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THE DEVELOPMENT OF HARVEST STRATEGIES FOR TROPICAL TUNA IN INDONESIA'S ARCHIPELAGIC WATERS

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ABSTRACT

Significant roles of the fishery in the Indonesia's archipelagic waters/IAW (FMAs 713, 714 and 715), with proportion of around 60% came from the IAW, and a strong residential behavior for skipjack (SKJ) and yellowfin tuna (YFT) encourage Indonesia to develop harvest strategies for the tropical tuna in the IAW. This is a priority action of the National Tuna Management Plan (NTMP) for tropical and neritic tuna. Fisheries operating in the IAW are mainly small scale commercial vessels. A specific harvest strategy framework that appropriate with the fishery characteristics has been developed. This paper describes the process of harvest strategy (HS) development for the tropical tuna in the Indonesia's archipelagic waters (FMAs 713, 714 and 715). The HS is developed scientific works (including data collection, analysis/modelling and series technical and consultative stakeholder workshops as well as expert consultancies. Four technical workshops and seven stakeholder workshops have been done between 2015 and 2017. An interim HS (consisted of management objective, limit reference point, monitoring, analysis, harvest control rule and management measure) has been determined and agreed. Continues collaboration and commitment from related stakeholders including Government, fishers, fishing association, NGOs by adopting co-mangement and participatory approach in implementing the agreed harvest strategy, through data collection and sustain supports.The time series of catch and effort data, and size data could be used to monitor the fishery, stok status and its performance.In addition, involvement of relevant international tuna experts through expert consultancies are integrated process with the technical and stakeholder workshops. This HS development process is still on-going and can be refined, as HS development is a cycle and an iterative process.

Keywords: Harvest strategy; harvest control rule; tropical tuna; archipelagic waters

INTRODUCTION

Indonesia has claimed to be an archipelagic nation through Juanda Declaration of 1957, which referring to the Law of the Sea Convention (UNCLOS).From the eleven designated Indonesia's Fisheries Management Areas (FMAs), FMAs 713, 714, 715, 716 and 717 are related to the Western and Central Pacific Fisheries Commission (WCPFC) area. FMAs 713, 714 and 715 are Indonesia archipelagic waters (IAW) which not belongs to the WCPFC convention area, whereas the other two FMAs 716 and 717 that have 12 nm of territorial waters are also located 200 nm ofthe Indonesian Economic Exclusive Zone (IEEZ). The IEEZ is under the WCPFC Convention Area (WCPFC-CA) which is under the management of this commission, unlike the archipelagic waters. The IAW is under the statistical area of the WCPFC, which Indonesia has a sovereignty rights to manage its fishery (Anon, 2017).

The IAW, FMAs 713, 714 and 715 have been considered to have a higher contribution to the Indonesian tuna catch relative to the IEEZ, with proportion of around 60% came from the IAW (Anon, 2017, Satria *et al*., 2014; Satria *et al*., 2015; Satria *et al*., 2016; Satria *et al*., 2017).Fisheries operating in the IAW are mainly small scale commercial vessels using pole and line, purse seine, handline, troll line and gillnet, which highly influencing the livelihood for the small scale fishers. These vessels mostly fish using or nearby fish aggregating devices (FADs), and they targeting tropical tuna, comprised of approximately 65% skipjack (*Katsuwonus pelamis* - SKJ), followed by 28% yellowfin (*Thunnus albacares* - YFT) and 6% bigeye tuna (*T. obesus* - BET) in 2016 (Satria *et al*., 2017).

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The important and significant role of the fishery in the IAW (Anon, 2017) and a strong residential behavior for SKJ and YFT reported by Rice *et al.* (2014) encourage Indonesia to develop harvest strategies (HS) for the tropical tuna (SKJ, YFT and BET) in the IAWwhich in line with the recent conservation and management measure (CMM) 2017-01 of the WCPFC on tropical tuna. This is consistent with Indonesia's rights and commitment to the sustainable management for these nationally but also regionally important resources. Furthermore, the development and implementation of the HS is a priority action of the National Tuna Management Plan (NTMP) for tropical and neritic tuna (MMAF, 2015) as stated in the Ministerial Decree of Marine Affairs and Fisheries No. 107/2015.In addtion, there is a need and strong request from tuna industries to establish HS in relation to fishery certifications for tuna fishery in the IAW.Indonesia has initiated the development of HS for tropical tuna in the IAW since November 2014. The aim of developing the HS is to enable Indonesia to manage its tropical tuna fishery within its IAW with an adaptive way which can be measurable and predictable in achieving its management objective. This work is a participatory and consultative process which involved various relevant stakeholders, including central and local Governments, managers, fishing associations, industries, companies, Non-Government Organisations (NGOs), scientists and experts.

Some guidelines are available for developing HS (DAFF, 2007, Sloan *et al*., 2014, NZ Govt., 2011, NZ Govt., 2008) including for the limited data fishery (Dowling *et al*., 2015; Prince *et al*., 2011). Harvest strategies have been developed by Australia for Northern Prawn Fishery (Dichmont *et al*., 2014) and Eastern Tuna and Billfish Fisheries (Campbell & Dowling, 2003).However, Indonesia itself has specific fishery characteristics and yet complicated challenges facing by Indonesia including multi gears,large size of fleets and socio-economic aspects of the fishers.This is a very first attempt to the develop harvest strategy for Indonesia's tuna fishery, a specific harvest strategy framework has been developed by involvement and assistance from experts of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australia through the West Pacific East Asia (WPEA) project. A case study of tuna fisheries in the IAW (FMAs 713, 714 and 715) will be explored as an example on developing HS for tropical tuna in IAW. This paper describes the process of the HS development for the tropical tuna in the Indonesia's archipelagic waters (FMAs 713, 714 and 715).

MATERIALS AND METHODS

Port-based sampling programs (or sometimes called as "port-based catch monitoring program") conducted either by Government institutions (Center for Fisheries Research and DGCF), Non-Government Organisations or tuna fishing industries between 2010 and 2015 were used within this paper. The sampling activities cover the following landing sites: Bitung, Ternate, Sorong, Fak fak, Tual, Ambon, Kendari, Sodohoa, Maumere, Larantuka, Bone, Mamuju, Majene and Gorontalo (Figure 1). The data recorded catch by species, effort data (number of days at sea) and vessel ID from different types of fishing gears catching tropical tuna. Data collected by a collaborative research project between CFR (Center for Fisheries Research) and the WCPFC has the longest time series landing data (Table 1). This data set has been annually audited by the South Pacific Community (SPC) through regular Port Sampling Data Audits.

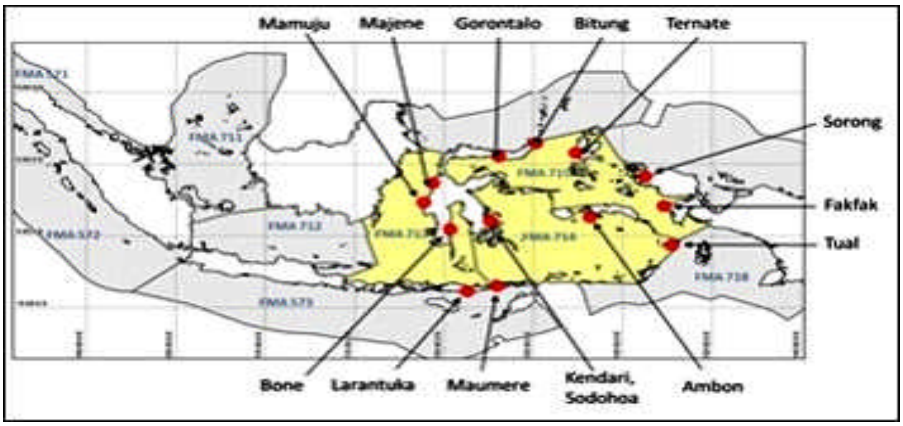

Figure 1. Map showing Locations of sampling sites (including sampling sites of CFR and WCPFC, CFR and CSIRO, and MDPI data collection programs) which covers the main tuna landings places in the Indonesia's FMAs 713 - 715. The yellow areas show the three FMAs. Modification of the Ministerial Regulation of Marine Affairs and Fisheries No. 18/ 2014 on Indonesian Fisheries Management Area (Satria & Sadiyah, 2017).

In addition to the port-based sampling program, National logbook and on-board observer data collected in 2016 were used in the HS work to convert the number days at sea into number of fishing days (as the number of fishing days was chosen to represent effort). Note that, the National logbook and on-board observer data prior to 2016 are still trial and effort information were incomplete. The CFR-WPCFC port-based sampling program has started to record number of fishing days as well as number of days at sea since 2016. This 2016 CFR-WCPFC data set was also used to convert the number days at sea (data prior 2016) into number of fishing days using linear regression analysis.

Minimum data requirements for the HS development were defined through the first technical workshop, which must contain at least catch (by species by gear) and effort data (number of days at sea or fishing days), and size (fish length) data, and the data are long-term series data (at minimum for three years).The data sources available were then selected using those criteria. Data sets which meet the criteria were then used for the HS work.

The HS is developed through two main processes, scientific works (including data collection, analysis/ modelling and series technical and consultative stakeholder workshops). At the same time, the involvement of relevant international tuna experts has been continuously maintained. Four technical workshops and seven stakeholder workshops have been done between 2015 and 2017. Components of HS consisted of monitoring, assessment/analysis, decision rule/harvest control rule (HCR), management measure and implementation (Anon, 2017).

Table 1. Summary of data sets available from FMAs 713, 714 and 715. Data sets agreed during the 2nd stakeholder workshop for harvest strategy development are data collected from 2010-2015 (as the first attempt)

Data series name	Sampling period	Sampling frequency	FMA coverage	% landing/gear coverage	Source of effort/catch data	Rel. abundance?	Size indices?	On going?
CFR-WCPFC (WPEA)	2010 ->	Daily	713, 714, 715, 716 & 717	30% of # vessels landed. PL,PS,SHL,TLH,TR,LHL,LL	Effort (fishing days, hooks), total catch volume per port-sampled vessel	√, SKP, YFT, BET, ALB(Bitung)	√	√
CFR - CSIRO (ACIAR)	Oct 2013 - Dec 2015	Daily	714, 715	20% of # vessels landed. Mainly HL and TL, but also PL, PS at 4 ports	Number of fishing days, catch per trip recorded by enumerator		√	Data collection at Kendari is still on-going under CFR
RIMF (Research Institute for Marine Fisheries)	2011, 2013	Daily, sometimes weekly	714, 716	PL,PS,HL,TL	No effort data		√	
National logbook	2012 - 2014	Per trip	713, 714, 715	LL, PS, TR	No effort data		√	
RITF (Research Institute for Tuna Fisheries)	2002	2 observer trips only	714	LL	Number of hooks available			
AP2HI (AsosiasiPerikanan Pole and Line danHandline Indonesia)	2010 ->	Monthly aggregate	714, 715, 716	HL, PL	No effort data			√
SFP (Sustainable Fisheries Partnership)	2015	Not everyday??	714	HL	No effort data		√	
MDPI (MasyarakatdanPerikanan Indonesia)	2012 ->	Daily	713, 714, 715	HL,PL	Number of fishing days & catch (not clear)	√, YFT, SKP,?BET?	√	√
WWF (World Wildlife Fund)	2006 ->	Daily	714	HL <5GT, GN	Number of fishing days (no available for Wakatobi)		√	√
PSB (PerikananSamoderaBesar)	1978-1994	Set by set data by skipper	714	LL, 1 fishing company	Number of hooks available & catch per set (No. of fish)			
Logbook Bitung	2011 - 2013		714, 715	PS				
National statistics/catch estimate workshop	2002 ->		713, 714, 715	all gears	Estimated total catch for each FMA	x		√

RESULTS AND DISCUSSION

Results

Data Collection Program and Data Selection for HS Development

In general data collection activities for tuna fisheries prior 2010 was limited, incomplete scientific knowledege and insufficient data, hence can not be used to have accurate asessment (Gillet, 2013), since then in 2010 through the CFR – WCPFC collaborative research project (WPEA project) a port-based catch monitoring program has sucessfully established, regularly supervised and improved. In early 2014, the data collection protocol (Widodo, *et al*., 2013) was referred and followed by relevant NGOs and associations.

The available data sets for the HS work are mainly port-based catch monitoring programs which generally

aimed to estimate total catch by gear by species, not really focus on effort data collection (some of the programs collected lower resolution of effort data, i.e. number of days at sea). The observer and logbook data collected prior 2016 could not be used for current HS work due to the programs were still in developing stage. However, the improved observer and logbook data collected in 2016 were used in the HS work (conversion from number of days at sea into number of fishing days).

Through series of technical and stakeholder workshops, three data sets that meet the minimum data requirements for developing HS were selected. These three data sets were the CFR-WCPFC port-based catch monitoring programs, CFR-CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) port-based sampling program (collaborative research project between CFR and CSIRO funded by ACIAR– Australian Centre for International Agricultural Research), and MDPI (Masyarakat dan Perikanan Indonesia) data collection program). Number of landings by PL vessels recorded by the three data sets and its temporal coverage (by quarter) varied (Figure 2), with the CFR-WCPFC data set has the largest number of landings recorded from 2010 – 2015. Sampling activities of the three data sets (CFR – WCPFC, CFR – CSIRO and MDPI) cover the IAW (FMAs 713, 714 and 715) (Figure 2).

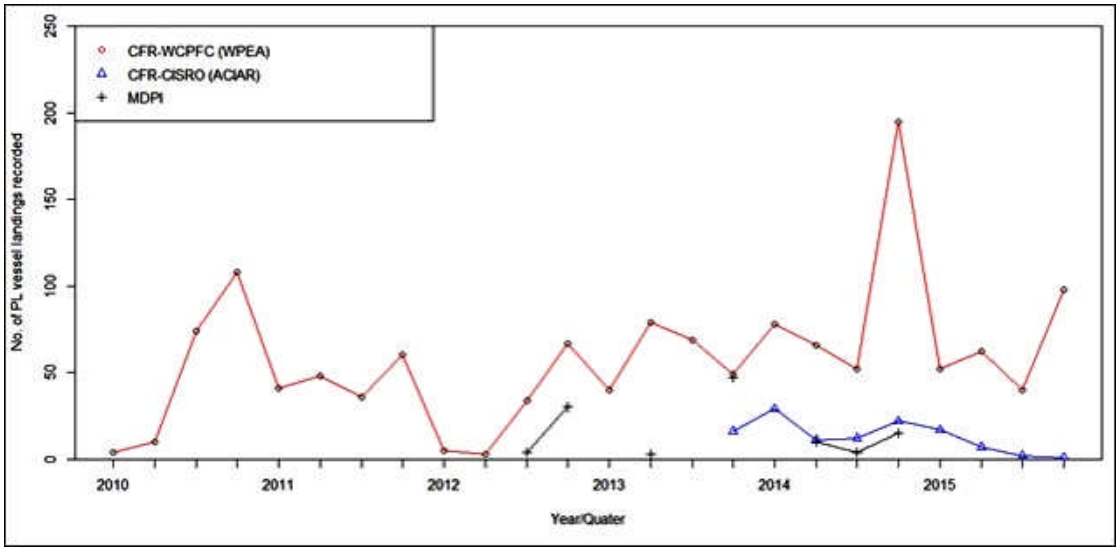

Figure 2. Number of landings by PL vessels recorded by the three data sets between 2010 and 2015.

Process of HS Development for Tropical Tuna in the IAW

Process of HS development for the tropical tuna in the IAW is described in Figure 3. This process has been commenced with the initiation of HS inclusion in the NTMP draft and the Indonesia's statement in the WCPFC to manage its IAW in 2014. This was then followed by stakeholder and technical workshops. The 1st and 2nd stakeholder workshops were held in 2015, with the main output is an agreement of the HS definition and framework. At the same time, the task force for the HS development was established.

In 2016, the 3rd and 4th stakeholder workshops were held, and 9 candidates of management objectives and 8 candidates of management measures were determined and agreed. In addition, the 1st and 2nd technical workshops were undertaken, which identified the data available from various sources and applying the Length-based Spawning Potential Ratio (LB-SPR), respectively. LB-SPR is one of methods to assess stock status for data limited fishery (Hordyk *et al*., 2015a, b). Since the LB-SPR method was found to be inappropriate method due its assumption could not be fulfilled by the data available (Satria and Sadiyah, 2017), the data limited approach (standardised CPUE for SKJ from PL fishery and mean length) was applied. This method was advised by the international experts during the 2nd technical workshop. The operating model (as a test bed for evaluating candidates of HS, under the process of management strategy evaluation – MSE) has started to be developed but not explained in this paper. In 2017, one management objective and five management measures were agreed during the 5th – 7th stakeholder workshops (using risk-based assessment). Expert consultations and training are also important and integrated part of this process. One of the essential output from the expert consultations is component of a harvest startegy that should be established, which illustrated in Figure 4.

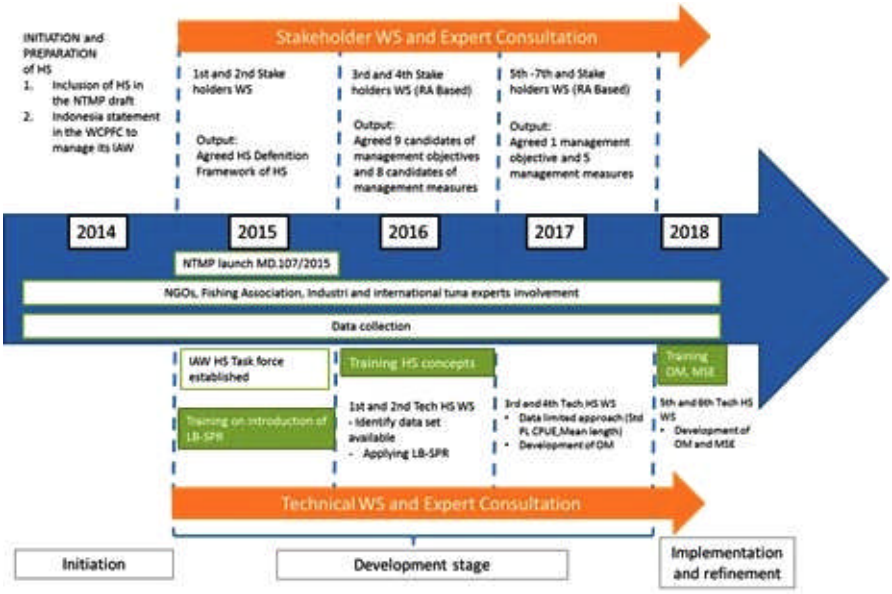

Figure 3. Process of harvest strategies development for the tropical tuna (SKJ, YFT and BET) in the Indonesia's archipelagic waters.

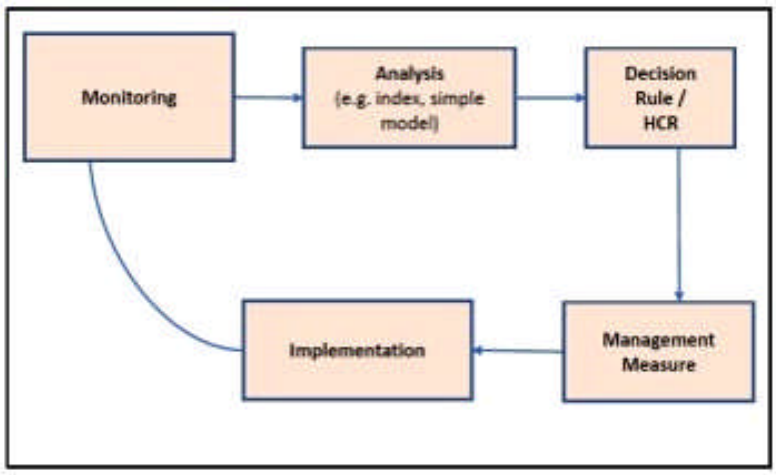

Figure 4. Illustration of four components of a harvest strategy (Monitoring, Analysis, HCR and Management Measure) and its implementation presented by Campbell Davies during the training on HS concept in 2016 at CSIRO Hobart, Australia. The implementation is to investigate the impact of the selected management measure/s of each harvest strategy candidate on the stock, which can be used as a basis to refine the harvest strategy candidate.

Components of a harvest strategy are conceptually illustrated in Figure 4. Monitoring (data collection), analysis, decision rule/harvest control rule (HCR) and management measure are the main component of a harvest strategy. Importantly, a management objective and reference points (target and limit reference points) are determined to identify each component of the HS and also used in the MSE process.

Management objective, and limit and target reference points

Seven consultative stakeholder workshops have been conducted to determine management objectives, reference point (LRP-TRP), and potential management measures. One management objective was selected during the stakeholder workshops using risk assessment (adapted from Fletcher, 2016), from nine capture fisheries development objective that referred to Article 3 Fisheries Act No. 31/2004 on Fisheries which was amended by Fisheries Act No. 45/2009. In general, the agreed management objective is to ensure the sustainability of SKJ, YFT and BET fisheries (Anon, 2017).

The limit reference point (LRP) was determined to be compatible with the WCPFC that is spawning stock biomass (SSB) above 0.2 of the unfished level with a

probability of 90 percent (Anon, 2017). This is then adopted to the operational objective, as to maintain SSB above the LRP of 0.2 $SSB_{F=0}$, with the probability of 90%. The target reference point has not been yet agreed as this needs to further consider socio-economic aspects of the fishery (Anon, 2017).

Monitoring

From the data sets available from the fishery in the IAW, catch per unit effort (CPUE) data and size data were the main data collected from the tropical tuna fishery that considered to be the best indicators for abundance of the tropical tuna species (i.e. PL for SKJ, HL/LL for YFT and BET). Therefore, form of monitoring for tuna fishery in the IAW is CPUE and size data. The effort data for CPUE is number of fishing days for SKJ caught by pole and line. Number of hooks is an ideal effort data for YFT and BET tuna caught by longline. In the meantime, the number of longline vessels have decreased since the enforcement of the ministerial regulation on moratorium of ex-foreign fishing vessel and fishing vessel built overseas in 2015 (Ministerial decree No. 56/Permen-KP/2014) operated in both IAW and IEEZ (FMAs 715, 716), from 127 in 2015 to 1 in 2016 (Satria *et al.*, 2017). Making the CPUE estimation from longline fishery in the IAW is still a big challange.

Assessment/Analysis - Abundance PL and LL/HL

The assessment part could be complicated analyses (e.g. stock assessment) but could be simple analyses. Due to the limited data situation, the simple analyses, CPUE standardisation and mean size, were used. The CPUE standardisation is undertaken to estimate abundance indices for each tuna species, by applying, for example generalised linear model (GLM) or generalized additive model (GAM).

Harvest Control Rule (HCR)

Empirical harvest strategy is considered to be the most plausible for the tropical tuna in the IAW, considering the data availability. The empirical harvest strategy is based on indices of relative abundance (standardised catch rates using PL data for SKJ and LL/HL data for YFT and BET), and/or size structure of 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 less complicated to more straightforward to implement.

Management Measures

From the 15 (fifteen) management measures stipulated in Article 3, Law No 31 Year 2004, on Fisheries, and amended by Law 45 year 2009 on Fisheries, 8 (eight) management measures were selected through selection processes at the 4thand 5thStakeholder Workshop. Subsequently, a risk-assessment process was completed at the 6thStakeholder Workshop, and the following 5 (five) priority selected management measures were selected:

a. Limit on use of Fish Aggregating Devices.
b. Spatial closures (of important spawning or nursery grounds) and temporal closures (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.

DISCUSSION

Indonesia is facing poor situated data with the most complex fishery in the world whilts often claim being able to manage its fishery consistent with sustainable principle. Indonesia is entering a very important and critical stage to demonstrate of its first of tropical tuna HS in the Archipelagic waters which sound scientific acceptable and robust outcome. Most importantly, the HS is expected to be feasible and implementable. An empirical harvest strategy is considered to be the most practical for the tropical tuna fishery in the IAW, which has been developed and tested for the Australian longline fishery (Prince *et al*., 2011). Reasonably, a trial can be taken as fisrt stage followed by necessary improvement. Some other countries have also developed empirical harvest strategies and has been successful for their domestic fisheries, such as New Zealand for rock lobster fisheries (New Zealand Ministry for Primary Industries, 2016), and South Africa for sardine and anchovy fisheries (Plaganyi *et al*., 2007).

Eventhough data collection and monitoring have been established with strong involvement from NGOs and fishing industries it is also predicted that potential obstacle may occur to implement the HS. Insufficient commitment and lack of capacity at all levels were major constraints. Among other things, sustain participatory and support from the industry, private and independence body are important parts in

developing and implementing the HS. An integral part for sucessfull HS is the existence of designated research and scientific unit that play an essential role in developing, maintaining and evaluating the HS and its performance.

The increase and continous support and participation from fishing industry, association, and NGOs, to the importance of having an apropriate monitoring and data colection to develop and implement IAW-HS has just entering an important stage. However, in order to implement the HS in the IAW it is required a national regulation as a fundamental operational measures, i.e. NTMP, which implementable and feasible. These measures shall be complied by the relevant local governments, industries and fishing communities that is consistent with the NTMP and RFMO CMMs. In addition, it is also a challenge to introduce and familiarize the IAW-HS to the IOTC and WCPFC and elaborate this in the relevant CMM of these RFMOs.

The availability of data that meet the minimum requirement for developing a HS is an essential part that could influence the successful of the HS development and its implementation and performance. From many data sets collected by various institutions, currently only three data sets were selected to develop the HS. The continuous involvement and support from all stakeholder sectors through improvement in their data collection programs, will increase the number of data sets used in the HS development and the robustness of the HS. Once more data available, the HS can be refined, as HS development is a cycle (Dowling *et al*., 2015) and an iterative process. As an example, the HS (or called as Management Procedure) of southern bluefin tuna (*Thunnus maccoyii* - SBT) in the CCSBT has been revised in 2011 (CCSBT, 2011) due to under reporting catch (Campbell & Kennedy, 2010).

It is recognized during the stakeholder workshops the importance of management objectives that addressing socio-economics issues such as to increase the welfare of the local fishers and its community. However it is also realized that socio economic data were not well designed, collected and recorded to support the current HS process. Hence the WS agreed to include socio economic in the future data collection and will iclude in the analyis once the data available. The five candidate management objectives agreed for the IAW HS were mostly adressing the biology and the fish stock surrounding its sustainability. With general assumption that if these agreed objectives are achieved, socio economic objectives will likely to be achieved as well.

In the HS development, the target reference point needs to be defined. The target reference point would require to consider that the IAW has a specific characteristic, located between the Pacific (under the WCPFC) and Indian (under the IOTC) Oceans and might have a connection to the two oceans. In the meantime, the target reference point for SKJ has been agreed by WCPFC is that the spawning biomass should be 0.5 estimated unfished spawning biomass on average (WCPFC, 2015), whereas IOTC has adopted the target reference point as 0.4 of estimated unfished spawning biomass (IOTC Resolution 16/02 on harvest control rules for skipjack tuna in the IOTC area of competence). Therefore, the target reference point for the SKJ in IAW will be set and tested between 0.4 and 0.5 of estimated unfished spawning biomass.

While in general it has been agreed by IOTC and WCPFC to set limit references point, the reference that should be avoided, for SKJ that the spawning biomass sholud be 0.2 of the estimated unfished spawning biomass. The management measures for highly migratory tropical tuna is heading towards limit on catch and effort for all flag states. After the limitation is taken, the performance of Harvest strategy should be able to be tested in the frame of MSE. IAW SKJ is predicted to have similar limit reference points for 0.2 of estimated unfished spawning biomassand target reference points 0.4-0.5 of estimated unfished spawning biomass. Operationally it is required to develop a monitoring mechanism with stock indicators as dynamics reference for fishery manager to control and ensure the stocks is within the target reference points.

It is widely known that standardized CPUE can be used as an indicator to inform the manager the status of a fish stock (Maunder & Punt, 2004, Bigelow & Maunder, 2007, Maunder *et al*., 2006). Standardized CPUE that generated from operational catch and effort data are mostly not available in the poor data situation. Hence standardized LPUE (landing per unit effort) resulted from landing data in common case can be used to estimate abundance indices when catch operational data not available, for example in the Philippines tuna fishery (Bigelow *et al*., 2017). In addition, series of mean length data as common data collected by port sampling program also potentially be used as an indicators by managers beside the information of total catch and its species composition by gear that landed and recorded overtime. At the minimum, apropriate series data of catch, effort and size by gear and by species with well coverage that colected for more than three years will become basic requirement in developing IAW harvest strategy. These CPUE and length.

CONCLUSION

Most cases of fisheries in Indonesia are complex and encounter limited data situation while demand sounds having appropriate and acceptable fisheries management at national and international levels.Harvest strategy is an unavoidable tool to date that demonstrates the performance of the selected fishery that can be measureable and predictable, which isnot so simple yet not so complicated, but works and implementable. Taking into account of the characteristic and complexity of the small scale tuna fishery as well as vast archipelagic area, it is required to continue collaboration and commitment from related stakeholders imcluding Government, fishers, fishing association, NGOs by adopting co-mangement and participatory approach in implementing the agreed harvest strategy. Continous data collection and sustain support is unavoidable effort to be taken by the flag state to be able to have series of data that are used to monitor the fishery, stok status and its performance.

Indonesia's tuna in archipelagic waters at current condition has more than 6 years series of port sampling data as based monitoring performance of Harvest Strategy for SKJ, YFT and BET using data of catch, mean length and CPUE.Noting the situation of limited data that deal with the source of uncertainty the management aproach should be very precautionary. Continues improvement of operational data should be continued and focused on improvement of the standardised CPUE .

National regulation for managing tuna fisheries with approprite harvest strategy is required in line with international regulation with apropriate enforcement. The involvement of the relevant experts, scientists and fishery managers is an integrated part in developing the Harvest strategy and MSE.Regular monitoring and evaluating the adopted HS is required and subject to be reviewed.

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