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Quebec Region

Proceedings of the Regional Peer Review on the Unit 1+2 Redfish Management Strategy Evaluation

Meeting Dates: April 25 to 26 and May 4, 2018
Location: Mont-Joli, Quebec

Chairperson: Hugues Benoît
Editors: Stéphanie Labbé-Giguère and Julie Marentette

Maurice Lamontagne Institute
Fisheries and Oceans Canada
850 Route de la Mer, P.O. Box 1000
Mont-Joli, Quebec G5H 3Z4

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

This document contains the proceedings of the regional peer review on the Unit 1 and 2 redfish Management Strategy Evaluation. The meeting was held from April 25 to 26, 2018, at the Maurice Lamontagne Institute in Mont-Joli, followed by a conference call on May 4, 2018. Nearly 40 participants from DFO's Science Branch and Fisheries Management, the fishing industry, external experts, universities, federal and provincial government organizations, as well as non-governmental organizations, were in attendance. The overall objective of this meeting was to review the operating models, catch control rules and simulated management procedures for the Unit 1 and 2 redfish management strategy evaluation. Aspects for consideration under this review were identified following a series of meetings of the Redfish Rebuilding Plan Working Group, formed in December 2016. These proceedings provide an overview of the key points made during presentations and discussions in April 2018, along with recommendations and conclusions presented during the review. A summary of the various topics of discussion and decisions from the Working Group meetings prior to the April 2018 meeting is also included in the Appendix. These proceedings complement a Science Advisory Report and Research Document.

BACKGROUND

The purpose of this peer review is to validate and approve the scientific process begun in December 2016 by the Redfish Rebuilding Plan Working Group, which consists of several stakeholders. Several prior meetings were held to identify the aspects under consideration in this review. A summary of the various topics of discussion and decisions made during these meetings is included in Appendix 1, and the bulk of the work is available in a Research Document (McAllister et al. 2018).

Day 1 – Wednesday, April 25, 2018

INTRODUCTION

Chairperson Hugues Benoît welcomes participants (Appendix 2) and outlines the objectives of the meeting in relation to the Terms of Reference (Appendix 3). The Chairperson presents the two arbitrators: Mathieu Desgagnés (Fisheries and Oceans Canada, DFO) and Colin Millar (International Council for the Exploration of the Sea, ICES). Some additional instructions are provided as to how the meeting and question period will proceed to centralize discussions on clarifying the subject matter presented and on the scientific integrity discussion. Some explanations are also provided about the expected consensus process for the review. The agenda for both days of the meeting (Appendix 4) is reviewed and accepted.

Exceptionally, it should be noted that the meeting proceeded via conference call on May 4, 2018, so that the text in the various parts of the Science Advisory Report (SAR) could be reviewed, purely for editorial purposes. However, all discussions were held, and decisions were made, during the meeting when all participants were present.

SUMMARY OF THE MANAGEMENT STRATEGY EVALUATION (MSE)

Murdoch McAllister begins by mentioning that the content presented over these two days of meetings consists of an overview of the MSE process, most of which is available in a Research Document (McAllister et al. 2018). He presents the reasons and background that triggered the MSE, as well as the potential benefits of the process for scientists and various industry stakeholders. He highlights the importance of reducing model-related conflicts to facilitate the stock assessment process and meet healthy stock management objectives as well as industry objectives.

- An Oceana Canada representative clarifies his role as an observer rather than a participant in the MSE process.
- A participant specifies that the 2016 redfish stock assessment was accepted, as was the recent 2018 one, despite the need to revise the population dynamics model.

OVERVIEW OF THE FISHERY AND DATA SOURCES

Caroline Senay presents an overview of the Unit 1 and 2 redfish fishery by describing the geographic areas of the fishery, the biology and ecology of the two species (*Sebastes mentella* and *S. fasciatus*), as well as the various methods used to differentiate them. A brief history of landings is presented, along with a description of the various management measures. Data used for the MSE is related to several historical series of length frequencies from dockside and at-sea sampling programs. Indices are available by species as a result of the annual August DFO and GEAC surveys.

- A participant specifies that the dockside and at-sea sampling program is carried out by external companies, not DFO, as is the GEAC survey. A participant asks why the Unit 2 survey is not carried out by DFO. The GEAC specifies that it carries it out voluntarily, despite the costs incurred.
- A participant asks whether data from the GEAC surveys carried out in December before the 2000s are excluded from models. The GEAC data used for the MSE is limited to data from surveys carried out in August.
- A participant specifies that Unit 1 size frequency data is taken not exclusively from the commercial fishery, but also from an index fishery because the fishery is under moratorium since 1995.

Daniel Duplisea presents the main data manipulations carried out for the MSE. The first modification presented is the result of the arrival of strong *S. fasciatus* recruit cohorts from the Grand Banks of Newfoundland. To facilitate model adjustments, the high abundance of the 7-17 cm cohort was replaced by the average abundance of the 12 cm cohort. The second modification stems from a commercial catch survey where no distinction is made between the two species. Commercial catches are therefore separated by species based on the proportion indicated in the August surveys for each management unit.

- The point was raised that if periods of strong local *S. mentella* cohorts arrive at the same time as the Great Banks *S. fasciatus* cohorts, the removal and replacement of abundance rates could be problematic for Unit 1.
- A participant questions the possible implications of extending the catch split identified in the August surveys to all commercial catches, which take place at various times of the year, at various depths, and using various gear. Catch data related to depth was insufficient and limited the exploration of various scenarios. However, stress models for other proportions of species were included in the process to account for this uncertainty (models 10 and 11).
- A participant asks whether spatial models were considered for this MSE. This option was explored, but was deemed problematic partially because of the large spatial distribution of the last strong *S. mentella* cohort.
- Some participants ask that the method described to separate catches by species be further clarified in the Research Document, and that certain sections presenting alternative species separation methods be removed.

OPERATIONAL MODELS

The Chairperson reminds participants that it is important to bear in mind that models are not perfect, and that the objective of the review is to verify whether models are scientifically credible to limit the main uncertainties and allow good management measures to be established. He explains that there is an exceptional circumstances protocol and that, based on the proposed plan, the MSE will be revised periodically (every five years at the latest).

Murdoch McAllister presents the operational models, which are structured based on age, size and catch split. He reviews the various inputs and life history parameters such as estimates for redfish growth, natural mortality (M) and sexual maturity. These parameters are extremely important for the models. The values and estimates used are taken from a review of available literature. M estimates present a particular challenge because of uncertainties related to maximum age estimates for redfish. The fishery was also divided into two selectivity groups to represent changes in commercial fishing gear over time. A third group may also be tested eventually.

- A participant asks about the effect of cannibalism on M parameterization, particularly since the arrival of the strong cohort in 2011-2013. The effect of cannibalism was tested. Three models could be used to notably test the effect of doubled M and the possibility of no recruitment for 20-40 years (Operational Model [OM] 3, 15, 16).
- A participant asks whether there might be a ghost effect on the growth curve: If there is a strong Grand Banks cohort, could this reduce growth in the local stock? It is mentioned that another model could explore this option and be considered in the future.
- A participant expresses concerns about M consistency over time, given all the changes that have occurred in the ecosystem (e.g., climate change). There was evidence of a change in M over time, notably for cod. The M consistency hypothesis is scientifically sound, given that there is no evidence of a change in redfish M. Various scenarios were tested (OM 4 and 8), but more data would be required for further testing.

Murdoch McAllister continues to present operational models and explains the likelihood functions as well as the various software programs and coding languages used to validate results.

- A participant asks about the “q” (catchability) parameter. It is noted that the fish can be at various locations in the water column, which may explain changes in “q” between the various units.
- A participant asks about the validity of future stock projections. It is noted that the MSE will be reviewed within five years, at the latest.

RESULTS

Murdoch McAllister begins to present the model results section. For *S. mentella*, the model is well adjusted to the survey signal, mainly for Unit 1. It should be noted that the model is better at predicting strong rather than weak abundance. As for adjusting to the signal from fishery data, the model is good for some years, but not overall. In general, the model predicts too many large fish and an abundance that is too widely dispersed. For *S. fasciatus*, the model indicates better adjustment than for *S. mentella* for both the survey and fishery signal, and adjustment is especially good for recent years. Separating data into two selectivity groups greatly improved estimates.

- A participant voices discomfort at the fact that the model was not adjusted to length frequency data. The difficulty in adjusting the model may stem from rare events that occurred for these populations, such as the arrival of strong cohorts. Although the model demonstrates an acceptable level of reliability, over time, more work could be done to obtain better adjustment.
- A participant asks about the selectivity curve. It is noted that significant catches were surveyed in the 1960s, which significantly encouraged a larger biomass estimate. The presence of catches over 50 kt could mean that biomass was very high or that strong cohort events may have occurred. The decline in the 1990s may have been caused by a negative event, such as an increase in natural mortality.
- The retrospective graphs presented are erroneous. They need to be updated.
- A participant asks about the reasons behind the arrival of such strong cohorts in 2011-2013. It is noted that even a low number of broodstock fish can produce enough larvae to create similar cohorts.

Murdoch McAllister explains the two model categories (basic and stress models) and explains that within the MSE process, one model is not enough to achieve the reliability required to test the validity of management procedures under various uncertainties. A series of 18 models was

used to take account of and cover the various cases of uncertainty. The reference model (one of the basic models) is the model considered the most representative of each stock. The basic model with the greatest impact on management procedure performance is the one representing the section of catches aimed at *S. mentella*.

- A participant suggests adding further details to the table describing the various models in the Research Document to specify what is being tested.
- A participant stresses the importance of growth parameters. One research recommendation could consist of exploring various growth parameters.
- Upon a request for clarification of the wide range of recruitment scenarios addressed by models, it is mentioned that the reference model assumes that recruitment will be similar to the past through a bootstrap process. Other scenarios are presented, such as no strong cohort within 20 years.
- Several participants want to know how the model simulates and addresses the uncertainty related to separating catches by species. Models 10 and 11 address this issue and assume that the separation will be similar to the past using a bootstrap process. A participant asks whether catch separation projections are biased, given that the historical data used with the bootstrap method stems mainly from Unit 2, as Unit 1 is under moratorium. Models 10 and 11 could be refined. Checks need to be conducted. However, this shows that information is missing in terms of monitoring catches, which suggests that knowing how catches are separated by species should be a priority for monitoring.
- A participant asks what impact it would have on management procedures if the industry could target one species in particular (e.g., if fish harvesters could target *S. mentella*). A presentation is scheduled later in the agenda about a specific case of perfect catch sharing, even if Working Group members do not consider perfect targeting possible for the time being.

Day 2 – Thursday April 26, 2018

INTRODUCTION AND OPERATIONAL MODELS CONTINUED

NATURAL MORTALITY:

- Several participants argue over the way natural mortality (M) is addressed in the series of operational models. A participant notes that stress models do not test a high enough mortality rate compared to what has been observed in the past for other species, notably cod. Considerable M variations may be observed in the Gulf (up to three or four times higher than the estimated base value, or much lower) because of climate change phenomena, density-dependence, a decline in prey, etc. Another participant asks why a range of M values were not included in the model instead of a fixed parameter, given its varying nature. It was agreed that the fact that M is doubled in one of the models adequately addresses the natural mortality issue, but that this value could be revised over time (in no later than five years) through an MSE revision process. M-related research recommendations could also be made, and the various Bayesian approaches could be reviewed.
- It is mentioned that a recent Norwegian/Russian redfish stock assessment could substantiate future M-related research recommendations.
- It is suggested that the section on natural cod mortality be removed from the Research Document.
- Several comments are made about the possible mass emigration of the stock in the event of adverse weather conditions and about the required precautionary approach for various circumstantial phenomena. It was agreed that the exceptional circumstances protocol, which

will be detailed later, should take account of and include these potential problems. DFO can also always report any significant changes in the redfish populations through CSAS Science Response reports.

SEPARATING CATCHES BY SPECIES:

- A participant asks whether the series of models is reliable enough to predict and properly represent the potential mismatch between the separation of catches by species identified in the fishery and those identified in surveys. It is noted that models 10 and 11 test a proportion of 20% to 80% of either species. It is also noted that reliability can be improved for this uncertainty.
- A participant mentions that the steepness parameter suggests uncertainty about stock productivity. He mentions that the model seems to cover the recruitment portion well, but growth does not seem to be in line with what has been observed in the Gulf (slower growth). He asks for various growth curves to be tested within the series of basic models to cover the uncertainty of a different or slower growth rate, as seen in the Gulf. He mentions that slower growth could have an impact in the short-term, i.e., before a periodic revision of the MSE. It is agreed that the tests required to include various growth curves were carried out but inconclusive. It is also agreed that this aspect should be included in the research proposals.

MANAGEMENT PROCEDURE AND HARVEST CONTROL RULES

Murdoch McAllister concludes the presentation of operational models by explaining the two approaches (parametric and non-parametric) to test deviations in future recruitment. He continues with management procedures for both species and the steps leading to harvest control rules using the J_y index. This index is calculated using annual surveys in Unit 1, but only for large fish (>29 or 30 cm).

- It is mentioned that the steps leading to harvest control rules were the product of a consensus.
- The fact that management procedures are based on redfish stock over 29 cm and not the spawning stock is questioned. The reasons justifying the choice of 29 cm rather than 22 cm (the legal size) are requested. This is a precautionary measure related to the uncertainty in species composition. It is agreed that it would be important for clarifications on this decision, made by the Working Group, to be included in the Research Document.

Dr. McAllister continues his presentation on the 21 different management procedures, which are separated into two groups: capped and uncapped. He presents the 12 different performance indicators in relation to the various management objectives identified by the Working Group.

- Participants agree that all management procedures tested under the MSE are appropriate, and that none seems to have been forgotten.
- A participant asks why reference points were based on survey data without model output. It is agreed that the decision made by the Working Group in this regard be documented in the research document.

Dr. McAllister presents the results of simulations obtained through the series of models for each of the selected management procedures. All management procedures allowed for stock conservation objectives (objectives 1, 2 and 3) to be met. However, no management procedures allowed for objective 5, concerning low catch rates for fish under 25 cm, to be met. The most critical stress tests are OM3 and OM14, where several management procedures did not produce the desired results. Mainly uncapped management procedures failed performance tests.

- It is mentioned that the fact that all management procedures fail to meet objective 5 could stem from the way future recruitment is simulated.
- Several participants report irregularities for several simulations. After 20 years of simulations, several indicators change unexpectedly (notably for model 3). It is mentioned that some deviances may stem from the bootstrap process, and that some results have yet to be validated.
- Several participants mention that the initial years of the fishery are problematic because of the small fish protocol. A participant notes that if the size at maturity changes in line with population growth changes, the small fish protocol must also change to actually protect immature fish. It is agreed that this could be included in the research recommendations. Another participant voices concerns about the impact of the small fish mortality rate (discards) related to fishing activities. It is agreed that this uncertainty was covered in models 23 and 24.
- A participant points out that hyperstability is another source of uncertainty and that the Unit 1 survey cannot be proportional to the actual abundance of stocks.

PERFECT CATCH SEPARATION

Dr. McAllister presents the results of a special evaluation request submitted to the Working Group to determine what can be done in the event of perfect targeting (i.e., separation) of the two species in fish harvesters' catches. Management procedures' performance in relation to the three conservation objectives and total allowable catch (TAC) improved in the simulations carried out. It is agreed that sampling to estimate species composition in commercial redfish catches should be a high monitoring priority.

EXCEPTIONAL CIRCUMSTANCES

Julie Marentette presents the exceptional circumstances protocol, the various results that can trigger it, and the various steps that lead to a review period.

- A participant suggests that the Unit 2 survey not being carried out be considered an exceptional circumstance, as is the case for the Unit 1 survey.
- A participant suggests considering that high catches in scientific surveys also be added as an exceptional circumstance, just like low catches.
- Some participants wonder whether it is necessary to further define and specify what constitutes an exceptional circumstance for the protocol. It is agreed that it should be defined as a "significant difference" for this protocol.
- A participant mentions that a five-year waiting period is too long before conducting an MSE review. It is mentioned that Fisheries Management may take action throughout the year to remedy the fishery by imposing certain measures, rather than triggering the MSE process.
- A participant mentions that exceptional circumstances observed could be annually reported through a CSAS Science Response or the Integrated Fisheries Management Plan (IFMP).
- It is agreed that this protocol will be added in an appendix to the Research Document.

ALTERNATIVE MODELS

Dr. McAllister presents additional results about the combination of survey indices for Unit 1 and 2. Preliminary results suggest that Unit 1 stocks decrease faster than Unit 2 when biomass is low, meaning that geographic contraction between the two units could be possible. Preliminary analyses suggest a better fit to the survey data according to these parameters.

- All stakeholders agree that this hypothesis should be included in the research recommendations and should not be addressed under this MSE, given that this MSE is only preliminary. However, based on these latest preliminary tests, it must be strongly recommended that the MSE be reviewed within five years, at the latest.

REFERENCE POINTS

Julie Marentette presents the reference points taken from the reference model. She presents the various TACs based on the various models used and the five management procedures that will be considered. Based on the precautionary approach, these reference points indicate that the *S. mentella* stock is in the healthy zone, and that *S. fasciatus* is in the precautionary zone.

Day 3 – Friday, May 4, 2018 – Conference call

SCIENCE ADVISORY REPORT REVIEW

A draft of the Science Advisory Report (SAR) was sent to participants for review before the conference call. The purpose of the conference call was to review the SAR so that a draft would be available for the Advisory Committee meeting on May 10, 2018.

BACKGROUND SECTION

- Some participants question the maximum depth for *S. mentella* abundances mentioned in this section.
- It is decided that details in the SAR will be limited to general information, and that the Research Document will include all information with appropriate references.

ASSESSMENT SECTION

- It is agreed that further details should be included in Table 1 on the objectives and performance indicators for the Unit 1 and 2 redfish MSE process to define the word "maximize" (in point 4) as well as the "SSB_x" and "SSB" abbreviations.
- Some participants expressed doubts about the relevance of leaving time intervals in point 6 of Table 1 (intervals 10-20 and 10-40). It is decided that these intervals will remain to maintain the time perspective.
- Discussions are held about recruitment compensation. It is suggested that the text be complemented by adding that a large part of the uncertainty will be determined by the probability of a strong cohort in the future.
- It is agreed that these specifications will be added to further describe the models and their assigned numbers.
- In the reference points and catch control rule section, a difference was noted between the text in the SAR, in the Research Document and in the document presented during the peer review (exploitation rates are below about 75% of Umsy, as opposed to 95% presented during the review). Clarifications are needed on this point and should be added to the Research Document.
- In the section on management procedure performance in relation to objectives, it is estimated that the MSE implementation period will be five years, even though this phase must be approved by senior management.
- Figure 4 must be revised to ensure that all components are included.

OTHER CONSIDERATION SECTION

- For the research recommendations section, it is agreed that some comments will be addressed at a later time, outside the conference call.
- Discussions are held about the supplementary research presented by Murdoch McAllister on the potential geographic contraction of the redfish distribution. Some participants consider that this supplementary research is not part of the MSE because it is too preliminary to be considered as scientific evidence. Other participants are more inclined to consider this aspect in the current MSE process because of the many implications it has on the future management of these stocks. It is agreed that the spatial distribution of redfish between units 1 and 2 should be a research priority.
- A participant makes several proposals to add to research recommendations. It is agreed that scientific questions are important, but that the majority of them do not fit into the SAR's Terms of Reference.

SUMMARY SECTION

- Participants discuss the importance of more rigorous monitoring (increasing coverage through samplers and observers in relation to the small fish protocol) of species and size composition to collect more accurate data for future evaluations.

APPENDIX 1- WORKING GROUP RECORD OF DISCUSSION

Redfish Working Group
December 19, 2016
Conference Call
Record of discussion

Opening Remarks:

Adam Burns, chair of the Redfish Working Group, opened the meeting with a round of introductions and a brief overview of the purpose of the meeting: to provide an update on the development of the Rebuilding Plan, the science assessment framework model and the proposal for a Management Strategy Evaluation (MSE) approach. Clarification on the membership of the working group was also provided by the chair. Membership of this working work, while not restrictive, should include experts from the fishing industry and provinces that can contribute to the relevant duties of the Working Group (i.e. development of Precautionary Approach compliant harvest strategy for the Unit 1 and 2 Redfish stock).

Status update rebuilding plan:

Sandra Courchesne gave a brief summary of key events in the Unit 1 and 2 Redfish fisheries leading up to the creation of the Redfish Unit 1 and 2 Working Group in 2014. The draft Rebuilding Plan Objectives developed by the Working Group were circulated to the group prior to the conference call for reference.

- Commercial moratorium implemented in Unit 1 in 1995.
- Unit 2 TAC was reduced significantly beginning in 1995 (25Kt to 14Kt).
- In 2010, COSEWIC assessed the Gulf of St. Lawrence/Laurentian Channel (Unit 1 and 2) population of (*mentella*) Redfish as endangered AND the Atlantic Population (*fasciatus*) Redfish as threatened.
- In 2011 a Recovery Potential Assessment (RPA) was completed using a Bayesian population model. The production model was also used to define LRPs for each species for the combined assessment unit.
- The production model observed that biomass estimates for both species were below their respective LRPs. However, uncertainties with the population model were noted by the peer - review committee.
- DFO's Precautionary Approach requires a rebuilding plan for depleted stocks. As a result, in 2014, a Unit 1 and 2 Redfish Working Group was created to develop a precautionary approach compliant rebuilding plan and HCR.
- The Working Group met multiple times over the 2014 to 2016 period and agreed on Draft Rebuilding Plan Objectives and Milestones (these were distributed prior to the call).

Status update stock assessment framework:

Daniel Duplisea gave a summary of science work on developing an assessment framework model for Unit 1 and 2 Redfish.

- The 2011/2012 production model for Redfish did not adequately take into account young Redfish – thus a new modelling approach was needed.
- In December 2015 an assessment framework meeting was held to identify a suitable statistical model to assess Redfish. Multiple issues were noted with both models presented (DFO and Industry funded) at the framework meeting and as a result, no model was adopted at the time.

- A full stock assessment was completed in March 2016 based on indices which confirmed the presence of the strong 2011, 2012 and 2013 year classes.
- Work on addressing the modeling issues continued over the spring /summer of 2016 which included a study of historical catches.
- A follow up framework meeting was scheduled for November 15-17, 2016. The historical catch study revealed issues related to reported catch and catch composition.
- Given the multiple issues encountered a model for redfish could not be put forward for the November framework meeting and science decided that the U1&2 redfish assessment should continue to be based on survey indices as done in March 2016. The November Framework meeting was therefore cancelled.

Follow-up conversation on assessment framework model:

- An ACPG representative asked for further details on the catch compositions issues discovered by science in their research.
- DFO explained that recently conducted interviews with industry members active in the 1980s and 1990s indicated small Redfish weren't fully represented in the historical catch data.

Management Strategy Evaluation (MSE) Overview:

Daniel Duplisea presented on overview of the steps involved with a MSE approach and the benefits of such an approach.

- MSE is comprised of stock and fishery objectives as well as steps taken to achieve the objectives.
- The MSE process involves 1) development of an operating model to represent the dynamics of the fishery and to generate future simulated data; 2) an estimation model to assess the state of the stock and derive Reference points, and; 3) Harvest Control Rules to determine what management actions should happen in light of the state of the stock.
- Outputs from the MSE are a set of performance measures that quantifies the effectiveness of the operating model and performance of the harvest strategy to meet specified objectives.
- Benefits of a MSE approach; multiple candidate operating models can be used to test performance against measureable objectives, provides a robust and defensible management system that takes into account scientific uncertainty and meets fishery objectives.

Follow-up conversation on MSE:

- Representative for Acadian harvesters asked questions related to pre- 2011 mature biomass spawning rates/activity and those observed from the 2011 mature biomass, factors affecting reproduction and differences in mortality rates observed by science.
- DFO indicated that the numbers of mature spawning biomass pre -2011 was not that much different to that observed in 2011 and there were likely several other factors at play that prevented the earlier recruitment year classes from surviving. DFO also noted that Redfish reproductive success is an area of ongoing research within DFO.
- FFAW asked whether it is a safe assumption that the 2011-2012 strong year classes were the most significant recruitment potential in the fishery in recent years.
- DFO indicated that there is uncertainty as to just how large the recruitment is, but the 2011 and 2012 year classes are definitely considered significant.
- ACPG representative asked whether the Redfish assessment model takes into account effects of Redfish on other species.
- DFO noted that the operating model is to assess the status of Redfish and would not look at effects on other species. However, the effects of other species on Redfish recruitment may

be considered in the assessment. It was also noted that ecosystem interactions in the Gulf was a research topic for science.

Next Steps

- The Chair proposed moving forward the MSE approach for Unit 1 and2 Redfish. No opposition was raised by members. As such an update would be provided at the GGAC and the 3ps Advisory Committee meetings.
- GEAC representative noted that Unit 2 Maritimes based participants needed to be updated on the developments and the SFGAC should also be informed.
- DFO agreed to raise the recommendations of the WG at the SFGAC as well.

Timing of next Working Group meeting:

- March 24, 2016 after the GGAC was one option proposed, the other option was a date to be determined in April 2017 in Montreal.
- The March 24 option was generally accepted, however GEAC could only tentatively agree and some inshore Quebec harvesters preferred a meeting before GGAC.
- DFO will re-visit possible alternative dates.

Redfish Working Group
March 24, 2017
In person meeting – Moncton, NB
Record of discussion

Opening Remarks:

Adam Burns, chair of the Redfish Working Group, opened the meeting with a round of introductions and a brief overview of the purpose of the meeting:

1. Engage the Redfish Working Group regarding management objectives and harvest control rules, to be incorporated into the Management Strategic Evaluation (MSE).
2. To make tentative work-plans around the next steps for the MSE process.

Overview of Management Strategy Evaluation (MSE):

Murdoch McAllister gave a presentation on MSE and its components, focusing on definitions, the process of MSE and what was required at this meeting. This included management objectives, harvest control rules, and a list of things that could be built into the models. The deck for this agenda item was circulated in advance.

Discussion on MSE:

- Participants asked to clarify why the best-model approach was not possible in this fishery. Fisheries and Oceans Canada (DFO) Science stated that the best-model approach had been attempted several times for redfish and had not led to a successful model being chosen. Murdoch McAllister indicated that the idea of MSE is to capture uncertainty and test a number of models at once. It also changes the conversation away from what is the best model to what is the best management strategy that will achieve the objectives for the fishery and conservation.
- In response to questions about allocation of total allowable catches (TAC) among the different redfish management units, the Chair clarified that access and allocation matters are not related to this MSE process or part of the working group's mandate. In addition, operational management measures for the proper control and monitoring of the Unit 1 and 2 Redfish fisheries are important but would be better placed for the advisory committees.
- The Chair also clarified that fishery and stock objectives for the MSE should be in the context of identifying the management strategy that will guide future TACs levels for Unit 1 and Unit 2 Redfish fisheries.

Management Objectives:

DFO resource management gave a brief overview of prior Unit 1+2 Redfish Working Group meeting outcomes, the criteria needed to produce management objectives, and a summary of the long-term and short-term objectives from the Redfish Rebuilding Plan. The presentation also included some suggested management objectives for Redfish which were intended to be used as starting points for discussion. The deck for this agenda item was circulated in advance.

Discussion on Objectives:

- FFAW suggested that limiting TAC changes to 15% was not critical given stocks are anticipated to be well within the healthy zone in the near future, and this only becomes an issue when stocks are rebuilding. The FFAW also noted the need to leave small fish in the water now and in the future to continue potential for recruitment in future years. Thus the minimum fish size should be much higher than 22cm.
- GEAC indicated that market value for redfish was highest for fish over 28 cm and that it was desirable to have a fishery for more than 10-15 years. TAC changes should be predictable

for the long-term. GEAC also suggested a 25 cm minimum fish size, instead of 22 cm. In response to this discussion, FFAW indicated they would consider the sizes and come back with a minimum size recommendation.

- Participants noted there is currently a small market for Redfish for bait and for fillets but the later has collapsed and the bait market can only sustain a certain level overtime before becoming saturated. Many participants agreed that the market value for small fish is very poor and the future fishery should be focused on larger fish for access to more valuable markets.
- The concept of a stepped approach for TAC increases and a range of catch limits for various small size categories had some merit for evaluation in the MSE.
- Several participants expressed interest in the redfish-shrimp dynamic and whether this could be incorporated into the MSE. The MSE science advisor (Murdoch McAllister) noted that ecosystem-based modelling would be very difficult to address, prolonged and costly given this would require looking at interactions between all species in the Unit 1 & 2 ecosystem, not just redfish and shrimp. It was suggested that a starting point would be to look at how redfish biomass changes over time, which would be part of the MSE simulations.
- Several participants indicated that such an exercise would not be advantageous given the current capacity of the Redfish fishery and would generate more questions than answers.
- GEAC indicated that with respect to stability in catch long term, it was premature to put a hard number on the maximum desirable catches over the long-term.

Management Procedures and Harvest Control Rules (HCRs):

DFO explained that HCRs are a component of management procedures, presented some suggested HCRs for Redfish as starting points for discussion.

Discussion on HCRs:

- FFAW felt that HCRs should include a rule related to exceptional circumstances given the current low spawning stock biomass (SSB) and potential dramatic increase to above the upper stock reference point (USR). GEAC agreed, and suggested that a gradual ramp-up period was needed and HCRs would be used for declines.
- Some members noted that the moratorium for Unit 1 should no longer apply in light of the anticipated increases in mature biomass to begin in 2018-2020. The Chair noted that removing the moratorium would require ministerial decision and the outcomes of the MSE process would provide guidance to the Minister in that decision.
- GEAC indicated that it was hard to suggest HCRs without seeing some initial simulation runs. The MSE science advisor clarified that a simple starting set of HCRs was needed first, and then a final set of HCRs could be developed later. GEAC suggested a scenario with F=0 as a possible simulation run, and simple rules with increments such as 4,000, and 8,000 t.

MSE Workplan:

A draft workplan was distributed to all participants prior to the meeting.

MEETING OUTCOMES:

To orient the MSE process, GEAC and DFO put forward some ideas on Objectives, HCR and performance metrics for testing in the initial MSE processes that were reflective of the meeting discussions. There will be other opportunities for the working group to offer input on refinements and/or other HCR.

Draft Objectives:

- Increase SSB above the lower reference point (LRP) and into Healthy Zone in 10 years, 90-95% probability.
- Once in the Healthy Zone, maintain stocks above USR with a 90-95% probability.
- Minimize the catch of young fish (categories of < 22 cm, 22-24 cm, 24-27 cm, percentages limits to be determined)

Draft Harvest Control Rules:

- TAC increase thresholds for 5-8 years, starting in 2018 and a global Redfish TAC of 17,000 t (both Units combined).
  - In first 5 years, increase the TAC by 2,500t per year beginning in 2018, followed by a constant catch (at 40,000t of SSB).
  - Once relative F (mortality by fishing) exceeds 8%, decline TAC by 5,000t steps.
  - Apply an exploitation rate of 5% of SSB in each year.
- May reach maximum 30,000t-50,000 t TAC over 20-40 years

Other things to be explored in the simulation models:

- Species and spatial composition ranges. Discussion on plausible ranges to be discussed by the working group in mid-June.
- Size-frequency distribution by depth (although it is unclear whether this is biologically realistic) – effects of closing areas.
- Gear selectivity in relation to fish size (e.g., mesh size).
- Effects of possible reduction in growth of fish in large cohorts.
- How to treat the two redfish species (modelling separately, and together; and methods to simulate catch of the two stocks).
- Historical discards at sea of smaller fish.
- Size-dependent natural mortality.
- Incorporation of environmental conditions.
- Simulations over 40 years.

Next Steps:

- A technical modelling meeting involving DFO Science staff, the University of British Columbia (UBC) external modellers as well as an industry selected external modelling expert will be held before this (May or June) in Vancouver.
- Updates from the technical science meeting will be provided to the Working Group via a teleconference in mid-June.
- Next in person Working Group meeting to review the initial MSE outputs to be planned for fall (e.g., September or late August), in Montreal or Halifax.

Redfish Technical Meeting
May 24—26, 2017
In person meeting – Vancouver, BC
Record of Discussion

Presented Approach

Operating Model (OM; fish population dynamics)

- A base age-structured dynamics model was proposed (i.e., an R analog to a SCALE model although TMB was discussed; SCALE ref. Duplisea et al. 2016), along with 9 additional variants to address under-reported catch (i.e., discarding), catch splits by species, alternative recruitment scenarios, capacity for future fisheries to target desired species, and alternate growth rates and natural mortalities. The SCALE model infers age structure from catch-at-length data. Fixed catch-splitting.
- The OM is conditioned by two other models, a) stochastic delay difference and b) age-structured production model, which provide estimates of parameters (B0, steepness, adult and recruitment indices, etc.).

Management Procedure (MP; Harvest Control Rule and assessment model)

1. **Model Free:** Derived from the analogous Canadian Pollock MSE, use a ratio of a short-term running average of survey biomass index to the mean historical survey biomass index. After discussion, the denominator will be calculated as:

$$(1/17)\sum_{2000}^{2016}[\mathrm{SBI(U1)}+\mathrm{SBI(U2)}]*(17/33)+(1/16)\sum_{1984}^{1999}[\mathrm{SBI(U1)}]*(16/33)$$

   The HCR with this MP will use a gradual ramp-up approach for setting TACs, and fixed constraints for decreasing TACs if the assessment ratio falls below a given threshold. Unit 2 survey values will be imputed where necessary to compute the denominator.
2. **Model-based:** Use stochastic delay difference model and OM data outputs to produce SSBt, Rt, CR, MSY-based reference points and scaling parameter for catch under-reporting/discarding. Will be set aside for now.

Updates and Additions

- GEAC would be interested in seeing fish size-based outputs along various bins bounded by 24, 27 and 30 cm.
- GEAC has proposed stepwise TAC as a HCR (additional model-free MP): 16,500 t in 2020, 24,000 t in 2022, 32,000 t in 2024 and 40,000 t in 2026 (this is over both Units 1 and 2).
- Sensitivity analyses – verify whether the use of two survey data series in model-based MP, and one combined survey data series in model-free MP, will be problematic.
- We will try sensitivity analysis on catch species split. Reduce the number of OM variants to consider by removing optimistic recruitment scenarios. Continue to use reduced number of OM variants.
- The ‘disappearing cohorts’ for S. fasciatus, and other data contamination issues, pose problems for model fit and require close attention. May try to fit with and without them.
- Down-weighting of commercial catch at length because of uncertainties.
- Two-step (biphasic) recruitment estimation to simulate redfish spasmodic recruitment events: a low recruitment Ricker- or Beverton-Holt type stock-recruit relationship with high probability of occurring, and a high-recruitment with low probability.
- Limit survey data by strata that most represent fishery footprint to get better estimate of catch split by species.

Selectivity – given that commercial catch and survey catch differ, addressed as follows. Survey selectivity is stationary. For the commercial fishery there is a catch selectivity and an annual retention selectivity. The retention selectivity has a random walk and the catch selectivity has a fixed offset from the retention selectivity.

Redfish Technical Meeting
September 14-15, 2017
In person meeting – Vancouver, BC
Record of Discussion

Day 1 – September 14, 2017

RECAP: The Chair presented opening remarks and meeting participants introduced themselves. The MSE process to date was reviewed. Input from multiple stakeholder groups in the Redfish fishery was received at the Working Group meeting in March. The main focus of this meeting day is to review the Operating Model (OM) that has been developed, and also to examine what will be tested in Management Procedures (MPs).

Operating Model

The OM presented was a Stock Reduction Analysis (SRA) model. The model is fully age-structured and there is a separate model for each species (*S. mentella* and *S. fasciatus*), but both are structured similarly. MPs will be tested in both models (both species) simultaneously so advice can be given for both stocks.

An offset parameter was used to differentiate selectivity curves for catches killed and retained. Discard mortality is assumed to be 100%. A random walk for the offset parameter, as discussed in May, did not work, so a fixed scenario was used instead. This fixed offset scenario is open for discussion.

Discussion

Key points examined were fleet selectivity, the splitting of catch data by species, the disappearing Grand Banks cohorts of *S. fasciatus*, recruitment and recruitment multipliers, ways of approaching discarding and discard mortality, advice for Unit 1 and Unit 2. A recommendation was made to develop a list of key issues as a worry list (expanded below with discussion for each subject).

- Participants discussed the observer coverage, which is 10-15%.
- Variation in natural mortality (M) will be explored. Currently, M = 0.1 for *S. mentella* is used (literature derived), while *S. fasciatus* is a bit higher.
- Timelines were discussed: the team would continue to explore OMs for one week, then develop closed-loop simulations over the next two weeks in preparation for the October Working Group Meeting. The preferred situation would be to have a provisional OM and set-up of the closed-loop simulation completed prior to the next working group meeting.
- Survey data from U2 (i.e., species splits from 2016) are not yet available. These data are with the DFO Newfoundland & Labrador region, which has been made aware of the need for these data.
- The importance of consistency in use and presentation of recruitment parameters (compensation ratio versus steepness) was discussed.
- The possibility was raised that recruitment could have undergone a regime shift over the time series. It may be possible to sample, e.g., the last 30 years of recruitment deviates and project these into future for simulations.
- Evaluating model uncertainty: One recommendation was to develop an MCMC, and develop a core set of parameters from each OM, and develop a the stress test set of OMs. The uncertainty in the OM would be explored via the creation of a joint distribution of steepness and stock size, and then take the joint mean and also four distant points.

- Model fit currently based on Carl Walter's SRA suggestion from the May meeting. It is suggested to try another operating model fit using proportions of length rather than CPUE at length, take out q_survey_CPUE because don't need it should proportions at length be used instead of CPUE at length. And use multinomial or multivariable logistic likelihood function instead; likely have to estimate annual variances for it. Because fits are not good and conflicting and with a likelihood function on survey CPUE at length plus the swept area survey biomass index, this is double dipping on abundance/using same data two times. There is a need to separate abundance from composition.

Day 2 – September 15, 2017

RECAP: Discussion resumed on the operating model and simulations. The Precautionary Approach framework suggests that 1.5 to 2 generations are allocated to rebuilding a stock out of the Critical Zone. A couple of generations for simulation may be sufficient to explore the impacts of operating the fishery at various levels or intensities.

Participants also discussed and set goals and next steps for the October Working Group Meeting in Halifax, described in the section below. The importance of developing a closed-loop simulation was highlighted, even if the OM applied still had further refinements to make to it.

Summary of Main Technical Issues ("Worry List")

- **Fleet selectivity**: The data available are not fully divided by fleet. There are both inshore and offshore components in the U1+2 Redfish fishery. Currently, there is single fleet representation in the model.
- **Species splits**. The methods used to split catch by species are not 100% accurate, which may result in data contamination. Currently, the species split from Unit 1 is used to inform species splits in commercial catch. The MPs tested should be able to evaluate what happens when the survey catch fails to match the distribution of the redfish stocks. It was not clear when depth assumptions, and anal fin ray counts were used to differentiate the species in the surveys for Unit 2. After further discussion, it was determined that fin rays were used in 2009, 2014 and 2016 U2 surveys and depth the rest of the time.
- **Grand Bank cohorts of *S. fasciatus***: Cohorts that disappear from U1+2 around age 4 are a data contamination problem. Genetic studies have confirmed these fish belong to another stock. Because of imperfect species splitting, these cohorts also affect the *mentella* data. The current OM uses high coefficient of variation (CVs) to downweight these specific cohorts, but the model is still tracking these cohorts so the CV approach may not be entirely effective. This affects the recruitment function. There is no systematic genetic sampling done every year (e.g., of otoliths), it is done when the need arises.
    - An emigration factor (e.g., an epsilon) could be added.
    - A recommendation was made to eliminate the catch-length data in the relevant size classes for known Grand Bank cohorts from *fasciatus* and *mentella* data when fitting the multinomial or multivariate logistic function. This could be done on the data prior to species splits.
    - Another option was to apply an emigration factor to address Grand Bank cohorts when they appear.
- **Recruitment**: Currently allowing inter-annual variability (with sigma r) in recruitment, with a Beverton-Holt function. A weak informative prior was assigned to steepness/RecK from Forrest et al. 2010 work with rockfish. Currently, no autocorrelation with historic recruitment.

- **Recruitment multiplier:** Historical recruitment estimates have been dealt with in the OM by means of a multiplier in 1956 (5x) and 1980 (2.5x) to accommodate pulses of recruitment. These numbers were derived from literature and older DFO reports suggesting large historical cohorts. The assumptions around the relative strength of the old cohorts has strong implications for B0 estimates and steepness. This should be explored through alternative scenarios, or other means. How is B0 affected without the multiplier? A possible scenario was suggested to set the recruitment multiplier to 1 for all years, let historical recruitment deviates for the initial age structure be estimated freely, and set different prior probabilities on B0. However, that would increase the number of parameters to estimate from the data. Data from 1950s not informative. There may be another version that can free R_hist_rec and flatten out the rec_multiplier.
    - Reference made to Valentin et al. 2015
- **Discard mortality:** A challenge is that we have catch retained data, but not catch killed. An offset parameter was used in the presented OM to differentiate logisitic selectivity curves for catches killed and retained. Discard mortality is assumed to be 100%. A random walk for the offset parameter, as discussed in May, did not work, so a fixed scenario was used instead. The discarding ratio was set to 1.2 prior to 1986, and 2 for 1986-1994 and 1.2 for 1995 and onwards. A 20% discard rate in modern times was felt to be high by a meeting participant, but past models showed 2x was reasonable. The fishery was not quota based until post-2000. In the 1970's there would have been little incentive to discard as there was no quota.
    - A recommendation was made to use a multinomial or multivariate logistic likelihood function to the proportion at length data.
    - 57 length bins are not needed – a recommendation was made to only use the length bins needed each year so that 0s are avoided. For example, where a gap exists, spread the proportion at length in the initial bin prior to the gap across all classes leading up to the final bin with a zero in it..
    - A gamma function for selectivity was also recommended.
    - A random walk could be re-attempted in combination with the above advice.
    - References should be sought from Carl Walters to determine why he had recommended the catch length per unit of effort likelihood function.
    - An alternative OM with a 22-cm retention function will be explored, where anything less than 22 cm is discarded.
    - A recommendation was that discarding may be 10% or less for the modern era, and possibly 20% for the 1980s.
    - A recommendation was to use a multiplier of 1.2 prior to 1986, 2 for 1986-1994, and then 1.1 for 1995 to the present.
- **Time Series**: The current OM may not capture changes in gear across the time series. Three blocks of selectivity should be able to accurately capture what happened in the fishery. Gear has shifted from bottom trawl to midwater trawl within time series, so size structure of catch may not stay the same because the gear will target different life-history stages and habitat. Need to look at data and see (midwater vs bottom) where are the big fish? Question of what does this do to signal in biomass. May need location and shape variation. Problem with catch data split by survey, survey is on bottom, and then smoothed by year (proportion between species).
- **Advice for Unit 1 versus Unit 2**: The model describes the aggregate stock. Recommendations were made to explore options for partitioning stock into U1 and U2, as there are species and size variation between the two units. The U1 survey index, on which

the model was conditioned, may or may not fully account for stock dynamics in U2. U2 survey data are not yet available from DFO NL region, as mentioned above.

- **Main Axes of Uncertainty for Model:** these include growth and the possibility that it is density-dependent, recruitment and steepness/recruitment regimes, natural mortality, catch (magnitude of historical catch and discarding), future vulnerability schedule by species and across units, initial conditions (initial conditions and the recruitment/multiplier). These will not be discussed in October, but later in the MSE timeline.
    - **Core Group:** base OM (sampling joint posterior distributions as discussed). Weight by AIC plausibility; down-weight depending on whether the AIC is too large (based on delta AIC threshold; e.g., 10). Natural mortality hypotheses, steepness/initial conditions, historic catch
    - Reference for natural mortality in *Sebastes*:
    - **Stress Test Group:** Growth, recruitment regimes, future vulnerability schedules; AIC-non-credible models.

Goals for October Working Group Meeting

The October WG meeting is non-technical and needs a clear message.

- Discussion at this meeting will focus on two MPs and the outcomes of closed-loop simulations (as performance metrics), not the OM.
    - Model example will be for one species (i.e., *S. mentella*)
    - MP with steps as previously proposed
    - Volatility built into HCR: limit annual drops in TAC by setting the maximum drop to 5000 t; and limit TAC increases by a maximum of either 1500 (slow) or 2500 t (fast).
- Show outputs in relation to objectives discussed in March meeting. Show draft reference points (LRP and USR, e.g., 10% of B0, 40 and 80% of Bmsy) and what they look like.
- Key Messages:
    - Caveats – need more MPs, non-technical 'worry list' and approaches to deal with these
    - The need for input on objectives, and prioritize them
    - The first time an ongoing process (e.g., sablefish) gets updated – show what the early trigger points would be when the stock falls out of the MSE process and needs review (as per recent CSAS guidance)
- Show gaps, a schematic for data holdings and model choices. Use tables as shown below to increase accessibility to stakeholders
    - Trade-offs of foregone yield, triggering of small fish protocol

Working Objectives (revised from March 2017)

Stock/Conservation Objectives

- Increase SSB above Blim into Healthy Zone in 10 years, 90-95% probability
- Once in Healthy Zone – 95% chance of maintaining stock above USR

Fishery Objectives

- Minimize catch of young fish (i.e., Small Fish Protocol)
- Cap TAC at 40,000 t
- Volatility (5 k max drop)
- Maximize catch of fish > 27 cm

Working Performance Metrics (revised from May 2017)

1. Proportion of simulations where the TAC reaches 40,000 t in 2026.
2. Average number of years the maximum TAC was realized following the initial ramp-up period.
3. Percentage of years with 0 catch.
4. Percentage of years above reference points (LRP/USR)
5. Percentage of years with catch less than the current Unit 1 and 2 TAC (short and long term (10 years versus life of projection)).
6. Average drop in catch in periods of ramping down (ramping down means catches drop more than 2 years in row). Percent of time changes > 5k t
7. Average annual catch.
8. Percentage of years where the Small Fish Protocol is triggered (percent of catch where fish < 22 cm is greater than 15%).
9. Percentage of years where percent of fish > 27 cm is greater than [80%] (peak market value)
10. Proportion of years where the ratio of F:Fmsy by species > 1.

Action Items Following Meeting

- CS to look for old observer data (1970s), and when the 22 cm small fish protocol came in, sex ratio in survey. CS to look for other reference points in other Sebastes. COSEWIC triggers for assigning Endangered, Threatened status.
- MM, RL to discuss catch at length likelihood function with CW – reference to support use of retained CPUE?
- MM, RL to prepare proposal for eliminating disappearing cohorts to DFO biologist for review
- JM to look into source of 17,000 t TAC from March Meeting
- JM to set up conference calls described below

Model - Next Steps (Immediate)

- Correct survey biomass (total, not mature). Key for October meeting.
- Reframe the catch-length data to remove Grand Banks cohorts of *S*. *fasciatus*. Use multivariate logistic likelihood function, only fitting to the size bins where you have length data in each year.
- Catch/kill biomass ratio restructuring.

MSE Process - Next Steps

- Conference call to discuss progress with developing the OMs – week of Sept 25
- Conference call to discuss initial closed-loop simulation – week of Oct 3
- October 12-13 Working Group Meeting in Halifax
- December 2017 or January 2018 – another Technical Meeting
- Spring 2018 – CSAS Meeting

Redfish Working Group
October 12-13, 2017
In person meeting – Halifax, NS
Record of Discussion

October 12 Working Group Meeting Minutes

Opening Remarks:

Adam Burns, chair of the Redfish Working Group, opened the meeting with a round of introductions and a brief overview of the purpose of the meeting:

1. Present preliminary outputs based on the candidate Harvest Control Rules resulting from management procedures relative to the management, fishery and conservation objectives defined at the last working group meeting in March 2017; and,
2. Obtain more input on the objectives and management procedures

The Chair re-iterated that work on fitting the data and modelling refinements are ongoing thus outputs are preliminary and subject to change.

Overview - Recap of progress in the MSE process:

Sandra Courchesne provided a brief overview of the key events since the establishment of the working group and leading up to the October 12 working group meeting. It was noted that subsequent to each working group meeting, a Record of Discussion is distributed to members of the working group. Past Record of Discussion are available to any member who may not have received these at the time.

Overview – Update on Technical MSE meetings:

Daniel Duplisea and Murdoch McAllister presented a few slides to illustrate areas of discussion for these technical meetings and progress to date on technical modelling aspects.

Based Operating Model:

Daniel Duplisea and Murdoch McAllister presented a few slides on the key features of the base Operating Model (OM) and the challenges at play in developing the base OM, including the periodic appearance of *S. fasciatus* cohorts from the Grand Banks stock. It was noted that at this time the base OM is focused on the *S. mentella* redfish species. Work on developing a *S. fasciatus* base OM is ongoing and it is expected to have similar assumptions to the *S. mentella* model. Preliminary results from the most recent estimations were illustrated to the working group.

- Industry asked whether the base OM would be peer reviewed prior to the peer review of the MSE as a whole, referencing that this was the process done for the NAFO managed Greenland halibut stock. A technical peer- review process for the OM before the main MSE delivery was suggested.
- Scientists indicated that there are no plans to have a separate peer review of the base OM prior to the MSE peer review process tentatively planned for March 2018. It was further noted that the technical meetings that are open to all and have other MSE experts (to date in May, September and October, another proposed for December) is essentially filling a peer review function. Criticisms and suggestions related to the OM development and other technical components of the MSE that have come out of the technical meetings have been documented in meeting reports and have been taken on in OM development and have led to largely improved data fits. Initiating a full OM peer review process would be both redundant with the technical meeting function and would delay timelines for progress.

- The Chair clarified that DFO had no intentions of forcing the completion of the MSE processes for a March peer review if it was felt that the MSE was not ready or could not pass peer review.
- Industry asked whether the base OM includes environmental trends/ecosystem factors in the modelling since redfish is only part of the Gulf of St. Lawrence fisheries Strategy. Scientists indicted that the OM is not able to apply an ecosystem approach for multiple species. The OM is concentrated on redfish and incorporates some biological factors related to redfish such as recruitment and natural mortality.
- GEAC noted that the OM does not currently contain spatial structure and that the OM should not assume the fish are available equally throughout Unit 1 and 2. GEAC suggested other OM models should be done to provide outputs for alternative "what if scenarios" such as; a) catch at 125% of the quota as real kill to account for discarding; b) growth rates reduced by 25% or higher to reflect density-dependence; c) and natural mortality increasing by 50% or a plausible level to reflect cannibalism. A worst-case scenario OM was requested (including all the above impacts on discarding, growth and natural mortality). GEAC requested that the 'what if' scenarios that will be used for future projections of the operating model not be limited by what the historical data indicate happened in the past, because we are facing conditions in the future that have not been seen in the past.
- The FFAW inquired about how the different versions of OM, which represent different what-if scenarios, would be considered as either likely or unlikely. Scientists responded that they would use a quantitative method to determine how well each OM fits the data. This could be discussed further in the technical meeting.
- There was some discussion about gear specifications and by-catch. The Chair noted that while these issues were very important, the appropriate forum to raise gear specification and by-catch management matters would be the advisory committees. Some work could be done outside of the MSE process to develop by -catch profile for the redfish fishery. One option could be to assess data from fisheries monitoring programs and surveys for relative abundance of by-catch species vs redfish fishing effort.

Candidate Management Procedures and Harvest Control Rules:

Daniel Duplisea and Murdoch McAllister presented outputs based on the 3 Management Procedures (MP)/Harvest Control Rules (HCR) put forward as a starting point for the MSE. These were developed on the basis of discussions and ideas put forward by stakeholders at the March 2017 meeting.

1. Each have catch limits determined by ratio of the average survey biomass index of the past three years to the average historic survey biomass index.
2. All have 40 kt cap.
3. Differ in when they start to ramp up and how quickly they get to 40kt;
    - Different TACs set for 2018 and2019;
    - Different Maximum allowed increases in following years

It was noted that the preliminary outputs were based on Unit 1 survey data at this time. Issues surrounding the Unit 2 survey data were noted.

The Chair clarified that the MP and HCR used for these preliminary outputs were intended to start the MSE process and should not to be considered final. The working group is invited to provide suggestions and adjustments to the MP and HCR.

Discussion on Objectives and Performance metrics:

- Gulf industry noted that one objective should be to move the Unit 1 fishery from moratorium to full commercial status starting with the 2018 season.

- FFAW reiterated their view that a 40kt TAC cap in the entire Unit 1+2 area is not warranted in light of the anticipated increase in redfish biomass going forward. GEAC noted the objective was intended to space out maximum yield for many years. Gulf industry noted that TACs above 50kt in the Gulf (Unit 1) were historically unsustainable and therefore they support a TAC cap approach but caps other than 20 kt in Unit 1 should be tested.
- GEAC suggested adding objectives related to both species as there may be different objectives for each in terms of achievability.
- GEAC noted that the probability of 90-95% is excessive in relation to the draft objective of keeping SSB within the healthy zone given the natural boom-bust nature of redfish stocks.
- Respecting the objective to catch fish >27cm, some members felt other fish sizes should be explored in the modelling.
- GEAC noted that 22 cm minimum size for application of the small fish protocol is somewhat less than the length at 50% maturity for *S. mentella* females (~25 cm). Fish size is an economic issue but is also a conservation issue in the MSE process.
- A biologically meaningful size category for assessing biomass greater than or equal to would therefore be 25 cm in addition to the market driven size preference threshold of 27 cm.
- GEAC suggested that the working group develop thresholds for the performance metrics, i.e. what is acceptable, after applicable results of data runs have been reviewed.

Discussion on Management Procedures and HCRs:

- Gulf industry raised the point that markets dictate landings and stability in catch is important. This point was acknowledged as an element of the MPs which DFO indicated is open for further adjustment to be tested in the OM.
- There was support for using a three year average smoothing factor however GEAC suggested that a 3 year average may be a little low.
- The FFAW asked about the current exploitation rate (ER) for Unit 2 and suggested that ER be included in the OM outputs. The FFAW also requested that OM outputs be done for no cap scenarios as well as the preliminary 40Kt cap. As fishing mortality declines relative to the size of the stock, natural mortality may become more significant. GEAC suggested that the ER may be 4%, but this would need confirmation from Science.
- FFAW had some concern that the 40 year projection was too long. It was noted that redfish are very long lived and 40 years reflected 2 generations. Projections for at least 2 generations would be required to see any differences.
- Gulf industry noted that the Unit 1 fishery needs to be opened as a commercial fishery even with a low TAC to start to have more data available for a better idea of stock productivity for future modelling results. It was also noted that in the 1970s and 1980s, fishing was done in months that are not available for fishing now, and this may affect how catch data are interpreted.
- Aboriginal groups and Gulf industry raised the matter of distribution of the TAC between the 2 management Units (Unit 1 and Unit 2). It is acknowledged that the working group should discuss this matter and explore methods for distribution of the TAC (e.g. relative to the survey ratio) such that advice can be provided for Unit 1 and Unit 2 separately.

Next Steps:

- The Draft Objectives and HCR developed in March 2017 as well as a list of plausible HCR will be circulated to the working group for further input. Alternate HCR will be tested in the OM and results will be presented at the next working group meeting.
- Working on the OM will continue with technical MSE experts convening as required. The working group members were reminded of the technical MSE meeting planned for the

morning of October 13th. Participation in this meeting is voluntary and open to working group members.
- Discussion on the exceptional circumstances protocol and the implementation period for the MSE was deferred to the next working group meeting.
- December 13, 2017 in Halifax was agreed as the date and location for the next in person Working Group meeting.
- A technical meeting may be held in Halifax either on the 12th or 14th of December. As in all previous technical meetings, working group members are welcome to attend but participation is voluntary.

October 13 Technical Meeting Minutes

Introduction

The Chair introduced the meeting, which is to focus on developments in the Operating Model (OM), and get feedback on both the OM, and Management Procedures (MPs). Technical meetings are informal with no translation, but bilingual staff are present to help with any questions in French.

It was noted that in the Working Group meeting on October 12, questions had been raised regarding bycatch issues and reference points, and how we classify OMs. All of these could be discussed at this technical meeting.

Participants introduced themselves, and the technical team led by Murdoch McAllister described the OM.

- Age-structured model of population dynamics, for Unit 1+2 together. Catch data start around 1960, although the model starts in the 1950s to initialize the simulated redfish population. The model is fitted to the survey data.
- The model is fitted to available Unit 2 survey biomass index data, with a lower weight as a result of the larger residual variance in model fits to Unit 2 survey data versus Unit 1. OM fits will be distributed to the meeting participants.
- Landings records are of catch retained, not catch killed. The results of the OM are sensitive to the ratio of catch retained:catch killed.
- The data are contaminated by imperfect species splits between *Sebaste mentella* and *S. fasciatus*, and multiple *S. fasciatus* stocks (i.e., not just Unit 1+2 *S. fasciatus*, but the temporary presence of cohorts of Grand Banks *S. fasciatus* as well). This OM uses data with known Grand Banks cohorts removed which has improved model fit.

Fleet Splits

- Points were made about temporal changes in fleet composition with respect to the types of fishing gear (e.g., mid-water vs. bottom trawl) and how the gear was applied (e.g., depths) and how the modelling results could be affected by a) shifts in gear usage over the historical time series, and b) changes in gear in forward projections.
    - More specifically, participants discussed that the fishery may have gone through several gear changes in Units 1 and 2. Specific details and dates concerning gear change over time in the redfish fishery will be compiled by participants following these discussions. The current OM is based on a single fleet however there are selectivity blocks which can capture changes in overall selectivity of the fishery. Better documenting some of the probable selectivity block shifts would be useful for documenting the MSE OM development.

- Other aspects of the fishery's gear history were discussed, although details (time periods and gear) were to be confirmed later. For example: Mobile 65-100' fleets may have been significant to 1986, after which the mobile <65' and >100' fleets became more prominent.
- ***Discarding rates*** (i.e., the ratio of catch killed:retained) would also vary across gear types; for example, the midwater trawl would catch higher numbers of juvenile fish. Recruitment was poor from 1989-2011 and discarding is considered less of a problem in this period. The gap between catch killed and catch retained could also narrow in the future. If the assumed ratio is far from the actual ratio, it would affect perceived stock productivity.
- There would also be reason to want to know what happens in the future, if the fishery gear (and thus selectivity) changes versus what is used in the past or present. For example, what happens if gears that lead to substantial discarding of juvenile fish are pursued. It was agreed however that this is the in the domain of TAC allocation by fleet and would not be explicitly considered in the MSE process.

- A participant indicated that discarding rates should be low now due to 5-10% observer and 100% Vessel Monitoring System (VMS) coverage in Unit 2, and that the Small Fish Protocol is not always satisfied in landings. Industry and resource managers in the DFO Maritimes and Newfoundland and Labrador regions may have information on this.
- The technical team noted that the current OM is using selectivity blocks (where the selectivity varies over the time series, but in discrete blocks of time) as the most parsimonious way to model the average selectivity of the fishery in historic years. If information is available about the key factors affecting selectivity in historic years, that information could be assessed by the technical team so that the impact of new selectivity information on model fit could be evaluated against the current OM. However, the model cannot accommodate changes in selectivity without external specifications for these time blocks.
  - Information on historical fishery gear usage, and thus selectivity, may be found in industry records and in DFO CSAS data.
- The technical team also noted that the OM is not strongly forced to fit the fishery catch length, it is instead constrained to fit survey catch length and the units 1 and 2 trawl survey indices.

Species Splits

- The technical team noted that the OM splits catch in the commercial fishery by catch in the surveys, but that this is one assumption, and other assumptions could be explored in different OM scenarios. Species could be split by depth, for example.
- Species splits have also been collected by a Unit 2 harvester/processor in 2016.
- However, participants noted that the depth relationship for the species (i.e., where *S. mentella* is found in deeper waters) does not hold true for all of Unit 1+2; for example, in the fan area of Unit 2, *S. fasciatus* are found in deep waters. In addition, depth of water column varies spatially, so data from bottom-trawl records may be at more shallow depths in certain regions.
- It is also possible that there were seasonal changes in fishing time (i.e., before and after the moratorium) that are not yet accounted for in the time series.

Summary – Fleet and Species Splits

- It was agreed that concerns about fleet and species splits encompassed items 1-4 and 6 of the presented list technical challenges to be addressed:
  1. Uncertainty in catch biomass retained by species

2. Uncertainty in catch biomass killed by species
3. Uncertainty in historical selectivity
4. Developing ways to accommodate uncertainty in catch biomass killed and retained
6. Developing ways to represent the unit 1 and 2 fisheries in the future

- Participants noted the difficulty in predicting future fleet and gear selectivity as well as impacts on bycatch in relation to resource management issues such as allocation that may be addressed through the Rebuilding Plan working group.
- The technical team requested 2-4 additional selectivity scenarios, with literature-based rationales for gear/discarding changes, from participants to develop into further OMs. Time period for participants to submit these - **2-3 weeks**.
- The technical team will explore whether removing catch from the likelihood function would add additional benefits in terms of using Akaike's Information Criterion (AIC) to examine the suitability of model fits in different scenarios.

Fitting Length Composition Data

- This represented item 5 of the technical challenges list: Developing suitable statistical algorithms for fitting length composition data.
- The technical team noted that opening up the standard deviation of age of 50% maturity in the model allowed for a much improved fit. This improvement in fit will become apparent with AIC.
- The next step will be to test the sensitivity to modelling composition with a multivariate logistic function as recommended in earlier technical meetings. Current fits with the multinomial seem to be much improved over previous fits however.

Historic Recruitment

- This represented item 7 of the technical challenges list: Developing ways to address uncertainty in historic and future recruitment.
- The OM uses zero prior means for historical recruitment in 1956 and 1980, together with non-unit multipliers. The multipliers were formed based on past scientific literature that indicated certain historic years as having large cohorts. It would be preferable to replace the multipliers (e.g., 2.5) with non-mean zero recruitment deviate priors for all years currently having non-unit multipliers and allow the model to update the recruitment deviate priors in place of the pre-specified multipliers. The plausibility of different types of recruitment assumptions can be evaluated with AIC.
- There may be some signals in the data of a 1980 cohort, but 1956 is too far back for there to be catch records. Literature evidence suggests there were large cohorts in 1948, 1956, 1958, 1974 and 1980; the cohorts in the 1950s formed the basis of the initial development of the redfish fishery in the 1960s.
- Participants discussed how spreading the large initial cohorts over 1-2 years may affect the model – this is an option for a sensitivity analysis.
- Approaches based on unfished biomass (B0) as opposed to recruitment multipliers were not considered favourable, although it may be more common to model B0. Use of B0 may result in issues with reference points with redfish in relation to spasmodic recruitment patterns over time.
- Documentation was requested to justify why years of large cohorts, and multipliers were selected. It was also agreed that it is important to document what things were tried, and did not work.

Future Recruitment

- The OM currently explores three different scenarios for future recruitment:
  - Recruitment trajectories like the ones seen since 1978 (possible big cohort within 20 years and beyond)
  - Weak recruitment 2018-2037 (possibility of big cohorts afterwards)
  - One or more strong recruitments 2018-2037
- Preliminary projections have bootstrapped future recruitment from past recruitment time series (20 year sequences then stitched together, drawing with replacement, starting in 1974)
- Discussed options for modifying this future recruitment method included: looping, picking different starting points, starting from 1970 instead of 1974, and focusing on precautionary (worst-case) scenarios (i.e., no recruitment pulses over the simulation), as there have been long periods without good recruitment in the past.

Harvest Control Rules (HCRs)

- It was noted that in the Working Group meeting, questions were raised about the inclusion of a cap in HCRs.
- It is possible to examine a wide array of HCRs with/without caps and with different ramps. If an HCR is without a cap, harvest could be defined as a percentage.
- Participants noted that it was important to see how the different types of HCRs affected future potential yield from the fishery, and the stock, including size of fish landed.
- It was pointed out that it would be necessary to formulate scenarios for how future fleet capacity could develop, since it could be possible that under some HCRs it could not be feasible, either practically or economically, for the fleet to capture entirely the catch limits specified by some of the candidate HCRs. It was agreed that industry members would be consulted for input on specifications for how fleet capacity could increase in future years and specifically how scenarios for the maximum catches that could be taken by the fleet could develop in the future.

Bycatch

- Bycatch is certainly important going forward however it was acknowledged that because the bycatch profile will reflect both the fleet allocations as well as abundance and availability of bycatch species to different gears then this would not be included directly in the MSE.

Next Steps

- Technical meeting participants invited to propose joint selectivity/ catch-by-species/ discarding scenarios in 2-3 weeks.
- The UBC technical team to prepare a suite of possible Harvest Control Rules made available for review by participants (e.g., 10-12). Comments would be solicited from Working Group on possible TAC trajectories and capacity.
- Document gear selectivity blocks over time, species splitting, cohort removal methods as well as strong year classes back as far as possible to help inform the model fits.
- Next Working Group meeting tentatively scheduled for December 13 in Halifax.

Redfish Working Group and Technical Meetings
December 12-14, 2017
In person meeting – Halifax, NS
Record of Discussion

Technical Meeting Minutes – December 12

Introduction

- The Chair welcomed everyone to the meeting and conducted a round table of introductions.

Operating Models

- Murdoch McAllister presented the progress on Operating Models completed since October. Operating models have been prepared for both *S. mentella* and *S. fasciatus*, and fits to both survey and fishery catch-at-length data were presented and reviewed. Umsy for *S. mentella* was around 6%, lower than for *S. fasciatus*.
- Currently, the models do not employ implementation error.
- The models use both Unit 1 and Unit 2 survey data in the likelihood function (Unit 2 only simulated every other year; Unit 1 data have a longer time series and are completed annually). Both Unit 1 and 2 survey biomass ratios show a similar pattern over time.

Accounting for Historical Fisheries Selectivity

- Caroline Senay described how blocks (time periods) of historical fisheries selectivity were developed, using landings and observer at sea catch-at-length data in DFO records from the 1970s to present. A cluster analysis was performed on the catch-at-length data to find time periods where selectivity was similar (looking specifically for 2-3 groupings of years). The catch-at-length was expressed as quantiles across units for each year, weighted proportionately across all gear types (so the catch-at-length data represented the overall selectivity for a given year).
- In these data, there is little evidence of discarding in that the fish lengths reported by observers at sea were similar to or greater than fish lengths reported from the landings.
- Three time period scenario: early years to 1984, 185-1993, then 1994 to present.
- Two time period scenario: early years to 1993, then 1994 to present.
- A participant asked about how the observer coverage compared to the landings coverage, and what information was available in the records that described what was asked from the observers. That information is likely hard to find. DFO had authorized at-sea observers in the 1970s and 1980s under a science program in existence at that time.
- Another participant noted that just because the observers sampled what fish hit the deck of ships, does not mean that entire hauls weren't discarded at sea in the 1980s or at other times, which would not be reflected in the observer length data.
    - **ACTION**: Caroline Senay to look into whether these activities were recorded by observers.
- A participant recalled that 30% of fish were around 38 cm during the historical time period represented in the data. However, the corresponding observer data indicated that the 75th quartile for that period was around 35 cm (large fish, similar to what the participant recalled).
- A participant noted that in 2016, there was an inconsistency between what the people on the vessels reported seeing (lots of small fish), and the data presented for the selectivity analysis. DFO is waiting for more midwater trawl data from 2016.
- A participant noted that survey selectivity in Unit 1 cannot be a knife-edge because the biomass of the 2011 cohort in the Unit 1 survey has increased every year since first detected in 2013 and peaked this year.t. Age at 50% selectivity should be greater in Unit 2

in order to couple with the known movements of older fish. The analytical team noted that age of 50% selectivity was approximately at 2 years in Unit 1 and 6 years in Unit 2. Growth in body weight of the 2011-2013 cohorts and the recruitment of the large 2013 cohorts in 2015 could thus account for much of the increase in Unit 1 survey biomass since 2013. It was also pointed out that survey selectivity is a function of availability of fish of different size rather than gear differences between Unit 1 and 2 surveys.

- Murdoch McAllister also presented a "stress test" Operating Model that assumed a dome-shaped selectivity curve. This model version shows improved fits to the fishery catch-at-length data, and changes in estimates of Umsy and the historical trajectory for spawning stock biomass for *S. mentella* but relatively small differences in parameter estimates and management quantities for *S. fasciatus* Akaike's Information Criterion (AIC) is lower for, and thus favoured, the dome-shaped model over the normal logistic selectivity operating model for *S. fasciatus*. The AIC results on asymptotic versus dome-shaped selectivity were vice versa for *S. mentella*. However, it was noted that due to skepticism about potential mechanisms for dome-shaped selectivity for redfish, the base case form of selectivity would be asymptotic for both species, even if AIC was lower for a fit with dome-shaped selectivity.
- A participant asked whether there was any reason to expect a dome-shaped selectivity curve such that 20 year old fish would not be caught. Possible reasons could be: the older fish occupy deeper waters or areas where trawl can't access as easily.
- Another noted that dome-shaped selectivity builds cryptic biomass that doesn't show up anywhere in the data and that this was unlikely to be the case.

Accounting for Historical Recruitment

- Murdoch McAllister described that past cohort strength was provided from the survey data on catch-at-length, and a literature review that suggested several large cohorts occurred early on in the history of the redfish fishery.
- A meta-analysis was completed for 20 populations of rockfishes to get a quantification of cohort strength. In 18 of those, there were recruitment multipliers of greater than 5 or 10. These data were used to calculate a mean recruitment multiplier ($e^{2.07}$) that will act as a prior for the redfish models in years that large cohorts were present. However, it was not possible to assign the very earliest cohorts (approximately 1946, 1956, 1970) to either *S. mentella* or *S. fasciatus*. It was noted that written descriptions of which cohort years were used were needed for peer review.
    - **ACTION**: Caroline Senay to look up stock assessments for redfish in Iceland (NAFO) to provide additional estimates of cohort strength and biomass from Virtual Population Analyses.
- For the earlier years in the model, every year's recruitment is estimated with a prior (either 1, or a multiplier).
- A participant noted that constraining the priors on early cohorts too low might have cascading effects on model mortality (M or F), or discards. Sensitivity analyses will be completed by the analytical team.
- It was recommended that the vertical axis for the plot of annual recruitment over years should have the units of recruitment labelled (e.g., billions of fish) to avoid confusion.
- The most recent years of good recruitment (2011-2013) for both species were much larger than prior years of strong cohorts for *S. mentella*, though for *S. fasciatus* of similar order of magnitude to the 1981 cohort. An anticipated consequence of the large 2011-2013 cohorts for both species is the emergence of very high redfish biomass by the mid-2020s. It had been mentioned in previous meetings that this could cause density dependence in both growth and natural mortality. However, it was also mentioned that survey length modes for both species indicate that density dependent growth is not apparent in the strong cohorts.

Future big recruitment events could become more common, but this might produce unrealistic biomasses in the Gulf. A participant expressed concern about fixed natural mortality given the enormous sizes of the recent strong year classes. A Lorenzen curve could be applied such that early years have higher natural mortality, although it could result in even higher estimates of age-1 recruitment to accommodate for the fact that the year classes had higher mortality and needed to be brought down to the levels seen in the survey to date.

- **ACTION**: Caroline Senay to examine recruitment of these cohorts to the survey gear.
- **ACTION**: Analytical team to try a model with a Lorenzen mortality curve with empirical justification and run sensitivity analyses on priors for strong cohort strength (either half, or double the values). This is expected to affect *S. mentella* more than *S. fasciatus*.

Data Inputs

- Murdoch McAllister noted that data regarding catch retained for 2015-2017 are still preliminary, and the model projections are sensitive to variations in these landings data. Updated landings numbers are expected from DFO in the next few weeks.
  - **ACTION**: DFO (Daniel Duplisea, Caroline Senay) to provide new data before end of December but this is not likely to be useful until new splits are computed (see below)
- Participants discussed the timing and location of surveys conducted in units 1 and 2. Four surveys are conducted in Unit 2, but the only one that has been sampling the entire area is the industry survey that occurs every two years. Both surveys are done in August-September. The 2014 data-point from Unit 2 cannot be rescued except by depth (DFO-NL may be able to help with this, or estimate from survey strata).
- A participant noted that fishery species splits may be different than the species splits derived from the surveys, which is of issue since the survey species splits are used to divide fishery landings by species along the entire time series. In Unit 2 in recent years, the fishery is dominantly on *S. fasciatus*. It was suggested that survey strata could be mapped onto where the fishery landings are actually coming from, to more precisely get species splits from the survey data that apply to the fishery landings. Coordinates for the Unit 2 survey strata should be available from a Res Doc from the last assessment (Kulka and Atkinson 2016).
  - **ACTION:** DFO (Daniel Duplisea, Caroline Senay) to look into providing new species split scenarios from Units 1 and 2, reweighted by landings and proportion by area covered from the survey strata; data to be given to analytical team within one month. Data from Unit 2 industry would be of assistance (may be available for 2017, January-March).

Accounting for Future Recruitment

- Murdoch McAllister noted that currently, future recruitment is simulated by bootstrapping in a cyclical fashion historical recruitment from 1970 onwards in 20-year sections. This allows for natural autocorrelation to persist in the recruitment deviates. One concern is that if the cycles end up such that several strong year classes end up very close to each other, the biomass of the simulated stock rapidly increases to unrealistic levels.
- One possible solution proposed was to extend the sampling back to 1950 but this is speculative period in the model with very little data and it was noted that this may solve the problem at the expense of introducing a poorly known part of the model estimation into projections.
- A participant observed that it will be important to justify how future projections are run, including plausibility.
- A participant noted that in the literature, there are typically 5-12 years between strong cohorts, and that the model could be constrained to do this. However, there is the risk of

making unrealistic predictions if the model is constrained incorrectly, and autocorrelation may be different among different stocks.
- Another participant noted that some of the Operating Model variants, that restrict good cohorts either over the next 20 or next 40 years, do take into account some of this variation.
- It may be possible to sample without replacement, or use a sampling distribution.
    - **ACTION**: Analytical team to try two types of bootstrapping for future recruitment: a fully empirical method, and a parametric bootstrap where the autocorrelation was characterized and random draws for 40 years.

Accounting for Density Dependence

- Murdoch McAllister described an Operating Model with high natural mortality (double the M) as one way to look at the effects of density dependent mortality, which may be present when multiple strong year classes are in the population together.
- Another way to explore density dependence impact on growth in the future may be to reduce Linf (asymptotic length in von Bertalanffy growth equation).

Sensitivity Analysis of Tuning Parameters

- Murdoch McAllister described how sensitivity in some of the tuning parameters (components of the catch limit equation in the Harvest Control Rule) has been explored. For example, the original HCR used an average survey biomass index over 3 trailing years. Results were presented showing the effects of using 1 to 11 trailing years. The use of 3 years seems to be supported by the preliminary results, although plans to change recruitment simulation methods may affect these analyses. Some results were also presented on changing the slope of the relationship of the survey biomass ratio to the catch limit recommended by the HCR.
- A participant noted that, with an increasing number of trailing years used in the average, the more a lag time would come into effect. Too many years in the average would mean that the stock index ratio used to calculate the catch limit may not ramp up or down quickly enough if the stock goes up or down.

Preliminary Simulations

- Some preliminary results of simulations of Operating Models against 10 priority Harvest Control Rules were presented (also to be discussed at the Working Group meeting December 13). An HCR with maximum TAC changes limited to 15% per year was not completed.
- The Small Fish Protocol is likely to be violated in 2018-2019 under some HCRs, and large fish > 27 cm do not form the majority of the catch until around 2022.
- There are indications that exploitation rate for *S. mentella* increases sharply in 2020 with increasing catch limits, before dropping again. This suggests that early ramp caps may be too high in some Harvest Control Rules.
- If natural mortality is assumed to be doubled, harvest rates over time become much larger for both species than in the base Operating Model.

Working Group Meeting Minutes – December 13

Opening Remarks:

Adam Burns, chair of the Redfish Working Group, opened the meeting with a round of introductions and a brief overview of the purpose of the meeting:

1. Present outputs based on the refined list of candidate Harvest Control Rules resulting from the management procedures relative to the management, fishery and conservation objectives defined at the last working group meeting in March 2017;
2. Obtain more input on the objectives, performance metrics and management procedures; and,
3. Finalize recommendations for the Management Strategy Evaluation to undergo a CSAS peer-review in March 2018.

The Chair noted that there is still work to be completed on the modelling (i.e. fitting the data, catch composition) which may result in refinements to outputs. As such another working group meeting is anticipated.

Review Objectives and Performance Metrics:

Sandra Courchesne noted that the candidate Objectives, Performance Metrics and Harvest Control Rules (HCR) were distributed to working group members for comment October 23, 2017. Taking into account feedback received, DFO and MSE experts developed a streamlined list of candidate Objectives, Performance Metrics and HCR (Appendix 1) which would form the basis of the modelling outputs discussed at this present (December 13) meeting. Feedback received and the streamlined list was distributed to working group members on November 30, 2017. The streamlined list (Appendix 1) was also presented in detail by Murdoch McAllister.

Base Operating Models (OMs; *S. mentella* and *S. fasciatus*):

Murdoch McAllister presented slides on modelling work completed since October, key base operating model (OM) fits for both the *S. mentella* and *S. fasciatus* redfish species and ongoing work needed on the base OMs.

- Industry asked for clarification on the number of base OMs.
  - Murdoch noted that there are 4 types of OMs of focus in the current presentation, including the base OM. Three alternative OMs are being tested relative to different recruitment scenarios, one for high mortality and one for an alternate type of fisheries selectivity (dome-shaped), although this one was not used in simulations. It is common to have over a dozen OMs.
- It was suggested that the OM be differentiated as either a base OM or a stress test for the next meeting.
- A question was asked about the exploitation rate (Umsy) associated with the 37Kt MSY harvest rate presented for the OM fit for S. fasciatus.
  - Murdoch clarified that harvesting at a constant rate or U of 16% would yield an average harvest of 37Kt over time.

Simulations of Candidate Management Procedures and Harvest Control Rules:

Murdoch McAllister reviewed how the Harvest Control Rule (HCR) was calculated and applied to both species, and then presented outputs for 10 of the 11 candidate HCRs from the streamlined list (time constraints prevented the generation of results for all 11 HCRs). It was noted that the results were presented for the base OM but four alternative OMs were shown.

- All HCRs looked at led to high harvest rates in the first few years of implementation, with worse results for those HCRs with a ramp starting in 2018. Simulations projected lots of small fish in the catch through to 2021, such that the Small Fish pProtocol was projected to be triggered 100% of the time in 2018 and 2019 and more than 20% of the catch was less than 25 cm from 2018 to 2020.
- Industry asked what the stock status would have looked like if HCR 1 (i.e. removal cap of 40Kt for Unit 1 and 2 combined) had been applied to Unit 1 in the 1990s.

    - Murdoch estimated that the catch would have been around 20-30Kt resulting in less depletion and possibly avoiding a moratorium in Unit 1.
- Industry asked if the model accounted for the potential of another strong year class in the future.
- Murdoch confirmed the OMs captured this scenario and several others.

Discussion on Base OM and simulation results:

- Several members asked about the specifications for HCR 18, which unlike the other HCRs simulated shutting the fishery down if the Small Fish Protocol (SFP) was violated. It was noted that the performance metric associated with Objective #4 (Maximize the number of years where fish < 22cm represent < 15% of the catch- and small fish protocol is not triggered), is applied to all OMs and as such the relevance of HCR 18 was questioned. The analytical team indicated that if the WG participants could not avoid small fish, the SFP should be included in the HCR.
- Murdoch clarified that the catch was split by species from the beginning of the time series, and the way the catch split was done (based on information from the surveys) may be done by a different method in the future.
- GEAC noted that the performance metrics for Objective #4 (mean number of years where fish <22cm represent <15% of catch) will give a sense of the risk that the SFP will be applied.
- Gulf industry suggested that the SFP be reviewed in a different light as the biomass should not be assumed to be consistently mixed of both small and adult sized fish. They believe there are periods where the small and large fish are separated and targeting specific areas can yield catches of predominately larger fish.
- A question was asked about the 1988 “disappearing” cohort and if this data was used. It was confirmed by DFO science that the 1988 cohort was removed from the data sets given there was no genetic connection found to the U1+2 stocks; instead it is linked to the Grank Bank stock. By removing the 1988 cohort data the model did fit better.
- All members appeared to assume a) that ramp and maximum caps = TAC, and b) that TAC = total landings. Murdoch clarified that the OMs uses the lesser value of either the cap or the catch limit from the HCR (the “lacrosse stick” rule) as the TAC in any given year. Furthermore, when a given HCR stipulates a ramp starting in the future (2020, etc.), the model assumes status quo landings are taken in 2018-2019 (not status quo TAC) until the ramp and HCR is first implemented.
- There was general frustration at the complexity and formatting of the simulation results slides. It was requested that figures and labels be more visible with clearer references to what HCR each slide is reflecting and wanted to see the simulation results in advance of the next working group meeting to allow time for stakeholder review.
- The Chair asked the group if achieving a fishery that yields a high proportion of larger (more valuable) fish (e.g. >27cm) was a primary objective. The Chair noted that if this was the primary objective, the more small fish are removed from the fishery now, the longer the wait to achieve a fishery predominately made up of >27 cm fish.
- While some members reserved comment as simulation results were still preliminary and the upcoming stock assessment would provide insight on the status of the Spawning Stock Biomass (SSB), there was general consensus that a fishery focused on larger (>27 cm) was the primary objective for the Unit 1 and 2 fishery.
- There was a brief discussion on current market demands for redfish and the need to develop new markets and new gear technologies during the transition years until the fish are predominantly >27cm. This lead to some discussion about why full quotas are not currently taken, why current TACs do not reflect biomass distribution and whether to lift the

moratorium in Unit 1 during the transition period. The Chair re-iterated that the working group was mandated to make recommendations on removals (using the MSE and HCRs) and not changes to the current management regimes.

- In light of the fact that all HCRs tested resulted in high harvest rates, and summarizing ongoing discussions, the Chair identified two new HCRs to be tested prior to the next working group meeting. HCR1 simulated status quo catch for two years (2018-2019) and should remain in play.
    - Simulate status quo catch (~3 kt) 2018-2021, then apply the "lacrosse" stick formula of the HCR to direct TAC thereafter (which is an HCR with no caps)
    - catch/TAC of 5, 5, 10, and 10 kt for the four years of 2018-2021, then apply the "lacrosse" stick

Discussion on Exceptional Circumstances Protocol:

Sandra Courchesne presented an overview of the components of an Exceptional Circumstances (EC) protocol for U1+2 Redfish, and provided the 4X5 Western Pollock Exceptional Circumstances protocol as an example to help begin the development of an EC protocol for Unit 1 and 2 Redfish. Sandra committed to distributing the overview and 4X5 Western Pollock example as well as a draft EC protocol for Unit 1 and 2 Redfish to working group members prior to the next meeting.

Next Steps:

- It was agreed that the next in person Working Group meeting will be planned for the week of March 26, 2018 in Montreal (e.g., March 27-28).
- Slides with the simulation results based on the 10 HCR presented at the December 13, 2017 meeting will be distributed to members for review.
- A list of refined HCRs and simulation results for the next working group meeting will be distributed 1 week prior to the next meeting to allow time for review.
- Exceptional Circumstances (EC) protocol documents (overview, a 4X5 Western Pollock example as well as a draft EC protocol for Unit 1 and 2 Redfish) will be distributed to members in advance of the next WG meeting.
- A pre-peer review science meeting in Mont-Joli, Quebec is being considered for the week of February 19, 2018. As per usual practise, working group members are welcome to participate in this discussion which will be at the technical level.

Technical Meeting Minutes – December 14

- This meeting focused on consolidating the different Operating Models and HCRs to be used in the Redfish MSE process, based on input received earlier in the week. Not every uncertainty needs to be represented with an Operating Model; for example, sensitivity analyses could be conducted by changing priors placed on strong year classes early in the time series (to double, or half their current values).
- A participant noted there is a lag in Unit 2 survey biomass indices from recent years, relative to Unit 1. This is expected to change moving forward into 2018 as fish age and move into Unit 2 (age of 50% selectivity is around 2 years for Unit 1, 6 for Unit 2). This difference reflects a spatial structure in the stock, not a gear change (the Unit 2 survey is conducted with DFO protocols and all survey data are converted into Teleost-Campelen units).
- Estimates of spawning stock biomass (SSB) are already increasing in the model with the new strong year classes, even though they are quite young. Estimates of age at 50% maturity in the *S. mentella* model are 9.6 years, with a standard deviation of 2 (which is broad).

- The base Operating Model uses two time periods of fisheries selectivity (1951-1993, and 1994-present). A three-time-period scenario will be explored but is expected to produce similar results and thus might not be made into one of the robustness testing scenarios.
- A participant requested that fisheries selectivity graphs use different coloured lines for blocks and units.
- Currently, models indicate a combined MSY (both species) of around 70,000 t. At a previous Working Group meeting, it was noted that historically, redfish decreased when landings were over 50,000 t. However, it was noted that if Umsy was applied, the total % of fish taken each year would change with the stock biomass (more when stock was greater, less when stock was less abundant).
- Catchability (q) estimates are quite high (>1) in Unit 2. This could be because of the presence of other redfish stocks in Unit 2, or as a result of herding/fishing in areas with high densities.
    - A participant suggested that if there are multiple stocks in Unit 2, it may appear as higher discards. Exploration of this may be desired by peer reviewers. However, this result may be affected by updated species splits that emphasize more *S. fasciatus* in locations fished in Unit 2.
- A participant noted that the proportion of fish retained over time varied quite a bit. This proportion is a function of the ratio killed:retained, and the value of q will affect this. If participants feel proportion retained should be higher in recent years, this could be explored by conducting sensitivity analyses for the offset.
    - **ACTION**: Analytical team to explore an offset scenario with 2 versus 3 periods.
- Retrospective analyses may be helpful in these models.
- It was recommended that the axis labelled “recruitment residuals” should be relabelled as “recruitment deviates”.

Reference Points

- The current reference point (Bref, Upper Stock Reference or USR; a proxy for Bmsy) will be the average SSB for *S. mentella* from 1984-1990, and *S. fasciatus* from 1984-1992. The Limit Reference Point (LRP) will be 20% Bref.

Harvest Control Rules/Management Procedures

- On the screen, Murdoch McAllister and meeting participants identified a number of new variants of Harvest Control Rules numbered 21-34 (which, when incorporating management constraints before implementation are Management Procedures). In many new Management Procedures, the starting point of a ramp in TAC was shifted back to 2020 or 2022, and otherwise assumes that catch rates until the starting year remain similar to the status quo (2015 landings).
- The shift to a 2022 start for ramps would create a 4-year window that would cover off a period that current simulations indicate is when *S. mentella* could experience a high exploitation rate if catch limits are increased too quickly, and also to maximize catch of >27 cm fish.
- A participant noted the importance of communicating the different HCRs to stakeholders.
- The list of Harvest Control Rules will be distributed separately to the Working Group for feedback.

Operating Models

- On the screen, Murdoch McAllister and meeting participants identified 20 Operating Models, both core models (credible) and “stress test” models (less credible) that account for various

types of uncertainty in the redfish fishery including recruitment, mortality, fisheries selectivity, species splits and density dependence.
- The list of Operating Models will also be distributed separately to the Working Group for feedback.

Scoring of Management Procedures

- If red and green scores are desired for each Management Procedure under each Objective, as described in the December 13 Working Group meeting, passing/failing probabilities need to be assigned for each Objective.
- Temporal plots may best show where the Small Fish Protocol is violated. Alternatively, performance metrics could focus on the first 5 years of simulations (all but the one which scores whether TAC > 40,000 t).

Redfish MSE Pre-Peer Review
Institut Maurice Lamontagne, Mont Joli, QC
February 21-22, 2018
Record of Discussion

Introduction

- Daniel Duplisea (the chair) welcomed participants. The purpose of this meeting was to seek technical feedback on the operating models, data and harvest control rules for the Redfish Management Strategy Evaluation (MSE) before the CSAS peer review in April, which will also be held at IML. This meeting was informal and although no simultaneous translation was available, bilingual staff were available and participants were encouraged to ask questions in either official language during the meeting.
- Participants asked about stocks and fishery objectives for the MSE, including whether it was possible to consider ecosystem objectives and why an objective was in place for catch of large redfish.
- It was clarified that in addition to the CSAS peer review in April, there is also a more formal meeting with Fisheries Management that will be held at the end of March, in Montreal, where the objectives of the MSE and decisions about choosing management procedures will be discussed.
- Murdoch McAllister reviewed the initiation of the MSE process, the past history of technical and working group meetings for the U1+2 Redfish MSE process to date, as well as a brief background of the U+2 Redfish fishery.

Operating Model (OM) Discussion

- Murdoch McAllister described the model. The base OM for the Redfish MSE is an age and size-structured model, using data inputs of fish biomass and length composition from both the research surveys in Units 1 and 2, as well as the fishery. The model is not spatially structured. The time series represents catch data for both *Sebastes* spp. and thus the fishery catch data are split by species according to the survey data. The method of splitting by species is still being refined. To address the issue of 'disappearing' cohorts of *Sebastes fasciatus* from the Grand Bank stock, length data from years with three known Grand Banks cohorts were removed.
- The models uses two time blocks for fisheries selectivity (vulnerability), three time periods for catch killed:retained ratios to accommodate historical periods of discarding, and an offset function for A50 of the catch killed and catch retained functions.
- The model was coded in both Excel and ADMB and as it was not possible to use Markov-chain Monte Carlo methods, parameter estimate uncertainty was instead characterized by a Hessian approximation method.
- It was noted that the model used literature-based growth parameters that may differ from other estimates. However, there is a lot of variation in the literature for growth rates in redfish, and sensitivity tests may be needed.
- The maturation functions were described for both species including the newly-proposed cut-offs for mature fish (age 4 for *S. fasciatus*, and 6 for *S. mentella*).
- A question was asked about the estimation of error variance. It may be important to report sensitivity tests for the fixed variances of the lognormal and fixed sample sizes in the multinomial likelihood functions.
- Participants asked for clarification about the use of the Beverton-Holt stock-recruitment relationship in the model for historical recruitment deviates.
- Regarding strong priors on recruitment events in the 1950s and 1960s, Murdoch McAllister clarified that these were based on existing reports in the literature of strong year classes.

- A participant noted that fishery catch predictions from the model were very similar in many years, resembling a Gaussian distribution. However, the model does show responses to large cohorts at several points in the time series, including in 2017.
- Participants then asked about the effective sample size of the multinomial likelihood function, whether the effective sample size was large enough and asked for clarification regarding the down-weighting of the fishery versus survey length composition data. In the model, the fishery length composition data are given a lower weight (Neffective of 10/y) than that of the surveys (25/y).
- Another participant noted that the model fits to past fishery data are important for peer review since the projections need to model what the fishery will catch.
- In reviewing the table of parameters for the different OMs, it was noted that the OMs with the Lorenzen M and dome-shaped fisheries selectivity had different estimates of B0, because of different life history characteristics for older fish.
- It was noted that the Maritimes region port sampling may give a better picture of the U2 stock.
- A participant noted that estimates of Umsy and M need to be biologically relevant, although Umsy may be case-study-dependent.
- A participant asked about the strong correlation in historical recruitment deviates between the two species, and whether this was affected by imperfect species splits. There is some information on past strong cohorts from genetic analyses, confirming the species, but this has not been a systematic study of all cohorts.

Harvest Control Rule (HCR) Discussion

- Murdoch McAllister reviewed the 18 management procedures and the HCR, and how its parameters were tuned. It is important to note that once set and implemented, the HCR will be in place to generate TAC recommendations and under the MSE, only exceptional circumstances would allow the HCR to be revisited.
- The current HCR has been tuned such that it will not generate exploitation rates (U) above Umsy more than 5% of the time.
- Some participants suggested the use of a minimum TAC in the design of the HCR, such that the HCR would never output a catch limit lower than X, could be helpful – or could be destructive for the stock. The minimum limit could be set to the historical lowest TAC (10 kt), or lowest landings (3 kt).

Results Discussion

- Murdoch McAllister reviewed a number of future trajectories and results of different management procedures using several operating models.
- A participant asked why vulnerable biomass decreased over time if exploitation rates were approximately 1%. The decline is due to natural mortality.
- Participants asked about Umsy and reference points. The proposed USR is based on a Bmsy proxy. Murdoch McAllister clarified that Umsy is better defined than Bmsy, which needs accurate historical catches. Umsy stays more stable than Bmsy given uncertainty around catches and life history parameters affecting population dynamics.
- Participants asked about higher exploitation rates (e.g., 5%). It was noted that earlier in the MSE process discussions on markets occurred, and industry does not want to harvest very large quantities (250 kt) of redfish.
- In a summary of results, Murdoch McAllister noted that capped and uncapped procedures differed in average catch and average annual variation in catch. The trade-offs between catch retained, and catch variability and stock objectives was larger for uncapped than capped management procedures. Performance metrics are sensitive to the start year of

ramps, and the size of the ramps, and the different types of OMs. Lots of small fish are predicted in the catch through 2021.

Peer Review and Working Group Meeting Discussion

- Participants suggested that the CSAS meeting will have a Research Document and Science Advisory Report. A Working Paper should be distributed one week before the meeting.
- Communication of MSE results with DFO Management was emphasized as a priority.

Main Comments and Recommendations

MODEL AND DATA INPUTS

1. There was a recommendation to compare the model predictions of fishery length composition by species with the combined-species fishery catch length composition records. This would be a diagnostic to evaluate the extent to which there was species-specific information in the fishery length composition data. This will be targeted for the CSAS meeting at the end of April.

2. It was noted that the 2017 fishery length composition data are still very preliminary. The model will be fitted to fishery length composition data from both units up to 2016, sorted by species. The model will also be fitted to survey length composition from unit 1 up to 2017 and unit 2 up to 2016. The fishery composition data from both units for the two species separated are to be provided by DFO to UBC by Friday.

3. The second time block of fishery selectivity (or, vulnerability) was considered by some participants to be less credible than the first time block for *S. mentella*, because the second time block vulnerability function was knife-edged. This second function is also the fishery vulnerability curve that gets projected forward. While it may be possible to use the fisheries vulnerability curve of the first time block for *S. mentella* instead of the second in forward projections, the question remained for how long would that assumption be valid. It was decided to create a stress-test OM where the first fishery vulnerability curve was projected forward for only 5 of the 40 simulated years (2017-2022).

4. The selectivity/vulnerability curves also differ between Unit 1 and 2 surveys for both species. A participant noted that the proportion of small fish in Unit 1 versus Unit 2 surveys will change dramatically in the next few years. This may affect the survey selectivity (vulnerability) curves in the future. It was suggested to combine the survey indices and calculate a combined vulnerability function.

5. Participants felt that the proportion of catch retained (p-retained) for S. *fasciatus* was too low. There are two possible ways to address this: put a prior on the steepness of the fishery selectivity curve for the second time block of *fasciatus*, to make it steeper, more like *S. mentella*. Another way would be to use the p-retained data from *S. mentella* in recent years where it was felt the data were more accurate, and use those as pseudo-datapoints (mean of 0.95 or 0.90, SD of 0.05, 1995 to present) to force a better p-retained for *S. fasciatus*. A higher steepness would also cause p-retained to increase. The technical team will explore different vulnerabilities and offsets, or catch killed:retained ratios for the latter period in the time series, to make the p-retained outputs conform to higher values after 1994 while not affecting model fit.

6. The high q (constant of proportionality) for the U2 survey was noted for both species (as q > 1). It is not clear what the cause of this is, in relation to the U1 survey (unaccounted for migration, mortality or unreported catch). One solution would be to put a strong prior for q of 0.5 on the catch:kill ratio and allow the model to estimate those ratios from 1984-1995 instead of fixing them at 2. However, it was also noted that q is a diagnostic and has previously been found to be high in earlier attempts to model U1+2 redfish.
7. There was a recommendation to stack the two (Unit 1 and 2) surveys together in years where they are both available. Both surveys are in Teleost Campellen units. However, it was not considered desirable by the technical team to alter how the U1 survey index is used in the model, because this is the longer time series, encompassed part of the past stock decline in the 1990s, and also is the only one at this time to contain the 2011-2013 strong year class signal.
8. Two different weightings (Neffective for the multinomial likelihood function) were suggested for the fishery length composition (change from 10/y to either 25 or 5/y, while keeping Unit 1 survey length composition at 25/y).
9. In response to questions about the level of natural mortality used in the models and whether it is high, DFO Science will do a small literature review of natural mortality in different redfish stocks.

RESULTS

The technical team noted there was a need to reduce the list of OMs that are carried forward in simulation, as many yielded similar results. Stress-test OMs that may not be carried forward include: 5 (reduced future recruitment), 12 (alternative fishery selectivity – 3 time blocks), 13 (alternative offset) and 19 (alternative prior mean for strong cohorts).

The HCR will be tuned to ensure that it does not exceed Umsy > 5% of time, does not predict past catch limits of 0 kt, and predicts past catch limits of less than what was actually retained for 2013 onward. The use of minimum catch limits will be discussed with RM. Two additional management procedures were added to the list of 18, including a minimum catch limit (as variations of HCR1 and HCR22).

Participants asked if catches were limited by the abundance of *S. fasciatus*, since the new cohorts are largely *S. mentella*. A participant recommended a performance metric that looked at catch taken from all one species as a risk factor.

NEXT MEETINGS IN MSE PROCESS

It was recommended to update explanations and illustrations of the harvest control rule with the newly-tuned parameters and realistic simulated data, in order to show how the rule would have retroactively applied to historical landings. It would be particularly helpful to show how the rule would have applied in years when the stock biomass index is very low.

It was recommended to make the colours of individual projections clearer in graphs showing projections over time.

It was pointed out that DFO Science needs to double-check that 40 year simulations (i.e., 2 generations) are wanted by Fisheries Management, as 60-year simulations may be needed for redfish under COSEWIC.

DFO Science will work with Resource Management to develop the Request for Advice and Terms of Reference for the upcoming CSAS peer-review meeting, as well as draft a Science Advisory Report.

Redfish Working Group
March 26-28, 2018
In person meeting – Montreal, QC
Record of Discussion

Opening Remarks Technical session:

Sandra Courchesne opened the meeting with a round of introductions and a brief overview of the structure of meeting sessions for the three days (March 26 to 28).

- March 26 and the morning of the 27th is the technical workshop part of the meeting where Murdoch McAllister will provide the MSE results in more detail
- The official working group meeting would be on March 28th where discussion on results and trade off will occur. It was also noted that this would be the last meeting of the working group and as in previous working group meetings; DFO has offered a pre-meeting with Indigenous representatives that will take place on March 27th starting at 13:00.

DFO science staff indicated that work on the modelling will continue leading up to the April CSAS peer review planned for April 25 and 26, 2018 and as such, some refinements to outputs presented at the working group meeting could occur.

MSE Technical presentation:

Murdoch McAllister presented detailed information to the working group on updates to operating models, updates to candidate management procedures (MPs), the behaviour of candidate MPs under some Core operating models and stress test operating models.

- Industry asked for clarification on where model parameters for growth, natural mortality (M) and maturation functions came from. Murdoch indicated these came from literature sources.
- Participants asked about operating models that explored different values for M, especially high future. Murdoch noted that there were two stress tests for M (historic and future M lowered, or increased), and a core model that used a Lorenzen M function.
- Stakeholders asked how the surveys in Unit 1 and 2 were differentially weighted in the models. Murdoch clarified that there was less confidence in the Unit 2 survey as it had a shorter time series, was only conducted every other year, did not yet have the new cohorts in it as strongly as the Unit 1 survey, and problems with data fits indicated that it may have stock contamination issues.
- A question was asked about the use of Umsy (exploitation rate at MSY), how it was derived, and the confidence in it. Murdoch explained that the Umsy is calculated from a population dynamics model making assumptions about maximum sustainable yield and using M, growth, and recruitment information. A low Umsy means that the steepness of the stock-recruitment relationship is low. DFO also noted that removal rates related to maximum sustainable yield are considered limits under the precautionary approach.
- M. McAllister explained what was meant by values of q for the Unit 1 and 2 surveys (the constant of proportionality, the scalar parameter relating the survey data to the stock abundance)
- Concerns were raised about the possibility that the new cohorts would show density dependence. DFO clarified that length and weight information is being tracked, as is stomach contents, and there is no sign yet of decreased growth. However if that were to be observed, that should be in the Exceptional Circumstances Protocol. Newer data showing that there is now cannibalism being observed in redfish has not been added to the model. Cannibalism would be something to keep in mind for future models.

- M. McAllister explained a range contraction hypothesis for redfish and noted that this would be a very important question for future research, as it may relate to patterns in the surveys (and high values of q, especially in Unit 2 versus Unit 1).
- Stakeholders noted that the HCR was now based on a survey index ratio (Jy) that only focused on large fish and asked how this might affect the function of the HCR. Murdoch noted that using only large/old fish was a way to stabilize the HCR and prevent exploitation rates from being driven too high too quickly by the abundance of small fish every time a new large cohort comes in to the stock. Furthermore, this was a relative index (large fish both in the current survey index, and in the historical survey index used as a reference period), and does not prevent increases in catch limits with new cohorts, or prohibit fishing of small fish.
- Several participants were interested in the size composition of the catch. However, the presented results were only for the performance metrics that had previously been defined (i.e., fish < 22 cm < 15% of catch). It was noted that the proportion of fish < 27 cm declined over time. M. McAllister clarified that this was because natural mortality causes a decay in the proportion of these fish over time. DFO also noted that M in recent years was not known precisely. Values around 0.1 were used in the models.
- Participants noted that there weren't a lot of differences in results across the different types of MPs. Murdoch explained that this is because the new incoming cohorts were large and their presence is enough to eliminate any differences in performance as a result of different ramps, etc.
- Stakeholders asked about catch splits, and future active monitoring to improve catch splits. M. McAllister noted that the current HCR would need to be modified if catch split information changed in the future.
- Several stakeholders noted that the redfish biomass is higher than ever seen before, and drew comparisons with other fisheries such as Iceland where percentages higher than Umsy may be harvested (e.g., 10%, not 1%). DFO noted that fishing above Msy was not permitted under DFOs PA Policy Framework.
- The concept of an ecosystem-based approach (EBFM) for all stocks in the Gulf of St. Lawrence was raised by some members given the potential impact the large redfish cohorts would likely have on other stocks in the Gulf such as Northern Shrimp. Some industry members felt that research on the impacts of this biomass on other species would be very important for the future. In the meantime, without an established EBFM approach, it was recommended that higher exploitation rates be considered. However, others felt that high exploitation rates would be risky considering that M is uncertain in the future. DFO noted that while this type of modelling would be ideal for fisheries management purposes, the modelling technologies and resource capacity were not developed enough at this time to consider such an approach.

Opening Remarks Working group session:

Sandra Courchesne briefly reviewed the objectives for the working group meeting (March 28th):

1. Present outputs based on the refined list of Operating Models, candidate Harvest Control Rules (management procedures) relative to the fishery and conservation objectives defined through previous working group meetings;
2. Finalize recommendations for the Management Strategy Evaluation framework to undergo a CSAS peer-review in April 2018.

The Chair also re-iterated the mandate of the working group to provide recommendations on a PA compliant rebuilding plan and associated HCR for Redfish in Unit 1 and 2. As such there is an expectation that the working group will provide a list of the top two –three MPs that best meet the MSE objectives agreed to by the working group. The recommendations of the working group

would then be presented to the Redfish Advisory Committee in May 2018 for further consideration.

MSE summary of results:

Julie Marentette presented a brief background of the MSE process to date, illustrations of how the Harvest Control Rule works, MSE Results and the performance by each Objective and main trade-offs.

The new Reference Points (RP) for each species of redfish as per the Base OM identified through the MSE process, Umsy (exploitation rate at maximum sustainable yield) calculated for each species were also presented.

RP	Description	*Sebastes mentella*	*Sebastes fasciatus*
LRP	Limit Reference Point: 40% of model computed spawning stock biomass (SSB) from 1984-1990 (*S. mentella*) or 1984-1992 (*S. fasciatus*)	148 kt B_{2017}/LRP = 2.70	132 kt B_{2017}/LRP = 1.30
USR	Upper Stock Reference: 80% of model computed spawning stock biomass (SSB) from 1984-1990 (*S. mentella*) or 1984-19*fasciatus*)	297 kt B_{2017}/USR = 1.35	263 kt B_{2017}/USR = 0.65
Umsy	Exploitation rate at Maximum Sustainable Yield	0.041	0.094

- A table illustrating the PA zones in past based on these new LRPs was requested by members.

A summary of results indicated that performance did not vary widely across different MPs. The presence or absence of caps, additional features such as a SFP or maximum 15% change in catch limits often mattered more for MP performance than the year the ramp starts (2018, 2020, 2022). Capped MP trade-offs were affected by the size of the maximum cap (40 to 120 kt). Uncapped MP performance was related to whether the Harvest Control Rule was used at 100% or 80% strength. MP performance could be sensitive to other Operating Model specifications (e.g. Increased future M, or alternative past and future M; Different ways to simulate future recruitment; decreased future recruitment; different ways to split the catch and alternative catch:kill ratios and steepness). Some objectives and/or performance metrics were recommended for removal (as noted in the DFO deck) since they did not provide any useful differences in MP performance.

Discussion on summary of results:

- Several members noted a preference for a precautionary management strategy for Redfish and supported a delay in applying TAC increases starting in 2020 in light if the high abundance of small fish expected in the biomass from 2018 to 2020 and markets for their fleets would be focused on larger fish. There was also support for the need to include a maximum cap to avoid repeating management mistakes from the past (i.e. 1980s) which resulted in significant declines in stocks.
- There were several opposing views that supported a phased in TAC increase approach starting in 2018 to allow time for harvesters to test selectivity of various gears and

techniques and identify potential by-catch profiles as well as develop markets. It was noted that it would be difficult to have a viable Redfish fishery without having a transition period to prepare for a fully commercial fishery with a significant TAC level. Several members expressed interest in the removal of the Unit 1 moratorium.

- A member noted that gradual ramp up of TAC increases in the next four-year period (amounts to be determined) could be considered a common view for the working group.
- Members noted that projections for the next 10 years should be the focus of the model outputs given uncertainty increases the farther out they go. Information on exploitation rates for the next 10 years was requested from the technical team.
- Question on projected size composition in the catch over 2018 to 2020. The technical team was asked to provide projected average length composition of the commercial fishery for each of 2018, 2019, 2020 and 2021. In addition, a summary of the biomass per species-unit-year, with different length thresholds was requested.
- Concerns were noted regarding uncertainties in natural mortality and it was suggested that a double M scenario, one of the stress test OMs, should be a core OM. The technical team was asked to provide performance results & trade offs for candidate MPs using the OM2xM.
- It was noted that the model provides a combined species TAC (for *S. fasciatus* and *S. mentella*) and therefore the catch limits produced by the HCR are constrained by the less abundant *S. fasciatus* biomass. It was suggested that separating *S. mentella* from *S. fasciatus* in the model could produce a TAC for each species and as a result a higher TAC for *S. mentella* as the more abundant species. The technical team was asked to run simulations for species separated catch to understand what the HCR estimate would be for each species if species could be reliably differentiated and reported in the catch, including possible targeting of *S. mentella*. However DFO noted that both species are important from a conservation perspective. The technical team noted that data on actual species split would need to be obtained and tested in the model to de-couple *S. mentella* and *S. fasciatus* with some degree of certainty, and to be able to use such a model in choosing a management procedure in the future.
- The working group tabled the following for further consideration: capped MPs #1, 14 and a modified uncapped MP which would be a combination of MP 12 and 25, with specified catch limits for 4 years (2018 to 2021), followed by the application of MP 12 in 2022 and thereafter (i.e., HCR at 80%).

The MPs in question are noted below for reference. The modified MP 12/25 will be redefined and distributed to working group members subsequent to the meeting along with associated outputs.

Capped MP

No.	Ramp Start	Ramp End	Ramp Start Cap	Max Cap	Notes on HCR
1*	2020	2027	14.5 kt	40 kt	Before ramp start year, assume ~3 kt per year.
14	2020	2027	14.5 kt	40 kt	Like 1, but with an annual change of 15% maximum after 2028 (i.e., after the ramping period is complete).

Uncapped MP

No.	HCR Start	Notes on HCR
12	2020	Before start year, assume ~3 kt per year. Catch limit from the HCR formula is multiplied by 80% (a decrease of 20% and a more conservative procedure)
25	2018	Set catch limits at 5 kt in 2018, 5 kt in 2019, 10 kt in 2020,10 kt in 2021, then use the HCR formula afterwards.

Exceptional Circumstances Protocol:

- It was agreed that the review of the draft exceptional circumstances protocol would be done via email subsequent to the Working Group meeting. Feedback will be requested before April 13, 2018 to ensure a finalized protocol is available for the CSAS peer review process April 25 and 26, 2018.

Next Steps:

- The updated decks presented at the meeting will be circulated to participants subsequent to the meeting.
- Objectives and performance metrics will be refined as per DFO recommendations given no opposing views were presented by working group members.
- Outputs of the proposed MPs (#1, 14 and the modified MP (combination of MP 12 and 25) as well as specific stakeholder requests will be distributed to the working group once available.
- The MPs tabled by the working group will be presented to the Redfish Advisory Committee in May 2018 to inform final advice for the Minister.

Appendix 1

Updated and revised candidate Objectives, Performance Metrics and Harvest Control Rules for the Unit 1 and 2 Redfish MSE process.

Please note there will be further opportunities to provide input on these items at the Redfish Working Group meeting on December 13, 2017.

Table 1. Candidate MSE Objectives to be used for December 13, 2017 meeting, matched to the corresponding Performance Metrics.

Candidate Stock Objectives	
1	Increase SSB of each of *S. mentella* and *S. fasciatus* above the lower reference point (LRP) and into the Healthy Zone in 10 years (90-95% probability).
Corresponding Performance Metrics	1a: Proportion of simulations where SSB of each species exceeds LRP in 10 years (90-95% probability). 1b: Proportion of simulations where SSB of each species exceeds USR in 10 years (90-95% probability).
2	Once in Healthy Zone, maintain SSB of each of *S. mentella* and *S. fasciatus* above the Critical Zone (90-95% probability), and in the Healthy Zone (50% probability).
Corresponding Performance Metrics	2a: Proportion of years the SSB of each species is above the LRP after 10 years. 2b: Proportion of years the SSB of each species is above the USR after 10 years.
3	Maintain exploitation rate U of *S. mentella* and *S. fasciatus* below Umsy, 50% probability.
Corresponding Performance Metrics	3: Proportion of years where the ratio of U:Umsy by species < 1.

Candidate Fishery Objectives	
4	Maximize the number of years where fish < 22 cm represent < 15% of catch (and Small Fish Protocol is not triggered).
Corresponding Performance Metrics	4: Mean number of years where fish < 22 cm represent < 15% of catch.

Candidate Fishery Objectives	
5	Maximize the number of years where fish < 25 cm represent < 15% of catch.
Corresponding Performance Metrics	5: Mean number of years where fish < 25 cm represent < 15% of catch.
6	Maximize the duration of high annual catch.
Corresponding Performance Metrics	6a: Average annual catch in a) 10-20, b) 10-40 years. 6b: Proportion of simulations where catch limit reaches or exceeds 40,000 tons by 2028 (i.e., after the large cohorts are expected to fully recruit to the fishery). 6c: Mean number of years where the catch limit is as large or larger than 40,000 tons in the years 2028-2057. 6d: Proportion of years with > 2017 landings [2017 will be a reference year; note 2016 catch killed = approx. 4040 t assuming 1:1 catch kill:retained ratio]
7	Maximize catch of large fish (>27 or >30 cm).
Corresponding Performance Metrics	7a: Proportion of years where percentage of fish > 27 cm is > 80%. 7b: Proportion of years where percentage of fish > 30 cm is > 80%.
8	Maintain the stability of the fishery (annual changes in TAC are consistent with industrial capacity).
Corresponding Performance Metrics	8a: Percentage of years where recommended TAC is < 20% different from previous TAC. 8b: Average Annual Variation in TAC (percentage) during a) 10-20 years, b) 10-40 years.

Table 2. Harvest Control Rules (HCRs) to be used for December 13 Working Group meeting. Emphasis will be placed on presenting the results of HCRs shown in green although results from all HCRs will be available for discussion. [1]Please note that capped HCRs use a recommended catch limit that is calculated based on ratio of 3 year trailing average survey biomass index to a reference index (1984-2016).

Candidate HCR	
HCR-1	Cap. Ramp starts in 2020 at 14.5 kt to 2027 at 40 kt.[1]
HCR-2	Cap. Ramp starts in 2018 at 17 kt to 2024 at 40 kt. [1]
HCR-3	Cap. Ramp starts in 2020 at 17 kt to 2026 at 40 kt. [1]
HCR-4	Cap. Ramp starts in 2018 at 14.5 kt to 2025 at 40 kt. [1]
HCR-5	Cap. Ramp starts in 2020 at 14.5 kt to 2032 at 60 kt. [1]
HCR-6	Cap. Ramp starts in 2018 at 17 kt to 2029 at 60 kt. [1]
HCR-7	Cap. Ramp starts in 2020 at 14.5 kt to 2042 at 100 kt. [1]
HCR-8	Cap. Ramp starts in 2020 at 14.5 kt to 2047 at 120 kt. [1]
HCR-9	Cap. Ramp starts in 2020 at 14.5 kt to 2057 at 160 kt. [1]
HCR-10	TAC = uncapped, 1.2* HCR-1 (Umsy not used to calculate HCR)
HCR-11	Cap. Ramp starts in 2020 at 15 kt to 2025 at 35 kt. [1]
HCR-12	TAC = uncapped, 0.8* HCR-1 (Umsy not used in this HCR)
HCR-13	TAC = uncapped, constant harvest rate, HCR-1 uncapped (Umsy not used to calculate HCR)
HCR-14	[HCR-1 with] an annual change of 15% maximum after 2028 (i.e., after the ramping period is complete).
HCR-15	[HCR-1 with] a cap of 4% on combined absolute survey biomass (3-yr average) in Unit 1 up to 2027 and a similar cap of 8% on total combined survey biomass (3-yr average) after 2027 (i.e., after the strong 2011 cohorts have fully recruited to the fishery).
HCR-16	Cap. Ramp starts in 2018 at 14.5 kt, to 80 kt in approximately 2035.
HCR-17	Cap. Ramp starts in 2020 at 14.5 kt, to 80 kt in approximately 2037.
HCR-18	HCR-6] paired with Small Fish Protocol at 22 cm and a maximum increase or decrease in catch limit of 5,000 t.
HCR-19	2-3 year ramp-up period. Cap. Ramp starts in 2018 at 20 kt, reach 60 kt in 2020

Candidate HCR	
HCR-20	2-3 year ramp-up period. No cap. Ramp starts in 2018, reach 1.2* HCR-1 in 3 years.

APPENDIX 2- LIST OF PARTICIPANTS

Name	Affiliation	Apr 25, 18	Apr 26, 18	May 4, 18
Archibald, Devan	Oceana Canada	x	x	-
Belley, Renald	DFO - Science - Quebec	x	x	-
Benoît, Hugues	DFO - Science - Quebec	x	x	x
Bernier, Denis	DFO - Science - Quebec	x	-	-
Boudreau, Paul	Madelipêche	x	-	-
Bourdages, Hugo	DFO - Science - Quebec	x	x	x
Bourdages, Yan	Association des Capitaines propriétaires de la Gaspésie (ACPG)	x	x	-
Brassard, Claude	DFO - Science - Quebec	x	x	-
Brulotte, Sylvie	DFO - Science - Quebec	x	x	-
Bruneau, Benoît	DFO - Science - Quebec	x	-	-
Cantin, Guy	DFO - Science - Quebec	x	-	-
Cantin, Pierre	Association des pecheurs de crevettes de Matane (APCM)	x	x	-
Carruthers, Erin	Fish, Food and Allied Workers Union (FFAW)	x	x	-
Castonguay, Martin	DFO - Science - Quebec	x	x	-
Cerqueira, Andy	MAPAQ	x	x	x
Couillard, Jean-Pierre	ACPG	x	x	-
Cyr, Charley	DFO - Science - Quebec	x	x	x
Desgagnés, Mathieu	DFO - Science - Quebec	x	x	x
Duplisea, Daniel	DFO - Science - Quebec	x	x	x
Dupuis, Vincent	ACPG	x	x	-
Ferguson, Annie	Government of New Brunswick	x	x	x
Ford, Jennifer	DFO – Fisheries Management - Maritimes	x	x	x
Grelon, Damien	Merinov	x	-	-
Hurtubise, Sylvain	DFO - Science - Quebec	x	-	-
Juillet, Cédric	DFO - Science - Quebec	x	x	-
Karbowski, Chelsey	Ecology Action Centre	x	x	-
Labbé-Giguère, Stéphanie	DFO - Science - Quebec	x	x	x
Lavoie, Cécile	DFO – Fisheries Management - Gulf	x	x	-
Licandeo, Roberto	University of British Columbia	x	x	-
Marentette, Julie	DFO - Science - Ottawa	x	x	x
McAllister, Murdoch	University of British Columbia	x	x	-
Millar, Colin	International Counsil for the Exploration of the Sea (ICES)	x	x	-
Morin, Bernard	DFO – Fisheries Managament - Quebec	x	x	x
Nadeau, Paul	Association des pêcheurs de la Basse-Côte-Nord (APBCN)	x	x	-
Parent, Éric	DFO - Science - Quebec	x	x	-
Poirier, Mélanie	DFO - Science - Quebec	x	-	-
Pomerleau, Corinne	DFO - Science - Quebec	x	x	-
Roussel, Eda	Fédération régionale acadienne des pêcheurs professionnels (FRAPP)	x	x	x

Name	Affiliation	Apr 25, 18	Apr 26, 18	May 4, 18
Roy, Virginie	DFO - Science - Quebec	x	-	-
Senay, Caroline	DFO - Science - Quebec	x	x	x
Van Beveren, Elisabeth	DFO - Science - Quebec	x	x	-
Vascotto, Kris	Groundfish Entreprise Allocation Council (GEAC)	x	x	x
Velasquez, Sandra	DFO - Science - Quebec	x	-	-

APPENDIX 3- TERMS OF REFERENCE

Unit 1+2 Redfish Management Strategy Evaluation

Regional Peer Review – Quebec Region

25-26 April 2018
Mont-Joli, QC

Chairperson: Hugues Benoit

Context

The Unit 1+2 redfish fishery targets two species, the Acadian Redfish (*Sebastes fasciatus*) and Deepwater Redfish (*Sebastes mentella*), both slow-growing and long-lived livebearing groundfish that are very similar in appearance. Landings data represent aggregate catch and survey sampling (using primarily fin ray counts, or genetic analyses) are currently used to differentiate the catch by species. Recruitment is spasmodic, with long periods of low recruitment interspersed with periods of strong year classes that may support the fishery for many years.

The redfish fishery began in the 1950s and experienced three periods of high exploitation (1954-1956, 1965-1976, and 1987-1992), using both bottom and midwater trawls. In 1993-1994, landings declined considerably. In 1993 the fishery was also divided into management Units 1, 2 and 3 with Units 1 and 2 considered to comprise the same stock and with initial TACs of 60,000 t and 28,000 t respectively. Unit 1 was placed under moratorium in 1995, with an index fishery permitted since 1998 (currently 2,000 t). Unit 2 continued to support a commercial fishery, with a TAC of 8,500 t since 2010. An assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010) identified *S. mentella* in Units 1+2 as endangered, and *S. fasciatus* as threatened. More recently, survey data indicate the presence of three strong year classes (2011-2013, largely *S. mentella*) that are expected to recruit to the fishery in 2018-2020 (DFO 2016).

Following the COSEWIC Assessment, limit reference points (LRP) were established for various Canadian managed redfish stocks in 2011, placing Unit 1+2 redfish stocks in the critical zone of the precautionary approach framework (DFO 2012). These reference points were derived from a state-space Bayesian implementation of the Schaefer surplus production model (McAllister and Duplisea 2011, 2012) which did not take into account available length composition data. It was therefore agreed that other approaches would be considered in the future to develop a more accurate population dynamics model (DFO 2012). However, the failure to adopt an assessment model for redfish in 2015 (DFO 2017) and recent doubts cast on the veracity of historical catch statistics (Duplisea 2016) provided the impetus for embarking on a Management Strategy Evaluation approach in 2016-2018. The best model approach (DFO 2017) does not seem to be a reconcilable way forward under the current circumstances and given uncertainty in redfish biology, data problems including important errors in catch reporting, highly variable recruitment dynamics of redfish as well as varied and possibly conflicting objectives in the stakeholder group.

In this meeting, operating models will be presented for the two redfish stocks in this area and management procedures including harvest control rules will be tested via simulation of operating models against stakeholder objectives determined from previous meetings. A ranked set of acceptable management procedures for the fishery should result from the present process.

Objectives

The overall objective of this peer review meeting is to review the operating models, harvest control rules and simulated management procedures for the Unit 1+2 Redfish Management Strategy Evaluation, on which Total Allowable Catch (TAC) recommendations will be based. Specifically, the meeting will:

- Review the simulation runs of the Management Procedures on a set of core and stress-test Operating Models (OMs) for each species of Redfish for a time period of 40 years (2 generations)
- Develop Limit Reference Points and recommended Upper Stock Reference Points for each Redfish species
- Evaluate Management Procedures against the objectives, performance metrics and acceptable thresholds established via the Redfish Working Group in 2017-2018, including identifying which Management Procedures are acceptable, and their recommended rank for further consideration.
- Evaluate the formulation and parameters of the Harvest Control Rule that will apply to each species of Redfish in the Unit 1+2 Redfish stock
- Provide advice on which Management Procedures pass objectives and under which OM assumptions, assuming a global catch limit for Units 1 and 2
- Provide advice on on-going information-support requirements and implementation processes with respect to the adoption of Management Procedures and MSE. This includes setting appropriate periods for MSE review and assessment schedules, as well as the development of exceptional circumstances protocols (monitoring of indicators and other events that would trigger an earlier than scheduled assessment)
- Identify where to focus future research efforts to provide the greatest improvements to management advice.

Draft working documents will be provided for distribution prior to the meeting.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science, Ecosystems and Fisheries Management sectors)
- Provincial representatives
- Invited external (to DFO) science reviewers
- Academics
- Aboriginal communities/organizations
- Fishing industry representatives
- Other invited experts (environmental non-government organizations)

References

COSEWIC. 2010. COSEWIC assessment and status report on the Deepwater Redfish/Acadian Redfish complex *Sebastes mentella* and *Sebastes fasciatus*, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 81 pp.

DFO. 2012. Reference points for redfish (*Sebastes mentella* and *Sebastes fasciatus*) in the northwest Atlantic. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/004. (Erratum: June 2013).

DFO. 2016. Assessment of Redfish Stocks (*Sebastes fasciatus* and *S. mentella*) in Units 1 and 2 in 2015. DFO Can. Sci. Adis. Sec. Sci. Advis. Rep. 2016/047.

DFO. 2017. Proceedings of the Zonal Peer Review of the Assessment Framework for Units 1+2 Deepwater (*Sebastes mentella*) and Acadian Redfish (*Sebastes fasciatus*) and for Unit 3 Acadian Redfish; December 8 to 11, 2015. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2016/038.

Duplisea, D.E. 2016. Context and interpretation of reported redfish catch in Unit 1+2 in the 1980s and 1990s based on interviews with industry participants. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/103. v + 11 p.

McAllister, M. and Duplisea, D.E. 2011. Production model fitting and projection for Atlantic redfish (*Sebastes fasciatus* and *Sebastes mentella*) to assess recovery potential and allowable harm. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/057 vi + 75 p.

McAllister, M. and Duplisea, D.E. 2012. Production model fitting and projection for Acadian redfish (*Sebastes fasciatus*) in Units 1 and 2. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/103 iii + 34 p.

APPENDIX 4- AGENDA

Wednesday, April 25		
9:00 – 9:15	Introduction	Chair
9:15 – 9:45	Overview of MSE	M. McAllister
9:45—10:15	Fishery Overview and Sources of Data	C. Senay, D. Duplisea
10:15—10:30	*Refreshment Break*	
10:30-12:00	Operating Models	M. McAllister
12:00 – 13:00	*Lunch Break (lunch not provided)*	
13:00—14:30	Operating Models Cont'd	M. McAllister
14:30-14:45	*Refreshment break*	
14:45 – 17:00	Operating Models Cont'd	M. McAllister

Thursday, April 26		
9:00 – 9:30	Introduction Summary of Day 1. Unfinished discussions / Additional items	Chair
9:30 – 10:15	Harvest Control Rule and Management Procedures	M. McAllister
10:15—10:30	*Refreshment Break*	
10:30-12:00	Harvest Control Rule and Management Procedures continued	M. McAllister
12:00 – 13:00	*Lunch Break (lunch not provided)*	
13:00—14:30	Harvest Control Rule and Management Procedures continued Information Support /Research Requirements and MSE Implementation	M. McAllister
14:15—14:30	Exceptional Circumstances	J. Marentette
14:30-14:45	*Refreshment break*	
14:45 – 17:00	Science Advisory Report	Chair