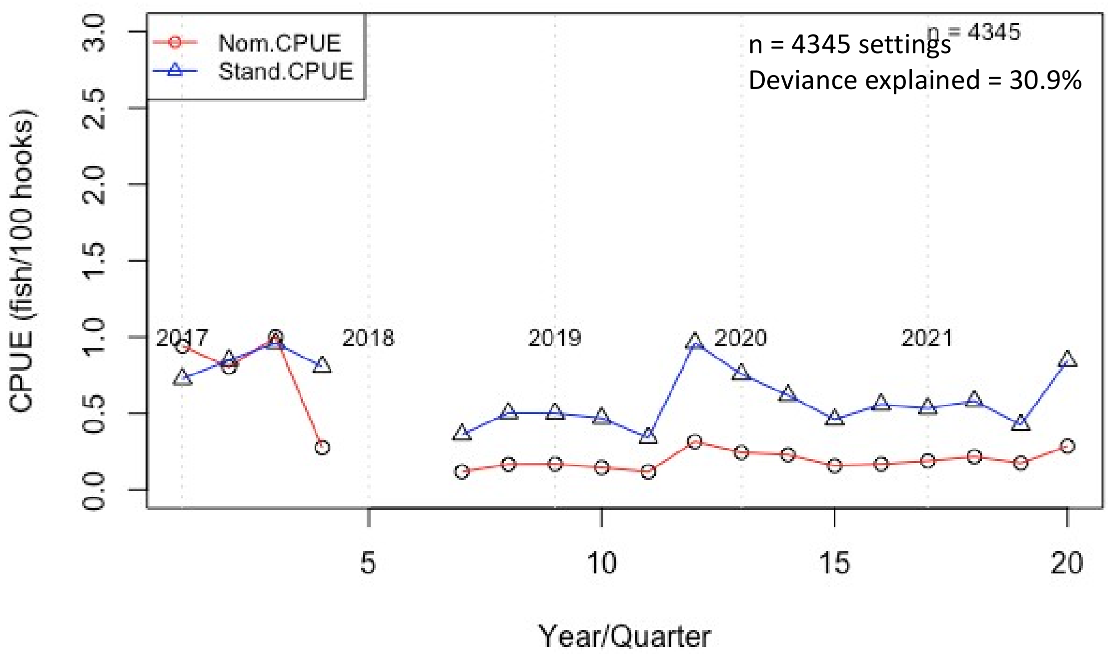

Figure 7.1.13. Example of CPUE standardisation for YFT from longline logbook data from across Indonesian archipelagic waters.

7.1.7 Empirical harvest strategies for skipjack and yellowfin tuna

Empirical harvest strategies were identified as the most appropriate form of harvest strategy for implementation in IAW based on experience in similar contexts in Australia and elsewhere (e.g. Davies et al. 2007; Prince et al. 2016). Empirical harvest strategies are based on indices of relative abundance, such as standardized catch rates and/or average size in the catch, and relatively simple analysis methods, rather than quantities, such as spawning biomass and fishing mortality, estimated from more complex stock assessment models used in model-based harvest strategies. Empirical harvest strategies have the advantage of being more transparent and easily understood by non-technical audiences and being more straightforward to implement as they require less technical expertise. International experience comparing empirical and model-based harvest strategies through simulation testing has demonstrated that it is possible to achieve comparable management performance using simpler empirical harvest strategies. The components of each harvest strategy, including the adaptive feedback loop, for skipjack and yellowfin are illustrated in Figure 7.1.14.

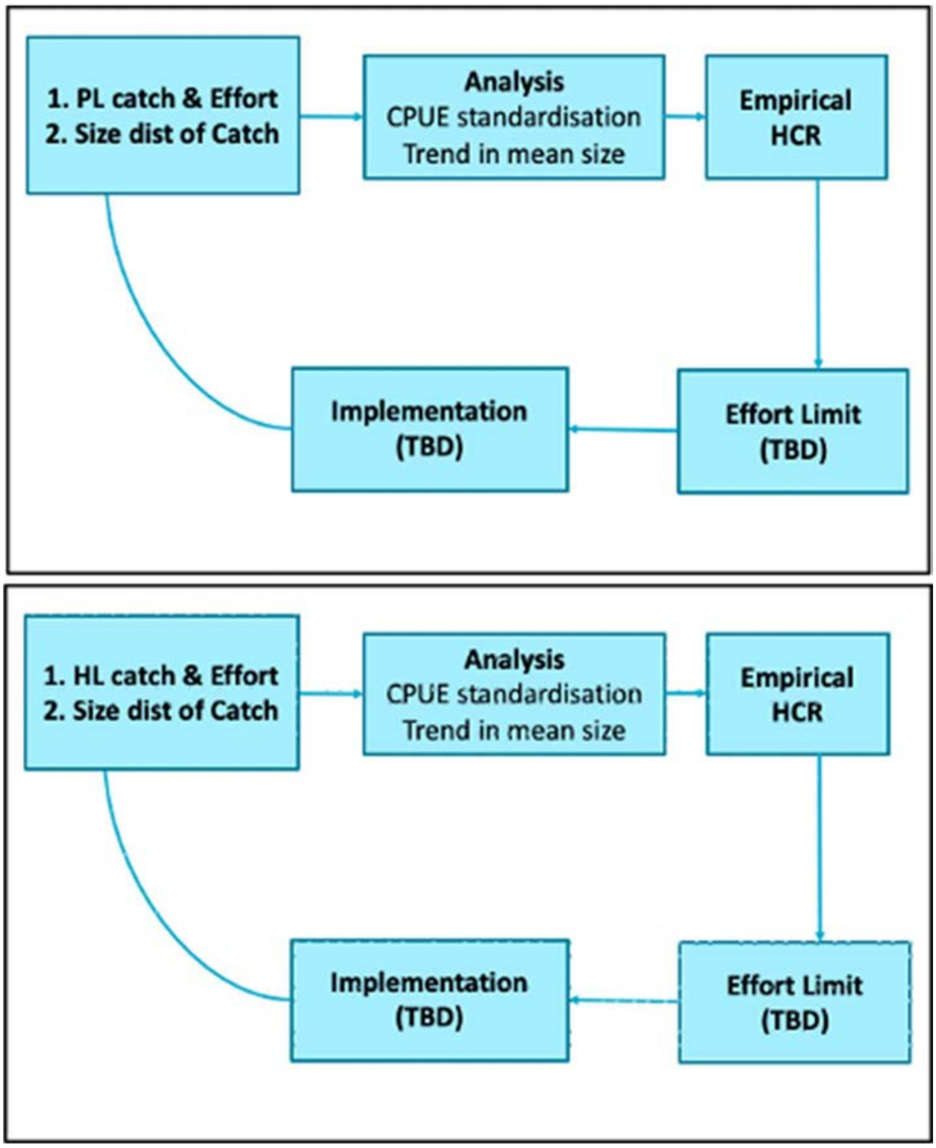

Figure 7.1.14. Conceptual diagram of the components of the empirical harvest strategies adopted for skipjack (top) and yellowfin (bottom) tuna and the adaptive feedback loop.

The two harvest strategies are quite similar in principle but differ in their a) input data series and b) the specifics of the empirical HCRs used (see Hoshino et al. 2020 and TR3 and 4 for more technical details). The prototype versions of these harvest strategies were tested using MSE in 2018 (Hoshino et al. 2018; Hoshino et al. 2020) and the first three components adopted as part of the interim framework for harvest strategies in IAW launched in 2018. The expectation at that time was that some form of input control (effort control and/or spatial/temporal closures) would be used as the management measure for implementation (Anon. 2018).

7.1.8 Management measures for implementing changes in fishing pressure from the empirical HCR

Specifying and implementing the management measures to be used to affect the change in fishing pressure recommended by the HCR (the "Effort Limit " in Figure 7.1.14) was one of the most challenging aspects of the process for a number of reasons, including: the diversity of views among stakeholders (see Appendix 3, stakeholder survey); the complexity of the tuna fishing fleets and fishing communities; the governance and regulatory environment; the relationship of the harvest strategy with existing management measures and the WCPFC processes; and the relatively limited experience with adaptive harvest strategies and operational fisheries management (see Hoshino et al., In prep/press for elaboration on these issues). Despite these challenges there was also growing recognition of the need for more active management of the fishery in IAW and mounting pressure to have a full harvest strategy adopted to facilitate certification of fisheries for export products. Hence, following the review of the most recent stock assessment advice from the WCPFC Scientific Committee at the first harvest strategy implementation 2018, the stakeholders agreed to cease to issue further licenses for vessels greater then 30GT in archipelagic waters (Figure 7.1.1). This was subsequently implemented by MMAF and represented the first major step toward limiting entry to the fishery.

This decision was reinforced the following year, when updated WCPFC stock assessments indicated that declining trends in both skipjack (Vincent et al. 2019) and yellowfin in the Indonesia area and skipjack below the limit reference point adopted as part of the harvest strategy framework. The results of the updated MSE work in 2021 also reinforced the need to maintain the momentum to adopt and implement feedback harvest strategies for the wider fishery by demonstrating that; a) control of only the large-scale vessels (>30GT) was likely to be insufficient to rebuild stock above the limit reference point and b) adaptive feedback management was more likely to rebuild stocks faster that non-adaptive, or constant effort policies; recent increases in the small scale handline fleet had resulted in substantial increases in the catch of YFT, in particular. The clear need to consider management measures that could be applied to the small-scale sector, as well as the larger vessels, initiated reviews of the regulatory arrangements and the existing measures that were available to the central government (Anon. 2021, Hoshino et al In prep).

7.1.9 COVID-19, Measurable fishing policy and institutional change

The impact of the COVID-19 pandemic on the harvest strategy process varied. The health and economic impacts, and associated travel restrictions meant that it was not possible to conduct the planned level of face-to-face engagement, but this was managed via use of webinars. Technical, stakeholder and capacity building activities continued and to a large degree the monitoring programs adapted to COVID-safe protocols and maintained a very good level of monitoring coverage. The most substantial impact has been the budget reductions post-2021 and the reductions in central government expenditure on fisheries monitoring and management activities. For example, this has resulted in the cessation of the BRPL program and restricted activities that Indonesian scientists are able to participate in due to the lack of operating budgets.

In addition to the disruption caused by COVID-19, the institutional restructure associated with the creation of BRIN and the transfer of research and scientific capability from MMAF to BRIN disrupted some activities and resulted in some delays while roles and responsibilities between MMAF and the newly created Centre for Fishery Research in BRIN were established. Despite these substantial disruptions, the momentum and progress with the harvest strategy implementation process was maintained and the annual data exchange, technical and stakeholder workshops were completed. This, more than anything else, demonstrates the ownership and leadership of the process by the Indonesian fisheries managers, scientists and stakeholders.

In late 2022, a new ministerial regulation on quota and zone-based fishery management policy (*Penangkapan Ikan Terukur* – PIT, Regulation No. 11/2023) was announced by the Minister of MMAF, under which quota or allocation for Indonesian fish resources, including tropical tuna, is to be set up for each FMA. This was somewhat of a surprise to the stakeholder groups, given that output control measures were previously considered to be less feasible options than other potential management measures due to factors including: a limited capacity to accurately estimate total landings of tuna in Indonesia; a lack of near real-time reporting to be able to close the fishery/FMA when the quota limit is reached; and limited surveillance capacity to monitor compliance. It remains unclear how decisions on zone-based (i.e. FMA-based) TACs, stipulated in the PIT policy, could be integrated into the empirical harvest strategy, where the advice on the levels of harvest would be based on pre-agreed decision rules and feed-back monitoring. These remain substantial issues to be addressed in the further refinement and implementation of the harvest strategy.

In addition to the management and monitoring challenges, the PIT regulation has implications for the design and MSE testing of the empirical harvest strategies. The current simulation models are designed to evaluate effort controls, not output controls such as quota. This means that the operating models will need to be reformulated and re-coded in future to allow for quota/catch-based management measures to be evaluated along-side the existing effort-based measures (see 7.4).

7.1.10 Precautionary catch reduction

Notwithstanding the uncertainty about the implementation of the new Ministerial regulation, the stakeholder workshop in November 2022 agreed to a precautionary catch reduction of up to 10% of the 2021 catch level over the next 3 years, to be implemented once the new ministerial regulation is officially in place. The agreed aims of this measure are to reduce the risk of overfishing and to provide more time for completion of simulation testing of candidate harvest strategies through comprehensive MSE. The proposal to reduce catch was made due to concerns around declining trends in catches, in catch per unit effort (CPUE) and in the size of skipjack tuna in catches evident in the harvest strategy monitoring data series. In addition, there were concerns around substantial increases in Indonesia's yellowfin tuna catches by small-scale handline gears in recent years and the previous results of the preliminary MSE for yellowfin tuna which indicated a high probability of the species' stock falling below the LRP for the Nation's archipelagic waters if the current high levels of catch continue.

7.1.11 Harvest strategies for tropical tuna in archipelagic waters of Indonesia

Following the 2022 review and renewal of the National Tuna Management Plan (Figure 7.1.1) and the 2022 Technical and Stakeholder workshops, where progress on the harvest strategy action plan was reviewed (Anon., 2022), the MMAF updated the harvest strategy framework to include a revised and updated action plan and the need to integrate the PIT, precautionary catch reduction and Implementation of the empirical harvest strategies for yellowfin and skipjack tuna (Figure 7.1.15). The updated framework was presented by Dr Fayakun Satria in a keynote address to stakeholders at the Indonesian Tuna Conference in Bali in May 2023 and the official "Harvest strategies for tropical tuna in archipelagic waters of Indonesia" (Anon., 2023, Appendix XX) was launched by the by the Minister for

Marine Affairs and Fisheries, Mr Sakti Wahyu Trenggono, on World Oceans Day in 8, June, 2023.

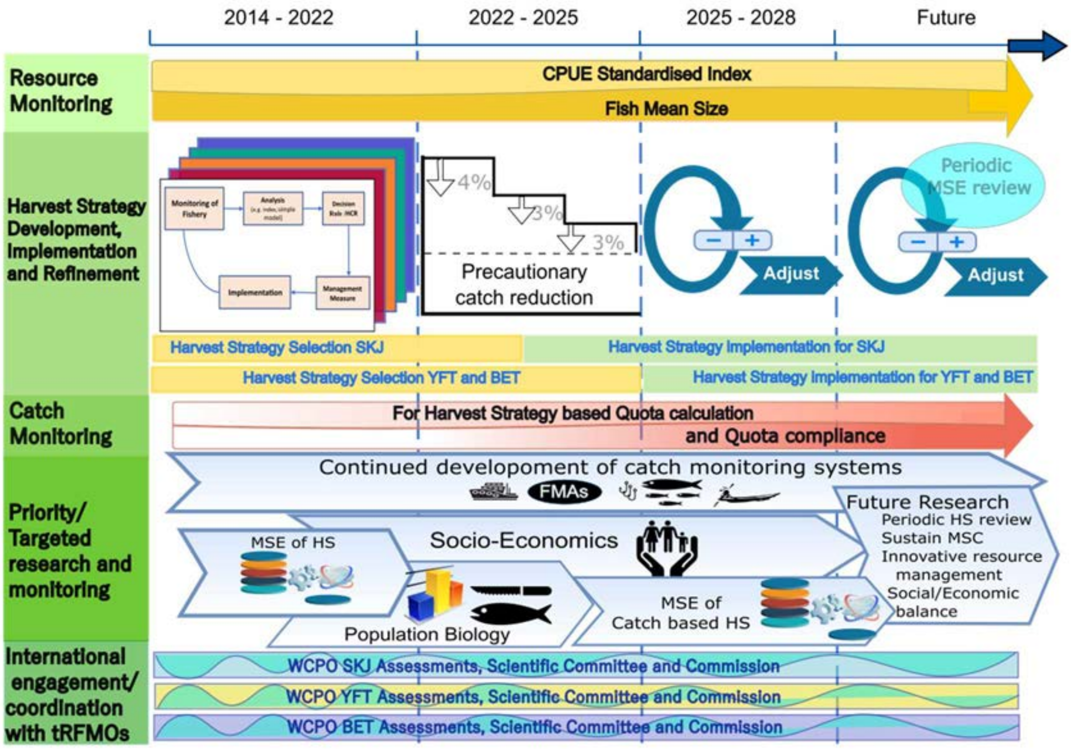

Figure 7.1.15. Schematic representation of the elements of the Harvest Strategy for tropical tuna in IAW fisheries and broader regional engagement in the Western Pacific Ocean. The green boxes on the right of the figure identify key elements of the harvest strategy framework to support sustainable management of tuna into the future. The yellow and red arrows represent, respectively: i) ongoing data collection programs that provide the input data required to calculate the indices used in the Harvest Control Rule, and ii) to monitor the effectiveness of implementation of the harvest strategy in controlling the level of fishing. Harvest Strategy row illustrates the relationship between the implementation of the Precautionary Catch reduction and the Empirical HS for the tropical tuna in IAW, following completion of the updated MSE program. The Priority Research and Monitoring row illustrates the key data gaps and associated research and monitoring that have been identified as needing to be filled through the harvest strategy design and MSE process. The International Engagement row represents Indonesia's engagement in the WCPFC through the participation in the Commission and scientific processes, such as, submission of national reports, catch and effort statistics and compliance with Conservation and Management Measures agreed by the Commission. Source: Modified from Anon., (2023).

7.2 Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction)

7.2.1 Fish sampling

Biological samples were collected from nearly 8,000 BET, YFT and SKJ across the Indonesian archipelago over a 28-month period (Figure 7.2.1; Table 7.2.2). As outlined in the Methods, the target was to collect samples from 100 fish (year 1) and 50 fish (year 2) per month of each species in the three sampling regions (west, central, east). Although the monthly target was not achieved, the average number of fish sampled per species and region in each month was 31, surpassing expectations considering travel restrictions due to the COVID-19 pandemic. The number of fish sampled was relatively even across the three regions (Figure 7.2.2), although the highest total for all species was in the east (i.e., landed in Bitung). Fish landed and sampled in Bitung were caught over a broad spatial range and adjacent to those landed in Kendari (central region) and further work will be required to more accurately differentiate between the two groups based on specific catch locations. Unfortunately, it was not possible to complete that work during the current project. Hence, for the reproductive analysis below we combined the Bitung and Kendari samples (eastern region) and the Palabuhanratu and Cilacap samples (western region). The total number of biological samples and data (e.g., sex, gonad weight, visual reproductive stage) collected by species during the project is shown in Table 7.2.3. Over 16,500 biological samples (i.e., otoliths, fin spines and gonad subsamples) were collected during the project, which represents one of the most comprehensive samples collections for tropical tuna.

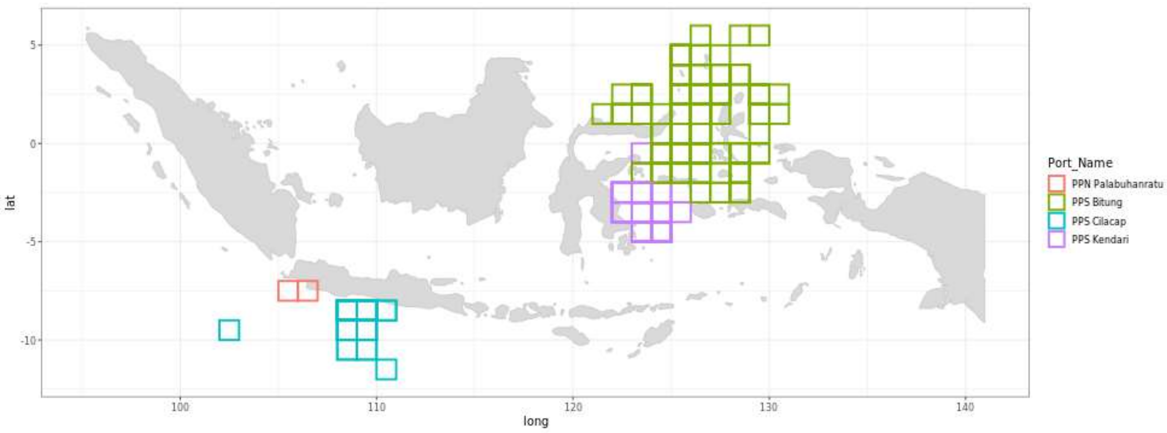

Figure 7.2.1. Locations where sampled fish were caught by landing port.

Table 7.2.2. Number of fish sampled for the population biology study by species and month for each port.

		Palabuhanratu (west)			Cilacap (west)		Kendari (central)			Bitung (east)			
Year	Month	BET	YFT	SKJ	BET	YFT	BET	YFT	SKJ	BET	YFT	SKJ	Total
2019	Sep									1	22	32	55
	Oct	5	37	57			19	36	53	22	36	43	308
	Nov	3	34	55			35	40	66	26	50	63	372
	Dec	10	29	48			33	38	57	22	65	76	378
2020	Jan	2	69	87			29	36	52	25	51	65	416
	Feb		34	37			32	29	45	28	50	55	310
	Mar		24	37			27	39	44	23	52	60	306
	Apr		38	40			18	29	38	28	51	44	286
	May	1	27	20			33	40	60	22	47	57	307
	Jun	5	33	33			29	38	45	35	54	58	330
	Jul		33	46						46	58	42	225
	Aug	5	14	37	15	40	18	34	50	22	27	42	304
	Sep	5	16	31	41	15	21	34	64	16	56	41	340
	Oct	6	25	43	49	10	27	30	48	23	57	50	368
	Nov	1	20	32	22	7	33	36	47	22	39	45	304
	Dec		22	26	9		44	35	65	21	44	38	304
2021	Jan				20	43	24	27	18	21	41	43	237
	Feb		31	31	13	2	21	26	55	21	28	34	262
	Mar	6	41	41	27	12	19	35	46	23	45	61	356
	Apr		36	22	12	13	7	26	42	22	48	51	279
	May		26		17	7	16	22	38	24	46	53	249
	Jun		21	27	29	7	26	24	29	19	40	45	267
	Jul		36	32	15	7	14	18	43	15	36	32	248
	Aug		50	44	7	8	15	23	37	35	38	59	316
	Sep	11	17	29	10	17	21	37	40	23	47	54	306
	Oct				23	2				22	33	41	121
	Nov				26	7				30	40	52	155
	Dec				7	8				19	38	58	130
	Total	**60**	**713**	**855**	**342**	**205**	**561**	**732**	**1082**	**656**	**1239**	**1394**	**7839**

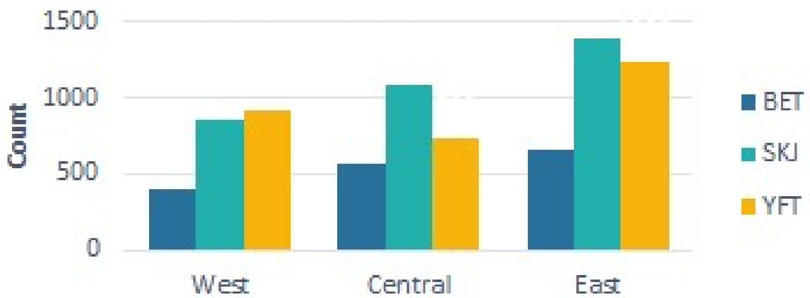

Figure 7.2.2. Total number of fish sampled by species in the western (Palabuhanratu and Cilacap), central (Kendari) and eastern (Bitung) regions.

Table 7.2.3. Number of fish with otoliths, fin spines and gonads weighed, classified, subsampled and frozen by species and sex. I = immature, F = female, M = male, U = unknown sex.

Species	Sex	Length	Weight	Otoliths	Fin spines	Gonad weight	Gonad visually classified	Gonad sample histology[1]	Gonad frozen[2]
BET	I	894	894	884	894	33	41	1	2
	F	412	410	406	396	405	405	267	191
	M	293	292	280	280	281	280	2	1
	U	20	5	20	18	2	2	2	2
Total		**1619**	**1601**	**1590**	**1588**	**721**	**728**	**272**	**196**
YFT	I	1477	1477	1465	1459	309	248	2	1
	F	715	708	704	603	708	710	398	304
	M	660	646	650	422	634	646	6	16
	U	37	9	37	32	1	3		
Total		**2889**	**2840**	**2856**	**2516**	**1652**	**1607**	**406**	**321**
SKJ	I	1194	1194	1161	1193	128	104	1	4
	F	1102	1102	1079	1100	1089	1089	757	635
	M	1032	1032	1011	1029	1030	1030	7	17
	U	3	3	3	3	1	3	1	1
Total		**3331**	**3331**	**3254**	**3325**	**2248**	**2226**	**766**	**657**
Grand total		**7839**	**7772**	**7700**	**7429**	**4621**	**4561**	**1444**	**1174**

[1] = Gonad subsamples for histology were not required for males or females <80 cm, 60 cm and 30 cm FL for BET, YFT and SKJ, respectively, as these fish will be immature.

[2] = The aim was to retain gonads from females if the macroscopic phase was actively spawning with hydrated oocytes present as these were potentially suitable for estimation of batch fecundity.

7.2.2 Length frequency distribution

Figure 7.2.3 shows the length frequency distributions of fish sampled by species during the project. The smallest fish were ~13 cm FL for all three species and the largest were 80 cm, 182 cm and 194 cm for SKJ, BET and YFT, respectively. Small fish <60 cm FL dominated the sampling of both BET and YFT, while the majority of SKJ sampled were between 25 and 55 cm FL. Appendix 7 show separate length frequency plots by region for each species.

For any biological study, one of the most important aspects is the number of samples collected across the size range of fish to estimate reproductive and growth parameters. For estimating maturity ogives, it is important to sample both immature and mature fish, but particularly the size range of fish maturing for the first time. For BET and YFT, this size is expected to be around 80-100 cm FL, and 30-50 cm for SKJ based on studies in other regions.

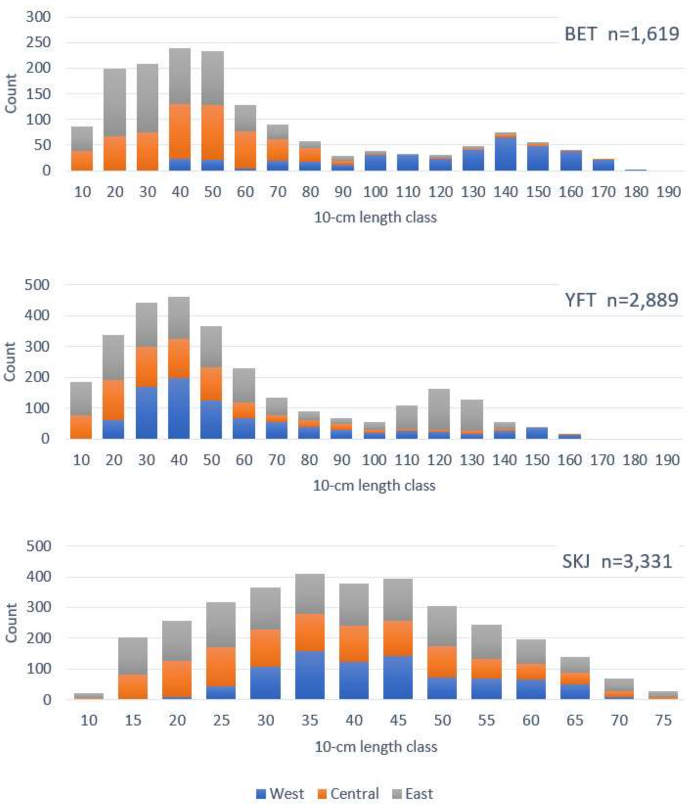

Figure 7.2.3. Length frequency of fish sampled by region for each species. West = Palabuhanratu and Cilacap, Central = Kendari, and East = Bitung. The lower boundary of each length bin is shown. See Appendix 7 for separate size distribution plots by region for each species.

7.2.3 Length–weight relationships

Paired length (FL) and weight (W) data were available for 7,772 fish. After removing clear outliers, 7,725 fish were available for analysis. Further data checks and removal of outliers is required, particularly for SKJ sampled in the west (see Figure 7.2.4).

The length-weight data and fitted power curves did not vary substantially between male and female BET, YFT or SKJ in any region (see Appendix 7). A small difference is noticeable in the LWRs between male and female SKJ in the western region (see Appendix 7). However, further investigation is needed due to the considerable outliers still present in the data that could potentially affect the result. Based on the combined data (i.e., males, females, indeterminate and unknown sex) for each species, we found no difference in the LWR among regions (Appendix 7). Therefore, we developed a single combined LWR for each species (Figure 7.2.4) and these are collectively shown in Figure 7.2.5. The estimated *b* parameters for SKJ, BET and YFT were 3.36, 3.04 and 2.96, respectively. A value of *b*>3 indicates that SKJ exhibit a positive allometric growth pattern where their girth increases disproportionally to their length (i.e., they gain weight faster than length), whereas *b* values close to 3 for BET and YFT indicate they have isometric growth.

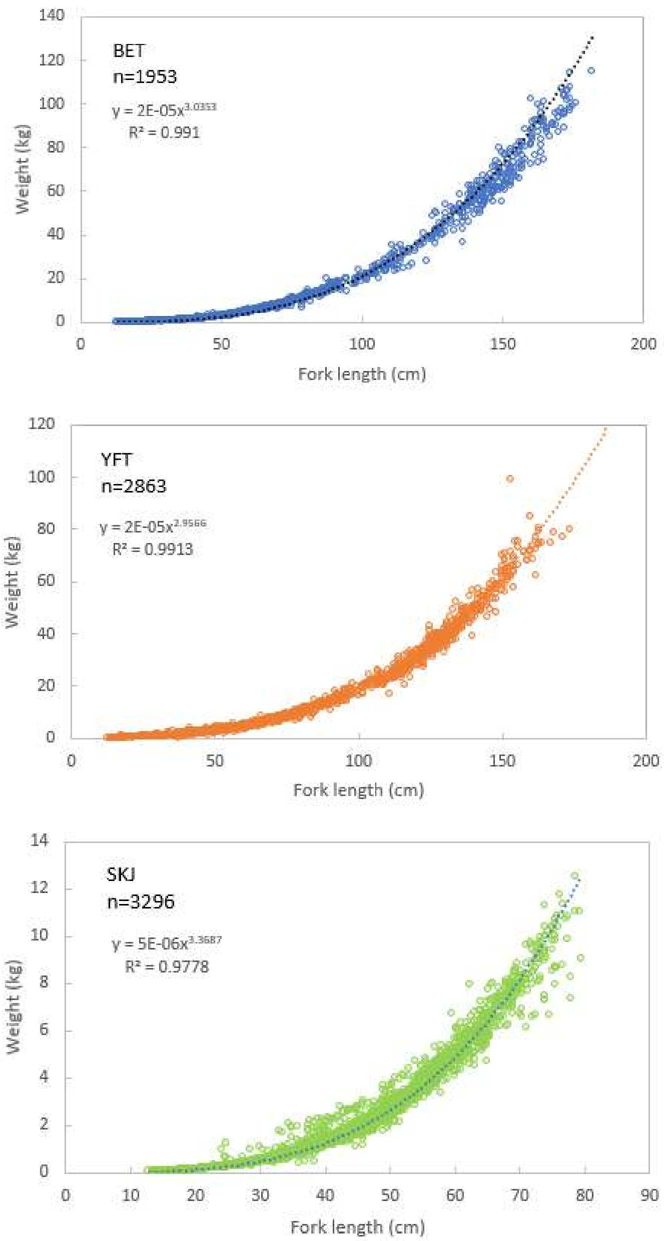

Figure 7.2.4. Length-weight relationships and fitted power curves for BET, YFT and SKJ. Sample sizes and power curve parameters are shown.

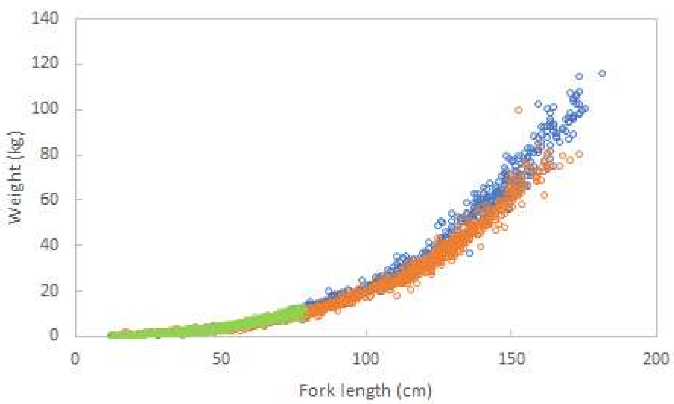

Figure 7.2.5 Comparison of length-weight relationships for BET (blue), YFT (orange) and SKJ (green).

7.2.4 Macroscopic reproductive analysis

As noted above, given the spatial distribution of samples available in the project (Figure 7.2.1), we divided the data into two regions: eastern samples (Bitung and Kendari) and western samples (Palabuhanratu and Cilacap) for the preliminary reproductive analysis below. These results are based on the macroscopic (visual) classification of gonads and gonad weight data. The histological analysis of ovary samples for accurate reproductive classification of females, and estimation of spawning fraction and fecundity was not able to be completed due to the disruption associated with the substantial institutional restructure in Indonesia (MMAF-BRIN) during the project.

Bigeye tuna

Of the 1,619 BET sampled in the project, approximately 45% had their gonads removed, weighed and classified macroscopically. Most of the remaining fish were classed as indeterminate as their gonads were too small to determine sex. BET had the lowest number of gonads collected of the three species, and the sampling was particularly low in the eastern region where very few mature fish were sampled.

Western region

Based on the gonad weight data, most fish <110 cm FL showed little gonad development (weighing <100 g) and, therefore, it appears they would not have spawned in the near future (Figure 7.2.6). The majority of spawning capable fish had gonads weighing ~200-500 g, but the largest weighed nearly 2000 g for females and 900 g for males. Approximately 50 large males (130-175 cm FL) had very small gonads, weighing <100 g and were classed as immature or early developing (Figure 7.2.6). The reason for the lack of gonad development in these fish is unknown and requires further investigation. Several large females also had small gonads <100 g but were classed as spawning capable; histological analysis of the ovaries is required to confirm if the classification is correct. Although additional work is required, the preliminary macroscopic results indicate that BET in spawning condition (i.e., spawning capable) were present throughout the year (Figure 7.2.7). However, sample sizes were too low in some months to conclusively define the spawning periodicity. The mean monthly GI data also did not show a distinct seasonal pattern (Figure 7.2.7). The smallest spawning capable fish were 110 cm FL for females and 90 cm FL for males. Only two fish samples were classed as regressing (i.e., post spawning).

Figure 7.2.8 shows the preliminary maturity ogives for male and female BET in the western region. The estimated L_{50} was 108.4 cm FL for females. However, the number of fish sampled was low in the size range of fish maturing for the first time (~80-110 cm FL), which leads to uncertainty in the model. For males, the maturity model is very uncertain given the presence of large immature fish in the data.

Eastern region

There were very limited samples of BET in the eastern region to determine gonad development or spawning periodicity (Figure 7.2.6, 7.2.7). Additionally, the majority of sampled fish were immature (Figure 7.2.8), leading to uncertainty in the maturity models.

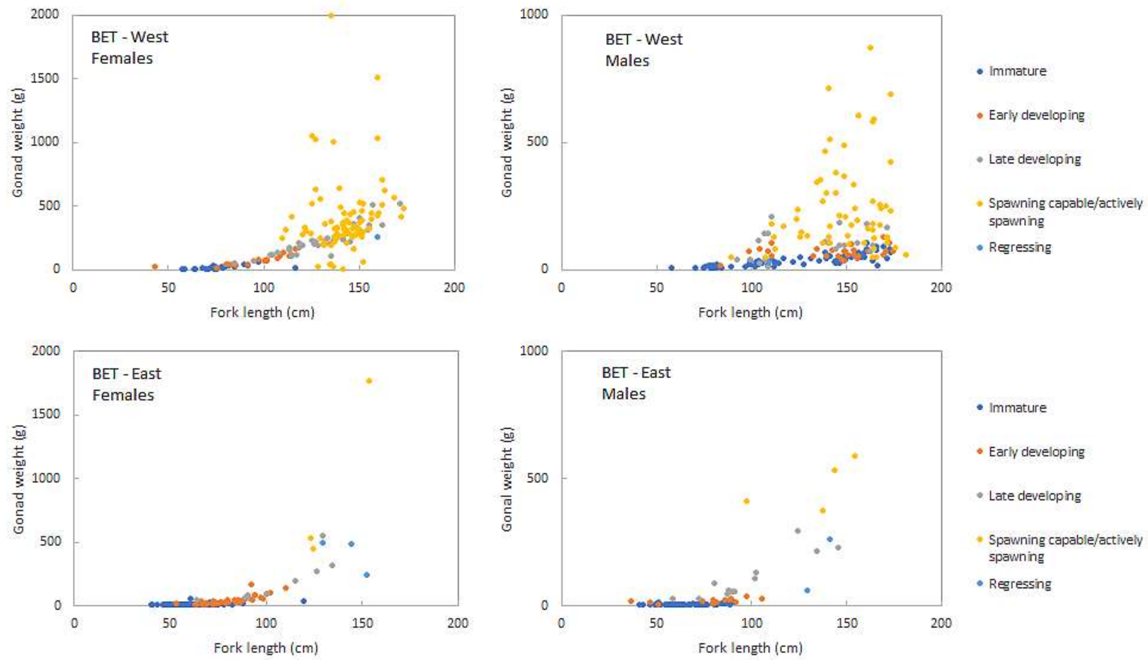

Figure 7.2.6 Gonad weight to length by sex and macroscopic development class for BET caught in the western and eastern regions. Note the different scales for the x-axis for males and females.

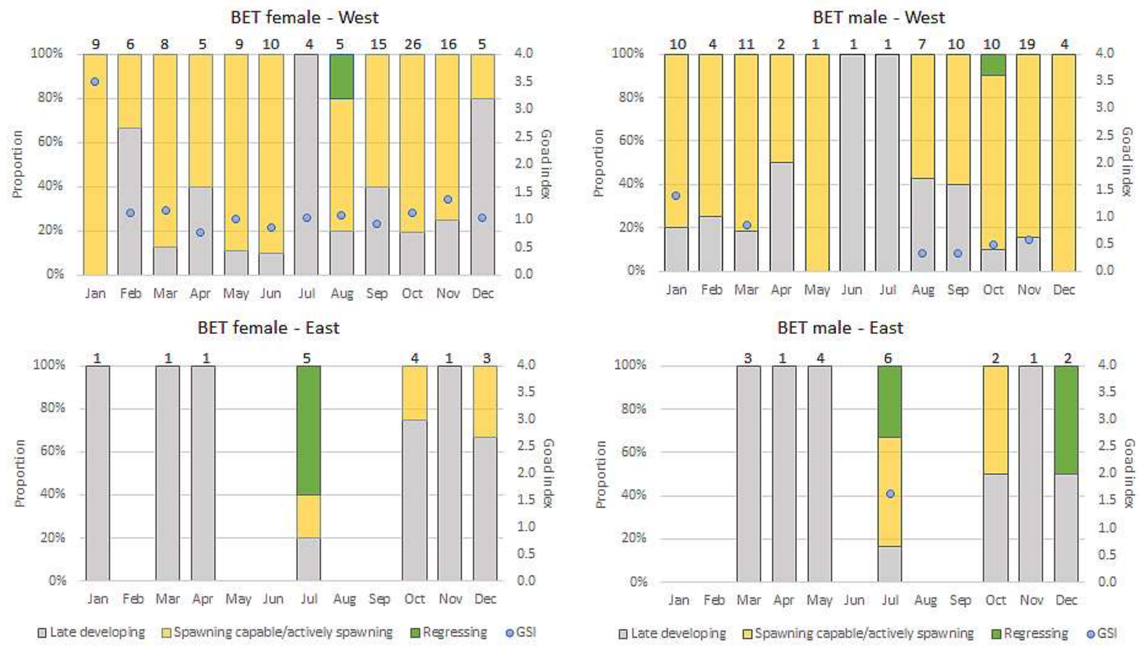

Figure 7.2.7. Proportion of mature BET each month by macroscopic development class (left axis, stacked bars) and monthly gonad index (right axis, blue circles). Development classes are late developing (grey), spawning capable (yellow) and regressing (green). Sample sizes are shown along the top of each bar. Monthly gonad index is not shown if n≤5.

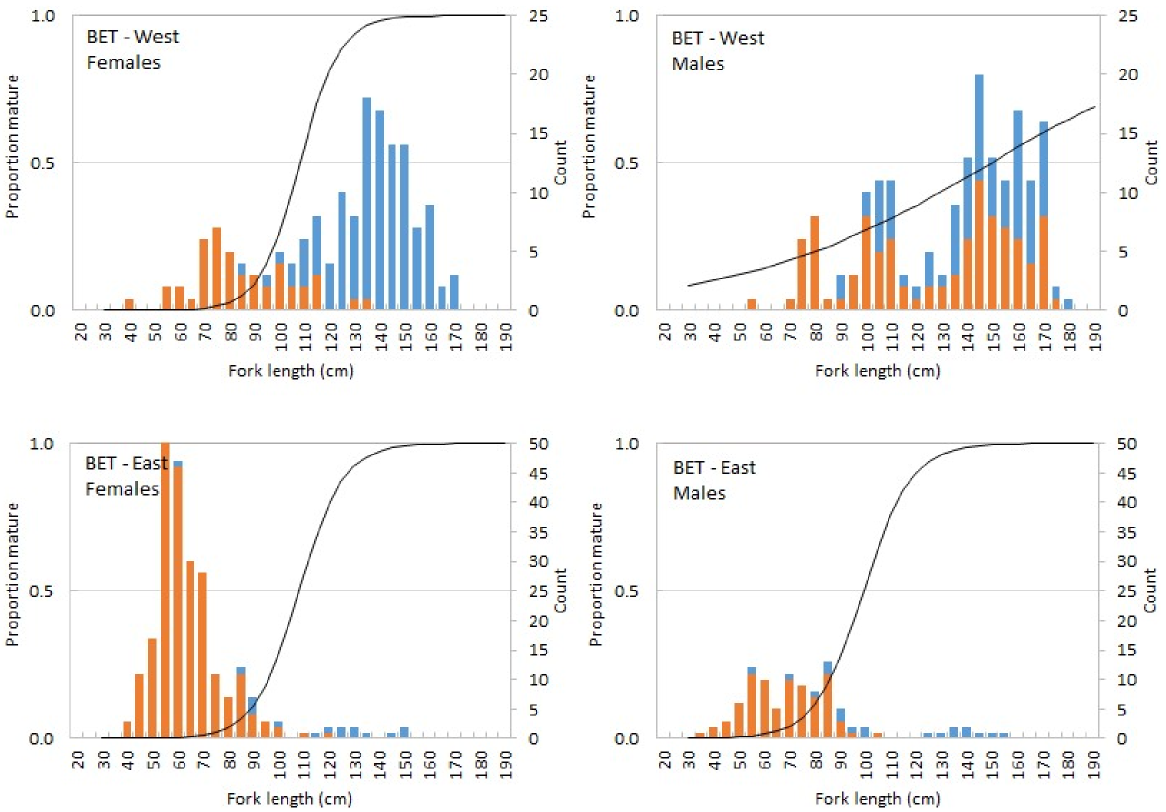

Figure 7.2.8. Estimated maturity ogive (i.e., proportion mature by length) (left axis) and length frequency (right axis) for male and female BET from the western (top) and eastern (bottom) regions. The length frequency shows immature (orange bars) and mature (blue bars) fish based on macroscopic classification of gonads. Note the different scales for the right axis for western and eastern regions.

Yellowfin tuna

Of the 2,889 YFT sampled in the project, ~55% had their gonads removed, weighed and classified macroscopically. Most of the remaining fish were classed as indeterminate as their gonads were too small to determine sex.

Western region

Based on the gonad weight data, most fish <100 cm FL showed little gonad development and are unlikely to have spawned in the near future (Figure 7.2.9). Although the sample size was low in some months, the preliminary macroscopic data indicates that YFT can spawn throughout the year, which is consistent with the lack of a distinct seasonal pattern in the mean monthly GI data for mature fish (Figure 7.2.10). Preliminary maturity ogives for YFT are shown in Figure 7.2.11. Samples sizes were relatively large compared to BET, and L_{50} was estimated at 108 cm FL for females and 106 cm FL for males. The smallest spawning capable/actively (spawning) fish were 103 cm and 106 cm FL for females and males respectively.

Eastern region

The pattern of gonad development of YFT in the eastern region was somewhat different to YFT in the west. For example, the smallest spawning capable fish were 63 cm and 70 cm FL for females and males respectively, which is substantially smaller than YFT in the west. Figure 7.2.9 shows that a sizeable proportion of fish between ~60 and 100 cm FL (both sexes) had heavier gonads for their size compared to YFT in the west. This pattern was observed for fish landed in both Kendari and Bitung (result not shown). Although the accuracy of the macroscopic classification of ovary development needs to be verified through histological analysis, the ovary weight data suggests real differences are present. The preliminary maturity ogives for YFT are shown in Figure 7.2.11. L_{50} was estimated to be 81 cm FL for females and 79 cm FL for males.

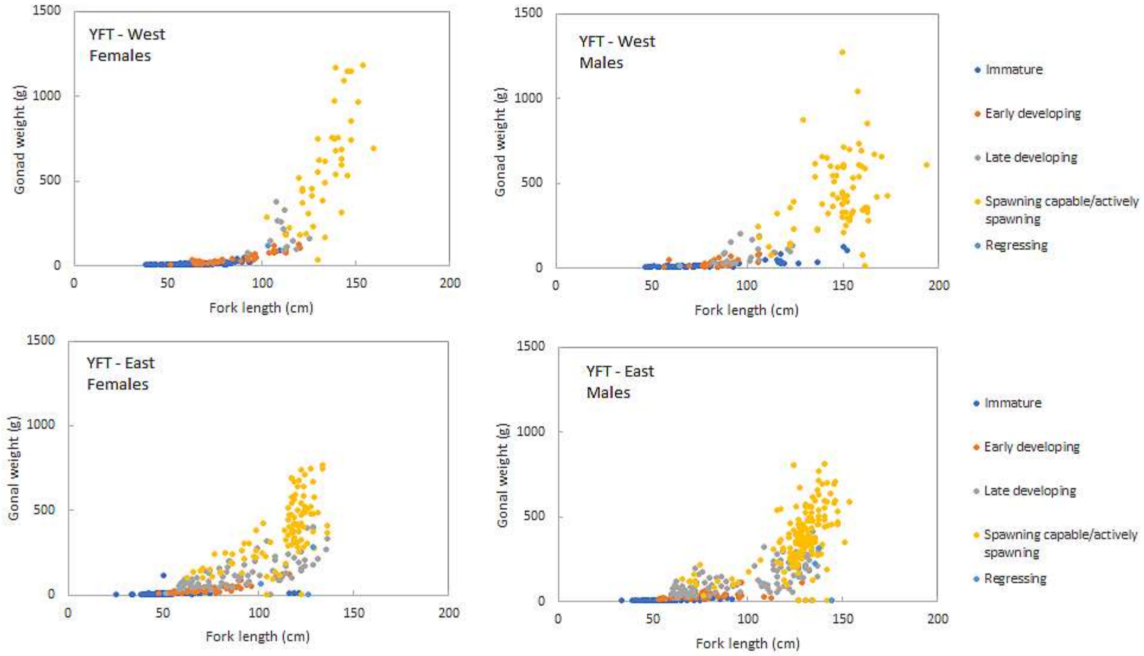

Figure 7.2.9. Gonad weight to length by sex and macroscopic development class for YFT caught in the western and eastern regions.

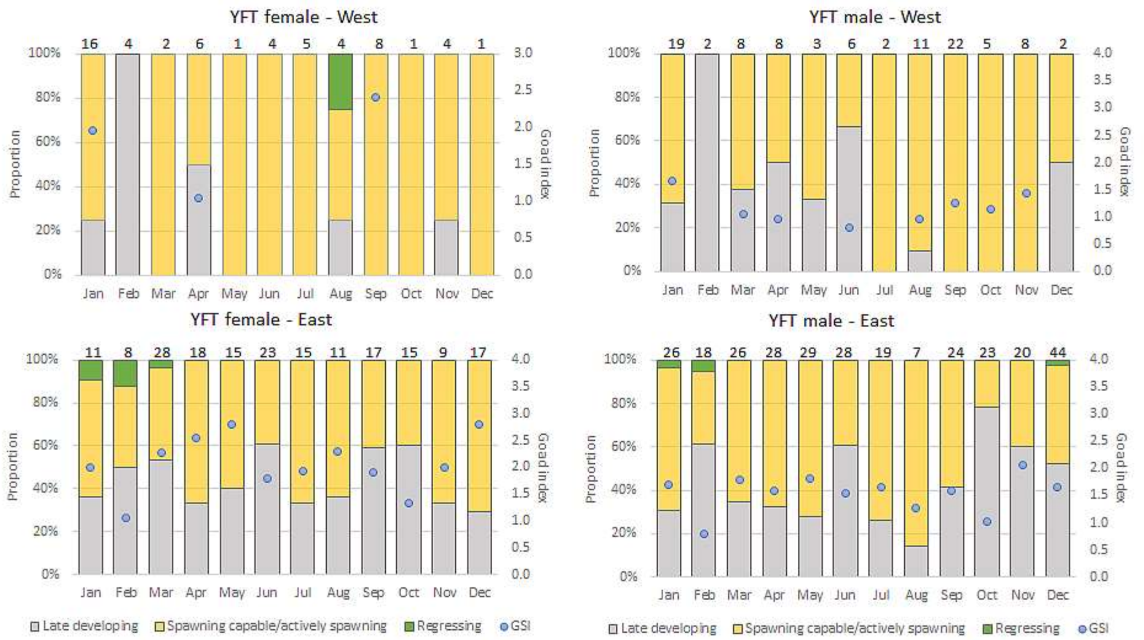

Figure 7.2.10. Proportion of mature female YFT each month by macroscopic development class (left axis, stacked bars) and monthly gonad index (right axis, blue circles). Development classes are late developing (grey), spawning capable/actively spawning (yellow) and regressing (green). Sample sizes are shown along the top of each bar. Monthly gonad index not shown if n≤5.

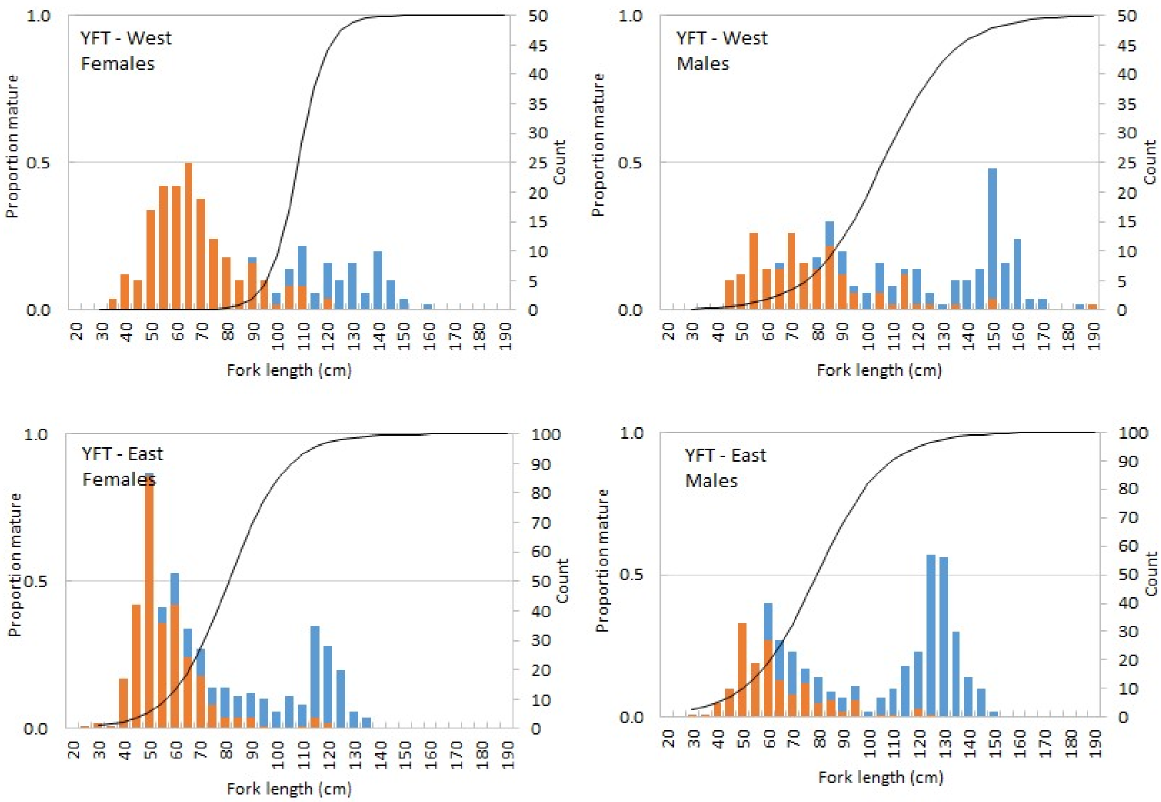

Figure 7.2.11. Estimated maturity ogive (i.e., proportion mature at length) (left axis) and length frequency (right axis) for male and female YFT from the western (top) and eastern (bottom) regions. The length frequency shows immature (orange bars) and mature (blue bars) fish based on macroscopic classification of gonads. Note the different scales for the right axis for western and eastern regions.

Skipjack

Of the 3,331 SKJ sampled in the project, ~67% had their gonads removed, weighed and classified macroscopically. Most of the remaining fish were classed as indeterminate as their gonads were too small to determine sex. Among the three species in the project, SKJ had the highest number of gonads collected, and the number of fish per length class for both immature and mature fish was sufficient to estimate more certain maturity models.

Western region

Based on the gonad weight data, most fish <40 cm FL showed little gonad development and are unlikely to have spawned in the near future (Figure 7.2.12). SKJ classed as late developing were sampled year-round but very few spawning capable/actively spawnig fish were sampled (Figure 7.2.13), suggesting the area sampled is not prime spawning habitat for SKJ. The gonad weight of several fish classed as late developing was higher than fish classed as spawning capable, suggesting that the macroscopic classification may be incorrect; this needs to be verified microscopically through histological analysis of the ovaries. This misclassification, however, is unlikely to affect the estimation of length-at-maturity because both late developing and spawning capable fish are classed mature. The smallest mature fish were 40 cm and 39 cm FL for females and males respectively, and the preliminary maturity ogives based on the macroscopic data estimated L_{50} to be 48 cm and 50 cm FL for females and males respectively (Figure 7.2.14).

Eastern region

A large proportion (~30%) of SKJ sampled in the eastern region were classed as spawning capable/actively spawning and this proportion did not vary substantially across the year, suggesting the area is prime spawning habitat (Figure 7.2.12). The pattern of gonad development and maturity of SKJ in the eastern region is similar to SKJ in the west. For example, the smallest mature fish were 40 cm and 41 cm FL for females and males respectively, and the preliminary estimates of L_{50} were 45 cm and 47 cm FL (Figure 7.2.14).

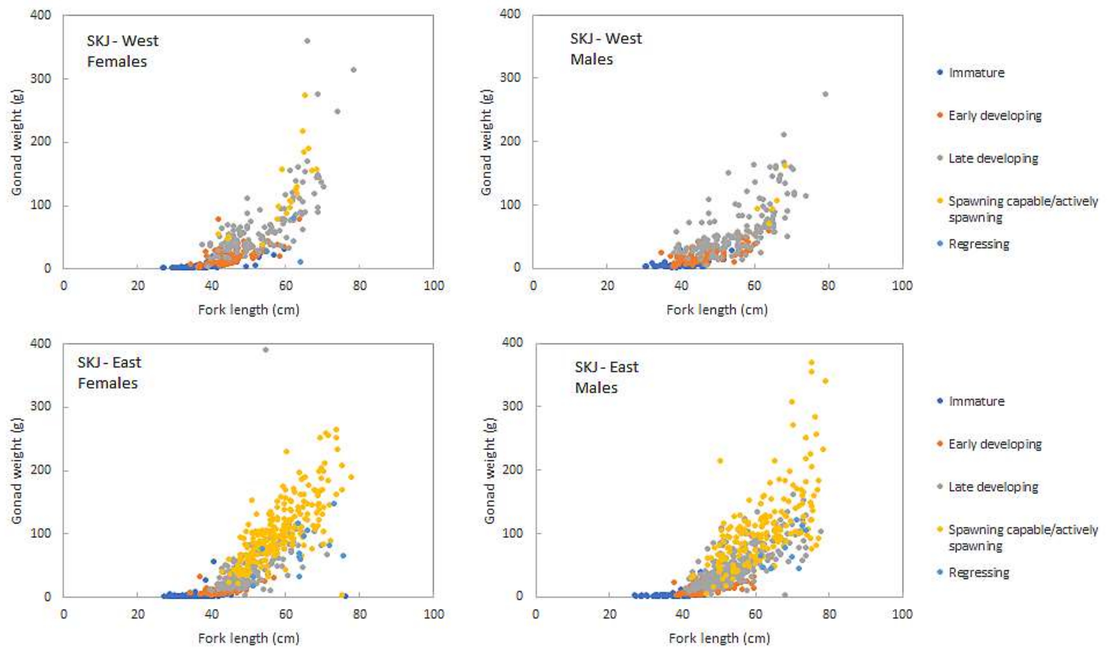

Figure 7.2.12. Gonad weight to length by sex and macroscopic development class for SKJ caught in the western and eastern regions.

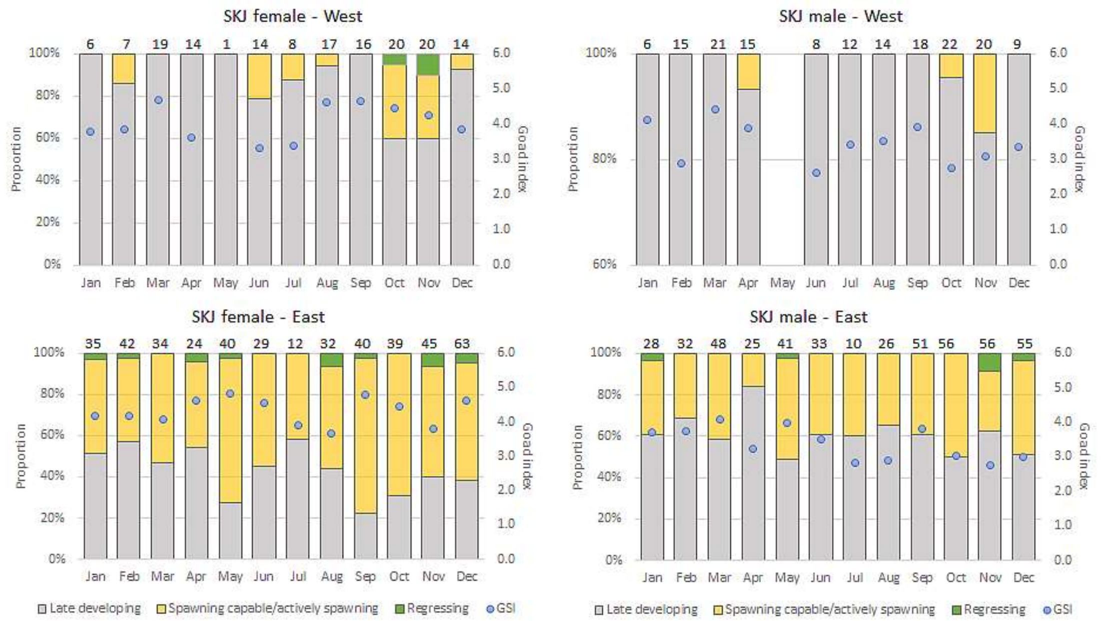

Figure 7.2.13. Proportion of mature female SKJ each month by macroscopic development class (left axis, stacked bars) and monthly gonad index (right axis, blue circles). Development classes are late developing (grey), spawning capable/actively spawning (yellow) and regressing (green). Sample sizes are shown along the top of each bar. Monthly gonad index is not shown if n≤5.

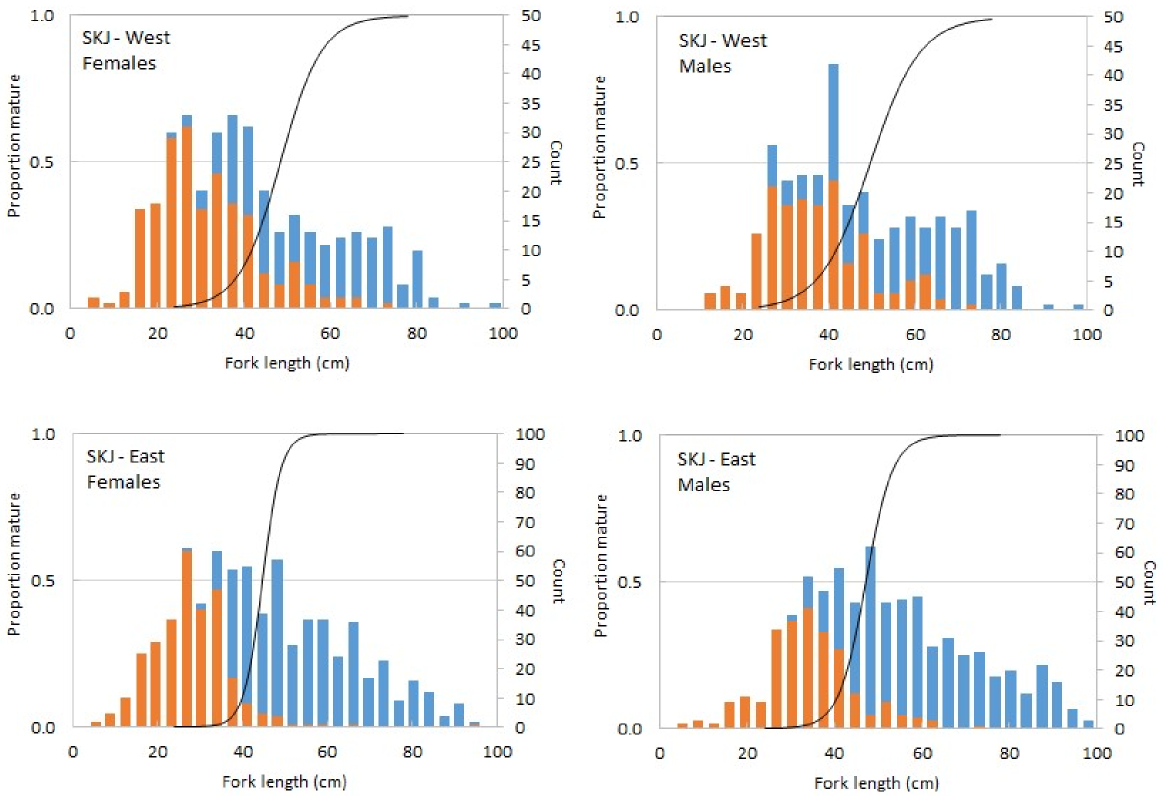

Figure 7.2.14. Estimated maturity ogive (i.e., proportion mature at length) (left axis) and length frequency (right axis) for male and female SKJ from the western (top) and eastern (bottom) regions. The length frequency shows immature (orange bars) and mature (blue bars) fish based on macroscopic classification of gonads. Note the different scales for the right axis for western and eastern regions.

7.2.5 Summary

The biological sampling component of the project was extremely successful, with nearly 8,000 BET, YFT and SKJ sampled over 28 months providing >16,000 individual samples (gonads, otoliths and fin spines) and gonad weight and reproductive phase data for >4500 fish. The aim was to obtain reproductive and growth parameters for the three species across the region.

The reproductive results presented here are preliminary as they are based on macroscopic classification of gonads in the field and are likely to incorporate a degree error. Previous studies have indicated that macroscopic criteria alone are not accurate for staging gonads, particularly for females that are mature but post spawning as their ovaries appear macroscopically immature. As noted previously, the intention of the project was to prepare and read histological sections of ovary samples and compare the results with the macroscopic classifications to determine error rates. The histological data would then be used to finalise the maturity ogive parameters by length and age, estimate spawning fraction at length/age, and identify ovaries suitable for estimation of batch fecundity. In addition to the reproductive work, the intention of the project was to also prepare and read otoliths and fin spines to estimate age and growth parameters.

Given the success of the sampling program and preliminary results for the reproductive biology, future work should focus on the following areas in collaboration with Indonesian researchers:

- Finalising the sampling data set including investigating and removing potential data outliers.
- Preparing histological section of all ovary samples and thin sections of a representative subset of otoliths and fin spines.
- Completing “Train the Trainer” workshops in Indonesia on reading the ovary histology and otoliths/spines, and on data analysis and modelling.
- Finalising the reproductive data set and estimate maturity ogives, spawning frequency, batch fecundity and potential annual fecundity parameters (length and possibly age based)
- Finalising the age data set and estimate growth parameters.
- Examining spatial and temporal variation in reproductive and growth parameters.
- Publishing results in peer-review journals.

7.3 Examine the potential social and economic impacts of alternative management measures through surveys and bio-economic modelling

To achieve Objective 3, a study to collate and review previous/ongoing data collection programs related to socio-economic information of the tropical tuna fisheries in Indonesia was undertaken in 2019 through a desktop review and in-person interviews. The review study identified at least 21 programs/studies documenting social and economic aspects of the tropical tuna fisheries in Indonesia (Hoshino et al. 2019a, Appendix 5). It was found that the available socio-economic studies are case studies in nature and have focused on a specific region (e.g. bay, port) or a certain fishery, hence limited quantitative information is currently available that allows a cross-regional comparison of the relative importance of, or dependence on, the tropical tuna fisheries. Moreover, Indonesia lacks systematic social and economic data collection systems for these important fisheries. This situation limits the scope for providing advice on the likely socio-economic impacts of alternative management actions. The study recommended the Indonesian government to strengthen institutional capacity to establish long-term strategies for collecting socio-economic data for tuna fisheries in Indonesia through e.g., research capacity building and improved collaborations among research agencies and private sector. The review study further recommended several targeted research that can improve the availability and utilization of socio-economic data for the management of tropical tuna fisheries in Indonesia, including 1) a comprehensive study characterizing the tropical tuna fisheries in Indonesia, in terms of production, fleet characteristics, market, employment, and household demographics; and 2) quantification of the flow-on effects of the tropical tuna industries to the regional and national economy.

The work has been very well received. The team continued to engage with the Centre for Fisheries Socio-Economics and the NGOs involved in the Walton Family Foundation. The team acted as trusted advisors, providing expert advice to the workplans of the Tuna Consortium, their draft reports and various meetings organised by the Tuna Consortium. Through this engagement we have aligned activities and built collaborations and funding opportunities. This has resulted in three coordinated projects focussed on the social and economic aspects of the tuna fisheries in IAW: (i) a SRA for the team at University of Technology Sydney (UTS); (ii) a CSIRO-CFR collaboration (which directly follows the above targeted research recommendations, focused on the characterisation of the tropical tuna fisheries and quantification of the flow-on effects of the tuna fishery to regional economy); and (iii) an Indonesian NGO project funded by the Walton Family Foundation. The team also hosted a UTS researcher (Nick McLean) as a visiting fellow, resulted in his successful commission of the SRA project (FIS/2020/109), and increased understandings of the relevant concepts of harvest strategies and quantitative data requirements.

The project also raised awareness of the importance of socio-economic data collection among stakeholders and the government officials. For instance, the 3rd Stakeholder Implementation Workshop held in 2-3 March 2021 agreed 'preparation and initiation of socio-economic data form standards and collection of socio-economic data.' This is evidence of MMAF's commitment towards building a systematic economic time series data collection system for the Indonesian tuna fisheries, and on the road towards developing capacity to be able to track changes in economic performance of the fisheries and accumulate necessary data for future bioeconomic modelling. This is also more direct evidence of a successful path to impact developed through the collaboration approach of the project team.

7.4 Evaluate operational harvest strategies for tropical tuna in Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies

A substantial outcome of this component is the development of the "Harvest Strategy Framework for Tropical Tuna in Indonesian Archipelagic Waters" and its official adoption in May 2018 and revised framework adoption in June 2023. The framework document outlines the set of actions required to complete the development of operational harvest strategies, including fisheries monitoring, analysis, harvest control rules and associated management measures to meet the management objectives of the tuna fisheries, paving the way towards implementation of operational harvest strategies aimed at achieving long-term sustainable goals.

The framework defines a specific and measurable operational objective to be "to maintain spawning stock biomass above the limit reference point (LRP) of 0.2 of the unfished level, with the probability of 90%." The rationale for this was to avoid declines in the average recruitment, subsequent reductions in long-term sustainable catches from the fishery and risk to the stock. This LRP was consistent with those adopted by several tuna RFMOs, including WCPFC and IOTC. Moreover, based on the preliminary results of the Management Strategy Evaluation (MSE) and the latest stock assessment results that indicate declining trend of the stocks, the stakeholders recommended the government to adopt policy measures, including a ban on new licenses for vessels over 30GT in 2019 and adoption of a precautionary catch reduction plan in 2023, as agreed at the Stakeholder Workshop in November 2022. These policy decisions are evidence that the project has already had direct impacts for the management of this important fishery.

Under this component four technical reports have been produced jointly by the project team and Indonesian scientists: (1) Selectivity of skipjack tuna and yellowfin tuna for the Indonesian tropical tuna fisheries (TR1-2021); (2) Key uncertainties to be considered in the operating models (OMs) for use in the Management Strategy Evaluation for the Indonesian tropical tuna fisheries (TR2-2021); (3) Updates of operating model and preliminary results of Management Strategy Evaluation to evaluate relative performance of harvest strategies for skipjack tuna fisheries in Indonesia (TR3-2021); (4) Updates of operating model and preliminary results of Management Strategy Evaluation to evaluate relative performance of harvest strategies for yellowfin tuna fisheries in Indonesia (TR4-2021).

Another substantial outcome of the technical process has been the establishment of partnerships to improve the focus and coordination among organizations/programs engaging in tuna data collection. These enhanced partnerships are evidenced by various invitations by the partner institutions to review their workplans, their reports and joint projects that are facilitated by this project. The list of relevant projects and publications (outside of this project) is given in Table 7.4.1.

Table 7.4.1 List of relevant projects and publications

No	Project name	Implementing institution	Funder
1	Development of prototype operating models for exploring harvest strategies for tropical tuna in Indonesian archipelagic waters: case studies for skipjack and yellowfin tuna	CSIRO	WPEA-WCPFC
2	Improving Institutional Capacity for Operational Monitoring and Management of Tuna Fisheries in Indonesia (PI: Campbell Davies, 2018-2020)	CSIRO	Walton Family Foundation (WFF) Grant: 2018-885
3	Characterizing the socio-economic contribution of the tropical tuna fisheries in Indonesia (PI: Eriko Hoshino, 2020-2023)	CSIRO & BRIN	WFF Grant: 00101981
4	Developing social and economic monitoring and evaluation systems in Indonesian tuna fisheries to assess potential impacts of alternative management measures on vulnerable communities (PI: Nick McLean, 2020-2023)	UTS & BRIN	ACIAR SRA (FIS/2020/109)
5	Tuna Consortium Project Phase I (2019-2022) & Phase II (2022- 2024)	MDPI, IPNLF, TNC, Marine Change, EDF, WWF	
	Publications	**Related project No**	**Funder**
1	Hoshino, E., Proctor, C. H., Satria, F., Sadiyah, L. and Davies, C. R. (2019). A desktop review of the current fishery management and advisory structures for tuna in Indonesia. CSIRO Oceans and Atmosphere. CSIRO, Hobart, Australia	2	WFF
2	Hoshino E, Lewis, T., Satria, F, Sadiyah, L. Davies, C. (2021). Summary of data reporting requirements and minimum data standards of tuna Regional Fisheries Management Organization applicable to Indonesia. CSIRO Oceans and Atmosphere, Hobart, Tasmania, Australia	2	WFF
3	Satria, F., L. Sadiyah, E. Hoshino, I.G.B. Sedana, J. Dell (2023). Characterising the tropical tuna fisheries in Indonesia. Technical Report prepared for the Walton Family Foundation. 2023. CSIRO Environment Unit, Hobart, Australia	3	WFF
4	Hoshino, E. S. Pascoe, I. van Putten (2023). Quantifying the flow-on economic contribution of the tropical tuna fisheries in Indonesia. Technical Report prepared for the Walton Family Foundation. 2023. CSIRO Environment Unit, Hobart, Australia	3	WFF
5	Lewis, A., and Davies, C.R. 2021. Review of tropical tuna stock structure and connectivity. Report to the International Pole and Line Foundation and Walton Family Foundation Tuna Consortium. March 2021. 30p.	5	WFF

7.5 Develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant tuna RFMOs

- Provided technical and financial support to Mr Irwan Jatmiko (BRIN) for his PhD project.
- Provided technical and financial support for two ACIAR John Dillon fellowship recipients (Ms Tri Ernawati and Ms Ririk Sulistyaningsih) to provide additional training in Hobart.
- Provided financial support to 2 Indonesian scientists (Dr Fayakun Satria and Dr Lilis Sadiyah) to attend advanced stock assessment workshops in July 2023 organised by SPC, the main scientific body who conduct regional tuna stock assessments on behalf of WCPFC.

The above activities were identified as priority in the ACIAR-Indonesia Strategic Plan and draw on the work programs and priorities identified by the three relevant tuna RFMOs' Commissions and Scientific Committees. For example, Dr Satria is the new head of the Research Centre for Fishery (RCF) of BRIN and Dr Sadiyah is the leader of the Pelagic Fisheries Research Group under RCF/BRIN. They have been playing key roles in translating scientific knowledge into tuna fisheries policy decision-making since the mid-2000s, hence building capacity of these key personnel who can act as knowledge brokers between science, policy and stakeholders is crucial.

Building capacity for fisheries managers to gain hands-on experiences on modern scientific-based decision-making process is also crucial in developing operational fisheries management capability for Indonesian tuna scientists and managers and their engagement in the tuna RFMOs. To this end the original plan was to provide financial and logistic supports for key DGCF personnel to visit Australian Fishery Management Authority (AFMA) in Canberra. However, due to the travel restrictions related to COVID-19 and restructure of the Indonesian government it was postponed several times and, eventually, was not possible to complete within the project.

The project also facilitated the discussions on the development of a systematic socio-economic data collection system for tuna fisheries in Indonesia. The WFF Tuna Consortium has initiated a socio-economic focus group (SEFG) among the members of tuna monitoring data providers (who have been collecting operational catch, effort and size data) and they have committed to collect additional socio-economic data in support of the government to develop and implement harvest strategies. Our team member (Eriko Hoshino) has been invited as an external expert member of the SEFG and has been providing technical advice to the focus group meetings and discussions.

8 Impacts

The project has generally been very successful in achieving its proposed project outcomes, with the exception of the population biology study to provide key parameter estimates for the harvest strategy and MSE work and for improvement of the regional stock assessments conducted by SPC. For the other objectives, the project outcomes have been achieved and, in several cases, there has been substantive progress with the proposed development outcomes from the original theory of change (Appendix 1). These include the institutionalisation of the harvest strategy process within the MMAF and strong engagement of industry bodies, Indonesian NGOs, the strategic leverage of international donors and their investment in research and monitoring, and the individual and institutional capacity building in harvest strategies, fisheries management, generally, and engagement in the scientific and management bodies of the RFMOs. These are summarised below against the original proposed impacts and outcomes.

8.1 Scientific impacts – now and in 5 years

Based on the original theory of change and pathways to impact (Appendix 1), the scientific impacts achieved from now and in 5 years are summarised in Table 8.1.1.

One of the key scientific impacts of this project is the demonstration of the utility of empirical harvest strategies as a practical, operational management tool for developing coastal nations, such as Indonesia, that harvest highly migratory fish stocks with high degree of uncertainty at various levels of the management process and the natural system.

The empirical harvest strategies developed under the project use the local indicators of stock abundance to adjust the levels of fishing intensity of larger Indonesian tuna fleet without requiring complex stock assessment models. The approach provides a mechanism for adaptive management, that is, the coastal nations can implement fisheries policy when the conditions of the local stocks appear to be declining or increasing, because the management actions are, by design, based on local data series, with which the stakeholders are familiar, and pre-agreed harvest control rules. Prior evaluation and selection of the harvest strategy in a manner consistent with the regional stock assessments also provides a mechanism to translate regional decisions set by tuna RFOMs to local actions.

Our technical work through simulation evaluation of potential harvest strategies (i.e. Management Strategy Evaluation, MSE) for yellowfin tuna also demonstrated that domestic fisheries regulations applied only to the large-scale Indonesian tuna fleet are unlikely to be effective in maintaining tuna stocks at sustainable levels. Rather, an overall reduction in fishing intensity for all segments of the Indonesian tuna fleet, including small-scale fisheries that dominate the catches in recent years, is likely to be necessary. It also demonstrated how the quality of fisheries monitoring data (catch, effort and size of fish) affect our ability to accurately estimate local indicators of stock abundance, and hence our ability to adjust fishing intensity before depleting stocks further. Through this process, major data gaps, including the lack of quantitative socio-economic data to be able to evaluate potential S-E implications of harvest strategies were also highlighted, which led to a new initiative by data providers to extend current fishery monitoring programs to include additional S-E data collection and improved coordination of investments in research and monitoring across the stakeholders and the Ministry.

There is ample evidence from terrestrial conservation and fisheries that stakeholder involvement throughout the process of resource management is key to effective negotiation and compromise, acceptance of the rules and, hence, the sustainability of resource use (Cochrane et al, 1998, Bunnefeld 2011). Our project provided additional evidence for the value of HS/MSE approach in strengthening stakeholder consultation, direct engagement in the science and policy development process, and generating strong buy-in from the government and stakeholders, which in turn promote sustainable resource uses. While there remain substantial challenges to the implementation of effective operational monitoring and management of tuna fisheries in IAW, this project has facilitated and delivered, in partnership with many others, a sound foundation to take this initiative forward.

Life history traits of fish are vital inputs to stock assessments and operating models for MSE, and for calculating reference point for sustainable fishery management. Accurate information on age-based life history parameters (e.g., longevity, length/age at maturity, growth rates) are not available for tropical tunas in Indonesian waters, or indeed for much of the Indian-Pacific Ocean. A two-year biological sampling program established under this project collected ~16,500 samples, which represents one of the most comprehensive collections for tropical tuna. The completion of its analysis was interrupted by the institutional disruption caused by the BRIN-MMAF transition. The completion of the processing and analysis will advance the current scientific knowledge of the stocks and their structure, thereby promoting sustainable management of tuna resources in Indonesia and nearby regions. The quality of the collection means it is also likely to provide insights into the basic biology of these species. For example, the seasonal pattern in reproductive output and monthly samples of fin spines and otoliths can help determine whether new methods using multiple hard-parts can be used to estimate the age of skipjack tuna.

Table 8.1.1. Scientific impacts achieved from now and in 5 years by Objective (OBJ).

OBJ	Situation at the start of the project	Project target outcomes	Assumptions	Scientific impacts achieved
1	Indonesia has committed to development of harvest strategy (HS) for tuna fisheries under NTMP	Development of an appropriate HS framework and implementation plan for tuna fisheries in Indonesian archipelagic waters	Cooperation and momentum that has been built (by Indonesia and partners) can be maintained between MMAF directorates, industry sectors, NGOs to complete development process by December 2017.	Initial evaluation (by MSE) of operational harvest strategies for skipjack and yellowfin tuna completed. Identification of monitoring data sources and refinements. Establishment of formal data exchange protocols between MMAF and stakeholders. Key information gaps and required research activities were identified and included in Action Plan of HS Framework. Interim HS framework launched in 2018. Revised and updated version launched by Minister in June 2023.
2	Productivity of yellowfin, bigeye and skipjack tuna in the	Improved understanding of productivity of	Assumes ongoing monitoring programs have	New knowledge of population biology.

	Indonesian archipelago not well understood with high level of uncertainty in productivity and stock status.	yellowfin, bigeye and skipjack tuna in the region.	been successful in collecting the necessary data.	Extended publication records of scientists in both Indonesia and Australia. Reduced uncertainty in regional stock assessments and harvest strategies.
3	Limited social and economic studies exist regarding tuna fisheries in Indonesia, no effort has been made to collate and analyse existing data.	Improved baseline knowledge of social and economic status of tuna fisheries in Indonesia through development of database.	Assumes high level of cooperation of government agencies, fishing associations, and NGOs in providing information.	Improved baseline knowledge of socio-economic status of tuna fisheries Improved coordination among partners and government agencies to collect socio-economic data from tuna fishing, paving the way towards enabling Indonesian scientists and government agencies to track the social and economic status for next iteration of HS implementation.
4	No formal Harvest Strategy for tuna exists in Indonesia. Consistent monitoring protocols and sampling design developed across different monitoring programs.	Consistent monitoring protocols and sampling design developed across different monitoring programs. Initial Harvest Strategy framework for yellowfin and skipjack tuna developed and formalised.	Assumes: i) ongoing monitoring programs have been successful in collecting the necessary data and information for the Harvest Strategy development; ii) Necessary management measures can be effectively implemented at relevant level of Indonesian jurisdiction	Enabling Indonesia scientists to test/ develop example harvest strategies to improve the sustainability of the tuna resources and provide policy advice based on science. Raised scientific profile of Indonesia in tuna RFMOs and other regional fisheries fora. Market certification (e.g. MSC) achieved and increased the likelihoods of export approval (e.g. EU) for some sectors of the tuna fisheries. Improved understanding of the cost-benefit and likely performance of different forms of harvest strategy in 'data-poor", developing world context.
5	Long-term collaborative engagement between CSIRO and AMAFRHRD in tuna R&D	Strategic plan to facilitate transition from capacity building to strategic	Assumes mutual interest and high levels of cooperation are maintained	Lessons learnt for development and implementation of science partnerships

		science collaboration		Fisheries scientists and government agencies in Indonesia more active and prominent in international pelagic fisheries science arenas, including Scientific Committees of RFMOs. Strong collaborative links across project team were important in maintaining momentum and progress through COVID-19 and MMAF-BRIN transition.

8.2 Capacity impacts – now and in 5 years

The project had had substantive capacity impacts across a number of its components as listed in Table 8.2.1.

Table 8.2.1. Capacity impacts across projects by Objective (OBJ).

OBJ	Situation at the start of the project	Project target outcomes	Assumptions	Capacity impacts achieved
1	Limited opportunities for scientists and government agencies in Indonesia to learn practical aspects of Harvest Strategy implementations.	Improved understanding of DGCF and CFR staff in implementing Harvest Strategy based on Australian and relevant international experiences (i.e. CCSBT and IOTC).	Assumed experience between science and management are shared.	Scientists and government agencies in Indonesia provided with practical guidance necessary for Indonesian application. Improved communication and cooperation between government agencies in Indonesia and Australia. Improved participation by Indonesian scientists and managers in relevant tuna RFMOs (i.e. CCSBT, IOTC, WCPFC) Strength of cooperation important in HS and CCSBT monitoring programs managing the MMAF-BRIN transition.
2	Limited training opportunities for Indonesian scientists to build capacity in contemporary population biology and analysis methods.	Well-developed skills of Indonesian scientists in tuna reproductive biology.	Indonesian scientists have sufficient time allocation to effectively participate in research	Trainer-the-trainer approach successful for science of population biology and port sampling for population biology. Improved Indonesia's capacity to meet its reporting obligations to the RFMOs with high-quality data and scientific contributions.
3	Little capacity to evaluate social and economic impacts of tuna fisheries in Indonesia.	Potential socio-economic impacts of potential Harvest Strategy evaluated through the development of Management Strategy Evaluation.	Indonesian scientists have sufficient time allocation to effectively participate in research	Improved capacity for scientists and government agencies to incorporate social and economic data into the design of Harvest Strategy.
4	No consistent monitoring protocols and sampling design across existing monitoring programs.	Improved and consistent monitoring data collection.	Sufficient resourcing and coordination among monitoring	Formal data exchange and review process has institutionalized data review and refinement process across MMAF and

			programs to affect change.	stakeholders leading to improved consistency and quality of data sets for HS and regional stock assessments.
5	Limited opportunities for scientist in Indonesia to obtain necessary skills in developing and operationalising tropical tuna Harvest Strategy.	Candidate Harvest Strategy developed for operational management of tropical tuna in Indonesia.		Improved capacity for effective implementation of Harvest Strategy for tropical tuna in Indonesia.

8.2.1 Objectives 1 & 5: Harvest Strategies and Management Strategy Evaluation and Stock Assessment:

Both the technical and stakeholder consultation processes (lead by MMAF and supported through this project) have substantially increased the policy/management (DGCF) and scientific capacity (CFR, RIMF, RITF) of Indonesia for domestic and international engagement. This is evident through the increasingly independent leadership of technical and policy processes at domestic and international level. For example: i) the formalized data exchange, validation and analysis process for the monitoring series to be used in the HS has now been running independently for more than 6 years and is institutionalized within CFR and DGCF and the participating Industry bodies and NGOs, and: ii) the quality of the reporting and engagement in the WCPFC harvest strategy processes of the WCPFC at the scientific committee and commission, including independently authored working papers by Indonesian scientists and fisheries managers. In the latter, Indonesian scientists are seen as among the most informed on the topic of HS and MSE and actively participate in technical discussions at the scientific committee (Rob Scott, SPC, *pers comm.*). The monitoring data collected for the HS has also contributed directly to Indonesia's performance against the obligatory national reporting requirements of members to the WCPFC. This has resulted in a steady improvement in Indonesia's compliance score for monitoring and scientific data.

8.2.2 Objective 2: Fisheries population biology:

The population biology component has contributed to improving the technical and theoretical understanding of population biology methods of selected of mid-senior level BRIN staff and a new cohort trained in sampling for biological studies and the coordination and management of large-scale field sampling for tuna fisheries research. If the preparation of histological sections of ovaries and sections of spines and otoliths can be completed, training can continue and Indonesian scientists should develop skills in tuna reproductive biology, age estimation and estimating biological parameters. This will improve Indonesia's capacity to meet its reporting obligations to the RFMOs with high-quality data and scientific contributions. In addition, support from this project has contributed to Dr Irwan Jatmiko's PhD on Kawaka and allowed him to work with leading age and growth specialists in Australia to develop methods for interpretation of daily and annual ageing methods. His valuable expertise will be relevant to many of the important, understudied neritic species in Indonesia when he returns in 2023-24 at the completion of his PhD.

8.2.3 Objective 3: Socio-economics:

During this past 3 years there has been increasing interest from stakeholders and Indonesian NGOs in the potential social and economic impacts/benefits that may arise from the harvest strategy. We have very successfully built partnerships with the relevant MMAF research institutes (Research Centre for Fisheries Socio Economics) and other Australian social researchers with experience in Indonesia (McClean et al. at UTS) as well as members of the Walton Family Foundation (WFF) “Tuna consortium” to coordinate and align research and monitoring activities. This was facilitated by the completion of the S-E desktop review for this project. Consultation and extension activities led by Eriko Hoshino have resulted in: i) an ACIAR funded project (McClean et al., FIS/2020/109) to focus on the social interdependencies among fishery-dependent communities and development of conceptual frameworks for provincial and national scale monitoring; and ii) a second socio-economic study funded by WFF (Satria et al. 2023; Hoshino et al. 2023 in Table 7.4.1) focused on national scale economic indicators and aimed at providing a national scale socio-economic characterization of the structure of the tuna fishery and to quantify indirect and induced economic impacts beyond direct economic benefits (from fish sales). This support and collaboration has continued through the current year with Nick McClean being hosted at CSIRO for 6 months (and extended for another 2.5 years), where he engaged with a wider range of social, economic and fisheries researchers and has built strong collaborative links between the research groups. Finally, we have continued to provide direct input and guidance at the researcher level and through solicited advice to the WFF on the design and implementation of other socio-economic data collection and analysis activities being undertaken by the WFF Tuna Consortium.

8.2.4 Public-private/stakeholder engagement:

As noted earlier, we have been very active in cultivating strong collaborative arrangements and guiding the investment/activities of NGO and Industry bodies and their engagement with MMAF. In doing so, we have been careful to retain our (CSIRO) independence from the NGO activities (i.e. we are an advisor to WFF directly and the Tuna Consortium, but not a partner of the Tuna Consortium). This has been important, given the delicate balance with the MMAF and NGO research versus lobbying/activist activities in Indonesia. This has assisted in building technical capacity in the Tuna Consortium in harvest strategies, international tuna science and management and resulted in better alignment of investments and less duplication of activities. The quality of our contributions here has resulted in Campbell Davies becoming a trusted advisor/reviewer for both WFF and Packard Foundation.

8.3 Community impacts – now and in 5 years

To date the major impacts of the project have been at the institutional/public-private level as outlined in section 3.2.

There have also been indirect impacts across the economic, social and environmental dimensions associated with government and private sector initiatives seeking fisheries certification (i.e., Marine Stewardship Certification, or MSC). These involve improvements in industry and MMAF monitoring and reporting for nominated fisheries seeking certification and flow on benefits relating to market access in the EU and USA, in particular, which flow from the scientific and capacity building activities of this and related projects.

The development and implementation of harvest strategy for skipjack and yellowfin tuna has been a deciding factor in the certification of at least three Indonesian fisheries and the adoption of outputs of this project by MMAF, Industry bodies and NGO has directly contributed to this outcome to date. It will be some time before the scale of the direct and indirect economic, social and environment impacts can be gauged.

Engagement with Walton Family Foundation Tuna Consortium resulted in increased number of NGOs and industry bodies participating in fisheries monitoring programs and coordinated project activities by partner institutions.

8.3.1 Socio-economic impacts

The above MSC certification is a significant milestone for the Indonesian tuna industry, allowing continued access to the major fish markets (EU, USA). While the extent of socio-economic impacts is not yet documented for the tropical tuna fisheries in Indonesia, previous studies worldwide on the impacts of MSC certification reported increased volumes of catches, price premium, job creation, and increase in reputation. Given increasing the export value of tuna products is a high priority objective for the Indonesian government, the potential for socio-economic impacts can be larger than currently recognised. The project lay the groundwork for further economic research and raised awareness of the importance of socio-economic data collection, as evidenced by the commitment by MMAF to develop socio-economic data collection system. The project also resulted in three separate projects focused on social and economic data collection of tuna fisheries aiming to enable Indonesian scientists and decision makers to maximise the economic benefits and minimise adverse social impacts while achieving conservation objectives.

8.3.2 Environmental impacts

The process of harvest strategy development resulted in improved understanding among the government and stakeholders about the importance of fisheries monitoring data for the sustainable management of tuna resources, and Indonesia’s obligations to meet data provisions required by the three tuna RFMOs. These include accurate monitoring of not only targeted fish but also by-catch species, including threatened and endangered species. Improved monitoring through this project has contributed to improve the accuracy of operational data that are used by regional tuna stock assessments, thereby directly contributing to the improved management of tuna species in wider Western Pacific regions. This further resulted in the Indonesian government’s commitment to regulate the fishery by introducing various policy measures to reduce fishing mortality to improve the current declining trend of tuna stocks, and to implement operational harvest strategies for these stocks in the coming years. As noted, there are still substantial challenges to achieving this aim, however, this project has significantly contributed to the development of the necessary technical and institutional foundations required for success.

9 Conclusions and recommendations

9.1 Conclusions

The process of empirical harvest strategy development has: highlighted (1) the critical importance of establishing reliable time series of catch and effort data through monitoring; 2) the need for partnerships to establish common monitoring protocols; 3) the value of stakeholder engagement in arriving at agreed management objectives and actions required; 4) commitments by MMAF leaders and Provincial leaders to limit harvest levels, based on the best scientific advice available, to achieve better management outcomes; 5) the need for capacity development in the skills for both assessing and integrating data into the harvest strategy process, and 6) improved communication strategies to achieve strong engagement by stakeholders. The formal adoption of the interim Harvest Strategy Framework by the Ministry in May 2018 and the updated Framework in June 2023 were significant achievements and are important milestones on the road towards implementation of an operational fisheries management system for achieving long-term sustainability of these nationally and regionally significant fisheries. The process facilitated several new initiatives by the Indonesian government since 2018, including the new data integration initiatives among key partners engaged in tuna fisheries data collection. These initiatives include the implementation of e-logbook reporting, seen as a highly significant advancement in information gathering on fishing operations in the Indonesian waters. The harvest strategy process provided the focus and momentum for agreement on the need to establish common monitoring protocols, both on resources and on socio-economic aspects. In addition, the outcomes from the stakeholder workshops included agreement for no additional effort of industrial and semi-industrial tuna vessels operating in the IAW, and a precautionary reduction in catch of up to 10% over the next 3 years. These actions will allow time for conducting comprehensive simulation testing of candidate harvest strategies required to evaluate the likely effectiveness of proposed quota management measures prior to implementation, aimed at reducing the risks of overfishing and maintaining sustainable catch levels to support food security, livelihoods and national export revenues.

Institutional capacity-building in fisheries management in a system as complex as internationally managed fisheries, such as tuna, takes time, relevant expertise and sustained engagement at a technical, management and policy level. The achievements of this project and project team were built on the foundations of 15 years of strategic investment in research and capacity building for tropical tuna, which was supported by a decade of similar work on southern bluefin tuna. In the absence of this sustained investment and commitment, what has been achieved in this and the related projects and activities would not have been possible. The most significant indication of success of this project (and the prior strategy and investment) is the degree to which the harvest strategy process, in the broadest sense of being an adaptive management, data driven, scientific process, has been adopted and driven by the Indonesian fisheries management, scientists and stakeholders. With the exception of the more specialist technical aspects (e.g. MSE modelling and aspects of the socio-economic component), the CSIRO team provided facilitation and expert advisory roles, and enabled local champions to drive the process. This has been central to creating the ownership, trust and confidence to maintain the momentum and see the harvest strategy implementation process to conclusion.

This was also the case with the population biology, to even a greater degree. With the exception of the initial design and training components, the population biology was led by the Indonesian team. The sampling objectives were largely achieved for all three species for both otoliths, spines and gonads under extenuating circumstances (particularly the COVID-19 pandemic) by the Indonesian team. The samples represent one of the most comprehensive biological sampling programs for age, growth and reproduction for tropical tuna and is a credit to the project team. As noted, the processing and analyses of these samples are a very high priority. The results will not only inform the inputs to the IAW harvest strategy and operating models for the future MSE, they will be a significant input to the regional stock assessments for the WCPFC, conducted by SPC. Beyond this, they will also inform the design of potential application of close-kin mark recapture studies of yellowfin tuna, which are currently being considered in both the Indian and Pacific Oceans.

Finally, while the focus of this project (and the prior projects referred to above, see Appendix 1, Attachment 1) is on tropical tuna, the institutional and individual capacity building impacts of this project extend into a range of other important fisheries in Indonesia. The scientists, managers and NGOs engaged in the harvest strategy process participate in monitoring, assessment and management processes for a wide range of other fisheries. Hence, the relevant experience and expertise built through this project will contribute to the fisheries science and management capability available for research and management of Indonesian fisheries more generally.

9.2 Recommendations

There are a number of outstanding issues and uncertainties for tropical tuna fisheries in Indonesia, including changes in fleet dynamics (Hoshino et al. 2021d), lack of implementation of regulated use of FADs (MMAF 26/2012), the limited capacity to monitor small-scale fishing operations in a cost-effective and sustainable way, and improving understanding of the interaction among different fisheries and non-fisheries sectors to inform the design of management measures for tuna and other fisheries.

Currently the major monitoring projects for tuna in Indonesia are funded externally, and post-COVID impacts on the national budget have resulted in substantial reductions in Indonesian government funding for scientific research and catch monitoring programs. This follows on from significant reductions in national funding for fisheries research between 2015 and 2021 (MMAF 2022b). This has important implications for the implementation of the action plan for the harvest strategy, in the immediate and longer-term, as uptake of existing monitoring programs, and their continuation and improvement, by the Indonesian government are prerequisites to implementation of the harvest strategy. External organizations can, in tandem, continue to assist local and central governments and industry with capacity building, stakeholder engagement, and dissemination and translation of scientific advice, but the development of sustainable financing models for essential monitoring and analysis activities, which is generally a core function of central governments, has been raised as an urgent priority for government, industry and donors to address.

In this regard, further improvement in finer scale operational catch and effort data for all sectors of the fishery remains a high priority. This will not only improve Indonesia's compliance with tuna RFMOs' data requirements (in all three RFMOs) and improve the regional stock assessments, they will assist in building the necessary information base for bioeconomic modelling, which was not possible to complete in the current project because of the lack of this data. The scale of the catches of the small-scale fisheries, particularly for yellowfin tuna, and the launch of the PIT regulation on allocation and quota management, further highlight the need to develop cost-effective ways to monitor catch and effort of this important sector. Reviewing the success of recent investments in a range of remote and smart-phone technologies that have been trialled over the past few years for chain of custody and fisheries monitoring purposes, with a focus on small-scale fishers, would be valuable to identify where to target future activities.

Similarly, while rapid technological development may offer new options for monitoring catch and/or effort, new genetic and statistical approaches to assessing fisheries, such as close-kin mark recapture have been demonstrated to provide fishery-independent estimates of abundance for highly migratory tuna (Bravington et al. 2016; Davies et al. 2020). There is considerable interest in applying these methods to tuna and non-tuna stocks, other than southern bluefin tuna, including the tropical tunas in the Pacific and Indian Oceans (Bravington et al. 2021; Hillary et al. 2022; Anon. 2023; Davies et al. 2023), in part due to the increasing unreliability of the conventional CPUE indices used in the regional stock assessments. The completion of the population biology component of this project and population genetics capability and large-scale tissue sampling capability developed among Indonesian scientists in the previous ACIAR (Proctor et al. 2018) and IOTC (Davies et al. 2020) stock structure projects mean the wider project team would be well placed to assess the logistic feasibility of applying this method to either tropical tuna or neritic tuna. The commencement of a large capacity building project to assess the feasibility of applying these methods to adjacent Pacific tuna stocks (the Coupling Climate & Fisheries Science to Secure Pacific Futures (CCFSPF) partnership) provides the opportunity to coordinate activities within the regional science and management umbrella for future consistency and efficiency should a full-scale program be supported.

It was evident from the wider engagement in the harvest strategy process after 2018, by NGOs and other agencies of MMAF, that there is limited capacity and experience to undertake interdisciplinary/multidisciplinary research, and that there is a strong degree of siloing among the different agencies/institutes. For example, there has been limited formal collaboration among AMAFRHR research agencies (Hoshino et al. 2019a). This is not a situation that is restricted to Indonesian fisheries. It is possible that the creation of the new national research agency (BRIN) may provide an opportunity to increase inter/multidisciplinary collaboration, although the current structure does appear to be largely disciplinary orientated. The longer-term, programmatic nature of the ACIAR support for fisheries research has promoted a broader, multidisciplinary approach. The broad systemic nature of the issues that remain to be addressed for completion of the harvest strategy implementation, and to examine how the success to date can be scaled and transferred to other contexts, provides a rich environment for developing multidisciplinary, systems-science approaches to research for development.

In this context, the potential to extend the program approach to neritic tuna in Indonesia and elsewhere in the region is high, given the parallels and interactions with tropical tuna in Indonesia. Neritic tuna is an important species group for commercial coastal fishing and small-scale fishers, in particular, throughout south-east Asia and the Indo-Pacific. The Indonesian fleet accounted for about one-third (~170,000 tonnes) of the total neritic tuna catch in the Indian Ocean, with approximately 40,000 tonnes attributed to eastern little tuna (IOTC-WPTT21 2019). Despite the significance of these tuna species for local industries and household consumption, there is limited knowledge regarding their current stock status, particularly at a regional level (Wijopriono and Rachmawati 2015), with the majority of donor and international foundation funding being targeted at the higher value, internationally traded tropical tuna. In many of the fisheries that target neritic tuna, they also catch juveniles of the tropical tunas, which share habitats when they are young. Hence, it is not possible to manage either fishery completely independently. Improving the understanding of the fish, the fisheries and the communities and markets they support in the context of rapid global and technological change would provide a valuable foundation for designing effective, integrated policy and management.

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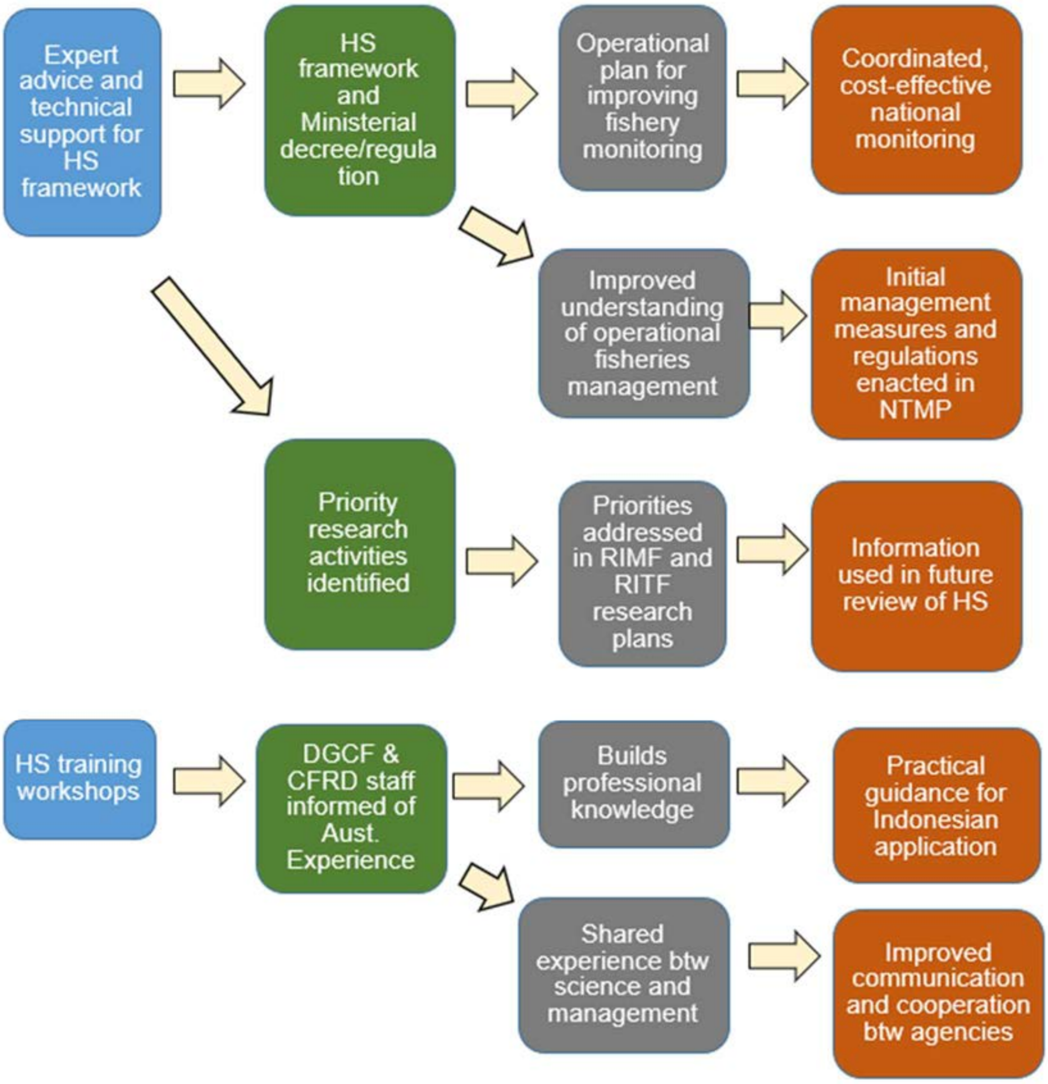
11 Appendixes

11.1 Appendix 1: Impact Pathways – from research outputs to development impact

The foundations of the pathways to impact for the project have been established through the long-term relationships with the Research Institute for Tuna Fisheries in Bali and DG-Capture Fisheries, the current and previous ACIAR tuna projects (Table 1) and the current development of harvest strategies for Indonesian tuna fisheries under the auspices of the National Tuna Management Plan.

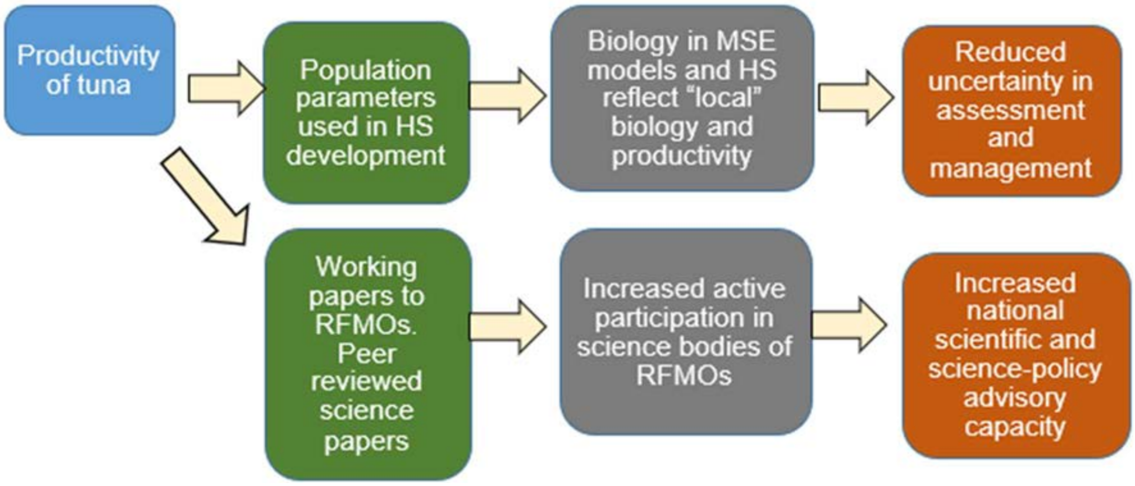
The pathways to impact for each objective are illustrated below and articulated in more detail in each of the tables.

Objective 1: To develop and evaluate harvest strategies for tropical tunas in FMA 713-715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies



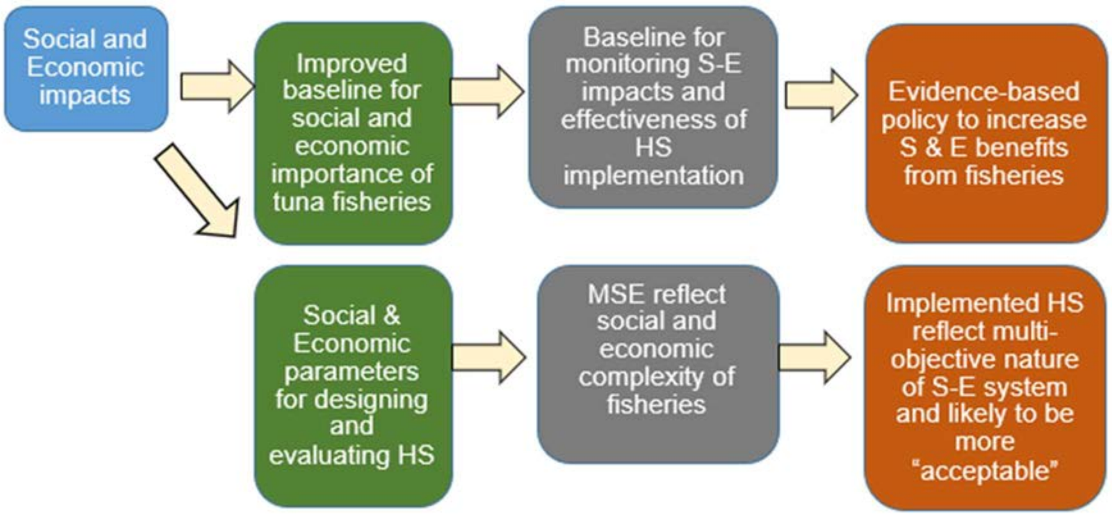
Objective 2: Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction).

Project Activity Project Output Project Outcome Development Outcome



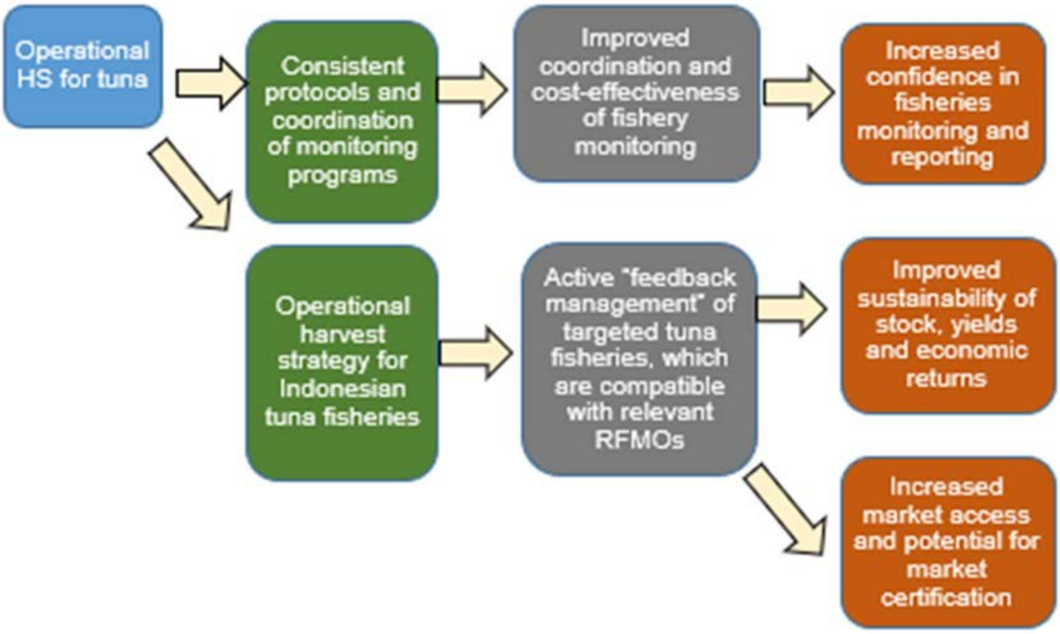
Objective 3: Examine the potential social and economic impacts of alternative management measures through surveys and bio-economic modelling

Project Activity Project Output Project Outcome Development Outcome



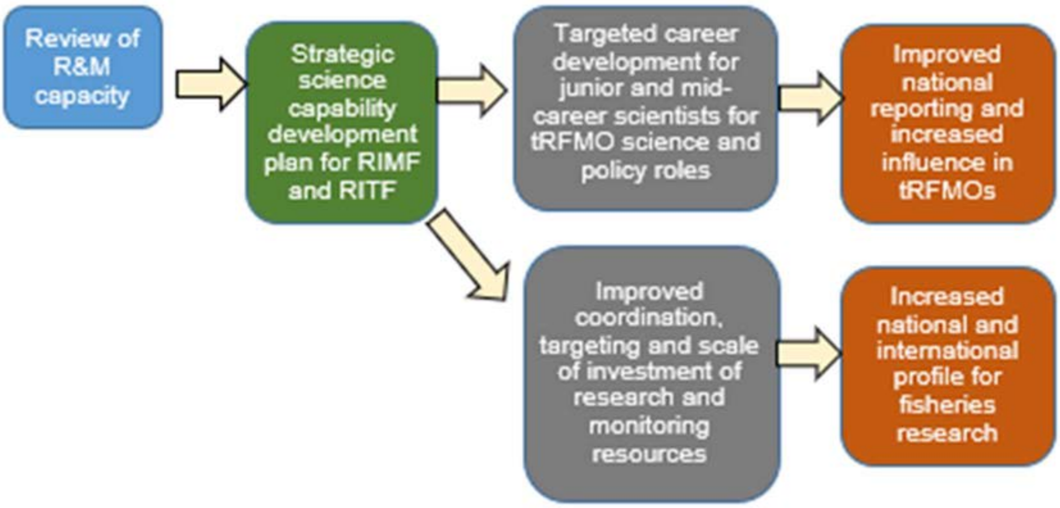
Objective 4: Evaluate operational harvest strategies for tropical tuna in Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies

Project Activity | Project Output | Project Outcome | Development Outcome



Objective 5: Develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant tuna RFMOs.

Project Activity | Project Output | Project Outcome | Development Outcome



Previous and current ACIAR tuna projects and collaborators

ACIAR's long history of support of collaborations between Indonesia and Australia in tuna fisheries research began in 2002 with project FIS/2001/079, and then followed with projects FIS/2002/074 and FIS/2009/059. A summary of these projects is provided below in Table 1. Additional detail on the history of collaborations is presented as a case study *"Success of Indonesia–Australia collaborations on tuna fisheries in Bali"* in ACIAR Technical Report 88 (2015). The projects have followed a well-defined, strategic path with the ultimate goal being sustainable tuna fisheries, and Indonesia having the research capacity and 'systems' capacity to achieve and maintain effective fisheries management for that goal.

Table 1: Summary of objectives and key outputs/impacts for previous ACIAR-CSIRO-Indonesian investments in tuna fisheries research.

Project	Objectives/Activities	Key Outputs/Impacts
FIS/2001/079 *A review of Indonesia's Indian Ocean tuna fisheries and extension of catch monitoring at the key off-loading ports* Jan 2002 – Dec 2003	• To expand the Benoa (Bali) longline monitoring program to other key tuna landing ports (Jakarta and Cilacap) and include coverage of all tuna and bycatch species; • To review Indonesia's commercial and artisanal/small scale tuna fisheries.	• In collaboration with IOTC and OFCF, achieved expansion of the monitoring to the other ports; • Established improved sampling protocols and improved reporting to RFMOs; • The Country Report (review output) made recommendations for further improvements to monitoring and reporting procedures, many of which have since been implemented.
FIS/2002/074 *Capacity development to monitor, analyse and report on Indonesian tuna fisheries* Aug 2005 – May 2010	• To improve and extend existing national systems and capabilities for the collection, compilation and analysis of reliable, high quality fisheries data for Indian Ocean tuna longline fisheries in Indonesia; • To conduct a thorough review on Indonesia's tuna fisheries operating in the eastern region, including Banda Sea and Western Pacific Ocean waters; • To develop a broader based capacity within MMAF to analyse and interpret fisheries data and to ultimately be able to independently produce and report fisheries assessments in line with international requirements for shared fish stocks.	• Established an observer program for the Bali longline fleet, enabling a much improved understanding of that fishery; • Provided a JAF (PhD) capacity development opportunity for Lilis Sadiyah, who has subsequently become a key scientist at CFR; • Provided the necessary information on key tuna landing ports in eastern Indonesia that enabled WCPFC/SPC/Indonesia to select ports for the Western Pacific and East Asia monitoring program; • Assisted the transition of Benoa field station to formal research facility (Research Institute for Tuna Fisheries).
FIS/2009/059 *Developing research capacity for management of Indonesia's pelagic fisheries resources* Aug 2012 – Jun 2017 *(In progress)*	• To define the population structures of yellowfin and bigeye tuna in Indonesia's archipelagic waters and connectivity to populations in adjoining regions; • To assess and characterise Indonesia's tuna fisheries that are based around FADs; • To communicate the project's findings and recommendations.	• Achieved a large-scale sampling program for yellowfin and bigeye tuna across 11 sampling locations, providing materials for a 3 technique, holistic study of population structures. The final outputs will be of high importance in the current Harvest Strategy

		development and to RFMO stock assessments; • The 3 years of enumeration for the FAD based tuna fisheries will enable a much improved understanding of dynamics of fisheries in terms of vessel operations by gear, catch, FAD types, numbers, and ownership; • Preliminary socio-economic assessment of the FAD fisheries has provided data and capacity development important to future needs in the Harvest Strategy development; • Recommendations will be made to assist in developing FAD management options as part of the Harvest Strategy development and implementation.

Related Activities

There are several current fisheries monitoring programs in Indonesia that have synergistic objectives to our current ACIAR tuna project, FIS/2009/059, as well as to those of our earlier project FIS/2002/074. All of these activities have relevance to the current Harvest Strategy development. Brief summaries of these programs are as follows:

- Western Pacific and East Asia (WPEA) monitoring program

  This program, funded by Global Environment Facility (GEF) and coordinated by WCPFC, established improved monitoring of tuna fisheries in Indonesia, Philippines and Vietnam in 2009. Based on the outcomes of the fisheries review of FIS/2002/074, Bitung (North Sulawesi) and Kendari (SE Sulawesi) were chosen as the Indonesian monitoring locations. Sorong (West Papua) and Mamuju (East Sulawesi) have since been included. The Indonesian program is centred on daily port-based monitoring by enumerators, managed by CFR, with inputs from SPC and WCPFC. Its main objective is to collect data to enable Indonesia to better meet its reporting requirements to WCPFC for its relevant Fisheries Management Areas, FMAs 713 –717. The data from the Western Pacific and East Asia program is viewed as having high importance in the current Harvest Strategy development for the FMAs 713 – 715;

- Research Institute for Tuna Fisheries (RITF)

  RITF (Bali) conducts its own fisheries monitoring activities, funded by the Indonesia Government budget. RITF maintains the long term port-based monitoring program for the Benoa longline tuna fleet (i.e. the program commenced by CSIRO with Indonesia in the early 1990s and subsequently expanded in project FIS/2001/079 in 2002. RITF also maintains the observer program established by project FIS/2002/074. In addition, in recent years, RITF scientists have also done fisheries surveys in 16 other locations for domestic fleets (purse seine, and handline/troll-line) operating within the Indian Ocean statistical area;

- Masyarakat Dan Perikanan Indonesia (MDPI)

  MDPI, an NGO based in Bali, was initiated by the Fishing and Living initiative of company ANOVA Seafoods. It established and maintains a port-based monitoring program that has expanded to 10 locations in Nusa Tenggara Timur, Ambon, and Maluku. Their initial focus was hand-line/troll-line fisheries but they have now expanded to include pole and line, and they are working closely with the industry association, Asosiasi Pole and Line dan Handline Indonesia (AP2HI). MDPI have been proactive in assisting in the Harvest Strategy development process, with key inputs in organisation of the Harvest Strategy workshops and providing support funding for technical expertise;

- Sustainable Fisheries Partnership (SFP)

Sustainable Fisheries Partnership, in common with MDPI, have established port-based monitoring in eastern Indonesia. Their primary focus is improving the knowledge on the fishing operations and landings by the artisanal/small scale tuna fisheries. Their most recent research includes fitting small scale fishing vessels with spot-trackers, to access fishing vessel behaviours.

Appendix 2: Summary report of enumeration and samples collection for ACIAR FIS-2016-166 Harvest strategies for Indonesian tropical tuna fisheries to increase sustainable benefits.

15th August 2023

Report Authors

IGNATIUS TRI HARGIYANTO, HETY HARTATY, PRATIWI LESTASI

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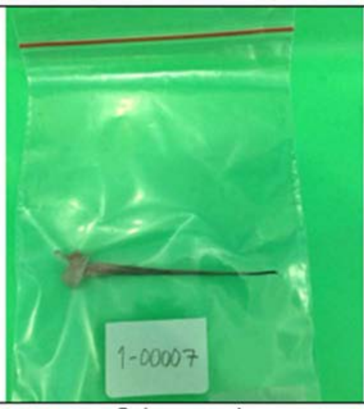
Palabuhanratu

Tuna fisheries in Palabuhanratu are mainly supplied by troll line/hand line. All troll line gears were using FADs during their fishing operations. There was only one tuna longline company (PT. Surya Agung Putrajaya) in Palabuhanratu. Only one vessel operated by this company since early 2019. Tuna (yellowfin and bigeye) and neritic tuna are the most important catches for fishermen operating out of Palabuhanratu waters. The size of tuna fishing vessels in Palabuhanratu is mostly less than 10 GT. All troll line/hand line vessels in the 5-10 GT size class using in-board power. The sampling activity included samples from both Palabuhanratu and Binuangeun. In general, it can be concluded that the tuna fishery in

Binuangeun originates from troll line/hand line vessels, and the fishing grounds of the troll line/hand line vessels are still in the FMA 573 area.

Hands-on training on how to collect and store samples has been provided to all the enumerators. Two designated enumerators in Palabuhanratu are Mr. Sepi Mahardika and Mr. Aris Sugiral, but mostly they worked in a team (Palabuhanratu Fishing Port staff), especially for collecting data and fish sampling. In the 3rd round of field surveys (December 2019), the enumerators are increasingly skilled at collecting biology samples (gonad, spine, and otolith) from any species (*Thunnus* spp and *Katsuwonus* sp) at any size.

Documentation of sample collection

	
YFT No. 1-00249 (90.0 cm; 14.3 Kg; Male)	Spine sample
	
Female Gonad (SKJ No. 1-00164; 61.5 cm; 5.3 kg)	Hydrated eggs (SKJ No. 1-00164; 61.5 cm; 5.3 kg)
	
Sample collection by PPN Palabuhanratu staff (Aris Sugiral)	Sample collection by PPN Palabuhanratu staff (Sepi mahardika)

Kendari

Kendari is one of the largest cities producing tuna resources in the central part of Indonesia. There are two tuna landing ports in Kendari, namely PPS Kendari and PPP Sodohoa. Tuna resources are caught using several fishing gears, including purse seine, handline/trolline and pole and line. All tuna landings are from Indonesian archipelagic waters, including FMA 713, 714, and 715, but most are from Banda Sea waters. The pole and line fishery lands its catch at Umbele Island every day and is transferred using a carrier ship to Kendari port every few days.

Biological sampling activities for skipjack, yellowfin, and bigeye tuna have been carried out since September 2019. Samples of tuna came from PPS Kendari, PPP Sodohoa, and Sodohoa Fish Market. HL fishing gear caught large tuna; PS and PL fishing gear and carrier vessels obtained a lot of small tuna resources. Since the beginning of the sampling, two enumerators, Ismail Agung Syah and Ahmad Rizal (who both have experience as enumerators in previous ACIAR projects), have been recruited to be trained and involved in sampling. Sampling was based on the sampling protocol that had been produced. The sampling process and enumerator training were carried out in stages over a period of 5 months (September 2019–January 2020). Researchers from the Centre for Fisheries Research carried out sampling tasks in the early stages. However, in the last two months, enumerators have already developed expertise in collecting samples, and researchers only provide supervision and assistance.

M Taufik and Ignatius Hargyatno (Reseacher CFR) train the enumerators

Ismail Agung and Ahmad Rizal (enumerators) taking gonad sample

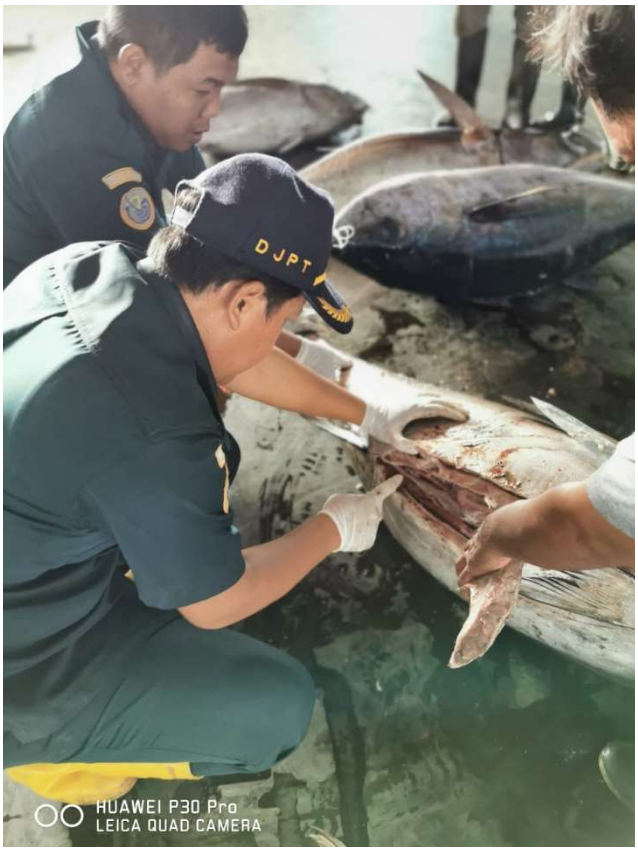
Gonad and otolith sample from Kendari

Cilacap

Based on the coordination meeting held on June 6, 2020, it was found that the samples from PPN Palabuhanratu could not cover the large fish of yellowfin and big eye tuna (>10 kg), so it was decided to carry out sampling activities at PPS Cilacap. PPS Cilacap is one of the fish landing centres for the southern region of Java and southeast Nusa Tenggara. The 2019 PPS Cilacap Annual Report shows that the leading products landed by fishing vessels are tuna (yellowfin and bigeye) and skipjack. The large bigeye and yellowfin tuna were caught by handline and longline fishing gear from Indian Ocean waters.

Sampling activities at PPS Cilacap began in August 2020. A total of three PPS Cilacap staff (Agung F. Nugroho, Moh. Iqbalsyah, and Taufik Hidayat) have attended training and practiced sampling tuna (yellowfin tuna and bigeye tuna) in accordance with the research objectives. The training included methods and techniques for obtaining fish samples, fish surgery to obtain biological samples (gonads, dorsal fin bones, otoliths and tissue), sample handling processes in accordance with standard procedures, as well as training in recording each sample collected.

Ignatius (researcher) conducting sampling training to enumerators (Agung and Taufik) at PPS Cilacap.



Taufik and Iqbal conducting gonad sampling activities at PPS Cilacap

Tuna landed in PPS Cilacap. Otolith, gonad and spine sample from Cilacap

Bitung

Bitung Ocean Fishing Port (PPS Bitung) is one of the government ports that provides unloading facilities for fishing vessels. This port will be busy in the morning from 05:00 to 09:00 due to the activities of unloading from mini purse seine vessels and the small holding vessels, which are obtained from large pelagic hand line vessels and demersal fish from small islands near Bitung. Aside from small vessels, there are also large vessels (>30 GT) that land their catch in Bitung, but they land it immediately in the warehouse or port of their fish company. PPS Bitung's purse seine fishing vessels captures fish in three fisheries management areas (FMA); FMA 715, 716, and 717. Large pelagic fish such as yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*) and skipjack tuna (*Katsuwonus pelamis*) dominate the catch. PPS Bitung's purse seine fishing vessels are both traditional and semi-modern in scale. The average ship is 98 - 162 GT. In addition to purseine vessels, handline and longline vessels are used to catch large pelagic fish in Bitung.

Data was collected in Bitung from September 2019 to December 2021 using length stratified sampling, which entails selecting and purchasing fish species with a preset size distribution of fork lengths and numbers. Skipjack tuna, yellowfin tuna, and bigeye tuna were among the fish sampled. Skipjack tuna has a target fork length distribution of 5 cmFL, while yellowfin and bigeye tuna have a distribution of 10 cmFL. The research samples collected were fairly diverse, including the fish's spine (first dorsal fin), genetics, gonads, and otoliths. Sampling was carried out by enumerators; Johndris, Rafli, and Gunawan, who had been recruited and trained previously and were accompanied by researchers from CFR, RIMF, and RITF. The collection and storage of samples were carried out as a team by staff from the research installation for large pelagic fish resources in Bitung, led by Adi Kuswoyo according to sampling protocol.

	
Researchers from CFR, RIMF and RITF with a fishermen when sampling collection, Bitung (2019)	Mr. Anung Widodo from CFR
	
Mr. Johndris enumerator of Bitung	Team Enumerator of Bitung
	
Ms. Pratiwi Lestari from RIMF and Mr. Irwan Jatmiko from RITF	Team Enumerator of Bitung taking otolith sample
	
Sample fresh gonad and spine for frozen storage	Sample gonad in Formalin

Biology samples recent status

All samples from four locations (Palabuhanratu, Kendari, Cilacap, and Bitung) are collected and stored in each location (Table 1). Since the last survey trip (Juni 2023), the preserved ovary (formalin) has already been sent to KKI Gondol, Bali (except Palabuhanratu). Samples from Kendari (frozen ovary, otolith, and spine) and Bitung (otolith and spine) have already been sent to BRIN Laboratory in Ancol, Jakarta.

Table 1. Number of samples collected and location 31 August 2023

No.	Port Name	Fish Count	Ovary formalin	location	Ovary frozen	location	Otolith	location	Spine	location
1	PPN Palabuhanratu	1628	231	PPN Palabuhanratu	158	PPN Palabuhanratu	1347	PPN Palabuhanratu	1349	PPN Palabuhanratu
					39	RITF Lab	274	Denpasar	274	RITF Lab
2	PPS Bitung	3289	557	Gondol Lab	466	PPS Bitung	2642	Laterio Lab Ancol	2347	Laterio Lab Ancol
					61	RITF Lab	594	Denpasar	542	RITF Lab
3	PPS Cilacap	547	211	Gondol Lab	210	PPS Cilacap	532	Laterio Lab Ancol	546	Laterio Lab Ancol
4	PPS Kendari	2388	442	Gobdol Lab	179	Laterio Lab Ancol	1833	Laterio Lab Ancol	1879	Laterio Lab Ancol
					61	RITF Lab	489	Denpasar	502	RITF Lab
Total		**7852**	**1441**		**1174**		**7711**		**7439**	

11.2 Appendix 3: Sampling protocol for population biology

KEMENTERIAN KELAUTAN DAN PERIKANAN

BRIN
NATIONAL RESEARCH AND INNOVATION AGENCY

CSIRO

ACIAR Project FIS/2016/116

SAMPLING PROTOCOL FOR POPULATION BIOLOGY STUDY

Australian Government

Australian Centre for International Agricultural Research

Contents

1. Introduction

In 2017, CSIRO Oceans and Atmosphere (Australia) in collaboration with Centre for Fisheries Research (Indonesia) commenced a 4-year collaborative project on tropical tuna the Indonesian waters. The project, *“Harvest Strategies for Indonesian tropical tuna fisheries to increase sustainable benefits”*, is funded by the Australian Centre for International Agricultural Research (ACIAR) and CSIRO. The overall objective of the project is to enable Indonesian fisheries scientists, industry and managers to improve the understanding of tuna population biology and the effectiveness of monitoring and management systems for Indonesian tuna fisheries. One of the project aims is to determine the productivity of skipjack tuna (SKJ), yellowfin tuna (YFT)and bigeye tuna (BET) in Indonesia by estimating relevant life-history parameters (age, growth, reproduction). The purpose of this manual is to provide a standardized set of sample collection techniques for use by trained observers at sea and port sampling by project staff.

2. Sampling objectives and priorities

The three tuna species being investigated in this project are YFT, BET and SKJ. Biological sampling will be undertaken in three regions (east, central and west) across the Indonesian archipelago. Initial sampling will be undertaken in three ports; Palabuhanratu, Kendari and Bitung. Additional sampling locations will be confirmed after sampling is established, and may include Muara Padang/Bungus, Ambon, Banda Neira, Nabire, Sorong and Jayapura.

The primary objective of the sampling program is to obtain sufficient samples of each species, from each location, to enable statistically robust analysis of the population biology between the sampling regions. Samples to be collected will include ovaries, otoliths and fin spines. Sampling may be extended to muscle tissue at a later time.

The project will use a staged sampling approach:

In **Year 1**, 100 fish (sexes combined) of each species will be sampled each month in the three sampling regions.

In **Year 2**, 50 fish (females only) of each species will be sampled each month in the three sampling regions.

Priorities of the plan are:

1. **To standardise sampling techniques, to the extent possible**;
2. **To maximise the quality** of fish sampled, the quality of samples obtained, and the quality of the samples on arrival to the laboratory from the field;
3. **To collect the samples from all sampling regions, each month**;
4. **To provide comprehensive training to all samplers, before going into the field, so they are competent and confident in methods of identification of relevant tuna species and the standardised collection procedures.** This is central to the collection of high quality samples, building research capacity in the region and the success of the project.

3. Sampling strategy

Adequate sampling of the whole length range of fish is needed to obtain robust estimates of age, growth, spawning and maturity parameters. Deciding on a single sampling strategy is difficult as samples are required for estimating different parameters.

A random sampling approach provides accurate estimates of growth parameters, but it is logistically difficult to undertake unless a formal randomised strategy is followed. Random sampling may also results in some (important) length classes being underrepresented such as large fish for estimating longevity and spawning parameters, or middle-sized fish for estimating maturity parameters. Length-stratified sampling is often recommended for developing age-length-keys but it can cause biases in estimates of mean length-at-age unless measures are taken to correct for any bias.

In this project, **an adaptive combination** of random and length stratified sampling will be used. This approach follows an initial period of random sampling each month, followed by a length stratified approach to “fill in” gaps in the sampling for length classes not adequately sampled. **It is important** that the type of sampling used (random or length stratified) is recorded on the data sheet for each sampling period (see Appendix II).

A **running tally of the length classes** of fish selected for sampling throughout the month should be recorded to determine the size classes to target during the “stratified sampling” period. This may be possible through an online system. **Our length classes for each species is given in Table 1.**

Table 1. Length classes used for the running tally of samples each month.

BET (10-cm)	YFT (10-cm)	SKJ (5-cm)
20	20	20
30	30	25
40	40	30
50	50	35
60	60	40
70	70	45
80	80	50
90	90	55
100	100	60
110	110	65
120	120	70
130	130	75+
140	140	
150	150	
160	160	
170+	170+	

4. Importance of accurate data

You have been selected to collect samples for scientific studies, and you are responsible for following the manual, measuring the fish and collecting and storing good quality samples. It is important to know that the data you collect must be done so with maximum accuracy. The information (fish size, fishing date, latitude and longitude etc.) have to be recorded on the Sampling Data Sheets in the format specified. **Erroneous data can be worse than not collecting it at all, as it undermines the reliability of the results of the study**.

5. Protocol for obtaining the fish

5.1. Port sampling

Ideally, **prior arrangements** will have been made with fishers and/or fishing companies at each location, with assistance of local contacts, to maximise the likelihood of access to high quality fish, and remove the need to go through auction process, or *ad hoc* purchases. The best situation is where small fish are sorted by species at sea and placed into boxes or crates for ready access and purchase on arrival into port. However, we realise this is not always the case.

Sampling teams need to be able to hand-pick the fish wherever possible, to ensure best quality and specified size of fish.

The project has fixed budget to purchase the fish to ensure high quality samples. However, once the biological samples are taken the fish are no longer needed. Prior to sampling, discussions should be had with local fisheries authorities and/or port authorities to determine to whom the fish can be donated. In most cases, the easiest and most appropriate option is to donate the fish to local staff who have assisted in the organisation and/or execution of the sampling. Donating to local charity or community associations may be other options worth exploring. However, under no circumstances must the fish be sold as that would breach the project regulations.

Ideally the fish **will be obtained as early as possible in the day** to allow time for the biological sampling during remainder of the morning – afternoon.

As soon as possible after purchase, the fish should be placed in **crushed ice**, in polystyrene boxes (either borrowed or purchased at the fishing port), or placed into a cool-room (not freezer), if available at the port.

5.2. Sampling at sea by observers or vessel crew

An A4 size instruction sheet for crew and observers is still being drafted.

6. Tools for biological sampling

There are a number of tools that should be compiled into a 'tool kit' before commencing sampling.

Tool Kit

- **Printed Sample Data Sheets** (two sided) with clipboard;
- **Pencils/biro** (for filling in data sheet - pens that will not smudge when wet);
- **Printed colour copy of this sampling protocol;**
- **Gloves** – disposable latex gloves to fit;
- **Tape measure;**
- **New sharp knife** (old knifes can be pitted and could pose problems for ovary histology samples);
- **Sharp nosed tweezers (forceps);**
- **Scalpel with solid blade** (to assist in dissection);
- **Cordless drill and hole saw** (for drilling otoliths from large bigeye and yellowfin);
- **Hacksaw and spare blade(s)** (to use if "lifting the lid" to remove otoliths);
- **Sample labels**;
- **Zip lock bags** (for retained ovaries and otolith vials);
- **Vials** (for otoliths)**;**
- **Water (**clean water for cleaning tools);
- **Head-torch** (to aid work in dim light situations);
- **Cool box** (with ice, for cool storage of vials boxes and ovaries in zip lock bags);
- **10% neutral buffered formalin**
- **Vials (pots)** for gonad sub-samples
- **Electronic balance** to weigh gonads
- **Coloured 'flagging tape'** (for tying around tuna tails for 'tracking' to processing)

7. Facilities for biological sampling

For the benefit of you, as samplers, but also for achieving the best quality samples, it is important you establish a good base for your biological sampling after arrival at each sampling location. Ideally, the facility you use as your 'lab' will be located not too far from the fish landing place, e.g., in a space within the fishing port, or a facility provided by Port Authority or by a fishing company. Your lab could also be a space on board a fishing vessel, if you have a good relationship with the skipper who sold you the fish!

Your facility for biological sampling should include the following:

- Sufficient space for you to work comfortably, and sufficient space for the fish boxes and your sampling equipment;
- Ideally a table or bench to allow you to work on the fish without having to bend over;
- Sufficient light so you can see what you are doing;
- Sufficient shade and ventilation so you can breathe and don't get too hot!

- Ready access to clean water, for washing your knives, scalpels, tweezers, and for washing your hands.

8. Biological sampling procedures

The following is the recommended order of steps in your biological sampling. Keeping to this order is important for the standardisation of sampling across locations and across sampling teams.

8.1. Confirming species ID

It is critically **important that you confirm the species ID of every fish prior to the samples being taken from that fish**. A combination of characteristics should be checked to ensure correct identification, see Appendix I: Fish Identification. The condition of the fish and any relevant details on identification should be noted on the Sampling Data Sheet. To discriminate between YFT and BET it may be necessary to examine the fish internally as detailed in Appendix I. These tunas can be easily misidentified at small size, particularly if the fish have lost condition since capture and external markings have faded.

8.2. Sampling Data Sheet

The Sampling Data Sheet (see Appendix II) is your main system of recording. **Please use a new sheet for each new batch of fish that you sample**. For port samplers, a **"batch"** may be a sample of fish you have obtained from one vessel, or possibly a sample you have obtained from a vessel owner or fishing company and may be mixed catch from more than one vessel. On the reverse side of the sheet there is space to record more detailed information about the source of the fish in each batch. This information is very important, as it may help with understanding any differences that we see in the analyses, among and between samples. For on board observers, a **"batch"** may be a sample of fish you have obtained in one fishing operation. See Appendix II: Sampling Data Sheet for further details of filling out the data sheet.

8.3. Specimen number, vials and labels

Among all the information that you record on the Sampling Data Sheet, **the Samples and Numbers are the most important**. Errors in recording the specimen number can be a disaster for the project.

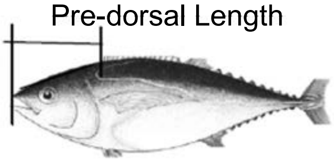
Otoliths will be collected in a labelled vial and placed in a 100-well cardboard box (see 8.6). Ovaries and fin spines will be collected and placed in separate zip lock bags and a label for the fish should be enclosed in the bag (see 8.6 and 8.8). Ovary subsamples will be placed in labelled vials (pots) filled with 10% buffered formalin (see 8.9).

8.4. Length measurement options

Measure the straight fork length (FL) of the fish to the **nearest lower half centimeter**, using a ruler or caliper and record on the Sampling Data Sheet. The FL measurement is taken from the tip of the lower jaw (tuna) to that most posterior edge of the tail curve which falls along the central body axis (see Table 2). The ruler should be taped down flat to whatever 'lab' bench you are using, and the fish measured on top of the ruler.

Where the fish is damaged, or only a portion of the fish is available to be measured, an alternative measurement may need to be taken. For tuna, pre-dorsal length is an option; straight distance from the tip of the upper jaw to the insertion of the first dorsal spine (see Table 2). The code for the measurement method used should be recorded on the Data Sampling Sheet – Length Code.

Table 1: Length measurement options for tunas (Source: Indian Ocean Tuna Commission).

Type	Description	Code
Fork Length 	Projected straight distance from the tip of the upper jaw to the shortest caudal ray (fork).	FL
Pre-dorsal Length 	Straight distance from the tip of the upper jaw to the insertion of the first dorsal spine.	LD1

8.5. Sampling otoliths for ageing

There are several ways otoliths can be removed from fish and the best way will be determined by the size of fish that you are working on. Removal of otoliths from small tunas may appear difficult to you at first, but once you have done a few fish, you will quickly develop the skill. The trick is learning the feel and even the sound of the otoliths as you reach down into the bone cavities with your tweezers. In most cases you will use these senses, rather than relying on seeing the otoliths, to remove them from the cavities in which they lie.

Two methods are outlined below:

Safety: When using a sharp knife or scalpel to remove otoliths, always remember to cut in the direction away from yourself and always be aware of where your hands and fingers are. If the knife slips during the cutting of fish's tissues and bone, you can sustain very serious injuries if you are cutting towards yourself or if one of your hands is in the way of the knife.

8.5.1. Lifting the lid technique (for small-sized tuna)

1. Lay the fish on its side on the plastic chopping board;
2. Using a large, sharp knife or hacksaw and taking great care not to cut yourself, make a vertical cut (dorsal – ventral) **at a point one eye-diameter distance from the posterior edge of the eye**, down to the level of an imaginary horizontal line across from the top of the eyes (Figure 1). It is critically important that this vertical cut is no closer to the eyes than the one eye-diameter distance**. If you cut too close, you will cut right through the otoliths**!;
3. Then make a second cut; an almost horizontal cut at the level of the top of the eyes, but with a slight angle down (no more than 10^o from horizontal) towards the tail, to intersect with your first cut (Figure 1). For first attempts, it is better not to cut too close from the supraorbital ridge, and to do successive small cuts then until the brain appears;

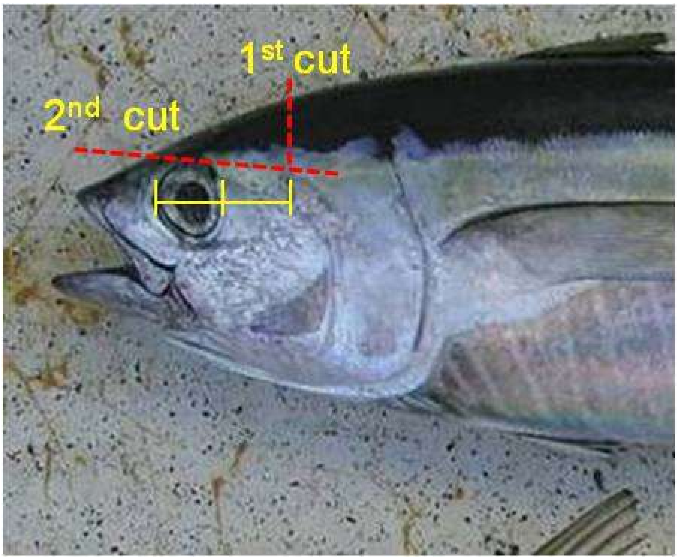


Figure 1: 'Lifting-the-lid' technique for removing otoliths. The first cut is made vertical, at one eye-diameter distance from rear margin of the eye. The second cut is almost horizontal at level of top of the eye.

4. You can now raise the top of the head, exposing the brain. This is called by some fisheries scientists the **"lifting-the-lid" technique of otolith removal** (Figure 2);

5. Carefully move aside the brain tissue with stainless steel tweezers provided, from the posterior area of the brain region. Do not discard the brain tissue, just in case you inadvertently entrap an otolith among that tissue while moving it. You may need to go through it later if you can't locate one or both of the otoliths!; **It is very important to work carefully because the otolith can easily be damaged at this stage;**

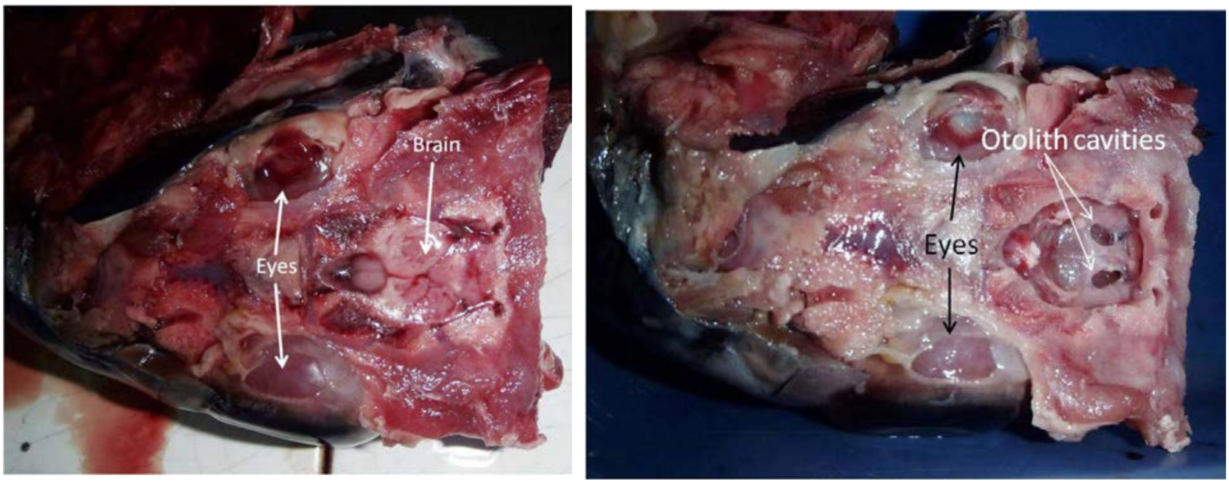
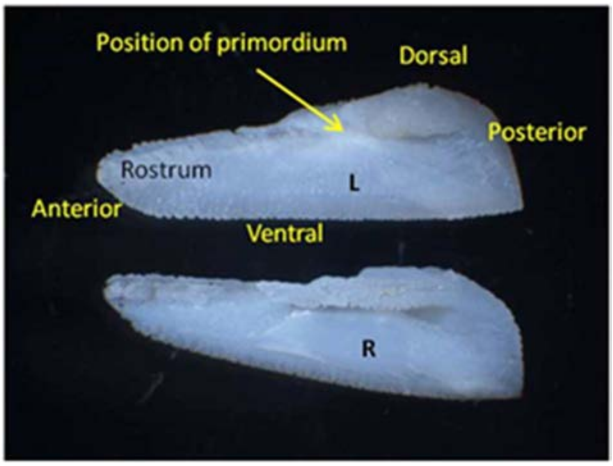


Figure 2: **Left** – The 'lid' lifted to expose the brain. **Right** – The brain tissue removed to expose the bone cavities in which the otoliths lie.

6. Using the fine pointed stainless steel tweezers gently look into the canals. The posterior end of the otolith is the most fragile (
7. Figure 3). Use small forceps to **CAREFULLY** extract the otolith from the bony capsules. As mentioned above, you can feel and sometimes hear the otolith against



the points of the tweezers;

Figure 3: Left (L) and right (R) sagittal otoliths from a southern bluefin tuna. The otoliths from other small tunas are of a very similar shape to these and the rostrums (the anterior, 'pointed' projections, in otoliths of small tunas are delicate and easily broken).

8.5.2. Drilling otoliths (if "lifting the lid" cannot be used)

A technique has been developed to remove otoliths from tuna which does not effecting the external condition or quality of the fish. The method uses a cordless electric drill and hole-saw to remove a core of material from the region around the brain containing the otoliths. This leaves the fish essentially intact, except for the core hole. We have found a 38mm hole-saw to be adequate for coring small fish (<120cm fork length) but a 44mm hole-saw is sometimes preferable for larger fish (

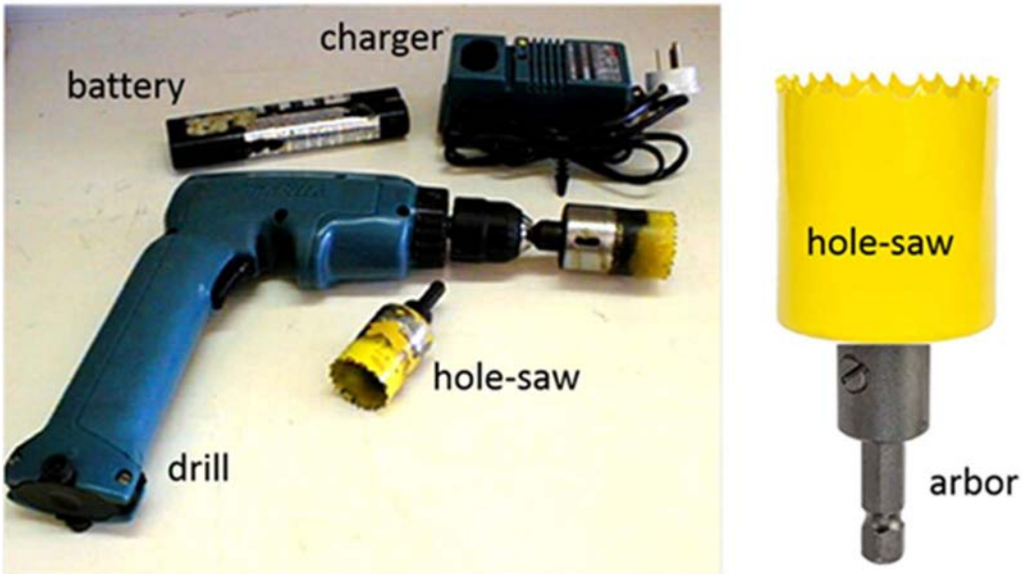


Figure 4). Sampling takes only 1-2 minutes per fish.

1. Lay the fish on its back and make sure all gill-filaments and surrounding tissue is removed as the core sample is drilled from inside the gill cavity. If you are removing otoliths from a head that has already been severed in processing, you will need to brace the head to stop it moving during drilling;
2.  h are visible /ertebra (
3. Figure 5). The location of the plates is one eye-diameter measurement behind the level of the eye. Sometimes residual tissue may obscure the plates; this should be scraped away with a knife or with the hole-saw itself prior to drilling. The line of coring is through the plate, with the drill initially directed slightly down and forward (i.e. on an angle roughly towards the eye on the opposite side of the head). Drill in as far as the hole-saw will allow. This may require the drill to be moved in/out a little so that it does not get jammed. Then remove the drill and switch to the other side. Drill onto the opposite basioccipital plate so that the two drill cuts intersect. This will usually detach the core from the surrounding bones. With practice and experience, you may find you can achieve the core by drilling from one side only;

4. Some force may be required to free the core. Care must be taken at this point not to break the vertebral column as this can reduce the market price of the fish. If lucky, the core will come out still inside the hole-saw and can be easily pushed out with a pair of tweezers. If the core does not come out of the fish easily, use your fingers to push it out. Occasionally, the core may break into a few pieces, but the otoliths are often still present and intact;
5. Remove the otoliths carefully with tweezers from the cavities. Initially, it may take some time to familiarise yourself with the orientation of the core and the location of the cavities. Look for the brain cavity and the semi-circular canals. To reduce sampling time, the core can be placed in a labelled bag and the otoliths removed at a later time. However, it is recommended that you try and find the otoliths in the first 10-20 cores and adjust your drilling angle if you are unsuccessful.

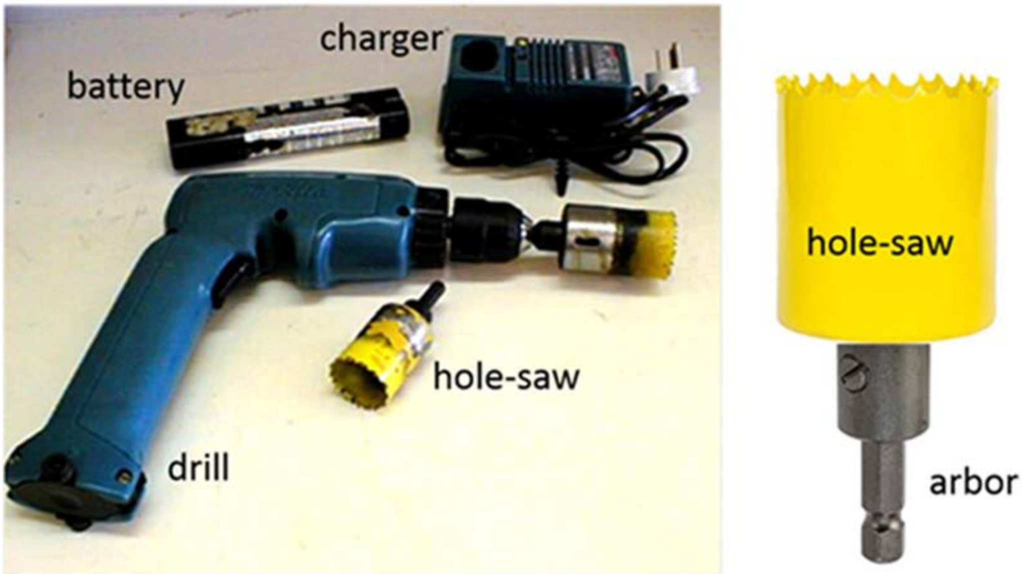


Figure 4. Cordless drill and hole saws used to remove otoliths.

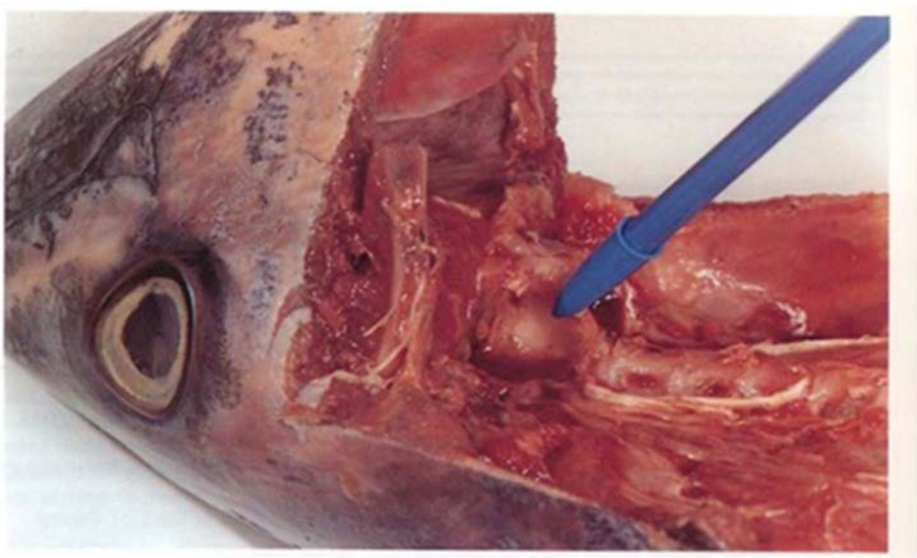


Figure 5. Cut-away tuna head to show position of the basioccipital plate (anterior to junction of spinal column to head).

8.6. Cleaning, labelling and storing otoliths

There are several steps to cleaning and storing the otoliths, and given that we may wish to do analyses of **otolith chemistry** in addition to analyses for ageing, it is important to use clean gloves and clean water (e.g. bottled “Aqua”) to reduce risks of contamination:

1. Being careful not to crush the otolith; gently grasp the otolith with the tweezers and raise it from the fish;
2. Place the first otolith onto a dark surface so it is safe while you extract the second otolith. The dark surface will make it easier to see and reduce risk of you losing it;
3. You need to carefully remove any adhering tissue, blood and other fluids from around the otoliths. Using a combination of the tweezers and your (gloved) fingers, very gently clean all the adhering membrane tissue and fluids (including blood) from around the otoliths. This needs to be done as soon as possible after extraction as the membrane is harder to remove after it has dried. Using a clean tissue and water squeeze bottle will also help to remove the tissue and fluid, and/or placing the otoliths into a petri dish with clean water and cleaning with forceps;
4. The otoliths from these small tunas are very fragile (especially those from small SKJ) and it is likely that, even with care, you will unavoidably break some of the otoliths during removal from the fish or through cleaning. In most cases, **we can still use these broken otoliths, so retain all the pieces**;
5. Once the otoliths are clean (they should be white), place them into a vial with a label, Then place the vial into the cardboard storage box (capacity 100 vials);
6. Ideally the capsules should be left open for 8 – 12 hours in a safe place (watch out for ants!) to allow the otoliths to fully air-dry. Closing the vial when the otolith is still moist is likely to result in mould growth on the otolith.

Important note: the otolith is very fragile. For this reason it is important to avoid unnecessary manipulation of the otolith and extreme care during otolith manipulation should be practiced in these initial stages.

8.7. Sampling fin spines for ageing – all SKJ and small BET and small YFT

The first spine of the first dorsal fin is removed whole from the base. Using a knife, cut the membrane joining the 1st and 2nd rays of the first dorsal fin (See Figure 6). Push the spine gradually forwards until the ligament breaks. Twist the spine from one side to the other alternately until it comes loose and pull it in order to extract it entirely, taking care not to break it at the base. Place the spine in a zip lock bag with as label for the fish, and keep cool until it can be cleaned and dried, or frozen.

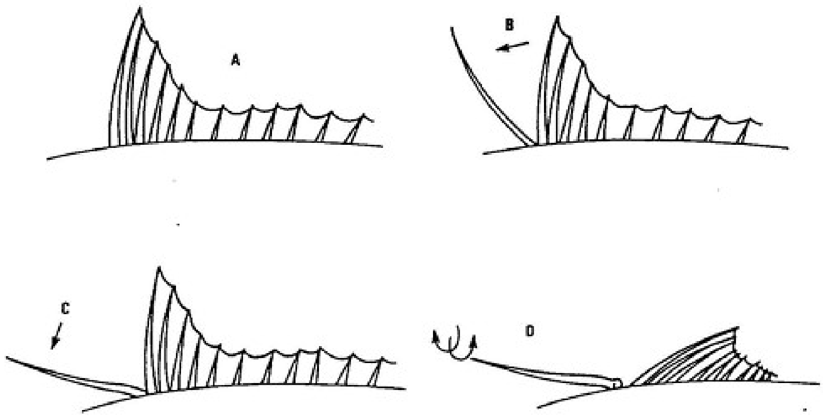


Figure 6: Technique for extracting the first spine of the first dorsal fin (from Ortiz de Zárate et. al, 2007).

Spines can be stored at -20°C until you are ready to clean them. To clean, place the spine in a container with warm to hot (not boiling) water for a few minutes. The excess tissue can be removed with tweezers and a soft toothbrush, without damaging the surface of the spine. Wash the spine and leave to dry completely. Store in a labelled paper bag (rather than a plastic bag as mould may grow if it is still slightly wet).

8.8. Removing gonads and sexing fish

To determine the sex of fish visual examination of the gonad (pair) is necessary. For whole fish you have bought, the best way to remove the gonads will be to make a shallow (approx. 1-2 cm) cut with a knife along the midline of the underbelly of the fish. Start approximately midway along the ventral surface of the fish and cut all the way to the vent. The gonads can be found near the small intestine towards the posterior dorsal wall of the body cavity (just below the fish's backbone) (Figure 7). With a knife cut the connective tissue to separate the gonad from the intestine. **Remove the entire gonad** by pulling it away from the dorsal wall of the body cavity (using your knife if needed) and cut the end of the gonad away from the vent. In some cases, the gonads will be removed along with other internal organs by the fishing vessel crew. However, the gonads may remain in the gut cavity and will need to be removed by hand.

To determine the sex and assess the visual (macroscopic) maturity status from the gonads, refer to Appendix III: Macroscopic identification of female and male gonads. Males and females have paired gonads. Ovaries in females are generally pinkish-orange in colour and have a circular cross-section with a lumen (hole) in the centre. Testes in males are firm, white/grey in colour and have a triangular cross-section.

If both gonads have been obtained, carefully cut away any fat attached to the gonads (may not be present) and weigh to the nearest gram. Record the weight of the gonads on the Sampling Data Sheet. Do not weigh the gonads if they are not complete (two whole lobes).

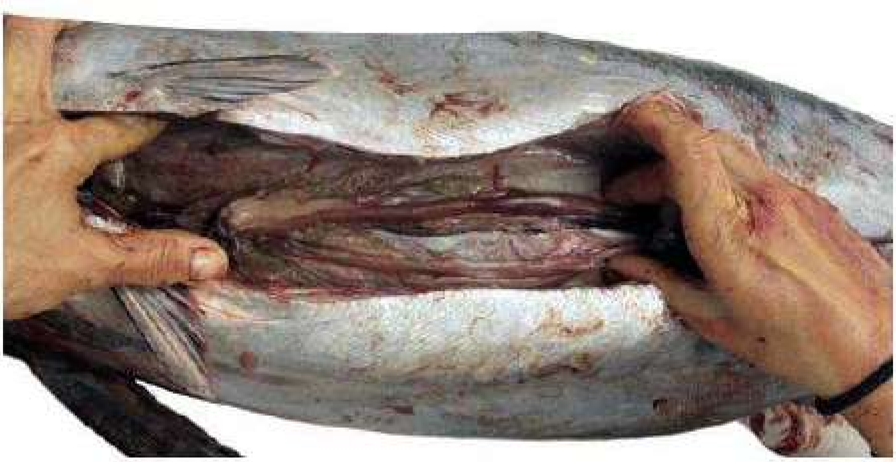


Figure 7: The gonads will be along the dorsal wall of the body cavity, near the fish's backbone. (Source: SPC sampling instruction).

8.9. Sub-sampling, labelling and storing ovary samples

Once the sex of the fish has been identified, the gonads from female fish (the ovaries) must to be subsampled for histological analysis. Using a clean sharp knife, carefully cut a 1.0 cm wide cross section from the middle of the larger ovary lobe (Figure 8). Place the subsample in a pre-filled and labelled vial of 10% formalin. If the cross section is too large to fit into the vial, a smaller sample can be taken from the cross section. Ensure that at least one or more lamellae are collected (Figure 8) from the ovary wall to the lumen.

It is important that all ovaries classed as ripe (stage 4 females, Appendix III) are retained for further analysis in the laboratory (i.e., to estimate batch fecundity). A ovary classed as ripe contains large translucent hydrated oocytes that are easily dislodged from the ovary material or are loose in lumen of ovary. Place ripe ovaries in a plastic bag with a label for the fish and freeze. If you are unsure if an ovary is ripe, freeze the ovary until histological analysis has determined whether it is suitable for fecundity analysis.

The gonads from male fish (the testes) can be disposed of. If you are unsure of the sex of the fish, take a subsample and retain the gonads following the procedure above.

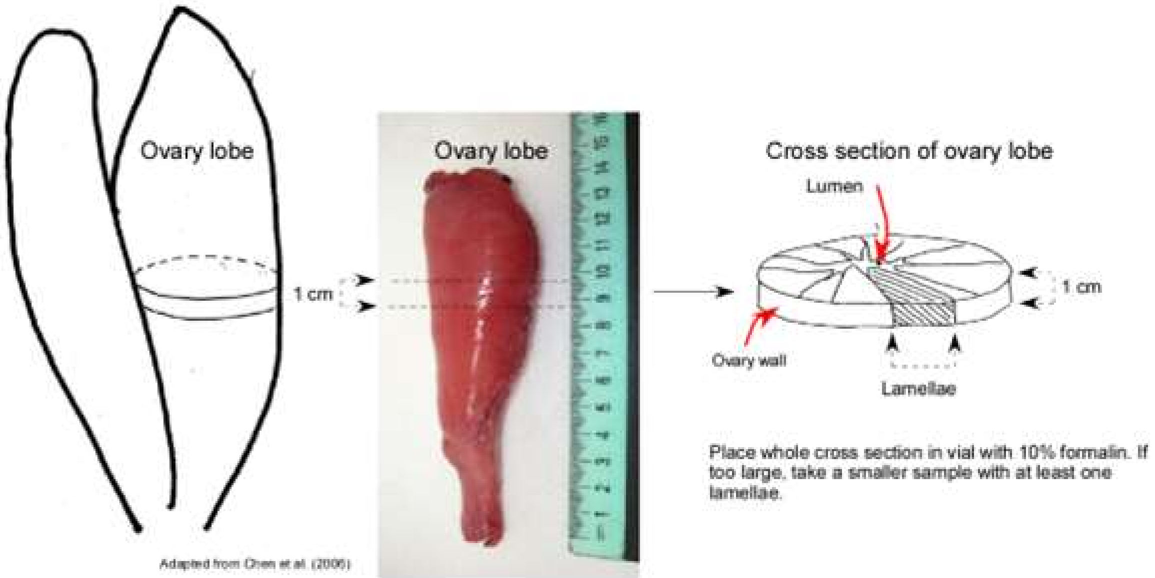


Figure 8. Ovary lobe with cross-section to be sampled indicated.

8.10. Sampling muscle tissue for genetics

Sampling of muscle tissue for genetics analyses is planned for this project, **but will not be done in the initial start-up of sampling.**

The highest priority when taking a sample for genetics analyses is to **ensure there is no cross-contamination between samples and to take the sample as close as possible to the fish death to avoid DNA degradation**. Remember to use ethanol for cleaning all instruments (or clean water if ethanol is not accessible). Rinse all tools in water before and between fish and use a tissue to wipe thoroughly and remove any tissue residue or blood from the blade. Repeat wiping with a second clean tissue.

The following is the recommended procedure (Figure 9):

1. Lay fish out on flat on chopping board. You will need a new (to avoid potential contamination in "pits" in corroded metal) large sharp knife, and ruler.

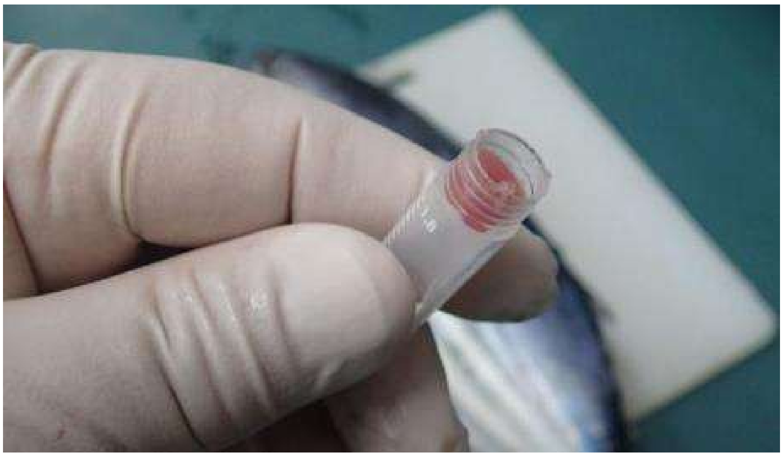
2. Clean one side of the fish using fresh tissues moistened with clean water to remove any blood and/or mucous on the skin.

3. Using a good sharp knife, make an incision on the cleaned side of the fish. This can be done in alternative locations on the fish where there is muscle, e.g. posterior of the head;

4. Take a slice of tissue that is about 1.5-2.5cm wide and **no more than 5mm thick** (3mm is thick enough);

5. Transfer the muscle tissue sample direct **to the pre-numbered vial (these can be pre-filled with RNAlater buffer or buffer added at time of sampling)**, again ensuring there is no contamination from your fingers at the mouth of the vial or on the inside of the vial lid. Push onto tube;

6. Trim away excess so a disc of tissue remains;



7. Push the disc of muscle tissue to the base of the vial using a clean, blunt instrument so that it is immersed in buffer and close tube;

Figure 9: Protocol for sampling muscle tissue for genetic analysis

8. With a dropper pipette, top up the vial with **RNAlater buffer** (see

9. Appendix IV: RNAlater-like buffer preparation) but leave an air gap of about 5mm at the top so the buffer does not overflow. To avoid any chance of cross-contamination, ensure that the end of the pipette does not make contact with the muscle sample.
10. Seal the vial and write down the number on the lid of the tube in the "Genetics Vial Number" column on your Sampling Data Sheet.
11. Place the sample vial onto ice in a closed container (e.g. small cool-box or polystyrene box).
12. At the end of the sampling session, the samples should be transferred to the Sample Vial Box. And the number range of samples recorded in permanent pen on the lid.
13. After the samples have been transferred to the Sample vial boxes, the boxes, with lids securely closed, should be placed on ice. **The samples need to be kept cool, at < 4ºC, for at least the first 24hrs.** After this time the samples can be transported at room temperature. For longer term storage, the samples should be stored in a refrigerator at 4 – 8ºC.

9. Reporting

At the end of each month, write a short report describing the samples collected and any difficulties you encountered such as difficulty obtaining fish or obtaining certain samples.

10. Transporting and delivery of samples

During sampling trips, the samples must be stored in conditions that ensure they are not damaged by either the movements of the vessel or during transport to the laboratory. Once sampling is complete, all samples together with the Sample Data Sheets must be delivered to the sampling coordinator of the area. If the sampling coordinator cannot be met in-person, contact him/her to organize the shipping of the samples. Further details to follow re data entry.

The following are important recommendations for the transport of your frozen samples (i.e. samples collected for vertebrae analyses):

- If the cool-box is at room-temperature, it must be cooled before the samples are placed inside for transport. This can be done by cooling with crushed-ice or by placing the cool-box into a freezer room or cool-room (e.g. the type used by fish processing company) for at least 30 minutes;
- The samples should be packed into the cool-box, surrounded by 'blue-ice' blocks which have been pre-frozen;
- All remaining space in the cool-box, between the samples and the blue-ice can be filled with balls of newspaper. These balls should also be pre-cooled;
- The lid of the cool-box should then be taped shut to prevent accidental opening during transport;

- Ideally, the cool-box should not be opened until the samples have been delivered to their destination and are ready to be transferred to another freezer.

Appendix I: Fish Identification

Tuna and Tuna-like Species Identification

BIGEYE TUNA (*Thunnus obesus)* BET

1. Pectoral fin thin, flexible and pointed at tip reaching in line with second dorsal fin (and beyond second dorsal fin in specimens > 50 cm;
2. Irregular, vertical, widely spaced white/silver lines or marks. Some rows of dots but few and irregular;
3. Flat tail fork, with less distinct notch compared to yellowfin tuna (YFT);
4. Body deep and rounded, greater depth versus fork length ratio compared to YFT;
5. Body outline rounded, forming smooth arc snout to tail, top and bottom;
6. Larger eye diameter compared to YFT of same fork length;
7. Greater head length to total length ratio than for YFT.

Figure 10: Bigeye tuna[2]. Fish of approximately 45cm FL.

[2] *Photo: from White et al (2013) Market fishes of Indonesia, adapted from Itano, D. (2004) Handbook for the identification of yellowfin and bigeye tunas in fresh condition. SCTB Working Paper, FTWG-INF-5.*

YELLOWFIN TUNA (*Thunnus albacares)* YFT

1. Pectoral fin thicker and stiffer (than for BET) and rounded at tip (in juveniles). Just reaching start of second dorsal fin;
2. Closely spaced white/silver lines, alternated with rows of dots extending to below pectoral fin. Lines in 'chevron' like pattern that extends from tail to posterior margin of head;
3. Notch on tail fork more pronounced than for BET;
4. Body elongate, narrower in breadth and more torpedo-like than BET;
5. Body outline straight, between second dorsal fin and caudal fin on top and between anal fin and caudal fin underneath;
6. Smaller eye diameter compared to BET of same fork length;
7. Shorter head length to total length ratio than for BET.

Figure 11: Yellowfin tuna [3] Fish of approximately 45cm FL.

[3] *Photo modified from Itano, D. (2004) Handbook for the identification of yellowfin and bigeye tunas in fresh condition. SCTB Working Paper, FTWG-INF-5.*

Comparison of small YFT and BET in fresh condition

Figure 12: [4]: YFT and BET, of approximately 35 – 38cm FL, in fresh condition.

Comparative diagnostic features (by number) as shown in Figure 12 and Figure 13:

1. **Relative larger size of eyes in BET, compared to those in YFT;**
2. **Longer pectoral fins in BET, reaching to second dorsal fin;**
3. **More closely spaced vertical lines on YFT with dots in 'chevron' pattern. Broadly spaced and less regular lines in BET;**
4. **More rounded, broader body shape in BET. YFT more narrower in body and torpedo-like;**
5. **Longer head (to base of pectoral fin) in BET, relative to total body length;**
6. **More pronounced notch at centre of caudal fork in YFT.**

[4] *Photo modified from Itano, D. (2004) Handbook for the identification of yellowfin and bigeye tunas in fresh condition. SCTB Working Paper, FTWG-INF-5.*

Comparison of small YFT and BET in less-than-fresh condition

Figure 13: [5] **YFT and BET, of approximately 40 – 45cm FL, in less-than-fresh condition.**

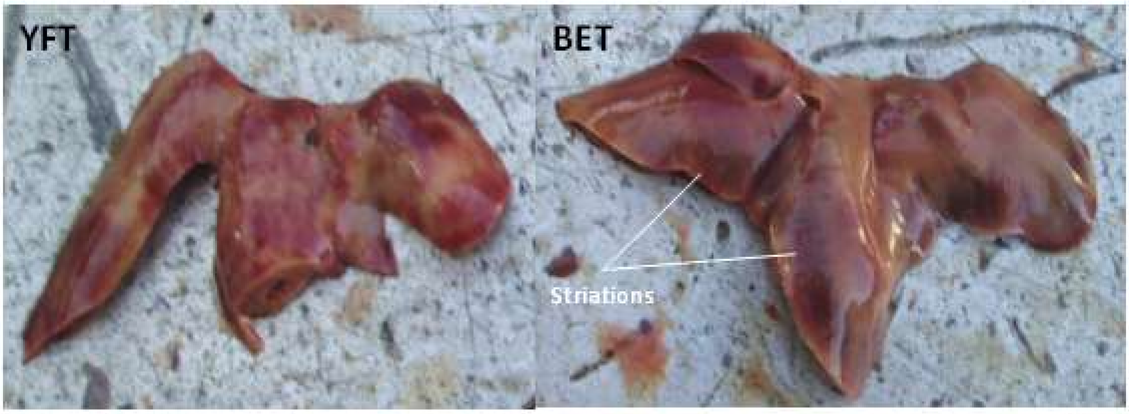
Comparative diagnostic features (by number) as shown in Figure 12 and Figure 13 (repeated from previous page):

1. **Relative larger size of eyes in BET, compared to those in YFT;**
2. **Longer pectoral fins in BET, reaching to second dorsal fin;**
3. **More closely spaced vertical lines on YFT with dots in 'chevron' pattern. Broadly spaced and less regular lines in BET;**
4. **More rounded, broader body shape in BET. YFT more narrower in body and torpedo-like;**
5. **Longer head (to base of pectoral fin) in BET, relative to total body length;**
6. **More pronounced notch at centre of caudal fork in YFT.**

[5] *Fukofuka, S. and Itano, D. (2005) Handbook for the identification of yellowfin and bigeye tunas in fresh, but less than ideal condition. Submitted to Scientific Committee Meeting of Western and Central Pacific Fisheries Commission, 8 – 19 August 2005, FT IP-1.*

Internal characteristics of yellowfin tuna and bigeye tuna

When external markings have diminished through time and or storage it may be necessary to identify these species by internal characteristics – the liver and swim bladder.



- Right lobe longer and thinner than rounded central and left lobes;
- Lobes of liver smooth, no striations.

- Three lobes with central lobe slightly bigger;
- Ventral surface of liver striated.

YFT
- Only in anterior half of body cavity;
- Inconspicuous, usually deflated or slightly inflated.

BET
- Occupies almost entire body cavity;
- Large, conspicuous, often inflated.

Figure 14: Identification of yellowfin and bigeye tuna using internal characteristics (~43cm fish)[6]

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[6] *Fukofuka, S. and Itano, D. (2005) Handbook for the identification of yellowfin and bigeye tunas in fresh, but less than ideal condition. Submitted to Scientific Committee Meeting of Western and Central Pacific Fisheries Commission, 8 – 19 August 2005, FT IP-1.*

Note: In cases where the swim-bladder is fully or partially deflated, it is still possible to see the swim-bladder tissue and determine its length relative to the body cavity.

SKIPJACK TUNA (*Katsuwonus pelamis)* SKJ

1. Distinguished from other tuna by 4 to 6 prominent dark longitudinal lines on belly;
2. Pectoral and ventral fins short;
3. Prominent caudal keel.

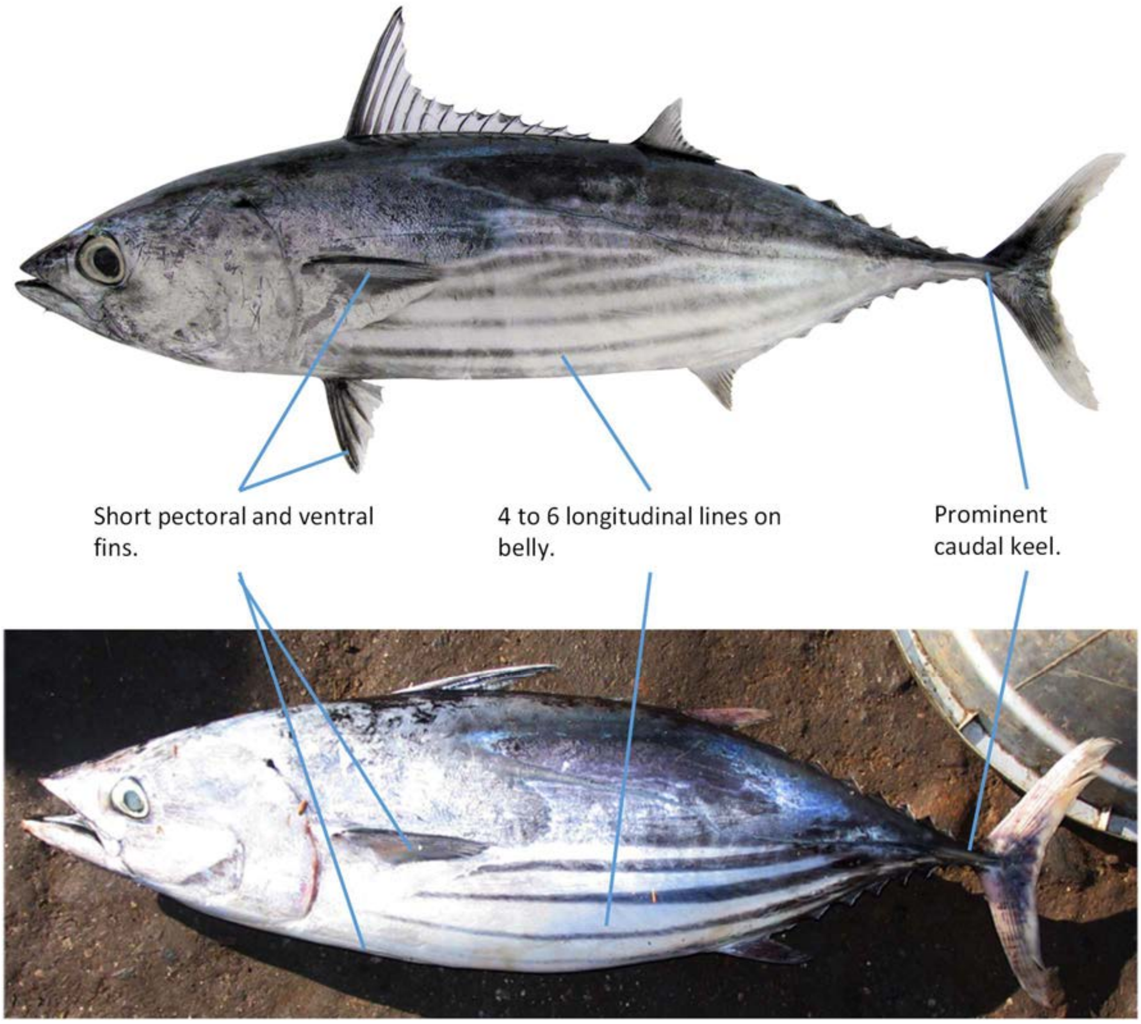

Figure 15: Skipjack tuna identification[7] [8]

[7] *Photo top: from White et al (2013) Market fishes of Indonesia*

[8] *Photo bottom: by W. White*

Appendix II: Sampling Data Sheet

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PUSRISKAN ACIAR Project FIS/2016/116 — **TUNA BIOLOGICAL SAMPLING FORM**

Sampling date: ____ /_____ /_______	Landing date: ____ /_____ /_______	Port:
Sampler:	Recorder:	Source of Fish:
Vessel Name / ID:	Skipper / fishing master:	Vessel type:
Catch location: (map on reverse)	Sampling strategy: Random: ☐ Length stratified: ☐	

	Sample no.	Species Code	Gear type	Length (cm)	Measure-ment type	Weight (kg)	Sex	Gonad weight (g)	Visual gonad stage	Ovary in formalin	Ovary frozen	Left otolith	Right otolith	Spine
1										☐	☐	☐	☐	☐
2										☐	☐	☐	☐	☐
3										☐	☐	☐	☐	☐
4										☐	☐	☐	☐	☐
5										☐	☐	☐	☐	☐
6										☐	☐	☐	☐	☐
7										☐	☐	☐	☐	☐
8										☐	☐	☐	☐	☐
9										☐	☐	☐	☐	☐
10										☐	☐	☐	☐	☐
11										☐	☐	☐	☐	☐
12										☐	☐	☐	☐	☐
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23										☐	☐	☐	☐	☐
24										☐	☐	☐	☐	☐
25										☐	☐	☐	☐	☐

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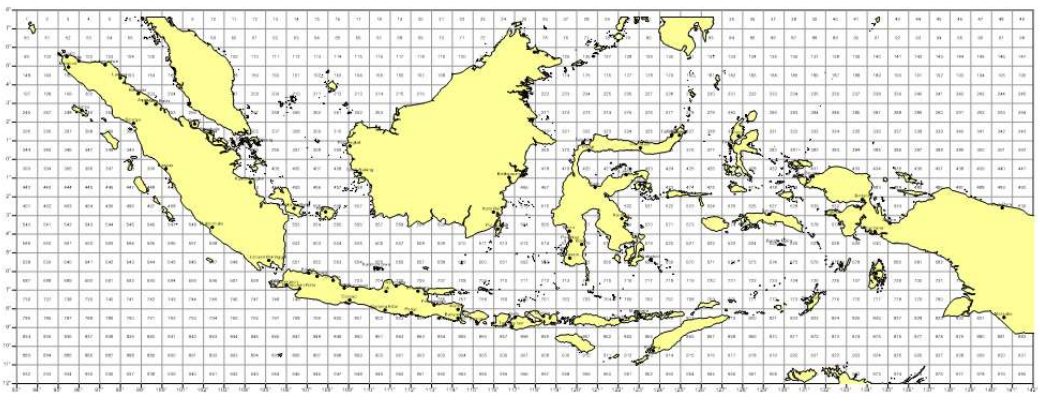
Codes:

Source of fish: Fishing Vessel (F), Processing Company (C), Market (M), Observer (O)

Vessel type: Hand-line/Troll-line (HL/TL), Pole and line (PL), Purse Seine (PS), Longline (LL), Gill Net (GN), Carrier Vessel (CV), Unknown (U)

Gear type: Troll-line (TL), Handline-Deep (HLD), Handline-Shallow (HLS), Pole and Line (PL), Purse Seine - FAD (PS-FAD), Purse Seine - Free school (PS-FS), Deep-Set Longline (DLL), Shallow-Set Longline (SLL), Gill Net (GN), Unknown (U)

Measurement type: Straight Fork Length (FL), Pre-dorsal Length (LD1)



Comments:

Appendix III: Macroscopic identification of female and male gonads

Table 3. Macroscopic identification of female and male gonads for yellowfin tuna (T*hunnus albacares*) in the Atlantic Ocean (based on Diaha et al., 2015; Coll Vol. Sci. Pap 71(1): 489-509).

	Criteria	
Stage	**Males**	**Females**
I (I = Indeterminate)	Gonads small ribbon-like, not possible to determine sex by gross examination	Gonads small ribbon-like, not possible to determine sex by gross examination
1	**Immature**; testes extremely thin, flattened and ribbon-like, but sex determinable by gross examination	**Immature**; gonads elongated, slender, but sex determinable by gross examination
2	Enlarged testes, triangular in cross section, no milt in central canal	**Early maturing**; gonads enlarged but individual ova not visible to the naked eye
3	**Maturing**; milt flows freely if testes pinched or pressed	**Late maturing**; gonads enlarged, individual ova visible to the naked eye
4	**Ripe**; testes large, milt flows freely from testes	**Ripe**; ovary greatly enlarged, ova translucent (hydrated), easily dislodged from follicles or loose in lumen of ovary
5	**Spent**; testes flabby, bloodshot, surface dull red, little or no milt in central canal	**Spawned**; includes recently spawned and post spawning fish, mature ova remnants in various stages of resorption, and mature ova remnants about 1.0 mm in diameter

Figure 16. Macroscopic identification for staging of ovaries (these images are from gonads of female YFT, but similar in other tuna species). (From Diaha et al., 2015; Coll Vol. Sci. Pap 71(1): 489-509).

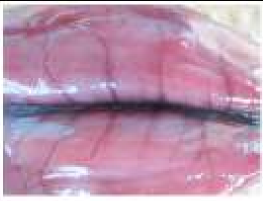
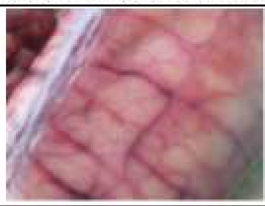
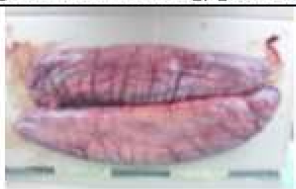
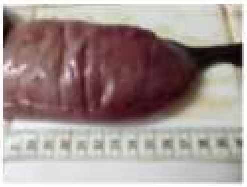
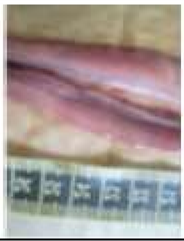
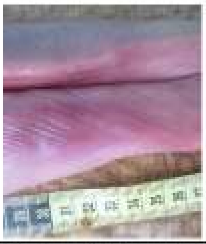
General aspect	External characteristics	Internal Characteristics
		
Stage 1: Immatures; Gonads elongated, slender, but sex determinable by gross examination.		
		
Stage 2: Early maturing; Gonads enlarged but individual ova not visible to the naked eye.		
		
Stage 3: Late maturing; gonads enlarged, individual ova visible to the naked eye.		
		
Stage 4: Ripe; ovary greatly enlarged, ova translucent (hydrated), easily dislodged from follicles or loose in lumen of ovary.		
		
Stage 5: Spawned; includes recently spawned and post spawning fish, mature ova remnants in various stages of resorption, and mature ova remnants about 1.0 mm in diameter.		

Figure 17. Identification of stage of development of testes (these images are from gonads of male YFT, but similar in other tuna species). (From Diaha et al., 2015; Coll Vol. Sci. Pap 71(1): 489-509).

General Aspect	External characteristics	Internal characteristics
		
Stage 1: Immature; testes extremely thin, flattened and ribbon-like, but sex determinable by gross examination.		
		
Stage 2: Enlarged testes, triangular in cross section, no milt in central canal.		
		
Stage 3: Maturing; milt flows freely if testes pinched or pressed.		
		
Stage 4: Ripe; testes large, milt flows freely from testes.		

Appendix IV: RNAlater-like buffer preparation

Recipe for an RNAlater-like buffer solution:

Makes 1.5 litres

935 ml of autoclaved, MilliQ water (or good quality distilled water)

700 g Ammonium sulfate

Stir until dissolved

Add 25 ml of 1 M Sodium Citrate

And 40 ml of 0.5 M EDTA

Adjust to pH 5.2 using concentrated sulphuric acid, H_2SO_4 (about 20 drops= 1 ml)

Store at room temperature

1. First, one should prepare or obtain the following stock solutions and reagents:
    a. 0.5 M EDTA disodium, dihydrate (18.61 g/100 ml, pH to 8.0 with NaOH while stirring);
    b. 1 M Sodium Citrate trisodium salt, dihydrate (29.4 g/100 ml, stir to dissolve);
    c. Ammonium Sulfate, powdered;
    d. Sterile water.
2. In a beaker, combine 40 ml 0.5 M EDTA, 25 ml 1 M Sodium Citrate, 700 gm Ammonium Sulfate and 935 ml of sterile distilled water, stir until the Ammonium Sulfate is completely dissolved.
3. Adjust the pH of the solution to pH5.2 using concentrated H2SO4. Transfer to a screw top bottle and store either at room temperature or refrigerated.

NOTE: Trained lab personnel should make, or be present to appropriately train in the making of the solution to ensure appropriate safety precautions are followed; particularly in relation to the use of concentrated sulphuric acid.

11.3 Appendix 4: Laboratory Inspections

Assessments of BRIN Laboratories suitability for Population Biology analyses.

Compiled by:
Dr. Fayakun Satria, Dr. Lilis Sadiyah, Ignatius Tri Hargiyatno, Hety Hartaty

There are four laboratories visited as follows: 1. Histopatologi Lab Gondol (Bali), 2. Laterio Lab (Ancol, Jakarta), 3. Genomic Lab (Cibinong) and 4. Serpong Lab (Tanggerang).

Gondol Lab (Bali)
There are several main lab instruments used in the Lab Gondol for reproductive analysis, as follows:

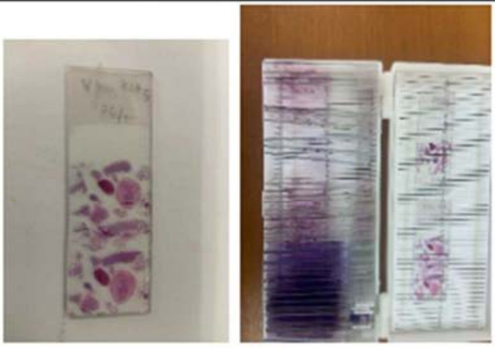
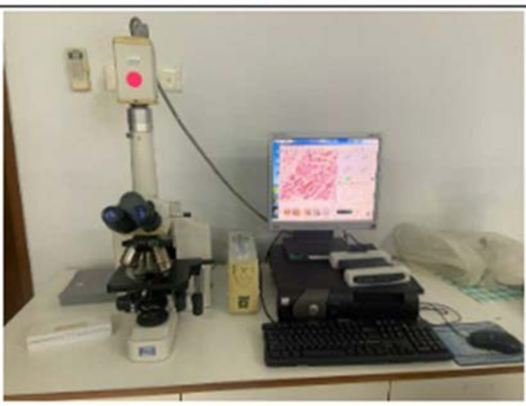
1. Automatic tissue processor (1 unit)
2. Rotary microtome (2 unit)
3. Parafin dispenser (1 unit)
4. Hot plate (1 unit)
5. Staining dishes (1 set)
6. Integrated camera microscope (1 unit)
7. Stereo microscope (1 unit)
8. Cold storage (1 room)

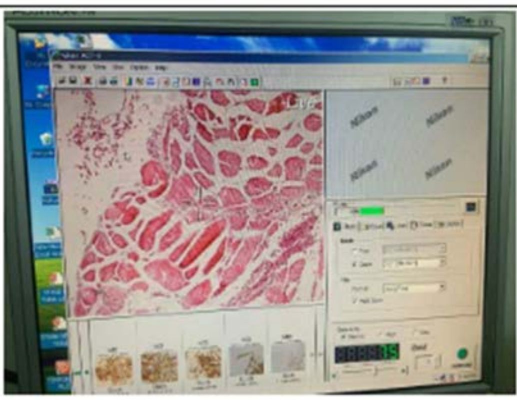
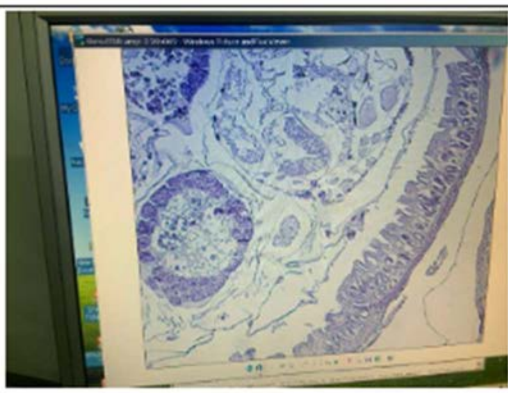
The Automatic tissue processor no longer works well, so it runs manually. The Integrated camera microscope is also very old and slow. These two main instruments are required to be updated. Maximum capacity for histology slides that can be produced in one run between 25-50 slides of samples per day.

In summary, the reproductive analysis for tuna (histology) can be conducted at this Lab using the current available instruments, but no Lab available for analysing otolith samples.

<u>Instruments at Gondol Lab</u>

	
Automatic Tissue Processor	Parafin dispenser and hot plate

	
Rotary microtome	Staining dishes
	
Slides	Staining rack
	
Integrated camera microscope	Stereo microscope

	
Imaging software	Histology image

Laterio Lab Ancol (Jakarta)
All required instruments for otolith analysis are available, except for the **Handle tool**.
There is no Lab for Gonad analysis.

Serpong Lab (Tangerang)
There are tools for histology analysis available (microtome available), but other accessories not available and no chemicals available. Furthermore, limited person available to conduct the lab work.

Genomic Lab (Cibinong)
Only available for genetic analysis. No histology (microtome) available, and no ageing instruments available.

11.4 Appendix 5: A Review of social and economic information available for the tropical tuna fisheries in Indonesia

A review of the social and economic information available for the tropical tuna fisheries in Indonesia

Report prepared for the Australian Centre for International Agricultural Research (ACIAR)

Eriko Hoshino, Craig Proctor, Fayakun Satria, Lilis Sadiyah, and Campbell Davies, November 2019

KEMENTERIAN KELAUTAN DAN PERIKANAN

Australian Government
Australian Centre for International Agricultural Research

CSIRO Oceans and Atmosphere

Suggested citation

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Important disclaimer

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Executive summary

The overall objective of the study was to review the existing social and economic studies and data collection programs as well as available approaches to obtain socio-economic indicators that could be useful for harvest strategy development and implementation for the tropical tuna fisheries in Indonesia. The review identified at least 21 projects/studies documenting the social and economic aspects of the tropical tuna fisheries in Indonesia that are either completed or ongoing.

While available case studies provide useful information as to potential issues to be considered in management decision-making, the focus has been on a specific location (e.g. bay, port) for a certain fishery and, to date, no attempts have been made to compare relative importance of, or dependency on, the tropical tuna fishery at regional or national scale from social and economic perspective. Moreover, quantitative metrics/indicators that can be directly incorporated into the modelling framework of the Indonesian tropical tuna harvest strategy are not currently available or are quite limited at best.

The regular fisheries data collection systems conducted by various agencies under Ministry of Marine Affairs and Fisheries (MMAF) have the potential to be developed into a systematic economic data collection system. For example, the Fisheries Port Information Center (PIPP) database run by the Directorate of Capture Fisheries (DGCF) of MMAF already records data related to fixed inputs (e.g. vessel gross tonnage) and some variable costs of fishing operations (e.g. fuel and ice). There may be a scope to extend such system to collect more comprehensive operating cost items as well as earnings on a periodic basis. Collaboration between MMAF and the NGOs/industry groups, who are already collecting economic data, is essential to obtain information for small-scale fishers who are not covered by the current national data collection systems. Social and economic data collection is currently outside of the scope of the proposed e-Integration Data management of Fish Resources (e-Mitrasdi). A private sector-government partnership on socio-economic data collection, similar to e-Mitrasdi, or the inclusion of socio-economic data collection protocols within the current partnership is likely to be useful in improving the socio-economic data collection by private sector. Moreover, improved collaboration among Indonesian scientists, as well as those members of the Indonesian Marine and Fisheries Socio Economics Research Network (IMFISERN), would be a good starting point to establish long-term strategies for collecting and managing socio-economic data for tuna fisheries in Indonesia.

1 Introduction

Indonesia is the second largest producer of fisheries products in the world and the largest producer of tropical tuna, contributing some 15% of global production (FAO 2018). The tropical tuna stocks and the fisheries that harvest them are central to food security, employment, regional economic development and national terms of trade. In recognising the importance of sustainable management of its tuna resources, Indonesia, led by Ministry for Marine Affairs and Fisheries (MMAF) and supported by stakeholder groups, initiated discussions on the potential to develop formal harvest strategies[1] for the management of Indonesia's tuna resources in October 2014. *The Harvest Strategy Framework for tropical tuna in Indonesian archipelagic waters* (hereafter referred to as the Framework) is a result of the extensive stakeholder consultation process between 2014 and 2018. The Framework outlines the interrelated set of actions required to complete the development of operational harvest strategies involving fishery monitoring, analysis, harvest control rules, and associated management measures to meet the management objectives for these important fisheries. The Framework was formally adopted by the Ministry in May 2018. The Framework recognises the critical importance of social and economic considerations in developing operational harvest strategies (MMAF 2018). However, Indonesia currently lacks systematic collection of social and economic data related to tropical tuna fisheries. This situation limits the scope for providing advice on the likely socio-economic impacts of alternative management actions.

The objectives of this report are three-fold:

1) To create a consolidated database of the recent and ongoing social and economic studies and data collected for fisheries and communities linked to tuna fisheries in Indonesia;
2) To provide a brief summary of common approaches and methods to produce indicators that may be applicable to inform the performance of tuna fisheries against social and economic objectives;
3) Recommend data collection strategies to derive the potential performance indicators applicable to the tropical tuna fisheries in Indonesia.

The above objectives are being met through collating information from a desktop review of literature and online information as well as email inquiries and in-person interviews with government, industry groups, and non-governmental organisation (NGO) personnel who have been involved in social and economic data collection for tuna fisheries in Indonesia. The information was collected between September 2018 and October 2019. The overall aim was to identify potential social and economic data sources that could be used for the development and implementation of tropical tuna harvest strategies in Indonesia.

The study was undertaken as a part of the Australian Centre for International Agricultural Research (ACIAR) – CSIRO funded project, "Harvest Strategies for Indonesian tropical tuna fisheries to increase sustainable benefits" (ACIAR Project FIS/2016/116), which is designed to assist the

[1] A harvest strategy is a formal decision-making process that sets out the management actions necessary to achieve defined management objectives in a given fishery. The harvest strategy outlines rules for setting the catch or effort level and data and criteria on which decisions will be based in order achieve the agreed long-term fishery objectives.

ongoing initiatives of Indonesia’s government to develop operational harvest strategies for tropical tuna in its archipelagic waters.

2 Collating social and economic studies and data collected for tuna fisheries in Indonesia

The objective of this section is to create a consolidated database of the recent and ongoing social and economic studies and data collected for fisheries and communities linked to tuna fisheries in Indonesia. This is done by collating information from a desktop review as well as interviews with government, industry group, and non-governmental organisation (NGO) personnel who have been involved in social and economic data collection for tuna fisheries.

The previous and ongoing projects and studies as well as data collection activities identified up to October 2019 are summarised in Table 1. The text below provides a brief summary of key institutions and their activities regarding social and economic data collection.

2.1 National programs and activities

The Ministry of Marine Affairs and Fisheries (MMAF) was established in 2000 as an expansion of the former Directorate General of Fisheries, which was part of the Ministry of Agriculture (FAO 2014). The institutional responsibility for fisheries management rests with the Directorate General for Capture Fisheries (DGCF) of MMAF, while the Agency for Marine and Fisheries Research and Human Resources (AMAFRHR) is responsible for fisheries research activities. The history of national fisheries data collection and statistics reporting systems in Indonesia, up to 2003, is detailed in Proctor et al. (2003) and more recently in Hoshino et al. (2019) although the system remained largely unchanged until 2016. This section focuses on the National programs that collect social and economic information as part of their ongoing data collecting operations.

2.1.1 Fishing port data collection by DGCF

The majority of Indonesia’s fishing ports are under the management of the DGCF. According to recent information provided by DGCF, the classifications of the fishing ports (total 538) are currently under review. Previously, under the National Fisheries Data Collection System (see Proctor et al. 2003 for more detail), there were three primary surveys that yielded the data for producing catch (production) and effort tables in both the provincial and national level annual reports: fishing companies (L-I survey); major landing places (L-II survey) and fishing villages (L-III) surveys.

Commercial (‘industrial’) fishing companies were required to keep records and make monthly reports of fishing activity and catch of their vessels. These monthly catch reports were supposed to be submitted by the companies to the local District Fisheries Office (DFO), and the DFO would send the information to DGCF via the Provincial Fisheries Office (PFO). Vessels that land catch at major landing places were surveyed using a two-sampling design, with landings by day a primary sampling unit and the number of vessel trips as secondary unit (see details in Proctor et al. 2003). At the majority of major landing places there is a central fish market or auctioning place. Fisheries Extension Officers were tasked with collecting most of the data at these marketing centres. However, data was also collected, via direct interview at the level of vessels, on the amount of catch that does not pass through these market centres (Proctor et al. 2003). This includes estimations, provided by vessel skippers/owners, of the amount of catch consumed during the trip, and that given upon landing to the vessel owner and crew for their and their family's personal consumption. Auction places in major landing places were required to complete monthly reports for each fishing gear type, similar to those provided by fishing companies.

For smaller level landing places (i.e. fishing villages), quarterly surveys were conducted by Fisheries Extension Officers. These surveys were essentially a census of fishing activity, via interviews with all or some of the fishing households/establishments in each selected village, that provided a total number of fishing units in each village, an average number of trips per quarter, and an average catch (by species group) per trip. The counting of fishing households/establishments, fishing vessels, and fishing units in each village was only done once per year, but the catch surveys were done each quarter (Proctor et al. 2003).

The Data and Statistics section within the Directorate of Fisheries Resources in DGCF (often referred to as "SDI" = *Sumber Daya Ikan*) had been responsible for national estimates of tuna catches up until 2016. The reporting structure of the statistical system started with the survey form (sampling) at the district level (processing/quarterly/annually), which was consolidated at the Provincial level as a report which was then fed into the National-level report. The data were then processed and publications were produced with the following types of data broken down within each Fisheries Management Area (FMA):

- Production by species and FMA
- Production by group of fisheries resources and FMA
- Production by species, province and FMA
- Fishing vessel by size and FMA

With the One Data Initiative (see Section 2.1.7) taking over the responsibility of producing national production statistics in 2017, the publications of these detailed fisheries production statistics are no longer available. Some measure of the catch landings can be obtained through the Fisheries Port Information Center (*Pusat Informasi Pelabuhan Perikanan* or PIPP, http://pipp.djpt.kkp.go.id/) to which data on total landings by species and the local market price are uploaded by local port authorities. However, the level of detail varies considerably and is not available for all ports. Previously, this website provided lists of active vessels by gear type at each port, but now the vessel information has been reduced to monthly summaries of the number of vessel port visits and associated landings, according to vessel size, but with no gear information.

While it is not publicly available through the PIPP website, DGCF has been recording time-series data on landed values of tuna by species, as well as crude measures for operational costs (i.e. the number of crews on board, quantity of fuel and ice) by fishing gears.

2.1.2 Research Centre for Marine and Fisheries Socio Economics

The Research Centre for Marine and Fisheries Socio Economics (RCMFSE) under the umbrella of AMAFRHR plays a key role for the collection of socioeconomic data across all fisheries in Indonesia. RCMFSE has three research groups: Marine and Fisheries Resource Management; Social Institutions;

and Business, Marketing and Trade. RCMFSE underwent an 80% budget cut in 2016 (RCMFSE, pers comm, 2019), which resulted in the end of the Center's long-term fisheries socio-economics panel data collection program. Since 2016, RCMFSE's focus areas are directed by the Ministry. The current research focus areas (in 2019) include the policy analysis on macroeconomic performance of the fisheries sector, marine debris, and research on sustainable fisheries development indicators based on ecosystem approach etc. While RCMFSE does not have a systematic data collection system specific to tuna, a number of studies related to tuna have been conducted, including the study on business investment structure of tuna fleet in Bitung (Wijaya et al. 2012), a social network study of skipjack tuna and 'tongkol' (frigate and bullet mackerels) commodity marketing in Kendari (Triyanti et al. 2014), and a value-chain study for skipjack tuna in Ambon, Maluku (Luhur and Yusuf 2017). The value-chain study in Ambon shows that the processing sector generated the largest value added, with the final value of skipjack tuna to be 5-hold of the values fishers generated.

RCMFSE has a number of domestic collaborators (such as Bogor Agricultural University and Pattimura University in Ambon) as well as international collaborators, such as the WorldFish Centre. There has been however, limited formal collaboration with other AMAFRHR research agencies, namely the Centre for Fisheries Research (CFR) and Research Institute for Marine Fisheries (RIMF) who conduct collection of biological and operational fisheries data, apart from participation by a senior scientist of RCMFSE in some of the Harvest Strategy Stakeholder Workshops that have also included regular participation by CFR scientists.

2.1.3 Central Bureau of Statistics

Indonesia's Central Bureau of Statistics (*Badan Pusat Statistik* or BPS) collects data related to fishing households. BPS is a non-departmental government institution directly responsible to the President of Indonesia (not part of MMAF). Its primary functions include providing census and survey data in a whole range of economy related fields (agriculture, forestry, fisheries, energy, trade, tourism etc.) to both government and public, and assisting statistics divisions of government departments and other institutions, in developing statistical collection and reporting systems (Proctor et al. 2003). With respect to fisheries statistics, BPS is primarily responsible for the annual census of fisheries households at the fishing village level, while DGCF is responsible for doing the more routine weekly and monthly sampling of catch at all levels of landing places (Proctor et al. 2003). The census data collected by BPS, related to tuna fisheries households, includes the National Socio-Economic Household Survey (SUSENAS, annual or semi-annual), National Demography Census (every 10 years ending in 0), National Agricultural Census a Fishing Household Subsector (every 10 years ending in 3), and Economic Census (every 10 years ending in 6), including Fish Consumption Statistics and Fish Processing Unit Statistics.

2.1.4 LIPI (Lembaga Ilmu Pengetahuan Indonesia)

The Indonesian Institute for Sciences (Lembaga Ilmu Pengetahuan Indonesia, or LIPI) is the governmental authority for science and research in Indonesia. LIPI reports directly to the President of Indonesia. Its main tasks are to assist the President in organizing research and development, to provide guidance and services in science and technology, and advise the government on national science and technology policy (http://lipi.go.id/). There are two divisions that deal with marine fisheries in LIPI: the Research Centre for Society and Culture, and the Research Centre for Earth Science. LIPI has a Centre for Tuna Conservation Program under the Earth Science division, which focuses on biology and fisheries oceanography related to tuna (e.g. to identify factors influencing spawning location etc.). While LIPI does not have a tuna specific socioeconomic program, LIPI does conduct studies related to fishing communities, traditional marine tenure systems, fisheries conflicts, and fisheries co-management across all regions and fisheries in Indonesia.

2.1.5 Universities and Indonesian Marine and Fisheries Socio Economics Research Network (IMFISERN)

There are a number of universities in Indonesia who conduct research related to marine capture fisheries, including tuna. Examples include the Faculty of Fisheries and Marine Science at Bogor Agricultural University (*Institute Pertanian Bogor* or IPB), Jakarta Fisheries University (also known as "Jakarta Fisheries High School"), the Marine Science and Fisheries Department of Pattimura University (Ambon), the Faculty of Fisheries and Marine Science at Riau University (Riau), the Faculty of Marine Science and Fisheries at Hasanuddin University (Makassar), the Department of Fisheries in the Faculty of Agriculture at Gadjah Mada University in Yogyakarta, and the Faculty of Fisheries and Marine Sciences at Diponegoro University in Semarang. Due to large numbers a comprehensive list of universities with marine/fisheries faculties or departments and their activities are outside of the scope of the present review. Some of the university academics and researchers participate in the Indonesian Marine and Fisheries Socio Economics Research Network (IMFISERN). IMFISERN is a forum of marine fisheries socio-economic researchers in Indonesia, which aims to strengthen the research network through the sharing of strategic problems related to the social research of fisheries and marine economies, as well as its indicative solutions. IMFISERN works as a platform for information sharing and collaboration among fisheries scientists who are engaged in social and economic researches related to fisheries in Indonesia.

2.1.6 National record of vessels authorized to fish for tuna

The National Record of Vessels Authorized to Fish for Tuna, Skipjack Tuna and Neritic Tuna within Indonesia Archipelagic and Territorial Waters and Exclusive Economic Zones (R-VIA) (MMAF 2019) was implemented in 2015 as part of the Ministerial Decree 107/KEPMEN/2015 which had the aims (1) to apply the principle of tracking (traceability) in the activities of catching tuna, skipjack tuna and tuna in the upstream sector; (2) to implement management measures for tuna, skipjack tuna based on rules established by RFMO; (3) to provide transparency in the management of fisheries for tuna, skipjack tuna and tuna in the territorial waters of Indonesia; (4) to ensure the activities of catching tuna, skipjack tuna and tuna has fulfilled the principle of tracking (traceability), so it can be received in the export market; and (5) to support the eradication of IUU Fishing activities.

R-VIA was suspended in 2017 after the initiation of One Data program. It has recently changed from RVIA to DIVA-Tuna (Database of Indonesian Vessels Authorised to Fish for Tuna) in 2019. DIVA-Tuna is expected to be fully operational by 2020. According to DGCF, the DIVA-Tuna include all size of vessels, including small-scale vessels less than 10GT that are not required to obtain fishing licenses.

2.1.7 One Data initiative

In 2017, the President Joko Widodo issued the new draft presidential decree for *Satu Data Indonesia* (One Data Initiative), which aims to strengthen data sharing and governance systems by establishing a common data portal. MMAF is one of seven pilot ministries under the One Data Initiative. One Data is funded by Indonesian Government via MMAF. Previously, budget was allocated to DGCF by MMAF and DGCF would in turn allocate budget to the Provinces for the collection, processing, tabulation, validation and publication of fisheries data. The responsibility for the overall processing and validation/verification of the data is now with One Data.

The publication of capture fisheries production data is now responsibility of PUSDATIN[2] (*Pusat Data, Statistik, dan Informasi Kementerian Kelautan dan Perikanan* = the Center for Data, Statistics and Information) which is under the One Data Initiative. PUSDATIN only reports highly aggregated data. A number of concerns have been raised in regards to the changes made since the establishment of One Data Initiative. This includes the concern that information regarding the number of fishing households, number of fishers, number of vessels and number of fishing gears is no longer collected under the new system.

2.2 Activities by International donors, NGOs and industry groups

Several data collection programs in collaboration with International donors, NGOs, and fishing associations have emerged in recent years. The following is a listing of the major initiatives by institutions, and is in alphabetic order.

2.2.1 ACIAR programs

As a part of the Australian Centre for International Agricultural Research (ACIAR) project FIS/2009/059: Developing research capacity for management of Indonesia's pelagic fisheries resources, a socio-economic survey was conducted for Kendari fishing port in Sulawesi. Structured interviews using questionnaire were undertaken between 2014 and 2015 to collect information regarding the demographic characteristics of the captains (age, years of experience), vessel size (length, width, depth, GT, engine horse power), fish hold capacity, number of crew, days at sea, number of fish aggregation device (FAD) deployed, as well as operational cost data (Proctor et al. 2019). Daily landing monitoring was also conducted between 2010 and 2014 to collect biological information. Data were collected from purse seine, handline/troll line, pole and line, and carrier vessel operators. A simple biomass dynamic bioeconomic model (Schaefer 1957) was constructed

[2] http://sidatik.kkp.go.id/

using the catch and effort between 2010-2014 to show that the current FAD associated tuna fisheries in Kendari generates substantial economic benefits (Proctor et al. 2019).

In a separate study funded by ACIAR, “Small-scale fisheries in Indonesia: benefits to households, the roles of women, and opportunities for improving livelihoods” (ACIAR FIS/2014/104), a review was conducted of the roles of small-scale fisheries, including the roles of women in 20 selected case studies, including the Fair Trade case study for tuna (see Section 2.2.2).

2.2.2 MDPI

Masyarakat Dan Perikanan Indonesia (MDPI) is an Indonesian NGO who have run a port monitoring and sampling program in eastern Indonesia since 2012. The MDPI currently has approximately 30 enumerators directly in the field site to collect daily catch and effort data on small-scale/artisanal tuna fisheries, fishing grounds, vessel numbers, trip characteristics, interactions with endangered, threatened and protected species, bait use, catch composition, and length measurements on a subsample of the catches (Duggan and Kochen 2016).

MDPI conducted an economic survey funded by Environmental Defence Fund in November 2015 in handline small-scale tuna fisheries and in five provinces of Eastern Indonesia. The aim of the survey was to understand the economic conditions and potential factors influencing wealth generated by these small-scale fisheries (Duggan et al. 2017). The sections in the interview cover four topics: vessel ownership, fixed and variable costs and background information. This survey aims to gather economic data from a number of MDPI sites across eastern Indonesia to facilitate economic analysis and interpretation of existing I-Fish data (www.ifish.id), a port sampling system for Indonesian small-scale tuna fisheries. In total 25 valid responses were obtained from the survey. The study found that approximately half of the small-scale tuna fishers in the five provinces received loan assistance from suppliers (also known as middlemen) to obtain vessels, hence they were tied to the specific suppliers to sell their catch, with lower bargaining power for a higher price. The supplier was also the most frequent provider of both ice and fuel, and transport for the catch to processing facility is often provided by the supplier. The study also found that fishing is the only source of income for 56% of respondents. As the majority of catch is exported (only the low quality fish is directed to the local market for domestic consumption), the impotence of the sector to food security may be limited, although the sector provides post-harvest employment in the area (Duggan et al. 2017). While the survey was conducted for a small number of participants, a discussion was underway (as of 2019) to identify the best approach for systematically collecting price and quality data for small-scale fisheries so that MDPI can implement a system and have a time-series.

MDPI is an implementing agency for the Indonesia handline tuna fishery improvement project (FIP), as part of the Anova Seafood’s Fishing & Living Initiative launched in 2011. MDPI also implemented a pilot project for Fair Trade USA certification for the Moluccan yellowfin tuna handline fishery in Indonesia in 2014. Fishermen involved in the Fair Trade program receive a premium for every kilo of Fair Trade certified fish exported, known as a Premium Fund (Duggan and Kochen 2016). Fair Trade is aimed at eliminating the role of intermediaries (i.e. middlemen) in the value chain and strengthening the position of smallholders by creating direct relationships with processors and traders. A follow up study, however, suggests that middlemen in Molucca have a large role in providing inputs into the fishery, getting fish to the market, and organizing the community (Bailey et al. 2016).

2.2.3 IPNLF[3] and AP2HI

In 2018, The International Pole and Line Foundation (IPNLF) in collaboration with the Association of Pole and Line and Handline Fisheries Indonesia, also known as *Asosiasi Perikanan Pole and Line dan Handline Indonesia* (AP2HI), had developed an onboard observer program for pole-and-line fisheries in Indonesia. The initiative is co-supported by the MMAF, and utilizes certified government trained observers for deployments. The program was designed to collect comprehensive data from pole-and-line fisheries on catch composition (length, volume, count) for all target and retained species (including bait); fishing effort, number and length of trips; areas and ports of operation; number of fishers and hooks; as well as whether or not there were ETP interactions. The objectives of the program were to update previous observer protocols and deployment efforts in order for pole-and-line tuna fisheries to meet requirements to achieve certification of the Marine Stewardship Council (MSC) standard, an international eco-label that requires robust fishery data collection to assess impacts to the environment and ecosystems.

Current deployments are focused in fisheries that are planned for MSC full assessment by the end of 2019, and they include landing centers such as Bitung, Maumere and Larantuka. It is planned to expand coverage of the observer program to other pole-and-line supply-chains to address a demand for these fisheries to enter into MSC full assessment, and those areas include but are not limited to Kendari, Ambon, and Sorong. There are also plans to expand the onboard observer program into large handline and troll line vessels and supply-chains catching tuna, that are able and appropriate to carry an observer.

In order to collect baseline socio-economic data and to be able to compare before and after MCS certification is in place, AP2HI/IPNLF has started the Fisheries Dependence Surveys in East Flores in 2017 and North Maluku in 2018. The program is funded by USAID SEA project, “Accelerating economic, social and environmental sustainability of small-scale coastal tuna fisheries” (see section 2.2.8). The data collect include income, expenditure, demographics, education, access to healthcare, and alternative livelihoods.

In 2017 IPNLF conducted a scoping study to identify key social and economic issues in Indonesia’s archipelagic waters skipjack and yellowfin tuna fisheries, which involved field interviews and surveys. The interviews yielded 43 respondents including fishers, processing factory workers, and middlemen. The study found that sub-adult yellowfin tuna and bigeye tuna play a role in local and possibly regional food security.

2.2.4 Sustainable Fisheries Partnership (SFP)

Sustainable Fisheries Partnership (SPF) is an international NGO working toward sustainable seafood supply chain and support small-scale producers through Fishery Improvement Projects (FIPs). SPF has supported FIPs in Indonesia for handline yellowfin tuna fishery in Banda Sea and handline/pole and line tuna fisheries in Indian Ocean and Western and Central Pacific Ocean

[3] Information in this section was provided by Mr Jeremy Crawford, SE Asia Director for the International Pole and Line Foundation.

(WCPO)[4]. The overall objective of those FIPs is to assist the fisheries to achieve a level of performance consistent with the MSC standard. The Indian Ocean and WCPO tuna FIPs are collaboratively implemented by MDPI, IPNLF and AP2HI.

In 2010 SPF conducted a supply chain study of the small-scale tuna handline from Banda Sea as a part of the Banda Sea yellowfin tuna FIP. According to the study, it is relatively common practice in the tuna industry to undertake all the processing states up to loining as close as possible to the landing areas, and to export the semi-processed product (tuna loins) to canneries in other countries. Fresh chilled tuna (bluefin, bigeye, and yellowfin) are caught by both longliners and pole and line gears and are transported by air as bullets or as loins. For frozen tuna, tuna is frozen immediately after the catch. Fresh and frozen tuna caught by purse-seiner, hook and line and longliners are delivered to canneries. The prices of yellowfin tuna are higher than those of skipjack because yellowfin tuna are often considered to be of better quality and also, because they are larger, produce less waste than do skipjack during processing. Canned yellowfin tuna and skipjack are usually labelled as light-meat tuna, except in Japan, where skipjack cannot be legally labelled as tuna. Albacore is marketed as white-meat tuna, which has a higher value than light-meat tuna.

2.2.5 Tuna Consortium

To improve effectiveness of NGOs working on tuna management in Indonesia, a new partnership, so called "Tuna Consortium" has been formed in early 2019 under a project funded by the Walton Family Foundation and organised by Nature Conservancy (TNC). The group supports the improvement of the Indonesian National Tuna Management Plan (NTMP) by assisting MMAF to develop a formal harvest strategy for tuna fisheries in archipelagic waters (Hatfield 2019). The tuna consortium work program has been developed in consultation with DGCF –SDI, CFR scientists, academia, and relevant experts, and has recently been approved. The work program is closely aligned with supporting the collection of socio-economic data and supply chain information, continued implementation of Fisheries Improvement Plans and certification under the Marine Stewardship Council. The aim is for it to be closely aligned with the work being led by DGCF and supported by the ACIAR harvest strategy project. The current work program for the consortium is scheduled to commence in the final quarter of 2019 and run for 2 years.

2.2.6 University of Technology Sydney (UTS)

A two-year project, "Assessing the Governance of Tuna Fisheries: Case Studies from the Indo-Pacific", led by the researchers at University of Technology Sydney (UTS), and funded by the David and Lucile Packard Foundation, commenced in December 2017. With case studies in Indonesia and the Solomon Islands, the study aims to develop approaches that can be widely applied across the Indian and Pacific Oceans to assist in the human dimensions of fisheries being taken into account in decision making. The case study in Eastern Indonesia (i.e. Maluku handline/troll line fisheries targeting yellowfin tuna, and Bitung purse seine/pole and line skipjack fisheries) found that the tuna fisheries in the region generate significant contributions to regional development and government revenues at provincial and national levels, as well as support employment and livelihoods along the value chain (McClean et al. 2019). For example, while the largest tuna fisheries have been primarily driven by export markets, the informal market chains selling coastal tuna species, low value bycatch in provincial and local markets provide substantial volumes of

[4] https://fisheryprogress.org/

fresh and smoked fish to rural and regional communities, contributing to food security. The tuna fisheries in Eastern Indonesia also support migrant workers, providing jobs and incomes for people with lower socio-economic backgrounds. The study also found that while men tend to be associated with fishing and roles that focus on trading higher quality fish, women have a key role in managing household income and local trading, enabling some women to leverage their financial and business literacy to achieve upward mobility and enter the export chain (McClean et al. 2019).

2.2.7 USAID Oceans

The USAID Oceans and Fisheries Partnership (USAID Oceans) is a partnership between USAID and the Southeast Asian Fisheries Development Center (SEFDEC). USAID Oceans works to strengthen regional cooperation to combat illegal, unreported, and unregulated fishing, promote sustainable fisheries and conserve marine biodiversity in the Asia-Pacific region (USAID Oceans 2017).

Their emphasis has been on developing a regional catch documentation and traceability system for ASEAN countries. USAID Oceans conducted an independent traceability assessment of tuna supply chains in Eastern Indonesia (Bitung region) in 2016 through subcontractors: Marine Change and FishListic. This project also consisted of a consortium of organizations including AP2HI, IPNLF, MDPI, which formed the Indonesian Coastal Tuna Sustainability Alliance (ICTSA). The primary objective of the ICTSA is to contribute to Indonesia's restoration and protection of marine and coastal ecosystems while also providing sustainable harvests of tuna to local communities (USAID Oceans 2017). ICTSA further aims to strengthen Indonesia's market competitiveness by promoting transparency in the supply chain, ensuring traceability and accountability throughout the tuna value chain (USAID Oceans 2017).

The 2016 audit only considered traceability through the "first mile" of the supply chain, which is from point of first off-loading at port by vessels, through the associated supply chain, and to loading into secure containers for shipment to the processing factory or for export. These assessments aimed to gain an understanding of the actors involved in the fisheries; the supply chains within which these actors participate; the catch documentation and traceability systems already in use and the gaps which exist within these to meet international traceability requirements. Of the five company supply chains audited, none were implementing a purposefully built traceability system or platform, apart from the everyday paper records that are produced as a course of doing business. While these systems provided the required components to prove the origin and legality of raw material through the supply chain and to the export market, the systems have limited confidence, credibility and robustness (USAID Oceans 2017).

The USAID Oceans conducted a Rapid Appraisal of Fisheries Management Systems in early 2017 to assess the status of the capture fisheries subsector in the Indonesian Fisheries Management Area (FMA) 716. The study assessed the tuna fishery sector, as well as the small pelagic fishery in FMA 716, including a value chain analysis, and gender study of the Bitung's tuna industry in 2016 (USAID Oceans 2018). According to the study, there are approximately 6,700 people engaged in fishing activities around the Bitung Oceanic Fishing Port (North Sulawesi), with 1,040 registered vessels (80% < 30 GT and 32% < 5 GT), 11 registered/licensed traders, 67 registered processors, and 7 registered tuna canneries. The study found that fishers, fishing crew, graders, collectors and land-based support crew (engaged in weighing, cleaning, icing and boxing) were men, while women were found among traders, fish sellers, seafood processors or land-based/factory workers, suggesting a gendered labour division (USAID Oceans 2018).

2.2.8 USAID Sea Project

The USAID Sustainable Ecosystem Advanced (USAID SEA) project is a five-year project (2016-2021) that supports the Government of Indonesia to improve marine and fisheries management and conservation at local, Regency, Province and National level, particularly with a focus on the provinces of West Papua, Maluku, and North Maluku that lie within in the Fisheries Management Area (FMA) 715[5]. USAID Sea project is funding AP2HI/IPNLF to implement the Fisheries Dependence Surveys in East Flores and North Maluku (See Section 2.2.3).

2.2.9 Wageningen University and Research Centre (Netherlands)

Wageningen University and Research Centre launched the BESTTuna program in 2012 aimed at contributing science to promote the sustainability of tuna stocks around the Coral Triangle and the Western Pacific. The 5-year project is funded by the Interdisciplinary Research and Education Fund (INREF) that supports cooperative research between research groups at Wageningen University (The Netherlands), Bogor Agricultural University (Indonesia), the University of the Philippines, the University of the South Pacific (Fiji) and the WWF-Coral Triangle Initiative. The project has financed a number of MSc, PhD and pos-doctoral students. In Indonesia the project has financed a survey to investigate the roles of middlemen for handline yellowfin tuna fishery in Molucca, Maluku before and after the Fair Trade certification (Bailey et al. 2016). A few more research topics for the Indonesian tuna fisheries have been proposed in the official website[6], but limited information regarding the detailed outcomes is available in the literature.

2.2.10 Western Pacific and East Asia (WPEA) project

Western Pacific and East Asia (WPEA) Sustainable Management Project of the Western Central Pacific Fisheries Commission (WCPFC) was established in 2009 to improve monitoring of tuna fisheries in Indonesia, Philippines and Vietnam, with funding from the Global Environment Facility (GEF). This was a direct outcome of the Indonesia and Philippines Data Collection Project (IPDCP) (WCPFC 2009), and during the past 10 years there have been two WPEA projects: The first was the Sustainable Management of Highly Migratory Fish Stocks in the West Pacific and East Asian Seas project (WPEA-OFM) which was followed by the WPEA Sustainable Management Project.

WPEA project has provided funding to MMAF (DGCF and CFR) to commence a study of skipjack tuna supply chain in Sikka Regency (FMA 714) in 2017. The study found that the pole and line fishery has a close connection with the live bait fishery, and scarcity of live bait (e.g. anchovies, juvenile scads and sardine) in recent years has had negative impacts on the skipjack production (Widodo et al. 2019). The study also found that between 2013 and 2017, about 85% of skipjack was caught by pole and line and the rest caught by surface handline and troll lines. About 90% of those catch are processed as frozen and katsuobushi, and the rest (about 10%) are marketed in local market as fresh skipjack. All of katsuobushi are exported to Japan while frozen skipjack are

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[5] https://www.sea-indonesia.org/

[6] https://www.wur.nl/en/Research-Results/Projects-and-programmes/BESTTuna/About.htm

exported to Japan, EU, and USA through exporters in Surabaya and Denpasar or sold as raw materials for tuna canneries in Denpasar, Surabaya and Jakarta. Of 67 pole and line boats in Sikka, 4 boats are owned by a large fishing and processing company, and the rest are owned by individuals (Widodo et al. 2019). In terms of business collaboration (partnership) there are at least 3 models, including: independent model where owners do not have collaboration with collecting company/buyers; plasma model, where owners are tied to a collecting/processing company through operational cost support; and company-owned where a company owns both vessels and processing company.

2.2.11 WWF-Indonesia

In 2017, the World Wildlife Fund for Nature (WWF)-Indonesia, funded by the USAID SEA Project, conducted a baseline study to collect ecology, fisheries, and social data along the coastal areas of Sawai Bay, Maluku. Data collection for the ecological and fisheries survey was conducted in 17 villages, while social data (e.g. education, occupation, income, religion etc.) was collected in 10 villages that have been active in fisheries and tourism sectors. The baseline data will be used in an advanced study on designing a MPA zone and a monitoring program for the site. The fishery survey includes the ex-vessel price of yellowfin tuna (3 grades/quality) and skipjack tuna and their prices along the supply chain.

Table 1. Summary of previous and ongoing socio-economic studies and data collection.

No.	Project name	Activities	Data collected	Area	Implementation organization	Founder	Status
1	ACIAR FIS/2014/104: Small-scale fisheries in Indonesia: benefits to households, the roles of women, and opportunities for improving livelihoods	Literature review and evaluate the findings from 20 past studies in coastal communities in Indonesia	Literature review	Across Indonesia	Murdoch University, Charles Darwin University	ACAIR	Completed
2	ACIAR project FIS/2009/059: Developing research capacity for management of Indonesia's pelagic fisheries resources	Socio-economic and bio-economic research	Socio-economic information, detailed vessel data, perceptions of fishery status	Kendari Port, Sulawesi Tenggara	DGCF/CFR/CSIRO	ACIAR/CSIRO	Completed, results published (Proctor et al. 2019)
3	Assessing the Governance of Tuna Fisheries: Case Studies from the Indo-Pacific region	Governance assessment focusing on wellbeing of tuna fishing communities	Establish key indicators of community wellbeing and methods to track changes over time	Maluku handline/troll line yellowfin fisheries, and Bitung purse seine/pole and line skipjack fisheries	University of Technology Sydney, Indonesian Institute of Science (LIPI)	David and Lucile Packard Foundation	Commenced in 2017, completed and published (McLean et al. 2019)
4	Asset management and business financing structure of tuna fishery by different season	Interviews with 37 owners of vessels (both <5GT and 5-10GT)	Investments, fixed costs and variable costs of business	Bitung	Wijaya et al. 2012	RCMFSE	Completed
5	Fair Trade USA-SEAFOOD pilot programme	port sampling, fisher association establishment, ETP awareness events, Safety at Sea trainings, Fair Trade Committee meetings, fisher logs and ETP logs	operational and catch data, vessel data, traceability information, price and quality data	Maluku, North Maluku and Central Sulawesi	MDPI and Harta Samudra	ANOVA seafood and Coral Triangle Processors	Pilot ongoing for the six-year certification audits. Paper published (Bailey et al 2016)
6	PhD project (BESTTuna)	Uncertainty in Bioeconomic Model for Tuna Fishery: Source, Harvest Strategy and Enhanced Information	Operational effort and catch data, including on-board consumption and upreported catch, catch used as bait. Unclear about cost and price data.	Bitung	BESTTuna, University of Wageningen, Netherlands		Completed in 2017. No publication on bioeconomic.

7	PhD project (BESTTuna)	Bio-economic modelling of financial incentives for tuna fisheries management (including resource rent calculations for effort based "Vessel Day Scheme")	Unclear	WCPO	BESTTuna, University of Wageningen, Netherlands		Completed in December 2017, results yet to be published
8	Pusat Informasi Pelabuhan Perikanan (DGCF)	Port census data by enumerators	Vessel name, owner, registration number, vessel size, crew, fuel, ice, price of fish, volume of fish by species name		DGCF		Ongoing
9	SFP Fisheries Improvement Projects (FIPs): Socio economic study of the small scale tuna handline from Banda Sea		Operational cost data	Handline yellowfin tuna at Banda Sea (FMA 714)	Yayasan Alam Indonesia Lestari (LINI)/ Sustainable Fisheries Partnership (SPF)	UNDP/GEF?	
10	The Fishing & Living initiative (ANOVA Seafood): Indonesia Handline Fishery Improvement Project (as part of the national FIP at the time)	port sampling, co-management establishment, Fair Trade certification, vessel registration	Operational and catch data, vessel data, price and quality data	Eastern Indonesia	MDPI	ANOVA Seafood	Ongoing
11	The Role of Fishers Social Networking of *Thunnus sp.* Commodity Marketing: A Case Study in Kendari	Interviews with fishers and retailers	Relationship among actors, social network functions, network pattern maintenance, number of fishers, and production.	Kendari	Triyanti et al 2014	RCMFSE	Completed
12	USAID Oceans	Socio-economic study (supply chain) and traceability needs assessment	Socio-economic data (Income, demographics, education, access to healthcare)	Bitung, Sulawesi Utara	USAID Oceans/MDPI/ Marine Change	USAID Oceans	Ongoing
13	USAID Oceans. Labour and gender studies, value-chain study	Interviews with 244 respondents		Bitung	Marine Change	USAID Oceans.	Completed in 2017

14	USAID SEA project: Accelerating economic, social and environmental sustainability of small-scale coastal tuna fisheries	Fisheries dependence surveys	Baseline research on socio-economic data (Income, expenditure, demographics, education, access to healthcare, alternative livelihoods) before and after certification	East Flores (2017) and North Maluku (2018)	AP2HI	USAID SEA	Ongoing
15	USAID SEA project: Fisheries data for sustainable fisheries management in WPP 715	port sampling, co-management establishment, fisher association establishment, ETP awareness events, Safety at Sea trainings, Fair Trade Committee meetings, fisher logs and ETP logs, socio-economic surveys	operational and catch data, vessel data, traceability information, household status information, price and quality data	Maluku, North Maluku	MDPI, Anova, CTP and Harta Samudra	USAID SEA	Ongoing
16	UCSB SFG project: Benefits of Fisheries Sustainability in Indonesia	Develop a bio-economic model of the benefits of fisheries reform and recovery in Indonesia.	Unclear, focus on IUU fishing from skipjack fishery based on global datasets.	Indonesian EEZ	University of Santa Barbara California.		http://sfg.msi.ucsb.edu/projects/benefits-fisheries-sustainability-indonesia
17	Value Chain Analysis of Skipjack Tuna in Ambon, Maluku	Interviews with 4 agencies, 11 fishers, 13 merchants, 7 processors	Value added generated, production, price, number of vessels, equipment used, trade and market	Ambon	Luhur and Yusuf 2017	RCMFSE	Completed
18	WPEA Sustainable Management project: Indonesian tuna supply chain analysis	Supply chain study on Skipjack tuna caught by PL		FMA 714 (Sikka)	CFR/DGCF	WPEA/WCPFC	Completed and published (Widodo et al. 2019)
19	WWF Indonesia Fisheries Improvement Program	Consumer surveys on eco labelled products in Indonesia	Survey conducted in 2017 for Indonesian consumers	Jakarta, Medan, Surabaya, Denpasar and Makassar	WWF Indonesia	WWF	Completed
20	WWF project	Operational costs data collection	Operational costs data collection for Handline YFT (fuel, bait, distance, catch, sale price)	Wakatobi, Sulawesi Tenggara	WWF		Completed (2008-2012)

21	WFF project	Performance of FAD based tuna fishing in the south of East Java waters	Unclear	East Java	WWF Indonesia, Faculty of Fisheries and Marine Science of University of Brawijaya		Completed (March 2016-July 2017)

3 A brief summary of approaches to derive social and economic indicators

3.1 Why social & economic indicators?

According to the Article 3 Law No. 31/2004 on Fisheries and amended by Law No. 45/2009, Indonesia has nine diverse management objectives for capture fisheries: 1) Increase small scale fishermen welfare; 2) Increase the country's income and foreign exchange; 3) Promote work expansion and enjoyment; 4) Increase the availability and consumption of fish protein resources; 5) Optimise fish resources management; 6) Increase productivity, quality, value added and competitiveness; 7) Improve the availability of raw materials for fish processing industry; 8) Achieve fish resources and environment utilization optimally; and 9) Ensure fish resource sustainability.

To ensure those social and economic objectives are being met, it is necessary to monitor social and economic performance of the fishing sector. However, the ability to monitor changes in economic performance is often constrained by lack of basic economic information on the fishery (Pascoe et al. 2019). This has been the case for the Indonesian tuna fishery, as there is no systematic data collection from tuna fisheries that enable tracking of social and economic impacts from management changes.

There are numerous fishery performance indicators that have been developed to assess the sustainability of fisheries, including social and economic performance indicators (e.g. FAO 1999, Lery et al. 1999, Franquesa et al. 2001, Tietze et al. 2005, Anderson et al. 2015, Brinson and Thunberg 2016) . A comprehensive review of available indicators is outside the scope of the present study, but here we present a brief summary of common and relatively simple approaches to derive social and economic indicators that may be applicable to the Indonesian tropical tuna fisheries.

3.2 Direct economic values

3.2.1 Gross Value of Production (GVP)

Economic performance of resource industries is often described in terms of Gross Value of Production (GVP). GVP is a measure of the value of fishery production generated by commercial fishers and is calculated by multiplying the weight of production by the landed unit value (i.e. beach price). GVP provides industry and policymakers with information about the gross income generated from the commercial harvest of wild-catch stocks (ABARES 2018). However, GVP does not take into account the costs associated with the production, and hence does not reflect the financial performance (or economic health) of the fishing industry. Where the price information is not available or varies, total catch in a specific time period, as a crude proxy for GPV, has been used during the performance evaluations of candidate management procedures for the Southern bluefin tuna fisheries (Hillary et al. 2015). The annual tuna catch in the Western Central Pacific Ocean, estimated for 2018 by Fisheries Management Area (FMA), is summarised in Table 2. The average ex-vessel price (beach price) of tuna by species may be obtained from the port-based monitoring programs such as PIPP (see Section 2.1.1). The price of tuna varies substantially depending on the species of tuna (with yellowfin tuna being higher than skipjack tuna) as well as the quality of tuna, which may be related to the gears employed and the size of fish. However, the regional variation in price, impacts on gears or size on price, as well as the impacts of supply (landed) quantity on price are not well understood. Using the estimated landing data (Table 2) and price data (when available) the calculation of GVP is straightforward.

Table 2. Total tuna catch (skipjack, yellowfin, bigeye) for all gear within FMA 713, 714, 715, 716, 717 and FAO area 71 estimated for 2018. Source: WCPFC 2019. Annual report to 15th SC session, September 2019

FMA	Skipjack	Yellowfin	Bigeye	Total
FMA 713,714,715	215,010	167,363	15,755	398,353
FMA 716, 717	76,432	48,096	3,818	128,425
FAO 71	291,442	215,460	19,573	526,778
Gear (Area)				
Longline (FMA 716, 717, high seas)		7,707	1,255	8,962
Purse seine (FMA 716,717)	15,650	5,951	441	22,043
Pole and line (FMA 716,717)	35,685	3,137	392	39,215
Handline (FMA 716,717)	3,407	19,022	460	22,935
Troll line (FMA 716,716)	5,137	745	309	6,191
Gillnet (FMA 716,717)	1,950	303	3	2,256
Others (FMA 716,717)	14,602	11,230	959	26,824

3.2.2 Gross Value Added (GVA)

Another commonly used economic (financial) performance indicator is Gross Value Added (GVA). GVA represents the income and other benefits generated by an industry after the cost of the intermediate inputs have been deducted from GVP. More specifically in fisheries, GVA represents the sum of incomes generated (both crew and owner-operator), boat profits, depreciation, returns to capital and taxes paid. GVA represents the contribution of the industry to overall gross domestic product (GDP), and hence is a measure of the contribution of the industry to the overall economy (Pascoe et al. 2018). GVP is derived from information from an economic cost and earnings survey of the fisheries. The cost and earnings survey provides a “snapshot” of the economic performance of the fleets, as well as providing a measure of the level of incomes currently being generated in the fishery. The survey is designed to collect information on revenue and costs for individual fishing vessels. Key information required includes the price of each species and the costs and earnings of the individual fishing boats. The key cost information includes a measure of the running costs (e.g. fuel, ice, bait), crew costs, annual fixed costs (e.g. harbour dues, administration costs, licence fees, maintenance) and capital costs (e.g. values of the boat and gear).

An example of cost and earning survey:

a. Earnings (income) source
    - Landing of fish (sales values)
    - Other source (specify)
b. Cost category
    - Captain wage
    - Crew payment
    - Unpaid labour
    - Fuel
    - Food and crew provisions

- Ice
- Bait
- Repair, maintenance for vessels, gear and equipment
- Insurance
- Interest to financial services
- Purchase of permits using with the vessel
- Office cost (if any)

c. Business operations and capital assets/debts
    - Number of fishing days (separated from days at sea)
    - Year vessel built
    - Values of licence
    - Monthly business loan repayment

Cost and earning surveys may be conducted for the major fleet (longline, purse seine, handline, pole and line) every two to three years. The Western Central Pacific Fisheries Commission (WCPFC) is currently developing guidelines on economic data collection, including templates for cost and earning surveys by gear types, in order to assist the member countries to voluntary submit their economic data to the Commission (FFA 2019). As Indonesia is a member of WCPFC, it may be more appropriate to adopt their guidelines when finalised.

3.2.3 Net present value (NPV) of profits

Discounted future profits or net present values (NPV) of profits from the industry is a popular capital budgeting technique that takes into account the time value of money. Maximising the flow of future profits from the fishing industry is the major objective of fisheries management in Australia, which is often interpreted as targeting maximum economic yield (MEY). This involves balancing higher revenues (through higher catches) and lower harvesting costs (through lower fishing effort and more abundant stocks, which allows fish to be caught more easily, reducing the unit cost of capture). Calculating NPV of a fishery resource requires a construction of a bioeconomic model, which specifies a functional relationship between the levels of harvesting (catch), fishing effort[7], and the abundance of fish stock (or an indicator of fish stock abundance), estimated from observed historical (time series) fisheries data. Due to high cost of developing and maintaining bioeconomic models, implementation of economic targets using bioeconomic models to real world fisheries have been limited to a small number of data-rich and high-valued fisheries (Hoshino et al. 2017).

Several bioeconomic models have been developed for tuna fisheries in the Western Central Pacific Ocean (WCPO). Bertignac et al. (2000) attempts at identifying conditions that would maximise the NPV profits from the tuna fisheries in the waters of the Pacific Island nations and concluded that increased economic returns could be gained by decreasing the size of all fleets, with the possible exception of the tuna longline fleet. Reid et al. (2006) also showed that a 30% reduction of effort across all fleets would result in a possible overall increase in economic returns. Kompas et al. (2010) estimated a biomass target that maximises the NPV of profits from the WCPO tuna fisheries

[7] The fishing effort is a measure of the amount of fishing, and often expressed in terms the number of hours or days spent fishing, numbers of hooks used (e.g. in longline), number of sets (e.g. in purse seine), numbers of poles (e.g. in pole and lines), kilometres of nets towed, or combination of them.

and shown that decreasing fishing effort for the purse seine, frozen longline and fresh longline fisheries by 44%, 40% and 51%, respectively, for at least the 2008- 2012 period is needed to double the NPV received from the WCPO tuna resource. Kirchner et al. (2014) evaluated economic outcomes of the tropical tuna fishery in the WCPO under different effort reduction scenarios by gear types. The study found that changes in the unassociated (free-schools) purse seine effort did not contribute to large changes in the overall NPV profits, but a small decrease in the fish aggregation device (FAD) and tropical longline fishery showed large increases in the NPV.

In Indonesia, the lack of stock abundance indicators as well as fine scale effort data in sufficient length by gear type would be the major limiting factor to construct a bioeconomic model, particularly for small-scale tuna fisheries because currently small-scale vessels less than 10 GT are not required to obtain fishing licenses and limited information is available regarding their effort levels. Even for larger vessels, the unit of effort has not been consistently reported (i.e. "days at sea" reported rather than "fishing days"), although improvements have been reported since 2017. Limited availability of fine scale unit of effort data (e.g. numbers of hooks, sets, poles, hours or distance towed etc) is another limiting factor as it could affect the accuracy of the model. Nevertheless, a bioeconomic model was constructed for tuna fisheries in Kendari (see Section 2.2.1), however, the simplified assumption on population dynamics used in the model and the use of non-standardized catch per unit effort as an abundance index of tuna is likely to limit its practical application.

3.3 Flow-on effects to regional and national economy

Fisheries provide not just direct economic benefits from fish sales but wider social and economic impacts. Estimation of the total impact of a change in marine harvesting or processing requires measurement of the changes that occur elsewhere in the economy. In other words, the economic importance of the fishing industry depends upon the relationship of fishing to the rest of the economy. One technique available to obtain these measurements is called input-output (IO) analysis. IO is an accounting system which records the sales of each industry to every other industry and to final consumers that can be used to trace connections between industries in the economy (Briggs et al 1982). For marine fisheries, an increase in the output (i.e. fish harvest) increases the demand for output in its supplying industries (e.g. processing, restaurants), and in industries which supply the suppliers (e.g. nets and traps, fuels) and so on. These inter-industry effects can be measured as "multiplier coefficients" in IO analysis. The output multiplier, for instance, estimates the total change in sales for one industry or region resulting from an increase in sales in other industries or regions. The employment multiplier shows the change in employment for the economy as a whole that results from the change in employment of a particular sector. In Indonesia, IO models have been used to investigate the linkages among production sectors in an economy, including marine sector (Nurkholis et al. 2016). However, regional models using IO or estimations of fishing sector specific multipliers have not been undertaken. Although multiplier effects from small-scale fisheries may be significant, it is proven to be difficult to estimate because indirect and induced multiplier effects of small-scale fishing activities are generally not disaggregated at national level (FAO 2005, Béné et al. 2007).

Different methods have been proposed to estimate regional multipliers. Regional multipliers can be derived using Input-Output models or Computable General Equilibrium (CGE) models. The former is static, in that it assumes that other sectors do not change their production processes in response to the change in output from one of the industries in the economy, while CGE allows for other industries, prices and costs to adjust also in response to the change in the industry considered. The complexity of the latter make them less appropriate for small regional analysis (Pascoe et al. 2018). Development of regional models using either IO analysis or CGE require substantial detail about all the industries in the economy, not just the industry of key interest. An alternative method to IO analysis has been developed to estimate regional and industry specific multipliers based on cost shares and location of expenditure, both derivable from a survey of key industries of interest (Stoeckl 2007). This produces estimates of multipliers that are equivalent to IO based multipliers under some conditions, and have been found to produce similar estimates in most conditions. As this is an inexpensive (survey-based) alternative approach to produce multipliers compared to more data intensive approaches, it may be more appropriate for Indonesian context, although further research is required (i.e. review of available regional and national accounting data and tables) to identify the applicability of the traditional and alternative methods to estimate flow-on effects of the Indonesian tuna fisheries.

3.4 Dependency indicators

Dependency on fishing is typically measured by economic indicators such as employment and income levels, although non-economic indicators such as culture and other social factors may be taken into account in determining fishing dependency (Fofana 2006). Where a high proportion of the working population are employed in the catching and down-stream industries this is a strong indication that the region is fisheries dependent. Symes (2000) suggests that economic criteria for defining fisheries dependent area should be based on employment, added value and the contribution of fisheries to the regional economy because they are the most accessible and straightforward. While fisheries dependency in developed countries may be accessed through the multipliers (3.3) above, other indicators have been used in developing countries where the data requirements for regional IO models are prohibitive. Stanford et al. (2013) used the total number of fishers whose main source of income is fishing; the percentage of the workforce employed as fishers, and the total production of fish and shellfish as fishing dependency indicators in West Sumatra in Indonesia, using the decadal census data of employment and poverty, social-economic survey data collected by BPS, and fisheries statistics collected at the provincial and district level by the Department for Marine Affairs and Fisheries (*Departemen Kelautan dan Perikanan*, DKP). The use of existing public data, however, may be limited for the purpose of quantifying the dependency on tuna fisheries because of the aggregated nature of the data (e.g. fish consumption is not disaggregated by fish species).

3.5 Measuring fishing capacity and capacity utilization

Because fisheries management often restrict the levels of effort or catch through direct input or output control measures, it is important for resource managers to be able to track changes in fishing capacity. Management of fishing capacity requires some estimate of the existing level of fishing capacity in a fleet and the corresponding level of excess capacity in the fishery. To this end, many countries have developed a range of capacity indicators, mostly based on physical attributes of the fleet (FAO 2000). Key indicators of capacity applied in many countries are measures such as gross tonnage (a measure of the volume of the vessel), engine power, and the number of boats. In some countries composite measures, such as "vessel capacity units[8], based on a combination of characteristics, have also been developed. These units are assumed to be linearly related to the harvesting ability of each vessel. In reality, however, even if management regulations freeze fleet size and/or tonnage, the ability of vessels to catch more fish can still increase as a result of technological improvement or switch to unregulated inputs, known as "effort-creep." A voluntary reduction of the number of the Japanese distant water longline boats in the early 1980s, for instance, resulted in increases in the number of hooks used by each operation by 20-30% on average (Suzuki et al. 2003).

As alternative to the physical capacity measures above, production-based measures of capacity have been developed that relate to the potential level of output or input of a fleet. According to the Food and Agriculture Organization of the United Nations (FAO) Technical Working Group on Managing Fishing Capacity, fishing capacity is defined as:

"the maximum amount of fish over a period of time (year, season) that can be produced by a fishing fleet if fully utilised, given the biomass and age structure of the fish stock and the present state of the technology" (FAO 2000).

In the above definition, fishing capacity is defined in terms of potential output. "Capacity utilization" can be defined in this context as the ratio of observed output (catch, landings) to potential maximum output given the characteristics of the vessels and the state of the stocks (Gréboval 2003). The measure ranges from zero to one, with a value less than 1 indicating underutilization of the existing capacity (e.g. the current output is less than the potential output). The existence of capacity underutilization may imply the existence of excess capacity (Pascoe et al. 2004). That is, the existing level of capacity is greater than that required to harvest the resource at the current level. Changes in capacity utilization over time can provide information on the effectiveness of management in controlling fishing capacity (Pascoe et al. 2004). For example, increasing capacity utilization may indicate that capacity management is working.

The existence of underutilized capacity indicates a waste of resources, as the same catch could have been taken with fewer boats operating at full capacity. The additional vessels are therefore not adding any additional value to the industry and the costs incurred by these vessels directly reflect the economic cost to the industry and society as a whole of the excess capacity (Pascoe et al. 2004).

Different methods have been proposed to try to estimate fishing capacity, depending on data availability. The FAO Technical Working Group on Managing Fishing Capacity proposed a hierarchy

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[8] For example, the UK defines vessel capacity units (VCUs) as: VCU = length*breadth + 0.45*kw. VCUs are used as the basis for capacity management in the UK (Pascoe et al. 2004).

of levels of data availability (from level 0 to 4, with level 0 being no available quantitative data) to determine the most appropriate methods for each case (FAO 2000). Two practical approaches for most cases are the peak-to-peak method (Klein 1960) and Data Envelopment Analysis (DEA) (Färe et al. 1989, Färe et al. 1994, Kirkley and Squire 1999). The peak-to-peak method defines capacity by estimating the observed relationship between catch and fleet size over time (Klein et al. 1973). The approach is based on identifying peaks, or periods of full utilization defined as the maximum value of the ratio of output to capital stock (e.g. catch per vessel). In practice, a peak year is often identified on the basis of having a yield per producing unit that is significantly higher than both the preceding and following years (Gréboval 2003). While the peak-to-peak approach is the most widely applicable and least demanding of data[9] for examining capacity utilization, it has short comings, i.e. it completely ignores the biological characteristics of the fish or changes in stock conditions (Kirkley and Squire 1999). Empirical applications of peak-to-peak analysis can be found in the USA (Ballard and Roberts 1997), global estimate (Garcia and Newton 1997) and Pascoe et al. (2003) provides more empirical examples in various countries.

DEA is a mathematical programming method to determine optimal solutions given a set of constraining relations, such as total allowable catches, bycatch, restrictions on fishing time, and socio-economic concerns such as minimum employment levels (Kirkley and Squire 1999). There are two primary orientations of the DEA approach: output and input. The input-based measure considers how inputs may be reduced relative to a desired output level, such as total allowable catches. The output-based measure indicates how output could be expanded to reach the maximum physical (primal capacity) level, given the input levels. DEA can be used to estimate the maximum possible output or capacity corresponds to the output which could be produced given full and efficient utilization of variable inputs, but constrained by the fixed factors, the state of technology, and when included, the resource stock (Kirkley and Squires 2003). With cost data (e.g. cost of each input price), DEA can be used to estimate the least-cost (cost minimising) number of vessels and fleet configuration. DEA has been suggested as the preferred approach to capacity measurement in fisheries (Kirkley and Squire 1999, FAO 2000, Gréboval 2003). As DEA is a non-parametric, one need not to specify functional relationship between production inputs and outputs, which may suit for data limited conditions.

Measuring fishing capacity to allow for DEA to be undertaken, it is necessary, at the very least, to obtain a data set detailing fixed inputs (fixed physical characteristics of the vessels) to the fishery and the associated output (catch). The data on the physical characteristics could include, among other attributes, gross tonnage (GT), vessel length, well capacity, engine horsepower and/or freezing capacity per day. DEA has been applied widely to a number of fisheries, but limited examples exist where DEA has been applied to data limited conditions. Among them includes the Malaysian purse seine fishery (Kirkley et al. 2003), and small-island mixed fisheries in Indonesia (Yamazaki et al. 2018). Ried et al. (Reid et al. 2004, Reid et al. 2005, Reid and Squires 2006) examined the feasibility of applying DEA to measure fishing capacity of the global longline and pole-and-line fleets, and concluded that there was not sufficient data to allow for a meaningful DEA to be conducted at that time.

[9] require information on only total fishery output and the level of physical inputs (Pascoe et al. 2004).

The DEA is purely deterministic and thus cannot accommodate the stochastic nature of fisheries (Kirkley and Squire 1999), although there are ways around it (e.g. bootstrapping). Other methods are also available, including the use of stochastic production frontiers (SPF). A detailed overview of methods available for estimating capacity and capacity utilization is given by Kirkley and Squire (1999), Pascoe and Gréboval (2003) and Pascoe et al. (2004), which provides a capacity assessment framework shown in Figure 1.

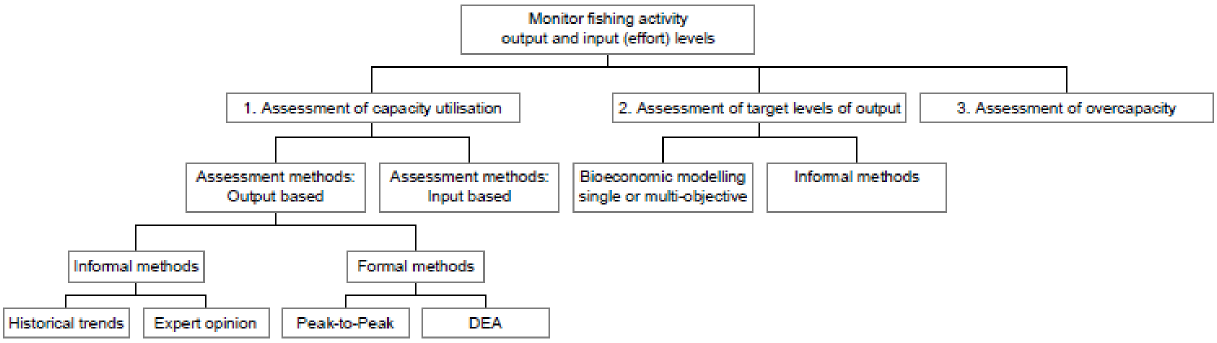

Figure 1. The capacity assessment framework proposed by Pascoe et al. (2004)

4 Key findings and recommendations for further research

The overall objective of the study was to review the existing social and economic studies and data collection programs as well as available approaches to obtain socio-economic indicators that could be useful for harvest strategy development and implementation for the tropical tuna fisheries in Indonesia. The review identified at least 21 projects/studies documenting the social and economic aspects of the tropical tuna fisheries in Indonesia that are either completed or ongoing. These involve both qualitative (descriptive) and quantitative analyses, including supply chain studies for small-scale yellowfin handline fishery in Banda Sea (FMA 714), skipjack pole and line fishery in Sikka (FMA 714), and value chain studies in Ambon (FMA 715) and Bitung (FMA 716). These available studies have highlighted the importance of the tropical tuna fisheries in Indonesia in terms of food security, jobs, and livelihoods of small coastal communities. Even though tuna are largely exported, the industry provides raw materials and jobs for local canneries and lower quality tuna species are supplied as food for local communities (Widodo et al. 2019). Larger vessels may also provide an opportunity for job security for the poor (e.g. migrant fishers)(McClean et al. 2019), although the extent on their dependency on the tuna fisheries is not well understood. Little information exists as to the gender roles in the tuna industry in Indonesia. However, a study in Bitung (USAID Oceans 2018) highlighted women's contributions in the processing and marketing for the domestic market, similar to the findings of the study in the Pacific Island nations (Demmk 2006).

While available case studies provide useful information as to potential issues to be considered in management decision-making, the focus has been on a specific location (e.g. bay, port) for a certain fishery (Section 2, Table 1) and, to date, no attempts have been made to compare relative importance of, or dependency on the tropical tuna fishery at regional or national scale (e.g. dependency for export, employment etc) from social and economic perspective. Moreover, quantitative metrics/indicators that can be directly incorporated into the modelling framework of the Indonesian tropical tuna harvest strategy are not currently available or quite limited at best. To avoid a situation where a management measure may adversary impact on a specific region or communities more than others, there is a need to establish quantitative indicators that can be used to assess the degree of fisheries dependency by regions and evaluate the implications of any changes in supply or demand. Estimating regional multipliers through an input-output model or alternative methods (summarised in Section 3) may help to fill this gap and we recommend conducting further research to assess the feasibility of applying different methods to obtain dependency indicators including multipliers that capture flow-on effects of the tropical tuna fisheries in Indonesia.

The regular fisheries data collection systems conducted by various agencies under MMAF have the potential to be developed into a systematic economic data collection system. For example, the Fisheries Port Information Center (PIPP) database run by DGCF already records data related to fixed inputs (e.g. vessel gross tonnage) and some variable costs of fishing operations (e.g. fuel and ice). There may be a scope to extend such system to collect more comprehensive operating cost items (e.g. bait, lubricant, maintenance, loan, depreciation of gear and boats etc.) as well as earnings (other than fish sales) on a periodic basis. Moreover, by establishing the linkage between the physical attributes of inputs (e.g. vessel length, gross tonnage), units of fishing activities (e.g. days fished, hooks deployed) and quantity landed from individual vessel the system may be able to provide necessary data over time to measure fishing capacity and capacity utilization for mid to larger vessels, using quantitative approaches such as Data Envelopment Analysis (DEA). Collaboration between MMAF and the NGOs/industry groups, who are already collecting economic data, is essential to obtain information for small-scale fishers who are not covered by the current national data collection systems. We recommend conducting a design study to develop a systematic data collection system(s) of social and economic data by the Government that allow tracking of socio-economic performance of the fishery before and after policy interventions.

Uncertainty regarding the catch and effort data from small scale tuna fisheries has been highlighted by WCPFC (2010) and more recently by Yuniarta et al. (2017). There has been little information about the fishing effort other than the number of vessels for small-scale fisheries that land in coastal villages. Coastal districts that support a large number of coastal villages can have several catch landing places, including beach landing places with no wharves. Some will have a fish auction centre (*Tempat Pelelangan Ikan*) close to the landing site but others do not. This situation makes it difficult to monitor activities by the small-scale vessels. DGCF, in collaboration with the Indian Ocean Tuna Commission and the Overseas Fishery Cooperation Foundation (OFCF) of Japan, did conduct a trial program of monitoring of the small-scale fisheries at smaller landing centres in North and West Sumatra with some success (Moreno 2015, Stobberup and Geehan 2015), but experienced problems in recruiting sufficient reliable enumeration staff.

Ideally all vessels catching tuna, including small-scale fisheries (i.e. vessels less than 10GT who are not required to obtain license), should be registered and their activities to be monitored using nationally consistent data collection protocol. A call to establish agreed common monitoring protocols led the central government (DGCF) to begin the process of catch data integration among collaborative partners who carry out catch data collection in FMAs, called e-Integration for Data Management of Fish Resources (e-Mitrasdi). The team for this purpose has been formed through Decree of DGCF No 17/KEP-DJPT/2019. At least 12 partners have committed to join e-Mitrasdi and regular meetings have occurred since December 2018 (MDPI 2019). However, the collection of social and economic data is outside of the scope of the proposed system. The stakeholder consultation process over the past several years has raised a great awareness among the industry and advocacy groups for the need to collect socio-economic data to assist the government to improve the sustainable management of tuna resources. There have been increasing requests by stakeholder groups for guidance in collecting socio-economic data that could be used for the development and implementation of harvest strategies. A private sector-government partnership, similar to e-Mitrasdi or the inclusion of socio-economic data collection protocols within the current partnership is likely to be useful in improving the socio-economic data collection by private sector.

Currently there has been little formal collaboration between the research agencies under MMAF: Centre for Fisheries Research (CFR), Research Institute for Marine Fisheries (RIMF) and the Research Centre for Marine and Fisheries Socio Economics (RCMFSE). Similarly, the collaboration between CFR/RIMF (under MMAF) and the Indonesian Institute for Sciences (LIPI) (who reports directly to the President) is limited. Improved collaboration among Indonesian scientists as well as those members of the Indonesian Marine and Fisheries Socio Economics Research Network (IMFISERN) would be a good starting point to establish long-term strategies for collecting and managing socio-economic data for tuna fisheries in Indonesia.

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11.5 Appendix 6: Lists of Capability Building, Population Biology, Technical and Stakeholder Meetings

Table 1. Capacity building workshops for TT Harvest Strategy

Date	Workshop title	Location	Indonesian Attendance (online)	Australian Attendance
May 2015	Indonesian Harvest Strategy Development workshop	Bogor, Java		
July- August 2016	Data exploration and MSE training workshop	CSIRO, Hobart	7 (?)	7
April 2019	Preliminary Analysis of harvest Strategy Data Workshop	Bogor, Java/Online	20	3
May 2019	The Second Workshop of Harvest Strategy Implementation	Bali	50	3
20-28th Feb 2023	Tropical Tuna MSE and Harvest Strategy Training Workshop	CSIRO Environment, Marine Labs Hobart	3(3)	10

Table 2. Technical and consultative meetings for development of framework for harvest strategy for tropical tuna in the IAW, including the earlier meetings which predate the current project.

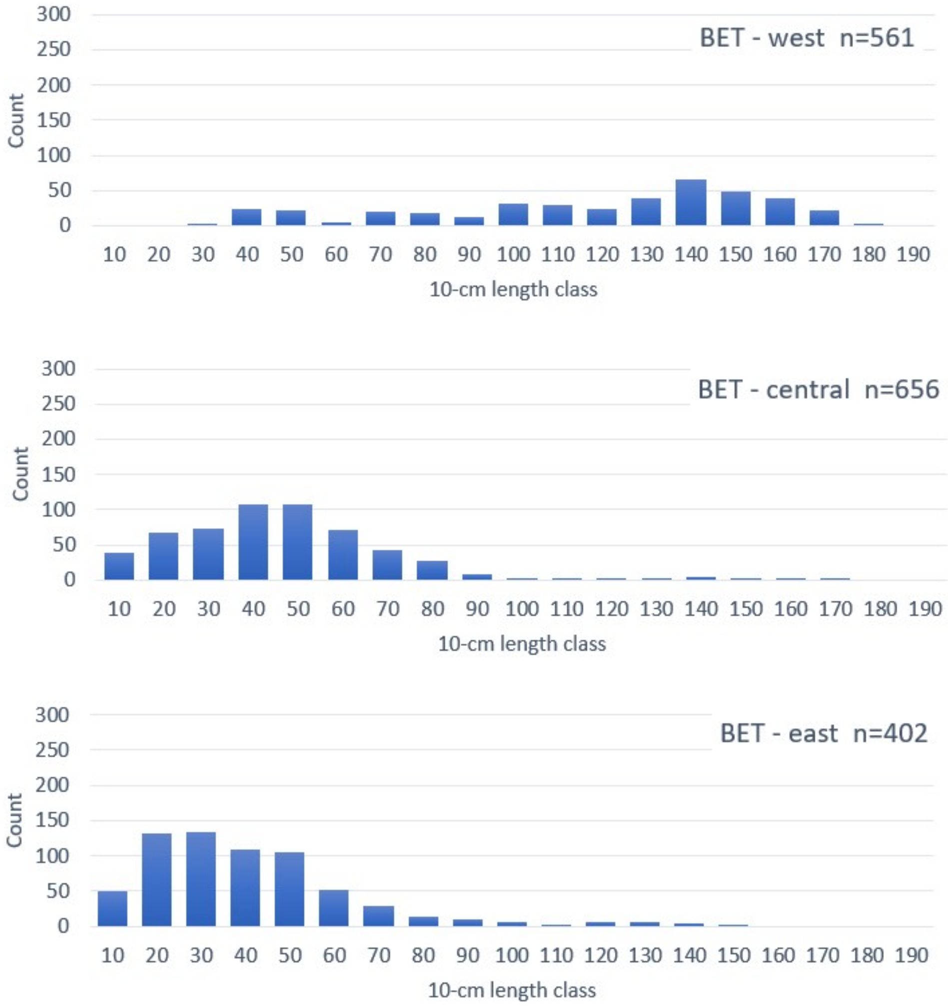
Date	Meeting	Location	Indonesian ACIAR project attendance	Australian ACIAR project attendance
October 30-31, 2014	Preparation meeting	Bogor, Jawa Barat (West Java)	8	4
March 25-27, 2015	Harvest strategy preparation and introduction meeting (1st Stakeholder Consultation)	Bogor, Jawa Barat (West Java)		
May 18-22, 2015	2nd Stakeholder consultation	Bogor, Jawa Barat (West Java)	7	2
August 10, 2015	Pre-workshop for data analysis	Bogor, Jawa Barat (West Java)		
November 16-18, 2015	3rd Stakeholder consultation	Kuta, Bali		
November 19-20, 2015	Baseline data to develop harvest strategies	Kuta, Bali		
April 4-7, 2016	1st Technical meeting for harvest strategy development	Bogor, Jawa Barat (West Java)	10	3
November 10-11, 2016	2nd Technical meeting for harvest strategy development	Denpasar, Bali	8	2
November 14-16, 2016	4th Stakeholder consultation	Bogor, Jawa Barat (West Java)	8	2
March 6-7, 2017	3rd technical meeting for harvest strategy development	DKI Jakarta/Special Capital Region of Jakarta	8	3

March 8-10, 2017	5th Stakeholder consultation	DKI Jakarta/Special Capital Region of Jakarta		
July 12-13, 2017	6th Stakeholder consultation	Loka Riset Perikanan Tuna, Bali/Tuna Research Center, Bali		
October 30-31, 2017	4th Technical Meeting	Bogor, Jawa Barat (West Java)	8	3
November 22-23, 2017	7th Stakeholder consultation	Bogor, Jawa Barat (West Java)		
November 22-23, 2018	1st Stakeholder Implementation	Bogor, Jawa Barat (West Java)		
October 28-29, 2019	5th Technical Meeting	Bogor, Jawa Barat (West Java)	7	3
October 30-31, 2019	2nd Stakeholder Implementation	Bogor, Jawa Barat (West Java)	7	3
February 24-25, 2021	6th Technical Meeting	Bogor, Jawa Barat (West Java)	7	5
March 2-3, 2021	3rd Stakeholder Implementation	DKI Jakarta/Special Capital Region of Jakarta		
December 9-10, 2021	7th Technical Meeting	Bogor, Jawa Barat (West Java)	7	5
December 13-14, 2021	4th Stakeholder Implementation	Bogor, Jawa Barat (West Java)		
November 21-22, 2022	8th Technical Meeting	Bogor, Jawa Barat (West Java)	9	3
November 23-25, 2022	5th Stakeholder Implementation	Bogor, Jawa Barat (West Java)		

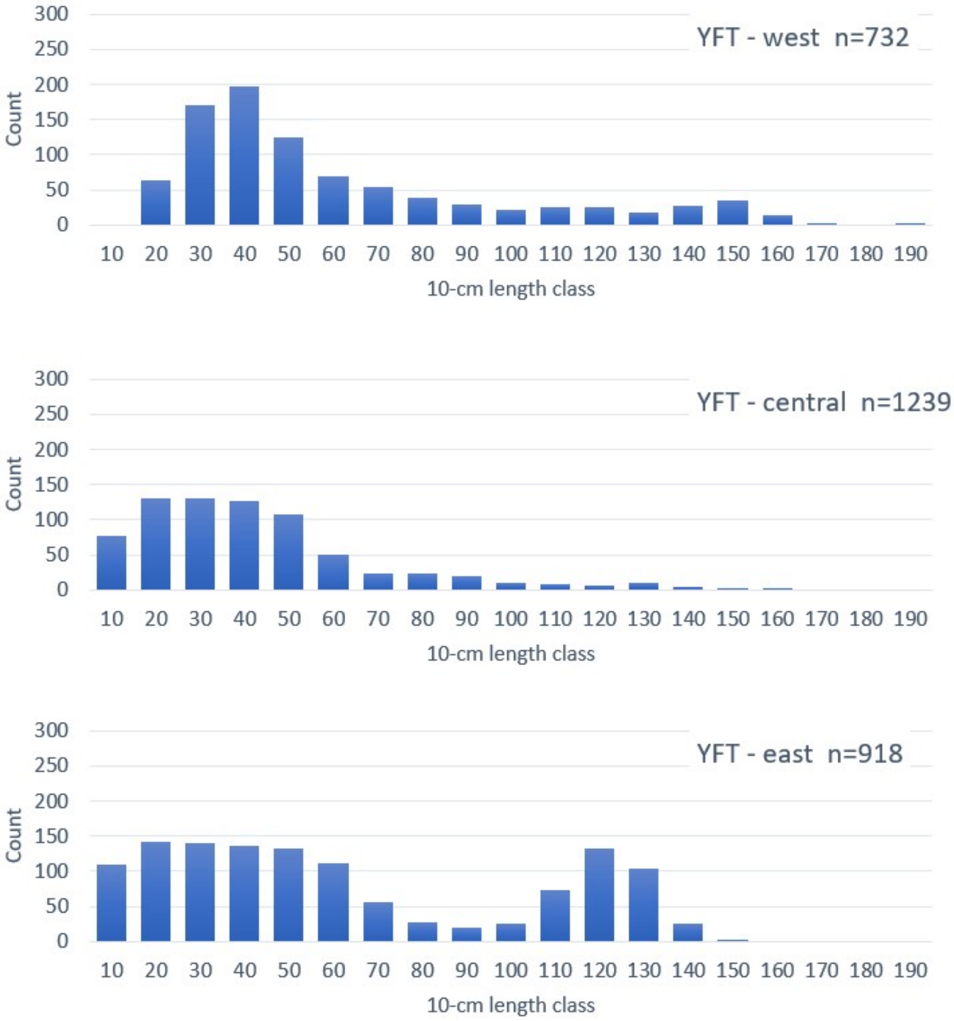
Table 3. Planning meetings and training workshops for the population biology component of the project.

Date	Meeting	Location	Indonesian ACIAR project attendance	Australian ACIAR project attendance
March 4-5, 2019	Project Planning Workshop	Sanur, Bali	10	4
July 9-10, 2019	2nd Biological Sampling Planning Work	Harris Hotel, Kuta, Bali	17	3
September 11-12, 2019	Training workshop	Research Institute Tuna Fisheries, Bali	24	2
November 29-30, 2021	Population Biology Training Workshop (hybrid)	Research Institute Tuna Fisheries, Bali	30 (16 online)	7 (online)
August 15-19, 2022	BRIN-CSIRO Indonesian Tuna Research workshop	CSIRO, Hobart	4	

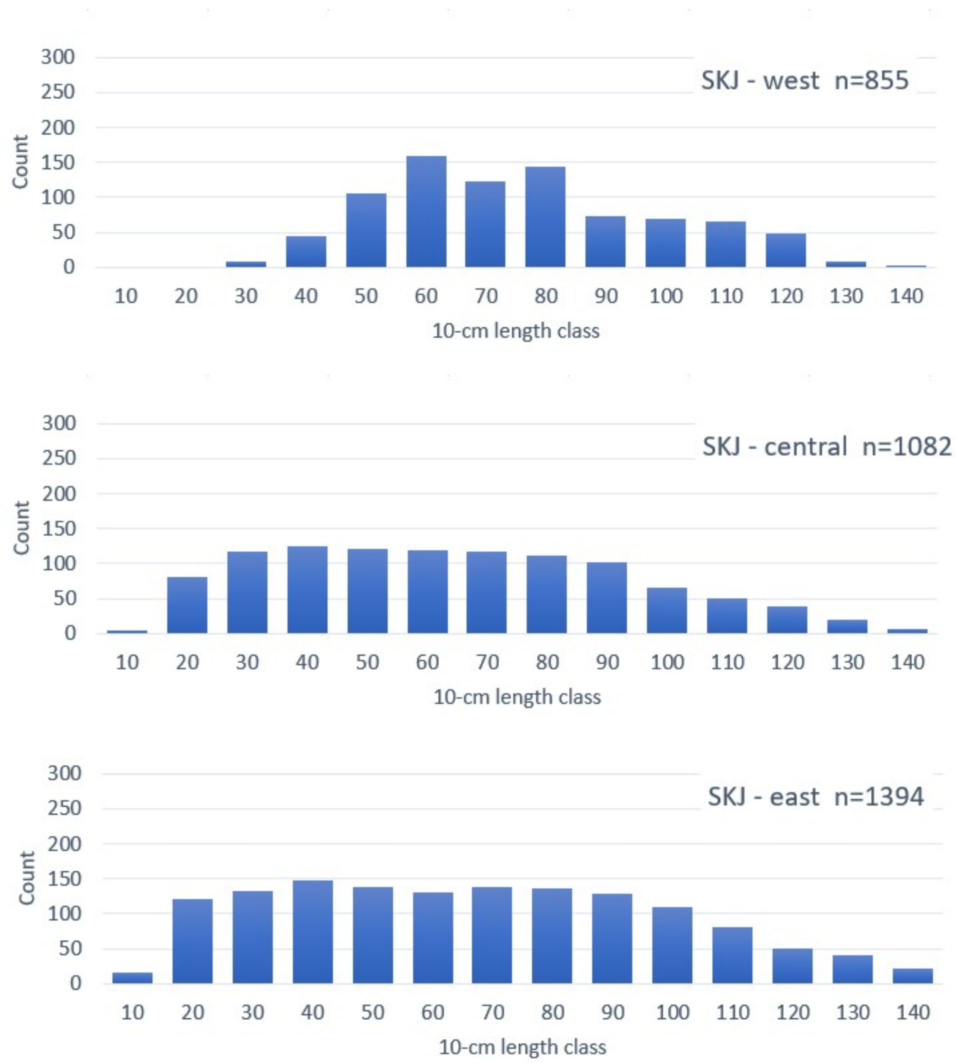
11.6 Appendix 7: Population biology - extra figures



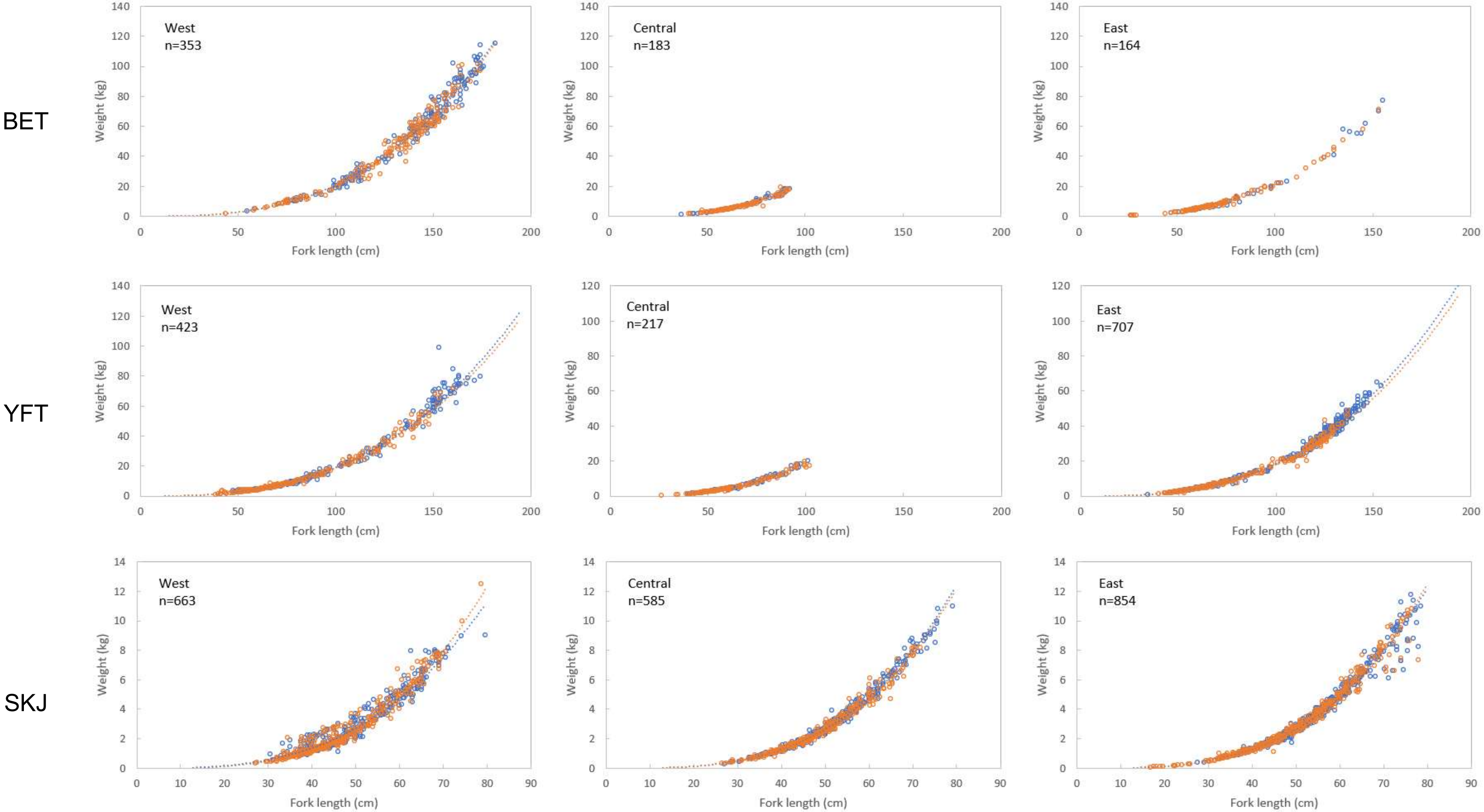
Length frequency of fish sampled by region for BET. West = Palabuhanratu and Cilacap, Central = Kendari and East = Bitung. The lower boundary length value of the bin is shown.



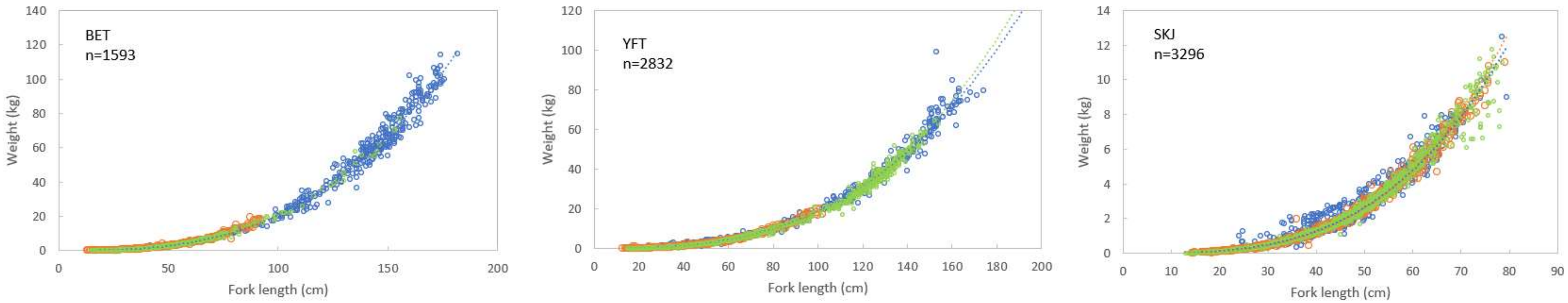
Length frequency of fish sampled by region for YFT. West = Palabuhanratu and Cilacap, Central = Kendari and East = Bitung. The lower boundary length value of the bin is shown.



Length frequency of fish sampled by region for SKJ. West = Palabuhanratu and Cilacap, Central = Kendari and East = Bitung. The lower boundary length value of the bin is shown.



Length-weight relationships for BET, YFT and SKJ by sex for each region (west, central and east). Female = orange circles, male = blue circles. Power curves fit to the data are shown if there were sufficient data across the full size range for the species. Sample sizes are shown.



Length-weight relationships for all BET, YFT and SKJ by region (i.e., males, females, indeterminate and unknown sex combined). West = blue circles, central = orange circles, east = green circles. Power curves fit to the data are shown if there were sufficient data across the full size range for the species. Sample sizes are shown.

11.7 Appendix 8: Interim Harvest Strategy Framework 2018

KEMENTERIAN KELAUTAN DAN PERIKANAN

FRAMEWORK FOR HARVEST STRATEGIES FOR TROPICAL TUNA IN ARCHIPELAGIC WATERS OF INDONESIA

FRAMEWORK FOR HARVEST STRATEGIES FOR TROPICAL TUNA IN ARCHIPELAGIC WATERS OF INDONESIA

Ministry of Marine Affairs and Fisheries of
The Republic of Indonesia
2018

INTRODUCTION

Fisheries Management Areas (IFMA) number 713, 714, and 715 are within Indonesian archipelagic waters and, as such, are Indonesia's sovereignty. These waters are well-known for their abundance of tuna resources such as skipjack tuna, yellowfin tuna, and bigeye tuna, which are categorized as highly migratory species. The results of a large tuna tagging study conducted by SPC (2009-2010) indicates that while the majority of these tunas are recaptured within the archipelagic waters, there is exchange other IFMAs and with the wider WCPO..

In accordance to United Nation Convention of the Law of the Sea (UNCLOS) 1982, which has been ratified by Indonesia through Act No. 17 Year 1985, highly migratory species are managed by international or regional cooperation. In this case, Indonesia a has strong commitment and concern on managing tuna resources in all Indonesian waters including its archipelagic waters based on the provisions adopted by Tuna Regional Fisheries Management Organizations (RFMOs).

In 2015, as one of the significant outputs of the 1st Bali Tuna Conference held at the end of 2014, the implementing rules and standards from RFMOs has been set in the Ministerial Decree of Marine Affairs and Fisheries of the Republic of Indonesia Number 107/KEPMEN-KP/2015 concerning Fisheries Management Plan of Tuna, Skipjack and Neritic Tuna (NTMP). As mandated by this Ministerial Decree and consistent with the Western Central and Pacific Fisheries Commission (WCPFC) conservation and management measures number 2014-06, the Framework for Harvest Strategies for Tropical Tuna in Archipelagic Waters of Indonesia is introduced during the 3rd Bali Tuna Conference in May 2018.

This framework document will be used by the Ministry and Indonesian stakeholders as the basis for the development of operational harvest strategies for tuna in the Indonesian archipelagic waters (IFMA 713, 714, and 715) to ensure the sustainability of yellowfin tuna, bigeye tuna and skipjack tuna resources in those waters areas. This Harvest Strategy Framework outlines the interrelated set of actions required to complete the development of operational harvest strategies (fishery monitoring, analysis, harvest control rules and associated management measures) to meet the management objectives for these important fisheries.

This framework has been developed through consultative stakeholder processes since 2014. Support and sustained cooperation from the relevant domestic tuna stakeholders and also international fisheries experts from Commonwealth Scientific and Industrial Research Organization (CSIRO) and WCPFC have made significant contribution to the development of this harvest strategy framework and are very much appreciated.

Jakarta, May 2018
Director General of Capture Fisheries

M. Zulficar Mochtar

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1. Interim harvest strategies for tropical tuna in archipelagic waters of Indonesia

1.1. Fishery Policy and regulatory context

As part of a range of initiatives aimed at achieving sustainable social and economic benefits from the harvest of tuna resources in Indonesian archipelagic waters, Indonesia intends to develop and implement scientifically-tested harvest strategies to manage the level of targeted fishing on these tuna resources. The development and implementation of this harvest strategy framework is a priority action of the National Tuna Management Plan (NTMP) for tuna and neritic species and associated action plans, which has been set out in the Ministerial Decree of Marine Affairs and Fisheries of the Republic of Indonesia Number 107/KEPMEN-KP/2015. The harvest strategy framework is an important step in the process of development, testing and implementation of harvest strategies for yellowfin tuna, skipjack tuna and bigeye tuna fisheries in Indonesian archipelagic waters (Indonesia Fisheries Management Areas/IFMA number 713, 714 and 715).

The development of harvest strategies for major tuna species is also o sistent with I donesia’s rights a d obligatio s as a member of the Regional Fisheries Management Organizations (RFMOs) responsible for governance of these highly migratory stocks: Western Central Pacific Fisheries Commission, Indian Ocean Tuna Commission and Commission for the Conservation of Southern Bluefin Tuna. Importantly, implementation of the monitoring, assessment, harvest control rules and management measures, which are essential elements of a harvest strategy, are central to achieving Marine Stewardship Council (MSC)-certification for Indonesian tuna fisheries.

The NTMP sets out a five-year plan for implementing action plans including development and implementation of harvest strategies, and to gain MSC certification. This addendum to the NTMP describes the management objectives and harvest strategy framework (Appendix 1) developed through a two-year technical and consultative processes (Appendix 2). The harvest strategy framework details the forms of harvest strategy developed through these processes, that will be refined and implemented for the management of fishing effort targeting tropical tuna in Indonesian Archipelagic Waters. It includes an updated action plan (Appendix 3 and 4) of specific information requirements, consultation processes and institutional arrangements required for the implementation of harvest strategies for each species.

1.2. Management Objectives

From the nine management objectives for capture fisheries, as stipulated in Article 3 Law No. 31 Year 2004 on Fisheries, and amended by Law No. 45 year 2009 on Fisheries, it was agreed by series of stakeholder workshops that the management objective for yellowfin tuna, bigeye tuna and skipjack tuna is:

“to ensure the sustaina ility of yello fin tuna, bigeye tuna and skipjack tuna resour es” through harvest strategy implementation.

1.3. Operational Objectives

To maintain spawning stock biomass (SSB) above the limit reference point (LRP) of 0.2 of the unfished level with the probability of 90%.

1.3.1. Reference Points

A reference point is the benchmark that scientists and managers use to compare the current status of a stock or fishery to a desirable state (Target Reference Point) or a state to be avoided (Limit Reference Point), due to an increased probability of undesirable consequences.

1.3.1.1. Limit Reference Point

The default limit reference point for tuna in archipelagic waters is to maintain spawning stock biomass above 0.2 of the unfished level with a probability of 90%.

The rationale for this Limit Reference point is to avoid the stock being reduced to a level that average recruitment declines, which would result in reductions in long-term sustainable catches from the fishery.

The appropriateness of this limit reference point will be examined as part of the harvest strategy testing and selection process (Appendix 3 and 4).

1.3.1.2. Target Reference Point

A target reference point for tuna in archipelagic waters has not been decided as it requires more detailed consideration of implications for social and economic objectives for the fishery.

The current WCPFC target reference point for skipjack is that the spawning biomass should be 50 percent of the unfished spawning biomass on average (CMM 2017-01), while current IOTC Target Reference Point for skipjack is that the spawning biomass should be forty percent of the estimated unfished spawning biomass on average (IOTC Resolution 2016-02).

Alternative target reference points for skipjack tuna, yellowfin tuna and bigeye tuna will be investigated, based on stakeholder surveys and using Management Strategy Evaluation (MSE) testing as part of the Action Plan for harvest strategy implementation (Appendix 3 and 4).

1.3.2. Stock Status

Assessment of stock status of highly migratory tunas is provided through regional stock assessments. In the case of stock assessments for IFMA 713, 714 and 715, these assessments are conducted by the Ocean Fisheries

Program of the SPC as part of the regular regional stock assessment process for each species and reviewed and agreed by the Scientific Committee of the WCPFC. This harvest strategy framework uses these regional stock assessments as the best source of scientific advice on stock status for skipjack, yellowfin tuna and bigeye tuna.

1.3.3. Performance measures for HS selection

The aim of a harvest strategy is to achieve an appropriate balance of the social, economic and stock conservation objectives for the fishery. Performance measures are more detailed summary statistics generated during the testing and selection of harvest strategies that relate to the performance of the harvest strategy with respect to stock, fishery, economic and social objectives. It is desirable to have a wide range of performance measures that relate directly to the important components of the fishery and wider community and economy. This allows government and stakeholder to make judgements about the trade-offs among social and economic benefits for alternative harvest strategies and select a final form of harvest strategy that is most likely to provide the best compromise among multiple objectives and acceptable performance overall. This is done as part of the Management Strategy Evaluation process (see Figure 1 and (Appendix 3 and 4).

Initial input for the development of performance measures was obtained from stakeholder using a structured survey at the 4th stakeholder workshop in 14-16 November 2016[1].

[1] Anon 2016. Survey Report: Questionnaire analysis on tuna fisheries in relation with the harvest strategy development of tuna in WPPNRI 713, 714, 715.DGCF November, 2016.

2. Harvest Strategy Framework for skipjack, yellowfin tuna and bigeye tuna in Archipelagic waters

A harvest strategy is a carefully considered and agreed plan for ***monitoring*** and ***assessing*** a fishery and adjusting the level of fishing (relative to the previous year) using a specified ***management measure*** according to the ***harvest control rule*** to meet the specific objectives *for the fishery (Figure 1).*

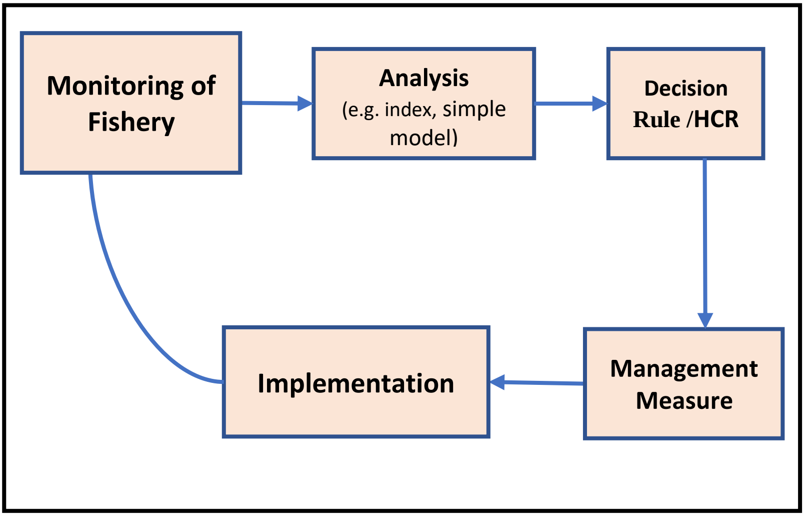

Figure 1: *Conceptual illustration of the components of a harvest strategy. It is the combination of components that define an individual harvest strategy and determine its likely performance. Hence, if one, or more component(s) is (are) changed, this is considered a different harvest strategy. As part of the harvest strategy development and evaluation process, each component is specified in detail. This allows the relative performance of different harvest strategies to be tested through simulation modelling. The harvest strategy considered to have the most appropriate balance of performance across stock, social and economic objectives can then be selected for implementation in the fishery.*

2.1. Empirical harvest strategy

In the case of tuna in WPP 713, 714 and 715, it was considered that empirical harvest strategies were most appropriate. Empirical harvest strategies are based on indices of relative abundance, such as standardised catch rates, and/or average size in the catch, and relatively simple analysis methods, rather than the population dynamics/stock assessment models used in model-based harvest strategies. Empirical harvest strategies have the advantages of being more transparent and more easily explained to non-technical audience and being more straightforward to implement and, hence, requiring less technical expertise. Experience in other fisheries and modelling studies comparing empirical and model-based harvest strategies indicate that it is possible to achieve comparable management outcomes from empirical harvest strategies.

2.2. Management Measures

From the fifteen management measures stipulated in Article 3, Law No. 31 Year 2004, on Fisheries, and amended by Law No. 45 Year 2009, on Fisheries, 8 (eight) management measures were selected through selection processes at the 4th and 5th Stakeholder Workshop. Subsequently a risk-assessment process was completed at the 6th Stakeholder Workshop, and the following five priority selected management measures were selected:

a. Limit on use of Fish Aggregating Device.
b. Spatial closure (of important spawning or nursery grounds) and temporal closure (during important events, such as spawning).
c. Number of fishing days (per gear, for semi industrial and industrial vessels).
d. Number of vessels – limited entry (per gear; for semi industrial and industrial vessels through licensing, permits, taxing, royalties).
e. Total Allowable Catch (TAC) limits per Fishery Management Area.

2.3. Management Strategy Evaluation

In order to examine, to the extent possible, that a harvest strategy is likely to a) meet the specified objectives for the fishery; and b) be robust to major uncertainties in the status and dynamics of the stock and the fishery and effectiveness of monitoring and management, it is considered best practice to develop a range of alternative, practically feasible harvest strategies and compare their relative performance is using a simulation modelling approach known as Management Strategy Evaluation (MSE)[2].

A set of MSE models have been developed for skipjack and yellowfin tuna, based on the relevant WCPFC regional stock assessments[3]. These MSE models have been used to develop and conduct preliminary testing of general forms of empirical harvest strategy for skipjack and yellowfin tuna, based on the available information[4] and monitoring series[5], and examine the general feasibility of proceeding with the framework for harvest strategies for skipjack tuna, yellowfin tuna, and bigeye tuna.[6]

These MSE models also provide the basis for testing the performance of a specific alternative harvest strategies and providing government and stakeholders with results to refine and select the most appropriate harvest strategy for implementation for each species. This will be completed as part of the MSE technical and consultation process (see Action Plan, appendix 3).

2.4. Consultation

The process for development of the framework for harvest strategies for tropical tuna has been conducted in a consultative, collaborative and multi-stakeholder approach.

Lead government departments were the Directorate of Fish Resources Management - Directorate General of Capture Fisheries and the Centre for Fisheries Research both under the Ministry of Marine Affairs and Fisheries. Under the direction of the Directorate of Fish Resources Management and

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[2] Punt and Donavan 2007, Developing management procedures that are robust to uncertainty: lessons from the International

[3] Hoshino et al 2017. SPC assessments used in 2017 Tech WS, Sidayah et al 2017.

[4] Dutto et al report on the available data series

[5] Sidayah et al 2017 CPUE and Ernawati et al selectivity

[6] Davies et al 2017, summary and conclusion presentation to stakeholder 2017 workshop

by instruction from the Director General for Capture Fisheries a steering committee was established.

Additionally, a technical group was established and led by the Centre for Fisheries research, which included technical guidance and input from Commonwealth Science and Industrial Research Organization (CSIRO), with extensive experience in harvest strategies and MSE, and supported by various stakeholders, including NGOs and academics.

Thirdly, coordinated again by the Directorate for Fish Resources Management, the progress was regularly communicated to and input sought from a wider stakeholder group including government officials and scientists, provincial governments, NGOs and industry (Appendix 2).

3. Relationship between harvest strategy for archipelagic waters and relevant Regional Fisheries Management Organizations

Indonesian archipelagic waters (IFMA 713, 714, and 715) are Indonesia's sovereignty. These waters are well-known for the abundance of tuna resources such as skipjack tuna, yellowfin tuna, and bigeye tuna. These species are categorized as highly migratory species.

According to UNCLOS (1982) which has been ratified by Indonesia through Act No. 17 Year 1985 that highly migratory species are managed by international or regional agreement, in this case is tuna Regional Fisheries Management Organization (tRFMO). The results of a large tuna tagging study conducted by SPC (2009-2010) indicates that while the majority of these tunas are recaptured within the archipelagic waters, there is exchange other IFMAs and with the wider WCPO. However, Indonesia has a strong commitment to managing tuna resources within its archipelagic waters in a sustainable manner and consistent with the intent of measures adopted by RFMOs, such as through the implementation of harvest strategy. This includes the use of the most recent WCPFC stock assessments in the MSE models used to develop and test the harvest strategies for skipjack and yellowfin tuna (See Appendix 1 and 2).

4. Action plan for refinement, testing and selection of harvest strategies and operational implementation for tropical tuna fisheries in 713, 714 and 715

Implementation of harvest strategies for tuna in IAW requires the following priority activities to be completed:

1. Maintenance, extension and improvement of fisheries monitoring and data collection programs
2. Targeted research
    a. Representative age, growth and reproductive biology parameters for archipelagic waters
    b. Operational catch and effort data for pole and line and hand line fisheries to improve CPUE standardisation
    c. Review and design of port monitoring programs to improve estimation of total catch and effort in archipelagic waters
3. Testing, refinement and selection of operational objectives and harvest strategy
    a. Technical work program
    b. Stakeholder consultation
4. Specification and implementation of management measures
    a. Refine detail of preferred management measure(s) which are considered operationally feasible to implement, monitor and enforce.
    b. Determine necessary regulatory and monitoring requirements for implementation
5. Confirmation of regulatory and institutional arrangements required for harvest strategy implementation
    a. Regulations
    b. Institutional roles and responsibilities
    c. Consultative and advisory forums

6. Policy, stakeholder and science capacity development for harvest strategy implementation

The action plan for implementation (Appendix 3) provides an overview of activities, schedule, responsible agency and contributing partners. A draft of a more detailed action plan is at Appendix 4.

APPENDIX 1. Framework for Harvest Strategy for Skipjack, Yellowfin Tuna, and Bigeye Tuna in Archipelagic Waters of Indonesia

1. Management Objectives

Ensure the sustainability of tuna resources in archipelagic waters of Indonesia through harvest strategy implementation.

a. Reference Points

i. Limit Reference Point

The default limit reference point for skipjack, yellowfin and bigeye tuna in archipelagic waters is to maintain spawning stock biomass above 0.2 of the unfished level with a 90% probability.

This is consistent with the default limit reference points recommended by the WCPFC Scientific Committee and adopted by WCPFC8[7].

ii. Target Reference Point

A target reference point for tuna in archipelagic waters has not been decided. The issue of target reference points requires more detailed consideration of the implications of species specific target reference points for the broader social and economic objectives for the fishery.

The WCPFC adopted target reference point for skipjack tuna of 0.5 of unfished spawning biomass on average[8], while the IOTC has adopted Target

[7] Report of the 7th meeting of the Scientific Committee of the WCPFC (https://www.wcpfc.int/meetings/7th-regular-session-scientific-committee) and adopted at WCFPC8, based on Preece et al 2012 (https://www.wcpfc.int/node/2745).

[8] WCPFC14, CMM 2015-06, https://www.wcpfc.int/system/files/CMM%202015-06%20CMM%20on%20a%20Target%20Reference%20point%20for%20WCPO%20Skipjack%20Tuna.pdf

Reference Point for skipjack of 0.4 estimated unfished spawning biomass on average[9].

Alternative target reference points for skipjack tuna, yellowfin tuna and bigeye tuna in the Indonesian archipelagic water will be investigated, based on stakeholder consultation, as a part of technical and consultative work program for harvest strategy implementation.

2. Harvest Strategy Framework

a. Potential Monitoring Data Series

The potential monitoring data series that could be used as an inputs to harvest strategies were identified during the technical consultation process during 2016[10]. These are:

i. Catch and effort data from pole and line fishery for skipjack tuna, deep hand line fishery (and potentially longline fishery) for yellowfin and bigeye tuna sourced from port sampling, logbook, and observer on board data] used to calculate CPUE.

ii. Size distribution of catch from pole and line fishery for skipjack tuna, deep hand line fishery (and potentially longline fisher) for yellowfin tuna and bigeye tuna sourced from port-based sampling programs (CFR-WCPFC- WPEA project, MDPI, etc.).

b. Analysis Method

i. CPUE standardization to provide a relative abundance index.

ii. Calculation of trend in average size of fish in catch from pole and line fishery (skipjack) and deep hand line or longline fishery (yellowfin, bigeye).

c. Forms of Harvest Control Rule

[9] IOTC Resolution 2016-02, http://iotc.org/cmm/resolution-1602-harvest-control-rules-skipjack-tuna-iotc-area-competence.

[10] Exploratory analysis of the Indonesian port-sampling data, Hobart, July 2016; 1st Technical Workshop, Bogor, April 2016.

i. Empirical harvest control rule. Preliminary MSE testing considered a weighted combination of standardized CPUE and average mean length of fish in catch from the selected fishery[11].

d. Management Measures
   i. Effort controls
   ii. Specific details of management measures and implementation requirements need to be specified and will be determined through consultation and technical work plan (Appendix 3 and 4).

3. Priority Information Needs

a. Operational, disaggregated catch and effort information for the Indonesian fisheries to improve the accuracy of estimating CPUE index from the monitoring data series identified.
b. Continuation and expansion of coverage of port-based monitoring (e.g. through increasing the sample sizes or sampling locations) for estimation of total catch and size distribution of catch.
c. Population biology of skipjack, yellowfin and bigeye tuna in archipelagic waters (age, growth, reproduction) in order to better understand the productivity of those species in the Indonesian archipelagic waters.
d. Given that social and economic objectives which have been identified as important during the Stakeholder consultations, social and economic data and indicators need to be collected.
e. Improve the data collection for small scale fisheries.
f. Feasibility assessment for implementation of alternative forms of effort management measures.

[11] Hoshino, E. R. Hillary, C. Davies and C. Proctor, 2018. Development of prototype operating models for exploring harvest strategies for tropical tuna in the Indonesian archipelagic waters: case studies for skipjack and yellowfin tuna. Draft report to the Western Central Pacific Fisheries Commission, 2018.

APPENDIX 2. Summary of Technical and Consultative Process for Development of Framework for Harvest Strategy for Skipjack, Yellowfin Tuna and Bigeye Tuna in Indonesian Archipelagic Waters

Multiple stakeholder consultations and technical workshops have taken place over the last 2 years, fostering a transparent and participative environment for harvest strategy development.

Date	Meeting type	Location
October 30 -31, 2014	Preparation meeting	Bogor, Java
March 25-27, 2015	Harvest strategy preparation and introduction meeting	Bogor, Java
May 18-22, 2015	Stakeholder consultation and expert meeting	Bogor, Java
August 10, 2015	Pre-workshop for data analysis	Bogor, Java
November 16-18, 2015	Stakeholder consultation	Kuta, Bali
November 19-20	Baseline data to develop harvest strategies	Kuta, Bali
April 4-7, 2016	1st Technical meeting for harvest strategy development	Bogor, Java
November 10-11, 2016	2nd Technical meeting for harvest strategy development	Denpasar, Bali
November 14-16, 2016	Stakeholder consultation	Bogor, Java
March 6-7, 2017	3rd technical meeting for harvest strategy development	Jakarta, Java
March 8-10, 2017	5th Stakeholder consultation	Jakarta, Java
July 12-13, 2017	6th Stakeholder consultation	Loka Tuna, Bali
October 2017	4th Technical Meeting	Bogor, Java
November 2017	7th Stakeholder consultation	Bogor, Java

APPENDIX 3. Summary Action Plan for Indonesian Archipelagic Water Tuna Harvest Strategy 2018-2023

HS Component		Progress to date as per May 2018		Required Action	Lead Agency	Time frame
Management Strategy Evaluation	Harvest Strategy	Management Objectives	To ensure the sustainability of yellowfin tuna, bigeye tuna and skipjack tuna resources	familiarize the agreed Management objectives at national levels (Province and district)	DGCF	2018-2019
		Operational Objectives	To maintain spawning stock biomass (SSB) above the limit reference point (LRP) of 0.2 SSBF=0, *with the probability of 90% during the 10 years projection period*	take into account in the determination of MM to the OM and tested; Consider TRP in light of results of MSE testing	DGCF, AMFRHR	2018
		Monitoring	MAINTAIN Port sampling data collection Bitung, Kendari, Sodohoa, Sorong, Majene (since 2011). Review existing government, industry and NGO programs and design and prioritise long-term monitoring requirements for harvest strategy implementation	Increase Data collection program by X % from the 2018 base line through strong collaboration with industry, fishing association and NGOs, log book, observer, RVIA, SIMKADA	DGCF, AMFRHR, MDPI, AP2HI, SFP, ATLI, ASTUIN	2018-end (Long term continues program)
		Analysis	CPUE Standardization and Mean Length from Pole and Line (SKJ) and Hand Line (YFT).	Conduct annual analysis, Data maintenance, handling and exploration, consulting, reporting and refine CPUE	AMFRHR, CSIRO	

		Harvest Control Rule (HCR)	Empirical harvest strategy indices of relative abundance (standardized catch rates), and/or size structure of the catch	Complete MSE testing of final HCRs; Adopt and implement the HCR	AMFRHR, CSIRO AMFRHR, CSIRO	2018-2019
		Management Measure (MM)	1. Limit on use of Fish Aggregating Devices, 2. Spatial closures (of important spawning or nursery grounds) and temporal closures (during important events such as spawning). 3. Number of fishing days (per gear, for semi industrial and industrial vessels). 4. Number of vessels – limited entry (per gear; for semi industrial and industrial vessels through licensing, permits, taxing, royalties).	Issue the HS management measures through MMAF Decree/regulation, familiarize and enforce the measure to Province and District as well as Industry; Register All Fishing Boat/gear through RVIA and SIMKADA	DGCF, PROVINCE, DISTRICT	2018-2019
			5. Total Allowable Catch (TAC) limits per Fishery Management Area.	Evaluate the compliance and Effectiveness of the MM	DGCF	2020
	MSE testing	OM has been developed and updated		Update OMs with most recent SPC stock assessment and new biology and fishery parameters; Complete MSE testing of final HSs	DGCF, AMFRHR, CSIRO	2019-2020
	Targeted Research	**Biology and fishery parameters has been defined for IAW**		age, growth and reproductive biology to estimate productivity, operational catch and effort data for CPUE indices	AMFRHR, CSIRO	2018-2023

Note: **AMFRHR:** Agency for Marine and Fisheries Research and Human Resource; CSIRO**:** Commonwealth Scientific and Industrial Research Organisation; **DGCF:** Directorate General for Capture Fisheries; **MDPI:** Masyarakat dan Perikanan Indonesia; **NGO:** Non-Government Organization; **RVIA:** Record of Vessels Authorized to fish for tuna skipjack tuna and neritic tuna; SIMKADA: Sistem Informasi Izin Kapal Daerah.

APPENDIX 4. Draft detail action Plan for a five-year implementing the IAW tuna Harvest strategy (2018-2023)

No	Technical Activity	Rational for activity	Location	WPP	Gear	Species	Project/ Management Organization	Implementing Organization	Timeline Proposed
MONITORING									
1	Port side enumeration	Gathering information on tuna for submission to Indonesian research and stock assessments. Monitoring to gather length, CPUE and other data for the HS OM.	Lombok, Kupang,Seram Utara, Seram Selatan, Buru Utara, Buru Selatan, Ambon, Bisa, Manado, Sangihe, Bitung, Sorong, Toli-Toli, Bone	713, 714, 715, 716, 717, 572, 573	HL, PL, TL	YFT, BET, SKJ, ALB	MDPI, SEA USAID, Oceans USAID	MDPI	Ongoing
2	Port side enumeration	Gathering information on all aspects of the tuna FAD-based fisheries. Hopefully to assist HS development process.	Padang, Palabuhanratu, Kendari, Sorong	572, 573, 714, 715, 717	HL/TL, PL, PS	Main focus YFT, SKJ, BET but also non-target species (i.e. characterisation of all catch on tuna FADS).	**ACIAR Project FIS/2009/059**, CSIRO in partnership with CFR	CFR-CSIRO	Oct 2013 - present (at Kendari and Palabuhanratu). Oct 2013 - March 2015 (at Padang and Sorong).

3	Landing/port site enumeration	Monitoring to gather length, CPUE and other data for the HS OM	Bandaneira, Ambon	714	HL	YFT, BET	SFP-LINI	SFP-LINI	Ongoing
4	Port side enumeration	Monitoring to gather length, CPUE and other data for the HS OM	Bandaneira	714	HL	YFT	PT Intimas Surya; PT KML	PT Intimas Surya; PT KML	Ongoing
5	Port side enumeration	Monitoring to gather length, CPUE and other data for the HS OM	Ambon	714	LL	YFT, BET	PT MPM/PT KML	PT MPM/PT KML	yearly, starting 2017 data
6	Port side enumeration	Monitoring to gather length, CPUE and other data for the HS OM	Bitung, Kendari, Sodohoa, Sorong, Majene, Gorontalo	713, 714, 715, 716, 717	PL, PS, HL, TL, LL, GN	YFT, BET, SKJ	WCPFC (WPEA project)	CFR	Starting 2010
7	Observer onboard	Collect operational CPUE and fishing position, length in catch		All 11 areas	PL, PS, HL, LL	YFT, BET, SKJ, ALB	DGCF (National Observer Program)	DGCF	Starting 2013
8	Logbook filled by captains onboard	Collect operational CPUE and fishing position		All 11 areas		YFT, BET, SKJ, ALB	DGCF (National Logbook Program)	DGCF	Starting 2013
DATA MANAGEMENT									
9	E-BRPL (E-national stock assessment data)	One gate stock assessment data from Port sampling and Scientific observer	Indonesia	All	All	all species	BRPL-CFR, KOMNAS,	BRPL	On Going

10	Production data (One Data)	Contribute to National Statistical data, One Data	Indonesia	All	All	all species	One Data	One data	Ongoing
11	Logbook	CPUE for the HS	Indonesia	All	All	all species	DGCF	DGCF	Continuing
12	Database- I-Fish for fisheries data management. Protocols developed to meet RFMO and national government standards.	To create template for industry-oriented data collection in the supply chain to contribute to high level data, especially for small scale fisheries where a current gap exists. Support data needs towards eco-certification	Indonesia	573, 713, 714, 715, 716, 717	HL/TL, PL	Main focus YFT, SKJ, BET but also non-target species and encounters with Endangered, threatened and protected species	MDPI	MDPI	2012-present
13	IDAPAR- Indonesian data coordination platform.	Aiming to create one door into Indonesian government for 'external' data. Aim to create coordination amongst industry, NGOs and others creating data and wishing to share with government- type of coordination platform.	Indonesia	All	all	all species	MDPI	MDPI	In development

TARGETED RESEARCH										
14	• Complete biological sampling of yellowfin, bigeye and skipjack tuna across the Indonesian archipelago; • Analyse biological samples and model the resulting data to estimate life-history parameters.	Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction)		713.714.715		BET,SKJ,YFT	**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	2014- 2020
15	• Socio-economic analyses and bio-economic modelling of tuna fisheries sectors and relevant communities; • Propose potential social and economic performance measures or indicators that can be incorporated in to the simulation evaluation framework (Management Strategy Evaluation); • Examine the potential trade-offs	Examine the potential social and economic impacts of alternative management measures through surveys and bio-economic modelling		713.714.715		BET,SKJ,YFT	**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	Ongoing until minimum 2019

	among social, economic and stock conservation objectives of various harvest strategies.								
16	Observer onboard	Fishing activities, CPUE, Biological Data, ETP inventory	Ambon	714	LL	YFT, BET and other pelagic	Loka Tuna Benoa and RIMF	Loka Tuna Benoa and RIMF Cibinong	starting in 2018
17	Marine and fisheries Survey	Exploratory, Ground check, sampling (Hydro acoustics, experimental fishing)	All	All	all	All	RIMF	Cibinong	Continuing
Fisheries management									
18	Provide expert advice to DGCF and CFRDCFR on the development and selection of operation harvest strategies, consistent with the National Tuna Harvest Strategy Framework (see Objective 1);	Evaluate operational harvest strategies for tropical tuna in Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies		713.714.715		BET,SKJ,YFT	**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	
19	Supporting HS process at National government for	Evaluate operational harvest strategies for tropical tuna in		713.714.715		BET,SKJ,YFT	MDPI-Various donors	MDPI	2017- 2018

	Indonesian Archipelagic waters-713, 714, 715 for SKJ, BET and YFT	Indonesia's Fisheries Management Areas 713 – 715 and provide technical advice to MMAF on selection and implementation of trial harvest strategies							
20	Supporting implementation of the NPOA Tuna on various topics	Certification, FIP implementation	Indonesia general			BET,SKJ,YFT	MDPI-Various donors	MDPI	
21	Support provincial level co-management initiatives- DMC/KPDP-data Management committees.	To support provincial level capacity building, to create multi stakeholder for a on fisheries management and to create data improvements to lead to better management on provincial levels.	Maluku, Maluku Utara, Sulawesi Utara, Sulawesi Selatan, NTT, NTB	573, 713, 714, 715, 716, 717	HL, TL, PL	BET,SKJ,YFT	MDPI-Various donors	MDPI	
22	Boat registration	Compliance to traceability	Ambon and Banda	714	HL	YFT	PT Intimas Surya; PT KML	PT Intimas Surya; PT KML	Ongoing
23	Vessel tracking	Understanding fishing grounds	Banda Sea	714	HL	YFT	SFP - LINI	SFP - LINI	ongoing

LEGISLATION									
24	Development of Fads Regulation						DGCF, Bureau of Law MMAF	DGCF, Bureau of Law MMAF	2019
25	Develop Ministerial decree for Harvest Strategy	Current regulation related to tuna management are scattered and aim to have a single regulation for tuna fisheries		ALL	ALL	ALL	DGCF, Bureau of Law MMAF	DGCF, Bureau of Law MMAF	2019
26	Supporting development of FAD regulatory update	Current FAD regulation has not been adequate in reaching FAD management objectives. Increasing pressure has created a need for an update to FAD regulation initiated by a proposed FAD amnesty to get an initial understanding on FAD density	National	National	HL, TL, PL, PS	all Tuna	MDPI-Various donors	MDPI	January 2018-December 2021

CAPACITY BUILDING									
27	• Review of current and proposed tuna research and monitoring activities and staff capabilities across CFRDCFR and DGCF, where appropriate, and institutional mechanisms for scientific advice and engagement in tuna RFMOs; • Develop a 5-10 year capability plan for tuna research and management and tuna RFMO engagement. • Provide targeted support for individual participation in formal and informal tuna RFMO technical meetings, for example through small grant proposals for capacity development funding from CCSBT.	Develop an operational capability plan for Indonesian tuna fisheries science and engagement in the relevant					**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	January 2018-December 2021

28	Conduct training workshops for Indonesian scientists to build capacity in contemporary population biology laboratory and analysis methods	Determine the productivity of skipjack, yellowfin and bigeye tuna in Indonesia by estimating relevant life-history parameters (age, growth, reproduction)		713.714.715		BET,SKJ,YFT	**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	
	Supporting capacity building of HS technical team through funding for capacity building	To ensure the HS process developed for Tuna can be multiplied to other Indonesian fisheries by creating a strong base and understanding for HS methodology within the wider Indonesian government scientific and management team.	Indonesian	all	all	all	MDPI-Various donors	MDPI	
29	Safety at sea	Support fishers safety knowledge	Banda	714	HL	YFT	SFP-LINI	SFP-LINI	yearly
30	Best practice in post-harvest	Support fishers' knowledge in maintaining quality	Banda	714	HL	YFT	PT Intimas Surya	PT Intimas Surya	yearly

CONSULTATION									
31	Conduct policy, management and research training workshops on harvest strategy development and implementation with Department of Agriculture and Water Resources (DAWR), Australian Fisheries Management Authority (AFMA) and CSIRO. These will focus on practical experience with the Commonwealth Harvest Strategy Policy and providing concrete examples of the interaction between fisheries policy, management and science.	Facilitate policy and technical consultative processes for Harvest Strategy development		713.714.715		BET,SKJ,YFT	**ACIAR Project FIS/2016/116**, CSIRO in partnership with CFR	CSIRO	Ongoing-minimum 2020

OTHER									
32	Certification- FT and FIP work focused on MSC	These approaches create strong motivation for HS development and create a framework for moving towards good management	National	all	all	HL, TL, PL	MDPI	MDPI	
33	social economy survey	understanding the socio-economic aspects	Banda	714	HL	YFT	SFP-LINI	SFP-LINI	ongoing

Ministry of Marine Affairs and Fisheries of
The Republic of Indonesia

11.8 Appendix 9: HS questionnaire on objectives and ref points workshop

Direktorat Pengelolaan Sumber Daya Ikan
Direktorat Jenderal Perikanan Tangkap
Kementerian Kelautan dan Perikanan

Gedung Mina Bahari II Lantai 14
Jl. Medan Merdeka Timur No. 16 Jakarta Pusat 10110

DIREKTORAT PENGELOLAAN SUMBER DAYA IKAN
DIREKTORAT JENDERAL PERIKANAN TANGKAP
KEMENTERIAN KELAUTAN DAN PERIKANAN
2016

SURVEY REPORT
QUESTIONNAIRE ANALYSIS ON INDONESIA TUNA FISHERIES IN RELATION WITH THE HARVEST STRATEGY DEVELOPMENT OF TUNA IN WPPNRI 713, 714, 715

LAPORAN SURVEI HASIL KUISIONER PERIKANAN TUNA DI INDONESIA

Supported by

Western and Central Pacific Fisheries Commission
CSIRO
Yayasan Masyarakat dan Perikanan Indonesia
IPNLF International Pole & Line Foundation
AP2HI
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DIREKTORAT PENGELOLAAN SUMBER DAYA IKAN
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LAPORAN SURVEI
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IPNLF International Pole & Line Foundation
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Sustainable Fisheries Partnership

SUMMARY

This survey was conducted as part of a multi-stakeholder process for harvest strategy development, specifically related to WPPNRs 713,714,715. Harvest strategy development is both a regional and international requirement but more importantly it is national approach towards ensuring sustainability of our stocks and in this way supporting food security and economic development. Indonesia is working towards a process of Harvest Strategy development over a period provisionally of 4 years, 2014-2017. The feedback gathered by this survey aims to gather information on the views of a wide selection of stakeholders related to tuna fisheries in WPPNRIs 713,714,715 with the

RINGKASAN

Survei ini dilaksanakan sebagai bagian dari proses keterlibatan *multi stakeholer* untuk penyusunan *harvest strategy* tuna dan cakalang terutama terkait dengan WPPNRI 713,714,715. Penyusunan *harvest strategy* merupakan persyaratan regional dan internasional, tetapi hal yang lebih penting adalah bahwa hal tersebut merupakan pendekatan nasional untuk memastikan keberlanjutan stok tuna dan cakalang, guna mendukung ketahanan pangan dan pembangunan ekonomi nasional. Indonesia sedang melaksanakan proses penyusunan *harvest strategy* tuna dan cakalang yang diperkirakan akan berlangsung selama 4 (empat) tahun yaitu 2014 2017. Umpan balik yang diperoleh dari survei ini ditujukan untuk mengumpulkan informasi tentang pandangan dari berbagai lapisan

view towards ensuring that management development which results from the HS development process is created in a multi-stakeholder approach, incorporating opinions and objectives of these stakeholders, thus aiming to ensure compliance, commitment and support by the range of actors as the process continues.

stakeholder terkait dengan perikanan tuna dan cakalang di WPPNRI 713,714 dan 715 dengan maksud untuk menjamin bahwa pengembangan pengelolaan perikanan tuna melalui penyusunan *harvest strategy* dilakukan melalui pendekatan keterlibatan berbagai lapisan stakeholder, mengelaborasi pendapat dan tujuan stakeholder, untuk menjamin kepatuhan, komitmen dan dukungan dari berbagai pihak selama proses berlangsung.

The primary interest of tuna fisheries in Indonesia is related to food security and the secondary is related to economic development at national level. But at the same time, there is a reflection that conservation of tuna fisheries resources is become an important issue/interest. Even though the state of Indonesia's tuna fisheries is average, but ok condition, but there is a strong views that the state is considered as poor condition. This views is become an appropriate justification to strengthen tuna fisheries management practices in Indonesia in order to increase the state to become good condition in the future.

Perikanan tuna di Indonesia memiliki peran penting, utamanya terkait dengan ketahanan pangan dan pengembangan ekonomi nasional. Namun pada saat yang sama, isu konservasi sumberdaya tuna juga menjadi hal yang sangat penting. Meskipun kondisi pengelolaan perikanan tuna Indonesia dinilai rata rata dan kondisi baik, tetapi pada saat yang sama terdapat pandangan kuat yang menyimpulkan bahwa kondisi pengelolaan perikanan tuna Indonesia dewasa ini dalam keadaan tidak baik. Keadaan ini dapat dijadikan dasar yang memadai untuk memperkuat praktek pengelolaan tuna di Indonesia, dengan tujuan meningkatkan kualitas pengelolaan menjadi lebih baik pada masa yang akan datang.

The major pressures on the condition of Indonesia's tuna fisheries particularly in WPP713, 714, 715 and threats to their sustainability are (i) Too many purse-seine fleet, (ii) Too many deployed FAD, (iii) Destructive fishing practices. This view indicates there is an urgent need to manage purse-seine fisheries and FAD limitation, as well as destructive fishing practices to ensure the sustainability of tuna resources in the area.

Tekanan utama terhadap kondisi sumberdaya tuna di Indonesia terutama di WPPNRI 713, 714 dan 715 yang dapat mengancam keberlanjutan adalah (i) terlalu banyak armada purse seine, (ii) terlalu banyak rumpon yang ditebar dan (iii) adanya praktek penangkapan tuna secara destruktif (merusak). Pandangan ini menunjukkan adanya kebutuhan segera untuk mengelola perikanan purse seine dan pembatasan penebaran rumpon, termasuk menertibkan praktek penangkapan ikan yang merusak guna menjamin keberlanjutan sumberdaya tuna di wilayah tersebut diatas.

The most appropriate management measure for skipjack tuna particularly in WPP713, 714, 715 are (i) implement catch quota system, (ii) limit FAD deployment and (iii) limit fishing effort. It is also recommended to enlarge mesh size for purse-seine, establish conservation area and Limit Fishing gear type in skipjack tuna fisheries.

Tindakan pengelolaan yang memadai untuk cakalang terutama di WPPNRI 713,714 dan 715 adalah (i) pembatasan penebaran FAD, (ii) melaksanakan sistem kuota hasil tangkapan dan (iii) pembatasan upaya penangkapan (*fishing effort*). Disamping itu, juga terdapat rekomendasi untuk memperbesar ukuran mata jaring purse seine, menetapkan wilayah konservasi dan pembatasan jenis alat penangkapan ikan untuk cakalang.

The most appropriate management measure for yellowfin tuna are (i) implement catch quota and Limit FAD, (ii) limit fishing permit, fishing effort and fishing gear size, auxiliary fishing gear and (iii) limit vessel size. It is also recommended to enlarge mesh size for purse-seine, establish conservation area, purse-seine moratorium and determine minimum size of YF tuna allowable to landing.

Tindakan pengelolaan yang memadai untuk madidihang adalah (i) pembatasan FAD, (ii) melaksanakan sistem kuota hasil tangkapan (iii) pembatasan upaya penangkapan. Disamping itu, juga terdapat rekomendasi untuk memperbesar ukuran mata jaring purse seine, menetapkan wilayah konservasi, moratorium purse seine dan menentukan ukuran madidihang minimum yang bisa didaratkan.

The most appropriate management measure for bigeye tuna are (i) implement catch quota, (ii) Limit FAD, (iii) fishing effort and fishing gear size (iv) limit fishing permit (v) limit auxiliary fishing gear and (vi) limit vessel size. It is also recommended to establish conservation area for BET, implement closing and open system, limit number of fishing fleet and deploy observer on-board.

As conclusion, this survey reflect on the thinking of the wider scope of stakeholder presenting that industries have the same ideas as managers and scientist about potential management needed and the same opinion on the status of the tuna stocks. This lays basis for a collaborative approach to harvest strategy development and hopefully to an industry commitment to ensure that successful management will be implemented, supported by a strong government presence.

Tindakan pengelolaan yang memadai untuk tuna mata besar adalah (i) melaksanakan sistem kuota hasil tangkapan, (ii) membatasi penebaran FAD, (iii) membatasi upaya penangkapan. Disamping itu, juga terdapat rekomendasi untuk menetapkan wilayah konservasi tuna mata besar, melaksanakan sistem buka tutup, membatasi jumlah armada penangkapan dan memobilisasi petugas pemantau diatas kapal.

Sebagai kesimpulan, survei ini mencerminkan pemikiran dari berbagai lapisan stakeholder yang menunjukkkan adanya kesamaan pendapat dan gagasan antara pelaku usaha dan petugas pengelola (*manager*) serta ilmuwan (*scientist)* tentang adanya potensi kebutuhan menajemen dan juga memiliki pendapat yang sama tentang status stok perikanan tuna. Hal ini menjadi landasan yang tepat untuk melakukan pendekatan kolaboratif dalam penyusunan *harvest strategy* tuna dan cakalang, dengan harapan terwujudnya komitmen pelaku usaha (industri) untuk menjamin agar pengelolaan yang baik akan dilaksanakan, didukung dengan kehadiran pemerintah yang kuat.

PREFACE

KATA PENGANTAR

As an international agreement, United Nation Fish Stocks Agreement 1995 provide principles and guidance for the management of highly migratory fish stocks, including support for reference points-based management. The treaty calls on States to take a number of steps, among other including to determine, on the basis of the best scientific information available, stock-specific reference points and the action to be taken if they are exceeded. The development of harvest strategy/harvest control rule is an approach to determine the stock-specific reference points.

In implementation of action plan of Objective 1.c. WPPNRI 713,714,715.3 of the Minister Decree Number.107/KEPMEN-KP/2015 of 25 August 2015 on Fisheries Management Plan for Tuna, Skipjack Tuna and Neritic Tuna, Directorate of Fisheries Resource Management, Directorate General of Capture Fisheries has initiated a development of the harvest strategy/harvest control rule harvest strategy/harvest control rule. Due to the complexity of this works, collaboration has been established with the working unit within MMAF, Concerned Local Government, University,

United Nation Fish Stocks Agreement 1995 merupakan perjanjian internasional yang telah menetapkan prinsip dan acuan pegelolaan sediaan ikan yang beruaya jauh *(highly migratory fish stocks)* termasuk mendukung penerapan praktek pengelolaan berdasarkan titik acuan *(reference point).* Perjanjian internasional tersebut mengharuskan setiap Negara mengambil berbagai langkah, meliputi antara lain "menentukan, berdasarkan informasi ilmiah terbaik yang tersedia, titik acuan stok jenis sediaan ikan serta aksi aksi yang akan dilakukan jika jumlah ikan hasil tangkapan melebihi titik acuan yang telah ditentukan". Hal tersebut hanya dapat dilakukan melalui penyusunan *Harvest Strategy/Harvest Control Rules.*

Dalam rangka melaksanakan rencana aksi Tujuan 1.c. WPPNRI 713,714,715.3 Keputusan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 107/KEPMEN KP/2015 tanggal 28 Agustus 2015 tentang Rencana Pengelolaan Perikanan Tuna, Cakalang dan Tongkol, Direktorat Pengelolaan Sumber Daya Ikan telah bernisiatif melakukan penyusunan *Harvest Strategy /Harvest Control Rules.* Mengingat pekerjaan ini mempunyai sifat dan kompleksitas tertentu, maka penyusunan *Harvest Strategy/ Harvest Control Rules* ini dilakukan bekerjasama dengan Unit Kerja Eselon I LIngkup KKP, Pemerintah Daerah Provinsi dan Kabupaten/Kota terkait, Perguruan Tinggi, organisasi regional/

regional/ international organization such as WCPFC, CSRIRO-Australia as well as NGO and Association such as Masyarakat dan Perikanan Indonesia (MDPI), *International Pole and Line Foundation (IPNLF), The Nature Conservation* (TNC), Asosiasi Pole and Line dan Handline Indonesia (AP2HI), Sustainable Fisheries Partnership (SFP), Asosiasi Tuna Longline Indonesia (ATLI) Bali, Asosiasi Tuna Indonesia (ASTUIN), Asosiasi Perikanan Tangkap Terpadu (ASPERTADU), and Industries.

In developing of the harvest strategy, the stakeholder's perception on the Indonesia tuna fisheries is one of the important aspects. For this reason, the agenda at the Harvest Strategy/Harvest Control Rules Workshop in Bali, 16-20 November 2015 including the research on stakeholder's perception on the Indonesia tuna fisheries by filling-out the questionnaire. This step is very urgent in relation to the implementation of collaborative approach in the development of the Harvest Strategy/Harvest Control Rules. All information included in this report may inspire the team to finalize the development of Harvest

internasional yakni WCPFC, CSIRO Australia serta dengan berbagai LSM dan Asosiasi seperti Masyarakat dan Perikanan Indonesia (MDPI), *International Pole and Line Foundation (IPNLF), The Nature Conservation* (TNC), Asosiasi Pole and Line dan Handline Indonesia (AP2HI), Sustainable Fisheries Partnership (SFP), Asosiasi Tuna Longline Indonesia (ATLI) Bali, Asosiasi Tuna Indonesia (ASTUIN), Asosiasi Perikanan Tangkap Terpadu (ASPERTADU), dan para pelaku usaha.

Salah satu aspek penting dalam penyusunan *Harvest Strategy/Harvest Control Rules* adalah persepsi stakeholder terhadap perikanan tuna Indonesia. Oleh karena itu, kegiatan workshop di Bali, 16 20 November 2016 mencakup pengisian kuisioner oleh berbagai stakeholder mengenai persepsi mereka terhadap kondisi perikanan tuna Indonesia. Analisis terhadap persepsi stakeholder ini sangat penting sebagai wujud pelaksanaan pendekatan kolaboratif dalam penyusunan *Harvest Strategy/Harvest Control Rules.*yang guna menjamin terlaksananya strategi pengelolaan di kemudian hari. Kiranya informasi dalam laporan ini memberikan inspirasi bagi tim penyusun agar dapat menyelesaikan kegiatan *penyusunan Harvest Startegy* untuk tuna Madidihang dan Cakalang

Strategy/Harvest Control Rules for Yellowfin Tuna and Skipjack Tuna within IFMA 713,714,715 in accordance with the agreed time framework namely 2014-2017.

Finally, we very much appreciate the *Harvest Strategy/Harvest Control Rules team* for providing this report.

di WPPNRI 713,714 dan 715 sesuai dengan kurun waktu yang telah ditentukan yaitu 2014 2017.

Akhirnya, kami mengucapkan terima kasih kepada tim penyusun *Harvest Strategy/Harvest Control Rules* atas tersusunnya laporan ini.

Jakarta, April 2016

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DAFTAR ISI

SURVEY REPORT

QUESTIONNAIRE ANALYSIS ON INDONESIA TUNA FISHERIES

A. SCOPE OF QUESTIONNAIRE

The questionnaire consist of 12 topics in which there are ten (10) closed-question and two (2) opened-question. The topics of the questionnaire are as follow:

1. Primary interest of tuna fisheries in Indonesia
2. Secondary interest of tuna fisheries in Indonesia
3. Current assessment of the state of Indonesia's tuna fisheries
4. Sort of information/indicators as a base of the state of the stocks and the fishery on.
5. The best indicators of the status
6. Ideal level of indicators identified in 6
7. The major pressures on the condition of Indonesia's tuna fisheries in WPP713, 714, 715 and threats to their sustainability.
8. The most appropriate options/ tools/measures for manages these pressures.
9. Sort of management measures are the most appropriate for skipjack tuna.

LAPORAN SURVEI

HASIL KUISIONER PERIKANAN TUNA DI INDONESIA

A. RUANG LINGKUP KUISIONER

Kuisioner terdiri dari 12 topik pertanyaan, 10 diantaranya berupa pertanyaan tertutup (*closed question*) dan 2 pertanyaan terbuka (*opened-question*). Topik kuisioner adalah sebagai berikut:

1. Peranan utama perikanan tuna di Indonesia.
2. Peranan lain perikanan tuna di Indonesia.
3. Penilaian kondisi perikanan tuna di Indonesia.
4. Informasi/indikator yang mendasari penilaian kondisi perikanan tuna di Indonesia.
5. Indikator terbaik untuk status perikanan tuna.
6. Tingkat ideal indikator yang teridentifikasi pada butir 5.
7. Tekanan utama terhadap kondisi perikanan tuna Indonesia terutama di WPPNRI 713,714 dan 715.
8. Opsi tindakan pengelolaan yang terbaik untuk mengelola tekanan terhadap sumberdaya tuna.
9. Tindakan pengelolaan yang paling layak untuk cakalang.

10. Sort of management measures are the most appropriate for yellowfin tuna
11. Sort of management measures are the most appropriate for bigeye tuna
12. The difference of fleet and gear (Industrial, commercial, artisanal).

The Questionnaire was originally developed by international expert in English version and modified by workshop participants into Bahasa Indonesia **(Attachment 1)**.

10. Tindakan pengelolaan yang paling layak untuk madidihang.
11. Tindakan pengelolaan yang paling layak untuk tuna mata besar.
12. Perbedaan armada dan alat panangkapan ikan antara industri/komersial dan artisanal.

Kuisioner diatas disusun oleh ahli internasional dalam Bahasa Inggris dan diterjemahkan serta dimodifikasi kedalam Bahasa Indonesia oleh peserta workshop (**Lampiran 1**).

B. RESPONDENT

The questionnaire is presented to respondents at the Harvest Strategy Workshop was held by Directorate General of Capture Fisheries (DGCF) at 16-20 November 2015 in Bali. There are 54 respondents in this regards, composed of scientist (12), NGO (7), Managers (22), Fishing Industries and Association (9) as well as International Expert (4). List of respondents is shown in the **attachment 2**.

B. RESPONDEN

Daftar pertanyaan dipresentasikan kepada responden pada workshop *Harvest Startegy* yang diselenggarakan oleh Direktorat Jenderal Perikanan Tangkap pada tanggal 16 20 November 2015 di Bali. Terdapat 54 responden yang terdiri dari peneliti (12), LSM (7), Dinas Perikanan (22), pelaku usaha dan asosiasi (9) dan *expert* internasional (4). Daftar responden sebagaimana **lampiran 2.**

C. ANALYSIS OF QUESTIONNAIRE

Analysis to the respondents' response is undertaken by each topics, with the following preliminary conclusion:

C. ANALISIS KUISIONER

Analisis jawaban responden dilakukan berdasarkan topik pertanyaan melalui penentuan bobot (*weight*) untuk setiap jawaban responden, dengan hasil sementara sebagai berikut:

1. Primary interest related with tuna fisheries in Indonesia

No	Primary Interest	Total weight	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Food Security	14,80	2	3,69	15	4,34	5	4,29	3	2,48	0	0
2	Commercial Activity	12,03	1	1,85	12	3,47	3	2,57	5	4,14	0	0
3	Economic Development at	11,16		2,46		3,08		2,86		2,76		0
	a. Local	12,08	1	1,85	12	3,47	5	4,29	3	2,48	0	0
	b. Regional	10,49	2	3,69	9	2,60	2	1,71	3	2,48	0	0
	c. National	10,91	1	1,85	11	3,18	3	2,57	4	3,31	0	0
4	Knowledge (Science and Social, Cultural, Economic Research)	18,30	3	5,54	7	2,02	4	3,43	4	3,31	1	4
5	Conservation of Fisheries Resource	13,58	2	3,69	11	3,18	3	2,57	5	4,14	0	0
6	Conservation of biodiversity	7,81	1	1,85	6	1,73	3	2,57	2	1,66	0	0
7	Other	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0
TOTAL		100,00	13	24	83	24	28	24	29	24	1	4

Note: FIA = Fishing Industries and Association; IE = International Expert

The above table reflect that the primary interest of tuna fisheries in Indonesia respectively as (i) knowledge, (ii) food security, (iii) conservation of fisheries resources, (iv) economic development at national, regional and local and (vi) conservation of biodiversity.

Dari tabel diatas diketahui bahwa kepentingan utama perikanan tuna di Indonesia secara berturut turut terkait dengan (i) pengetahuan, (ii) ketahanan pangan, (iii) konservasi sumberdaya ikan, (iv) pengembangan ekonomi lokal, nasional dan regional, dan (v) konservasi keanekaragaman hayati.

But when perception is based on the national respondents, the primary interest of tuna fisheries in Indonesia is differ from the previous perception and become respectively as (i) food security, (ii) knowledge, (iii) conservation of fisheries resource, (iv) commercial activity,(v) economic development at national, regional and local level, (vi) conservation of biodiversity.

Namun demikian, bilamana persepsi didasarkan pada pandangan responden nasional maka kepentingan perikanan tuna Indonesia mengalami perubahan dan secara berturut turut terkait menjadi (i) ketahanan pangan, (ii) pengetahuan, (iii) konservasi sumberdaya ikan, (iv) kegiatan komersial, (v) pengembangan ekonomi nasional, regional dan lokal (vi) konservasi keanekaragaman hayati.

2. Secondary interest of tuna fisheries in Indonesia

No	Secondary Interest	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Food Security	13,45	2	4,80	4	1,96	2	3,69	3	3,00	0	0,00
2	Commercial Activity	10,21	1	2,40	4	1,96	1	1,85	4	4,00	0	0,00
3	Economic Development at	12,75		2,40		2,94		3,08		4,33		0,00
	a. Local	9,78	0	0,00	6	2,94	1	1,85	5	5,00	0	0,00
	b. Regional	10,18	1	2,40	6	2,94	1	1,85	3	3,00	0	0,00
	c. National	18,28	2	4,80	6	2,94	3	5,54	5	5,00	0	0,00
4	Knowledge (Science and Social, Cultural, Economic Research)	8,74	0	0,00	10	4,90	1	1,85	2	2,00	0	0,00
5	Conservation of Fisheries Resource	20,68	3	7,20	6	2,94	3	5,54	1	1,00	1	4,00
6	Conservation of biodiversity	8,67	1	2,40	7	3,43	1	1,85	1	1,00	0	0,00
7	Other	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
	TOTAL	100,00	10,00	24,00	49,00	24,00	13,00	24,00	24,00	24,00	1,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert

The above table (national and international respondent) reflect that the secondary interest of tuna fisheries in Indonesia respectively as (i) conservation of fisheries resources, (ii) food security, (iii) economic development at national, regional and local, (iv) commercial, (v) knowledge and (vi) conservation of biodiversity.

Dari tabel diatas (responden nasional dan internasional) dapat diketahui bahwa kepentingan tambahan (*secondary interest*) perikanan tuna di Indonesia secara berturut turut terkait dengan (i) konservasi sumberdaya ikan, (ii) ketahanan pangan, (iii) Pengembangan ekonomi, (iv) kegiatan komersil, (v) pengetahuan dan (vi) konservasi keanekaragaman hayati.

As a conclusion, the above two (2) tables reflect that there are three (3) areas of the interest of tuna fisheries in Indonesia which are related to (i) food security, (ii) economic development at national, regional and local level and (iii) conservation of fisheries resource.

Berdasarkan pandangan pada 2 (dua) tabel diatas dapat disimpulkan bahwa terdapat 3 (tiga) kepentingan perikanan tuna Indonesia, dan secara berturut turut terkait dengan (i) ketahanan pangan dan (ii) pengembangan ekonomi pada tingkat nasional, regional dan lokal dan (iii) konservasi sumberdaya ikan.

3. Current assessment of the state of Indonesia's tuna fisheries

No	Current Assessment	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Good Condition	4,80	0	0	4	4,8	0	0	0	0	0	0
2	Average, but, ok condition	51,40	5	20	12	14,4	2	8	3	9	0	0
3	Poor Condition	43,80	1	4	4	4,8	4	16	5	15	1	4
TOTAL		100,00	6,00	24,00	20,00	24,00	6,00	24,00	8,00	24,00	1,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert

Even though most of respondent indicates that the state of Indonesia's tuna fisheries is average, but ok condition, nevertheless they

also reflect their views that the state is considered as poor condition. This views lay a basis to strengthen tuna fisheries management practices in Indonesia in order to increase the state to become good condition in the future.

Meskipun mayoritas responden menyatakan kondisi pengelolaan perikanan tuna Indonesia dalam keadaan rata rata, tetapi baik, namun demikian tercermin juga pandangan kuat yang menyatakan bahwa kondisi pengelolaan perikanan tuna Indonesia dalam keadaan buruk (*poor condition*). Pandangan ini menjadi justifikasi yang memadai untuk melakukan penguatan praktek pengelolaan perikanan tuna Indonesia dalam rangka meningkatkan kondisi praktek pengelolaaan menjadi lebih baik pada masa yang akan datang.

4. Sort of information/indicators as a base of the state of the stocks and the fishery on

No	Indicators of the Stocks	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Annual/Seasonal Catch Level	19,80	1	2	12	5,24	2	2,67	5	9,23	1	0,67
2	Catch Rate per trip/day	12,72	2	4	2	0,87	4	5,33	1	1,85	1	0,67
3	Average size/volume of fish in the catch	20,95	3	6	9	3,93	5	6,67	2	3,69	1	0,67
4	Proportion of small and large fish in the catch	11,36	2	4	5	2,18	2	2,67	1	1,85	1	0,67
5	Revenue for Business	4,90	0	0	7	3,05	0	0,00	1	1,85	0	0,00
6	Net economic return to the fishery at national or regional level	4,46	0	0	6	2,62	0	0,00	1	1,85	0	0,00
7	Quality and Supply of fish to the market	3,98	0	0	3	1,31	2	2,67	0	0,00	0	0,00
8	National/International stock assessment	13,80	3	6	6	2,62	2	2,67	1	1,85	1	0,67
9	Economic assessment of the productivity of the fishery	6,92	1	2	4	1,75	1	1,33	1	1,85	0	0,00
10	Other	1,10	0	0	1	0,44	0	0,00	0	0,00	1	0,67
TOTAL		100,00	12,00	24,00	55,00	24,00	18,00	24,00	13,00	24,00	6,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert
*) Fishers' Welfare
**) Research Output

The perception of the state of the tuna stocks which is average but ok condition, is based on (i) Average size/volume of fish in the catch, (ii) the Annual/Seasonal Catch Level, (iii) National/International stock assessment, (iv) Catch Rate per trip/day, (v) Proportion of small and large fish in the catch, (vi) Economic assessment of the productivity of the fishery, (vii) Revenue for

Persepsi tentang kondisi stok tuna rata rata tetapi dalam baik (ok) secara berturut turut didasarkan pada indikator (i) ukuran rata rata hasil tangkapan, (ii) hasil tangkapan tahunan, (iii) *assessment* nasional/internasional, (iv) *catch rate /trip*, (v) proporsi ikan berukuran kecil dan besar, (vi) assessment ekonomi produktifitas perikanan, (vii) penerimaan bisnis, (viii) *net economic return* perikanan pada tingkat nasional dan

Business, (viii) Net economic return to the fishery at national or regional level, (ix) Quality and Supply of fish to the market. It is mentioned that the state of tuna resource is has to be reflected by the fishers' welfare and research output.

regional, (ix) kualitas dan pasokan ikan ke pasar. Selanjutnya juga disebutkan bahwa kondisi sumberdaya tuna dari suatu Negara digambarkan melalui kesejahteraan nelayan dan hasil penelitian.

5. The best indicators of the status

No	The best Indicator of the Status	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Stock	39,77	4	13,71	15	7,66	4	6,40	5	8,00	1	4,00
2	Fishery	12,89	1	3,43	6	3,06	3	4,80	1	1,60	0	0,00
3	Contribution of the fishery to economy of :	0,00		0,00		0,00		0,00		0,00		0,00
	Local	11,00	0	0,00	9	4,60	2	3,20	2	3,20	0	0,00
	Regional	9,97	0	0,00	7	3,57	2	3,20	2	3,20	0	0,00
	National	22,65	2	6,86	9	4,60	3	4,80	4	6,40	0	0,00
4	Social/Cultural wellbeing of Indonesia community	3,71	0	0,00	1	0,51	1	1,60	1	1,60	0	0,00
TOTAL		100,00	7,00	24,00	47,00	24,00	15,00	24,00	15,00	24,00	1,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert

*) better life, average saving, basic need, education.

**) less catch, fish size is getting smaller, fishing area is getting far.

***) purchasing power increased.

The indicator of the status as mentioned in the para 4, is reflected by (i) stocks, (ii) contribution to economy of national level, local level and regional level as well as fishery, (iii) fisheries, (iv) Social/Cultural wellbeing of Indonesia community. Respondents also provide additional indicators of the status such as better life, average saving, basic need, education, less catch, fish size is getting smaller, fishing area is getting far away, exchange-rate of fishers.

Indikator status perikanan tuna sebagaimana disebutkan pada para 4 secara berturut turut dicerminkan oleh (i) stok, (ii) kontribusi pada ekonomi nasional, lokal dan regional, (iii) kondisi perikanan, dan (iv) kondisi sosial/kultural rakyat Indonesia. Para responden juga menyampaikan indikator tambahan seperti kehidupan yang lebih baik, jumlah tabungan, pemenuhan kebutuhan dasar, menurunnya hasil tangkapan, ukuran ikan semakin mengecil, daerah penangkapan semakin jauh dan nilai tukar nelayan meningkat.

6. Ideal level of indicators identified in 5

Scientist	Managers	NGO	FIA	IE
Spawning and recruitment Biomass Rate	Catch	Healthy Stock, not overfishing	Raw material supply	Time series of good data
Fishing Rate	Fish Size	Harvest Strategy	Scientific Evidence of the Stocks	Catch Trend
B current > Bmsy	Fishing area distance	Harvest Control Rule	Fishers' income increased	
Number of mature/adult fish	Fishers' income and welfare	Historical Catch	Fishers are able to pay tax	
		Logbook Data	Fishers Exchange Rate increased.	
		Reference Point		
		CPUE		
		Raw Material Price		
		Average Salary		

The level of indicators of the status as identified in Para 5, among others are (i) $B_{current} > B_{msy}$, (ii) number of mature/adult fish (fish size), (iii) healthy stocks, not over-fishing, (iv) CPUE, (v) catch trend, (vi) fishers' income increased.

Tingkat ideal dari indikator status sebagaimana disebutkan pada Para 5, antara lain (i) $B_{current} > B_{msy}$, (ii) jumlah ikan dewasa (ukuran ikan), (iii) stok yang sehat, tidak *over fishing*, (iv) CPUE, (v) tren hasil tangkapan dan (vi) pendapatan nelayan meningkat.

7. The major pressures on the condition of Indonesia's tuna fisheries in WPP713, 714, 715 and threats to their sustainability

No	The Major Pressure	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Too many purse-seine fleet	52,90	6	18,00	15	11,25	4	5,65	6	16,00	1	2,00
2	Too many longline fleet	3,57	0	0,00	1	0,75	2	2,82	0	0,00	0	0,00
3	Too many handline fleet	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
4	Too many trolling fleet	1,41	0	0,00	0	0,00	1	1,41	0	0,00	0	0,00
5	Too many pole and line fleet	0,00	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
6	Too many gillnet fleet	10,40	0	0,00	2	1,50	3	4,24	1	2,67	1	2,00
7	Too many deployed FAD	53,14	6	18,00	17	12,75	5	7,06	5	13,33	1	2,00
8	Destructive fishing practices	28,65	2	6,00	12	9,00	4	5,65	3	8,00	0	0,00
9	Others	2,82	0	0,00	0	0,00	2	2,82	0	0,00	0	0,00
	TOTAL	100,00	8,00	24,00	32,00	24,00	17,00	24,00	9,00	24,00	2,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert
*) Wastage/poor quality

The views on the above table reflects the major pressures on the condition of Indonesia's tuna fisheries in WPP713, 714, 715 and threats to their sustainability are (i) Too many purse-seine fleet, (ii) Too many deployed FAD, (iii) Destructive fishing practices, (iv) Too many gillnet fleet, (v) Too many longline fleet and (vi) Too many trolling fleet. This view indicates there is an urgent need to manage purse-seine fisheries and FAD limitation, as well as destructive fishing practices in order to ensure the sustainability of tuna resources in the area. In addition, there is an indication that respondents did not reflect their negative views to pole and line fisheries.

Tabel diatas mencerminkan pandangan bahwa tekanan utama terhadap kondisi perikanan tuna Indonesia terutama di WPPNRI 713, 714, 715 dan ancaman terhadap keberlanjutan adalah (i) terlalu banyak kapal purse seine, (ii) terlalu banyak penebaran FAD, (iii) adanya praktek penangkapan ikan yang merusak, (iv) terlalu banyak armada gillnet, (v) terlalu banyak armada longline, dan (vi) terlalu banyak *trolling line*. Pandangan ini mengindikasikan pentingnya pengelolaan perikanan purse seine dan pembatasan FAD, termasuk pemberantasan praktek penangkapan ikan yang merusak untuk menjamin keberlanjutan sumberdaya tuna di wilayah tersebut. Selanjutnya terdapat indikasi bahwa semua responden tidak menyampaikan keluhan terhadap keberadaan pole and line.

8. The most appropriate options/tools/measures for manages these pressures

Scientist	Managers	NGO	FIA	IE
Reduce purse-seine	Moratorium Purse-Seine	MCS	Reduce Purse-seine fleet	Effective rule and management
Limit number of purse-seine	FAD management	Law Enforcement	Stop Fishing Permit for purse-seine	Limit number of purse-seine and gillnet
Enlarge mesh-size at the cod-end for purse-seine	MCS and Law Enforcement	Transparency	FAD Management	Close and open season
FAD management		Creating input control	Limit number of FAD	Industries engagement
MCS and Law Enforcement		Limit Number of Fishing Fleet		
		Eliminate gear type which do not diff between adult and juvenile		
		FAD Management Plan		
		HCR		

It is recommended that the most appropriate options/tools/measures for manages these pressures as indicated in Para 7 are (i) reduce purse-seine number, (ii) implement FAD management (FAD Limitation) and (iii) conduct MCS and law enforcement effectively.

Tindakan pengelolaan yang terbaik untuk mengelola tekanan utama terhadap perikanan tuna sebagaimana disebutkan pada para 7 adalah (i) mengurangi jumlah purse seine, (ii) melaksanakan pengelolaan FAD (pengurangan jumlah FAD) dan (iii) melaksanakan MCS dan penegakan hukum secara efektif.

9. Sort of management measures are the most appropriate for skipjack tuna

No	Management Measures for Skipjack	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Catch Quota	21,00	1	2,00	13	5,29	5	5,71	5	6,67	1	1,33
2	Limit Fishing Permit	11,27	1	2,00	5	2,03	4	4,57	2	2,67	0	0,00
3	Limit fishing effort (fishing day)	13,54	2	4,00	8	3,25	2	2,29	2	2,67	1	1,33
4	Limit Fishing Gear size	11,21	1	2,00	10	4,07	1	1,14	3	4,00	0	0,00
5	Limit Vessel Size	6,58	0	0,00	4	1,63	2	2,29	2	2,67	0	0,00
6	Limit auxiliary fishing gear.	9,80	1	2,00	7	2,85	2	2,29	2	2,67	0	0,00
7	Limit FAD	24,19	5	10,00	11	4,47	5	5,71	2	2,67	1	1,33
8	Others	2,41	1	2,00	1	0,41	0	0,00	0	0,00	0	0,00
TOTAL		100,00	12,00	24,00	59,00	24,00	21,00	24,00	18,00	24,00	3,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert
*) enlarge mesh size for purse-seine and establish conservation area.
**) Limit Fishing gear Type

The most appropriate management measure for skipjack tuna are (i) FAD Limitation, (ii) implement catch quota, (iii) fishing effort limitation (iv) fishing permit limitation, (v) fishing gear size limitation, (vi) auxiliary fishing gear limitation, (vii) vessel size limitation. It is also recommended to enlarge mesh size for purse-seine, establishment of conservation area as well as fishing gear type limitation.

Tindakan pengelolaan yang sesuai untuk cakalang adalah (i) pembatasan FAD, (ii) melaksanakan sistem kuota hasil tangkapan, (iii) pembatasan upaya penangkapan (iv) pembatasan SIPI, (v) pembatasan ukuran API, (vi) pembatasan alat bantu penangkapan ikan, dan (vii) pembatasan ukuran kapal. Sebagai tambahan, terdapat juga rekomendasi untuk memperbesar ukuran mata jaring purse seine, menetapkan wilayah konservasi cakalang dan pembatasan jenis alat penangkapan ikan untuk cakalang.

10. Sort of management measures are the most appropriate for Yellowfin Tuna

No	Management Measures for Yellowfin	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Catch Quota	20,89	2	2,67	11	4,89	5	5,45	6	6,55	1	1,33
2	Limit Fishing Permit	12,32	2	2,67	7	3,11	4	4,36	2	2,18	0	0,00
3	Limit fishing effort (fishing day)	12,81	3	4,00	7	3,11	2	2,18	2	2,18	1	1,33
4	Limit Fishing Gear size	11,03	2	2,67	9	4,00	1	1,09	3	3,27	0	0,00
5	Limit Vessel Size	5,49	1	1,33	2	0,89	2	2,18	1	1,09	0	0,00
6	Limit auxiliary fishing gear.	12,32	2	2,67	7	3,11	2	2,18	4	4,36	0	0,00
7	Limit FAD	22,26	5	6,67	10	4,44	5	5,45	4	4,36	1	1,33
8	Others	2,87	1	1,33	1	0,44	1	1,09	0	0,00	0	0,00
TOTAL		100,00	18,00	24,00	54,00	24,00	22,00	24,00	22,00	24,00	3,00	4,00

Note: FIA = Fishing Industries and Association; IE = International Expert
*) enlarge meh-size for purse-seine
**) Purse-seine moratorium
***) Determine minimum size of catch

The most appropriate management measure for yellowfin tuna are (i) FAD Limitation, (ii) implement catch quota and Limit FAD, (iii) fishing effort limitation, (iv) fishing permit and auxiliary fishing gear limitation, (v) fishing gear size limitation, (vi) vessel size limitation. It is also recommended to enlarge mesh size for purse-seine, establishment of conservation area, purse-seine moratorium and determine minimum size of YF tuna allowable to landing.

Tindakan pengelolaan yang sesuai untuk madidihang adalah (i) pembatasan FAD, (ii) melaksanakan sistem kuota hasil tangkapan, (iii) pembatasan upaya penangkapan, (iv) pembatasan SIPI dan alat bantu penangkapan ikan, (v) pembatasan ukuran alat penangkapan ikan dan (vi) pembatasan ukuran kapal penangkap ikan. Sebagai tambahan, terdapat juga rekomendasi untuk memperbesar ukuran mata jaring purse seine, menetapkan wilayah konservasi madidihang, moratorium purse seine dan menetapkan ukuran ikan madidihang yang boleh didaratkan.

11. Sort of management measures are the most appropriate for bigeye tuna

No	Management Measures for Bigeye	Total	Respondent									
			Scientist		Managers		NGO		FIA		IE	
			24%	Weight	24%	Weight	24%	Weight	24%	Weight	4%	Weight
1	Catch Quota	23,03	4	5,33	12	5,65	5	5,00	5	5,71	1	1,33
2	Limit Fishing Permit	11,78	2	2,67	6	2,82	4	4,00	2	2,29	0	0,00
3	Limit fishing effort (fishing day)	13,91	3	4,00	7	3,29	3	3,00	2	2,29	1	1,33
4	Limit Fishing Gear size	11,86	2	2,67	8	3,76	2	2,00	3	3,43	0	0,00
5	Limit Vessel Size	7,50	1	1,33	4	1,88	2	2,00	2	2,29	0	0,00
6	Limit auxiliary fishing gear.	10,92	2	2,67	6	2,82	2	2,00	3	3,43	0	0,00
7	Limit FAD	17,53	3	4,00	8	3,76	5	5,00	3	3,43	1	1,33
8	Others	3,48	1	1,33	0	0,00	1	1,00	1	1,14	0	0,00
TOTAL		100,00	18,00	24,00	51,00	24,00	24,00	24,00	21,00	24,00	3,00	4,00

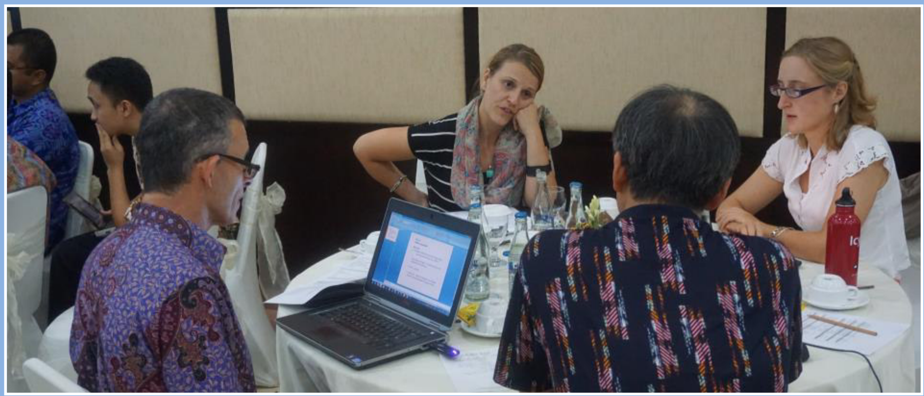
Note: FIA = Fishing Industries and Association; IE = International Expert
*) Establish Conservation area for BET
**) Closed/Open Season; Limit number of fishing fleet
***) Deploy observer on-board

The most appropriate management measure for bigeye tuna are (i) implement catch quota, (ii) FAD Limitation, (iii) fishing effort limitation, (iv) fishing gear size limitation, (v) fishing permit limitation, (vi) auxiliary fishing gear limitation and (vii) vessel size limitation. It is also recommended to establish conservation area for BET, implement closing and open system, limit number of fishing fleet and deployment of observer on-board.

Tindakan pengelolaan yang sesuai untuk tuna mata besar adalah (i) melaksanakan sistem kuota hasil tangkapan, (ii) pembatasan FAD, (iii) pembatasan upaya penangkapan, (iv) pembatasan ukuran API, (v) pembatasan SIPI, (vi) pembatasan alat bantu penangkapan ikan dan (vii) pembatasan ukuran kapal penangkap ikan. Sebagai tambahan, terdapat juga rekomendasi untuk menetapkan wilayah konservasi untuk tuna mata besar, menerapkan sistem buka tutup, pembatasan jumlah armada dan pengawasan oleh petugas pemantau diatas kapal.

From those three (3) tables related to appropriate management measures, it is recommended to implement three (3) measures to manage skipjack tuna, yellowfin and bigeye tuna such as (i) FAD Limitation, (ii) Implement catch quota system and (iii) Fishing Effort Limitation. To ensure the compliance aspect by vessels, it is also recommended to deploy observer on-board to such as purse-seine fisheries.

Dari 3 tabel diatas yang berkaitan dengan tindakan pengelolaan yang sesuai, dapat disimpulkan terdapat 3 (tiga) rekomendasi utama untuk pengelolaan cakalang, madidihang dan tuna mata besar yaitu (i) pembatasan FAD, (ii) melaksanakan sistem kuota hasil tangkapan dan (iii) pembatasan *fishing effort*. Untuk memastikan aspek kepatuhan, juga direkomendasikan untuk melakukan pengawasan dengan petugas pemantau diatas kapal pada kapal purse seine.



12. The difference of fleet and gear (Industrial, commercial, artisanal)

a) Industrial/Commercial

Scientist	Managers	NGO	FIA	IE
Inboard engine	Fiberglass vessel	Greater than 30 GT	Better engine and equipment.	Purse-Seine and Gillnet
LOA >20 meter	Modern gear type	Processed product	Auxiliary gear	
Fishing area >12 nm	Greater than 30 GT	Export oriented	Fishing Fleet (more than 1 vessels with size greater than 5 GT)	
Auxiliary gear and Auxiliary Engine	Larger size of fishing gear	Discard of unwanted catch	Gear type other than handline	
Fish Hold with Freezing facility	Fishing area beyond 12 nm	Disregard for zoning, better infrastructure, better understanding and ability to implement rules	Profit oriented	
Developed technology	Profit oriented	Vessels owned by company	Large coverage of Fishing area	
		5 vessel below 5 GT are belong to 1 person	Catch quality is guaranteed	
		Operational cost is covered by company	Partnership pattern	
		Fish finder	Safety is guaranteed	
		Larger gear, less selection, more ecological input		
		Better catch handling		
		More efficient		
		VMS and Observer		

b) Artisanal

Scientist	Managers	NGO	FIA	IE
Outboard engine	Wooden Vessel	5-10 GT and less than 5 GT	Simple gear type.	Collaboration partnership.
LOA <20 meter	Traditional gear type	Catch for local need.	Coverage fishing area is limited	The gap between industrial and artisanal is getting narrower.
Wooden Vessel	Less catch	Almost no bycatch	Vessel is less than 5 GT	
Fishing area <200nm	Smaller than 30 GT	No discard, low fuel consumption, higher employment, unlicensed.	Catch for daily life	
Ice	Fishing area 4 nm	Vessel is personal property	handline	
One day fishing		Operational cost is personal expenditure.	Catch quality is poor	
Limited technology		Smaller gear, less ecological input	Manual data recording	
		Improvement in quality system needed.	Regardless safety	
		More employment in coastal area.	Mostly no fishing permit or not registered.	
			No Access to Bank (Non- bankable).	

There is a wide range of views in relation to the difference between commercial and artisanal tuna fishery as indicated in table A and table B above. But the common criteria recommended for commercial tuna fisheries are (i) using developed technology and better equipment (ii) using vessel greater than 30 GT with freezing facilities, (iii) profit oriented and (iv) using auxiliary fishing gear. It is also recommended that purse-seine and gillnet are to be presumed as commercial tuna fisheries and/or other than handline.

Terdapat pandangan yang luas terkait dengan perbedaan antara perikanan tuna komersial dan artisanal sebagaimana terdapat pada Tabel A dan Tabel B. Namun demikian, kriteria umum yang direkomendasikan untuk perikanan tuna komersial adalah (i) mengggunakan teknologi terkini dan peralatan yang lebih baik, (ii) menggunakan kapal penangkap ikan berukuran diatas 30 GT dilengkapi fasilitas pendingin, (iii) bersifat mencari untung dan (iv) menggunakan alat bantu penangkapan ikan. Terdapat juga rekomendasi bahwa purse seine dan gillnet harus dianggap sebagai perikanan tuna komersial dan/atau alat tangkap selain pancing ulur.

While the common criteria for artisanal tuna fisheries are (i) limited technology or traditional fishing gear type, (ii) wooden vessel, (iii) poor handling of catch (ice), (iv) fishing at the coastal area. It is also stated that the gap between industrial and artisanal tuna fisheries is getting narrower.

Sedangkan kriteria untuk perikanan tuna artisanal adalah (i) penggunaan teknologi sederhana atau alat penangkapan ikan tradisional, (ii) kapal kayu, (iii) penanganan ikan hasil tangkapan kurang baik, (iv) wilayah penangkapan di perairan pantai. Juga dinyatakan bahwa perbedaan antara perikanan komersial/industri dan artisanal semakin lama semakin mengecil.

D. CLOSURE

All views in this report will be considered as a formal information in supporting the development of harvest strategy for tuna fisheries in IFMA 713, 714 and 715.

D. PENUTUP

Pandangan responden dalam laporan ini akan dipertimbangkan sebagai informasi yang formal untuk mendukung penyusunan *harvest strategy* perikanan tuna di WPPNRI 713,714 dan 715.

LAMPIRAN

Lampiran 1. Kuisioner Dalam Penyusunan Harvest Strategy Pengelolaan Tuna di Indonesia

A. Bahasa Inggris

Questions for stakeholders to assist in eliciting objectives for Indonesian tuna fisheries

1. What is the nature of your involvement in in Indonesian tuna fisheries?
   a. Fisher (including representatives)
      - Commercial
        - Local
        - National
        - Industrial
      - Artisanal
      - Type of gear
      - Area (713, 714, 715)
        - Primary ground(s)
      - Port(s)
      - Target species
      - Seasonal targeting

   b. Processor
      - Area (713, 714, 715)
      - Port(s)/Primary grounds serviced

   c. Port Manager
   d. Fishery Manager
   e. Conservation-NGO
   f. Fishery-NGO
   g. Fishery Scientist
   h. Regional development

2. What is your (or your constituents) primary interest in Indonesian tuna fisheries?
   a. Food security
   b. Commercial activity
   c. Economic development at local; regional; national scale
   d. Knowledge (Science and social, cultural, economic research)
   e. Conservation of fisheries resources
   f. Conservation of biodiversity
   g. Other?

3. What is your (or your constituents) secondary interest in Indonesian tuna fisheries?
   a. Food security
   b. Commercial activity
   c. Economic development at local; regional; national scale
   d. Knowledge (Science and social, cultural, economic research)
   e. Conservation of fisheries resources
   f. Conservation of biodiversity
   g. Other?

4. What is your current assessment of the state of Indonesia's tuna fisheries?
   - Good condition
   - Average, but ok, condition
   - Poor condition

5. What sort of information/indicators do you base your assessment of the state of the stock and the fishery on?
   - Annual/seasonal catch levels
   - Catch rates per trip/day
   - Average size/volume? of fish in the catch
   - Proportion of small and large fish in the catch/market
   - Revenue for business
   - Net economic return to the fishery at a national or regional level
   - Quality and supply of fish to the market
   - National/international stock assessments
   - Economic assessment of the productivity of the fishery
   - Other

6. What do you think are the best indicators of the status of the:
    - Stock?
    - Fishery?
    - Contribution of the fishery to local/regional/national economy?
    - Social/Cultural wellbeing of Indonesian community (and why)?

7. What would you consider an “ideal” level of the indicators identified in 6. i.e. what level of each of these indicators would coincide with your desired state for the stock, fishery and social/cultural benefits?

8. What do you consider the major pressures on the condition of Indonesia’s tuna fisheries in WPP 713, 714, 715 and threats to their sustainability?

9. What do you consider the most appropriate options/tools/measures for managing these pressures?

10. In the case of catch and effort from the legitimate Indonesian fishing fleets, what sort of management measures (e.g. catch quota’s, license limitation, effort limits, size/gear limits) are the most appropriate for:
    a. Skipjack?
    b. Yellowfin?
    c. Bigeye?

11. And how do you think they differ for different fleets (industrial, commercial, artisanal) and gears?

B. Bahasa Indonesia

1. Apa keterlibatan/peran Anda pada perikanan tuna di Indonesia?
    a. Nelayan (termasuk perwakilan)
        - o Komersial
            - Lokal
            - Nasional
            - Ekspor
        - o Artisanal
        - o Jenis Alat Tangkap (sebutkan) ....

        - o Daerah Penangkapan
            - WPPNRI 713
            - WPPNRI 714
            - WPPNRI 715
        - o Pelabuhan Pangkalan/Pendaratan (sebutkan) ....

        - o Spesies Target
            - Tuna Madidihang
            - Tuna Mata Besar
            - Cakalang
            - Tongkol
        - o Musim Penangkapan (sebutkan) ....

    b. Pengolah
        - o Lokasi
            - WPPNRI 713
            - WPPNRI 714
            - WPPNRI 715
        - o Pelabuhan Utama perolehan bahan baku (sebutkan) ....

    c. Manajer Pelabuhan (pegawai)
    d. Manajer Perikanan (pegawai dinas)
    e. LSM Konservasi

f. LSM Perikanan
g. Peneliti Perikanan

2. Menurut Saudara apa kepentingan utama perikanan tuna Indonesia?
   a. Ketahanan Pangan
   b. Aktivitas Komersial
   c. Pembangunan ekonomi:
      o Lokal
      o Kawasan
      o Nasional
   d. Pengetahuan (ilmu pengetahuan dan penelitian sosial, budaya, ekonomi)
   e. Konservasi sumber daya perikanan
   f. Konservasi Biodiversity
   g. Lainnya (sebutkan) ....

3. Menurut Saudara apa kepentingan lainnya perikanan tuna Indonesia?
   a. Ketahanan Pangan
   b. Aktivitas Komersial
   c. Pembangunan ekonomi:
      o Lokal
      o Kawasan
      o Nasional
   d. Pengetahuan (ilmu pengetahuan dan penelitian sosial, budaya, ekonomi)
   e. Konservasi sumber daya perikanan
   f. Konservasi Biodiversity
   g. Lainnya (sebutkan) ....

4. Apa penilaian anda tentang kajian status perikanan tuna Indonesia?
   - Kondisi yang baik
   - Kondisi cukup baik
   - Kondisi yang kurang baik

5. Apa Indikator (ciri) yang mendukung pendapat Saudara pada butir 4?
   a. Hasil tangkapan tahunan/musiman
   b. Laju tangkap per trip/hari
   c. Rata-rata ukuran/volume? ikan pada hasil tangkapan
   d. Proporsi ikan kecil dan besar pada hasil tangkapan/pasar
   e. Keuntungan usaha
   f. Keuntungan bersih untuk perikanan tingkat nasional atau regional
   g. Kualitas dan ketersediaan ikan di pasar
   h. Pengkajian stok tingkat Nasional/international
   i. Pengkajian ekonomi dari produktivitas perikanan
   j. Lainnya (sebutkan) ....

6. Apa menurut Anda indicator terbaik untuk menggambarkan status/kondisi perikanan tuna:
   a. Stok
   b. Usaha Perikanan
      Kontribusi perikanan terhadap ekonomi
      o Lokal
      o Regional
      o Nasional
   c. Kesejahteraan sosial/budaya masyarakat Indonesia, sebutkan mengapa?

7. Menurut anda apa kondisi ideal indikator nomor 6 di atas, (sebutkan indikator yang anda inginkan terhadap jawaban yang anda pilih di atas)

8. Menurut Saudara apa faktor utama yang menimbulkan tekanan utama pada kondisi perikanan tuna di WPPNRI 713, 714, 715 yang mengancam keberlanjutan
   a. Jumlah Armada Purse Seine terlalu banyak

b. Jumlah Armada Longline terlalu banyak ☐
c. Jumlah Armada Handline terlalu banyak ☐
d. Jumlah Armada Tonda terlalu banyak ☐
e. Jumlah Armada Huhate terlalu banyak ☐
f. Jumlah Armada Gillnet terlalu banyak ☐
g. Jumlah Rumpon yang ditebar di laut terlalu banyak ☐
h. Adanya praktek penangkapan yang merusak (bom dan/ atau racun) ☐
i. Lainnya sebutkan ....

9. **Sebutkan cara atau tindakan untuk mengelola faktor yang mengakibtkan tekanan pada nomor 8 (yang anda pilih)**

10. **Dalam hal pengelolaan hasil tangkapan per upaya penangkapan, sebutkan tindakan pengelolaan yang sesuai terhadap cakalang:**
a. Penerapan kuota hasil tangkapan ☐
b. Pembatasan SIPI ☐
c. Pembatasan upaya penangkapan (hari operasi) ☐
d. Pembatasan ukuran alat penangkapan ikan ☐
e. Pembatasan ukuran kapal ☐
f. Pembatasan alat bantu penangkapan ☐
g. Pembatasan rumpon ☐
h. Lainnya sebutkan ....

11. **Dalam hal pengelolaan hasil tangkapan per upaya penangkapan, sebutkan tindakan pengelolaan yang sesuai terhadap Tuna Madidihang:**
a. Penerapan kuota hasil tangkapan ☐
b. Pembatasan SIPI ☐
c. Pembatasan upaya penangkapan (hari operasi) ☐
d. Pembatasan ukuran alat penangkapan ikan ☐
e. Pembatasan ukuran kapal ☐
f. Pembatasan alat bantu penangkapan ☐
g. Pembatasan rumpon ☐
h. Lainnya sebutkan ....

12. **Dalam hal pengelolaan hasil tangkapan per upaya penangkapan, sebutkan tindakan pengelolaan yang sesuai terhadap mata besar:**
a. Penerapan kuota hasil tangkapan ☐
b. Pembatasan SIPI ☐
c. Pembatasan upaya penangkapan (hari operasi) ☐
d. Pembatasan ukuran alat penangkapan ikan ☐
e. Pembatasan ukuran kapal ☐
f. Pembatasan alat bantu penangkapan ☐
g. Pembatasan rumpon ☐
h. Lainnya sebutkan ....

13. **Menurut anda apa perbedaan armada perikanan dan alat tangkap antara Industri dan Artisanal (sebutkan):**
Industri

Artisanal

Lampiran 2. Daftar Peserta yang Menghadiri Workshop Ketiga Penyusunan Harvest Strategy Pengelolaan Tuna di Indonesia (*List of workshop Participant/Respondent)*

No	Nama	Instansi
1.	Wudianto	Puslitbangkan
2.	Duto Nugroho	Puslitbangkan
3.	Fayakun Satria	Puslitbangkan
4.	Lilis Sadiyah	Puslitbangkan
5.	Anung Widodo	Puslitbangkan
6.	I Gede Bayu	Puslitbangkan
7.	Teguh Nugroho	RIMF/BPPL
8.	Siti Hajar	Puslit Sosek KP
9.	Chandra N	STP
10.	Soni Koeshendrajana	Puslit Sosek KP
11.	Irwan Jatmiko	LP2T-Bali
12.	Indriatmoko	Puslitbangkan
13.	Davidsen R. Moto	WWF – ID
14.	Windy Rizki	WWF – ID
15.	Wiro Wirandi	MDPI
16.	Andrew Harvey	IPNLF
17.	Purwanto	TNC – IFP
18.	Elle Wibisono	TNC
19.	Gayatri	SFP
20.	Nurlindah	DKP Sulsel
21.	Zeni W.	DKP NTB
22.	Muhtar Imato	DKP Gorontalo
23.	I A Riyastini	DKP Bali
24.	M. Effendy Sadjid	DKP Kota Ternate
25.	Ahmad Guntur W.	DKP Kalsel
26.	Willem Jerry Bakarbessy	DKP Sorong
27.	Irma Mansur	DKP Maluku Utara
28.	Endah Sismiaty	DKP Kaltim
29.	Maruji	DKP Jatim
30.	Abbas	PPI Paotere Makasar
31.	Roberth Laisina	DKP Kupang
32.	Christian Mamangkey	DKP Sulut
33.	Deddy Mandak	DKP Bitung
34.	Andi Tenri Abeng	DKP Bone
35.	Wawan Jurwanto	DKP Sulbar
36.	Reynaldo Hiariej	DKP Maluku
37.	Ganef Wurgiyanto	DKP NTT
38.	Luluk Maria S	PPN Pengambengan
39.	Luh Putu Ari Widiana	PPN Pengambengan
40.	Arkadius S. Bella	DKP Sikka
41.	Yohanes Juan Bulen	DKP. Flores Timur
42.	Agus A. Budhiman	AP2HI
43.	Tita Nopitawati	AP2HI
44.	Tian Adi Pratama	Aspertadu
45.	Slamet AM	Aspertadu
46.	Richi Richado	PT. Bandar Nelayan
47.	Agung Adhinatha	PT. Primo Indo Ikan
48.	Muhammad Bilahmar	ASTUIN
49.	Bambang Novantoro	ATLI
50.	I Nyoman Sudarta	ATLI
51.	Craig Proctor	CSIRO
52.	Sung Kwon Soh	WCPFC
53.	Momo Kochen	MDPI
54.	Deirdre Duggan	MDPI
55.	Saut Tampubolon	Dit. Pengelolaan SDI
56.	Yayan Hernuryadin	Dit. Pengelolaan SDI
57.	Novia Tri Rahmawati	Dit. Pengelolaan SDI

11.9 Appendix 10: HS framework 2023

FRAMEWORK FOR HARVEST STRATEGY FOR TROPICAL TUNA IN ARCHIPELAGIC WATER OF INDONESIA

KEMENTERIAN KELAUTAN DAN PERIKANAN
DIREKTORAT JENDERAL PERIKANAN TANGKAP

PREFACE

The Fisheries Harvest Strategy is a comprehensive framework that outlines the necessary management actions for a fishery to achieve predetermined biological, ecological, and socio-economic objectives. The decision to implement a fisheries harvest strategy for tropical tuna management was derived from the Minister of Marine Affairs and Fisheries Decree of 2015 and 2021, which established the National Tuna Management Plan (RPP TCT). The most recent Tuna Management Plan was officially updated through the Minister of Marine Affairs and Fisheries Decree (Kepmen KP) Number 121 of 2021.

Within the National Tuna Management Plan, the Indonesian Tropical Tuna Fisheries encompass three areas: (1) Indian Ocean Tuna Fisheries, (2) Pacific Ocean Tuna Fisheries, and (3) Archipelagic Water Tuna Fisheries (Indonesia Archipelagic Waters-IAW). The Archipelagic Waters under the full sovereignty of Indonesian marine waters hold unique characteristics due to the presence of Highly Migratory Fish Species (HMFS) and Straddling Fish Species (SFS). Consequently, the management of these fisheries is distinct from that of the Indian Ocean and Pacific Ocean tuna regional fisheries bodies. These waters are renowned for their abundance and production of tuna, in particular skipjack tuna, yellowfin tuna, and bigeye tuna. Furthermore, in accordance with national fisheries legislation, Indonesia is firmly committed to managing tuna resources across the country in alignment with the conservation and management measures adopted by Tuna Regional Fisheries Management Organizations (RFMOs).

The development of the Harvest Strategy commenced in 2014, initiated by the Ministry of Marine Affairs and Fisheries in collaboration with local governments, non-governmental organizations, businesses, and experts, including support from Research Center for Fishery-BRIN, SPC-WCPFC and CSIRO Australia. In 2018, the drafting process resulted in the creation of the "Framework for Harvest Strategy for Tropical Tuna in Archipelagic Water of Indonesia". Subsequently, a comprehensive Harvest Strategy document was finalized in 2023. The architecture of this Harvest Strategy for the fishery was established based on monitoring and modeling of skipjack tuna, yellowfin tuna, and bigeye tuna resource utilization, utilizing an Empirical Harvest Strategy approach. Consequently, the Harvest Strategy provides valuable insights into the current state of the fishery and offers management directives that must be implemented to enhance the condition of the Stock, particularly through the determination of quotas within the quota-based fishing policy.

Lastly, heartfelt gratitude and appreciation are extended to Acting Director General of Capture Fisheries, Director of Fish Resources Management, and all parties involved in the meticulous preparation of this document, whose unwavering dedication has contributed to its success.

Jakarta, June 2023
Minister of Marine Affairs and Fishery
of the Republic of Indonesia
Sakti Wahyu Trenggono

TABLE OF CONTENTS

1. Fishery Policy and Regulatory Context

Indonesian archipelagic waters (FMA 713, 714, and 715) are Indonesia's sovereignty. These waters are well-known for the abundance of tuna resources such as skipjack tuna, yellowfin tuna, and bigeye tuna. These species are categorized as highly migratory species.

According to UNCLOS (1982) which has been ratified by Indonesia through Act No. 17 Year 1985 that highly migratory species are managed by international or regional agreement, in this case is tuna Regional Fisheries Management Organization (tRFMO). The results of a large tuna tagging study conducted by SPC (2009-2010) indicates that while the majority of these tunas are recaptured within the archipelagic waters, there is exchange with other FMAs and with the wider Western and Central Pacific Ocean (WCPO). Indonesia has a strong commitment to managing tuna resources within its archipelagic waters in a sustainable manner and consistent with the intent of measures adopted by RFMOs, such as through the implementation of harvest strategy. This includes the use of the most recent Western and Central Pacific Fisheries Commission (WCPFC) stock assessments in the Management Strategy Evaluation (MSE) models used to develop and test the harvest strategies for skipjack and yellowfin tuna to provide for consistency between the two processes.

As part of a range of initiatives aimed at achieving sustainable social and economic benefits from the harvest of tuna resources in Indonesian archipelagic waters, Indonesia intends to develop and implement scientifically-tested harvest strategies to manage the level of targeted fishing on these tuna resources. The development and implementation of this harvest strategy framework is a priority action of the National Tuna Management Plan (NTMP) for tuna and neritic species and associated action plans, which has been set out in the Ministerial Decree of Marine Affairs and Fisheries of the Republic of Indonesia Number 107/KEPMEN-KP/2015 as amended by Ministerial Decree of Marine Affairs and Fisheries of the Republic of Indonesia Number 121/KEPMEN-KP/2021. The recommendation from this Harvest Strategy will be used as a reference for the implementation of Government Regulation Number 11 year 2023 on Quota-based Fishing (*Penangkapan Ikan Terukur*) which will be applied including to tuna fisheries. The harvest strategy framework is an important step in the process of development, testing and implementation of harvest strategies for yellowfin tuna, skipjack tuna and bigeye tuna fisheries in Indonesian archipelagic waters (Indonesia Fisheries Management Areas/FMA number 713, 714 and 715).

The development of harvest strategies for major tuna species is also consistent with Indonesia's rights and obligations as a member of the Regional Fisheries Management Organizations (RFMOs) responsible for governance of these highly migratory stocks: Western Central Pacific Fisheries Commission (WCPFC), Indian Ocean Tuna Commission (IOTC) and Commission for the Conservation of Southern Bluefin Tuna (CCSBT). Importantly, implementation of the monitoring, assessment, harvest control rules and management measures, which are essential elements of a harvest strategy, are central to achieving Marine Stewardship Council (MSC)-certification for Indonesian tuna fisheries.

The 2021 NTMP sets out a five-year plan for implementing action plans including development and implementation of harvest strategies and to maintain and extend *Marine Stewardship Council* (MSC) certification. This additional document supporting the 2021 NTMP describes the management objectives and harvest strategy framework developed through a continuation of the technical and consultative processes since the launch in 2018 (Table 1). The harvest strategy framework summarizes the forms of harvest strategy developed through these processes, that will be refined, scientifically tested and implemented for the management measures targeting tropical tuna in Indonesian Archipelagic Waters. It includes an updated action plan (Supplementary Material) of specific information requirements, consultation processes and institutional arrangements required for the implementation of harvest strategies for each species.

2. Management Objectives

From the nine management objectives for capture fisheries, as stipulated in Article 3 Law No. 31 Year 2004 on Fisheries, and amended by Law No. 45 year 2009 on Fisheries, it was agreed by series of stakeholder workshops that the management objective for yellowfin tuna, bigeye tuna and skipjack tuna is "*to ensure the sustainability of yellowfin tuna, bigeye tuna and skipjack tuna resources*" through harvest strategy implementation.

3. Operational Objectives

To maintain spawning stock biomass (SSB) above the limit reference point (LRP) of 20% of the unfished level with the probability of 90%.

3.1. Reference points for IAW

A reference point is a benchmark that scientists and managers use to compare the current status of a stock or fishery to a desirable state (Target Reference Point) or a state to be avoided (Limit Reference Point), due to an increased probability of undesirable consequences. This harvest strategy framework uses the regional stock assessments as the best source of scientific advice on stock status for skipjack, yellowfin tuna and bigeye tuna and for comparison of stock status with reference points.

3.1.1. Limit Reference Point

The default limit reference point for tuna in archipelagic waters is to maintain spawning stock biomass above 20% of the unfished level with a probability of 90%.

The rationale for this Limit Reference point is to avoid the stock being reduced to a level that average recruitment declines, which would result in reductions in long-term sustainable catches from the fishery.

3.1.2. Interim Target Reference Point

A target reference point (TRP) for tuna in archipelagic waters has not been decided as it requires more detailed consideration of implications for social and economic objectives for the fishery. These considerations will be informed by results of MSE for final set of harvest strategies for each species.

The current WCPFC interim TRP for skipjack is that the spawning biomass should be between 36 percent and 50 percent of the unfished spawning biomass on average (WCPFC18-2021-10), while current IOTC TRP for skipjack is that the spawning biomass should be 40 percent of the estimated unfished spawning biomass on average (IOTC Resolution 2016-02). For yellowfin tuna, IOTC' interim TRP is the fishing mortality that gives maximum sustainable yield

(FMSY). A TRP for yellowfin tuna has not been agreed by WCPFC, however, pending agreement on a TRP, the spawning biomass depletion ratio (spawning biomass relative to unfished spawning biomass) is to be maintained at, or above, the average depletion for 2012-2015 (CMM 2020-01).

Alternative target reference points for skipjack tuna, yellowfin tuna and bigeye tuna for IAW will be investigated, based on stakeholder surveys and technical working group consultations, supplemented by additional Management Strategy Evaluation (MSE) testing as part of harvest strategy implementation.

3.2. Stock Status

Assessment of stock status of highly migratory tunas is provided through regional stock assessments. In the case of stock assessments for FMA 713, 714 and 715, these assessments are conducted by the Ocean Fisheries Program of the Pacific Community (SPC) as part of the regular regional stock assessment process for each species and reviewed and agreed by the Scientific Committee of the WCPFC. This harvest strategy framework uses these regional stock assessments as the best source of scientific advice on stock status for skipjack, yellowfin tuna and bigeye tuna. These regular estimates of stock status (~3 years) will be compared to the reference points for the harvest strategy framework to monitor performance of harvest strategy implementation.

Based on the most recent assessments conducted by SPC, overall (across all regions in Western Central Pacific) median spawning biomass depletion (relative to unfished level) of skipjack tuna for the recent period (2018-2021) was estimated at 51 percent (Jordan et al 2022). Although depletion in region 5 (which include IAW) was much greater, with median depletion in the terminal year (2021) of around 32 percent of the unfished spawning biomass (Figure 1).

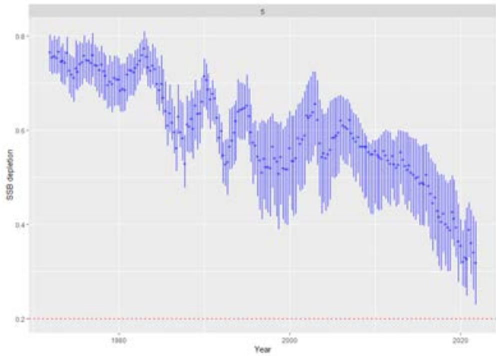


Figure 1. Spawning stock biomass (SSB) depletion in region 5 across 18 structural uncertainty grid models between 1972 and 2021. Data were extracted from the output files from the SPC website Skipjack Assessment Results (spc.int). The dot in the middle of the bar is median, and the height of the bar is 80 percentile range.

Overall (across all regions) median spawning biomass depletion of yellowfin tuna for the recent period (2015–2018) was estimated at 58 percent. Meanwhile, the depletion in tropical regions is notably greater (Vincent et al. 2020), with median depletion in the terminal year (2018) in region 7 (which include IAW) being around 36 percent (Figure 2).

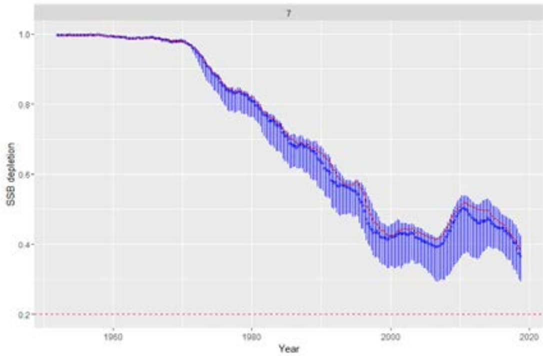


Figure 2. Yellowfin tuna SSB depletion (SSB/SSBF=0) in region 7 between 1952 and 2018. The height of the error bars indicates 20th and 80th percentile, the blue dots are 50 percentile (median) and red solid line is the diagnostic case. The horizontal dotted red line is the limit reference point. Data were extracted from the SPC stock assessment outputs files from the SPC website Yellowfin Assessment Results (spc.int).

3.3. Performance measures for HS selection

The aim of a harvest strategy is to achieve the stock conservation objectives for the fishery, while providing an appropriate balance across social and economic objectives. Performance measures are more detailed summary statistics for these objectives that are generated during the testing and selection of harvest strategies. They relate to the performance of the harvest strategy with respect to stock, fishery, economic and social objectives. It is desirable to have a wide range of performance measures that relate directly to the important components of the fishery and the wider Indonesian community and economy. This allows Government and stakeholder to make judgements about the trade-offs among social and economic benefits for alternative harvest strategies and select a final form of harvest strategy for operational implementation that is most likely to provide the best compromise among multiple objectives and acceptable performance overall. This selection process is done as part of the Management Strategy Evaluation process (see Figure 6).

Initial input for the development of performance measures was obtained from stakeholder using a structured survey at the 4th stakeholder workshop in 14-16 November 2016.

4. Conceptual Harvest Strategy for Skipjack Tuna, Yellowfin Tuna and Bigeye Tuna in Archipelagic Waters

A harvest strategy is a carefully considered and agreed plan for ***monitoring*** and ***assessing*** a fishery and adjusting the level of fishing (relative to the previous year) using a specified ***management measure*** according to the ***harvest control rule*** to meet the specific objectives *for the fishery* (Figure 3).

Analysis

Fishery

model)

HCR

Implementation

Measure

Figure 3. Conceptual illustration of the components of a harvest strategy. It is the combination of components that define an individual harvest strategy and determine its likely performance. Hence, if one,

or more component(s) is (are) changed, this is considered as a different harvest strategy. As part of the harvest strategy development and evaluation process, each component is specified in detail. This allows the relative performance of different harvest strategies to be tested through simulation modelling. The harvest strategy considered to have the most appropriate balance of performance across stock, social and economic objectives can then be selected for implementation in the fishery.

4.1. Empirical harvest strategy

Empirical harvest strategies were selected as the most appropriate form of harvest strategy for implementation in IAW. Empirical harvest strategies are based on indices of relative abundance, such as standardized catch rates, and/or average size in the catch, and relatively simple analysis methods, rather than quantities, such as spawning biomass and fishing mortality, estimated from more complex stock assessment models used in model-based harvest strategies. Empirical harvest strategies have the advantages of being more transparent and easily understood by non-technical audiences and being more straightforward to implement and, hence, requiring less technical expertise. International experience comparing empirical and model-based harvest strategies through simulation testing has demonstrated that it is possible to achieve comparable management performance using simpler empirical harvest strategies.

4.2. Empirical Harvest Control Rules for IAW

An example of the general form of the harvest control rule proposed for empirical harvest strategy for tropical tuna in IAW is shown in Figure 4.

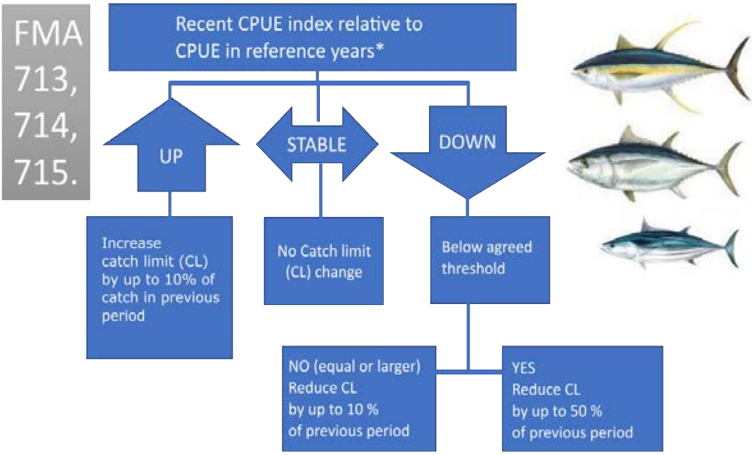


Figure 4. Flow diagram illustrating operation of empirical harvest control rule of a similar form to that proposed and initially tested for tropical tuna in Archipelagic waters of Indonesia.
*) Stakeholders agreed reference years, i.e., 2014-2016.

The preliminary design and MSE simulations used standardized pole and line CPUE and mean size as input data for skipjack and standardized handline CPUE and mean size as input for yellowfin tuna[1]. The input data series are quality controlled as part of data collection and the annual data submission process. Results of analysis are presented, discussed and consulted at the regular technical and stakeholder workshops.

More comprehensive MSE testing of specific forms of empirical harvest strategy for each species in IAW needs to be completed to ensure that the final harvest strategies selected for implementation:

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[1] Further details can be found in Hoshino *et al.* 2020. Development of pilot empirical harvest strategies for tropical tuna in Indonesian archipelagic waters: Case studies of skipjack and yellowfin tuna. Fisheries Research 227. https://doi.org/10.1016/j.fishres.2020.105539

i) Are consistent with and operationally integrated with the new Regulation No. 11/2023 on quota- and zone-based fishing (Penangkapan Ikan Terukur – PIT);
ii) Include operational constraints consistent with stakeholder feedback (e.g., reference years for CPUE, frequency of HS calculation (1, 2 or 3 years), minimum and maximum size of change in level of fishing at each decision);
iii) Have been tested with MSE models calibrated with the most recent regional stock assessments; and
iv) Meet the objectives of the Harvest Strategy Framework and shown to be robust to major uncertainties, as demonstrated by MSE.

4.3. Precautionary Catch Reduction Plan

A precautionary catch reduction plan was agreed by the 8th Stakeholders WS to undertake immediate management action in the absence of full MSE for the skipjack and yellowfin in the IAW. This recommendation was based on review of the most recent assessment and indicators of stock status in WCPO for skipjack tuna[2] and yellowfin tuna[3]. In addition, there is a need for integration of Regulation No. 11/2023 and the Harvest Strategy framework for operational implementation harvest strategies for skipjack and yellowfin in IAW and that this would not be practically achievable before 2025.

The recommendation for a precautionary catch reduction by the 8th Stakeholder WS was based on:

- The consistently declining trend in spawning biomass of skipjack in region 5 from the regional stock assessments (Figure 1);
- A stock depletion of 32 percent for skipjack in region 5 for the most regional stock assessment, which is lower

[2] Stock assessment of skipjack tuna in the western and central Pacific Ocean: 2022. SC18-SA-WP-01. https://meetings.wcpfc.int/node/16242

[3] Stock assessment of yellowfin tuna in the western and central Pacific Ocean: 2020. SC16-SA-WP-04. https://meetings.wcpfc.int/node/11694

than the agreed interim target reference point ($SB/SB_{F=0} = 0.36\text{-}0.50$);

- A declining trend in skipjack catches since 2013 and CPUE since 2014 in IAW;
- Decrease in the size (fish length) at full selection for skipjack in IAW, which is indicative of overfishing;
- Substantial increases in yellowfin catches in IAW since 2018; and
- Preliminary MSE results for yellowfin indicating that if the current high level of catch continues into the future there is a high probability of the yellowfin stock biomass falling below the Limit Reference Point for IAW.

Given the above concerns of the skipjack in region 5 and yellowfin tuna in region 7 (which include IAW), the 8th Stakeholder workshop agreed that:

i) a precautionary catch reduction of approximately ten percent (10%) from the 2021 catch level should be implemented as a series of annual reductions commencing after the quota based ministerial regulation is officially enforced (4% in year 1, 3% in year 2 and 3% in year 3 see Figure 5) The catch data reference will be taken from the Indonesia Tuna Fisheries Annual Catch Estimates data as determined through the workshop convened each year involving the relevant stakeholders, including WCPFC-SPC.

ii) The empirical catch-based harvest strategy will be implemented in the future (ideally 2025/26) following integration of Regulation No. 11/2023 and the Harvest Strategy framework and selection of scientifically tested empirical harvest strategies for skipjack and yellowfin following completion of the updated MSE process (Figure 6).

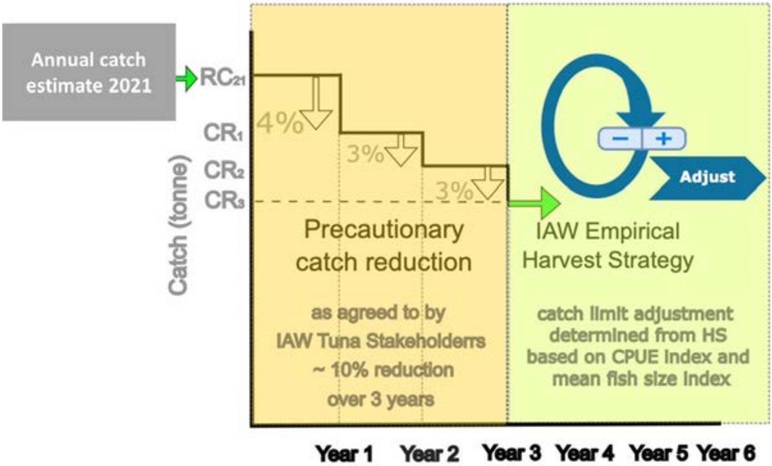
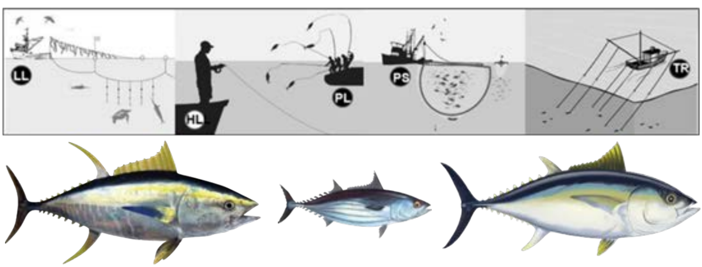


Figure 5. Representation of how the proposed 3-year stepped reduction in tuna catch will precede the initiation of the Empirical Harvest Strategy for Tuna in the IAW. This precautionary reduction plan will allow the completion of comprehensive MSE of Harvest Strategies which will incorporate recent updates to Indonesia's National Tuna Management Plan. The decision to reduce catches from the Average estimated annual tuna catch from 2022, by ~10% over three years, was made by Stakeholders during the 8th IAW Tuna Stakeholder Workshop following results the most recent update of SKJ stock status in region 5 (see Figure 1). RC =Reference Catch, CR = Catch Reduction.

a)



b)

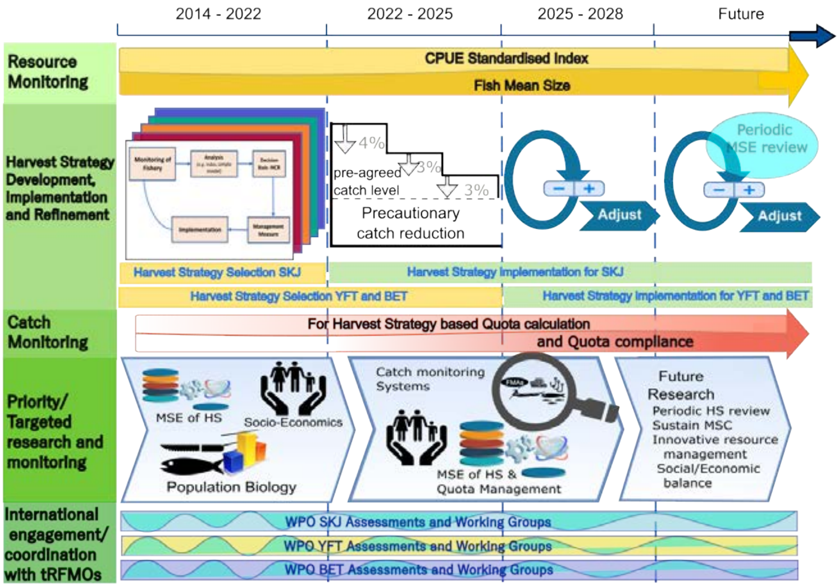


Figure 6. Overview of Sustainable Management of Tuna Resources in IAW. a) Primary Tuna species SKJ, YFT, BET (clockwise) and Fishing methods (LL – Longline, HL – Handline, PL – Pole and Line, PS – Purse Seine, TR – Troll Line. b) Summary of the Harvest Strategy Overview of Sustainable Management of Tuna Resources in IAW. a) Primary Tuna species SKJ, YFT, BET (clockwise) and Fishing methods (LL – Longline, HL – Handline, PL – Pole and Line, PS – Purse Seine, TR – Troll Line. b) Summary of the Harvest Strategy for IAW tuna fisheries in context of Indonesian continuing engagement in regional sustainable management of Tuna resources in the Western Pacific Ocean. The green boxes on the left of the figure identify key elements that will support sustainable management of tuna management into the future. Yellow and Red arrows represent the ongoing data collection programs that underpin all other activities and processes depicted in this figure. Harvest Strategy row summarizes the steps to the Implementation of Empirical HS developed for the sustainable management of Tuna Resources in IAW.

4.4. Management measures

From the fifteen management measures stipulated in Article 3, Law No. 31 Year 2004, on Fisheries, and amended by Law No. 45 Year 2009, on Fisheries, 8 (eight) management measures were selected through selection processes at the 4th and 5th Stakeholder Workshop. Subsequently a risk-assessment process was completed at the 6th Stakeholder Workshop, and further select five priorities management measures. There are various efforts have been undertaken to implement those measures including issuing the related regulations and through stakeholder engagement during regular technical and stakeholder workshops. Progress of the implementation of those measures are summarized as follow:

a. Limit on use of Fish Aggregating Device (FAD).
   - FAD management developed through MMAF regulation No. 18/2021 concerning placement fishing gear and auxiliary fishing gear in FMA, and MMAF decree No. 7/2022 concerning FADs allocation within the 3rd fishing lane in FMA that limits the placement and number of FADs in FMA >12 nm.

b. Spatial closure (of important spawning or nursery grounds) and temporal closure (during important events, such as spawning).
   - Amendment of MMAF regulation No. 4/2015 by MMAF regulation No. 26/2020 on prohibition of fishing in the important events and habitat of YFT at FMA 714 between October and December.

c. Total Allowable Catch (TAC) limits per Fishery Management Area.
   - Initial fishing allocation policy in FMA was introduced by MMAF through DGCF Decree No. 132/Kep-DJPT/2018. This policy has been updated by DGFC Decree No. 9, 20-29/ Kep-DJPT/2020.

- Quota- and zone-based fishing policy is regulated through Government Regulation No. 11/2023 on quota- and zone-based fishing (Penangkapan Ikan Terukur – PIT).
- Based on Government Regulation No. 11/2023, the breakdown of TAC by commodity and FMA will be further developed through Ministerial Regulation of MMAF.
- Through a series of technical and stakeholder workshops, it is agreed by the 8th stakeholder workshop in 2022 to take an action in implementing precautionary catch reduction plan for tropical tuna in the IAW.

The following two agreed management measures of (1) number of fishing days, (2) number of vessels will be considered further, as necessary.

4.5. Management strategy evaluation

In order to examine that a harvest strategy is likely to; a) meet the specified objectives for the fishery; and b) be robust to major uncertainties in the status and dynamics of the stock and the fishery and effectiveness of monitoring and management; it is considered best practice to develop a range of alternative, practically feasible harvest strategies and compare their relative performance is using a simulation modelling approach known as Management Strategy Evaluation (MSE)[4].

A set of MSE models have been developed for skipjack and yellowfin tuna, based on the relevant WCPFC regional stock assessments[1]. These MSE models have been used to develop and conduct preliminary testing of empirical harvest strategy

[4] Punt and Donavan. 2007. Developing management procedures that are robust to uncertainty: lessons from the International Whaling Commission. ICES Journal of Marine Science, Volume 64, Issue 4. https://doi.org/10.1093/icesjms/fsm035

for skipjack and yellowfin tuna, based on the available information and monitoring series, and examine the general feasibility of proceeding with the framework for harvest strategies for skipjack tuna, yellowfin tuna, and bigeye tuna.[5]

These MSE models also provide the basis for testing the performance of a specific alternative harvest strategies and providing government and stakeholders with results to refine and select the most appropriate harvest strategy for implementation for each species. The pilot MSE work to test example harvest strategies, which adjust the level of fishing effort for large-scale Indonesian fleet (licensed by central Government) in response to local abundance indices, and/or technical measure (to mimic reduction in FAD to reduce juvenile fishing mortality) suggest that overall reduction in fishing mortality for Yellowfin in the region is likely to be necessary in order to maintain/achieve the conservation objective of the stock and taking into account the interaction of tropical tunas in the IAW. A precautionary approach to reduce SKJ catch will imply the reduction of the other species (YFT and BET). These previous MSE work has not explored catch-based management measures (i.e. catch quota), and further model development/refinement and additional MSE testing is required to identify the relative performance of catch-based harvest strategies. This will be completed as part of the MSE technical and consultation process.

The process for development of the framework for harvest strategies for tropical tuna has been conducted in a consultative, collaborative and multi-stakeholder approach. Lead government departments were the Directorate of Fish Resources Management - Directorate General of Capture

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[5] Davies *et al.* 2017. Summary and conclusion presentation to stakeholder 2017 workshop.

Fisheries under the Ministry of Marine Affairs and Fisheries and the Centre for Fisheries Research under the National Research and Innovation Agency. Under the direction of the Directorate of Fish Resources Management and by instruction from the Director General for Capture Fisheries, a steering committee was established.

Additionally, a technical group was established and led by the Centre for Fisheries Research, which included technical guidance and input from Commonwealth Science and Industrial Research Organization (CSIRO), with extensive experience in harvest strategies and MSE, and supported by various stakeholders, including Non-Government Organizations (NGOs) and academics. Thirdly, coordinated by the Directorate for Fish Resources Management, the progress was regularly communicated to, and input sought, from a wider stakeholder group including government officials and scientists, provincial governments, NGOs and industry.

5. Implementation and Refinement of Harvest Strategies for Tropical Tuna Fisheries in FMA 713, 714 and 715

Implementation of harvest strategies for tuna in IAW requires the following priority activities to be completed:

1. Fisheries monitoring through data collection programs
2. Targeted research
   a. Representative age, growth and reproductive biology parameters for archipelagic waters
   b. Operational catch and effort data for pole and line and handline/longline tuna fisheries to improve CPUE standardization.
   c. Review port monitoring programs to improve estimation of total catch and effort in archipelagic waters.

3. Testing, refinement and selection of operational objectives and harvest strategy
   a. Technical work program
   b. Stakeholder consultation
4. Specification and implementation of management measures
   a. Refine detail of preferred management measure(s) which are considered operationally feasible to implement, monitor and enforce.
   b. Determine necessary regulatory and monitoring requirements for implementation.
5. Confirmation of regulatory and institutional arrangements required for harvest strategy implementation.
   a. Regulations
   b. Institutional roles and responsibilities
   c. Consultative and advisory forums
6. Policy, stakeholder and science capacity development for harvest strategy implementation.
7. Sustainability of funding for harvest strategy program data will be provided by Government and other legitimate funding resources.

6. Adaptive Management (Exceptional Circumstances)

When a harvest strategy is adopted, it is used to calculate the level of harvest (i.e., catch/effort) to be advised. It is important to check for any exceptional circumstances or conditions which would make implementation of this advice risky or inappropriate. If there are concerns or exceptional circumstances, a process can be followed to evaluate the severity and impact of the exceptional circumstance and recommend an appropriate action or actions. The types of exceptional circumstances that are commonly considered, fall into three categories: i) Information on the stock, fishing operations, population dynamics parameters, or biology that is outside the range considered during MSE testing of the adopted harvest strategy; ii) Input data to the harvest strategy that are missing, have changed, or outside the range simulated in the MSE; iii) Implementation of the harvest strategy that is inconsistent with the advice (e.g. total catch is greater than the total allowable catch recommended by the harvest strategy). The definitions of types of exceptional circumstances conditions and actions that can be considered, will be also decided through further technical and consultation processes.

In case the policies, and socio-economic conditions, or other natural factors have the potential to impose a significant influence on the fish stock status, to the extent that it indicates drastic changes in the stock, adaptive measures will be implemented based on an evaluation of the situation.

7. Technical and Consultative Process

Multiple stakeholder consultations and technical workshops, fostering a transparent and participative environment for harvest strategy development. Summary of technical and consultative process for development of framework for harvest strategy for skipjack, yellowfin tuna and bigeye tuna in Indonesian archipelagic waters is presented below.

Table 1. Technical and consultative meetings for development of framework for harvest strategy for tropical tuna in the IAW

Date	Meeting	Location
October 30-31, 2014	Preparation meeting	Bogor, Jawa Barat (West Java)
March 25-27, 2015	Harvest strategy preparation and introduction meeting (1st Stakeholder Consultation)	Bogor, Jawa Barat (West Java)
May 18-22, 2015	2nd Stakeholder consultation	Bogor, Jawa Barat (West Java)
August 10, 2015	Pre-workshop for data analysis	Bogor, Jawa Barat (West Java)
November 16-18, 2015	3rd Stakeholder consultation	Kuta, Bali
November 19-20, 2015	Baseline data to develop harvest strategies	Kuta, Bali
April 4-7, 2016	1st Technical meeting for harvest strategy development	Bogor, Jawa Barat (West Java)

Date	Meeting	Location
November 10-11, 2016	2nd Technical meeting for harvest strategy development	Denpasar, Bali
November 14-16, 2016	4th Stakeholder consultation	Bogor, Jawa Barat (West Java)
March 6-7, 2017	3rd technical meeting for harvest strategy development	DKI Jakarta/Special Capital Region of Jakarta
March 8-10, 2017	5th Stakeholder consultation	DKI Jakarta/Special Capital Region of Jakarta
July 12-13, 2017	6th Stakeholder consultation	Loka Riset Perikanan Tuna, Bali/Tuna Research Center, Bali
October 2017	4th Technical Meeting	Bogor, Jawa Barat (West Java)
November 22-23, 2017	7th Stakeholder consultation	Bogor, Jawa Barat (West Java)
November 22-23, 2018	1st Stakeholder Implementation	Bogor, Jawa Barat (West Java)
October 28-29, 2019	5th Technical Meeting	Bogor, Jawa Barat (West Java)
October 30-31, 2019	2nd Stakeholder Implementation	Bogor, Jawa Barat (West Java)
February 24-25, 2021	6th Technical Meeting	Bogor, Jawa Barat (West Java)
March 2-3, 2021	3rd Stakeholder Implementation	DKI Jakarta/Special Capital Region of Jakarta
December 9-10, 2021	7th Technical Meeting	Bogor, Jawa Barat (West Java)
December 13-14, 2021	4th Stakeholder Implementation	Bogor, Jawa Barat (West Java)
November 21-22, 2022	8th Technical Meeting	Bogor, Jawa Barat (West Java)
November 23-25, 2022	5th Stakeholder Implementation	Bogor, Jawa Barat (West Java)

Acknowledgements

Ministry of Marine Affairs and Fisheries sincere gratitude for invaluable collaboration and contribution from Research Center for Fishery-BRIN, CSIRO Australia, and support from Indonesia Tuna Consortium initiative (Yayasan Konservasi Alam Nusantara, Yayasan Masyarakat dan Perikanan Indonesia, and Yayasan IPNLF Indonesia).

Supplementary Material

Matrix of Implementation Monitoring for tropical tuna Harvest Strategy in the IAW

No	Technical Activities	Source of Data and Information	Fisheries	Species	Unit of Authorities	Implementing Agency and Partners
1.	Data Collection for Dependent Data	• Statistics of Capture Fisheries • Annual Report to RFMO • Fishing Logbook • On-board Observer • DGCF Licensing and Provincial Data Portal (SIMKADA) • Port Sampling	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	• DGCF Secretariat • Directorate of Fisheries Resources Management • Directorate of License and Fishermen Affairs • Research Organization for Earth Sciences and Maritime - BRIN	Directorate of Fisheries Resources Management
2.	Data Collection for Independent Data	• National Research and Innovation • Research by Government's partners	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	• Research Organization for Earth Sciences and Maritime - BRIN	• Research Organization for Earth Sciences and Maritime - BRIN • NGOs and Fishing Association • International/Regional/Bilateral Partners • Universities

No	Technical Activities	Source of Data and Information	Fisheries	Species	Unit of Authorities	Implementing Agency and Partners
3.	MSE testing	• Research and Innovation • Government's partners	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	• Research Center for Fishery – BRIN • CSIRO	• Research Center for Fishery – BRIN
4.	Input for Implementation of Management Measures	• Quota-based fishing • FAD management • Spatial and temporal fishing closures	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	• Directorate of Fisheries Resources Management • Directorate of License and Fishermen Affairs	Directorate of Fisheries Resources Management
5.	Technical Consultation	• Data preparation and pre-analysis • Results of HS Monitoring and Review	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	• Directorate of Fisheries Resources Management • Government's partners	Directorate of Fisheries Resources Management

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    - Ignatius Tri Hargiyatno, M.Si.,
    - I Gede Bayu Sedana, S.Kom.,
    - Sri Patmiarsih, S.Pi.,
    - Ade Setia Januar, S.Pi., M.Si.,
    - Muhammad Anas, S.Pi, M.S.E.M.A,
    - Satya Mardi, S.Pi.,
    - Indah Pratiwi Kamba S.Pi.,
    - Rista Devi Juniar, S.Pi.,
    - Anang Wahyu Susilo, S.Pi., M.Si.,
    - Campbell Davies, Ph.D.,
    - Eriko Hoshino, Ph.D.,
    - Richard Hillary, Ph.D.,
    - James Dell, Ph.D.

3. *Support Partners*:
    - Saut Tampubolon, *Deputy Chief,* USAID Ber-IKAN;
    - Wildan, *Small Scale Fisheries Lead*, USAID Ber-

IKAN;
- Dr. Peter Mous, *Director of Sustainable Fisheries Program*, Yayasan Konservasi Alam Nusantara;
- Shinta Yuniarta, *Tuna Program Manager*, Yayasan Konservasi Alam Nusantara;
- Glaudy Perdanahardja, *Fisheries Senior Manager*, Yayasan Konservasi Alam Nusantara;
- Prayekti Ningtias, Fisheries Policy Specialist, Yayasan Konservasi Alam Nusantara:
- Shannon Hardisty, *Indonesia Strategy Manager*, Yayasan *International Pole and Line Foundation* Indonesia;
- Wiro Wirandi, *Indonesia*, Yayasan *International Pole and Line Foundation* Indonesia;
- Yasmine Simbolon, Direktur Masyarakat dan Perikanan Indonesia, Masyarakat dan Perikanan Indonesia;
- Putra Satria Timur, *Fisheries Lead*, Masyarakat dan Perikanan Indonesia;
- Supporting partners: - Program Tuna Consortium (Prof. Dr. Ir. Budy Wiryawan - Science Advisor, Dr. Toni Ruchimat - Policy Advisor, Thilma Komaling, SE, MPP Strategic Lead).

4. *Secretariat*:
   - Mumpuni Cyntia Pratiwi, S.Pi., M.S.,
   - Saraswati, S.Pi.,
   - Ahmad Noval, A.Md.

11.10Appendix 11: A selection of project related photos

Bali Tuna Conference 2018 group photo

Cambell Davies (CSIRO) giving a keynote speech at the Bali Tuna Conference in 2018.

Fayakun Satria (BRIN) giving a keynote speech at the Indonesian Tuna Conference in 2023

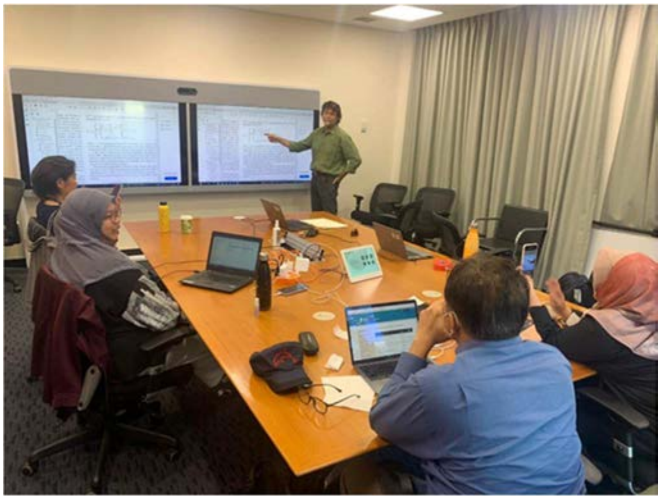
Indonesian Harvest strategy workshop, October 2019.


Biology training workshop, September 2019

Capacity building workshops for harvest strategies in Hobart in 2018, 2022 and 2023.

Capacity building Workshop 2018, CSIRO Hobart

Capacity building Workshop 2022, CSIRO Hobart



Capacity building Workshop 2023, CSIRO Hobart

Capacity building Workshop 2023, CSIRO Hobart

Kendari East Sulawesi

Small Purse Seine Boats Kendari Fishing Port

Kendari fishing port

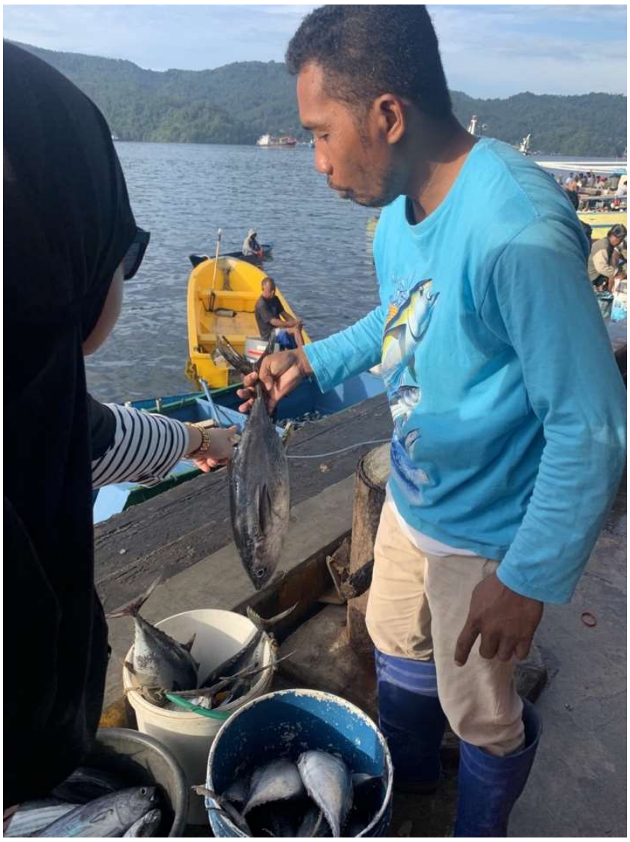
Bow detail of Kendari Small purse seiners.

Kendari Fish Market. Mix of Small BET, YFT. “Tongkol” and Skipjack Tuna

Naomi Clear, Ignatius Tri Hargiyanto, Ririk Kartika Sulistyaniningsih, Lead Enumerator Ismail Agung Syah , Wudianto

Sample Recovery, Bitung, North Sulawesi, June 2023

Bigeye Tuna, landed from Small Purse Seine Boat, Bitung Fishing Port



Lead DGCF enumerator Jondris Dily with small Longtail tuna (Tongkol), Bitung Fishing Port, North Sulawesi, June 2023

Light Boats, Bitung Fishing port. Light Boats use jig and handline and are known to act as mobile FADs and cooperate with small purse seine boats, swapping information on fish volumes for transhipment of ice and catch.

Longtail Tuna off loaded at Bitung early morning fish market at fishing port.

Bigeye Tuna, offloaded from small purse seine, Bitung fish port.

Prihatiningsih (BRIN), DGCF enumerator, Dr Jim Dell, Anung Widodo (BRIN), Hety Hartaty (BRIN)

Small utility boats in Bitung Fishing port, North Sulawesi June 2023

Skipjack catch from small purse seine, Bitung Fishing Port, North Sulawesi June 2023

Prihatiningsih, Dr Fayakun Satria, Hety Hartaty and Dr Jim Dell with frozen ovary samples ready to be shipped from Bitung DGCF offices, North Sulawesi to BRIN Laterio, Ancol, Jakarta, June 2023.

Small Purse Seine offloading at Bitung Fishing port, North Sulawesi, June 2023.

Small “tongkol”, mixed species of mackerel, neritic tuna species and tropical tuna, off loaded at Bitung Fishing port, North Sulawesi, June 2023

Small Purse Seine offloading at Bitung Fishing port, North Sulawesi, June 2023. Note the bamboo booms that act as surface floats for the net, and the boxes of SKJ tuna ready for offloading.

Large Yellowfin tuna that were landed from small purse seine boats, Bitung Fishing port, North Sulawesi, June 2023. Note that large tuna are generally not captured in small purse seine nets, as they can easily escape during the net closure. It is most likely that, these fish were transhipped from other vessels, perhaps the small handlining/jigging light boats that spend many nights at sea, working collaboratively with vessels with other gear types, relaying information on fish aggregations, and exchanging, food, fuel and catch with larger vessels.

Small handling/jigging light boats, Bitung Fishing Harbour, North Sulawesi, June 2023