REPORT OF THE 2017 MEETING OF THE
ICCAT WORKING GROUP ON STOCK ASSESSMENT METHODS (WGSAM)
(Madrid, Spain, 8-12 May 2017)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat offices in Madrid, Spain from 8-12 May 2017. Dr Miguel Neves dos Santos, on behalf of the ICCAT Executive Secretary, welcomed the participants to the meeting.

Dr Michael Schirripa, the Stock Assessment Methods Working Group Rapporteur, chaired the meeting. Dr Schirripa again welcomed meeting participants ("the Group") and proceeded to review the Agenda which was adopted with minor changes (**Appendix 1**).

The List of Participants is attached as **Appendix 2**.

The List of Documents presented at the meeting is attached as **Appendix 3**.

The following participants served as Rapporteurs for various sections of the report:

Section	Rapporteurs
1	M. Schirripa, P. de Bruyn
2	F. Forrestal, C. Brown, P. de Bruyn
3	G. Melvin, P. Carpi
4	D. Die, G. Galland
5	G. Diaz, P. de Bruyn, L. Kell
6	M. Schirripa
7	P. de Bruyn

1.1 Use and formation of Study Groups

Intersessional work is critical to the success of the WGSAM. Similar to the stock assessment process, directed effort must be devoted to requests in order to ensure that they receive the attention they deserve. In an effort to develop more focused attention and results to the recommendations put forth to the WGSAM, the Working Group will begin the practice of forming recommendation specific Study Groups (SG). The members of each SG will have a particular interest or expertise pertaining to the recommendation and will take "ownership" of addressing the recommendation. These Study Groups will be identified by the participants for particular recommendations. They can be as large or as small as required by the task. Participation in a Study Group will be with the understanding that each member will share the workload of the SG. The SG will be responsible for starting and completing the task and reporting on their finding at a subsequent WGSAM meeting. Each SG will persist until such time that the Working Group agrees that the associated recommendation has been successfully resolved if possible. Once completed, the Study Group can be disbanded.

The Group supported this approach. It was suggested that a coordinator be assigned to each Study Group to ensure a cohesive and organized effort. Further, the Group recommended that membership of the Study Group should be broad across CPCs and participation was encouraged. It was noted that the Sharks and Small Tunas Species Groups are currently using this approach with success. Such Study Groups may also be a good avenue for funding. It was further suggested that the Chair of the Species Group from which the recommendation originated should be a member of the Study Group so that the objective of the recommendation is made clear. The Group also remarked that reaching across other tuna RFMOs could be beneficial as well. Overall the Group was positive towards the approach. In an effort to begin to use this new approach two Study Groups were formed, the northern albacore MSE Study Group and the CPUE Standardization Study Group. The two Groups directly address two current objectives of the WGSAM as they pertain to the ICCAT Strategic 5 Year Plan.

2. CPUE standardization / incorporation of oceanographic and environmental processes

2.1 Revision of CPUE Table for Species Groups

Document SCRS/2017/081 proposed a revision of the current table and procedure used to evaluate CPUE series. This current procedure has been utilized for several years to evaluate CPUE series for inclusion in assessment models. However, it has become apparent that the process is time-consuming and needs to be updated to streamline the work of the various groups. The document proposed replacing the quantitative scoring system with a qualitative system with fewer options.

The Group was generally in favour of the revision of the CPUE table. It was also commented, that the process of evaluating CPUE series was important and should continue. The Group agreed that replacing the quantitative scoring system was a good idea, however the criteria proposed required further revision in order to be less restrictive. Several comments were made regarding the content of the tables and these were incorporated into a revised table (**Table 1**). It was clarified that these tables should be used as a checklist to critically evaluate the CPUE series and assess their suitability for inclusion in assessment models. An important observation was that some Groups now have Fisheries Independent Indices of abundance available and that this table should also be flexible enough for use in assessing these types of indices.

In addition, the Group agreed that in the future, authors that present previously evaluated series that have merely been updated, should include the previous evaluation of the index as an appendix in their relevant SCRS document. They should clearly highlight any changes in the CPUE data and standardization process made to the previously presented index. The species groups should then be able to assess these series far more rapidly and only make changes to the previous evaluation if absolutely necessary.

Lastly, the Group was reminded that table 1 in the Report of the 2012 Meeting of the ICCAT Working Group on Stock Assessment Methods (Anon., 2013) provided instructions for authors describing the information required to facilitate the appropriate construction and evaluation of CPUE series. The Group reiterated that these guidelines should be used by all authors presenting CPUE papers to the ICCAT WGSAM.

2.2 Presentation of CPUE standardization and LLSIM (simulated) data

Document SCRS/2017/103 reports progress made to develop catch per unit indices of the Tunisian bluefin tuna purse seine and swordfish longline fisheries. As of now, there is not a usable index for the bluefin tuna purse seine fishery in the Mediterranean, however, there is progress towards obtaining a time series for the swordfish longline fishery. The document provided an overview on the types of data that will be collected to standardize the CPUE data, including fishing strategies and environmental data.

The Group discussed the difficulties in standardizing purse seine effort data, noting that search time is a more significant measure of effort than overall trip length. The use of VMS as a source of data can aid in defining time spent searching for fish versus time steaming to fishing grounds. It was noted that it may be helpful to collaborate on BFT purse seine CPUE indices with other CPCs to integrate variables into the standardization methods that can be used for stock assessments.

Longline fisheries are known to be spatially and temporally dynamic, it was noted that it is necessary to have enough contrasts in the longline datasets to capture changes in fishing strategy. The author noted the CPUE longline index would not be available for this year's Mediterranean swordfish assessment as it began one year ago.

Document SCRS/2017/099 referred on methods to integrate various fishing tactics (referred to as compromises in the document) in standardizing catch per unit effort (CPUE) for Moroccan fisheries. The work consisted of conducting a dynamic fleet analysis and identification of fishing tactics compromises. A boosted regression tree (BRT) was used to standardize CPUE indices for target species.

The authors noted that the use of this approach (the combined dynamic fleet fishing tactic compromise and boosted regression tree) avoids large numbers of zeros that would occur if all the data were used. A clarification was provided about the use of target species in the models. Within each fishing tactic examined, there are several target species and the models contain one species as the response variable and the others within the group are included as explanatory variables.

It was discussed how the SWO index from this study compares to the index that has been provided to the northern Atlantic swordfish assessment for the same fishery and that it may be helpful to compare indices derived from different methods. It was noted that this was an interesting approach given the unique and dynamic nature of the fisheries as gear type, fishing tactics and target species have spatiotemporal shifts. Interaction effects have yet to be explored and it was discussed that this approach does not have the same constraints on correlations as GLMs. Gear variables were not included in the standardization as gears were accounted for in the dynamic fleet analysis.

Document SCRS/2017/066 on the longline simulator (LLSIM) contains information on how the current iteration of the simulator was built and how it can be used to address CPUE standardization studies. LLSIM can match: a) geographical temporal distribution of a stock based on biological parameters and habitat preference, b) detailed fishing effort allocation for multiple longline fleets, and c) detailed environmental covariates.

The Group discussed the tendency for longline hooks to be at different depths throughout the duration of the set and the difficulty in knowing the true depth of the hooks. The authors noted that adjustments had been made to the gangion and float line depths reported in the logbooks. The authors noted that strict adherence to the realistic depiction of hook depth is not required to achieve the objectives of this particular study, but acknowledged that closer depiction of a more realistic distribution of hook depth maybe more important to address other potential objectives. It was suggested that the authors consider the examination of available time depth recorders for future work and the impact on the nominal CPUE if the depths of the hooks were shallower than estimated.

The authors noted that the flexibility of the modeling framework allowed for both the inclusion of other CPCs' fleet structures and alternative environmental conditions. It is important to emphasize that the simulator is now a new tool available that can be used for many purposes. It was suggested that the authors examine the level of detail in the data needed to detect the underlying abundance trend i.e. observer data vs logbook data. This would be helpful in identifying the type of error present, observational or process error, which could be used for MSE. The Group was reminded that the data and configuration used to run LLSIM needed to match the question being asked. This work was framed on testing why CPUE does not necessarily follow abundance. While LLSIM has many applications, it does not model changes in abundance due to fishing as there is no feedback mechanism.

Overall the Group was very supportive of the LLSIM modeling effort and thought that it represented a good way forward to address many of the CPUE related issues that the Group was originally intending to address. It was noted that the LLSIM simulator is an excellent tool to test important scenarios such as combining several sources of indices of abundances, multispecies standardization and evaluation of target versus non-target species catch rates. It was recommended to continue with this area of research.

The Group was then presented with a further use of the tool, namely providing simulated catch data from the LLSIM simulator to stock assessment scientists to determine if the underlying population trends could be replicated with different methods of CPUE standardization. It was pointed out that not all analysts knew the details of the operation of the fleet and this could affect the way in which data were treated and the final model selected. However, if scientists were conducting data exploration and using the percentage of the deviation explained to select variables, the resulting models would not necessarily be dependent on knowledge of the fishery. It was discussed that it is preferable for the analysts to know the history of the fishery and the management regulations as that is what currently occurs. It was noted that most of the confidence intervals for the standardized indices included the 'real population' trend even though sometimes the mean trend of the CPUE did not follow the population. In general, all standardized CPUEs were closer to the real population trend than the nominal CPUE. The Group noted that not all indices are created equal and as such, consideration should be given to not giving them equal weight in the stock assessment. There was discussion on the appropriate use of CVs as measures of uncertainty around abundance indices as they may reflect observation error alone rather than certainty in the estimation of abundance.

It was discussed that in the simulated data there may not be enough of an overlap between the time periods when J and circle hooks were used, potentially creating a problem with interpreting the hook effect. However, some analysts correctly found the underlying abundance despite this potential problem. One possible explanation for the difficulties the analysts had in finding the increasing population trend may have been that the trend was confounded by the gear fishing deeper over time and in a less suitable blue marlin habitat.

The next steps for the project include examining the choices around error distribution and how that could influence the standardized indices. This is particularly important if the CPUE is for a bycatch species as the proportion of zeros can be very high. CPUE standardization is a process that requires knowledge of the data, the fishery and the management regulations. Choosing the factors considered in the model is the final step in the process. It was noted

that using SAS or R code can produce different results due to the way empty cells are treated and this should be considered when making decisions about which variables and interactions are included. Area, month, years and interactions are common factors in most CPUE analyses, but the inclusion of other factors (like gear characteristics) require knowledge of the fleet. In this presentation, most of the standardized CPUE indices are within the confidence intervals. However, if there is a strong trend in the final few years, it can influence the assessment results.

The results of the blind study showed that ICCAT scientists use many different approaches to the CPUE standardization process and that some approaches reproduced the "true" trend from the simulator better than others. The full results of the study have yet to be thoroughly described however all analysts communicated that the study was very educational. Further examination of the study results will shed more light on how the general CPUE standardization process can be improved and refined for more consistent results.

Document SCRS/2017/097 presented the results of using simulated data from the LLSIM to standardize an index of relative abundance for blue marlin with Generalized Linear Mixed Models under a delta lognormal model approach. It was noted the final three years of the time series did not contain environmental variables which caused SAS to overestimate the abundance trend. This was the result of SAS filling in the empty cells of the matrix by using the average values of the coefficients from the years containing environmental variables. It was noted that this method differs from the one used by R software, which leaves those cells blank.

A question was raised on the reasons behind the observed interaction effects between years and bait and if this could be a result of how the effort data was generated for the simulator. It was discussed that patterns in gear changes could manifest as an interaction year effect, though only two way interactions were examined. One primary conclusion of the work was that the extensive data exploration helped to solidify what should be included in the CPUE table (**Table 1**).

Document SCRS/2017/065 reported on work that has been done to refine the longline simulator. It centers around decomposing catchability at the hook into an essential gear coefficient (k) and a habitat effect (H) that varies in time and 3-D space. The approach provides a basis for estimating a habitat coefficient (w) that explicitly quantifies the effect of habitat quality on catchability on each set with potential for use as a covariate for CPUE standardizations. The presentation stated that investigations into this new method were already underway using the LLSIM model, but that the work was too preliminary to arrive at any firm conclusions. However, preliminary work has shown that the method seems to be superior to current methods of including environmental data. Work will continue in this area to further test the robustness of the new method.

Document SCRS/2017/100 presented a potential project for using simulated datasets was presented. Depending on the data type and/or fishery type, the approaches used for CPUE standardization can vary substantially. The document included a possible roadmap for CPUE standardization given the fishery and data type.

The Group discussed ways in which model performance could be assessed and compared across different levels of data detail, ranging from the observer program to the trip level. The Group expressed support for pursuing efforts to address changes in longline targets, particularly examining changes in hooks per basket.

It was suggested that the historical environmental data could be used to gain information on early CPUE indices where gear and logbook data are lacking. It may be useful to test the predictive value of the environmental data by developing effort covering one area of the fishery and use that to predict CPUE in another area where the fishery operates and CPUE data are available.

The Group was asked what topics they thought might make good candidates for future CPUE simulation studies. Several members of the Group felt that standardizing for changing target species would be a good choice as it pertains to many of the species under ICCAT. The presenters noted however that to accomplish this a second species would need to be added to the LLSIM model, which is currently able to model up to six species. Swordfish was identified as a good choice for the second species. The presenters noted that including swordfish in the model was underway but could proceed much more effectively by having access to more PSAT tagging data from this species, both in the eastern and western Atlantic. It was also noted that the need and request for PSAT tagging data was one of the recommendations made by the SWO Species Group.

2.3 Presentation of proceedings of the BFT CPUE workshop held in Mexico City

The West Atlantic BFT Rapporteur gave the Group feedback on the bluefin tuna meeting in Mexico to develop a multi-nations CPUE index. The participants at that meeting successfully combined the raw longline catch, effort and environmental data from Canada, Japan, Mexico and the U.S. while still preserving confidentiality. Major challenges were associated with targeted vs non-targeted fisheries. Unfortunately, the Group was unable to develop a usable CPUE index within the meeting's stated parameters. This, however, does not preclude future efforts from continuing to explore a subset of the data to develop a broader spatial index. It is still possible for smaller pairings of CPCs to work together and it was noted that the real-time meeting was very helpful for exploring several different gear combinations.

3. Harvest Control Rules, Limit Reference points and Management Strategy Evaluation (MSE)

ICCAT's Working Group on Stock Assessment Methods (WGSAM) was provided with an overview of the "Updated evaluation of harvest control rules for north Atlantic albacore through Management Strategy Evaluation" (SCRS/2017/093). This work built on two other documents (SCRS/2017/091 and SCRS/2017/092) that explained the details of the OM grid and the Observation Error Model (OEM) specifications. In 2016, the Group evaluated, using Management Strategy Evaluation (MSE), a series of Harvest Control Rules (HCR) under 10 Operating Model (OM) scenarios (potential realities). WGSAM, the Albacore Species Group, Panel 2, and the SCRS requested additional work. This work was scheduled under the Albacore Research Plan adopted by the SCRS, and included (i) developing an OEM that considers actual CPUE series' error structure, age-classes, dynamic catchability and other properties; (ii) expanding the grid of the Operating Models (reality scenarios against which the HCRs are intended to be robust); (iii) implementing alternatives for HCRs, including bounded TACs (https://github.com/laurieKell/albn), and, (iv) improving ways of communicating the results of the evaluations, including recommendations on performance indicators from Panel 2. These indicators included: measures of stock status, safety, yield and stability. The following provides a summary of the WGSAM's evaluation of changes and improvements to the albacore MSE framework.

Rec. 16-06 states that "in 2017, the SCRS shall refine the testing of candidate reference points (e.g. $SSB_{THRESHOLD}$, SSB_{LIM} and F_{TARGET}) and associated harvest control rules (HCRs) that would support the management objective to maintain the stock in the green quadrant of the Kobe plot with at least a 60% of probability and with a low probability of being outside biological limits, while maximizing long-term yield and average catch, and minimizing the inter-annual fluctuations in TAC levels". All evaluations by the ad hoc MSE Working Group were based on this objective. In fact, the MSE used in SCRS/2017/093 was tailored specifically to support the process to discuss and eventually adopt a HCR for North Atlantic albacore in 2017.

Major differences exist between the MSE framework of 2016 and 2017. In 2016 the operating model was based on MFCL with 10 scenarios and a Management procedure using a biomass dynamic model (which used a single abundance index). In 2017 the OMs, were also conditioned on Multifan-CL (complex model) but in this case 132 alternative scenarios (potential realities) were considered (Table 1in SCRS 2017/093). The management procedure was again based on a biomass dynamic model (BioDyn) but used 4 abundance indices that included fleet specific selectivities. Evaluations were based on the operating models with all results calculated and averaged across the 132 OM when MSE was projected from 2016 to 2045.

The evaluations indicated that all HCRs tested would enable achieving ICCAT's management objective of maintaining stocks at or above SSB_{MSY} with a probability of 60% or more, however, some differences were found between HCRs, expressed as tradeoffs between the different performance statistics. For instance, although all HCRs meet the objective regarding stock status, higher yields were associated with lower probabilities of being in the green zone. Other features of the evaluations were the higher F_{TAR} the higher the catch, and for the tested HCRs the shutdown probability was 0 as they kept the stock at a level where it could produce catch.

Several questions were raised during the overview presentation. It was apparent that some clustering of CV's was occurring for the 132 scenarios. This was likely attributed to the strong correlation between estimates of r (intrinsic growth rate of the population) and K (carrying capacity) parameters of the production model. The Group also highlighted that the true dynamics of stock biomass in the OMs (based on MFCL) were more variable than the perceived biomass trajectories using BioDyn. In fact, short term catches averaged over projected OMs were lower than the recent TAC. This was thought to be because BioDyn under estimated changes in biomass, thus the perception of a recovery was slower with BioDyn than with Multifan. Another reason to explain this finding was that most (59%) of the OMs considered as potential realities started the projections with a stock size below B_{MSY}.

An important point to keep in mind is that the OM is a potential reality, not necessarily the true reality. All OMs were weighted equally. The Group also noted that the set of HCRs would be robust to relatively pessimistic scenarios considered within the OM grid, which is one of the objectives of MSE.

It is important to note the MPs employed in the MSE framework are consistent with the current assessment approach. In other words, the MP mimicked the last stock assessment as much as possible. Thus, taking management decisions and applying these HCRs to the outcome of the last northern albacore stock assessment would be appropriate, since this has been simulation tested. The Study Group did not attempt to expand to other stock assessment models (as part of the MP) or other species. Extension of the evaluations results beyond northern albacore is inappropriate.

The Group discussed the limitations and restrictions of the current MSE approach for albacore, in particular regarding the utilization of additional/different assessment models in the MP in the future. The HCRs evaluated are used in combination with the BioDyn assessment model used for the last assessment. The performance of these HCRs may change if a different model is used in the MPs. It is important to note that the albacore approach and testing was tailored for a specific set of objectives. Since the current albacore stock assessment procedure has been simulation tested, future management decision by the Commission can be taken by applying one of these HCRs. Alternative assessment models would need to be simulation tested before taking decisions based on their outputs. It was pointed out that relating reference points from an alternative model may not be a trivial task.

A fundamental concept of the MSE approach is to evaluate tradeoffs. Choices or tradeoffs are available in the Performance Indicators identified by the Commission if they want to implement a strategy. However, concern was expressed that some tradeoffs were difficult to discern as presented. The Group noted the importance of improving the presentation of the results to make the tradeoffs more obvious.

The Group concluded that the Study Group sufficiently addressed the tasks requested, through a transparent process (welcoming participation of any interested Scientists and sharing results beyond the Study Group as they became available). Therefore the SG has completed a thorough evaluation on a range of HCRs requested by the Commission including the reporting on all the performance indicators chosen by the Commission.

Currently there is a three year cycle for feedback between the MP and the OM, so future TACs could be updated every three years based on the chosen HCR. In the longer term the Group discussed the periodicity to fully review the performance of the MP. The Group discussed several options but no firm agreement was reached on the process or the timeframe, but the general idea was to conduct a full assessment no earlier than 2 three year cycles.

A mechanism is also needed to effectively communicate the 15 performance indicator results to the Commission. Although the results were provided following exactly the requirements of Panel 2, the current set of visuals is simply too cluttered for easy exploration. One possible option would be to reduce/condense the range intervals to reduce visual requirements for plots such as the spider plots used for the 2016 MSE. Another suggestion was to express outputs in a manner similar to other RFMOs with guidance from the managers at the meeting of the Standing Working Group to Enhance Dialogue Between Fisheries Scientists and Managers (SWGSM) on their preference. A third approach discussed by the Group was to use different tones of shading to better visualize the performances of the different indicators under each HCR (**Appendix 4**). The Group felt that this approach has potential as a tool to communicate MSE results to the Commission and agreed to explore ways to further develop and improve the proposed or other approaches. It might also be possible test the presentation options with managers prior to the SWGSM meeting for comments.

WGSAM discussed the best structure required to support the development and review of MSE activities by the SCRS. The discussion was driven by the need to have a structured approach for the definition of appropriate HCRs and for MSE developments to be coordinated by the SCRS.

The Group agreed on the importance of involving the SCRS at an early stage of the process and the need to engage with managers from the beginning. The Group also highlighted the difficulties encountered by the Northern Albacore MSE Study Group due to the challenges of coordination in establishing a clear roadmap: in particular, it would greatly benefit the process to have the objectives of the MSE agreed from the Commission at the start.

During the discussion it was suggested to have an informal Group within WGSAM that would review and provide guidance to all Groups doing MSE analyses. However, it was recognized that the SCRS capacity to do MSE work is limited and therefore often requires external experts to be contracted. Another suggestion was to have two parallel sub-groups during the WGSAM, but the Group agreed that there would be the risk to have one of the two

dominating the discussion and that the workload of WGSAM is already too heavy, therefore the idea was dropped. The final proposal, which was supported by the Group, was to create an ad hoc Study Group (SG) preferably involving at least one member from each species group and one or more MSE expert. A coordinator should be appointed and clear terms of reference should be prepared to be presented at the next SCRS meeting. The very first role of the SG should be to engage with all the relevant experts and to formulate the process towards the definition of a roadmap. The SG should interact with all Species Groups that are working on MSE (SWO, BFT, TRO) and should reach across to other RFMOs and take advantage of what has been done already.

The SCRS will be requested to provide feedback on the structure and the work done by the SG, and consider whether the Study Group should eventually morph into a Working Group MSE.

4. Progress on the SCRS Science Strategic Plan

The SCRS Chair identified three objectives within the plan which are the main responsibility of the WGSAM and the Group discussed the progress that has been made to date in respect to the targets included in the plan. The Group discussed and summarized progress on each of those objectives (**Table 2**).

The SCRS Chair also presented the schedule of assessments and the MSE road map adopted (Annex 7.2 to the *Report for Biennial Period 2016-2017, Part I (2016), Vol. 1*) by the Commission in 2016. The new road map is a modification of the previous one included in Rec. 15-07. This year assessments of 5 stocks will be conducted (BFT E, BFT W, ALB Med, SWO N, SWO S and SMT. In 2018 two assessments are predicted (BUM and BET). The MSE roadmap says, that, if possible, the Commission is expecting to be in a position to select and implement an HCR for ALB N (2017), BFT (2018), SKJ W (2019), SWO N (2020) and TRO (2021).

The Group noted that the combination of the number of stock assessments and MSE work will be very challenging to be accomplished by the small group of analysts that can do the work. It is therefore important to continue to increase stock assessment capacity among SCRS scientists. Moreover the Group pointed out that unless the Commission specifies management objectives for BFT, SWO and tropical tunas the SCRS cannot carry out MSE for those stocks. The Group agreed, however, that it would be best for the SCRS to provide some input to the SWGSM in regards to such performance indicators. The Group agreed that if the Commission had the same objectives for BFT and SWO N that it has for ALB N then it would be appropriate to use the same performance indicators developed for ALB N for the other two species.

For the tropical tunas the Group had more trouble providing guidance to the SWGSM but reiterated that the MSE should be multispecies, including a multispecies HCR(s). Again it is absolutely essential that managers clarify the objectives it has for tropical tunas.

5. Other matters

5.1 Format of Executive Summaries

Document SCI/2016/079 was reintroduced by the Secretariat. The document describes a Secretariat's proposal to standardize and reduce the length of the SCRS Executive Summaries and Detailed Reports. This proposal was first introduced by the Secretariat to the SCRS in 2016. During the 2016 annual meeting, the SCRS requested that the Group further review the proposal and provide its recommendations.

The Group agreed on the need to better standardize the SCRS Executive Summaries. The Group recalled that the SCRS already provided guidelines for the standardization of the Executive Summaries as did the Commission through Res. 11-14, Res. 11-17, and Res. 13-15. Therefore, the current lack of standardization among some of the SCRS Executive Summaries is more the result of the different Species Groups not complying with the established guidelines than the lack thereof. The Group expressed concern that the proposed templates might result in an oversimplification of the information that is currently provided to the Commission in the Executive Summaries. For example, the proposed use of summary tables using colors to depict stock status was rejected by the Group as this approach cannot convey the complexities and caveats associated with the determination of stock status. In other words, the Group strongly felt that the best way to provide all the important information associated to the stock status determination and the management advice was by providing detailed explanatory text and that the SCRS should not provide a 'shortcut' in the form of the mentioned tables. The Group discussed that, generally speaking, the Commission only uses the SCRS annual reports to guide their discussions and that, only rarely, the

Commission takes into consideration the information provided in the Detailed Reports. Therefore, the Group felt that reducing the information provided in the Executive Summaries might not be the best approach to guide the Commission in their deliberations. In addition, there is a disparity in the information provided by the Species Groups given the differences in the fisheries and the available data. Hence, the Group agreed that the proposed guidelines were not flexible enough to accommodate all situations.

Despite the concerns the Group had with the Secretariat's proposal, there was agreement that all Species Groups should take on the task of fully reviewing the text of their Executive Summary. The Group discussed and agreed that the Executive Summaries should be limited to information that supports the determination of the status of the stocks and the management advice (exemptions are made for those Species Groups for which full assessments have never been conducted). For example, the Group felt that lengthy description of the biology of the species (e.g. feeding habits, habitat descriptions) are not warranted and instead all biological parameters used in stock assessments are more useful information to include in the Executive Summaries. Similarly, lengthy descriptions of the history of different fisheries could be significantly curtailed or eliminated. In other words, the Group felt that many Executive Summaries continue to maintain text that was introduced many years ago and that the utility of keeping such texts must be thoroughly reviewed. The Group also discussed if the Executive Summaries for species for which a stock assessment was not conducted should continue to include detailed information regarding all aspects of the last assessment. In summary, the Group agreed that the Executive Summary templates proposed by the Secretariat would make difficult to provide to the Commission all the information/concepts that the SCRS considers important. However, a review of the Executive Summaries to curtail information that is not considered essential to support the stock status determination and management advice has been warranted for some time and should be conducted.

The Secretariat indicated that when conducting stock assessments using ownCloud, Group members have read and write access to the Analysis folder and only read access to other folders such as the Statistics folder. The Statistics folder contains the Task I and II data and the catch-at-size (CAS) data, while the Analysis folder contains data like the CPUE provided by CPCs and processed datasets such as the Catch-at-age (CAA). Ideally to ensure the assessments are transparent requires a framework, such as that being developed by ICES (https://github.com/ices-tools-prod/icesSAG) to organise data, methods, and results so they are easy to find and can easily be rerun later with new data. The user interface http://www.stockassessment.org and the use of make files was also highlighted by the t-RFMO MSE WG as an example of such an open and transparent framework, which could be used for both stock assessments and development of MSE.

Agreeing to a common structure for folders on the ownCloud folders will be an important step forward. This would help the documentation of the steps in the data analysis chain required to conduct a stock assessment. Currently, a common format structure in the Analysis folder is being set up for the upcoming SWO and BFT stock assessments as test cases.

The Group also proposed to create a database that holds all the results required in the Executive Summaries, i.e. those required to generate the Kobe Phase Plots, the Kobe Strategy Matrix and the summary table. For the Kobe Phase Plots the proposed structure is

Method	*scenario*	*iter*	*year*	*stock*	*harvest*	B_{MSY}	F_{MSY}
ASPIC	1	1	1950	2.446750	0.003861122	739845.1	0.1702451
ASPIC	1	1	1951	2.487394	0.004304142	739845.1	0.1702451
ASPIC	1	1	1952	2.521801	0.008725962	739845.1	0.1702451

and for the Strategy Matrix

Method	*scenario*	*iter*	*year*	*stock*	*harvest*	B_{MSY}	F_{MSY}	*TAC*
ASPIC	1	1	2016	1.040404	0.8333996	739845.1	0.1702451	50000
ASPIC	1	1	2017	1.061294	0.3567425	739845.1	0.1702451	50000
ASPIC	1	1	2018	1.162858	0.3272334	739845.1	0.1702451	50000

These databases can be easily generated using a R script using methods in the Kobe package. The Kobe package is on CRAN (https://cran.r-project.org/web/packages/kobe/index.html) and is also in the ICCAT Software Catalogue. It can read all the outputs from the ICCAT assessment methods, creating a common data frame. That can then be used to help automate production of WG Reports and Executive Summaries, see the vignette for examples of how to use the package https://cran.r-project.org/web/packages/kobe/vignettes/kobe.pdf.

For example the results from ASPIC are written to files with extensions that identify their contents, i.e. bootstrapped assessment results are found in .bio and projections based on these in .prb files. There is therefore a .prb file for each TAC. The Kobe Aspic method can read the results by specifying a .bio file, and multiple .prb files e.g.

```
Reading in the bootstrapped assessment
### Results from ASPIC bootstrapped assessment
bio ="http://www.iccat.int/stocka/Models/ASPIC/albs/2011/run2/aspic.bio"
assmt =kobeAspic(bio)
head(assmt)
iter year stock harvest bmsy fmsy
1 1 1956 1.800000 0.0004169473 110448.7 0.2479588
2 1 1957 1.873086 0.0139635494 110448.7 0.2479588
3 1 1958 1.915449 0.0198786446 110448.7 0.2479588
4 1 1959 1.940032 0.0891123383 110448.7 0.2479588
5 1 1960 1.928930 0.2009482466 110448.7 0.2479588
6 1 1961 1.880085 0.2110163113 110448.7 0.2479588
and a projection for a single TAC
## Results from an ASPIC Projection
prb ="http://www.iccat.int/stocka/Models/ASPIC/albs/2011/run2/aspic_15000.prb"
prj1 =kobeAspic(bio,prb)
tail(prj1)
iter year stock harvest bmsy fmsy
71151 500 2020 0.7997950 0.7527672 206883.8 0.1173888
71161 500 2021 0.8408805 0.7162019 206883.8 0.1173888
71171 500 2022 0.8835242 0.6819915 206883.8 0.1173888
71181 500 2023 0.9273448 0.6502398 206883.8 0.1173888
71191 500 2024 0.9719148 0.6209882 206883.8 0.1173888
71201 500 2025 1.0167761 0.0000000 206883.8 0.1173888
```

The Kobe package has similar methods for all the main assessment methods and has already been used to collate all the results used in the Executive Summaries. If all the results are placed in a common folder structure, then it will be relatively simple to use the methods in the package to collate results and automate the production of the Executive Summaries (Kell, 2011).

5.2 Peer review of stock assessments, revision of the list of experts

The Secretariat presented a list of stock assessment experts, who had expressed their willingness to conduct external reviews or serve as external experts for ICCAT stock assessments. The Group was asked to comment on the list and provide updates, suggestions or modifications to the Secretariat. The list is included as **Appendix 5**.

5.3 SCRS Annual Dashboard

Authors of Document SCRS/2017/101 presented a prototype of a Shiny App that uses a series of input files available from the ICCAT website and other publicly available sources to summarize information about stock status and biology, catch (Task I and Task II data), and current management regulations. Interactive figures – including a Kobe plot – are available to the user. Several of the figures can be manipulated to display data from only one CPC, useful for displaying national statistics. The Group agreed that the App is a useful tool to allow managers to have a graphical representation of updated catch trends and stock status. There was some concern, however, that the stock status section of the App may simplify complex stock assessment issues too much, potentially misleading users regarding the SCRS's certainty with respect to the status of ICCAT managed stocks. The Secretariat reminded the Group that there is now R code available to produce all of the standard plots for the annual species Executive Summaries and suggested that this code could be incorporated into the App. The Group made some minor suggestions for improvement to the App (e.g. identification of the last year of catch data used, to labels and correction of some coding errors) but also noted that the App could form the basis of a management strategy evaluation (MSE) tool that could be used by managers or other interested users to hypothetically manipulate stocks using a harvest strategy or management procedure. It was also noted that development was proceeding to develop a generic application, led by the t-RFMO Working Group, to present the results of MSE to t-RFMO managers.

5.4 SubCom STAT Recommendation on data dissemination

The Group was presented with the current draft rules for data dissemination that were prepared by the Sub-committee on Statistics with input from the Secretariat and different Species Group Rapporteurs. It was noted to the Group that the presentation of the rules had the goal of obtaining further input to continue developing and improving the draft rules. The rules encompassed 3 main elements:

1) Dissemination of Task I and II data: In general, the Group agreed that access to new Task I and II data and estimated products should be restricted between the data submission deadline (July 31) and the time the data are reviewed and approved by the Species Groups during the last week of September and the SCRS during the plenary meeting the first week of October.

2) Access to the ownCloud prior to and during SCRS meetings: The Group agreed with the proposed rule that access to the ownCloud continue to be given to those that have registered to attend a particular meeting (the current practice), but access to the ownCloud during the meeting should only be granted to those that are attending the meeting. In other words, those that registered to attend the meeting, but do not attend the meeting will not have access to the ownCloud during the meeting any longer. Exceptions will be made upon request for those head scientists of delegations that are unable to attend a particular meeting. Access to the ownCloud for those that are not attending the meeting (and are not head scientists of delegations) will be considered on a case by case basis by the Species Group Rapporteurs and SCRS Chair.

3) Dissemination of stock assessment results: To increase the transparency of the stock assessment process, it was proposed that an open access folder with all inputs and outputs from the stock assessment runs be made available. The Group discussed which data should be made available (e.g. only runs used to provide management advice, all runs, only base case) and the Group was unable to reach consensus.

Other issues were discussed like the need to find a balance between transparency and maintaining the confidentiality of certain data sets. The Group also discussed if the rules should be flexible enough to allow the Species Group Rapporteurs to decide which data will be made available in the open access folder. Other technical aspects were also discussed; however, these technical aspects were more related to the implementation of the rules than the rules themselves. In summary, the discussion held by the Group once again made clear the complexity of this issue and the need to maintain further consultations within the SCRS with the goal of presenting final rules for data dissemination for discussion and approval at the next meeting of the SC-STAT and SCRS annual meeting. In general, the Group felt that the discussion and the provided suggestions will significantly improve the current draft rules and it also recommended that future discussions on this issue take into consideration the recommendations of the 'Independent Performance Review of ICCAT'.

5.5 ICCAT Software Catalog

A new procedure was proposed by the SCRS for the ICCAT Software Catalogue based on the Science Strategic Plan for 2015-2020. The first step was to solicit the views of the rapporteurs and software developers via a questionnaire, following which a new catalogue was developed using a *github* repository see https://github.com/ICCAT/software/wiki. The latest version of ASPIC was placed in the repository as a template for updating the catalogue. Following this other methods, e.g. SS, VPA-2box, mpb have been added to the catalogue.

The Group discussed what types of software should be in the catalogue, e.g. should software used for MSE be in the catalogue. The Group agreed that this may be too difficult and that for the time being only software used for the actual assessments and CPUE standardisation needs be added. Any stock assessment software should be simulation tested. The Group recommends a Study Group be formed to facilitate the simulation testing of all software in the catalogue. This topic needs to be reviewed annually and so should be part of WGSAM's agenda each year.

5.6 Quantification of the relative importance of the different uncertainties and prioritization of future research

Presentation SCRS/P/2017/013 provided on the quantification of the relative importance of different sources of uncertainty in the stock assessment and analysis chain for Atlantic bigeye and yellowfin. In this work the authors quantified uncertainty due to data processing for a Virtual Population Analysis stock assessment. A factorial design was used and factors include conversion of Task I and II data to catch-at-size, ageing method, growth curve, natural mortality, choice of CPUE series, and plus group assumptions. The approach showed that the most important

source of uncertainty depends on the stock and quantity, for bigeye the greatest source of uncertainty was due to the CAS followed by choice of CPUE series for F/F_{MSY}, while for B/B_{MSY} it was M followed by CAS. In contrast for yellowfin for F/F_{MSY} it was the plus group assumptions followed by the ageing method and for B/B_{MSY} it was M followed by the growth model. The study identified the relative importance of the main sources of uncertainty and will allow the prioritisation of future research, e.g. under the AOTTP and the benefits of reducing the risk of failing to achieve target reference points and to avoid limits. The approach could be run for other ICCAT stocks and could be used to condition Operating Models as part of MSE.

An example of an empirical HCR was also presented. In an MSE setting reference points are tuned, i.e. CCSBT provides a model-free example of an MP that is based on year-to-year changes and trends in empirical indicators (i.e. CPUE and fisheries independent indices); reference levels are then tuned to meet management objectives using MSE. Where tuning refers to adjusting the parameters of the MP to try and achieve the stated objectives represented by the OM. Model-based MPs, for example those based on a stock assessment model, may include the estimation of MSY-based reference points, but the values of F, F_{MSY}, B and B_{MSY} from the OM do not need to be equivalent to their proxies in the MP, e.g. if a stock assessment model used in the MP is structurally different from that used to condition the OM.

6. Recommendations

The Group recommended that Species Groups should include in their 2018 work plans the task of reviewing their Executive Summaries with the goal of complying with already existing standardization guidelines. The Species Groups should take into consideration that the information included in the Executive Summaries is to support the stocks status determination and the management advice. Therefore, the Species Groups must consider excluding from the Executive Summaries information that does not support the stated purpose.

The Group recommends that the current CPUE table should be replaced with the newly proposed table (**Table 1**) that is simplified and provides "pull down" menus to comment on CPUE series, in order to reduce unnecessary discussions at future data preparatory meetings. In addition, it is the recommendation of the authors that any previous evaluation of a presented CPUE analysis should be included in the updated CPUE paper presented to the SCRS. This will allow the Group to quickly determine whether the series has been evaluated previously or if any substantial changes to the series have been made and thus if a new evaluation is necessary.

The Group recommends that the ALB N MSE Study Group explore alternative candidate output graphics and summaries based on the ALB N MSE results, including those used by other RFMOs. These summaries could be presented and used as examples at the SWGSM meeting for the participants' consideration and feedback for their future use. Further, that the head delegates of each CPC, or their designees, should share similar examples of these summaries with their CPC delegates and the albacore Species Group to get feedback prior to the SWGSM meeting. These summaries could be based not only on the ALB N MSE work but also the results from other MSEs.

7. Adoption of the report and closure

The Report was adopted during the meeting. The Chair thanked the participants and the Secretariat for their work during the week. The meeting was then adjourned.

References

Anonymous. 2013. Report of the 2012 Meeting of the ICCAT Working Group on Stock Assessment Methods (Madrid, Spain - April 16-20, 2012). ICCAT Col. Vol. Sci. Papers. 69(3): 1354-1426.

Kell, L. 2011. A standardised way of presenting Species Group Executive Summaries. Collect. Vol. Sci. Pap. ICCAT, 66(5): 2213-2228.

Table 1. Table for evaluating CPUE series by species groups (Note, table will be provided in excel, and the options will be in the form of pull-down menus).

	Will be used in current stock assessment? State model/s.					
	SCRS Doc No:					
	Index Name:					
	Data Source (state if based on logbooks, observer data etc.):					
1	Do the authors indicate the percentage of total effort of the fleet the CPUE data represents?	Yes	No	NA		
2	If the answer to 1 is yes, what is the percentage?	0-10	11-20	21-30	31-40	41-50
		51-60	61-70	71-80	81-90	91-100
3	Are sufficient diagnostics provided to assess model performance?	Sufficient	Incomplete	None		
4	How does the model perform relative to the diagnostics	Well	Mixed	Poorly		
5	Documented data exclusions and classifications?	Yes	No	NA		
6	Data exclusions appropriate?	Yes	No	NA		
7	Data classifications appropriate?	Yes	No	NA		
8	Geographical Area	Atlantic	Atl N	Atl S	Atl NW	Atl NE
		Atl SW	Atl SE	Tropical	Med	Localised (<10x10)
9	Data resolution level	Set	Trip	OTH		
10	Ranking of Catch of fleet in TINC database (use data catalogue)	1-5	6-10	11 or more		
11	Length of Time Series	0-5 year	6-10 years			
		11-20 years	Longer than 20 years			
12	Are other indices available for the same time period?	None	Few	Many		
13	Are other indices available for the same geographic range?	None	Few	Many		
14	Does the index standardization account for Known factors that influence catchability/selectivity? (e.g. Type of hook, bait type, depth etc.)	Yes	No			
15	Estimated annual CVs of the CPUE series	High	Medium	Low	Variable	
16	Annual variation in the estimated CPUE exceeds biological plausibility	Likely	Possible	Unlikely		
17	Are data adequate for standardization purposes?	Yes	No			
18	Is this standardised CPUE time series continuous?	Yes	No			
19	For fisheries independent surveys: what is the survey type?	Acoustic	Aerial			
		Larval	Other (explain below)			
20	For 19: Is the survey design clearly described?	Yes	No			
21	Other comments					

Table 2. Progress towards the Science strategic plan. Only objectives that are the main responsibility of the WGSAM are here listed.

Goal	Objective	Measureable targets	Main responsibility	Notes on measurable targets
RESEARCH PRIORITIES				
1.2	Quantification of the relative importance of the different uncertainties and prioritization of future research	Simulation approach developed for each main species. At least one collaborative SCRS or peer reviewed research paper describing the relative merits of different research actions, for each main species.	WGSAM	Simulation have been done for tropical tunas and are currently been done for albacore to evaluate the importance of various sources of uncertainty to the outcome of the assessment.
3.2	Further improve standardization of CPUEs for their use as reliable indices of abundance	SCRS or peer reviewed paper on best practices to standardize CPUEs of different nature. Peer reviewed paper on the use of floating objects to monitor relative abundance.	WGSAM	Work on best practices for CPUE standardization of longline well advanced through a WGSAM study group and by EU-CECOFAD on purse seine. The CECOFAD project has also done work on the estimation of biomass from acoustic sensors used in FADs.
STOCK ASSESSMENTS AND ADVICE				
1.1	Integration of the different forms of uncertainties (e.g. natural variability and or lack of knowledge) in status diagnoses and projections	Development of a more standardized Terms of Reference for the Data Prep Meetings (and Assessment meetings?) that include a more complete analysis of the advice and uncertainty from the previous assessment. Further evaluate the quality of the fisheries data and related to the knowledge of the species.	WGSAM	No TOR exist for data prep or assessment meetings, only common practice. The WGSAM and the tRFMO MSE WG have been reviewing approaches developed for other fishery commissions to improve quality of the auditing process for stock assessments.

Appendix 1

Tentative Agenda (revised)

1. Opening, adoption of agenda and meeting arrangements
   - Assignment of Rapporteurs
   - Use and formation of Study Groups

2. CPUE standardization / incorporation of oceanographic and environmental processes
   - Revision of CPUE Table for Species Groups
   - Presentation of CPUE standardization of LLSIM (simulated) data
   - Presentation of proceedings of the BFT CPUE workshop held in Mexico City

3. Harvest Control Rules, Limit Reference points and Management Strategy Evaluation (MSE)
   - Current status and progress
   - Review of the recent decision on ALB Harvest Control Rule

4. Progress on the SCRS Science Strategic Plan

5. Other matters
   - Format of Executive Summaries
   - Peer review of stock assessments, revision of the list of experts
   - SCRS Annual Dashboard
   - SubCom STAT Recommendation on data dissemination.
   - ICCAT Software Catalog
   - Quantification of the relative importance of the different uncertainties and prioritization of future research

6. Recommendations

7. Adoption of the report and closure

Appendix 2

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Appendix 3

List of Documents and Presentations

Reference	Title	Authors
SCRS/2017/065	Longline data simulation: a paradigm for improving CPUE standardization	Goodyear C.P., Schirripa M. and Forrestal F.
SCRS/2017/066	Testing robustness of CPUE standardization using simulated data: Findings of initial blind trials	Forrestal F.C., Goodyear C.P., Schirripa M., Babcock E., Lauretta M. and Sharma R.
SCRS/2017/081	Tools to guide the selection of CPUE series – revisited and revised	Bruyn P.A. and Schirripa M. J.
SCRS/2017/091	Options for an Observation Error Model for North Atlantic albacore MSE	Merino G., Kell L.T., Arrizabalaga H., Santiago J., Sharma R., Ortiz de Zarate V., and De Bruyn P.
SCRS/2017/092	Uncertainty grid for North Atlantic albacore Management Strategy Evaluation: Conditioning Operating Models	Merino G., Kell L.T., Arrizabalaga H., Santiago J., Sharma R., Ortiz de Zarate V., and De Bruyn P.
SCRS/2017/093	Updated Evaluation of Harvest Control Rules for North Atlantic albacore through Management Strategy Evaluation	Merino G., Kell L.T., Arrizabalaga H., Santiago J., Sharma R., Ortiz de Zarate V. and De Bruyn P.
SCRS/2017/097	Standardized catch rates for simulated longline data	Ortiz M.
SCRS/2017/099	Some methodological approaches to standardizing catch per unit effort in mixed fisheries: application to target species in the longliners of Morocco	Serghini M., Habiba H. and Aziza L.
SCRS/2017/100	A roadmap for CPUE standardization using simulated/observed data: proposed study	Sharma R., Cooper A., Coelho R. and Schirripa M.
SCRS/2017/101	SCRS Annual dashboard: a new tool to complement the management advice to the Commission	Santiago J., Arrizabalaga H., Merino G. and H. Murua
SCRS/2017/103	Des orientations pour la standardisation des captures par unités d'effort selon la stratégie de pèche et les variables environnementales: espadon et thon rouge de la méditerranée	Zarrad R. and Missaoui H.
SCRS/P/2017/013	Integrating uncertainty from data processing into population assessment	Carruthers T., Kell L. and Palma C.

Appendix 4

Example for presenting MSE results

Cells are shaded with darker cells containing higher values and lighter cells lower values. Table has been sorted on the B_{mean} vales (in descending order). Shading is a preliminary example and the SCRS should define the exact characteristics for presentation. See key below for column definitions.

HCR			Stock Status					Safety		Catch			Stability				
Ftar	**Bthresh**	**δTAC**	**B_{min}**	**B_{mean}**	**F_{mean}**	**pGr%**	**pRed%**	**pB_{lim}%**	**pB_{int}%**	**Y1**	**Y2**	**Y3**	**MAP**	**var**	**pshut**	**p10%**	**maxTACc**
0.60	0.80		0.63	2.04	0.51	93	0	100	5	23.16	21.06	28.34	1.21	23831204	0	19.90	8.71
0.60	1.00		0.62	2.02	0.51	92	1	100	6	23.17	20.61	28.31	1.22	25115893	0	20.00	8.74
0.60	0.60		0.65	2.02	0.51	93	0	100	5	23.17	21.14	28.24	1.20	23205511	0	19.84	8.69
0.70	1.00		0.47	1.95	0.56	92	1	100	6	23.36	21.95	31.10	1.37	32925401	0	20.48	9.78
0.70	0.60		0.45	1.91	0.58	90	2	100	7	23.63	23.05	30.80	1.31	29258517	0	19.31	9.35
0.70	0.80		0.41	1.88	0.59	88	2	100	7	23.54	22.97	30.79	1.31	29273034	0	19.62	9.59
0.80	1.00		0.37	1.81	0.61	83	2	100	11	23.93	22.62	32.56	1.49	40178188	0	20.76	10.67
0.80	0.80	20%	0.34	1.76	0.62	86	3	100	9	24.30	24.49	32.32	1.42	32943413	0	19.95	10.25
0.80	0.60		0.28	1.76	0.65	83	3	100	10	24.25	24.80	32.49	1.42	33355009	0	19.55	10.28
0.90	1.00		0.25	1.70	0.68	79	5	100	13	24.44	23.62	34.34	1.61	49680127	0	21.14	11.51
0.90	0.60		0.23	1.66	0.71	81	6	100	12	25.46	26.75	33.73	1.53	33965430	0	20.21	10.76
0.90	0.80		0.23	1.65	0.70	78	6	99	14	24.81	26.22	33.42	1.51	37624019	0	20.88	10.75
1.00	1.00		0.19	1.62	0.73	76	7	99	13	24.46	24.46	35.26	1.69	50345619	0	21.41	11.92
1.00	0.80		0.19	1.58	0.76	72	9	99	16	25.33	27.15	34.77	1.66	41008046	0	21.21	11.60
1.00	0.60		0.12	1.44	0.87	66	13	98	19	25.45	28.68	34.54	1.67	39145738	0	21.00	11.74

Appendix 4 (continued)

Key to performance indicators (Table from Appendix 4 to Annex 4.6 of the *Report for Biennial Period 2016-2017, Part II (2016), Vol. 1*.)

	PERFORMANCE INDICATORS AND ASSOCIATED STATISTICS	**UNIT OF MEASUREMENT**	**TYPE OF METRICS**
	1 Status		
B_{min}	1.1 Minimum spawner biomass relative to B_{MSY}	B/ B_{MSY}	Minimum over [x] years
B_{mean}	1.2 Mean spawner biomass relative to B_{MSY}	B/ B_{MSY}	Geometric mean over [x] years
F_{mean}	1.3 Mean fishing mortality relative to F_{MSY}	F/ F_{MSY}	Geometric mean over [x] years
pGr%	1.4 Probability of being in the Kobe green quadrant	B, F	Proportion of years that $B \geq B_{MSY}$ & $F \leq F_{MSY}$
pRed%	1.5 Probability of being in the Kobe red quadrant	B, F	Proportion of years that $B \leq B_{MSY}$ & $F \geq F_{MSY}$
	2 Safety		
pB_{lim}%	2.1 Probability that spawner biomass is above B_{lim} ($0.4B_{MSY}$)	B/ B_{MSY}	Proportion of years that $B > B_{lim}$
pB_{int}%	2.2 Probability of $B_{lim} < B < B_{thresh}$	B/ B_{MSY}	Proportion of years that $B_{lim} < B < B_{thresh}$
	3 Yield		
Y1	3.1 Mean catch – short term	Catch	Mean over 1-3 years
Y2	3.2 Mean catch – medium term	Catch	Mean over 5-10 years
Y3	3.3 Mean catch – long term	Catch	Mean in 15 and 30 years
	4 Stability		
MAP	4.1 Mean absolute proportional change in catch	Catch (C)	Mean over [x] years of $(C_n - C_{n-1})/ C_{n-1}$
var	4.2 Variance in catch	Catch (C)	Variance over [x] years
Pshut	4.3 Probability of shutdown	TAC	Proportion of years that TAC=0
p10%	4.4 Probability of TAC change over a certain level	TAC	Proportion of management cycles when the ratio of change $(TAC_n - TAC_{n-1})/TAC_{n-1} > X\%$
maxTACc	4.5 Maximum amount of TAC change between management periods	TAC	Maximum ratio of change

Appendix 5

List of external experts

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