Commission for the Conservation of
Southern Bluefin Tuna

みなみまぐろ保存委員会

Report of the Second Meeting of the Stock Assessment Group

19-28 August 2001
Tokyo, Japan

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1. Opening

1. The independent chair, Dr. John Annala, opened the meeting and welcomed member delegations from Australia, Japan and New Zealand and observers from the Republic of Korea and Taiwan.

2. Mr. Brian Macdonald, the new Executive Secretary of CCSBT who replaced Mr. Campbell McGregor in late July, was introduced to the participants. He emphasized the importance of the work of the Stock Assessment Group and Scientific Committee to the success of CCSBT8 in October 2001 in Miyako, Japan.

3. Each head of delegation introduced the members of their delegation. The list of participants is at **Attachment 1**.

4. The representatives of Korea and Taiwan expressed their gratitude for being invited to the meeting.

2. Appointment of rapporteurs

5. Each country appointed rapporteurs. A member of the Advisory Panel was assigned to each agenda item to assist in drafting the report.

3. Adoption of agenda

6. The draft agenda was adopted with two revisions. The agreed agenda is at **Attachment 2**

4. Admission of documents and finalization of document list

7. A draft list of documents for the meeting was submitted by participants, which is at **Attachment 3.** The meeting assigned the documents against the agreed agenda considering the main purpose of SAG meeting was to update the stock assessment. The assignment of agenda items is also shown in **Attachment 3.**

5. Matters arising from SC5 and CCSBT7 (refer to docs CCSBT-SC/0108/Rep3, Rep 6)

5.1 Report on Stock Projection Models

8. During the Stock Assessment Process Workshop (Tokyo May 2000), a project was initiated to verify Australian and Japanese stock projection software and identify the sources of discrepancy. Dr. Ana Parma of the external Advisory Panel co-ordinated the project and reported that it has been essentially completed. Differences in projections were attributed to 6 sources, which were further investigated. The advisory panel suggested 3 modifications related to: 1) Stock-Recruitment parameter estimation, 2) implementation of stochastic stock-recruitment variation and 3) choice of years for determining fishery selectivity. The advisory panel recommendations were implemented and it was verified that the different software routines produce very similar results given identical initial conditions. The modified projections methods have been used in results presented at the 2001 SAG.

5.2 Inputs to Assessments

9 Data inputs for the 2001 stock assessment were generated largely in accordance with previous years (refer to documents CCSBT-SC/0108/21, /35). A number of additional modifications were implemented according to the March 2001 SC meeting (and subsequent correspondence for clarification of details). All time series were updated to include the newest data , and a number of inputs were recalculated to account for the change in growth curves, including catch-at-age matrices, weight-at-age, tag releases, tag recoveries, tag reporting rates, variable and constant squares and geostatistical CPUE indices. In addition, new CPUE indices (“proxy geo-statistical” and “proxy B-ratio”), and catch-at-length matrices were generated.

10 There were a number of concerns expressed about the data that need to be clarified (refer to CCSBT-SC/0108/35). The Taiwanese longline catch includes deep sea longline catch, fresh small longline catch and gillnet catch with assumed different catch size. Some Taiwanese catch data of 1989-92 is included in both the longline catch data and gillnet catch data resulting in double counting. These discrepancies only became evident to participants during the meeting. The amount of double counting is 107-319t in given years. Some discrepancies between the official and verified Korean catch statistics and those used by the CCSBT were also noted.

11 In 2001, a number of issues arose during the input data and data exchange process that substantially reduced the time available for assessment and analysis. The input data generated by Japan and Australia contain some minor discrepancies that have not been resolved (e.g implementation of substitution rules and CPUE standardization). It was noted that development of a centralized CCSBT database and unified data generation system should eliminate a number of the data problems in the future.

12 Other related issues (task 2.3 from CCSBT-SC/0108/info02) were referred to Agenda item 8.

6 Assessment Approaches to be used in 2001

13 Scientists from Australia and Japan presented overviews, based on CCSBT-SC/0108/Info/06, of the stock assessment approaches each had used for the 2001 SBT stock assessment. Both had used a range of approaches including the ADAPT VPA used in the past. Japan's VPA approach (CCSBT-SC/0108/31) as well as Australia's (CCSBT-SC/0108/20) was the same as that used in 1998. In addition, Japan had used a stock production model (CCSBT-SC/0108/24) which builds on an earlier approach tabled at this meeting for background (CCSBT-SC/0108/BGD01). The third approach used by Japan was a cohort analysis based on catch-at-size (CCSBT-SC/0108/32). In addition to the VPA, Australia had tabled assessment approaches based in part on statistical catch-at-size models presented in earlier CCSBT meetings. The statistical catch-at-age time series model (CCSBT-SC/0108/19) is based on the approach of Hilborn et al. (1998). Their statistical catch-at-size time series model (CCSBT-SC/0108/13) builds on

their earlier work, tabled as background (CCSBT-SC/0108/27). Australia noted that while stock assessments had been done based on all of their three approaches, only the ADAPT VPA and statistical catch-at-age approaches had been taken through for projections.

7 SBT stock assessment

7.1 Biology and stock structure of SBT

14 CCSBT-SC/0108/12 and CCSBT-SC/0108/16 suggest that the current estimates of mean age at maturity (8 years) was implausible and the age at 50% maturity should be 11-12 years old based on the data from SBT caught on the spawning ground by the Indonesian longline fishery. Information in paper 12 suggested that the absence of 7 years old fish and low numbers of 8 years old fish in the Indonesian fishery is not because fish in the size range for these ages are not caught but the fish in the size range that are caught are small fish of older ages. Representativeness of the catch in the Indonesian fishery with respect to the whole spawning stock, the selectivity of the Indonesian fishery, and cohort strength on the age distribution of the Indonesian catch were discussed. Australia stated that a range of alternative hypotheses for the age at maturity should be considered that include older ages than those currently considered in stock assessment runs. Members of the Advisory Panel suggested that a value of age 8 seems unlikely for the mean age of maturity. It was agreed that a technical sub-group on estimation of age at maturity list the outstanding issues and decide how to treat age at maturity. It was agreed that uncertainty exists about the age of maturity for SBT and that a range of values for the age of 50% maturity should be considered in conducting assessments. The report of the technical sub-group is shown in **Attachment 4**.

7.2 Country Reports

15 Australia, Japan, New Zealand, and Taiwan briefly presented reports on their fisheries as a review of the information related to the stock assessment. It was noted that as tuna farming has developed in Australia, the surface fishery now takes over 99% of the Australian TAC in 2000-01. The longline fishery in NZ, after a period of declining CPUE from at least 1980 to 1993 has increased to the levels seen

in the mid-1980s. This trend is, however, confounded by changes in areas fished.

7.3 Estimates of catch

16 The issues related to the data inputs for 2001 assessment were discussed under this agenda item. The data inputs used in Australian assessment were summarized in CCSBT-SC/0108/21. It was noted that Japanese reference cases used the same input data as Australia, but that different sets of data were also used in its sensitivity analyses. Data used for size based analysis by Japan were in CCSBT-SC/0108/32.

17 CCSBT-SC/0108/35 presented a comparison of the Taiwanese longline catch-at-age estimates with and without the Mauritius data, as well as those based on data provided by Taiwan. The results indicated that different assumptions about Taiwan's catch produced very different catch-at-age patterns. This issue is considered as part of the sensitivity analyses in some assessments.

18 CCSBT-SC/0108/17 reported Taiwanese catches and size distribution based on catch monitoring in Mauritius and Cape Town. The meeting noted that the comparisons between the logbook sampling by Australia and official Taiwanese catch statistics showed close agreement. The study indicated that most SBT caught by the Taiwan in the Indian Ocean are less than seven years old with a mode around age four and in some years also age 6, which is different to the age distribution of the Japanese longline fishery. It was noted that most length data presented in the paper were converted from weight. Due to previous agreements on weight-to-length conversion methods, a gap or hiatus often appeared in the resulting length frequency estimates (e.g. Figure 7, page 15). The meeting noted that this reflects a general problem related to how the weight-length relationship had been developed in the 1994 workshop, and should be corrected so that artificial patterns in the length frequency data are avoided in the future. The authors of CCSBT-SC/0108/17 concluded that it would be inappropriate to use the size distribution of fish caught in the Japanese longline fishery for estimating the size distribution of fish by the Taiwanese fleet.

19 CCSBT-SC/0108/11 reported catch by the Indonesian longline fishery operating out of Bali based on catch monitoring. The estimated SBT landing in 2000 was 980t, which was less than half of the previous year. The meeting expressed a desire to have geographical data collected so that changes in catch patterns (seasonality,

magnitude of the catch, size composition) could be more carefully evaluated. It was noted that there has been ongoing effort to collect such data, but that the operational characteristics of this fishery make it difficult to collect reliable data of this sort.

20 CCSBT-SC/0108/14 used simulation to examine the errors in the age distribution produced using cohort slicing. The results indicated that with non-equilibrium age composition, the catch-at-age numbers estimated using cohort slicing can have large errors even for young ages. In discussion, it was suggested that it was important to examine the effect of using cohort slicing on the estimate of cohort strength from the assessments.

21 Australia addressed several issues related to catch and nominal catch rates in the Japanese longline data (CCSBT-SC/0108/22). There is a trend in the ratio of the reported landings to catch estimates over time with respect to number at age and weight at age. The cause(s) of the deviation from one-to-one in the ratio is still unknown and thus further work is needed to determine the sources of the discrepancies. It was noted that this deviation had an impact only on the estimation of surface catch as an input to assessments. Interpretation of the recent age specific catch rate was confounded by inconsistency in changes and rebuilding patterns among age classes. In particular, the high catch rate of age 4 and 5 for cohorts born in the late 1980s and early 1990s did not result in correspondingly high catch rates from these cohorts as they become older in spite of relatively low catches from them. The document noted that reported catch rates in the EFP generally exceed those reported in the commercial catches. Specifically, "…if the EFP catch rates are representative of the catch rates that could be expected under normal commercial operations, they raise questions both about the motivational factors underlying where fishing occurs and how the catch rates should be interpreted in terms of abundance."

22 In response it was pointed out that the comparisons with the EFP related either to different months, or to small and hence likely unrepresentative of commercial fishing samples in the same month, and were thus of questionable reliability. Several methods such as a Shepherd-Nicholson fit (an analysis of variance method testing for year, age and cohort effects), plots by cohort, and residual plots were suggested for further investigation of the nominal age-specific CPUE.

23 A technical sub-group of the SAG was convened by Dr. R. Hilborn to discuss fishery indicators including interpretations of catch rates. The sub-group's report is attached at **Attachment 5.**

24 CCSBT-SC/0108/28 presented the standardized CPUE indices by Japan using the agreed interim method for the 2001 assessment . Although the CPUE indices estimated by Australia (provided through communication prior to the meeting) and by Japan showed similar trends, there were slight differences observed in trends. In general, the catch and effort of Japanese longline data used for the CPUE indices is based on log book information for all years except for the most recent year of the assessment, for which mainly RTMP information was used. Retrospective analyses indicated that this inconsistency of data sources caused differences between logbook-based estimates and RTMP-based estimates for the most recent year (CCSBT-SC/0108/28). For future years, Japan plans to develop indices based on RTMP data in order to monitor recent changes of stock using a consistent data source. However, the meeting agreed that the RTMP estimate of CPUE index for year 2000 be used as a proxy in the 2001 assessment while keeping in mind the potential bias induced by different sources of the last year's data.

7.4 Catch-at-age/size assessments

25 There was agreement within the SAG to consider the results of six different assessment models developed by Japan and Australia and use them as a basis for advice to the Scientific Committee.

26 The six assessment approaches and corresponding documents are:

- Japanese ADAPT VPA – CCSBT-SC/0108/31
- Australia ADAPT VPA – CCSBT-SC/0108/20.
- Surplus-Production models (Japan)- CCSBT-SC/0108/24.
- Statistical time series model based on catch-at-age (Australia)- CCSBT-SC/0108/19.
- Statistical catch-at-age/length model (Australia) – CCSBT-SC/0108/27 and 13.
- Cohort analysis based on catch at length (Japan)- CCSBT-SC/0108/32.

***ADAPT VPA stock assessments*.**

27 Japan presented its ADAPT VPA results in CCSBT-SC/0108/31, using the 1997 priority set of options as the basis for the analysis. They presented results on the effects of the modification of the inputs into the VPA, and on the effects of 6 plus-group options and two CPUE indices (B-ratio proxy and geo-proxy).

28 Results were presented for relative trends and absolute abundance values. Parental biomass had steadily decreased since 1979, but has recently been increasing or remained stable in the last few years. The amount of decrease and increase depends on the plus-group assumptions. The assessment results are also very sensitive to the CPUE indices and to whether the Australian or Japanese calculations of these indices with the same assumptions are used, even though the differences between these indices are very small.

29 A small working group was convened to evaluate why such big differences in VPA results originate from small differences in CPUE series. The conclusion was that there were conflicts in the data related to CPUE trends primarily for the plus group and for younger ages in more recent years, and that these resulted in estimates that were imprecise and hence very sensitive to minor changes in input data, particularly assumptions and estimates of plus group abundance.

30 An analysis of Japanese ADAPT VPA results was presented in the context of identifying robust trends and considering plausibility of different assumptions (CCSBT-SC/0108/34). Absolute recruitment estimates are very robust both in absolute and relative terms. This in turn translates into robust biomass estimates for SBT of age 5-7. Age 8-11 estimates are also reasonably robust, but the 12+ biomass estimates which comprise the bulk of the spawning biomass are very sensitive to assumptions. It was noted that several diagnostics might be useful for defining plausibility of VPA results, including consideration of estimated fishing mortality in different age classes, and arguments about minimum productivity levels that are required to support observed catches. The plausibility of both very high and very low age 12+ biomass is questionable on the grounds of unsustainability of the resource throughout assessment period for the former case and extremely high fishing mortality for the latter. The possibility of recruitment regime shifts was

noted. The document also noted that all VPA models examined showed a large peak in total mortality and a rising recent trend for ages 1-4, in contrast to a generally stable pattern of mortality for the other ages.

31 The Australian ADAPT VPA results from CCSBT-SC/0108/20 provide an update of the preferred set of options specified by Australia and Japan in 1998. Weighted average results were calculated to synthesize across the range of uncertainties examined in each of the "preferred sets". In general the VPAs had a poor fit to the plus-group CPUE index and were sensitive to the inclusion of the continuity term that linked the terminal age to the plus group (C1 plus-group model). Results were presented for the different plus-group options, two CPUEs, and in the "Australian preferred set" for three ages of maturity (Age8,10 and 12), as well as other uncertainties. Unlike the Japanese ADAPT VPA, results were not highly sensitive to the choice of CPUE and whether the proxy geo or proxy B-ratio index was used. Both the Australian and Japanese "preferred sets" indicated that current parental biomass was 43-70%of the 1988 level, < 31-43% of the 1980 level and <13-19% of the 1960 level. Recruitment was < 46-48% of the 1980 recruitment level and the trend indicated a long term decline. All of the VPAs showed significant lack of fit. In discussion, it was argued that there was an inconsistency between mortality rates and effort trends.

32 The overall conclusion from the both ADAPT VPA papers (CCSBT-SC/0108/20 and 31) is that recruitment estimates were reasonably robust to the various model structure and data input uncertainties. Since 1980, relative trends in parental biomass were generally similar between models, but absolute estimates of parental biomass were very sensitive to the uncertainties examined. The combination of fixed estimates of recruitment and the scaling of the parental biomass levels resulted in a wide range of estimates for the productivity of the stock.

Surplus-Production Models

33 The application of age-aggregated (AAPM) and age-structured (ASPM) surplus production models to the most recent SBT data was presented (CCSBT-SWG/0011/16, CCSBT-SC/0108/24). These models were proposed as a simple alternative assessment with the potential to avoid several key problems in the VPA, including plus-group specification, questionable catch-at-age data, and

contradictory age-specific CPUE indices. It was suggested that these models might be more robust than the VPA, useful for making TAC decisions in a management procedures framework and perhaps able to assist immediate TAC advice. Each of the models (Fox, Schaefer, Age-Structured) was fitted to two alternative CPUE indices based on the proxy-geostatistical and proxy-B-ratio time series for a particular age-aggregation (and for biomass aggregation). The age-structured production model had a possible advantage over the aggregated models, in that the time lag between spawning and recruitment to the exploited component of the biomass was taken into account. It was noted that a delay-difference model might be worth considering to achieve a similar effect. The addition of the three most recent years of data substantially improved the precision with which productivity-related parameters were estimated. These models generally fitted the CPUE indices very well, and estimated a continuous biomass decline into the late 1980s, followed by relatively constant biomass (but sometimes slightly increasing or decreasing) up to 2000. Current replacement yield estimates, from a range of plausible models, suggested that the stock could slowly increase or decline under current catch levels.

34 CCSBT-SC/108/24 stated that its results suggested current sustainable yields in the region of average annual catches over the last decade of some 16 thousand tonnes, consistent with broadly flat CPUE trends over this period. It was pointed out that a number of results showed replacement yield estimates less than 16 thousand, and there was considerable variation among different model results. Concerns were raised about possible biases in the estimates of replacement yields due to not taking into account of age structure. These are discussed further under the section dealing with projections.

Statistical time series assessment based on catch-at-age data.

35 Australia presented a statistical time series assessment model based on catch-at-age data (CCSBT-SC/0108/19). This builds on the work by Drs. Butterworth, Ianelli and Hilborn. The Australian implementation of the model was modified in several ways: more fisheries (4) were distinguished, different variances were used to penalize recruitment deviations for the early and late periods, and the catch-proportions- by- age component of the likelihood was broken into two components (age 0-11 and age 12plus group, and proportions within the plus-group),

which were assigned different weights (sample sizes) in the likelihood. Also, the direct aging data for the Indonesian fishery were included with their own effective sample size. The fixed age used to standardize selectivity for the CPUE-abundance relationship was generalized to allow for alternatives ages, and summing over several ages, to better account for possible effects of changes in targeting.

36 Sensitivity of the results was presented for model uncertainty and data input uncertainty for the suggested reference points and the estimate of steepness. The model uncertainty included variations in the relative weights given to different likelihood components. The results were very robust to a wide range of uncertainties examined. Also, in contrast to VPAs, the results were insensitive to the use of different CPUE indices. For data input uncertainty, sources examined were similar to those used in the VPAs (maturity age 10 and age12 – results for age 8 were handed out in an addendum to the paper, natural mortality, tag reporting rates, CPUE, total catch-at-age). Estimates of recruitment and recruitment trends were very robust. Results were much more sensitive to data input uncertainties than to model uncertainties. The most influential uncertainties were natural mortality, tag reporting rate and catch-at-age. The new data since 1998 led to more stable results, consistently high productivity estimates (high steepness) and a strong signal of decline in the parental biomass. The Indonesian direct ageing data appeared to be highly informative. The model and current data did not allow for discrimination between whether the stock was going up or down in recent years.

37 Overall the data input uncertainty set indicated that the current SSB is 49% of the 1988, 29% of the 1980 and 6% of pre-exploitation model. The effects of the use of the auto correlation term in the recruitment series and a smaller variance in the early recruitment estimates (to down weight information in the early catch-at-age data) were discussed further and there was a recommendation from the Advisory Panel to use a uniform variance for the stock-recruitment relationship throughout. In response it was stated that results were presented both with auto- correlation and with uniform variances but neither of these affected the results.

38 Questions were asked about the estimated increase in selectivity for older ages in the Japanese longline fishery in recent years. It was noted that increases are estimated by other assessment methods, and might have resulted from: 1) problems in the

estimation of growth and cohort slicing, 2) size-composition sampling errors in the early years, 3) the possibility of the stock having gone through a period of very low recruitment just prior to the start of the fishery. However, examination of selectivity patterns over time in this statistical catch at age model indicated no major shift to older ages in recent years. A shift in estimated selectivity of the spawning fishery towards older ages was noticed. This corresponds to the time when the main catch data from the spawning ground shifted from being taken by Japanese vessels to Indonesian vessels. Japan noted that the possible implications of this shift in terms of age at maturity (which could consequently be lower than indicated by recent age composition data from the recent Indonesian fisheries – Figure8 of CCSBT-SC/0108/12) were discussed.

Statistical approach based on catch-at-length/age

39 Assessment results from a statistical catch-at-age and –length "integrated analysis" model were presented (CCSBT-SC/0108/13). This model was formulated to avoid two of the main problems perceived in the ADAPT VPAs. Catch-at-length prediction was used instead of catch-at-age, to avoid cohort-slicing problems and a large aggregated plus group (and the corresponding assumption of homogeneity for all fish of age 12+ was used). Catch was modeled directly from observed effort (and transient effective effort deviations) instead of adopting GLM-standardized CPUE as independent age-specific abundance indices. Additionally, maturity-at-age was estimated within the model. The reference case demonstrated a plausible fit to most of the data, with similar dynamics to the age-structured assessments. Concern was expressed about the plausibility of an estimated increase in selectivity of older ages in the Japanese longline fishery on the feeding grounds in recent years. Sensitivity analyses indicated that sensible model behaviour was dependent on the tagging data, while current status and productivity were sensitive to several model assumptions. Catch-at-length/age data were reasonably fitted across a wide range of dynamics, raising possible concerns about the actual information content in cohort-slicing and/or the assumption of independent CPUE indices in catch-at-age models. From the sensitivity trials, sets of "optimistic" and "pessimistic" models were identified in terms of current stock status relative to 1980, and stock-recruitment productivity. These models were then refitted with a range of input data uncertainty (high and low mortality, high and low tag reporting rates). The resulting range of estimated dynamics showed rather similar relative trends in

dynamics over the period 1970-2000. Parental biomass trends in the last several years were fairly flat. Over the last two years, SSB may have been increasing or decreasing depending on the input data (for both the optimistic and pessimistic model sets), with a combined range of change to 91-121% of the 1998 level. The resulting stock-recruitment curve "steepness" estimates ranged from 0.23-0.66, and current spawning stock biomass estimates relative to 1980 ranged from 20-76 %. Current biomass relative to the unfished levels was estimated at 4-11 %.

Cohort analysis based on catch at length

40 An exploratory application of cohort analysis based on catch-at-length was presented by Japan (CCSBT-SC/0108/32). The model was developed, primarily, to avoid the problem of estimating catch-at-age distributions from cohort-slicing. The population was described by a joint age and length structure, and growth was modeled on a 6-monthly basis via a transition matrix. The population dynamics operated in a forward VPA fashion, where observed catch-at-length was removed from the population. The likelihood function incorporated Indonesian spawning ground age composition data, and GLM-standardized CPUE indices as independent relative abundance indices for eight length classes. Various formulations were explored, including changing the weightings in the objective function terms, and allowing temporal changes in catchability for each length class. The model had trouble fitting all the data simultaneously when allocating the same weight to CPUE indices for different size groups, especially among large size groups. This formulation did not fit the high CPUE values observed in large size groups from the mid 1960s to the mid 1970s. This indicated that the shift from cohort slicing to the use of size data did not cure the inconsistencies observed in the cohort-sliced age-based among CPUE indices of older age groups. It was noted that the CPUE conflict might result from the assumed independence of CPUE time series, and that this problem affected all the age-based models that used multiple CPUE indices as well. It was considered that the reliability of CPUE would differ according to size groups because of the large differences in actual number of fish taken among size groups. The model incorporating weighting on this basis was considered to be the most plausible among models explored. The estimations were roughly consistent with those of other models (ADAPT VPAs and the statistical model of Dr.Butterworth et al.) based on different concepts.

Reference Points

41 A paper on fishing mortality reference points from the VPA and catch-at-age models was presented by Australia (CCSBT-SC/0108/18). The reference points presented integrate yield per recruit and stock recruitment considerations, assuming current selectivities. "The Australian and Japanese preferred set" ADAPT VPA results suggested that current fishing mortality is above F_{MSY}, while the statistical catch-at-age model reference points suggested F_{MSY} was probably not being exceeded. Current fishing mortality was estimated to be in excess of the more conservative reference points ($F_{TY,0.1}$, $F_{TY,0.2}$)[1] regardless of the models examined.

42 In discussion, reservations were expressed about such reference points if estimated stock recruitment relationships are not well determined. There is further discussion of this topic under Agenda 7.5 on stock projections.

Summary of assessment model results

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[1] $F_{TY,0.1}$, $F_{TY,0.2}$ and $F_{TY,0.0}$ (where the suffix TY refers to total yield) are described by Punt,1993 (where they are denoted by $f_{0.1}$, $f_{0.2}$. They are equivalent concepts with respect to a total yield curve as $F_{0.1}$, $F_{0.2}$,etc (Gulland and Borema, 19??) are to a curve of yield per recruit plotted on fishing mortality rate. That is they are the levels of fishing mortality rate at which the slope of the total yield curve is 10% or 20% or 0% of the slope of the curve at zero fishing mortality. Clearly, since the 0% slope corresponds to the maximum of the total yield curve, $F_{TY,0.0}$ is equivalent to F_{MSY}. Since $F_{TY,0.1}$, $F_{TY,0.2}$ must be on the ascending limb of the total yield curve they are more conservative reference points than $F_{TY,0.0}$. A total yield curve is a plot against fishing mortality rate of either the equilibrium yield of a production model or in dynamic pool/age structured-production models, the product of the yield per recruit and the equilibrium recruitment to be expected at a given level of fishing mortality rate. The equilibrium recruitment is calculated by reference to the fitted stock recruitment relationship and spawning stock per recruit curve.

Punt, A.E. 1993. The comparative performance of production-model and ad hoc tuned VPA based feedback-control management procedures for the stock of Cape hake off west coast of South Africa. pp.283-299. In: S.J. Smith, J.J. Hunt and D. Rivard [Ed.] Risk evaluation and biological reference points for fisheries management. *Can. J. Fish. Aquat. Sci. Spec. Publ.* 120

43 A summary of assessment model results as follows:

- At the time of the most recent round of quota reductions (1988), spawning stock size was well below levels in 1980 and earlier and has declined further since then, with a possible upturn in recent years.
- The models consistently indicate a decline in recruitment with recruitments in the 1990s less than half of those in earlier years.
- The models consistently indicate the combination of high recruitment and high spawning stock in early years, with low recruitment and low spawning stock in more recent years.
- Overall, stock biomass has been roughly stable since the mid 1990s or early 1990s (depending on the model) with possible slight increases or decreases – thus recent removals are closed to recent surplus production.
- Quota reductions in all fisheries in 1988 (and earlier) and subsequent changes in the selectivity pattern for the surface fishery reduced fishing mortality rates and led to an increase in abundance of younger fish.
- It is unclear if the increases in young fish abundance have resulted in increases in abundance of older ages.
- Age structured models show strong autocorrelation in recruitment residuals that are partially due to aging errors resulting from cohort slicing
- If we assume constant catchability over time, there are inconsistencies in CPUE by age or by size – some models partly resolve this by letting selectivity or catchability change over time. This problem is especially strong in the plus group or larger sizes. The problem may be related to difficulties in estimating catch-at-age distributions and changing growth rates.
- While there is considerable uncertainty in absolute stock sizes, models are much more consistent regarding trends in abundance during the last decade.
- There is general agreement that the new approaches tabled at this meeting resolve some of the problems with the ADAPT VPA (and its associated cohort slicing) that have been used for SBT.

44 A summary of the assessment model results is at **Attachment 6**.

7.5 Projections

45 A number of SBT stock projections were presented using different stock assessment

model results and future catch scenarios.

46 Australia presented results based on both the ADAPT VPA and Statistical Catch-at-age model approaches (CCSBT-SC/0108/23) but did not do projections based on the statistical catch-at-length stock assessment model. With the Statistical catch at age model approach the estimated probability of recovery was lower than using the ADAPT approach. It was noted that of the two CPUE indices used, the proxy for the Geostatistical was more optimistic than the proxy for the B-ratio. The apparent lack of sensitivity to the plus-group options was due to the probabilities of recovery being so low. ADAPT VPA based projections were run with both the Australian and Japanese "preferred" uncertainty sets. Other than the three modifications suggested by the Advisory Panel, since the last SC meeting, the projection approach is the same as that used in 1998. The intent of the analysis was to provide directly comparable results with what Japan and Australia considered "best" assessments in 1998. In this regard, the projection results are considerably more pessimistic than those presented in 1998. For the Australian and Japanese "preferred" uncertainty sets, the estimates of the probability of recovery to the 1980 level by 2020 were between 6-7% and the probability that the parental biomass would be above the 2000 level in 2020 was between 24-57% under constant current (2000) catch levels. Projection results for the statistical catch at age assessment results yielded probability of recovery of less than 1% and an estimate of 18% that the parental biomass would be above the 2000 level in 2020 under constant 2000 catch levels. All of the projection results yield low probability of recovery to the 1980 level by 2020. They also suggest that there is substantial probability of future declines in parental biomass under current catches. Substantial catch reductions would be required to ensure that there was a 50-75% probability of recovery and a low probability of no further declines. Projection results are more pessimistic under scenarios in which all future catches are taken by longline fisheries compared to the current mixture of fisheries or scenarios with all surface catches for the CCSBT catches.

47 In response to the last point , Japan pointed out that such conclusions rest heavily on poorly estimated stock-recruitment relationships, and that yield per recruit computations (see below) show opposite results. The presenter responded that yield per recruit results did not provide a reliable basis for projecting recovery to 2020 in this situation. The presenter further responded that lack of fit was not an

issue in the results from this paper (CCSBT-SC/0108/23) as the Statistical catch at age results (CCSBT-SC/0108/19) showed good fits. The problems were more likely to be with the ADAPT runs where the S/R relationship looks nearly linear.

48 Japan presented projections based on their age aggregated (AAPM) and age structured (ASPM) production models (CCSBT-SC/0108/24). Projection results were tabulated for various constant catch scenarios over the next 20 years with bootstrap estimates of the 90% confidence intervals. The ASPM required information about the proportion of the catch by different gear types and this was achieved by assuming a split in the catch of 38% by the surface fishery and 62% by longline fisheries as in 2000. The presenter noted that the AAPM based projections based upon age 6-7 CPUE were more optimistic than the projections based on CPUE biomass of ages 4+. The ASPM based projections were less optimistic. This behaviour was linked, in part, to the strong decrease in selectivity at older ages assumed for the longline fishery.

49 In discussion it was noted that projections based on age-aggregated production models may not be appropriate because the current age structure is far from equilibrium due to changes in the fishery and the large catches of juveniles in the 1980s. When questioned on the robustness of the model in these circumstances the presenter argued that simple biased estimators may be preferable to more complex and more variable ones. In respect to the questions of the adverse effects of a non-stationary age structure on the models the presenter responded that general simulation tests have shown this not to be a major concern, but that such tests have not included cases where such time lags and changes in selectivity are occurring together. Because the ASPM approach explicitly addresses these aspects it is, in principle preferable to the AAPM approach.

50 Australia noted that projection results from age structured models suggest that the effects of time lags and changed selectivities can result in substantially more pessimistic projections. In particular catch projections were more pessimistic (CCSBT-SC/0108/23) if all catches were assumed to be taken on older ages. This is contrary to the predictions of ASPM, perhaps due to time lag effects

51 Japan also presented projection results based on their ADAPT VPA stock assessments (CCSBT-SC/0108/31 & CCSBT-SC/0108/34). They noted three types

of results corresponding to estimates of fishing mortality ranging from immediate recovery (very high F) with the higher the estimate of F the faster the recovery, to continuing substantial declines in the parental biomass (very low F). Neither of these were considered reasonable, so both the high and low F scenarios were rejected in favour of intermediate scenarios. In these papers estimates of probability of recovery are not presented; instead plots of parental stock trajectories are shown. The presenter noted that the projection results are driven by the 12+ biomass ; this is the portion of the stock where information is the least reliable and there is no clear way to distinguish between scenarios where the plus-group biomass is either very high or very low when the results are synthesised. As such results should be viewed with caution. The documents also examined sustainability under a range of catch combinations between surface and longline fisheries. The results given in the document (CCSBT-SC/0108/34) indicated that the stock would be sustainable under the current recruitment and catch levels and that a reduction in surface catch would provide higher equilibrium spawning stock biomass. It was noted that the sustainability of stock levels is highly sensitive to recent recruit levels.

52 In discussion it was noted that the plausibility of the different VPA models in terms of their fit to the input data meant that not all of the plotted trajectories should be treated equally.

53 Japan also examined the behaviour of three fishery components (surface, longline and spawning ground fisheries) in terms of yield-per-recruit (Y/R) and spawning biomass-per-recruit (SB/R) in CCSBT-SC/0108/36. This analysis suggests that for the same proportional removal rates, from a Y/R perspective the longline fishery does better than the surface fishery while the reverse is true from a SB/R perspective. Looking jointly at Y/R and SB/R (similar to a yield curve) the longline and spawning ground fisheries do better in terms of estimated equilibrium total yield.

54 In discussion it was noted that shorter-term projections were likely to reverse this effect due to time lag in the contribution of cohorts to the spawning stock.

55 Discussion was re-opened on CCSBT-SC/0108/18 in respect to the potential use of F-reference points. Australia suggested that since F-reference points are not tied to a constant catch they offer a different perspective on the stock. In discussion it was

noted that a range of stock assessment models have been used that have qualitatively different S/R relationships. While F-reference points that do not incorporate a formal S/R relationship (eg $F_{0.1}$and Frep) are independent of its choice, the use of such reference points open us to the criticism that we are ignoring S/R relationships. Australia stated that for that reason they would prefer to include F_{rep} because it gets away from assumptions about the S/R relationship. In response, it was stated by Japan that the appropriateness or otherwise of the Frep[2] reference point depended strongly on the form of the available stock-recruit plot, and further that the forms evident for SBT suggested that it would not be appropriate for this resource.

56 Under discussion of future research Japan presented alternative computations related to reference points, based upon yield per recruit, recent recruitment estimates, and distinguishing between different fisheries. The results suggested F0.1 steady –state yields of some 17000 tonnes for longline only fisheries, and some 10000 tonnes for surface or spawning ground only fisheries. Concerns were raised but there was no time for discussion.

57 An oral presentation was made by Australia of the aerial survey component of the recruitment Monitoring Program with a view to determining whether aerial survey results might be useful in evaluating which projection scenarios might be plausible. Australia reported that since 1998, the aerial survey program and analyses has been undergoing extensive review both internally in CSIRO and externally under the collaborative recruitment monitoring program. This has been prompted by the fact that the accumulated body of data collected in the program was suggesting that some of the fundamental assumptions that had gone into the original design and

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[2] F_{rep} (often also called F_{med})is described by Sissenwine and Shepherd 1987. Technically it is calculated on the basis of estimates of spawning stock and recruitment as the fishing mortality corresponding to the spawning stock biomass per recruit ratio with half the historical observations of this ratio being higher and half lower. In some cases it is calculated on the entire available historic record while in other cases it is calculated on a stated number of the most recent estimates. Clearly, if it is used as a comparative basis, pre -agreement is needed on the years for which it is to be calculated.

Sissenwine, M.P. and Shepherd, J.G. 1987. An alternative perspective on recruitment overfishing and biological reference points. Can. J. Fish. Aquat. Sci. **44**(4) 913-918.

implementation may not be valid. In addition, there were increasing logistic difficulties in terms of availability of spotters and planes for conducting the survey. Particular concerns include: (1)That line transect approach for analyzing the data appear inappropriate; (2)That the survey appears not to be able to provide estimates by age; (3) There are consistent differences in the estimates of patch size (i.e. total tonnes of fish) between different spotters. Given the variability among spotters determining absolute (in contrast to relative) biomass is problematical; (4) That a strip transect approach should be used for analysing the existing data and that a variety of analytical approaches should be considered. Initial analyses have yielded CV of 30-40%; and (5) Interpretation of the 1999 and 2000 survey results are complicated by the fact that the surveys planes had one spotter/pilot and one trainee spotter instead of the previous use of a spotter/pilot and one additional trained spotter. The presenter emphasized that the primary focus of the aerial survey has always been to produce a relative abundance index; it was never intended to provide absolute abundance estimates.

58 It is not yet clear whether these data will be useful but the importance of developing a juvenile index was reaffirmed. Work on archival tagging is still ongoing and it is hoped that in subsequent meetings these data will be useful for scaling aerial sightings estimates to absolute values. It was noted work on the analyses of archival tags is on-going as part of the collaborative Recruitment Monitoring Programme and results of this work when completed will be reported at future meetings.

59 CSIRO has initiated a pilot project to evaluate existing commercial spotting data. The project is still in progress and final results are not available. It should be noted that the amount of historic data that has been able to be retrieved from the industry has been relatively small and patchy with no data in a large number of years. The spatial coverage is also quite variable and highly concentrated and substantial problems exist in interpreting them. Independent of these data, commercial spotters have indicated that it is their impression that juvenile SBT abundance within the Great Australian Bight has increased since the early 1990s.

60 Extensive discussion of the potential impact of the form of the stock recruitment relationship on the projections led to general agreement that it is important to explicitly consider the form of the relationship and not automatically fit a Beverton-Holt model without considering the fit to the data. It was agreed that

objective criteria needed to be used in deciding what form of the stock recruitment curve should be used and that one needs to be careful about rejecting plausible relationships based on short term deviations from the fitted curve.

Summary of Projection results:

61 - In general, assessments that resulted in low historical abundance/high-F scenarios also indicated higher productivity and thus higher probability of stock recovery. The opposite was true for high historical abundance and low productivity scenarios.

- Projections made assuming status quo (2000) catches resulted in increasing or decreasing biomass trends depending on model assumptions and input data.

- The 2000 global catch levels appear to be roughly close to replacement yield, either below or above depending on small differences in the assessments. Consequently projections show divergent trends under current catch levels ranging from recovery to continued decline. As a result, overall probability statements about whether the stock will increase or decrease if catch levels are maintained at the 2000 level are sensitive to the weightings given to alternative cases.

- Overall, few of the scenarios presented resulted in recovery to the 1980 spawning biomass level by year 2020 under status quo catches.

62 For projections based on specific assessment models:

- The high sensitivity of biomass trends estimated by the ADAPT VPA with respect to small variations in CPUE indices in combination with different plus group methods was amplified in the projections. These slight differences in data input determined whether estimates of the stock would increase or decrease.

- Projections based on the statistical catch-at-age model showed stock decreases at current catch levels for most scenarios.

- No projection results were tabled based on assessments using catch-at-length data.

- Results from the Fox AAPM surplus production model and the ASPM indicated similar diversion of projections at current catches depending on CPUE time series and assumptions used.

7.6 Fishery Indicators

63 Australia presented an update of a range of SBT fisheries indicators (CCSBT-SC/0108/25), some of which had served as a basis for confirming model outputs in the late 1980s. While there was considerable discussion of this paper and the relevance of some indicators, it remains clear that the indicators examined are not exhibiting the unambiguously negative stock status signals that were evident in the late 1980s. From the indicators compiled, some suggest improving stock condition while others suggest cause for continuing concern and some show no trend. Japan also tabled results of several fishery indicators (CCSBT-SC/0108/34, figure 13) which also showed a mixture of signs about the stock. It was noted that the acoustic survey in the last two years had trouble locating schools of small SBT and last year had found almost none. A tagging program operating at the same time had similarly found trouble finding small SBT in an area immediately adjacent to the Japanese survey. Increasing CPUE of juvenile SBT by the Australian surface fishery (purse seine and pole-and-line) in recent years was noted (CCSBT-SC/0108/34). However, in discussion the difficulties of interpreting CPUE for purse seine and pole and line fisheries were noted. Also the CPUE for purse seine was an index of catch per set and does not reflect the actual measure of searching effort. Interpretation of the changes in CPUEs presented is also highly confounded by operational and marketing factors.

8 Research and Technical requirements for future stock assessments

64 The adopted agenda was adjusted in light of discussions, to combine agenda items 8 and 9.

CPUE modeling alternatives for future assessments

65 Both Japan and Australia briefly presented their papers on future CPUE modeling.

66 Japan applied tree regression methods (CART and CHAID algorithms) to estimate standardized CPUE indices (CCSBT-SC/0108/30). CPUE trends by CART appeared to be relatively time-invariant. Sums of squares for both CART and CHAID were lower than that for GLM, and this indicates that GLM analyses can be improved. Document CCSBT-SC/0108/29 by Japan discussed problems of the B-ratio method originally developed by Campbell et al. (1995, 1996) and proposed a simplified B-ratio method as a potential alternative. Japan considers that the B-ratio indices are negatively biased because the assumption that fishermen are able to target does not hold from observations of actual data.

67 Australia presented their view on future CPUE modeling based on CCSBT-SC/0108/09. The following approaches were identified for further consideration; (1) joint bi-variate modeling of catch and effort (CCSBT-SC/0108/10), (2) geo-statistical modeling (CCSBT-SC/0108/08), (3) modeling consistently fished areas, and (4) explicit catch prediction based on effort. Although the B-ratio model does not appear to be an adequate approach, the relationship between the density of fish and distribution of fishermen is an important factor to incorporate into the range of interpretations of catch and effort data. Information needed to improve CPUE modeling was identified as follows; (1) finer scale resolution information on catch, effort and size, (2) non-SBT catch, (3) physical environment, (4) gear operating characteristics and, (5) the effects of management decisions. These issues should be considered within the CPUE component of the SRP.

68 Although the report of WG on the SRP (CCSBT-SC/0108/Info/02) indicated that the Advisory Panel should select an appropriate CPUE modeling approach during the SAG meeting, there was not enough time to discuss this issue adequately. A technical sub-group of the SAG was convened by Dr. J. Pope to discuss future alternative CPUE modeling. The meeting recommends examining the possible need for a workshop on alternative CPUE modeling. The report of this sub-group meeting is at **Attachment 7**.

Future assessment modelling directions

69 Two directions for the future work of the SAG and SC were discussed. These

include:

1) work towards a management procedure for SBT which would be robust relative to a wide variety of assessment models included in the evaluation of the management strategy.
2) Work on future stock assessment models for SBT to directly advise on quota recommendations.

70 The meeting stated its preference to work on developing a management procedure rather than focus on reaching agreement on an interim assessment approach. Japan, however noted that there were issues more pertinent to the Scientific Committee and the Commission that would need to be considered in those fora when discussing this issue further.

71 Given the population dynamics and long lived nature of SBT, it is unlikely that updating the stock assessments in the next year or two would provide a substantially different picture of the status of the stock. Cautions were raised against moving towards less frequent assessments without adequately preparing frameworks to respond to unexpected changes both in fisheries and stocks as well as our perceptions. A preference was indicated to conduct the next formal assessment of the stock in another 2-3 years. It was noted that the frequency of assessments will be decided by the Commission.

72 The advisory panel was asked to give their advice on future directions for stock assessment models. Their views were similar. They were encouraged to see the wide range of models presented at this meeting. They suggested that new work on the ADAPT VPA was not worth pursuing. They stated that future work should be along the lines presented in the statistical models that incorporate length data and direct aging data. They noted that these models are sometimes perceived to be more complicated, but they in fact clarify some of the issues identified in the ADAPT VPAs and do not require complex manipulation of the data outside of the model. Under the framework of the statistical modelling approach a hierarchy of models of differing complexity can be conducted and their fit to the data examined. It was also suggested that the simpler production models might provide a complementary perspective to the age/length models, while avoiding many of the ADAPT-VPA problems.

73 It was noted that it was unrealistic to expect the SC to provide adequate assessment advice based on a single model. The meeting noted that the SC and Commission requested the Advisory Panel lead the development of management procedures. The Advisory Panel responded by submitting a proposed plan for developing management procedures to be discussed at the SC.

74 The meeting also acknowledged the importance of further work on stock assessment modelling approaches, which would include CPUE modelling alternatives. The SAG recommends to the SC that for the purposes or advancing these two related issues that a workshop in 2002 should be considered to address these issues in the context of developing management procedures.

Additional reference points

75 At the Management strategy workshop in May 2000 it was recommended that consideration of additional statistics for reporting assessment results should be discussed at subsequent SAG and SC meetings. In this context Australia produced paper 18 on additional reference points. They suggest that agreement should be reached on a list of stock status reference points, projection-related reference points, recent recruitment reference points and fishing mortality reference points. These should be considered for provision of interim management advice while the management procedures are developed.

76 Prior to the SAG, Australia and Japan exchanged lists of reporting statistics. The SAG chair recommends that the SC discuss the process to develop a common set of reporting statistics and produce an agreed list for use in future.

77 Japan commented that there was lack of clarity as to the purpose " reference points" were intended to serve, and this aspect should be further discuss in the Scientific Committee.

Direct Aging

78 The SAG recommends to the SC that a direct aging workshop be held, for discussion of comparison of aging procedures and establishment of a central otolith archive. Each member was asked to prepare a report on the status of the collection

of otoliths by each country, within its capability, for the SC next week.

Research Priorities

79 The following table summarizes agreements by the SAG under agenda Item 9 dealing with research priorities:

Research Activity	***Priority***
Spawning Dynamics	Low
Size/age at maturity*	Low-High
CPUE on spawning grounds	Medium
Length-weight conversion	High
Cohort slicing	Low
Uncertainty and bias in catch-at-size	High
Catch substitution rules	Medium
Direct aging	High
Recruitment monitoring	High
Archival Tagging	High

*There were differing views on this topic.

9 Other Business

80 The only item raised under this agenda was the timing of the data exchange process leading up to the regular SBT stock assessment. It was noted that since the current agreement for exchange had been reached, the timeline had proven problematic with several of the key data exchanges being late. The cumulative effect of the delays was that up to 4-5 weeks was lost resulting in inadequate time for the analyses and report preparation. These delays also resulted in papers only being available only at the start of the SAG. While there was considerable understanding of the difficulties that the timing of the existing process caused, it was noted that the timing was a compromise between the timing of the annual Commission meeting and the time when the most recent Japanese longline data would become available. Therefore, it seemed unlikely that there would be much flexibility in the data exchange schedule. It was also noted that several aspects of the exchange process would be changing as the CCSBT moves towards a common database for assessment and the arrival of the CCSBT database manager should alleviate some of the present difficulties. The Secretariat signaled their intent to review the existing procedure in consultation with the Parties after the new database manager has joined

the Secretariat.

10 Finalisation and adoption of meeting report

81 The report of the meeting was adopted.

11 Close of meeting

82 The meeting was closed at 2:00pm, 28 August.

John Annala
The Chair of the 2nd meeting of Stock Assessment Group

Attachment 1

List of Participants
CCSBT
Stock Assessment Group Workshop
19-28 May 2001
Tokyo, Japan

CHAIR

Dr John ANNALA
Science Policy Manager
Ministry of Fisheries
PO Box 1020
Wellington
New Zealand
Phone: +64 4 470 2661
Fax: +64 4 470 2669
Email: annalaj@fish.govt.nz

ADVISORY PANEL

Dr James IANELLI
REFM Division
7600 Sand Pt Way NE
Seattle, WA 98115
USA
Phone: +1 206 526 6510
Fax: +1 206 526 6723
Email: jim.ianelli@noaa.gov

Dr Ana PARMA
Centro Nacional Patagonico
Pueto Madryn, Chubut
Argentina
Phone: +54 2965 451024
Fax: +54 2965 451543
Email: parma@cenpat.edu.ar

Professor Ray HILBORN
School of Fisheries Box 355020
University of Washington
Seattle, WA 98195
USA
Phone: +1 206 543 3587
Fax: +1 206 685 7471
Email: rayh@u.washington.edu

Dr John POPE
The Old Rectory
Burgh St Peter
Norfolk, NR34 0BT
UK
Phone: +44 1502 677377
Fax: +44 1502 677377
Email: PopeJG@aol.com

SCIENTIFIC COMMITTEE CHAIR

Mr Andrew PENNEY
Pisces Research & Management Consultants
22 Forest Glade
Tokai Road, Tokai 7945
South Africa
Phone: +27 21 7154238
Fax: +27 21 7154238
Email: piscescc@iafrica.com

AUSTRALIA

Dr John KALISH
Senior Research Scientist
Fisheries & Forestry Sciences Division
Bureau of Rural Sciences
Dept. of Agriculture, Fisheries & Forestry
PO Box E11, Kingston ACT 2604
Phone: +61 2 6272 4045
Fax: +61 2 6272 4014
Email: john.kalish@brs.gov.au

Mr Jonathon BARRINGTON
Program Manager
Strategic Fish Policy
Fisheries & Aquaculture
Dept. of Agriculture, Fisheries & Forestry
GPO Box 858, Canberra ACT 2601
Phone: +61 2 6272 4975
Fax: +61 2 6272 4215
Email: jonathon.barrington@affa.gov.au

Dr Tom POLACHECK
Senior Research Scientist
Tropical and Pelagic Ecosystems Program
Division of Marine Research
CSIRO
PO Box 1538
Hobart, TAS 7001
Phone: +61 3 6232 5312
Fax: +61 3 6232 5012
Email: tom.polacheck@marine.csiro.au

Ms Ann PREECE
Research Scientist
Tropical and Pelagic Ecosystem Program
Division of Marine Research
CSIRO
P.O. Box 1538
Hobart, Tas 7001
Phone: +61 3 6232 5336
Fax: +61 3 6232 5012
Email: ann.preece@marine.csiro.au

Dr Dale KOLODY
Research Scientist
Tropical and Pelagic Ecosystem Program
Division of Marine Research
CSIRO
P.O. Box 1538
Hobart, Tas 7001
Phone: +61 3 6232 5121
Fax: +61 3 6232 5012
Email: dale.kolody@marine.csiro.au

JAPAN

Dr Sachiko TSUJI
Section Chief
Temperate Tuna Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6042
Fax: +81 543 35 9642
Email: tsuji@affrc.go.jp

Dr Norio TAKAHASHI
Senior Resercher
Temperate Tuna Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6043
Fax: +81 543 35 9642
Email: norio@affrc.go.jp

Mr Tomoyuki ITOH
Temperate Tuna Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6043
Fax: +81 543 35 9642
Email: itou@affrc.go.jp

Mr Hiroyuki KUROTA
Temperate Tuna Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6043
Fax: +81 543 35 9642
Email: kurota@affrc.go.jp

Dr Kazuhiko HIRAMATSU
Section Chief
Mathematical Biology Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6014
Fax: +81 543 35 9642
Email: hira@affrc.go.jp

Mr Hiroshi SHONO
Mathematical Biology Section
National Research Institute of
Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka 424-8633
Phone: +81 543 36 6039
Fax: +81 543 35 9642
Email: hshono@affrc.go.jp

Prof Doug BUTTERWORTH
Department of Mathematics and Applied
Mathematics
University of Cape Town
Rondebosch 7701
South Africa
Phone: +27 21 650 2343
Fax: +27 21 650 2334
Email: dll@maths.uct.ac.za

Dr Susan HOLLOWAY
Department of Mathematics and Applied
Mathematics
University of Cape Town
Rondebosch 7701
South Africa
Phone: +27 21 650 2343
Fax: +27 21 650 2334

Mr Hisashi ENDO
Deputy Director
International Affairs Division
Resources Management Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3591 1086
Fax: +81 3 3502 0571
Email: hisashi_endo@nm.maff.go.jp

Mr Kouichi ISHIZUKA
Deputy Director
Resources and Environment Research Div.
Resources Development Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3501 5098
Fax: +81 3 3592 0759
Email: kouichi_ishiduka@nm.maff.go.jp

Mr Teruaki MITSUISHI
Assistant Director
International Affairs Division
Resources Management Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3591 1086
Fax: +81 3 3502 0571
Email: teruaki_mitsuishi@nm.maff.go.jp

Mr Takato MAKI
International Affairs Division
Resources Management Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3591 1086
Fax: +81 3 3502 0571
Email: takato_maki@nm.maff.go.jp

Mr Kenichi NOTOU
Section Chief
Far Seas Fisheries Division
Resources Management Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3591 6582
Fax: +81 3 3591 5824
Email: kenichi_noto@nm.maff.go.jp

Mr Hideki KATO
Section Chief
Resources and Environment Research Div.
Resources Development Dept.
Fisheries Agency
1-2-1 Kasumigaseki, Chiyoda-ku
Tokyo 100-8907
Phone: +81 3 3501 5098
Fax: +81 3 3502 1682
Email: hideki_kato@nm.maff.go.jp

Mr Nozomu MIURA
International Division
Federation of Japan Tuna Fisheries
Cooperative Associations
3-22 Kudankita 2-chome, Chiyoda-ku
Tokyo 102
Phone: +81 3 3264 6167
Fax: +81 3 3234 7455
Email: section2@intldiv.japantuna.or.jp

Mr Taro TAKESHITA
International Division
Federation of Japan Tuna Fisheries
Cooperative Associations
3-22 Kudankita 2-chome, Chiyoda-ku
Tokyo 102
Phone: +81 3 3264 6167
Fax: +81 3 3234 7455
Email: section2@intldiv.japantuna.or.jp

Mr Kosuke HIGAKI
Deputy Manager
National Ocean Tuna Fisheries Association
1-1-12 Uchikanda Chiyoda-ku, Tokyo 101
Phone: +81 3 3294 9634
Fax: +81 3 3294 9607

NEW ZEALAND

Dr Talbot MURRAY
Pelagic Project Leader
National Institute of Watr & Atmospheric
Research Ltd
PO Box 14-901, Kilbirnie, Wellington
Phone: +64 4 386 0300
Fax: +64 4 386 0574
Email: t.murray@niwa.cri.nz

OBSERVERS

REPUBLIC OF KOREA

Dr Sung-Kwon SOH
Counsellor for Fisheries
Office of the Director General for Intl.
Cooperation
Ministry of Maritime Affairs and Fisheries
139 Chungjong-No 3, Seodaemun-Gu
Seoul 120-715
Phone: +82 2 3148 6995
Fax: +82 2 3148 6996
Email: sksoh@momaf.go.kr

TAIWAN

Dr Shui Kai CHANG(Eric)
Deep Sea Fisheries Research and
Development Center
Fisheries Administration
Council of Agriculture
No. 1, Fishing Harbour North 1st Road
Chine Cheng District
Kaohsiung 80628
Taiwan
Tel: +886 7 8137437
Fax: +886 7 8136592
email: skchang@mail.dsfrdc.gov.tw

CCSBT SECRETARIAT

PO Box 37, Deakin West ACT 2600
AUSTRALIA
Phone: +61 2 6282 8396
Fax: +61 2 6282 8407

Mr Brian MACDONALD
Executive Secretary
Email: bmacdonald@ccsbt.org.au

Mr Morio KANEKO
Deputy Executive Secretary
Email: mkaneko@ccsbt.org.au

Ms Chika SCALLY
Administrative Officer
Email: cscally@ccsbt.org.au

INTERPRETERS

Ms Akiko TOMITA

Ms Midori OTA

Ms Emiko Kodama

Attachment 2

Agenda
Second Stock Assessment Group Meeting
19 - 28 August 2001
Tokyo, Japan

1 Opening
   1.1 introduction of participants and administrative matters

2. Appointment of rapporteurs

3. Adoption of agenda

4. Admission of documents and finalisation of document list

5. Matters arising from SC5 and CCSBT7
   5.1 Report on stock projection models
   5.2 Inputs to assessments

6. Assessment Approaches to be used in 2001

7. SBT stock assessment
   7.1 Biology and stock structure of SBT
   7.2 Country reports
   7.3 Estimates of catch
   7.4 Catch at age/size assessment
   7.5 Projections
   7.6 Indicators

8. Research and technical requirements for future stock assessments
   8.1 Framework for evaluation of models used
   8.2 CPUE modelling alternatives for future assessments
   8.3 Investigation of spawning dynamics
   8.4 Estimation of size at maturity
   8.5 CPUE of SBT on the spawning ground
   8.6 Length-weight relationship
   8.7 Cohort slicing
   8.8 Uncertainty and bias in estimates of catch at age and size
   8.9 Substitution rules
   8.10 Direct aging data
   8.11 Estimation of the abundance indices juvenile SBT from aerial sightings/archival tagging data
   8.12 Stock-recruitment relationships
   8.13 Additional reference points

8.14 Future assessment modelling directions
8.15 Development of a common database

9. Other business

10. Finalisation and adoption of meeting report

11. Close of meeting

Attachment 3

List of Documents
Scientific Committee (SC) & Stock Assessment Group (SAG)

(CCSBT-SC/0108/)		SAG Agenda item
1.	Draft Agenda of SAG	
2.	List of Participants of SAG	
3.	Draft Agenda of SC	
4.	List of Participants of SC	
5.	List of Documents－SC&SAG	
6.	Catch (and Effort) Data Collection Systems	
7.	Summary of Information Observer Programs	
8.	(Australia) Spatio-Temporal Analysis of Southern Bluefin Tuna Catch Per Unit Effort Data: A Best Linear Unbiased Predictor Approach. by P.J. Toscas[1], W.N. Venables[1] and T. Polacheck	**8.2**
9.	(Australia) Where to with Modelling CPUE? Tom Polacheck, Ann Preece, Dale Kolody	**8.2**
10.	(Australia) Modelling Catch and Effort in the Southern Bluefin Tuna Fishery. Peter J. Toscas, William N. Venables and Mervyn R. Thomas	**8.2**
11.	(Australia) Catch Monitoring of the Fresh Caugh t Tuna by the Bali-Based Longline Fishery. Tim Davis and S. Nurhakim	**7.3**
12.	(Australia) Length at Age Distribution of Southern Bluefin Tuna in the Indonesian Longline Catch on Spawning Grounds	**7.1**
13.	(Australia) Application of a Statistical Catch-at-Age and -Length Integrated Analysis Model for the Assessment of Southern Bluefin Tuna Stock Dynamics 1951-2000. Dale Kolody and Tom Polacheck	**6, 7.4**
14.	(Australia) The effects of using cohort slicing to estimate age distributions. Paige Eveson and Tom Polacheck	**7.3**
15.	(Australia) Proposal for Conventional Tagging Program within the Scientific Research Program of the Commission for the Conservation of Southern Bluefin Tuna. Tom Polacheck, John Gunn, Clive Stanley.	**7.3**
16.	(Australia) Size and Age at 50% Maturity in SBT: An integrated view from published information and new data from the spawning ground. Tim Davis, Jessica Farley and John Gunn.	**7.1, 7.4**
17.	(Australia) Taiwanese SBT catches and their size distribution in the Indian and Atlantic Oceans based on catch monitoring in Mauritius and Cape Town. Jessica Farley, Eric Chang, John Gunn.	**7.3**
18.	(Australia) The Status of Southern Bluefin Tuna Relative to Fishing Mortality Reference Points. Tom Polacheck and Neil Klaer.	**7.4, 7.5** **8.13**

19.	(Australia) An Integrated Statistical Time Series Assessment of the Southern Bluefin Tuna Stock based on Catch at Age Data. Tom Polacheck and Ann Preece.	**6, 7.4**
20.	(Australia) Assessment of the Status of the Southern Bluefin Tuna Stock Using Virtual Population Analysis – 2001. Tom Polacheck, Ann Preece and Dan Ricard.	**6, 7.4**
21.	(Australia) Summary of the primary data inputs to CSIRO's 2001 stock assessment models. A. Preece, T. Polacheck, D. Kolody, P. Eveson, D. Ricard, P. Jumppanen, J. Farley and T. Davis.	**5.2, 7.3**
22.	(Australia) Trends in Catch, Effort and Nominal Catch Rates In the Japanese Longline Fishery for SBT. Tom Polacheck and Dan Ricard.	**7.3**
23.	(Australia) Southern Bluefin Stock and Recruitment Projections - Neil Klaer, Tom Polacheck, Ann Preece, Dale Kolody, Dan Ricard.	**7.5**
24.	(Japan) Addendum To: CCSBT-SWG/0011/16: Exploratory analyses of southern bluefin tuna dynamics using production models. : Doug.S. Butterworth and Susan J Johnston	**6, 7.4, 7.5**
25.	(Australia) Fishery Indicators for the SBT Stock. John Gunn, Tom Polacheck. Ann Preece, Dan Ricard, Paige Eveson, Tim Davis, Jessica Farely, Neil Klaer, Dale Kolody	**7.6**
26.	(Australia) Some Comments on CPUE Tuning Indices in Repsonse to Questions from External Scientists. Tom Polacheck, Dale Kolody and Ann Preece.	
27.	(Australia) A Statistical Catch-at-Age/Length Integrated Model for Southern Bluefin Tuna Stock Assessment. Dale Kolody and Tom Polacheck	**6, 7.4**
28.	(Japan) Abundance indices of Southern Bluefin Tuna based on the Japanese longline fisheries data, 1969-2000, along the interim approach agreed for the 2001 Stock Assessment. : N. Takahashi, S. Tsuji, T. Itoh and H. Shono.	**7.3**
29	(Japan) Consideration on the B-ratio model and its potential alternative. : N. Takahashi and S. Tsuji.	**8.2**
30.	(Japan) Preliminary analysis for CPUE standardization and area stratification by tree regression model. : H. Shono, S. Tsuji, N. Takahashi, and T. Itoh.	**8.2**
31.	(Japan) Stock assessment and future projection of the southern bluefin tuna based on the ADAPT VPA. : K. Hiramatsu and S. Tsuji.	**6, 7.4, 7.5**
32.	(Japan) Exploration of cohort analysis based on catch at length data for southern bluefin tuna. : H. Kurota, S.Tsuji, N. Takahashi, K. Hiramatsu, and T. Itoh.	**6, 7.3, 7.4**
33.	(Japan) Proposal on framework of Tagging Program under the CCSBT/SRP. : S. Tsuji	
34.	(Japan) Review of history in recognition of stock status and some consideration on principles in developing management procedures. : S. Tsuji.	**7.4, 7.5, 7.6**

35.	(Japan) Notes on data to be used for the 2001 Stock Assessment and its exchange process. : S. Tsuji.	**5.2, 7.3**
36.	(Japan) Steady-State Comparison of the Consequences of the different selectivity Patterns in the SBT Fishery S.J.Johnson and D.S.Butterworth	**7.5**

（CCSBT-SC/0108/SBT Fisheries ）

Australia-Australia's 1999-2000 and 2000-01 Southern Bluefin Tuna Fishing Season. J.L. Foster, C.M. Robins and A.E. Caton and K.F. Williams. 7.2

Japan- Review of Japanese SBT Fisheries during 1998-2000. : T. Itoh and K. Notou 7,2

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- Murray,T & K. Richardson

Korea—

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（CCSBT-SC/0108/BGD ）

1. (Japan) CCSBT-SWG/0011/16: Exploratory analyses of southern bluefin tuna dynamics using production models. : D.S. Butterworth and E.E. Plangányi. **6**

（CCSBT-SC/0108/Info ）

1. List of Procedures and Arrangements for SAG&SC
2. Report of the working group on implementation of the CCSBT scientific research program
3. Conceptual figure of the management procedure of CCSBT (The Secretariat's understanding of the report of MSWS)
4. The Commission's work as proposed by the Management Strategy Workshop (29-31 May 2000), regarding the Development of the a Management Procedure Process Work Plan
5. Proposal on interim database format for data maintained at the Secretariat of the CCSBT
6. Brief Description of Modifications (Japan and Australia) 6

（CCSBT-SC/0108/Rep ）

1. Report of the First Meeting of the Stock Assessment Group
2. Report of the Fourth Meeting of the Scientific Committee
3. Report of the Stock Assessment Process Workshop
4. Report of the Management Strategy Workshop
5. Report of the Scientific Meeting for Development of a SRP for the CCSBT and Overview of Progress on Stock Assessment
6. Report of the Fifth Meeting of the Scientific Committee

Classification of List of Documents

（**CCSBT-SC/0108/**　）

Documents to be discussed at the meeting and not yet given a document number of CCSBT, to be classified into this category.

（**CCSBT-SC/0108/SBT Fisheries**　）

The documents titled “Country SBT Fisheries Review”, to be classified into this category.

（**CCSBT-SC/0108/BGD**　）

Documents to be discussed at the meeting and already given a document number of CCSBT in the previous meeting, to be classified into this category.

（**CCSBT-SC/0108/Info**　）

Documents not to be discussed at the meeting but presented for information and reference, to be classified into this category.

（**CCSBT-SC/0108/Rep**　）

The previous report of CCSBT to be classified into this category.

（**CCSBT-SC/0108/WP**　）

The draft of the document and report developed through the discussion of the meeting and documents of informal meetings, to be classified into this category.

Attachment 4

Working paper for maturity age group

Introduction

In plenary it was agreed to consider scenarios with alternative ages of 50% maturity (Ages 8,10,12). However, the delegations had different views on which range of values to use. Consequently this working group was convened to allow the differing views of age of 50% maturity to be more clearly understood by all members and to discuss how the age of 50% maturity could be estimated with more certainty in the future. Thus this report has two sections. The next section presents the delegations current views of the evidence for various ages of 50% maturity. The last section documents the views of the individual scientists asked to give the potential advantages and disadvantages of the four possible approaches identified for the estimating age of 50% maturity. These approaches are:-

1. The search for spawning signals in calcified tissues,
2. The use of tagging information on spawning behaviour,
3. Improvements in estimates of selectivity estimates for the spawning fishery, and
4. The use of physiological indicators of maturity.

One or more of these might form the basis of future scientific programs to help estimate the age of 50% maturity, which is an important parameter for understanding and managing the SBT stock.

1. Understanding where we are now

Japan's position on maturity age

- The 1994 Workshop agreed to use age 9 as 50% maturity, and then adjusted to a knife-edge maturity vector in order to correspond to scenario using age 8 and older as plus group. We support to maintain the 1994 Workshop agreement unless more definitive evidence showing the other (age 12 as 50% maturity) become available.
- The age composition of Indonesian catch is a combination result of selectivity, maturity vector, and relative cohort sizes caused by previous exploitation. These three factors must be separated when considering maturity vector. It is too dangerous to assume Indonesian catch as non-biased representation of spawning stock.
- If size distribution of fish in spawning area represents spawning fish, age 9 will be appropriate judging from age composition of catch taken by Japanese fishery. This is the procedure taken in the 1994 Workshop.
- Biological examination showed that age 9 is capable to spawn.
- If the selectivity of Indonesian fishery has not been changed in recent years, reappearance of young fish (age 8 – 12) in the recent three years supports younger age maturity than determined by age composition of 1995 –1997. Judging from curve observed in left edge of age composition of 2001 Indonesian catch, age 9 or 10 seems more appropriate as 50% maturity.
- Absence of young fish of large size seems strange. But a simple model can explain age composition of Indonesian catch without problem under the assumption of non-age-selective take of fish from each size group if variation of individual growth is allowed. This suggests that lack of young age in Indonesian catch is an artifact caused by ignoring individual growth fluctuation.
- Summary of biological information is confusing and needs to revisit :
    - GI > 2 in 1960's and 1970's : mature at 130 cm corresponding to age 7 in 1970 and age 6 in 1980 growth curves.
    - Oocyte diameter > 0.4 mm : mature at 152 cm corresponding to corresponding to age 10 in 1970 and age 9 in 1980 growth curves.
    - GI > 2 in 1995 (we are not completely sure about sampling bias) : mature at 162 cm corresponding to age 12.5 in 1970 and age 11.5 in 1980 growth curves..

Australia Position
Rational for Relative Weighting to give
Alternative Hypotheses for the Mean age of Maturity

Age 8

Based on the information and data available, the possibility that the current mean age of maturity for SBT is as low as eight years of age seems highly improbable. There are a number of compelling pieces of information and analyses that lead to this conclussion:

1) Extensive sampling of fish caught on the spawning ground in the Indonesian fishery have found no age seven fish and very small numbers of eight year old fish. This is despite the fact that these age range of fish are commonly caught in the longline fisheries off the spawning ground in substantially higher proportion then the older age classes which are caught on the spawning grounds. While age specific selectivity may exist in the Indonesian fishery with respect to fish that actually spawn, the selectivity would need to be very high if in fact 50% or more of the eight year old fish and substantial percentage of the seven year old fish were in fact spawning.
2) In terms of gear, there is no reason why age 7 and 8 year old fish would not be caught if they were in the waters in which the Indonesian fishery operate. While there appears to be some size segregation related to depth on the spawning grounds, ~10-25% of the SBT sampled in a year have come from landing in which Bigeye dominate the total tuna catch (i.e. assumed to be from deep sets). Thus, even if the age 7 and 8 year old fish were disproportionately found in the deep waters they should still have been caught if they were in fact present.
3) The Indonesian fishery does catch fish within the size range of 7 and 8 year old fish caught found off the spawning ground. However, these are smaller fish of older ages indicating that if age 7 and 8 year old fish were common on the spawning grounds they should have been caught.
4) Historic Japanese size data do not indicate substantive latitudinal or longitudinal size segregation within the spawning ground.
5) Histological studies of fish off the spawning grounds caught during the first half of the spawning season estimated a mean length of maturity of either 152 or 162 cm based on two different maturity criteria. These estimates potentially biased downward because not all smaller fish meeting the maturity criteria would be expected to spawn. The mean size of age 7 and 8 fish of the spawning ground is substantially below 152cm.

Finally, while there is substantial information suggesting that age 7 and age 8 fish are at most rarely mature, there is no positive information despite extensive sampling to suggest that substantial number of fish of these ages ever spawn,

Age 10

Based on the direct aging data from the spawning grounds, there are clearly animals of age 10 spawning. However, relative to their distribution in catches off the spawning ground they are clearly substantially under-represented. Thus, if age 10 was the actual age of maturity, there would need to be substantial age selectivity occurring towards older fish within the Indonesian fishery among the fish that actually spawn. As such, the relative weight that one assigns to an age 10 hypothesis for the mean age of maturity depends upon the relative plausibility for substantive age selectivity in this fishery among those fish that actually do spawn.

We note that estimates of selectivity for the Indonesian fishery from catch at age models are estimates of selectivity from the global stock. As such, these estimates do not allow one to separate whether low selectivity for age 10 fish is the result of the fish not being available (i.e. not spawning) from whether they are in fact spawning but are not being caught. While there is evidence of some size segregation with depth on the spawning ground, it is not at all obvious what would be the appropriate weight to assign to the size (or age) composition from different depths in order to get a representative sample of the fish on the spawning grounds. The fact that the size distribution is different in the Indonesian fishery from that caught by Japanese training vessels (presumably because of targeting different depths) does not provide any basis for determining the extent of size selectivity occurring in either fishery among those fish that actually are found on the spawning ground. In this regard, it should be noted that a mixture of depth ranges appears to be represented in the Indonesian catches while the Japanese catches apparently are from deeper sets targeting bigeye. This would suggest that the Japanese catches would tend to be biased towards the smaller fish that do occur on the spawning grounds.

Figure 9 in CCSBT-SC/0108/12 strongly indicates that there is a size as well as an age component in determining the age of maturity. Thus, for each age below 15, the data suggests that the size distribution of fish caught on the spawning ground within an age class is skewed towards larger individuals. This suggests that full recruitment to the spawning stock is unlikely before ~15 at the youngest[1]. However, even when the size distributions are the same for an age class off and on the spawning ground, this does not mean this age class has been fully recruited. Even for age 12, recruitment to the spawning stock simply based on size appears far from complete.

All of the above suggests that given the current data, age 10 should be considered as within the plausible range for the age of maturity. However, the available data suggest that age 10 is likely to be a low estimate.

Age 12

The above discussion provides the basis for suggesting that age 12 is certainly within the range of plausible values for the age of maturity for SBT. The results in CCSBT-SC/0108/16 provide an estimate of between ages 11 and 12 for the age of maturity based on comparisons of the size distributions on and off the spawning grounds. Depending upon the size selectivity occurring in either of the two fisheries sampled, the estimate could be biased either up or down. Given the available data, an age older then 12 could still be considered within the plausible range. As such, the weight given to age 12 relative to age 10 encompasses also the plausibility that the age of maturity may be older then 12.

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[1] There are other mechanisms that could contribute to this differential (e.g. differential residence time for males and females on the spawning grounds combined with sexual dimorphism in length),

Based on these considerations, we would assign a small weight at most to age 8, and a greater weight to age 12 then age 10.

2. Ideas for making progress

Determination of mean age of maturity in southern bluefin tuna based on calcified tissues

Uncertainty remains regarding the mean age of maturity for southern bluefin tuna. Determination of the age of maturity on the basis of direct sampling of SBT on the spawning ground is difficult due to the distribution of fishing activities on the grounds and the likelihood that the entire spawning ground is sampled without bias. Alternate methods are required to determine the mean age of maturity and investigations based on hard parts (calcified tissues) are considered one possible solution due to their ability to record physiological and environmental events in the life of a fish.

Several hard parts and analytical methods may be of use to determine the age of maturity. Possible tissues of use include otoliths, vertebrae, operculae, fin spines and fin rays and cleithrae. Otoliths are generally considered most suitable to investigations requiring hard parts due to the fact that, unlike bone, they are not resorbed and retain a faithful record of past events in a fish's life. In tuna, otoliths are the most studied hard part although significant research has been completed on vertebrae as well.

There are potential impediments to the use of particular hardparts and these should be considered before embarking on a research involving these tissues. First, many tissues are not readily available from high value SBT destined for sashimi markets. This is due to the processing typically completed on board vessels where several parts are discarded including operculae, fins and cleithrae. Vertebrae, although retained, are difficult to collect due to the inability to sample these structures without causing significant damage to the fish. Although vertebrae may be available from the caudal peduncle region these vertebrae are small and may contain an incomplete record. Otoliths are considered most suitable for this work due to the ability to obtain samples and a demonstrated ability of these structures to retain interpretable increment width and chemical information. Nevertheless, other structure should be considered for investigation if available.

Oxygen isotope thermometry
Southern bluefin tuna spawn in the warm waters of the Java Sea and, when spawning, would experience very elevated temperatures relative to those on the feeding grounds. These temperature may be 15 degrees or more above the feeding grounds and would be easily detected by measurement of oxygen isotopic ratios. However, the majority of tunas are homeothermic and maintain body temperatures significantly above ambient. Temperate tunas are particular good at thermoregulation and a large SBT would maintain body temperatures well above ambient while on the feeding grounds due to this ability. Furthermore, the thermal inertia of a large spawning size SBT would serve to obscure further any changes in environmental temperature associated with seasonal effects or a latitudinal spawning migration. Oxygen isotopes are unlikely to be of use in age of maturity investigations.

Trace element chemistry and reproduction

Studies on other fish species have demonstrated changes, associated with reproduction, in the trace element chemistry of otoliths. These changes are caused by calcium binding proteins in the blood, notably the egg yolk protein vitellogenin, which increase in the blood prior to reproduction. Changes in the concentration of free and bound calcium and other trace elements in the blood are reflected in the trace element content of otoliths. Although this technique may demonstrate the deposition of yolk in ovarian tissues of SBT, this does not necessarily confirm movement to the spawning grounds or effective spawning. In the early 1990s the possibility that trace element chemistry might be of use in identifying spawning age fish and the frequency of spawning was investigated. The results of the research were considered to be negative, however, a similar study may be worthy of further investigation. Several factors support this including the fact that the SBT otoliths used in the earlier study were from fish that may have been younger than the age of maturity. At that time samples were not available from the Indonesian fishery on the spawning grounds. Therefore, changes in trace element chemistry, notably strontium, may not have been evident due to the fact that the fish sampled may have been too young/small. Furthermore, improvements analytical methods used to measure trace elements may make it feasible to identify previously undetectable elements that are impacted by reproduction.

Isotopes, trace elements and water masses

The water masses of the upper layers of the Java Sea are different from those on the feeding grounds of SBT. These water masses are likely to have unique chemical signatures based on stable isotopes, radioisotopes or trace elements. Studies on a range of fish species have demonstrated that otoliths retain chemical signatures that are characteristic of particular habitats, and it is likely that unique chemical signatures exist for the feeding and spawning habitats of SBT. Development of more sensitive and higher resolution analytical techniques may make recognition of these potential signatures feasible. However, at this time it would be difficult to determine what otolith constituents would be most likely to provide the appropriate information and a significant pilot study would be required. Similar work has been undertaken on Atlantic bluefin tuna in an attempt to resolve the stock hypothesis question on that species. It is important to reinforce the fact that identification of unique signatures and movement between the spawning ground and feeding ground would not necessarily provide conclusive evidence regarding age at maturity, but only evidence of movement between the two grounds.

Potential for Tagging to Reduce Uncertainty in the Age of Maturity

Conventional Tagging

Conventional tagging would appear to provide only limited potential to reduce the current uncertainty in the age of maturity. This is because interpretation of conventional tagging data would depend upon estimates/assumptions about the size selectivities opperating in the spawning and non-spawning fisheries. As the issue of selectivity is considered the primary source of uncertainty in the current data, conventional tagging experiments would appear to offer little potential to resolve the age of maturity for SBT.

Archival and pop-up tags

Both archival and pop-up tags offer the potential to provide quantitative estimates of the age of maturity. This is because they provide the possibility of determining what fraction of the fish tagged went to the spawning grounds in a given year. In theory, they can provide this information over several years. Thus, there are several different sorts of experimental designs that could be considered. For example a large number of sub-adults could be tagged and based on the long term recaptures (or pop-ups) one could look at the proportion of fish that went to the spawning ground at different ages. Alternatively, a large range of fish could be tagged in a given year and the proportion within each size/age class that went to the spawning grounds could be used to estimate the age of maturity. For either approach, care would need to be taken both in the design and analyses to avoid inducing fishery selectivity biases into the estimates (e.g. spawning and not spawned fish may have differential probabilities of being re-captured and fish in some locations/area of a particular age/size may be more likely to spawn).

There are a number of logistical and feasibility considerations that would make such experiments difficult:

1) The number of years for which data can be recorded is limited due to battery life (~5 years at maximum);
2) There is little experience tagging large SBT and specialize gear/procedures may be required to ensure that tagging induced mortality rates are low;
3) Reporting rates are likely to vary among fisheries and would be a substantial confounding effect if it were differential between the spawning and non-spawning ground fishery. This is particularly an issue for the archival tags, but even for pop-up tags, accounting for tags that don't pop-up could be an issue. Thus, ensuring that reporting rates are high and can be estimated may require high observer coverage particularly as the number of tags that are likely to be released would be relatively small.
4) For pop-up tags, there would be no way to obtain direct aging estimates of the age of the fish tagged. This may be a substantial problem with the use of this technology. If large fish are tagged, it would be impossible to determine whether the fish that actually spawned are from younger age classes or smaller fish from older age. The other alternative would be to tag smaller fish for which age can be reliably estimated from their length.

5) For archival tags, obtaining direct age estimates would require collection of the otolith at the time of recapture. Previous experience has shown that this is likely only to be feasible if observers are on board the vessels.
6) Archival and pop-up tags are expensive. The number of tags that may be required to obtain reasonably realiable estimates could be large (particularly if there is a substantive lags between the age at which fish were tagged and the age when fish are fully mature).

Comments on the Estimation of SBT Maturity-at-Age via spawning grounds selectivity estimation

Different tuna fisheries exhibit different selectivities on the SBT spawning grounds:

- deep-set bigeye fisheries tend to catch smaller SBT than the shallow-set yellowfin fisheries
- The Japanese spawning ground fishery that targeted SBT prior to 1970 seems to have caught smaller individuals than the current aggregate Indonesian by-catch fishery.
- Recent Japanese research and training fisheries apparently also catch smaller individuals.
- There is evidence that there are length and age-based components to the probability of a fish being mature

If we had reliable estimates of selectivity in all fisheries, it would be reasonably easy to estimate Maturity-at-age from catch distributions. The difference in estimated abundance on and off the spawning grounds would provide the required estimate (assuming that all fish on the spawning grounds are mature). Two possibilities for estimating selectivity include model-based inferences from population dynamics models, and direct experimental tests. It is not obvious how experiments could be designed because any sampling gear is going to have a specific selectivity. For the model-based approach:

- spawning ground selectivity is potentially highly confounded with maturity
- it is not possible to directly estimate presence of an age group on the spawning ground if the fishery does not catch any of these individuals
- selectivity and maturity must be considered simultaneously in this approach.
- estimation within a population dynamics model is possible, but probably requires some assumptions about the functional form of the maturity-at-age and selectivity (including constraints based on selectivities across adjacent ages, either length-based or otherwise).

Advantages of attempting the estimation:

- provides a unified consistent integration across all the data in the assessment
- should provide an indication of the uncertainty

Disadvantages:

- may be essentially indeterminate
- estimates may be an artifact of the selectivity and maturity functional relation assumptions
- simultaneous estimation of a stock-recruitment curve may also influence the estimated maturity (ie where selectivity and maturity are completely confounded, improved fit to the SR might be attained by altering the maturity). This might contribute substantially and incorrectly to the perceived precision of the maturity/selectivity estimation).

Physiological indicators

	Advantage	Disadvantage
Gonad Index		
	Easy to measure Able to detect spawning potential during preparatory phase (i.e samples from outside of spawning area can be used)	Not very informative Quick resorption (within few weeks) make a detection of spawning experience after completion of spawning season.
Histological examination (yolked oocytes)		
	Certain level of preparation is required but not too much Able to detect spawning potential during preparatory phase (i.e samples from outside of spawning area can be used)	Not very informative (about the same as G.I.) Quick resorption (within few weeks) make a detection of spawning experience after completion of spawning season.
Histological examination (hydrated oocytes/post-ovulatory follicles)		
	Clear evidence of sapwning activities Certain level of preparation is required but not too much	Detectable period is very short (maybe upto 24 hours from spawning event)
Hormone examination		
	Able to detect spawning potential and/or spawning experiences during relatively long time (in several months level)	Collection of blood samples at sea is extremely difficult for tuna (quick congregation, problem in centrifuge on boat etc)

Attachment 5

Summary of indicators of stock status and trends

The purpose of this document is to provide a brief summary of the stock status indicators and trends. These data are independent of any stock assessment models and are drawn from papers #25 presented by Australia, and #34 presented by Japan.

Our goal is to reduce the multitude of indicators to a few pages and a few graphs. To do this we have chosen to only use quantitative measures that we believe may be useful. Thus we have excluded measures such as the density of fish in New South Wales where no quantitative numbers were available at the SAG meeting, and quantitative measures such as the number of areas fished, which is difficult to interpret due to the impacts of quota regulation.

We categorize the indicators into three groups, CPUE trends over time, CPUE trends in the Japanese longline fishery by cohort, and a miscellaneous group including aerial survey, acoustic survey, tagging and growth rates.

CPUE trends over time

Figure 1 shows 6 different CPUE trends, all are nominal fish/1000 hooks. We show ages 4-7, 8-11 and 12+ from the Japanese longline fishery in areas 4-9, CPUE in the New Zealand zone, Taiwanese CPUE and Korean CPUE. Table 1 summarizes the trends in three ways, the ratio of 2000 to 1995 cpue, an index of recent direction; the ratio of 2000 to 1988, an index of performance since the major quota reductions of 1988; and the ratio of 2000 to 1980, 1980 being a common reference year in CCSBT.

Table 1. Trends in CPUE

	Current trend 2000/1995	2000/1988	2000/1980
Japanese 4-7	0.93	3.04	0.79
Japanese 8-11	1.63	1.13	0.29
Japanese Plus Group	0.64	0.36	0.29
New Zealand	0.82	2.51	0.53
Taiwan	2.01	4.17	
Korea	0.39		

Since 1988 all CPUE indices except the plus group in the Japanese longline fishery have increased, in some cases dramatically so, but the decline in the plus group is a serious concern. All indices are lower in 2000 than in 1980, with the Japanese age 4-7 the closest. Trends since 1995 are mixed, with some indices increasing and some decreasing.

We place the most faith in the Japanese longline data as these fleets have been most consistent in fishing patterns over time. The recovery of New Zealand CPUE since 1988 is encouraging since the decline of New Zealand CPUE was one of the indicators of concern in 1988. It is difficult to interpret the contradictory trend of the Taiwanese and Korean CPUE. It is noted that the Taiwanese CPUE includes only data with SBT catch greater than zero.

CPUE trends by cohorts

Figure 2 shows the trend in CPUE by cohort aggregated in groups of 5 cohorts. The result are summarized in Table 2.

Cohorts	CPUE ages 3-5	CPUE ages 6-8
80-85	0.21	0.10
86-90	0.64	0.22
91-96	0.40	0.24

We see the cohorts 1986-1990 were as much as three times more abundant than the 80-85 cohorts at ages 3-5, but by ages 6-8 were only twice as abundant. The 1991-1996 cohorts have been twice as abundant as the 1980-1985 cohorts across all ages. CPUE at ages 3-5 is thought to reflect a combination of recruitment and fishing mortality at ages 1-2. These results indicate the reduced quotas after 1988 have resulted in lower fishing mortality rates, leading to better survival to age 8.

Other indices

Other indices we include are acoustic survey estimates of age 1 fish in western Australia, aerial survey estimates of age 3 in the Great Australian Bight, and tagging estimates of fishing mortality rates. Figure 3 shows these indicators.

The acoustic estimates of age 1 fish off western Australia show a dramatic decline in 2000 and 2001, which is of clear concern, although the survey method is considered experimental.

The aerial index of age 3 abundance is similarly considered of questionable utility, but shows a slightly declining trend. For 1999 and 2000 two estimates are available depending upon how different observers are weighted, and the survey was not conducted in 2001 due to logistic problems.

Tagging estimates of fishing mortality rate are shown as cumulative survival from fishing, and show an increasing trend in fishing mortality at ages 3 and 4 for the 1993 and 1994 cohorts.

Figure 1. Trends in CPUE

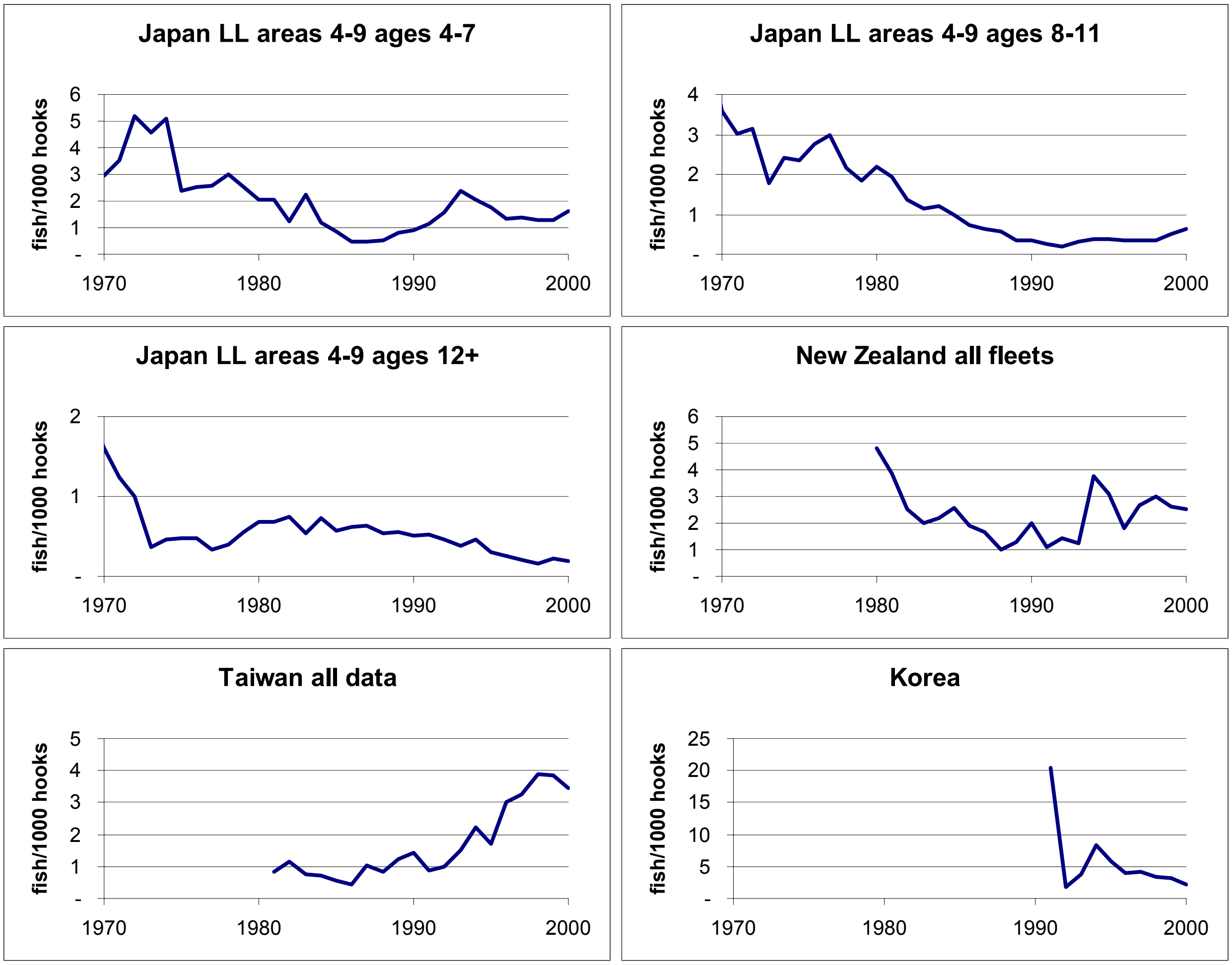


Figure 2. Trends in cohort CPUE.

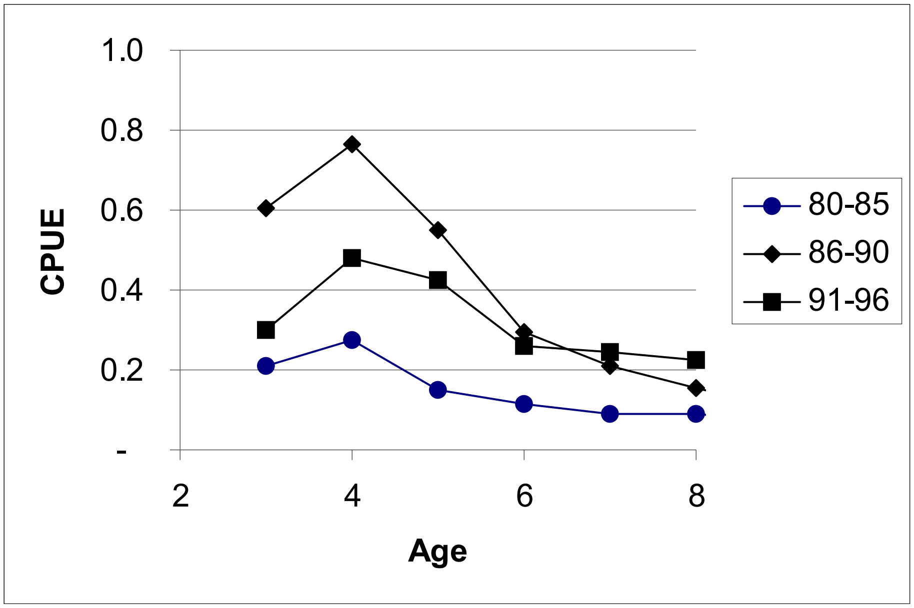
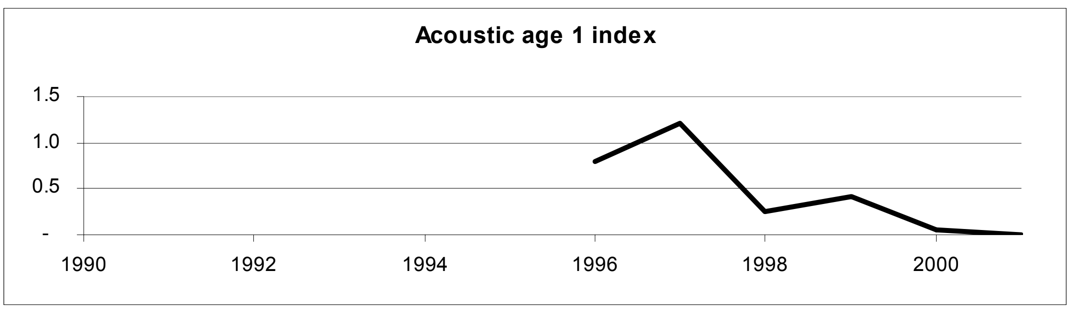
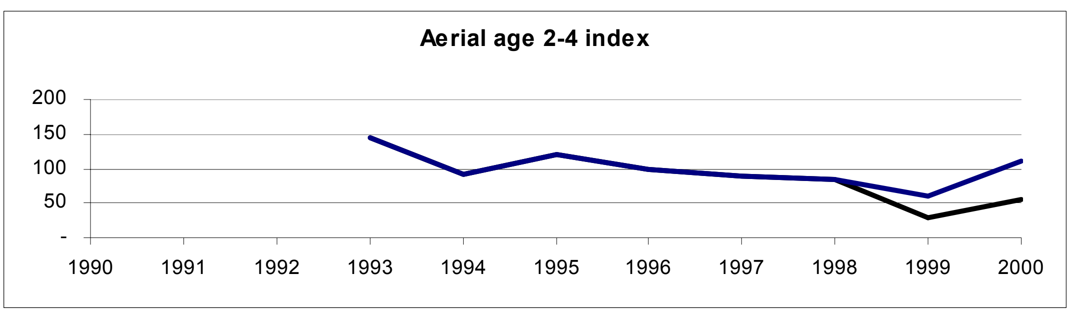
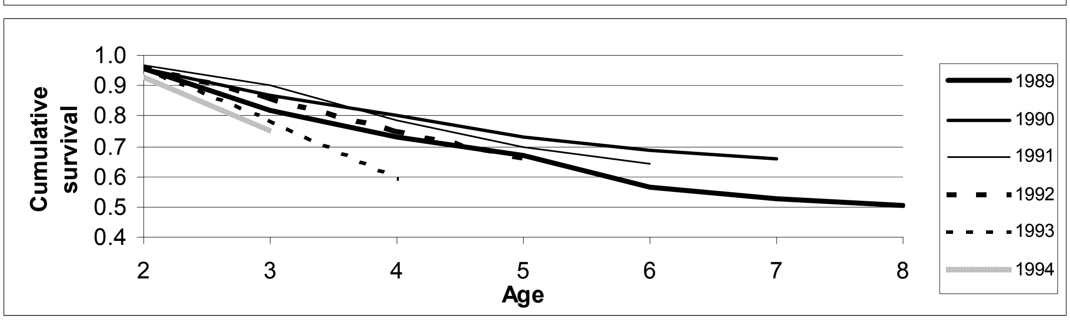


Figure 3. Other indices.



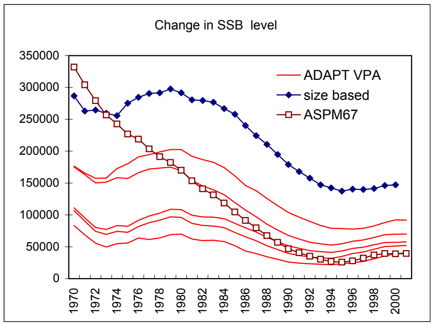


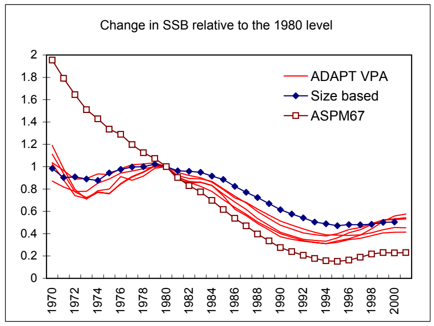


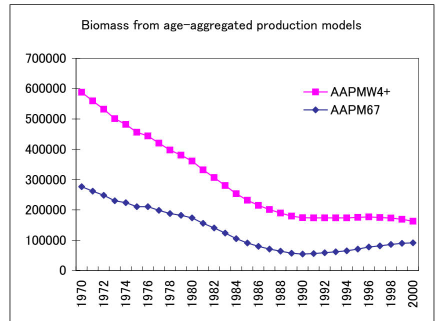
A comparison of assessment results for Australian and Japanese model runs. Australian VPA results shown are the mean weighted results from the Australian preferred set and the Japanese preferred set as defined in 1998. Australian catch-at-age model shows mean and range of preferred model set and data uncertainty. Australian statistical catch-at-age/length model results show range from optimistic and pessimistic models (maximum likelihood estimates) with input data uncertainty. Japanese ADAPT VPA cases include C1J08, C4J08, C5J08, C6J08. Japanese production model cases are A6-7w0.8 and W4W0.8.

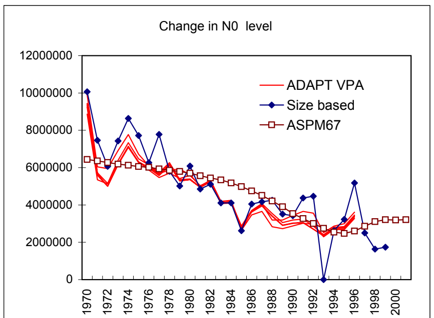
	Australia			Japan			
	Adapt VPA	Statistical catch-at-age	Statistical catch-at-length (and age)	Adapt VPA	Length VPA	Age structured production model	Production model
Spawning stock biomass							
2000/1980	0.31-0.43	0.29 (0.11-0.51)	0.17-0.76	0.41-0.53	0.50	0.23	0.45-0.52
2000/1988	0.43-0.70	0.47 (0.21-0.74)	0.49-1.21	0.73-0.99	0.70	0.58	0.86-1.43
2000/1998	0.91-1.02	0.99 (0.75-1.10)	0.91-1.21	1.07-1.11	1.04	1.05	0.94-1.06
Age 12+ biomass							
2000/1980	0.31-0.42	0.28 (0.11-0.48)	0.15-0.79	0.31-0.62	0.48	0.12	
2000/1988				0.44-0.69	0.53	0.25	
2000/1998				0.94-1.37	1.00	0.94	
Age 8-11 biomass							
2000/1980	0.38-0.44	0.43 (0.17-0.70)	0.40-0.96	0.48-0.60	0.55	0.52	
2000/1988				1.17-1.53	1.28	2.27	
2000/1998				1.02-1.30	1.11	1.12	
Age 5-7 Biomass							
2000/1980	0.41-0.43	0.26 (0.05-0.56)	0.23-0.63	0.46-0.52	0.26	0.48	
2000/1988				1.90-1.92	1.23	3.09	
2000/1998				0.75-0.90	0.63	0.70	

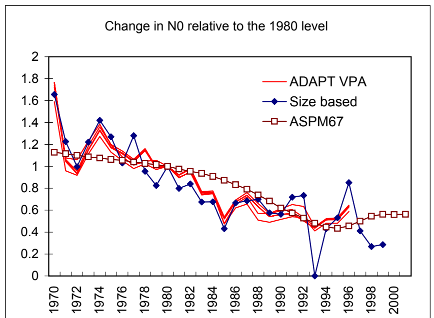
Summary of Japanese prefered results of assesments.

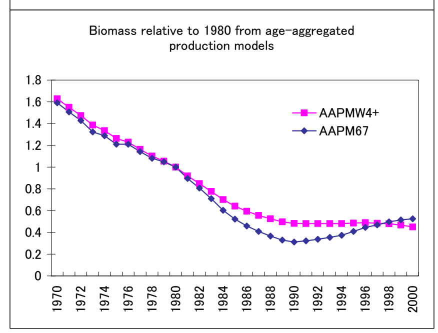


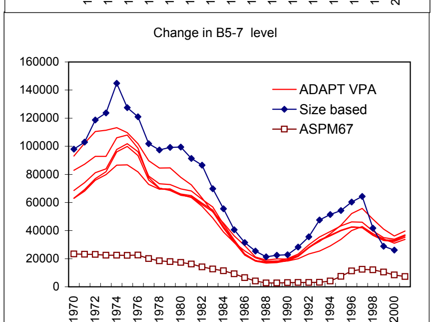


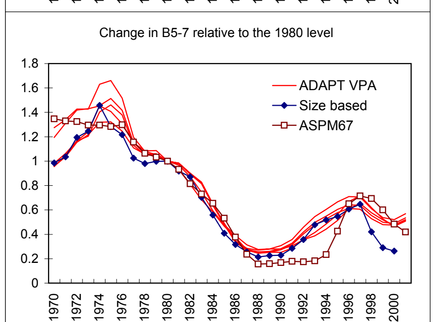


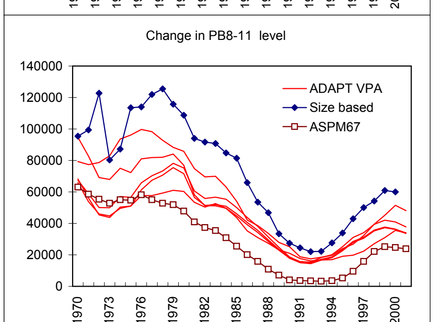


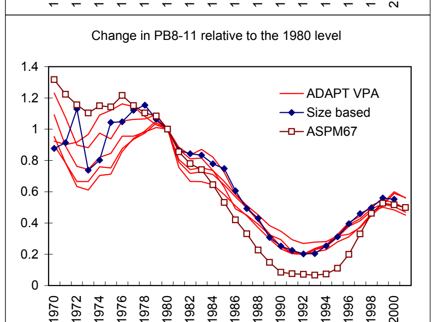


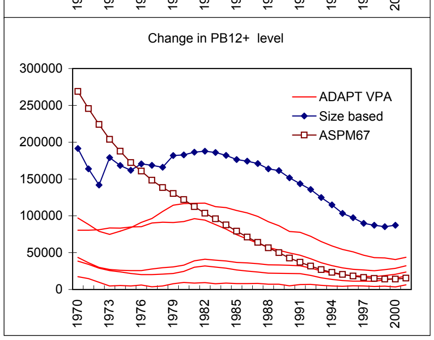


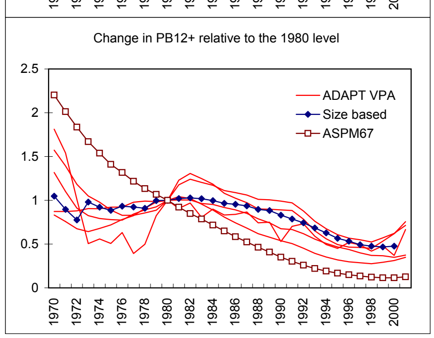








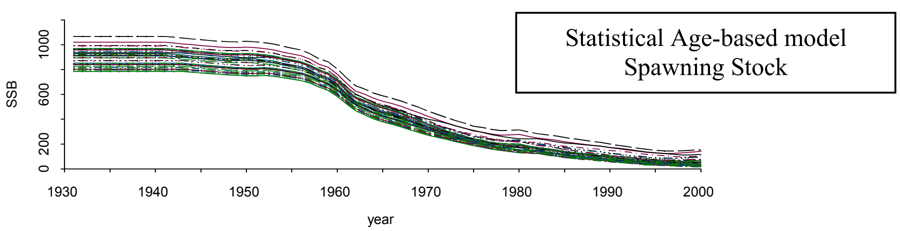


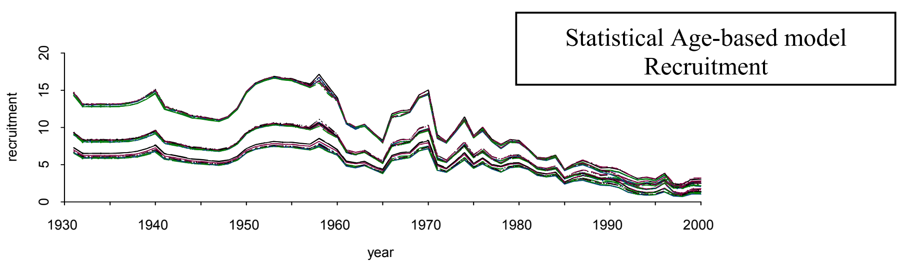


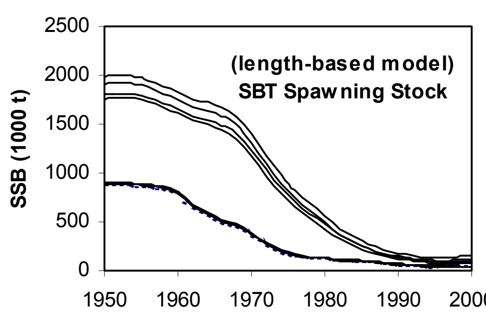
Summary of Australian SBT stock assessment results 2001.

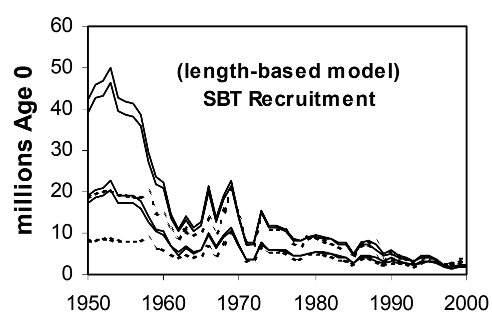
The table below provides a summary of the results from the stock assessments presented by Australia. The two statistical models are considered to provide a more reliable basis for assessing the SBT stock as agreed in the SAG. The plots below show the range of estimates of recruitment and spawning stock biomass from the two statistical models.

Reference Point	ADAPT VPA	Statistical Catch-at-age	Statistical Catch-at-age/length
SSB 2000 : SSB unfished	0.13 - 0.19	0.06 (0.02 – 0.14)	0.04 – 0.11
SSB 2000 : SSB 1980	0.31 - 0.43	0.29 (0.11 – 0.51)	0.17 - 0.76
SSB 2000 : SSB 1988	0.43 – 0.70	0.47 (0.21 – 0.74)	0.49 – 1.21
SSB 2000 : SSB 1998	0.91 – 1.02	0.99 (0.75 – 1.10)	0.91 – 1.21
Recr 1991-95 : 1976-80	0.48	0.36 (0.27-0.49)	0.42 – 0.65
Proportion of the current catch that would give 50% probability of fishing mortality rate < reference rate $F_{TY0.1}$	0.35 – 0.60	0.73	-
Proportion of the current catch that would give 50% probability of fishing mortality rate < reference rate $F_{TY0.2}$	0.33 – 0.60	0.50	-









Notes:

- The VPA results are the mean weighted results from the Australian preferred set and the Japanese preferred set as defined in 1998. These preferred sets represent each party's best assessment in 1998. Weightings include convergence, delegation input weight and the lack of fit weight. (see CCSBT/SC/0108/20)
- SSB unfished refers to the spawning stock biomass pre-exploitation. SSB 1960 is used in place of SSB unfished in the VPA results.
- Statistical Catch-at-age model shows mean and range for the data set uncertainty in CCSBT/SC/0108/19. Statistical catch-at-age/length model results show range from optimistic and pessimistic models (maximum lilkelihood estimates) with input data uncertainty. (see CCSBT/SC/0108/13)

Attachment 7

Meeting of CPUE modelling Group, 0900-1000h 25/8/2001-08-25

Workshop

The aim was to discuss ideas that might form the basis of the work of the proposed inter-sessional workshop on this subject. Members were asked to indicate their availability for such a workshop and initial responses are shown at appendix A.

Review of new results and proposed approaches.

Statistical Approaches.

It was noted that most of the reported approaches seemed to refine existing trends in CPUE rather than suggesting markedly different trends. An exception was the CART results in Paper 30. It would be interesting to examine why these were different. It was also noted that two of the statistical assessment models had suggested changes in catchability and hence changes in effective effort at size or age. This and other results suggested including age or size in the modelling might be helpful. Possibly multivariate approaches might help

Possible concomitant variables and better understanding of the catching process.

It was noted that if anything high catchability was found at the beginning rather than at the end of the Japanese Long Line CPUE time series and this contradicted the usual assumptions of increasing efficiency of effort with improvements in technology. Consequently, considerations of concomitant variables such as by-catch levels, numbers of hooks per set, operating patterns of fishermen and behaviour of fish might be helpful. Hence we need to identify additional information that needs to be obtained and analysed either at the workshop or, recognising problems of data confidentiality, prior to a workshop (by Japanese scientists in the case of the Japanese Long Line data). Information on fish behaviour via archival tags might also illuminate problems such as the lower selection of larger fish in the long line catches.
There is obviously a need to refine a list of the data and analysis requirements for the proposed Workshop and this might be attempted in the margins of the SC next week.

Other CPUE sets.
It was considered that it would be very helpful to develop other CPUE time-series. In particular it would be helpful to develop a series for the Taiwanese fisheries. It would be highly desirable to develop a CPUE index or its proxy for the Indonesian fishery on the SBT spawning area. However, this seems less likely to emerge at present.

Appendix A

CPUE Workshop

John Pope	Probably not 2001
Tom Polacheck	Not 2001, not March-July 2002
Dale Kolody	Not December 2001-January 2002
Talbot Murray	Schedule for 2002 not clear
Jim Ianelli	Schedule for 2002 not clear
Doug Butterworth Susan Holloway	2001 mid December only possibility 2002 January-February difficult, committed to IWC Sometime in April
Sachiko Tsuji	Not available during January-March 2002
Sung-Kwon Soh	Not but let us know the date
Ana Parma	Not 2001