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Proceedings of the Regional Peer Review of the Southwest Nova Scotia/Bay of Fundy Herring Framework: Part 2 – Management Strategy Evaluation Conditioning Operating Model Review

Meeting dates: January 21–22, 2020
Location: Dartmouth, Nova Scotia

Chairpersons: Darek Moreau and Tara McIntyre
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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

A regional peer review of the Southwest Nova Scotia/Bay of Fundy Herring Framework: Part 2 – Management Strategy Evaluation Conditioning Operating Model Review was held on January 21–22, 2020, at the Northwest Atlantic Fisheries Organization headquarters in Dartmouth, Nova Scotia. As set out in the Terms of References (ToR) the focus was to review the structure and fitting of an example operating model that will be used as the basis for all of the operating models in the management strategy evaluation (MSE). Participants in this meeting included, DFO Science, DFO Resource Management, DFO Ecosystem Management, DFO Policy, Aboriginal Communities/Organizations, Non-Government Organizations, Fishing Industry, and external experts.

This proceedings document includes a summary of the presentations and is a record of the meeting discussions and conclusions. A Research Document resulting from this meeting will be published on the Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat's (CSAS) Website once it becomes available.

INTRODUCTION

Atlantic Herring is a pelagic species found on both sides of the North Atlantic. Herring spawn in discrete locations, to which they are presumed to home. Herring first mature and spawn at three or four years of age (23–28 cm), then begin a predictable annual pattern of spawning, overwintering, and summer feeding, which often involves considerable migration and mixing with members of other spawning groups. The Northwest Atlantic Fisheries Organization (NAFO) areas 4VWX management unit contains a number of spawning areas. Spawning areas in close proximity with similar spawning times, and which share a larval distribution area, are considered part of the same complex. For evaluation and management, the 4VWX Herring fisheries are divided into four components:

1. Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component;
2. Offshore Scotian Shelf banks spawning component;
3. Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component;
4. Southwest New Brunswick migrant juveniles.

Recommendations from the last assessment framework conducted in 2011 included a focus on model improvement and exploration for the next framework (DFO 2011). This assessment framework will focus on the SWNS/BoF spawning component. The last stock assessment for this component was conducted in 2018 (DFO 2018), and a stock status update was provided in 2019 (DFO 2020). The 2018 assessment identified the framework assessment as a priority and in 2019 the SWNS/BoF spawning component was identified to be in the Critical zone.

Fisheries and Oceans Canada (DFO), Maritimes Region has decided to proceed with a management strategy evaluation (MSE) process as the framework for SWNS/BoF Herring. This meeting was the second of three Science Advisory Process meetings to develop this MSE, and involved a peer-review of the conditioning operating model (OM) to be used in the MSE. The first meeting was in February 2019 and addressed the data inputs.

The objective of this meeting was to review the structure and fitting of an example OM that will be used as the basis for all of the operating models in the MSE. This involved a review of:

- the rationale for the data inputs;
- the rationale for the selected modelling approach;
- model specifications (i.e., equations for population dynamics, statistical functions, and numerical procedures);
- parameter estimates used in the OM;
- suitability of the OM to be used to model a range of uncertainties for the fishery;
- prior assumptions and error structure in the OM.

The review of the conditioning operating model differs from the review of a standard assessment model. The focus of the review of a standard assessment model is on model goodness of fit, whereas the focus of this review was on the suitability of the operating model to be used to model a range of uncertainties for the fishery. The code (R/Template Model Builder) was made available to the reviewers so anything documented in the working paper (Carruthers et al. 2023) can be replicated.

See Appendix 1 for the Terms of Reference (ToR) and see Appendix 2 for the list of participants. This meeting was held at Dartmouth, Nova Scotia from January 21 to January 22, 2019 (see Appendix 3 for the Agenda). A follow-up meeting will be held on May 26 to May 27, 2020, to continue reviewing the working paper which will be revised based on input from the present meeting.

PRESENTATIONS AND DISCUSSION

DAY 1: JANUARY 21, 2020

Rapporteurs: M. Barrett and M. Greenlaw

The meeting started with the introduction of the Chairs, T. McIntyre and D. Moreau. T. McIntyre went over the Canadian Science Advisory Secretariat (CSAS) Guidelines for peer-review meetings. This was followed by a round table of introductions and then a review of the meeting objectives by T. Barrett. The Terms of Reference was reviewed and a list of items outside the scope of the meeting was presented.

Clarifications of the objectives of the meeting followed. The objective was to determine the structure and fitting of an example OM that will be used as the basis for all of the operating models in the MSE. The OM was used to model possible uncertainties that were discussed at the first MSE workshop. This meeting was not to approve a base model to be used in the framework but to look at the modelling approach, to determine if the framework can be used for fitting OMs and to scope scenarios (alternative hypotheses). The model represents a model of population dynamics and is not an assessment model for the stock.

The purpose was also to make sure that the technical work was done correctly. For example, should a statistical catch-at-age (SCA) or virtual population analysis (VPA) be used? Are these the technical tools to interact with the data and is the approach appropriate? Since there were no previously agreed upon scenarios (alternative hypotheses), another CSAS meeting on goodness of fit and credibility will be held, but first the OM structure had to be agreed upon. This meeting will provide feedback on the sort of decisions needed for the OM and to make sure that reviewers and others were comfortable going forward.

A brief history of meetings related to the MSE was described. Previous frameworks of this stock were in 2006 and 2011 where all models were rejected (DFO 2006, DFO 2011) and the suggested approach was to explore MSE. In February 2019, there was a data inputs meeting and the first MSE Workshop was held in October 2019, where data were identified and the approaches to be used examined (Singh et. al. 2020). This January 21–22 meeting was a peer-review of modelling approach. A list of uncertainties and the management objectives for the fishery were identified at an MSE Workshop II held immediately following this meeting on 23–24 January, 2020 (see Appendix 4).

An overview of the MSE process and terminology was presented. It was emphasized that this meeting was just to review the OM structure and whether this OM structure could be used for conditioning.

The MSE Workshop II, held after this meeting, focused on identifying key uncertainties (see Appendix 4). SCA and VPA did not work in the past due to several data issues; however, in MSE data issues can be down weighted as appropriate. It was pointed out that in the United States (US) Herring fisheries a feeding model was examined for adequate feeding metrics.

Data inputs, computations, and assumptions

The 4VWX Herring management units were reviewed to provide some background for the fishery. The management of the SWNS/BoF spawning component does not include the New

Brunswick Weir fishery even though it is spatially within the SNWS/BoF area. Mixing does occur and group distinctions may not be as clear, and there appears to be connectivity to the Offshore Banks and Scotian Shelf as well as to the US Gulf of Maine. Catch occurs in spawning and feeding areas. There has been a shift in the time range when acoustic surveys are being conducted and there may be both increased survey effort and/or change in spawning locations or timing as in Scots Bay. This points to uncertainties and it was considered an important point to discuss at the workshop being held after this meeting.

Catch at Age

The fishery catch-at-age (CAA) and the acoustic survey CAA were calculated from the data collected. If spawning changes over time, to an earlier time, this would influence the weight-at-age. This shift to earlier spawning has been observed in the last few years in Scots Bay. There is need for a consistency correlation matrix to track cohorts through time. A consistency correlation matrix was requested of the Herring Unit to perform a check on the SWNS/BoF CAA data (with reviewer B. Berges), as was done for the North Sea Herring. This was completed during the meeting and shared with participants.

The landings data were reworked for the CAA and there were revisions to catches that did not get reported in prior years. The CAA was recalculated by fleet from 1999–2018. It was requested that the CAA be extended back to 1968. Any changes in gear type would result in changes in selectivity. Some landings data may not match data reported in assessment documents due to corrections made outside the database. There are discrepancies between the catch database and published reports. The historical catches have greater uncertainty than the more recent data (since dockside monitoring began). This uncertainty was captured using catch multipliers (Table A3 of the working paper).

A check should be made to make sure that data from Little Hope purse seine were not included in the landings data. It is best to do a thorough check of the data, make the best effort to correct the data set and then move forward.

The converted age data from lengths were used. While there is a lot of age data, the age data are not random because sampling is stratified with two fish aged per length bin. Length was used to get to the number of fish at different ages via an age-length key. On several occasions during this meeting, it was noted that the using actual age data would have been better than using age derived from length; however, this was the data collection protocol that was in place. Since the length data were binned by 1 cm, versus the 0.5 cm that it was measured by, it was noted that the effect of this should be explored by a sensitivity analysis (Figure A10b of the working paper).

Acoustic CAA

The acoustic CAA was done separately for German Bank and Scots Bay spawning grounds, and the catch-at-length (CAL) data were in one cm length bins. The point was made that that sometimes the capture of small fish occurs on German Bank and it was explained that this would be addressed in fleet modelling. The question was raised as to why there were no Age 0 fish. For fall spawning fish, on January 1st the fish are likely to be less than 3 cm and not caught in the fishery. Spring and summer spawning fish, however, also exist within the component. In the past the VPAs could not handle Age 0.

All of the weight-length relationships are fairly tight and there is confidence in the output of the *a*'s (intercepts) and *b*'s (slopes) for the weight-length regression equations. It would be good to look at the data by spawning grounds to see if they are similar. It would also be useful to see if the length bins can be used to follow cohorts.

Larval survey data

There was no standardization of the larval data that were provided; however, this was recommended to be done if the data are to be used within the MSE. It is estimated that there is 3–5% mortality per day of the larvae. Spawning stock biomass (SSB) can be linked to number of larvae per m^2. The data are numbers in m^3 and in models, biomass is the output; however, there are no data on the size of the SSB at the time of the larval surveys. The assumption about larval density is that it reflects the densities in German Bank and Scots Bay. Fecundity can change over time, so when scaling up to biomass, this also has to be examined. Data were collected at a time when conditions were different and there may now be more contributions from other spawning sites. The larval data can be included to test robustness and if the data are not reflective of the entire stock, the data should not be used. This is not a current data set and has not been used in the past, even though the set was available, because it was tried and rejected.

Recruitment Index

The issue of using seabird diet as an index of Age 2 recruitment was discussed. The challenge was that there are no abundance data of Age 2 fish. While the seabird data point to a possible juvenile index, the data from near the SWNS/BoF area indicate that the relationship was not strong. The data will be examined further to see if there are any relationships that would be useful.

Acoustic Index

The possibility of biomass from any other spawning areas being included in the index was discussed. It is believed to be minor for the acoustic surveys on the spawning grounds. If other spawning areas emerge later then this may have to be addressed under an exceptional circumstances protocol in the MSE, as long as there is some way to determine the contributions to the overall SSB. If new SSB show up in the catch and in the indices it would be challenging to include in the MSE process, but it can be done.

Historical data would be important in helping to show productivity changes. Since there were no acoustic surveys the historical baseline catches would have to be used. If this is done there is need for a clear description of the data being used. One approach would be to change q to reflect the changes in contribution of other spawning areas. This topic can be moved to the discussion on uncertainties. Exceeding 10% may need to be included in the model and whether such data can be included should be considered.

Modelling approach and software

T. Carruthers gave a presentation on the MSE process and described the model as a stock reduction analysis (SRA) which assumes no error in the catch data. This SRA is used for OM conditioning and can create different scenarios to the base case fit along with assumptions about the data. The model starts assuming at equilibrium unfished conditions in 1968. This is an assumption based on the catches; however, catches may be available as far back as the early 1900s. These data are digitized and georeferenced by port and will need to be looked at to see if they can be used. In the initial data sets, there are four fleets and the data area aggregated from the two major spawning grounds. The CAL is used directly and is the primary source of composition data (CAA are derived from CAL cohort slicing). All data were weighted at 1, except compositions for the weirs and purse seines that were arbitrarily weighted by 0.5 and 0.25 to provide roughly equal contribution to the total likelihood among selectivity parameters (these fleets have roughly 2x and 4x as many length observations, respectively).

Age dependent natural mortality rate (M) vector came from previous assessments and is assumed to be M = 0.7 for Age 1, 0.35 for Age 2, and 0.27 for Age 3+. It may be possible to look at the M used in the Gulf of St. Lawrence for NAFO Division 4T Herring. Higher M values may reduce the conflict between the acoustic index and composition.

The *q* was estimated in the base model and selectivity was also estimated. Consideration should be given to estimating *q* in blocks. It is possible to address the changes in *q*. Market requirements have resulted in a fair amount of change to targeting of specific sizes of Herring in the fishery. In the past, it was 60–70% for roe, but now it is not an issue although there is some targeting of small fish which are not reflected in the acoustic survey data. It may be possible to place a time varying walk on *q*. Turnover rate on spawning grounds is also an issue and may change with time.

Base model fit to larval data

Larval survey data are assumed to be an index of SSB and at the very most should be used as a robustness test. The larval data show that 1980 was a low recruitment year and this is supported by what was demonstrated in the fishery and the data. The question was whether the model output catches the low and high points and if it leads to any difference to the fits.

Base model fit to acoustic survey length composition

The model fits well across years between the observed and predicted. The survey residuals tend to miss some of the younger age classes. Fish of 20 cm length (Age 2) should not be included in this plot because they would not be spawners, so small fish should be excluded. A filter may be needed based on the length; for example, in 2011 there may be juveniles present in the samples from the spawning grounds.

Base model fit to purse seine length composition data

The length composition data from the purse seine fleet combines both spawning area and off-spawning ground data. The fit is not as good and the primary source of the conflict is between the composition data and the acoustic survey data. Separating out the data by spawning ground and the other areas would be worth considering to see if it would resolve this conflict.

In the fit, the fleets refer to differences or similarities in catch groups and are related to selectivity. It may be possible to look at fleets by area since this is related to fishing for different sized fish. Spatial structure is worth taking a look at, but there may be a dome-shaped selectivity and this would be related to assumptions about the fishery. Examine the selectivity curves to see if it improves model fit. Every time this is done it can cause issues but this should be tried, to see if the fit is suitable and if it is reasonable. The fishing data will be parsed by fleet on-spawning grounds, and off-spawning grounds.

Base model fit to weir/gillnet/other gears length composition data

There are some fluctuations in some years and this is not seen in the acoustic survey data. The weir fishery is very much seasonal with catch being related to availability. This is reflected in the structure of the data. The gillnet length composition data show much narrower selectivity. The "Other gears" length composition data have really small sample sizes in some years and are not consistent. Misfits in future projections of the weir data may be explained by seasonal changes. Catch error is usually not the issue, it is usually catch bias that is the issue. The modelling team will think about how to deal with this in the model.

Some fits are with high precision but uncertainties within models can be passed on, due to catch uncertainties. There is implied purse seine age composition from cohort slicing. The overall base model fits are not far from what would be expected. There are some issues, but overall there is good fit. In some years, the Age 2 do not fit. How this compares with the data prior to 1999 would require parsing of the data.

There was a lot of discussion on sampling for ageing since only two fish per size bins were aged. One approach suggested was resampling with the age data as a possible approach. The issue requires a bit more exploration and it was agreed that this would be investigated by the MSE team to see if there is a solution.

Base model estimates of SSB - overall reflect the stock trajectory

Looking that the base model estimates of apical fishing mortality and applying a red-face test would indicate that this was not reflective of what we expect. The erratic behavior in the recruitment is caused by the larval survey. If the larval data are removed then this is not an issue. It is possible to divide the data into high and low productivity, to it break apart; e.g., 1970–1990 = high, 1990+ = low.

Environmental data incorporation is possible with MSE and may involve scenario testing. Suggested scenarios can be credibly and empirically supported, or the data can be used in the robustness test.

DAY 2: JANUARY 22, 2020

Rapporteurs: M. Barrett and M. Greenlaw

The day started off with a review of the questions from the previous day. The temporal trend in weight-at-age (WAA) for Herring is a decline for ages 3+. This is also observed in other stocks and is something that may be indicative of the entire ecosystem.

In relation to the WAA, and how to deal with the data going back in the model prior to 1999, this would require the actual catch and age data from that period. Consideration may also be needed for using a different way to calculate the condition index (LeCran vs. Fulton methods). The age-disaggregated acoustic index was done for each spawning ground. An approach to resolve this concern is to use the age data rather than the length-derived ages to overcome the smearing issue.

There was a slight change in the objectives for Day 2 since there were scenarios in the working paper that could cause confusion. It was suggested that the models would be finalized at the end of the next meeting in May 2020. Consensus on the modelling approach and a list of data considerations should be completed in time for the next round of modelling. It is expected that the reviewers will provide feedback on the working paper.

In the model, data used should match up by month (Age 1). The periods of data need to match up, the timing of surveys and the ages need to match up, and the WAA at timing of surveys also needs to match up. The model needs to be clear on the data being used and whether the data are detailed. Growth can be estimated from the length-weight relationships that are used to convert the acoustics to biomass, and are taken from the detailed samples.

Parameter *q*

The parameter *q* represents the vulnerable biomass or the catchability of the stock. In the model *q* is estimated as 2.8. The value of *q* is central to the issue of the stock being assessed. It is a calibration factor. The numbers predicted are adjusted by the *q* factor on what the model projects. The mismatch between the model prediction and the acoustic data (could be a data issue or a modelling issue) is the *q* factor.

Vulnerable biomass is what you see through the selectivity curve. If *q* is estimated there can be less confidence in the acoustic survey data as an index of absolute biomass, but if it is set to 1 then the index is used as an index of absolute biomass. This is a bigger issue when *q* is estimated because the model inferences could be wrong. While turnover rate on spawning grounds may have changed, there is presently no data to support it. Catches may also cause mismatch, for example, underreporting of US Herring catch. A dome-shaped selectivity curve indicates declining selectivity and this needs to be addressed when talking about a fixed *q* because it is not able to track year classes. It would be ideal to use age data directly rather than the length derived from age. Turnover rate is also captured in the model by *q*. Presently, there is a way of adjusting for turnover biomass on spawning grounds and if only Herring schools were analyzed in the acoustics, this will result in lower biomass estimates; however, it was noted that a review of the acoustic index was outside of the terms of reference for this meeting.

Recruitment

The model uses the Beverton-Holt recruitment curve with fixed steepness. It is fixed with high productivity or low productivity. The higher productivity occurs before 1990, and changes dramatically after that period. The assumptions of the model supported high steepness parameter estimates and the model converged under this range of values. The steepness parameter estimates support the notion that the stock can be heavily depleted and rebuild.

Operating model scenarios showing flexibility of the model

In the model, resilience may need to be changed overtime rather than being fixed. There are also temporal changes in M overtime. Productivity is another important factor that needs to be considered in models. This is considered in the model on time-varying somatic growth and can be changed by year. One way is to tie productivity parameters to something in the model (e.g., a model parameter like M); however, what that would be is not easy to identify.

Selectivity is fixed but it is different for the different fleets. This needs to be clarified in the working paper. Time-varying selectivity is possible but it was fixed in the model.

Missing Herring landings caught in US waters can be modelled by assuming 10% of catch is missing. It can be assumed as occurring in all years (10% underreported catch) and it can be fixed at 10%. This is just an example and it does not necessarily mean it is occurring in the US waters. The catchability *q* of acoustic surveys in the base model is 1 and it does not change over time. The suggestion was made to use blocks (certain year ranges) for changes in *q*.

Scenarios set 1: data interpretations

Being able to work backwards from the CAA may improve the model fit rather than using the larval survey. There is flexibility in the models but projections into the future are needed to see how this is handled by the model. Random effect is interesting and should be explored. In terms of the retrospective patterns, there appears to be differences in fit over the years. This issue of retrospective patterns has also been seen in US Herring models for many years. A recommendation was made to present a standardized retrospective and to note that in a recruitment driven fishery, retrospective patterns will be present.

The 1970–1999 larval survey and landings are driving the pattern seen in the model outputs. It was suggested that past VPAs could be used for reconstruction of population. This is a bit more complicated since there is fitting to the data in the future and also at the same time. It was also suggested to use the OM with low precision of larval survey and high precision of the acoustic survey data. In other MSEs, there are OM sensitivities that can be placed around the agreed upon reference model.

Scenario 2: natural mortality rate and resilience

Reference points are standardized and internal to the model. If you change the inputs you can change the reference points. Typical steepness is based on spawning availability and predators, and 0.85 (85% unfished recruitment at 20% unfished spawning biomass) has been used in other Herring stocks. There is variability in stocks and it is not clear if meta-analysis has been done on steepness. It was suggested that the MSE team run a likelihood profile on the steepness. It seems that the value of M and steepness are important components that have to be selected carefully, and right now the OM uses M = 0.2 for all ages, and steepness = 85%.

Scenario 3: time varying dynamics and unreported catch

There is a uniform trend over time in underreporting what is attributed to US catches and this will not influence the model output trend. The SSB in the model is calculated on the basis of the final year and is a toggle in the model. In terms of unreported catch, it is more important if it changes overtime than if it is constant.

Scenario 4: catchability of the acoustic survey index

The question was posed as to whether there would be a better fit if the acoustic survey was considered as an absolute index. If this is done it would not agree with the other data sources and the cost in the model for this to fit would be bigger. It would result in the need to artificially adjust the other data sources. The acoustic survey data set is influencing the model one way and the length-at-age a different way. This could be due to a number of issues. To resolve this may involve changing *q* from 1 and estimate dome-shaped selectivity. It was suggested that the complexity of the purse seine fishery be investigated some more.

Maximum sustainable yield (MSY) is calculated using a fixed stock recruitment curve and this changes with the year (in these cases the last few years are used). Equations for these can be found in Walters and Martel (2004). This can be decided on when looking at the performance metrics.

The selectivity curves of the gear types should be based on fleet complexity. Right now a single selectivity is being used; however, the purse seine fleet curve shows that it is not catching the older fish. This is related to *q* which is set at 1 right now, but it can be adjusted. The model is reasonably stable but the data conflicts need to investigated. The natural mortality rate (M) constraints were set at 0.5%.

CONCLUSIONS AND ACTION ITEMS

The Terms of Reference were reviewed and it was recommended that the CAA prior to 1999 was needed. It was also recommended to explore the age data rather than the length-at-age. A similar ageing method is used in the 4T Herring and the data are used in their models. In terms of historical data, it was suggested that use be made of the most recent VPA assessment as an additional index, purely as an investigative index and robustness test.

The SRA model requires the catch data to be correct, and the catch data prior to 100% dockside monitoring may be an issue. While biases could be created it is less so when the error is consistent, rather than under or over, when it would be more problematic. There may be ways to perform alternative catch reconstruction to fill in any missing removals and most of this was done in the historical data; however, in years where dumping of catch may have occurred this would not be captured by the data. Additionally, in the early 1980s there was a large roe fishery followed by a fishery for smaller fish. These changes in the targeting of fish has been gradual. This will affect the length frequency data. In terms of mortality, the previous VPAs used M = 0.2 while the US Herring models used 0.35.

When there is uncertainty in the stock recruitment relationship it affects the performance metrics and performance of the biological parameters in terms of yield-per-recruit. This will become important in the discussion on performance metrics but if there are no reference points there would be a high degree of uncertainty in recruitment regardless of the relationship. The recruitment curve used is the Berverton-Holt relationship; however, it was suggested to try the Ricker curve, which is usually used for long-lived species.

Seasonal management measures are not addressed in the OM right now and the testing of rules for setting the total allowable catch (TAC) is what the MSE will address. The MSE could also address what the performance (catch) would be taken from large and small fish, but not the spatial aspects. Spatial aspects can be simulated as alternative scenario approach. Management rules that control size classes can also be considered but regional management measures are not possible.

OVERVIEW AND TERMS OF REFERENCE REVIEW

The model specifications will consider some of the red-face tests, and a list of what those are will be in the trial specifications document. On the suitability of the OM to use temporal data (climate change), there is no formal way, but data can for example, be correlated with recruitment estimates. This would have to be a scenario, in this case, and tested using a robustness test on the OM. Environmental data could be incorporated into the process by sketching out what are the expected relationships between the environmental variables and Herring. There are also some suggestions from DFO on how to set the limit reference point (LRP) through the MSE process. On the acoustic index it was suggested that because there are uncertainties with turnover, and how it may affect the trends, that it may be possible to use the highest survey/area/year and check the trends to see if they are different.

The next meeting will use revised data and the uncertainties for preliminary round of MSE. It will require the use of MPs for which the MSE team will select some examples. After the next meeting participants will submit their own MP and the group will select which ones to use. A verbal example could then be developed to be tested. This can be done independently of the MSE technical team.

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APPENDIX 1: TERMS OF REFERENCE

Southwest Nova Scotia/Bay of Fundy Herring Framework: Part 2 – Management Strategy Evaluation Conditioning Operating Model Review

Regional Peer Review – Maritimes Region

January 21–22, 2020

Dartmouth, Nova Scotia

Meeting Chairs: Tara McIntyre and Darek Moreau

Context

Atlantic Herring is a pelagic species found on both sides of the North Atlantic. Herring spawn in discrete locations, to which they are presumed to home. Herring first mature and spawn at three or four years of age (23 to 28 cm), then begin a predictable annual pattern of spawning, overwintering, and summer feeding, which often involves considerable migration and mixing with members of other spawning groups. The NAFO areas 4VWX management unit contains a number of spawning areas. Spawning areas in close proximity with similar spawning times, and which share a larval distribution area, are considered part of the same complex. For evaluation and management, the 4VWX Herring fisheries are divided into four components:

- Southwest Nova Scotia/Bay of Fundy spawning component
- Offshore Scotian Shelf banks spawning component
- Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component
- Southwest New Brunswick migrant juveniles.

Recommendations from the last assessment framework conducted in 2011 included a focus on model improvement and exploration for the next framework (DFO 2011). This assessment framework will focus on the Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component. The last stock assessment for this component was conducted in 2018 (DFO 2018), and a stock status update was provided in 2019 (DFO 2019). The 2018 assessment identified the framework assessment as a priority and in 2019 the SWNS/BoF spawning component was identified to be in the critical zone.

Fisheries and Oceans Canada (DFO), Maritimes Region has decided to proceed with a management strategy evaluation (MSE) process as the framework for SWNS/BoF Herring. This meeting is the second of three Science Advisory Process meetings to develop this MSE, and will involve a peer-review of the conditioning operating model to be used in the MSE. The first meeting was in February, 2019 and addressed the data inputs. The third meeting, to be scheduled later in the year, will involve the review of the entire MSE process.

Objectives

The objective of this second meeting is to review the structure and fitting of an example operating model that will be used as the basis for all of the operating models in the MSE. This will involve a review of:

- the rationale for the data inputs;
- the rationale for the selected modelling approach;
- model specifications (i.e., equations for population dynamics, statistical functions, and numerical procedures);

- parameter estimates used in the operating model;
- suitability of the operating model to be used to model a range of uncertainties for the fishery;
- prior assumptions and error structure in the operating model.

The review of the conditioning operating model differs from the review of a standard assessment model. The focus of the review of a standard assessment model is on model goodness of fit, whereas the focus of this review is on the suitability of the operating model to be used to model a range of uncertainties for the fishery. The code (R/ Template Model Builder) will be available for reviewers so anything documented in the working paper can be replicated.

Expected Publications

- Proceedings
- Research Document

Participation

- DFO Science
- DFO Resource Management
- DFO Ecosystem Management
- DFO Policy
- Industry
- Contracted external experts

References

DFO. 2011. Proceedings of the Maritimes Region Science Advisory Process on the Assessment Framework for Southwest Nova Scotia/Bay of Fundy Herring; 24–28 January 2011. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/031: iv + 28p.

DFO. 2018. 2018 Assessment of 4VWX Herring. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/052.

DFO. 2020. Stock Status Update of 4VWX Herring for the 2018/2019 Fishing Season. DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/001.

APPENDIX 2: LIST OF PARTICIPANTS

Name	Affiliation
Allard, Karel	Environment and Climate Change Canada / Canadian Wildlife Service
Barrett, Melanie	DFO Maritimes - Science
Barrett, Tim	DFO Maritimes - Science
Bartlett, Mike	Woodstock First Nation
Berges, Benoit	Wageningen University & Research
Boone, Brian	NB Dept. Agriculture, Aquaculture & Fisheries (NBDAAF)
Boyce, Daniel	Dalhousie University and the Ocean Frontier Institute
Brushett, Rebecca	Ecology Action Centre
Bundy, Alida	DFO Maritimes - OESD
Carruthers, Tom	University of British Columbia
Cieri, Matthew	Maine Dept. of Marine Resources
Cogliati, Karen	DFO National Capital Region - Science Advisory
Cook, Adam	DFO Maritimes - Science
Debertin, Allan	DFO Maritimes - Science
d'Eon, Sherman	Cape Breeze Seafoods Ltd.
Diamond, Tony	University of New Brunswick
Gjerdrum, Carina	Environment and Climate Change Canada, Canadian Wildlife Service
Greenlaw, Michelle	DFO Maritimes - Science
Hatt, Terry	NB Agriculture, Aquaculture and Fisheries (NBDAAF)
Hooper, Tony	Connors Bros. Clover Leaf
Hordyk, Adrian	University of British Columbia
Hubley, Brad	DFO Maritimes - Science
Jayawardane, Aruna	Maliseet Nation Conservation Council (MNCC)
Kaiser, Tim	Scotia Garden Seafood Inc.
Kelly, Brianne	World Wildlife Fund (WWF) - Canada
Landriault, Marc	Comeau Seafoods
McDermid, Jenni	DFO Gulf Region - Science
Melvin, Gary	Herring Science Council
Mitchell, Vanessa	Maritime Aboriginal Peoples Council
Moreau, Darek	DFO Maritimes - Science
Muise, Leo	Nova Scotia Seafood Alliance and Nova Scotia Fish Packers Association
Munden, Jenna	Herring Science Council
Murphy, Hannah	DFO Newfoundland Region - Science

Name	Affiliation
Mussells, Claire	DFO Maritimes - Science
Saulnier, Billy	Comeau's Sea Foods Limited
Saulnier, Brian	SeaCrest Fisheries
Schaible, Justin	DFO Maritimes - Resource Management
Schleit, Katie	Oceans North
Scopel, Lauren	University of New Brunswick
Singh, Rabindra	DFO Maritimes - Science
Stephenson, Rob	DFO Maritimes - Science
Stirling, Roger	Seafood Producers Assn of NS (SPANS)
Stone, Heath	DFO Maritimes - Science
Turcotte, François	DFO Gulf Region - Science
van Beveren, Elisabeth	DFO Quebec Region - Science
Walsh, Matt	Connor's Bros
Wang, Yanjun	DFO Maritimes - Science
Waters, Christa	DFO Maritimes - Resource Management
Wetteland, Wendy	NB Aboriginal Peoples Council (NBAPC)

APPENDIX 3: AGENDA

AGENDA (January 21, 2020)	
9:00 - 9:30	
Introductions	Leads: Tara McIntyre and Darek Moreau
Welcome and Introductions	
9:30 - 10:00	
Presentation	Leads: Tim Barrett and Tara McIntyre
Meeting Objectives	
10:00 - 10:30	
Presentation	Lead: Tim Barrett
History of meetings and plan forward	
10:30 - 10:45	
Coffee break (provided)	
10:45 - 11:00	
Presentation	Lead: Tom Carruthers
MSE process and how this review fits into the process	
11:00 - 12:00	
Presentation and questions	Lead: Tim Barrett
Data inputs, computations, and assumptions	
12:00 - 1:00	
Lunch (not provided)	
1:15 - 3:00	

AGENDA (January 21, 2020)	
Presentation	Leads: Tom Carruthers and Adrian Hordyk
Modelling approach and software	
3:00 - 3:15	
Break	
3:15 - 5:00	
Presentation	Leads: Tom Carruthers and Adrian Hordyk
Base case fit and assumptions	

AGENDA (January 22, 2020)	
9:00 - 10:30	
Presentation	Leads: Tom Carruthers and Adrian Hordyk
Operating model scenarios showing flexibility of the model	
10:30 - 10:45	
Coffee break (provided)	
10:45 - 12:00	
Presentation	Leads: Tom Carruthers and Adrian Hordyk
How the model fits in the MSE process	
12:00 - 1:00	
Lunch (not provided)	
1:15 - 3:00	

AGENDA (January 22, 2020)	
Discussion and contingency	
3:00 - 3:15	
Break	
3:15 - 5:00	
Discussion	Leads: Tara McIntyre and Darek Moreau
Overview and have the meeting objectives been met? Acceptance of the paper and consensus of the reviewers Timeline for final report	

APPENDIX 4: LIST OF UNCERTAINTIES AND MANAGEMENT OBJECTIVES

Table A4.1. List of uncertainties to be addressed via model, projections or input and/or the scenarios developed at the MSE Workshop II on 23–24 January, 2020. Dash (-) = not applicable.

Uncertainty	*M/P/I/R/S	Scenarios	Considerations
Recruitment	P	low, medium, high scenarios, consideration of stochasticity, trend; different stock recruitment relationships	change in prey fields, phenology, temperature, ecosystem changes, egg predation, larval condition
Mortality	M/P	multispecies E+E VPA, 1–2 (0.64) 3+ (0.37), a higher value than 0.2, time varying mortality	predators, condition factor, temperature, prey
Growth	M/P	mean of last 3 years,	temperature, weight-at-age changes, ecological drivers, condition (fat content), diet, density dependence, environment
Acoustic Survey	I	max survey, inbox only, all acoustic surveys	-
Catch Uncertainties	M/P/R?	0% and 100% weir catch, 3:1 ratio, 2X weir and shut off	weir catch, increase demand for bait, selectivity?
Mixing Migration	M/P	20% area 2 US catch (Kanwick & Libby 2009) 20% of area 1 catch; see same document for movement in other direction	US catches
Future selectivity	P	variable selectivity to deal with changes in juvenile vs. adult fish	variability in juvenile vs. adult fish
Larval Survey	M/P	change precision	keep it or not?
Data inputs	I	-	updates to all data inputs
Resilience (steepness)	S	Beverton-Holt (BH) (high steepness; lower steepness); T. Carruthers to propose scenarios; sensitivity scenario (BH vs other Stock Recruitment models)	-
Initial condition	R	robustness set (equilibrium catch pre 1960s). Average catch over 3 generations (Research Doc). Robustness set (old VPA as an index).	old VPA data?
Behaviour (spawn location)	-	catch (addressed above), biomass included in other areas (index)	-
Age error	S	-	-

*M/P/I/R/S = Model/Projection/Input/Reference/Sensitivity

Table A4.2. List of Management Objectives for the Herring fishery developed at the. MSE Workshop II on 23–24 January, 2020.

List of Management Objectives
Get stock to Healthy Zone
Have Stability in spawning stock biomass (SSB)
Maintain SSB at B_{MSY}
Assess tradeoffs of juvenile vs adult fish
Rebuilding biomass
Maintain Indigenous access
Broad stable age structure
Maintain Ecosystem services
Biomass for birds
Improve Yield