Annex 9

STOCK ASSESSMENT OF ALBACORE TUNA IN THE NORTH PACIFIC OCEAN IN 2011

REPORT OF THE ALBACORE WORKING GROUP STOCK ASSESSMENT WORKSHOP

International Scientific Committee for Tuna and Tuna-like Species
in the North Pacific Ocean

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Executive Summary

The current assessment of the status and future trends in the north Pacific albacore tuna (*Thunnus alalunga*) stock was completed in June 2011 using fishery data through 2009. This assessment was conducted using the Stock Synthesis modeling platform (Version 3.11b) and is based on the assumption that there is a single well-mixed stock of albacore in the north Pacific Ocean.

The Albacore Working Group (ALBWG) developed a seasonal, length-based, age-structured, forward-simulation population model with a focus on providing reliable estimates of population dynamics and stock abundance. Major changes to model inputs and structure in this assessment relative to the 2006 assessment include the use of catch-at-length data rather than catch-at-age data, 16 age-aggregated fisheries defined by gear, location, season, and catch units (weight or number) rather than 17 age-specific fisheries, a new growth model, and use of conditional age-at-length data not previously available.

The stock assessment required a substantial amount of data including catch, catch-per-unit-effort (CPUE), and catch size compositions. Catch and CPUE for all fisheries have been updated through 2009 for this assessment, i.e., four more years of data were available following the last assessment in 2006. A reference run of the VPA model configured as in the 2006 assessment, but with updated catch-at-age and CPUE indices, was conducted to compare important estimated quantities for model-related changes. Analyses were carried out to assess the sensitivity of the results to assumptions including data-weighting (both between data types and relative weightings of different sources within a data type), biology (stock-recruitment relationship, natural mortality, growth), and fishery selectivity patterns. Stochastic future projections of the stock were conducted to estimate the probability that future SSB will fall below the average of the ten historically lowest estimated SSBs (SSB-ATHL) in at least one year of a 25-yr (2010-2035) projection period. The base-case scenario for projections assumes average recruitment and constant F (at current F level, $F_{2006\text{-}2008}$), but sensitivity of the results to alternative harvest scenarios (constant catch and constant $F_{2002\text{-}2004}$), two recruitment scenarios (high and low levels), and alternative structural assumptions (down-weighting of the length composition data, stock-recruitment relationship, growth) was investigated. Retrospective analysis to assess the level of bias and uncertainty in terminal year estimates of biomass, recruitment and fishing mortality was also conducted.

The SS3 base-case model estimates that SSB has likely fluctuated between 300,000 and 500,000 t between 1966 and 2009 and that recruitment has averaged 48 million fish annually during this period. The pattern of F-at-age shows fishing mortality increasing to its highest level on 3-yr old fish and then declining to a much lower and stable level in mature fish. Current F (geometric mean of 2006 to 2008, $F_{2006\text{-}2008}$) is lower than $F_{2002\text{-}2004}$ (current F in the 2006 assessment). Future SSB is expected to fluctuate around the historical median SSB (~405,000 t) assuming F remains constant at $F_{2006\text{-}2008}$ and average historical recruitment levels persist. $F_{2006\text{-}2008}$ is approximately 30% below $F_{SSB\text{-}ATHL\ 50\%}$ and there is about a 1 % risk that future SSB will fall below the SSB-ATHL threshold in at least one year in the projection period, i.e., current F is well below the 50% probability level. However, if recruitment is lower than the historical average and F remains constant at $F_{2006\text{-}2008}$, then the risk of future SSB falling below the threshold by the end of the projection period increases to as high as 54%.

Sensitivity and retrospective analyses assessed the impact of alternative assumptions on the assessment results. These analyses revealed scaling differences in estimated biomass (total and SSB) and, to a lesser extent, recruitment, but few differences in overall trends. Relative F-at-age patterns were not affected by different assumptions, except when the growth curve parameters from the 2006 assessment were used, and $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$. Although there is considerable uncertainty in absolute estimates of biomass and fishing mortality, the estimated trends in both quantities are robust and advice-based on F_{SSB} is not affected by this uncertainty. Terminal year estimates of biomass and recruitment show no bias, but there is a high level of uncertainty in the most recent recruitment estimates. Given these findings, WG believes that the current parameterization of the base-case model is reasonable.

Both the SS3 base-case model and the VPA reference run estimated similar historical trends in SSB and recruitment, but with different scaling for biomass. The scaling difference is largely attributable to the different growth curves used in SS3 base-case model and the VPA reference run. A sensitivity run of the base-case model in which growth parameters were fixed to those used in the VPA, reduced the scaling of biomass to the level of the VPA reference run. Sensitivity analyses of future projections show that stock status and conservation advice is relatively insensitive to these scaling differences. The WG concluded that the growth curve used in the 2006 assessment is not representative of growth in north Pacific albacore. Based on the agreement in trends of estimated quantities between the VPA and SS3 base-case model, the ability to explain the scaling differences between models, and the robustness of the stock status and conservation advice to these differences, the WG concluded that the SS3 model will replace the VPA as the principal model for north Pacific albacore assessments.

The north Pacific albacore stock is considered to be healthy at current levels of recruitment and fishing mortality. Since current $F_{2006\text{-}2008}$ is about 71% of $F_{SSB\text{-}ATHL}$ and the stock is expected to fluctuate around the long-term median SSB (~405,000 t) in the foreseeable future given average historical recruitment levels and constant fishing mortality at $F_{2006\text{-}2008}$, the WG concluded that overfishing is not occurring and that the stock likely is not in an overfished condition. However, recruitment is a key driver of the dynamics in this stock and a more pessimistic recruitment scenario increases the probability that the stock will not achieve the management objective of remaining above SSB-ATHL threshold with a probability of 50%. Thus, if future recruitment declines about 25% below average historical recruitment levels due either to environmental changes or other reasons, then the impact of $F_{2006\text{-}2008}$ on the stock is unlikely to be sustainable. Therefore, the working group recommends maintaining present management measures.

The WG also reviewed fisheries data from 2010 and updated Category I (annual nominal catch and effort), II (spatially stratified monthly catch and effort), and III (size composition sampled from the catch) fishery data. The provisional estimate of total catch in 2010 is 69,364 t, which is 13% lower than the 2009 catch. The majority of this change is accounted for by a reduction in albacore catch by the Japanese pole-and-line fishery. These data are preliminary and subject to change since not all countries catching north Pacific albacore had reported their data to the WG at the time of this review.

Table of Contents

1.0 Introduction

1.1 Welcome and Opening Remarks

The ISC-Albacore Working Group (ALBWG or WG) stock assessment workshop was held at the National Research Institute of Far Seas Fisheries (NRIFSF) in Shizuoka, Japan, 4-11 June 2011. This workshop was originally scheduled for 14-29 March 2011 but was postponed because of a strong earthquake in the sea off northeastern Japan on 11 March 2011. The WG expressed its sympathies to the victims of this event.

Dr. Uozumi**,** NRIFSF Director, welcomed the participants to the meeting. In his address, Dr. Uozumi expressed his appreciation for the concern of WG members regarding their colleagues and the Japanese people who survived the Tohoku earthquake. He noted the long history of albacore fisheries and that the results of this assessment will be of great concern to many countries. He also reflected on the long history of scientific cooperation on north Pacific albacore and he observed that the ISC Albacore Working Group is an effective forum for exchanging data, presenting research, and developing improvements to provide a more reliable and realistic stock assessment and management advice for albacore. He stressed that Japan recognizes the important scientific contributions the Working Group is making to the understanding of the North Pacific albacore population and in closing, Dr. Uozumi wished participants a valuable and productive session leading to reliable conclusions for the assessment.

John Holmes chaired the workshop and welcomed working group members. In his opening remarks, Holmes noted that substantial progress had been achieved on several modeling issues since the October 2010 workshop in La Jolla, CA, and that this progress was the result of productive discussions of these issues among WG members via email. He reminded working group members that collaboration and cooperation would be important for completing the assessment at this workshop and the importance of doing so as five years have elapsed since the last assessment of this stock. The WG decision-making process is consensus-based, which means obtaining as much agreement as possible among members, but not necessarily 100% unanimity. Working group members will make some important decisions in the absence of perfect understanding and they should continue their collaborative and cooperative approach. Finally, Holmes wished WG members a productive and successful workshop.

The WG reviewed the goals of the stock assessment workshop. The workshop is charged with completing a full assessment of the North Pacific albacore stock using fishery data through 2009, and developing scientific advice and recommendations for fisheries managers on current stock status, future trends, and conservation. The WG also reviewed national fisheries in 2010 and updated Category I, II, and III fishery data.

A total of 23 participants from Canada (CAN), Chinese Taipei (TWN), Japan (JPN), United States of America (USA), the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC) Chair, and the Science Committee Chair of the Western and Central Pacific Fisheries Commission (WCPFC) attended the Workshop and introduced themselves (Appendix 1).

The WG Chair discussed the reporting of the stock assessment results and scientific advice. First, a workshop report (this report) capturing discussion, key outputs and conclusions, and advice and recommendations on the assessment will be prepared in accordance with past practice and submitted to the ISC11 Plenary Session in July 2011 for approval and transmittal to both the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC). Second, following discussion at the ISC10 Plenary Session (ISC 2009) and at the Sixth Regular Session of the Northern Committee of the WCPFC (Northern Committee 2010), there may be an opportunity to send the stock assessment document to an independent external peer review. The goals of this review would be to obtain feedback on the adequacy, appropriateness, and application of the modeling and other methods for providing scientific advice to managers and to solicit advice on research to improve the assessment model. This review would require a second document that comprehensively summarizes background information, assumptions and their rationale, the methodology, results, and interpretation of the stock assessment in one document, rather than over a series of workshop reports. Drafting of this document would commence after the ISC11 Plenary session.

The WG recognizes the important contributions to this assessment made by Simon Hoyle (Secretariat of the Pacific Community) and Alex Aires-da-Silva (Inter-American Tropical Tuna Commission), neither of whom was able to attend the stock assessment workshop. Simon was instrumental in addressing growth and selectivity issues and identifying options that ultimately formed the basis for decisions recorded in this document. Much of the discussion on these issues, led by Simon via email, is captured as background material in Appendix 7. Alex attended the Modeling Subgroup meeting (see Appendix 4) and was an influential voice during working sessions that addressed and resolved parameterization and modeling issues with the Stock Synthesis (SS) platform and developed the base-case model, sensitivity runs, and future projection package recommended to the full WG at the assessment workshop that followed.

2.0 Adoption of Agenda and Assignment of Rapporteurs

A provisional agenda circulated by email prior to the workshop received several revisions which were discussed and accepted. The revised agenda shown in Appendix 2 was adopted for this workshop meeting. Sixteen working papers were presented at the workshop (Appendix 3).

Rapporteuring duties for specific sections were assigned to Chiee-Young Chen, Gerard DiNardo, John Holmes, Momoko Ichinokawa, Shigehide Iwata, Hidetada Kiyofuji, Suzy Kohin, Takayuki Matsumoto, Koji Uosaki, Vidar Wespestad, and Zane Zhang.

A Modeling Subgroup meeting was convened at the National Research Institute of Far Seas Fisheries in Shizuoka, Japan, 30 May-03 June 2011. The goals of this meeting were to review model parameterization issues and develop recommendations for the base case model, sensitivity runs, and future projection scenarios to the full assessment workshop. The report of the Subgroup meeting is attached as Appendix 4.

The adopted agenda lists the main topics covered during the assessment workshop. However, this workshop report does not strictly follow the agenda in its organization. Instead, the assessment report is arranged to highlight the assessment methodology, results, conclusions, and scientific advice and the necessary background studies and information needed to understand the assessment. This arrangement of the report means that discussion and work related to the base-case scenario recommended by the Modelling Subgroup (Agenda Item 4), SS and VPA data review (Agenda Item 7), structural and input parameter decisions (Agenda Item 8), choice of sensitivity runs (Agenda Item 9), and input decisions for conducting future projections (Agenda Item 10) were moved from the main report to Appendix 5.

References to working papers presented at this assessment workshop are cited in this report using the working paper number, i.e., ISC/11/ALBWG/01. Full citations are found in Appendix 3. Working papers presented at earlier workshops are cited using the author-year system plus the working paper number, i.e., Teo et al. (2010; ISC/10-3/ALBWG/02) and are included in the literature list at the end of the report.

3.0 Review of 2010 Fisheries Data

3.1 Mexico (ISC/11/ALBWG/01)

Summary — This paper contains the complete historic record of north Pacific Albacore (NPALB) catches for Mexico from 1961 to 2010 and continues the series of yearly reports provided by the INAPESCA-México to the ISC-Albacore Working Group. Catches of NPALB by purse seiners occur sporadically in the Northwest region of México when fishing for juvenile Pacific blue fin tunas; albacore is not a primary target species of commercial fisheries in Mexico. For this reason, albacore catches by the Mexican tuna fleet have been low relative to catches of other tuna species during the last few years. The total reported catch for albacore in 2009 was 17 t and the preliminary figure for 2010 is 25 t. NPALB are also caught incidentally by some small-scale coastal longline fisheries targeting pelagic sharks and swordfish, although the number of albacore caught is low. In addition, there is a USA sport fishery targeting albacore which operates under permits within Mexican waters. Catch data from this fishery for 1998 to 2007 were presented by Mexico for the first time last year; updates for 2008-2010 are not yet available. Size data are not available for albacore caught by Mexican tuna fisheries.

Discussion: It was clarified that catch estimates for purse seine vessels are based on observer data. All Mexican vessels carry logbooks and all of the major tuna seiners (363 t or more) have had scientific observers since 1992. There are no data on the number of vessels or other measures of effort in a given year, although these catches are attributed to 5-7 vessels targeting juvenile Pacific bluefin for pen ranching operations. U.S. sport fishery catches in Mexican waters for 2008-2010 are reported by the U.S and are included in the catch table (Appendix 6).

3.2 Canada (ISC/11/ALBWG/10)

Summary — Total annual catch and effort by the Canadian troll fleet in 2010 were 6,497 tonnes (t) and 7,532 vessel-days, respectively, for 157 vessels actively targeting albacore. These figures represent a 15% increase in catch and effort and a 16% increase in fleet size relative to 2009. The increased fleet size was due to an increase in vessels operating within Canadian coastal waters and the high seas. The Canadian fishery operated within a latitudinal range of 39 to 53°N and from the west coast of North America to 147°W in 2010, continuing the pattern observed since the 2006 fishing season of staying within the eastern Pacific Ocean (east of 150°W). Roughly 51% of the catch and 53% of the effort occurred in the US coastal waters, well below the average for 2000-2009 of 79% and 78%, respectively. In contrast, 36% of the catch and 39% of the effort occurred in Canadian waters and 14% of the catch and 8% of the effort occurred in adjacent high seas waters, double the long-term averages in both areas. Two modes at 64-66 and 74-76 cm were equally dominant in size composition data sampled from the catch (range 51-90 cm), corresponding to 2- and 3-yr old fish. The most common length frequency pattern sampled from the Canadian catch exhibits the first mode at 64-66 cm FL. The two-mode pattern in 2010 is rarer, but together with above average catch rates in northern waters and changes in the contribution of different areas to total catch, is consistent with a northward shift of the albacore population along the west coast of North America in 2010.

Discussion: The number of vessels increased in recent years and no more than 110 Canadian troll vessels operate in US waters between 15 June and 31 October in accordance with treaty conditions. CPUE has levelled off in recent years, after about 15 years of monotonic increases, which were attributed to factors such as the increasing experience of captains in the fishery, improved fish finding technology and changing ocean conditions.

3.3 Chinese Taipei (ISC/11/ALBWG/07)

***Summary* —** Taiwanese longline fisheries operating in the North Pacific Ocean were briefly reviewed. Most of the North Pacific albacore catch is contributed by the large-scale tuna longline fishery (LTLL), and only a minor proportion comes from small-scale tuna longline fishery (STLL). Albacore catches by the LTLL fishery are seasonal and occur mainly in the 1st and 4th quarters of the year; Taiwanese longliners rarely fish in the 2nd and 3rd quarters. The annual Taiwanese albacore catch has fluctuated between 1,866 and 3,990 t in recent years (2005-2010), with only 13-24 albacore-targeting vessels actively operating in the North Pacific Ocean during this period. Preliminary data for 2010 are 2,236 t of catch from 19 vessels in the LTLL fishery targeting albacore.

Discussion: It was clarified that the figures presented are catch and effort for the large-scale longline (LTLL) fishery, the small-scale longline fishery (STLL) data were not included in this report. The recovery rate of STLL fishery logbooks is low and the few logbooks available may not provide sufficient or reliable information. The STLL fishery constitutes less than 15% of the total annual TWN albacore catch. It was noted that estimates of the STLL catch are compiled and reported in the national report to the ISC Plenary session and that the WG catch table (Appendix 6) includes both the STLL and LTLL catches for TWN as separate categories.

A question was asked about the absence of quarterly catch maps for 2010 in the working paper since maps for 2007-2009 were provided. The author answered that the 2010 maps were not included because the 2010 data are preliminary and most logbooks were not available when the data for this report were compiled. Those logbooks that were returned are primarily from the first quarter of 2010 and as a result a quarterly map for 2010 would not show all four quarter distributions at this time.

It was noted that the TWN LL fleet likely changed fishing grounds from the south Pacific Ocean (1989-1993) to the north Pacific Ocean around 1993-1994. A question was raised about whether this change in fishing grounds was due to a change in the targeting behaviour of the fleet from bigeye tuna to albacore. There is no clear evidence of a change in targeting practices, but albacore fishing grounds are generally found north of 15 °N and bigeye fishing grounds are further south in tropical waters. Some WG members requested maps showing the spatial distribution of effort for TWN LL fishery.

The WG noted that effort data as either vessel numbers or 1000s of hooks were not provided and asked Chinese Taipei to include these data in its fishery reports in the future.

3.4 Japan (ISC/11/ALBWG/13)

Summary **—** Japanese albacore catch and effort data in the north Pacific were compiled from the *Annual Report of Catch Statistics* by the Japanese government and logbook data. Albacore is mainly caught by pole-and-line and longline fisheries. Total Japanese catch in 2009 was revised from the figure presented at the July 2010 ALBWG meeting to 55,878 t, which is about 15,000 t higher than the 2008 catch. This increase is largely accounted for by target switching in the pole-and-line fleet from skipjack (whose abundance was low in waters near Japan in 2009) to albacore. The preliminary total Japanese catch in 2010 was 45,134 t, and is about 11,000 t lower than the 2009 catch.

Discussion: The WG noted that the preliminary 2010 catch is 20% less than 2009, mostly due to lower catches in the purse seine (PS) and pole-and-line (PL) fisheries. The lower PL catch in 2010 was due to a change in targeting from albacore to skipjack, especially the middle-sized PL vessels. However, vessels in this fishery will change their target back to albacore if skipjack abundance is low. Albacore is not the main target species for the PS fishery.

The WG noted that aggregated Category I effort data and monthly Category II catch-effort data were not provided and asked Japan to include these data in its fishery reports in the future.

3.5 United States (ISC/11/ALBWG/15)

Summary **—** In the U.S., north Pacific albacore are targeted commercially by a surface (troll and pole-and-line) fishery and a high seas longline fishery and recreationally by sport fishers. Annual U.S. landings of albacore for the past 10 years (2001-2010) have averaged 13,808 ± 1,704 (mean ± SD) metric tons (t) and represent roughly 17% of the total north Pacific albacore landings. Of the U.S. fisheries operating during this period, the commercial surface fishery (troll and pole-and-line) is the largest averaging 86% of the annual landings, followed by the recreational fishery with roughly 9%, and finally the longline fishery taking just 3% of the annual landings. Other gears that catch albacore in small amounts include pelagic drift gillnets, purse seines and an artisanal troll/handline fishery near Hawaii. Provisional U.S. landings in 2010 totalled 13,145 t, down from 13,813 t in 2009. The surface fishery (troll and pole-and-line) landed 12,004 t and operations were concentrated in a relatively confined area off Oregon and Washington. The number of commercial vessels fishing with troll and pole-and-line gears was

653. Port samplers measured 46,577 fish with a mean size of 72 cm FL landed by the surface fishery. Overall, 2010 catch and effort were down slightly when compared to 2009.

Discussion: It was questioned how sport fishery catches, which are reported in number of fish, were converted to weights. Albacore sport catches are reported by the states through port sampling programs and are converted to weight using the commercial surface fleet sampling data. Although sport catches are sampled for length, the sample size is not large enough to be considered representative of the catch so these data are not used for conversion at present. Slightly larger fish are caught by the sport fleet than the commercial surface fishery so the converted catch data for the sport fishery may be underestimated. The problem of separating catches from troll and pole-and-line gears were discussed and USA scientists noted that it is likely that catches by these gears will not be separated in the future; a final decision will be made by July 2011.

The WG noted that aggregated monthly Category II catch-effort data were not provided and asked the USA to include these data in its fishery reports in the future.

3.6 Updating and Adoption of Catch Table (ISC/11/ALBWG/16)

The WG reviewed a revised version of the north Pacific albacore catch and effort (vessel number) Tables 1 and 2. Updated values were provided during the meeting or extracted from the fishery reports provided by member nations to finalize the catch table for the 2011 Plenary. The updated tables were approved and adopted as ISC/11/ALBWG/16 on 8 June 2011 and are attached to this report as Appendix 6. No updates were received from Korea, China, for the Taiwan offshore longline (STLL) fisheries, or from non-member nations providing data through submissions to the SPC.

A question was asked about whether Chinese longline catch data in the north Pacific for 1988 to 2010, which were obtained via the WCPFC in 2010, were incorporated into the ”Other longline” category. The data manager, John Childers, indicated by email that data from 2004-2009 were incorporated into the “Other Longline” category of the catch table.

The updated catch table (Appendix 6) includes revisions to some 2008 and 2009 catch data, which were generally less than 1,000 t. The 2011 stock assessment is based on an earlier version of the catch table approved 15 December 2010 and so does not use the updated figures for 2008 and 2009 nor the 2010 data.

3.7 Data Issues for the Statistics Working Group (STATWG)

The WG Chair requested that WG members discuss data issues or ISC database issues that should be raised for action by the STATWG. The WG noted that it was important to report effort data as well as catch data in national reports. The WG was concerned with data reporting from China. Last year Chinese catch data for 1988 to 2009 were obtained from the SPC. It is not known if 2010 data are available. Lastly, Korea has not reported 2010 fishery data, despite attempts by the WG Chair to obtain these data.

The WG chair discussed inconsistencies between submitted data and metadata in the ISC database raised in an email to WG Chairs on 17 May 2011 from the database administrator, Izumi Yamasaki. WG members agreed to address the specific questions and comments from the DA as soon as possible.

The procedures for archiving assessment models and data files was raised as issue for the STATWG.

4.0 Work Assignments

The WG defined spatial and temporal fisheries for length-based modeling and reviewed the data to be used in the modeling at a data preparation workshop in October 2010 (ALBWG 2010). The data review identified several issues requiring further attention and resolution prior to commencing the assessment. These issues were assigned to WG members and the results of their work and WG decisions based on these results, are reported in this section.

4.1 Comparison of length compositions from Taiwan longline, Japan pole-and-line, and U.S. longline fisheries (ISC/11/ALBWG/04)

Summary — The objective of this study was to compare the length compositions of the Taiwan longline fishery early (TWN LL-1: 1996-1998) and late periods (TWN LL-2: 2003-2008), Japan pole-and-line (large fish) (JPN PL), and the USA swordfish-targeting longline (USA LL) fisheries. Overall length compositions were derived for these four fisheries from logbook, observer, and port sampling data. As has been previously observed, the length compositions for TWN LL-1 and TWN LL-2 are dissimilar. However, the USA LL had a similar length composition to TWN LL-2, indicating that TWN LL-2 has relatively representative length compositions for that period. However, neither JPN PL nor USA LL length compositions were similar to TWN LL-1. Therefore, mirroring the selectivity of TWN LL-1 to JPN PL or USA LL may not be ideal. If the ALBWG considers the TWN LL-1 length compositions to be approximately representative of the albacore caught by the TWN LL fishery during that period, it may be more appropriate to use the 'super-year' concept to estimate a selectivity curve from the length composition data during the early period.

Discussion: Previous albacore assessments in 2004 and 2005 have struggled with TWN LL size composition data. The problem is that in the early period (1996-1998), size composition sampling is not considered representative of the fishery either spatially or temporally and the available data are qualitatively different than data from the later period. The early period had higher proportions of smaller fish and their length compositions were highly variable whereas the modes during the late period are relatively stationary and the fish are larger.

There was discussion about removing the TWN LL size data entirely for the early period (1996-1998) or conducting a sensitivity analysis in which the length composition data were further down-weighted. The Modeling Subgroup conducted a number of trials using the quarterly size data and recommended the 'super-year' approach (see Appendix 4). One concern raised about this recommendation is that any trends in the quarterly size data for the years aggregated into the 'super-year' would be lost. However, because it is for a short period when the TWN sampling program was ramping up and the sampling involved relatively few fish, the WG agreed to use the 'super-year' approach for the early TWN LL size data in the SS3 base-case model.

4.2 Updated time series associated with albacore fisheries based in the Northeast Pacific Ocean (ISC/11/ALBWG/05)

***Summary* —** During the October 2010 ALBWG meeting, U.S. scientists presented detailed descriptions of the data sources and methods used to develop time series for albacore fisheries in the Northeast Pacific. The ALBWG reviewed these time series, accepted the VPA time series and suggested some changes to the SS3 time series: 1) catch in metric tons rather than number of fish, and 2) changing the gear filter on the size composition database for the U.S. troll fishery to remove large fish that were not part of the troll fishery. Details on updates to the time series are presented in this working paper. All time series have been updated to include data from 2009. Otherwise, all VPA time series remained the same as previously described. However, several changes were made to the SS3 time series. Most importantly, catch time series are now in metric tonnes rather than thousands of fish. Improvements were also made to the U.S. troll length compositions by improving the gear filter on the database. Methods and data sources for the U.S. longline length composition data and all CPUE time series remained the same.

Discussion: It was pointed out that the USA LL CPUE index might be improved by separating the shallow-set and deep-set fisheries. In response, it was noted that the shallow-set swordfish and the deep-set bigeye fisheries, in which albacore are non-target catch, operate in different areas so the inclusion of an area term in the GLM used to standardize CPUE partly accounts for the different fisheries. The total landings for the USA LL fishery are a tiny proportion (< 0.5%) of the overall north Pacific albacore catch, and dividing the fishery further would likely have little effect on the assessment other than increasing the number of estimated parameters.

It was also noted that standardization of the USA/CAN troll fishery should consider calibrating for the change in operational area of this fleet since the late 1990s, i.e., a contraction in the area of operations from the western and central Pacific Ocean back towards the North American coast in the eastern Pacific Ocean (EPO). Simultaneously, the Japanese pole-and-life fishery underwent a similar contraction in operating range towards the Japanese coast at approximately the same time. It was also noted that the CPUE indices of the JPN PL and USA/CAN troll fisheries exhibit similar trends up to 2004, but then diverge for unknown reasons. The Working Group accepted the methods used to prepare the eastern Pacific fishery data for the assessment.

Future research after the assessment will explore separating out the two sectors of the USA LL fishery and standardization of the USA/CAN troll and JPN PL CPUE indices for the changes in operational areas that occurred through the 1990s and 2000s.

4.3 Estimation of alternative growth curve combining Japanese pole-and-line size data and reported growth curves (ISC/11/ALBWG/06)

***Summary* —** A growth curve for north Pacific albacore was estimated based on the modes in length frequency histograms of catch by the Japanese pole-and-line fishery and growth curves reported in other studies. Length data from 997,440 fish, ranging between 26 and 120 cm fork length (FL) in size, were used. Monthly length frequency histograms for each year were created and used to detect modes. Allocation of lengths to age was done based on studies in which a von Bertalanffy growth curve was fitted to the data. In several scenarios, length-at-age for large fish and L_∞ were borrowed from other studies. Estimates of growth curve parameters differed depending on the scenario (assumptions). The value of L_∞ was, if not fixed, close to that of growth curve for other studies whose length-at-age for large fish were used and whose length-at-age was used for allocation of length to age. It seems that L_∞ from the Suda (1966) growth curve is implausibly large.

Discussion: The Working Group noted that the hybrid growth curves estimated in this paper reveal the influence of growth assumptions on estimates of L_∞ and K, especially assumptions concerning the growth of large fish. The WG noted that the results in this working paper are more or less consistent with those in ISC/11/ALBWG/02. The WG was pleased with this work, but concluded that it would not affect the choice of a growth curve for the SS3 base-case model because it was no longer considering the use of fixed growth curve parameterization in the base-case model (see Appendix 4).

4.4 Fork length at 95th percentile of cumulative length frequency as an indicator of maximum length for albacore prior to 1965 (ISC/11/ALBWG/19)

Summary **—** During the October 2010 workshop in La Jolla, USA, the ALBWG noted that SS3 outputs may be sensitive to the growth curve used in the model and that the L_∞ value in the reference case, 146.46 cm, (from Suda 1966), may be too high. The ALBWG proposed that a more appropriate L_∞ value could be approximated from estimates of the 95th percentile of the cumulative length frequency distributions of both the USA and JPN LL fisheries. In this paper, fork lengths at the 95th and 99th percentiles of annual cumulative length frequencies and maximum fork length for albacore in the Japanese longline fishery in the north Pacific Ocean from 1948 to 1965 are examined to assess suitability of the L_∞ value estimated by Suda (1966). Fork lengths at the 95th and 99th percentiles were between 98 and 115cm and 108 and 119cm, respectively, in 1948–1964. The maximum size measured during this period ranged between 117 and 130cm FL. Based on these results, it was concluded that the size of albacore caught by Japanese longline fisheries prior to 1965 was less than 130 cm FL (consistent with findings for the USA LL fishery), and that these sizes are smaller than the L_∞ value (146.46 cm FL) estimated by Yabuta and Yukinawa (1963).

Discussion: The WG noted that the 95th and 99th percentile values are lower than the asymptotic size of the Suda growth curve (146.46 cm FL) and so support using a smaller maximum size when modeling growth in the base-case model. The dataset that Suda used was compiled when the JPN LL fisheries (larger fish) operated in the western Pacific and mostly captured albacore < 120 cm FL; fish > 120 cm FL are more commonly found in the central Pacific and so were not available to the JPN LL fishery during this period. Thus, differences in estimates of L_∞ (and other growth curve parameters) could be related to a regional bias in sampling or regional differences in growth.

5.0 Biological Studies

5.1 Age and growth of North Pacific albacore (ISC/11/ALBWG/02)

Summary **—** Age and growth of North Pacific albacore (*Thunnus alalunga*) were assessed by examining annual growth increments in sagittal otoliths from 338 fish collected throughout the North Pacific Ocean. A wide size range of albacore (53-128 cm fork length, FL) was collected in the western, central and eastern Pacific Oceans in an attempt to incorporate size-at-age information over juvenile, sub-adult, and adult life history stages. Overall, ages ranged from 1 to 15 years with the majority of fish between 2 to 4 years of age. Growth models fit otolith-based size-at-age well and a bias-corrected form of Akaike's Information Criterion indicated that the specialized von Bertalanffy (VB) model provided the best fit. Biological parameters of the specialized VB model included $L_\infty = 120.0$ cm, $K = 0.184$ yr^{-1}, and $t_0 = -1.945$ yr. Daily ages of several age-1 fish (55-61 cm FL) were also determined and confirmed that annual age class assignments were correct with daily ages ranging from 378 to 505 days. In addition to otolith-based techniques, dorsal fin spines and length frequency (LF) analysis were used to generate estimates of size-at-age. In general, fin spine ages matched otolith-derived ages (85% of samples) and results of the VB growth model generated from LF analysis provided similar size-at-age for the first five age classes, but estimated smaller sizes for fish ages 6 to 9, which may be a product of the limited size distribution from fishery-dependent data. Results from this preliminary age and growth research suggest North Pacific albacore are a relatively long-lived tuna species and provides updated biological parameters that may be useful to future stock assessment models incorporating age-specific life history information.

Discussion: This paper and the postponement of the workshop led to considerable discussion and exploratory analysis among WG members via email concerning albacore age and growth. Appendix 7 documents these results as background information to the Modeling Subgroup recommendation on growth and the decision by the WG to accept this recommendation.

ISC/11/ALBWG/02 provides the first new data on north Pacific albacore age and growth in at least a decade. The WG concluded that the otolith data will be used as conditional age-at-length information in the base-case model.

Fractional ages were assigned to otoliths based on a May 1 birth date in this paper. A question was asked about the birth date used in SS3 and how the model accounts for fractional ages. Rick Methot (the architect of SS) responded by email that SS assumes a January 1 birth date and that the model uses integer ages only. The ages reported in the paper for 20 otoliths collected from the JPN LL fishery between Jan and May were rounded up to the integer year for use in the assessment model. Fractional ages of fish caught from May onwards were rounded down to the integer year for use in the assessment model.

It was noted that the von Bertalanffy growth curve does not fit the pattern of growth in young albacore very well. The aging of young fish in this working paper was validated by daily ring counts up to about age-1 and by annual rings on dorsal fin-rays up to about age-3 and so is considered reasonably reliable. The poor fit to young fish might be caused by regional differences in growth rates. Most of the data for large fish are from the northeastern Pacific, while Suda (1966) is based on samples from the western Pacific, where smaller fish predominate.

5.2 Age and growth of albacore *Thunnus alalunga* in the North Pacific Ocean (ISC/11/ALBWG/IP/01)

Note: This paper was in review for publication in the *Journal of Fish Biology* at the time of this workshop. Although the paper was submitted after the submission deadline, it was accepted because it contains new data concerning age and growth of north Pacific albacore.

Summary **—** Age and growth of North Pacific albacore (*Thunnus alalunga*) were investigated using obliquely sectioned sagittal otoliths in samples of 126 females and 148 males. The results obtained in otolith edge analysis indicated that the zones composed of relatively compact micro-increments in sectioned otoliths are annual growth marks and are mainly formed during September and February. The results of the age evaluation of first annulus formation indicated that the first annulus does not represent the growth of a complete year. An age estimate (0.75 yr) for first annulus formation is proposed in this study. The oldest fish age observed in this study was 10 years old for females and 14 years old for males. The von Bertalanffy growth parameters [L_∞ (cm FL), K (yr^{-1}), t_0 (yr)] obtained were 103.5, 0.340, −0.53 for females and 114.0, 0.253, −1.01 for males. Sexual size dimorphism between males and females seemed to occur after reaching sexual maturity. A power function for expressing the length-weight relationship obtained by sex-pooled data was $a = 2.964 \times 10^{-5}$ and $b = 2.928$.

Discussion: This working paper used obliquely sectioned otoliths rather than a transverse section, which is the more common technique. The oblique sectioning method was not fully validated in the paper and otoliths were read by one person and as a result the accuracy and precision of ages produced by this technique are not known. The von Bertalanffy growth curve parameter estimates, especially L_∞, differ from those estimated in ISC/11/ALBWG/02 and in preliminary SS3 model runs (see Appendix 7). Furthermore, the estimate of L_∞ is inconsistent with existing size composition data for the TWN LL fishery, in which some fish larger than 130 cm are observed. The WG suggested that these differences may reflect regional bias in sampling since the albacore in this study were sampled from the western Pacific Ocean only. This paper also presents evidence of statistically significant sex-related differences in growth rates after age 6, with males reaching a larger maximum size than females. The WG noted that albacore fishery data are not sex-specific so there was no way to use this finding in the assessment model.

6.0 Stock Assessment Studies

6.1 Probable Values of Stock-Recruitment Steepness for North Pacific Albacore Tuna (ISC/11/ALBWG/11)

Summary **—** The simulation method of Mangel et al. (2010) was used to estimate probable values of stock-recruitment steepness for a Beverton-Holt stock-recruitment curve for north Pacific albacore (*Thunnus alalunga*). Information on albacore life history parameters including growth, maturity at age, average weight at length, natural mortality rate and reproductive ecology

of albacore tuna was used. Mean steepness ranged from 0.84 to 0.95, depending upon the choice of growth curve. Sensitivity analysis to the assumed value of age-0 natural mortality found that increasing the natural mortality rate schedule reduced the estimates of mean steepness, regardless of the assumed growth curve used. The authors conclude that the mean steepness of North Pacific albacore stock-recruitment relationship was less than 1.0, and that assuming a mean steepness of 1.0 (as in the last assessment) is biologically implausible because it implies that there is an infinite amount of compensation in the stock-recruitment relationship.

6.2 Calculation of the steepness for the North Pacific Albacore (ISC/11/ALBWG/18)

Summary — The steepness of the stock-recruitment relationship affects the results of a stock assessment and the stock management strategy. In this working paper, the steepness of the stock recruitment relationship for north Pacific albacore is estimated using the model proposed by Mangel et al. (2010). Mean steepness was estimated to be 0.95, assuming the von Bertalanffy growth curve fitted to otolith data in ISC/11/ALBWG/02. Sensitivity analysis for the assumptions of early life history longevity and maximum age shows that the estimated steepness increases as the length of the early life history period increases and maximum age in the stock increases. Steepness was not sensitive to the assumed age at 50% maturity. Based on the fact that the estimated steepness of the relationship is close to 1.0, environmental forcing is probably an important determinant of recruitment strength in the north Pacific albacore stock.

Discussion: The WG noted that the estimated steepness of the stock-recruitment relationship is related to the length of the early life history period in the analyses in ISC/11/ALBWG/11 and 18 and that there the definition of this period is ambiguous. The growth curves used in both ISC/11/ALBWG/11 and 18 were different shapes than the curve used in the base-case model. A plot of stock size and recruitment estimates is not informative concerning steepness. The WG discussed how to proceed based on these working papers and concluded that it would continue with the assumption of h = 1.0 in the base-case model, but include a sensitivity run assuming h = 0.85. However, the WG recognized that estimating steepness using Mangel et al.'s method is difficult because it depends largely on ambiguously specified parameters of the early life history of the fish. The definition of $F_{SSB\text{-}ATHL}$ implicitly assumes a stock-recruitment relationship since it seeks to prevent recruitment overfishing by maintaining SSB above the SSB-ATHL threshold (ATHL – average of the ten historically lowest estimated SSBs). It was concluded that this reference point would not provide an overly optimistic view of current stock status even with the assumed steepness (h) of 1.0 in base-case model. Further research on plausible steepness values prior to the next assessment is recommended.

7.0 Model Description - Parameterization and Assumptions

A seasonal, length-based, age-structured, forward-simulation population model was used to assess the status of the north Pacific albacore stock. The model was implemented using Stock Synthesis (SS) Version 3.11b (Methot 2011; http://nft.nefsc.noaa.gov/Stock_Synthesis_3.htm). Subcomponents within SS include a population model, an observation model and a statistical model. The population model is used to simulate the size structure of the population and the observation model uses the data inputs and selectivity functions to relate the simulated population to the data. The statistical model estimates best-fit model parameters by maximising a log-likelihood objective function, consisting of both likelihood (data) and prior information components. The base-case model is compared with a VPA reference run in order to understand and explain model-related differences in outputs, but only outputs from the SS model were used to assess current status and develop recommendations on conservation to managers. In this section, the base-case model parameterization, data sources, structural uncertainties, and the context for key sensitivity analyses regarding fishery data, biological parameters, and other modeling assumptions are described.

7.1 Stock Structure

North Pacific albacore tuna is assumed to be one well-mixed stock inhabiting the Pacific Ocean north of the equator from 10°N to 55°N latitude and between 120°E and 120°W longitude. This area includes all of the known catches of albacore in the north Pacific Ocean between 1966 and 2009 (Figure 7.1) and is supported by evidence from genetic, tagging, and seasonal fishing pattern studies (Suzuki et al. 1977; Chow and Ushima 1995; Takagi et al. 2001; Ichinokawa et al. 2008a).

7.2 Movements

North Pacific albacore are highly migratory and these movements are likely influenced by oceanic conditions (e.g., Polovina et al. 2001; Zainuddin et al. 2006, 2008). Details of the migration remain unclear, but seasonal movements have been observed (Ichinokawa et al 2008a), especially among juvenile fish (less than 5 years old; Childers et al. 2011). A portion of the juvenile fish are believed to move into the eastern and western Pacific Ocean in the spring and early summer, returning to the central Pacific Ocean in the late fall and winter where mixing among the eastern and western juveniles probably occurs. Adults tend to be distributed more widely than juveniles and migrate to lower latitudes to spawn. In this assessment, albacore were assumed to be distributed throughout the north Pacific Ocean, and region and season-specific movement rates were not explicitly modeled. However, region and season-specific fishery definitions were used to represent differences in the availability of different-sized fish in different regions and seasons (see Section 7.4).

7.3 Biology

7.3.1 Growth

Preliminary modeling during the October 2010 workshop (ALBWG 2010) demonstrated that there is uncertainty in growth curve parameter estimates and that the SS model outputs may be sensitive to growth curve parameterization, i.e., fixed or estimated, and the form of the curve. The WG established through additional runs and email discussion prior to this workshop (see Appendix 7) that estimating growth within the SS3 model resulted in the best fit to the length data and that the resulting growth parameter estimates were corroborated by independent parameter estimates produced when a von Bertalanffy curve was fitted to the otolith data in ISC/11/ALBWG/02. Based on these findings, the WG used a von Bertalanffy growth function to model the relationship between fork length (cm) and age for north Pacific albacore within the base-case model:

$$L_A = L_\infty + (L_1 - L_\infty)e^{-K(1-A)},$$

where L_A is the length-at-age A, L_∞ is the theoretical maximum length, K is the growth coefficient, and L_1 is the size of the youngest fish (A_1). The asymptotic length, L_∞, is:

$$L_\infty = L_1 + \frac{L_2 - L_1}{1 - e^{-K(A_2 - A_1)}},$$

where L_1 and L_2 are the sizes associated with ages near the youngest A_1 and oldest A_2 ages in the data. In this assessment, L_1 and L_2 were chosen as size at age 1 and L_∞, respectively. The growth parameters K, L_1, L_∞, and CVs for L_1 and L_∞, were estimated in the SS model to account for the variability in size-at-age distributions. Conditional age-at-length data from ISC/11/ALBWG/02 (see Section 5.1) were used to help with the estimation of these growth parameters since preliminary modeling results also showed that they stabilize the growth curve parameter estimates with respect to different model configurations.

The 2006 assessment (ALBWG 2007) used a hybrid growth curve in which mean length-at-age of juvenile albacore was estimated from surface fishery data and the mean length-at-age of adult albacore was approximated using the Suda (1966) growth curve. Suda's parameter estimates were 40.2 cm for L_1, 146.46 cm for L_∞, and 0.149 yr^{-1} for K. The WG concluded that Suda's (1966) estimated growth curve was not representative of the relationship between length and age in north Pacific albacore (see Section 5). However, a sensitivity run was performed in which the growth curve parameters in the SS3 base-case model were fixed to Suda's (1966) estimates for comparison with the 2006 assessment.

Although there is evidence of sexually dimorphic growth in the western Pacific Ocean (ISC/11/ALBWG/IP/01), the available fishery data are not sex-specific so both sexes are combined in the assessment model.

7.3.2 Weight-at-Length

Weight-length relationships are used to convert catch-at-length to weight-at-length data. A previous study (Watanabe et al. 2006; ISC/06/ALBWG/14) reported that there were seasonal differences in the relationship between weight (kg) and fork length (cm) of north Pacific albacore. The seasonal weight-at-length relationships used in this assessment are:

$$\text{Quarter 1 (Q1): } W_L(kg) = 8.7 \times 10^{-5} L(cm)^{2.67},$$
$$\text{Quarter 2 (Q2): } W_L(kg) = 3.9 \times 10^{-5} L(cm)^{2.84},$$
$$\text{Quarter 3 (Q3): } W_L(kg) = 2.1 \times 10^{-5} L(cm)^{2.99},$$
$$\text{Quarter 4 (Q4): } W_L(kg) = 2.8 \times 10^{-5} L(cm)^{2.92},$$

where W_L is weight at length L. These seasonal weight-at-length relationships were applied as fixed parameters in the SS model.

7.3.3 Maturity

Following Ueyanagi (1957), 50% of the albacore at age-5 and all fish age-6 and older are assumed to be mature. This maturity ogive was also used in the 2006 assessment (see Uosaki et al. 2006; ISC/06/ALBWG/19). However, since the 2011 assessment employs a length-based model, a sensitivity run using a length-based maturity schedule was conducted.

7.3.4 Spawning and Recruitment

North Pacific albacore probably spawn over an extended period from March through September in the western and central Pacific Ocean. Recent evidence based on a histological assessment of gonadal status and maturity (Chen et al. 2010a) shows that spawning in the western Pacific Ocean peaks between March-April, which is consistent with evidence from larval sampling surveys in the same region (Nishikawa et al. 1985). In contrast, studies of albacore reproductive biology in the central Pacific have concluded that there was a probable peak spawning period between June and August (Ueyanagi 1957; Otsu and Uchida 1959). Although albacore spawning may occur over an extended period, the WG assumed that there is one spawning and recruitment period in the second quarter of the year (Q2) based on the evidence from Nishikawa et al. (1985) and Chen et al. (2010a).

A standard Beverton and Holt stock-recruitment model was used in this assessment, with steepness (*h*) fixed at 1.0 (see section 6.0), because the likelihood profile on h shows minimum total likelihood occurs at h = 1.0 with the base-case model. The standard deviation of log-recruitment (sigmaR) was fixed at 0.6. The log of the virgin recruitment level, R_0, and annual recruitment deviates were estimated by the SS3 model. The offset for the initial recruitment relative to virgin recruitment, R_1, was assumed to be negligible and fixed at 0. Based on preliminary runs during the Modeling Subgroup meeting (Appendix 4), three eras are assumed for recruitment: early (1954-1968), main (1969-2007), and late (2008-09). Bias adjustment for recruitment was performed during the main era, but not during the early or late eras. A sensitivity analysis was performed in which steepness (*h*) was assumed to be 0.85 based on the findings in ISC/11/ALBWG/11 and ISC/11/ALBWG/18.

7.3.5 Natural Mortality

The natural mortality rate (M) was assumed to be 0.3 yr^{-1} across all ages, which is the same assumption used in the 2006 assessment (Uosaki et al. 2006; ISC/06/ALBWG/19) as no new data or analyses that support a change in this assumption are available. A sensitivity analysis assuming an M of 0.4 yr^{-1} (average M of the mortality vector assumed for south Pacific albacore; see Hoyle and Davies 2009) was performed.

7.3.6 Maximum Age

In this assessment, the maximum age of north Pacific albacore was assumed to be 15 years, which is the age of the oldest fish reported in ISC/11/ALBWG/02.

7.4 Fisheries

More than 50% of the albacore harvested in the north Pacific Ocean since 1952 have been taken in surface fisheries that catch smaller, predominately juvenile albacore. The major surface fisheries are the CAN troll, USA troll and pole-and-line fisheries, and the JPN PL fisheries. Longline fisheries tend to catch less than 50% of north Pacific albacore by weight and generally catch larger and older albacore. The major longline fisheries are the JPN and TWN LL fisheries. Total annual catches of albacore in the north Pacific Ocean peaked in 1976 at about 126,000 t, declined to the lowest level in 1991 at about 37,000 t, then increased to a second peak in 1999 at about 125,000 t (Figure 7.2).

Sixteen fisheries were defined on the basis of gear, location, season, and the unit of catch (numbers or weight) (Table 7.1). The aim was to define fisheries so that temporal changes in size distributions were relatively limited over the time series, especially seasonal differences. Preliminary analysis revealed strong seasonal differences in the size of fish caught (and hence temporally varying selectivity) in two fisheries (F6 and F7), which resulted in the decision to split these fisheries further into seasonal fisheries (F6s1, F6s2, F7s1 and F7s2) (see Appendix 4 for details). The operational areas of all defined fisheries are shown in Figure 7.3.

7.5 Data

Data used in this assessment included fishery-specific catches, length compositions, abundance indices, and conditional age-at-length data. These data were compiled and frozen for the assessment as of 15 December 2010. Data sources (fisheries) and temporal coverage of the available datasets are summarized in Figure 7.4.

The time period modeled in this assessment is 1966−2009. Within this period, catch and size composition data were compiled into quarters (Jan−Mar, Apr−Jun, Jul−Sep, Oct−Dec). Although some fisheries have catch data time series extending back to at least 1952, size composition sampling programs were either inconsistent or non-existent prior to 1966 and effort and location information are not always reliable.

7.5.1 Catch

This assessment used quarterly catch data from 1966 to 2009. Time series of quarterly catch were developed using logbook data so that the annual catch was consistent with the Category I data archived in the ISC-ALBWG database catalogue. Catch was reported in metric tons (t) for most fisheries, except for catches from the JPN OLLF1 and OLLF2 (F6s1, F6s2, and F8) and TWN LL (F12) fisheries, which were reported in 1,000s of fish. Catch was treated as known with negligible error. The historical catches used in this assessment are shown in Figure 7.2.

7.5.2 Abundance Indices

Annual indices of relative abundance were developed for eight fisheries (Table 7.2, Figure 8.1). Estimated annual values and CVs for each index are shown in Table 7.3. A season was assigned to each index based on the annual quarter in which the majority of catch was recorded. Visual inspection of all CPUE indices grouped by fishery type (surface or longline) showed that they exhibit similar trend patterns. Correlations between all surface indices and all longline indices were reasonably positive, which the WG interpreted as indicative of consistency among CPUE series, i.e., they do not exhibit major conflicts. However, a discrepancy in recent trends since 2000 between S2 (USA LL) and the other longline indices was noted. This discrepancy may be due to the relatively small area of operation of fishery F2 (USA LL) and is considered a signal that the reliability of this index as an indicator of overall abundance is low relative to other indices. Details of the methods and sources of data used to derive these indices can be found in references shown in Table 7.2. The coefficients of variation (CVs) of these indices were fixed in the base-case model based on the WG's judgement concerning the reliability of each index as an indicator of overall albacore abundance (see Section 7.7 for details).

Seasonally separated and annual CPUE indices for F6 were examined during the Modeling Subgroup meeting (Appendix 4). The S6 annual index is largely driven by the first quarter (Q1) CPUE index in this fishery and it was noted that catch in Q1 of F6 is the largest component of the JPN LL catch and therefore it was important to include in the model. The S6 index is the annual CPUE index for F6 rather than a true Q1 index. The WG agreed to this approach because there was no working paper supporting the development of the quarterly index at the workshop and because it was not possible to calculate a quarterly index once the data were frozen for the assessment as per ISC policy. Further research to document the methods used to develop a quarterly index for F6s1 and the characteristics of that index is a high priority recommendation for the next assessment.

7.5.3 Length Composition Data

This assessment used quarterly length composition data from 1966 to 2009. Length frequency data were available for eight fisheries (Figure 7.5) and were compiled using 1-cm size bins for 26-90 cm, 2-cm size bins for 90-100 cm, and 4-cm size bins for 100-140 cm, where the labels mark the lower boundary of each bin as required by SS. Each length frequency observation consisted of the actual number of albacore measured for most fisheries and catch-at-size data for JPN PL and JPN LL fisheries. Most of these fisheries exhibit clear and relatively stationary modes for a given quarter throughout the time series (Figure 7.5).

Fork lengths of albacore for JPN LL (F6s1, F6s2, and F8, 1966-2009), and JPN PL fisheries (F4 and F5, 1968-2009) were measured to the nearest cm at the landing ports or onboard fishing vessels. Catch-at-size data were derived from the actual size data by the National Research Institute of Far Seas Fisheries (NRIFSF) (see ISC/11/ALBWG/08).

Fork lengths of albacore (to the nearest cm) for the UCLTN and pole-and-line fishery (F1, 1966-2009), and USA LL fishery (F2, 1994-2008) were collected through port sampling and longline observer programs, respectively, and were compiled by the Southwest Fisheries Science Center (SWFSC) (Teo et al. 2010; ISC/10-3/ALBWG/02). Length composition data from the CAN component of the UCLTN fishery were not used in this assessment because the WG considered the data from the USA component to be representative of the entire fishery. Length compositions for the USA LL fishery in 2009 were not used in this assessment due to errors in the database for that year.

Fork lengths of albacore (to the nearest cm) for the TWN LL fishery (F12, 1995-2009) were measured onboard fishing vessels and compiled by the Overseas Fisheries Development Council (OFDC), Taiwan (Chen et al. 2010; ISC/10-3/ALBWG/08). The WG previously concluded that length composition data from several years (1995, 1999, 2000, 2002) were not representative of the TWN LL fishery in terms of spatial and temporal scope. In addition, length composition data were not available for 2001 nor during the historical period from 1966 to 1994. Previous analysis demonstrated that length compositions from 1996-1998 were substantially different from the length compositions from 2003-2009 due to changes in the fishing operations of this fishery (Chen et al. 2010b, ISC/10-3/ALBWG/08; ISC/11/ALBWG/04).

Length composition data from the early period of the TWN LL fishery (1996-1998) were combined into a single 'super-year' in order to reduce the influence of observed inconsistencies during this period (ISC/11/ALBWG/04). A super-year blends size data across multiple years and causes the model to calculate an expected length composition for each time period in the super year sequence. All of these expected compositions will have equal weight in the calculation of the expected super-year value.

Effective sample sizes for length composition data of all fisheries were scaled to the average number of trips for the UCLTN fishery (N ~ 113.65), such that the average effective sample size for each fishery is equal to 113.65.

7.5.4 Conditional Age-at-Length

Otolith-based ages and fish sizes (fork length, cm) from ISC/11/ALBWG/02 were used to construct conditional age-at-length data for four fisheries (F1, F2, F6s1, and F8). The ages assume a birth date of 01 May and as a result fractional ages of fish sampled prior to 01 May were rounded up while those sampled after 01 May were rounded down since the base-case model assumes integer ages. Otolith-based ages from this study are assumed to have standard errors of ±2 years for fish older than 5 years and ± 1 years for fish 5 years and younger.

7.6 Initial Conditions

Initial fishing mortality was estimated for two surface (F1, F4) and one longline fishery (F7) and the initial equilibrium catch was calculated as the 14 year average of total catch (1952-1965) in these fisheries. The average catch in F1, F4, and F7 was 19,499, 28,575, and 18,180 t, respectively.

7.7 Data Weighting

Two types of weighting were used in the model: (1) weighting of the different data types (sources of information, e.g., length compositions, abundance indices, and conditional age-at-length) relative to each other, and (2) relative weighting among CPUE indices. Length composition and conditional age-at-length data from all fisheries were down-weighted by using lambda values of 0.01 and 0.1 respectively, relative to the abundance indices with a lambda of 1.0. A sensitivity run was conducted in which the length composition data were up-weighted relative to the base-case using a lambda of 0.025. An additional sensitivity run was conducted to assess the impacts when conditional age-at-length data are not down-weighted (lambda = 1.0).

There is no objective method of establishing weightings (lambda) for different information sources in the SS model. The WG compared SSB estimates from preliminary base-case model runs with values reported for other tuna stocks, particularly south Pacific albacore (Table 7.4) and on this basis down-weighted the length composition data (lambda = 0.01) so that the scaling of the estimated quantities was considered biologically plausible and consistent with productivity reported in other assessments.

The WG considered S6 (CPUE index of F6s1) to be the most reliable indicator of albacore abundance and tuned the base-case model to S6 by assuming a fixed CV of 0.2. The CV is a measure of the weighting of these data in the model, with a lower CV (higher weighting) forcing the model to fit the index more tightly than an index with a higher CV value (lower weighting). The relative weightings (CVs) used for the other CPUE indices in this assessment, based on the WG's judgement of their reliability as indicators of albacore abundance, were:

1. S1 = 0.4 (1966-1999), 0.5 (2000-2009);
2. S2 = 0.5;
3. S3 = 0.3;
4. S4 = 0.3;
5. S5 = 0.4 (1985-2003), 0.5 (2004-2009);
6. S7 = 0.4; and
7. S8 = 0.5.

Both S1 (from F1 – UCLTN) and S5 (from F5 – JPN PLSF) have two weightings, depending on the time block. Both of these indices are surface fishery indices and the down-weighting of these indices in recent years (CV = 0.5) relative to the earlier periods (CV = 0.4) reflects a change in the operational area of each fishery from broad areas of the Pacific Ocean early in the time series towards the coasts of North America and Japan, respectively, in recent years. A sensitivity analysis was performed to check these weightings by fixing the CV of S6 at 0.2 and estimating the CVs of the other indices in the model, i.e., allow the data to determine the weightings.

7.8 Selectivity

Selectivity in the assessment model is fishery-specific and is assumed to be length-based. Selectivity affects the size distribution of the fish removed from the population and the expected length-frequency distribution and is, therefore, an influential component of the model given the relative importance of length-frequency data in the total log-likelihood function. Selectivity patterns were estimated for all fisheries with length composition data.

Selectivity patterns for all surface fisheries (F1, F4, F5) were assumed to be dome-shaped and constant over time. In order to improve the robustness of the F4 selectivity pattern, the width between the ascending and descending limbs (the top) was fixed at a value of -4. The initial and final parameters of the dome-shaped selectivity patterns were not estimated by the model; all other selectivity parameters were estimated.

Selectivity patterns for the longline fisheries were either asymptotic (flat-topped) or dome-shaped, depending on the size of fish encountered by the fishery. Since the largest albacore were caught by F2 and F8, asymptotic selectivity was assumed for F2 and F8. However, dome-shaped selectivity was assumed for F6 and F12 because inspection of the length composition data demonstrated that these fisheries caught smaller fish than F2 and F8. Two time-periods were implemented for selectivity in F2 (2001-2004, other years), F6s1 (1966-1992, 1993-2009), and F12 (1995-2002, 2003-2009) to account for time-varying length composition data observed in these fisheries. Sensitivity runs for selectivity assumptions were conducted in which the selectivity of F6s1 was assumed to be asymptotic and time blocks were removed one-by-one from the F2, F6s1, and F12 selectivity patterns.

Selectivity patterns of fisheries without length composition data were mirrored to the selectivity patterns of fisheries with similar operations, area, and season for which a selectivity pattern was estimated. Mirrored selectivity patterns were as follows:

1. F3 mirrored F1;
2. F7s1 and F13 mirrored F6s1;
3. F7s2 mirrored F6s2;
4. F9 mirrored F8; and
5. F10 , F11 and F14 mirrored F5.

7.9 Catchability

Catchability (Q) is estimated using the assumption that survey indices are proportional to vulnerable biomass with a scaling factor of Q and is assumed to be constant over time for all indices.

8.0 Results

8.1 Model Fit Diagnostics

Model fits to the data and likelihood components were systematically checked by the WG. Total likelihood for the base-case model was approximately 67.4 units.

8.1.1 Abundance Indices

Model fits to CPUE indices were considered acceptable given the relative weightings (CVs) on these indices (Figure 8.1). The fit to S1 (F1 - UCLTN) was poor from 2005-2009 when trends in this index conflict with trends in S4 (F5 - JPN PLSF). The model does not fit S2 (F2 – USA LL) well, exhibiting positive residuals early in the series and negative residuals in recent years. This poor fit may be related to the limited area of this index relative to the area of the stock and standardization may not have accounted for changes in catchability related to regulatory changes experienced by this fishery (e.g., a 2001-2004 closure of the shallow-set swordfish component of this fishery).

8.1.2 Length Composition

Model fits to length composition data aggregated by fleet were good (Figure 8.2) considering that the length composition data were down-weighted in the model with lambda = 0.01 (see Section 7.6.2). These fits may be the result of the clear and relatively stationary modes in the data (Figure 7.5). Pearson residual plots of length composition fits show positive residual patterns, especially for large fish in F6s1 (mid-1980s to early 1990s) and F8 (1980s to mid-1990s) (Figure 8.3). The WG considered these fits acceptable given the time blocking applied to selectivity patterns of some fisheries and the down-weighting of the length composition data.

8.1.3 Conditional Age-at-Length

The estimated growth model fit the conditional age-at-length data relatively well, especially older fish from F1, F2, and F10 (Figure 8.4). However, estimated length-at-age was slightly higher than expected for data from F6 and lower than expected for age-1 and age-2 fish from F1. These poor fits to the data may be indicative of regional differences in growth that are assumed to be negligible in this model, but will be investigated in the period between assessments.

8.2 Model Parameter Estimates

8.2.1 Growth

The estimated parameters values for the von Bertalanffy growth model in this assessment were L_1 = 44.4 cm, L_∞ = 118.0 cm, K = 0.2495 yr^{-1}, CV_1 = 0.0599, and CV_2 = 0.0339. These estimates are similar to estimates of these parameters when a von Bertalanffy model was fitted to otolith data independently (ISC/11/ALBWG/02 - see Section 5.1). However, the growth model in this assessment is substantially different from the growth model based on Suda (1966) parameter estimates used in the 2006 assessment (Figure 8.4). The most noticeable differences are that the Suda growth model estimates a substantially larger L_∞ (146.46 cm) than this assessment and the Suda growth model does not fit the conditional age-at-length data for fish less the age-3 or older than age-6 well.

8.2.2 Selectivity

All selectivity parameters were relatively well estimated and within their boundaries, although the selectivity curve for F5 had a wider and flatter top than expected. After examining the estimated selectivity curves (Figure 8.5) and their associated length composition data fits, the WG concluded that the estimated selectivity curves were reasonable.

8.3 Stock Assessment Results

8.3.1 Total and Spawning Stock Biomass

Total stock biomass estimated by the base-case model exhibits different trends at the beginning, middle and end of the model period (Figure 8.6A). Biomass declines from approximately 1.0 million tonnes around 1971 to about 500,000 t by the late 1980s, followed by a steady increase to the highest estimated level (1.2 million tonnes) by 1996. Since the mid-1990s, stock biomass has been steadily declining to around 800,000 t by 2009 (Figure 8.6A).

Spawning stock biomass (SSB) estimated by the base-case model has gone through three phases during the modeled time period (Figure 8.6B): (1) an early phase from the 1966 to the mid-1970's when estimated SSB was relatively high around 400,000 t, (2) a middle phase during 1980's in which SSB declined to approximately 300,000 t, and (3) a recent period of higher SSB from the 1990's to 2009. During this recent phase, estimated SSB increased and reached its highest level in 1999 (about 504,000 t). The estimated SSB in 2009 is near the historical median of about 405,000 t (Table 8.1).

8.3.2 Recruitment

Average estimated recruitment was approximately 48 million fish annually and the CV of the recruitment time series was 0.24 (Table 8.1). Three periods were apparent in the estimated recruitment time series (Figure 8.6C): (1) a low recruitment period (1978-1987), and (2) two high recruitment periods (1966-1977, 1988-2009). These recruitment periods may reflect the influence of changing ocean conditions on stock dynamics, but existing research supporting this hypothesis is limited at present.

8.3.3 Fishing Mortality

Since retrospective analysis of the assessment model did not reveal any specific bias in estimates of terminal year fishing mortality (see Section 8.5), current fishing mortality for this assessment was defined as the age-specific geometric mean of the estimated annual instantaneous rate of fishing mortality from 2006 to 2008, ($F_{2006\text{-}2008}$). Juvenile albacore experience the highest fishing mortality while adult albacore experience a lower, but relatively stable level of fishing mortality (Figure 8.7). $F_{2006\text{-}2008}$ increases to a maximum at age-3 and then declines to a relatively low, but stable level through ages 7 to 15 (Figure 8.7). In addition, $F_{2006\text{-}2008}$ is consistently lower than $F_{2002\text{-}2004}$ (current fishing mortality in the 2006 assessment) up to age-6, after which both measures of F are similar.

8.4 Convergence (Jitter analysis)

Jitter analysis is a quality control procedure used to ensure that the model is not converging on a local minimum. Jitter values of 0.1, 0.2, and 0.3 were randomly added to all parameters and 50 trials were run for each jitter value (Figure 8.8). Five of 50 trials failed to converge when jitter values of 0.2 and 0.3 were added. Visual inspection of SSB plots shows that trends and levels are consistent with the base case, regardless of the jitter value applied. However, as jitter values increase, confidence intervals increased, perhaps due to changes in selectivity curves, but total model likelihood did not change, remaining at approximately 67 units. Based on these results, the WG concluded that the assessment model is relatively stable and is probably converging on a global minimum.

8.5 Retrospective Analysis

Retrospective analysis was conducted to assess the consistency of stock assessment results by sequentially eliminating one year of data while using the same base-case model parameterization. In this analysis, the WG removed up to four years of data and examined changes in SSB and recruitment as more data are removed from the model. The results of this analysis are useful in assessing bias and uncertainty in terminal year estimates.

Retrospective analyses were conducted by removing one year (2009), two years (2009 and 2008), three years (2009, 2008, and 2007) and four years (2009, 2008, 2007, and 2006) of data (Figure 8.9). The retrospective analyses show the same relative trends in the estimates of SSB, i.e., there is no pattern of differences consistent with bias in terminal estimates of SSB. Some uncertainty is present in terminal year point estimates of SSB, but the magnitude of this uncertainty is minimal relative to the confidence intervals around SSB estimates. In contrast, the retrospective analyses show that recent recruitment estimates tend to exhibit much higher uncertainty than SSB, but are not biased. Based on these results, the WG did not use recruitment estimates for 2008 and 2009 in the future projection analysis (see Section 8.8).

8.6 Sensitivity to Alternative Assumptions

Sensitivity analyses examine the effects of plausible alternative assumptions on the base-case model results. The sensitivity analyses conducted in this assessment (Table 8.2) are categorized into three themes, including (1) data weighting, (2) biology, and (3) selectivity. For each sensitivity run, comparisons of spawning stock biomass and recruitment trajectories, as well as F-at-age for two temporal periods (2002-2004 and 2006-2008) and likelihood profiles, were completed.

8.6.1 Dropping Each CPUE Index

This set of sensitivity runs was conducted to assess which CPUE indices were most influential in determining the scaling, trends and trajectories of estimated quantities in the base-case model. Dropping individual indices (setting lambda = 0 for that index) revealed that S7 was the most influential index for scaling and trends in SSB and recruitment (Figure 8.10). When other indices are removed, the scaling of SSB and to a lesser degree, recruitment, change, but the pattern of trends or trajectory remained consistent with the base-case model. Dropping S1 and S2 scaled SSB up relative to the base-case while dropping all other indices, including S7, scaled SSB down relative to the base-case. S7 had the largest scaling effect of all indices.

8.6.2 Changing Length Composition Data Weighting

Up-weighting the length composition data (lambda = 0.025) relative to the base-case weighting (lambda = 0.01) scales SSB and recruitment up, while down-weighting length composition data (lambda = 0.001) relative to the base-case scales SSB and recruitment down (Figure 8.11). Changing lambda does not alter trends or trajectories in either quantity. In addition, the F-at-age pattern scales up and down with lambda, but $F_{2006\text{-}2008}$ is consistently lower than $F_{2002\text{-}2004}$.

8.6.3 Estimating CVs for CPUE indices

In this run the CV for S6 was fixed = 0.2 because the WG considers this index to be the most reliable indicator of north Pacific albacore abundance, and the CVs for all other indices were estimated by the model. Although estimating the CVs resulted in more pessimistic SSB and recruitment scenarios than the base-case model, the trends and trajectory of these quantities did not change (Figure 8.12). The estimated CVs are:

S1 – 0.387,
S2 – 0.827,
S3 – 0.282,
S4 – 0.309,
S5 – 0.453,
S6 – 0.2 (fixed),
S7 – 0.200, and
S8 – 0.305.

Most of the estimated CVs are similar to the CVs used in the base-case scenario (see Section 7.7), except for S2, which was much greater than assumed in the base-case model. The F-at-age pattern from this run was relatively stable and $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$.

8.6.4 Growth Parameters Fixed to Suda Estimates

When the growth parameters were fixed to the Suda (1966) estimates, SSB and recruitment decreased relative to the base-case model and F-at-age was much higher for all age classes, with a different pattern and substantially higher F at older ages than in the base-case model (Figure 8.13). Total likelihood of the base-case model was more than 100 units better than the Suda sensitivity run (Figure 8.13E). Since the 2006 assessment used the Suda growth curve parameters, this sensitivity run was also conducted as a future projection scenario (see Section 8.8) to assess the robustness of management advice to this important change in the assessment model. Despite the different F-at-age pattern, $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$.

8.6.5 Steepness (h) = 0.85

Reducing steepness (h) from 1.0 (base case) to 0.85 increased the scaling of SSB and recruitment, but decreased F-at-age relative to the base-case model (Figure 8.14). Total likelihood of the base-case model is slightly better than the total likelihood for h = 0.85 (Figure 8.14E). The increases in SSB and recruitment are likely related to the model increasing recruitment to compensate for catches removed from the stock since model has relatively little information on virgin biomass and recruitment to anchor the stock-recruitment relationship (Figure 8.15).

8.6.6 Up-weighting Conditional Age-at-Length Data

Up-weighting the conditional age-at-length data (increasing lambda from 0.1 in the base-case to 1.0) results in slightly higher SSB and recruitment estimates, but the general trends remain the same (Figure 8.16). F-at-age patterns are consistent with the base-case, as is the finding that $F_{2006\text{-}2008}$ is lower than $F_{2002\text{-}2004}$.

8.6.7 Natural Mortality = 0.4 yr^{-1}

Changing the assumed natural mortality (M) for all ages from 0.3 yr^{-1} (base case) to 0.4 yr^{-1} led to higher scaling of SSB and recruitment and a decrease in F-at-age, although $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$ (Figure 8.17). Total likelihood favours the base-case model.

8.6.8 Length-based Maturity Schedule

The WG considered a sensitivity run assuming a length-based maturity schedule important because the base-case model is length-based, rather than age-based. Using a length-based maturity schedule (length of 50% maturity was 85 cm FL) rather than the age-based maturity schedule in the base case model resulted in a higher scaling of SSB relative to the base-case estimates, but no change in recruitment levels or trends (Figure 8.18). The WG interpreted these results as an indication that the maturity schedule is influential in scaling SSB because the length-based schedule used in this sensitivity run caused age 4 to be included in SSB estimates, contrary to the age-based schedule (age-5 and older). Further research is needed between assessments to develop an appropriate length-based maturity schedule.

8.6.9 Asymptotic Selectivity for F6

Assuming asymptotic or flat-topped selectivity for F6 rather than the dome-shaped selectivity pattern applied in the base-case model results in substantially lower SSB and recruitment relative to the base-case, but no changes in the trend patterns for either quantity (Figure 8.19). F-at-age is higher and importantly, F-at-age for large fish caught by longline is higher relative to F-at-age of younger fish caught by surface fisheries. The impact on total likelihood is substantial, increasing likelihood by more than 10 units relative to the base-case, i.e., the assumption of asymptotic selectivity for F6 leads to a poorer fitting model.

8.6.10 Removal of Selectivity Time-blocks

Removing time blocks one-by-one for selectivity on fisheries F2, F6, and F14 lowered the scaling of SSB relative to the base-case for all time blocks removed, but did not have much impact on recruitment levels or trends (Figure 8.20). F-at-age patterns were identical to the base-case model and $F_{2006\text{-}2008}$ was consistently lower than $F_{2002\text{-}2004}$, regardless of which time-block was removed. Selectivity patterns in other fisheries did not change (Figure 8.21) and the WG concluded that the use of time blocks in base-case model is consistent with the available data.

8.6.11 Summary of Sensitivity Analyses

The scaling of SSB estimated by the base-case model is substantially affected by (1) the relative weighting of abundance indices and length composition data; (2) the selectivity assumption for fishery F6; (3) a length-based maturity schedule; and (4) the growth curve. Recruitment estimates were also affected by these alternative assumptions, but the magnitude of change was less than observed for SSB estimates. The pattern of F-at-age was affected only by fixing the growth curve to the Suda (1966) parameter estimates and selectivity assumption for fishery F6 and for both runs F-at-age for adult fish (age-5 and older) was higher relative to F-at-age in other sensitivity runs. All sensitivity runs show that $F_{2006\text{-}2008}$ is consistently lower than $F_{2002\text{-}2004}$ and that the SSB and recruitment trajectories remain relatively consistent. Sensitivity runs examining the impacts of higher natural mortality and up-weighting conditional age-at-length data had relatively little impact on model estimated quantities. Although there is uncertainty in absolute estimates of SSB and recruitment, F_{SSB} calculations are likely unaffected because the pattern of trends in SSB and recruitment were robust to alternative assumptions.

8.7 Fishery Impact Analysis

The impact of each fishery category on the spawning stock biomass was evaluated. The analyses were conducted using the base-case model and dropping the annual (1966-2009) and initial equilibrium catches for longline (USA, JPN, TWN, KO), surface (UCLTN and JPN PL), and “other” miscellaneous fisheries (fisheries other than those in the longline and surface categories) from the SS3 base-case data file one-by-one and calculating the SSB trajectory for each scenario. The magnitude of differences in the simulated spawning biomass trajectories with and without fishing indicates the impact of the major fishery types on the spawning biomass of north Pacific albacore (Figure 8.22). Surface fisheries, which harvest the smaller immature juvenile fish, had the largest impact for almost the entire modeled period, especially during 1970s and 1980s. The impact of longline fisheries on the stock increased after the mid-1990s and in recent years is close to the impact of surface fisheries. The increased longline impact may be related to a concurrent decline in surface fishery effort at the same time. The impact of “other” fisheries was usually minimal relative to the surface and longline categories. However, the impact of these fisheries became larger during late 1980s and 1990s when high seas driftnet fishing was occurring prior to the implementation of a ban in 1993, although their overall influence on SSB was apparently small relative to the impact of surface and longline fisheries.

9.0 Future Projections

Stock projections were used to estimate the probability that future SSB will fall below a threshold defined as the average of the ten historically lowest SSB estimates (SSB-ATHL) in at least one year of a 25-yr (2010-2035) projection period (see ISC/11/ALBWG/14). These projections were made in response to a request from Northern Committee (NC) of Western and Central Pacific Fisheries Commission (WCPFC). The base-case configuration assumes current fishing mortality ($F_{2006\text{-}2008}$) and random resampling of historically estimated recruitment (1966-2007) during the stock assessment period.

The stochastic future projections are based on an age-structured population dynamics model identical to SS in principle, and are implemented in R with coding that was used in the assessment of Pacific bluefin tuna (see Ichinokawa et al. 2008b; ISC/08/PBFWG-1/15). The projections were conducted based on results of the base-case model configuration and each projection is based on 200 bootstrap replicates to estimate parameter uncertainty followed by 10 stochastic simulations of future trends. Detailed algorithms for conducting the projections with options for future scenarios, and reference points, including F_{SSB}, are described in Ichinokawa (2011), which is available electronically at: http://cse.fra.affrc.go.jp/ichimomo/

A constant F scenario using current fishing mortality ($F_{2006\text{-}2008}$) was used as the base-case of the future projection analysis. Projections with $F_{2002\text{-}2004}$ were also conducted for comparative purposes because the 2006 assessment defined current fishing mortality as the geometric mean of apical F for 2002-2004, $F_{2002\text{-}2004}$. Although a constant catch scenario was conducted, the WG considered it unrealistic for this stock because catch is largely dependent on annual recruitment, and hence, this scenario is treated as a sensitivity run. The constant catch sensitivity run was based on average quarterly catches between 2006 and 2008, assuming that total quarterly catch weights are constant in the future, but not partial catches by fleet. The total catch in weight assumed in the constant catch scenario is 75,224 t (average for 2006-2008). Because the total weights are derived from SS estimates, they are not exactly equal to the officially reported catch weights.

Recruitment for future projections was randomly resampled from the historical recruitment time series estimated by the base-case model (Figure 9.1). Retrospective analysis of the base-case (Figure 8.9) indicated that there was relatively large uncertainty in recruitment estimates (although these estimates were not biased) in the final two terminal years (2008 and 2009) so the WG dropped these years from the time series for future projections. In addition, based on the historical trend of estimated recruitment in the base-case, a low recruitment phase (1978-1987) and high recruitment phase (1988-2004) were identified and used for independent sensitivity runs. Recruitment scenarios and average recruitment levels for those periods are:

1. Base-case: estimated from 1966 to 2007: average R = 47,895,000, CV; 0.24;
2. Run 2: low recruitment phase from 1978 to1987: average R = 35,171,000, CV; 0.16; and
3. Run 3: high recruitment phase from 1988-2004: average R = 54,373,000, CV; 0.22.

Structural sensitivity runs of the base-case scenario included future projections in which: (1) growth curve parameters were fixed to the Suda growth curve; (2) length composition data were down-weighted using lambda = 0.001; and (3) steepness of the stock-recruitment (h) was assumed to be 0.85. All future projection scenarios and associated sensitivity runs are summarized in Table 9.1.

The $F_{SSB\text{-}ATHL\text{-}50\%}$ reference point was estimated for several recruitment scenarios and structural sensitivity runs to assess the robustness of scientific advice stemming from the base-case model to plausible alternative assumptions. Important runs requiring reference point calculations included:

- base-case;
- low recruitment;
- replacing the growth curve with the Suda curve;
- down-weighting the length composition data with lambda = 0.001;
- high recruitment;
- steepness; h = 0.85; and
- current F from the 2006 assessment ($F_{2002\text{-}2004}$).

The projections begin 1 January 2008 for consistency with the base-case recruitment scenario. Sensitivity runs conducted with projections beginning 1 January 2009 and 1 January 2007 (ISC/11/ALBWG/14) confirmed that the starting year is not influential to short- and long- term future projection results. Known catches for 2008, 2009 and 2010 were used for future projections. Total catch weights for 2008 and 2009 were derived from estimates by SS, while total catch in 2010 was based on preliminary catch weights in the WG catch table (Appendix 6). Note that catch weights used for the future projections (shown in Table 9.2) differ slightly from those reported in the updated catch table in Appendix 6 because they were taken from an incompletely updated catch table.

9.1 Base-case Scenario Results

Box plots of projected recruitment, SSB, and total catch for the base-case scenario using $F_{2006\text{-}2008}$, and $F_{2002\text{-}2004}$ are shown in Figure 9.2. Under the base-case scenario ($F_{2006\text{-}2008}$), SSB is expected to fluctuate around the historical median SSB, while $F_{2002\text{-}2004}$ would result in a decrease of future median SSB to below the base-case scenario. Because $F_{2006\text{-}2008}$, is lower than $F_{2002\text{-}2004}$ (Figure 8.7), future SSB is higher than expected compared to the $F_{2002\text{-}2004}$ harvesting scenario. The median SSB in the constant catch scenario increases relative to the constant F2006-2008 scenario (Figure 9.3), but the increase is moderate.

9.2 Alternative Recruitment Scenarios

Alternative recruitment scenarios and structural sensitivity runs produced future median SSB trajectories, after scaling the results to SSB_{2008}, that were similar to the base-case (Figure 9.4). SSB_{2008} was used to scale these results because it is estimated to be approximately equal to the historically observed median SSB level in the base-case model. Low recruitment resulted in future median SSB stabilizing at about 70% of SSB_{2008}. Sensitivity runs with Suda growth parameters or high recruitment both resulted in future SSB about 15% above SSB_{2008}. Only the low recruitment scenario increased the probability that future median SSB would fall below SSB-ATHL by the end of the projection period to greater than 50% (Table 9.3). Future SSB levels relative to current SSB in 2008 were relatively insensitive to the other assumptions that were tested.

Based on these results, the WG concluded that the future SSB projection results were robust to alternative structural assumptions and recruitment scenarios. If the current average historical recruitment level and fishing mortality ($F_{2006-2008}$) do not change, then SSB is expected to fluctuate around the historical median level in the short-term and over the 25-yr projection period.

9.3 Biological Reference Points

The Northern Committee of the Western and Central Pacific Fisheries Commission established an interim management objective for north Pacific albacore in 2008. The objective is to maintain the spawning stock biomass (SSB) above the average of the ten historically lowest estimated points (ATHL) with a probability greater than 50% (Northern Committee 2008). The NC requested that the ALBWG evaluate the status of the north Pacific albacore stock against $F_{SSB-ATHL\ 50\%}$ for a 25-yr projection period. $F_{SSB-ATHL\ 50\%}$ is the fishing mortality, F, that will lead to future minimum SSB falling below the SSB-ATHL threshold level at least once during the projection period (2010-2035).

The F-based reference point $F_{SSB-ATHL}$ is one of a group of simulation-based biological reference points (BRP) using spawning biomass thresholds proposed for north Pacific albacore (Conser et al. 2005; ISC/05/ALBWG/06). Unlike other BRPs used in fisheries management, F_{SSB} is not an equilibrium concept and therefore does not assume that future SSB or yield will remain constant at some specified level. As a simulation-based BRP, $F_{SSB-ATHL}$ can incorporate non-equilibrium dynamics, uncertainty in the stock size estimates, and other parameters from the assessment as well as uncertainty in recruitment in future years.

The SSB-ATHL threshold can be derived from point estimates of SSB or bootstrap estimates of ATHL. Uncertainty in the estimated SSB time series was evaluated with parametric bootstrap analysis (Figure 9.5), which demonstrated that point estimates of SSB are subject to high uncertainty and are negatively biased relative to the median of the bootstrap estimates throughout the time series. An SSB-ATHL threshold level was estimated in each bootstrap iteration and these estimates were used in calculating $F_{SSB-ATHL}$ since using point estimation of SSB-ATHL did not properly reflect the effect of future harvesting strategies (ISC/11/ALBWG/14). Using the bootstrap estimates of SSB-ATHL captures some of the uncertainty in the historical spawning biomass estimates and may, therefore, be a conservative estimate of this quantity.

9.3.1 $F_{SSB-ATHL-50\%}$ Reference Point

The sensitivity of $F_{SSB-ATHL}$ estimates to different recruitment scenarios and structural assumptions described in Section 9.1 is shown in Table 9.4 using the ratio of $F_{2006-2008}/F_{SSB-ATHL}$ (F-ratio). The F-ratio in the base-case projection is estimated to be 0.71, which means that current F ($F_{2006-2008}$) is about 30% lower than the F that will result in future SSB falling below the

SSB-ATHL threshold level at least once during the 2010-2035 projection period. Although the estimated $F_{SSB\text{-}ATHL}$ depends on future projection scenarios, the F-ratios of most $F_{SSB\text{-}ATHL}$ estimates are well below 1.0, except for the low recruitment and Suda growth curve runs, where the ratio is approximately 1.0. However, since the Suda growth curve is not representative of growth in this stock (see Section 5.0), the estimation of the F-ratio from the Suda growth curve run is not considered a plausible future scenario. Consequently, the WG concluded that $F_{SSB\text{-}ATHL}$ and the resulting advice based on this reference point is probably robust to different plausible structural assumptions in the base-case model. However, if future recruitment is lower than the historical average level, then the risk that future SSB falls below SSB-ATHL will increase to 54% (Table 9.3).

9.3.2 Other Candidate Reference Points

No other reference points are currently used in north Pacific albacore management. A suite of candidate reference points and their associated estimates from the base case scenario are presented when discussing stock status (Section 11.1).

10.0 VPA Reference Run

The ALBWG switched from the virtual population analysis (VPA) model used in the 2006 assessment to a statistical catch-at-length model in the present assessment. VPA assumes that the observed catch-at-age data are known without error and that the fishing selectivity pattern varies from year to year, whereas the statistical catch-at-length model assumes that the selectivity pattern is fixed over time and that differences between observed and model-predicted catch-at-length data reflect errors associated with age reading and other sources of error.

10.1 Data

The VPA-2BOX platform uses a ‘one zone’ hypothesis which requires a single catch-at-age (CAA) matrix. This matrix was developed by combining the various fishery-specific matrices constructed by the individual nations with fishery data updated through 2009. Whereas the 2006 assessment defined 17 age-specific fisheries, the VPA reference run at this Workshop used six age-aggregated fisheries (Table 10.1). Six CPUE indices were prepared from five fisheries (UCLTN, JPN PL (1972-1984, 1985-2009), JPN LL, USA LL and TWN LL) by individual nations (Table 10.2 and Figure 10.1). Partial catch vectors were used to estimate selectivity-at-age for each index.

10.2 Parameterization

The VPA reference run used the same parameterization as the previous assessment in 2006, with updated catch-at-age and new abundance indices between 1966 and 2009. Natural mortality was assumed to be constant over time and across all ages (M = 0.3). Recruitment was defined as total number of age-1 fish. Based on results from Ueyanagi (1957), this VPA run assumed that the median age of maturity of north Pacific albacore was age-5 and that fish at age-6 or older are fully mature. The growth model from Suda (1966) was applied, which differs from the growth model used in the SS3 base-case, but is consistent with parameterization in the 2006 assessment.

10.3 Results

The SSB estimates for recent years were at relatively high levels, averaging approximately 115,000 t. The estimated SSB in 2009 (about 143,500 t) was 40% above the overall time series average (102,300 t) (Figure 10.2A). Recruitment declined from 1970 to 1988 and has remained between 20 and 45 million fish since 1994 (Figure 10.2B).

Overall trends in F-at-age were similar for all ages in the reference run and the 2006 assessment (Figure 10.3). One important difference is that F-at-age for the oldest fish has decreased while F-at-age 4 has increased since 2005 in the reference run, relative to the 2006 assessment results. Overall, $F_{2006\text{-}2008}$ is lower than $F_{2002\text{-}2004}$, which is consistent with the SS3 base-case model results.

10.4 Conclusions

Recent biomass trends in the VPA reference run have changed with respect to the 2006 assessment results. In general, SSB estimates in this VPA were relatively flat after 2003 rather than declining as in the 2006 assessment. This more optimistic result was probably due to the addition of 4 more years of catch data. Recruitment has remained between 20 and 45 million fish since 1994, near the middle of the range for the entire time series

11.0 Current Stock Status and Conservation Advice

11.1 Stock Status

The SS3 base-case model estimates that SSB has fluctuated between 300,000 and 500,000 t between 1966 and 2009 and that recruitment has averaged 47.9 million fish annually during this period. A comparison of these figures with SSB estimated in the VPA reference run shows that both the SS3 base-case model and the VPA reference run estimated similar historical trends in SSB and recruitment with different scaling, especially for biomass, and lower current $F_{2006\text{-}2008}$ relative to $F_{2002\text{-}2004}$. The scaling difference is largely attributable to the use of the Suda growth curve in the VPA reference run while the SS3 base-case model estimated the growth parameters. A sensitivity run in which growth parameters were fixed to Suda parameter estimates used in the VPA model, reduced the scaling of biomass to the level of the VPA reference run (Figure 8.13), although the F-at-age pattern differs substantially from all other runs (highest F occurs at ages older than 7 years) and total likelihood strongly favours the base-case model configuration by approximately 100 likelihood units. Evidence derived from recent sampling of the stock (ISC/11/ALBWG/02, ISC/11/ALBWG/IP/01; see Figure 8.4) supports the WG conclusion that the Suda growth curve used in the 2006 assessment is not representative of growth in north Pacific albacore. Although the sensitivity analyses reveal considerable uncertainty in absolute estimates of biomass and fishing mortality, stock status and conservation advice are relatively insensitive to these uncertainties because since the trends in SSB are recruitment are robust to the different plausible assumptions tested by the WG.

Based on the agreement in trends of estimated quantities between the VPA and SS3 base-case model, the ability to explain the scaling differences between models, and the robustness of the stock status and conservation advice to these differences, the WG unanimously concluded (with no dissenting opinions) that the SS3 base-case model is representative of the population dynamics and abundance of north Pacific albacore and that this model will replace the VPA as the principal model for north Pacific albacore assessments. All of the control, starter, and forecast files for the consensus base-case scenario are shown in Appendix 8.

Sensitivity and retrospective analyses (Sections 8.4-8.6) assessed the impact of many uncertainties and alternative assumptions on the assessment results. Given the model fits to the data and sensitivity analyses based on conservative parameters, the base-case model is stable and produces a reasonable representation of the history of stock abundance. Actual stock parameters may be higher so estimated quantities such as total biomass and SSB probably are not over estimates of true abundance.

Estimates of $F_{2006\text{-}2008}$ (current F) relative to several F-based reference points used in contemporary fisheries management are presented in Table 11.1. The estimates are expressed as the ratio of $F_{2006\text{-}2008}/F_{ref\ point}$, which means that when the ratio is less than 1.0, $F_{2006\text{-}2008}$ is below the reference point estimate. The F_{MAX}, F_{MED} and $F_{0.1}$ reference points are based on yield-per-recruit analysis while the $F_{20\text{-}50\%}$ reference points are spawning biomass-based proxies of F_{MSY}. Since $F_{2006\text{-}2008}$ is close to F_{MED} and well below the MSY proxy rates, the WG infers that overfishing of the north Pacific albacore stock is unlikely at present.

Yield-per-recruit calculations resulted in a flat yield curve (Figure 11.2), with the ratio of $F_{SSB\text{-}ATHL}/F_{2006\text{-}2008}$ at 1.41. Based on the spawning biomass per recruit (SPR) calculations (relative to F = 0) $F_{2006\text{-}2008}$ is approximately equivalent to $F_{50\%}$, which is much higher than $F_{17\%}$ estimated in the 2006 assessment (ALBWG 2007). Increasing $F_{2006\text{-}2008}$ by 41% to $F_{SSB\text{-}ATHL}$ results in a 24% increase in yield and 23% decrease in SPR. However, these increases in F and yield would require an even higher increase in fishing effort. Very little of the increased yield is achievable for longline fisheries, most of the increase would occur in the surface fisheries (Figure 11.2)

Although biomass-based reference points have not been established for north Pacific albacore, SSB is currently around the long-term median of the stock and is expected to fluctuate around the historical median SSB in the future, assuming average recruitment levels continue and fishing mortality remains at $F_{2006\text{-}2008}$ levels. Current $F_{2006\text{-}2008}$ is about 71% of $F_{SSB\text{-}ATHL}$ using the same assumptions of F and recruitment, the probability that SSB will fall below the SSB-ATHL threshold at least once during the projection period (2010-2035) is about 1 % (Table 9.3). The WG concludes that overfishing is not occurring and that the stock likely is not in an overfished condition. However, the risk that SSB will fall below the SSB-ATHL threshold by the end of the projection period increases to 54% if recruitment declines substantially (about 25%) below the current average historical recruitment level (Table 9.3).

11.2 Conservation Advice

The north Pacific albacore stock is considered to be healthy at current levels of recruitment and fishing mortality. The sustainability of the stock is not threatened by overfishing as current $F_{2006-2008}$ is about 71% of $F_{SSB-ATHL}$ and the stock is expected to fluctuate around the long-term median SSB (~405,000 t) in the short- and long-term future given average historical recruitment levels and constant fishing mortality at $F_{2006-2008}$ (Figure 9.2). However, a more pessimistic recruitment scenario increases the probability that the stock will not achieve the management objective of remaining above the SSB-ATHL threshold with a probability of 50%. Thus, if future recruitment declines about 25% below average historical recruitment levels due either to environmental changes or other reasons, then the impact of $F_{2006-2008}$ (current F) on the stock is unlikely to be sustainable. Increasing F beyond current levels will not result in proportional increases in yield as a result of the population dynamics of this stock (Figure 11.2). Therefore, the working group recommends maintaining the present management measures.

12.0 Research Recommendations

The 2011 assessment of north Pacific albacore is based on the best available biology, fishery data, and modeling techniques at this time. Nevertheless, the WG identified several research recommendations during the assessment process that could improve the assessment model. These recommendations are categorized into six areas and for each recommendation priorities and achievability by the next assessment were assigned by the WG. The recommendations for future research are:

1. Age and growth modeling
    - i. Improved sampling from all regions, particularly focusing on fish < 60 cm and fish greater than 85 cm FL (**high, achievable by next assessment**)
    - ii. Validation of aging procedures (annulus) and comparison of aging by multiple readers (**high, achievable by the next assessment**)
    - iii. Daily growth ring analysis of otoliths from young albacore to validate aging, especially time of annulus formation, and investigate growth patterns in young fish (**high, achievable**)
    - iv. Further investigation into regional differences in growth rates in central, eastern and western Pacific (**high, achievability uncertain**)
    - v. Combine results of ISC/11/ALBWG/IP/01 with ISC/11/ALBWG/02 (**high, achievability uncertain**)
    - vi. Further investigation into the appropriate growth model for albacore (Richards, von Bertalanffy, Gompertz, etc.) after enhanced sampling (**high, achievability uncertain for next assessment since depends on sampling time frame**)
    - vii. Document currently available samples on sampling plan to determine where further effort is needed (**low, achievable**)

2. Spatial patterns Analyses
    - i. Explore existing tagging data to determine if further effort is needed and design statistically justified program, e.g., to estimate natural mortality, estimate growth in different regions, ground-truth abundance estimates (**high, achievability is uncertain**)

ii. Investigate spatial and temporal distribution by size to assist in fishery definitions (**high, achievable by next assessment)**
iii. Investigate spatial and temporal changes in size composition of JPN LL fisheries to support the use of appropriate selectivity (**high, achievable for next assessment)**
iv. Investigate spatial and temporal changes in size composition of TWN LL fisheries to support the use of appropriate selectivity
v. Cooperative tagging (pop-up satellite, archival) of large albacore to understand movement patterns of mature fish and bring movement into the model **(high, achievability long-term beyond next assessment)**
vi. Cooperative tagging (pop-up, archival) of young albacore in the western Pacific to understand their movement patterns and bring movement into the model **(high, achievability long-term beyond next assessment)**
vii. Cooperative sampling for otolith microchemistry (stable isotopes, trace elements) across regions **(high, achievability long-term beyond next assessment)**

3. CPUE Analyses
   i. F8 (JPN LL south) increases and decreases in 1990s, the model cannot explain these trends so further exploration is needed (**high, uncertain if complete resolution achievable for next assessment**)
   ii. Document the development and trends of the F6s1 quarterly CPUE index (**high, achievable by next assessment)**
   iii. Split the USA LL fishery into shallow-set and deep-set fisheries (**high, achievable by next assessment)**
   iv. Investigate different CPUE trends in surface fisheries in EPO (UCLTN) and WPO (JPN PL) since 2005 (**high, achievable for next assessment**)
   v. Investigate CPUE standardization procedures, GLM vs. Delta log-normal, etc. to improve indices. Should take advice developed at ISC11 plenary session, into account (**low, achievable for next assessment**)

4. Maturity
   i. Samples of maturity by length are required to determine length at which 50% are mature (**medium, achievability uncertain for next assessment**)
   ii. Improved sampling of large fish in central and eastern Pacific is needed to determine if spawning occurs, when it occurs, and fecundity by length (**low, long-term beyond next assessment**)

5. Data Issues
   i. Investigate length composition anomalies in USA LL fishery with respect to very large fish (**high, achievable by next assessment)**
   ii. Document historical socio-economic factors of fisheries to understand changes in fishing grounds, fishing strategies, market developments that may influence CPUE (**high, achievable for next assessment)**
   iii. Provide information on targeting practices and effort in all fisheries (**high, achievable for next assessment**)
   iv. Document existing national sampling programs (**high, achievable for next assessment)**

6. Model Improvements
    i. Explore scaling in the model, including weighting of different information sources (**high, achievability uncertain for next assessment)**
    ii. Explore the stock-recruitment relationship, especially steepness estimate **(high, achievable for next assessment)**
    iii. Explore the incorporation of explicit spatial structure and sex-specific growth in the model (**medium, long-term beyond the next assessment**)
    iv. Incorporate existing conventional tagging data into the model (**high, achievable for next assessment**)
    v. Explore the impact of environmental covariates on abundance indices, movement patterns, etc. (**medium, achievable for next assessment**)

13.0 Administrative Matters

13.1 Workplan for 2011-12

The WG discussed workplans for 2011-12. The WG Chair noted that an informal two-day slot was available July 14-15 for the WG in advance of the ISC11 Plenary session in San Francisco, USA. This time will be used to prepare the stock assessment presentation, but is not a formal meeting and no formal report will be made.

The WG Chair indicated that the next meeting of the WG would be scheduled in July 2012, in advance of the ISC12 Plenary meeting. The WG agreed to request 2 days. This meeting will be used to update national fisheries, respond to CIE reviews of the assessment, and report on progress against the high priority and achievable research items listed in Section 12.0.

13.2 National Contacts

National contacts for the ALBWG were confirmed as:

Canada – John Holmes and Zane Zhang
Japan – Koji Uosaki
Mexico – Luis Fleischer
Korea – Jae Bong Lee
Chinese Taipei – Shean-ya Yeh, Chiee-Young Chen
USA – Steve Teo, Suzy Kohin
SPC – Simon Hoyle
IATTC – Alexandre Aires-da-Silva

13.3 Next Meeting

The next meeting of the ALBWG will be two days in length and will be held in July 2012, exact dates and location to be determined at the ISC11 Plenary Session.

13.4 Other Matters

The WG discussed contracting the Center of Independent Expertise (CIE) to conduct an external review of the assessment. There is an opportunity to submit the assessment for a "desktop" review since a planned review of the striped marlin assessment has been postponed. WG members agreed that it was desirable to get an external appraisal as a way to improve the assessment. It was noted that the Terms of Reference for the reviewers was critical to the success of this process and that the Terms of Reference should specify a review of the process and findings, but not the data. In response to an inquiry by the ISC Chair during the workshop, the CIE indicated that it could conduct an albacore review provided the assessment report and relevant supporting documents were submitted in a timely fashion. As this is a U.S. process, USA scientists (Steve Teo and Hui-hua Lee) will be listed as contacts on the Statement of Work. The WG discussed an 01 October 2011 submission date and January 2012 review reporting deadline. The WG Chair was tasked with drafting the Terms of Reference and the assessment report for the CIE. The WG agreed to go forward with this process.

14.0 Clearing of Report

A draft of the report was reviewed by the WG prior to adjournment of the assessment workshop. After the workshop, the WG Chair distributed a second draft of the report via email for review, comment, and approval by the participants. Subsequently, the WG Chair evaluated suggested revisions, made final decisions on content and style, and provided the report for the ISC11 Plenary to review.

15.0 Adjournment

The Chair expressed his appreciation to WG members for their cooperation and hard work, which ensured a successful workshop. He also thanked the hosts (NRIFSF, Japan) for their hospitality and overall meeting arrangements.

The 2011 north Pacific albacore stock assessment workshop of the ISC-ALBWG was adjourned at 15:50 on 11 June 2011.

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Table 7.1. Descriptions and numbers of fisheries defined for the SS3 base-case assessment model.

Fishery	Fishery Description	Boundaries and Seasonal Coverage
F1	USA/Canada troll & pole-and-line (UCLTN)	• 10-55°N latitude by 160°E-120°W longitude
F2	USA longline (USA LL)	• 10-45°N latitude by 170°E-130°E longitude
F3	EPO miscellaneous (EPOM)	• EEZ waters along the coasts of USA, Canada and Mexico
F4	Japan pole-and-line (south) – large average-sized fish (JPN PLLF)	• 25-35°N latitude by 130°E-180° longitude in Q2
F5	Japan pole-and-line (north) – small average-sized fish (JPN PLSF)	• 35-45°N latitude by 140°E-180° longitude in Q2 and Q3
F6s1	Japan offshore longline (north / season 1 / numbers of fish) – smaller average-sized fish (JPN OLLF1	• 25-40°N latitude by 120°W-180° longitude in Q1
F6s2	Japan offshore longline (north / season 2 / numbers of fish) – smaller average-sized fish (JPN OLLF1)	• 25-40°N latitude by 120°E-180° longitude in Q2
F7s1	Japan coastal longline (north / season 1 / weight) – smaller average-sized fish (JPN CLLF1)	• 25-40°N latitude by 120°E-180° longitude in Q1
F7s2	Japan coastal longline (north / season 2 / weight) – smaller average-sized fish (JPN CLLF1)	• 25-40°N latitude by 120°E-180° longitude in Q1
F8	Japan offshore longline (south / north s3-4 / numbers of fish) – larger average-sized fish (JPN OLLF2)	• 25-40°N latitude by 120°E-180° longitude in Q3 and Q4 • 25-40°N latitude by 120°W-180° longitude in Q2-Q4 • 10-25°N latitude by 120°E-120°W longitude all year round
F9	Japan coastal longline (south / north s3-4 / weight) – larger average-sized fish (JPN CLLF2)	• 25-40°N latitude by 120°E-180° longitude in Q3 and Q4 • 10-25°N latitude by 120°E-120°W longitude all year round
F10	Japan gill net (JPN GN)	• 20-55°N latitude by 120°E-160°E longitude
F11	Japan miscellaneous (JPN M)	• E.E.Z. along Japan coasts
F12	Taiwan longline (TWN LL)	• 10-55°N latitude by 120°E-120°W longitude
F13	Korea and Others longline (KO LL)	• 10-55°N latitude by 120°E-120°W longitude
F14	Taiwan and Korea gill net (TK GN)	• 20-55°N latitude by 120°E-180° longitude

Table 7.2. CPUE indices used in the SS3 base-case assessment model.

Index	Fishery description	Time series	Reference
S1	USA/CAN troll (F1 - UCLTN)	1966-2009	Teo et al. (2010; ISC/10/ALBWG-3/02)
S2	USA longline (F2 - USA LL)	1991-2009	
S3	Japan pole-and-line (F4 - JPN PLLF)	1972-2009	Kiyofuji and Uosaki (2010; ISC/10/ALBWG-3/07)
S4	Japan pole-and-line (F5 - JPN PLSF)	1972-1984	
S5	Japan pole-and-line (F5 - JPN PLSF)	1985-2009	
S6	Japan longline (F6 - JPN OLLF1 and F7 - JPN CLLF1)	1972-2009	Matsumoto (2010; ISC/10/ALBWG-3/04)
S7	Japan longline (F8 - JPN OLLF2 and F9 - JPN CLLF2)	1972-2009	
S8	Taiwan longline (F12 – TWN LL)	1995-2009	Chen et al. (2010; ISC/10/ALBWG-3/08)

Table 7.3. North Pacific albacore abundance indices developed for the SS3 base-case model. Units are weight (JPN PL fisheries) and number of fish (all other indices). Main season refers to annual quarters where 1 = Jan-Mar, 2 = Apr-June, 3 = July-Sept, and 4 = Oct-Dec.

	UCLTN		USA LL		JPN PL2 - larger fish		JPN PLL3 - smaller fish (early period)		JPN PL3 - smaller fish (late period)		JPN LL (Fishery I- smaller fish)		JPN LL (Fishery II- larger fish)		TWN LL	
Index	S1		S2		S3		S4		S5		S6		S7		S8	
Main season	3		3		2		3		3		1		1		1	
Year	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV	CPUE	CV
1966	90.8459	0.0763											1.4360	0.0567		
1967	138.7865	0.0816											1.3868	0.0498		
1968	112.9091	0.0712											1.2618	0.0515		
1969	99.6598	0.0783											1.0029	0.0524		
1970	127.4874	0.0647											1.1782	0.0482		
1971	95.9675	0.0734											0.8721	0.0526		
1972	80.0587	0.0635			0.0370	0.0729	0.0528	0.1063			4.1144	0.0511	1.1120	0.0570		
1973	86.6313	0.0672			0.0394	0.0335	0.0499	0.0693			4.6954	0.0488	1.5249	0.0391		
1974	108.1492	0.0549			0.0453	0.0482	0.0553	0.0632			4.9615	0.0585	1.6459	0.0378		
1975	116.1248	0.0631			0.0471	0.0451	0.0447	0.1841			3.1809	0.0478	1.6475	0.0343		
1976	77.8496	0.0582			0.0381	0.0337	0.0485	0.0665			3.8288	0.0412	1.5381	0.0292		
1977	55.8463	0.0557			0.0298	0.0358	0.0236	0.1204			3.1139	0.0422	1.7913	0.0265		
1978	82.3323	0.0706			0.0286	0.0615	0.0531	0.0680			2.9052	0.0400	1.1290	0.0273		
1979	54.7658	0.0831			0.0393	0.0261	0.0464	0.0567			2.8797	0.0418	1.1446	0.0279		
1980	42.1214	0.0808			0.0408	0.0348	0.0504	0.0579			2.6038	0.0477	1.0934	0.0271		
1981	59.3827	0.0693			0.0325	0.0480	0.0152	0.2421			2.7981	0.0354	1.0418	0.0261		
1982	49.3858	0.0569			0.0345	0.0627	0.0388	0.0579			3.1905	0.0369	1.5286	0.0249		
1983	60.3264	0.0563			0.0324	0.0544	0.0313	0.1026			2.8958	0.0376	1.6136	0.0269		
1984	64.5650	0.0557			0.0389	0.1063	0.0362	0.0694			3.1064	0.0412	1.2419	0.0278		
1985	79.0365	0.0704			0.0404	0.0720			0.0172	0.1391	2.7365	0.0427	1.1721	0.0273		
1986	47.0426	0.1002			0.0352	0.0619			0.0287	0.0755	2.8996	0.0390	1.2760	0.0300		
1987	34.0500	0.1065			0.0316	0.1275			0.0179	0.1969	2.5192	0.0400	1.1635	0.0270		
1988	71.1995	0.1779			0.0428	0.0738			0.0093	0.1427	2.7794	0.0417	1.0149	0.0272		
1989	32.5861	0.1247			0.0432	0.0549			0.0152	0.2617	3.0032	0.0462	1.0240	0.0289		
1990	46.2233	0.1040			0.0436	0.0736			0.0342	0.0618	3.9338	0.0431	1.0364	0.0315		
1991	44.0167	0.0843	1.7392	0.0475	0.0385	0.4018			0.0555	0.0731	3.3750	0.0477	1.2123	0.0337		
1992	69.1531	0.0786	2.1348	0.0509	0.0678	0.1101			0.0365	0.1706	3.0558	0.0498	1.0655	0.0283		
1993	58.7956	0.0636	2.4073	0.0537	0.0333	0.2600			0.0259	0.1538	5.1161	0.0437	1.4425	0.0324		
1994	94.5308	0.0727	3.0313	0.0611	0.0411	0.1920			0.0714	0.1113	4.7830	0.0377	1.6906	0.0283		
1995	55.5957	0.0713	4.3978	0.0488	0.0868	0.3305			0.0519	0.0737	4.0916	0.0360	2.3395	0.0200	29.4674	0.0263
1996	85.5895	0.0626	5.8160	0.0494	0.0420	0.2191			0.0289	0.1825	5.1974	0.0337	2.6887	0.0202	49.8742	0.0217
1997	49.1973	0.0656	6.5153	0.0524	0.0658	0.3152			0.0746	0.0434	5.6403	0.0325	3.5928	0.0212	45.7498	0.0224
1998	146.1602	0.0583	4.4589	0.0474	0.0374	0.1982			0.0709	0.0542	5.3485	0.0322	4.3474	0.0214	21.2906	0.0334
1999	54.2124	0.0438	5.8205	0.0476	0.0616	0.1671			0.0473	0.0617	4.0164	0.0296	4.0053	0.0211	20.3758	0.0255
2000	65.5909	0.0591	2.3632	0.0578	0.0416	0.1355			0.0386	0.0659	4.0671	0.0362	4.3854	0.0212	21.4379	0.0341
2001	95.8247	0.0507	3.3225	0.0563	0.0336	0.1458			0.0506	0.0441	3.5976	0.0311	3.9174	0.0211	12.9967	0.0465
2002	145.2481	0.0613	1.0681	0.0546	0.0599	0.1353			0.0918	0.0480	4.3971	0.0298	3.4494	0.0208	12.3165	0.0388
2003	134.3242	0.0701	0.8901	0.0577	0.0426	0.3033			0.0450	0.2265	3.4019	0.0295	2.4393	0.0228	13.7703	0.0306
2004	166.2718	0.0696	0.9744	0.0504	0.1051	0.0390			0.0253	0.1312	2.4395	0.0301	1.8594	0.0217	8.2501	0.0170
2005	82.6032	0.0579	0.6818	0.0462	0.0463	0.0628			0.0381	0.0564	4.3689	0.0299	1.7994	0.0225	8.7805	0.0191
2006	180.3983	0.0608	0.5378	0.0469	0.0436	0.2149			0.0352	0.0801	3.9390	0.0318	2.3460	0.0237	13.5438	0.0163
2007	106.0199	0.0756	0.4105	0.0549	0.0705	0.0720			0.0409	0.1166	3.3796	0.0311	2.4588	0.0231	13.8258	0.0170
2008	110.3124	0.0827	0.6077	0.0550	0.0352	0.2817			0.0134	0.3451	3.3634	0.0311	2.0355	0.0230	16.4724	0.0207
2009	122.7863	0.0675	0.4537	0.0560	0.0440	0.3122			0.0296	0.1356	3.1821	0.0336	2.0127	0.0244	14.0754	0.0237

Table 7.4. Estimated spawning stock biomass for several tuna species and stocks at the beginning and end of the assessment time period used to determine a down-weighting value (lambda) for length composition data in the 2011 assessment of north Pacific albacore.

Species	Stock	Assessment Year	Assessment period	Reference	Spawning biomass estimates (x 1000's t)			
					Start	High	Low	End
albacore	North Pacific	2006	1966-2005	ALBWG (2007)	60	160	60	115
albacore	North Pacific	2004	1975-2003	Stocker (2005)	60	120	50	110
albacore	South Pacific	2006	1960-2005	Langley and Hampton (2006)	390	500	270	270
albacore	South Pacific	2009	1960-2008	Hoyle and Davies (2009)	460	506	253	274
albacore	North Atlantic	2009	1930-2007	ICCAT (2010)	150	170	20	40
albacore	South Atlantic	2007	1956-2005	ICCAT (2008)	290	290	70	80
Pacific bluefin	Pacific	2006	1952-2005	PBFWG (2006)	100	170	20	80
Atlantic bluefin	Eastern Atlantic	2008	1970-2006	ICCAT (2009)	250	300	100	100
Atlantic bluefin	Western Atlantic	2008	1970-2007	ICCAT (2009)	45	45	7	8
Southern bluefin	Southern bluefin	2009	1931-2009	CCSBT (2009)	1,000	1,000	45	45
bigeye	WCPO	2009	1952-2007	Harley et al. (2009)	600	600	100	100
bigeye	EPO	2010	1975-2009	Aires-da-Silva and Maunder (2011)	210	230	80	100
yellowfin	WCPO	2009	1952-2008	Langley et al. (2009)	5,000	7,500	1,500	1,500

Table 8.1. Spawning stock biomass and recruitment time-series estimated by the base-case model for the 2011 north Pacific albacore assessment

Year	Spawning biomass (t)	Recruitment (x1000 fish)
Virgin	857,138	55,381.1
1966	416,016	50,133.3
1967	398,986	49,155.9
1968	389,813	51,323.5
1969	389,303	54,464.1
1970	409,518	44,200.7
1971	436,472	60,480.4
1972	436,742	55,089.0
1973	426,010	52,093.3
1974	408,849	37,136.4
1975	383,956	43,313.2
1976	363,717	53,538.9
1977	350,553	43,672.4
1978	341,099	32,625.9
1979	317,859	36,766.9
1980	298,930	35,993.5
1981	298,225	38,812.7
1982	293,942	42,563.6
1983	279,693	34,156.1
1984	267,377	29,383.4
1985	263,935	30,581.1
1986	264,530	43,678.8
1987	277,001	27,152.4
1988	281,203	49,385.9
1989	278,347	58,132.8
1990	276,500	65,216.3
1991	290,250	47,235.2
1992	298,809	69,277.8
1993	315,771	54,879.0
1994	364,731	68,726.6
1995	425,450	38,831.3
1996	459,003	68,999.6
1997	482,592	42,322.1
1998	495,364	41,296.7
1999	504,284	78,060.9
2000	476,738	51,007.6
2001	461,486	46,990.1
2002	446,178	55,507.1
2003	417,903	41,311.2
2004	428,487	61,036.6
2005	432,963	40,499.7
2006	413,820	41,381.5
2007	406,885	45,194.6
2008	397,088	44,970.5
2009	405,644	55,381.1

Table 8.2. Sensitivity analyses of the north Pacific albacore base-case model in 2011.

Data weighting

- Dropping each CPUE one-by-one by setting lambda = 0
- Up-weight and down-weight length composition data relative to the base-case model with lambda = 0.025 and 0.001, respectively
- Fix CV for S6 = 0.2, estimate CVs for all other CPUE indices

Biological assumptions

- Replace estimated growth curve with fixed Suda growth curve (continue to use ageing data)
- Reduce steepness (h) from 1.0 (base case) to 0.85
- Increase weighting of conditional age-at-length data from lambda = 0.1 (base-case) to lambda = 1.0
- M = 0.4 for all ages
- Use length-based maturity schedule in place of age-based schedule in the base-case

Selectivity

- Assume F6 selectivity is asymptotic using logistic form (flat-topped)
- Remove time blocks for selectivity one-by-on on fisheries F2, F6, and F14

Table 9.1. Summary of future projections for the base-case, low and high recruitment scenarios, and sensitivity runs.

	Fssb scenario							Sensitivity scenarios			
	Base case	Run 1 (Previous current F)	Run 2 (Low recruit)	Run 3 (High recruit)	Run 4 (growth curve)	Run 5 (Length lambda)	Run 6 (Steepness=0.85)	Starting year = 2009	Starting year =2007	Current F definition	CC scenario
SS scenario	Base case				Using suda's growth	Length lambda= 0.001	Steepness=0.85				
Recruitment	Random sampling from 1966-2007		Random sampling from 1978-1987	Random sampling from 1988-2004							
Harvesting scenario	constant F with current F										constant catch with current average catch
Starting year	1st Jan, 2008							1st Jan, 2009	1st Jan, 2007		
Current F definition	2006-2008	2002-2004								2005-2007	
Fssb need	yes	yes	yes	yes	yes	yes	yes	no	no	no	no

Table 9.2. Assumed quarterly catch weights from 2008-2010 used for future projections. Quarterly catch in 2010 is estimated from the average quarterly catch ratio and an earlier version of the catch table shown in Appendix 6, while total quarterly catches for 2008 and 2009 are derived from estimates in the assessment model and are not identical to the quarterly totals calculated from the catch table in Appendix 6.

Quarter	Quarterly Catch Ratio (2000-2010)	2008	2009	2010
Qt1	0.14	13,178	9,901	9,839
Qt2	0.33	23,393	37,359	22,804
Qt3	0.40	21,100	21,928	27,469
Qt4	0.13	7,594	8,474	8,943
Total		**65,265**	**77,662**	**69,056**

Table 9.3. Probability of future spawning stock biomass falling below the bootstrap estimate of SSB-ATHL in future projection scenarios and structural sensitivity runs.

	Base case	Run 1 ($F_{2002\text{-}2004}$)	Run 2 (Low recruit)	Run 3 (High recruit)	Run 4 (growth curve)	Run 5 (Length lambda)	Run 6 (Steepness=0.85)
2012	0.0	0.0	0.0	0.0	10.8	0.0	0.0
2013	0.0	0.0	0.0	0.0	25.1	0.0	0.0
2014	0.0	0.0	0.0	0.0	29.8	0.1	0.0
2015	0.1	0.3	0.8	0.0	30.9	0.2	0.3
2016	0.3	0.5	1.9	0.0	31.8	0.4	0.9
2017	0.4	0.9	3.8	0.0	32.7	0.7	1.5
2018	0.5	1.5	8.3	0.0	33.4	1.1	2.1
2019	0.5	2.0	12.7	0.0	34.4	1.2	2.6
2020	0.6	2.6	16.7	0.0	35.2	1.2	3.3
2021	0.7	3.1	20.9	0.0	36.0	1.4	4.1
2022	0.7	3.6	24.7	0.0	37.0	1.5	5.3
2023	0.8	4.2	27.6	0.0	38.0	1.6	5.7
2024	0.9	4.8	30.6	0.0	38.8	1.6	6.3
2025	0.9	5.3	33.6	0.0	39.6	1.9	6.8
2026	0.9	5.8	36.0	0.0	40.3	2.0	7.3
2027	0.9	6.5	38.9	0.0	41.0	2.2	8.1
2028	1.0	7.0	41.3	0.0	41.9	2.4	8.9
2029	1.0	7.4	43.4	0.0	42.4	2.5	9.5
2030	1.1	7.9	45.5	0.1	43.4	2.8	10.1
2031	1.1	8.4	47.0	0.1	43.8	3.0	10.9
2032	1.2	8.9	48.8	0.1	44.3	3.1	11.6
2033	1.2	9.2	50.1	0.1	44.6	3.1	12.2
2034	1.3	9.8	51.6	0.1	44.8	3.2	12.5
2035	1.3	10.3	52.9	0.1	45.2	3.5	13.2
2036	1.3	10.7	53.9	0.1	45.7	3.5	14.2

Table 9.4. Estimates of $F_{SSB-ATHL}$ 50% for a 25-yr projection period (2010-2035) under two harvest scenarios ($F_{2006-2008}$, $F_{2002-2004}$), three recruitment scenarios, and three alternate structural assumptions. Relative estimates of F as the F-ratio are shown rather than absolute estimates. F-ratio = $F_{2006-2008}/F_{SSB-ATHL}$ run estimate.

Projection Run	F-ratio
Base case	0.71
Run 1 (F2002-2004) (Current F in 2006 assessment)	0.83
Run 2 (Low recruit)	1.01
Run 3 (High recruit)	0.60
Run 4 (growth curve)	0.99
Run 5 (Length lambda)	0.77
Run 6 (Steepness=0.85)	0.71

Table 10.1. Age-aggregated fishery definitions developed for the VPA reference run.

Japan pole-and-line (1972 – 1984)
Japan pole-and-line (1985 – 2009)
Japan longline (1972 – 2009)
USA/Canada troll (1966 – 2009)
USA longline (1991 – 2009)
Taiwan longline (1995 – 2009)

Table 10.2. Age-aggregated abundance indices developed for the VPA reference run. Units are weight (JPN PL fisheries) and number of fish (all other indices).

	JPN PLSF-A	JPN PLSF-B	JPNLL	UCLTN	USALL	TWNLL
1966				90.8		
1967				138.8		
1968				112.9		
1969				99.7		
1970				127.5		
1971				96.0		
1972	0.0449		2.09	80.1		
1973	0.0446		2.31	86.6		
1974	0.0503		2.37	108.1		
1975	0.0459		1.90	116.1		
1976	0.0433		2.24	77.8		
1977	0.0267		1.56	55.8		
1978	0.0408		1.53	82.3		
1979	0.0429		1.48	54.8		
1980	0.0456		1.38	42.1		
1981	0.0239		1.81	59.4		
1982	0.0367		1.96	49.4		
1983	0.0319		1.60	60.3		
1984	0.0376		1.60	64.6		
1985		0.0288	1.60	79.0		
1986		0.0319	1.54	47.0		
1987		0.0247	1.34	34.1		
1988		0.0260	1.41	71.2		
1989		0.0292	1.47	32.6		
1990		0.0389	1.81	46.2		
1991		0.0470	1.57	44.0	1.74	
1992		0.0522	1.80	69.2	2.13	
1993		0.0296	2.44	58.8	2.41	
1994		0.0562	2.87	94.5	3.03	
1995		0.0694	3.00	55.6	4.40	29.5
1996		0.0354	3.94	85.6	5.82	49.9
1997		0.0702	4.63	49.2	6.52	45.7
1998		0.0542	4.30	146.2	4.46	21.3
1999		0.0544	4.30	54.2	5.82	20.4
2000		0.0401	3.95	65.6	2.36	21.4
2001		0.0421	3.48	95.8	3.32	13.0
2002		0.0759	2.87	145.2	1.07	12.3
2003		0.0438	2.20	134.3	0.89	13.8
2004		0.0652	1.94	166.3	0.97	8.3
2005		0.0422	2.79	82.6	0.68	8.8
2006		0.0394	2.78	180.4	0.54	13.5
2007		0.0557	2.33	106.0	0.41	13.8
2008		0.0243	2.31	110.3	0.61	16.5
2009		0.0368	2.97	122.8	0.45	14.1

Table 11.1. Potential reference points and estimated F-ratio using Fcurrent ($F_{2006\text{-}2008}$), associated spawning biomass and equilibrium yield. $F_{SSB\text{-}ATHL}$ is not equilibrium concept so SSB and yield are given as median levels.

Reference Point	$F_{2006\text{-}2008}/F_{RP}$	SSB (t)	Equilibrium Yield (t)
$F_{SSB\text{-}ATHL}$	0.71	346,382	101,426
F_{MAX}	0.14	11,186	185,913
$F_{0.1}$	0.29	107,130	170,334
F_{MED}	0.99	452,897	94,080
$F_{20\%}$	0.38	171,427	156,922
$F_{30\%}$	0.52	257,140	138,248
$F_{40\%}$	0.68	342,854	119,094
$F_{50\%}$	0.91	428,567	99,643

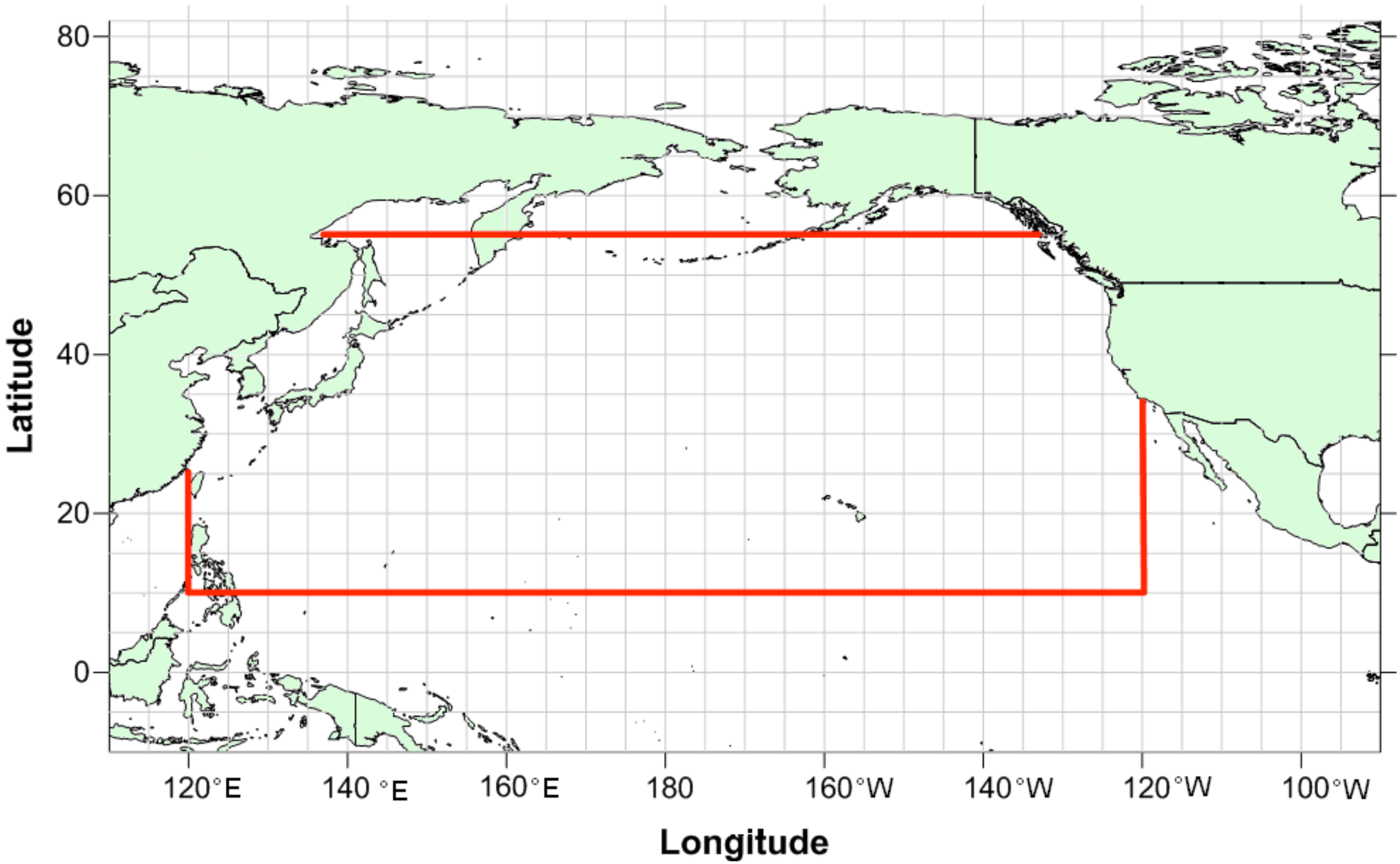


Figure 7.1. Spatial domain (red box) of the north Pacific albacore stock (*Thunnus alalunga*) and the 2011 stock assessment.

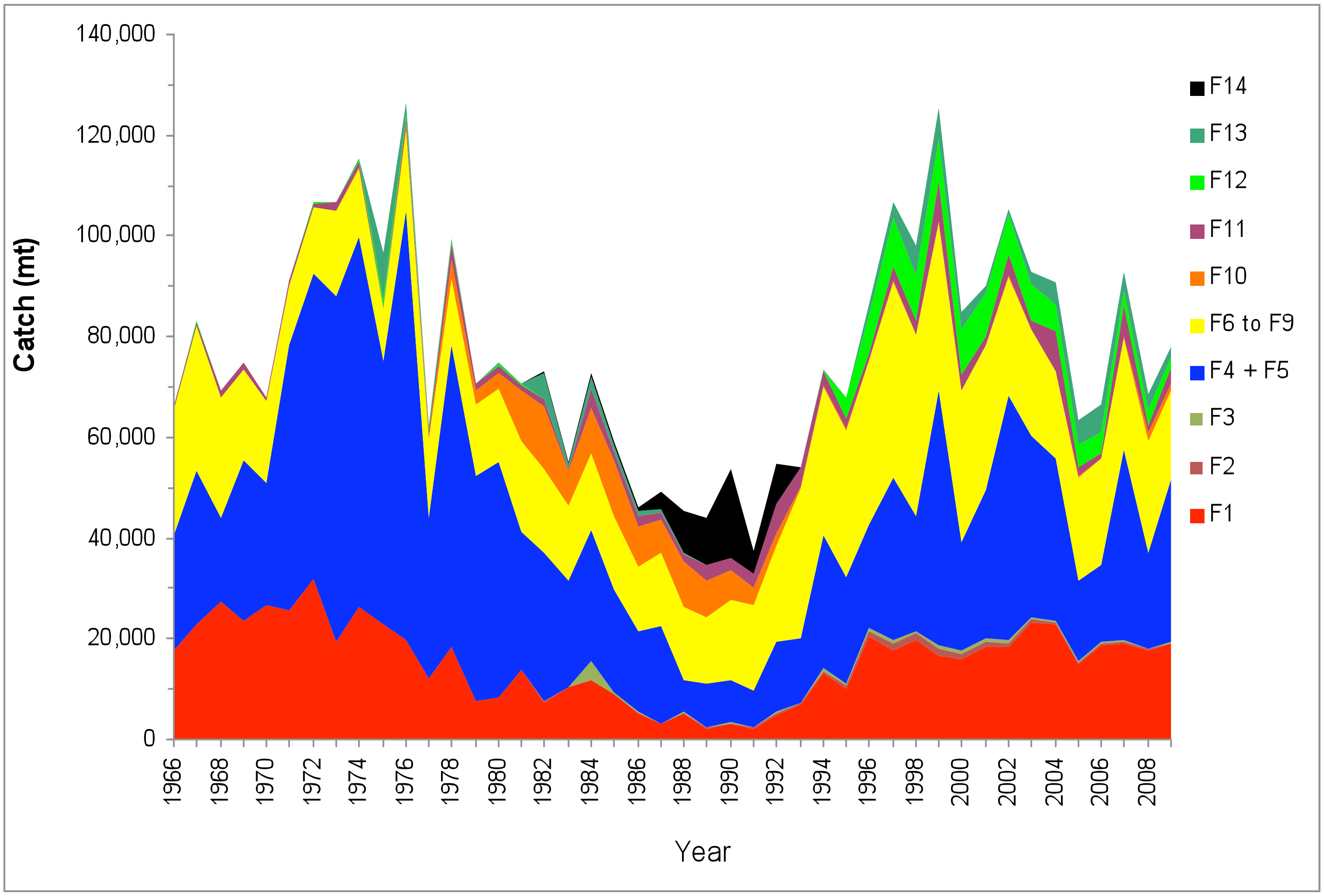


Figure 7.2. Catch history (t) of north Pacific albacore by fisheries used in the assessment model during the modeled period, 1966-2009. See Table 7.1 and Figure 7.2 for fishery definitions and the spatial and temporal boundaries of these fisheries.

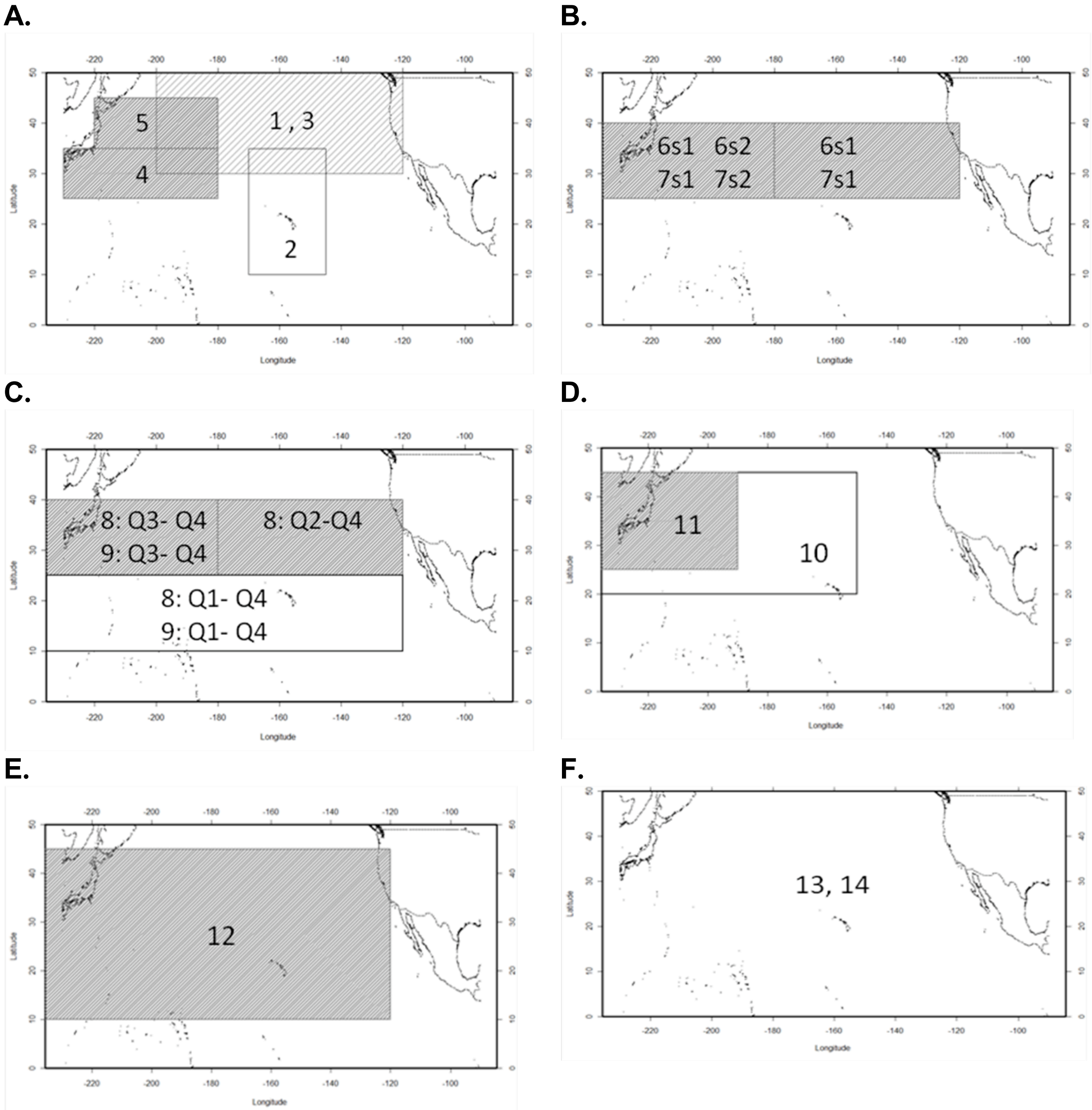


Figure 7.3. Maps showing main seasons and areas of operation of (A) EPO surface fisheries (F1 & F3), JPN PL fisheries (F4 and F5) and USA LL fishery (F2); (B) JPN OLLF1 and CLLF1 fisheries (F6s1, F6s2, F7s1, F7s2), where F6s1 and F7s1 operate during the first quarter and F6s2 and F7s2 operates in the second quarter; (C) JPN OLLF2 and CLLF2 fisheries (F8 & F9); (D) JPN GN (F10) and JPN M (F11) fisheries; (E) TWN LL fishery (F12); and (F) the KO longline fishery (F13) and TWN and KOR GN fishery (F14).

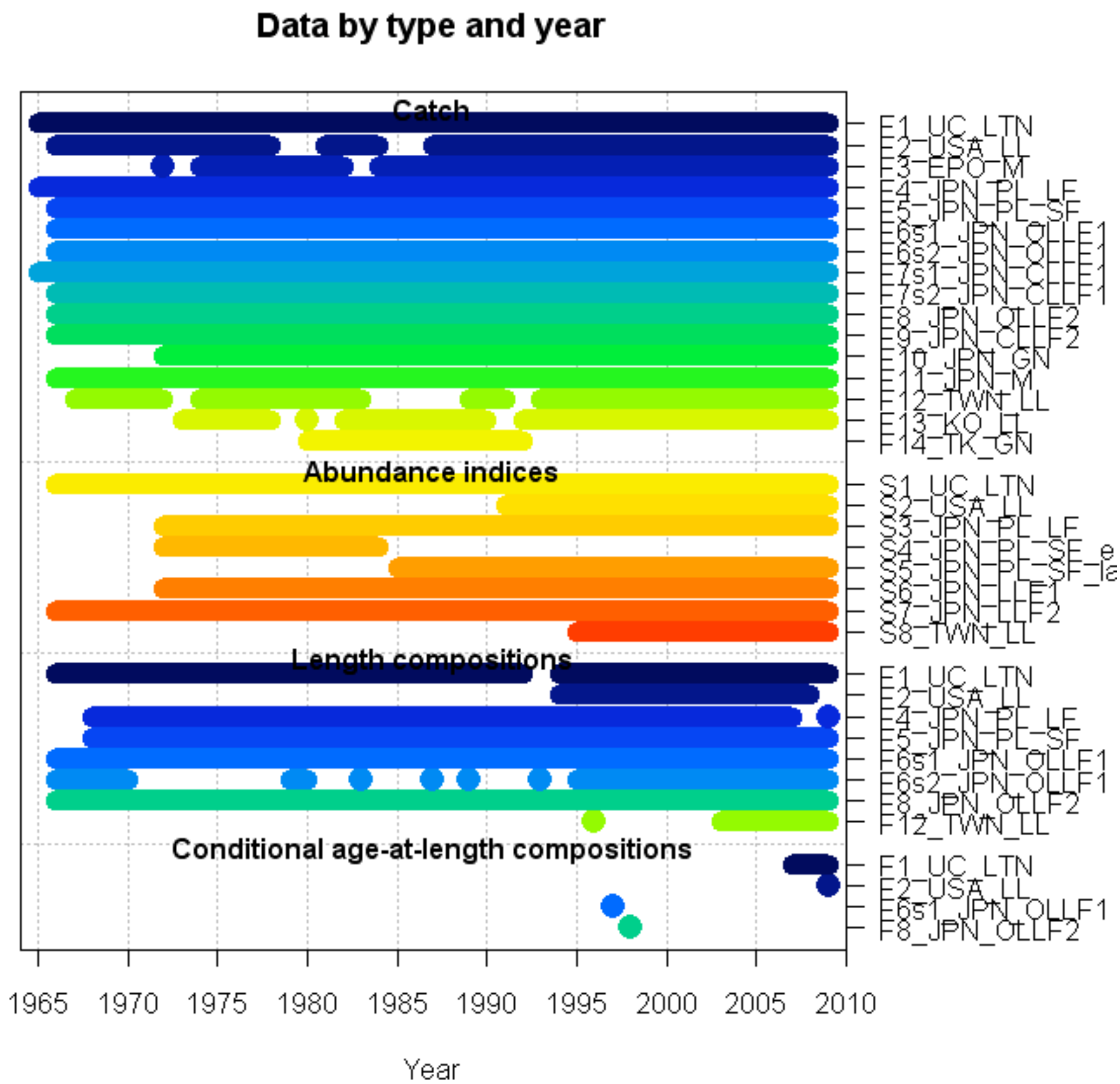


Figure 7.4. Temporal coverage and sources of catch, CPUE, length composition and ageing data used in the 2011 assessment of north Pacific albacore.

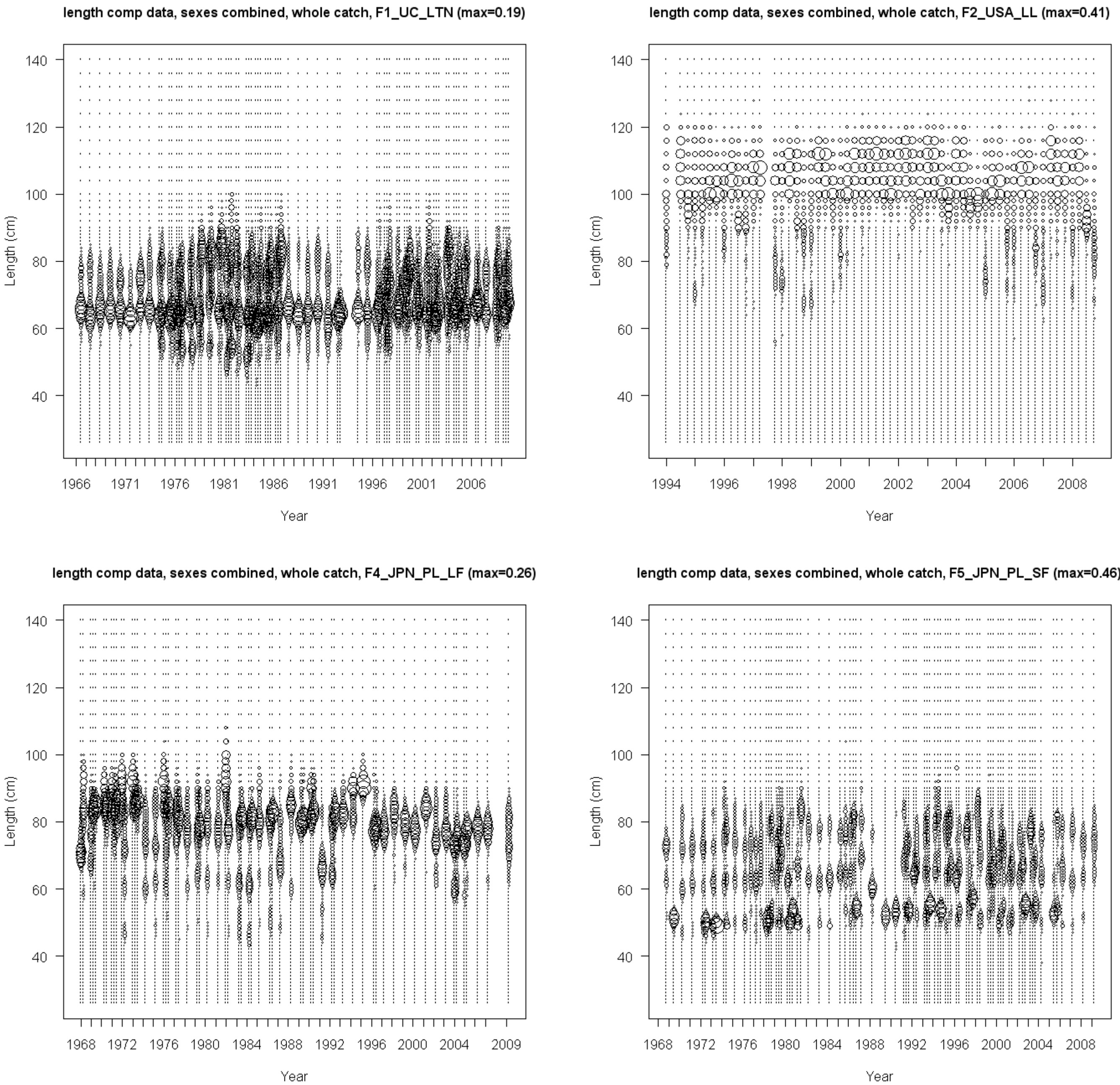


Figure 7.5. Annual length compositions of fisheries used in the assessment (F1, F2, F4, F5, F6s1, F6s2, F8, and F12 – see Table 7.1). Size of circles is proportional to the number of observations. Length composition data from other fisheries are not available for the assessment and selectivity patterns for these fisheries are mirrored to fisheries with length composition data.

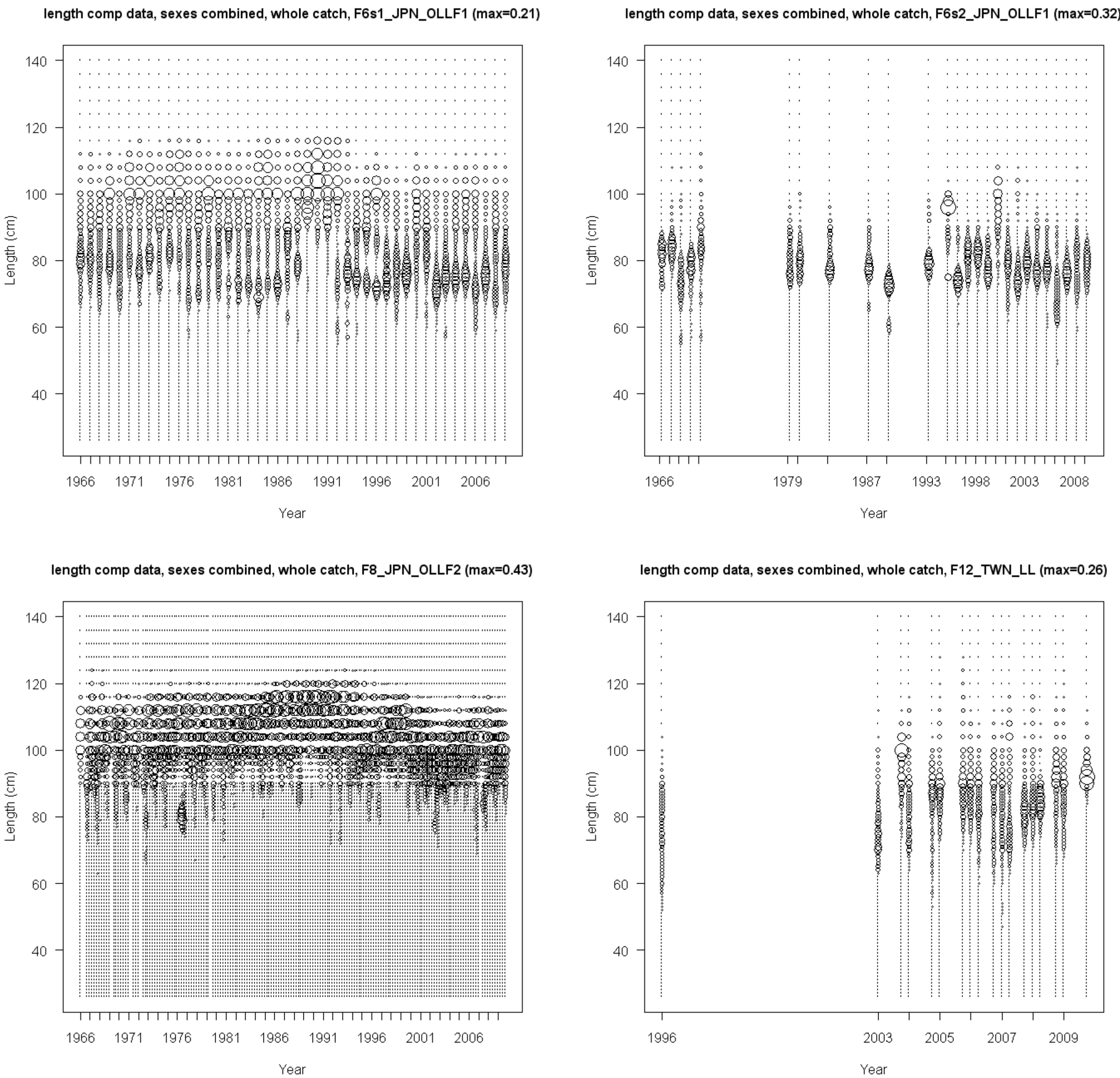


Figure 7.5. Continued.

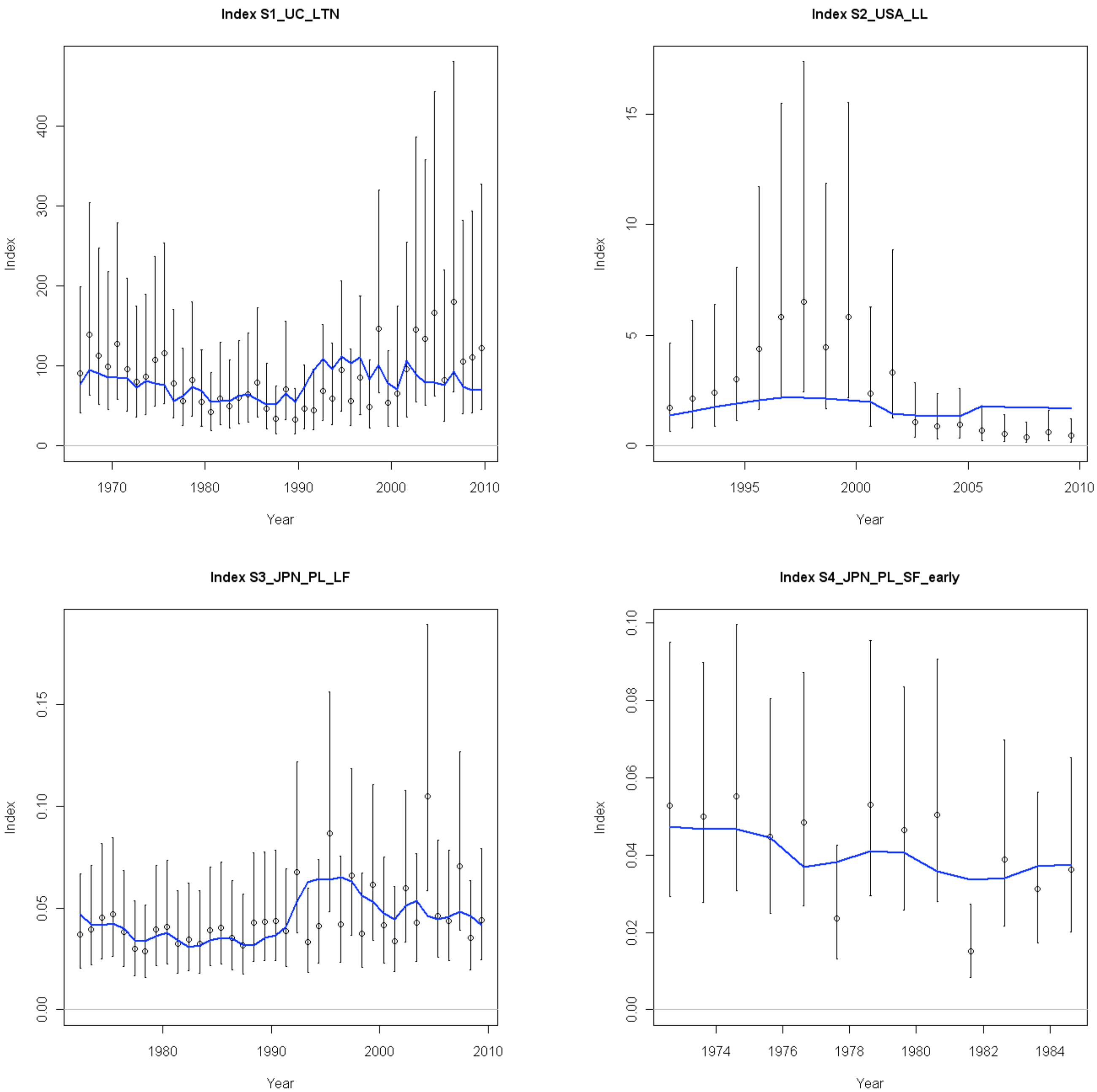


Figure 8.1. Model fits to the standardized CPUE data from different fisheries used in the assessment. The blue line is the model predicted value and the open circles are observed (data) values. The vertical lines represent the estimated confidence intervals (± 2 standard deviations) around the CPUE values. The numbers in the panels correspond to the index numbers in Table 7.2.

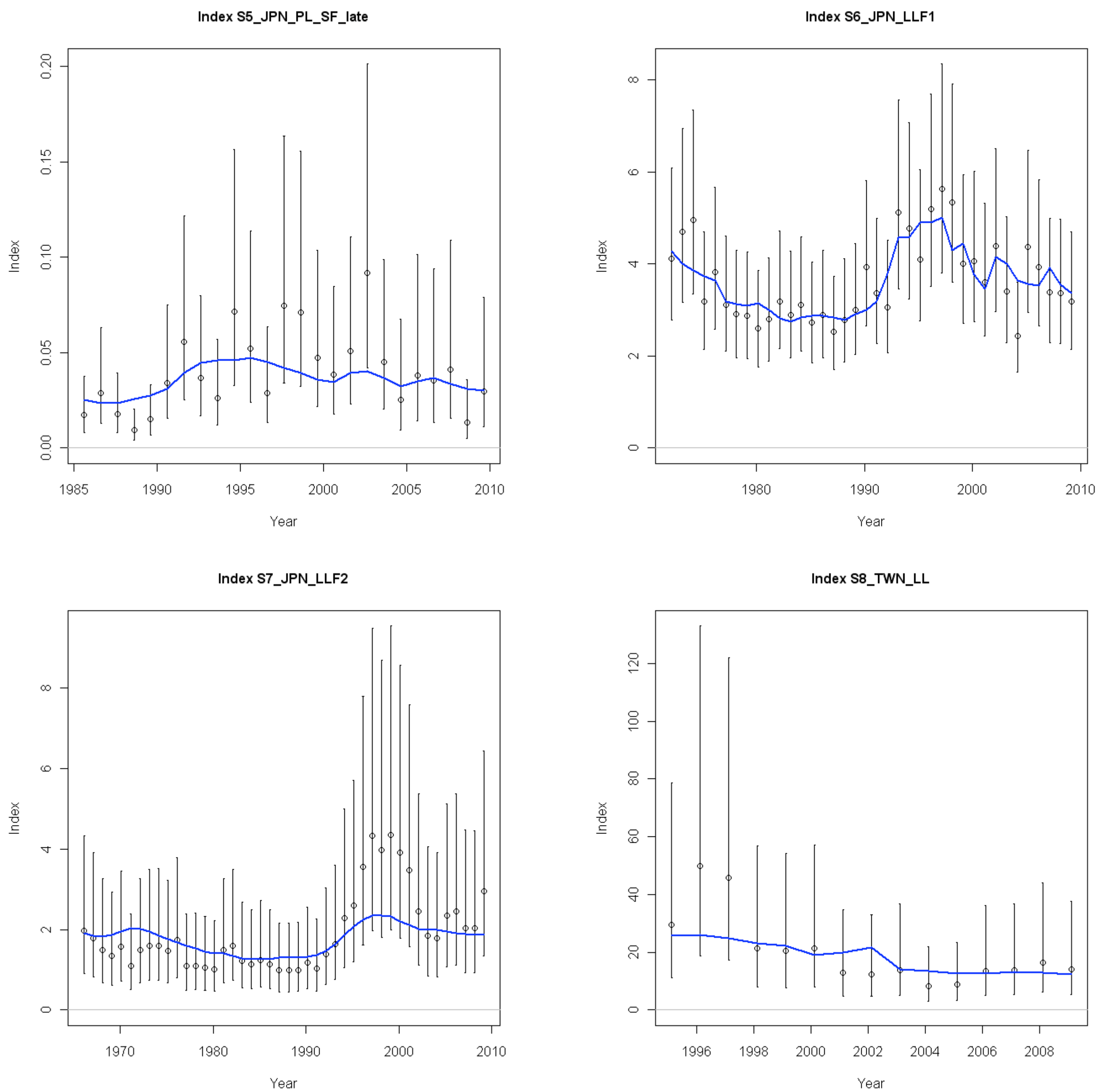


Figure 8.1. Continued.

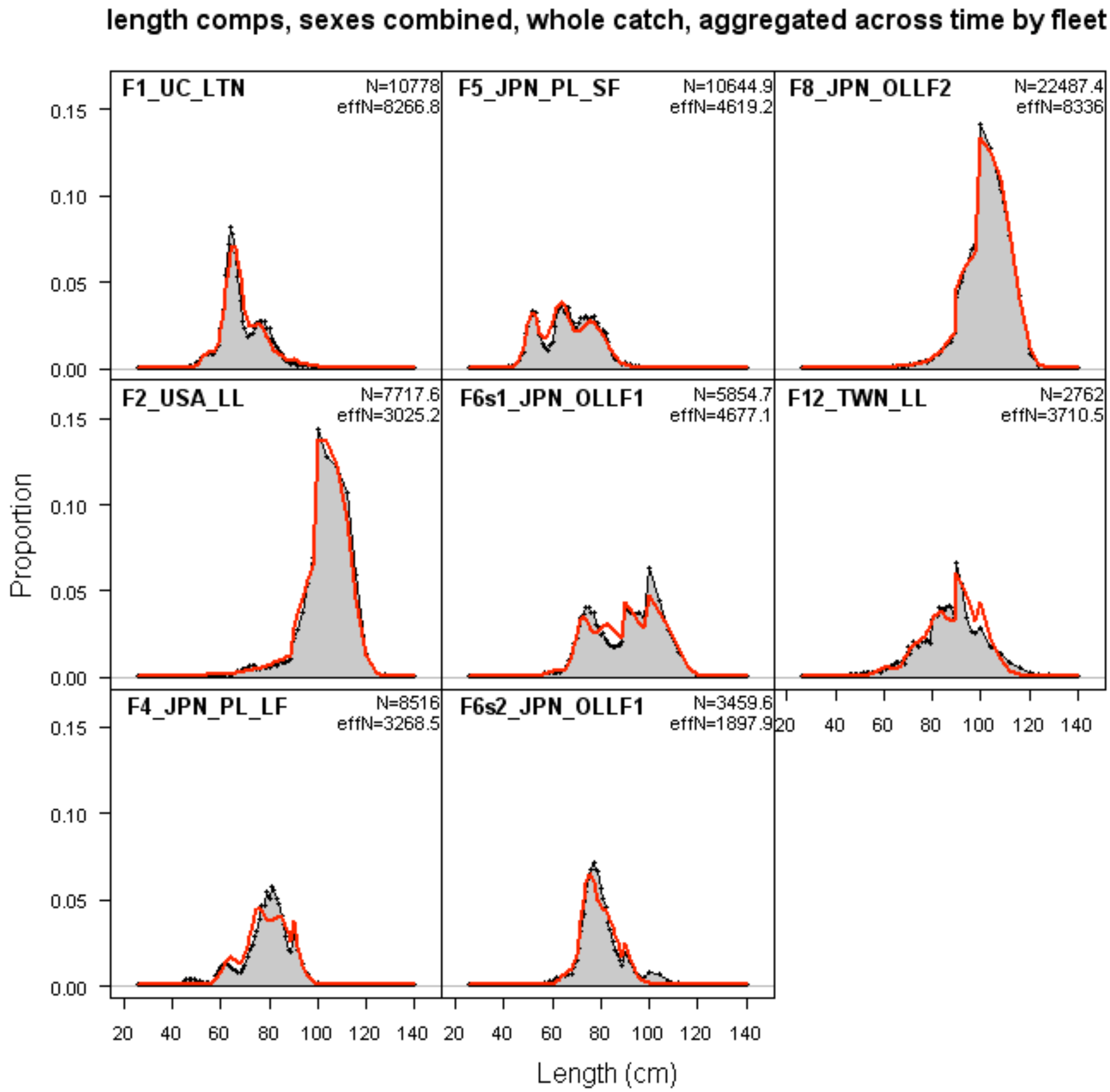


Figure 8.2. Comparison of observed (gray shaded area) and model predicted (red line) length compositions for fisheries used in the north Pacific albacore stock assessment (F1, F2, F4, F5, F6s1, F6s2, F8, and F12 – see Table 7.1 and Figure 7.2 for spatial and temporal boundaries of these fisheries).

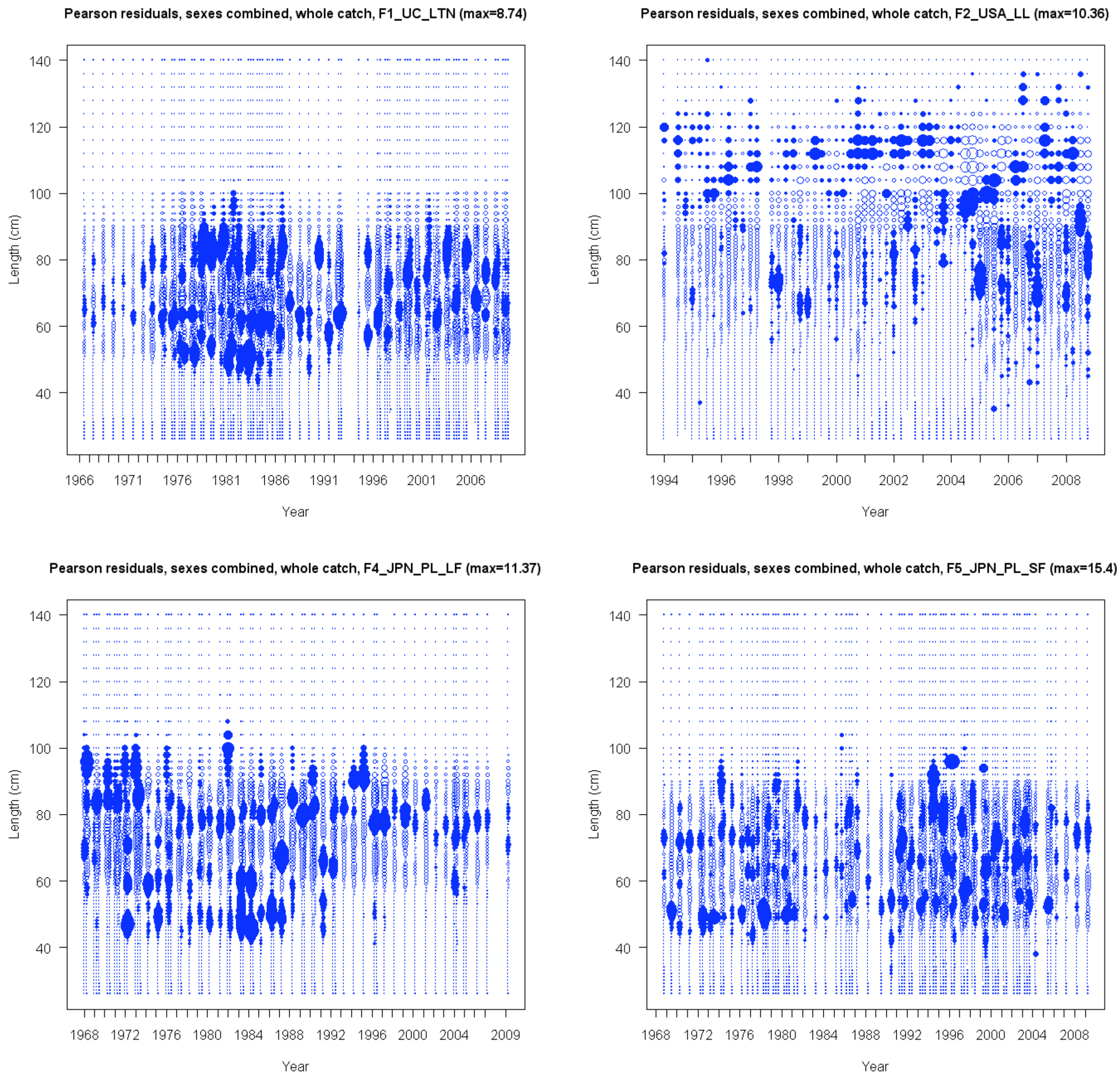


Figure 8.3. Pearson residual plots of model fits to the length-composition data for the albacore fisheries used in the assessment model (F1, F2, F4, F5, F6s1, F6s2, F8, and F12 – see Table 7.1 and Figure 7.2 for spatial and temporal boundaries of these fisheries). The filled and hollow blue circles represent observations that are higher and lower than the model predictions, respectively. The areas of the circles are proportional to the absolute values of the residuals.

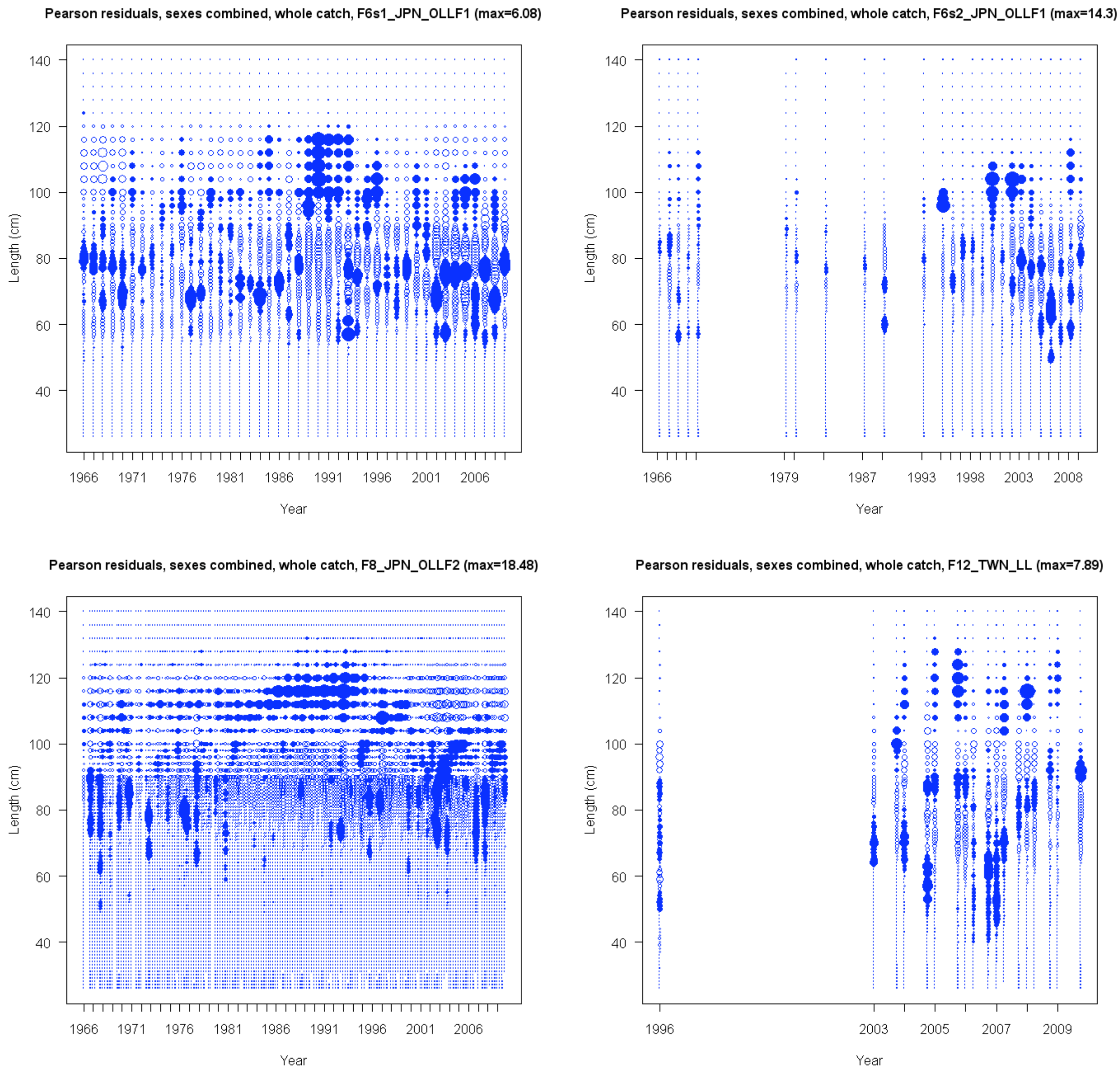


Figure 8.3. Continued.

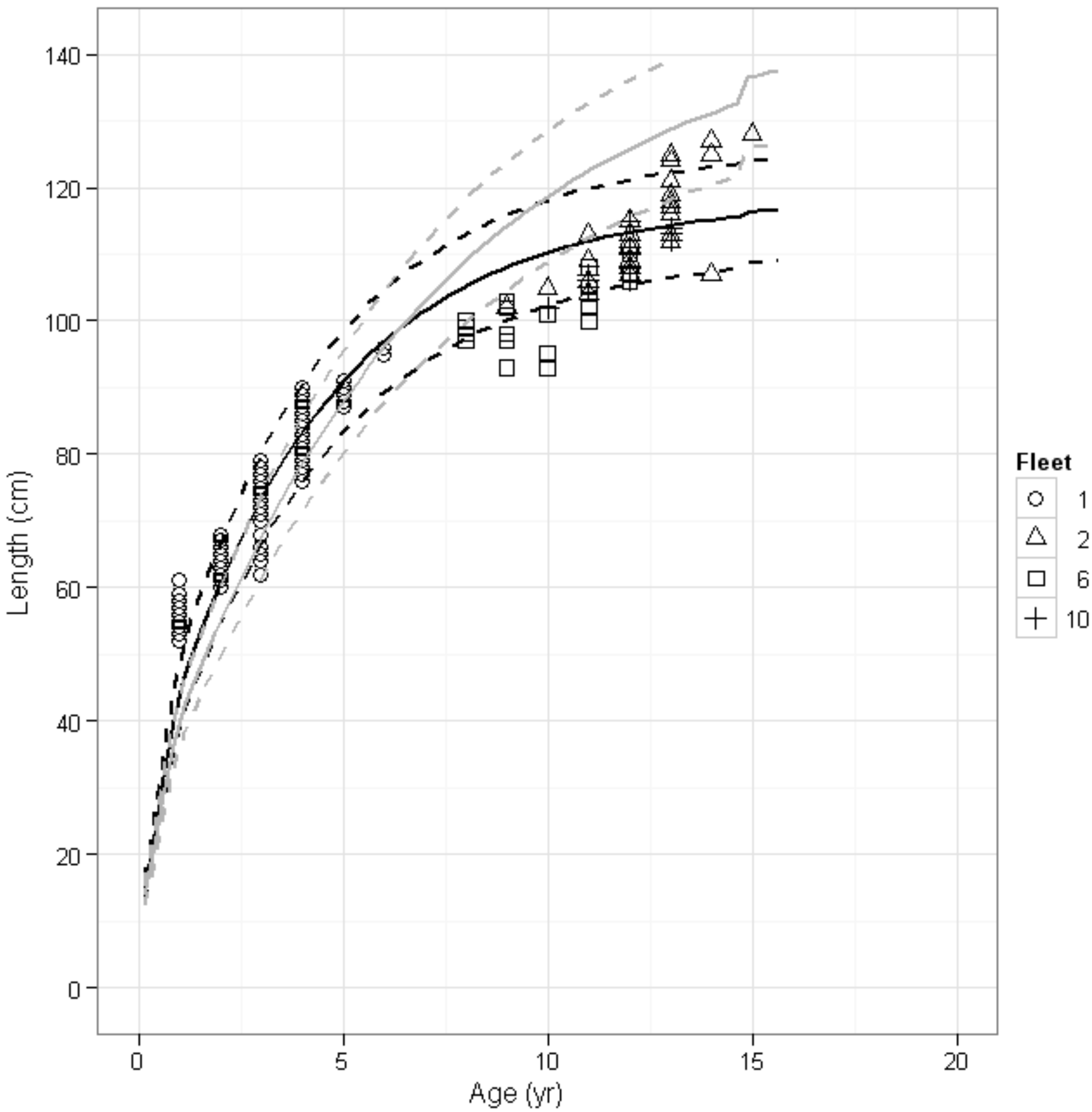


Figure 8.4. Comparison of the Suda growth curve used in the 2006 assessment of north Pacific albacore (grey) with the estimated growth curve in the 2011 assessment model. Points represent observed ages by fleet reported in ISC/11/ALBWG/02.

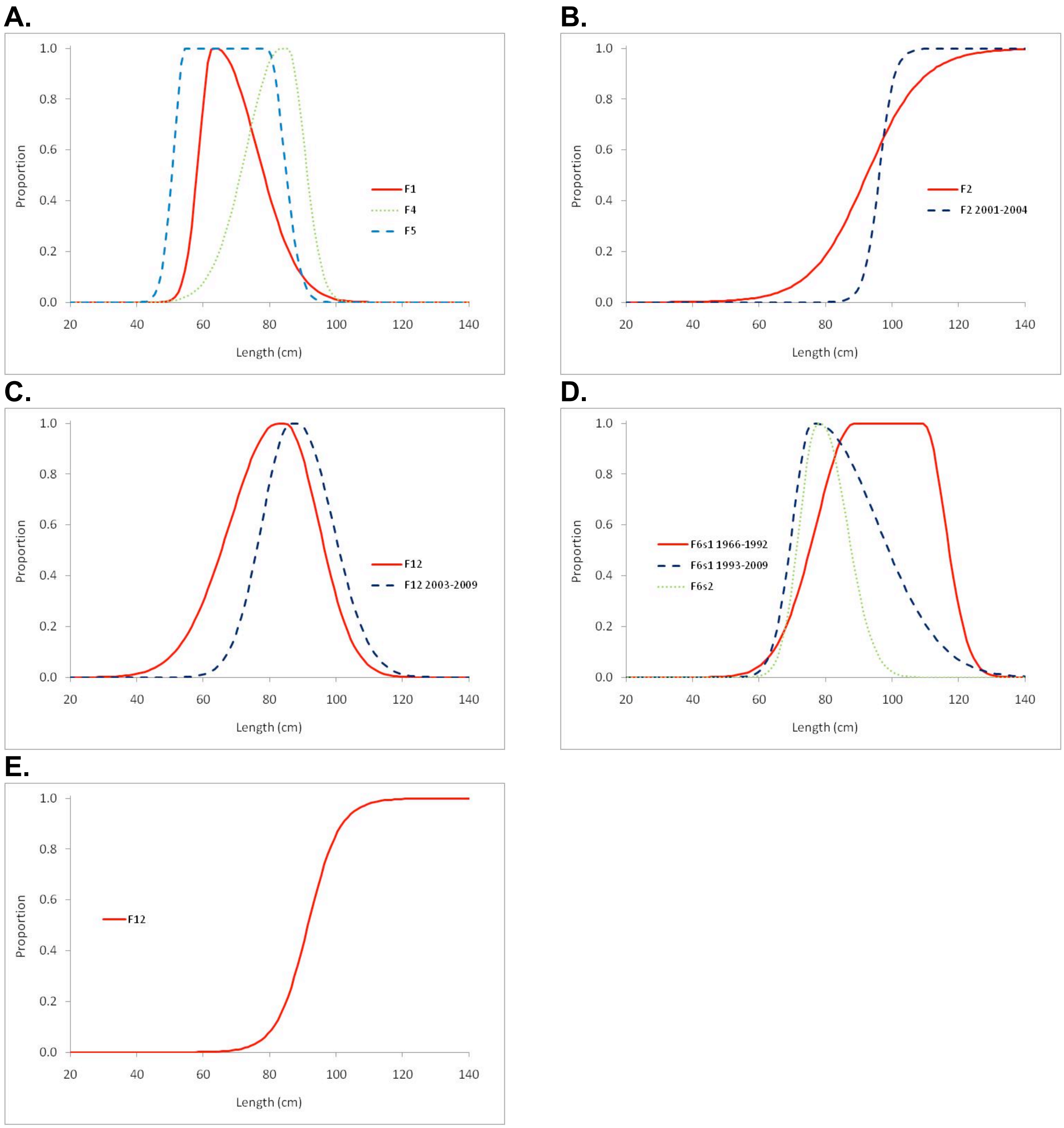
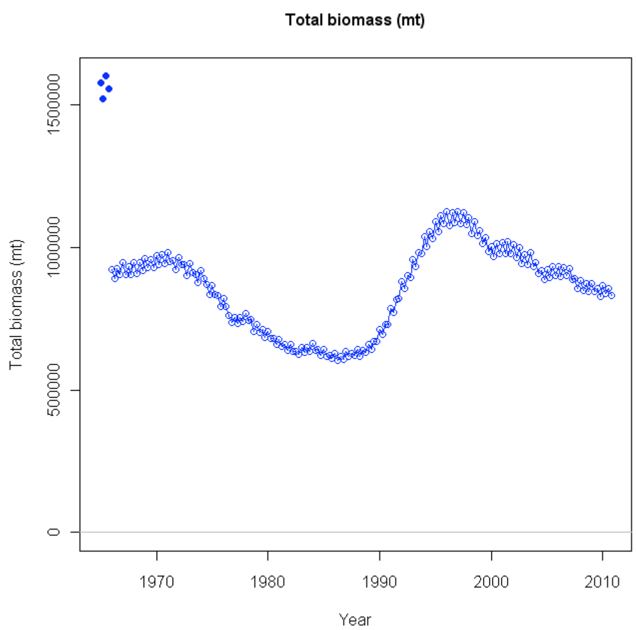
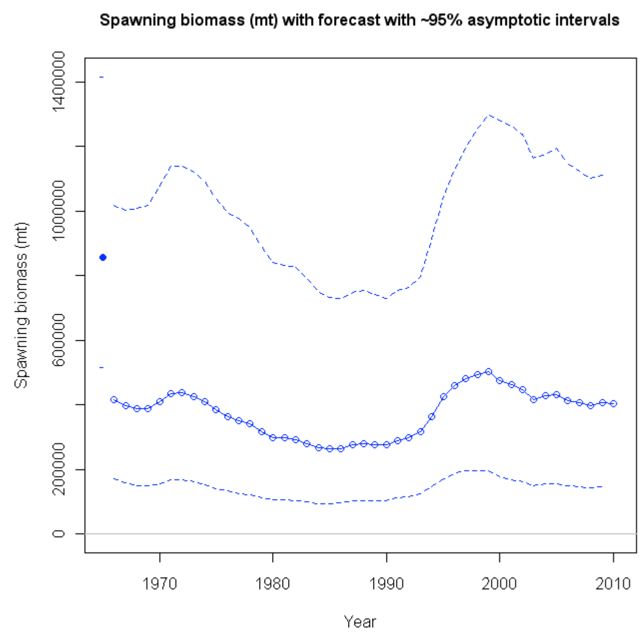


Figure 8.5. Length selectivity of fisheries estimated by the north Pacific albacore assessment model: (A) surface fisheries - F1 (red solid line), F4 (green dotted line), and F5 (blue dashed line); (B) US longline fishery (F2) during 2001-2004 (blue dashed line) and the remaining period (red solid line); (C) TWN LL fishery (F12) 1995-2002 (red solid line) and 2003-2009 (blue dashed line); (D) JPN OLLF1 and CLLF1 fisheries: F6s1 during 1966-1992 (red solid line) and 1993-2009 (blue dashed line), and F6s2 (green dotted line); and (E) JPN OLLF2 and CLLF2 fisheries (F8).

A.



B.



C.

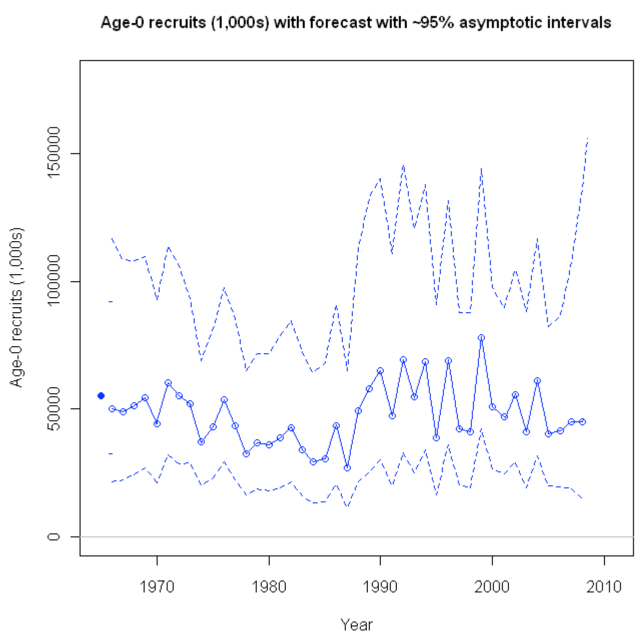


Figure 8.6. Estimated total biomass (A), spawning biomass (B), and age-0 recruitment (C) of albacore tuna in the north Pacific Ocean. The open circles represent the maximum likelihood estimates of each quantity and the dashed lines in the SSB (B) and recruitment (C) plots are the 95% asymptotic intervals of the estimates (± 2 standard deviations) in lognormal (SSB – B) and arithmetic (recruitment – C) space. Since the assessment model represents time on a quarterly basis, there are four estimates of total biomass for each year, but only one annual estimate of spawning biomass and recruitment.

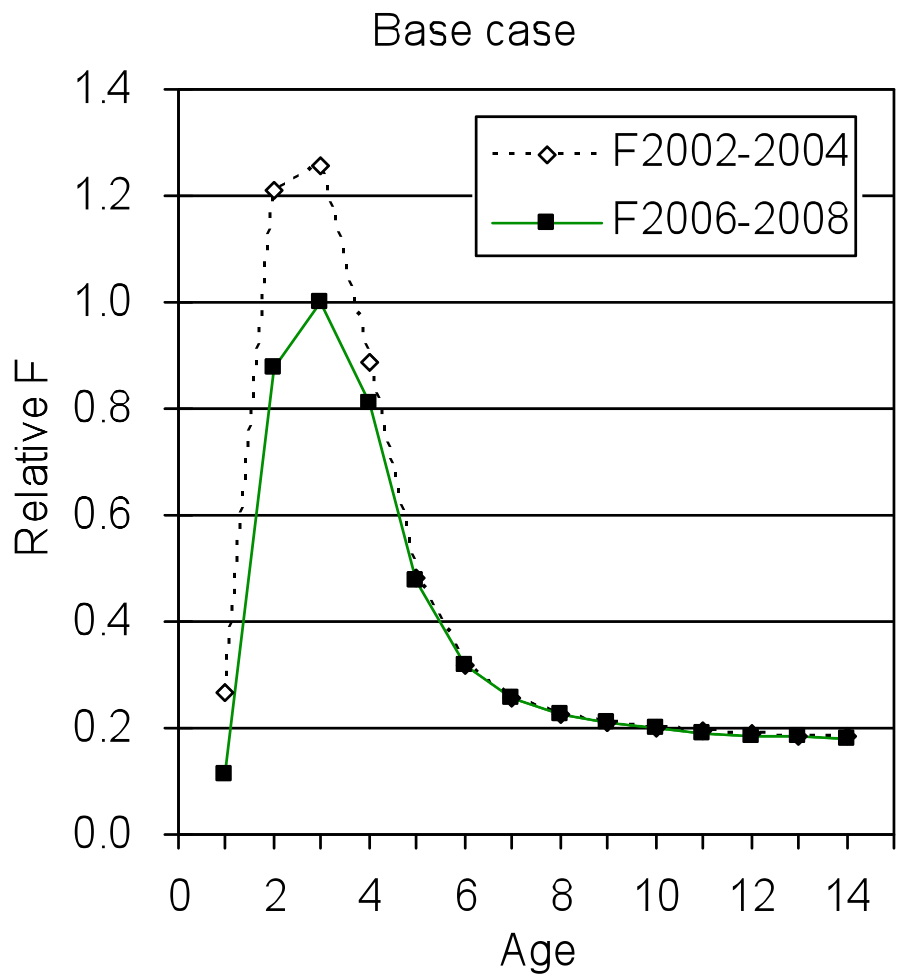


Figure 8.7. Estimated fishing mortality-at-age for the base-case scenario ($F_{2006\text{-}2008}$) and $F_{2002\text{-}2004}$ (current F in the 2006 assessment). Results are scaled to the highest F-at-age in the $F_{2006\text{-}2008}$ series.

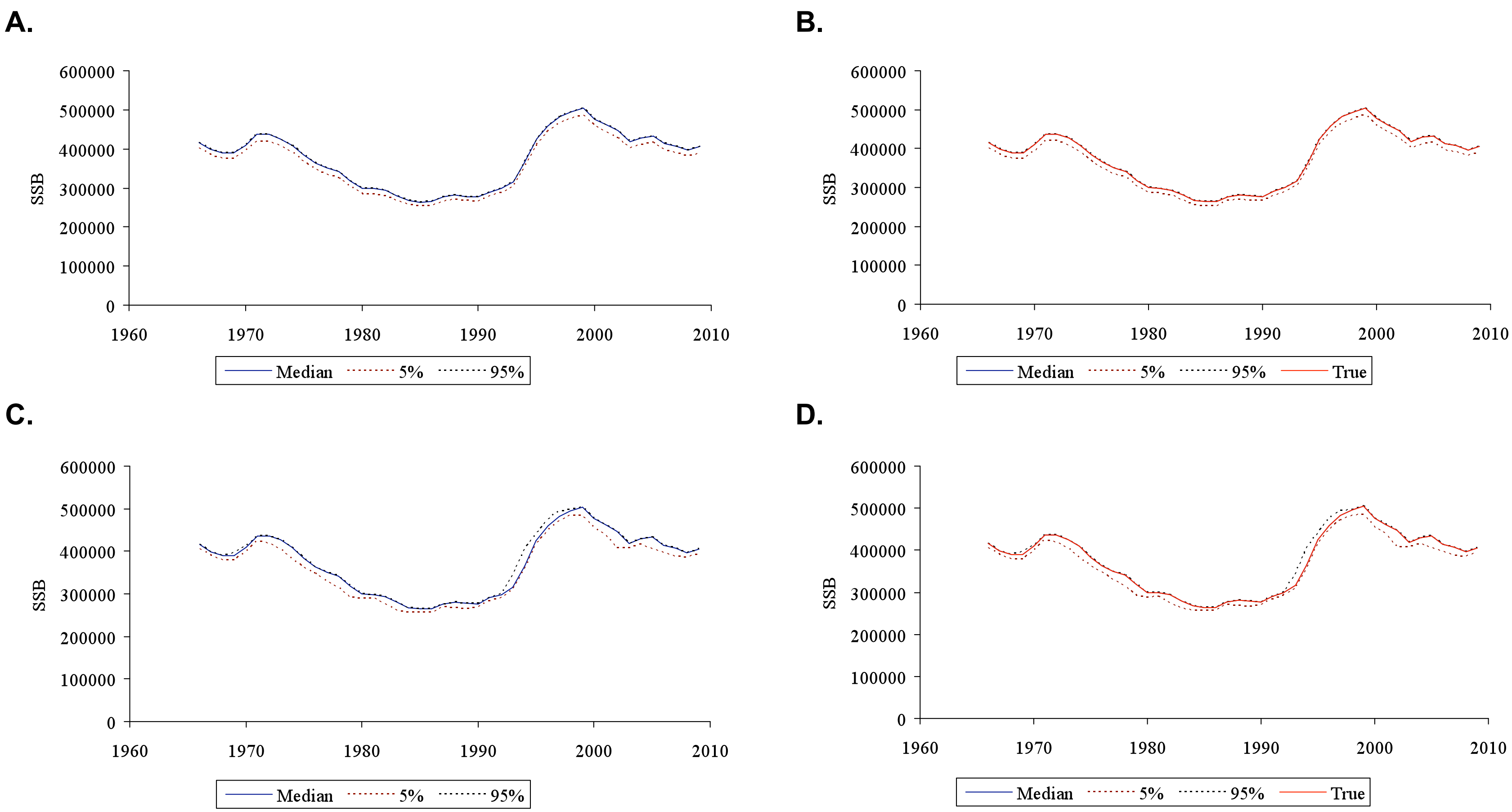
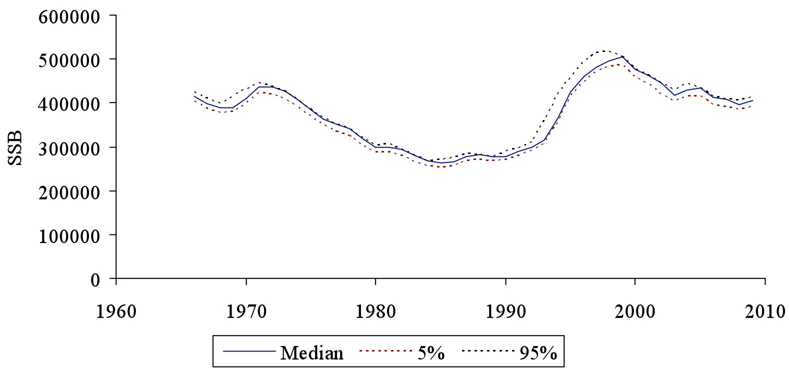


Figure 8.8. Spawning biomass time series estimated when jitter values of 0.1 (A) and 0.2 (B) were randomly added to parameters (blue lines) and base-case estimates of the SSB time series (C,D – red lines). Dotted lines are 5% and 95% confidence limits.

E.



F.

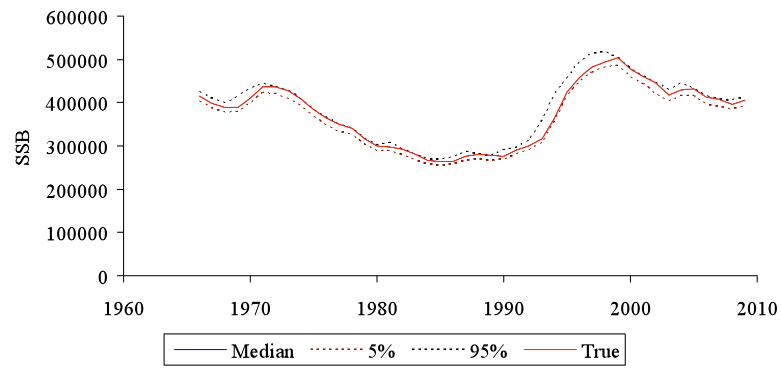


Figure 8.8. Continued. Spawning biomass time series estimated when jitter values of 0.3 (E) were randomly added to parameters (blue lines) and base-case estimates of the SSB time series (F – red lines). Dotted lines are 5% and 95% confidence limits.

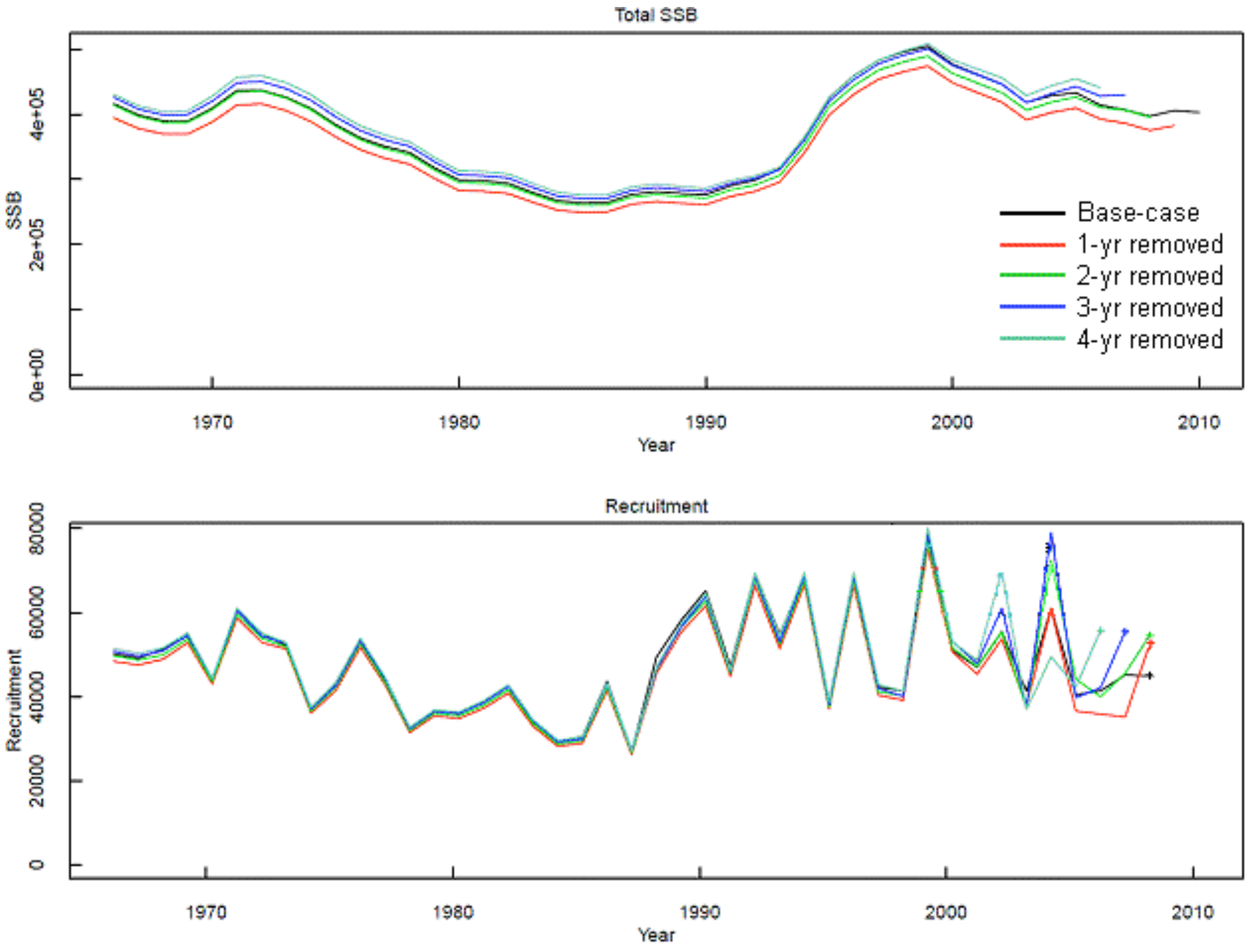
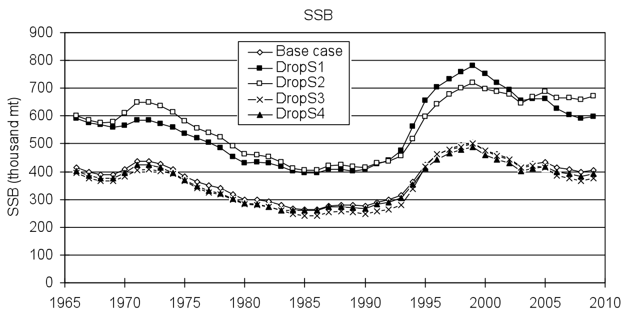
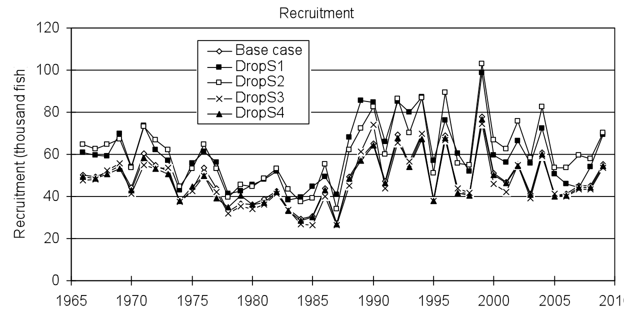


Figure 8.9. Retrospective analysis results showing spawning stock biomass (top) and recruitment (bottom) estimate trajectories when 1 to 4 years of data (2009 – 2006) are removed from the base-case model.

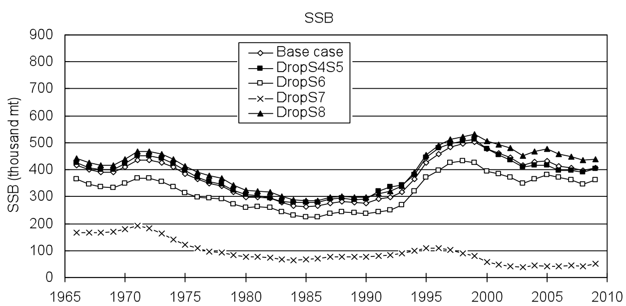
A.



B.



C.



D.

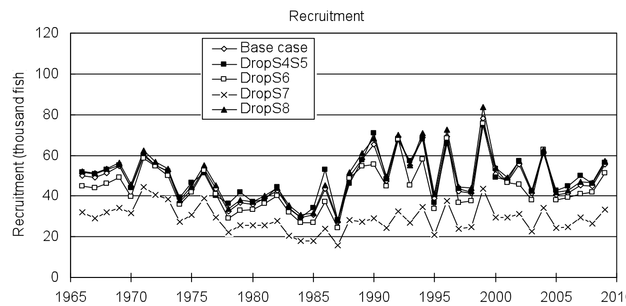


Figure 8.10. Estimates of spawning stock biomass (A,C) and recruitment (B,D) when individual CPUEs indices are dropped from the base-case model.

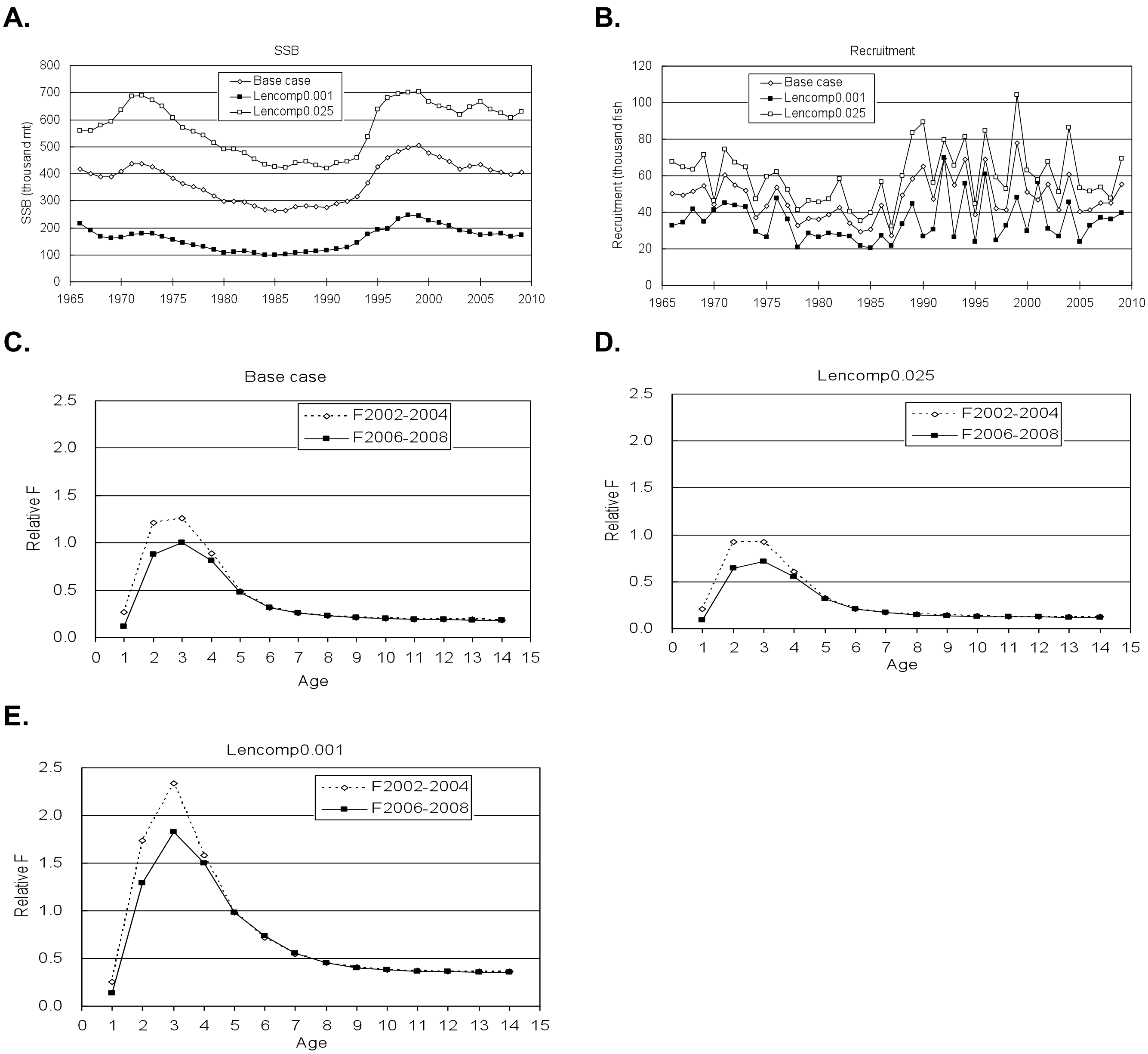


Figure 8.11. Estimates of spawning stock biomass (A), recruitment (B), and F-at-age (C,D,E) for the base-case and sensitivity runs assuming length composition lambdas = 0.025 and =0.001. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

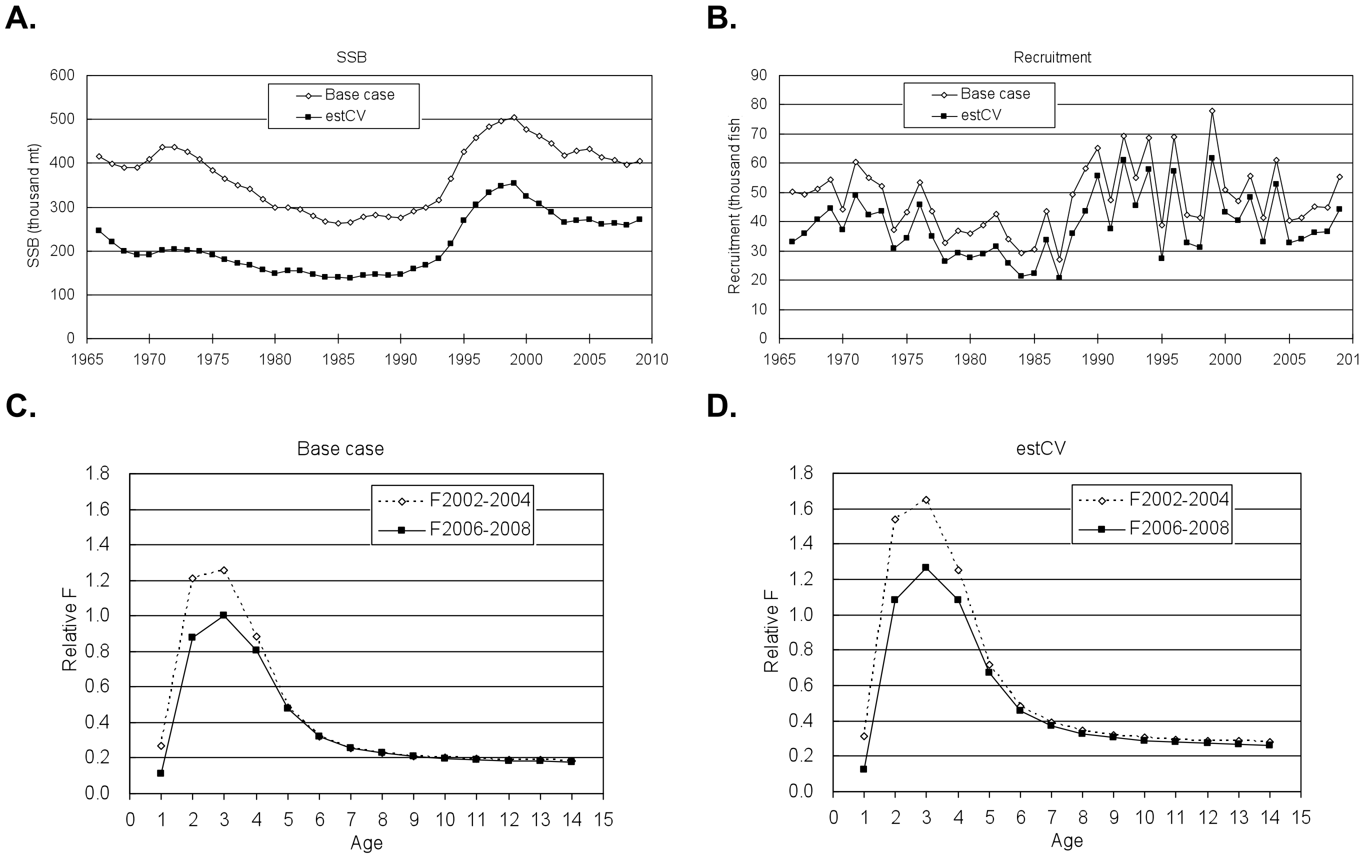


Figure 8.12. Estimates of spawning biomass (A), recruitment (B), and F-at-age (C,D) for the base case and the sensitivity run in which CV for S6 is fixed = 0.2 and all other CPUE index CVs are estimated. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

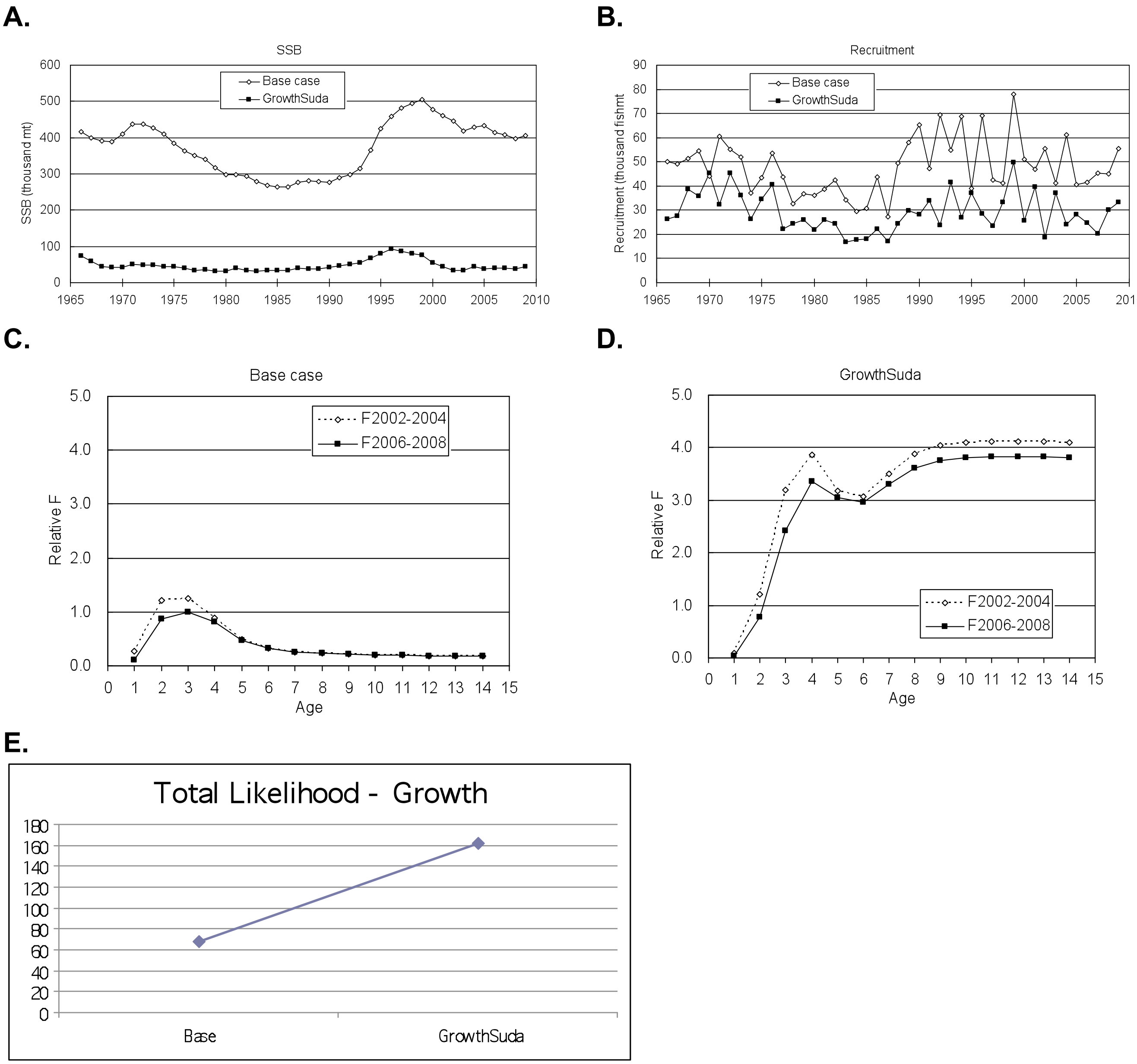


Figure 8.13. Estimates of spawning biomass (A), recruitment (B), and F-at-age (C – Base-case; D-Suda estimates) and total model likelihood (E) for the base case and sensitivity run in which growth curve parameters are fixed to Suda's (1966) estimates. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

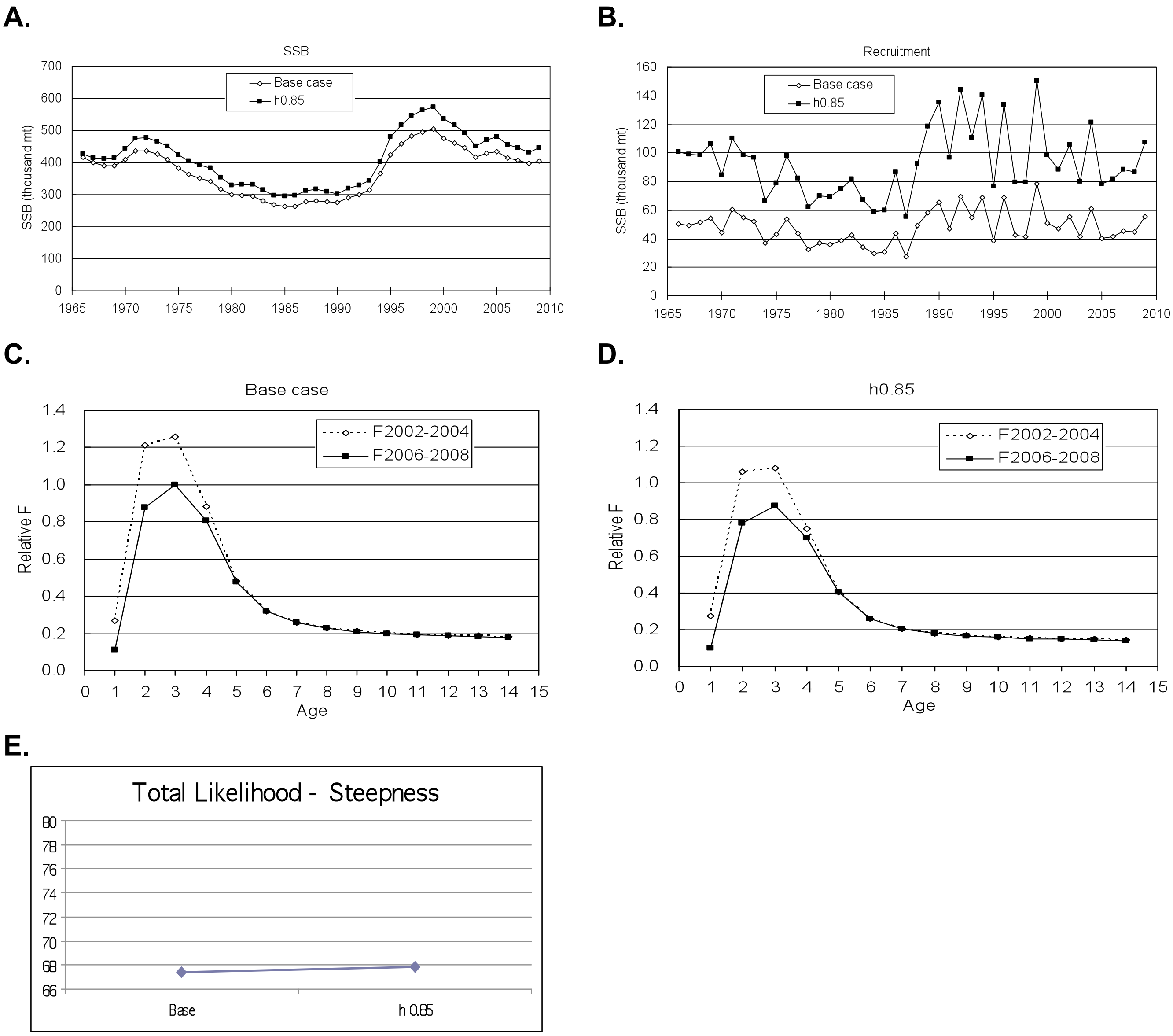


Figure 8.14. Estimates of spawning biomass (A), recruitment (B), F-at-age (C,D), and total likelihood (E) for the base-case and steepness (h) = 0.85. F-at-age plots are scaled to the highest age-specific $F_{2006-2008}$ (= 1.0) on the base-case plot (C).

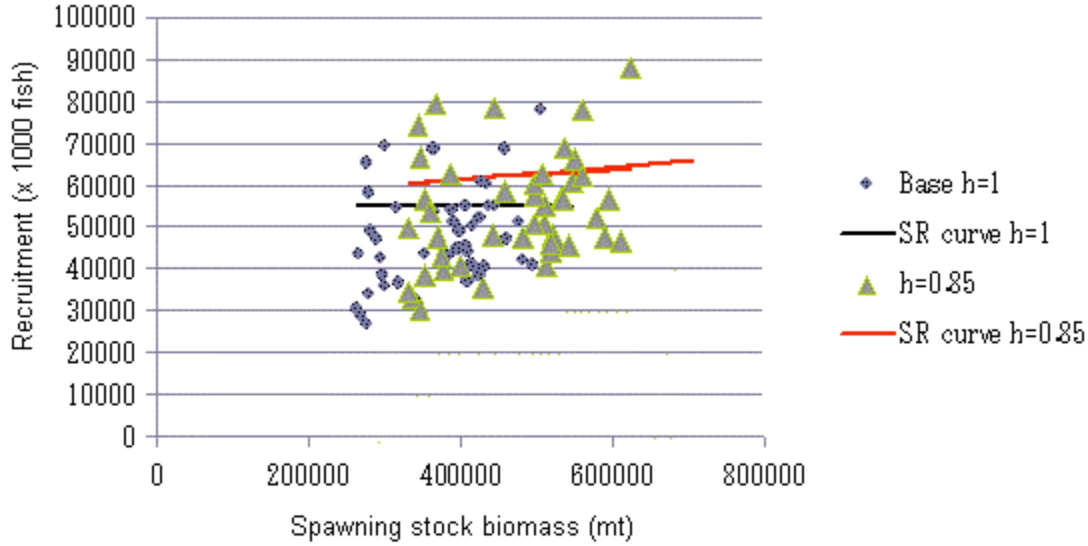


Figure 8.15. Spawning stock biomass and recruitment in the base-case model using two steepness assumptions: h = 1.0 (base-case) and h = 0.85 (sensitivity run.

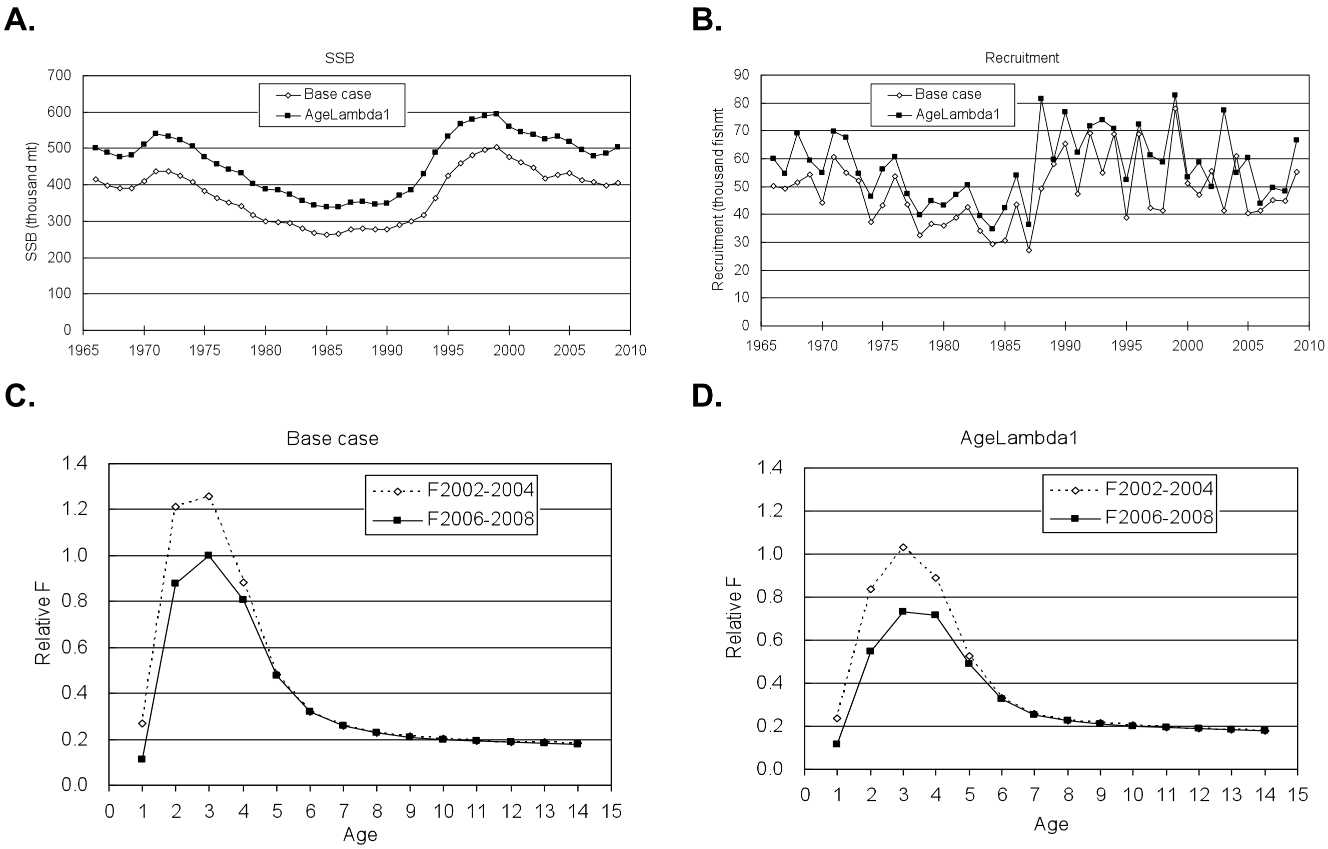


Figure 8.16. Estimates of spawning biomass (A), recruitment (B), and F-at-age (C – Base-case; D-aging lambda = 1) for the base case and sensitivity run assuming aging lambda = 1.0. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

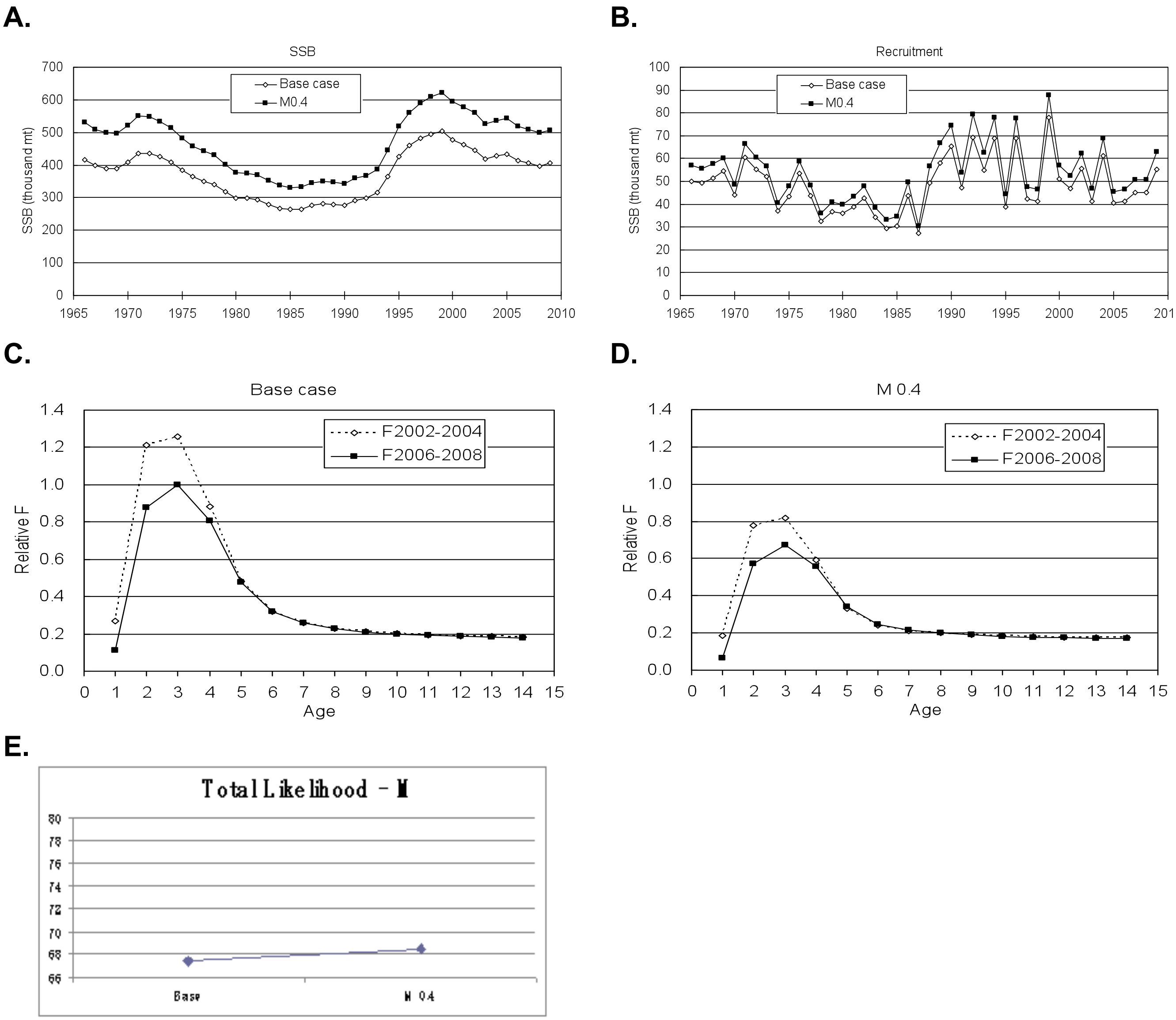


Figure 8.17. Estimates of spawning biomass (A), recruitment (B), F-at-age (C,D), and total likelihood for the base-case model and sensitivity run assuming M = 0.4 yr^{-1} for all ages. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

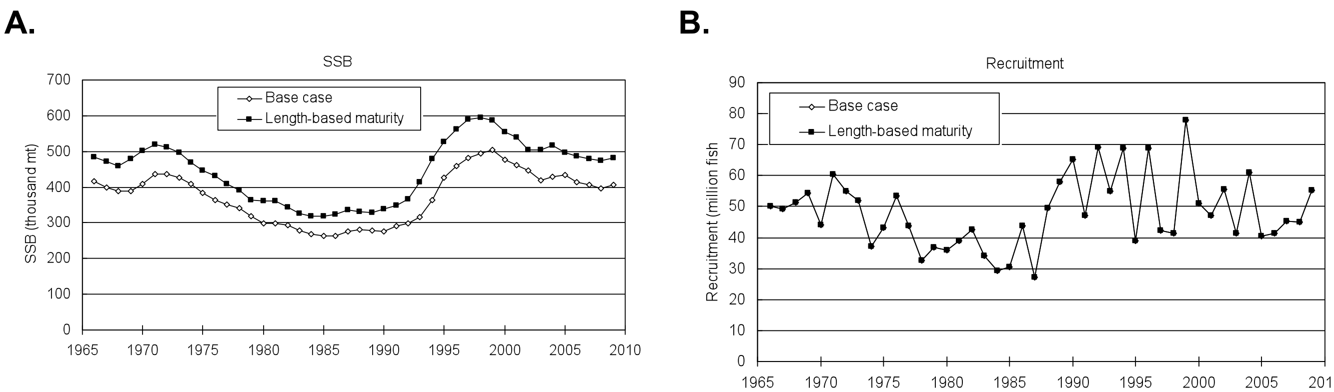


Figure 8.18. Estimates of spawning stock biomass (A) and recruitment (B) for the base-case (age-based maturity) and a sensitivity run using a length-based maturity schedule. Note that recruitment levels and trajectories are identical in the base-case and sensitivity run.

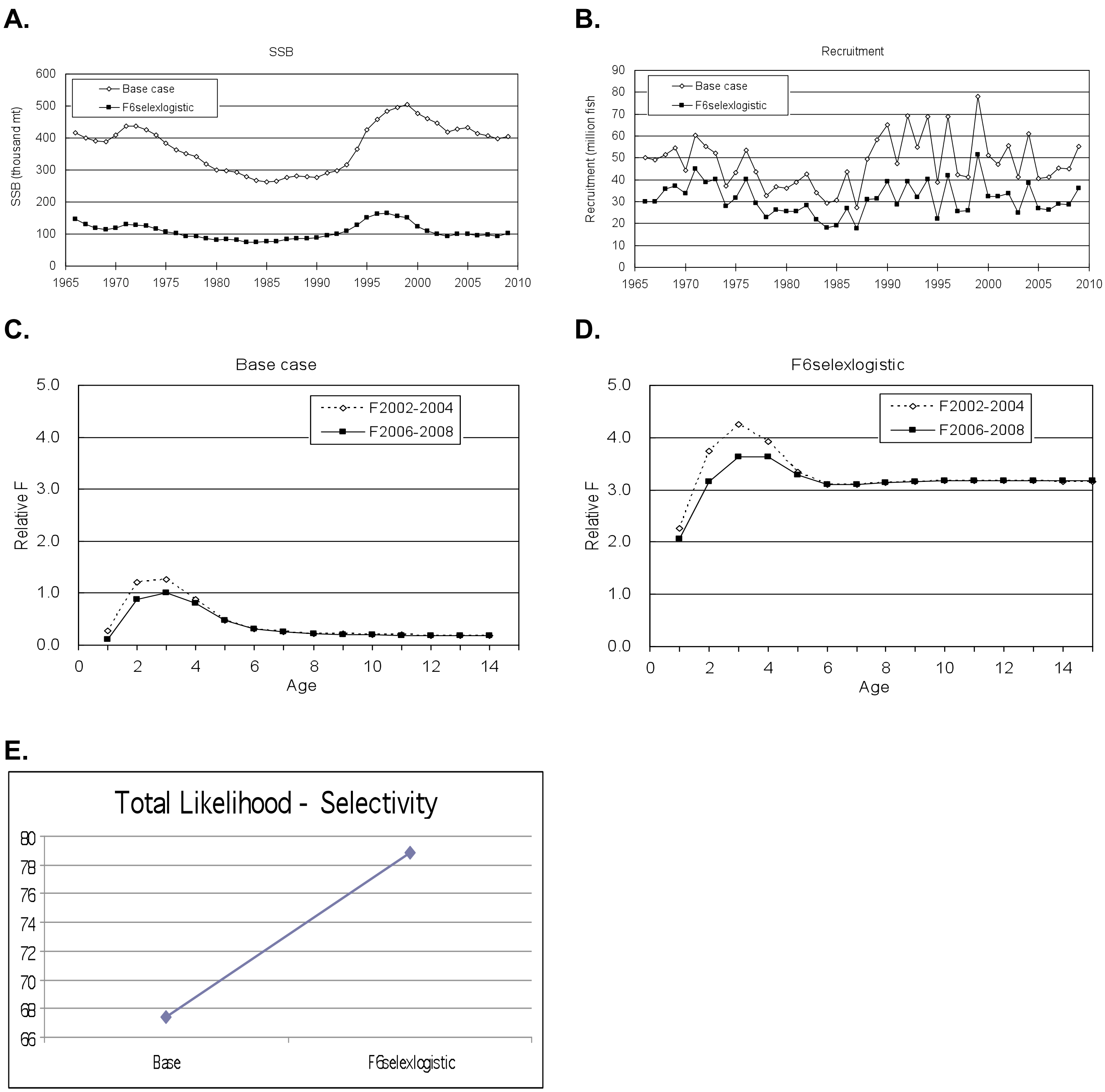


Figure 8.19. Estimates of spawning biomass (A), recruitment (B), F-at-age (C,D), and total likelihood (E) for the base-case model and a sensitivity run assuming that selectivity for fishery F6 is asymptotic rather than dome-shaped. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

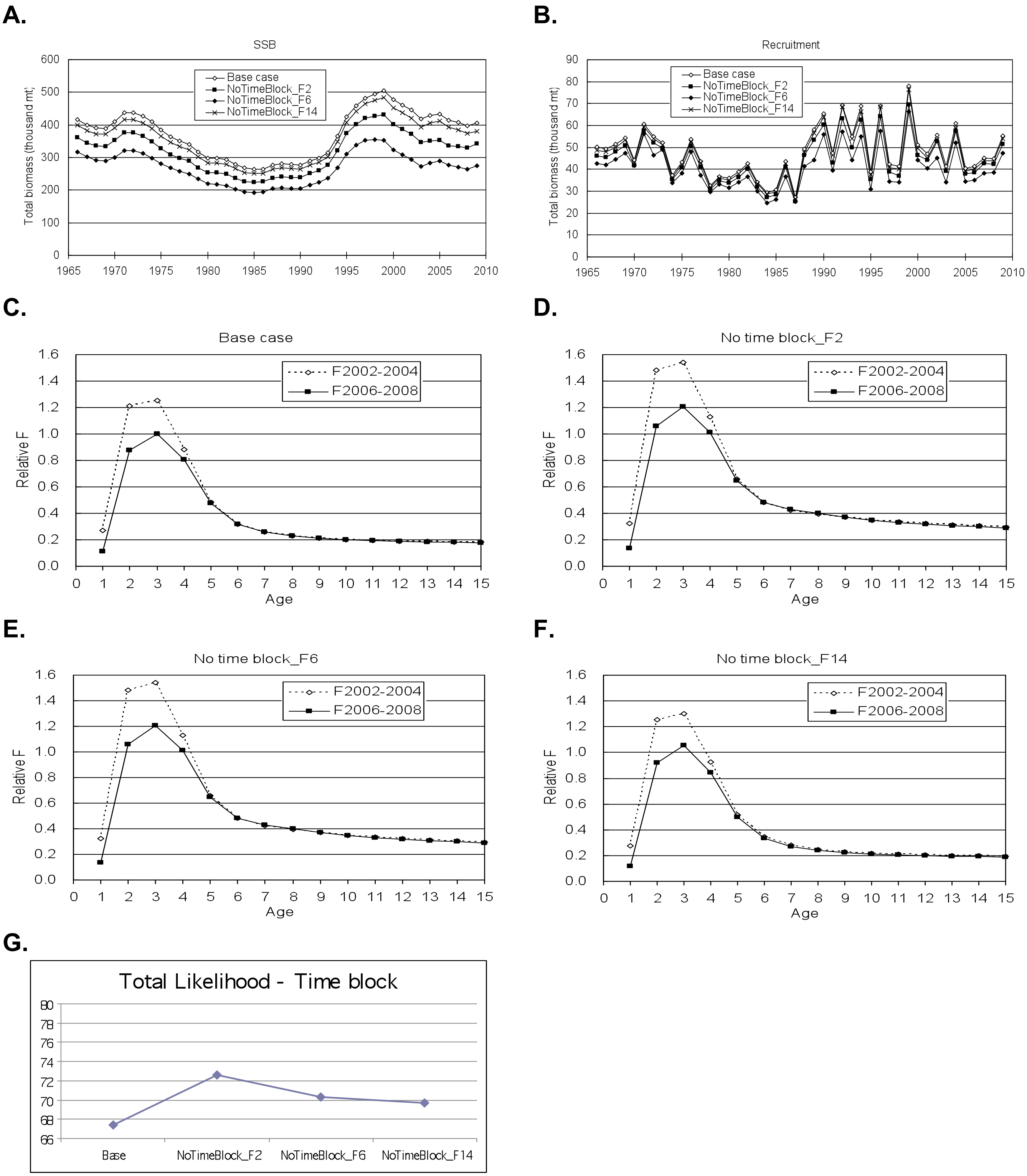


Figure 8.20. Estimates of spawning biomass (A), recruitment (B), F-at-age (C-F), and total model likelihood (G) for the base case scenario and sensitivity runs in which time blocks on selectivities for fisheries F2, F6, and F14 were removed. F-at-age plots are scaled to the highest age-specific $F_{2006\text{-}2008}$ (= 1.0) on the base-case plot (C).

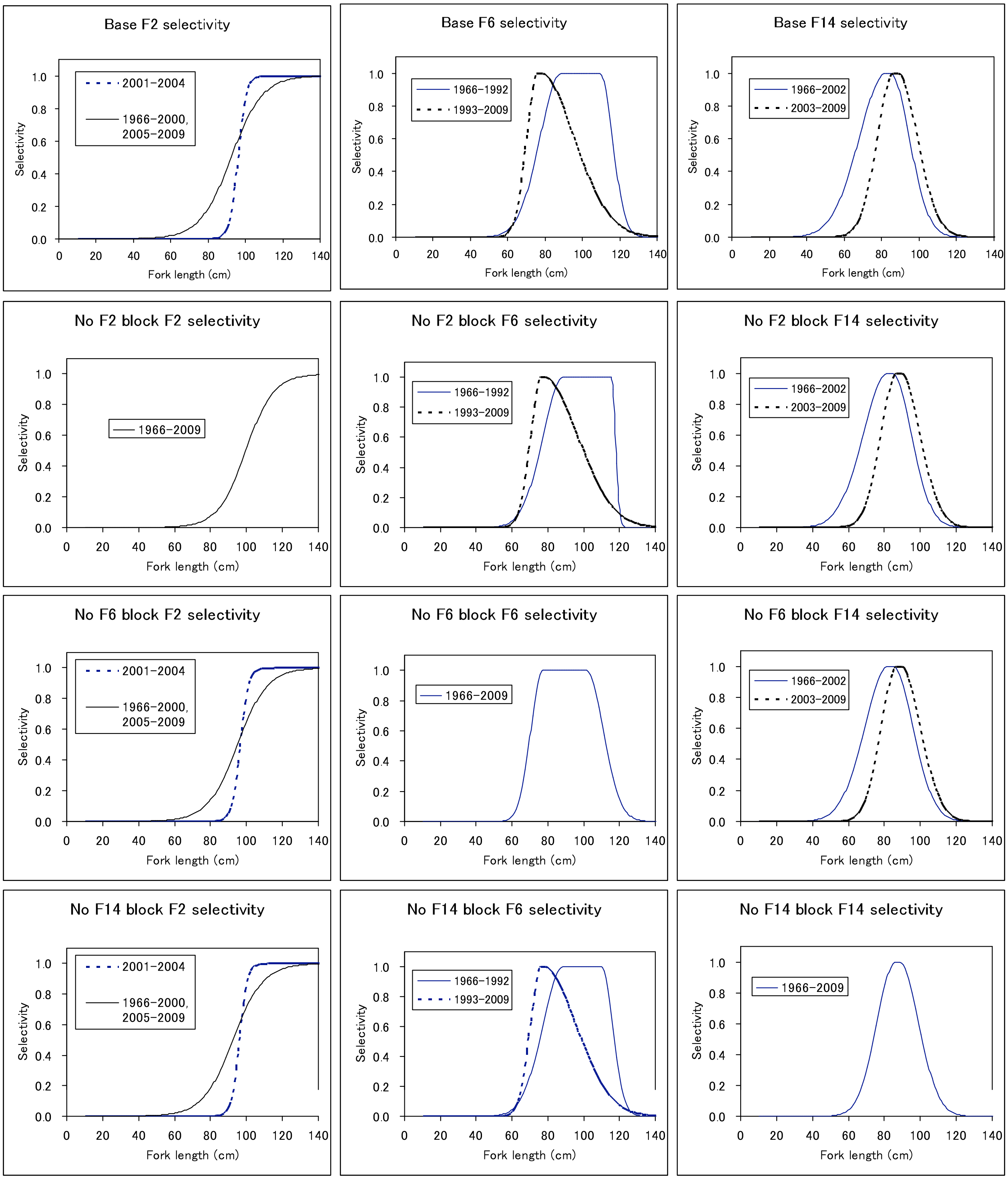


Figure 8.21. Estimated fishery selectivity patterns for the base case and sensitivity run when time blocks were sequentially removed from fisheries F2, F6, and F14.

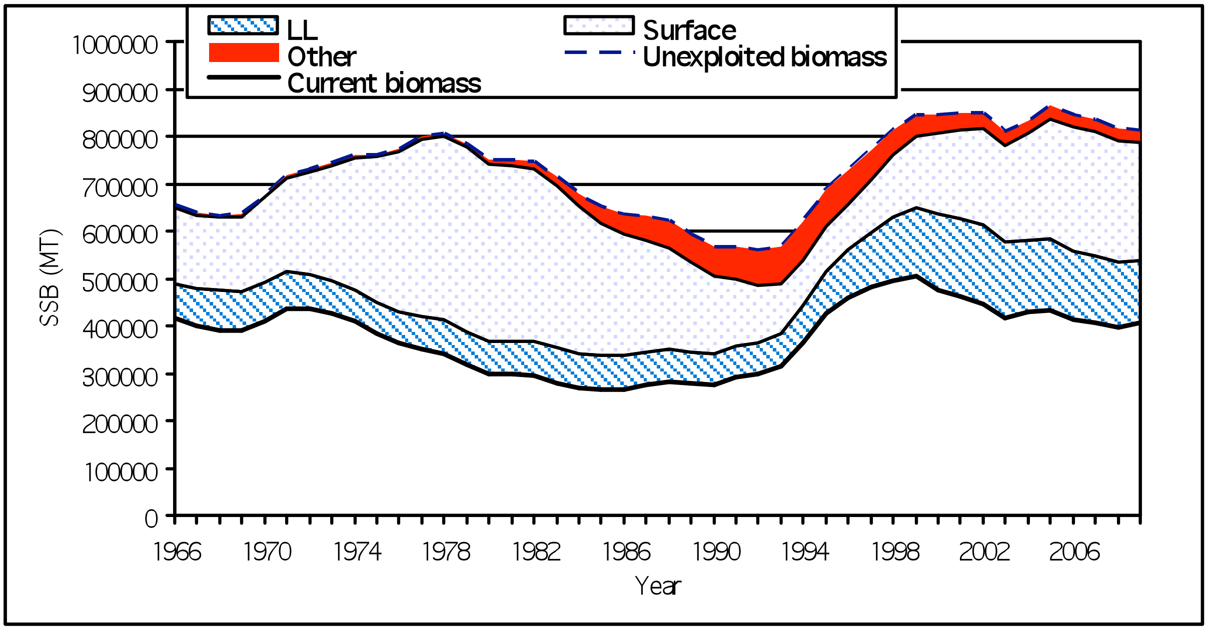


Figure 8.22. Trend of spawning stock biomass of a simulated population of north Pacific albacore that was unexploited (top dashed line) and predicted (solid line) by the base case model. The shaded areas show the portions of the impact attributed to each major fishing method. LL: longline (USA, JPN, TWN, KOR and others), surface: UCLTN and JPN PL, Other: miscellaneous fisheries not included in the longline and surface categories.

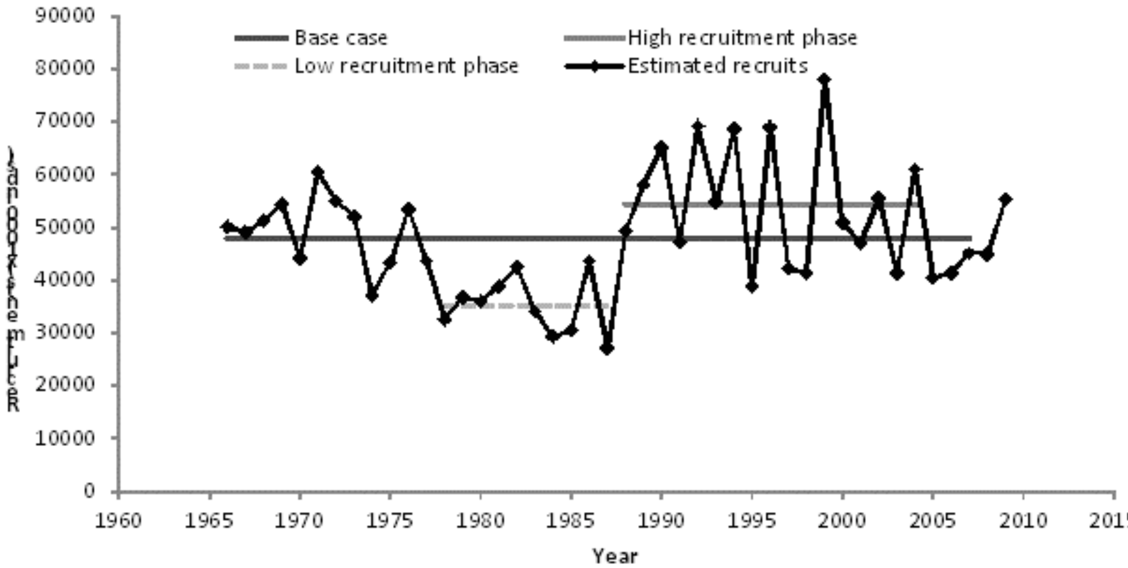


Figure 9.1. Historical trends in recruitment of north Pacific albacore (age-0) estimated by the SS3 base-case model and the assumed periods of low and high recruitments used for future projection scenarios.

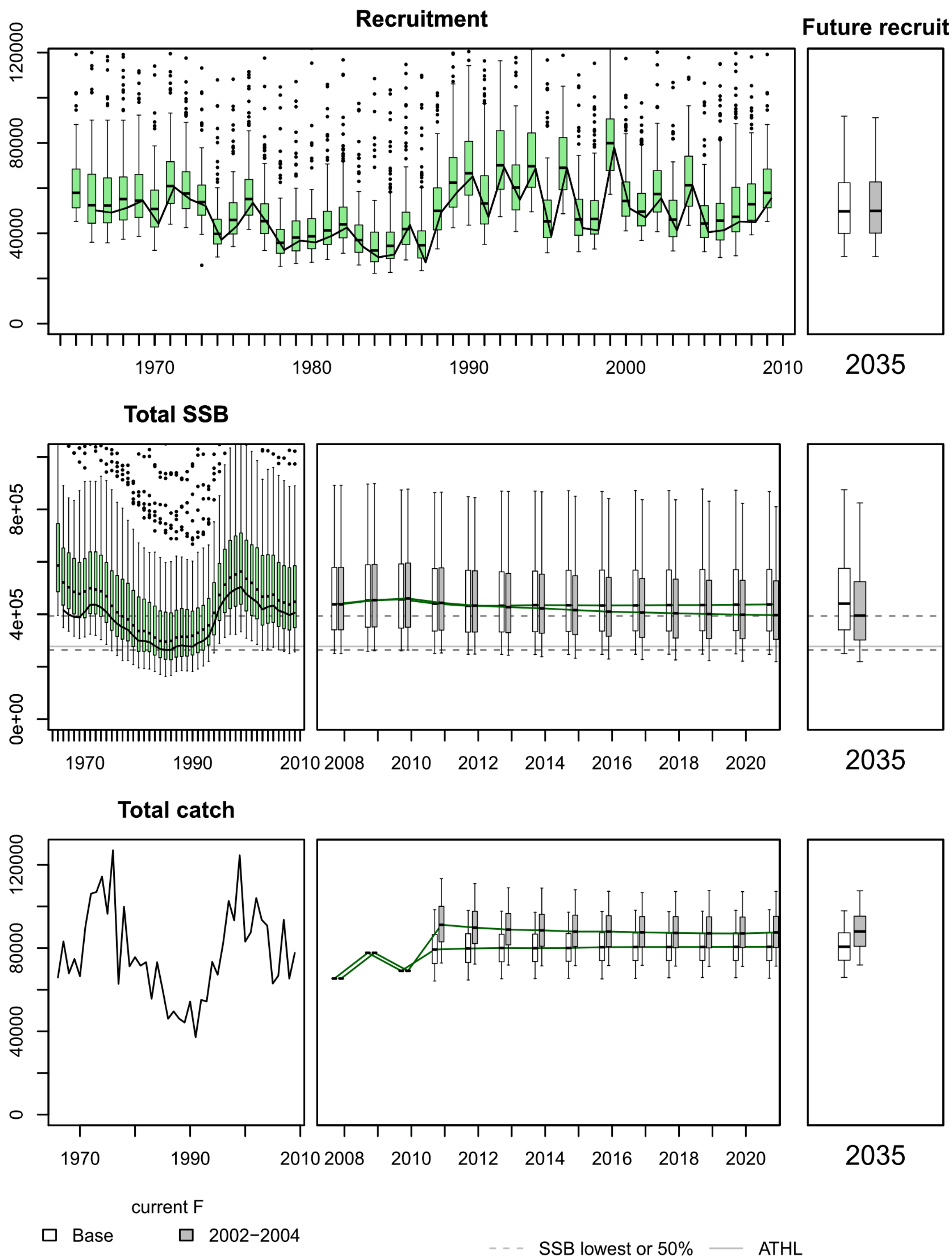


Figure 9.2. Past and future trajectories on recruitment (top), SSB (middle) and total catch (bottom), estimated with 2 harvesting scenarios of base case ($F_{2006\text{-}2008}$) and $F_{2002\text{-}2004}$. The lines from the boxes represent 90% confidence intervals, and lower and upper end of boxes represent 25th and 75th percentiles. Open circles are extreme values.

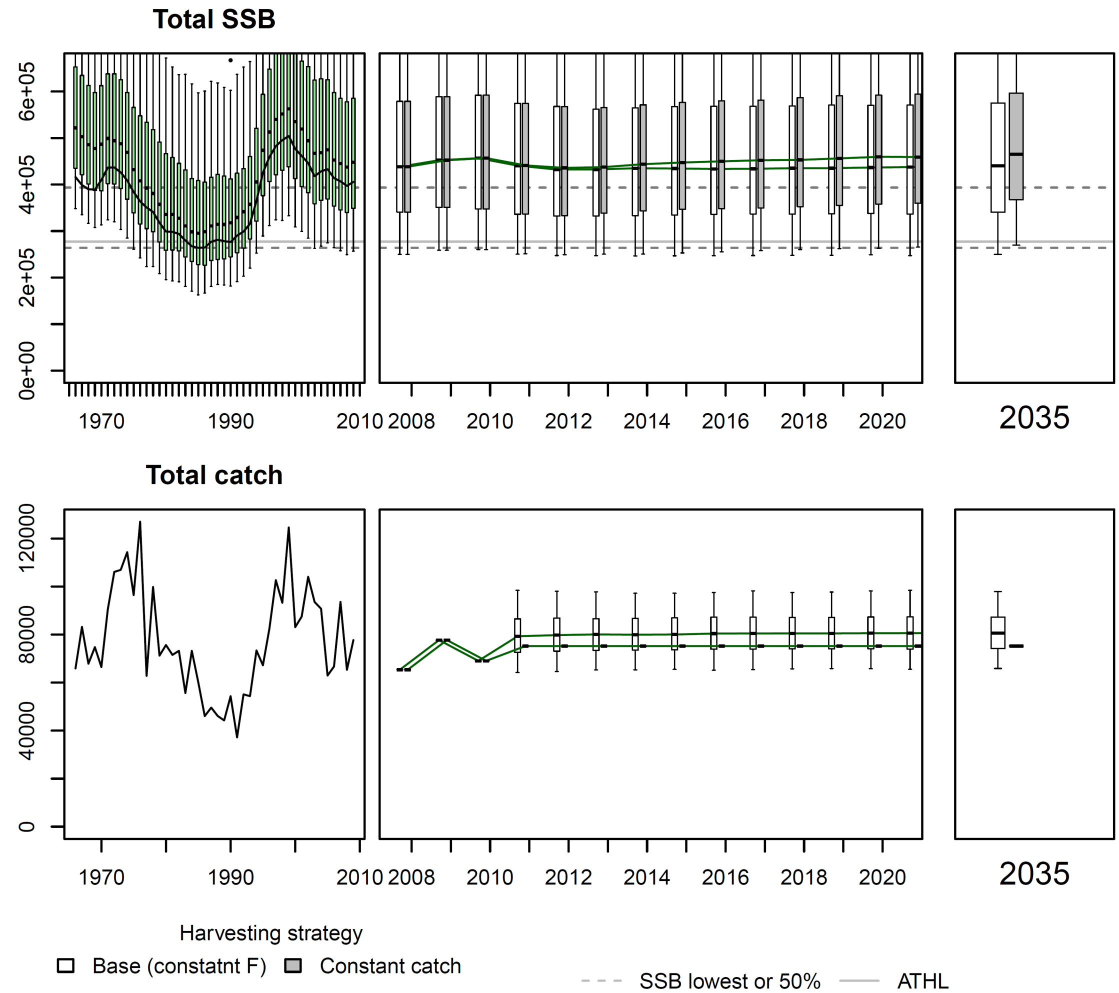


Figure 9.3. Past and future trajectories on SSB estimated with two harvesting scenarios (constant $F_{2006\text{-}2008}$) and constant catch (average catch from 2005 to 2007).

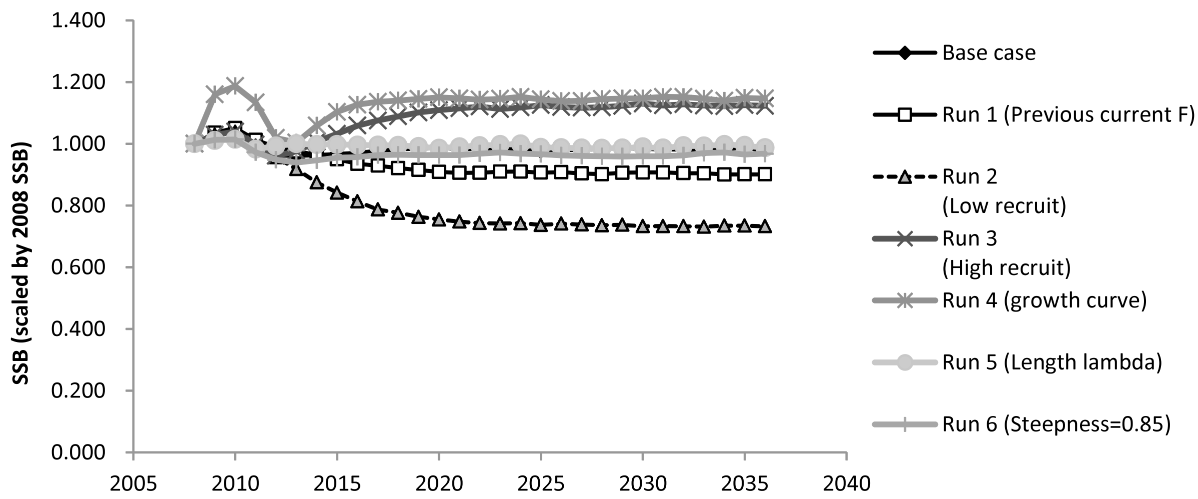


Figure 9.4. Comparison of SSB trajectories of among 7 future projection runs testing harvesting and recruitment scenarios and assessing structural sensitivities. Results are scaled to SSB_{2008}, which is approximately the long-term median SSB during the modeled period, 1966-2009.

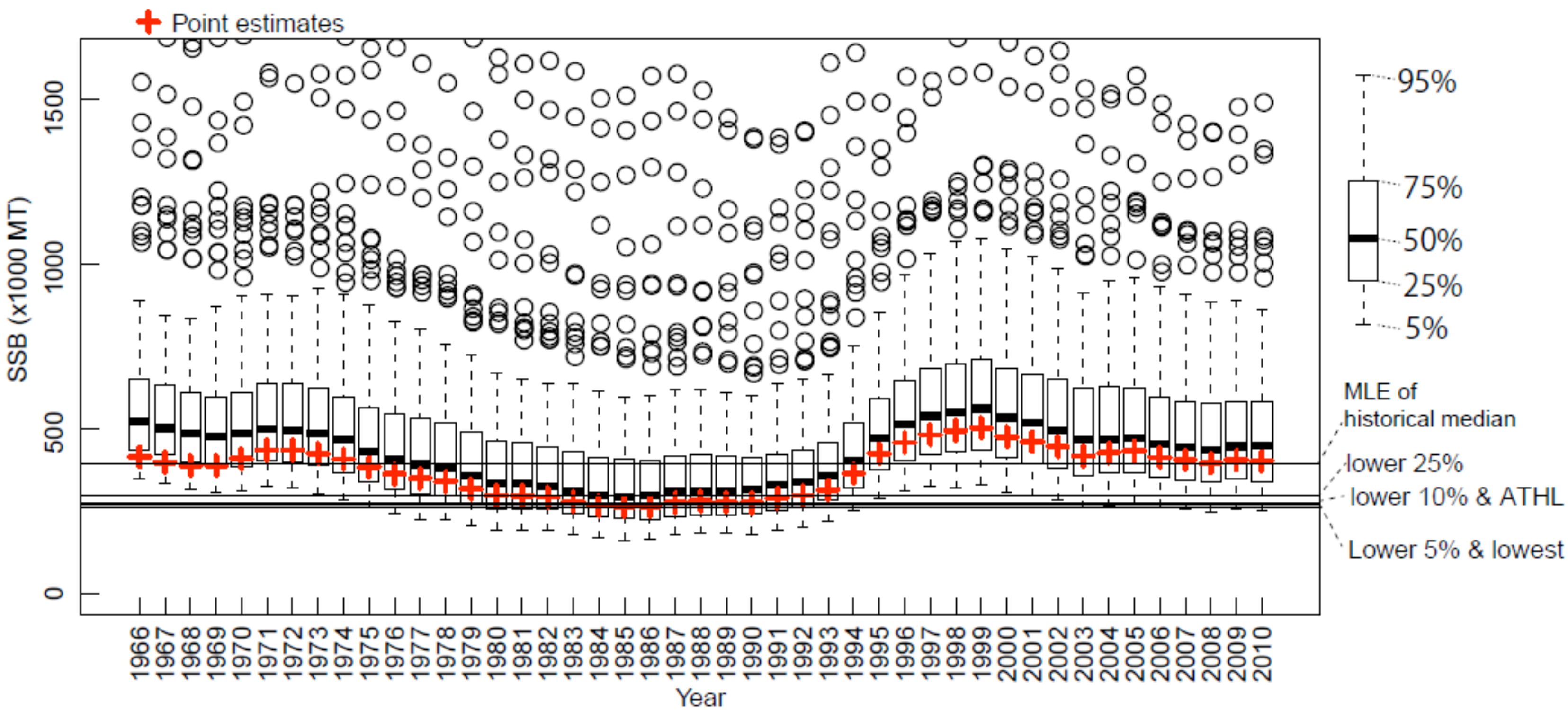


Figure 9.5. Historical SSB time series and confidence intervals estimated from 200 bootstrap results. The lines from the boxes represent 90% confidence intervals, and lower and upper end of boxes represent 25th and 75th percentiles. Open circles are extreme values. The figure also shows horizontal lines representing the maximum likelihood estimate of the historical median spawning biomass, the lower 5th, 10th and 25th percentiles, and the ATHL. The red crosses are the point estimates of spawning biomass from the base-case assessment model.

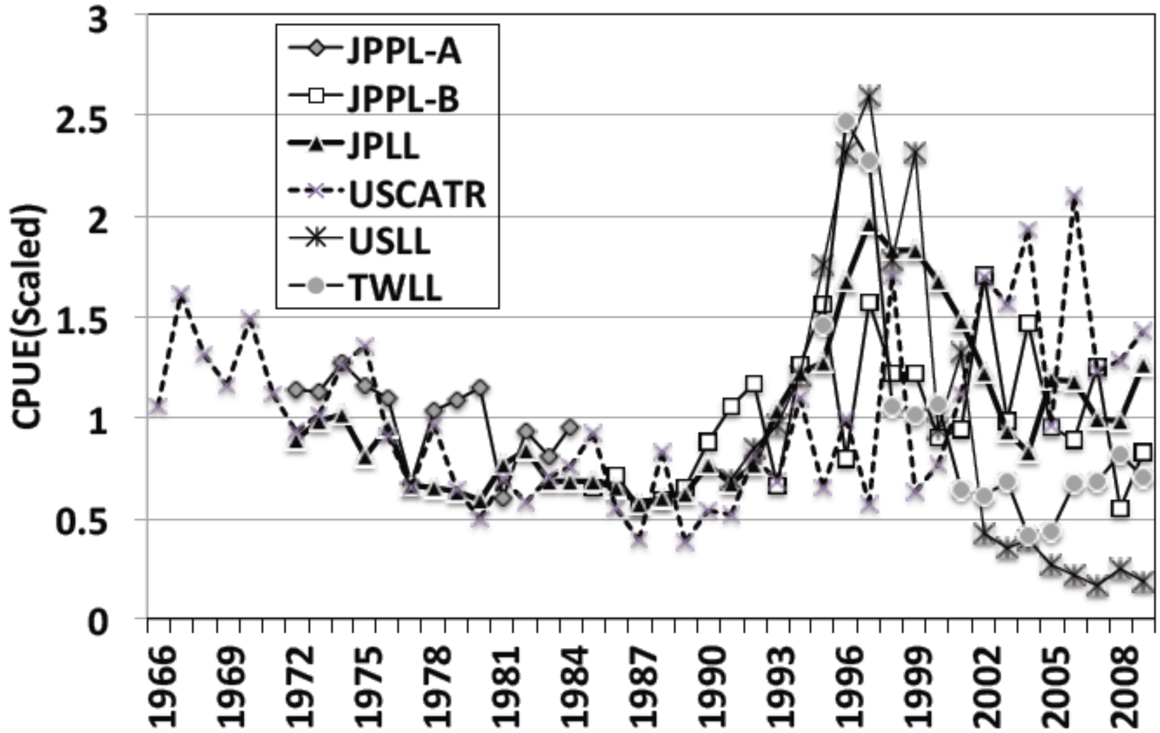
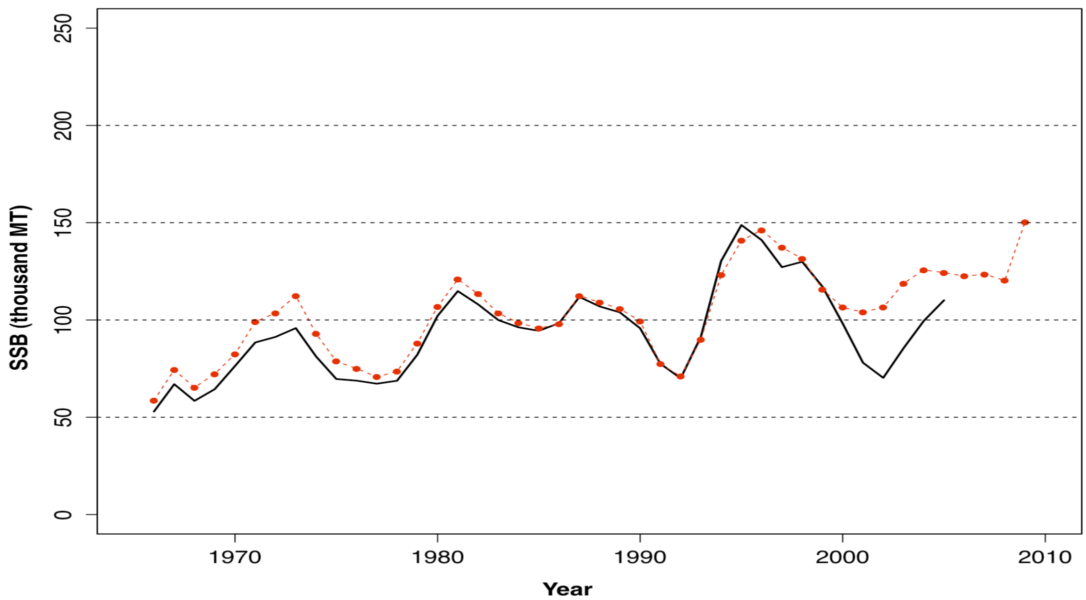


Figure 10.1. CPUE indices for north Pacific albacore used in the VPA reference run. JPN PL fishery A-1972-1984 and B-1985-2009, JPN LL fishery (1966-2008), USA LL (1991-2009), UCLTN fishery (1966-2009) and TWN LL fishery (1995-2008).

A.



B.

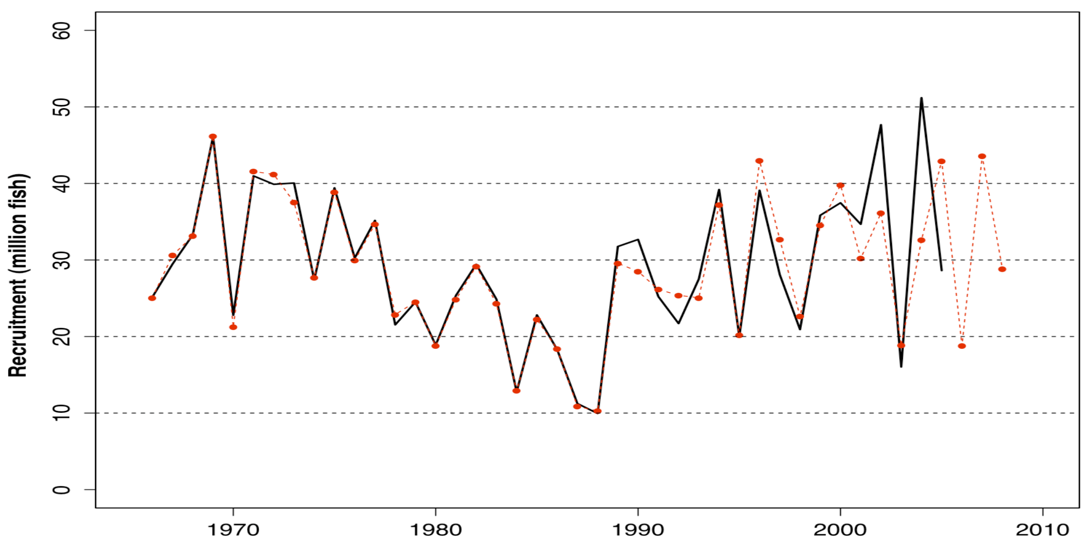


Figure 10.2. Estimated spawning stock biomass (A) and recruitment at age-1 (B) time series in the VPA reference run (red) and from the 2006 stock assessment (black).

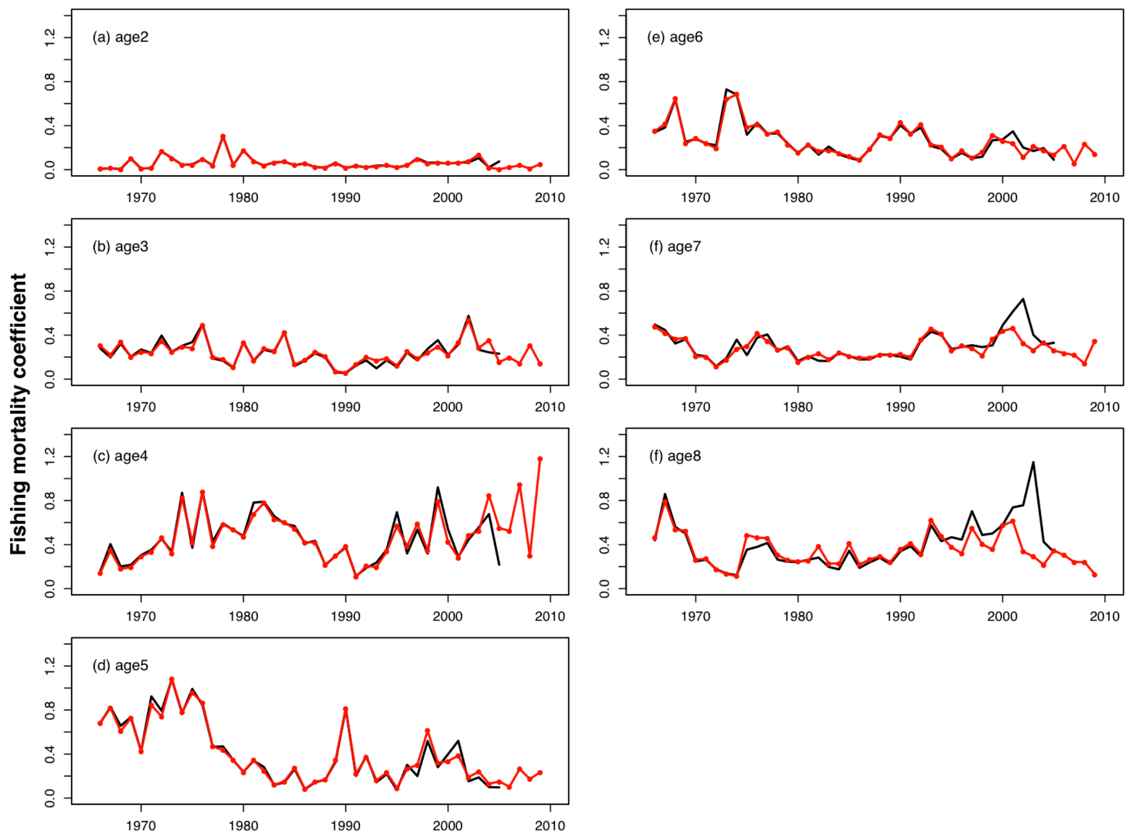


Figure 10.3. Fishing mortality coefficients for each age estimated in the VPA reference run (red) and the 2006 stock assessment (black).

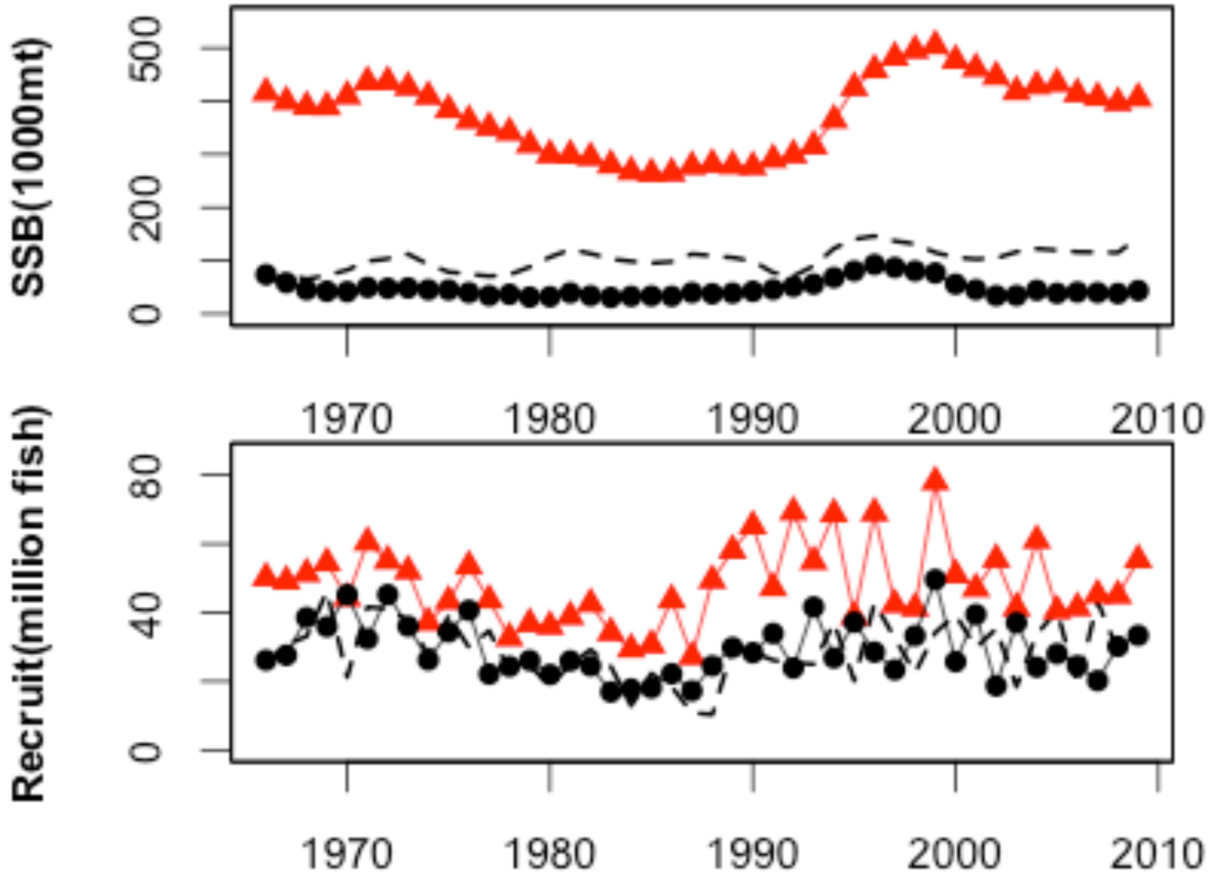


Figure 11.1. Spawning stock biomass (top) and recruitment (bottom) estimated in the VPA reference run (black dashed line) and SS3 base-case model (red triangles). Black circles are estimates of SSB and recruitment when growth curve parameters were fixed to Suda (1966) estimates as a sensitivity run of the SS3 base-case model. Recruitment is estimated at age-1 in the VPA reference run and at age-0 in SS3 base-case model so trends may be offset by one year.

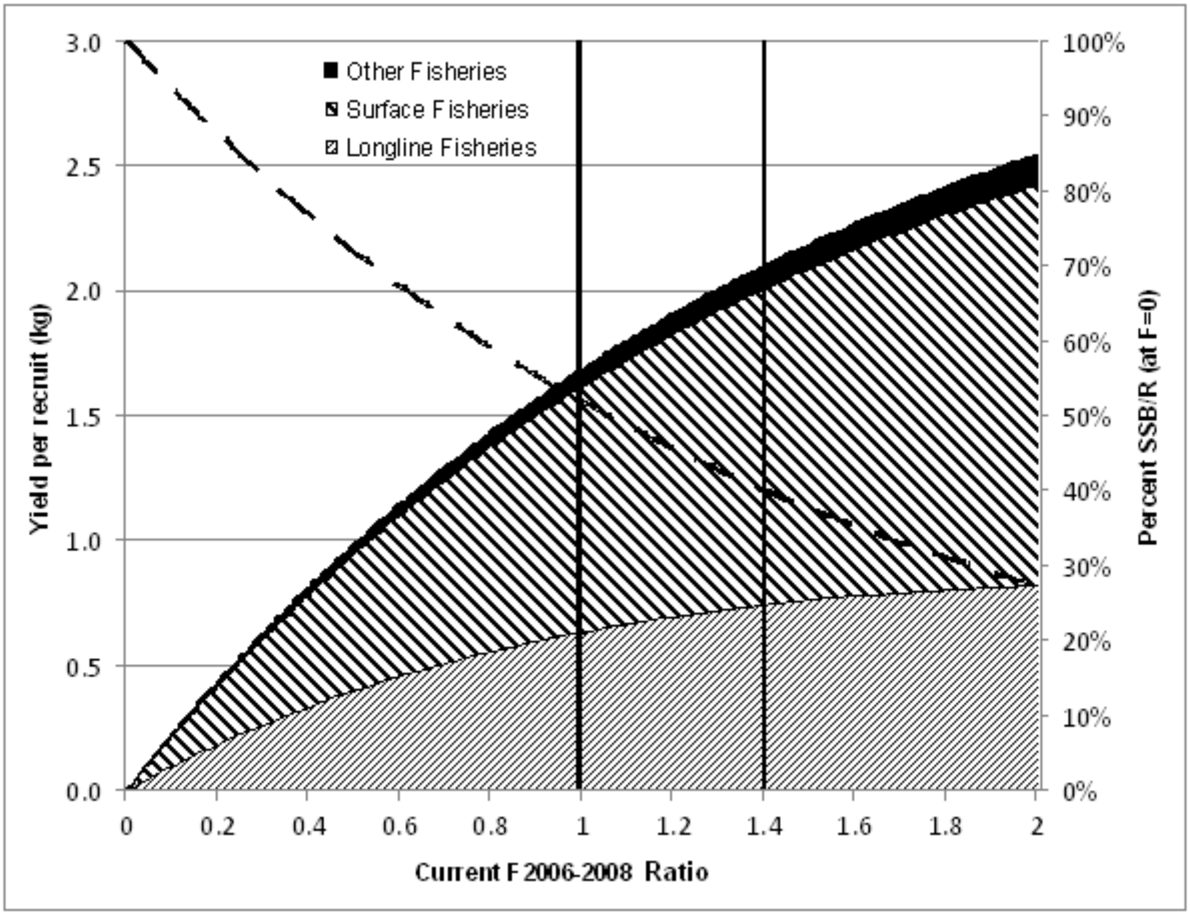


Figure 11.2. Equilibrium yield-per-recruit (shaded areas) for major fishery type and SPR (percent of SSB/R relative to F = 0) (dashed line) as a function of fishing mortality rate (F) for north Pacific albacore associated with the base-case model. The current fishing mortality rate multiplier (F = 1.0 at F = $F_{2006\text{-}2008}$) is based on the fully-selected F observed from the geometric mean of F-at-age estimates from 2006-08. Vertical lines show $F_{2006\text{-}2008}$ (F-multiplier = 1.0) and $F_{SSB\text{-}ATHL}$ (F-multiplier = 1.41).

APPENDIX 1

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APPENDIX 2

ISC-ALBWG Stock Assessment Workshop

4-11 June 2011

Adopted Agenda

1. Opening of Albacore Working Group (ALBWG) Stock Assessment Workshop
    i. Welcoming remarks
    ii. Introductions
    iii. Scheduling
2. Adoption of Agenda and Assignment of Rapporteurs
3. Reporting on work assignments from last meeting **(WP 04, 05, 06, 19)**
4. Report and recommendations from the modeling subgroup meeting
5. Review of Biological Studies (**WP 02, IP 01**)
6. Review of Stock Assessment Studies (**WP 03, 09, 11, 12, 18**)
7. Review of data (SS and VPA)
8. Model structure and input parameters (SS3 & VPA reference-case)
    a. Fisheries
    b. effective sample size
    c. growth
    d. stock-recruitment relationship (h)
    e. data weighting (CPUE)
9. Define sensitivity analysis runs
10. Future projections **(WP 14)**
    a. Refine initial conditions for projections
    b. Definition of current F (F2005-2007, F2006-2008)
    c. Constant F and constant catch scenarios
    d. Future recruitment – random resampling of historical recruitment, others?
    e. Initial projection year – 2008 (base), 2009 or 2007 (sensitivity)
    f. Catch in final years – use known 2009 catch; what about 2010 catch?
    g. F_{SSB} calculation
11. Review SS3 base-case runs for north Pacific albacore assessment
12. Review VPA reference-case run
13. Review sensitivity analysis results
14. Biological reference points for stock status (IATTC and WCPFC)
15. Review stock projection results
16. Determine current status and develop conservation advice
    a. Compare results of SS3 and VPA-2BOX reference runs
    b. Conclusions on current condition relative to reference points and uncertainty
    c. Projection estimates
    d. Develop conservation advice
17. Research Recommendations
18. Review Catch/Effort Data (Category I, II, & III data)
    a. Review of data for 2010 **(mostly via email: WP 01, 07, 10, 13, 15)**

   b. Update and Adopt Catch Table **(WP 16)**
   c. Issues for STATWG
19. Administrative Matters
   a. Workplan for 2011-12
   b. Update national contacts for ALBWG
   c. Time and place of next meeting
   d. Other matters
20. Rapporteurs and participants complete assigned sections of workshop report
21. Draft of workshop report circulated for review
22. Clearing of Report
23. Adjournment

APPENDIX 3

List of Working Papers

		Availability
ISC/11/ALBWG/01:	Mexican progress report on the albacore tuna fishery. Luis A. Fleischer and Michel Dreyfus	Contact details only
ISC/11/ALBWG/02:	Age and growth of North Pacific albacore (*Thunnus alalunga*). R. J. David Wells, Suzanne Kohin, Steven L.H. Teo, Owyn E. Snodgrass, and Koji Uosaki	Contact details only
ISC/11/ALBWG/03:		**Withdrawn**
ISC/11/ALBWG/04:	Comparison of length compositions from Taiwan longline, Japan pole-and-line, and U.S. longline fisheries. Steven L. H. Teo, Chiee-Young Chen, and Takayuki Matsumoto	Full paper on ISC website
ISC/11/ALBWG/05:	Updated time series associated with albacore fisheries based in the Northeast Pacific Ocean. Steven L. H. Teo	Full paper on ISC website
ISC/11/ALBWG/06:	Estimation of alternative growth curve of north Pacific albacore based on Japanese pole-and-line size data and reported growth curves. Takayuki Matsumoto	Contact details – checking for full availability
ISC/11/ALBWG/07:	Recent Aspects of Taiwanese Albacore-targeting Longline Fisheries in the North Pacific Ocean, 2011. Wu Ren-Fen, Hung-I Liu, and Chiee-Young Chen	Contact details – checking for full availability
ISC/11/ALBWG/08:	Review of developing Japanese albacore fishery data to apply to stock synthesis model. Takayuki Matsumoto and Koji Uosaki	Contact details – checking for full availability
ISC/11/ALBWG/09:		**Withdrawn**
ISC/11/ALBWG/10:	The Canadian Troll Fishery for North Pacific Albacore Tuna in 2010. John Holmes	Full paper on ISC website
ISC/11/ALBWG/11:	Probable Values of Stock ‐ Recruitment Steepness for North Pacific Albacore Tuna. Jon Brodziak, Hui-Hua Lee, and Marc Mangel	Full paper on ISC website
ISC/11/ALBWG/12:	Preliminary North Pacific albacore population analysis using VPA-2BOX and future	Contact details –

	projection using PRO-2BOX for 1966-2009. Kiyofuji, H., Iwata, S., Kai, M., Ichinokawa, M., Matsumoto, T., Uosaki, K. and Takeuchi, Y.	checking for full availability
ISC/11/ALBWG/13:	Review of Japanese albacore fisheries as of 2011. K. Uosaki, H. Kiyofuji and T. Matsumoto	Contact details – checking for full availability
ISC/11/ALBWG/14:	Future projection for the North Pacific albacore, based on stock assessment conducted in 2011. Momoko Ichinokawa et al.	Contact details – checking for full availability
ISC/11/ALBWG/15:	Review of the U.S. albacore surface fishery in the north Pacific in 2010. John Childers, Suzy Kohin, and Amy Betcher.	Full paper on ISC website
ISC/11/ALBWG/16:	North Pacific albacore catches and number of vessels fishing for albacore in the north Pacific Ocean. John Childers	Full paper on ISC website
ISC/11/ALBWG/17:		**Withdrawn**
ISC/11/ALBWG/18:	Calculation of the steepness for the North Pacific Albacore. By Shigehide Iwata, Hiroshi Sugimoto and Yukio Takeuchi	Contact details – checking for full availability
ISC/11/ALBWG/19:	Fork length at 95th percentile of cumulative length frequency as an indicator of maximum length for albacore *Thunnus alalunga* in the Pacific Ocean prior to 1965. Hiroshi Ashida, Masashi Okada and Koji Uosaki	Contact details – checking for full availability
Information Papers		
ISC/11/ALBWG/IP/01	Age and growth of albacore *Thunnus alalunga* in the North Pacific Ocean. K.-S. Chen, T. Shimose, T. Tanabe, C.-Y. Chen, and C.-C. Hsu	Contact details only

APPENDIX 4

ISC-ALBWG Model Subgroup Meeting, 30 May-3 June 2011

Report to the Assessment Workshop

The model subgroup of the ISC-ALBWG met 30 May – 3 June 2011, at the National Research Institute for Far Seas Fisheries in Shizuoka, Japan. Fifteen scientists from Canada, the IATTC, Japan and the United States participated in the meeting (Attachment 1).

John Holmes chaired the meeting and briefly welcomed participants to the meeting. He noted that the goals of the meeting were: (1) to develop recommendations to the full working group concerning all of the major modeling issues that have been identified, and (2) to produce base case scenario for recommendation to the full ALBWG.

A draft agenda was circulated prior to the meeting, but was very loosely organized. The group developed a checklist of modeling issues for discussion and organized an agenda based on these issues. Additional input was received via an email to the Chair. The agenda adopted for the meeting is shown in Attachment 2.

Rapporteurs were not assigned to specific sections of the agenda. John Holmes captured the major points of discussion and recommendations for reporting to the full ALBWG.

Three working papers, ISC/11/ALBWG/03, ISC/11/ALBWG/08, and ISC/11/ALBWG/12, were reviewed by the Modeling Subgroup and used as the basis for discussion and formulation of recommendations for the base-case model. These working papers were not reviewed or subsequently discussed directly by at the assessment workshop.

1.0 Data Issues/Overview

Catch-at-length, length composition, CPUE, and catch-at-size data were reviewed for all fisheries during the Modeling Subgroup meeting. This review was necessary because a conflict was detected between some of the size composition data and CPUEs in the some of the JPN LL fisheries after the fishery definitions were finalized at the October 2010 workshop and there was concern that the problem may not be restricted to these fisheries alone. The problem with the JPN LL fishery data, seasonal variability in length composition, was documented and the impact of splitting JPN LL fisheries into seasonal fisheries was assessed (Matsumoto and Uosaki 2011; ISC/11/ALBWG/08). This working paper demonstrated that the problems with these fisheries are of sufficient magnitude that the only viable option was to split the JPN LL fisheries (F6 and F7) into two seasonal fisheries. After much discussion this course of action was recommended by the Subgroup to the full WG. At the same time, USA scientists recommended deleting size composition data from 2009 in the USA LL fishery (F2) from the assessment dataset because errors were found in that database for that year (see Lee et al. 2011; ISC/11/ALBWG/03). Since the data were frozen for the assessment, the recommendation to delete them rather than substituting new data was made by the Modeling Subgroup.

1.1 Review of Japan Data Files for SS3

Several data files, each correcting the previous file, were submitted by Japan after the data were frozen for the assessment on 15 December 2010. All of the corrections were to the size data for the pole-and-line and longline fisheries. Three problems were found and corrected in succession:

1. Use of the wrong length bin definition – SS defines length bins using the lower limit whereas in the Japan size database, length bins are defined by the upper limit. This error was corrected in file distributed to ALBWG members on 27 Feb 2011;
2. Substitution error or inappropriate procedure was used when the number of size measurements in a 5° x 10° spatial block did not meet minimum criteria of 500 fish measured for pole-and-line and 200 fish for longline fisheries. This error was corrected in the file distributed on 27 Feb 2011.
3. Use of the wrong size data. Between the time when data were extracted for compiling the assessment data file, the Japanese database size database was updated. As a result, the 2001 and 2005 size composition data for the pole-and-line and longline fisheries were incomplete in the original data file. This error was corrected in a file dated 10 Mar 2011 and distributed to the ALBWG on 01 Apr 2011.

The Modeling Subgroup recommends using the updated data file distributed on 01 Apr 2011.

1.2 United States Longline Data

US scientists noted that there was a problem with the 2009 longline size composition data related to an error in the database from which the data were extracted. They recommended using the US data distributed to the ALBWG in Jan 2011, but deleting the 2009 size composition data.

The subgroup discussed the SS size composition data in general and recommended a review of the size composition data for the USA, TWN, and JPN longline fisheries. The goal of the review is to look at the very large fish, e.g., > 130 cm, which appear fairly regularly in the USA LL data. Some WG members believe these fish are less common and so there is concern that some of these measurements could be from other species wrongly identified as albacore.

2.0 VPA Reference Run and Preliminary SS3 Modeling

2.1 Preliminary North Pacific albacore population analysis using VPA-2BOX and future projection using PRO-2BOX for 1966 – 2009 (ISC/11/ALBWG/12)

Summary — Virtual population analysis (VPA) was conducted to estimate spawning biomass (SSB), recruitment, and fishing mortality coefficients (F) with fishery data updated to 2009 and to compare these results to the findings of the 2006 stock assessment. Future projections were also conducted using a similar configuration to the last assessment and potential biological reference points were calculated. Changes in recent SSB were small and SSB has remained at a relatively high-level averaging about 115,000 t. Recruitment in recent years also exhibits small variability. The most obvious difference between the current and last assessment results is that F estimated for the oldest (plus) age-group(s) has decreased substantially in recent years. This reduction in F is reflected in the estimate of current F and biological reference points. Based on the results of the future projections, it is recommended that current F should be defined as the geometric mean of age 4 for 2005-2007. However, in the constant F projection scenario, SSB could not be maintained above the average of 10^{th} historical lowest observations with 50% probability.

Discussion: The VPA parameterization was essentially identical to the 2006 assessment, but major differences between this reference run and the 2006 assessment was the fishery definitions (from 17 age-specific fisheries to 6 age-aggregated fisheries) and updated catch-at-age data through 2009. Spawning biomass exhibits similar trends to the 2006 assessment, fluctuating between 50,000mt and 150,000mt, averaging 102,339 t. One difference was that SSB did not decrease after 2000 as it did in the 2006 assessment . Recruitment also exhibit the same trends as in the 2006 assessment, declining between 1970 and 1988 and then increasing. Recruitment fluctuated between 20 and 40 (million fish).

The author noted that the JPN LL CPUE index was standardized for 1966-2009 in the data submitted before the meeting rather than 1972-2009 as agreed by the WG, and the latter was used for the analyses in the document. The author showed figures for the revised index, which changed little from the original. The WG accepted the revised figures.

The Modeling Subgroup discussed how the VPA run results were going to be used in the assessment. It was noted that the intent was not to provide two different assessments. Rather the intent was to compare important model outputs (SSB, recruitment, Fcurrent, F-at-age matrix) from the VPA reference and SS3 base-case models to assess and explain model-related changes. The future projections and reference point information in this working paper will not be needed to accomplish this objective. The subgroup also discussed how Fcurrent is calculated in VPA2Box. Fcurrent is defined as the apical (highest observed) F. In 2006, this occurred at age 8, but in the run reviewed it occurred for age 4. Current F decreased from 0.75 (age 8) in 2006 assessment to 0.60 (age 4) in this run. The Modeling Subgroup does not recommend rerunning the VPA at the full assessment workshop as most of the issues under discussion are not likely to result in changes that affect VPA calculations

The Modeling Subgroup agreed that future projections and reference point calculations from the VPA model will not be used in this assessment – the reference run will only be used as a tool to assess and understand model-related changes through comparisons of the SSB and recruitment time series and F-at-age matrices of the reference run and the SS3 base-case scenario. Stock status and conservation advice are based on the SS3 base-case model and future projections.

2.2 Preliminary Population Analysis of North Pacific Albacore Based on the Stock Assessment Program *Stock Synthesis* 3 (ISC/11/ALBWG/03)

Summary **—** The last albacore stock assessment was conducted in 2006 using a Virtual Population Analysis model (VPA-2BOX) (Uosaki et al., 2006a, ISC/06/ALBWG/19). At that time updated modeling was performed using an alternative modeling platform (Stock Synthesis, SS) based on similar parameterization to the VPA model (Anon., 2008a, ISC/08/ALBWG/06). Although the age-based SS model presented similar results, it was believed that a length-based SS model would better reflect the nature of fisheries catching albacore without outside process error. This paper presents a preliminary model for north Pacific albacore (*Thunnus alalunga*) using Stock Synthesis (Methot 2011, http://nft.nefsc.noaa.gov/Stock_Synthesis_3.htm). SS is a software program that implements a length-based/age-structured, forward-simulation population model with great flexibility to address parameterization (such as selectivity, catchability, stock-recruitment relationship, biological parameters, etc.) and uncertainty within the overall model. This paper is intended to 1) present general descriptions of data sources and methods used in the length-based SS model, 2) present uncertainties in regards to current data and auxiliary information, and 3) perform key sensitivity analyses regarding fishery and biological data/parameters and critical modeling assumptions. The overall objectives of the assessment are to estimate population parameters, such as time series of recruitment, biomass and fishing mortality, which are used to determine current stock status.

Discussion: This working paper describes the model configuration and parameterization used for early exploratory analyses with SS3. The paper formed the basis for the consensus base-case scenario developed by the Modeling Subgroup and described in detail in Sections 7, 8, and 9 of the assessment workshop report. This paper was not reviewed by the full WG during the assessment workshop because it is superseded by the base-case scenario that was recommended by the Modeling Subgroup. This paper also generated considerable comment on some aspects of the configuration and parameterization of the SS3 model, which is captured in Appendix 5.
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3.0 Review of Japanese SS Data

3.1 Review of developing Japanese albacore fishery data to apply to stock synthesis model (ISC/11/ALBWG/08)

Summary — This paper summarizes methods used to compile Japanese albacore fisheries data for analysis in the SS3 stock assessment model. Quarterly catch and size (catch-at-size) data for each fishery and CPUE indices for longline and pole-and-line fisheries were created and submitted. Catch by quarter and area was calculated with logbook data, but logbook data (temporal and spatial information on catch) are either not available for several fisheries or a portion of the modeled period. When logbook data were missing, the quarterly and spatial composition of catch was assumed to be the same as that estimated from landings data and/or different years or fishery. Catch-at-size was calculated by substituting size data only from the same time/area stratum when size samples were inadequate. Standardized CPUEs for longline and pole-and-line fisheries were created. After data distribution, several errors were found in longline and pole-and-line catch-at-size data due to the use of incorrect program codes, inappropriate assumptions, or an older (less precise) version of the size database. These deficiencies were subsequently corrected.

Discussion: This working paper describes the catch estimation method for the coastal LL fishery (< 10 GRT) and the reasons behind the data distributed to the WG on Feb 1, 2011 and the subsequent correction in the March 22, 2011, data distribution. The procedures used to estimate catch, catch-at-size, and CPUE for Japanese fisheries were briefly reviewed. The Subgroup did not have many questions as the procedures were well described and straightforward.

3.2 Selectivity of Japanese Longline Fishery

At the October 2010 data preparation workshop, the ALBWG decided that selectivity for the USA and JPN LL fisheries would be asymptotic or flat-topped in shape (modeled with a logistic curve) and that selectivity for all other fisheries would be dome-shaped. Preliminary SS3 model runs with this configuration found that SSB tended to be low and F for older fish tended to be high relative to VPA results in the 2006 assessment. Examination of the spatial distribution of size data showed that fish ≥ 120 cm tended to be measured more often south of 25°N in the central and eastern Pacific and less often north of 25°N. Large fish tend to be more abundant in the central and eastern Pacific whereas the JPN LL operates largely in the western Pacific. Thus, large fish may not be fully available to the LL fishery and as a result dome-shaped selectivity for this fishery may be reasonable.

3.3 Japanese Longline Length Composition

The subgroup reviewed the length composition data for F6 and F8 (JPN LL fisheries) because preliminary SS3 runs had shown misfits to the length composition data from these fisheries. The definition of F6 included catches from Q1 and Q2, but the review found substantial differences in length compositions between Q1 (fish ranging from 70 to 120 cm) and Q2 (only small fish 70-90 cm). Review of the F8 data showed that in Q1 and Q2 there was a higher ratio of large fish and lower ratio of small fish than in Q3 and Q4. Seasonal plots of USA LL and JPN LL (F8) length composition data were examined and showed that the data in these fisheries were quite similar. The Modeling Subgroup concluded that the F6 data show clear evidence of a seasonal problem but that it was not clear that such a problem is evident in the F8 data.

The Subgroup recommended using the same shaped selectivity for the USA LL (F2) and JPN LL (F8 – large-sized fish) by season.

4.0 Growth

Much debate on growth occurred among ALBWG members via email prior to this meeting and this debate is captured in Appendix 7. The primary problem seems to be fitting the growth model at the younger ages and the large-sized Hawaiian fish. The Subgroup noted that there may be regional differences in size-at-age and suspects that there may be regional differences in growth rates. For example, temperatures in the EPO are warmer than in the WPO and fish in the EPO may grow faster and reach larger sizes than fish in the WPO. Most of the age data in Wells et al. (2011, ISC/11/ALBWG/02) are from EPO samples. If there are regional differences in growth, then there is no simple way to deal with area-growth interactions in the present assessment. The Subgroup concluded that L_∞ is less than 146.46 cm estimated by Suda (1966).

The Subgroup recommends estimating growth within the model using a von Bertalanffy curve (because it seems to be a better shape for the data than Richards), conditional age-at-length, and estimating size-at-age variability (CVs). Because the size composition data seem to be driving growth parameter estimates, the Subgroup recommends a sensitivity run down weighting the size composition data and using a Richards curve which in theory should fit better than a von Bertalanffy growth model.

5.0 Length Composition Data

The Subgroup reviewed the raw length composition data and Pearson residual bubble plots for the surface and longline fisheries aggregated by fleet and season. Surface fishery data do not appear to exhibit seasonal patterns in length compositions, but longline data exhibit several problems.

Since different length composition data were found in Q1 and Q2 of fishery F6 (JPN offshore longline), the Subgroup recommends separating this fishery into two seasonal fisheries. If the model is fitted to the CPUE data, then the existing annual CPUE index should be applied to the Q1 fishery since most of the catch-effort data in F6 occurs during this period. Although time blocks might improve fits, especially for Q2 of F6, it was suggested that this not be attempted until after fine tuning of the selectivity parameters has been completed.

6.0 Effective Sample Size

There is a need to weight fisheries relative to each other and to weight length composition data relative to CPUE data. Three ways are available for weighting: (1) effective sample size in the data file, (2) the variance adjustment factor in the model, and (3) lambda. Methods 1 and 2 directly change sample size, which affects the relative weights and variance assumed by the model likelihood components. These changes can be influential in bootstrapping results, which is important for this assessment since bootstrapping is used to assess $F_{SSB\text{-}ATHL}$. The third method changes only the relative weighting.

US scientists briefly explained the procedure used to estimate effective sample size in ISC/11/ALBW/03 because it differed from the procedure the ALBWG adopted at the data preparation workshop in October 2010. Effective sample sizes were assumed to be the number of trips for the UCLTN and USA LL fisheries, assuming each trip is an independent sample. The fishery-specific ratios defined as sum of trips divided by total number of fish measured for the UCLTN and USALL fisheries were calculated to scale the effective sample sizes of the other fisheries by multiplying the number of fish measured in each quarter by the appropriate fishery ratio. In addition, the assumed maximum effective sample size was 500.

The Subgroup identified two issues: (1) appropriate sample size depending on the uncertainty in the length composition data, which can be done in the data file with sample size or variance adjustment, and (2) relative weighting of length data vs. CPUE through lambda – instead of a large effective sample size, use a smaller lambda such as 0.05.

The Subgroup recommended the UCLTN fishery as a reference, using the number of trips as the input sample size and then rescaling other fisheries so the average is the same as the average for the UCLTN fishery (137 trips). No recommendations were put forward with respect to the relative weight of length data vs. CPUE.

7.0 Batch 1 - Sensitivity Run Review

An SS reference case was established with the following parameterization (run by USA May 26): disaggregated seasonal fisheries, CPUE for F6 not fitted, growth estimated with internally assuming a von Bertalanffy model, CV F8 was fixed at 0.2, length composition lambda was fixed at 0.05, the catchability of F1 was estimated with random walk. This parameterization represents a reference case that the Subgroup agreed to use to explore alternate model runs. The Subgroup requested the following runs:

1. Sample size – rescale other fisheries to average of US troll (133) number of trips;
2. Remove random walk for F1 catchability;
3. Repeat fitting to F6 CPUE to season 1;
4. Repeat fitting with Richards curve;
5. Repeat with VB, increase aging error; and
6. Time block for season 1 of F6.

7.1 Rescale sample size to average number of trips for US troll

The Subgroup review various output plots including SSB and recruitment time series, fishery selectivity, and growth curve plots. These plots did not appear to have substantial changes relative to the same plots from the reference case run. Growth curve (von Bertalanffy) appeared to fit better; the Subgroup was interested in this issue because there is an increasing trend in growth at maximum age that seems driven by the selectivity of the US LL fishery, which continues to increase beyond the maximum size, which appears to be about 120 cm. This trend is driven by the appearance of a few large fish (>120 cm) in the US LL length composition data in recent years. The Subgroup talked about fixing the upper bound of the selectivity curve and estimating the ascending portion. The subgroup also discussed ageing error and how to parameterize it and suggested using an ageing error of ± 1 yr (SD) across all age groups.

The Subgroup recommends fixing the peak of the selectivity curve for the US LL fishery to be the same as during the 2001-04 period when only the deep-set fishery was operating and estimating the width of the ascending limb of the curve. If this approach is not satisfactory because estimates hit the upper bound, then all parameters for this selectivity function could be fixed.

It was noted that the problem with the selectivity function for F6s2 (width peak, steep descending arm) was related to the initial value of the width of the selectivity peak. Changing to a smaller initial value produce a more acceptable curve. However, the robustness of the new function to changes in starting values is not clear. The Subgroup recommended constructing a likelihood profile to assess local vs. global minima.

7.2 Rescaled sample size and random walk catchability for F1 removed

These changes appear to scale SSB output a little higher than the original scenario, but exhibiting the same temporal trends. Recruitment trends between scenarios are also similar up to about 1990, after which recruitment is higher in this new scenario. The Subgroup thought that this difference was possibly related to a change in catchability of the surface fisheries. It was noted that trends in JPN PL and USA troll were similar to 2005, then begin diverging. F1 catchability influences recent recruitment in the model.

7.3 Rescaled sample size, random walk removed, fitting to F6 CPUE

These changes appear to highlight a conflict in the data because component likelihoods in this run were worse than the reference scenario. The Subgroup noted that this poorer performance is related to the selectivity for F6s2 (JPN OLLF1).

The Subgroup agreed that its first priority is to resolve selectivity issues, especially for F6 and then revisit F1 catchability (Q). There are two options for F1 catchability: time blocks or fix early Q up to 1990, then use random walk thereafter.

There was a brief discussion of a point raised previously – the use of a small constant (0.001) added to length composition data to avoid 0 length bins. The Subgroup recommends a sensitivity run with a different constant to assess the potential impact on fit, especially the growth curve. It is thought that the constant might be important with respect to fit of the oldest age groups in the growth curve.

8.0 Fishery Selectivity

Selectivity problems were noted for fisheries F2, F6 and possibly F8. At least one fishery selectivity needs to be modeled logistically in order to stabilize the model, otherwise the model exhibits some arbitrary changes in outputs, usually related to what it believes is a large “cryptic biomass” in the population.

The Subgroup noted that the estimated selectivity of F2 increases at large sizes (> 120 cm) rather than reaching an asymptote. This selectivity is influenced by a few large fish in the recent length composition data. The Subgroup recommends fixing the peak to about 120 cm FL and then reviewing the data after the assessment because the peak should not change between runs.

Asymptotic selectivity for F8 seems to be acceptable based on Pearson residual plot of length composition fits, but some time blocks may be needed.

A likelihood profile of the width of the peak of the F6s2 selectivity curve shows that the model prefers lower values. Starting values need to be below 0. An examination of the component likelihoods supported the conclusion that this behaviour is driven by the length composition data. If the starting value is sufficiently low, then the selectivity curve behaves well.

The Subgroup recommends that further runs be conducted using negative initial values for the starting peak width of the F6s2 selectivity curve to ensure that the model is converging on a global minimum. A run using an initial value of -2 was completed and the results showed that the model converged on a value of about -8.8, with a nicely dome-shaped selectivity curve. The Subgroup concluded that selectivity for F6s2 can be estimated provided that an initial value for peak width of less than 0 is used. The model converges on an even lower value around -8.8 and this appears to be a global minimum.

The Subgroup then examined the length composition fits for F6s1 and noted that the model does not fit large fish well. It was recommended that two time blocks for selectivity be used: 1966-1993 (positive residuals for large fish) and 1994-2009 (negative residuals for small fish). A run was conducted with two time blocks and the Subgroup noted that the blocking improved the fit in the early time period and made the residual pattern more uniform across the whole time series. However, large positive residuals for large fish remain apparent for 1989-1992. The Subgroup recommend three time blocks: 1966-1988, 1989-1992, 1993-2009.

9.0 CPUE Indices

CPUE indices for F6 and F8 are the biggest challenges. The Subgroup examined seasonally separated and annual indices for F6 and F8 prepared by Japan. The F6 annual index is largely driven by the Q1 index. It was noted that catch in Q1 of F6 is the largest component of the JPN longline catch and therefore important to include in the model. The Subgroup recommends further runs with the new F6 selectivity (time blocks) fitting to CPUE for season 1 and not fitting to F6s1 and afterwards a final recommendation on seasonal CPUE will be made.

The annual CPUE index for F8 is largely driven by the Q3-4 CPUE. The model tends not to fit to the annual index between the mid 1990s and 2000s and this lack of fit is believed to be due to poor fit to the length composition data.

The Subgroup reviewed runs in which the model was fitted to F6s1 and not fitted to F6s1 CPUE. SSB trends were nearly identical and there was little difference in total likelihood. Two potential explanations were offered: something else such as size composition is driving the dynamics or the index is not informative. The Subgroup believes that the former explanation – size composition – is the source of the problem. Fits to the F6 and F8 indices revealed consistent signals, but the fit to F8 could be improved

There are two options for resolving the seasonal fishery issue: (1) apply the annual index for F6 to the Q1 fishery, respecting the ISC data policy and revise the index after the assessment to be truly seasonal, or (2) make an exception and open the "frozen" data to recalculate a truly seasonal index for F6s1.

The Subgroup reviewed model fits to other CPUE indices. The fit to the USA LL index shows a temporal change in residual pattern from negative residuals early to positive residual later. Fits to S2 – S5 were considered acceptable and fit to S6 was fine and S7 fit (F8 index) was improved. The fit to S8 (TWN LL) is not as bad as the fit to S2 (USA LL), but this index may need to be down-weighted or a catchability trend allowing large variability may need to be introduced. The Subgroup recommends either dropping S2 (USA LL CPUE index) or allowing temporally changing catchability.

The Subgroup then reviewed the spatial-temporal coverage of the three longline indices. The JPN LL fishery is 25X larger than the other two in terms of catch-effort and is much broader spatial in the western and central Pacific. The TWN and USA LL fisheries are largely restricted to the central Pacific and much shorter temporally. There is a clear need to down weight both the USA and TWN LL indices relative to the JPN LL index. The Subgroup recommends using random walk for the Q of the USA LL (S2). This effectively down weights this index. For S8 (TWN LL), the Subgroup also recommends using a random walk for Q to see if the residual pattern improves. This issue will be revisited after reviewing these results. One explanation for the declining Q in S8 is because the TWN LL has continuously changed its targeting from ALB to tropical tunas.

Pearson residual plots show large positive residuals at large size up to 1996 in fishery F8 and then negative residuals that coincide with the peak that is hard to fit in this index. The Subgroup suggested that time blocking 1966-1998 and modeling with logistic selectivity and 1998-2009 and letting the model estimate a dome-shaped selectivity pattern would work for this fishery..

A point was raised about time blocking. If time blocks are used for selectivity, then we also need to consider doing the same thing for catchability (Q). SS doesn't allow the user to do this without creating new fisheries. This approach will be considered in the period between assessments.

10.0 Batch 2 – Sensitivity Run Review

The Subgroup updated the reference case model from May 30 to include the following (May 31 reference case): New effective sample size, time block for size comp for F6 (3 blocks: 1965-1988, 1989-1992, 1993-2009), initial value for the selectivity P2 parameter for F6s2 as -2 (or smaller), and fitting to CPUE F6 (S? - Japan LL). The following exploratory runs were requested:

1. Fix Peak for F2
2. Random Q after 1991 for S1
3. Random Q for S2
4. Random Q for S8
5. Drop S2 (weight = 0)
6. Drop S8 (weight = 0)
7. Time block for size comp for F8 (1965-1997 logistic, 1998-2009 dome)
8. Fit to first season of index for F6

It was noted that David Wells (SWFSC, NOAA) believes that ageing error in ISC/11/ALBWG/02 is ± 1 year up to age 5 and ± 2 years ages 6-15.

10.1 Three time periods for F6s1 Selectivity

This run is part of the updated reference case, but was not reviewed earlier. The results show that three blocks do not improve selectivity estimates or model fits to individual components. A sharp descending limb is still evident for the early period selectivity and the residual pattern in the length composition data remains. The Subgroup recommends using one time block (2 time periods) to estimate selectivity for F6s1 as opposed to no blocks because 1 block improves the total likelihood relative to no block or two blocks (three periods).

As the runs requested above were based on using three time periods to estimate F6s1 selectivity, they were redone using one block (two time periods) during the workshop.

Catchability is estimated as a free parameter and is dependent on selectivity. Realized catchability will reflect changes in selectivity. Based on this argument, the Subgroup did not consider time blocking of Q to be necessary.

10.2 Fixed peak for S2 to 2001-2004 period
Fixing the peak did not improve model fits. Since the CPUE from F2 may not be used in the model, the Subgroup recommends mirroring F8 selectivity for F2 and that US scientists investigate the data for this fishery after the assessment.

10.3 No Time Block versus one block for F6s1 selectivity
One block (two time periods) improves the residual pattern relative to no block and length likelihood improved, especially for F6 with one block.

The Subgroup recommends using 1 block (two time periods) when estimating selectivity for F6s1. The length composition data for F6 should be reviewed after the assessment.

The Subgroup examined the selectivity curves for 1 block F6s1 and concluded that allowing the model to estimate the descending limb of the early period was not possible – the 6th parameter should be fixed. There is no simple way to proceed, but the Subgroup implemented an exploratory non-parametric run to estimate early period selectivity and ascertain if it was dome-shaped. The result of this run indicates that the selectivity curve is likely dome-shaped for the early period of F6s1. The Subgroup recommends fixing the location of the top of the dome to around 100 cm and fixing the width of top to a low value.

10.4 Drop S8 (TWN LL index)
The results of this run did not change any of the major model outputs. The Subgroup concluded that this index is not informative in the model and recommends dropping it from the base case, but including it in at least one sensitivity run.

10.5 F6s1 CPUE
A run was conducted in which the annual index for F6 was replaced with the true Q1 index estimated by Japan. The results do not appear to change SSB, recruitment or other important management quantities and the fit to F6s1 is good, as expected.

10.6 Time varying selectivity for S7 (JPN LLF2 (F8)
Two time periods have been used: the first, early period is modeled logistically and the second late period is modeled with a dome shape. This run improved the maximum residual and residual pattern for the length composition fit as well as the maximum likelihood, but there was still an issue with fitting to the peak of the CPUE (S7) and the fit is strange with a sudden jump plus a scaling issue in SSB was revealed. The Subgroup reviewed a run in which separate Qs were estimated for the late and early periods of S7. The difference in estimated Qs was not large and results were not good – scaling issue remains. One explanation for the scaling issue is that now there is no logistic selectivity for any of the longline fisheries in recent years so this destabilizes the model and results in declining SSB. There is a need to consider whether logistic selectivity in both the early and late periods for S7 is the appropriate way to proceed.

11.0 Batch 3 – Sensitivity Run Review

The Subgroup updated the reference case, based on the results of the previous runs, to include one block for selectivity in F6s1, no block for selectivity in F8 and model selectivity logistically, Q for S1 - estimate base parameter at first phase, estimate random Q at last phase, seasonal (true) CPUE S6. The following additional runs were requested based on the updated reference case:

1. Aging error
2. Drop CPUE S2, mirror selectivity to F8
3. CV for S6: 0.2; CV for S7: 0.4
4. One block for selectivity for F8
5. Random Q for S8
6. Random Q for S2

Work on these runs revealed a scaling issue in model output. There was considerable discussion to diagnose the underlying causation. The Subgroup identified two potential issues: (1) weighting of CPUE and length composition information through the length lambda, and (2) relative weighting among the CPUE indices (CV). The reference case up to this point has used a fixed length lambda of 0.05. Higher values result in a poorer fit to CPUE (since model interprets this has higher weight being given to length composition data), lower values result in a better fit – but outputs such as SSB are also scaled by this change. There appears to be a conflict between the length composition and CPUE information. The Subgroup believes that length composition data are less reliable so down-weighting them is probably the best approach, but there is no objective way to determine the appropriate lambda for length composition data. Two suggestions were made regarding the relative weighting among CPUE indices: (1) construct likelihood profiles of R_0 (average recruitment) to determine the influence of individual CPUEs on it, and (2) evaluate the CPUE time series for changes in Q and reassess assigned CVs, essentially deciding which CPUE series are believable and which series are less believable.

Based on a review of the CPUE time series the Subgroup makes the following recommendations:

- S1 (USA/CAN Troll) and S5 (JPN PL (north)) – CVs 0.4 up to 2004, 0.5 from 2005 to present. Both fisheries have contracted back to their respective coastlines since about 2000 (which may change Q) and they exhibit different trends in CPUE since 2005;
- S3 (JPN PL (south), S4 (JPN PL north – short time series) – CV remains 0.4;
- S6 (JPN LL (north)) – this fishery is considered the most important fishery by JPN scientists. CV was decreased from 0.25 to 0.2. The model will be tuned to this CPUE index because it is considered the most reliable indicator of abundance;
- S7 (JPN LL (south)) – CV increased from 0.2 to 0.4; there has been a shifting in targeting from ALB in recent years;
- S2 (USA LL) – this index is problematic and will be dropped; and
- S8 (TWN LL) – this index is also problematic and will be dropped.

Likelihood profiles of all CPUE indexes with respect to R_0 show inconsistencies among the indices. The reference case used an R_0 of 10.5 and S1 favoured that value. But S6 (considered the most reliable index) favours a value of 11.5. These inconsistencies or differences contribute to the scaling problem. If an R_0 of 11.5 is used in the model, it increases the scaling of recruitment and SSB.

It was noted that previous stable versions of the model used a fixed Q for S1. Fixed Q is not considered a defensible parameterization so when Q was estimated model instability began.

Several runs varying lambda and CPUE CVs pointed to the need to down-weight the length composition data via lambda. The Subgroup recommends a lambda of 0.01. This value seems to bring the scaling of SSB to a range that the group considers to be biologically plausible.

11.1 Updated Reference Configuration

The Subgroup review a run in which the reference case was updated with the agreed ageing error matrix (± 1 yr, 0-5 yr; ± 2 yr $\geq$ 6 years). Fits to the CPUE indices were very good, but a problem remains with an estimated selectivity parameter for F6s1 hitting a boundary. Some length composition fits were poorer than before, largely because lambda is lower (0.01) so it can't fit to the indices or remove the residual pattern. This result is the trade-off for lowering lambda. Aggregated length composition fits by fleet were very good.

12.0 Future Projections

The Subgroup discussed future projection scenarios. Management advice is based on the projections. Certain issues were identified including the definition of current F – the ALBWG tentatively accepted the geometric mean of 2006-2008, but preliminary retrospective analysis show a tendency to underestimate F in the terminal year. This retrospective pattern needs to be checked after the base case scenario has been established and run. However, the Subgroup recommends defining current F as the geometric mean of 2005-2007 based on this analysis. The Subgroup recommends runs using both $F_{2005\text{-}20007}$ and $F_{2006\text{-}2008}$ and for continuity with the previous assessment $F_{2002\text{-}2004}$.

Four projection scenarios were briefly discussed: constant F (using estimated current F), constant quarterly catch, low and high recruitment periods. The constant catch scenario will use average quarterly catches for the same period used to estimate current F for consistency.

The minimum reference point information that must be provided (for NC) is $F_{SSB\text{-}ATHL}$ 50% for a 25-yr projection period.

Future projections will begin in 2008 and will use 2008-2010 catches.

Initially 300 bootstrap runs and 20 stochastic simulations per run (6,000 replicates) were considered necessary to accurately estimate future trajectories of SSB. However, results of preliminary analysis in which the number of simulations was varied from 5 to 20 and bootstrap replicates ranged from 5 to 300 (Figure 1) show that future SSB trajectories stabilize at approximately 200 bootstraps and 10 simulations. The Subgroup recommended 200 bootstraps and 10 simulations of each bootstrap result (2000 replicates) for estimating F_{SSB} in all future projection analyses for this assessment.

13.0 Batch 4 – Sensitivity Run Review

The reference case was updated (June 2) to include the following: one block selectivity for F6, no block selectivity for F8, seasonal CPUE for S6, weight for size comps 0.01 (lambda); CV for S1: 0.04 (1965-1999), 0.5 (2000-2009); S2: 0.05; S5: 0.4 (1966-2003), 0.5 (2004-2009); S6: 0.2;

S7: 0.4; and S8: 0.5; updated ageing error matrix (±1 0-5, ± 2 ≥ 6) . The Subgroup requested the following runs:

1. Selectivity for F6S1 needs to be explored (early period)
2. Drop each index at once (one by one)
3. Weight for size comp for all fleets: 0.025
4. Drop CPUE S2, mirror selectivity F8
5. Likelihood profile on steepness

13.1 F6s1 Selectivity
The early period selectivity was hitting the boundary of the width parameter of the descending limb because the top became too wide. When the width parameter (P2) was relaxed, a much better curve with a reasonable descending limb was estimated and no boundary issues. There were slight improvements to the length comp residual patterns and selectivity is now clearly dome-shaped. The SSB trajectory did not change. The Subgroup concluded that this solution would be acceptable and recommended to the WG as long as it is robust. . Several runs fixing P2 at different values showed little change in the SSB trajectory but a likelihood profile for P2 is needed to confirm this finding.

A review of the likelihood plot for P2 shows that minimum likelihood occurs between -1 and 1. The estimated value in SS was -0.23. The conclusion is that this solution for F6s1 selectivity is acceptable and will be recommended to the Working Group.

13.2 Length Composition lambda = 0.025
This change tends to improve the fit to length composition data slightly. No issues were observed with selectivity curves. Biomass (SSB) was scaled up slightly relative to the reference case with lambda = 0.01.

The Subgroup concluded that the length composition lambda value controls the scale of model output for north Pacific albacore. However, overall trends do not change so the relative scale of important management quantities should remain the same regardless of the lambda choice.

Stock size appears to be much larger than estimated in 2006 with the VPA. One important reason for this is the Suda growth curve. An important sensitivity run will be to replace existing growth curve in SS with the Suda curve parameters; this should reduce stock size and will be done as a sensitivity run.

13.3 Mirror F8 Selectivity for S2
Dropping the CPUE for S2 and mirroring F8 selectivity scales SSB up beyond the effect of changing lambda to 0.025.

13.4 Dropping CPUE indices one-by-one
SSB and recruitment trends were similar with some scaling differences. Dropping S7 (JPN LL south) changed trends.

The Subgroup reviewed the base case parameterization, which is based on decisions made at the meeting, and the data file. It was noted that two base case scenarios will be presented to the full working group: a scenario using the annual F6 index for F6s1, and a scenario using the seasonal Q1 index for F6s1. The WG will decide the appropriate base case.

13.5 Retrospective Analysis
Retrospective analysis sequentially removes one year of data and then reruns the model to examine estimated quantities (SSB, recruitment for bias or uncertainty.. This analysis showed that there is a tendency to overestimate SSB, but there is no difference in trends at least for SSB and total B. Recent recruitment trends tend to vary depending on the year removed and recent recruitment seems to be overestimated in the terminal year, but this is uncertain anyway. Pattern is not clear but there appears to be a need to drop at least the last 2 years of estimated recruitment (2008 and 2009).

The Subgroup recommends the following recruitment scenarios: (1) resampling the 1966-2007 recruitment time series for future projections; (2) resampling a low recruitment regime (1978-1987); and (3) resampling a high recruitment regime (1988-2007). The starting year for future projections is tentatively 2008, but checks will be made starting at 2007 and 2009.

Stock-recruitment relationship – there is no strong evidence in the SSB and recruitment scatter plot of a relationship. But a sensitivity run assuming a relationship may be needed for future projections. A model sensitivity run with h = 0.85 is recommended..

A look at preliminary projections using current F defined as 2006-2008 suggests stock will stabilize around the median biomass of the time series.

14.0 Sensitivity Analyses

The Modeling Subgroup recommended the following sensitivity runs to evaluate model parameterization issues and sensitivities:

1. Jackknife each fishery – set lambda = 0 for CPUE, small for size comps (determine if 0.001, 0.0001, 0.00001, 0.000001 etc. etc?)
2. Length comp lambda = 0.025
3. Fix growth model parameters to Suda (1966 estimates, do not use ageing data)
4. Steepness: h=0.9
5. CV of L_∞ = 0.04 (current estimate is 0.015, which may be low)
6. M = 0.4 (ages 0-5), 0.3 (ages 6-15)
7. Likelihood profile of P2 for F6s1 selectivity
8. Reduce CV for S1 and S4&S5 CPUE to 0.2 (more informative than assumed in base-case)
9. Fix CV for S6, estimate for all other CPUEs
10. Assume F6 selectivity is flat-topped (logistic)
11. No time blocks for selectivity on 3 fisheries (one-by-one)
12. Maximum age = 20
13. Block catchability of CPUE anywhere time block is used – if Q can be estimated
14. Multiple recruitment periods (try to estimate proportions recruiting, if fails then fix)
15. Length-based maturity (may give different SSB than age-based maturity currently used)
16. Add constant for size comp = 0.0001
17. Use length multiplier (to sample size) to down weight length comps (after workshop)

It was noted that the ISC had requested that Working Groups conduct fishery impact analysis and that this will be necessary for albacore

The model subgroup meeting adjourned at 14:30 on 3 June 2011.

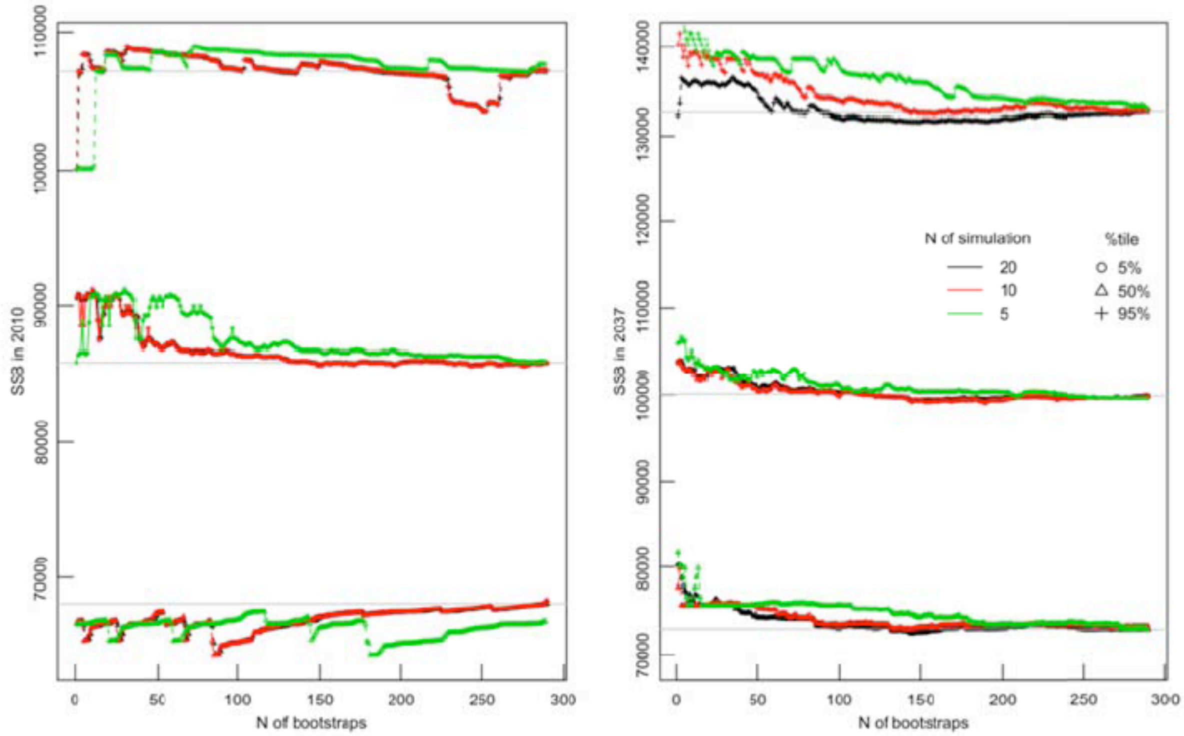

Figure 1. Percentiles of future SSB from 2010 to 2037 by N bootstrap replicates. These results are derived from preliminary future projection analysis based on a preliminary assessment that differs from the current base-case. Simulations are repeated 20 (black), 10 (red), and 5 (green) times in each bootstrap run.

ATTACHMENT 1

Table 1. List of Participants

Name	Agency
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ATTACHMENT 2

Modelling Subgroup Meeting

30 May – 3 June 2011

Agenda

1. Data overview/check (JPN data submissions/US LL size comp 2009)
2. VPA – continuity with last assessment
3. Review of JPN SS data submission
4. Growth
5. Length comps
6. Effective sample size
7. F6 in general, F8, F9 (seasonal selectivity change)
8. CPUE indices
9. Taiwan size comps
10. Time blocks/random walk if necessary (catchability)
11. Steepness
12. Diagnostics for base case scenario
13. Future projections
14. Sensitivity runs

APPENDIX 5

This Appendix contains the results of discussion and recommendations related to the base-case scenario recommended by the Modelling Subgroup (Agenda Item 4), SS and VPA data review (Agenda Item 7), structural and input parameter decisions (Agenda Item 8), choice of sensitivity runs (Agenda Item 9), and input decisions for conducting future projections (Agenda Item 10).

1.0 Report and recommendations from the modeling subgroup meeting

The Modeling Subgroup met 30 May – 3 June at NRIFSF to: (1) develop recommendations to the full working group concerning all of the major modeling issues that have been identified, and (2) to produce base case scenario for recommendation to the full WG. The full report of the Modeling Subgroup meeting is attached in Appendix 4. In this section, the recommended model parameterization and configuration for the consensus base-case scenario of the SS3 model are described along with recommendations on model diagnostics (residual plots, model fits, retrospective analysis) and sensitivity runs. The base case scenario and sensitivity runs presentation included a review of the data and model structure recommended by the modeling subgroup.

John Holmes provided a summary of the Modeling Subgroup Meeting, highlighting the agenda and major findings/recommendations to the WG. These recommendations are discussed more fully in the next sections.

1.1 Recommended Base-case Configuration for SS3

The 2011 assessment of the north Pacific albacore tuna stock will be conducted using Stock Synthesis ver. 3.11b (SS3). A reference run of the VPA model was made with VPA2Box software and updated fishery data through 2009 for continuity with the last assessment. Output from this run (SSB and recruitment trajectories, F-at-age, Fcurrent) will be compared with similar output from SS3 to assess model-related changes in the assessment.

Two versions of the SS3 base-case and sensitivity runs were presented: a version using a quarterly CPUE index for F6s1 and a version using the annual index for F6 and applying it to F6s1.

Two types of weighting were used in the model: (1) weighting of the different sources of information (length composition and CPUE) relative to each other, and (2) relative weighting among CPUEs. The modeling subgroup recommended down-weighting the length composition data from all fisheries using a lambda of 0.01 and a sensitivity run of lambda = 0.025. The model subgroup concluded that index S6 (JPN offshore longline fishery north - F6s1) is the most reliable indicator of albacore abundance and chose to tune the model to this index with a CV of 0.2. The model includes 7 other CPUE indices with the following relative weightings: S1 (USA/Can troll) CV = 0.4 (1966-1999), = 0.5 (2000-2009), S2 (USA LL) CV = 0.4; S3 (JPN PL south) CV = 0.4; S4 (JPN PL north) CV = 0.4; S5 (JPN PL north) CV=0.4 (1985-2003), = 0.5 (2004-2009), S7 (JPN LL south) CV=0.4; S8 (TWN LL) CV = 0.4 (2003-2009).

Effective sample sizes for length composition data for all fisheries were scaled to the average number of trips for the USA/CAN troll fishery (N ~ 113.65).

Biologically, the Subgroup recommends using the following assumptions because no new data or analyses have been presented since the last stock assessment that support changes to these assumptions: spawning and recruitment occur annually in the second quarter, only one recruitment period in the second quarter, natural mortality 0.3 yr^{-1} across all ages, and 50% maturity occurs at age 5, 100% maturity at age 6 and older. The Subgroup also recommends the use of seasonal weight-length relationships in Watanabe et al. (2006, ISC/06/ALBWG/14**)**

The growth assumption recommended by the Subgroup is a major departure from the previous assessment: for this assessment growth should be estimated within the model using a von Bertalanffy curve and conditional age-at-length data from Wells et al. (2011: ISC/11/ALBWG/02). Four parameters of the von Bertalanffy curve are estimated: L1 (L_{age-1}), L2 (L_{∞}), K, and CV of L2. The previous assessment fixed the growth curve to the Suda parameter estimates (L1 = 40.2 cm; L2 = 146.46 cm).

The maximum age recommended is 15 years, with early (1966-1968), main (1969-2007), and late (2008-09) eras for recruitment . Bias adjustment for recruitment is not recommended.

Initial fishing mortality was estimated for two surface (F1-USA/CAN troll; F4-JPN PL) and one longline fishery (F7 - JPN LL) and the initial equilibrium catch was calculated as the 14 year average of total catch (1952-1965) for F1, F4 and F7. These average catches were 19499, 28575, and 18180 t, respectively. Catchability (Q) for all fisheries and surveys was used as a scaling factor such that the estimate is median unbiased F.

A standard Beverton and Holt stock-recruitment model is recommended, allowing the model to estimate R_0, steepness (*h*) fixed at 1.0, and the standard deviation of the log-recruitment (sigmaR) fixed at 0.6. No R_1 offset is recommended.

Selectivity patterns for all surface fisheries (F1, F4, F5) were assumed to be dome-shaped and constant over time. It is recommended that the width between the ascending and descending limbs of the F4 selectivity (the top) be fixed at a value of -4. The initial and final parameters of the selectivity patterns should also be fixed at -999 and the other parameters estimated for these patterns.

The recommended selectivity patterns for the longline fisheries are either flat-topped (asymptotic) or dome-shaped. Flat-topped selectivity is recommended for F2 and F8 dome-shaped selectivity patterns are recommended for F6 and F12. Two time-periods were implemented for selectivity in F2, F6s1, and F12 to account for time-varying selectivity patterns observed in these fisheries. Selectivity in F3 (EPO miscellaneous) was mirrored to F1, F7s1 and F13 (KOR and other LL) were mirrored to F6s1, F7s2 was mirrored to F6s2, F9 was mirrored to F10, and F11 and F14 were mirrored to F5 selectivity.

The WG reviewed the recommended base-case model. The model fits well to the S6 and S7 indices, but less so to other indices. The former is expected as the model was tuned to this index.

Overall, fits to aggregated length composition data by fleet were considered acceptable. Some residual patterns remain in the length composition fits by year and fleet, particularly positive residuals for F6s1 and F8, but this is expected considering the down-weighting of the length composition data with lambda (λ). Total biomass and spawning biomass trends show two peaks in the early 1970s and 2000s. Spawning biomass fluctuates between 250,000 and 500,000 t. Recruitment shows a declining trend to 1989 followed by a higher recruitment period for 1990 onwards. Biomass and recruitment trajectories were identical regardless of the CPUE index used for F6s1, although applying the annual index to F6s1 tended to scale the absolute biomass up relative to the runs using the quarterly index.

1.2Sensitivity Runs

A total of 17 sensitivity runs were recommended by the Subgroup, but only the results of the first 11 runs were reviewed by the WG due to time constraints:

1. Jackknife each fishery – set lambda = 0 for CPUE, small for size comps (0.0001
2. Length comp lambda = 0.025
3. Replace growth curve with Suda curve (fix growth parameters to Suda and use ageing data)
4. Steepness: h=0.9
5. CV of L_∞ = 0.04 (current estimate is 0.015, which may be low)
6. M = 0.4 (ages 0-5), 0.3 (ages 6-15)
7. Likelihood profile of the P2 parameter for estimating F6s1 selectivity
8. Reduce CV for S1 and S4&S5 CPUE to 0.2 (more informative than assumed in base-case)
9. Fix CV for S6, estimate for all other CPUEs
10. Assume F6 selectivity is flat-topped (logistic)
11. No time blocks for selectivity on 3 fisheries (one-by-one)
12. Maximum age = 20
13. Block catchability of CPUE anywhere time block is used – if Q can be estimated
14. Multiple recruitment periods (try to estimate proportions recruiting, if fails then fix)
15. Length-based maturity (may give different SSB than age-based maturity currently used)
16. Add constant for size comp = 0.0001
17. Use length multiplier (to sample size) to down-weight length comps (after workshop)

The results of the first 11 sensitivity runs were reviewed by the WG. In general, changes to model configuration or parameterization scaled absolute biomass and recruitment up or down relative to the base case but did not change the temporal trends in the output for either parameter. Discussion of the sensitivity runs noted that estimated CPUE CVs were generally consistent with those recommended by the Subgroup with two exceptions: the model estimates a CV of 0.8 for S2 (USA LL) and 0.27 for S3 and S4 (JPN PL). The WG decided to leave the CV = 0.4 for S2 and change the CV for S3 and S4 to 0.3 for 1966-1999 and 0.4 for 2000-2009.

Retrospective analysis shows no specific trends in the either SSB or recruitment estimates. Although there is a tendency to overestimate SSB, there is no evidence of systematic bias. Recruitment estimates exhibit high uncertainty in recent years, with a tendency to overestimate terminal year recruitment. The WG concluded that the final 2 years of recruitment estimates should not be used for future projections, i.e., the sample period will be 1966-2007, and that for recruitment, future projections should begin with 2008. Although terminal year estimates of fishing mortality exhibit considerable uncertainty, these estimates are not consistently biased. The WG decided to use the geometric mean of 2006-2008 as its estimate of current F because the statistical uncertainty (95% confidence interval) in the estimated F_{2007} and F_{2008} were identical.

It was noted that fishery impact analysis was desirable in this assessment. This analysis compares biomass trends with fishing and the trends predicted in the absence of fishing assuming only that the impact of fishing on recruitment is through the stock-recruitment relationship. The WG briefly discussed the mechanics of conducting the analysis and initially concluded that there was insufficient time at the workshop to complete the analysis and review it. However, this analysis was subsequently completed and reviewed and will be included in the assessment.

The WG also discussed the sensitivity run in which growth was fixed to the Suda growth curve. In this run, the conditional age-at-length data (otolith data) were also dropped when they should have remained in the model. A question was asked about the birth date used for otolith aging (May 1) and in SS3 and how fractional ages are handled in SS3. Rick Methot (SS architect) was contacted to respond to this issue..

APPENDIX 6

Table 1. [1] North Pacific albacore catches (in metric tons) by fisheries, 1952-2010. Blank indicates no effort.
-- indicates data not available. 0 indicates less than 1 metric ton. Provisional estimates in ().

Year	Japan							Korea		Chinese-Taipei		
	Purse Seine	Gill Net	Set Net	Pole and Line	Troll	Longline	Other	Gill Net	Longline	Gill Net	Distant Water Longline	Offshore Longline
1952	154		55	41,787	--	26,687	182					
1953	38		88	32,921	--	27,777	44					
1954	23		6	28,069	--	20,958	32					
1955	8		28	24,236	--	16,277	108					
1956			23	42,810	--	14,341	34					
1957	83		13	49,500	--	21,053	138					
1958	8		38	22,175	--	18,432	86					
1959			48	14,252	--	15,802	19					
1960			23	25,156	--	17,369	53					
1961	7		111	18,639	--	17,437	157					
1962	53		20	8,729	--	15,764	171					
1963	59		4	26,420	--	13,464	214					
1964	128		50	23,858	--	15,458	269					
1965	11		70	41,491	--	13,701	51					
1966	111		64	22,830	--	25,050	521					
1967	89		43	30,481	--	28,869	477				330	
1968	267		58	16,597	--	23,961	1,051				216	
1969	521		34	31,912	--	18,006	925				65	
1970	317		19	24,263	--	16,222	498				34	
1971	902		5	52,957	--	11,473	354		0		20	
1972	277	1	6	60,569	--	13,022	638		0		187	
1973	1,353	39	44	68,767	--	16,760	486		3		–	
1974	161	224	13	73,564	--	13,384	891		114		486	
1975	159	166	13	52,152	--	10,303	230		9,575		1,240	
1976	1,109	1,070	15	85,336	--	15,812	270		2,576		686	
1977	669	688	5	31,934	--	15,681	365		459		572	
1978	1,115	4,029	21	59,877	--	13,007	2,073		1,006		6	
1979	125	2,856	16	44,662	--	14,186	1,139	0			81	
1980	329	2,986	10	46,742	--	14,681	1,177	6	402	--	249	
1981	252	10,348	8	27,426	--	17,878	699	16		--	143	
1982	561	12,511	11	29,614	--	16,714	482	113	5,462	--	38	
1983	350	6,852	22	21,098	--	15,094	99	233	911	--	8	
1984	3,380	8,988	24	26,013	--	15,053	494	516	2,490	--	–	
1985	1,533	11,204	68	20,714	--	14,249	339	576	1,188	--	–	
1986	1,542	7,813	15	16,096	--	12,899	640	726	923	--	–	
1987	1,205	6,698	16	19,082	--	14,668	173	817	607	2,514	–	
1988	1,208	9,074	7	6,216	--	14,688	170	1,016	175	7,389	–	
1989	2,521	7,437	33	8,629	--	13,031	433	1,023	27	8,350	40	
1990	1,995	6,064	5	8,532	--	15,785	248	1,016	1	16,701	4	
1991	2,652	3,401	4	7,103	--	17,039	395	852	0	3,398	12	
1992	4,104	2,721	12	13,888	--	19,042	1,522	271	1	7,866	–	
1993	2,889	287	3	12,797	--	29,933	897		21		5	
1994	2,026	263	11	26,389	--	29,565	823		54		83	
1995	1,177	282	28	20,981	856	29,050	78		14		4,280	
1996	581	116	43	20,272	815	32,440	127		158		7,596	
1997	1,068	359	40	32,238	1,585	38,899	135		404		9,119	337
1998	1,554	206	41	22,926	1,190	35,755	104		226		8,617	193
1999	6,872	289	90	50,369	891	33,339	62		99		8,186	207
2000	2,408	67	136	21,550	645	29,995	86		15		7,898	944
2001	974	117	78	29,430	416	28,801	35		64		7,852	832
2002	3,303	332	109	48,454	787	23,585	85		112		7,055	910
2003	627	126	69	36,114	922	20,907	85		146		6,454	712
2004	7,200	61	30	32,255	772	17,341	54		78		4,061	927
2005	850	154	97	16,133	665	20,420	234		420		3,990	483
2006	364	221	55	15,400	460	21,027	42		138		3,848	469
2007	5,682	226	30	37,768	519	22,336	44		56		2,465	451
2008	825	1,531	101	19,060	549	19,092	15		365		2,490	579
2009	2,076	149	33	31,172	410	21,995	43		(365)		1,866	(512)
2010	(308)	(149)	(33)	(21,757)	(410)	(22,434)	(43)		(365)		(2,236)	(512)

1 Data are from the ISC Albacore Working Group, June 8, 2011.

APPENDIX 6

Table 1. (Continued)

Year	United States								Mexico		Canada	Other		Grand Total
	Purse Seine	Gill Net	Pole and Line [2]	Albacore Troll [3]	Tropical Troll & Handline	Sport	Longline	Other	Purse Seine	Pole and Line [4]	Troll	Troll [5]	Longline [6]	
1952				23,843		1,373	46				71			94,198
1953				15,740		171	23				5			76,807
1954				12,246		147	13							61,494
1955				13,264		577	9							54,507
1956				18,751		482	6				17			76,464
1957				21,165		304	4				8			92,268
1958				14,855		48	7				74			55,723
1959				20,990		0	5				212			51,328
1960				20,100		557	4				141			63,403
1961			2,837	12,055		1,355	5	1	2	39	4			52,649
1962			1,085	19,752		1,681	7	1	0	0	1			47,264
1963			2,432	25,140		1,161	7		31	0	5			68,937
1964			3,411	18,388		824	4		0		3			62,393
1965			417	16,542		731	3	1	0		15			73,033
1966			1,600	15,333		588	8		0		44			66,149
1967			4,113	17,814		707	12				161			83,096
1968			4,906	20,434		951	11				1,028			69,480
1969			2,996	18,827		358	14		0		1,365			75,023
1970			4,416	21,032		822	9		0		390			68,022
1971			2,071	20,526		1,175	11		0		1,746			91,240
1972			3,750	23,600		637	8		100	0	3,921			106,716
1973			2,236	15,653		84	14		0		1,400			106,839
1974			4,777	20,178		94	9		1	0	1,331			115,227
1975			3,243	18,932		640	33	10	1	0	111			96,808
1976			2,700	15,905		713	23	4	36	5	278			126,538
1977			1,497	9,969		537	37		3	0	53			62,469
1978			950	16,613		810	54	15	1	0	23			99,600
1979			303	6,781		74	–		1	0	521			70,745
1980			382	7,556		168	–		31	0	212			74,931
1981			748	12,637		195	25		8	0	200			70,583
1982			425	6,609		257	105	21	0	0	104			73,027
1983			607	9,359		87	6		0	0	225			54,951
1984	3,728		1,030	9,304		1,427	2		107	6	50			72,612
1985	26	2	1,498	6,415	7	1,176	0		14	35	56			59,100
1986	47	3	432	4,708	5	196			3	0	30			46,078
1987	1	5	158	2,766	6	74	150		7	0	104			49,051
1988	17	15	598	4,212	9	64	307	10	15	0	155			45,345
1989	1	4	54	1,860	36	160	248	23	2	0	140			44,052
1990	71	29	115	2,603	15	24	177	4	2	0	302			53,693
1991	0	17	0	1,845	72	6	312	71	2	0	139			37,320
1992	0	0	0	4,572	54	2	334	72	10	0	363			54,833
1993		0	0	6,254	71	25	438		11	0	494			54,125
1994		38	0	10,978	90	106	544	213	6	0	1,998	158		73,345
1995		52	80	8,045	177	102	882	1	5	0	1,763	94		67,947
1996	11	83	24	16,938	188	88	1185		21	0	3,316	469	1,735	86,207
1997	2	60	73	14,252	133	1,018	1653	1	53	0	2,168	336	2,824	106,756
1998	33	80	79	14,410	88	1,208	1120	2	8	0	4,177	341	5,871	98,229
1999	48	149	60	10,060	331	3,621	1542	1	0	57	2,734	228	6,307	125,542
2000	4	55	69	9,645	120	1,798	940	3	70	33	4,531	386	3,654	85,052
2001	51	94	139	11,210	194	1,635	1295		5	18	5,248	230	1,471	90,189
2002	4	30	381	10,387	235	2,357	525		28	0	5,379	466	700	105,224
2003	44	16	59	14,102	85	2,214	524		28	0	6,861	378	(2,400)	92,873
2004	1	12	127	13,346	157	1,506	361		104	0	7,856	--	4,375	90,625
2005		20	66	8,413	175	1,719	296		0	0	4,845	--	4,315	63,295
2006		3	23	12,524	95	385	270		109	0	5,832	--	5,136	66,400
2007		4	21	11,887	98	1,225	250		40	0	6,075	--	3,539	92,717
2008	0	1	1,472	10,289	29	415	353	0	10		5,446		2,812	65,435
2009	39	3	2,218	10,575	99	677	203	0	17		5,643		1,581	79,677
2010	(18)	(3)	(1,874)	(10,130)	(99)	(685)	(203)	(2)	(25)		(6,497)		(1,581)	(69,364)

2 Albacore Pole-and-line catches for 2008 - 2010 are estimated from new procedures.
3 Albacore Troll catches prior to 2008 contain an unknown proportion of pole and line catch.
4 Mexico Pole-and-line catches for 1999 and 2000 include 34 and 4 metric tons, respectively, from longline.
5 Other Troll catches are from vessels registered in Belize, Cook Islands, Tonga, and Ecuador.
6 Other Longline data for 2004-2009 are from Peter Williams, SPC, for non-member nations. Other Longline also includes data provided by China.

APPENDIX 7

The ALBWG (or WG) stock assessment workshop was originally scheduled for 11-29 March 2011, but was postponed due to the Great East Japan earthquake and tsunami. During the period leading up to the reschedule workshop, considerable discussion occurred via email between WG members focusing on two topics: (1) age and growth of albacore, and (2) preliminary parameterization of the SS3 base-case model. The major points and conclusions drawn from these discussion are captured in this Appendix.

Age and Growth of North Pacific Albacore

Email discussion and comments on) ISC/11/ALBWG/02 prior to the workshop focused on two areas: (1) the mechanics of producing the age estimates, and (2) how to use these data to model growth in the assessment. The WG identified three issues with the ageing data including the lack of validation of annual increment formation (annuli), the fact that all of the ages were determined by one person so no precision estimates are available, and the very small sample sizes for ages > 4 years. It was noted that it would be useful to examine these data for any indications of regional or gear specific biases in the length at age of fish. The authors were asked to provide scatter plots by sampling area or gear (e.g. NWPO vs. EPO, or PL vs. Troll) in addition to Figure 3 and Table 2 because it appears that smaller-sized albacore were found in the EPO compared to NWPO. Table 2 shows CVs by age and for age classes with sample sizes >30, CV is around 0.04, which is much lower than values currently used in preliminary SS modeling. It was pointed out that in the current configuration of the SS model, age 1 is assigned to fish at the beginning of 2nd quarter, i.e., birth date in the model is April 1, whereas in the paper May 1 is defined as the birth date and was used to parameterize the growth curves. Thus, if the otolith-based growth curve is used, an adjustment of L_{min} or t_0 (age at L_{min}) will be necessary since the model uses the mean length in the middle of each season when fitting to length frequency data.

Several growth models were fitted to these data in ISC/11/ALBWG/02, with the specialized von Bertalanffy model exhibiting the best fit (based on AIC) and the Gompertz model a close second best. The WG noted that a comparison of mean sizes and CVs by age of aged samples and expected length- at-age revealed a tendency for the growth curves to underestimate length-at-age of younger (<= 7)and older (>=13) fish and overestimate length-at-age for fish aged 8-12. It was thought that this phenomenon might be affected by the timing of sampling. Since sample sizes for ages 7 to 9 are low, it was proposed that additional fits to the growth curve excluding these samples would aid the ALBWG in understanding the uncertainties of the current estimates conditional on these samples.

An important consideration is whether growth in the SS model should be fixed equal to an ageing-based growth curve (or some other growth model), or estimated within SS. The otolith-based growth curve and the SS estimated growth curve may not, even in principle, be the same since the assumptions behind them differ. A birth date is assumed when ageing (or measured from daily rings) and assumptions are made about the first annulus and the growth pattern at young ages. Stock assessment models usually make different implicit assumptions about the processes involved in fish growth. The growth curve is used to infer an approximate age for the fish first observed in the length-frequency data, but the age in quarters or months is unlikely to line up exactly between the two approaches, i.e., the average size of fish when they first appear in the model often fails to correspond to what is expected based on the growth curve. Modeling assumptions are internally consistent, but combining two incompatible assumptions will introduce bias. For example, using a growth curve estimated independently of the model reduces the number of parameters the model has to estimate, but it assumes that there is no error in the age-based growth curve. Given the amount of data in the model and the fact that estimating the growth curve within the model adds only a few parameters to a model that has hundreds of parameters, the bias-variance trade-off probably favours reducing bias by estimating the extra parameters.

There are other reasons to assume error in the ageing-based growth curve since it is not usually feasible to sample otoliths in a fully representative way across the entire population. The use of non-representative data matters because growth rates can vary with environmental conditions or other factors, spatially or through time. As a result, although the otolith based growth curve is a good way to observe the general pattern of albacore growth, it may differ slightly from the average pattern for the whole stock. The length frequency samples in the model have far larger sample size and are a more comprehensive information source through space and time, and so can be more informative about the average growth pattern of the stock. The main sources of growth information in these data are the sizes of the large fish (L_∞), and the way the size modes of small fish increase (growth rate at length, i.e., K and t_0).

Potential problems with the model-based growth parameter estimates, such as bias or lack of precision, also need to be considered. For example, K can be affected by length-frequency samples collected from an area with an unrepresentative growth rate - an issue that must be addressed whichever growth curve is used. Size modes may hard to observe or to follow through the data. Longline selectivity assumptions may be invalid, or selectivity may change through time and not be accounted for in the model. In these cases the key issue is to reduce conflicting information in the model. Alternative hypotheses concerning growth should be addressed in separate models.

Further modeling work was performed after the October 2010 meeting with updated catch-at-length data and parameterization of the model. The results of this work show that estimating growth within the SS3 model provides relatively robust and plausible estimates of growth parameters that are similar to those estimated from otoliths in ISC/11/ALBWG/02. This modeling work also showed that estimating growth within the model resulted in the best fit to the length data. This latter point is considered an important criterion to meet for a length-based model.

Three options for using the new ageing information within SS were considered: (1) fix the growth curve using externally estimated-parameters, (2) fitting these data as conditional age-at-length in which length and age observations are analogous to entries in an age-length matrix, and 3) using the externally estimated growth curve parameters as priors for internal estimation of the growth curve within SS. Based on the discussion summarized above, the ALBWG rejected the fixed growth curve option and supported the estimation of the growth curve within SS using conditional age-at-length data from the ISC/11/ALBWG/02 otolith paper. Letting the model estimate growth avoids introducing bias when the model tries to fit the size data in other ways.

Growth Curve Recommendations

During the October workshop at La Jolla, the ALBWG noted that the scaling of SS3 output may be driven by sensitivity to the growth curve used in the model. If the growth parameters were estimated in the model, then there was a tendency to estimate higher K and lower L_∞ than Suda (1966), which were used in the reference case runs. Three options were identified:

1. fit mean length-at-age for surface fisheries in the VPA and approximate mean length-at-age of adult albacore from the Suda growth curve as was assumed in the 2005 stock assessment;
2. construct a hybrid growth curve based on slicing and the Suda growth curve (see ISC/11/ALBWG/06); and
3. a growth curve based on new information from otoliths collected and aged by US scientists.

At the October 2010 workshop in La Jolla, the ALBWG noted that option 1 was included as a fall-back in case all other approaches failed and that option 2 was most likely to be considered as a sensitivity run. Thus, most effort has been expended exploring option 3 .

The ALBWG spent considerable time and effort on the growth curve because the model fit to the length data is an important problem to solve, given that the model appears to be highly sensitive to the estimated growth parameters, particularly L_∞. Several preliminary runs demonstrated that model outputs used to assess status, especially the scaling of absolute biomass and the resulting MSY-based reference points, are influenced by the growth curve. A fixed growth curve that doesn't fit the data can lead to problems elsewhere in the assessment because the model will try to reduce the likelihood by shifting some other parameter. It was suggested that if the ALBWG concluded that the growth curve had to be fixed in the short term (i.e., for this assessment), then it might be also necessary to reduce the effective sample size for the small fish fisheries, or at least catches of 60-80 cm fish, so that the lack of fit at this size range is less of a problem for the model.

Much of the modeling on which this preliminary decision was based assumed a von Bertalanffy growth curve for albacore. Further modeling of growth gradually built support for the idea that the von Bertalanffy curve may not be not suitable for north Pacific albacore. Non-von Bertalanffy growth patterns were found to fit the data better in many current tuna assessments, including those for south Pacific albacore (Hoyle and Davies 2009), WCPO bigeye (Harley et al. 2010) and yellowfin tune (Langley et al. 2009), and EPO bigeye and yellowfin tuna (Aires da Silva and Maunder 2011a,b), because the growth of young fish in these stocks tends to be more linear than predicted by the von Bertalanffy curve. When growth is forced to follow a von Bertalanffy curve, the model tries to fit the smaller fish by reducing K, which results in higher L_∞ since these parameters are strongly correlated. The model can still fit to the large observed fish by reducing the biomass, but it needs to adjust the growth curve to fit to the small fish. Since the mean lengths-at-age estimated in ISC/11/ALBWG/02) and ISC/11/ALBWG/06 are not inconsistent with more linear growth for smaller north Pacific albacore, the WG considered estimating growth internally within SS using a more flexible growth curve. At present, SS only has two growth curve options: von Bertalanffy and the Schnute-Richards generalized growth curve, which estimates one parameter more than the von Bertalanffy curve. Although the Schnute-Richards curve has more flexibility than the von Bertalanffy curve, it was considered worthwhile to run both models and do likelihood comparisons to evaluate which fits best to the north Pacific albacore data.

An alternative approach is to use conditional age-at-size data from the otolith-based ageing (ISC/11/ALBWG/02), which would allow some flexibility in terms of the growth curve that is not available when the parameters are fixed and stabilizes the curve as well. Some preliminary modeling results tended to show that using conditional age-at-size data reduces the sensitivity of estimated growth curve parameters to different model configurations. If this preliminary result can be confirmed, then the practical importance of this finding is that trivial or implausible model configurations are less likely to be influential in the determination of stock status.

Additional modeling work was conducted prior to the workshop examining the effect of using the Richards growth curve and conditional age-at-size data from the otolith work on model fits to the albacore length data and the sensitivity of parameter estimates to different configurations. The results of these runs show that the use of conditional age-at-size data from the otolith ageing helped to stabilize L_∞ for the growth model, although there remain some fitting problems, with smaller expected sizes-at-age for young fish resulting in larger sizes-at-age for old fish. One possibility to explain this lack of fit is that the implementation of the Richards curve in SS doesn't have enough flexibility at small sizes. However, the difference in L_∞ between configurations is smaller when the otolith data are used.

Since the lack of fit is most noticeable at younger ages, it was suggested that using fractional ages for the aged fish, based on an assumed birth date and date of capture, might improve the growth modeling, especially for the youngest fish. . Ages in the model do not have to line up exactly with true ages from the otoliths, although including age at length data from otoliths in the model will introduce a data conflict if the offset between the two ages is relatively large. Some offset from 'reality' is expected and shouldn't affect the estimated population parameters. The key issue is to ensure that the average expected length when fish are first observed in the model and the length increments between ages are correct. It was also suggested that removing otolith data for the young fish might improve the growth curve modeling, since the older, larger fish are more influential in stabilizing the L_∞ estimate.

Several more runs of the model exploring different suggestions for growth curve estimation to reduce the data conflict between young and old fish given the different growth assumptions for these ages and improve length composition fits pointed to the following combination of approaches as the most plausible:

- estimate variability of size-at-age (CV) within SS,
- Remove age 3 and younger otolith data to avoid the lack of fit to the fast growth period. Some WG members have suggested that up to age 8 or 9 otolith data could be removed;
- Include aging bias in the aging error matrix. Bias was +0.25 and +0.5 for season 3 and 4, respectively. Only otoliths from fishery 1 (US/CA troll) included an aging bias (i.e., the younger fish). Otoliths from USLL and JPLL did not have aging bias. The inclusion of

ageing bias substantially improved the fit to length composition data based on a reduction in likelihood; and
- extending the age structure to 20 yr. Extending the age structure did not impose much of a computational penalty, but it may affect SSB estimates.

It is also likely that some lack of fit to the length composition data is caused by insufficient flexibility in the selectivity curves, which use functional forms rather than a non-parametric spline-based approach.

2.0 Preliminary Population Analysis of North Pacific Albacore Based on the Stock Assessment Program *Stock Synthesis* 3 (ISC/11/ALBWG/03)

The ALBWG engaged in considerable discussion about this working paper via email prior to the workshop. This discussion focused on three primary topics related to parameterization of the model: (1) the methodology for estimating effective sample size, (2) the use of multiple spawning and recruitment periods, and (3) the use of time-varying selectivity.

2.1 Effective Sample Size

The WG agreed to estimate effective sample size outside of SS using the procedure described in Lee et al. (2010: ISC/10/ALBWG-3/03) for USA longline and troll fisheries. The WG noted that quarterly differences in sample size were not considered in this analysis and requested an update of effective sample size estimates to reflect these differences so that less precise quarterly data be down weighted. The ALBWG also suggested scaling of Japanese fisheries to average sample size from USA longline or troll fishery, depending on whether it was deep or surface fishery that was being scaled. However, in the working paper submitted to the present workshop (ISC/11/ALBWG/03) the number of trips as was used for effective sample size, assuming that each trip is an independent sample. Thus, the number of trips for the USA troll (UCLTN) and USA longline (USA LL) fisheries were used and ratios (defined as sum of trips divided by sum of number of fish measured for the USA troll and USA longline fisheries) were calculated to scale the input sample sizes of other fisheries without the actual number of trips information. This new procedure was substituted because during an internal NOAA workshop concerns were raised about the original methodology, including the lack of difference in samples size in Q3 and Q4 of the US troll length compositions, even though the number of trips and fish measured were very different. Using the number of trips was suggested as a more robust approach that would improve the contrast in sample size within each fishery, especially the USA troll and longline fisheries. As the ALBWG had not reviewed the number method for calculating effective sample size, concerns were raised about this substitution and it was concluded that the ALBWG would need to review and agree to the new procedure at the stock assessment workshop. There remain some concerns about the scaling, namely that using the average sample size from USA troll and longline fisheries may not be correct. In addition, some iterative tuning of the effective sample size will likely occur during the workshop.

2.2 Multiple vs. Single Spawning and Recruitment Periods

The SS working paper (ISC/11/ALWBWG/03) assumed multiple annual recruitment periods for albacore with 75% occurring in quarter 2 and 25% in quarter 3. Multiple recruitment periods were assumed for the preliminary modeling because recent NOAA research surveys have captured albacore larvae near Hawaii in August-September and because this assumption helped stabilize the growth curve and improve the fits to the length composition data. The WG noted that it has never discussed the multiple recruitment assumption and that the allocation of recruitment to different periods was done arbitrarily as there is no evidence in the literature (or the size composition data sampled in any of the fisheries) of more than one cohort per year in the north Pacific albacore stock. It was observed that the choice of single or multiple recruitment periods affects the estimated growth curve, especially $_{Lmax}$, which is influential in scaling SSB. More importantly, the software used for future projections is not compatible at present with the assumption of multiple recruitment periods – extensive recoding and testing would be required to achieve stable output if the decision was made to assume two recruitment periods.

A review of the reproductive biology of north Pacific albacore was conducted by the ALBWG. The literature generally indicates that albacore spawn over an extended period from March through September in tropical waters west of Hawaii. The most recent work on albacore reproduction (Chen et al. 2010) found that albacore spawning in waters off the east coast of Taiwan and the Philippines peaked in March-April, whereas the older literature (Ueyanagi 1957, 1969; Otsu and Uchida 1959) concludes that spawning activity was likely greatest in June-August in the central Pacific and north of Hawaii. Chen et al (2010) based their findings on histological analyses of male and female gonads which allowed them to accurately determine the level of gonadal maturation and whether a fish had spawned by the time it was sampled. In contrast, the methods used by Ueyanagi (1957) and Otsu (1959), which are based on gonad weight and egg diameter, respectively, are either not able to fully detect spawning fish in the population or are based on small sample sizes and are therefore less accurate than Chen et al. (2010). Ueyanagi (1969) reported the seasonal distribution of albacore larvae based on larvae sampling implemented by Japanese research vessels and training vessels during the 1960s, and found that larvae was sampled most frequently in May-June, and secondarily in July and August. A follow-up study by Nishikawa et. al. (1985), which analyzed three decades of (1950s-1970) of larvae sampling surveys, concluded that spawning likely occurs all year round, but that there was a probable peak spawning season in April-June in the western Pacific Ocean. Although the report of "peak of spawning" in March-April by Chen et al. (2010) is probably more reliable than conclusions in the older literature, these results are based on a sample of 74 females from a spatially-restricted area (Taiwan, Philippine) that may not be representative of entire spawning grounds in the north Pacific Ocean.

The ALBWG concluded that although albacore spawning may occur all year round or over an extended period, the strongest evidence from Chen et al. (2010) and Nishikawa et al. (there is one peak spawning period occurring sometime in the 2^{nd} quarter of the year. Thus, the WG recommended assuming a single recruitment period in the 2^{nd} quarter for the assessment.

2.3 Time-varying Selectivity Patterns

The third topic of email discussion was the occurrence of seasonal size patterns in the Japanese longline data. In the preliminary modeling, there appeared to be a conflict between the size composition data of the Japanese longline fisheries (F6 and F8) and their respective CPUE indices which drove the population dynamics away from the observed CPUEs. Since the size composition data are influential in driving the population dynamics in the SS model, achieving good fits to these data is important in a length-based model. Two options were considered to address this problem: (1) down-weighting the size composition data for both F6 and F8 fisheries, as suggested by Lee et al. (2011: ISC/11/ALBWG/03), and (2) setting up seasonal selectivity. The first option is probably not ideal and is considered a fall-back option in the event that other approaches fail. However, the version of SS used in this assessment (3.11b) does not implement seasonal selectivity, therefore the ALBWG considered using time blocks or establishing separate seasonal fisheries from fisheries currently defined as single fisheries as ways to capture the seasonality in size patterns. It was pointed out the current fishery definitions accepted at the October 2010 workshop are based on the size of fish caught, but also capture seasonality. For example, the F6 longline fishery is uses Q1 and Q2 data and F8 is based mostly on Q3 and Q4 data with Q1 and Q2 from the southern North Pacific. Although splitting size composition data from F6 into two fisheries based on quarter is a simple procedure, it creates a problem for the CPUE associated with F6 because these data are linked and the splitting would have to occur at the raw data or GLM standardization stages. It was suggested that it might be possible to assign the current CPUE (made with data from two seasons) to one of the new seasonal fisheries, but this was not considered ideal as it assumes that data compiled in two seasons are equivalent to data from one season. There is an additional problem with this procedure in that criteria used to establish which fisheries should be split are not clear. For example, the preliminary model provided reasonable fits to the size composition data, but a closer examination reveals that there could be some misfit in season 2 for F2_USA, season 1 and season 3 for F4_JPN_PL_LF, season 2 for F6_JPN_LLF1, and season 1 and season 2 for F8_JPN_LLF2.

The Super-year concept could also be used to model seasonal selectivity in SS3. For example, enter a pseudo-observation for season 1, put the actual annual data in a season 2 observation and put a pseudo-observation in season 3 in the super season sequence. This usage could be preferred if: fish are growing rapidly within the year so their effective age selectivity is changing within year as they grow; fish are growing within the year so fishery data collected year round have a broader size-at-age modes than a mid-year model approximation can produce; and it could be useful in situations with very high fishing mortality (but note that all seasons get equal weight in the super-season combination process).

Literature Cited

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Harley, S., Hoyle, S., Williams, P., Hampton, J., and Kleiber, P. 2010. Stock assessment of bigeye tuna in the western and central Pacific Ocean. Western and Central Pacific Fisheries

Commission, Scientific Committee, Sixth Regular Session, 10-19 August 2010, Nuku‘alofa, Tonga, WCPFC-SC6-2010/SA-WP-04, 105 pp.

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Langley, A., Harley, S., Hoyle, S., Davies, N., Hampton, J., and Kleiber, P. 2009. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. Western and Central Pacific Fisheries Commission, Scientific Committee, Fifth Regular Session, 10-21 August 2009, Port Vila, Vanuatu, WCPFC-SC5-2005/SA-WP-03, 125 pp.

APPENDIX 8

SS3 starter file used in the North Pacific albacore assessment for the base case.

```
#Starter file for North Pacific albacore assessment in 2011.
NPalb2011_data.dat # Data file
NPalb2011.ctl # Control file
0 # 0=use init values in control file; 1=use ss3.par
1 # run display detail (0,1,2)
1 # detailed age-structured reports in REPORT.SSO (0,1)
0 # write detailed checkup.sso file (0,1)
0 # write parm values to ParmTrace.sso (0=no,1=good,active; 2=good,all; 3=every_iter,all_parms; 4=every,active)
1 # write to cumreport.sso (0=no,1=like&timeseries; 2=add survey fits)
0 # Include prior_like for non-estimated parameters (0,1)
1 # Use Soft Boundaries to aid convergence (0,1) (recommended)
1 # Number of bootstrap datafiles to produce
10 # Turn off estimation for parameters entering after this phase
10 # MCeval burn interval
2 # MCeval thin interval
0 # jitter initial parm value by this fraction
-1 # min yr for sdreport outputs (-1 for styr)
-1 # max yr for sdreport outputs (-1 for endyr; -2 for endyr+Nforecastyrs
0 # N individual STD years
#vector of year values

0.0001 # final convergence criteria (e.g. 1.0e-04)
0 # retrospective year relative to end year (e.g. -4)
1 # min age for calc of summary biomass
1 # Depletion basis:  denom is: 0=skip; 1=rel X*B0; 2=rel X*Bmsy; 3=rel X*B_styr
1 # Fraction (X) for Depletion denominator (e.g. 0.4)
4 # SPR_report_basis:  0=skip; 1=(1-SPR)/(1-SPR_tgt); 2=(1-SPR)/(1-SPR_MSY); 3=(1-SPR)/(1-SPR_Btarget);
4=rawSPR
1 # F_report_units: 0=skip; 1=exploitation(Bio); 2=exploitation(Num); 3=sum(Frates)
0 # F_report_basis: 0=raw; 1=F/Fspr; 2=F/Fmsy ; 3=F/Fbtgt
999 # check value for end of file
```

APPENDIX 8

SS3 forecast file used in the North Pacific albacore assessment for the base case.

```
#Forecast file for North Pacific albacore assessment in 2011.
4 # Forecast: 0=none; 1=F(SPR); 2=F(MSY) 3=F(Btgt); 4=F(endyr); 5=Ave F (enter yrs); 6=read Fmult
# -4  # first year for recent ave F for option 5 (not yet implemented)
# -1  # last year for recent ave F for option 5 (not yet implemented)
# 0.74  # F multiplier for option 6 (not yet implemented
-3 # first year to use for averaging selex to use in forecast (e.g. 2004; or use -x to be rel endyr)
0 # last year to use for averaging selex to use in forecast
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt); 4=set to F(endyr)
0.4 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
1 # N forecast years
0 # read 10 advanced options
#0 # Do West Coast gfish rebuilder output (0/1)
#2008 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
#2010 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
#1 # Control rule method (1=west coast adjust catch; 2=adjust F)
#0.4 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40)
#0.1 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
#1 # Control rule fraction of Flimit (e.g. 0.75)
#0 # basis for max forecast catch by seas and area (0=none; 1=deadbio; 2=retainbio; 3=deadnum; 4=retainnum)
#0 # 0= no implementation error; 1=use implementation error in forecast (not coded yet)
#0.1 # stddev of log(realized F/target F) in forecast (not coded yet)
# end of advanced options
# placeholder for max forecast catch by season and area
1 # fleet allocation (in terms of F) (1=use endyr pattern, no read; 2=read below)
0 # Number of forecast catch levels to input (rest calc catch from forecast F
# 1 # basis for input forecatch:  1=retained catch; 2=total dead catch; 3=input Hrate(F)
#Year Seas Fleet Catch


999 # verify end of input
```

APPENDIX 8

SS3 control file used in the North Pacific albacore assessment for the base case.

```
# Control file for North Pacific albacore assessment in 2011.
#_data_and_control_files: NPalb2011_data.dat // NPalb2011.ctl
#_SS-V3.11b-opt;_09/23/2010;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB
1  #_N_Growth_Patterns
1 #_N_Morphs_Within_GrowthPattern
#_Cond 1 #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond  1 #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#
1 #  number of recruitment assignments (overrides GP*area*seas parameter values)
0 # recruitment interaction requested
#GP seas area for each recruitment assignment
 1 2 1
#
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4, age2=10
#
3 #_Nblock_Patterns
 1 1 1 #_blocks_per_pattern
# begin and end years of blocks
 2001 2004
 1993 2009
 2003 2009
#
0.5 #_fracfemale
0 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate
  #_no additional input for selected M option; read 1P per morph
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not implemented; 4=not implemented
1 #_Growth_Age_for_L1
999 #_Growth_Age_for_L2 (999 to use as Linf)
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
0 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A)
3 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pattern; 4=read age-
fecundity; 5=read fec and wt from wtatage.ss
#_Age_Maturity by growth pattern
 0 0 0 0 0 0.5 1 1 1 1 1 1 1 1 1 1
5 #_First_Mature_Age
1 #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0 #_hermaphroditism option:  0=none; 1=age-specific fxn
1 #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-GP1, 3=like SS2 V1.x)
1 #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in base parm bounds; 3=standard w/ no
bound check)
#
#_growth_parms
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
 0.1 0.8 0.3 0.3 -1 99 -1 0 0 0 0 0 0 0 # NatM_p_1_Fem_GP_1
 10 60 44.4038 40.2 -1 99 5 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 100 160 118.029 146.46 -1 99 5 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.01 0.4 0.249518 0.149 -1 99 5 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 0.01 0.3 0.0599166 0.1 -1 99 5 0 0 0 0 0 0 0 # CV_young_Fem_GP_1
 0.01 0.3 0.033914 0.08 -1 99 5 0 0 0 0 0 0 0 # CV_old_Fem_GP_1
```

```
 -2 2 8.7e-005 8.7e-005 -1 99 -3 0 0 0 0 0 0 0 # Wtlen_1_Fem
 -2 4 2.67 2.67 -1 99 -3 0 0 0 0 0 0 0 # Wtlen_2_Fem
 1 10 5 5 -1 99 -3 0 0 0 0 0 0 0 # Mat50%_Fem
 -5 5 -3.746 -3.746 -1 99 -3 0 0 0 0 0 0 0 # Mat_slope_Fem
 0 3 1 1 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem
 0 3 0 0 -1 99 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem
 -4 4 0 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_GP_1
 -4 4 0 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Area_1
 -4 4 -4 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_1
 -4 4 0 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_2
 -4 4 -4 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_3
 -4 4 -4 1 -1 99 -3 0 0 0 0 0 0 0 # RecrDist_Seas_4
 -4 4 1 1 -1 99 -3 0 0 0 0 0 0 0 # CohortGrowDev
#
#_seasonal_effects_on_biology_parms
 19 23 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
 -2 2 0 0 -1 99 -2 # F-WL1_seas_1
 -2 2 -0.80235 -0.80235 -1 99 -2 # F-WL1_seas_2
 -2 2 -1.42139 -1.42139 -1 99 -2 # F-WL1_seas_3
 -2 2 -1.1337 -1.1337 -1 99 -2 # F-WL1_seas_4
 -2 2 0 0 -1 99 -2 # F-WL2_seas_1
 -2 2 0.061726 0.061726 -1 99 -2 # F-WL2_seas_2
 -2 2 0.113195 0.113195 -1 99 -2 # F-WL2_seas_3
 -2 2 0.089505 0.09505 -1 99 -2 # F-WL2_seas_4
#
#_Cond -4 #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
3 #_SR_function
#_LO HI INIT PRIOR PR_type SD PHASE
 5 15 10.922 11.4 -1 99 1 # SR_R0
 0.2 1 1 0.75 -1 99 -4 # SR_steep
 0 2 0.6 0.6 -1 99 -1 # SR_sigmaR
 -5 5 0 0 -1 99 -1 # SR_envlink
 -10 10 0 0 -1 99 -1 # SR_R1_offset
 0 0 0 0 -1 99 -1 # SR_autocorr
0 #_SR_env_link
0 #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness
1 #do_recdev:  0=none; 1=devvector; 2=simple deviations
1969 # first year of main recr_devs; early devs can preceed this era
2007 # last year of main recr_devs; forecast devs start in following year
2 #_recdev phase
1 # (0/1) to read 13 advanced options
 1954 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 4 #_recdev_early_phase
 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for fore_recr_like occurring before endyr+1
 1954 #_last_early_yr_nobias_adj_in_MPD
 1969 #_first_yr_fullbias_adj_in_MPD
 2007 #_last_yr_fullbias_adj_in_MPD
 2009 #_first_recent_yr_nobias_adj_in_MPD
 1 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -5 #min rec_dev
 5 #max rec_dev
 0 #_read_recdevs
```

```
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_Yr Input_value
#
#Fishing Mortality info
0.1 # F ballpark for tuning early phases
-2008 # F ballpark year (neg value to disable)
3 # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
4 # max F or harvest rate, depends on F_Method
# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to read
# if Fmethod=3; read N iterations for tuning for Fmethod 3
5  # N iterations for tuning F in hybrid method (recommend 3 to 7)
#
#_initial_F_parms
#_LO HI INIT PRIOR PR_type SD PHASE
 0 3 0.268363 0.5 -1 99 1 # InitF_1F1_UC_LTN
 0 1 0 0 -1 99 -2 # InitF_2F2_USA_LL
 0 1 0 0 -1 99 -2 # InitF_3F3_EPO_M
 0 3 0.322517 0.2 -1 99 1 # InitF_4F4_JPN_PL_LF
 0 1 0 0 -1 99 -2 # InitF_5F5_JPN_PL_SF
 0 1 0 0 -1 99 -2 # InitF_6F6s1_JPN_OLLF1
 0 1 0 0 -1 99 -2 # InitF_7F6s2_JPN_OLLF1
 0 3 0.0918992 0.2 -1 99 1 # InitF_8F7s1_JPN_CLLF1
 0 1 0 0 -1 99 -2 # InitF_9F7s2_JPN_CLLF1
 0 1 0 0 -1 99 -2 # InitF_10F8_JPN_OLLF2
 0 1 0 0 -1 99 -2 # InitF_11F9_JPN_CLLF2
 0 1 0 0 -1 99 -2 # InitF_12F10_JPN_GN
 0 1 0 0 -1 99 -2 # InitF_13F11_JPN_M
 0 1 0 0 -1 99 -2 # InitF_14F12_TWN_LL
 0 1 0 0 -1 99 -2 # InitF_15F13_KO_LL
 0 1 0 0 -1 99 -2 # InitF_16F14_TK_GN
#
#_Q_setup
 # A=do power, B=env-var, C=extra SD, D=devtype(<0=mirror, 0/1=none, 2=cons, 3=rand, 4=randwalk);
E:0=num/1=bio/2=F, F:-1=norm/0=lognorm/>0=T
 #_A  B  C  D  E  F
 0 0 0 0 0 0 # 1 F1_UC_LTN
 0 0 0 0 0 0 # 2 F2_USA_LL
 0 0 0 0 0 0 # 3 F3_EPO_M
 0 0 0 0 0 0 # 4 F4_JPN_PL_LF
 0 0 0 0 0 0 # 5 F5_JPN_PL_SF
 0 0 0 0 0 0 # 6 F6s1_JPN_OLLF1
 0 0 0 0 0 0 # 7 F6s2_JPN_OLLF1
 0 0 0 0 0 0 # 8 F7s1_JPN_CLLF1
 0 0 0 0 0 0 # 9 F7s2_JPN_CLLF1
 0 0 0 0 0 0 # 10 F8_JPN_OLLF2
 0 0 0 0 0 0 # 11 F9_JPN_CLLF2
 0 0 0 0 0 0 # 12 F10_JPN_GN
 0 0 0 0 0 0 # 13 F11_JPN_M
 0 0 0 0 0 0 # 14 F12_TWN_LL
 0 0 0 0 0 0 # 15 F13_KO_LL
 0 0 0 0 0 0 # 16 F14_TK_GN
 0 0 0 0 0 0 # 17 S1_UC_LTN
```

0 0 0 0 0 0 # 18 S2_USA_LL
0 0 0 0 1 0 # 19 S3_JPN_PL_LF
0 0 0 0 1 0 # 20 S4_JPN_PL_SF_early
0 0 0 0 1 0 # 21 S5_JPN_PL_SF_late
0 0 0 0 0 0 # 22 S6_JPN_LLF1
0 0 0 0 0 0 # 23 S7_JPN_LLF2
0 0 0 0 0 0 # 24 S8_TWN_LL
#
#_Cond 0 #_If q has random component, then 0=read one parm for each fleet with random q; 1=read a parm for each year of index
#_Q_parms(if_any)
#
#_size_selex_types
#_Pattern Discard Male Special
24 0 0 0 # 1 F1_UC_LTN
1 0 0 0 # 2 F2_USA_LL
5 0 0 1 # 3 F3_EPO_M
24 0 0 0 # 4 F4_JPN_PL_LF
24 0 0 0 # 5 F5_JPN_PL_SF
24 0 0 0 # 6 F6s1_JPN_OLLF1
24 0 0 0 # 7 F6s2_JPN_OLLF1
5 0 0 6 # 8 F7s1_JPN_CLLF1
5 0 0 7 # 9 F7s2_JPN_CLLF1
1 0 0 0 # 10 F8_JPN_OLLF2
5 0 0 10 # 11 F9_JPN_CLLF2
5 0 0 5 # 12 F10_JPN_GN
5 0 0 5 # 13 F11_JPN_M
24 0 0 0 # 14 F12_TWN_LL
5 0 0 6 # 15 F13_KO_LL
5 0 0 5 # 16 F14_TK_GN
5 0 0 1 # 17 S1_UC_LTN
5 0 0 2 # 18 S2_USA_LL
5 0 0 4 # 19 S3_JPN_PL_LF
5 0 0 5 # 20 S4_JPN_PL_SF_early
5 0 0 5 # 21 S5_JPN_PL_SF_late
5 0 0 6 # 22 S6_JPN_LLF1
5 0 0 10 # 23 S7_JPN_LLF2
5 0 0 14 # 24 S8_TWN_LL
#
#_age_selex_types
#_Pattern ___ Male Special
10 0 0 0 # 1 F1_UC_LTN
10 0 0 0 # 2 F2_USA_LL
10 0 0 0 # 3 F3_EPO_M
10 0 0 0 # 4 F4_JPN_PL_LF
10 0 0 0 # 5 F5_JPN_PL_SF
10 0 0 0 # 6 F6s1_JPN_OLLF1
10 0 0 0 # 7 F6s2_JPN_OLLF1
10 0 0 0 # 8 F7s1_JPN_CLLF1
10 0 0 0 # 9 F7s2_JPN_CLLF1
10 0 0 0 # 10 F8_JPN_OLLF2
10 0 0 0 # 11 F9_JPN_CLLF2
10 0 0 0 # 12 F10_JPN_GN
10 0 0 0 # 13 F11_JPN_M
10 0 0 0 # 14 F12_TWN_LL
10 0 0 0 # 15 F13_KO_LL

```
 10 0 0 0 # 16 F14_TK_GN
 10 0 0 0 # 17 S1_UC_LTN
 10 0 0 0 # 18 S2_USA_LL
 10 0 0 0 # 19 S3_JPN_PL_LF
 10 0 0 0 # 20 S4_JPN_PL_SF_early
 10 0 0 0 # 21 S5_JPN_PL_SF_late
 10 0 0 0 # 22 S6_JPN_LLF1
 10 0 0 0 # 23 S7_JPN_LLF2
 10 0 0 0 # 24 S8_TWN_LL
#_LO HI INIT PRIOR PR_type SD PHASE env-var use_dev dev_minyr dev_maxyr dev_stddev Block Block_Fxn
 27.5 100 62.9045 66 -1 99 2 0 0 0 0 0 0 0 # SizeSel_1P_1_F1_UC_LTN
 -9 4 -8.22825 -3 -1 99 4 0 0 0 0 0 0 0 # SizeSel_1P_2_F1_UC_LTN
 -1 9 3.5143 4 -1 99 3 0 0 0 0 0 0 0 # SizeSel_1P_3_F1_UC_LTN
 -1 9 5.69924 5 -1 99 4 0 0 0 0 0 0 0 # SizeSel_1P_4_F1_UC_LTN
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_1P_5_F1_UC_LTN
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_1P_6_F1_UC_LTN
 45 130 92.3678 100 -1 99 2 0 0 0 0 0 1 2 # SizeSel_2P_1_F2_USA_LL
 0.1 30 24.5657 10 -1 99 3 0 0 0 0 0 1 2 # SizeSel_2P_2_F2_USA_LL
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_3P_1_F3_EPO_M
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_3P_2_F3_EPO_M
 27.5 130 83.3866 90 -1 99 2 0 0 0 0 0 0 0 # SizeSel_4P_1_F4_JPN_PL_LF
 -9 4 -4 -3 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_4P_2_F4_JPN_PL_LF
 -1 9 5.36443 4.6 -1 99 3 0 0 0 0 0 0 0 # SizeSel_4P_3_F4_JPN_PL_LF
 -1 9 3.97328 3 -1 99 4 0 0 0 0 0 0 0 # SizeSel_4P_4_F4_JPN_PL_LF
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_4P_5_F4_JPN_PL_LF
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_4P_6_F4_JPN_PL_LF
 27.5 100 54.7341 75 -1 99 2 0 0 0 0 0 0 0 # SizeSel_5P_1_F5_JPN_PL_SF
 -9 4 -0.931761 -3 -1 99 4 0 0 0 0 0 0 0 # SizeSel_5P_2_F5_JPN_PL_SF
 -1 9 3.21189 6 -1 99 3 0 0 0 0 0 0 0 # SizeSel_5P_3_F5_JPN_PL_SF
 -1 9 3.88478 3 -1 99 4 0 0 0 0 0 0 0 # SizeSel_5P_4_F5_JPN_PL_SF
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_5P_5_F5_JPN_PL_SF
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_5P_6_F5_JPN_PL_SF
 27.5 130 88.8463 89 -1 99 2 0 0 0 0 0 2 2 # SizeSel_6P_1_F6s1_JPN_OLLF1
 -9 4 -0.424186 -3 -1 99 4 0 0 0 0 0 2 2 # SizeSel_6P_2_F6s1_JPN_OLLF1
 -4 9 5.58817 6 -1 99 3 0 0 0 0 0 2 2 # SizeSel_6P_3_F6s1_JPN_OLLF1
 -4 9 4.49669 3 -1 99 2 0 0 0 0 0 2 2 # SizeSel_6P_4_F6s1_JPN_OLLF1
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 2 2 # SizeSel_6P_5_F6s1_JPN_OLLF1
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 2 2 # SizeSel_6P_6_F6s1_JPN_OLLF1
 27.5 130 77.6329 89 -1 99 2 0 0 0 0 0 0 0 # SizeSel_7P_1_F6s2_JPN_OLLF1
 -9 4 -8.38732 -3 -1 99 4 0 0 0 0 0 0 0 # SizeSel_7P_2_F6s2_JPN_OLLF1
 -4 9 4.06471 6 -1 99 3 0 0 0 0 0 0 0 # SizeSel_7P_3_F6s2_JPN_OLLF1
 -4 9 4.7943 3 -1 99 2 0 0 0 0 0 0 0 # SizeSel_7P_4_F6s2_JPN_OLLF1
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_7P_5_F6s2_JPN_OLLF1
 -999 -999 -999 -5 -1 99 -2 0 0 0 0 0 0 0 # SizeSel_7P_6_F6s2_JPN_OLLF1
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_1_F7s1_JPN_CLLF1
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_8P_2_F7s1_JPN_CLLF1
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_9P_1_F7s2_JPN_CLLF1
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_9P_2_F7s2_JPN_CLLF1
 45 130 91.5601 110 -1 99 2 0 0 0 0 0 0 0 # SizeSel_10P_1_F8_JPN_OLLF2
 0.1 30 13.9318 10 -1 99 3 0 0 0 0 0 0 0 # SizeSel_10P_2_F8_JPN_OLLF2
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_11P_1_F9_JPN_CLLF2
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_11P_2_F9_JPN_CLLF2
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_12P_1_F10_JPN_GN
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_12P_2_F10_JPN_GN
 1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_13P_1_F11_JPN_M
 -80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_13P_2_F11_JPN_M
```

27.5 130 82.5253 89 -1 99 2 0 0 0 0 0 3 2 # SizeSel_14P_1_F12_TWN_LL
-9 4 -4 -3 -1 99 -4 0 0 0 0 0 3 2 # SizeSel_14P_2_F12_TWN_LL
-1 9 6.03996 6 -1 99 3 0 0 0 0 0 3 2 # SizeSel_14P_3_F12_TWN_LL
-4 9 5.34978 3 -1 99 4 0 0 0 0 0 3 2 # SizeSel_14P_4_F12_TWN_LL
-999 -999 -999 -5 -1 99 -5 0 0 0 0 0 3 2 # SizeSel_14P_5_F12_TWN_LL
-999 -999 -999 -5 -1 99 -4 0 0 0 0 0 3 2 # SizeSel_14P_6_F12_TWN_LL
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_15P_1_F13_KO_LL
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_15P_2_F13_KO_LL
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_16P_1_F14_TK_GN
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_16P_2_F14_TK_GN
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_17P_1_S1_UC_LTN
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_17P_2_S1_UC_LTN
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_18P_1_S2_USA_LL
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_18P_2_S2_USA_LL
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_19P_1_S3_JPN_PL_LF
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_19P_2_S3_JPN_PL_LF
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_20P_1_S4_JPN_PL_SF_early
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_20P_2_S4_JPN_PL_SF_early
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_21P_1_S5_JPN_PL_SF_late
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_21P_2_S5_JPN_PL_SF_late
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_22P_1_S6_JPN_LLF1
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_22P_2_S6_JPN_LLF1
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_23P_1_S7_JPN_LLF2
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_23P_2_S7_JPN_LLF2
1 80 1 1 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_24P_1_S8_TWN_LL
-80 -80 -80 -80 -1 99 -4 0 0 0 0 0 0 0 # SizeSel_24P_2_S8_TWN_LL
#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
1 #_custom_sel-blk_setup (0/1)
45 130 96.1257 100 -1 99 2 # SizeSel_2P_1_F2_USA_LL_BLK1repl_2001
0.1 30 6.44513 10 -1 99 3 # SizeSel_2P_2_F2_USA_LL_BLK1repl_2001
27.5 130 76.0267 89 -1 99 2 # SizeSel_6P_1_F6s1_JPN_OLLF1_BLK2repl_1993
-9 4 -8.07952 -3 -1 99 4 # SizeSel_6P_2_F6s1_JPN_OLLF1_BLK2repl_1993
-4 9 4.22699 6 -1 99 3 # SizeSel_6P_3_F6s1_JPN_OLLF1_BLK2repl_1993
-4 9 6.5436 3 -1 99 2 # SizeSel_6P_4_F6s1_JPN_OLLF1_BLK2repl_1993
-999 -999 -999 -5 -1 99 -2 # SizeSel_6P_5_F6s1_JPN_OLLF1_BLK2repl_1993
-999 -999 -999 -5 -1 99 -2 # SizeSel_6P_6_F6s1_JPN_OLLF1_BLK2repl_1993
27.5 130 86.4651 89 -1 99 2 # SizeSel_14P_1_F12_TWN_LL_BLK3repl_2003
-9 4 -4 -3 -1 99 -4 # SizeSel_14P_2_F12_TWN_LL_BLK3repl_2003
-1 9 5.04604 6 -1 99 3 # SizeSel_14P_3_F12_TWN_LL_BLK3repl_2003
-4 9 5.43062 3 -1 99 4 # SizeSel_14P_4_F12_TWN_LL_BLK3repl_2003
-999 -999 -999 -5 -1 99 -5 # SizeSel_14P_5_F12_TWN_LL_BLK3repl_2003
-999 -999 -999 -5 -1 99 -4 # SizeSel_14P_6_F12_TWN_LL_BLK3repl_2003
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
1 #_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm bounds; 3=standard w/ no bound check)
#
Tag loss and Tag reporting parameters go next
0 # TG_custom: 0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0 #_placeholder if no parameters
#
1 #_Variance_adjustments_to_input_values
#_fleet: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_survey_CV
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_discard_stddev

 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 #_add_to_bodywt_CV
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 #_mult_by_lencomp_N
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 #_mult_by_agecomp_N
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 #_mult_by_size-at-age_N
0 #_discard_like: >0 for DF of T-dist(read CV in data file); 0 for normal with CV; -1 for normal with se; -2 for lognormal
0 #_DF_for_meanbodywt_like
#
4 #_maxlambdaphase
1 #_sd_offset
#
26 # number of changes to make to default Lambdas (default value is 1.0)
Like_comp codes: 1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
9=init_equ_catch; 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
#like_comp fleet/survey phase value sizefreq_method
 1 17 1 1 1
 1 18 1 1 1
 1 19 1 1 1
 1 20 1 1 1
 1 21 1 1 1
 1 22 1 1 1
 1 23 1 1 1
 1 24 1 1 1
 4 1 1 0.01 1
 4 2 1 0.01 1
 4 4 1 0.01 1
 4 5 1 0.01 1
 4 6 1 0.01 1
 4 7 1 0.01 1
 4 10 1 0.01 1
 4 14 1 0.01 1
 5 1 1 0.1 1
 5 2 1 0.1 1
 5 6 1 0.1 1
 5 10 1 0.1 1
 9 1 1 1 1
 9 4 1 1 1
 9 8 1 1 1
 11 1 1 0 1
 12 1 1 0 1
 13 1 1 100 1
#
0 # (0/1) read specs for more stddev reporting
 # 0 1 -1 5 1 5 1 -1 5 # placeholder for selex type, len/age, year, N selex bins, Growth pattern, N growth ages, NatAge_area(-1 for all), NatAge_yr, N Natages
 # placeholder for vector of selex bins to be reported
 # placeholder for vector of growth ages to be reported
 # placeholder for vector of NatAges ages to be reported
999