STOCK ASSESSMENT OF PACIFIC BLUEFIN TUNA

2014

PACIFIC BLUEFIN TUNA WORKING GROUP

International Scientific Committee for Tuna and Tuna-Like Species

in the North Pacific Ocean

EXECUTIVE SUMMARY

1. Stock Identification and Distribution

Pacific bluefin tuna (*Thunnus orientalis*) has a single Pacific-wide stock managed by both the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC). Although found throughout the North Pacific Ocean, spawning grounds are recognized only in the western North Pacific Ocean (WPO). A portion of each cohort makes trans-Pacific migrations from the WPO to the eastern North Pacific Ocean (EPO), spending up to several years of its juvenile life stage in the EPO before returning to the WPO.

2. Catch History

While historical Pacific bluefin tuna (PBF) catch records are scant, there are PBF landings records dating back to 1804 from coastal Japan and to the early 1900s for U.S. fisheries operating in the EPO. Estimated catches of PBF were high from 1929 to 1940, with a peak catch of approximately 47,635 t (36,217 t in the WPO and 11,418 t in the EPO) in 1935; thereafter catches of PBF dropped precipitously due to World War II. PBF catches increased significantly in 1949 as Japanese fishing activities expanded across the North Pacific Ocean. By 1952, a more consistent catch reporting process was adopted by most fishing nations and more reliable estimates indicate that annual catches of PBF fluctuated widely from 1952-2012 (Figure 1). During this period reported catches peaked at 40,383 t in 1956 and reached a low of 8,653 t in 1990. While a suite of fishing gears have been used to catch PBF, the majority is currently caught in purse seine fisheries (Figure 2). Historical catches (1952-2012) are predominately composed of juvenile PBF, but since the early 1990s, the catch of age-0 PBF has increased significantly (Figure 3).

3. Data and Assessment

Population dynamics were estimated using a fully integrated age-structured model (Stock Synthesis (SS) v3.23b) fitted to catch, size-composition and catch-per-unit of effort (CPUE) data from 1952 to 2013, provided by Members of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), Pacific Bluefin Tuna Working Group (PBFWG). Life history parameters included a length-at-age relationship from otolith-derived ages, and natural mortality estimates from a tag-recapture study and empirical-life history methods.

A total of 14 fisheries were defined for use in the stock assessment model based on country/gear type stratification. Quarterly observations of catch and size compositions, when available, were used as inputs to the model to describe the removal processes. Annual estimates of standardized CPUE from the Japanese distant water and coastal longline, the Taiwanese longline and the Japanese troll fleets were used as measures of the relative abundance of the population. The assessment model was fit to the input data in a likelihood-based statistical framework. Maximum likelihood estimates of model parameters, derived outputs and their variances were used to characterize stock status and to develop stock projections.

The PBFWG identified uncertainties in the standardized CPUE series, the procedures used to weight the data inputs (including catch, CPUE, and size composition) relative to each other in the model, and the methods used to estimate selectivity patterns. The influence of these uncertainties on the stock dynamics was assessed by constructing four different model runs, each with different updated CPUE and length composition data (Table 1). While no single model run provided a good fit to all sources of data that were deemed reliable, the PBFWG agreed on the depleted state of the stock among all scenarios, although estimates of current SSB varied. Long-term fluctuations in spawning stock biomass (SSB) occurred throughout the assessment period (1952-2012) and in the most recent period SSB was found to have been declining for over a decade. The recruitment level in 2012 was estimated to be relatively low (the 8^{th} lowest in 61 years), and the average recruitment level for the last five years may have been below the historical average level (Figures 4 and 5).

While the updated stock assessment model was unable to adequately represent much of the updated data, certain results are clear. Poor fit to the two adult indices of abundance and their associated size composition in the last two years indicate results are highly uncertain. Improvements to the model are advisable before re-assessing, and the current results with regard to the recent trends in SSB should be interpreted with caution.

4. Stock Status and Conservation Advice

Stock Status

Using the updated stock assessment, the 2012 SSB was 26,324 t and slightly higher than that estimated for 2010 (25,476 t).

Across sensitivity runs in the update stock assessment, estimates of recruitment were considered robust. The recruitment level in 2012 was estimated to be relatively low (the 8^{th} lowest in 61 years), and the average recruitment level for the last five years may have been below the historical average level (Figure 6). Estimated age-specific fishing mortalities on the stock in the period 2009-2011 relative to 2002-2004 (the base period for WCPFC Conservation and Management Measure 2010-04) increased by 19%, 4%, 12%, 31%, 60%, 51% and 21% for ages 0-6, respectively, and decreased by 35% for age 7+ (Figure 7).

Although no target or limit reference points have been established for the PBF stock under the auspices of the WCPFC and IATTC, the current F average over 2009-2011 exceeds all target and limit biological reference points (BRPs) commonly used by fisheries managers except for F_{loss}, and the ratio of SSB in 2012 relative to unfished SSB (depletion ratio) is less than 6%. In summary, based on reference point ratios, overfishing is occurring and the stock is overfished (Table 2).

For illustrative purposes, two examples of Kobe plots (plot A based on SSB_{MED} and F_{MED}, plot B based on $SSB_{20\%}$ and $SPR_{20\%}$, Figure 8) are presented. Because no reference points for PBF have yet been agreed to, these versions of the Kobe plot represent alternative interpretations of stock status in an effort to prompt further discussion.

Historically, the WPO coastal fisheries group has had the greatest impact on the PBF stock, but since about the early 1990s the WPO purse seine fleet has increased its impact, and the effect of this fleet is currently greater than any of the other fishery groups. The impact of the EPO fishery was large before the mid-1980s, thereafter decreasing significantly. The WPO longline fleet has had a limited effect on the stock throughout the analysis period. The impact of a fishery on a stock depends on both the number and size of the fish caught by each fleet; i.e., catching a high number of smaller juvenile fish can have a greater impact on future spawning stock biomass than catching the same weight of larger mature fish (Figures 9 and 10).

Conservation Advice

The current (2012) PBF biomass level is near historically low levels and experiencing high exploitation rates above all biological reference points except for F_{IOSS}. Based on projection results, the recently adopted WCPFC CMM (2013-09) and IATTC resolution for 2014 (C-13-02) if continued in to the future, are not expected to increase SSB if recent low recruitment continues.

In relation to the projections requested by NC9, only Scenario 6[1], the strictest one, results in an increase in SSB even if the current low recruitment continues (Figure 11). Given the result of Scenario 6, further reductions in fishing mortality and juvenile catch over the whole range of juvenile ages should be considered to reduce the risk of SSB falling below its historically lowest level.

If the low recruitment of recent years continues, the risk of SSB falling below its historically lowest level observed would increase. This risk can be reduced with implementation of more conservative management measures.

Based on the results of future projections requested at NC9, unless the historical average level (1952-2011) of recruitment is realized, an increase of SSB cannot be expected under the current WCPFC and IATTC conservation and management measures[2], even

[1] For the WCPO, a 50% reduction of juvenile catches from the 2002-2004 average level and F no greater than $F_{2002\text{-}2004}$. For the EPO, a 50% reduction of catches from 5,500 t. From the scientific point of view, juvenile catches were not completely represented in the reductions modeled under Scenario 6 for some fisheries although these reductions comply with the definition applied by the NC9.

[2] WCPFC: Reduce all catches of juveniles (age 0 to 3-(less than 30 kg)) by at least 15% below the 2002-2004 annual average levels, and maintain the total fishing effort below the 2002-2004 annual average levels. IATTC: Catch limit of 5000 t with an additional 500 t for commercial fisheries for countries with catch history. (1. In the IATTC Convention Area, the commercial catches of bluefin tuna by all the CPCs during 2014 shall not exceed 5,000 metric tons. 2. Notwithstanding paragraph 1, any CPC with a historical record of eastern Pacific bluefin catches may take a commercial catch of up to 500 metric tons of eastern Pacific bluefin tuna annually. (C-13-02), see https://www.iattc.org/PDFFiles2/Resolutions/C-13-02-Pacific-bluefin-tuna.pdf)

under full implementation (Scenario 1)[3].

If the specifications of the harvest control rules used in the projections were modified to include a definition of juveniles that is more consistent with the maturity ogive[4] used in the stock assessment, projection results could be different; for example, rebuilding may be faster. While no projection with a consistent definition of juvenile in any harvest scenario was conducted, any proposed reductions in juvenile catch should consider all non-mature individuals.

Given the low level of SSB, uncertainty in future recruitment, and importance of recruitment in influencing stock biomass, monitoring of recruitment should be strengthened to allow the trend of recruitment to be understood in a timely manner.

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[3] Although these measures assume F be kept below $F_{2002\text{-}2004}$, $F_{2009\text{-}2011}$ was higher than $F_{2002\text{-}2004}$.

[4] 20% at age 3; 50% at age 4; 100% at age 5 and older

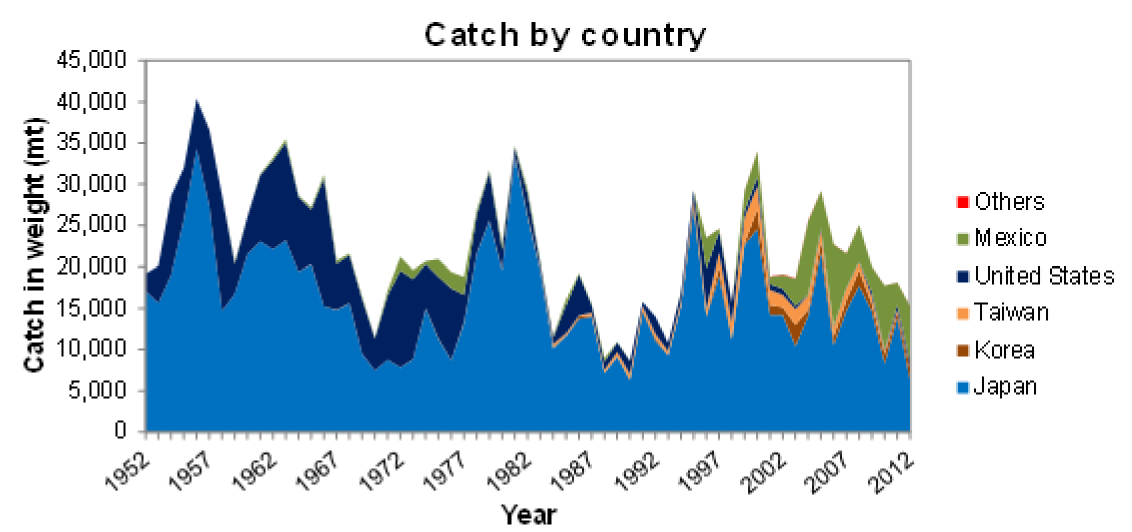

Figure 1. Historical annual catch of Pacific bluefin tuna (*Thunnus orientalis*) by country from 1952 through 2012 (calendar year).

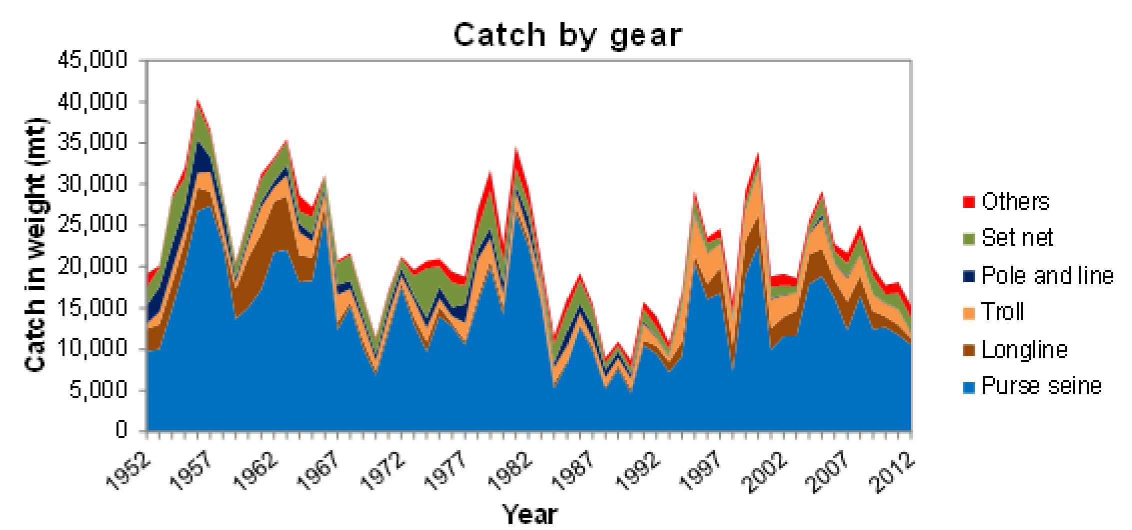

Figure 2. Historical annual catch of Pacific bluefin tuna (*Thunnus orientalis*) by gear type from 1952 through 2012 (calendar year).

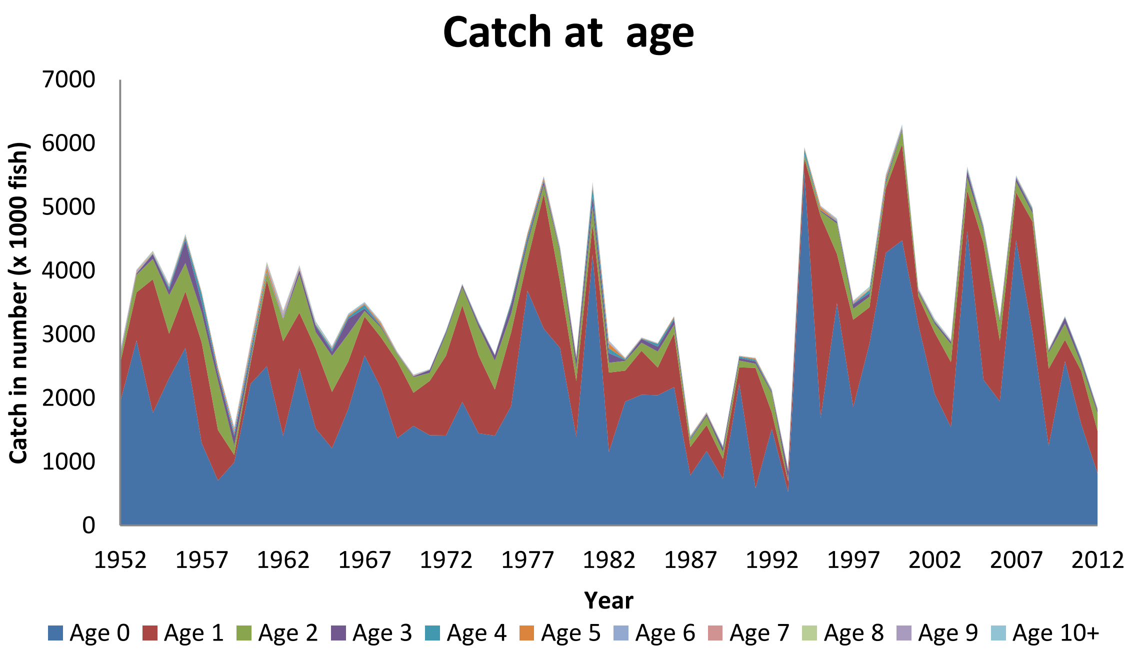

Figure 3. Historical annual catch-at-age of Pacific bluefin tuna (*Thunnus orientalis*) by fishing year (1952-2012; data for 1952 are incomplete).

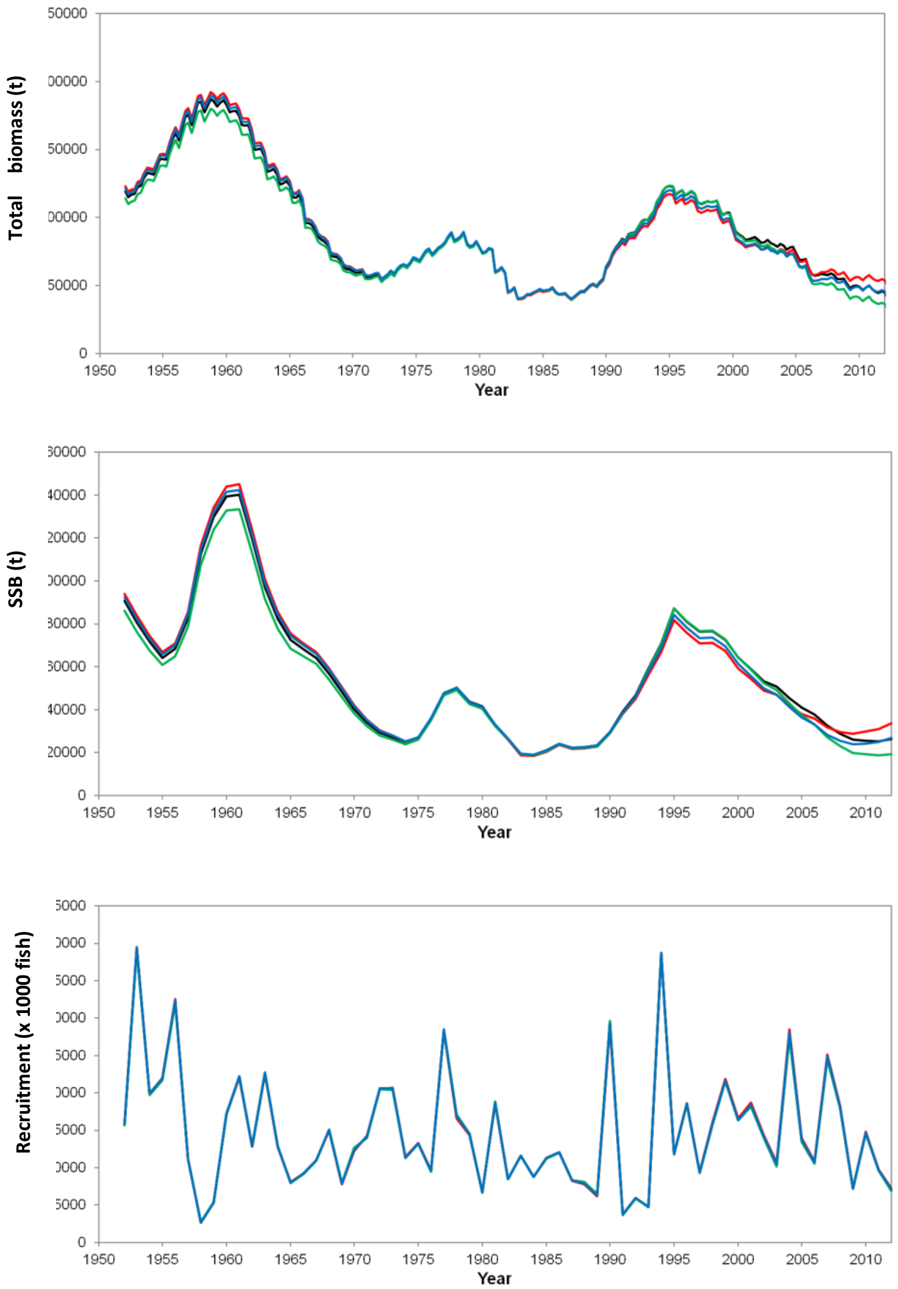

Figure 4. Pacific bluefin tuna (*Thunnus orientalis*) total stock biomass (TSB, upper panel), spawning stock biomass (SSB, middle panel) and recruitment (lower panel) estimated from four runs. Black, red, green and blue lines indicate Runs 1 through 4, respectively.

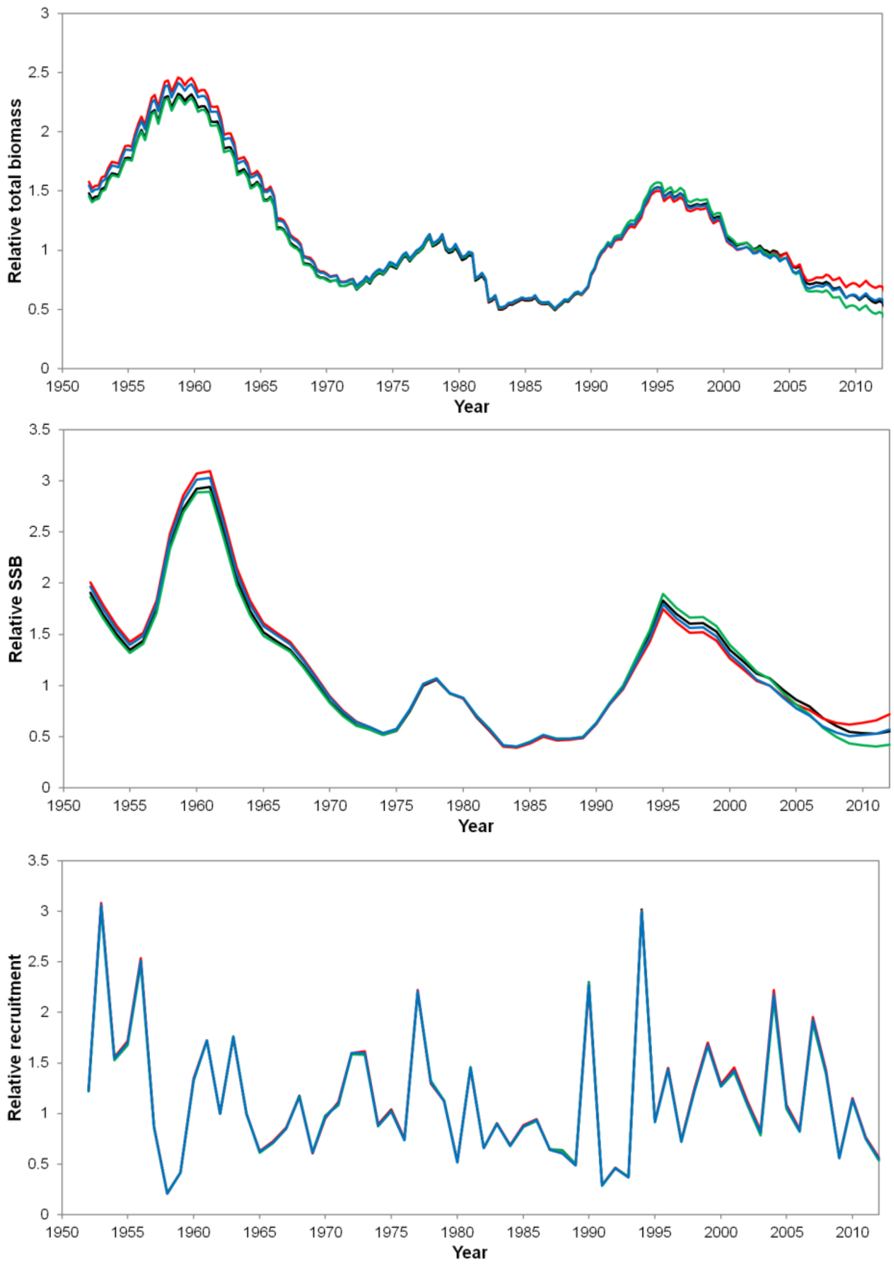

Figure 5. Relative values (to long-term average) of total Pacific bluefin tuna (*Thunnus orientalis*) stock biomass (TSB, upper panel), spawning stock biomass (SSB, middle panel) and recruitment (lower panel) estimated from four runs. Black, red, green and blue lines indicate Runs 1 through 4, respectively.

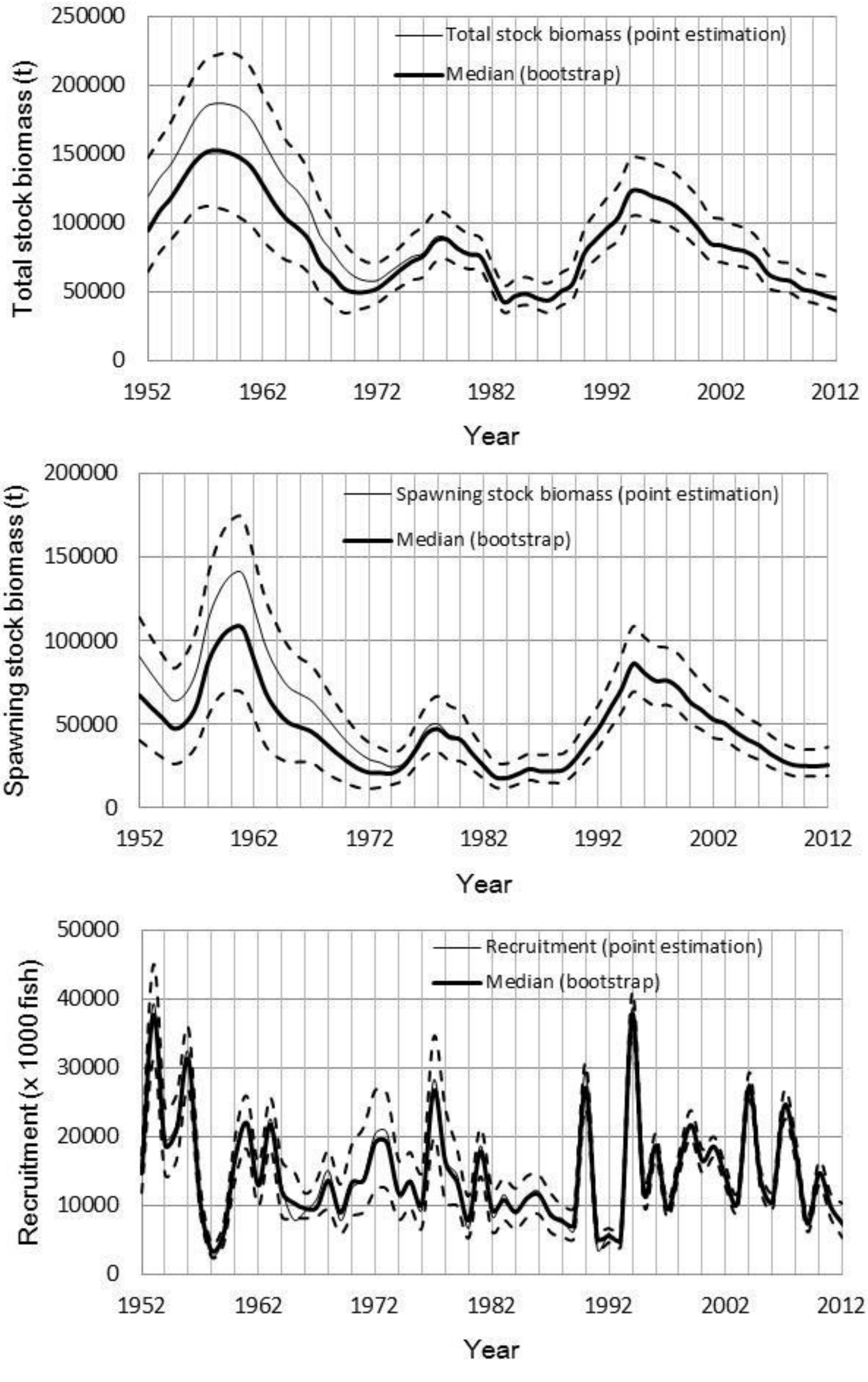

Figure 6. Pacific bluefin tuna (*Thunnus orientalis*) total stock biomass (upper panel), spawning stock biomass (middle panel) and recruitment (lower panel) of PBF from the base case run (Run1). Thick line indicates median, thin line indicates point estimate, and dashed lines indicate the 90% confidence interval

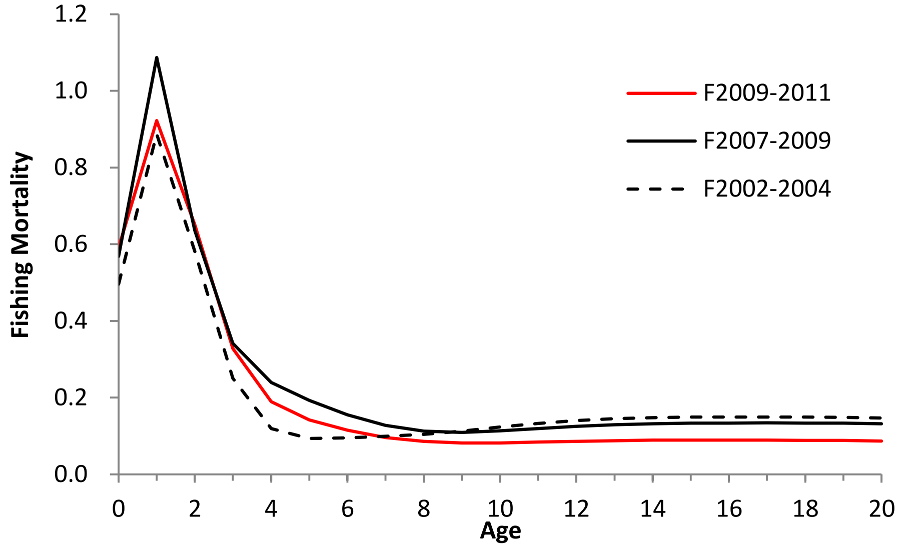

Figure 7. Geometric mean annual age-specific Pacific bluefin tuna *(Thunnus orientalis*) fishing mortalities for 2002-2004 (dashed line), 2007-2009 (solid line) and 2009-2011 (red line).

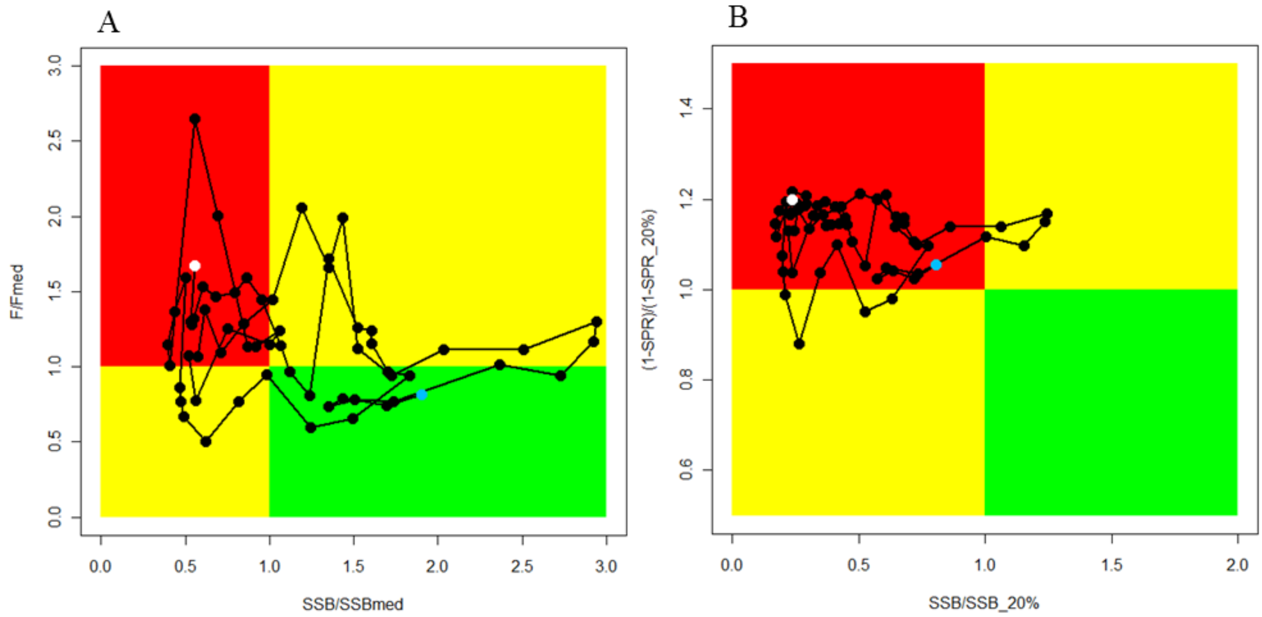

Figure 8. Alternative Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*). A. SSB_{MED} and F_{MED}; B. $SSB_{20\%}$ and $SPR_{20\%}$. Citation of these Kobe plots should include clarifying comments in the text. The blue and white points on the plot show the start (1952) and end (2012) year of the period modeled in the stock assessment, respectively.

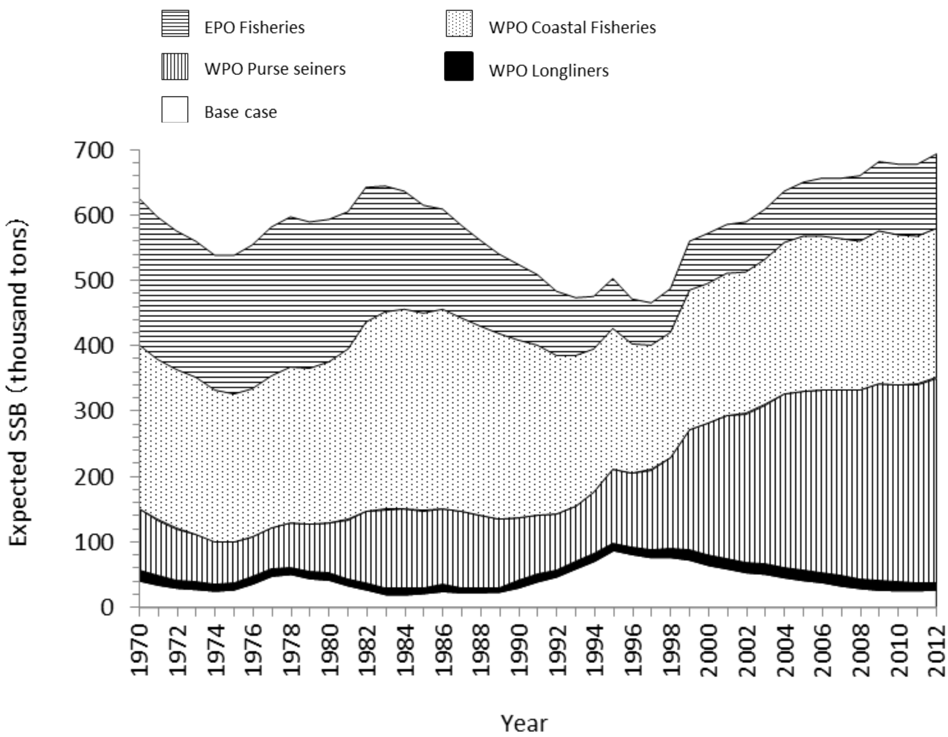

Figure 9. Trajectory of the spawning stock biomass of a simulated population of Pacific bluefin tuna (*Thunnus orientalis*) that was unexploited (topmost line) and that predicted by the base case (white area). The shaded areas between the two lines show the proportions of impact of each fishery.

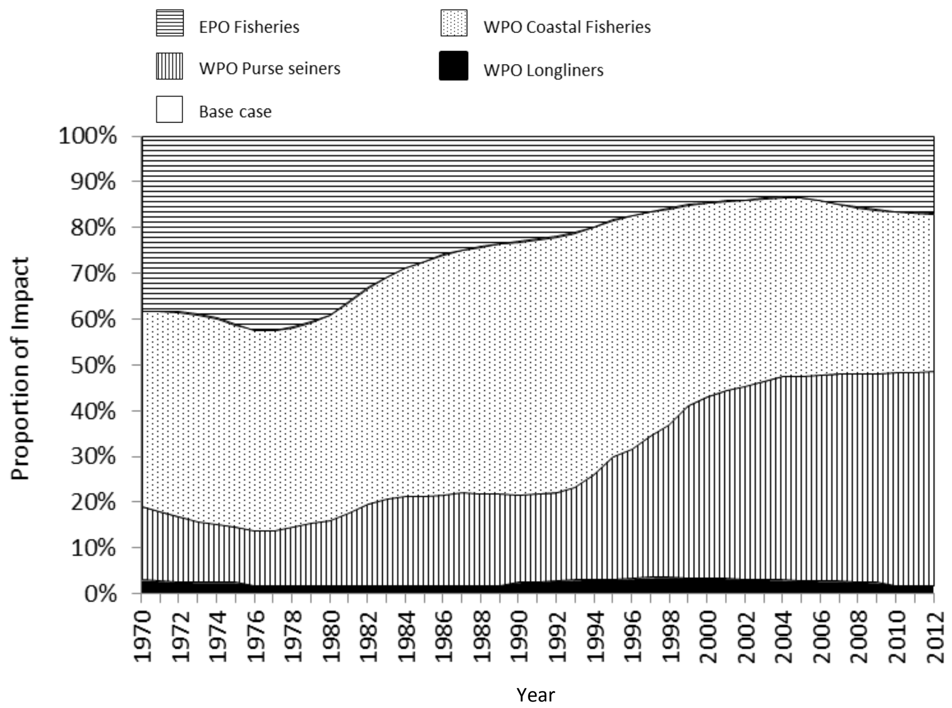

Figure 10. The proportion of the impact on the Pacific bluefin tuna (*Thunnus orientalis*) spawning stock biomass by each group of fisheries.

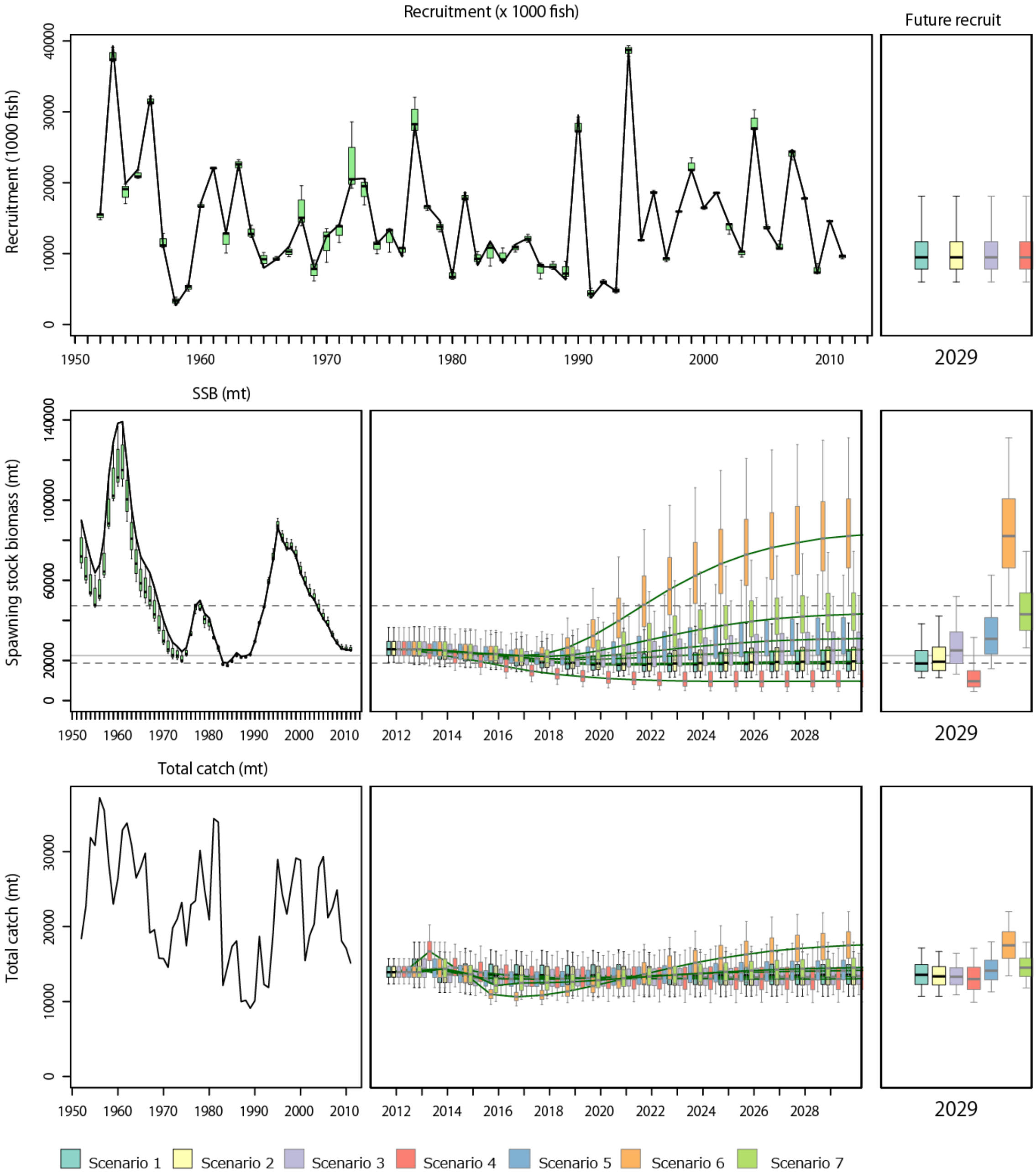

Figure 11-1. Comparison of future Pacific bluefin tuna (*Thunnus orientalis*) SSB trajectories in seven harvest scenarios (see full text for scenario definitions) under low recruitment conditions. Error bars represent 90% confidence limits.

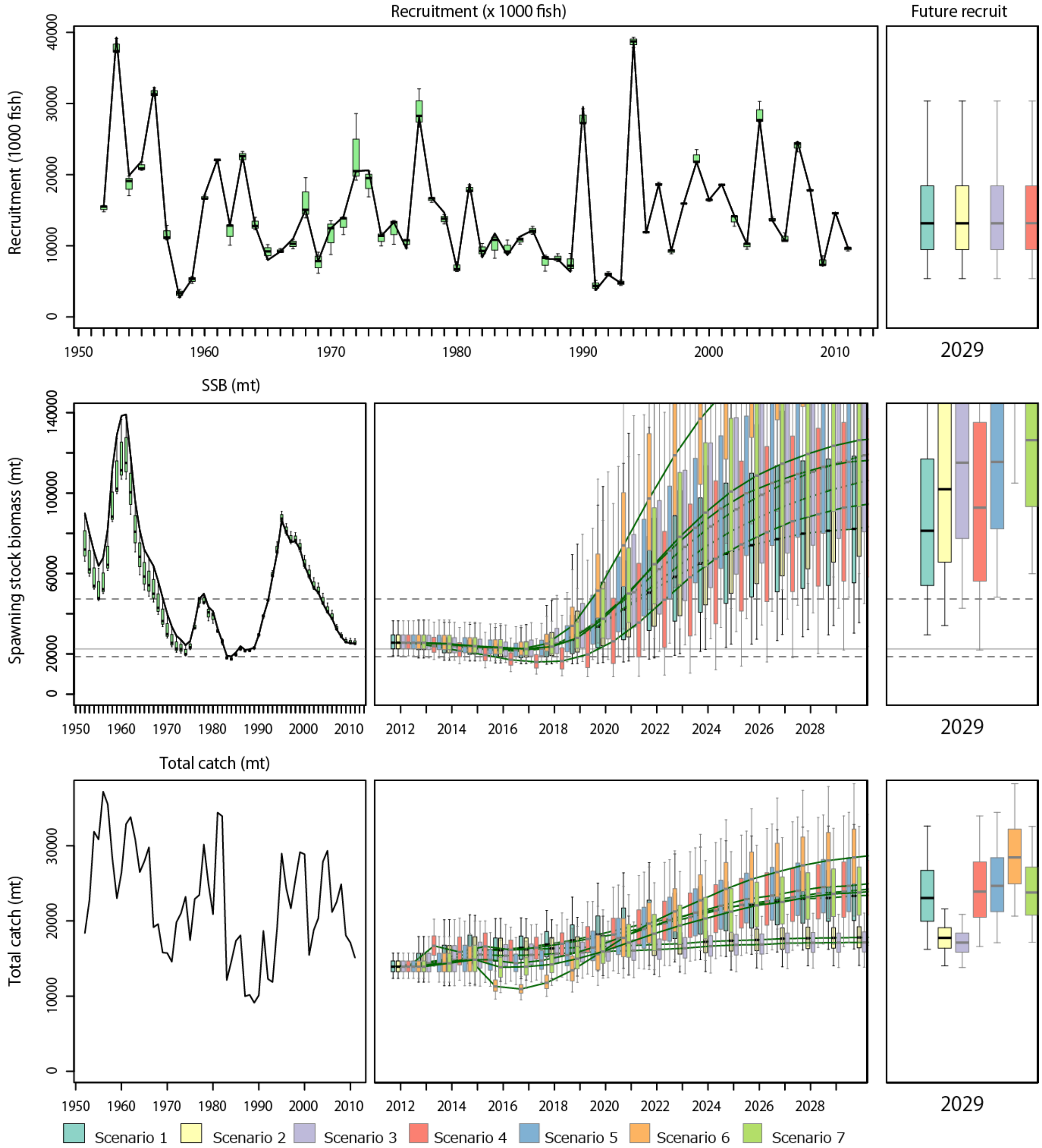

Figure 11-2. Comparison of future Pacific bluefin tuna (*Thunnus orientalis*) SSB trajectories in seven harvest scenarios (see full text for scenario definitions) under average recruitment conditions (resampling from recruitment in 1952-2011). Error bars represent 90% confidence limits.

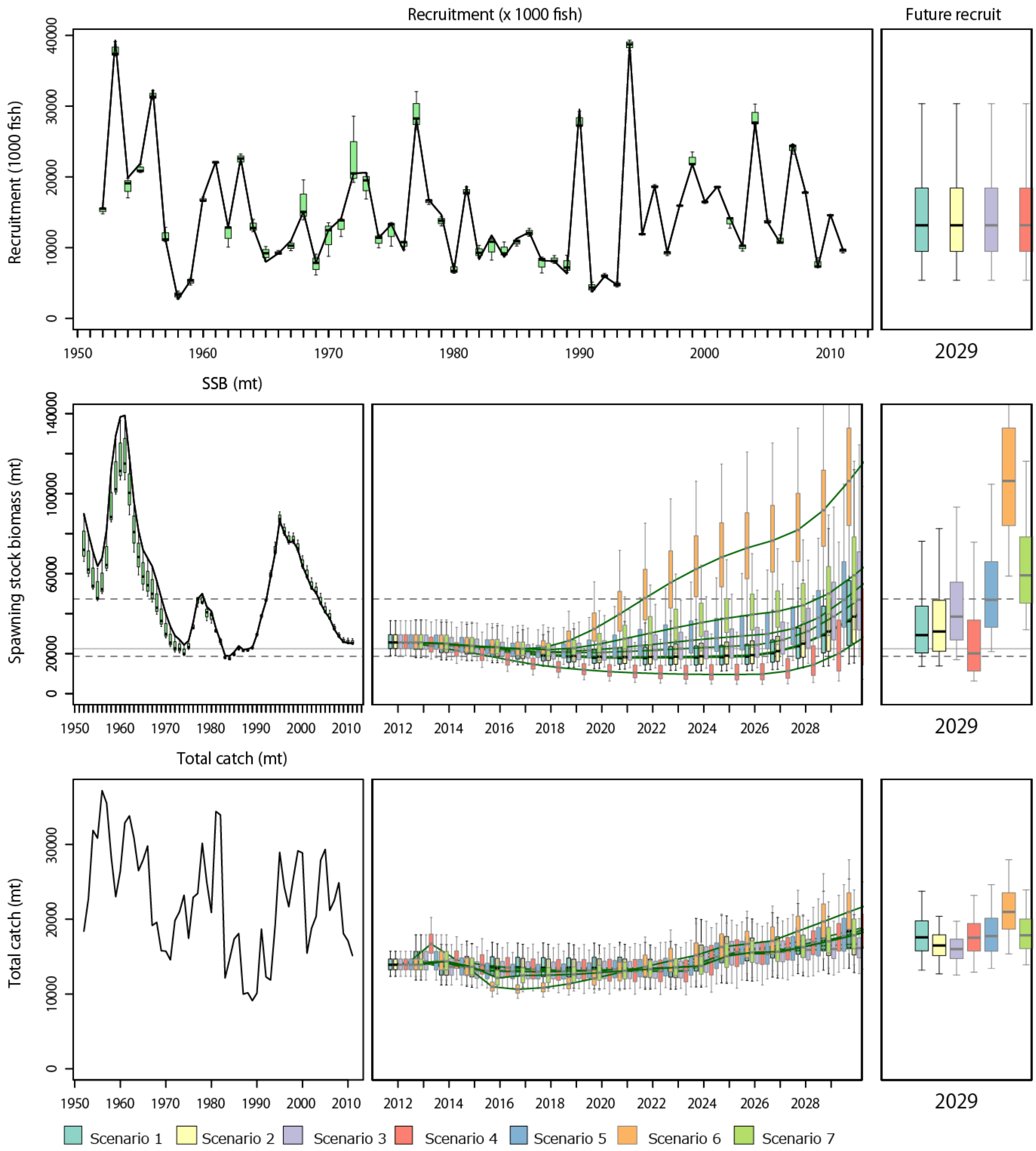

Figure 11-3. Comparison of future Pacific bluefin tuna (*Thunnus orientalis*) SSB trajectories in seven harvest scenarios (see full text for scenario definitions) assuming 10 years (2014-2023) of low recruitment followed by average recruitment after 2024 (resampling from recruitment in 1952-2011). Error bars represent 90% confidence limits.

Table 1. Model configurations for four runs evaluating the effect of updates of Pacific bluefin tuna (*Thunnus orientalis*) CPUE and size composition data for Japanese longline (JLL) and Taiwanese longline (TWLL). Run 1 is the base case assessment model.

Run number	CPUE		Size composition data	
	JLL (F15, S1)	TWLL (F23, S9)	JLL (F1)	TWLL (F11)
Run 1 (Base case)	Extending to 2012	Extending to 2012	Extending to 2011*	Extending to 2012
Run 2	Removing 2011 and 2012	Extending to 2012	Removing 2010 and 2011	Extending to 2012
Run 3	Extending to 2012	Removing 2011 and 2012	Extending to 2012	Removing 2011 and 2012
Run 4	Removing 2011 and 2012	Removing 2011 and 2012	Removing 2010 and 2011	Removing 2011 and 2012

*Size composition data in terminal year (2012) cannot be calculated by the estimation procedure proposed by Mizuno et al. (2012).

Table 2. Ratio of the estimated fishing mortalities $F_{2002\text{-}2004}$, $F_{2007\text{-}2009}$ and $F_{2009\text{-}2011}$ relative to computed F-based biological reference points for Pacific bluefin tuna (*Thunnus orientalis*) (PBF), depletion ratio (ratio of SSB in 2012 relative to unfished SSB), and estimated SSB (t) in year 2012 for four model configurations (runs). Run 1 is the base case assessment model for the PBF updated stock assessment. Values in the first eight columns above 1.0 indicate overfishing. See the full text for biological reference point definitions.

	F_{max}	$F_{0.1}$	F_{med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	$F_{30\%}$	$F_{40\%}$	Depletion Ratio	Estimated SSB(t) (yr=2012)
$F_{2002\text{-}2004}$										
Run1	**1.70**	**2.44**	**1.09**	**0.84**	**1.16**	**1.68**	**2.26**	**2.98**	**0.042**	**26,324**
Run2	1.73	2.47	1.09	0.85	1.16	1.68	2.26	2.99	0.054	33,736
Run3	1.78	2.55	1.16	1.03	1.24	1.79	2.40	3.17	0.031	19,369
Run4	1.77	2.52	1.13	0.89	1.21	1.75	2.36	3.11	0.043	26,952
$F_{2007\text{-}2009}$										
Run1	**2.09**	**2.96**	**1.40**	**1.08**	**1.48**	**2.14**	**2.87**	**3.79**	**0.042**	**26,324**
Run2	1.93	2.74	1.25	0.99	1.34	1.94	2.60	3.43	0.054	33,736
Run3	2.34	3.31	1.54	1.38	1.65	2.38	3.20	4.23	0.031	19,369
Run4	2.11	2.98	1.36	1.07	1.46	2.11	2.84	3.74	0.043	26,952
$F_{2009\text{-}2011}$										
Run1	**1.79**	**2.54**	**1.25**	**0.97**	**1.32**	**1.90**	**2.55**	**3.36**	**0.042**	**26,324**
Run2	1.61	2.30	1.11	0.88	1.19	1.71	2.29	3.02	0.054	33,736
Run3	2.02	2.86	1.37	1.23	1.46	2.11	2.83	3.73	0.031	19,369
Run4	1.77	2.52	1.20	0.95	1.29	1.85	2.49	3.27	0.043	26,952