REPORT OF THE 2019 INTERSESSIONAL MEETING OF THE ICCAT BLUEFIN TUNA SPECIES GROUP

(Madrid, Spain – 11-15 February 2019)

The results, conclusions and recommendations contained in this Report only reflect the view of the Bluefin Tuna Species Group. Therefore, these should be considered preliminary until the SCRS adopts them at its annual Plenary meeting and the Commission revise them at its Annual meeting.

Accordingly, ICCAT reserves the right to comment, object and endorse this Report, until it is finally adopted by the Commission.

1. Opening, adoption of agenda and nomination of rapporteurs

The meeting was held at the ICCAT Secretariat in Madrid from 11 to 15 February 2019. Mr. Camille Jean Pierre Manel, ICCAT Executive Secretary, welcomed the participants and opened the meeting. Dr John Walter (USA) and Dr Ana Gordoa (EU-Spain), the Rapporteurs for the western Atlantic and eastern Atlantic and Mediterranean stocks, respectively, served as co-Chairs. The Chairs proceeded to review the Agenda which was adopted after various changes (**Appendix 1**).

The List of Participants is included in **Appendix 2**. The List of Documents and Presentations presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents and presentations provided at the meeting are included in **Appendix 4**.

The following served as rapporteurs: Topics related to MSE: Carmen Fernandez, Day 1: Tristan Rouyer, Day 2: Molly Morse, Day 3: Gorka Merino, Day 4: Grantly Galland, and Trial Specification Document: Nicholas Duprey.

2. Review of 2019 Bluefin Tuna Work Plan

The main objectives of this meeting were: "To approve final set of Operating Models (OMs) and review progress to provide advice on Candidate Management Procedure (CMP) development" and "To provide input to the SCRS Chair on the content of the MSE presentation to Panel 2". The Chair of Panel 2 requested two presentations; a general overview of MSE and an update on the BFT MSE progress.

3. Description of developments since the September 2018 Bluefin Tuna Species Group Meeting

The developments were in line with what was requested in September 2018. The data until 2016 were included in the conditioning of the OMs, as were further data related to mixing and also some agreed changes concerning the modelling of recruitment. The reconditioning of the OMs was more challenging than anticipated, resulting in delays that impacted the preparatory work for the BFT MSE Technical Group (BFT MSE TG) meeting and the present meeting. Additionally, the impact of high Mediterranean catches of juvenile fish in the 1970s and 1980s was investigated and the results indicated that its magnitude was negligible (SCRS/2019/021).

4. Summary of outcomes from the 7-9 February meeting of the BFT MSE Technical Group

The SCRS Chair provided a summary of the main issues and a detailed report from the meeting. During the technical meeting an error was found in the MSE software code; new results, with the corrected software, become available for the present meeting.

5. Overview of the trial specification document (TSD)

The TSD (version 19-1) was presented and the overall contents of each section discussed. Multiple questions and comments (**Appendix 5**) arose within each section which will be taken into account in the TSD version produced at this meeting. The updated TSD (19-4) is included as an appendix to this meeting (**Appendix 6**).

As the TSD is a product of each meeting and, as such, should reflect updates made at specific meetings, an appointed Rapporteur will maintain the TSD during meetings while the Contractor will retain intersessional responsibility for maintaining the TSD. **Appendix 5** outlines a proposal for version control of the TSD. The updated TSD will be made available with the MSE code, operating model reports and full M3 and MSE code as soon as the most recent changes can be incorporated and documented. At some date when the TSD reaches a state of sufficient completion, it may be translated to all ICCAT languages. The SCRS Chair noted that decisions made about version control, documentation and dissemination could usefully be adopted for other ICCAT MSE endeavours.

6. Overview of OMs and specific example

The Group reviewed the contents and structure of an individual OM report. The Group focused not on the results of any particular OM but on the structure of the OM report, the input data and diagnostic plots in order to achieve a common understanding of how to evaluate OMs. This process afforded an in-depth view of an OM report and resulted in many clarifications and some improvements to the reports. The full series of comments are available as **Appendix 7**.

A concept critical to understanding the OMs is the concept of dynamic SSB_0 (MacCall *et al.* 1985) where the assumed equilibrium biomass benchmark (SSB_0) is a dynamic calculation of the unfished equilibrium spawning biomass under the prevailing stock recruitment relationship, calculated by projecting the current population forward assuming no fishing. Similarly, while the actual equilibrium SSB_{MSY} changes abruptly under a new stock recruitment relationship, the SSB_{MSY}/SSB_0 fraction (which reflects the stock recruitment relationship at the time and is calculated using recent selectivity) multiplied by the dynamic SSB_0 is used to estimate the benchmark SSB_{MSY}. This allows the benchmark SSB_{MSY} to follow the gradual change in the dynamic SSB_0 so as to avoid sharp breaks in stock status determination when the stock-recruitment relationship changes.

The concept is such that the population status is measured against the prevailing benchmark but with some lag due to growth of fish born prior to the stock recruitment change, and is useful when environmental regime shifts occur (A'mar *et al*. 2009) so that management responds to the status of the stock according to prevailing environmental conditions. While the MSE process makes no explicit statement of the plausibility of or mechanism behind any regime shifts at this time, the OMs have been specifically structured to include such shifts as possibilities for the purpose of developing management procedures that are robust to potential shifts. The Group notes that the task of plausibility weighting of OMs has not yet been conducted (see item 19).

7. Overview of data used for conditioning

The Group reviewed much of the data used for conditioning as they reviewed the TSD and the OM reports. Specific discussions about the input data as they related to sensitivity/robustness runs are found in other report sections. Stock of origin data were addressed in the presentation SCRS/P/2019/002. Specific discussions of the PSAT tagging led to a re-calculation of the ETAG (electronic tag) transition matrix: see section 9 below.

8. Recent developments from OMs; consideration of the Technical Group's suggestions for acceptability of conditioning

The MSE Contractor provided an update on ABT-MSE package version 4.4.5 regarding revisions made to OMs following requests from the 7-9 February Intersessional Meeting of the ICCAT Bluefin Tuna MSE Technical Group. Concerns addressed included surprisingly low historical biomass in the western stock. The Group had identified incorrect assignment of fish to strata, which were then assigned to the incorrect stock of origin data, and that some tagging data in those areas had been missing. These corrections resulted in an additional 160 tag transitions, additional movement exclusions (GSL (Gulf of Saint Lawrence) region Quarter 1 (Q1) and GOM (Gulf of Mexico) region Q3), and ensuring that all data from the Caribbean Sea region (formerly part of the GOM region) were assigned to the WATL (Western Atlantic) region. These changes were made both to the OMs and to the R code that is used to translate OM outputs. Results of these changes exhibited qualitative and quantitative differences in OM outputs, particularly changes in scale of western stock biomass and less extinction of the western stock.

The Group agreed that it would be useful to have additional review of the master index (and potentially consider alternatives), because the model's sensitivity to this cannot be tested by down-weighting this data source. Concerns were raised regarding the B_{MSY} and B_0 metrics, because the newly estimated biomass levels were consistently below B_{MSY}, which was not the case with the previous set of OMs. Possible explanations identified included 1) the new conditioning of OMs allows for better estimation of stock size than previously, 2) the Group should temper its expectations that the model will replicate the Group's understanding of the stocks based on recent stock assessments, and 3) use of the western hockey-stick stock recruit model should be reconsidered. It was also suggested to try the old movement matrix in the newly conditioned OMs to determine whether the differences may have been caused by the movement matrix or the spatio-temporal restrictions. Some of these concerns will be investigated intersessionally by the Contractor, through further sensitivity runs outlined below.

The Group developed the following list of sensitivity runs for the Contractor to conduct at the meeting. The purpose of these runs was specifically to identify sources of data conflict within the model and to evaluate sensitivity to model parameter assumptions:

1. Upweight length compositions
2. Individually downweight the genetic, otolith microchemistry, and PSAT tag data sources, one at a time, downweight both genetic and otolith microchemistry at the same time
3. Upweight landings
4. The six robustness tests identified in the TSD
5. Put the old PSAT transition matrix into the new OMs
6. Code MSY for Hockey stick SRR (if possible, post-meeting)
7. Senescence. It was noted that the Extended Scientific Committee (ESC) of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) found cryptic biomass estimates which were considered too high as a result of strongly domed selectivity, unless an increased value of M (natural mortality) was used for the older ages (senescence). Two possibilities were suggested for consideration by the Group:

    a) checking the age distribution implied by the current operating models in the population, both for the unfished B_0 and for the current SSB;
    b) adopting a similar older age M schedule to that used by the CCSBT SC for SBT – though there is no direct information to inform this for ABFT, it would not seem unreasonable to assume this in ABFT when it evidently occurs for a similar species in SBT. CCSBT uses Bayesian priors for M at age, so specific values to input, or, alternatively, similar prior distributions to use for ABFT would need to be considered intersessionally.

Conclusions from the sensitivity runs conducted at the meeting

Cases 1-4 were run during the meeting, but only for OM 1AI due to time constraints, and results were presented as time series of historical and projected future biomass, catch and harvest rate, for the western and the eastern stocks. The projections into the future were conducted with zero catch and with a current catch MP.

The main difference found in biomass trajectories was when the length compositions were upweighted, which resulted in larger stock biomass both for the western and the eastern stocks. Further investigation of the impacts of upweighting the length compositions, particularly on the estimated fleet selectivities, and stock mixing and movement, are necessary.

The Group considered the various M at older age options but reached no clear decision. It was generally considered that the priority should be trying to understand what had led to the changes in perception from the updated OMs, and that there was a need to see more complete results related to the influence of differential weighting of model data components.

Concerning weighting of datasets within OMs, indices that will be used in CMPs are often given priority. It was noted that, generally, in the conditioning of the models to data, movement (as informed by stock of origin data and ETAGs) and recruitment represented substantial sources of uncertainty. Generally recommended practice is to prioritize fitting the catch first (to get the scale of removals), the indices (to get trend) next and to give lesser priority to fitting length compositions (Francis and Hilbourn, 2011). The BFT

MSE TG Chair noted that the current iterative reweighting of data components is statistically justified and the downweighting of components conducted to date has been solely for sensitivity tests. Further consideration of alternative data weighting scenarios will be explored by the Intersessional Meeting of the Bluefin Tuna MSE Technical Group in July. This would be most effectively dealt with by developing specific hypotheses to be addressed by differentially weighting data components, such as the impact on movement estimated when fitting the length composition data better. The Contractor was tasked to prepare various sensitivity runs with differential weighting among data inputs for several representative OMs which enables the evaluation of data conflicts. It will also be useful to compare different likelihood components across OMs to evaluate fits to the data components.

Subgroup recommendations

Diagnostics for acceptability of OMs: any OM should be run in the MSE model with zero catch and current catch and the following checks should be made with particular attention to the extent to which CMP performance is impacted. A series of diagnostic plots and codes are provided as **Appendix 8**.

* *Checks of input data (redface test, must be passed before proceeding with the rest)*

Check correct data formatting (from raw to M3 input file); check of occurrence of gear types by region and season via appropriate plots (and correct, if necessary).

* *Likelihood fits*

Examine contribution of various likelihood components to determine if a data source is the main driver of model fit. Examine fits for systematic trends in residuals as evidence for severe model misspecification, noting the relative prioritization of data weighting in general practice in integrated modeling outline in "*Conclusions from the sensitivity runs conducted at the meeting".*

* *Model validation*

Mandatory (red face tests)

These scenarios represent implausible model results for which the following process should be followed. First these diagnostics could be indicative of an error in data or structural assumptions which needs to be investigated. Second if no obvious data error or structural assumption is identified then the models should be investigated further. The following set of criteria may be used to judge the implausibility of the models, keeping track of the criteria for which a model has failed.

1. Predicted annual catches by area should be similar to those observed (+/- 10%)
2. The SSB of the eastern stock must be greater than that of the western stock (in all years)
3. Fraction of spawning biomass in the spawning area in the spawning season, by stock, should be greater than 30% of the total SSB for each stock
4. The absolute biomass of the western stock in the East area in a year must be lower than the absolute biomass of eastern stock in the West area
5. No more than half of west stock biomass in the East area (annual, averaged over seasons)
6. The probability of remaining in an area cannot be greater than 99.9%
7. No eastern stock fish (i.e. 0 or an extremely small number) in the GOM
8. No western stock fish (i.e. 0 or an extremely small number) in the Mediterranean Sea (MED)
9. The bulk of the removals in the West area should be in WATL region, whereas in the East area should be in the MED

Desirable tests and further outputs:

1. MCMC plots (to understand within model uncertainty) of B/B_{MSY} and U/U_{MSY} (where U is the catch/biomass ratio)
2. Lack of seasonality in biomass in the Mediterranean would be surprising and require further investigation – this would be a concern if all OMs would behave in this way
3. Allocation of future catches should match experts' knowledge of spatio-temporal fleet distribution

4. In both past years and future projections, length and stock composition of catches by fleet and area should reflect experts' knowledge (e.g. the Japanese LL fleet does not catch age 1 fish); estimate proportion of fish in catch by fleet below approximately 30 kg
5. The contribution of biomass of one stock to the other area should not show abrupt changes
6. Compare the master index with the implied spatio-temporal biomass in the model: compare magnitude and trend (the concern is that the master index could be strongly determining trends)
7. According to ETAG data inspection, the bulk of the stock distribution should be in the north during July-November (GSL, WATL, Northeast Atlantic (NEATL) and East Atlantic (EATL) regions), and then migrates to southern regions (WATL, GOM, MED and South Atlantic (SATL) regions)

Sensitivity OM runs to be run in advance of a July meeting:

1. Investigate the impact of the master index (which is an estimate of relative biomass by regions, season and year) on results; this would require that a new master index is calculated so that it can be used in the OMs to check sensitivity regarding stock status relative to B_{MSY}
2. Alternative catch reconstruction from 1864 and 1964, if provided by April 1, 2019
3. Sensitivity to estimate separately the current selectivity of the Japanese longline fishery post 2010 (after the introduction of an Individual quota system (IQ) and change un size limits) and use it as the future selectivity of this fleet
4. Half mixing of eastern stock fish in the West area and no western stock fish in the East area
5. Various explorations of the posterior M-at-age from CCSBT
6. Exploration of other weightings of the length composition data
7. Pulse-like recruitment dynamics (instead of regime shift), i.e. two, three years of consecutive strong year-classes
8. Three line stock recruitment model (Porch and Lauretta, 2016)
9. Correlation between recruitment in the 2 stocks

Additional diagnostic plots to those outlined in **Appendix 8**

1. Produce piecharts of the spatial and seasonal distribution by stock into the future, by decade
2. Future projection intervals should be generated (and displayed) for the indices
3. Unavailable (cryptic) biomass to be calculated; details to be determined by the Contractor

9. Review of available documents

Document SCRS/2019/017 documented the evaluation of a model-based $F_{0.1}$ management procedure using an operating model conditioned on the 2017 East and West VPAs. Mixing is based on a Markov model (Galuardi *et al*., 2018) that uses satellite tagging data. The MSE uses a stock recruitment relationship similar to the two-line or low stock recruit relationship. The results indicate that the western stock (e.g. fish of both East and West origin in the West Area) was larger than western population (fish only of western birth origin) due to movement of eastern fish into the western area. There was low bias in estimation of $F_{0.1}$, however there was overestimation of its magnitude in the historical assessment period.

The MSE conducted in this paper is informative for the overall MSE process, but differs in a substantive manner from the ABT-MSE tool in that it uses a single model, rather than multiple operating models, and makes several simplified assumptions to create age composition data for use in a model-based management procedure.

Arrizabalaga *et al*. SCRS/P/2019/002: This presentation highlighted new results from analyses of otolith chemistry and genetics data. The observation was made that potentially as soon as an eastern fish departs from the Mediterranean for the Atlantic, its otolith chemistry signal starts to be less differentiable from the Gulf of Mexico fish. This may be due to the sharp gradient in delO_{18} chemistry between the Mediterranean and adjacent Atlantic waters (Schmidt *et al*., 1999).

When the same samples were analyzed for both otolith chemistry and genetics, different perceptions of stock assignments were produced. The otolith chemistry suggests more fish from the Gulf of Mexico in the eastern area, and the genetics data suggest fewer Gulf of Mexico fish in the eastern area (more consistent with the tagging methods).

The Group suggested that if the objective is to manage for the separate genetic populations, genetics should be used primarily to determine stock of origin, not otolith chemistry. The Group agreed this information provides a lens through which to look at the OM results, and an approach to consider for changes to future iterations of MSE.

10. Reports from GBYP activities

Reports of ICCAT GBYP International Workshop on ABFT Growth (Santander, 4-8 February 2019)

Dr Rodriguez-Marín summarized the findings of the GBYP International Workshop on ABFT growth that took place in Santander on 4 to 8 February. The motivation for the workshop was based on some issues around the catch at age and age length keys observed during the 2017 assessments, including some bias in the otolith age length keys (ALK) that overestimated age compared to spines. As a result of the workshop, some solutions to deal with the problems were suggested, including a new age assignment criterion and a review of the age reading protocol. In addition to the limited inter-calibration exercise carried out at the workshop on the reference samples, an inter-calibration exercise for GBYP samples read by an external ageing agency has been scheduled. Additional recommendations were offered to inspect alternatives to better accommodate stable isotopes and aging analyses on the same otolith, additional age validation studies (e.g. using tetracycline marks), collaboration with farms to gather hard parts, to track the available collections of calcified structures, and to coordinate research between different laboratories working on ABFT ageing.

The bias was observed mainly for individuals of ages 3-7 and older caught on the western Atlantic from readings of a single laboratory. The preparation and reading protocols have been revised and calibration studies have been proposed to improve the accuracy of age readings.

The Group also noted that ALKs were available only for some of the latest years of the time series, while it would be important to expand the time series as much as possible. The need to review the current growth curves used in the assessment was also recalled.

Report of GBYP activities

Dr Alemany presented the GBYP workplan for Phase 8 that was amended by the Steering Committee in December 2018, to accommodate some recommendations of the Commission, among others. The new activities planned include:

- The aging workshop already conducted (see paragraphs above)
- Develop an ALK based on the 2000 otoliths aged by Fish Aging Services in Phase 7 by applying the age class assignation criteria agreed during the aging workshop and proceed with the preparation of 2000 additional otoliths for reading, postponing their analysis to Phase 9
- Aerial survey: some sources of bias were detected, e.g. sightings of juvenile fishes were included in estimates of adult abundance. There is a schedule to revise the time series, develop new sighting protocols, and carry out calibration exercises, to minimize these biases
- New sets of data from e-tags will be included in the database
- A new study to estimate growth rate in farms is being designed
- Close kin mark recapture: consider re-evaluating this for the eastern stock, as a potential way to estimate biomass and/or exploitation rate

The last point on close kin mark recapture was discussed further. Mention was made that the western stock pilot study was positive, and that this will be presented in ICCAT soon. Clarification was provided that some Balearic larval collections are being analyzed to see the relatedness within and across tows.

Earlier feasibility studies by GBYP suggested large sample sizes needed to be genotyped and aged in order to be able to apply close-kin analysis to the eastern stock. Hence it was agreed that it was important to revisit these numbers to further assess feasibility. The Group was reminded that both ICCAT observers and CPC observers could be used to obtain genetic samples for most of the catch, but that the otolith sampling for ageing these fish would be very difficult.

Report of ICCAT GBYP Reproduction Workshop (Madrid, 26-28 November 2018)

The Co-Chair of the meeting led a presentation to summarize the draft report from the GBYP reproduction workshop that was held in November 2018. The workshop covered eight main topics: independent reviewers report, reproductive physiology, larval ecology, tuna aquaculture/reproduction, spawning habitat modelling, life history, ABFT fisheries, and implications of MSE/assessment. The differences in opinions led to interesting debates: in particular Davíd Macías demonstrated that spawning fraction ogive data from fish entering the Mediterranean caught in Spanish traps suggested a similar spawning fraction to that of the western stock but the group pointed that this result differed from the spawning ogive observed in the Mediterranean. The Group identified the following shortcomings: 1) the maturity ogive for eastern stock currently used in the assessment does not represent the fraction of spawners by age, 2) the maturity ogive for the western stock currently used in the assessment which is based on the age structure of the fleet does not represent the fraction of the spawning population. The Group concluded that both vectors used at present for the spawning fraction might be biased, but the magnitude of the bias is unknown.

11. Discussion of process to advise the Commission as to whether updated indices support continuation of management advice (comparing the updated indices with prediction intervals from the projections)

The Co-Chair described the process to evaluate whether the updated indices support continuation of the management advice outlined in Rec. 17-06 for 2020. The process involves projecting the 2017 stock assessment models forward in time to 2018 and plotting the observed updated indices on projection intervals. Indices that fall within 90% projection intervals indicate no reason for any change in advice. Indices that are below prediction intervals could warrant further consideration by the Group as to whether such a value is indicative of a problematic trend. This method allows for an objective comparison of the observed indices to predictions of the models. It requires that analysts can project forward the current VPA and Stock Synthesis models assuming recent catches for 2017 and that indices used in the assessment are updated by Monday September 23, 2019 of the Species Group meetings by index providers. The Group considered that this approach should be attempted for the September Species Group meeting.

12. Initial review of CMP results

Initial review of CMP results on the latest OMs was not conducted at this meeting.

13. Reference and robustness set review

A balanced set of OMs is needed in the Reference set and the individual OMs may need to be combined in some, possibly weighted, form for the convenient presentation of overall summaries and efficient presentation of the results of sensitivity analyses without creating an overwhelming quantity of output material to consider. Definition of the reference and robustness set has not yet been conducted.

To facilitate work between this meeting and the Intersessional Meeting of the Bluefin Tuna MSE Technical Group in July, it is desirable to entertain a preliminary set of operating models and an Interim grid was proposed, as follows:

Interim Grid (12 OMs in total)

Recruitment (2-phase, 1-phase, future shift) (3)	Factor levels 1 / 2 / 3
Abundance (best estimate) (1)	Factor level A
Spawning fraction / Natural mortality (M) ; (2)	Factor levels I (High M/ Early Mat), IV (Low M/ Late Mat)
Mixing (2 scenarios)	1) Mixing as it is now; 2) No western stock in East area and ½ mixing of eastern stock in West area

The discussion focused on including an alternative mixing scenario into the Interim grid. A scenario with no western stock fish in the East area and half of the mixing of eastern stock fish in the West area was proposed and elevated to the Interim grid. Presumably half of the mixing fraction of eastern stock fish in the West area would be achieved by reducing the currently estimated movement rates, while the Group leaves the exact mechanics to achieve the absence of western stock fish in the East area to the Contractor. The Group considered that abundance option B (fit to the 2017 VPA stock assessment trajectories closely) was no longer necessary, at this point, as the fits to the A version more closely resemble the assessment trajectories now, and this was removed from the Interim grid.

For the spawning fraction/ natural mortality (M) options the Group chose the two for which results covered the greatest range; I (high M, early maturity) and IV (low M, late maturity). The Group considered other options such as removing the regime shift hypothesis but felt that, at least at this stage, testing CMPs against regime shift hypotheses was an important feature to evaluate performance.

There were concerns that the Interim grid may not be appropriately balanced across recruitment scenarios; balancing and data weighting concerns remain to be addressed and the Group emphasized that the Interim grid is not the final Reference grid. Any final decisions on the reference and robustness sets could only be made in September by the SCRS on the advice of the Bluefin Tuna Species Group. Additionally, the matter of plausibility weighting of the OMs, an issue separate from data weighting, will also need to be considered in due course.

Several other options for consideration are listed as sensitivity runs to be conducted intersessionally. These are described in item 8 and may be considered later for elevation to the grid. These include the CCSBT high M at high ages and various data weightings that will be evaluated intersessionally. Other sensitivity runs include fitting to the Japan longline selectivity accounting for changes in recent selectivity, particularly the selectivity projected into the future.

The recommendations for alternative recruitment specifications as well as some other scenarios may need input from Group scientists to specify the scenarios more fully.

14. Review of performance statistics (e.g. average catch over projection period) and possible modifications

The Group reviewed several performance statistics and noted that several clarifications (noted below in item 24) would be requested from Panel 2. The Group discussed aspects of the calculation of different performance statistics but specific calculations and definitions will be further elaborated by or in conjunction with Panel 2.

Figures from Miller *et al*. 2018 show the fundamental trade-offs one finds across performance statistics. This paper provides recommendations for improving communication in MSE processes.

Previous meetings of Panel 2 and the Standing Working Group to Enhance Dialogue between Fisheries Scientists and Managers have stated their desired performance metrics (related to safety, stability, long-term catch, interannual variability), so it may be expected that they will also state their preferred metrics this time. A lesson learnt in previous MSE work was that catch is sometimes a compelling performance metric to stakeholders and that placing this performance in absolute terms focuses attention to the critical trade-offs necessary to make decisions. Presenting conflicting trade-offs between inter-management period variability in catch and total average catch over a time period in absolute terms (e.g. metric tons), allows stakeholders to immediately grasp the inherent trade-off between having higher catches on average and high variability between management periods compared to less variability in catch and lower yield over time. This allows stakeholders to reach decisions about desired performance in the face of trade-offs rather more quickly. Efficient and effective communication of the essential trade-offs is critical to providing stakeholders with necessary information to select a single MP (the Commission can eventually implement only one MP) from the suite of candidate MPs that will be presented.

Given its importance, the Group considered the interpretation of projected catch values from MSEs, and the associated challenges in communicating this to managers and stakeholders. It was concluded that MSE should provide the future probability envelope (such as e.g. median and some extreme percentiles, such as 5th and 95th percentiles) of possibilities for future outcomes when a particular MP is applied. Particularly since MPs are often based on the most recent TAC, the actual future TAC recommendation should have a high probability of being inside the envelope. However, its actual trajectory within the envelope is unknown at the time the MSE is projected forward to screen CMPs as the actual data which inform the MP have yet to be collected. This concept can be illustrated by 'worm' plots of individual simulated TAC trajectories obtained by applying the MP. In a well-functioning MSE, the absolute values matter.

It was also stressed that the point of MSE is to evaluate MPs that incorporate feedback control (e.g. the MP responds to signals it receives about abundance from the indices that are used in a defined manner within the MP). The reliability of predictions from and interpretation of MSE results are contingent on having properly characterised the existing uncertainty; which underscores the need for conditioning, balance across possible states of nature in the creation of the reference set of OMs and realistic generation of error to produce future monitoring data inputs in simulations. An essential part of the MSE process is to simulate the uncertainty envelope for the observed future indices, to be able to detect if the actual observations fall outside predicted ranges.

15. Prepare/Review materials for SWGSM/Panel 2 meeting (early March) to present options for operational management objectives and performance statistics (Glossary and ICCAT BFT MSE Quick Reference)

Addressed in item 24.

16. Review of further results from candidate CMPs

Further results of the candidate CMPs were not presented.

17. Discussion on presentation of CMP results

Discussion of presentation of very preliminary CMP results focused on recommendations in Miller *et al*. 2018 which included trade-off plots. Representation of the trade-offs between performance criteria across management procedures was noted as a critical aspect to convey to stakeholders.

18. Selection of tuning criteria to facilitate comparison of results from different CMPs

Tuning is the process of adjusting the control parameters of the MP for the purpose of achieving a desired result; an example is adjusting the target value (which would be a control parameter in this example) for an index used in characterizing stock status. Tuning is conducted in two stages for two different reasons. Initial tuning of CMPs to achieve the same common target standardizes performance across one common metric, allowing clear differentiation of the performance of different CMPs across the remaining performance metrics. This helps to serve as an initial ranking of CMPs scaled to a common denominator. It may be performed over one or several representative OMs but is not designed to obtain the actual tuning that would eventually be applied to set TACs.

The second round of tuning attempts to obtain good performance across all OMs in the reference set across the suite of management objectives considered most important by the Commission. This is the process by which MPs are tuned to be elevated to the status of final candidates for management consideration. In cases where the reference set covers broad ranges of plausible stock status and productivity, it is natural that not all MPs or even the same MP with different tuning criteria would perform equally, and hence clear trade-offs across performance metrics and OMs will occur. However, the process of CMP presentation to stakeholders is designed to indicate these trade-offs to allow the selection of a single CMP that best meets the multiple performance criteria.

Tuning conducted up to this stage (e.g. tuning to achieve B_{MSY} after 30 projection years) has been only to facilitate an initial comparison among CMPs and to illustrate trade-offs in catch versus stock biomass across OMs and across alternative tunings of CMPs. Tuning specifications for comparative CMP evaluation are addressed in item 8 of the Report of the 2019 Intersessional Meeting of the ICCAT Bluefin Tuna MSE Technical Group (Anon. in press).

19. Discussion of consolidation of results across different OMs, determination of and possible use of plausibility weighting

While the Group did not entertain any actual weighting of OMs, it did note several considerations for future weighting and criteria for inclusion of an OM in the reference set.

1. Criteria for inclusion in the reference set of high plausibility and large impact on results
2. Likelihood-based weights might be used, where appropriate
3. A Delphi process that allows for the incorporation of expert judgement

20. Discussion on development of Exceptional Circumstances provisions

Agenda item 20 issues were postponed until future meetings.

21. Comparison of future indices with probability envelopes predicted by OM projections

Agenda item 21 issues were postponed until future meetings.

22. Other matters

The Group discussed the matter in the 2019 workplan of addressing a request in Rec. 17-07 to evaluate “best catch rates”. The Group seeks further clarification on what is meant by ‘best catch rates’, particularly in what context and for what purpose in light of the substantial changes that have occurred in the fishery dynamics. Hence the Group seeks further clarification, which could occur within Panel 2.

The Group noted the need for further consideration of how to address the request of the Ecosystems Subcommittee and the requirements of several CPCs for stock status (e.g. B/B_{MSY}) and fishery status (e.g. F/F_{MSY}) time series under a management procedure approach where standard stock assessments may be conducted less frequently.

23. Recommendations

With financial implications

1. The Group requests an initial peer-review of the code and MSE output to ensure that the MSE specifications match the specifications outlined in the TSD. This will involve checking the MSE testing programs, checking that the calculations reflect written specifications in the TSD, and checking that the interface between M3 and the R code is functioning as intended. Additional tasks will be to itemize necessary additional documentation to the ABFT-MSE R package. (~1 month contract, likely after the Intersessional Meeting of the Bluefin Tuna MSE Technical Group in July once the specifications and code have better “stabilised”).

2. The Group will, when the MSE testing programs are finalized, request a full peer review of the conditioning and projection modules of the code to check that it is correct, and further provide commentary on assumptions inherent in the population dynamics, equations and modelling as to whether they are consistent with scientifically defensible best practices (likely a ~2 month contract for an external expert, likely sometime after the September Bluefin Tuna Species Group meeting).

Without financial implications

1. The Group recommends that the outputs (performance metrics by year-simulation-OM-CMP) of the MSE runs be retained in a database so that these can be used to support the assessment of CMP performance especially by the CMP developers.

24. Further discussion and planning of report/presentation for Panel 2

The Group's priorities for information and materials for Panel 2 focused on updates that the SCRS Chair and Bluefin Species Group Chairs can provide and clarifications that the Group requires for proceeding with MSE testing. These include: 1) an update on the Technical Group's progress toward MSE development; 2) draft management objectives included in ICCAT Resolution 18-03; and 3) communication of results.

Progress in MSE development

The Group felt that it has not progressed as far as it would have wished at this stage. There have been many necessary changes in conditioning the OMs and substantial additional coding activity during meetings. Adoption of conditioned OMs intended for this meeting cannot happen at this stage, and will be delayed to the September meeting of the Bluefin Tuna Species Group pending an additional Technical Group meeting in July that will review the appropriateness of the OM conditioning. Additionally and, intersessionally, further review of input data and evaluation of sensitivity runs will be conducted to support the July meeting. In the future, ample time between meetings is essential, so that needed coding and data error checking can take place outside meetings.

Despite the difficulties encountered, it was recognised that there has been substantial good progress to date, but that there is a risk that the MSE work will not be completed in time to provide TAC advice for 2021, and that managers should be made aware of this possibility. If some form of assessment is needed in 2020, the MSE finalisation will be delayed as it will be slowed by assessment work.

It was suggested that having simpler OMs (e.g. with 4 spatial regions and annual time step) may help progress faster and the need for the present high OM complexity was not evident to everyone. On the other hand, substantial effort has already been invested in the current OM structure, notably in reducing it from 10 areas to 7, and that an even simpler structure would likely also bring its own complications that would require resolution.

The Group slightly adjusted the ABFT MSE road map (**Appendix 9**) and identified two options for proceeding forward: see Section 25 regarding option A and option B. The Group considered that the Intersessional Meeting of the Bluefin Tuna MSE Technical Group in July should be able to ascertain if the OMs as conditioned at that time are ready for use or not. Therefore, the Intersessional Meeting of the Bluefin Tuna MSE Technical Group in September can be shorter than previously scheduled, and can focus especially on preparing presentations to assist the Bluefin Tuna Species Group.

The Group agreed that the SCRS Chair's presentation to Panel 2 would emphasise the complexity involved in modeling mixing and movement, particularly when scientific understanding continues to evolve rapidly during the process of MSE development. The SCRS Chair should begin to prepare Panel 2 for general features to be expected in the SCRS advice coming out of this process. Further, the Chair should highlight the challenges inherent in conditioning operating models to movement and mixing data, and that these challenges may necessitate some delay (e.g. option B, as defined in Section 27). The SCRS Chair will ensure the update is general but will be prepared with additional material to include slides on performance statistics, should he receive specific questions that require detailed answers. As part of the general presentation, the SCRS Chair will remind Panel 2 of the status of each bluefin stock, as presented to the Commission in 2017.

The SCRS Chair will also inform Panel 2 that the SCRS intends to include an option where catch is reduced to zero with the candidate management procedures, to illustrate the bounds on the extent to which the status and safety management objectives can be achieved under the most extreme case of closing the fishery. This exercise will allow the Commission to ensure that its objectives (as shaped by both likelihood of success and timelines) are not outside the bound of what is possible.

The Group highlighted the importance of conveying to Panel 2 that east-west interchange of bluefin implies that a TAC set for the west area may impact the eastern population and vice versa. It was noted that while the management implications of mixing remain unquantified, scientific evidence based on genetics, electronic tagging and otolith microchemistry, much of which has been recently collected and analysed through GBYP and its many scientific partners, illustrates that mixing exists.

Management objectives in Resolution 18-03

The Group carefully considered the draft management objectives produced by the Commission in Res. 18-03. There was recognition that further specificity in operational management objectives, even if only preliminary, would help scientists move the process forward. There was also strong agreement that objectives must come with the managers' preferred time period(s). To calculate performance statistics, the scientists need at least one time period to be specified. If Panel 2 does not indicate time periods, then scientists may suggest possibilities during the ongoing MSE development process.

Regarding the stability objective, the Group noted that it would be helpful for CMP development to get general guidance on the maximum percentage increase or decrease in TAC between management periods as well as on duration of the management periods. In recent years, bluefin has been managed on three-year TAC cycles, and without direction from Panel 2, CMP developers may need to choose a common period so that the candidate management procedures can all be developed using the same management periods.

Communication of results

The Group prepared an informational leaflet that highlights important MSE terms and concepts and serves as a reference guide for managers to use throughout the MSE development process (**Figure 1**). The SCRS Chair will include some of this information in his presentation to Panel 2. The Group's intention is to make it available in all three ICCAT languages before the Panel 2 meeting.

Regarding communications, a number of additional points were raised, including the need to differentiate MSE concepts from stock assessment concepts, a preference for focusing materials on the specifics of this MSE process (e.g. focusing on empirical management procedures in contrast to model-based procedures[1]), and the value in adapting content from existing ICCAT MSE materials. A recent publication (Miller *et al*. 2018), which reviews methods for improving communication in MSE processes, was highlighted as containing key figures useful for communicating the results of MSE.

25. Workplan and update of BFT roadmap (specifying future meeting agendas (July MSE TG, Sept BFT SG in particular), together with the process for moving forward

The Bluefin Tuna Species Group and Bluefin Tuna MSE Technical Group have made substantial progress in developing Operating Models; nonetheless practical considerations for planning 2021 TAC advice need to be considered. Given the complexity of the task of CMP adoption, the BFT WG considers it practical to consider two options for 2021 TAC advice. The first option (A) is to continue with the MSE development process as outlined in the Roadmap. The second option (B) is to begin planning for a 2020 stock assessment. These two options necessarily represent a bifurcation point for the Bluefin Tuna Species Group.

The Intersessional Meeting of the Bluefin Tuna MSE Technical Group in July outlined in the Roadmap will be a critical juncture in this path as the Bluefin Tuna MSE Technical Group will be tasked with evaluating whether the OMs meet acceptable criteria for presenting to the Bluefin Tuna Species Group. If the Bluefin Tuna MSE Technical Group considers that the OMs are not yet acceptable at this point, then they will notify the Bluefin Tuna Species Group that option B is the most likely path. If the Bluefin Tuna MSE Technical Group determines that the OMs meet acceptability criteria, they will be forwarded to the Bluefin Tuna Species Group in September, who will make a decision on whether to maintain the original Roadmap timeline (Option A) or to begin planning and preparation for a stock assessment. While work on the MSE can continue and will remain the eventual goal, Option B will likely delay the MSE process for at least one year to allow for a stock assessment to be conducted in 2020. A one-year delay would mean that the earliest possible presentation of CMPs to the Commission for potential adoption would be extended from the currently scheduled 2020 to, at minimum, 2021.

[1] Note that model-based CMPs are possible with the current MSE framework and are in development. However, in the first round of the MSE process it is not possible to test the current VPA and Stock Synthesis age structured models.

Options for B include a suite of potential methods to provide 2021 TAC advice, which could range from a full stock assessment, a straightforward update of the 2017 assessment, or alternative interim approaches to be determined. Note that, as the MSE is an iterative process, Option B ensures that it will remain possible to provide TAC advice in the future if unexpected delays occur in 2020 or beyond.

July BFT MSE TG → BFT SG → Option A (Continue with MSE)

↓

Option B (Initiate process for stock assessment)

Given the delays encountered in the process, the Species Group has revised the MSE roadmap (**Appendix 9**). Provided option A remains, the roadmap timeline will continue; however Option B will delay the workplan.

26. Adoption of the report and closure

Due to the limited time, some Agenda items were only partially reviewed prior to the close of the meeting: 12) Reference and robustness set review, 13) Review of performance statistics (e.g. average catch over projection period) and possible modifications, and 24) Recommendations. Therefore, these sections of the report were adopted electronically after the meeting. The remainder of the report was adopted during the meeting. The meeting was adjourned.

References

Anonymous. (in press). Report of the 2019 Intersessional Meeting of the ICCAT Bluefin Tuna MSE Technical Group (Madrid, Spain – 7-9 February 2019). Document SCRS/2019/001: 15 p.

A'mar, Z. T., Punt, A. E., and Dorn, M. W. 2009. The evaluation of two management strategies for the Gulf of Alaska walleye pollock fishery under climate change. ICES Journal of Marine Science, 66: 1614–1632.

Francis, R. C., and Hilborn, R. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences 68(6): 1124–1138.

Galuardi, B., Cadrin, S. X., Arregi, I., Arrizabalaga, H., Di Natale, A., Brown, C., Lauretta, M., and Lutcavage, M. 2018. Atlantic bluefin tuna area transition matrices estimated from electronic tagging and SATTAGSIM. Collect. Vol. Sci. Pap. ICCAT, 74(6): 2903-2921.

MacCall, A. D., Klingbeil, R. A., and Methot, R. D. 1985. Recent increased abundance and potential productivity of Pacific mackerel. CalCOFI Report, 26: 119–129.

Miller, S. K., Anganuzzi, A., Butterworth, D. S., Davies, C. R., Donovan, G. P., Nickson, A., Rademeyer, R. A. and Restrepo, V. 2018. Improving communication: the key to more effective MSE. Canadian Journal of Fisheries and Aquatic Sciences. http://www.nrcresearchpress.com/doi/pdf/10.1139/cjfas-2018-0134.

Porch C. E., and Lauretta M. V. 2016. On making statistical inferences regarding the relationship between spawners and recruits and the irresolute case of western Atlantic bluefin tuna (*Thunnus thynnus*). PLoS ONE 11(6): e0156767. doi:10.1371/ journal.pone.0156767

Schmidt, G. A., Bigg, G. R., and Rohling E. J. 1999. Global Seawater Oxygen-18 Database - v1.22. https://data.giss.nasa.gov/o18data/

Figure 1.

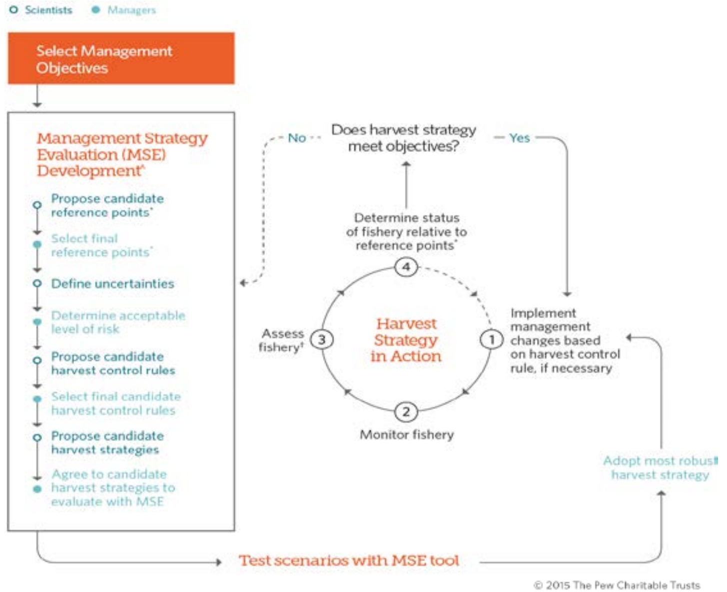
- ***Management procedure (MP)***: A pre-agreed framework for recommending or making fisheries management decisions, such as setting catch limits, that is designed to achieve specific ***management objectives***. A fully developed ***Management Procedure*** specifies which monitoring data will be collected, how the data will be analyzed, and what ***harvest control rule(s)*** will be applied. Also known as a harvest strategy.

- ***Operating model (OM)***: The part of the ***Management Strategy Evaluation*** that represents the "true" underlying status and dynamics of the population, fishery, and monitoring regime. There will be a number of Operating Models considered so as to capture the full range of uncertainties applying to the resource and fishery. Often two sets of Operating models are used: a "reference set" of the most plausible scenarios or hypotheses with the greatest impact on outcomes and a "robustness set" of unlikely but still possible scenarios or hypotheses.

- ***Harvest control rule (HCR)***: A rule that describes how the harvest is to be managed (e.g., catch- or effort-related limits) based on the state of a specified indicator(s) of stock status. Also known as a decision rule.

- ***Performance statistics***: A quantitative expression of a ***management objective***. Performance statistics compare the value of an indicator or variable (e.g., biomass, depletion) at a given point in time (or over a period of time, such as average catch over the next 20 years) to the stated objective for this indicator, so as to evaluate how well the objective is expected to be achieved under the MP being evaluated. Also known as performance metrics or performance measures.

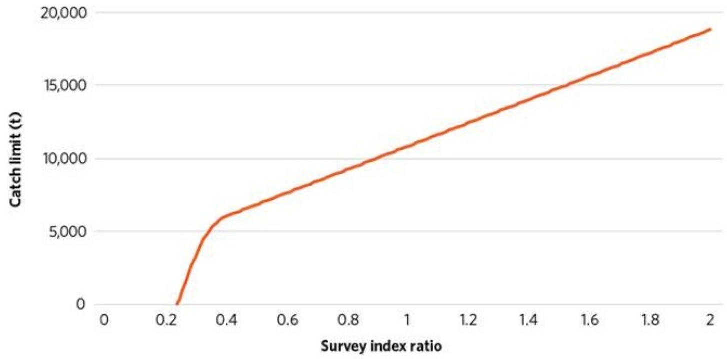
ICCAT BFT MSE quick reference



- ***Management Strategy Evaluation (MSE)***: A structured approach to evaluating management procedures against pre-defined goals and objectives.

- ***Management Objectives***: Formally adopted goals for a stock or fishery. These include high-level objectives often expressed in legislation, conventions, or similar documents. As the process progresses, they should also include operational biological and socio-economic objectives that are specific and measurable and possibly also associated timelines and minimum required probabilities that can be achieved.

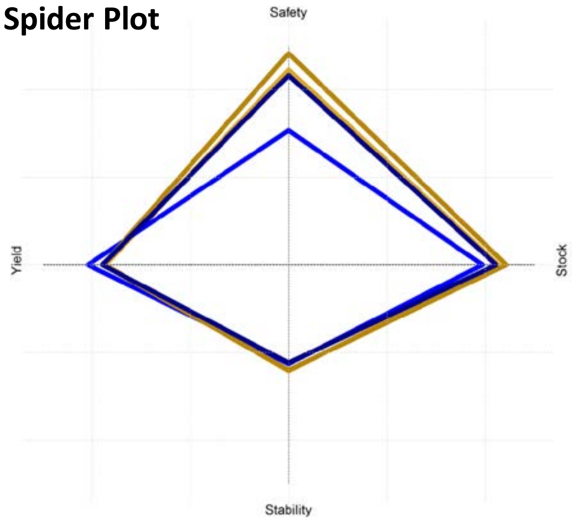
Example of a empirical management procedure



- Empirical management procedures can be used for making fisheries management decisions, such as setting catch limits. These decision rules can often be based on changes observed in a survey or CPUE index as seen in the above figure. As the survey index increases the Catch limits increase, as the survey index decreases the catch limits decrease.

- B_{MSY}: The biomass level producing maximum sustainable yield (MSY) at equilibrium.
- B_{LIM}: a level below which there is high probability that productivity is impaired and serious harm will occur.
- Fishing mortality rate (F): Continuous annual rate of loss of fish from a population due to fishing.
- F_{MSY}: The fishing mortality rate resulting in equilibrium biomass of B_{MSY} and, therefore, achieving MSY.

Spider Plot



- Spider plots are used to visualize the results of ***performance statistics*** of multiple ***management procedures*** in one figure. Better values are towards the outside, worse values are towards the inside. Here each colour represents a different ***management procedure.***

Appendix 1

Agenda

1. Opening, adoption of Agenda and nomination of rapporteurs
2. Review of 2019 Bluefin Tuna Work Plan
3. Description of developments since the September 2018 Bluefin Tuna Species Group Meeting
4. Summary of outcomes from the 7-9 February meeting of the BFT MSE Technical Group
5. Overview of the trial specification document
6. Overview of OMs and specific example
7. Overview of data used for conditioning
    - genetics and microchemistry
    - electronic tagging
    - approach used for the assignment of stock origin
    - movement/transition matrix
    - data guillotine: final decision on which data to be used in OMs
8. Recent developments from OMs; consideration of the technical group's suggestions for acceptability of conditioning
    - consideration of acceptability of each OM's reconditioning
    - proposals, if any, for modifications Overview of report of reproduction workshop
9. Review of available documents
10. Reports from GBYP Coordinator
11. Discussion of process to advise the Commission as to whether updated indices support continuation of management advice (comparing the updated indices with prediction intervals from the projections)
    - Ensure that CPCs update indices for the Species Group meeting
    - What catches to use for 2017 and 2018 (reported or reported + IUU)
12. Initial review of CMP results
13. Reference and robustness set review
14. Review of performance statistics (e.g. average catch over projection period) and possible modifications
15. Prepare/Review materials for SWGSM/Panel 2 meeting (early March) to present options for operational management objectives and performance statistics (Glossary and MSE leaflet)
16. Review of further results from candidate CMPs
17. Discussion on presentation of CMP results
18. Selection of tuning criteria to facilitate comparison of results from different CMPs
19. Discussion of consolidation at a future stage of results across different OMs, the possible use of plausibility weighting, and if so how that might be determined
20. Discussion on development of Exceptional Circumstances provisions
21. Comparison of future indices with probability envelopes predicted by OM projections
22. Other matters
23. Recommendations
24. Further discussion and planning of report/presentation for Panel 2
25. Workplan and update of BFT roadmap (specifying future meeting agendas (July MSE TG, Sept BFT WG in particular), together with the process for moving forward
26. Adoption of report and closure

Appendix 2

List of Participants

CONTRACTING PARTIES

CANADA

Carruthers, Thomas
335 Fisheries Centre, University of British Columbia, Vancouver Columbia V2P T29
Tel: +1 604 805 6627, E-Mail: t.carruthers@oceans.ubc.ca

Duprey, Nicholas
Science Advisor, Fisheries and Oceans Canada - Fish Population Science, Government of Canada, 200-401 Burrard Street, Vancouver, BC V6C 3S4
Tel: +1 604 499 0469, E-Mail: nicholas.duprey@dfo-mpo.gc.ca

Hanke, Alexander
Scientist, St. Andrews Biological Station/ Biological Station, Fisheries and Oceans Canada, 125 Marine Science Drive, St. Andrews New Brunswick E5B 0E4
Tel: +1 506 529 5912, Fax: +1 506 529 5862, E-Mail: alex.hanke@dfo-mpo.gc.ca

Maguire, Jean-Jacques
1450 Godefroy, Québec G1T 2E4
Tel: +1 418 527 7293, E-Mail: jeanjacquesmaguire@gmail.com

EUROPEAN UNION

Arrizabalaga, Haritz
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualde z/g, 20110 Pasaia Gipuzkoa, España
Tel: +34 94 657 40 00; +34 667 174 477, Fax: +34 94 300 48 01, E-Mail: harri@azti.es

Biagi, Franco
Directorate General for Maritime Affairs and Fisheries (DG-Mare) - European Commission, Rue Joseph II, 99, 1049 Bruxelles, Belgium
Tel: +322 299 4104, E-Mail: franco.biagi@ec.europa.eu

Di Natale, Antonio
Dipartimento di Science Biologiche, Geologiche ed Ambientali (BIGEA), University of Bologna, Piazza Porta San Donato 1, 40126 Bologna, Italy
Tel: +39 336333366, E-Mail: adinatale@acquariodigenova.it

Fernández, Carmen
Instituto Español de Oceanografía, Avda. Príncipe de Asturias, 70 bis, 33212 Gijón, España
Tel: +34 985 309 804, Fax: +34 985 326 277, E-Mail: carmen.fernandez@ieo.es

Garibaldi, Fulvio
Laboratorio di Biologia Marina e Ecologia Animale Univ. Degli Studi di Genova, Dipartimento si Scienze della Terra, dell'Ambiente e della Vita (DISTAV), Corso Europa, 26, 16132 Genova, Italy
Tel: +39 335 666 0784; +39 010 353 8576, Fax: +39 010 357 888, E-Mail: largepel@unige.it; garibaldi.f@libero.it

Gordoa, Ana
Centro de Estudios Avanzados de Blanes (CEAB - CSIC), Acc. Cala St. Francesc, 14, 17300 Blanes Girona, España
Tel: +34 972 336101, E-Mail: gordoa@ceab.csic.es

Merino, Gorka
AZTI - Tecnalia /Itsas Ikerketa Saila, Herrera Kaia Portualdea z/g, 20100 Pasaia - Gipuzkoa, España
Tel: +34 94 657 4000; +34 664 793 401, Fax: +34 94 300 4801, E-Mail: gmerino@azti.es

Rodríguez-Marín, Enrique
Ministerio de Ciencia, Innovación y Universidades, Instituto Español de Oceanografía, C.O. de Santander, Promontorio de San Martín s/n, 39009 Santander Cantabria, España
Tel: +34 942 291 716, Fax: +34 942 27 50 72, E-Mail: enrique.rmarin@ieo.es

Rouyer, Tristan
Ifremer - Dept Recherche Halieutique, B.P. 171 - Bd. Jean Monnet, 34200 Sète Languedoc Rousillon, France
Tel: +33 (0)4 42 57 32 37; +33 (0)7 82 99 52 37, E-Mail: tristan.rouyer@ifremer.fr

JAPAN
Butterworth, Douglas S.
Emeritus Professor, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701 Cape Town, South Africa
Tel: +27 21 650 2343, E-Mail: doug.butterworth@uct.ac.za

Miyagawa, Mitsuyo
2-19-4 Uragaoka, Kanagawa Yokosuka 239-0823
Tel: +27 70 7528 6049, E-Mail: mitsuyo.minami@gmail.com

Nakatsuka, Shuya
Head, Pacific Bluefin Tuna Resources Group, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 543 36 6035, Fax: +81 543 36 6035, E-Mail: snakatsuka@affrc.go.jp

Tsukahara, Yohei
National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shizuoka Shimizu-ku 424-8633
Tel: +81 54 336 6035, Fax: +81 54 335 9642, E-Mail: tsukahara_y@affrc.go.jp

Uozumi, Yuji
Visiting Scientist, National Research Institute of Far Seas Fisheries, Japan Fisheries Research and Education Agency, 5-7-1 Orido, Shizuoka Shimizu 424-8633
Tel: +81 54 336 6000, Fax: +81 54 335 9642, E-Mail: uozumi@affrc.go.jp; uozumi@japantuna.or.jp

KOREA(REP.)
An, Du Hae
National Fisheries Research and Development Institute, Distant-water Fisheries Resources Division, 216, Gijanghaean-ro, Gijang-eup, Gijang-gun, 46083 Busan Gyeongsangnam-do
Tel: +82 51 720 2310, Fax: +82 51 720 2337, E-Mail: dhan119@korea.kr

Lee, Mi Kyung
National Institute of Fisheries Science, Distant Water Fisheries Resources Research Division, 216 Gijanghaean-ro, Gijang-eup, Gijang-gun, 46083 Busan
Tel: +82 51 720 2332, Fax: +82 51 720 2337, E-Mail: ccmklee@korea.kr

MOROCCO
Abid, Noureddine
Chercheur et ingénier halieute au Centre Régional de recherche Halieutique de Tanger, Responsable du programme de suivi et d'étude des ressources des grands pélagiques, Centre régional de L'INRH à Tanger/M'dig, B.P. 5268, 90000 Drabed Tanger
Tel: +212 53932 5134, Fax: +212 53932 5139, E-Mail: noureddine.abid65@gmail.com

Haoujar, Bouchra
Ingénieur principal à la Division de la Protection des Ressources Halieutiques, Cadre à la Division de Durabilité et d'Aménagement des Ressources Halieutiques à la DPM, Ministère de l'Agriculture et de la Pêche Maritime, Service de l'Application de la Réglementation et de la Police Administrative, Nouveau Quartier Administratif, BP 476, Haut Agdal, Rabat
Tel: +212 666 155999, Fax: +212 537 688 134, E-Mail: haoujar@mpm.gov.ma

Hassouni, Fatima Zohra
Chef de la Division de Durabilité et d'Aménagement des Ressources Halieutiques à la DPM, Division de la Protection des Ressources Halieutiques, Direction des Pêches maritimes et de l'aquaculture, Département de la Pêche maritime, Nouveau Quartier Administratif, Haut Agdal, Rabat
Tel: +212 537 688 122/21; +212 663 35 36 87, Fax: +212 537 688 089, E-Mail: hassouni@mpm.gov.ma

NORWAY
Nottestad, Leif
Principal Scientist, Institute of Marine Research, P.O. Box 1870 Nordnesgaten, 33, 5817 Bergen Hordaland county
Tel: +47 99 22 70 25, Fax: +47 55 23 86 87, E-Mail: leif.nottestad@hi.no

TUNISIA
Zarrad, Rafik
Institut National des Sciences et Technologies de la Mer (INSTM), BP 138 Ezzahra, Mahdia 5199
Tel: +216 73 688 604; +216 97292111, Fax: +216 73 688 602, E-Mail: rafik.zarrad@instm.rnrt.tn; rafik.zarrad@gmail.com

UNITED STATES
Aalto, Emilius
120 Ocean View Blvd, CA Pacific Grove 93950
Tel: +1 203 809 6376, E-Mail: aalto@cs.stanford.edu

Brown, Craig A.
Chief, Highly Migratory Species Branch, Sustainable Fisheries Division, NOAA Fisheries Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 586 6589, Fax: +1 305 361 4562, E-Mail: craig.brown@noaa.gov

Lauretta, Matthew
NOAA Fisheries Southeast Fisheries Center, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +1 305 361 4481, E-Mail: matthew.lauretta@noaa.gov

Morse, Molly
University of Massachusetts, School for Marine Science & Technology, 836 S Rodney French Blvd, New Bedford MA 02744
Tel: +1 310 924 5554, E-Mail: mmorse1@umassd.edu

Walter, John
NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami Florida 33149
Tel: +305 365 4114, Fax: +1 305 361 4562, E-Mail: john.f.walter@noaa.gov

OBSERVERS FROM NON-GOVERNMENTAL ORGANIZATIONS

PEW CHARITABLE TRUSTS - PEW
Cox, Sean
School of Resource and Environmental Management, Simon Fraser University, 8888 University Drive, British Columbia Burnaby V5A1S6, Canada
Tel: +1 78 782 5778, Fax: +1 778 782 4968, E-Mail: spcox@sfu.ca

Galland, Grantly
Pew Charitable Trusts, 901 E Street, NW, Washington, DC 20004, United States
Tel: +1 202 540 6953, Fax: +1 202 552 2299, E-Mail: ggalland@pewtrusts.org

UNIVERSITY OF NORTH CAROLINA
Havice, Elizabeth
University of North Carolina Chapel Hill, Department of Geography, Carolina Hall CB 3220, Chapel Hill, NC-27510, United States
Tel: +1 919 962 3414, Fax: +1 919 962 1537, E-Mail: havice@email.unc.edu

SCRS CHAIRMAN
Melvin, Gary
SCRS Chairman, St. Andrews Biological Station - Fisheries and Oceans Canada, Department of Fisheries and Oceans, 285 Water Street, St. Andrews, New Brunswick E5B 1B8 Canada
Tel: +1 506 651 6020, E-Mail: gary.d.melvin@gmail.com; gary.melvin@dfo-mpo.gc.ca

******

ICCAT Secretariat
C/ Corazón de María 8 – 6th floor, 28002 Madrid – Spain
Tel: +34 91 416 56 00; Fax: +34 91 415 26 12; E-mail: info@iccat.int

Manel, Camille Jean Pierre
Neves dos Santos, Miguel
Ortiz, Mauricio
Kimoto, Ai

GBYP PROGRAM
Alemany, Francisco
Tensek, Stasa

Appendix 3

List of Papers and Presentations

Reference	Title	Authors
SCRS/2019/016	Origin and age composition of Norwegian catch	Arrizabalaga H., Lastra P., Rodríguez-Ezpeleta N., Rodriguez-Marín E., Ruiz M., Ceballos E., Garibaldi F., and Nøttestad L.
SCRS/2019/017	Evaluation of an F0.1 management procedure using an alternative management strategy evaluation framework for Atlantic bluefin tuna	Morse M. R., Kerr L. A., and Cadrin S. X.
SCRS/2019/021	Quantifying the Impact of Estimates of Recruitment Trends of Previously Unreported Catches of Age-0 Bluefin Tuna in the Mediterranean	T. Carruthers, D. Butterworth

SCRS/P/2019/002	Population structure and mixing: new information and analyses	Arrizabalaga H., Rodriguez-Ezpeleta N., Fraile I., Brophy D., Diaz-Arce N., Tsukahara Y., Richardson D., Varela J. L., Nøttestad L., Rodriguez-Marín E., Medina A., Hanke A., Abid N., and Lino P.

Appendix 4

SCRS Document and Presentations Abstracts as provided by the authors

SCRS/2019/016 - Age and genetic analyses on the Norwegian bluefin tuna were conducted to know more about the Norwegian catch composition in terms of cohorts and origin. In total, 446 individuals collected between 2013 and 2017 were genetically analyzed and the probability to belong to the Mediterranean Sea and Gulf of Mexico populations was estimated. Fin spines of 417 individuals from 2016 and 2017 were used for age reading. Results suggest that the large bluefin tuna individuals that feed in Norwegian waters in summer are predominantly of Mediterranean origin, and similar age classes were observed in 2016 and 2017, ranging between 6 and 14 years old, but mostly of 9 and 10 years old.

SCRS/2019/017 - We demonstrate a management strategy evaluation (MSE) that was designed to complement the ICCAT ABT-MSE tool. Similar to the ABT-MSE tool, ours includes a two-population, spatially structured operating model that has had input from the ICCAT Atlantic bluefin tuna community over several iterations. Our operating model is conditioned on seasonal movements derived from telemetry as well as ICCAT perceptions of recruitment, fishing mortality, and observation error. Our MSE supports the evaluation of management procedures that involve age-based estimation models, such as the current virtual population analysis and F0.1 management procedure adopted by ICCAT. Preliminary results indicate that the F0.1 management procedure is sustainable in the medium-term future (20 years), causing an initial decrease in spawning biomass followed by some rebuilding of both western and eastern populations. Relative inter-annual variation in yields was greater for eastern fisheries than western fisheries. This MSE approach will be used along with the ABT-MSE tool to facilitate workshops to gather input from U.S. fishery stakeholders.

SCRS/2019/021 updated the 2017 SCRS-agreed VPA assessment for the eastern Atlantic bluefin tuna to include previously unreported catches of age-0 tuna in the Mediterranean. Except for three years in the 1980s, the change in estimates of annual recruitment were negligible. The pattern that indicates a regime shift in the 1980s therefore remains. Consequently, no related change was proposed in the current specifications for the Reference Set of Operating Models for the Atlantic bluefin MSE.

SCRS/P/2019/002 - This presentation highlighted new results from analyses of otolith chemistry and genetics data. Data from recent years indicate a higher proportion of eastern fish in the western area than previously estimated. New population genetic results including Slope Sea larvae suggest weak but significant differentiation between Mediterranean, Gulf of Mexico and the Slope Sea. An integrated approach to stock discrimination, which takes advantage of both otolith chemistry and genetic techniques, demonstrated improved discrimination power. However, this approach also results in more unassigned fish (fish that are categorized as either Gulf of Mexico or Mediterranean depending on the assignment method). Possible explanations for these unassigned fish include a third population component that spawns outside the Mediterranean or Gulf of Mexico (e.g., Slope Sea, Bay of Biscay), or a migratory component of the Mediterranean population that migrates into the Atlantic Ocean as yearlings. The presentation also compared mixing proportions using genetics and otolith chemistry on exactly the same fish, and concluded that the otolith chemistry systematically provided higher western proportions in the east, compared to genetics. Genetic estimate low proportions of western origin fish in the east, which is consistent with electronic tagging observations.

Appendix 5

Changes, edits and comments to the Trials Specification Document (TSD) and Proposal for construction, management, tracking, translating, and updating TSD for MSE processes

General changes and comments:

The Group recommended the following current grid be entertained in the TSD. The TSD will not reflect these changes yet as this would have ripple effects on the document text and to the interim nature of the current grid.

Current Grid (12 in total)

Recruitment (2-phase, 1-phase, future shift) (3)	Factor levels 1/ 2/ 3
Abundance (best estimate) (1)	Factor level A
Spawn/ M (High M/ Early Mat; Low M/ late Mat)	Factor levels I, IV
Current / Low Mixing (2)	no West in East; ½ mix of East in West

The issue of shifting the boundary of the EATL and SATL areas southwards by 5º was raised. It was noted that this had already been discussed in the September 2018 meeting and considered that changes would imply major work and thus delay the process considerably. Therefore, it was agreed (in September 2018) not to make this change. The co-chair indicated that this could be discussed later in this meeting. There are several problems with making this shift; most notably it would require substantial refitting of the models and second much of the task 2 data cannot be separated across this boundary.

It was asked what fisheries data are used for SATL in addition to traps. It was noted that there are likely data from the Canaries, as well as the master index (SCRS/2017/019) which was constructed from fisheries information, including past fisheries, and can be used to fill what happens in areas for which no recent data are available.

It was noted that both "area" and "strata" are should be clearly specified in the TSD, as well as the word stock and population.

Section 2. Past data available:

Figure 2.1 (observed area transitions, by quarter, from PSAT tags corresponding to fish of known SOO) was explained in detail.

In principle, the MP would first be used in 2020, in order to set a TAC for 2021. As only data up to 2016 were used to condition the OMs, there was concern that the time lag between both dates may be too large. It was explained that 2016 referred to the data used for conditioning the OMs, but that more recent values of indices will be used in the MPs. Additionally, an Exceptional Circumstances protocol can incorporate other recent data.

With regards to Table 2.6 (SOO data), a figure shown in the previous week meeting, comparing genetics and otolith microchemistry data, as used by the OM, will be included in the TSD.

Section 3. Basic dynamics:

The Group reviewed Table 3.1 and observed that the only fleets given restrictions on quarters are the purse seines in the Mediterranean, and that some fleets are also given location restrictions. It was explained that these restrictions are based only on when and where it is known fish are never caught, and tell the model how to distribute catches (by area and quarter) among the fleets and the fleets' respective selectivities.

Section 4. Management options:

The frequency of setting TACs was discussed. Whether the TAC should be set annually, or every 2 or 3 years is largely a Panel 2 discussion. From a scientific perspective, a more informed discussion on this issue can occur once results from CMPs start to become available.

Section 5. Future recruitment and distribution scenarios:

There was some confusion about apparent redundancies between Section 5 and Section 9. It was, however, noted that the two sections have different purposes, as Section 9 is about combining different hypotheses to set the reference set of OMs and the robustness tests and that material from Section 9 would be moved to Section 5.

Section 6. Future catches:

It was clarified that, in the MSE model, catches until 2020 have been fixed at the agreed TAC values, also incorporating the agreed allocations. Some aspects that were not incorporated in the MSE, such as features related to how the west area TAC is distributed, should be reflected in the TSD. It was noted that some of the aspects not incorporated in the MSE might possibly be addressed through "extreme" robustness tests.

Section 7. Generation of future data:

Regarding data needed for application of MPs, lags for survey indices were discussed again, and agreed that it is very important. Presently, the TAC for year y+1 is decided in year y, at which point it is understood that the final year for which surveys are available is y-1. Once an MP is agreed, indices not used in the MP will be considered again when OMs are reconditioned, which may be expected to occur after approximately five years of application of the MP.

Section 8. Parameters and conditioning:

Exactly how the fleet selectivities are estimated and used in projections should be specified in the TSD.

Section 9. Trial specifications:

Although maturity did not appear to have an impact on the results examined in September 2018, the meeting last week decided to keep maturity in the interim Reference set until results from CMPs with the new reconditioned OMs become available
The following scenarios of future recruitment were put forward for potential robustness tests:

- pulse-like recruitment dynamics (instead of regime shift)
- three line model (by Clay Porch)
- correlation between recruitment in the 2 stocks

It was noted that, whereas these recruitment scenarios may be run as robustness tests, regime shift is the main feature seen in the past, this is why it has been included in the Reference set.

Presently, recruitment in projections is simulated without autocorrelation. It is, however, intended that autocorrelation should be included in the simulation of future recruitment, perhaps even in the Reference set. The autocorrelation estimated historically corresponds to 2-year blocks (as recruitment deviations were modelled historically as 2-year blocks, for pragmatic reasons). A subgroup developed a method to translate this to variance and autocorrelation on a yearly basis, for use in the generation of future recruitment. This will need to be added to the TSD. Technical note: autocorrelation will not be included when fitting the model to the historical data, but will be estimated from the residuals of the model fit.

Section 10. Performance measures/statistics:

The view was expressed that there must be consistency among tuna RFMOs in performance statistics, to avoid confusion to managers and stakeholders. Years 2017-2020 should not be part of the performance calculations, as 2021 is the first year for which the MP may provide a TAC.

Proposal for construction, management, tracking, translating, and updating Trial Specification Documents for MSE processes:

- Trail Specification document (TSD) needs to be constructed for each MSE. This should be an evergreen document to allow it to be updated as things change in the MSE
- At the end of a SCRS MSE meeting the approved version of the TSD at the end of the meeting would be added to the meeting report as an Appendix.
- TSD should have a version and date of version at the top of the document.

  - Version should be indicated by year (as two numbers e.g. 2019 = 19), a dash, and then a number. So the first version in 2019 would be 19-01. There would be no track changes in these versions of the document, comments would remain. Any changes made from one number to the next would be made with underline.
  - Version numbers would stay the same between official SCRS meetings. It would only be updated at the end of a SCRS meeting in which it was appended to the meeting report
  - Letters would be used to track versions between SCRS meetings. Therefore version 19-01 would become 19-01a when updates were made and distributed, in these letter versions track changes would be maintained from one letter version to the next version.
- Translation into French and Spanish would happen for the versions that are appended to the SCRS reports
- The trial specification document would be maintained by the Contractor

Appendix 6

SPECIFICATIONS FOR MSE TRIALS FOR BLUEFIN TUNA IN THE NORTH ATLANTIC
Version 19-4: February 15 2019

Specifications for the MSE trials are contained in a living document that is under constant modification. The most recent version of the document (Version 19-4: February 15 2019) can be found here.

Appendix 7

Main comments regarding OM reports

Section 1. Operating model scenario:

Description of OMs must be corrected, where needed.

Sections 3 and 4. Fits to CPUE indices and FI indices:

Some concerns were raised to the effect that longer time series appeared to have worse fits than shorter series. Most fits were not good, the model has to fit many different data sources and can not follow indices as closely as may be expected in more standard stock assessment models. On the other hand, the OMs in the MSE do not try to represent a best assessment but the aim is to cover the range of realistic possibilities. For indices considered for potential use in CMPs, priority was given to fishery-independent indices as well as commercial CPUE indices such that, when the set of indices is considered together, it is possible to monitor small, medium and large fish. One of the primary determinants that ruled out certain indices from further inclusion was very severe trends in the residuals that could be indicative of systematic lack of fit. Such systematic residual patterns would, when projected forward, result in very poor performance as MPs.

Section 5. Spawning biomass:

The concept of dynamic B_0 (permitting gradual changes in B_0 when R_0 changes) was explained. To allow for a gradual change in SSB_{MSY} we use the fraction of SSB_{MSY}/SSB_0 multiplied by the dynamic SSB_0 in the year of the calculation to determine the SSB_{MSY} benchmark. This allows for a similarly gradual change the benchmark SSB_{MSY} so as to not have a sharp breaks in stock status determination.

Some suggestions were offered to improve clarity concerning the dynamic B_0, such as indicating in the label of Figure 4a the stock-recruit relationship used in each period. It was also noted that it might help indicate that unfished spawning biomass was assumed in 1850 for modelling purposes.

Section 8. MSY reference points:

The two equilibrium B_0 values (i.e. for the two different R_0 values) should be shown in the tables. The F_{MSY} shown in OM report table could be replaced by U_{MSY}, because exploitation rate or the fraction of the population in average biomass that is removed annually is a more robust to changes in estimated selectivity, and easier to interpret, measure of the extent of exploitation.

Section 10. Estimated size selectivity:

Bad fits to length composition data were noted, and it was agreed to do a robustness test altering their weights to examine impact on CMP performance.

It was noted that some of the values (B/B_{MSY}) shown in the summary reports do not seem to coincide with those shown in the individual OM reports. This should be checked.

Appendix 8

Examples of Diagnostic Plots

This appendix contains diagnostic plots contributed by the CMP developers. The plots provide views of the input and output data from the ABTMSE 4.4.5 OM, OMI and MSE objects. Notes on potential issues are provided below and the R scripts used to produce the figures are available (Annex to this Appendix).

Figure 1
- LLOTH appears in GSL
- Catch for traps are not expected in GOM and GSL. Season of capture not possible for Canadian traps in WATL. [There are some catches (~3890t) for traps in ATW in taskI]. Is this consistent?
- Unknown fleet with catches in GSL and in wrong season

Figure 2
- Mediterranean dominated by younger ages. One could expect larger fish to be caught as well, for instance by traps
- Young fish (age 2-3) caught in GOM prior to 1964 is odd as is the catch at age for the NATL (absence of 5-10 yrs old fish)

Figure 3
- Much like Figure 1, the spatial repartition of the effort is unexpected
- Effort for traps varies a lot for a gear of this type

Figure 4
- How can western fish move from the MED to GOM or anywhere
- How can eastern fish move from the GOM to the MED or anywhere
- Young fish move to NATL from everywhere in Q4
- Young fish move to WATL from everywhere in Q1

Figure 5
- Relationship of current catches compared to those immediately prior
- Was the 2017 to 2020 catches attributed to the stock catch vector or the area catch vector?
- Meaning of C, CW, CWa

Figure 6
- No transitions will move a fish from the east area to the west area but east fish are in the west area

Figure 7
- Issues mirror those in Figure 2

Figure 8
- GSL total effort occurs in wrong quarter

Figure 9
- Task 1 versus total catch from OMI is similar but some differences between fleets

Figure 10
- Master index inputs don’t match outputs

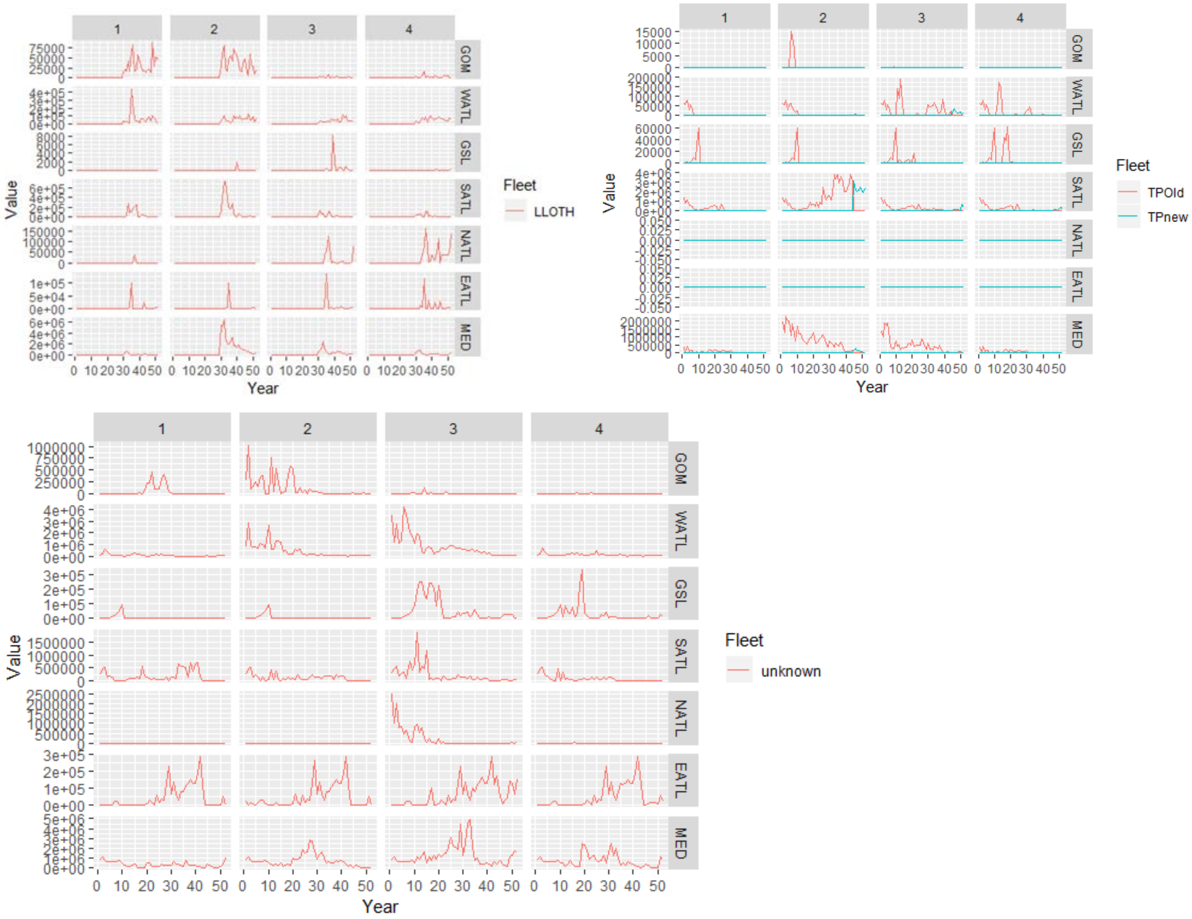


Figure 1. Catch plots demonstrating fleets associated with inappropriate areas and seasons.

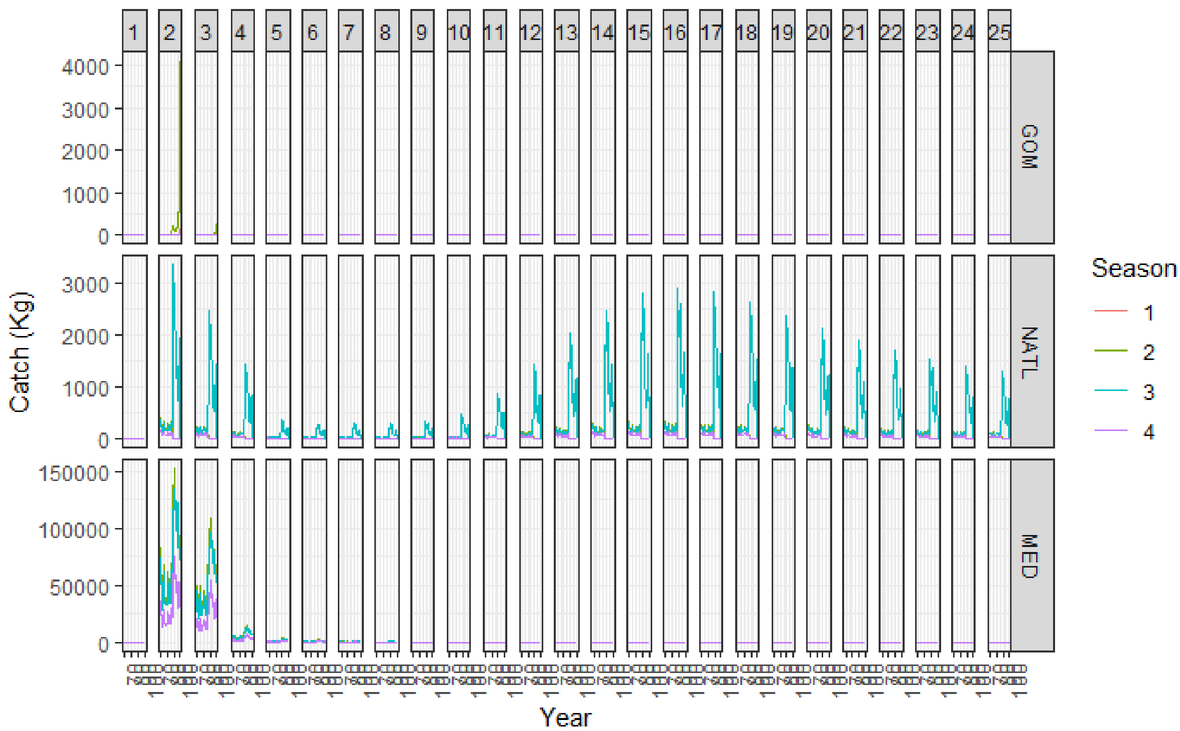


Figure 2. Historical catch (1856 to 1964) at age by area.

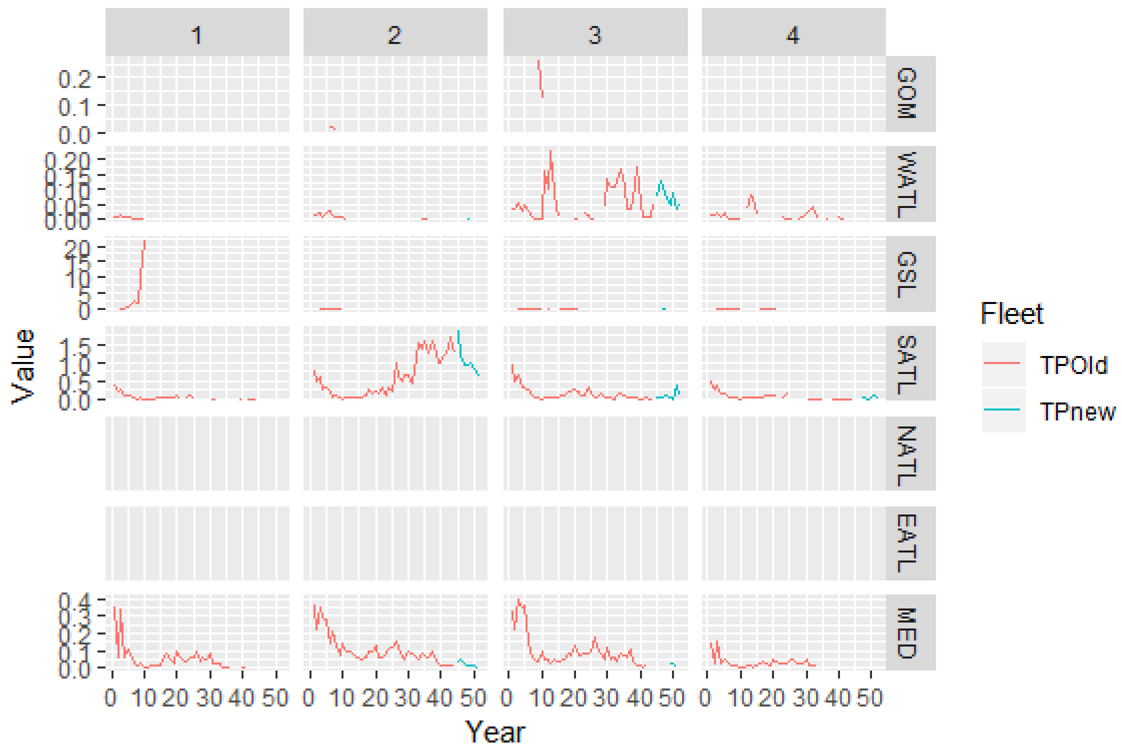


Figure 3. Observed effort plots by fleet, season and area.

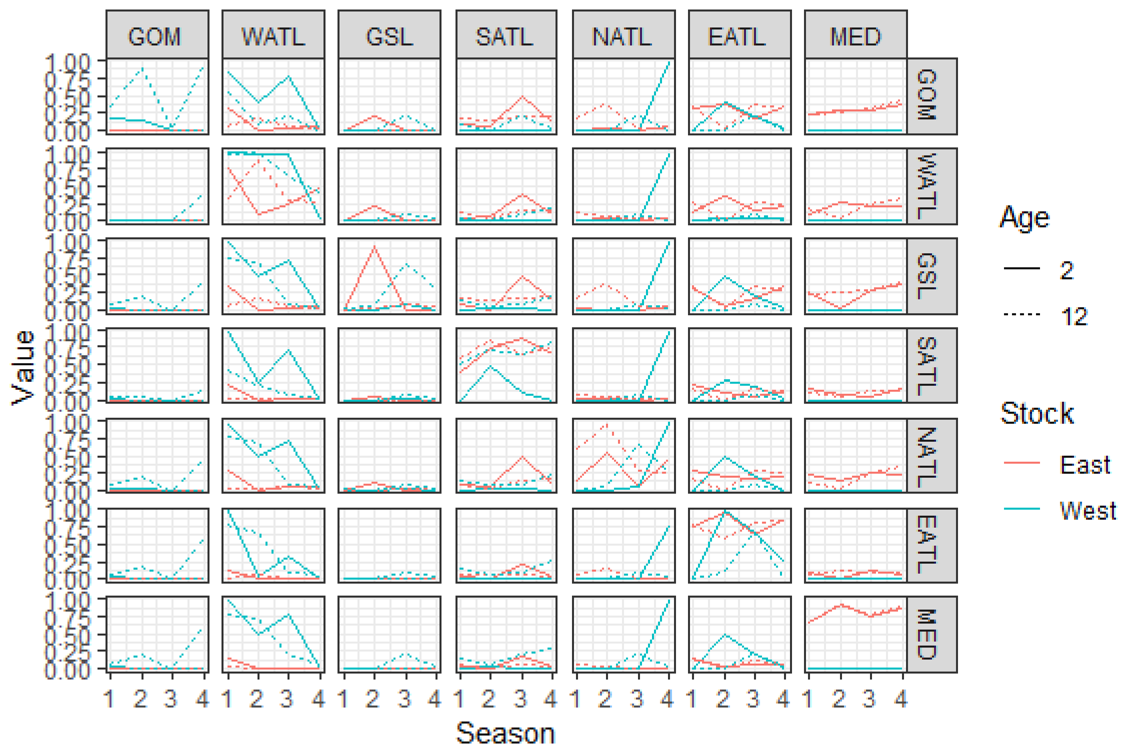


Figure 4. Stock movement by age, season, from area (rows) and to area for OM_1d.

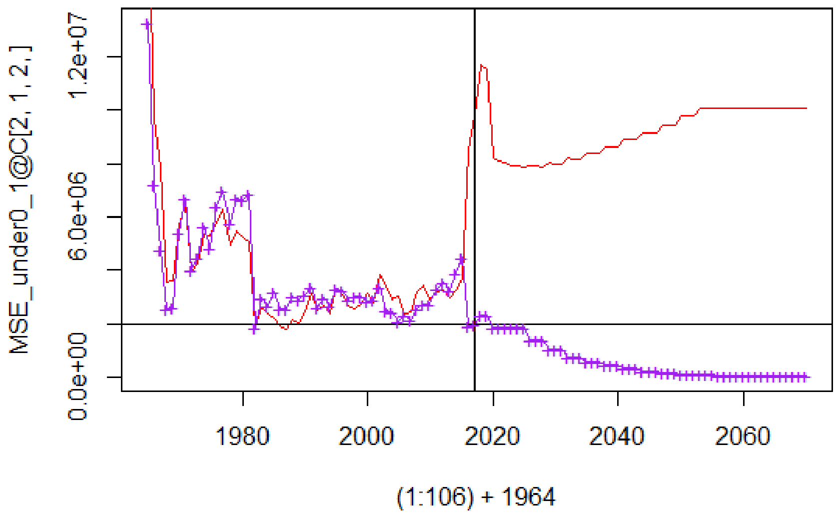


Figure 5. A comparison of catch by stock (West) and catch by area (West) in the historical and projected periods for OM_1d. Horizontal line equals 2000 MT and vertical line equals 2017.

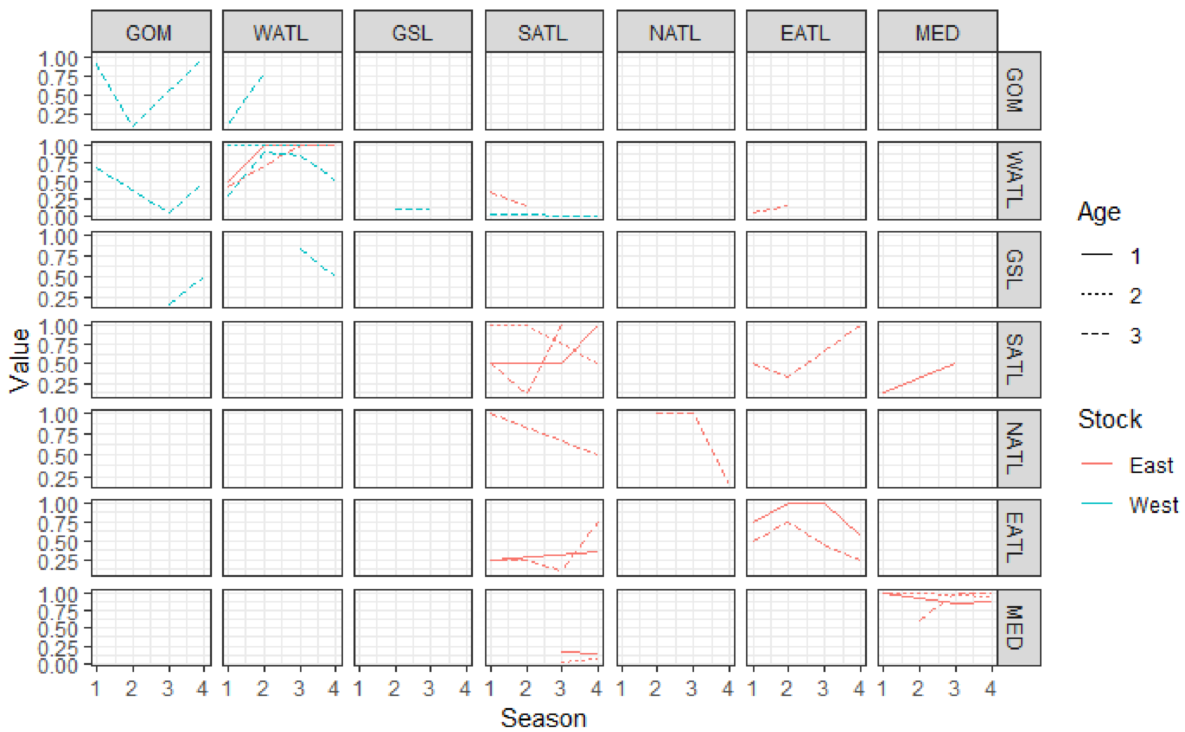


Figure 6. Stock movement by age, season, from area (rows) and to area for OM_1d based on the PSAT slot of OMI_1.

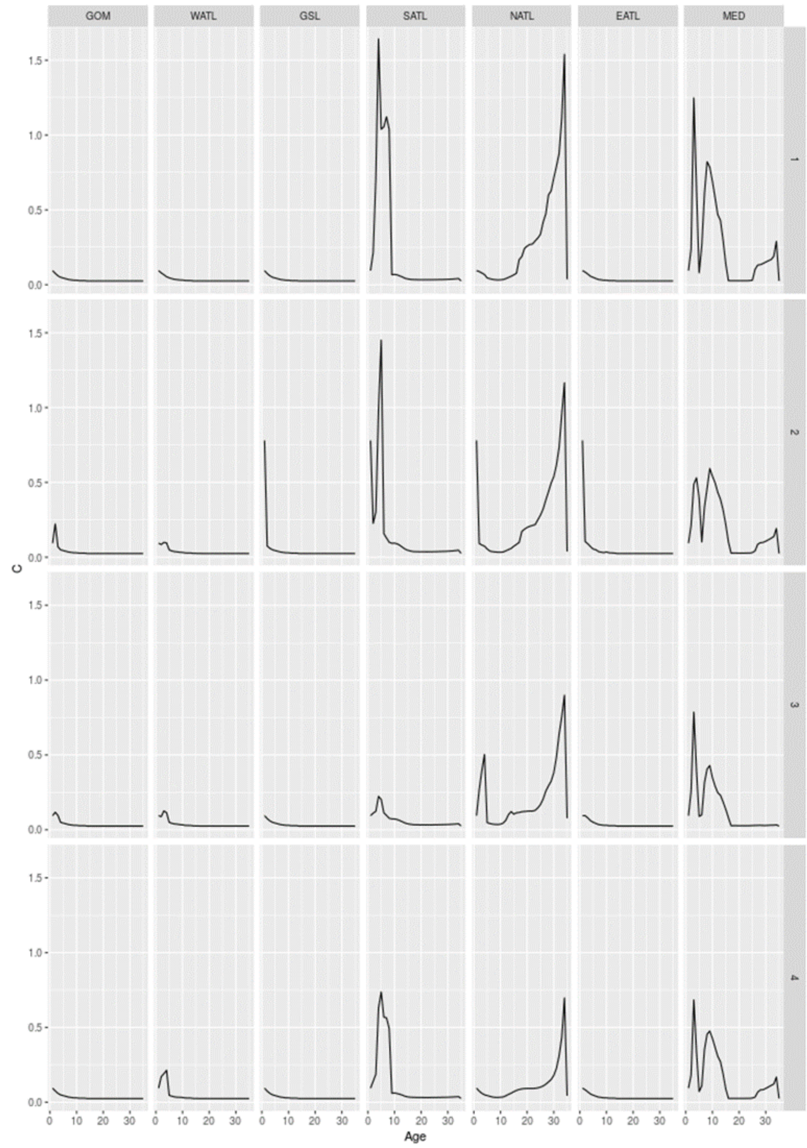


Figure 7. Average mortality rate (object hZ) by age, area and season for OM_1d.

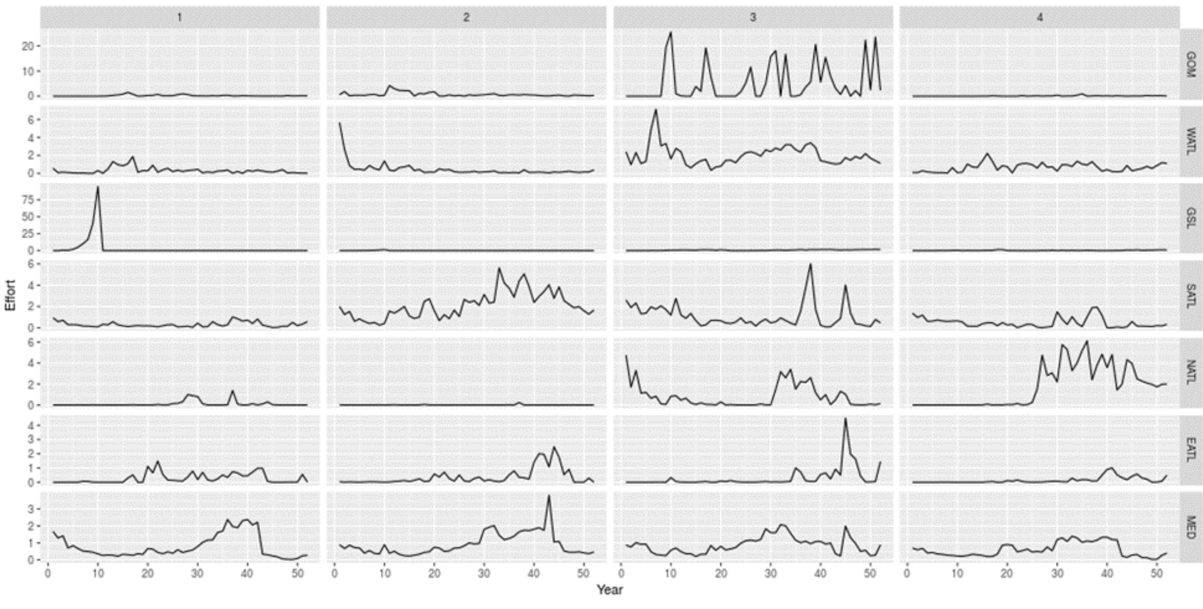


Figure 8. Total effort by season and area (OM or OMI).

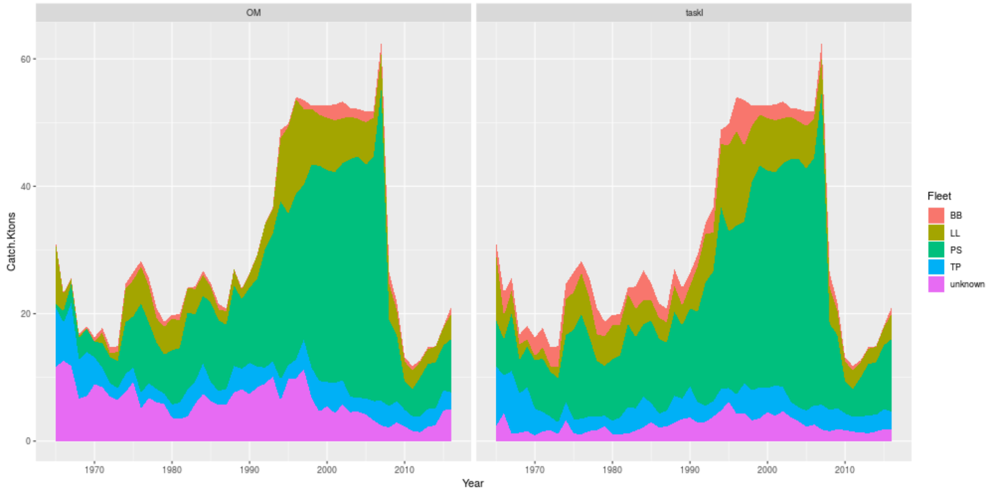


Figure 9. Comparison of Task I data with the OM_1 catch data by fleet.

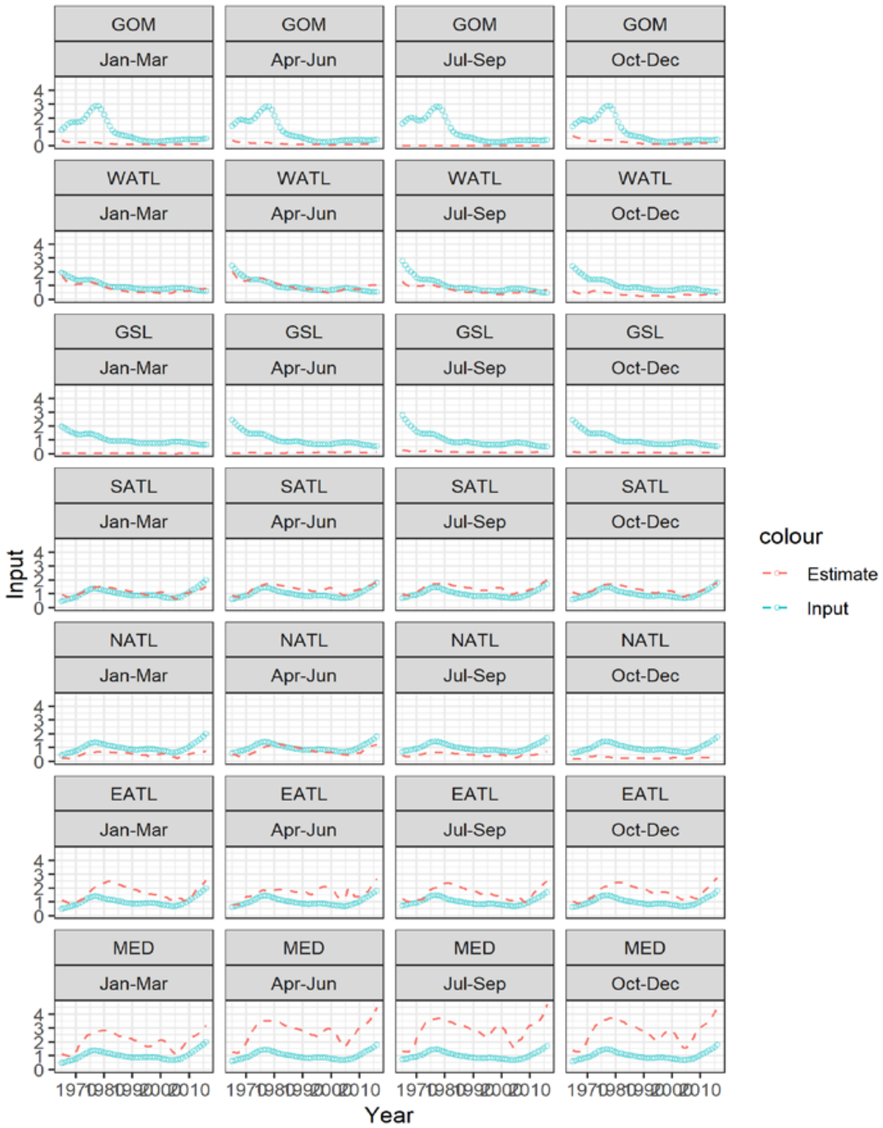


Figure 10. Master index inputs and outputs (OM & OMI).

Annex of Appendix 8

R Scripts for functions that produced the plots in this appendix

```
##########################################################################
#HCobs: an array of historical catch observations [year x subyear x age x area] from 1856 to 1964

HCatchPlot =
 function(OMobj, y_ind=1:101,a_ind = 1:7, g_ind = 1:35){
   AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")

 Bmass = data.table(melt(OMobj@HCobs))

 setnames(Bmass,c("Year","Season", "Age","Area","Value"))
 Bmass[,":=" (Area = factor(Area,labels = AreaLab))]


 P1 = ggplot(Bmass[Year%in%y_ind&Age%in%g_ind&Area%in%AreaLab[a_ind]], aes(x=Year,
y=round(Value,1), col=factor(Season),group=Season)) + geom_path() +  facet_grid(Area~Age,
scales="free_y") + labs(col = "Season") + ylab("Catch (Kg)") + theme_bw() + theme(axis.text.x =
element_text(angle = 90, hjust = 1))

 Bmass = Bmass[Age%in%g_ind, .(Value=sum(Value, na.rm=T)), by=.(Year,Season,Area)]

 P2 = ggplot(Bmass[Year%in%y_ind&Area%in%AreaLab[a_ind]], aes(x=Year, y=Value,
col=factor(Season),group=Season)) + geom_path() +  facet_wrap(~Area, scales="free_y", ncol=1) +
labs(col = "Season") + theme_bw() + theme(axis.text.x = element_text(angle = 90, hjust = 1))

 print(P1)
 print(P2)

  }

HCatchPlot(OMobj = OM_1, y_ind = 68:101, g_ind = c(1:35), a_ind = c(1:7))
HCatchPlot(OMobj = OM_1, y_ind = 48:101, g_ind = 1:7, a_ind = c(1,7))

##########################################################################
#HCobs: an array of historical catch observations [year x subyear x age x area]

HCatchPlot =
 function(OMobj, y_ind=1:101,a_ind = 1:7, g_ind = 1:35){
   AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")

 Bmass = data.table(melt(OMobj@HCobs))

 setnames(Bmass,c("Year","Season", "Age","Area","Value"))
 Bmass[,":=" (Area = factor(Area,labels = AreaLab))]


 P1 = ggplot(Bmass[Year%in%y_ind&Age%in%g_ind&Area%in%AreaLab[a_ind]], aes(x=Year,
y=round(Value,1), col=factor(Season),group=Season)) + geom_path() +  facet_grid(Area~Age,
scales="free_y") + labs(col = "Season")

 Bmass = Bmass[Age%in%g_ind, .(Value=sum(Value, na.rm=T)), by=.(Year,Season,Area)]

 P2 = ggplot(Bmass[Year%in%y_ind&Area%in%AreaLab[a_ind]], aes(x=Year, y=Value,
col=factor(Season),group=Season)) + geom_path() +  facet_wrap(~Area, scales="free_y", ncol=1) +
labs(col = "Season")
```

```
 print(P1)
 print(P2)

  }

HCatchPlot(OMobj = OM_1d, y_ind = 48:101, g_ind = 1:7, a_ind = c(1,7))

##########################################################################
# OM_1@ E          : num [1:72, 1:13, 1:52, 1:4, 1:7]

EobsPlot =
  function(OMobj,sim_ind = 1:72, y_ind=1:52,a_ind = 1:7, f_ind = 1:13){
 AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")
   FleetLab = c(OMI_1@Fleets$name, "unknown")
   # [1] "LLOTH"     "LLJPN"     "BBold_E"   "BBold_SE"  "BBnew"     "PSMedRec"
   # [7] "PSMedLOld" "PSMedSOld" "TPOld"     "TPnew"     "RRCan"     "RRUSA"
  Bmass = data.table(melt(OMobj@E))

  setnames(Bmass,c("Sim", "Fleet","Year","Season", "Area","Value"))
  Bmass[,":=" (Area = factor(Area,labels = AreaLab),
           Fleet = factor(Fleet,labels = FleetLab))]
  Bmass = Bmass[,.(Value=mean(Value,na.rm=T)), by=.(Fleet,Year,Season, Area)]


  ggplot(Bmass[Year%in%y_ind&Fleet%in%FleetLab[f_ind]&Area%in%AreaLab[a_ind]], aes(x=Year,
y=Value, col=factor(Fleet),group=Fleet)) + geom_path() +    facet_grid(Area~Season, scales="free_y") +
labs(col = "Fleet")
  }

EobsPlot(OMobj = OM_1d, f_ind = 9:10, a_ind = 1:7)

##########################################################################
# mov a very large array storing simulated movement by stock [sim x stock x age x subyear x movtype x
from area x to area] [1:72, 1:2, 1:35, 1:2, 1:4, 1:7, 1:7]
# OM_1d@mov[1,1,15,1,1,,]
# OM_1d@mov[1,1,5,1,1,,]

MovePlot =
  function(OMobj,sim_ind = 1:72, s_ind = 1:2, g_ind = 1:35, mt_ind =1:2, fa_ind = 1:7, ta_ind = 1:7){
 AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")
 StockLab = c("East","West")

 Bmass = data.table(melt(OMobj@mov))

  setnames(Bmass,c("Sim", "Stock","Age", "Mtype", "Season", "fArea", "tArea", "Value"))
  Bmass[,":=" (fArea = factor(fArea,labels = AreaLab),
           tArea = factor(tArea,labels = AreaLab),
           Stock = factor(Stock,labels = StockLab))]
  Bmass = Bmass[,.(Value=mean(Value,na.rm=T)), by=.(Stock,Age,Mtype,Season,fArea,tArea)]
  Bmass[, ":=" (fArea_S = paste(fArea,Season,sep="_"),
            tArea_S = paste(tArea,Season,sep="_"))]


P1 =
ggplot(Bmass[Mtype==1&Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind]],
aes(x=Season, y=Value, col=factor(Stock),group=Stock)) + stat_summary(fun.y = "sum", geom="line") +
facet_grid(fArea~tArea, scales="free_y") + labs(col = "Stock")+ theme_bw()

P2 =
```

```
ggplot(Bmass[Mtype==1&Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind], .(Val
ue = sum(Value, na.rm=T)), by=.(tArea_S,fArea_S,Season,Stock)], aes(x=tArea_S, y=fArea_S,
group=Season,col=factor(Season),size=Value)) + geom_point(alpha=.5) +  labs(col = "Season") +
facet_wrap(~Stock)+
scale_x_discrete(breaks=c("GSL_1","EATL_1","GOM_1","MED_1","NATL_1","SATL_1","WATL_1")) +
theme_bw() +
scale_y_discrete(breaks=c("GSL_1","EATL_1","GOM_1","MED_1","NATL_1","SATL_1","WATL_1"))+
theme(axis.text.x = element_text(angle = 90, hjust = 1))

print(P1)
print(P2)

ggplot(Bmass[Mtype==1&Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind]],
aes(x=Season, y=Value, lty=factor(Age),col=factor(Stock))) + geom_line() + facet_grid(fArea~tArea,
scales="free_y") + labs(lty = "Age", col="Stock") + theme_bw()
 }

MovePlot(OMobj = OM_1d, g_ind = c(2,32), fa_ind = 1:7)
##########################################################################
# Catch trends in historical and projected period

{plot(x=(1:106)+1964, MSE_under0_1@C[2,1,2,],type="l")
lines(x=(1:106)+1964,MSE_under0_1@CW[2,1,2,],col="red")
lines(x=(1:106)+1964,MSE_under0_1@CWa[2,1,2,],col="purple")
abline(h=2000000, v=2017)
points(x=(1:106)+1964,MSE_under0_1@CWa[2,1,2,],col="purple", pch="+")}

##########################################################################
# PSAT:a data frame of electronic tag movements [stock, age, subyear, duration til recapture (subyears),
from area, to area, number of tags]

PSATPlot =
  function(OMobj, s_ind = 1:2, g_ind = 1:35, sea = 1:4, dur=1:4, fa_ind = 1:7, ta_ind = 1:7){
 AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")
 StockLab = c("East","West")

 Bmass = data.table(OMobj@PSAT)

  setnames(Bmass,c("Stock","Age", "Season","Duration", "fArea", "tArea", "N","Value"))
  Bmass[,":=" (fArea = factor(fArea,labels = AreaLab),
            tArea = factor(tArea,labels = AreaLab),
            Stock = factor(Stock,labels = StockLab))]
  Bmass = Bmass[,.(Value=mean(Value,na.rm=T)), by=.(Stock,Age,Duration,Season,fArea,tArea)]
  Bmass[, ":=" (fArea_S = paste(fArea,Season,sep="_"),
             tArea_S = paste(tArea,Season,sep="_"))]


P1 = ggplot(Bmass[Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind]],
aes(x=Season, y=Value, col=factor(Stock),group=Stock)) + stat_summary(fun.y = "sum", geom="line") +
facet_grid(fArea~tArea, scales="free_y") + labs(col = "Stock")+ theme_bw()

P2 = ggplot(Bmass[Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind], .(Value =
sum(Value, na.rm=T)), by=.(tArea_S,fArea_S,Season,Stock)], aes(x=tArea_S, y=fArea_S,
group=Season,col=factor(Season),size=Value)) + geom_point(alpha=.5) +  labs(col = "Season") +
facet_wrap(~Stock)+
scale_x_discrete(breaks=c("GSL_1","EATL_1","GOM_1","MED_1","NATL_1","SATL_1","WATL_1")) +
theme_bw() +
scale_y_discrete(breaks=c("GSL_1","EATL_1","GOM_1","MED_1","NATL_1","SATL_1","WATL_1"))+
theme(axis.text.x = element_text(angle = 90, hjust = 1))
```

```
print(P1)
print(P2)

ggplot(Bmass[Age%in%g_ind&fArea%in%AreaLab[fa_ind]&tArea%in%AreaLab[ta_ind]], aes(x=Season,
y=Value, lty=factor(Age),col=factor(Stock))) + geom_line() + facet_grid(fArea~tArea, scales="free_y") +
labs(lty = "Age", col="Stock") + theme_bw()
 }

PSATPlot(OMobj = OMI_1, g_ind = c(1:4), fa_ind = 1:7)
```

```
## COMPARE CATCH TIME SERIES TO TASKI BY FLEET
OMobj <- OM_1d
d <- data.table(melt(OMobj@Cobs))
AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")
FleetLab = c(OMI_1@Fleets$name, "unknown")
setnames(d,c("Year","Season", "Area","Fleet","Value"))
d[,":=" (Area = factor(Area,labels = AreaLab),Fleet = factor(Fleet,labels = FleetLab))]
## catch by fleet
d$Fleet <- as.character(d$Fleet)
d$Fleet[which(d$Fleet %in% FleetLab[grep('PS',FleetLab)])] <- 'PS'
d$Fleet[which(d$Fleet %in% FleetLab[grep('BB',FleetLab)])] <- 'BB'
d$Fleet[which(d$Fleet %in% FleetLab[grep('LL',FleetLab)])] <- 'LL'
d$Fleet[which(d$Fleet %in% FleetLab[grep('TP',FleetLab)])] <- 'TP'
d$Fleet[which(d$Fleet %in% FleetLab[grep('RR',FleetLab)])] <- 'unknown'
d2 <- ddply(d,.(Year,Fleet),summarize,Catch.Ktons=(sum(Value)/1000000))
d2$Fleet <- as.factor(d2$Fleet)
d2$Fleet <- factor(d2$Fleet, levels = rev(levels(d2$Fleet)))
## compare to task I
file <- '/home/tristan/pcCloud/expertise/BFT/Docs/divers/task1.csv'
d <- read.csv(file)
bft <- d[which(d$Species=='BFT' & d$YearC>=1965 & d$YearC<=2016),]
bft$GearGrp <- as.character(bft$GearGrp)
bft$GearGrp[which(!bft$GearGrp%in%c('PS','BB','LL','TP'))] <- 'unknown'
bft$GearGrp <- as.factor(bft$GearGrp)
bft2 <- ddply(bft,.(YearC,GearGrp),summarise,q=sum(Qty_t))
taskI <- bft2
colnames(taskI) <- colnames(d2)
taskI$source <- 'taskI'
taskI$Catch.Ktons <- taskI$Catch.Ktons/1000
d2$source <- 'OM'
d2$Year <- d2$Year+1964
comp <- rbind(taskI,d2)
ggplot(comp, aes(x=Year, y=Catch.Ktons, fill=Fleet)) + geom_area()+facet_grid(.~source)

## historical Mortality code
OMobj <- OM_1d
d <- data.table(melt(OMobj@hZ))
AreaLab = c("GOM","WATL","GSL","SATL","NATL","EATL","MED")
setnames(d,c("stock", "Year","Season","Age","Area","Value"))
d[,":=" (Area = factor(Area,labels = AreaLab),stock = factor(stock,labels = c('East','West')))]
d2 <- ddply(d,.(Age,Season,Area),summarize,C=mean(Value,na.rm=TRUE))
ggplot(d2[which(d2$Age%in%c(1:35)),], aes(x=Age, y=C)) + geom_path()+ facet_grid(Season~Area)
```

Appendix 9

BFT MSE ROADMAP Revisions (February 14, 2019)

2018 (remainder)

SCRS (October)
Review progress on the MSE and recommend revisions

Commission (November)
Ideally the Commission would continue developing the conceptual management objectives proposed at SWGSM. This would be assisted by a presentation from the SCRS Chair.

2019

BFT MSE TG [2] (January)
Propose final reference set of OMs [3] with acceptable conditioning, and review progress on CMP [4]. Development. Initially propose key performance statistics[5].

BFT WG[6] (February/March)
Approve final set of OMs and review progress to provide advice on CMP development. Provide input to SCRS Chair on content of MSE presentation to Panel 2. Note that OM development was not at the stage where they could be approved, nor could progress on CMP development be evaluated.

Panel 2 (March)
Receive update on status of MSE and OMs, noting potential delay and possible need for 2020 stock assessment. Develop initial operational Management Objectives for Commission approval.

Data Guillotine (April 1)
This represents the guillotine for making revisions to the existing input data. Between February 14, 2019 and April 1, 2019, the developer in conjunction with CPC experts and Secretariat staff will carefully evaluate the data inputs focusing on benefitting from the extensive data cleaning work undertaken for the 2017. The Contractor will get the data from the Secretariat, run it to produce an OMI file that he will send to the Secretariat. The Secretariat will then check that the data the Contractor is using is essentially. This time will also allow the developer to conduct a number of quality checks in the code.

OM report deadline (Around May 1)
Distribute OM reports, revisions to MSE package to developers.

Webinar (Around June)
Webinar to ask the Contractor about further developments, issues, concerns. This may be an iterative process between Contractors and the developers.

---

[2] The Bluefin MSE Technical Group, consisting of core members and CMP developers, but open to attendance by other members of the BFT WG

[3] An Operating Model (OM) is a mathematical–statistical model used to describe the fishery dynamics in simulation trials, including the specifications for generating simulated resource monitoring data when projecting forward in time. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery.

[4] A Management Procedure (MP) is formally specified, and is a combination of monitoring data, analysis method, harvest control rule and management measure that has been simulation tested to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics. CMP refers to a candidate Management Procedure (i.e. proposed but not as yet adopted).

[5] A performance statistic relates to a quantity (e.g. average catch over projection period) evaluated in a simulation trial of one CMP under one OM.

[6] The Bluefin Working Group, being the group that regularly meets each year in the week before the SCRS meeting.

BFT MSE TG (July 23-27, Canada, possibly)
Evaluate acceptable conditioning of OMs, and review progress on CMP[7] development. Evaluate data weighting, conditioning, does it fit the model 'adequately'; more importantly does it matter and sensitivity tests. Evaluate a preliminary reference and robustness set of OMs. If appropriate: Begin tuning of CMPs on OMs. Review further development of CMPs refined to take account of Panel 2 inputs.

Intersessional work.
If appropriate: CMP developers further refine CMPs in advance of the September BFT MSE TG meeting.

BFT MSE TG (September 19-21, Madrid)
Compile candidate reference and robustness sets OMs. Compile summary of updated CMP results to facilitate BFT WG discussion.

BFT WG (September)[8]
Red light or green light, Reference and Robustness set.
Plan A: If green light: Approve final set of OMs and review progress to provide advice on CMP development. Review progress including inputs from Panel 2 for possible comment. Review current proposed CMPs, and then recommend CMPs to be retained for further refinement in the light of subsequent Commission-approved operational objectives. Provide feedback on possible operational Management Objectives. Initiate discussion on Exceptional Circumstances[9] provisions and OM plausibility. If green, prepare report for Panel 2 on draft operational Management Objectives for consideration by Commission.

Plan B: If OMs not approved by WG, then initiate plans for 2020 stock assessment and plans for delayed MSE process.

Note that the following schedule only applies to Plan A.
SCRS (October)
Endorse/or not final set of OMs for the MSE and recommended CMPs to be further explored. Provide feedback on possible operational Management Objectives.

Panel 2 (November 1-day before Commission meeting)
Prepare draft operational Management Objectives for consideration by Commission, taking account of input from SCRS.

Commission (November)
Commission to be updated on CMP structures, including projected performance of CMPs to provide feedback to SCRS and its subgroups. Finalize operational Management Objectives.

[7] A Management Procedure (MP) is formally specified, and is a combination of monitoring data, analysis method, harvest control rule and management measure that has been simulation tested to demonstrate adequately robust performance in the face of plausible uncertainties about stock and fishery dynamics. CMP refers to a candidate Management Procedure (i.e. proposed but not as yet adopted).
[8] If MSE progress inadequate, develop workplan to provide assessment-based TAC advice for 2021 during Sept 2020 BFT WG meeting.
[9] These are specifications of circumstances (primarily related to future monitoring data falling outside the range covered by simulation testing) where overriding of the output from a Management Procedure should be considered, together with broad principles to govern the action to take in such an event.