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Extension of the 2009 SCRS Meeting to Consider the Status of Atlantic Bluefin Tuna Populations with Respect to CITES Biological Listing Criteria

Madrid, Spain, October 21-23, 2009

1. Opening of the meeting and arrangements

The meeting was opened by Mr. Driss Meski, Executive Secretary, who welcomed participants. He thanked them and their organizations for their efforts to participate in this meeting which had been planned on short notice. Mr. Meski highlighted the relevance of the meeting to the work of ICCAT as a whole. Dr. Powers (Chair) also welcomed participants and stressed the need to focus on the terms of reference (Appendix 12 to the 2009 SCRS Report), given the short duration of the meeting.

The Agenda is attached as **Appendix 1** and the List of Participants is attached as **Appendix 2**.

The items in this Report do not necessarily follow the Agenda. The following served as Rapporteurs for various subjects:

Opening and closing: Secretariat
Document summaries: G. Diaz
CITES Criteria: J. Neilson
Analyses and results for the East: J.-M. Fromentin and G. Diaz
Analyses and results for the West: S. Cass-Calay and G. Diaz

2. Documents presented at the meeting

A number of documents were presented to the Committee that included stock projections, estimation of parameters relevant to the CITES criteria (e.g., virgin stock biomass, productivity) and other information relevant to the Terms of Reference for the meeting.

SCRS/2009/193 presented estimates of productivity of Atlantic bluefin tuna, *Thunnus thynnus* (BFT). The author pointed out that for many stocks it is difficult to estimate natural mortality. In the case of BFT, tagging experiments were unsuccessful in estimating natural mortality. For stock assessment purposes, estimates of natural mortality used by the SCRS were obtained from other similar species. Therefore, in the case of BFT, estimating productivity using only natural mortality can lead to wrong conclusions. Another approach to estimate productivity is to use the S-R relationship (shape and slope). However, S-R relationships are uncertain for both bluefin tuna stocks. Given the limitations just explained, the author used potential population growth rate (r’) as a way to estimate productivity. The document concluded that there is a large difference between the productivity of both stocks which is mostly based on the difference in age of maturity and that the productivity of eastern BFT is close to that of North Atlantic swordfish. The authors also compared growth between species. However, The Committee discussed the difficulties in comparing K among species because it is highly correlated with L_∞ and t_0. The conclusion of the document is that eastern BFT can be considered as a medium productivity stock and the western BFT as a low productivity stock. It was pointed out that age of maturity might depend on levels of exploitation, which could explain the differences observed between the stocks. But, in the case of the eastern stock, no change in age of maturity was observed in the last 40 years. If changes in age of maturity occurred due to exploitation then they might have happened at an earlier time. It was also pointed out that the perceived differences in life history between both stocks could be the result of thousands of year of some level of exploitation. The

Committee also discussed that growth was estimated from stocks that that are being heavily exploited and therefore it might not reflect the true growth of the population. It was also noted that calculation of r' were quite different from other estimates that were available to the Committee. However, it was pointed out that the information to estimate r' was obtained from parameter values published in scientific literature. The document concluded that given the differences in productivity between both stock of Atlantic bluefin tuna, a threshold of 15% (upper level of low productivity species and lower level of medium productivity species) therefore seems most appropriate.

Documents SCRS/2009/194,195 and 196 presented VPA results and projections for both BFT stocks. In the case of the eastern stock, projection scenarios included catch levels (reported and 'inflated'), 3 levels of steepness (0.5, 0.75, 0.99), 2 time series of recruitment, and with both perfect implementation and a 20% implementation error of TACs implemented by [Rec. 08-05]and three additional catch levels (i.e., 15,000 t, 8,500 t, and 0 t). For the western stock, projections were run using the TACs implemented by [Rec. 08-04] and additional levels of catch (i.e., 1,500 t, 1,000 t, 500 t, and 0 t). In the case of the eastern stock, the stock will further decline under the [Rec. 08-05] management scenario in most of the cases assuming a steepness of 0.5, but will increase with higher levels of steepness. Catches of 15,000 t or 8,000 t were projected to result in different levels of SSB increases depending on the assume steepness. Projections for the western stock showed catches of 1,800 t (Rec. 08-04) or lower will result in increases of the SSB. The median SSB increase by year 2018 estimated by combining all scenarios was 7.2% for the eastern stock and 10.6% for the western stock. Diagnostic plots showed that for the case of steepness 0.5 the model did not fit the observed data and that the estimated SSB0 values with this steepness were unrealistically high. Therefore, the Committee decided not to include the scenario of steepness=0.5 in future projections. The Committee also discussed if carrying capacity K was taken into consideration in the estimation of SSB0 in the context that ecosystem changes might alter historical values of K. There was a general agreement that K is inherently taken into consideration in the S-R relationship used. The Committee also discussed that, in the case of the Eastern stock, a great number of scenarios were considered and all were given equal weighting and that it might be necessary to reduce the number by excluding the less plausible ones. The Committee also agreed in maintaining both scenarios of full implementation of management regulations and a 20% implementation error as it was not up to this Committee to choose one scenario over the other. Finally, the Committee agreed to perform a detailed review of inputs and methodologies used by the authors of the three documents to verify that the estimated parameters are compatible.

SCRS/2009/197 described how to apply the criteria to marine exploited species. The document used ratios of biomass gain/loss as a proxy for product ivy and it concluded that Atlantic bluefin tuna is a low productivity species. The Committee discussed that mortality in the age range of 30-40 year is most probably higher than for ages 10-30; therefore using the same M=0.1 for all ages 10+ might lead to biased results. However, it was pointed out that the stock has very low numbers of fish in the ages 30+ and therefore they have very little influence in the estimation of overall biomass ratios.

SCRS/2009/198 presented updated CPUE series of BFT in Moroccan Atlantic traps estimated using a GLM approach with a negative binomial error assumption. Results indicated that the factors year and trap were highly statistically significant. Estimated CPUE series showed what the authors hypothesized to be a 13 yr abundance cycle. The average CPUE for the period after the second peak (2002-2009) is 2.4 times higher than the one of the first period (1989-1996). The study also highlights the increasing trend in the abundance (in number) of the bluefin tuna spawners migrating from eastern Atlantic to the Mediterranean since 2004. This upward trend in the CPUEs has been accompanied by an increase in the mean weight (Idrissi and Abid, SCRS/2009/176). The Committee discussed the possibility of abiotic (e.g. temperature) and biotic (e.g. prey availability) factors affecting the availability of fish to the traps. The Committee recognized the importance of the work, but it agreed that the results presented could not be taken into consideration into further consideration without also considering all other BFT CPUE time series.

Although not submitted as a SCRS document, the Committee also discussed the document titled 'Supplementary information to the draft proposal to CoP15 to include bluefin tuna (*Thunnus thynnus*) on Appendix I of CITES as proposed by Monaco' authored by A. Silfvergrip. Using an estimated harmonic mean of M, and estimates of age of maturation, generation time, population growth rate and K obtained from scientific literature, and comparing these values with standards established by the FAO and the American Fisheries Society (AFS) the author concluded that that Atlantic bluefin tuna is a low productivity species. The author also recognized that bluefin tuna has a high fecundity, but indicated that low productivity species with high fecundity is not uncommon among marine species.

3. Discussion of CITES Criteria

Mr. David Morgan (representing the CITES Secretariat) gave the Committee an introduction to CITES and the process for amending its Appendices, with special reference to commercially exploited aquatic species (see http://www.cites.org/eng/res/09/09-21R13.shtml). In brief, a species is to be considered for listing under Appendix 1 if at least one of the following criteria is met:

A. The wild population is small, and is characterized by at least one of the following:
   - i) an observed, inferred or projected decline in the number of individuals or the area and quality of habitat; or
   - ii) each subpopulation being very small; or
   - iii) a majority of individuals being concentrated geographically during one or more life-history phases; or
   - iv) large short-term fluctuations in population size; or
   - v) a high vulnerability to either intrinsic or extrinsic factors

B. The wild population has a restricted area of distribution and is characterized by at least one of the following:
   - i) fragmentation or occurrence at very few locations; or
   - ii) large fluctuations in the area of distribution or the number of subpopulations; or
   - iii) a high vulnerability to either intrinsic or extrinsic factors; or
   - iv) an observed, inferred or projected decrease in any one of the following:
     - – the area of distribution; or
     - – the area of habitat; or
     - – the number of subpopulations; or
     - – the number of individuals; or
     - – the quality of habitat; or
     - – the recruitment.

C. A marked decline in the population size in the wild, which has been either:
   - i) observed as ongoing or as having occurred in the past (but with a potential to resume); or
   - ii) inferred or projected on the basis of any one of the following:
     - – a decrease in area of habitat; or
     - – a decrease in quality of habitat; or
     - – levels or patterns of exploitation; or
     - – a high vulnerability to either intrinsic or extrinsic factors; or
     - – a decreasing recruitment.

The discussions of The Committee are summarized by criterion below. The majority of the considerations of the Committee focused on the third criterion.

Small Wild Population

The Committee discussed what the meaning of "small population" was in the CITES context. It was noted that while the CITES Annex Five (Resolution Conf. 9.24 (Rev. CoP14)) contains some examples of small populations, those guidelines were not necessarily developed with commercially-exploited aquatic species in mind. During the 2008 stock assessment, the SCRS estimated that the eastern stock included about 5 million individuals in 2007 (among which about 1,000,000 were spawners), while the western stock was about 10 times lower than the eastern one.

The question of effective population size was considered, and it was noted that a recent study of Mediterranean bluefin tuna was completed that compared genetic diversity from 1911 to 1926 to more contemporary (1999– 2007) samples (Riccioni *et al.* 2009, SCRS/2009/186). Those authors concluded that there was no loss of genetic diversity over the period examined. Their estimates of effective genetic population size (Ne) were in the order of 400-700 individuals, which would translate, from a genetic perspective, into subpopulation size estimates (obtained from genetic variation and empirical data for marine species) on the order of 10^6-10^7 (SCRS/2009/186). An estimate of effective population size is not available for the population as a whole. However, the Committee noted that genetic diversity can remain high for a considerable length of time, even when the population is at a low level of abundance.

The Committee concluded that Atlantic bluefin tuna probably could not be characterized as "small", in an absolute abundance sense.

Restricted Area of Distribution

Although the Atlantic bluefin tuna population is managed as two stocks, separated by the 45°W meridian, its population structure remains poorly understood and needs to be further investigated. Recent genetic and microchemistry studies as well as work based on historical fisheries tend to indicate that the Atlantic bluefin tuna population structure is complex. There have been documented disappearances and re-appearances of population components in both the east and west Atlantic (for a recent review of the spatial structure of Atlantic bluefin tuna, see Fromentin 2009). The Committee agreed that the spatial distribution of Atlantic bluefin tuna can be generally considered to be wide.

Marked Decline in Population Size

A participant asked if the "three generation" time frame would apply to Atlantic bluefin tuna in terms of defining recent declines in the CITES context. Mr. Morgan explained that for Atlantic bluefin tuna, as a commercially-exploited aquatic species in the CITES context, a 10-year period should be used. It was also clarified that both the historical extent of decline and recent rate of decline, as related to the criteria for CITES Appendix I for commercially exploited aquatic species, must be looked at in reference to the baseline population size or biomass.

The Committee then discussed the definition of the historical baseline, and enquired what the interpretation of CITES was. CITES Secretariat responded that there was no single view concerning this, and proponents and interested parties typically make a choice on a case-by-case basis. Some participants recalled that the Terms of Reference were that virgin biomass should be defined using the longest time frame that is possible. It was further noted that the Terms of Reference included both estimated virgin biomass and the highest observed value. The Committee noted the difficulty of defining B_0, and returned to this issue in other discussions.

The CITES Secretariat was asked to expand on the concept that "recent decline" could be observed as ongoing or as having occurred in the past (but with a potential to resume). Under the situation where there was a very low probability of a resumption of a decline, would a historical decline therefore still be of significance? It was clarified that in the CITES criteria, the historical decline is the primary criterion, and remains of key significance, regardless of available information on more recent declines, or the potential for a decline to resume or reverse.

The Committee enquired how CITES dealt with uncertainty in estimates of stock status in commercially exploited marine species. The CITES representative noted that Atlantic bluefin tuna had complete information relative to other species that have been included in the CITES Appendices in the past, and its experience with stock status advice that contained estimates of uncertainty was limited. The meeting Chair noted that the intent of the current meeting was to generate information on stock status that included measures of uncertainty.

4. Evaluation of Decline

4.1 Methods

All of the calculations made by the Committee were based on the results of the 2008 stock assessments of eastern and western Atlantic bluefin. Details of the assessment are contained in ICCAT Col. Vol. Sci. Pap. 64(1): 1-352.

The calculations aimed to estimate "decline" with regards to Annexes 2 and 5 of the CITES listing criteria. This was done:

1. From a historical perspective by comparing current (2009) population size (as measured by SSB) against both (a) unexploited population size, and (b) the maximum historical population size estimated in the stock assessment. (Note: the last year in the assessment was 2007, which means that the 2009 year was estimated from a projection of the assessment results).

2. From a future perspective by comparing future (2019) population size (as measured by SSB) against either (a) unexploited population size or (b) the maximum historical population size estimated in the stock assessment, and (c) by comparing population size in 2019 against that in 2009.

Besides some graphical displays, the results were couched primarily in terms of the probability that SSB was below 10%, 15% or 20% of the baseline (SSB_o or max[SSB_t]). These probabilities were calculated on the basis of the bootstrap results from the stock assessments and projections. In some cases, the probabilities of combined scenarios were calculated with equal weighting.

Stock-specific details about the methods used are given below.

4.1.1 Western stock

The 2008 "base case" stock assessment was used. The Committee considered that the two different methods used in the 2008 assessment for calculating the stock recruitment relationships (SRR) (so-called "high" and "low" recruitment scenarios, **Figure 1**) would be the basis for calculating SSB_o (which would be the SSB resulting from a long-term projection at F=0 using the VPA 2-Box software). The "high recruitment" scenario reflects a hypothesis that potential productivity has shown no trend over the assessment period; the latter reflects the hypothesis that productivity potential has shifted to a lower level after the late 1970s.

In the projections, the 2008 catch was set to 2,015t. Two management scenarios were considered: One following the TACs established in Rec. [08-04], and another one setting the catches in 2010 and after equal to 0. Perfect implementation was assumed for both scenarios.

4.1.2 Eastern stock

The Committee reviewed the approaches explained in SCRS/2009/194 to estimate the stock-recruitment relationship. Both approaches fix the steepness of the SRR and are fitted to the estimated

SSB and R observations (for either a subset of years or for the entire time series). The method requires the calculation of SSB/R at F=0, which can be done in two different ways. The Committee preferred the approach based on equilibrium per-recruit computations.

The BFTE assessment of 2008 considered three different steepness values (0.5, 0.75 and 0.99) and three different sets of SSB-R observations which coincided with periods of "low", "medium" or "high" recruitment: 1970-1980, 1970-2002, and 1990-2002, respectively.

A closer examination of the fitted relationships (**Figure 2**) indicated that the steepness=0.5 scenarios could not be supported by the observations, because the amount of catches that would have had to occur historically for the stock size to be at such low levels would have been huge. However, this does not correspond with our current knowledge about BFTE fisheries in the past 200 years. On the other hand, a steepness of 0.99 would also be difficult to justify on biological grounds, especially because it would imply very strong density dependence among young stages. For these reasons, the Committee decided to present all results, but to focus on the steepness=0.75 as the "base case".

The 2008 stock assessment was conducted using two catch data sets. One used the reported catches, and the other one used catches adjusted to reflect the estimated quantity of unreported and illegal fishing up to 2007 (the last year in the assessment). In terms of projections, for the scenarios that use reported catch, the 2008 catch was set to 23,850 t; for the scenarios that use adjusted catches, the 2008 catch was set to 34,120 t.

Thirty-six projections were made for the following combinations, assuming that catches in 2009 and thereafter would follow the TACs in Rec. [08-05]:

3 steepness levels (0.5, 0.75, 0.99)
2 recent catch levels in the VPA (reported or adjusted)
3 periods of SSB-R observations for the SRR (1970-1980, 1970-2002, and 1990-2002)
2 implementation levels (perfect, and 20% overages, as was assumed in 2008)

In addition, the Committee agreed that it would be useful to provide ICCAT with additional advice that reflects the management recommendations made by SCRS in 2009. For this reason, additional scenarios were considered with 2010-2019 catches of 15,000t (approximating an F_{max} strategy), 8,500t (approximating an $F_{0.1}$ strategy), and zero catches, with the "base case" steepness and the three recruitment levels, and perfect implementation.

4.2 Evaluation for the western stock

The described tables were constructed for the two 2008 western Atlantic bluefin base models, low and high recruitment (**Table 1**). For projection purposes, only two future catch levels were examined, 1) “perfect implementation” of Rec. 08-04 (1,900 t in 2009, 1,800 t in 2010 with 1,800 t carried forward until 2019 and 2) projection of zero catch allowed after 2009.

It is evident that the results of the analysis are dependent on the baseline chosen. If the maximum value of SSB during 1970-2007 is selected, the results suggest that the probability that the stock is at <10%, <15% or <20% of maximum SSB is 8%, 30% and 54%, respectively. Since the estimate of max SSB is not affected by the recruitment assumption, the results are identical for the high and low recruitment scenarios **(Table 1)**. If the SSB at unfished condition (SSB_0) is selected as the baseline, the probability that the stock is at <10%, <15% or <20% of SSB is 30%, 93% and 96% (respectively) for the low recruitment scenario. The high recruitment scenario indicates a near 100% probability that the stock is below 10% of SSB_0 **(Table 1)**. It should be noted that max SSB is a lower threshold (45,000 t) than SSB_0 (80,000 to 221,000 t).

The potential for improvement during the next ten years is also summarized in **Table 1**. Assuming perfect compliance of Rec. 08-04 and subsequent TACs of 1,800 t, the probability that SSB in 2019 will remain below 20% of either baseline is less than 15% for the low recruitment model. For the high recruitment model, the result is strongly dependent on the baseline selected. The probability that SSB in 2019 will remain below 20% of max SSB is 9% and the probability that SSB in 2019 will be below 20% of SSB_0 is 95%. However, in all cases the results indicate it is very unlikely that depletion will continue. In more than 99% of the model realizations SSB in 2019 was predicted to be greater than SSB in 2009. Not surprisingly, the potential to recover to levels above 20% of the baseline is near 100% if no catches are allowed after 2009.

After reviewing the probability tables for the western stock **(Table 1)** the Committee agreed that they only provide a 'snapshot' of the stock status and do not reflect the fact that the western stock has been 'overexploited' but stable for the past 2 decades (i.e., the stock has remained relatively stable at low levels of abundance; **Figure 3**). It was also recognized that although the tables might be difficult to interpret, they reflect the scientific uncertainty associated with the estimated probabilities. It was recognized that the Commission should be precautionary in the interpretation of the projections since past projections of stock status have proven overly optimistic.

The Committee also discussed the merit of producing probability tables that combined results from both recruitment scenarios. Combined advice would imply equal likelihood of both recruitment models. In past, the Committee has been unwilling to assign likelihoods for the recruitment scenarios, therefore implying that both scenarios were considered to be equally plausible. Therefore the Committee agreed not to include combined probabilities.

Both calculations of the baseline (max SSB and SSB0) have limitations. It was noted that maximum SSB was estimated from a time series that started in 1970 while there were periods of large catches in the 1960s. Therefore the short time series could give a false impression of the magnitude of maximum SSB (i.e. underestimated). The Committee also recognized that there is high uncertainty in the estimates of SSB_0 (median = 80,000 t when low recruitment is assumed, 221,000 t with high recruitment) while the estimate of max SSB is independent of our assumptions regarding recruitment scenarios. Therefore, the Committee recognized the need to include both baseline parameters, and interpret them with caution.

4.3 Evaluation for the eastern stock

The Committee reviewed the probability tables that included the results of 54 separate scenarios of different steepness and recruitment assumptions (**Appendix 3**). It was noted that different assumptions of steepness and recruitment levels produce very different estimates of virgin spawning stock biomass (SSB_0), ranging from about 825 thousand t to 2.81 billion t. The Committee emphasized that not all the values in the range are plausible and the wide range is the result of uncertainty in the assumption of steepness.

The probability tables included values for all the scenarios comparing SSB_{2009} and projected SSB_{2019} against three different proportions (benchmarks) of the SSB_0 and maximum SSB (0.1, 0.15, and 0.2), and the probabilities of $SSB_{2019} < SSB_{2009}$, an indication of future SSB decline or increase.

Time series of the ratios SSB_{year}/SSB_0 showed that, in most cases, the SSB of Eastern BFT was low throughout the time series (**Figure 4**). The Committee discussed particular cases where projected probabilities seemed to be inconsistent with the probabilities from the historical time series. However, it was pointed out that such perceived inconsistencies could be explained by the fact that uncertainty increases in projections and by the confidence intervals not being symmetrical around the median values.

The Committee agreed to consider the runs with an assumed steepness of 0.75 as base cases, since the runs with steepness = 0.5 resulted in implausible estimates of SSB_0 and the runs with a steepness value of 0.99 was thought not to reflect the biology of the species well (see **Appendix 3** for results of the last two cases). The Committee agreed, however, to present results for three recruitment scenarios (low, medium, and high) because they are all considered to be equally plausible (**Table 2**). The estimated SSB_0 for the three recruitment regimes under the 0.75 steepness assumption ranged from 1.0 to 11.7 million t. The probability of SSB_{2009} being lower than 0.15 max SSB were about 19% for the case of reported catches and approximately 23% for the adjusted catches. In both cases, these results were the same for the three recruitment scenarios (low, medium, and high). The probabilities with respect to $SSB_{2009} < 0.15SSB_0$ were between approximately 0.88 and 1.0 depending on the recruitment scenario. In the case of projections, the probability of $SSB_{2019} < 0.15$ max SSB ranged from 0.27 to 0.43 while the probability of $SSB_{2019} < 0.15SSB_0$ ranged from 0.67 to 1.0. Combined probabilities for the steepness 0.75 cases are presented in **Table 2**.

A complete set of estimated probabilities for the assumption of steepness of 0.75 are presented in **Table 2.**

Figure 4 illustrates the time series of the ratios of SSB_{year} / SSB_0 or / max SSB, with the three recruitment scenarios. Under the 0.75 and 0.99 steepness assumptions, the population is projected to increase, whereas under the steepness assumption of 0.5, the population declines **(Figure 4a)**. **Figure 4b** depicts the lowest and highest SSB_0 values resulting from assuming a steepness of 0.99 and low recruitment, and a steepness of 0.5 and high recruitment, and are meant to bracket the range of possibilities examined by the Committee.

5. Recommendations

5.1 Western Atlantic Bluefin Tuna

SCRS recommendations relative to ICCAT management objectives:

From the 2009 Executive Summary BFTW:

" In 2008, the Commission recommended a total allowable catch (TAC), inclusive of dead discards, of 1,900 t in 2009 and 1,800 t in 2010 [Rec. 08-04]. These TAC levels were projected to have a 75% chance of meeting the lower rebuilding targets under the "low recruitment" scenario (BFTW-Table 1), but less than a 50% chance of meeting the higher target under the "high recruitment scenario". As noted in 2008, the TAC should be lower if the assessment is positively biased or if there is management implementation error (both of which have occurred in the past). Analyses conducted during the Joint ICCAT - Canada Precautionary workshop as well as two subsequent analyses reviewed by the Committee (SCRS/2008/089, SCRS/2008/175) suggested that the projections made during past assessments were too optimistic. This is reinforced by the observation that, halfway through the rebuilding program, biomass was still below what it was at the beginning. Accordingly, the Committee continues to strongly advise against an increase in TAC."

SCRS summary conclusions relative to CITES criteria:

Small population and restricted area of distribution criteria (Criteria A and B)
The wild population of Western Atlantic Bluefin is not considered small (estimated numbers greater than 170,000 individuals ages 1 and older in 2008), nor is its distribution restricted (distributed throughout the Atlantic).

Marked decline in the population size criteria (Criteria C)
Consistent with the previous assessment and with the above management recommendations spawning biomass was estimated and expressed relative to measures of historical abundance. As noted above, actual observations of long term historical abundance are not available since data are limited to post-1970. Therefore, estimated long term potential spawning stock biomass (referred to as SSB_0 or more

simply B_0) was computed. However, there are two hypotheses about what that long term potential might be, as referenced by the "high recruitment scenario" and the "low recruitment scenario," above (see Section 4.1). The former reflects a hypothesis that potential productivity has shown no trend over the assessment period; the latter reflects the hypothesis that productivity potential has shifted to a lower level after the late 1970s. Note that uncertainties in the rate of historical decline as measured relative to SSB_0 mostly reflect uncertainties in the estimation of SSB_0 rather than in SSB_{2009}. Therefore, in addition to these hypotheses, the Committee evaluated spawning biomass relative to the maximum estimated during the period 1970-2009 (maximum $SSB_{1970\text{-}2007}$). Note that the estimates of long term potential spawning biomass are not estimates of historical biomass *per se*, but what the stock size might be if there were no fishing; conversely the maximum biomass only reflects historical abundance in the context of the post-1970 period and does not reflect higher abundances that probably occurred prior to 1970 in view of the high catches in the 1960s. These were the alternatives used to determine "historical abundance" (baseline) for CITES criteria.

There is a high probability (greater than 90%) that SSB in 2009 is less than 15% of long term potential (i.e. the probability that SSB_{2009} is less than 0.15 times SSB_0 is greater than 90%). The probability that SSB_{2009} is less than 15% of the maximum SSB estimated since 1970 is about 30%; and there is about a 54% chance that it is less than 20% of maximum $SSB_{1970\text{-}2007}$ **(Table 1)**.

If there were no catches in the years 2010 through 2019, there is a 63% chance that the SSB in 2019 would be less than 20% of the long term potential as measured by the "high recruitment" hypothesis; but if the "low recruitment" hypothesis were to be true, then the stock in 2019 is almost certain to be above 20% of long term potential. It is also almost certain that the stock in 2019 would be above 20% of maximum $SSB_{1970\text{-}2007}$, if there were no catches **(Table 1)**.

If there is perfect implementation of [Rec. 08-04] through the year 2019, projections indicate that it is almost certain that the stock will be higher in 2019 than it is in 2009 for both recruitment scenarios considered **(Table 1)**.

5.2 Eastern Atlantic Bluefin Tuna

SCRS recommendations relative to ICCAT management objectives:

From the 2009 Executive Summary BFTE:

" To address the various sources of uncertainties in the scientific diagnosis, especially regarding the data quality and availability, the Committee has investigated different quantitative approaches and it has considered a variety of scenarios for the projections. On this basis, the best advice of the Committee is currently to follow an $F_{0.1}$ (or another adequate F_{MSY} proxy) strategy to rebuild the stock, because such strategies appear much more robust than [Rec. 06-05] and possibly to [Rec. 08-05] (according to preliminary analyses) to a wide range of uncertainties about the data, the current status and future productivity. These strategies would imply much lower catches during the next few years (on the order of 15,000 t or less), but the long-term gain could lead to catches of about 50,000 t with substantial increases in spawning biomass. For a long lived species such as bluefin tuna, it will take some time (> 10 years) to realize the benefit."

SCRS summary conclusions relative to CITES criteria:

Small population and restricted area of distribution criteria (Criteria A and B)
The wild population of Eastern Atlantic Bluefin is not considered small (estimated numbers greater than 3 million individuals of ages 1 and older in 2008), nor is its distribution restricted (distributed throughout the Atlantic and Mediterranean).

Marked decline in the population size criteria (Criteria C)
As with the Western Atlantic Bluefin, “historical abundance” of Eastern Atlantic Bluefin Tuna was evaluated using both long term potential SSB_0 and the maximum observed over the period 1970-2007. However, long term potential SSB_0 of Eastern Atlantic BFT is even less well defined than that in the West. Therefore, as noted above the assessment incorporated various scenarios of productivity and catch history **(Table 2)**.

Based upon these analyses:

- There is a 96% probability that SSB in 2009 is less than 15% of long term potential (i.e. the probability that SSB_{2009} is less than 0.15 times SSB_0 is greater than 96%). The probability that SSB_{2009} is less than 15% of the maximum SSB estimated since 1970 is about 21% (see **Table 2** which also includes estimated probabilities of the stock being below other thresholds, including 20%).

- Projections indicate that perfect implementation of [Rec. 08-05] through the year 2019 will result in more than a 85% chance that SSB_{2019} will be less than 15% of long term potential, SSB_0. There is a 35% chance that SSB_{2019} will be less than 15% of the maximum $SSB_{1970\text{-}2007}$ **(Table 2)**.

- If there is imperfect implementation of [Rec. 08-05] through the year 2019 (in the order of 20% overages), then there is a 91% chance that SSB_{2019} will be less than 15% of long term potential, SSB_0. There is a 49% chance that SSB_{2019} will be less than 15% of the maximum $SSB_{1970\text{-}2007}$ **(Table 2**).

- If catches were to be kept at 15,000 t annually from 2010 to 2019 then there is a 78% chance that SSB_{2019} will be less than 15% of long term potential, SSB_0. There is a 24% chance that SSB_{2019} will be less than 15% of the maximum $SSB_{1970\text{-}2007}$ **(Table 2)**.

- If catches were to be kept at 8,500 t annually from 2010 to 2019 then there is a 66% chance that SSB_{2019} will be less than 15% of long term potential, SSB_0. There is a 9% chance that SSB_{2019} will be less than 15% of the maximum $SSB_{1970\text{-}2007}$ **(Table 2)**.

- If there were no catch from 2010 to 2019 then there is a 48% chance that SSB_{2019} will be less than 15% of long term potential, SSB0. There is a 0% chance that SSB2019 will be less than 15% of the maximum SSB1970-2007 **(Table 2)**.

- Projections indicate that perfect implementation of [Rec. 08-05] through the year 2019 will result in a 39% chance that the biomass in 2019 will be less than the biomass in 2009 **(Table 2)**.

- If there is imperfect implementation of [Rec. 08-05] through the year 2019 (in the order of 20% overages), then there is a 58% chance that the biomass in 2019 will be less than the biomass in 2009 **(Table 2)**.

- If catches were to be kept at 15,000 t annually from 2010 to 2019 then there is a 26% chance that SSB2019 will be less than SSB2009 **(Table 2)**.

- If catches were to be kept at 8,500 t annually from 2010 to 2019 then there is a 7% chance that SSB_{2019} will be less than SSB_{2009} **(Table 2)**.

5.3 Combined Eastern and Western Bluefin Tuna

The Committee has long used a stock definition in which management boundaries separate the Western Atlantic Bluefin from the Eastern Atlantic and Mediterranean. The Commission is familiar with this approach for both management and assessments. Additionally, this approach is consistent with precautionary management when stock identification is uncertain. Because of this, the Committee did not evaluate Eastern and Western BFT combined.

However, it has also been long noted that some BFT move across the management boundary between East and West and that because of that movement and the difference in size of the stocks (East being much larger than the West), then fisheries in the East might impact the population of BFT in the West.

6. Other matters

The delegate of Japan mentioned that his delegation would seek clarification during the 2009 Commission meeting about the rules of procedure to follow with respect to reports that have not been yet discussed by the Commission. The Secretariat noted that it has been common practice in recent years to post reports of inter-sessional meetings on the ICCAT Web Site once they are adopted by the Committee, unless instructed not to do so. Because of the controversial and politically-charged nature of the issues discussed at this meeting, the Chairman asked participants to consider refraining from distributing this report outside ICCAT before the Commission had an opportunity to read and discuss it.

7. Report adoption and closure

The report was adopted during the meeting. It will be annexed to the 2009 SCRS Report for consideration by the Commission. The Chair thanked all participants for their hard work. The meeting was closed.

This formally concluded the 2009 SCRS sessions.

References

Fromentin, J.-M. 2009. Lessons from the past: investigating historical data from bluefin tuna fisheries. Fish and Fisheries 10: 197–216.

Table 1. Probability of BFTW spawning stock biomass (SSB) being less than 10%, 15% or 20% of the baseline in 2009 and 2019. In A), the baseline is estimated by the maximum SSB in the time series, and in B) it is estimated by SSB_0. Projections are made with perfect compliance of Rec. [08-04] as well as with zero catch in 2010 and thereafter. Also tabulated, the probability of further decline (SSB 2019 < SSB 2009) and the median estimate of maximum SSB, or the median SSB_0, (from the 500 model realizations).

A)	**Historical Decline-probability of SSB_{2009}**			**10-Year projection (probability of SSB_{2019})**					
Recruitment	**<0.10 max SSB**	**<0.15 max SSB**	**<0.20 max SSB**	**TAC**	**<0.10 max SSB**	**<0.15 max SSB**	**<0.20 max SSB**	**$<SSB_{2009}$**	**Median Max SSB**
Low	0.088	0.298	0.542	[08-04]	0.004	0.016	0.056	0.000	45,390
High	0.088	0.300	0.542	[08-04]	0.012	0.038	0.090	0.014	45,390
Low	NA	NA	NA	0 t	0.000	0.000	0.000	0.000	45,390
High	NA	NA	NA	0 t	0.000	0.000	0.000	0.000	45,390

B)	**Historical Decline-probability of SSB_{2009}**			**10-Year projection (probability of SSB_{2019})**					
Recruitment	**$<0.10\ SSB_0$**	**$<0.15\ SSB_0$**	**$<0.20\ SSB_0$**	**TAC**	**$<0.10\ SSB_0$**	**$<0.15\ SSB_0$**	**$<0.20\ SSB_0$**	**$<SSB_{2009}$**	**Median SSB_0**
Low	0.302	0.926	0.996	[08-04]	0.006	0.036	0.152	0.000	79,969
High	0.996	1.000	1.000	[08-04]	0.544	0.848	0.952	0.014	220,948
Low	NA	NA	NA	0 t	0.000	0.000	0.000	0.000	79,969
High	NA	NA	NA	0 t	0.096	0.298	0.626	0.000	220,948

Table 2. Probability (base case) of BFTE spawning stock biomass (SSB, referred to as simply B, below) being less than 10%, 15% or 20% of the baseline in 2009 and 2019. In A), the baseline is estimated by SSB_0, and in B) it is estimated by the maximum SSB in the time series. Projections are made for different scenarios as explained in Section 4.1. Also tabulated, the probability of further decline (SSB 2019 < SSB 2009).

A)

				Historical Decline (probability)					10-Year projection (probability)				
Run	Steep	Rmax	Catch	$B_{2009}<0.10B_o$	$B_{2009}<0.15B_o$	$B_{2009}<0.20B_o$	Implem.	TAC	$B_{2019}<0.10B_o$	$B_{2019}<0.15B_o$	$B_{2019}<0.20B_o$	$B_{2019}<B_{2009}$	deterministic virgin SSB (million t)
4	0.75	low	report.	0.64	0.89	0.97	perfect	[08-05]	0.58	0.72	0.83	0.53	1.00
5	0.75	med	report.	0.99	1.00	1.00	perfect	[08-05]	0.69	0.87	0.95	0.37	2.19
6	0.75	high	report.	1.00	1.00	1.00	perfect	[08-05]	0.99	1.00	1.00	0.29	11.70
13	0.75	low	adjust	0.66	0.88	0.96	perfect	[08-05]	0.54	0.67	0.76	0.48	1.00
14	0.75	med	adjust	0.99	1.00	1.00	perfect	[08-05]	0.68	0.84	0.93	0.36	2.46
15	0.75	high	adjust	1.00	1.00	1.00	perfect	[08-05]	0.99	1.00	1.00	0.32	6.15
22	0.75	low	report.	0.65	0.90	0.97	20% err	[08-05]	0.76	0.85	0.91	0.80	1.00
23	0.75	med	report.	0.99	1.00	1.00	20% err	[08-05]	0.81	0.93	0.98	0.58	2.19
24	0.75	high	report.	1.00	1.00	1.00	20% err	[08-05]	0.99	1.00	1.00	0.44	11.70
31	0.75	low	adjust	0.67	0.88	0.96	20% err	[08-05]	0.69	0.77	0.86	0.71	1.00
32	0.75	med	adjust	0.99	1.00	1.00	20% err	[08-05]	0.77	0.88	0.95	0.52	2.46
33	0.75	high	adjust	1.00	1.00	1.00	20% err	[08-05]	0.99	1.00	1.00	0.45	6.15
37	0.75	low	report.				perfect	15,000	0.44	0.59	0.74	0.34	1.00
38	0.75	med	report.				perfect	15,000	0.58	0.80	0.93	0.24	2.19
39	0.75	high	report.				perfect	15,000	0.99	1.00	1.00	0.18	11.70
40	0.75	low	adjust				perfect	15,000	0.42	0.55	0.68	0.35	1.00
41	0.75	med	adjust				perfect	15,000	0.58	0.77	0.89	0.24	2.46
42	0.75	high	adjust				perfect	15,000	0.99	1.00	1.00	0.20	6.15
43	0.75	low	report.				perfect	8,500	0.21	0.34	0.50	0.09	1.00
44	0.75	med	report.				perfect	8,500	0.37	0.63	0.86	0.07	2.19
45	0.75	high	report.				perfect	8,500	0.97	1.00	1.00	0.06	11.70
46	0.75	low	adjust				perfect	8,500	0.23	0.34	0.45	0.09	1.00
47	0.75	med	adjust				perfect	8,500	0.40	0.67	0.83	0.06	2.46
48	0.75	high	adjust				perfect	8,500	0.98	1.00	1.00	0.05	6.15
49	0.75	low	report.				perfect	0	0.03	0.09	0.17	0.00	1.00
50	0.75	med	report.				perfect	0	0.13	0.34	0.63	0.00	2.19
51	0.75	high	report.				perfect	0	0.93	0.99	1.00	0.00	11.70
52	0.75	low	adjust				perfect	0	0.03	0.08	0.18	0.00	1.00
53	0.75	med	adjust				perfect	0	0.16	0.41	0.68	0.00	2.46
54	0.75	high	adjust				perfect	0	0.97	0.99	1.00	0.00	6.15
Steepness 0.75 [08-05] all runs				0.88	0.96	0.99			0.79	0.88	0.93	0.49	
Steepness 0.75[08-05] perfect impl.: Runs 4-6 & 13-15				0.88	0.96	0.99			0.75	0.85	0.91	0.39	
Steepness 0.75 [08-05] 20% error: Runs 22-24 & 31-33				0.88	0.96	0.99			0.84	0.91	0.95	0.58	
15,000 perfect impl.: Runs 37-42									0.67	0.78	0.87	0.26	
8,500 perfect impl.: Runs 43-48									0.53	0.66	0.77	0.07	
0 perfect impl.: Runs 49-54									0.37	0.48	0.61	0.00	

B)

				Historical Decline (probability)					10-Year projection (probability)				
Run	Steep	Rmax	Catch	B_{2009}<0.1 maxB	B_{2009}<0.15 maxB	B_{2009}<0.20 maxB	Implem.	TAC	B_{2019}<0.10 maxB	B_{2019}<0.15 maxB	B_{2019}<0.20 maxB	$B_{2019}<B_{2009}$	VPA maximum SSB (t)
4	0.75	low	report.	0.09	0.19	0.32	perfect	[08-05]	0.40	0.43	0.48	0.53	296,944
5	0.75	med	report.	0.09	0.19	0.32	perfect	[08-05]	0.31	0.33	0.36	0.37	296,944
6	0.75	high	report.	0.09	0.19	0.32	perfect	[08-05]	0.25	0.27	0.29	0.29	296,944
13	0.75	low	adjust	0.09	0.23	0.35	perfect	[08-05]	0.39	0.41	0.45	0.48	308,609
14	0.75	med	adjust	0.09	0.23	0.35	perfect	[08-05]	0.33	0.34	0.36	0.36	308,609
15	0.75	high	adjust	0.09	0.23	0.35	perfect	[08-05]	0.28	0.31	0.33	0.32	308,609
22	0.75	low	report.	0.10	0.20	0.33	20% err	[08-05]	0.58	0.61	0.65	0.80	296,944
23	0.75	med	report.	0.09	0.20	0.32	20% err	[08-05]	0.48	0.50	0.52	0.58	296,944
24	0.75	high	report.	0.09	0.20	0.32	20% err	[08-05]	0.39	0.41	0.43	0.44	296,944
31	0.75	low	adjust	0.10	0.24	0.36	20% err	[08-05]	0.54	0.58	0.62	0.71	308,609
32	0.75	med	adjust	0.10	0.23	0.35	20% err	[08-05]	0.44	0.46	0.48	0.52	308,609
33	0.75	high	adjust	0.10	0.23	0.35	20% err	[08-05]	0.39	0.41	0.43	0.45	308,609
37	0.75	low	report.				perfect	15,000	0.27	0.29	0.33	0.34	296,944
38	0.75	med	report.				perfect	15,000	0.20	0.22	0.26	0.24	296,944
39	0.75	high	report.				perfect	15,000	0.17	0.18	0.19	0.18	296,944
40	0.75	low	adjust				perfect	15,000	0.28	0.32	0.35	0.35	308,609
41	0.75	med	adjust				perfect	15,000	0.22	0.24	0.26	0.24	308,609
42	0.75	high	adjust				perfect	15,000	0.18	0.21	0.23	0.20	308,609
43	0.75	low	report.				perfect	8,500	0.10	0.11	0.13	0.09	296,944
44	0.75	med	report.				perfect	8,500	0.08	0.09	0.10	0.07	296,944
45	0.75	high	report.				perfect	8,500	0.06	0.07	0.09	0.06	296,944
46	0.75	low	adjust				perfect	8,500	0.09	0.11	0.13	0.09	308,609
47	0.75	med	adjust				perfect	8,500	0.07	0.09	0.11	0.06	308,609
48	0.75	high	adjust				perfect	8,500	0.06	0.08	0.09	0.05	308,609
49	0.75	low	report.				perfect	0	0.00	0.01	0.02	0.00	296,944
50	0.75	med	report.				perfect	0	0.00	0.01	0.01	0.00	296,944
51	0.75	high	report.				perfect	0	0.00	0.01	0.01	0.00	296,944
52	0.75	low	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
53	0.75	med	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
54	0.75	high	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
Steepness 0.75 [08-05] all runs				0.10	0.21	0.33			0.40	0.42	0.45	0.49	
Steepness 0.75[08-05] perfect impl.: Runs 4-6 & 13-15				0.09	0.21	0.33			0.32	0.35	0.38	0.39	
Steepness 0.75 [08-05] 20% error: Runs 22-24 & 31-33				0.10	0.22	0.34			0.47	0.49	0.52	0.58	
15,000 perfect impl.: Runs 37-42									0.22	0.24	0.27	0.26	
8,500 perfect impl.: Runs 43-48									0.08	0.09	0.11	0.07	
0 perfect impl.: Runs 49-54									0.00	0.00	0.01	0.00	

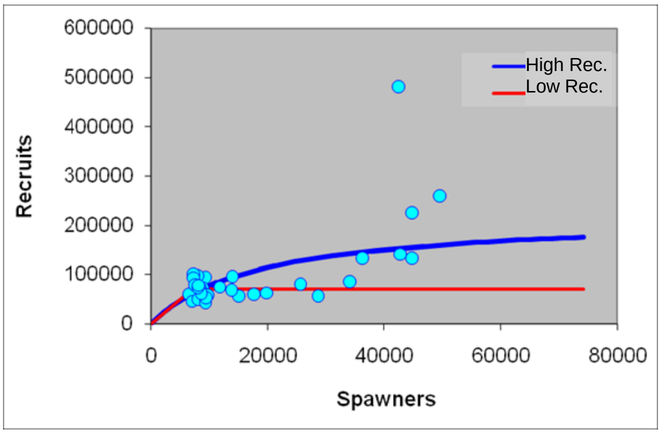

Figure 1. The spawner-recruit relationships assumed for western Atlantic bluefin: The two-line ("low recruitment") and Beverton and Holt ("high recruitment").

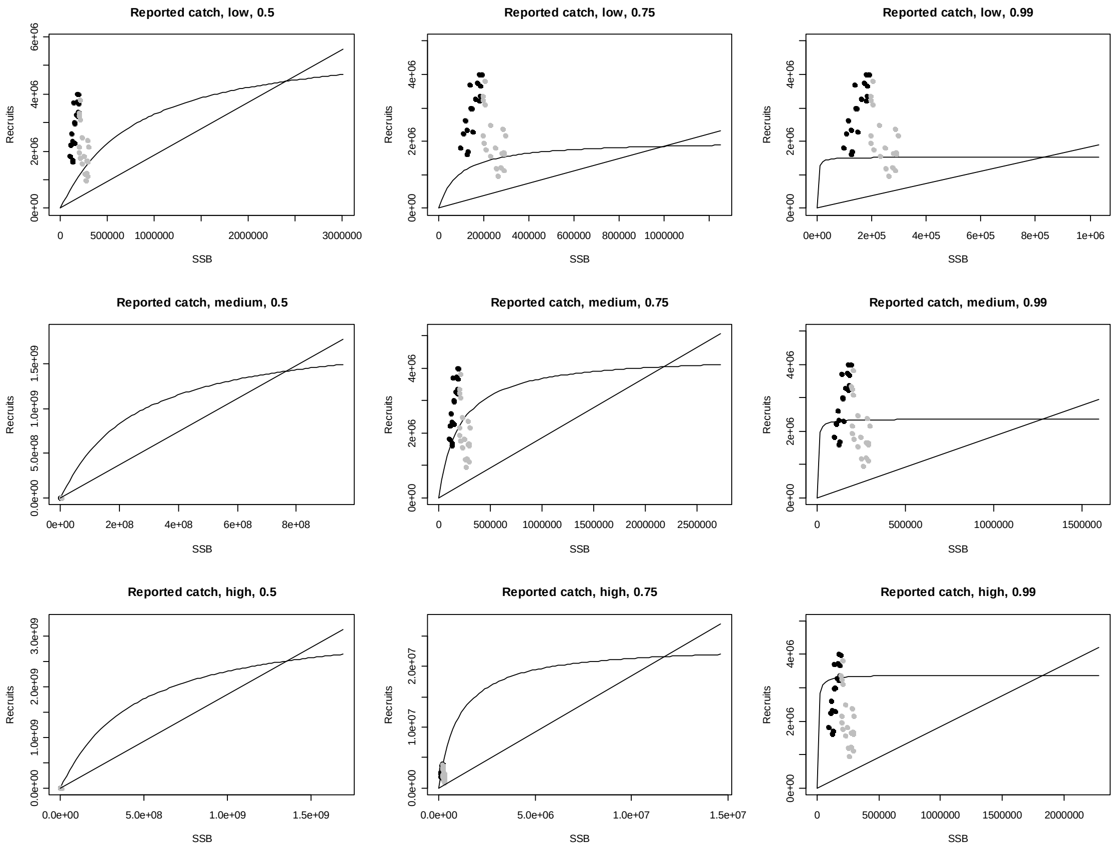

Figure 2. Assumed stock-recruitment relationships for BFT-E. Top row: fitted using 1970-1980 data ("low recruitment"); middle row: using 1970-2002 data ("medium recruitment"); bottom row: using 1990-2002 data ("high recruitment"). The left, center and right-hand-side columns correspond to steepness values of 0.5, 0.75 and 0.99, respectively. The data points are the estimated SSB-R data (gray=1970-1989; dark=1990-2002). The straight line is the replacement line at F=0, i.e., a line with slope equal to the inverse of $[SSB/R]_{F=0}$. Its intersection with the stock-recruitment relationship defines SSB_0 and R_0, the theoretical equilibrium biomass and recruitment under unfished conditions.

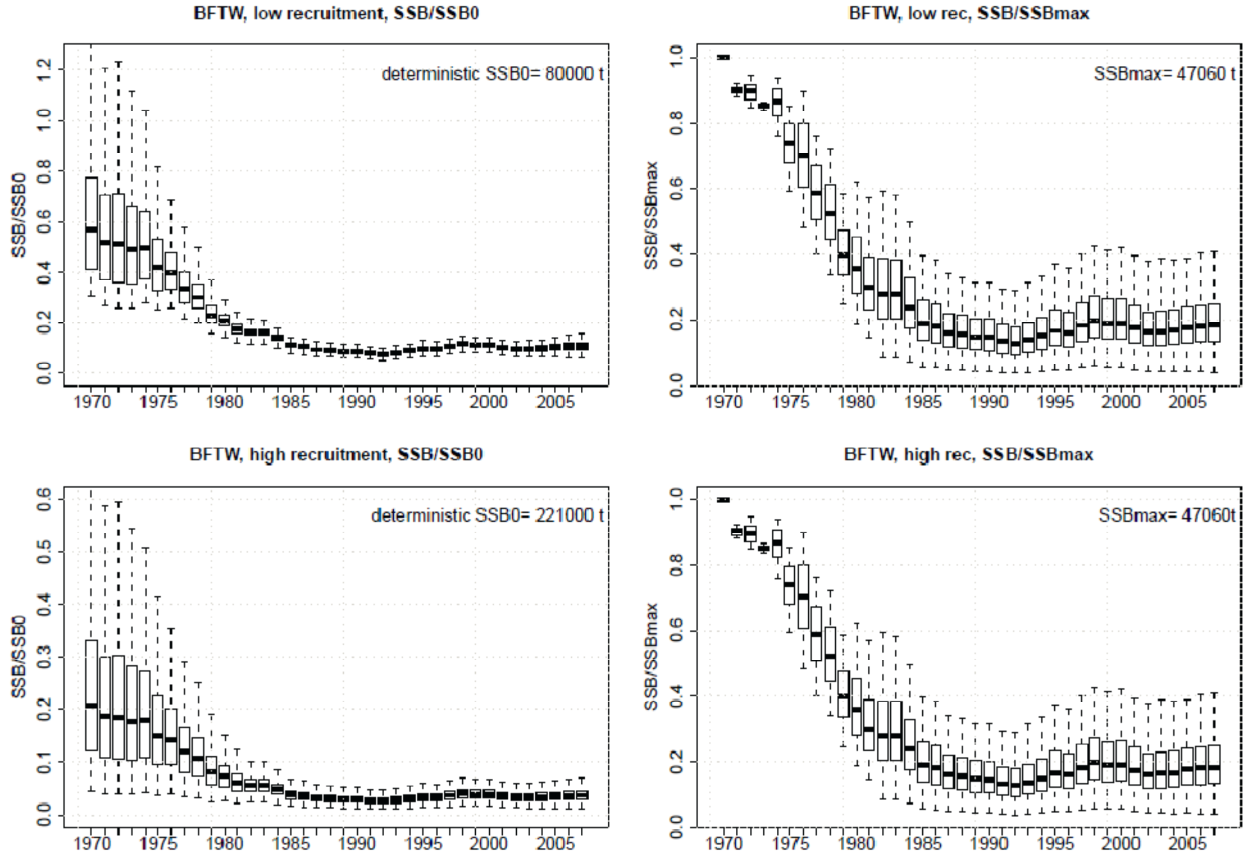

Figure 3. Trends in SSB relative to different baselines for BFTW. Top row: low recruitment scenario; bottom row: high recruitment scenario. Left hand side: baseline calculated by SSB_0, depending on the assumed stock-recruitment relationship. Right hand side: baseline calculated as maximum observed SSB in the time series. The boxes contain the central 50% of the observations and the whiskers 95%.

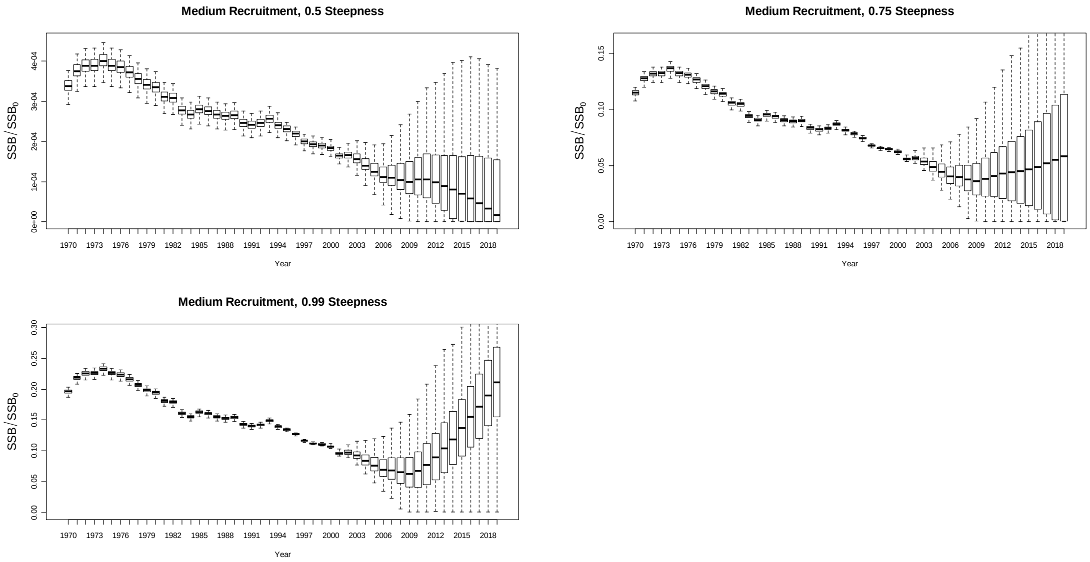

Figure 4a. Trends in spawning biomass for BFT-E relative to the baseline biomass estimated with different assumptions (note that the Y-axis scale differs between the various panels). The baseline is SSB_0 estimated with assumed steepness values of 0.5, 0.75 and 0.99, and using all of the SSB-R observations. The boxes contain the central 50% of the observations and the whiskers 95%.

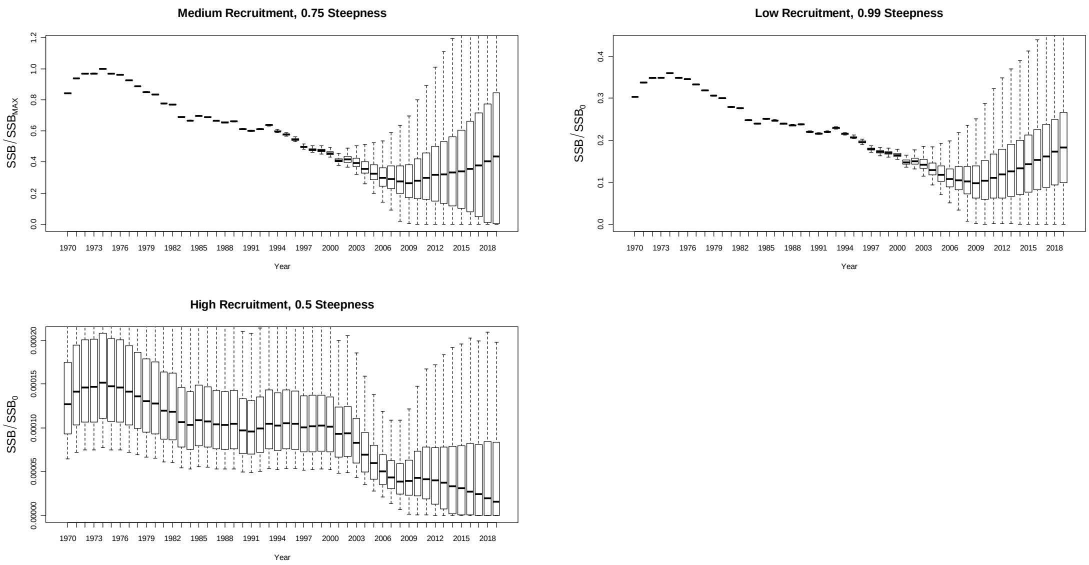

Figure 4b. Trends in spawning biomass relative to the baseline. The upper left panel uses the maximum SSB in the historical time series as the baseline. The two other panels correspond to the lowest and highest SSB_0 values resulting from assuming a steepness of 0.99 and low recruitment, and a steepness of 0.5 and high recruitment. The boxes contain the central 50% of the observations and the whiskers 95%.

Appendix 1

Agenda

1. Opening of the meeting and arrangements
2. Discussion of CITES Criteria
    2.1 Concepts
    2.2 Examples
3. Evaluation of the status of bluefin with regards to CITES Appendix I
    3.1 Eastern Bluefin
    3.2 Western Bluefin
4. Evaluation of the status of bluefin with regards to CITES Appendix II
    4.1 Eastern Bluefin
    4.2 Western Bluefin
5. Recommendations
6. Other matters
7. Report adoption and closure

Appendix 2

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Appendix 3

Complete calculations for BFTE

The tables show the estimated probability of BFTE spawning stock biomass (SSB, referred to as simply B, below) being less than 10%, 15% or 20% of the baseline in 2009 and 2019. In A), the baseline is estimated by SSB_0, and in B) it is estimated by the maximum SSB in the time series. Projections are made for different scenarios as explained in Section 4.1. Also tabulated, the probability of further decline (SSB 2019 < SSB 2009). The last column provides the baseline.

A)

				Historical Decline (probability)					10-Year projection (probability)				
Run	**Steep**	**Rmax**	**Catch**	**B_{2009}<0.10B_o**	**B_{2009}<0.15B_o**	**B_{2009}<0.20B_o**	**Implem.**	**TAC**	**B_{2019}<0.10B_o**	**B_{2019}<0.15B_o**	**B_{2019}<0.20B_o**	**B_{2019}<B_{2009}**	**deterministic virgin SSB (million t)**
1	0.5	low	report.	0.99	1.00	1.00	perfect	[08-05]	0.93	0.98	1.00	0.78	2.40
2	0.5	med	report.	1.00	1.00	1.00	perfect	[08-05]	1.00	1.00	1.00	0.73	766.00
3	0.5	high	report.	1.00	1.00	1.00	perfect	[08-05]	1.00	1.00	1.00	0.73	1352.67
4	0.75	low	report.	0.64	0.89	0.97	perfect	[08-05]	0.58	0.72	0.83	0.53	1.00
5	0.75	med	report.	0.99	1.00	1.00	perfect	[08-05]	0.69	0.87	0.95	0.37	2.19
6	0.75	high	report.	1.00	1.00	1.00	perfect	[08-05]	0.99	1.00	1.00	0.29	11.70
7	0.99	low	report.	0.51	0.79	0.92	perfect	[08-05]	0.25	0.40	0.56	0.16	0.83
8	0.99	med	report.	0.82	0.95	0.98	perfect	[08-05]	0.09	0.23	0.45	0.03	1.28
9	0.99	high	report.	0.94	0.99	0.99	perfect	[08-05]	0.03	0.09	0.26	0.01	1.83
10	0.5	low	adjust	0.98	1.00	1.00	perfect	[08-05]	0.87	0.95	0.98	0.70	2.35
11	0.5	med	adjust	1.00	1.00	1.00	perfect	[08-05]	1.00	1.00	1.00	0.67	971.34
12	0.5	high	adjust	1.00	1.00	1.00	perfect	[08-05]	1.00	1.00	1.00	0.67	2810.90
13	0.75	low	adjust	0.66	0.88	0.96	perfect	[08-05]	0.54	0.67	0.76	0.48	1.00
14	0.75	med	adjust	0.99	1.00	1.00	perfect	[08-05]	0.68	0.84	0.93	0.36	2.46
15	0.75	high	adjust	1.00	1.00	1.00	perfect	[08-05]	0.99	1.00	1.00	0.32	6.15
16	0.99	low	adjust	0.53	0.76	0.91	perfect	[08-05]	0.27	0.38	0.50	0.14	0.84
17	0.99	med	adjust	0.86	0.97	1.00	perfect	[08-05]	0.07	0.21	0.41	0.02	1.43
18	0.99	high	adjust	0.98	1.00	1.00	perfect	[08-05]	0.02	0.09	0.32	0.00	2.18
19	0.5	low	report.	0.99	1.00	1.00	20% err	[08-05]	0.96	0.99	1.00	0.92	2.40
20	0.5	med	report.	1.00	1.00	1.00	20% err	[08-05]	1.00	1.00	1.00	0.87	766.00
21	0.5	high	report.	1.00	1.00	1.00	20% err	[08-05]	1.00	1.00	1.00	0.87	1352.67
22	0.75	low	report.	0.65	0.90	0.97	20% err	[08-05]	0.76	0.85	0.91	0.80	1.00
23	0.75	med	report.	0.99	1.00	1.00	20% err	[08-05]	0.81	0.93	0.98	0.58	2.19
24	0.75	high	report.	1.00	1.00	1.00	20% err	[08-05]	0.99	1.00	1.00	0.44	11.70
25	0.99	low	report.	0.52	0.80	0.92	20% err	[08-05]	0.50	0.64	0.77	0.50	0.83
26	0.99	med	report.	0.82	0.95	0.98	20% err	[08-05]	0.28	0.48	0.69	0.12	1.28
27	0.99	high	report.	0.94	0.99	0.99	20% err	[08-05]	0.10	0.26	0.54	0.03	1.83
28	0.5	low	adjust	0.98	1.00	1.00	20% err	[08-05]	0.92	0.96	0.99	0.84	2.35
29	0.5	med	adjust	1.00	1.00	1.00	20% err	[08-05]	1.00	1.00	1.00	0.79	971.34
30	0.5	high	adjust	1.00	1.00	1.00	20% err	[08-05]	1.00	1.00	1.00	0.79	2810.90
31	0.75	low	adjust	0.67	0.88	0.96	20% err	[08-05]	0.69	0.77	0.86	0.71	1.00
32	0.75	med	adjust	0.99	1.00	1.00	20% err	[08-05]	0.77	0.88	0.95	0.52	2.46
33	0.75	high	adjust	1.00	1.00	1.00	20% err	[08-05]	0.99	1.00	1.00	0.45	6.15
34	0.99	low	adjust	0.53	0.77	0.91	20% err	[08-05]	0.46	0.59	0.69	0.44	0.84
35	0.99	med	adjust	0.86	0.97	1.00	20% err	[08-05]	0.27	0.42	0.61	0.07	1.43
36	0.99	high	adjust	0.98	1.00	1.00	20% err	[08-05]	0.08	0.27	0.50	0.01	2.18
37	0.75	low	report.				perfect	15,000	0.44	0.59	0.74	0.34	1.00
38	0.75	med	report.				perfect	15,000	0.58	0.80	0.93	0.24	2.19
39	0.75	high	report.				perfect	15,000	0.99	1.00	1.00	0.18	11.70
40	0.75	low	adjust				perfect	15,000	0.42	0.55	0.68	0.35	1.00
41	0.75	med	adjust				perfect	15,000	0.58	0.77	0.89	0.24	2.46
42	0.75	high	adjust				perfect	15,000	0.99	1.00	1.00	0.20	6.15
43	0.75	low	report.				perfect	8,500	0.21	0.34	0.50	0.09	1.00
44	0.75	med	report.				perfect	8,500	0.37	0.63	0.86	0.07	2.19
45	0.75	high	report.				perfect	8,500	0.97	1.00	1.00	0.06	11.70
46	0.75	low	adjust				perfect	8,500	0.23	0.34	0.45	0.09	1.00
47	0.75	med	adjust				perfect	8,500	0.40	0.67	0.83	0.06	2.46
48	0.75	high	adjust				perfect	8,500	0.98	1.00	1.00	0.05	6.15
49	0.75	low	report.				perfect	0	0.03	0.09	0.17	0.00	1.00
50	0.75	med	report.				perfect	0	0.13	0.34	0.63	0.00	2.19
51	0.75	high	report.				perfect	0	0.93	0.99	1.00	0.00	11.70
52	0.75	low	adjust				perfect	0	0.03	0.08	0.18	0.00	1.00
53	0.75	med	adjust				perfect	0	0.16	0.41	0.68	0.00	2.46
54	0.75	high	adjust				perfect	0	0.97	0.99	1.00	0.00	6.15
All runs [08-05] perfect impl.: Runs 1-18				0.88	0.96	0.98			0.61	0.69	0.77	0.39	
All runs [08-05] 20% error: Runs 19-36				0.88	0.96	0.98			0.70	0.78	0.86	0.54	
Base case [08-05] perfect impl.: Runs 4-6 & 13-15				0.88	0.96	0.99			0.75	0.85	0.91	0.39	
Base case [08-05] 20% error: Runs 22-24 & 31-33				0.88	0.96	0.99			0.84	0.91	0.95	0.58	
15,000 perfect impl.: Runs 37-42									0.67	0.78	0.87	0.26	
8,500 perfect impl.: Runs 43-48									0.53	0.66	0.77	0.07	
0 perfect impl.: Runs 49-54									0.37	0.48	0.61	0.00	

B)

				Historical Decline (probability)					10-Year projection (probability)				
Run	**Steep**	**Rmax**	**Catch**	**B_{2009}<0.1 maxB**	**B_{2009}<0.15maxB**	**B_{2009}<0.20 maxB**	**Implem.**	**TAC**	**B_{2019}<0.10 maxB**	**B_{2019}<0.15 maxB**	**B_{2019}<0.20 maxB**	**B_{2019}<B_{2009}**	**VPA maximum SSB (t)**
1	0.5	low	report.	0.09	0.19	0.32	perfect	[08-05]	0.56	0.59	0.64	0.78	296,944
2	0.5	med	report.	0.09	0.19	0.32	perfect	[08-05]	0.53	0.58	0.60	0.73	296,944
3	0.5	high	report.	0.09	0.19	0.32	perfect	[08-05]	0.53	0.58	0.60	0.73	296,944
4	0.75	low	report.	0.09	0.19	0.32	perfect	[08-05]	0.40	0.43	0.48	0.53	296,944
5	0.75	med	report.	0.09	0.19	0.32	perfect	[08-05]	0.31	0.33	0.36	0.37	296,944
6	0.75	high	report.	0.09	0.19	0.32	perfect	[08-05]	0.25	0.27	0.29	0.29	296,944
7	0.99	low	report.	0.09	0.19	0.32	perfect	[08-05]	0.13	0.16	0.19	0.16	296,944
8	0.99	med	report.	0.09	0.19	0.32	perfect	[08-05]	0.03	0.04	0.05	0.03	296,944
9	0.99	high	report.	0.09	0.18	0.32	perfect	[08-05]	0.01	0.01	0.01	0.01	296,944
10	0.5	low	adjust	0.10	0.23	0.35	perfect	[08-05]	0.53	0.57	0.61	0.70	308,609
11	0.5	med	adjust	0.10	0.23	0.35	perfect	[08-05]	0.50	0.55	0.58	0.67	308,609
12	0.5	high	adjust	0.10	0.23	0.35	perfect	[08-05]	0.50	0.55	0.58	0.67	308,609
13	0.75	low	adjust	0.09	0.23	0.35	perfect	[08-05]	0.39	0.41	0.45	0.48	308,609
14	0.75	med	adjust	0.09	0.23	0.35	perfect	[08-05]	0.33	0.34	0.36	0.36	308,609
15	0.75	high	adjust	0.09	0.23	0.35	perfect	[08-05]	0.28	0.31	0.33	0.32	308,609
16	0.99	low	adjust	0.09	0.23	0.35	perfect	[08-05]	0.13	0.15	0.20	0.14	308,609
17	0.99	med	adjust	0.09	0.22	0.34	perfect	[08-05]	0.02	0.02	0.03	0.02	308,609
18	0.99	high	adjust	0.09	0.22	0.34	perfect	[08-05]	0.01	0.01	0.01	0.00	308,609
19	0.5	low	report.	0.10	0.20	0.33	20% err	[08-05]	0.73	0.76	0.80	0.92	296,944
20	0.5	med	report.	0.10	0.20	0.33	20% err	[08-05]	0.69	0.73	0.76	0.87	296,944
21	0.5	high	report.	0.10	0.20	0.33	20% err	[08-05]	0.69	0.73	0.76	0.87	296,944
22	0.75	low	report.	0.10	0.20	0.33	20% err	[08-05]	0.58	0.61	0.65	0.80	296,944
23	0.75	med	report.	0.09	0.20	0.32	20% err	[08-05]	0.48	0.50	0.52	0.58	296,944
24	0.75	high	report.	0.09	0.20	0.32	20% err	[08-05]	0.39	0.41	0.43	0.44	296,944
25	0.99	low	report.	0.09	0.19	0.32	20% err	[08-05]	0.33	0.37	0.43	0.50	296,944
26	0.99	med	report.	0.09	0.19	0.31	20% err	[08-05]	0.11	0.14	0.15	0.12	296,944
27	0.99	high	report.	0.08	0.18	0.31	20% err	[08-05]	0.03	0.04	0.04	0.03	296,944
28	0.5	low	adjust	0.10	0.24	0.36	20% err	[08-05]	0.69	0.70	0.71	0.84	308,609
29	0.5	med	adjust	0.10	0.24	0.36	20% err	[08-05]	0.67	0.69	0.70	0.79	308,609
30	0.5	high	adjust	0.10	0.24	0.36	20% err	[08-05]	0.67	0.69	0.70	0.79	308,609
31	0.75	low	adjust	0.10	0.24	0.36	20% err	[08-05]	0.54	0.58	0.62	0.71	308,609
32	0.75	med	adjust	0.10	0.23	0.35	20% err	[08-05]	0.44	0.46	0.48	0.52	308,609
33	0.75	high	adjust	0.10	0.23	0.35	20% err	[08-05]	0.39	0.41	0.43	0.45	308,609
34	0.99	low	adjust	0.09	0.23	0.35	20% err	[08-05]	0.34	0.37	0.40	0.44	308,609
35	0.99	med	adjust	0.09	0.22	0.35	20% err	[08-05]	0.08	0.09	0.11	0.07	308,609
36	0.99	high	adjust	0.08	0.20	0.33	20% err	[08-05]	0.01	0.01	0.02	0.01	308,609
37	0.75	low	report.				perfect	15,000	0.27	0.29	0.33	0.34	296,944
38	0.75	med	report.				perfect	15,000	0.20	0.22	0.26	0.24	296,944
39	0.75	high	report.				perfect	15,000	0.17	0.18	0.19	0.18	296,944
40	0.75	low	adjust				perfect	15,000	0.28	0.32	0.35	0.35	308,609
41	0.75	med	adjust				perfect	15,000	0.22	0.24	0.26	0.24	308,609
42	0.75	high	adjust				perfect	15,000	0.18	0.21	0.23	0.20	308,609
43	0.75	low	report.				perfect	8,500	0.10	0.11	0.13	0.09	296,944
44	0.75	med	report.				perfect	8,500	0.08	0.09	0.10	0.07	296,944
45	0.75	high	report.				perfect	8,500	0.06	0.07	0.09	0.06	296,944
46	0.75	low	adjust				perfect	8,500	0.09	0.11	0.13	0.09	308,609
47	0.75	med	adjust				perfect	8,500	0.07	0.09	0.11	0.06	308,609
48	0.75	high	adjust				perfect	8,500	0.06	0.08	0.09	0.05	308,609
49	0.75	low	report.				perfect	0	0.00	0.01	0.02	0.00	296,944
50	0.75	med	report.				perfect	0	0.00	0.01	0.01	0.00	296,944
51	0.75	high	report.				perfect	0	0.00	0.01	0.01	0.00	296,944
52	0.75	low	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
53	0.75	med	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
54	0.75	high	adjust				perfect	0	0.00	0.00	0.01	0.00	308,609
All runs [08-05] perfect impl.: Runs 1-18				0.09	0.21	0.33			0.30	0.33	0.35	0.39	
All runs [08-05] 20% error: Runs 19-36				0.10	0.21	0.34			0.44	0.46	0.48	0.54	
Base case [08-05] perfect impl.: Runs 4-6 & 13-15				0.09	0.21	0.33			0.32	0.35	0.38	0.39	
Base case [08-05] 20% error: Runs 22-24 & 31-33				0.10	0.22	0.34			0.47	0.49	0.52	0.58	
15,000 perfect impl.: Runs 37-42									0.22	0.24	0.27	0.26	
8,500 perfect impl.: Runs 43-48									0.08	0.09	0.11	0.07	
0 perfect impl.: Runs 49-54									0.00	0.00	0.01	0	