International Scientific Committee
for Tuna and Tuna-like Species in the North Pacific Ocean
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April 18, 2016

Dr. Guillermo Compean
Director, IATTC

Dear Dr. Compean

The attached draft Executive Summary of the 2016 Pacific Bluefin Tuna Stock Assessment is provided as background information for the upcoming IATTC SAC meeting. The Executive Summary was completed by the ISC Pacific Bluefin Tuna Working Group (PBFWG) and was a collaborative effort. Please note this is a draft Executive Summary, and subject to change upon its review and discussion at 16th Meeting of the ISC Plenary in July 2016 (ISC16). The detailed assessment report and associated meeting report are not available at this time, and will be disseminated at the conclusion of ISC16.

Best regards,

Hideki Nakano, Ph.D.
ISC PBF WG Chair

Gerard DiNardo, Ph.D.
ISC Chair

2016 Pacific Bluefin Tuna Stock Assessment

ISC PBFWG

EXECUTIVE SUMMARY (***DRAFT***)

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 Pacific bluefin tuna (PBF) catch records prior to 1952 are scant, there are some PBF landings records dating back to 1804 from coastal Japan and to the early 1900s for U.S. fisheries operating in the EPO. Catch of PBF was estimated to be 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. Estimates indicate that annual catches of PBF fluctuated widely from 1952-2014 (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). Catches during 1952-2014 were predominately composed of juvenile PBF, but since the early 1990s, the catch of age 0 PBF has increased significantly (Figure 3).

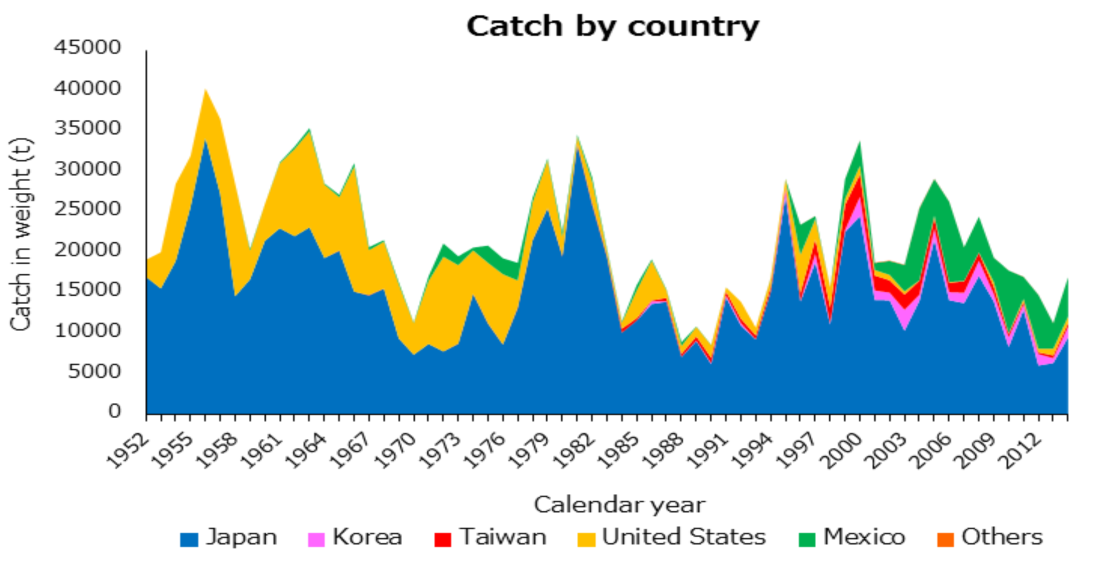

Figure 1. Annual catch of Pacific bluefin (*Thunnus orientalis*) tuna by country from 1952 through 2014 (calendar year).

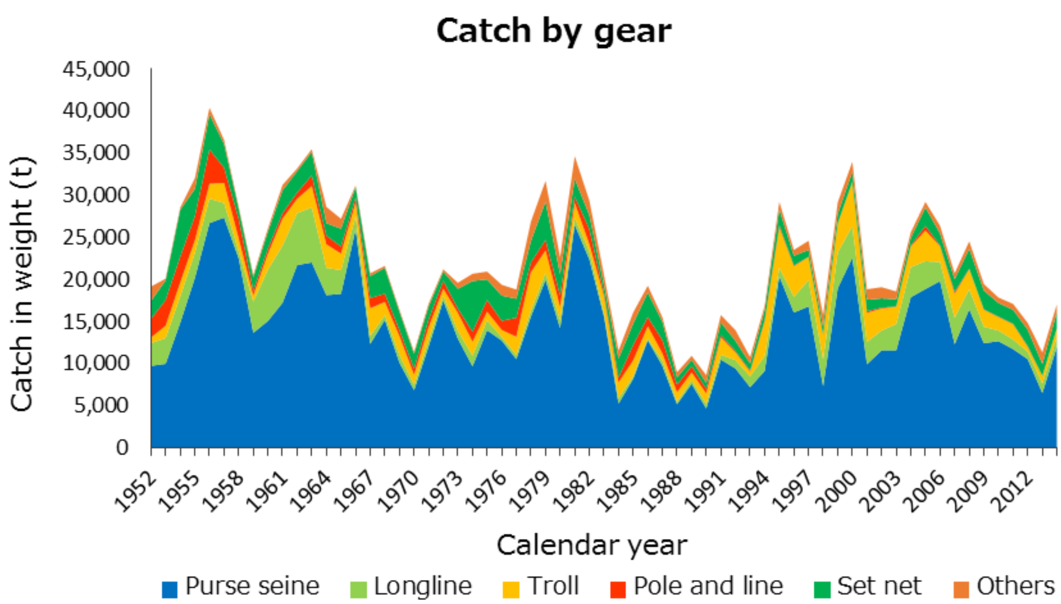

Figure 2. Annual catch of Pacific bluefin tuna (*Thunnus orientalis*) by gear type from 1952 through 2014 (calendar year).

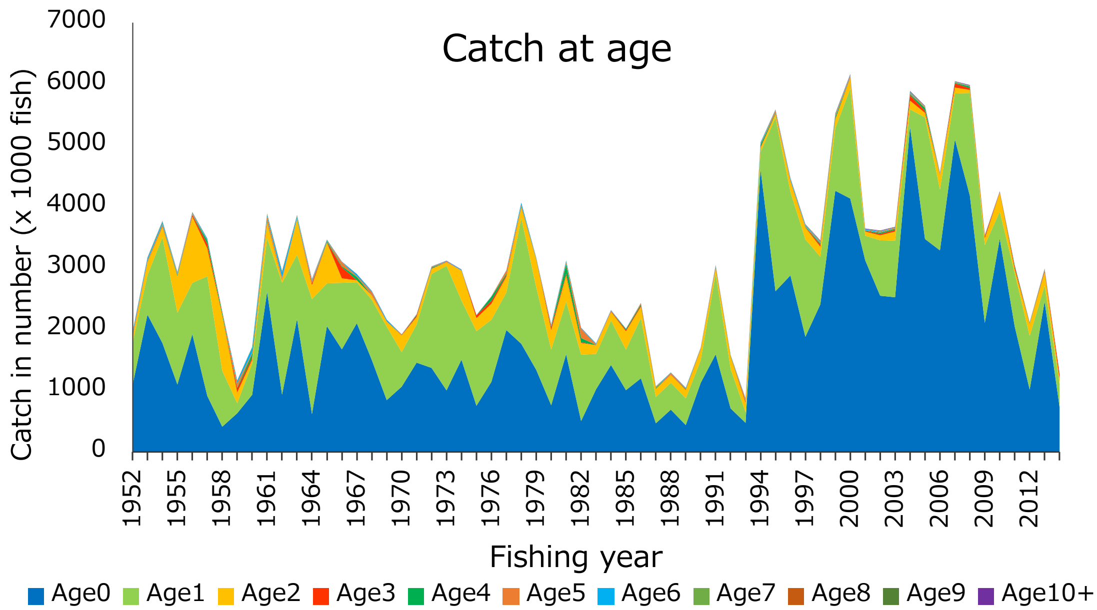

Figure 3. Annual catch-at-age of Pacific bluefin tuna (*Thunnus orientalis*) by fishing year (1952-2014; data for 1952 are incomplete).

3. Data and Assessment

Population dynamics were estimated using a fully integrated age-structured model (Stock Synthesis (SS) v3.24f) fitted to catch, size-composition and catch-per-unit of effort (CPUE) data from 1952 to 2015, 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) and non-ISC countries. 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 19 Fleets were defined for use in the stock assessment model based on country/gear/season/region 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, off-shore 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 fitted 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.

In the previous assessments, it was found that conflicts existed among data in the model. However, stock biomass trends were consistent among tested model runs and the PBFWG provided the conservation advice based on those results. The 2016 assessment model was developed and refined in the intervening three years based on improvements made by the PBFWG. The improvements include: more accurate historical catch data, a better estimate of size composition by fleet, improved standardization of abundance indices, a revised growth curve based on additional otolith information and standardization of aging techniques, and improved model settings to represent the best input data.

4. Draft Stock Status and Conservation Advice for discussion at ISC Plenary

Stock Status

The PBFWG conducted a bench mark assessment (base-case model) that used the best available fisheries and biological information. The base-case model fits the data considered reliable well and is internally consistent among most of the sources of data. The model is a substantially improved from the 2014 assessment. The base-case model indicates: (1) spawning stock biomass (SSB) fluctuated throughout the assessment period (fishing years 1952-2014) and (2) the SSB steadily declined from 1996 to 2010; and (3) the decline appears to have ceased since 2010, although the stock remains near the historic low. The model diagnostics suggest that the estimated biomass trend for the last 30 years is considered robust although SSB prior to the 1980s is uncertain due to data limitations.

Using the base-case model, the 2014 (terminal year) SSB was estimated to be around 17,000 t (Table 1 and Figure 4), which is about 9,000 t below the terminal year estimated in the 2014 assessment (26,000 in 2012). This is because the assessment model was refined and SSB over time shifted down over all; not because the SSB declined from 2012 to 2014.

Table 1. Trends in total biomass, spawning stock biomass and recruitment of Pacific bluefin tuna (*Thunnus orientalis*) estimated by the base-case model.

Fishing year	Total biomass (t)	Spawning stock biomass (t)	StdDev for SSB	CV for SSB	Recruitment (x 1000 fish)	StdDev for R	CV for R
1952	142813	108212	51499	0.48	8179		
1953	137353	101450	46448	0.46	26042	3105	0.12
1954	139364	91087	41170	0.45	32226	4144	0.13
1955	146129	77809	36124	0.46	14217	2513	0.18
1956	163529	71864	32832	0.46	34011	3487	0.10
1957	182294	78794	33194	0.42	12514	1802	0.14
1958	200485	106048	39701	0.37	3465	974	0.28
1959	206403	140043	49517	0.35	7935	1702	0.21
1960	209075	147553	53490	0.36	7357	988	0.13
1961	202076	160005	58187	0.36	24081	1981	0.08
1962	188481	144257	55540	0.39	10908	1918	0.18
1963	173255	122736	50030	0.41	27698	2743	0.10
1964	162393	108050	44642	0.41	5845	1771	0.30
1965	152760	95211	39257	0.41	11670	3763	0.32
1966	139185	91202	36562	0.40	8706	3797	0.44
1967	116884	84992	33830	0.40	11000	4165	0.38
1968	102751	79336	32471	0.41	13737	3327	0.24
1969	89360	65606	28055	0.43	6413	1882	0.29
1970	78444	55050	24126	0.44	6995	2823	0.40
1971	68848	47572	20601	0.43	12485	5302	0.42
1972	64929	40944	17224	0.42	22863	4853	0.21
1973	62646	35166	13932	0.40	11200	3007	0.27
1974	62227	28028	10892	0.39	13638	2299	0.17
1975	60621	25821	8703	0.34	10846	1962	0.18
1976	63393	28298	7469	0.26	8952	2739	0.31
1977	60786	33742	7610	0.23	25189	3803	0.15
1978	65461	30621	6984	0.23	15862	3771	0.24
1979	66308	25123	6404	0.25	11428	2285	0.20
1980	68629	27898	6119	0.22	7618	1943	0.26
1981	70024	26865	4718	0.18	11623	1464	0.13
1982	51827	23696	4267	0.18	6927	1379	0.20
1983	29347	13781	3336	0.24	10103	1513	0.15
1984	31271	11445	3012	0.26	9129	1802	0.20
1985	34365	11482	2756	0.24	9822	1784	0.18
1986	33930	13976	2766	0.20	7645	1405	0.18
1987	29499	13141	2887	0.22	6132	1261	0.21
1988	31410	14055	3082	0.22	8587	1212	0.14
1989	35221	13776	3094	0.22	4637	1196	0.26
1990	42721	17349	3557	0.21	18077	1637	0.09
1991	57036	22503	4217	0.19	12019	1328	0.11
1992	64882	28477	4912	0.17	4562	759	0.17
1993	74219	39327	6210	0.16	4374	775	0.18
1994	84249	47101	7441	0.16	28554	1319	0.05
1995	97759	61686	9579	0.16	17912	1581	0.09
1996	93811	61792	9665	0.16	17806	1114	0.06
1997	95164	56769	9320	0.16	11039	1117	0.10
1998	92261	56831	9052	0.16	15298	1181	0.08
1999	89995	53870	9041	0.17	23646	1143	0.05
2000	86247	52593	9055	0.17	14477	816	0.06
2001	75553	49569	8589	0.17	15923	723	0.05
2002	77575	47783	8125	0.17	13561	774	0.06
2003	74293	47785	7667	0.16	7930	694	0.09
2004	68736	41069	6908	0.17	26359	945	0.04
2005	63621	34266	6130	0.18	14760	852	0.06
2006	50596	28170	5370	0.19	11544	620	0.05
2007	43654	22440	4561	0.20	21658	877	0.04
2008	40843	16909	3792	0.22	20534	865	0.04
2009	34649	12814	2962	0.23	9044	627	0.07
2010	32083	11505	2472	0.21	15791	827	0.05
2011	32774	11860	2337	0.20	13485	1014	0.08
2012	34931	13795	2508	0.18	6112	744	0.12
2013	36485	15703	2805	0.18	11279	801	0.07
2014	35817	16557	3150	0.19	3689	893	0.24

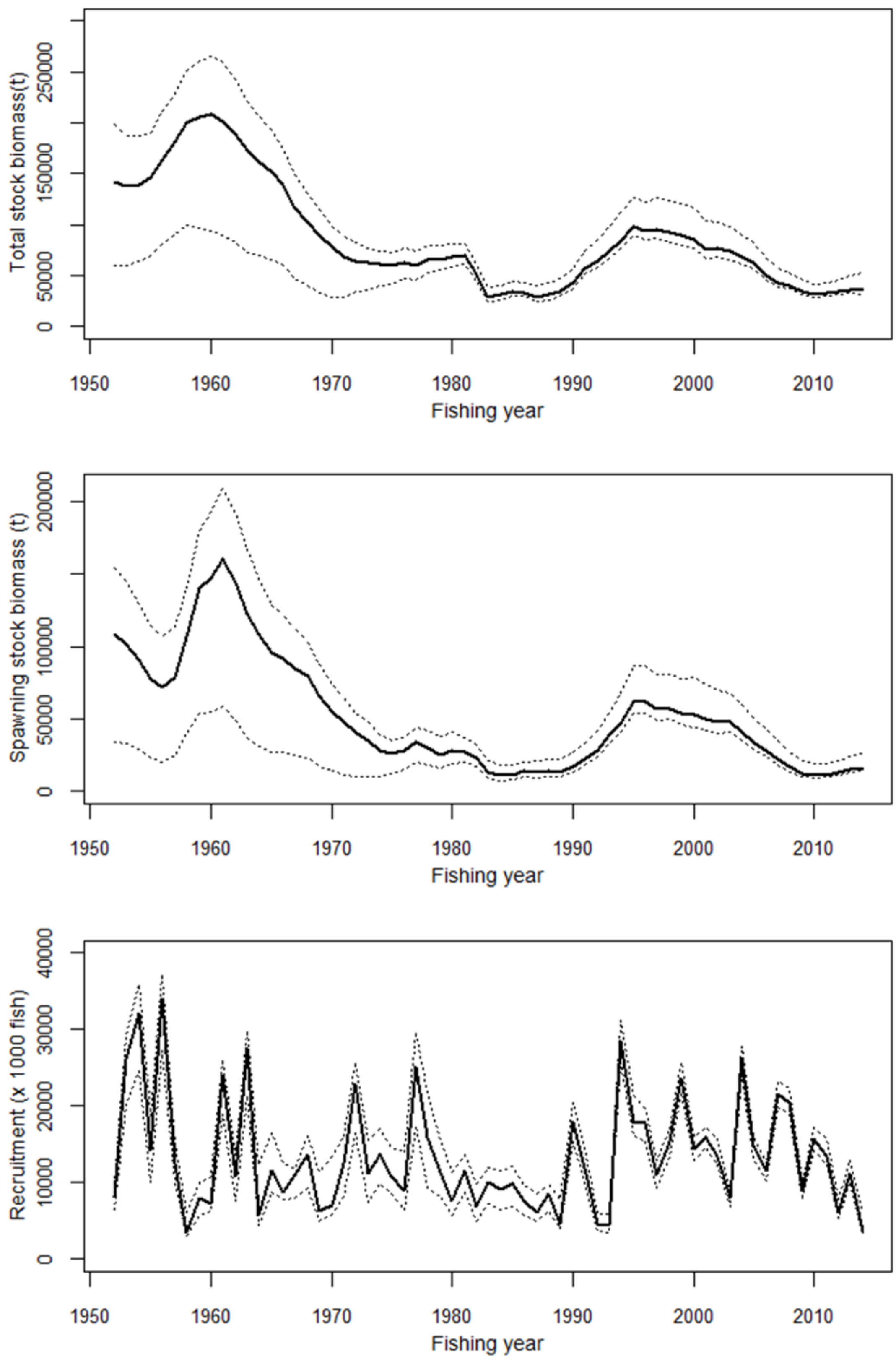

Figure 4. Total stock biomass (top), spawning stock biomass (middle) and recruitment (bottom) of Pacific bluefin tuna (*Thunnus orientalis*) from the base-case model. The solid line indicates point estimate and dashed lines indicate the 90% confidence interval.

Recruitment estimates fluctuate widely without an apparent trend. The 2014 recruitment was relatively low and the average recruitment for the last five years may have been below the historical average level (Figure 4). Note that recruitments in terminal years in an assessment are highly uncertain due to limited information on the cohorts. However, two of the last three data points from the Japanese troll CPUE-based index of recruitment, which was consistent with other data in the model, are at their lowest since the start of the index (1980). Estimated age-specific fishing mortalities on the stock during 2011-2013 and 2002-2004 (the base period for WCPFC Conservation and Management Measure 2015-04) are presented in Figure 5. Most age-specific fishing mortalities (F) for intermediate ages (2-10 years) are substantially above the 2002-2004 F while those for age 0 as well as ages 11 and above are lower (Table 2).

Table 2. Change of estimated age-specific *F*s of Pacific bluefin tuna (*Thunnus orientalis*) from 2002-2004 to 2011-2013.

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
change from F2002-2004 to F2011-2013	−28%	−1%	+96%	+4%	+86%	+43%	−9%	+81%	+21%	+23%	+5%	−5%	−7%	−8%	−9%	−10%	−10%	−10%	−11%	−11%	−11%

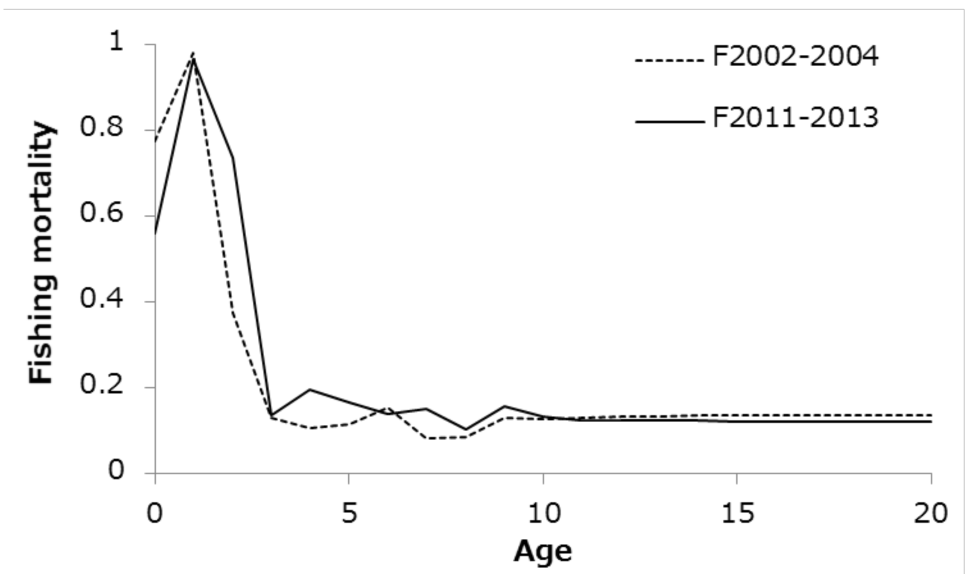

Figure 5. Geometric means of annual age-specific fishing mortalities of Pacific bluefin tuna (*Thunnus orientalis*) for 2002-2004 (dashed line) and 2011-2013 (solid line).

Although no limit reference points have been established for the PBF stock under the auspices of the WCPFC and IATTC, the 2011-2013 F exceeds the calculated biological reference points except for F_{MED} and F_{loss}, although F has decreased slightly in recent years, overall (Table 3). Note that possible effects on *F*s by the measures of both the WCPFC and IATTC starting in 2015 or by other voluntary measures were not incorporated. In this assessment, the ratio of SSB in 2014 relative to the theoretical unfished[1] SSB ($SSB_{2014}/SSB_{F=0}$, the depletion ratio) is 2.6%[2] and $SSB_{2012}/SSB_{F=0}$ is 2.1% indicating a slight increase from 2012 to 2014. Although the $SSB_{2014}/SSB_{F=0}$ for this assessment (2.6%) is lower than $SSB_{2012}/SSB_{F=0}$ from the 2014 assessment (4.2%) this is due to the changes in the model assumptions because SSB gradually increased in the last four years (Table 1 and Figure 4) and does not represent a decline in SSB from 2012 to 2014.

For illustrative purposes, two examples of Kobe plots (Figure 6: plot A based on SSB_{MED} and F_{MED}, plot B based on $SSB_{20\%}$ and $SPR_{20\%}$) are presented. Because no reference points for PBF have yet been agreed to, these versions of the Kobe plot represent two interpretations of stock status in an effort to prompt further discussion. In summary, if these were the reference points overfishing would be occurring or just at the threshold in the case of F_{MED}; and the stock would be considered overfished.

Table 3. Ratios of the estimated fishing mortalities F2002-2004, F2009-2011 and F2011-2013 relative to computed F-based biological reference points and SSB and depletion ratio for the terminal year of the reference period for Pacific bluefin tuna (*Thunnus orientalis*).

	F_{max}	$F_{0.1}$	F_{med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	$F_{30\%}$	$F_{40\%}$	Estiamted SSB for terminal year of each reference period	Depletion ratio for terminal year of each reference period
2002-2004	1.86	2.59	1.09	0.80	1.31	1.89	2.54	3.34	41,069	0.064
2009-2011	1.99	2.78	1.17	0.85	1.41	2.03	2.72	3.58	11,860	0.018
2011-2013	1.63	2.28	0.96	0.70	1.15	1.66	2.23	2.94	15,703	0.024

[1] "Unfished" refers to what SSB would be had there been no fishing.
[2] The unfished SSB is estimated based upon equilibrium assumptions of no environmental or density-dependent effects.

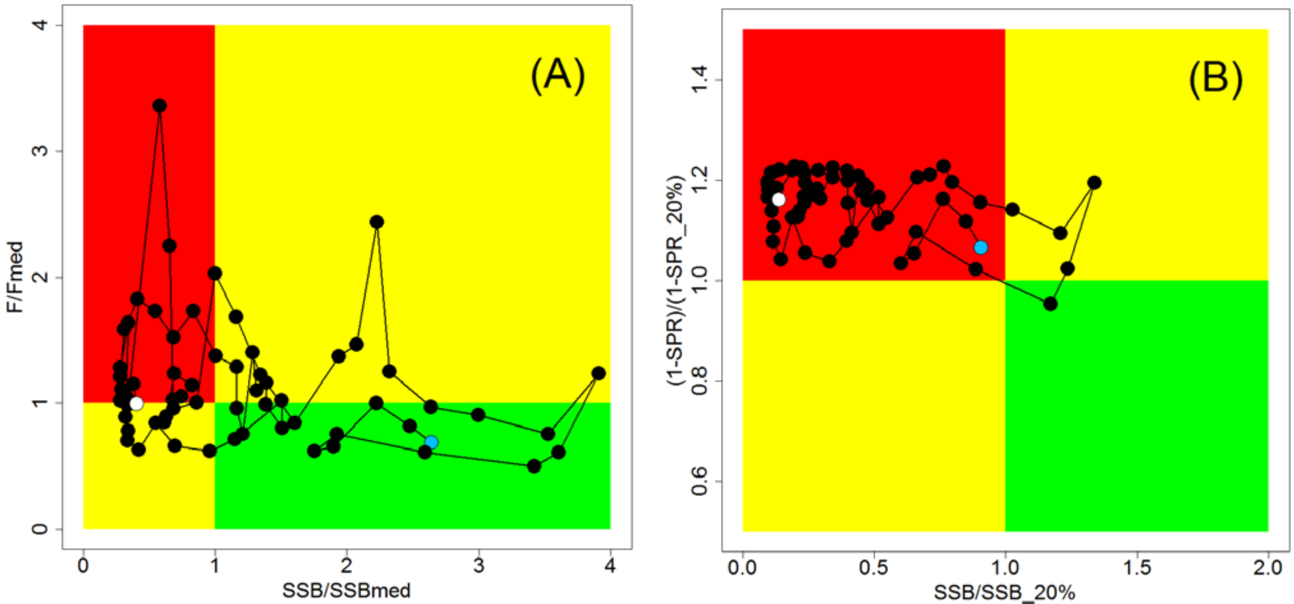

Figure 6. Kobe plots for Pacific bluefin tuna (*Thunnus orientalis*). (A) SSB_{MED} and F_{MED}; (B) $SSB_{20\%}$ and $SPR_{20\%}$. Note that SSB_{MED} is estimated as the median of estimated SSB over whole assessment period (40,944 tons) and F_{MED} is calculated as an F to provide SSB_{MED} in long-term, while the plots are points of estimates. The blue and white points on the plot show the start (1952) and end (2014) year of the period modeled in the stock assessment, respectively.

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 fleets, in particular those targeting small fish (age 0-1), have had a greater impact, and the effect of these fleets in 2014 was greater than any of the other fishery groups. The impact of the EPO fishery was large before the mid-1980s, decreasing significantly thereafter. The WPO longline fleet has had a limited effect on the stock throughout the analysis period (Figure 7). This is because 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.

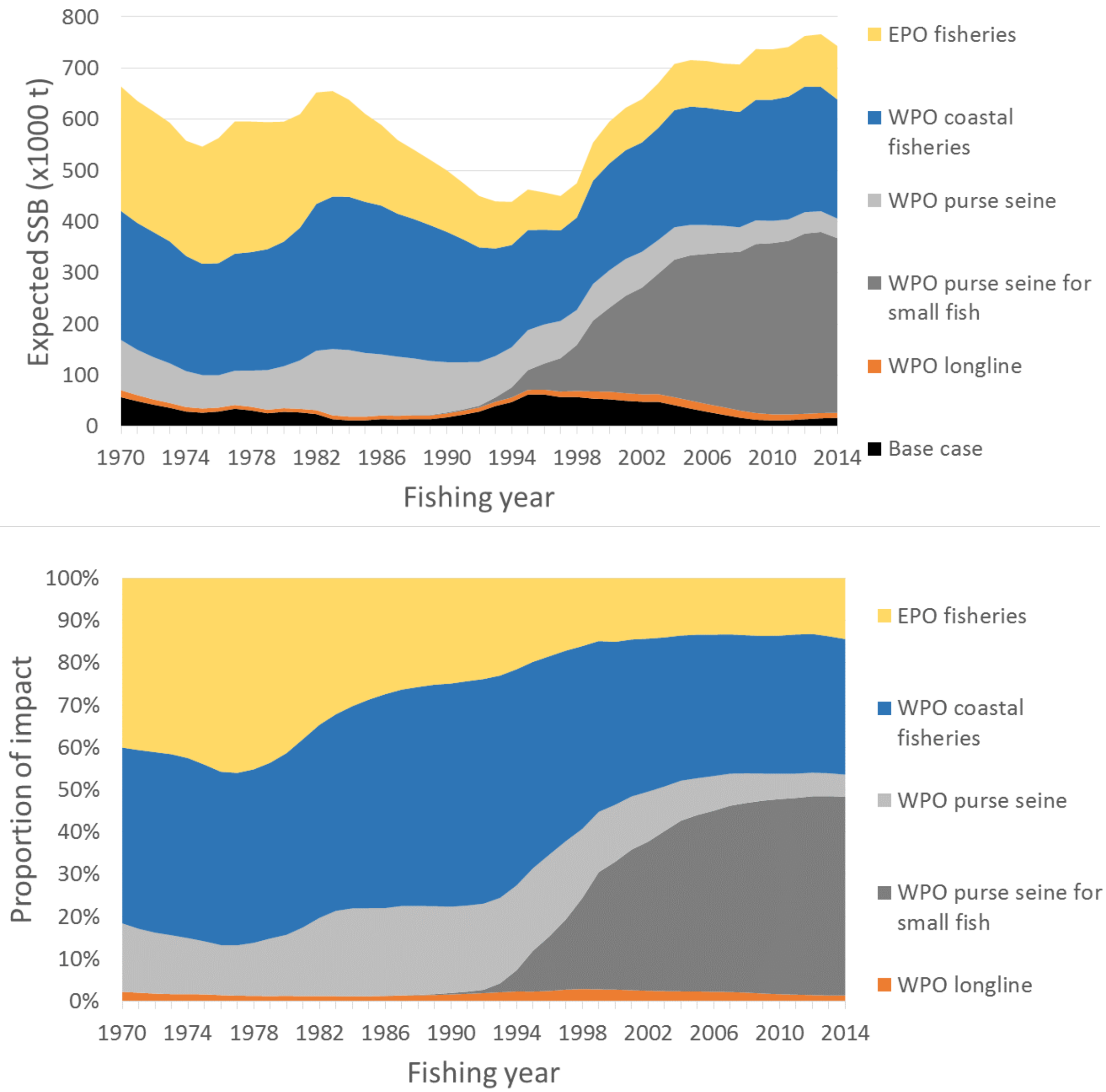

Figure 7. Trajectory of the spawning stock biomass of a simulated population of Pacific bluefin tuna (*Thunnus orientalis*) when zero fishing mortality is assumed, estimated by the base-case model. (top: absolute impact, bottom: relative impact). Fleet definition; WPO longline: F1, F12, F17. WPO purse seine for small fish: F2, F3, F18. WPO purse seine: F4, F5. WPO coastal fisheries: F6-11, F16, F19. EPO fisheries: F13, F14, F15.

Conservation Advice

The steady decline in SSB from 1996 to 2010 appears to have ceased, although SSB_{2014} is near the historic low and the stock is experiencing exploitation rates above all calculated biological reference points except for F_{MED} and $F_{loss.}$

The projection results based on the base-case model under several harvest and recruitment scenarios and time schedules are shown in Table 4 and Figure 8. Under all examined scenarios the initial goal of WCPFC, rebuilding to SSB_{MED} by 2024 with at least 60% probability, is reached and the risk of SSB falling below B_{loss} at least once in 10 years was very low.

Table 4. Future projection scenarios for Pacific bluefin tuna (*Thunnus orientalis*) and their probability of achieving various target levels by various time schedules based on the base-case model.

Harvesting Scenario #	Fishing mortality	Catch limit		Threshold of Small/Large fish	Recruitment scenario	Probability that SSB is more than SSB median (38,000 tons)			Probability that SSB is more than 43,000 tons (SSBmed@last assessment)			Probability that SSB is more than 10%SSB0			Probability that SSB is more than 20%SSB0			Average Catch	
		Small fish	Large fish			2024	2029	2034	2024	2029	2034	2024	2029	2034	2024	2029	2034	2019	2024
Scenario1	F2002-2004	scenario 6 in 2014 assessment		30 kg	Low recruitment	77.0%	88.8%	89.9%	64.3%	79.3%	81.9%	14.7%	28.0%	31.8%	0.0%	0.0%	0.1%	11619.2	13574.9
Scenario2		50% of 2002-2004 average catch for WPO fisheries, 3,300 tons for EPO commercial fisheries*	2002-2004 average catch for WPO fisheries		Low recruitment	69.3%	83.7%	86.6%	56.1%	73.9%	79.0%	13.6%	29.3%	35.4%	0.1%	0.4%	0.6%	11749.7	12994.2
					Average recruitment	99.6%	100.0%	100.0%	99.3%	100.0%	100.0%	96.3%	99.8%	100.0%	73.8%	95.0%	98.0%	12958.4	14750.8
					Stock Recruit Relationship w/ h=0.9	98.2%	99.8%	99.9%	97.5%	99.7%	99.9%	93.5%	99.4%	99.9%	72.0%	97.3%	99.6%	13087.3	15020.1
Scenario3		50% of 2002-2004 average catch for WPO fisheries, 2,750 tons for EPO commercial fisheries*		50 kg	Low recruitment	80.5%	91.5%	94.0%	69.1%	85.1%	88.5%	22.2%	43.6%	51.7%	0.2%	0.9%	1.3%	11404.4	12672.3
Scenario4				80 kg	Low recruitment	86.4%	94.6%	96.5%	76.6%	90.0%	93.0%	27.8%	51.8%	61.3%	0.2%	1.1%	1.6%	11292.6	12542.7
Scenario5		90% of scenario 2	same as Scenario 2	30 kg	Low recruitment	90.0%	96.5%	98.1%	81.5%	93.4%	95.9%	35.0%	61.7%	70.4%	0.3%	2.5%	3.7%	11306.4	12881.3
					Average recruitment	99.9%	100.0%	100.0%	99.9%	100.0%	100.0%	98.4%	100.0%	100.0%	82.2%	97.8%	99.3%	12442.0	14126.3
					Stock Recruit Relationship w/ h=0.9	99.4%	100.0%	100.0%	99.1%	100.0%	100.0%	97.0%	99.8%	100.0%	81.8%	99.0%	99.9%	12576.4	14448.2
Scenario6		same as Scenario 2	90% of scenario 2		Low recruitment	75.3%	88.2%	90.2%	61.7%	78.6%	83.4%	15.7%	32.5%	38.7%	0.1%	0.5%	0.7%	11496.2	12632.4
					Average recruitment	99.7%	100.0%	100.0%	99.5%	100.0%	100.0%	96.8%	99.9%	100.0%	75.1%	95.2%	98.1%	12686.3	14071.5
					Stock Recruit Relationship w/ h=0.9	98.9%	99.9%	100.0%	98.4%	99.9%	100.0%	95.0%	99.7%	100.0%	75.5%	98.0%	99.9%	12761.0	14379.7
Scenario7		90% of scenario 2			Low recruitment	90.3%	96.8%	98.3%	82.7%	94.2%	96.8%	39.4%	68.0%	77.4%	0.5%	3.5%	5.6%	11231.0	12607.1
					Average recruitment	99.9%	100.0%	100.0%	99.9%	100.0%	100.0%	98.5%	100.0%	100.0%	83.5%	98.1%	99.6%	12139.4	13461.7
					Stock Recruit Relationship w/ h=0.9	99.2%	100.0%	100.0%	99.0%	99.9%	100.0%	96.9%	99.8%	100.0%	81.6%	99.0%	99.9%	11227.3	12461.8
Scenario8		80% of scenario 2	same as Scenario 2		Low recruitment	97.5%	99.6%	99.9%	94.8%	98.9%	99.5%	65.4%	89.2%	94.0%	1.9%	14.5%	22.8%	10922.8	12688.4
Scenario9		same as Scenario 2	80% of scenario 2		Low recruitment	78.1%	89.9%	92.5%	65.0%	81.9%	86.3%	18.4%	37.1%	44.7%	0.2%	0.6%	0.9%	11327.0	12329.9
Scenario10		80% of scenario 2			Low recruitment	98.3%	99.8%	99.9%	96.3%	99.5%	99.8%	73.2%	93.8%	97.5%	3.1%	22.4%	34.1%	10585.9	11586.4
					Average recruitment	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	99.7%	100.0%	100.0%	91.0%	99.5%	100.0%	11194.1	12104.9
					Stock Recruit Relationship w/ h=0.9	99.8%	100.0%	100.0%	99.7%	100.0%	100.0%	98.7%	100.0%	100.0%	90.0%	99.7%	100.0%	11227.3	12461.8
Scenario11	F2011-2013	same as Scenario 2	same as Scenario 2		Low recruitment	82.6%	93.0%	95.0%	71.3%	86.4%	89.9%	23.6%	46.2%	56.0%	0.1%	1.2%	1.6%	12266.8	13587.4

* Catch limits for EPO commercial fisheries is applied for all the catch (small and large fish) made by the Fleets.

** Average recruitment referres to the recruitment for the whole assessment period while low recruitment referres to that of 1980-1989.

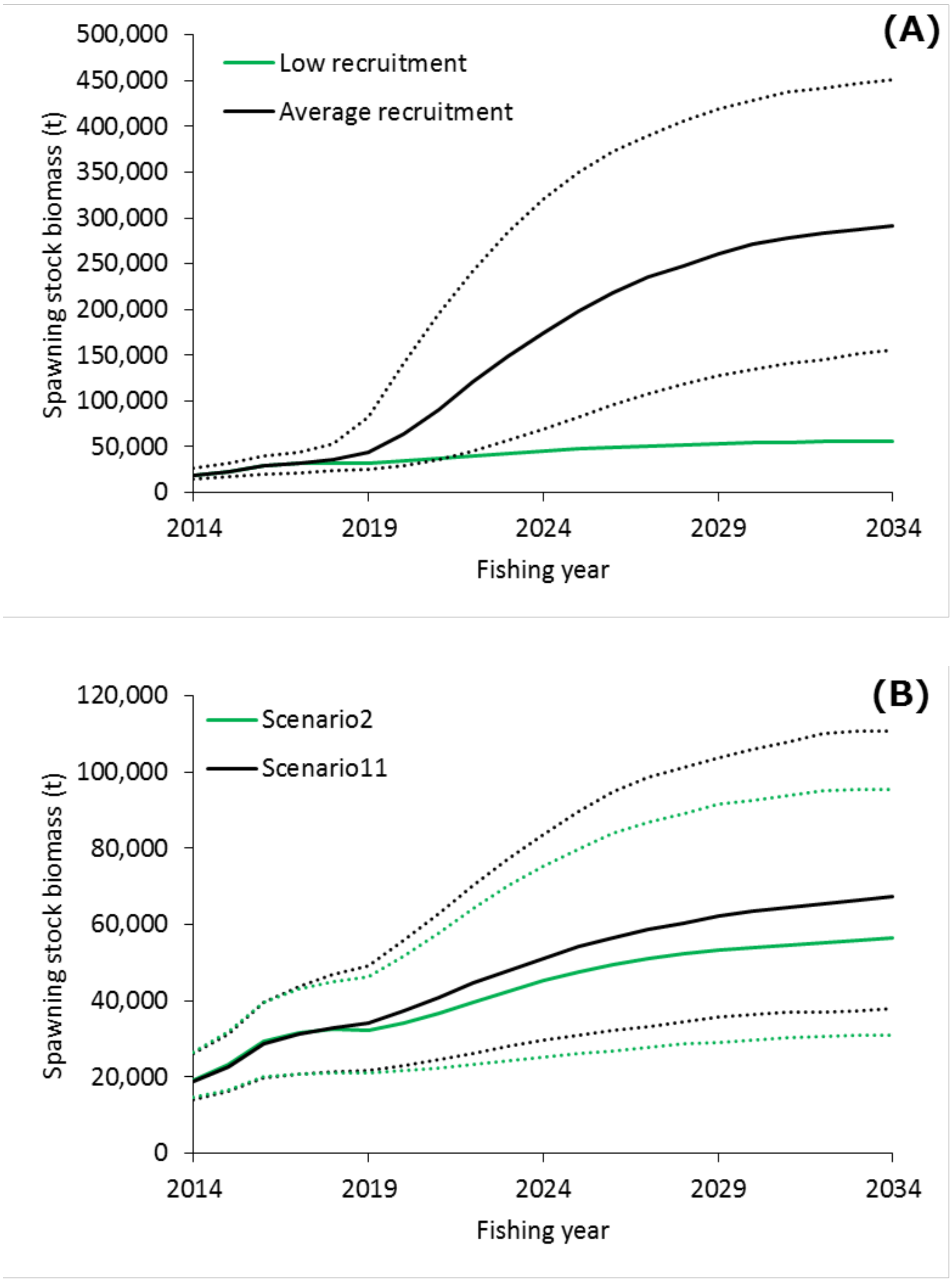

Figure 8. Comparisons of various projection results for Pacific bluefin tuna (*Thunnus orientalis*). (A) low recruitment vs. historical average recruitment (Scenario 2). (B) current CMMs (Scenario 2) vs. current F (Scenario 11) (low recruitment). The solid lines indicate median of bootstrapped projection results and dotted lines indicate 90% confidence interval.

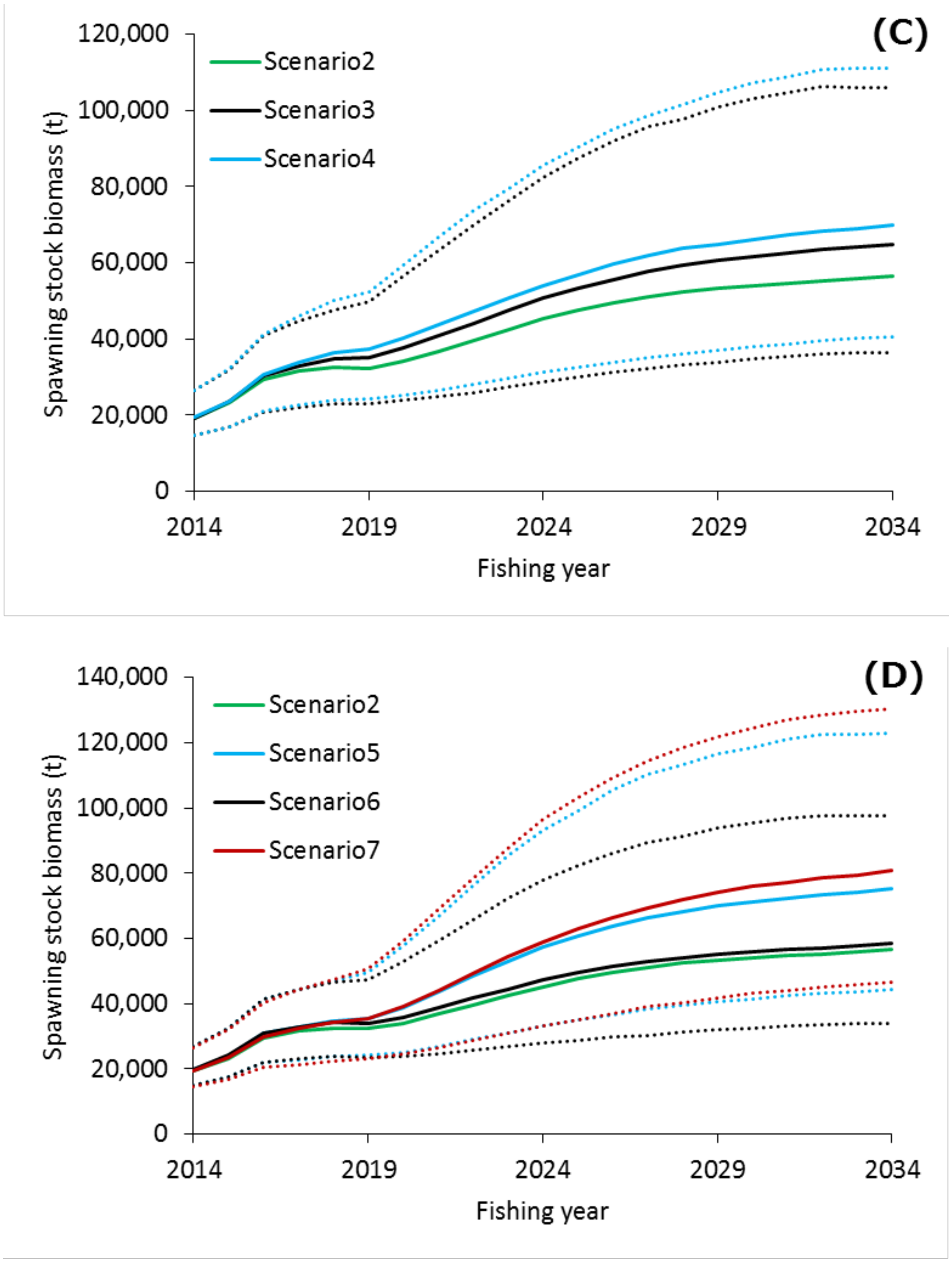

Figure 8 cont. Comparisons of various projection results for Pacific bluefin tuna (*Thunnus orientalis*). (C) different definition of small fish (30kg (Scenario 2) vs. 50kg (Scenario 3) vs. 80kg (Scenario 4)) (low recruitment). (D) current CMMs (Scenario 2) vs. additional 10% catch limit reduction for small fish (Scenario 5), for large fish (Scenario 6) and for all fish (Scenario 7) (low recruitment). The solod lines indicate median of bootstrapped projection results and dotted lines indicate 90% confidence interval.

The projection results indicate that the probability of SSB recovering to the initial WCPFC target (SSB_{MED} by 2024) is 69% or above the level prescribed in the WCPFC CMM if low recruitment scenario is assumed and WCPFC CMM (2015-04) and IATTC resolution (C-14-06) continue in force and are fully implemented (Table 4: Scenario 2 with low recruitment).

The PBFWG notes that there are technical inconsistencies in the calculation of SSB_{MED} in assessment and projection. The PBFWG also notes that the current calculation of SSB_{MED} in the projection uses up to the most recent estimates of SSB and unless a fixed period of years is specified to calculate SSB_{MED}, the calculation of SSB_{MED} could be influenced by future trends in spawning biomass. The Commissions may wish to refine the definition of the target taking this into consideration.

Scenario 2 with low recruitment has the lowest prospect of recovery among the examined harvest scenarios. The probability of achieving the WCPFC's initial target (SSB_{MED} by 2024) would increase if more conservative management measures were implemented, such as increasing the size in the definition of "small fish" or further reducing the catch limit, as shown in Table 4 and Figure 8. The projection results indicate that a 10% reduction in catch limit for small fish would have a larger effect on recovery than a 10% reduction in the catch limit for large fish under the definition of small/large fish in WCPFC CMM 2015-04(Figure 8 (D)).

The projections results assuming a stronger stock-recruitment relationship (where h=0.9) than in the assessment model are not necessarily more pessimistic than the low recruitment scenario.

The projection results assume that the CMMs are fully implemented and are based on certain biological or other assumptions. If conditions change, the projection results would be more uncertain. Given the low SSB, the uncertainty in future recruitment, and the influence of recruitment has on stock biomass, monitoring recruitment and SSB should be strengthened so that the recruitment trends can to be understood in a timely manner.