The Commission for the Conservation and Management of
Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

SCIENTIFIC COMMITTEE

SKIPJACK TUNA (*Katsuwonus pelamis*)

STOCK STATUS AND MANAGEMENT ADVICE

Contents

SC15 2019 (STOCK ASSESSMENT CONDUCTED)

a. Stock status and trends

1. SC15 noted that the total provisional catch in 2018 was 1,795,048 mt, a 10% increase from 2017 and a 1% decrease from 2013-2017. Purse seine catch in 2018 (1,469,520 mt) was a 15% increase from 2017 and a 2% increase from the 2013-2017 average. Pole and line catch (138,534 mt) was a 4% increase from 2017 and a 9% decrease from the average 2013-2017 catch. Catch by other gear (182,888 mt) was a 16% decrease from 2017 and 19% decrease from the average catch in 2013-2017.

2. SC15 agreed to use the 8-region model to describe the stock status of skipjack tuna because SC15 considers that it better captures the biology of skipjack tuna than the existing 5 region structure. Stock status was determined over an uncertainty grid of 54 models with assumed weightings as illustrated in Table SKJ-01.

3. The median values of recent (2015–2018) spawning biomass depletion ($SB_{recent}/SB_{F=0}$) and relative recent (2014–2017) fishing mortality (F_{recent}/F_{MSY}) over the uncertainty grid of 54 models (Table SKJ-02) were used to define stock status. The values of the upper 90th and lower 10th percentile of the empirical distributions of relative spawning biomass and relative fishing mortality from the uncertainty grid were used to characterize the probable range of stock status.

4. The spatial structure used in the assessment model is shown in Figure SKJ-01. Time series of total annual catch (1000's mt) by fishing gear for all regions is shown in Figure SKJ-02 and by region separately is shown in Figure SKJ-03. The annual average recruitment, spawning potential, and total biomass by model region for the diagnostic model are shown in Figure SKJ-04. The overall spawning potential summed across region for the diagnostic model is shown in Figure SKJ-05. The estimated annual average juvenile and adult fishing mortality for the diagnostic model is shown in Figure SKJ-06. The estimated impact of fishing (1 – $SB_{latest}/SB_{F=0}$) by region and overall regions for the diagnostic model is shown in Figure SKJ-07. The median and 80th percent quantile trajectories of fishing depletion for models in the weighted structural uncertainty grid in Table SKJ-01 is shown in Figure SKJ-08, where it can be seen that the median has been below the target since 2009. The Majuro plot shows the recent fishing mortality and spawning potential relative to the unfished spawning potential for all models in the structural uncertainty grid for (i) spawning potential in the recent time period (2015–2018) in Figure SKJ-09, and (ii) spawning potential in the latest time period (2018) in Figure SKJ-10. The Kobe plot shows the recent fishing mortality and spawning potential relative to spawning potential at MSY for all models in the structural uncertainty grid for (i) spawning potential in the recent time period (2015–2018) in Figure SKJ-11, and (ii) spawning potential in the latest time period (2018) in Figure SKJ-12.

5. SC15 noted that the median level of spawning potential depletion from the uncertainty grid was $SB_{recent}/SB_{F=0}$ = 0.44 with a probable range of 0.37 to 0.53 (80% probability interval). There were no individual models where $SB_{recent}/SB_{F=0} < 0.2$, which indicated that the probability that recent spawning biomass was below the LRP was zero.

6. SC15 noted that the grid median F_{recent}/F_{MSY} was 0.45, with a range of 0.34 to 0.60 (80% probability interval) and that no values of F_{recent}/F_{MSY} in the grid exceed 1. Therefore, SC15 noted that there was a zero probability that the recent fishing mortality exceeds F_{MSY}.

7. SC15 noted that the largest uncertainty in the structural uncertainty grid was due to the assumed tag mixing period. In addition, SC15 acknowledges that further study is warranted to investigate the uncertainty surrounding the appropriate mixing period for the tagging data.

8. SC15 acknowledges that the spatial extent of the Japanese pole-and-line fishery has decreased over the time period and that the future use of this standardized CPUE index within future stock assessments is uncertain.

9. Therefore, SC15 acknowledges that further study of alternative indices of abundance is warranted, such as investigation of standardizing the purse seine fishery and evaluation of the feasibility of conducting fishery independent surveys.

Table SKJ-01. Description of the updated structural sensitivity grid used to characterize uncertainty in the assessment.

Axis	Value	Relative weight
Steepness	0.65	0.8
	0.80	1.0
	0.95	0.8
Growth	Low	1.0
	Diagnostic	1.0
	High	1.0
Length composition scalar	50	0.8
	100	1.0
	200	1.0
Tag mix	1	1.0
	2	1.0

Table SKJ-02. Summary of reference points over the various models in the structural uncertainty grid. F_{mult} is the multiplier of recent (2014-2017) fishing mortality required to attain MSY, F_{recent} is the average fishing mortality of recent (2014-2017), SB_{recent} is the average spawning potential of recent years (2015-2018) and SB_{latest} is the spawning potential in 2018.

	Mean	Median	Minimum	10^{th} %ile	90^{th} %ile	Maximum
C_{latest}	1,755,328	1,755,693	1,749,846	1,753,471	1,757,057	1,757,083
$Y_{Frecent}$	1,877,914	1,864,040	1,679,600	1,737,702	2,043,556	2,135,200
f_{mult}	2.282	2.258	1.472	1.757	2.957	3.705
F_{MSY}	0.223	0.222	0.180	0.189	0.264	0.270
MSY	2,296,566	2,294,024	1,953,600	1,995,987	2,767,083	2,825,600
F_{recent}/F_{MSY}	0.461	0.447	0.270	0.343	0.600	0.679
$SB_{F=0}$	6,220,675	6,299,363	5,247,095	5,580,942	6,913,431	7,349,557
SB_{MSY}	1,100,947	1,064,400	631,900	723,742	1,544,060	1,688,000
$SB_{MSY}/SB_{F=0}$	0.175	0.176	0.117	0.131	0.225	0.23
$SB_{latest}/SB_{F=0}$	0.414	0.415	0.325	0.36	0.487	0.525
SB_{latest}/SB_{MSY}	2.468	2.382	1.551	1.779	3.356	3.925
$SB_{recent}/SB_{F=0}$	0.440	0.440	0.336	0.372	0.530	0.551
SB_{recent}/SB_{MSY}	2.623	2.579	1.601	1.892	3.613	4.139

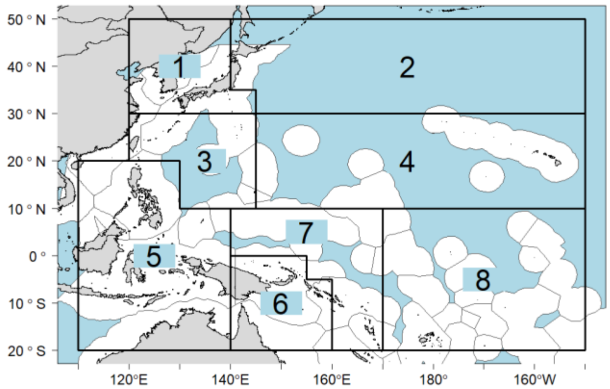


Figure SKJ-01. Eight region spatial structure used in the 2019 stock assessment model.

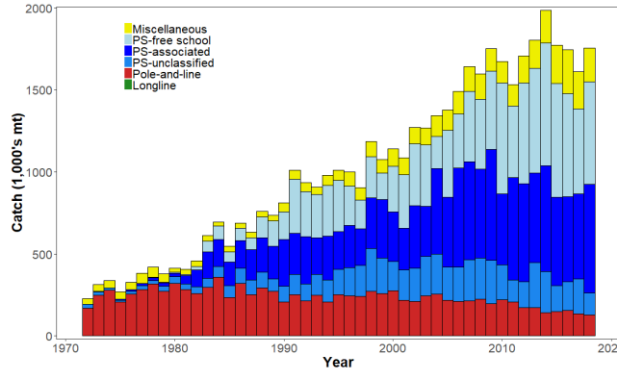


Figure SKJ-02. Time series of total annual catch (1000's mt) by fishing gear over the full assessment period.

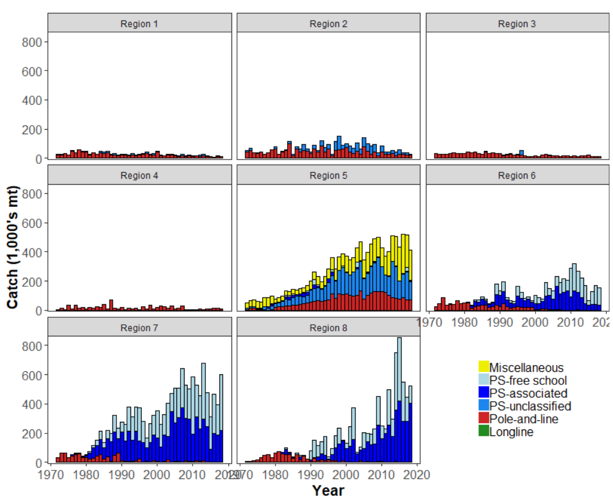


Figure SKJ-03. Time series of total annual catch (1000's mt) by fishing gear and assessment region over the full assessment period.

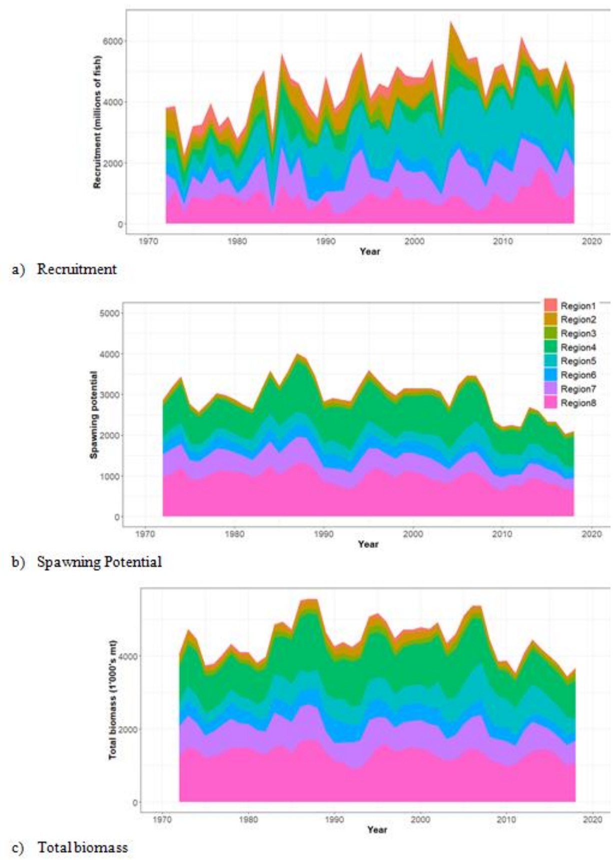


Figure SKJ-04. Estimated annual average recruitment, spawning potential and total biomass by model region for the diagnostic model, showing the relative sizes among regions.

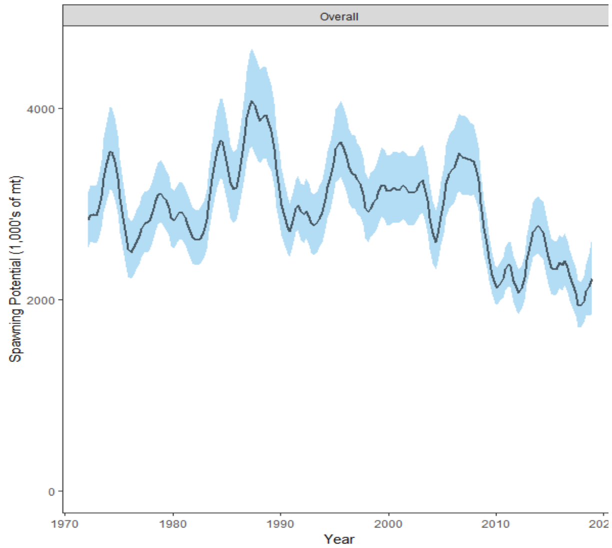


Figure SKJ-05. Estimated temporal overall spawning potential summed across regions from the diagnostic model, where the shaded region is ± 2 standard deviations (i.e., 95% CI).

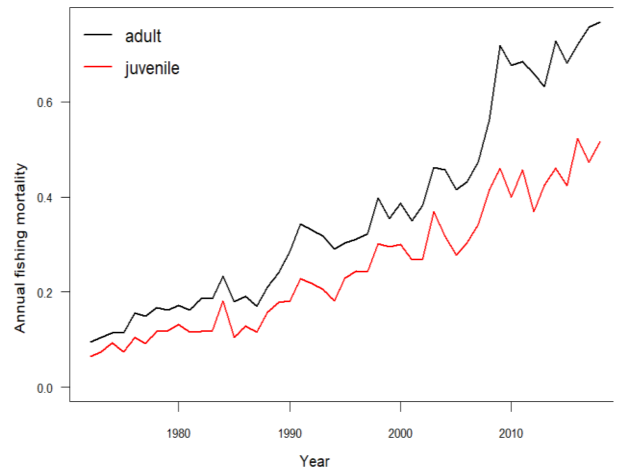


Figure SKJ-06. Estimated annual average juvenile and adult fishing mortality for the diagnostic model.

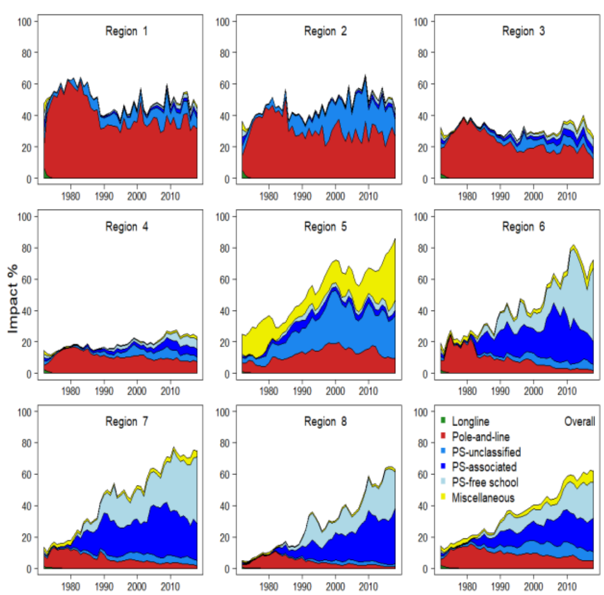


Figure SKJ-07. Estimates of reduction in spawning potential due to fishing (fishery impact = 1-SB_{latest}/$SB_{F=0}$) by region for the diagnostic model.

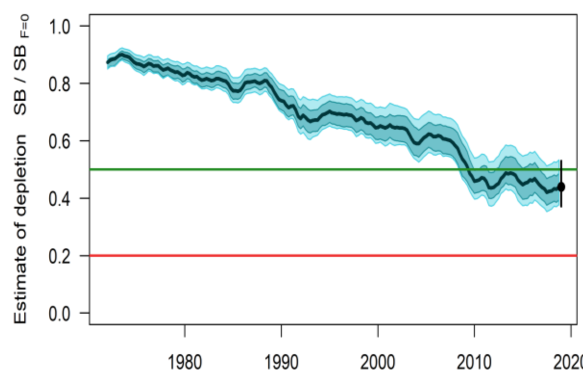


Figure SKJ-08. Plot showing the trajectories of spawning potential depletion for the model runs included in the structural uncertainty grid weighted by the values given in Table SKJ-01. Red horizontal line indicates the agreed limit reference point, the green horizontal line indicates the interim target reference point.

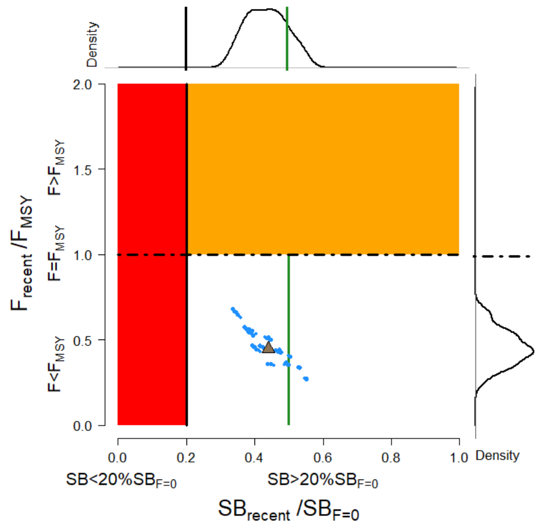


Figure SKJ-09. Majuro plot for the recent spawning potential (2015 – 2018) summarizing the results for each of the models in the structural uncertainty grid with weighting. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality, and marginal distributions of each are presented. Vertical green line denotes the interim TRP. Brown triangle indicates the median of the estimates. The size of the circle relates to the weight of that particular model run.

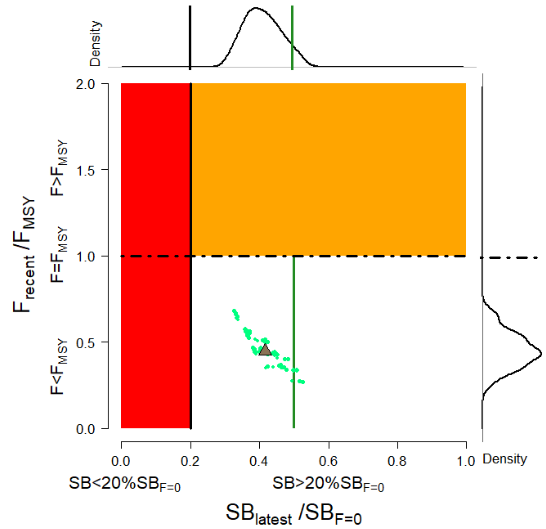


Figure SKJ-10. Majuro plot for the latest spawning potential (2018) summarizing the results for each of the models in the structural uncertainty grid with weighting. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality, and marginal distributions of each are presented. Vertical green line denotes the interim TRP. Brown triangle indicates the median of the estimates. The size of the circle relates to the weight of that particular model run.

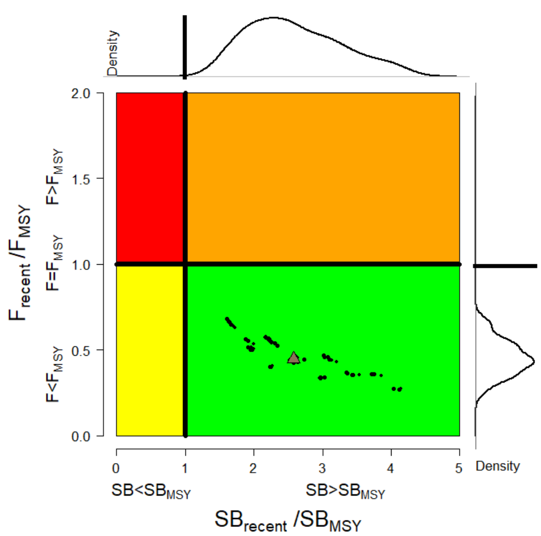


Figure SKJ-11. Kobe plot for the recent spawning potential (2015 – 2018) summarizing the results for each of the models in the structural uncertainty grid. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality and marginal distributions of each are presented. Brown triangle indicates the median of the estimates. The size of the circle relates to the weight of that particular model run.

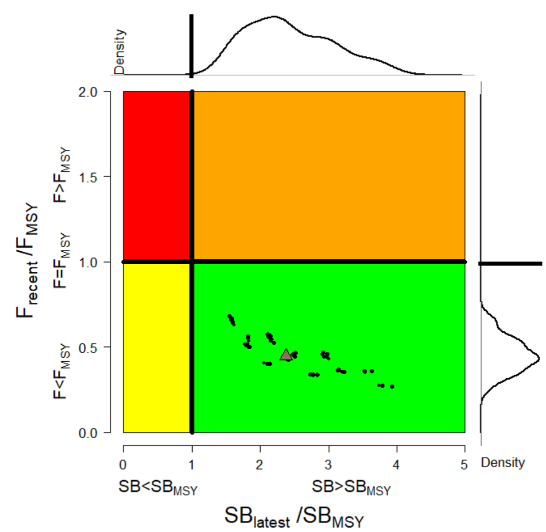


Figure SKJ-12. Kobe plot for the latest spawning potential (2018) summarizing the results for each of the models in the structural uncertainty grid. The plots represent estimates of stock status in terms of spawning potential depletion and fishing mortality and marginal distributions of each are presented. Brown triangle indicates the median of the estimates. The size of the circle relates to the weight of that particular model run.

b. Management advice and implications

10. SC15 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and the level of fishing mortality is sustainable.

11. The 2019 stock assessment includes additional data and a range of model improvements such as a change to the maturity schedule used in this assessment, with length-at-maturity now larger than in the previous assessment, which has resulted in a reduction in the estimate of potential spawning biomass, relative to the 2016 assessment.

12. SC15 noted that the stock was assessed to be above the adopted Limit Reference Point and fished at rates below F_{MSY} with 100% probability. Therefore, the skipjack stock is not overfished, nor subject to overfishing. At the same time, it was also noted that fishing mortality is continuously increasing for both adult and juvenile while the spawning biomass reached the historical lowest level.

13. The skipjack interim Target Reference Point (TRP) is 50% of spawning biomass in the absence of fishing. The trajectory of the median spawning biomass depletion indicates a long-term trend, and has been under the interim TRP since 2009 (i.e., for 10 years). Since the median spawning biomass has been consistently below the interim TRP, SC15 recommends that the Commission take appropriate management action to ensure that the biomass depletion level fluctuates around the TRP (e.g., through the adoption of a harvest control rule).

c. Research Recommendations

14. In order to maintain the quality of stock assessments for this important stock SC15 recommends:

a) continuing work to develop an index of abundance based on purse seine data and from FAD acoustic sensors;
b) evaluating the possibility of conducting fishery independent surveys to provide relative abundance indices;
c) conducting regular large-scale tagging cruises and expanding the infrastructure for rapid return of recaptured tags in a manner that provides the best possible data for stock assessment purposes;
d) investigating skipjack growth by validation studies of otolith readings and/or estimation of growth within MFCL from tag recapture data;
e) attempting to provide finalized catch estimates to SPC no later than June 1st.

SC14 2018 (FISHERY INDICATORS UPDATED)

a. Stock status and trends

15. SC14 noted that the total catch in 2017 was 1,624,162 mt, a 9% decrease from 2016 and comparable to the average from 2012-2016.

16. Purse seine catch in 2017 (1,280,311 mt) was a 7% decrease from 2016 and a 12% decrease from the 2012-2016 average. Pole and line catch (123,132 mt) was a 21% decrease from 2016 and a 23% decrease from the average 2012-2016 catch. Catch by other gear (218,175 mt) was a 13% decrease from 2016 and 1% decrease from the average catch in 2012-2016.

17. SC14 noted that under recent fishery conditions (2017 catch level for longline and other fisheries and effort level for purse seine), the skipjack stock was initially projected to decrease for a short period as recent relatively high recruitments move out of the stock. Median F_{2019}/F_{MSY} = 0.47; median $SB_{2019}/SB_{F=0}$ = 0.45; median SB_{2019}/SB_{MSY} = 1.67. In the longer term, assuming long term average recruitment, modest increases in the stock were projected.

b. Management advice and implications

18. SC14 noted that no stock assessment has been conducted since SC12. Therefore, the advice from SC12 should be maintained to achieve the objectives set in CMM 2017-01, pending a new assessment or other new information. For further information on the management advice and implications from SC12, please see https://www.wcpfc.int/node/27769

c. Research Recommendations

19. SC14 discussed a proposal for an alternative regional structure to be considered in the next skipjack stock assessment (SC14-SA-WP-04) and recommended that the pre-assessment workshop consider how this proposal might be included in the next assessment.

20. SC14 supports an ongoing tagging program for skipjack tuna to ensure a reliable indicator of skipjack tuna abundance in the stock assessment.

21. SC14 recommended that the Scientific Services Provider continue research on standardizing purse seine CPUE for use in the assessment.

SC13 2017 (FISHERY INDICATORS UPDATED)

a. Stock status and trends

1. SC13 noted that the total catch in 2016 (1,816,762 mt) was comparable to that in 2015 and a 2% increase over 2011-2015. (see SC13-SA-WP-02)

2. Purse seine catch (1,408,110 mt) was comparable to both 2015 and the 2011-2015 average. Pole and line catch (151,441 mt) was a 1% decrease from 2015 and an 11% decrease from 2011-2015 average. Catches by other fisheries (251,470 mt) were 2% higher than in 2015 and 26% higher than 2011-2015 average.

3. SC13 noted that under recent fishery conditions (2016 catch level for LL and other fisheries and effort level for purse seine), the skipjack stock was initially projected to decrease for a short period and then to increase as recent relatively high recruitments move through the stock. Median F_{2018}/F_{MSY} = 0.37; median $SB_{2018}/SB_{F=0}$ = 0.47.

b. Management advice and implications

4. SC13 noted that no stock assessment has been conducted since SC12. Therefore, the advice from SC12 should be maintained, pending a new assessment or other new information. For further information on the management advice and implications from SC12, please see https://www.wcpfc.int/node/27769

SC12 2016 (STOCK ASSESSMENT CONDUCTED)

a. Stock status and trends

1. SC12 noted that the skipjack catch in 2015 was 1,827,750 mt, was a 9% decrease over 2014 and a 3% increase over the average for 2010-14.

2. Purse seine skipjack catch in 2015 was 13% lower than that in 2014 and effort 21% lower.

3. The SC12 was unable to reach consensus on the description of stock status based on the 2016 stock assessment.

4. SC12 notes that the majority of member countries agreed on the following description of WCPO skipjack tuna status and trends.

Majority view of stock status and trends

5. A majority of SC12 CCMs selected the reference case model as the base case to represent the stock status of skipjack tuna (column "Ref Case" in Table SKJ2). To characterize uncertainty, those CCMs chose the structural uncertainty grid. Summaries of important model quantities for these models are shown in Table SKJ2.

Table SKJ1. Description of the structural sensitivity grid used to characterise uncertainty in the assessment. The reference case option is denoted in bold face.

Axis	Levels	Option
Steepness	3	0.65, **0.80**, or 0.95
Mixing period	2	**1 quarter mixing**, 2 quarters mixing
Length composition weighting	3	Sample sizes divided by 10, **20**, or 50
Tagging overdispersion	3	**Default level**, Estimated, or Fixed (moderate) level

Table SKJ2: Estimates of management quantities for the selected stock assessment models. For the purpose of this assessment, "recent" is the average over the period 2011–2014 and "latest" is 2015. The column "Ref Case" shows summaries for the reference case and the remaining columns are the quantiles of the structural uncertainty grid, e.g. 5% and 50% are the 5% quantile and the median (50% quantile), respectively. Option 1 in the text recommends basing management advice on the reference case model and considering the uncertainty represented by the 5% and 95% quantile columns. Option 2 recommends basing management advice on the range of model runs in the structural uncertainty grid, as represented by the 5% and 95% quantile columns.

Quantity	Ref Case	50%	5%	25%	75%	95%
C_{latest}	1,679,528	1,679,444	1,678,646	1,679,170	1,679,497	1,679,592
MSY	1,891,600	1,875,600	1,618,060	1,785,400	1,976,700	2,199,880
$Y_{F_{recent}}$	1,594,800	1,607,000	1,486,660	1,533,200	1,755,200	1,808,860
f_{mult}	2.23	2.07	1.57	1.85	2.29	2.62
F_{MSY}	0.24	0.24	0.21	0.22	0.26	0.28
F_{recent}/F_{MSY}	0.45	0.48	0.38	0.44	0.54	0.64
SB_{MSY}	1,626,000	1,628,000	1,258,700	1,425,750	1,852,750	2,166,100
SB_0	6,764,000	6,359,500	5,214,050	5,853,750	7,095,250	8,340,450
$SB_{F=0}$	7,221,135	6,876,526	5,778,079	6,408,578	7,425,353	8,555,240
SB_{latest}/SB_0	0.62	0.55	0.43	0.49	0.59	0.71

$SB_{latest}/SB_{F=0}$	0.58	0.51	0.39	0.47	0.57	0.67
SB_{latest}/SB_{MSY}	2.56	2.15	1.6	1.81	2.43	3.08
$SB_{recent}/SB_{F=0}$	0.52	0.49	0.4	0.46	0.52	0.57
SB_{recent}/SB_{MSY}	2.31	2.04	1.58	1.82	2.32	2.65

6. Trends in estimated recruitment, spawning biomass, fishing mortality and depletion are shown in Figures SKJ 1-4.

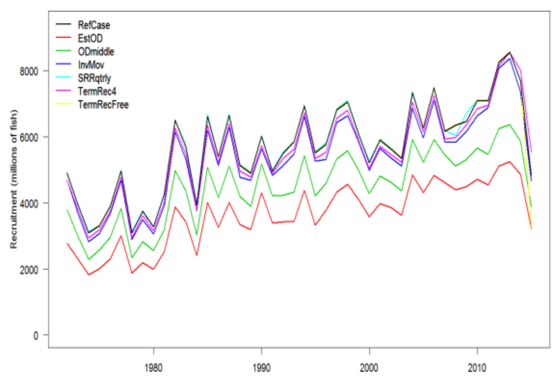


Figure SKJ1: Estimated annual recruitment (millions of fish) for the WCPO obtained from the reference case model and six additional runs.

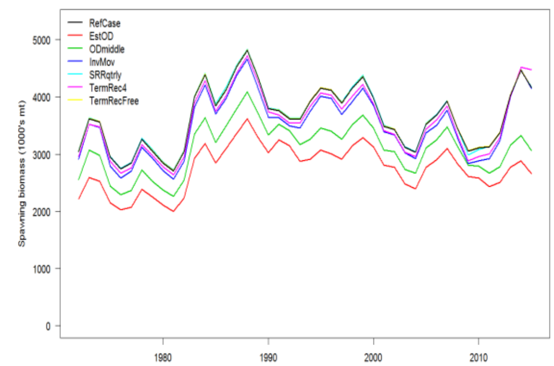


Figure SKJ2: Estimated annual average spawning potential for the WCPO obtained from the reference case model and six additional runs.

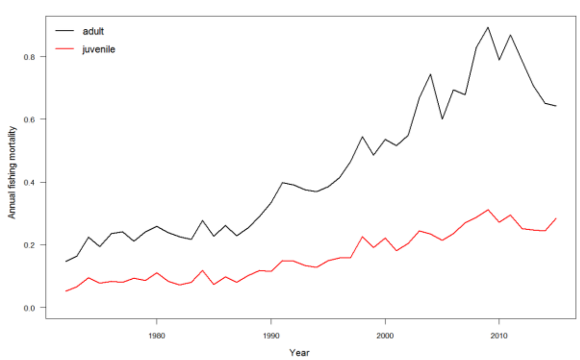


Figure SKJ3: Estimated annual average juvenile and adult fishing mortality for the WCPO obtained from the reference case model.

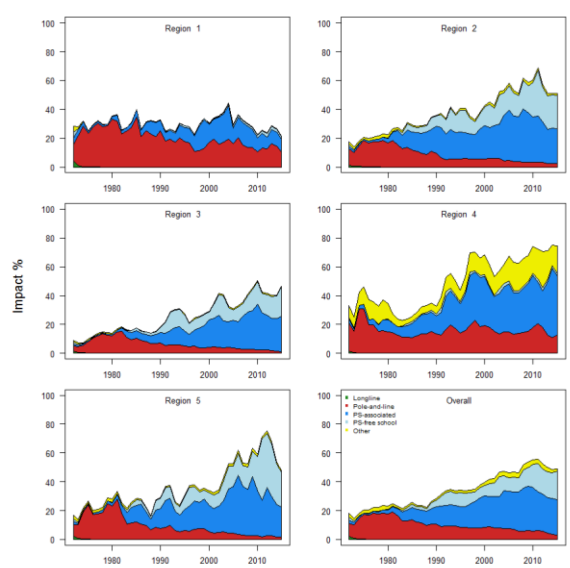
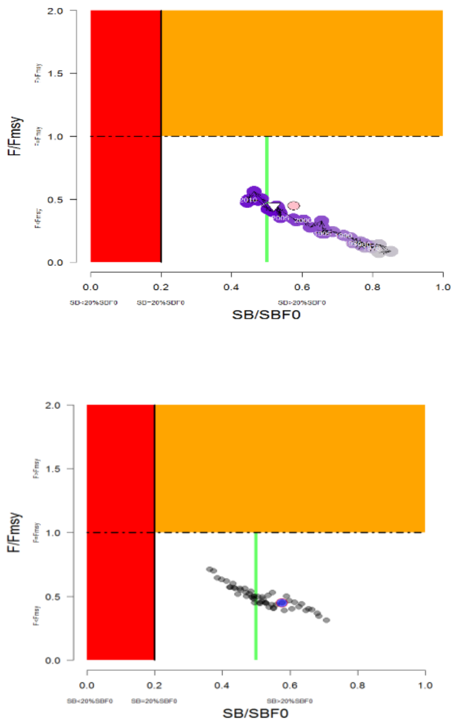


Figure SKJ4: Estimates of reduction in spawning potential due to fishing (fishery impact = *1-*$SB_t/SB_{t,F=0}$) by region and for the WCPO attributed to various fishery groups for the reference case model.



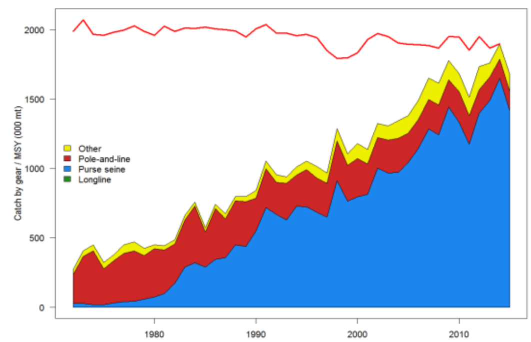


Figure SKJ5: Temporal trend for the reference case model (top) and the structural uncertainty grid (bottom panel) in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning potential levels lower than the agreed LRP, which is marked with the solid black line ($0.2SB_{F=0}$). The orange region is for fishing mortality greater than F_{MSY} ($F=F_{MSY}$; marked with the black dashed line). The green line indicates the interim target reference point 50%*SBF=0*.

Figure SKJ6: History of annual estimates of MSY compared with catches of three major fisheries for the reference case model.

7. Dynamics of most model quantities are relatively consistent with the results of the 2014 stock assessment, although there has been a period of several subsequent years with high recruitments and increased spawning biomass.

8. Fishing mortality of all age-classes is estimated to have increased significantly since the beginning of industrial tuna fishing, but fishing mortality still remains below the level that would result in the MSY (F_{recent}/F_{MSY} = 0.45 for the reference case), and is estimated to have decreased moderately in the last several years. Across the reference case and the structural uncertainty grid F_{recent}/F_{MSY} varied between 0.38 (5% quantile) to 0.64 (95% quantile). This indicates that overfishing is not occurring for the WCPO skipjack tuna stock (Figure SKJ 5).

9. The estimated MSY of 1,891,600 mt is moderately higher than the 2014 estimate due to the adoption of an annual, rather than quarterly, stock-recruitment relationship. Recent catches are lower than, but approaching, this MSY value (Figure SKJ 6).

10. The latest (2015) estimate of spawning biomass is well above both the level that will support MSY (SBlatest/SBMSY = 2.56, for the reference case model) and the adopted LRP of 0.2 SBF=0

(SBlatest/SBF=0 = 0.58, for the reference case model), and SBlatest/SBF=0 was relatively close to the adopted interim target reference point (0.5 SBF=0) for all models explored in the assessment (structural uncertainty grid: median = 0.51, 5% and 95% quantiles = 0.39 and 0.67).

Alternative view of stock status and trends

11. China, Japan and Chinese Taipei considered it is not possible to select a base-case model from various sensitivity models in the 2016 assessment, given the advice from the Scientific Service Provider that a suite of the sensitivity models were plausible. Therefore, these members considered that it would be more appropriate to provide advice to WCPFC13 on skipjack stock status based on the range of uncertainty expressed by the alternative model runs in the sensitivity analysis rather than based on the single base case model (represented by the 5% and 95% quantiles of the structural sensitivity grid presented in Table SKJ2).

12. The estimated MSY of the WCPO skipjack stock ranges from 1,618,060 mt (5% quantile) to 2,199,880 mt (95% quantile) across the alternative skipjack stock assessment models represented in the sensitivity grid. These CCMs also noted that some alternative models indicate that the 2015 biomass is below the adopted TRP of 0.5SBF=0.

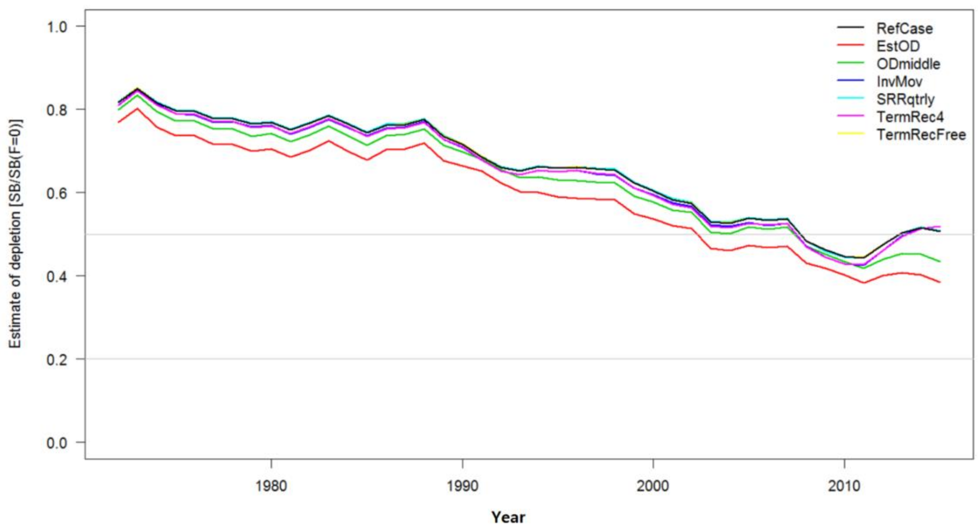


Figure SKJ 7. Estimated fisheries depletion SB/SBF=0, for each of the sensitivity models.

b. Management advice and implications

13. SC12 noted that the skipjack assessment continues to show that the stock is currently moderately exploited and fishing mortality level is sustainable. The recent catches are fluctuating around and some models also indicate that the stock is currently under the TRP.

14. SC12 noted that fishing is having a significant impact on stock size and can be expected to affect catch rates. The stock distribution is also influenced by changes in oceanographic conditions associated with El Niño and La Niña events, which impact on catch rates and stock size. Additional purse-seine effort will yield only modest gains in long-term skipjack tuna catches and may result in a corresponding increase in fishing mortality for bigeye and yellowfin tunas. The management of total effort in the WCPO should recognize this.

15. SC12 noted that skipjack spawning biomass is now around the adopted TRP and SC12 recommends that the Commission take action to keep the spawning biomass near the TRP and also advocates for the adoption of harvest control rules based on the information provided.

16. In order to maintain the quality of stock assessments for this important stock, SC12 recommends 1) continued work on developing an index of abundance based on purse seine data; 2) regular large scale tagging cruises and complementary tagging work continue to be undertaken in a way that provides the best possible data for stock assessment purposes.

17. SC12 also notes that the current method of calculating the TRP is based on the most recent 10 years of recruitment information. However, the information on spawning potential, SB2015, which is used to evaluate current stock status relative to the TRP can change very rapidly for skipjack which mature at age 1 and this rapid maturation may provide an optimistic status evaluation when recruitment is estimated have an increasing trend but is estimated with substantial uncertainty, as is currently observed in the case of skipjack which does not have a fishery-independent index of recruitment strength.

18. There is ongoing concern by at least one CCM that high catches in the equatorial region may be causing a range contraction of WCPO skipjack tuna, thus reducing skipjack tuna availability to fisheries conducted at higher latitudes than the Pacific equatorial region. SC12 reiterates the advice of SC11 whereby there is no demonstrated statistical evidence for SKJ range contraction. As a result, SC12 recommends that ongoing research on range contraction of skipjack tuna be continued in the framework of Project 67.

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