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**HARVEST STRATEGIES FOR TROPICAL TUNA IN ARCHIPELAGIC WATERS OF
INDONESIA: UPDATE**

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Harvest Strategies for Tropical Tuna in Archipelagic Waters of Indonesia: Update in 2023

The Western and Central Pacific Fisheries Commission (WCPFC) has adopted the Conservation and Management Measure on establishing a harvest strategy for key fisheries and stocks in the Western and Pacific Ocean (CMM 2014-06) to ensure the long-term conservation and sustainable use of the highly migratory fish stocks of the WCPO in 2014. In the following year, a work plan for the adoption of harvest strategies (HS) has been agreed. The development and implementation of harvest strategies for major tuna species is also consistent with Indonesia's sovereign rights and obligations as a member of the international governance bodies for these highly migratory stocks: Regional Fisheries Management Organizations (RFMOs). Indonesia intends to develop Harvest Strategies within its Archipelagic Waters which are compatible with measures mandated by the RFMOs. In addition, implementation of the monitoring, assessment and management measures, which form the essential elements of a harvest strategy, are central to achieve certification of fisheries to international standards for sustainability, an important milestone for the private sector in Indonesia, and to safeguard against local depletions of tuna stocks.

Indonesia intends to develop scientifically-tested harvest strategies for tropical tuna in the Indonesia's Archipelagic Waters (IAW). This development has been initiated since November 2014. The aim of developing the HS is to enable Indonesia to manage its tropical tuna fishery within its IAW in an adaptive way which can be measurable and predictable in achieving its management objective. This work is a participatory and consultative process which involves a spectrum of relevant stakeholders,

including central and local Government, fishery managers, fishing associations, industry stakeholders, private sector companies, international and local Non-Government Organizations (NGOs), fishery scientists and experts.

Indonesia's Archipelagic Waters (IAW) encompass Fisheries Management Areas (FMAs) 713, 714 and 715, and are identified as the priority areas for this initiative due to the significant role it plays for Indonesian tuna fisheries. In recent years, the proportion of tuna catches from those areas has increased relative to the national tuna catches. A strong residential behaviour has been reported by Rice et al. (2014)¹ for skipjack, and highlighted during the WPEA, *Three Country Stock Assessment Workshop*, held in Vietnam in 2015, for skipjack and yellowfin tuna. Therefore, the development and implementation of harvest strategies for tuna fisheries in Indonesian archipelagic waters is very important and at the same time demonstrates Indonesia's commitment to long-term sustainability of these nationally and regionally important resources. It is the intention that this process will initially focus on these three FMAs but will, at a later date, be expanded to include all national waters.

This is the first attempt to develop harvest strategies for Indonesia's tuna fisheries under the national plan, a specific harvest strategy framework has been developed through a collaborative work between the Center for Fisheries Research (CFR), Directorate General for Capture Fisheries (DGCF), Ministry of Marine Affairs and Fisheries (MMAF), Indonesia and the WCPFC under the West Pacific East Asia – Sustainable Management (WPEA-SM) with the involvement of the Commonwealth Scientific and Industrial Research Organization (CSIRO) experts. The WPEA project has supported the development of Indonesia's National Tuna Management Plan (NTMP) in 2017, to date it has been reviewed and revised by DGCF under MMAF decree no.121 year 2021. Moreover, the WPEA support the port-based sampling program for at least 12 years data and trigger the development of interim harvest strategy framework for tropical tuna fishery in Indonesia's archipelagic waters (FMAs 713, 714 and 715).

In the nineteenth regular session of the commission in December 2022 of the WCPFC has agreed on the conservation and management measure on a management procedure for Skipjack tuna in the WCPO with a harvest control rule (WCPFC19 Summary Report Attachment G). Indonesia's has continuously provided an update for its harvest strategy of tropical tuna in the Archipelagic Waters in the documents WCPFC16-2019-DP20_rev1, WCPFC-SC16-2020/MI-IP-24 and WCPFC-SC17-2021/MI-IP-14(Rev.01). For Indonesia's case the development and implementation of this harvest strategy is very challenging since it needs to involve cross sectors of stakeholders, convincing high level policy makers, and ensuring the compliance of fishing actors and the continuation of the long term fishery monitoring. The recent progress of this work has been substantially entering to the implementation stage of the harvest strategy, yet other scientific work is still ongoing such as finalization of tropical tuna biological parameters and the development of the complete effort and/or catch-based operating model (i.e. in collaboration with ACIAR-CSIRO Australia). However, an immediate action that adopts a precautionary approach needs to be undertaken, taking into account the recent stock assessment for the depletion of SKJ in particular for the region 5 of WCPO (which Indonesia waters in this region). In addition, the agreed target reference point and harvest control rule for SKJ in the WCPFC needs to be considered. The tropical tuna HS in the IAW has been signed by the MMAF Minister in June 2023 with expectation towards better utilization, better monitoring of the tropical tuna in the IAW and long term sustainability of the resources. This document is a living document that can be revised based on best scientific evidence available. The framework for HS for tropical tuna in archipelagic waters of Indonesia can be read in Attachment 1.



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, which are under full sovereignty of Indonesia's marine waters, hold unique characteristics due to the presence of Highly Migratory Fish Species (HMFS). Consequently, the management of these fisheries is distinct from that of 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

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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 and Indonesia’s engagement in the WCPFC harvest strategy process.

The 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 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 (F_{MSY}). 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 the period 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).

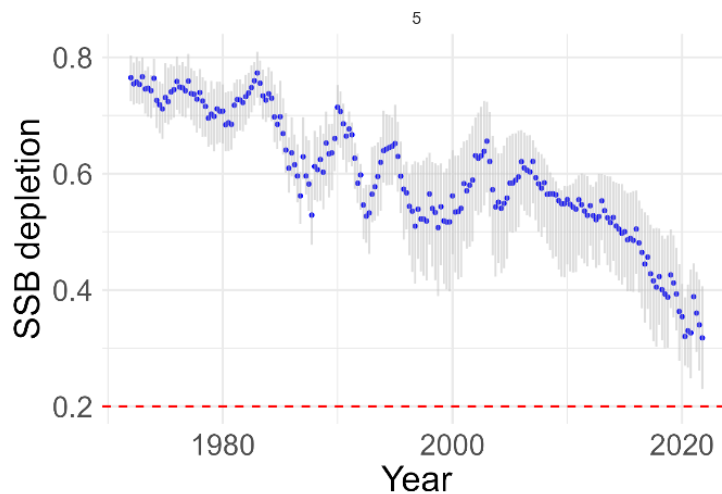


Figure 1. Spawning stock biomass (SSB) depletion in region 5, which includes IAW, across 18 structural uncertainty grid models between 1972 and 2021. Data were extracted from the output files from the SPC website Skipjack Assessment Results (spc.int). The blue dot in the middle of the bar is median,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

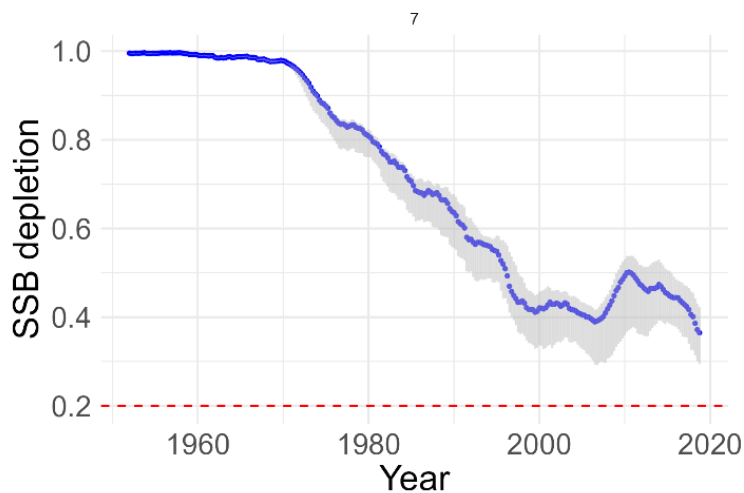


Figure 2. Yellowfin tuna SSB depletion (SSB/SSBF=0) in region 7, which includes IAW, between 1952 and 2018. The height of the grey error bars indicates 20th and 80th percentile, the blue dots are 50 percentile (median). The horizontal dotted red line is the limit reference point. Data were extracted 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).

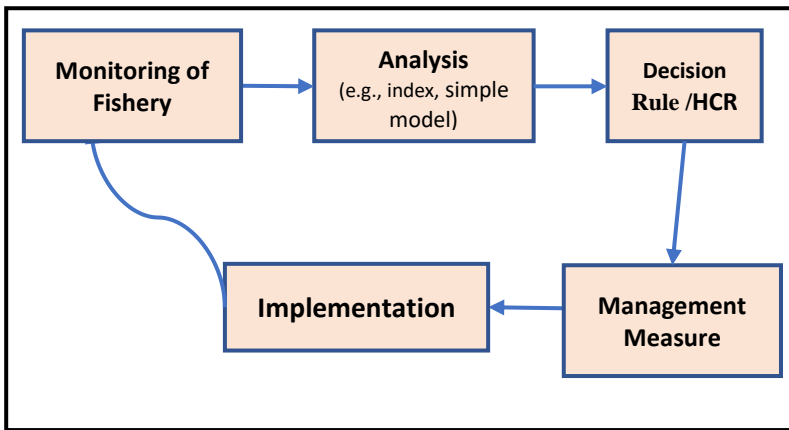


Figure 3. Conceptual illustration of the components of a harvest strategy. It is the combination of components that define an individual harvest strategy and determine its likely performance. Hence, if one, or more component(s) is (are) changed, this is considered as a different harvest strategy. As 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, known as Management Strategy Evaluation (MSE).. 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.

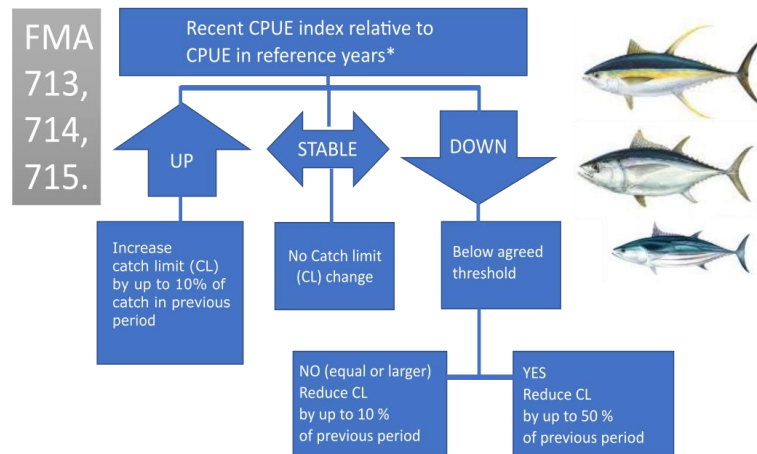


Figure 4. Flow diagram illustrating operation of empirical harvest control rule of a similar form to that proposed and initially tested for tropical tuna in Archipelagic waters of Indonesia.
*) Stakeholders agreed reference years, i.e., 2014-2016.

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 tuna¹. 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:

- 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 tuna² and yellowfin tuna³. 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);

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>

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>

- A stock depletion of 32 percent for skipjack in region 5 for the most regional stock assessment, which is lower than the agreed interim target reference point ($SB/SB_{F=0} = 0.36-0.50$);
- 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:

- 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.
- 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).

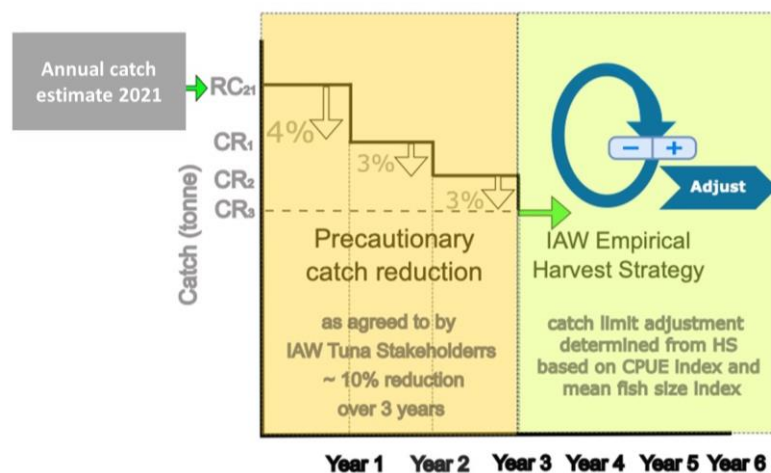
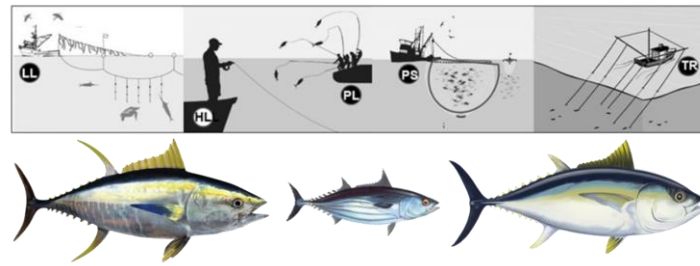


Figure 5. Representation of how the proposed 3-year stepped reduction in tuna catch will precede the initiation of the Empirical Harvest Strategy for Tuna in the IAW. This precautionary reduction plan will allow the completion of comprehensive MSE of Harvest Strategies which will incorporate recent updates 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)

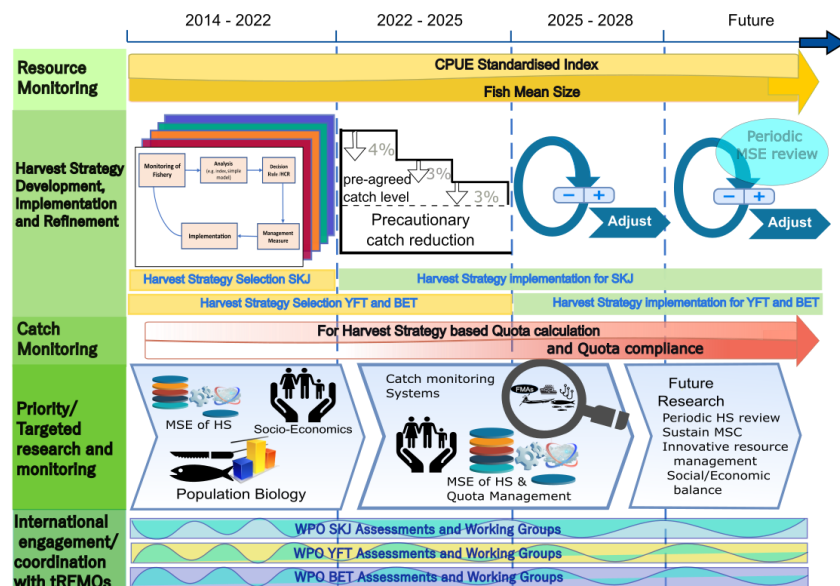


Figure 6. Overview of harvest strategy framework of for tropical tuna in IAW. a) Primary Tuna species YFT SKJ, BET (left to right) and Fishing methods (LL – Longline, HL – Handline, PL – Pole and Line, PS – Purse Seine, TR – Troll Line. b) Schematic representation of the elements of the Harvest Strategy 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 to 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 (see Supplementary Material for more detail. 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.

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 assessments¹. These MSE models have been used to develop and conduct preliminary testing of empirical harvest strategy 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.

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>

⁵ Davies *et al.* 2017. Summary and conclusion presentation to stakeholder 2017 workshop.

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 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 (1 st Stakeholder Consultation)	Bogor, Jawa Barat (West Java)
May 18-22, 2015	2 nd Stakeholder consultation	Bogor, Jawa Barat (West Java)
August 10, 2015	Pre-workshop for data analysis	Bogor, Jawa Barat (West Java)
November 16-18, 2015	3 rd Stakeholder consultation	Kuta, Bali
November 19-20, 2015	Baseline data to develop harvest strategies	Kuta, Bali
April 4-7, 2016	1 st Technical meeting for harvest strategy development	Bogor, Jawa Barat (West Java)
November 10-11, 2016	2 nd Technical meeting for harvest strategy development	Denpasar, Bali
November 14-16, 2016	4 th Stakeholder consultation	Bogor, Jawa Barat (West Java)
March 6-7, 2017	3 rd technical meeting for harvest strategy development	DKI Jakarta/Special Capital Region of Jakarta
March 8-10, 2017	5 th Stakeholder consultation	DKI Jakarta/Special Capital Region of Jakarta
July 12-13, 2017	6 th Stakeholder consultation	Loka Riset Perikanan Tuna, Bali/Tuna Research Center, Bali
October 2017	4 th Technical Meeting	Bogor, Jawa Barat (West Java)
November 22-23, 2017	7 th Stakeholder consultation	Bogor, Jawa Barat (West Java)
November 22-23, 2018	1 st Stakeholder Implementation	Bogor, Jawa Barat (West Java)
October 28-29, 2019	5 th Technical Meeting	Bogor, Jawa Barat (West Java)
October 30-31, 2019	2 nd Stakeholder Implementation	Bogor, Jawa Barat (West Java)
February 24-25, 2021	6 th Technical Meeting	Bogor, Jawa Barat (West Java)

Date	Meeting	Location
March 2-3, 2021	3 rd Stakeholder Implementation	DKI Jakarta/Special Capital Region of Jakarta
December 9-10, 2021	7 th Technical Meeting	Bogor, Jawa Barat (West Java)
December 13-14, 2021	4 th Stakeholder Implementation	Bogor, Jawa Barat (West Java)
November 21-22, 2022	8 th Technical Meeting	Bogor, Jawa Barat (West Java)
November 23-25, 2022	5 th Stakeholder Implementation	Bogor, Jawa Barat (West Java)

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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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • National Research and Innovation • Research by Government's partners 	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	<ul style="list-style-type: none"> • Research Organization for Earth Sciences and Maritime - BRIN 	<ul style="list-style-type: none"> • Research Organization for Earth Sciences and Maritime - BRIN • NGOs and Fishing Association • International/Regional/Bilateral Partners • Universities
3.	MSE testing	<ul style="list-style-type: none"> • Research and Innovation • Government's partners 	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	<ul style="list-style-type: none"> • Research Center for Fishery – BRIN • CSIRO 	<ul style="list-style-type: none"> • Research Center for Fishery – BRIN
4.	Input for Implementation of Management Measures	<ul style="list-style-type: none"> • Quota-based fishing • FAD management • Spatial and temporal fishing closures 	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	<ul style="list-style-type: none"> • Directorate of Fisheries Resources Management • Directorate of License and Fishermen Affairs 	Directorate of Fisheries Resources Management
5.	Technical Consultation	<ul style="list-style-type: none"> • Data preparation and pre-analysis • Results of HS Monitoring and Review 	HL, PL, PS, LL and other fishing gears	YFT, BET, SKJ and others	<ul style="list-style-type: none"> • Directorate of Fisheries Resources Management • Government's partners 	Directorate of Fisheries Resources Management

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