PACIFIC BLUEFIN TUNA STOCK ASSESSMENT

SUMMARY

19-21 December 2012
Webinar

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1. Stock Identification and Distribution

Pacific bluefin tuna (*Thunnus orientalis*) is a single Pacific-wide stock that is 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 their juvenile stage in the EPO before returning to the WPO.

2. Catch History

While historical Pacific bluefin tuna (PBF) catch records are scant, PBF landing records from coastal Japan date back to as early as 1804 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 59,000 mt (47,000 mt in the WPO and 12.000 mt in the EPO) in 1935; thereafter estimated catches of PBF dropped precipitously due to WWII. Estimated 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 annual catches of PBF fluctuated widely from 1952-2011 (Figure 1). During this period reported catch peaked at 40,383 mt in 1956 and reached a low of 8,653 mt in 1990. While a suite of fishing gears catch PBF, the majority are caught in purse seine fisheries (Figure 2). Historical catches (1952-2011) are predominately comprised of juvenile PBF, and 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 v3.23b; SS) fitted to catch, size composition and catch-per-unit of effort (CPUE) data from 1952 to 2011 provided by ISC Pacific Bluefin Tuna Working Group (PBFWG) members. Life history parameters included a length-at-age relationship from otolith-derived ages and natural mortality estimates from a tag-recapture study.

A total of 14 fisheries were defined for use in the stock assessment model based on country/gear stratification. Quarterly observations of catch and (when available) size composition were inputs into the model to describe the removal processes. Annual estimates of standardized CPUE from the Japanese distant water and coastal longline, Taiwanese longline and Japanese troll fleets were used as measures of population relative abundance. 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 recognized uncertainties in standardized CPUE series, the procedures used to weight data inputs (catch, CPUE, 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 20 different models, each with alternative data weightings and structural assumptions (Table 1). While no single model scenario provided a good fit to all sources of data deemed reliable, there was general agreement among all scenarios in terms of the key model results; long-term fluctuations in spawning stock biomass (SSB) occurred throughout the assessment period (1952-2011) and SSB in recent years has been declining for over a decade, however, there is no evidence of reduced recruitment (Figures 4 & 5). Age-specific fishing mortality has increased 8-41% in the recent period (2007-2009) relative to the baseline period (2002-2004) used in recent CMMS by the WCPFC and the IATTC.

4. Status of Stock

The model configuration associated with Run 2 was chosen as the base-case assessment model to determine stock status and provide management advice, acknowledging that while it represents the general conclusions above, the model was unable to reconcile all key data sources (Figure 6). Based on the trajectory of the base-case model stock biomass (age 0+) and SSB are estimated to be 53,216 mt and 22,606 mt, respectively, in 2010. The recent 5-year average level of recruitment (2006-2010, calendar year) was 15.6 million fish. Estimated age-specific fishing mortalities on the stock in the recent period (2007-2009) relative to 2002-2004 (the base period for the current WCPFC conservation and management measure 2010-04) show 4,17, 8, 41 and 10% increases for ages 0,1,2,3 and 4+, respectively (Figure 7). Although no target or limit reference points have been established for the Pacific bluefin tuna stock under the auspices of the WCPFC and IATTC, the current F (average 2007-2009) is above all target and limit biological reference points (BRPs) commonly used by fisheries managers (Table 2), and the ratio of SSB in 2010 relative to unfished SSB is low (Table 3).

Stock projections of spawning biomass and catches of Pacific bluefin tuna from 2011 to 2030 were conducted assuming four alternative harvest scenarios. A quarterly based age-structured simulation model was used for the projections, and included uncertainty in the population size-at-age at the starting year of stock projection (2011), fishing mortality at age, and future recruitment levels. Future recruitments used in the projections were randomly resampled from the dynamic period (1952-2009). Six thousand future projection simulations (300 SS bootstrap runs with 20 stochastic simulations each) were conducted for each of the harvest scenarios.

The four harvest scenarios analyzed were: (1) constant fishing mortality at current *F* ($F_{2007\text{-}2009}$); (2) constant fishing mortality at $F_{2002\text{-}2004}$; (3) constant fishing mortality at $F_{2007\text{-}2009}$ and setting catch limitations on purse seine fleets in the EPO and WPO; and (4) constant fishing mortality at $F_{2002\text{-}2004}$ and setting catch limitations on purse seine fleets in the EPO and WPO. Projection results are shown in Figure 8.

The future projections indicate that:

(1) The median SSB is not expected to increase recover substantially from the present median SSB in Scenario (1);

(2) The median SSB is expected to increase to approximately 41,000 mt by 2030 in Scenario (2);

(3) The median SSB is expected to increase to approximately 50,000 mt by 2030 in Scenario (3); and

(4) The median SSB is expected to increase substantially to approximately 83,000 mt by 2030 in Scenario (4).

In summary, based on the reference point ratios, overfishing is occurring (Table 2) and the stock is overfished. Model estimates of 2010 spawning stock biomass (SSB) are at or near their lowest level and SSB has been declining for over a decade; however, there is no evidence of reduced recruitment.

5. Conservation Advice

The current (2010) PBF biomass level is near historically low levels and experiencing high exploitation rates above all biological reference points (BRPs) commonly used by fisheries managers. Based on projection results, extending the status quo (2007-2009) fishing levels is unlikely to improve stock status.

Recently WCPFC[1] (entered into force in 2011) and IATTC[2] (entered into force in 2012) conservation and management measures combined with additional Japanese voluntary domestic regulations aimed at reducing mortality[3], if properly implemented and enforced, are expected to contribute to improvements in PBF stock status. Based on those findings, it should be noted that implementation of catch limits is particularly effective in increasing future SSB when strong recruitment occurs. It is also important to note that if recruitment is less favorable, a reduction of F could be more effective than catch limits to reduce the risk of the stock declining.

The ISC requires advice from the WCPFC regarding which reference point managers prefer so that it can provide the most useful scientific advice. Until which time a decision is rendered, the ISC will continue to provide a suite of potential biological reference points for managers to consider.

[1]WCPFC CMM 2010-04 specifies that "… total fishing effort by their vessels fishing for Pacific bluefin tuna in the area north of the 20 degrees north shall stay below the 2002-2004 levels for 2011 and 2012, except for artisanal fisheries. Such measures shall include those to reduce catches of juveniles (age 0-3) below the 2002-2004 levels, except for Korea. Korea shall take necessary measures to regulate the catches of juveniles (age 0-3) by managing Korean fisheries in accordance with this CMM. CCMs shall cooperate for this purpose." For full text see: http://www.wcpfc.int/node/3407
[2]IATTC Resolution C-12-09 specifies that "… 1. In the IATTC Convention Area, the commercial catches of bluefin tuna by all the CPCs during the two-year period of 2012-2013 shall not exceed 10,000 metric tons; 2. The commercial catch of bluefin tuna in the commercial fishery in the Convention Area shall not exceed 5,600 metric tons during the year 2012; 3. Notwithstanding paragraphs 1 and 2, 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." For full text see: iattc.org/PDFFiles2/Resolutions/C-12-09-Conservation-of-bluefin-tuna.pdf
[3] This is described in WCPFC-NC8-2012/DP-01. For full text see; http://www.wcpfc.int/system/files/documents/meetings/northern-committee/8th-regular-session/delegation-proposals-and-papers/NC8-DP-01-%5BEXPLANATION-AND-IMPLEMENTATION-CMM-2010-04%5D.pdf

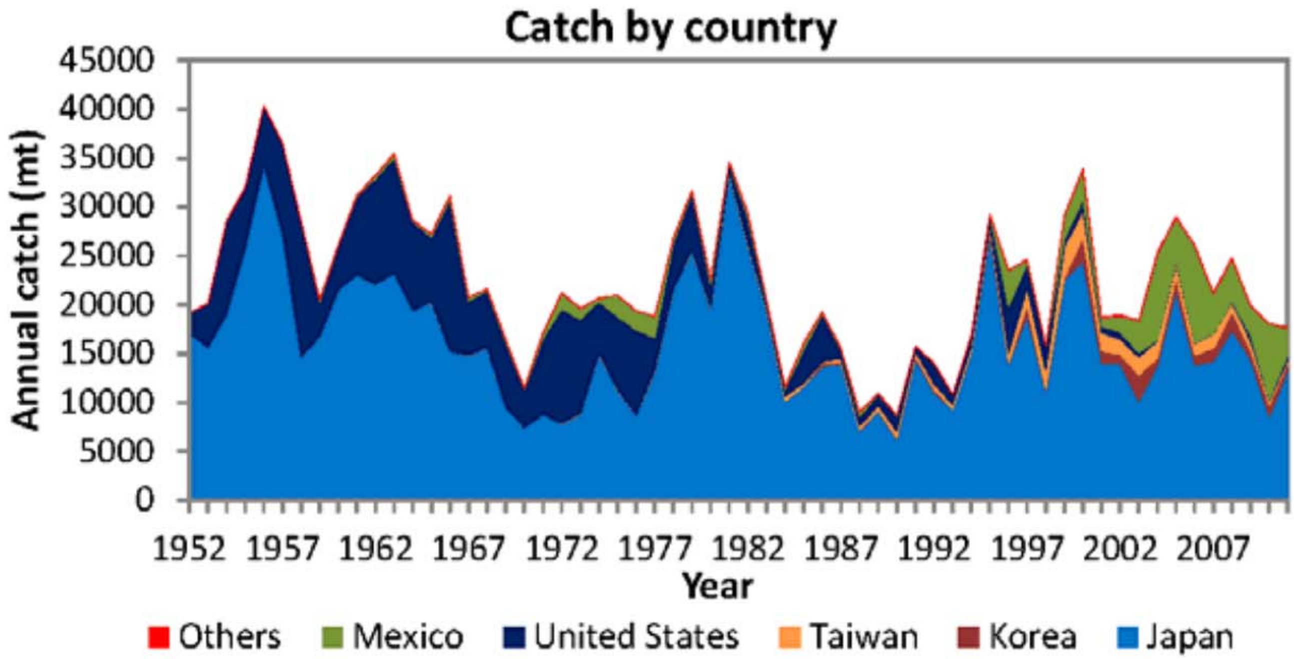

Figure 1. Historical annual catch of Pacific bluefin tuna by country, 1952-2011(data in calendar year 1952 and 2010 are incomplete).

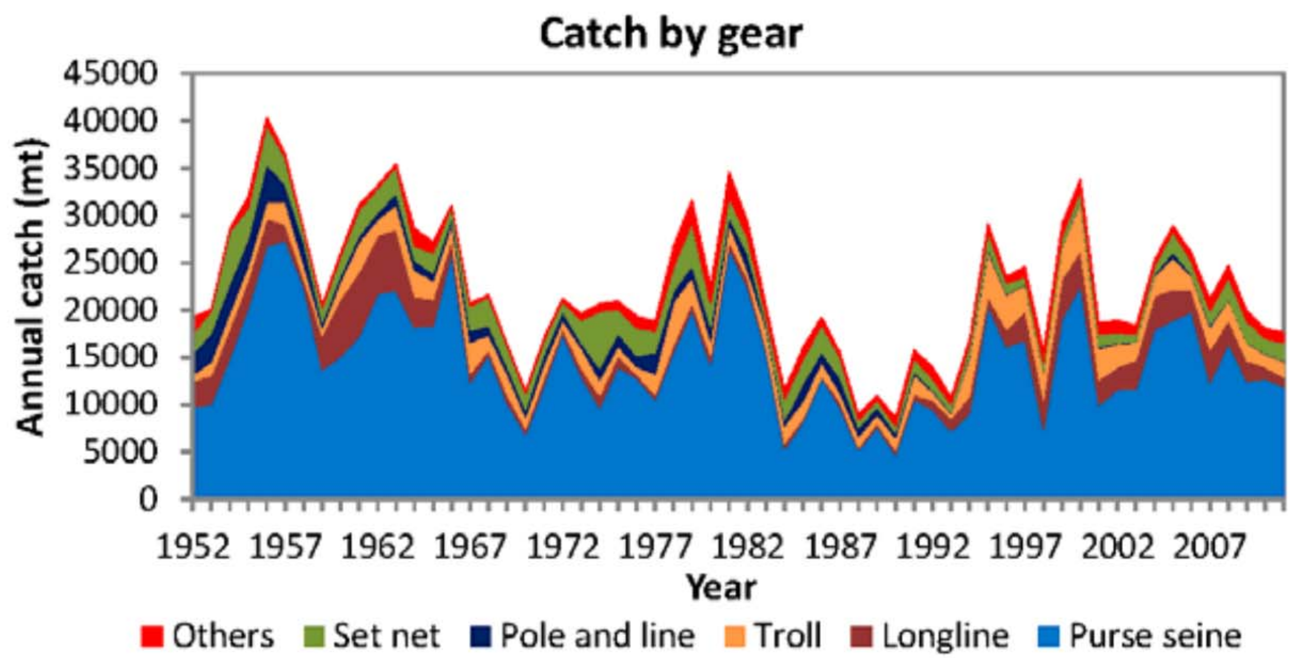

Figure 2. Historical annual catch of Pacific bluefin tuna by gear, 1952-2011(data in calendar year 1952 and 2010 are incomplete).

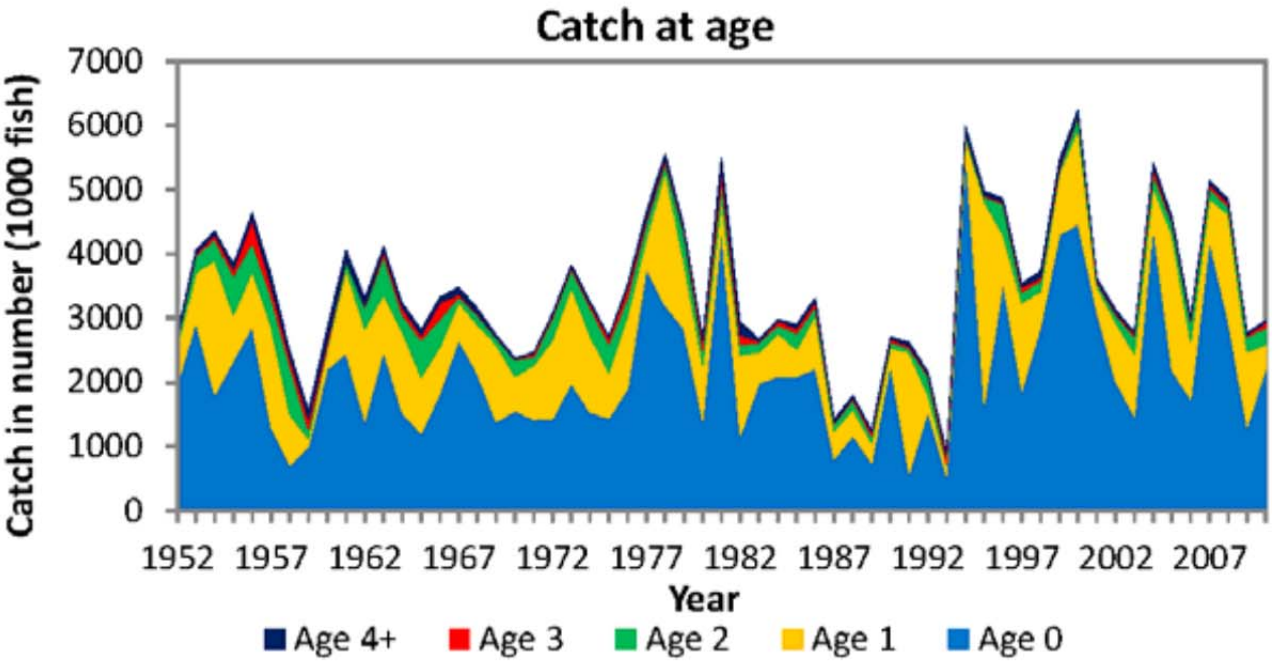

Figure 3. Historical annual catch-at-age of Pacific bluefin tuna in 1952-2011.

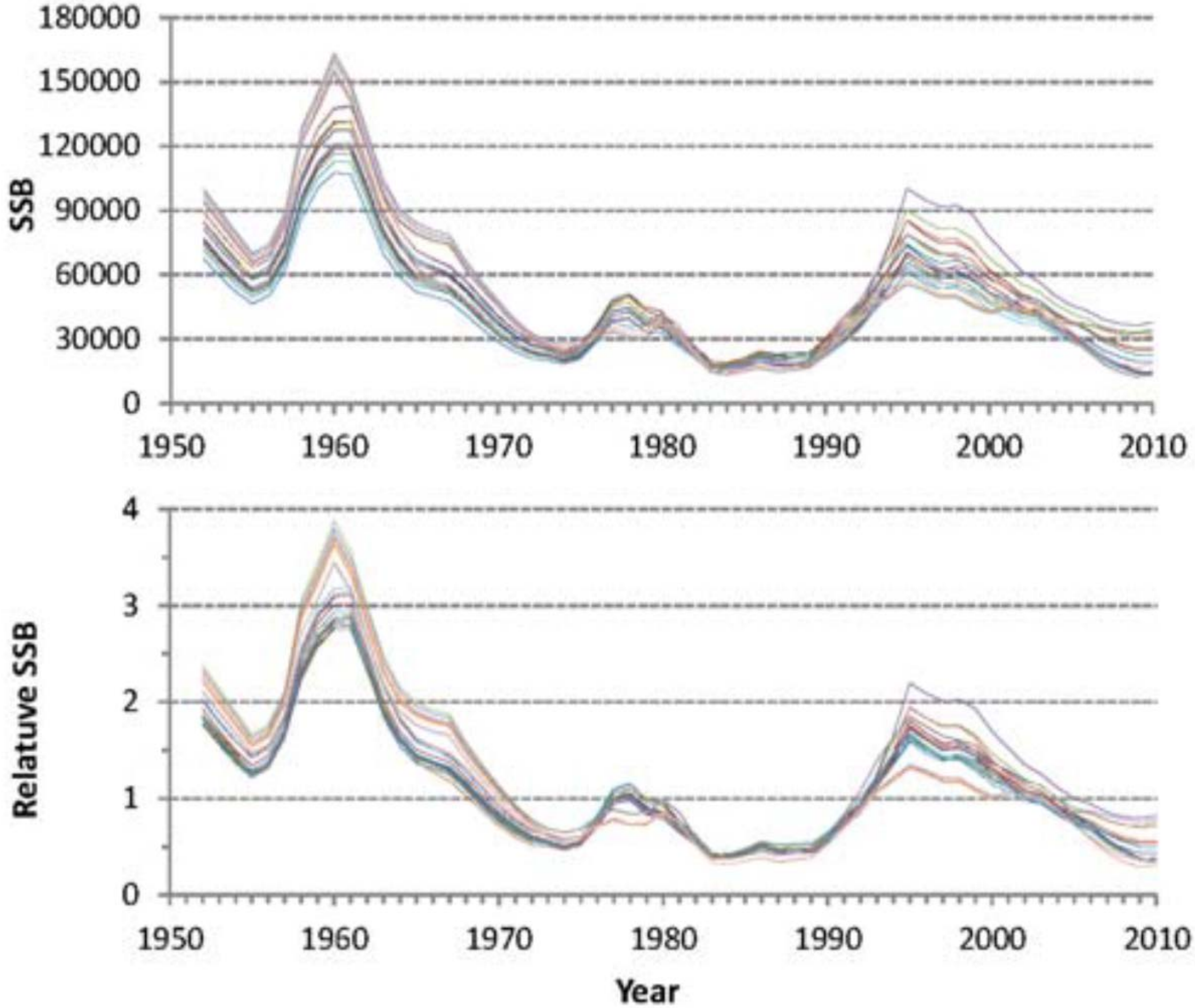

Figure 4. Absolute and relative spawning stock biomass (SSB) (mt) estimated for 20 trial runs with different combination of parameters (see Table 1). Relative time series are calculated by dividing absolute SSB by the respective median values of each run.

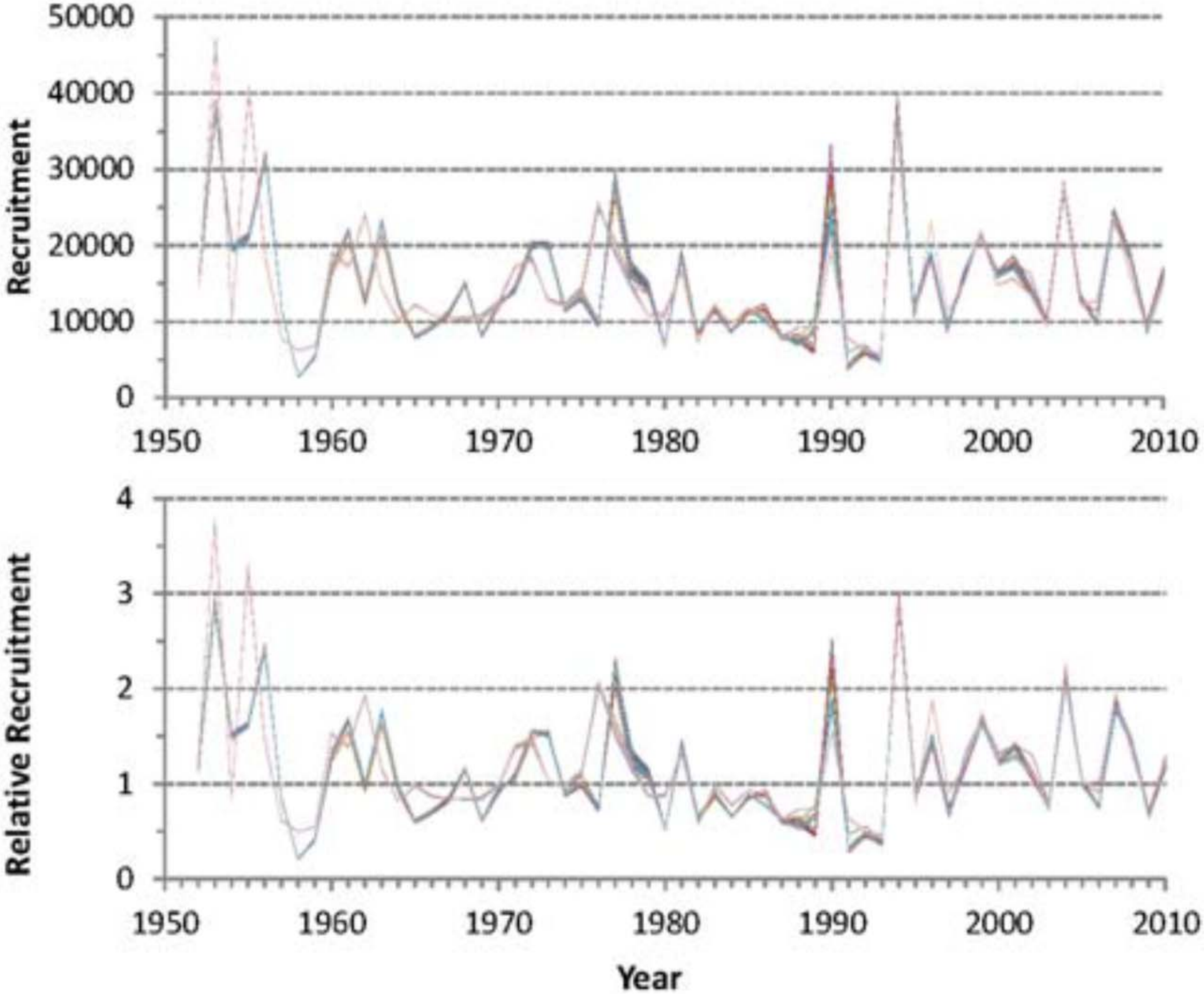

Figure 5. Absolute and relative recruitment (thousands of fish) estimated for 20 trial runs with different combination of parameters (see Table 1). Relative time series are calculated by dividing absolute recruitment by the respective median values of each run.

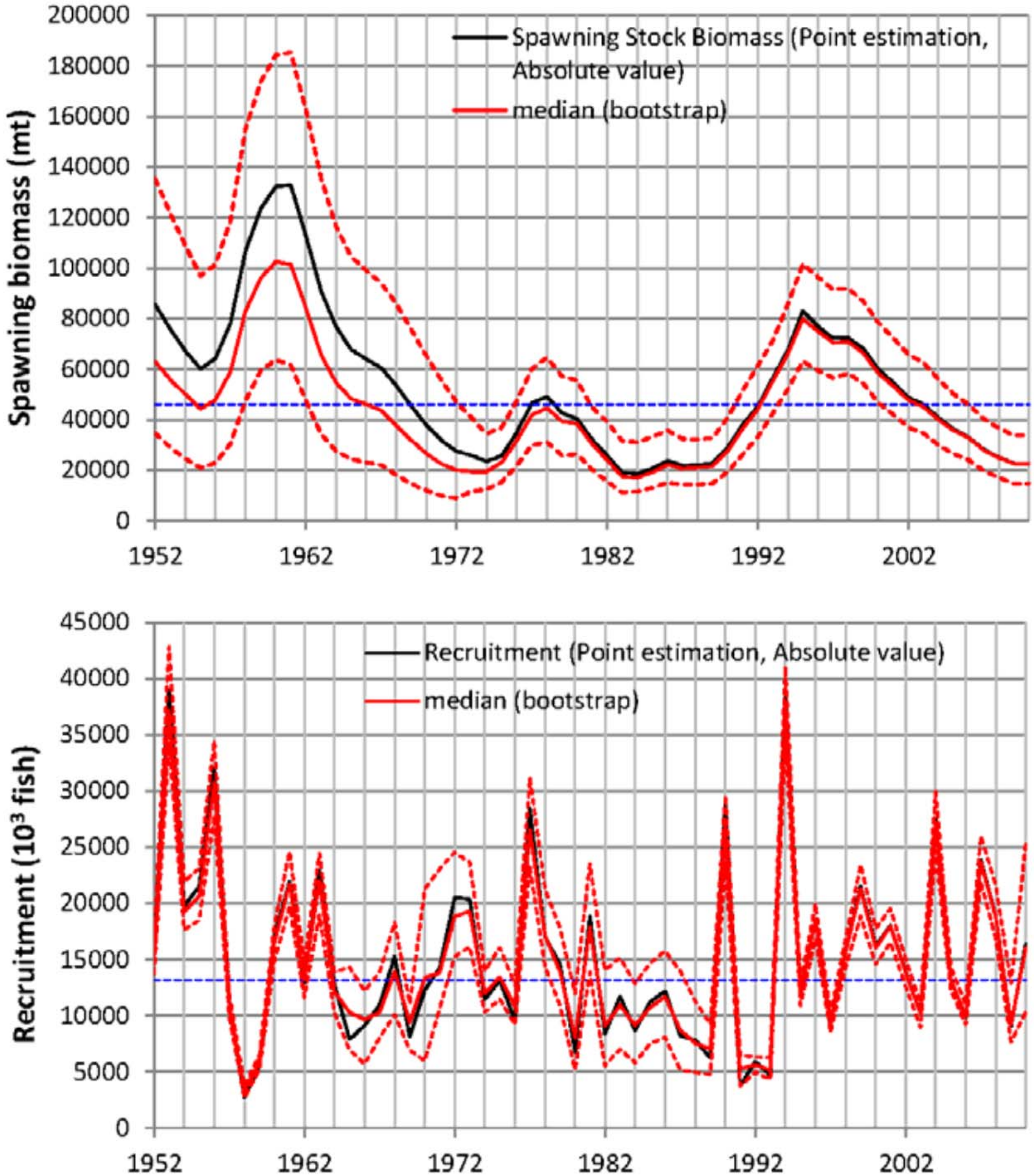

Figure 6. Spawning biomass (SSB) and recruitment estimated for the base case model run (black lines). Dashed red line and solid red lines indicate 80% confidence intervals and median time series estimated from bootstrapping the base case model. Dashed blue lines indicate the overall median SSB and recruitment associated with the base case model.

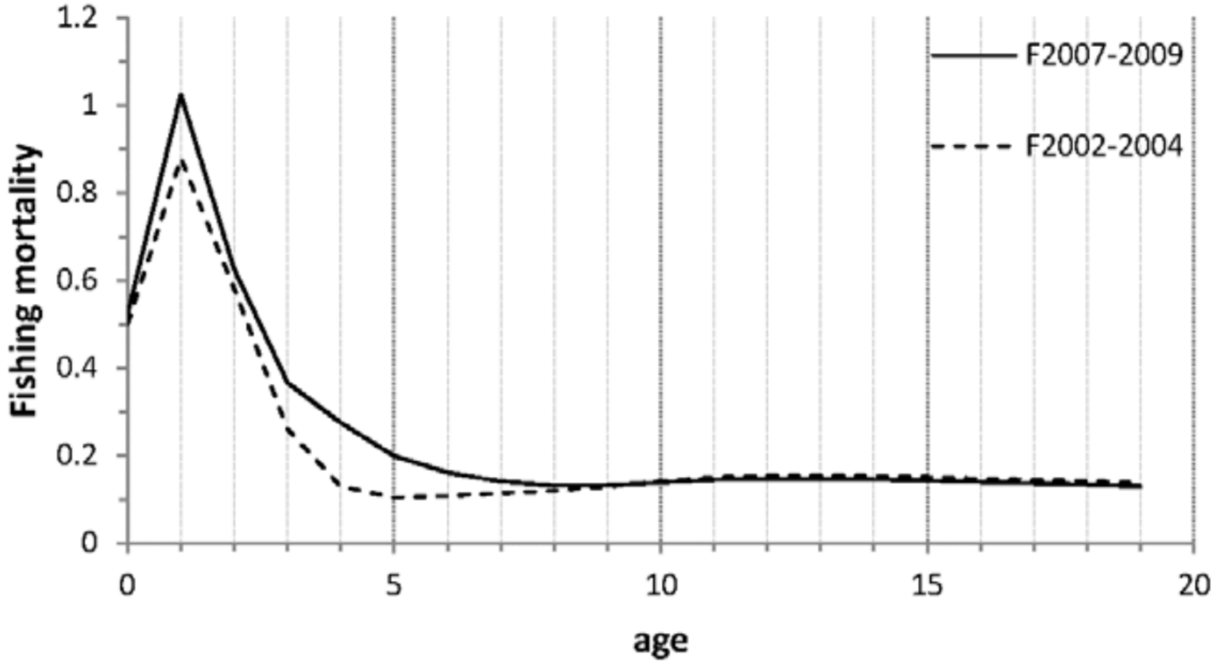

Figure 7. Average age-specific fishing mortality during 2002-2004 and 2007-2009.

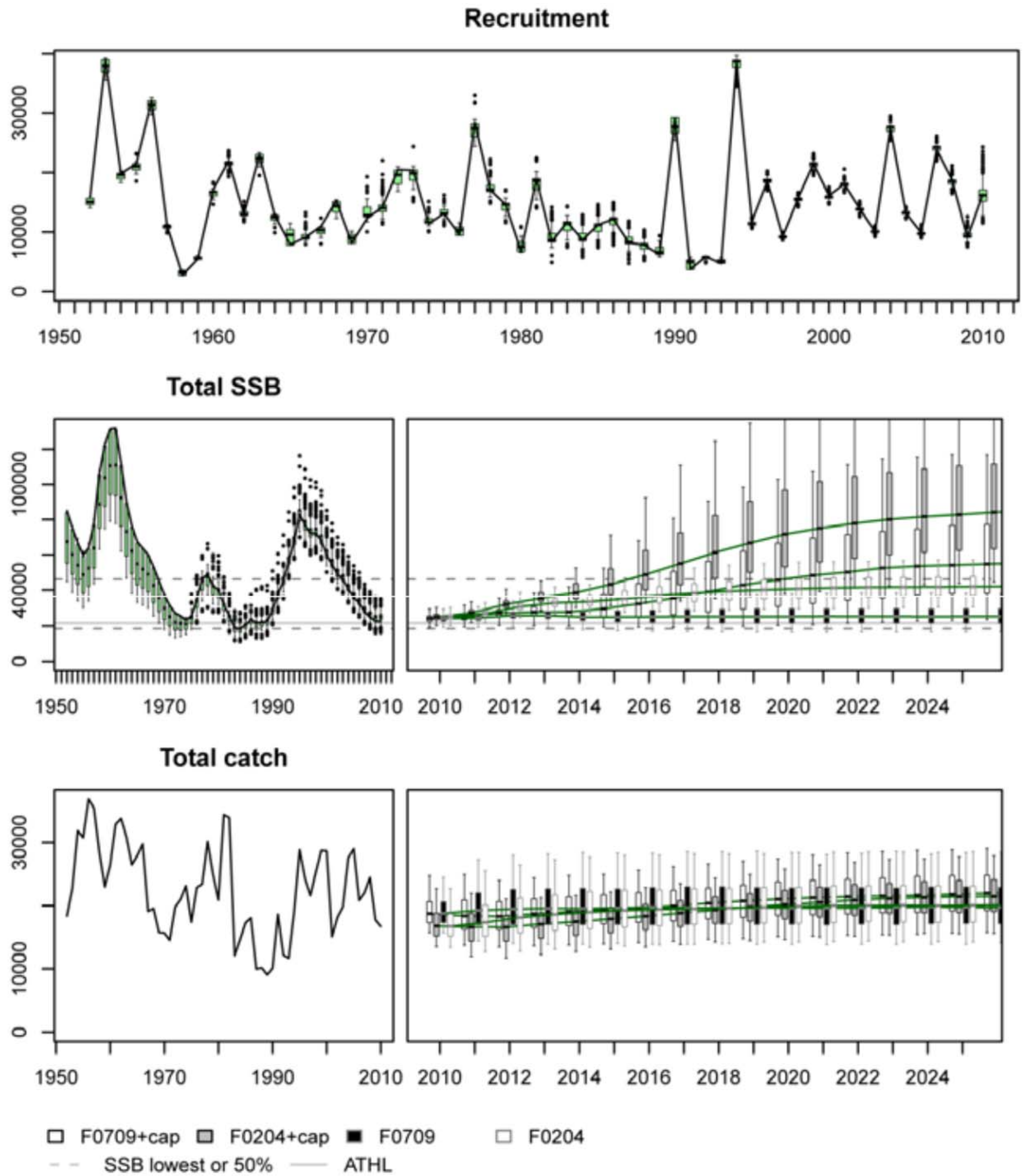

Figure 8. Expected recruitment, spawning biomass, and total catch from 2011 to 2030, based on future projections. Four scenarios were used in the projections: (1) $F_{2007\text{-}2009}$; (2) $F_{2002\text{-}2004}$; (3) $F_{2007\text{-}2009}$ with catch limits (cap) on purse seine fleets in EPO and WPO; and (4) $F_{2002\text{-}2004}$ with catch limits (cap) on purse seine fleets in EPO and WPO. Bars indicate 80% confidence intervals.

Table 1. Model configurations for the 20 model runs. Run 2 is the base case model (see the stock assessment report or the different CV and Effective Sample Size (EFFN) values.

Run#	CPUE for recent LL	CV for CPUE S1	EffN for F3	Size selectivity estimated	Size composition fitted
1	S1 and S9	CPUE CV #1	EffN #1	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
2	S1 and S9	CPUE CV #1	EffN #2	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
3	S1 and S9	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
4	S1 and S9	CPUE CV #2	EffN #2	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
5	S1	CPUE CV #1	EffN #1	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
6	S1	CPUE CV #1	EffN #2	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
7	S1	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
8	S1	CPUE CV #2	EffN #2	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
9	S9	-	EffN #1	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
10	S9	-	EffN #2	Mirror to other fleet: F6, 13. Fixed: F14. Estimated: The rest of Fleets.	All Fleets except Fleet 6, 13, 14
11	S1	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Estimated: The rest of Fleets.	All fleets except F6, F13
12	S1	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Fixed: F3, 4, 7, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6, F7,F12,F13,F14
13	S1	CPUE CV #2	EffN #2	Mirror to other fleet: F6, 13. Fixed: F3, 4, 7, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6, F7,F12,F13,F14
14	S9	-	EffN #1	Mirror to other fleet: F6, 13. Fixed: F3, 4, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6,F12,F13,F14
15	S9	-	EffN #2	Mirror to other fleet: F6, 13. Fixed: F3, 4, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6,F12,F13,F14
16	S9	-	EffN #1	Mirror to other fleet: F6, 13. Estimated: The rest of Fleets.	All fleets except F6, F13
17	S1 and S9	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Estimated: The rest of Fleets.	All fleets except F6, F13
18	S1 and S9	CPUE CV #2	EffN #1	Mirror to other fleet: F6, 13. Fixed: F3, 4, 7, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6, F7,F12,F13,F14
19	S1 and S9	CPUE CV #1	EffN #1	Mirror to other fleet: F6, 13. Fixed: F3, 4, 7, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6, F7,F12,F13,F14
20	S1 and S9	CPUE CV #1	EffN #2	Mirror to other fleet: F6, 13. Fixed: F3, 4, 7, 12, 14. Estimated: The rest of Fleets.	All fleets except F3, F4, F6, F7,F12,F13,F14

Table 2. Ratio of several common biological reference points to the estimated fishing mortality from 2002-2004 (F_{0204}) and 2007-2009 (F_{0709}). Values less than 1.0 indicate that estimated fishing mortality is higher than the reference point.

	F_{max}	$F_{0.1}$	F_{med}	F_{loss}	$F_{10\%}$	$F_{20\%}$	$F_{30\%}$	$F_{40\%}$
F_{0204}	0.57	0.40	0.91	1.19	0.85	0.58	0.43	0.33
F_{0709}	0.48	0.34	0.73	0.95	0.68	0.47	0.35	0.26

Table 3. Computed F-based biological reference points (BRPs; F_{max}, F_{med}, and $F_{20\%}$) for Pacific bluefin tuna relative to $F_{2002\text{-}2004}$ and $F_{2007\text{-}2009}$, estimated depletion rate (ratio of SSB in 2010 relative to unfished SSB), and estimated SSB (mt) in year 2010 for 20 model configurations (Runs). Run 2 is highlighted as it represents the base case model for the PBF stock assessment. F-ratio based BRP values less than 1 indicate overfishing.

	F_{max} ($F_{2002\text{-}2004}$)	F_{max} ($F_{2007\text{-}2009}$)	F_{med} ($F_{2002\text{-}2004}$)	F_{med} ($F_{2007\text{-}2009}$)	$F_{20\%}$ ($F_{2002\text{-}2004}$)	$F_{20\%}$ ($F_{2007\text{-}2009}$)	Depletion Ratio	Estimated SSB (mt) (yr = 2010)
Run 1	0.54	0.45	0.90	0.71	0.56	0.45	0.032	20,030
Run 2	0.57	0.48	0.91	0.73	0.58	0.47	0.036	22,606
Run 3	0.51	0.39	0.88	0.63	0.53	0.38	0.022	13,678
Run 4	0.54	0.41	0.89	0.64	0.55	0.40	0.025	15,794
Run 5	0.58	0.49	0.93	0.75	0.59	0.48	0.037	23,794
Run 6	0.60	0.50	0.97	0.78	0.60	0.49	0.041	25,595
Run 7	0.52	0.39	0.90	0.65	0.53	0.39	0.022	13,996
Run 8	0.54	0.40	0.90	0.65	0.55	0.40	0.024	15,388
Run 9	0.61	0.54	0.94	0.82	0.61	0.53	0.047	30,085
Run 10	0.63	0.57	0.96	0.84	0.63	0.55	0.051	32,519
Run 11	0.51	0.38	0.92	0.64	0.54	0.38	0.022	13,141
Run 12	0.46	0.39	0.82	0.66	0.48	0.39	0.021	13,060
Run 13	0.46	0.39	0.82	0.66	0.48	0.38	0.021	12,944
Run 14	0.62	0.55	0.98	0.82	0.64	0.54	0.051	31,196
Run 15	0.60	0.55	1.04	0.87	0.64	0.54	0.053	32,741
Run 16	0.61	0.55	1.04	0.87	0.65	0.55	0.054	33,383
Run 17	0.49	0.38	0.91	0.63	0.54	0.37	0.021	12,838
Run 18	0.46	0.39	0.81	0.65	0.48	0.39	0.022	13,389
Run 19	0.50	0.45	0.83	0.74	0.50	0.45	0.030	18,419
Run 20	0.49	0.45	0.82	0.74	0.50	0.45	0.030	18,206