Unveiling the Stock Status of Oceanic Tuna Resources in Sulu-Sulawesi Seas

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Oceanic tuna species are the most economically-important commodities of the Southeast Asian region, not only because of their high export values, but also as source of nutrients for the local populace. In an effort towards advocating the sustainable utilization and management of oceanic tuna resources in the region, the Training Department (TD) of the Southeast Asian Fisheries Development Center (SEAFDEC) has been exerting efforts to determine the stock statuses of these tuna resources, especially for the skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), and bigeye (*Thunnus obesus*) tuna resources. Considering that information on these highly migratory species remains limited, the six-year Project of SEAFDEC/TD "Offshore Fisheries Resources Exploration in Southeast Asia" launched in 2013, gave more focus on the "Development of Joint Research Program for Tuna Research Surveys in the Sulu-Sulawesi Sub-regional Area (SSS)," which included the important Activity, "Assessment and Management for Sustainable Utilization of Skipjack Tuna (SKJ), Yellowfin Tuna (YFT), and Bigeye Tuna (BET) Resources in the SSS." Because the stocks of SKJ, YFT and BET in the SSS belong to the West-Central (WC) Pacific stock, the stock assessments would not be meaningful if focus is made solely in the SSS. Nonetheless, stock assessments were carried out to learn the local statuses in the SSS just **as crude references**, along with capacity building for the three (3) countries exploiting SKJ, YFT, and BET, namely: Indonesia, Philippines, and Malaysia. Results of the stock assessment by "A Stock Production Model Incorporating Covariates (ASPIC)" suggested that the local stock statuses of these tuna species in the SSS were highly and likely much worse than in the whole WC Pacific Ocean for SKJ and BET in the past, *i.e.* there were likely strong local depletions by higher fishing pressures in the SSS. However, the most recent stock statuses based on the Kobe plot (the stock status projectory diagram) of YFT in 2015 and BET in 2017, indicated that these were in the safe (green) zones, although the stock status of SKJ was still in the unsafe (yellow) zone, but not too serious. From these facts and from the precautionary point of view, it is therefore recommended that the total catch limits of these tuna species in the SSS should not be increased from the localized MSY levels, *i.e.* 240,000 t for SKJ, 133,000 t for YFT, and 18,000 t for BET. Since SEAFDEC is not the international organization mandated to make recommendations on catch limits, these recommended catch limits could not be considered legally binding, but the countries harvesting these three (3) species should constructively bear these recommendations in mind for the sustainability of their respective oceanic tuna resources.

In the Southeast Asian region, skipjack tuna (*Katsuwonus pelamis*) (SKJ), yellowfin tuna (*Thunnus albacares*) (YFT), and bigeye tuna (*Thunnus obesus*) (BET) are the most commercially important oceanic tuna species (**Figure 1**) that inhabit their oceanic waters, especially in the north eastern Indian Ocean side of FAO Marine Fishing Area 57 (**Figure 2**) and the western Pacific Ocean side of the FAO 71 (**Figure 3**). It should also be noted, however, that from the perspectives of regional management, tuna fisheries in the waters of Southeast Asia are under the supervision of two tuna Regional Fisheries Management Organizations (RFMOs), *i.e.* the Indian Ocean Tuna Commission (IOTC) and the Western Central Pacific Fisheries Commission (WCPFC).

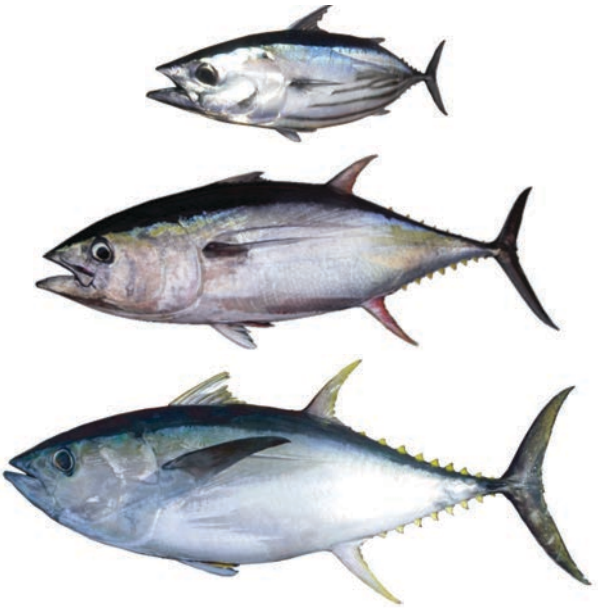


Figure 1. Most economically-important oceanic tuna species in the Southeast Asian region *(top to bottom)*: skipjack tuna (SKJ), yellowfin tuna (YFT), and bigeye tuna (BET)

Although WCPFC and IOTC cover very wide management areas, while the Southeast Asian waters are much smaller, the production of SKJ, YFT and BET in the Southeast Asian waters are quite high (**Table 1**), *i.e.* the average catch of SKJ, YFT and BET during 2013-2017 was 714, 000 t, 334,000 t and 99,000 t, respectively, which were more than 30% of the WCPFC and IOTC combined productions for each species.

The high production of SKJ, YFT and BET resources, and the importance of the resources to the Southeast Asian region, prompted the Southeast Asian Fisheries Development Center (SEAFDEC) to promote the sustainable utilization and management of these tuna species. However, information on their local situation in the Southeast Asian waters is limited, so that in its attempt to improve such a situation, the SEAFDEC Training Department (TD) launched the Project "Offshore Fisheries Resources Exploration in Southeast Asia (2013-2019)," which included the Activity "Assessment and

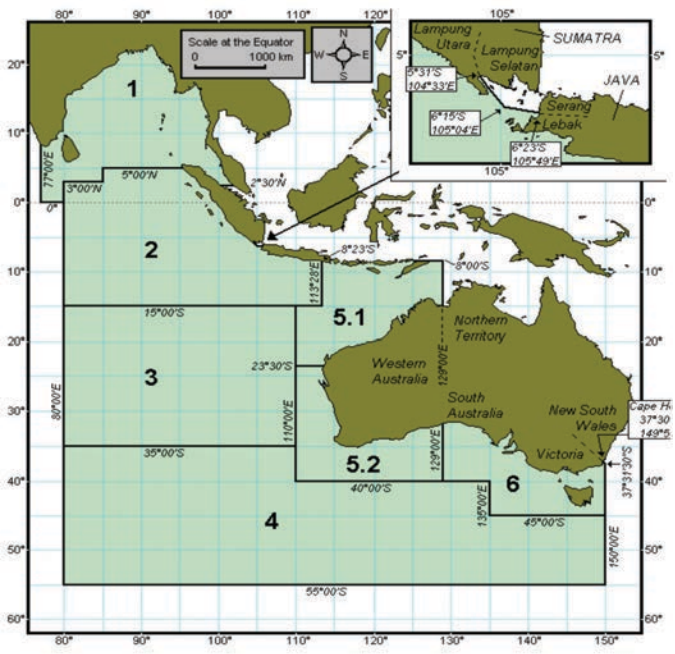


Figure 2. FAO Marine Fishing Area 57 in Southeast Asia covers the marine fishing areas of Myanmar, Thailand (Andaman Sea), Malaysia (West Coast of Peninsular Malaysia), and Indonesia (Malacca Strait, West Sumatra and South Java, and Bali-Nusa Tenggara)

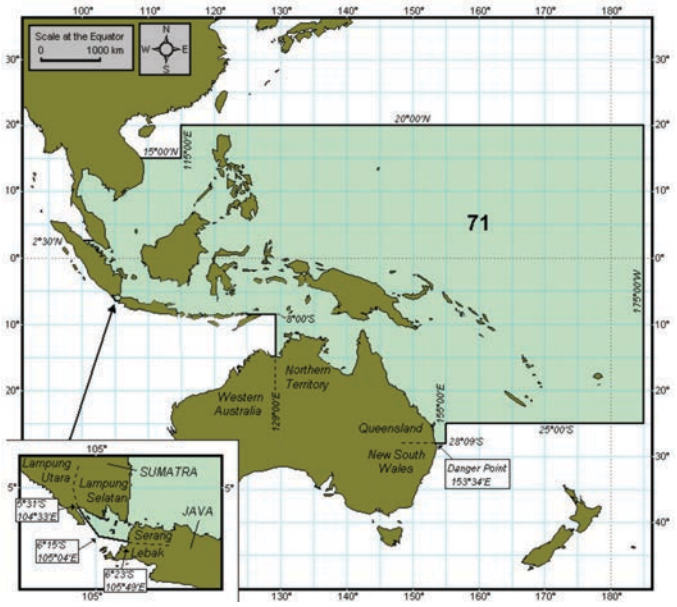


Figure 3. FAO Marine Fishing Area 71 in Southeast Asia covers the marine fishing areas of Thailand (Gulf of Thailand), Cambodia, Viet Nam (Southwest Viet Nam), Malaysia (East Coast of Peninsular Malaysia, Sarawak, and Sabah), Singapore, Brunei Darussalam, the Philippines (Luzon, Visayas, and Mindanao), and Indonesia (East Sumatra, North Java, Bali-Nusa Tenggara, South-West Kalimantan, East Kalimantan, South Sulawesi, North Sulawesi, and Maluku-Papua)

Table 1. Production of SKJ, YFT and BET from FAO Marine Fishing Areas 57and 71 in Southeast Asian Waters ('000 tonnes)

Year	2013			2014			2015			2016			2017			5-year average (2013-17)
Fishing Area / Species	57	71	Total	57	71	Total	57	71	Total	57	71	Total	57	71	Total	
Skipjack tuna (SKJ)	95	608	703	72	663	735	74	673	747	72	593	665	97	621	718	**714**
Yellowfin tuna (YFT)	61	290	351	45	318	363	46	322	368	37	277	314	40	247	287	**334**
Bigeye tuna (BET)	36	55	91	32	65	98	33	67	100	22	49	71	22	113	135	**99**
Total	192	953	1,145	149	1,046	1,196	153	1,062	1,215	131	919	1,050	159	981	1,140	**1,147**

Source: SEAFDEC (2015; 2017a; 2017b; 2018; 2019a)

Note: Production in Area 71 is much higher than in Area 57, i.e. the composition of catch between Area 71 vs. 57 in average for 5 years (2013-2017) by species are as follows: SKJ (89% vs. 11%), YFT (86% vs. 14%) and BET (69% vs. 31%)

Sustainable Utilization of SKJ, YFT, and BET Resources in the Sulu-Sulawesi Sub-regional Area (SSS)" with funding support from the Japanese Trust fund (JTF) II.

Assessment and Sustainable Utilization of SKJ, YFT, and BET Resources in the SSS

This article describes the Activity using results of stock assessments from the Second SSS practical workshop (WS) in 2019 with some additional information, which include five topics, namely: "Capacity Building", "Stock Structure", "Catch and CPUE", "Stock Assessment and Stock Status", and "Recommendations on Catch Limits."

Capacity Building

As one of the important objectives of this Activity, capacity building on stock and risk assessments for technical staff from the Association of Southeast Asian Nations (ASEAN) Member States (AMSs) was promoted through two (2) practical workshops (WS) organized by SEAFDEC/TD. The First WS was conducted in Davao, Philippines in 2015 (SEAFDEC, 2017c), and the Second WS was at the premises of SEAFDEC/TD in Samut Prakan, Thailand in 2019 (SEAFDEC, 2019b) (**Picture 1**).

Picture 1. Second practical workshop on stock and risk assessment of SKJ, YFT, and BET in the Sulu-Sulawesi Seas Project (May, 2019) (SEAFDEC/TD)

Based on the catch and catch per unit of effort (CPUE) data, "A Stock Production Model Incorporating Covariates (ASPIC)" by Prager (2004) was applied for the stock assessments. In addition, four (4) menu-driven sets of software specially developed for SEAFDEC, were used to easily conduct the necessary processes without the use of any computer programming languages. These four sets of software are: "CPUE standardization", "ASPIC (batch job)", "Kobe I (Kobe plot)", and "Kobe II (risk assessments). They have been gradually developed since 2013 and improved to reflect the requests from the SSS WS participants and also those from the SEAFDEC-Sweden Neritic Tuna Project WS in 2016-2020 also using these software (Nishida, 2020). In SEAFDEC, four software have been successfully and efficiently utilized during the capacity buildings on relevant stock and risk assessment (SEAFDEC, 2020; Kaewnuratchadasorn *et al*., 2020).

Stock Structure

Although the SSS in the Southeast Asian waters is a considerably small part of the Western and Central Pacific Fisheries Commission (WCPFC) Convention Area (**Figure 4** *above*), it embraces an area of about 900,000 km^2 of waters and the marine environment of this area is bestowed with rich resources of SKJ, YFT and BET that migrate around, and is shared by three (3) bordering marine fish producing countries, namely: Indonesia, Philippines, and Malaysia (**Figure 4** *below*). Thus, the SSS had been considered the most appropriate site in the Southeast Asian waters for this Activity, which was aimed at learning the stock statuses of these three important oceanic tuna species. Since it was necessary that the stock assessments should be conducted within the same stock to provide plausible and meaningful management suggestions, the stock structure was examined prior to conducting the stock assessments. In the entire Pacific Ocean, the stock structures of these three species were assumed to be of two stocks, *i.e.* the Western-Central (WC) Pacific stock and the Eastern stock, which are managed by the WCPFC and the Inter-American Tropical Tuna Commission (IATTC), respectively (**Figure 4** *above*). Considering that the stocks of SKJ, YFT and BET in the SSS belonging to the WC Pacific stock, it would not be meaningful to conduct any stock assessments solely for the SSS.

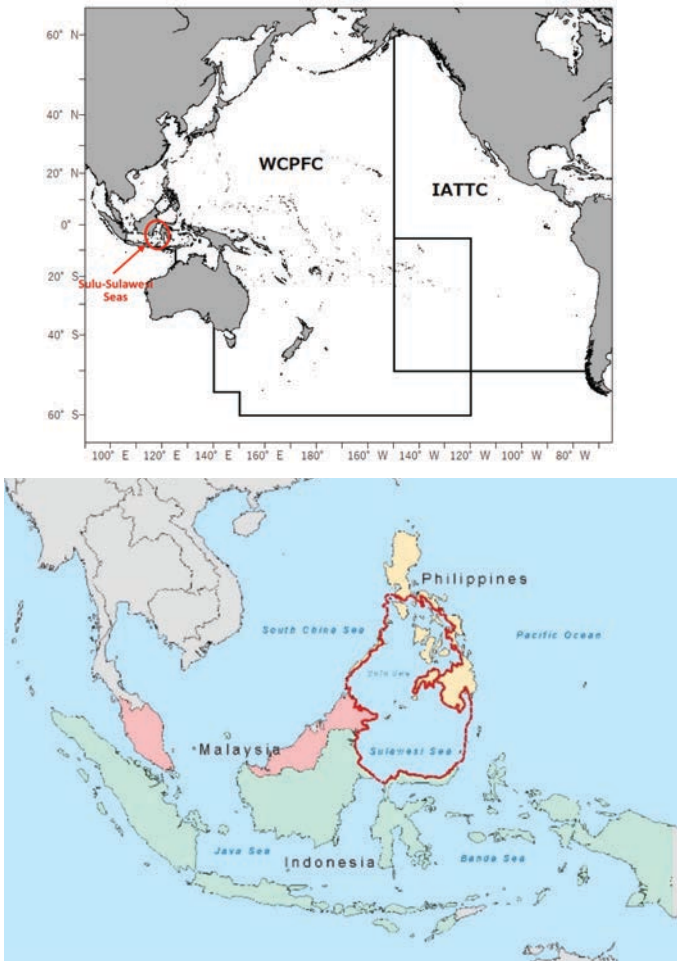


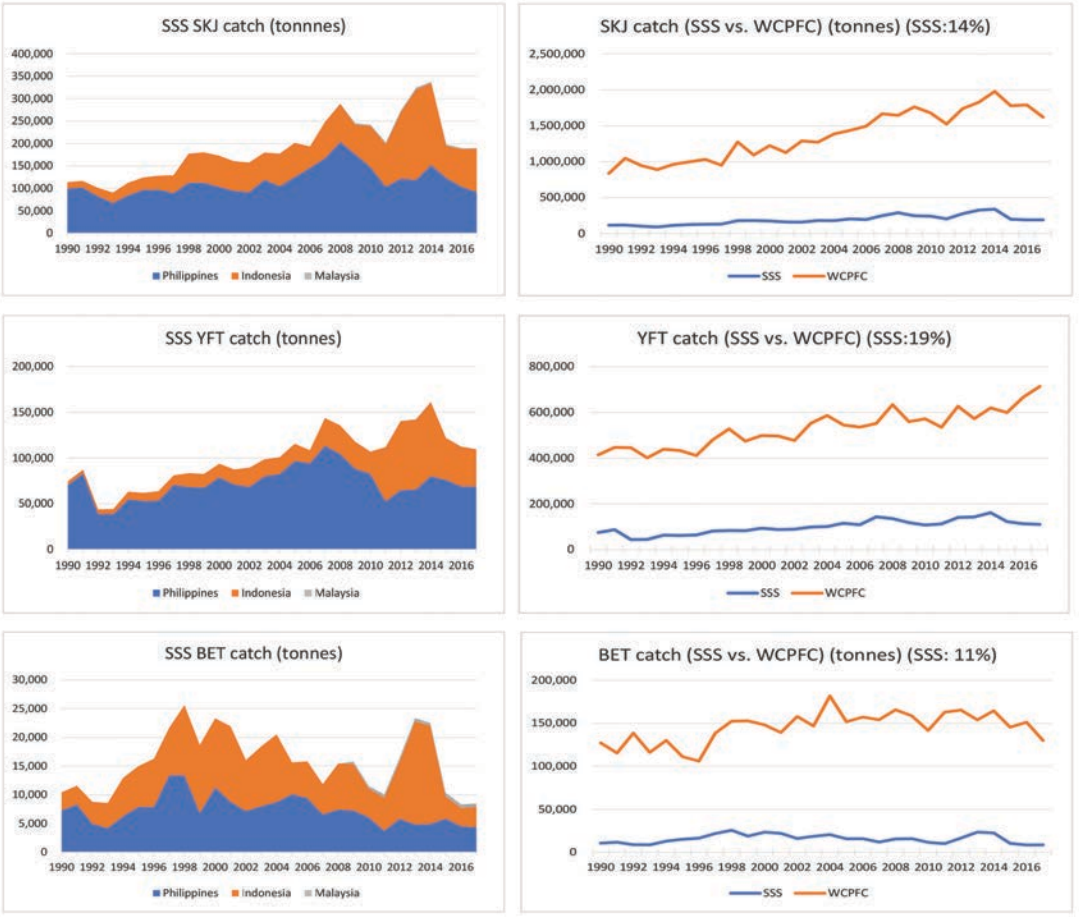
Figure 4. *(above)* WCPFC and IATTC Convention Areas and the location of the Sulu-Sulawesi Seas (SSS); *(below)* Sulu-Sulawesi Sea (formerly known as Sulu-Celebes Sea), SEAFDEC Sub-regional area bordered by the Philippines, Indonesia, and Malaysia, a very small part of the WCPFC Conventional Area

If stock assessments were to be conducted only for the SSS, theoretically the stock status should be identical to those of the WC Pacific stock, because the key parameters such as biomass ratio (B/Bmsy) and F ratio (F/Fmsy) are supposed to be identical in both areas where the same stock inhabits, *i.e.* the Kobe plots (the stock status trajectory) in the SSS and WCPFC should be identical. However, if two Kobe plots were heterogeneous, this would imply that the local situation (stock statuses) in the SSS may be affected by unique localized anomalies such as fishing pressures, movements between the SSS and WCPFC, environmental conditions, number of FADs deployed, and others. Therefore, the stock statuses of these three oceanic tuna species in the SSS would have been likely reflected by the integration of these factors. Under such circumstances, stock assessments carried out to learn the local situation just **as crude references**, considering that the results might not be meaningful as it is not known as to what extent such anomalies had affected the local stock statuses of these three oceanic tuna species.

Catch and CPUE

Catch and CPUE were the two basic inputs to run ASPIC. However, since the official catch statistics are not available solely for the SSS, the total catch was computed by combining the estimated catch by country, provided by WS participants from three (3) countries (Indonesia, Philippines, and Malaysia), based on the best available scientific catch data from these countries. **Box 1** (*left*) shows the SSS catch by species from three countries, and **Box 1** (*right*), comparison of the catch between the SSS and WCPFC in 1990-2017 (WCPFC, 2020). The average catch compositions of the SSS over WCPFC were 14 % (SKJ), 19 % (YFT), and 11 % (BET). Another input, the nominal CPUE (handline, purse seine and ring nets) were provided from the Philippines, which was standardized by WS participants to practice the CPUE standardization techniques and used for the stock assessments (ASPIC) which was also practiced by the participants.

Box 1. *(left)* The trend of SKJ, YFT, and BET catch in the SSS of the Philippines, Malaysia and Indonesia (1990-2016) and *(right)* Comparison of catch by species between the SSS and WCPFC



Stock Assessment and Stock Status

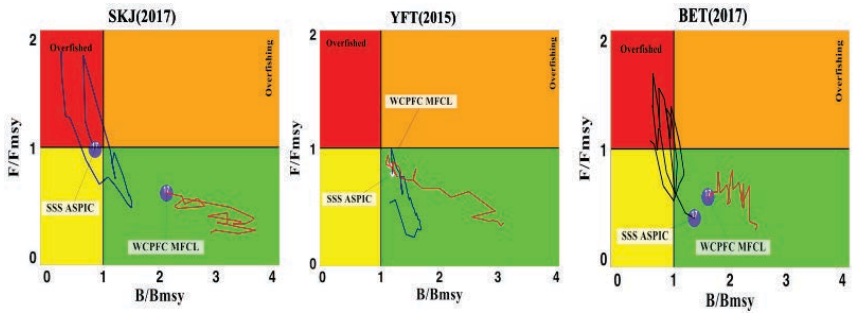
Kobe plots for SKJ (1990-2017), YFT (1990-2015) and BET (1990-2017) based on results of stock assessments were overlaid with those available in WCPFC (WCPFC, 2020), which made use of the stock assessment model, "A length-based, age and spatially-structured model for fisheries stock assessment (MULTIFAN-CL or MFCL)." **Box 2** shows the comparison of the two Kobe plots (the SSS *vs*. WCPFC) for SKJ, YFT, and BET *(left to right)*.

These plots should be looked with caution because the stock assessment models used are different, *i.e.* ASPIC for the SSS and MFCL for WCPFC. In addition, the results in the SSS could have been affected by the integrated anomalies caused by the aforementioned factors.

Even with such caution, it is likely suggested that: (a) the past stock statuses of the three oceanic tuna species in the WC Pacific Ocean were safe since all trajectories are within the green zones; (b) as for the SSS, the past stock statuses of YFT was safe, while those of SKJ and BET were not safe since majority of the stock status trajectories are in the red or yellow zones; (c) it is likely that the biomass ratio (B/Bmsy) of SKJ and BET in the SSS was locally affected detrimentally by

Box 2. Comparisons of the Kobe plots between SSS and WCPFC for SKJ, YFT, and BET

Note: (1) Year (*e.g.* 2017 or 17) represents the most recent stock status year (the last year of the stock assessments)
(2) **B:** Total biomass (ASPIC) and Spawning Stock Biomass (MFCL)



higher fishing pressure and/or any of the other aforementioned anomalies; and (d) although the Kobe plot patterns between the SSS and WCPFC were different for all species, the most recent stock statuses for YFT (2015) and BET (2017) were similar, *i.e.* in the green zone in both the SSS and WCPFC, while the stock status of SKJ in the SSS was unsafe since it was in the yellow zone, although this was not too serious as it was closer to both B/Bmsy=1 and F/Fmsy=1.

Conclusion and Recommendations

It should be well noted that the results of the stock assessments should be considered with caution for reasons that were explained above. However, it is highly likely that the stock statuses of the tuna species in the SSS were much worse than in the whole WC Pacific Ocean for SKJ and BET, *i.e.* there were likely strong local depletions by higher F and/or by other factors explained previously. In the SSS, the most recent stock statuses of YFT (2015) and BET (2017) were in the safe (green) zones, although the stock status of SKJ was in unsafe (yellow) zone. From the standpoint of the precautionary approaches, it is recommended that the total catch limits in the SSS should not be increased from the (localized) MSY levels by species as shown in **Table 2**.

Table 2. Recommended catch limits and the current catch levels (2013-2017) of three oceanic tuna species in the SSS

	SKJ (t)	YFT (t)	BET (t)
Recommended catch limits	240,000	133,000	18,000
Current catch levels, 5-year average catch (2013-2017)	248,000	130,000	15,000

Note: Current catch levels, 5- year average (2013-2017), were based on the data used during the Second practical workshop on stock and risk assessment of SKJ, YFT, and BET in the Sulu-Sulawesi Seas (May, 2019)

Because SEAFDEC is not the organization mandated to make recommendations on catch limits, unlike RFMOs and the ASEAN, these recommendations could not be considered legally binding. Nevertheless, since Indonesia and the Philippines have been harvesting more than 98 % of the total catch of each species of SKJ, YFT and BET, these countries should constructively bear these recommendations in mind for the sustainability of their respective oceanic tuna resources and fisheries.

Final Remarks

This article describes mainly the stock statuses of SKJ, YFT and BET resources in the SSS. The other important tuna resources, the neritic tunas in the Southeast Asian waters, have been separately handled by the SEAFDEC-Sweden Project, and the results of the stock assessments of the narrow-barred Spanish and Indo-Pacific king mackerel were published (Kaewnuratchadasorn *et al.*, 2020). Meanwhile, those for longtail tuna and kawakawa would be published in the near future.

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