Boosting the Management of Economically Important Fishery Resources in the Southeast Asian Region: the Seer Fishes in Focus

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Neritic tunas, such as kawakawa, longtail tuna, frigate tuna, bullet tuna, and seer fishes, are commercially important species in the Southeast Asian region. Among these species, two seer fishes, *i.e.* the narrow-barred Spanish mackerel and Indo-Pacific king mackerel, command higher prices in the markets. In 2017, for example, these two seer fishes were the most expensive products among all marine capture species (SEAFDEC, 2020). Thus, it is deemed essential that stock assessments of these two seer fishes should be carried out to ensure their sustainable utilization and fisheries, and to provide scientific advice to policy makers for the sustainable management of the resources. This article therefore introduced the most recent stock status and management advice on narrow-barred Spanish mackerel and Indo-Pacific king mackerel in the Southeast Asian region (SEAFDEC, 2019).

The fisheries production of the Southeast Asian region in 2017 indicated that in terms of quantity, tunas and tuna-like species including the seer fishes contributed about 16 % to the total production from marine capture fisheries (SEAFDEC, 2020). Among the marine capture species, two seer fishes, *i.e.* narrow-barred Spanish mackerel and Indo-Pacific king mackerel, were the most expensive products at US$ 3,711/t, while the average price for the other neritic tuna species was 2.4 times lower at US$ 1,579/t. Another example also indicated that in 2018, the narrow-barred Spanish mackerel ranked second as the highest priced top 10 fish and fishery products exported by Thailand (DOF, 2019).

In the waters of Southeast Asia, narrow-barred Spanish mackerel and Indo-Pacific king mackerel have been exploited for many years by the SEAFDEC Member Countries and Bangladesh (**Figure 1** and **Figure 2**). These two figures were complied during the "Practical Workshop on Stock Assessment of Indo-Pacific King Mackerel and Narrow-barred Spanish Mackerel in the Southeast Asian Waters" organized by SEAFDEC in 2018. These two figures show that the average catch during the five-year period (2012-2016) of narrow-barred Spanish mackerel and Indo-Pacific king mackerel were 213,000 t and 32,000 t, respectively, of which the former is 6.7 times higher compared to the latter. Indonesia dominated the countries that exploit both species, accounting for 76 % and 80 % of the total catch, respectively.

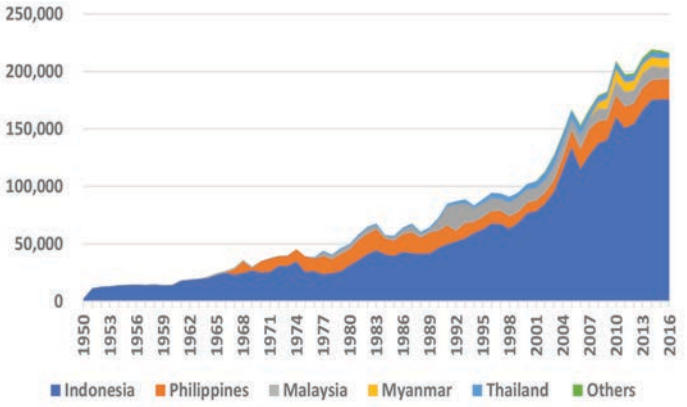


Figure 1. Catch trend of narrow-barred Spanish mackerel in the Southeast Asian waters (1950-2016)
Note: Others refer to Bangladesh, Viet Nam, and Brunei Darussalam

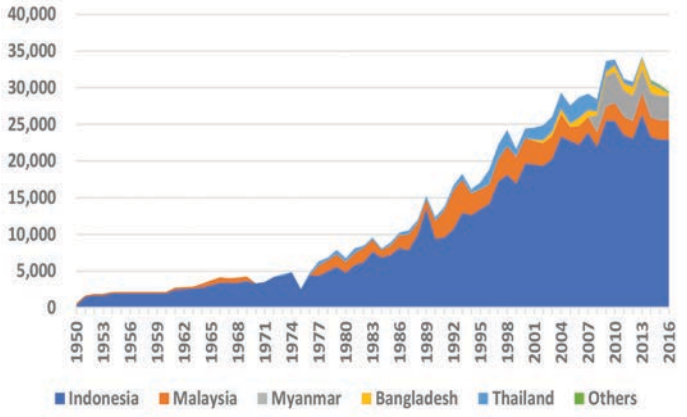


Figure 2. Catch trend of Indo-Pacific king mackerel in the Southeast Asian waters (1950-2016)
Note: Others refer to Viet Nam, Philippines, and Brunei Darussalam

Biology, ecology, and fisheries of two seer fishes

The narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lacepède, 1800) (**Figure 3**) is a migrating species commonly found in Indo-West Pacific region from the Red Sea and South Africa to Southeast Asia, north to China and Japan and south to Australia (Randall, 1995). Inhabiting the nearshore waters of less than 100 m depth (Collette, 2001), this species is caught by different fishing methods and gears such as drift net, gill net, hook and lines, and purse seine, by commercial, artisanal and recreational fisheries. This species often associates itself in small schools and feeds on anchovies, sardines, and squids. Its length ranges from 30 cm to 70 cm, and could reach to 100 cm. On the other hand, the Indo-

Figure 3. Narrow-barred Spanish mackerel

Figure 4. Indo-Pacific king mackerel

Pacific king mackerel, *Scomberomorus guttatus* (**Figure 4**) migrates along the coastal waters throughout the Indo-West Pacific Ocean. This species is caught mainly by gillnet and trolling and is targeted in commercial and artisanal fisheries in Southeast Asia. The length of the adult fish ranges from 40 cm to 55 cm. Both species of seer fishes are fast swimmers and predatory in nature.

Figure 5 shows the geographical distribution ranges of the narrow-barred Spanish mackerel and Indo-Pacific king mackerel.

Stock and risk assessments of seer fishes

In 2013, the Southeast Asian Fisheries Development Center (SEAFDEC) launched the seven-year project "*Fisheries and Habitat Management, Climate Change and Social Well-being in Southeast Asia (2013-2019)*" with funding support from the Government of Sweden (Kaewnuratchadasorn *et al*., 2020). Also known as the SEAFDEC-Sweden Project, it included among others, an activity that focused on the management of neritic tuna resources in the Southeast Asian region. One of the outputs of such activity was the Regional Plan of Action on Sustainable Utilization of Neritic Tunas in the ASEAN Region or the RPOA-Neritic Tunas (SEAFDEC, 2015). Considering that neritic tunas are among the most-economically important pelagic species in the region that necessitate sustainable management of the resources, the RPOA-Neritic Tunas was adopted by the ASEAN Member States (AMSs). In the course of the adoption of the RPOA-Neritic Tunas, SEAFDEC in collaboration with the AMSs and with funding support from the SEAFDEC-Sweden Project, conducted the first stock and risk assessment of two neritic tuna species in 2016, *i.e*. longtail tuna (*Thunnus tongol*) and kawakawa (*Euthynnus affinis*) in the Pacific and Indian Ocean sides, using A Stock-Production Model Incorporating Covariates (ASPIC) (SEAFDEC, 2017; Siriraksophon, 2017). Having enhanced the capacity to conduct stock assessment of other species, SEAFDEC in collaboration with the AMSs, conducted the second stock and risk assessments to estimate the stock status of two seer fishes, *i.e.* the narrow-barred Spanish mackerel (*Scomberomorus commerson*) and the Indo-Pacific king mackerel (*Scomberomorus guttatus*) (SEAFDEC, 2019; Kaewnuratchadasorn *et al*., 2019).

As in the kawakawa and longtail stock and risk assessment in 2016, two stock structures for seer fishes were also assumed to occur in the Southeast Asian waters, *i.e*., Pacific Ocean side stock and Indian Ocean side stock. Thus, four stock assessments were carried out (two species for two stocks) using the four softwares developed for capacity building, *i.e.*

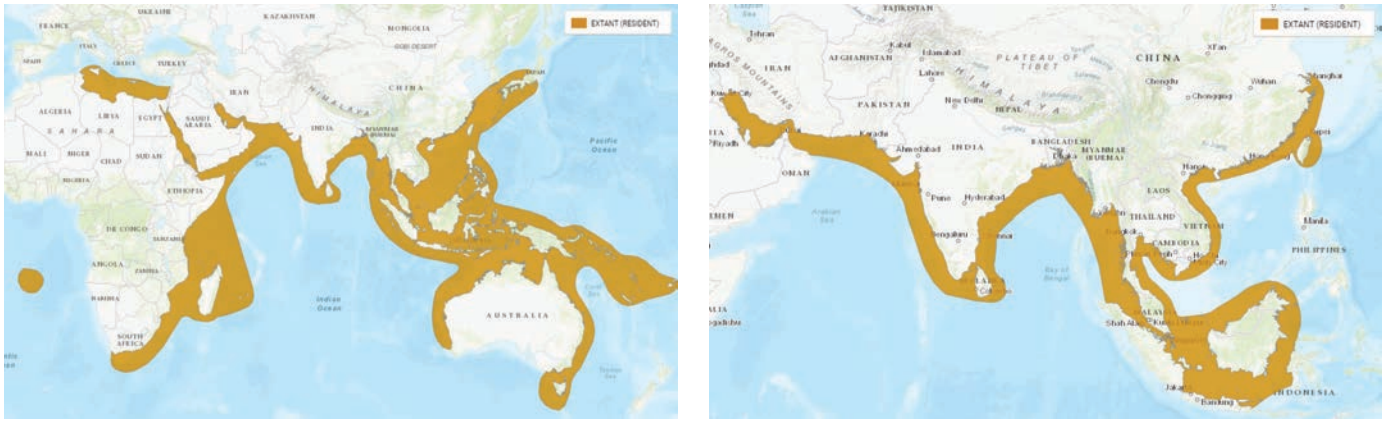


Figure 5. Geographical distribution range of narrow-barred Spanish mackerel *(left)* and Indo-Pacific king mackerel *(right)*
Source: IUCN (2011a & 2011b)

CPUE standardization, ASPIC, Kobe plot, and risk assessment (Nishida, 2020). Specifically, the risk assessment (Kobe II strategic matrix) presents the probabilities of violating (not sustaining) the TBmsy (Total biomass at the MSY level) and Fmsy (fishing pressure at the MSY level) in three years and 10 years later using 10 different catch levels, the current catch (0 %), MSY, ±10 %, ±20 %, ±30 %, and ±40 %. In deciding for the optimum total allowable catch (TAC) level from the Kobe II strategic matrix, tuna RFMOs normally select catch levels at probability < 50 % violating (not sustaining) the TB/TBmsy, and the F/Fmsy in 10 years. The neritic tuna project also follows this concept. ***It should be well noted however that the suggested TAC levels are just references for participating countries to consider because SEAFDEC is not a legally-oriented RFMO, thus the said TAC suggestion is not binding***.

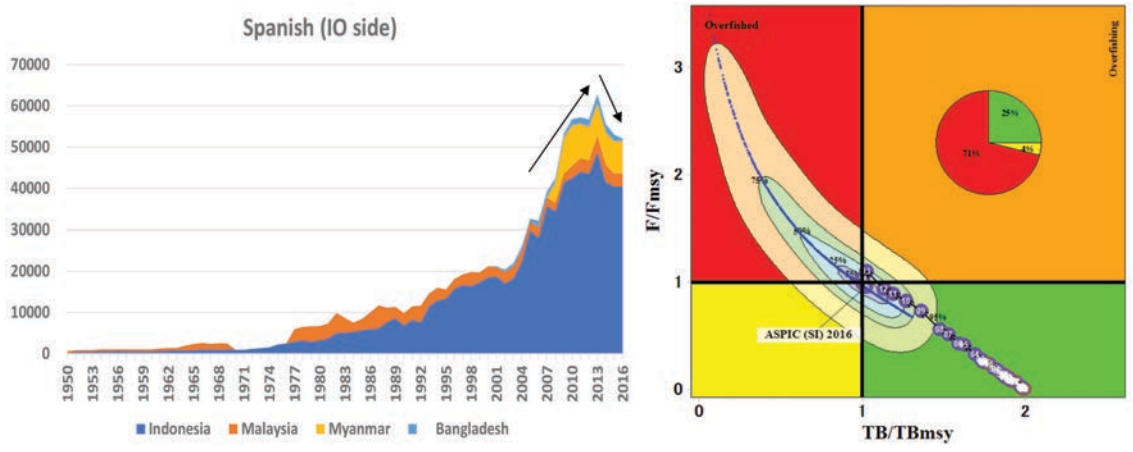
The uses of ASPIC needs two types of input data (nominal catch and nominal CPUE) by area (Pacific and Indian Ocean side). Nominal catch (1950-2016) were sourced from FAO, IOTC, and SEAFDEC Member Countries, which were compiled by area, country, and year, while nominal CPUE (catch and effort) (1994-2016) were sourced from Philippines, Thailand, and Malaysia, which were compiled by area, country, gear, sub-area, year and season (quarter or month).

Results of stock and risk assessments of two seer fishes in the Pacific Ocean and Indian Ocean sides of the Southeast Asian waters, and the suggested TAC following SEAFDEC (2019), are described below.

1. Narrow-barred Spanish mackerel (Indian Ocean side)

For the narrow-barred Spanish mackerel in the Indian Ocean side, results of the stock assessment (**Box 1**) suggest that MSY=55,170 t and the stock status (2016) is in the green zone of the Kobe plot but very close to MSY levels, *i.e.* TB/TBmsy=1.03 and F/Fmsy=0.93. It should be noted that the stock status in 2013 was in the orange zone because the catch had been continuously increasing until 2013, then the stock status in 2014-2016 changed to the green zone as catch started to decrease from 2014. The results of the risk assessment (Kobe II strategic risk matrix) suggest that TAC should be

Box 1. Catch, stock status and suggested TAC for the narrow-barred Spanish mackerel (Indian Ocean side)



Catch by country *(left)* and the **stock status** represented by the Kobe plot *(right)*:
Green (safe) zone but very close to MSY, TB/TBmsy=1.03 and F/Fmsy=0.93 and MSY=55,170 tons

Strategic risk matrix (Kobe II):

Probabilities (%) of violating TBmsy and Fmsy in 2019 and 2026.

The current catch level* (average 2014-2016) is 54,090 t.

Suggested TAC < 54,090 t

(the current catch level* should be reduced by at least 10 %) to secure the MSY levels (TB and F) with the risk probability violating MSY (TB and F) < 50 % in 10 years.

Probabilities(%) violating TBmsy and Fmsy in 3 and 10 years.

Color legend				
Risk levels	Low risk	Medium	Medium	High risk
Probabilty	0 - 25%	25 - 50%	50 - 75%	75 - 100%

	0%	20%	40%	60%	70%	80%	90%	100% Current catch (*)	102% MSY level	110%	120%	140%
10 catch scenarios (tons)	0	10,818	21,636	32,454	37,863	43,272	48,681	54,090	55,170	59,499	64,908	70,317
TB2019 < TBmsy	33	38	42	47	50	54	57	62	62	67	71	76
F2019 > FMSY	0	27	29	35	39	43	51	63	65	74	91	100
TB2026 < TBmsy	13	27	29	33	36	41	46	63	59	80	95	100
F2026 > FMSY	0	27	29	33	36	40	46	64	59	84	100	100

(*)The current catch level: Average catch in 3 recent years(2014-2016).

< 55,170 t (the MSY level) or 10 % reduction of the current catch level (the average catch in 2014-2016 was 54,090 t), in order to secure the MSY (TB and F) with the risk probability violating MSY (TB and F) < 50 % in 10 years (refer to the black dotted box in the matrix). For reference, in the stock assessments conducted by IOTC, the results suggested that the stock statuses (2015 and 2018) were in the red zones, which indicated that the stock status in the whole Indian Ocean is likely less safe than that of the Southeast Asian waters. The details of the comparison are shown in **Figure 6 (Box 5)**.

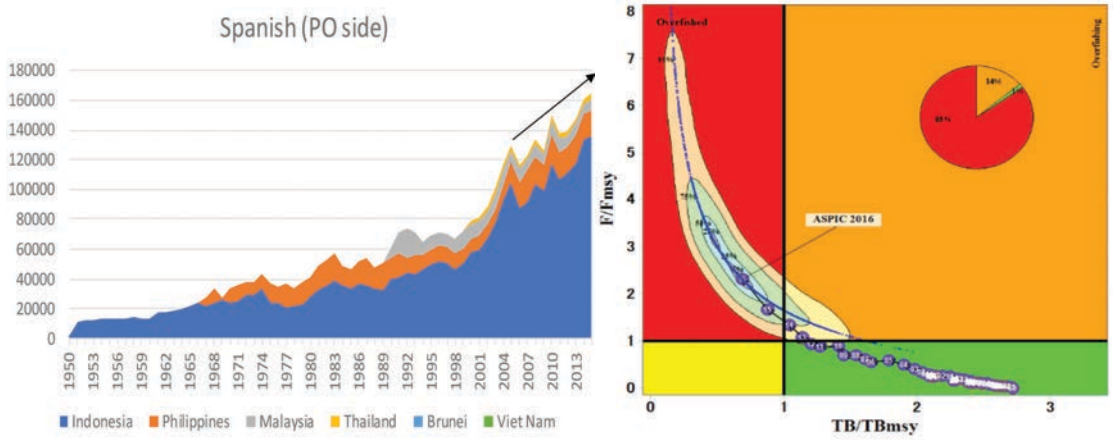
2. Narrow-barred Spanish mackerel (Pacific Ocean side)

Results of the stock assessment of the narrow-barred Spanish mackerel in the Pacific Ocean side (**Box 2**) suggest that MSY=129,200 t and the stock status (2016) is in the red zone of the Kobe plot very far from the MSY levels, *i.e.* TB/TBmsy=0.46 and F/Fmsy=2.33. This implies that the stock is seriously overfished and is in overfishing condition, which could be due to the continuous increases of the catch since the start of fisheries without any signs of decline. The results of the risk assessment, *i.e.* strategic risk matrix (Kobe II) suggest that TAC should be < 98,274 t to secure MSY (TB and F) with risk probability violating MSY levels (TB and F) < 80 % in 10 years. This means that the current catch level of 163,790 t (average of 2014-2016) should be decreased at least by 40 %. It should be noted however, that the TAC concept of probability < 50 % was not applied in this case because if such concept was used, the catch need to be reduced by more than 90 % (refer to the black dotted box in the matrix), which will significantly impact on the fishers, and thus had been avoided. Therefore, the 80 % level is suggested exceptionally for this case with one strong condition that this stock needs to be assessed every year until the stock status recovers and is in the green (safe) zone.

3. Indo-Pacific king mackerel (Indian Ocean side)

Results of the stock assessment of the Indo-Pacific mackerel in the Indian Ocean side (**Box 3**) suggest that MSY=15,130 t and the stock status (2016) is in the green zone of the Kobe plot far away from the MSY levels, *i.e.* TB/TBmsy=1.33 and F/Fmsy=0.63, indicating a very healthy condition of the stocks. This is because the catch has been decreasing during the last

Box 2. Catch, stock status and suggested TAC for narrow-barred Spanish mackerel (Pacific Ocean side)



Catch by country *(left)* and the **stock status** represented by the Kobe plot *(right)*:
Red zone, *i.e.* **seriously overfished** and **overfishing**; TB/TBmsy=0.46 and F/Fmsy=2.33 and MSY=129,200 t

Strategic risk matrix (Kobe II)

Probabilities (%) of violating TBmsy and Fmsy in 2019 and 2026

Current catch level* (average 2014-2016): 163,790 t

TAC suggested < 98,274 t

(40 % reduction of the current catch level*) to secure the MSY levels (TB and F) with risk probability < 80% in 10 years

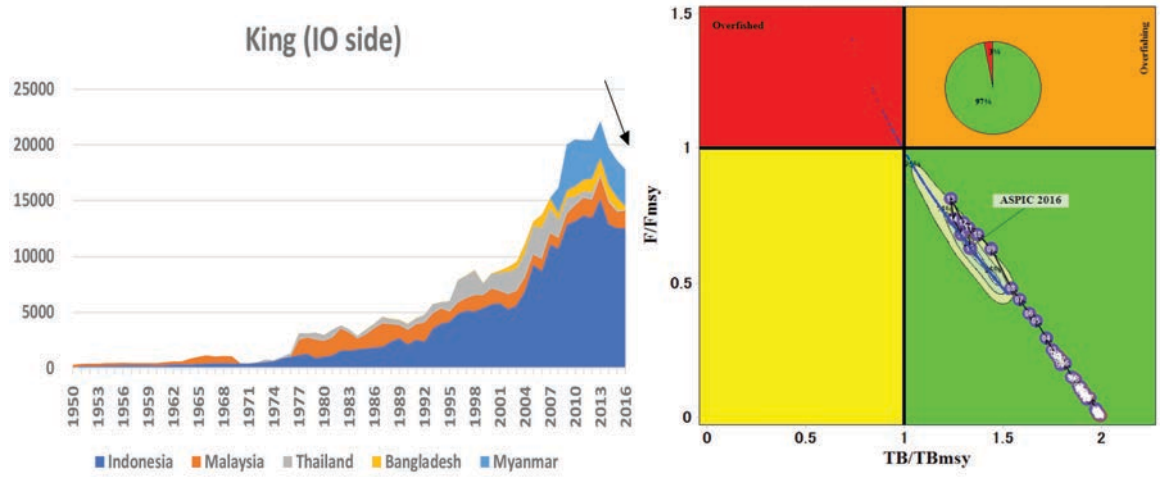
Probabilities(%) violating TBmsy and Fmsy in 3 and 10 years.

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

	0%	20%	40%	60%	70%	80%	90%	78% MSY level	100% Current catch (t)	110%
10 catch scenarios (tons)	0	32,758	65,516	98,274	114,653	131,032	147,411	129,200	163,790	180,169
TB2019 < TBmsy	81	86	90	94	96	97	98	100	100	100
F2019 > FMSY	0	68	75	86	91	96	100	100	100	100
TB2026 < TBmsy	2	67	72	79	86	91	97	98	100	100
F2026 > FMSY	0	67	72	79	86	91	98	99	100	100

(*)The current catch level: Average catch in 3 recent years(2014-2016).

Box 3. Catch, stock status and suggested TAC for Indo-Pacific king mackerel (Indian Ocean side)



Catch by country *(left)* and the **stock status** presented by Kobe plot *(right)*:
green zone and far from MSY (TB and F) healthy condition; TB/TBmsy=1.33 and F/Fmsy=0.63 and MSY=151,300 t

Strategic risk matrix (Kobe II)

Probabilities (%) of violating TBmsy and Fmsy in 2019 and 2026

Current catch level* (average 2014-2016) is 11,592 t

TAC suggested < 15,130 t (MSY) (current catch level* can be increased by 31 %) to secure the MSY levels (TB and F) with risk probability < 50 % in 10 years.

Probabilities(%) violating TBmsy and Fmsy in 3 and 10 years.

Color legend				
Risk levels	Low risk	Medium	Medium	High risk
Probabilty	0 - 25%	25 - 50%	50 - 75%	75 - 100%

	60%	70%	80%	90%	100% Current catch (*)	110%	120%	130%	131% MSY level	140%
10 catch scenarios (tons)	6,955	8,114	9,274	10,433	11,592	12,751	13,910	15,070	15,130	16,229
TB2019 < TBmsy	5	5	6	6	6	7	8	8	8	9
F2019 > FMSY	2	2	2	3	4	5	6	8	9	16
TB2026 < TBmsy	2	2	2	2	3	5	7	33	38	87
F2026 > FMSY	2	2	2	2	3	4	6	36	42	97

(*)The current catch level: Average catch in 3 recent years(2014-2016).

five years (2012-2016). The results of the risk assessment, *i.e.* strategic risk matrix (Kobe II) suggest that TAC can be < the MSY level (15,130 t) to secure the MSY (TB and F) with risk probability violating MSY levels (TB and F) < 50 % in 10 years (refer to the black dotted box in the matrix). This means that the current catch level of 11,592 t (average of 2014-2016) could be increased by 15 %. However, the stock status of this species in the whole Indian Ocean as suggested by IOTC is unknown because there were not enough information in conducting reliable stock assessments (IOTC, 2019).

4. Indo-Pacific king mackerel (Pacific Ocean side)

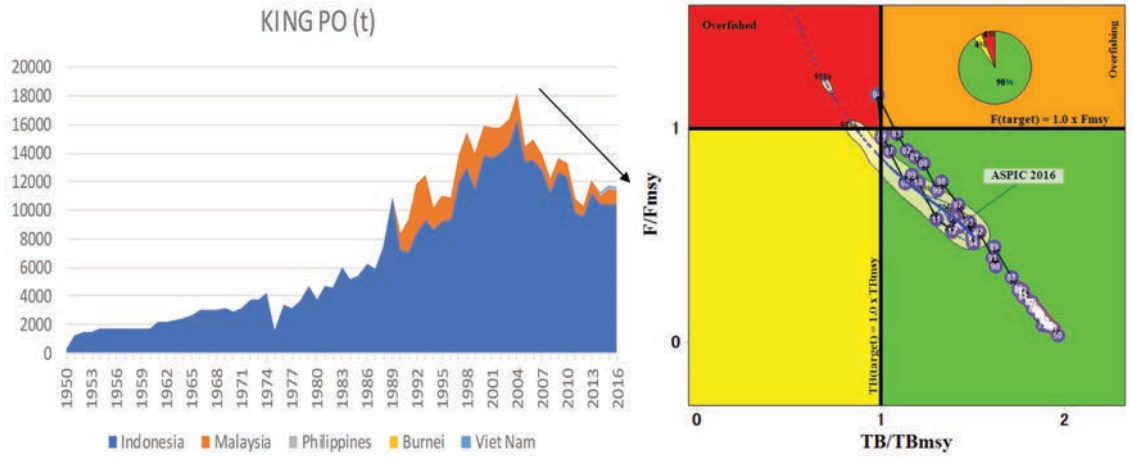
Results of the stock assessment of the Indo-Pacific mackerel in the Pacific Ocean side (**Box 4**) suggest that MSY=21,500 t and the stock status (2016) is far away from the MSY levels, *i.e.* TB/TBmsy=1.45 and F/Fmsy=0.63 indicating a very healthy condition of the stock. This is because the catch has been decreasing for the last 13 years (2004-2016). The results of the risk assessment, strategic risk matrix (Kobe II) suggest that TAC can be < the MSY (21,500 t) level to secure the MSY (TB and F) with risk probability violating MSY (TB and F) < 50 % in 10 years (refer to the black dotted box in the matrix). This means that the current catch level of 18,719 t (average of 2014-2016) can be increased by 31 %.

Conclusion and Recommendations

Results of the stock and risk assessments of narrow-barred Spanish mackerel and Indo-Pacific king mackerel should be considered with caution because there were uncertainties in the input data, *i.e.* catch and CPUE. With this in mind, the summary as outlined in **Table 1** showing the results of the stock and risk assessments of these two species in the Pacific and Indian Ocean side could still be used as reference. From the results, only the stock of narrow-barred Spanish mackerel in the Pacific Ocean side is in the red zone and is in serious overfishing and overfished conditions. Thus, the current catch should be reduced drastically, *i.e.* by more than 40 % of the current catch level, to sustain the resources and the fisheries.

In addition, the stock status of the narrow-barred Spanish mackerel in the Indian Ocean side is in the green zone, and very close to the MSY (TB and F). However, since 71 % of uncertainties around the stock status in 2016 is in the red zone, the current catch should be reduced by 10 %. Such

Box 4. Catch, stock status and suggested TAC for Indo-Pacific king mackerel (Pacific Ocean side)



Catch by country *(left)* and the **stock status** is presented by the Kobe plot *(right)*:
green zone far from MSY (TB and F), *i.e.* in very healthy condition: TB/TBmsy=1.45 and F/Fmsy=0.63 and MSY=21,500 t

Strategic risk matrix (Kobe II)

Probabilities (%) of violating TBmsy and Fmsy in 2019 and 2026

Current catch level* (average 2014-2016): 18,719 t

TAC suggested < 21,500 t
(MSY) (current catch level* can be increased by 15 %) to secure the MSY levels (TB & F) with risk probability < 50 % in 10 years.

Probabilities(%) violating TBmsy and Fmsy in 3 and 10 years.

Color legend				
Risk levels	Low risk	Medium	Medium	High risk
Probabilty	0 - 25%	25 - 50%	50 - 75%	75 - 100%

	60%	70%	80%	90%	100% Current catch t)	110%	115% MSY level	120%	130%	140%
10 catch scenarios (tons)	11,231	13,103	14,975	16,847	18,719	20,591	21,500	22,463	24,335	26,207
TB2019 < TBmsy	1	2	3	5	8	12	14	16	23	30
F2019 > FMSY	0	0	0	0	3	11	20	29	63	97
TB2026 < TBmsy	0	0	0	1	8	34	40	70	96	100
F2026 > FMSY	0	0	0	0	5	31	49	76	100	100

(*)The current catch level: Average catch in 3 recent years(2014-2016).

Table 1. Summary of the stock status of narrow-barred Spanish mackerel and Indo-Pacific king mackerel (2016), and management advice TAC. *(Note) the current catch level, MSY and TAC values are rounded to 100 t.*

	Spanish mackerel		King mackerel	
	Pacific side	Indian side	Pacific side	Indian side
Stock status (2016) (*)	85 %	25 % (green) but 71 % (red)	90 %	97 %
TB/TBmsy (**)	0.46	1.03	1.45	1.33
F/Fmsy (**)	2.33	0.93	0.63	0.63
Current catch level (tons) (average 2014-2016)	163,800	54,100	18,700	11,600
MSY (t)	129,200	55,200	21,500	15,100
Management (TAC) advices (t)	98,300	48,700	21,500 (MSY)	15,100 (MSY)
Catch reduction (-) or increase (+) (t) (***)	-65,500	-5,400	+2,800	+3,500
% Catch reduction by (-) or increase by (+) (***)	-40 %	-10 %	+31 %	15 %

Note (*) Color in the Kobe plot (2016) and % represents its composition of uncertainties.
Note (**) Yellow color means that MSY levels are not secured.
Note (***) Differences between the current catch and TAC

Box 5. Summary of stock assessment of neritic tuna species conducted by SEAFDEC and IOTC

Southeast Asian Fisheries Development Center (SEAFDEC)

The Neritic Tuna Project of SEAFDEC covers seven commercially important neritic tuna species in the Southeast Asian waters, *i.e.*, kawakawa (*Euthynnus affinis*), longtail tuna (*Thunnus tonggol*), narrow-barred Spanish mackerel (*Scomberomorus commerson*), Indo-Pacific king mackerel (*Scomberomorus guttatus*), frigate tuna (*Auxis thazard*), bullet tuna (*Auxis rochei*), and bonito (*Auxis rochei*). To date, four most economically important species in the Pacific and Indian Ocean sides had been assessed as shown in **Table 2**.

Table 2. Stock status of the four most important neritic species in the Southeast Asian waters

Species considered	Area of coverage	Stock status	TB/TBmsy, F/Fmsy	Stock status year
Kawakawa	Pacific Ocean side	green	1.12, 0.88	2018
	Indian Ocean side	red	0.82, 1.39	2018
Longtail tuna	Pacific Ocean side	green	1.52, 0.53	2018
	Indian Ocean side	green	1.24, 0.67	2018
Narrow-barred Spanish mackerel	Pacific Ocean side	red	0.46, 2.23	2016
	Indian Ocean side	green	1.03, 0.93	2016
Indo-Pacific king mackerel	Pacific Ocean side	green	1.45, 0.63	2016
	Indian Ocean side	green	1.33, 0.63	2016

Note: TB: Total biomass, F: Fishing mortality and colors refer to those used in the Kobe plot.

Indian Ocean Tuna Commission (IOTC)

Under the IOTC, the Neritic Tuna Working Group (NTWG) covers the six important management species, *i.e.* kawakawa (*Euthynnus affinis*), longtail tuna (*Thunnus tonggol*), narrow-barred Spanish mackerel (*Scomberomorus commerson*), Indo-Pacific king mackerel (*Scomberomorus guttatus*), frigate tuna (*Auxis thazard*), and bullet tuna (*Auxis rochei*) in the IOTC area of competence. **Table 3** shows the stock status of such species (IOTC, 2019 and 2020). **Figure 6** shows the comparison of the stock statuses of narrow-barred Spanish mackerel between IOTC (whole Indian Ocean) and SEAFDEC (SE Asian waters in the Indian Ocean).

Table 3. Stock status of six management species in the IOTC Area of Competence (IOTC, 2019 and 2020)

Species considered	Stock status	TB/TBmsy, F/Fmsy	Stock status year
Kawakawa	green	1.13, 0.98	2018
Longtail tuna	red	0.69, 1.52	2018
Narrow-barred Spanish mackerel	red	0.80, 1.24	2018
Indo-Pacific king mackerel	unknown	Unknown	2018
Frigate tuna	unknown	Unknown	2018
Bullet tuna	unknown	Unknown	2018

Note: TB: Total biomass, F: Fishing mortality and colors refer to those used in the Kobe plot.

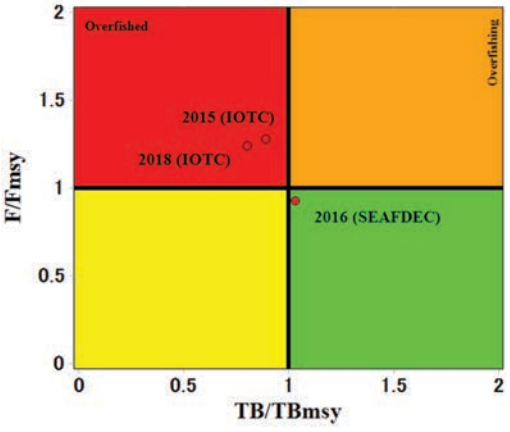


Figure 6. Comparison of the stock statuses of narrow-barred Spanish mackerel between IOTC (whole Indian Ocean) (2015 and 2018) based on the Stock Reduction Analysis and SEAFDEC (SE Asian waters in the Indian Ocean) (2018) based on ASPIC. This indicates that there are likely more fishing pressures in the whole Indian Ocean than in the Southeast Asian waters.

reductions need to be considered equally for the Member Countries exploiting these two stocks. Otherwise, the goal towards sustainable utilization and fisheries could not be achieved. Furthermore, considering that these species are exploited by multiple gears in multi-species fisheries, simple reductions would be difficult to undertake because the gears used in the fisheries could catch the other species with healthy stock status. Therefore, a strategy of reducing the catch should be developed and implemented taking into consideration holistically the factors relevant to the fishery

of such species, *i.e.* species compositions, stock statuses, fishing seasons, fishing grounds, commercial values, and the socioeconomics of fishers. One of the effective strategies is to establish temporal closed area and season where these two species catches (densities) are high, while others are low. Each Member Country should consider such strategy holistically based on its own unique situation of these factors.

Finally, for serious unhealthy stocks like the narrow-barred Spanish mackerel in the Pacific Ocean side, stock assessment should be conducted every 1-2 years until the stock status changes to the safe condition otherwise it might be too late to manage the recovery of the stock. For healthy stocks, the stock assessment cycle could be every 3-4 years but routine monitoring of the catch and CPUE trends are essential.

For reference, results of the stock status of neritic tunas including the narrow-barred Spanish mackerel and Indo-Pacific king mackerel in the whole Indian Ocean, assessed by SEAFDEC and the Indian Ocean Tuna Commission (IOTC), are summarized in **Box 5**.

Acknowledgement

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