Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2024/006

Quebec Region

Proceedings of the Regional Peer Review on the Assessment Framework for Atlantic Herring (*Clupea harengus)* Stocks on the West Coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw): Part 1 - Review of Available Data for Modelling

April 4-5, 2023
Mont-Joli, Quebec

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February 2024

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280
ISBN 978-0-660-69651-5 Cat. No. Fs70-4/2024-006E-PDF

Correct citation for this publication:

DFO. 2024. Proceedings of the Regional Peer Review on the Assessment Framework for Atlantic Herring (*Clupea harengus*) Stocks on the West Coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw): Part 1 - Review of Available Data for Modeling, April 4–5, 2023. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2024/006.

Aussi disponible en français :

*MPO. 2024. Compte rendu de l'examen par les pairs régional sur le cadre d'évaluation pour les stocks de hareng de l'Atlantique (*Clupea harengus*) de la côte ouest de Terre-Neuve et de la Basse-Côte-Nord du Québec (divisions OPANO 4RSw) : Partie 1 - Révision des données disponibles pour la modélisation, 4-5 avril 2023. Secr. can. des avis sci. du MPO. Compte rendu 2024/006.*

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SUMMARY

This document presents the proceedings of the peer review on the assessment framework for Atlantic herring (*Clupea harengus*) stocks on the west coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4Rsw): Part 1 - Review of available data for modelling. This review, which was held simultaneously at the Maurice Lamontagne Institute in Mont-Joli and virtually over Zoom on April 4 and 5, 2023, brought together approximately 30 participants from DFO science and management, the industry, and provincial and university representatives. These proceedings describe the highlights of the meeting presentations and discussions and outline the recommendations and conclusions resulting from the review.

INTRODUCTION

Atlantic herring (*Clupea harengus*) populations on the west coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw) are characterized by two spawning components. Spring spawners generally spawn in April and May, and fall herring, in August and September. Spring and fall spawning herring are considered separate stocks and are assessed separately. A first series of acoustic surveys was carried out in the fall between 1991 and 2002. A second series of surveys was initiated in the fall of 2009 and continued until 2021. These surveys target aggregations of both spring and fall spawners as they congregate near shore to feed, before beginning their migration to their wintering grounds. A summer acoustic survey was also initiated in 2019 to target fall spawner aggregations during their spawning season. The data collected from these surveys are used to calculate biomass indices and age composition for the two spawning stocks. The 2016 and 2018 assessments used a sequential population analysis (SPA) model to determine the status of the herring stocks on the west coast of Newfoundland (DFO 2016, 2018). The model used commercial fishery data and was calibrated with acoustic abundance indices. In 2020, concerns about certain aspects of the fall acoustic survey, particularly with respect to changes in catchability, led to the rejection of the SPA model as the basis for scientific advice, which resulted in the rejection of reference points and the precautionary approach. During the 2020 assessment, it was determined that the review of the assessment framework was a priority. This meeting is the first of two and will be used to review the available data in order to establish a new assessment model and propose a new sampling and estimation methodology for the acoustic survey abundance index.

PART 1: REVIEW OF INPUT DATA

Meeting chair Jean-Martin Chamberland welcomed participants and went over the science review process and objectives as well as the role of the participants. The terms of reference and agenda were presented (Appendices 1 and 3). Participants were then asked to introduce themselves (Appendix 2).

The reviewing biologist, Kim Émond, thanked all collaborators and went over the context for the meeting, as presented above in the introduction. In particular, she highlighted the sources of uncertainty that had led to this review: stock structure (4R vs. 4Sw), acoustic surveys (timing, spatial coverage, representativeness of biological samples, analytical methods) and identification of the spawning group. This last item will not be covered in this review. The objective of this first meeting was to address and reduce sources of uncertainty, review the available data in order to establish a new assessment model and propose a new sampling and estimation methodology for the acoustic survey abundance index. The second meeting will focus on the development of a population model and limit reference point.

ACOUSTIC TAGGING

Kim Émond presented an acoustic telemetry study on Atlantic herring in the northern Gulf of St. Lawrence (GSL). She went over the context and presented the methodology and results. In total, 36 VR2AR acoustic release receivers were deployed in 2021–2022. Most of these receivers were located at sites in 4R and 4Sw with significant commercial landings of herring. Data from other networks (Ocean Tracking Network) were also used. Considering only the data from herring tagged in 2021, the study showed that herring movements between Divisions 4R and 4Sw were frequent. Over 80% of tagged herring migrated to another division. The frequency of movement between 4Sw and 4R and the general pattern of north-south migration

observed in this study suggest that it would be more appropriate to expand Division 4R to include Subdivision 4Sw for stock assessment purposes.

- It was specified that all tagged herring were measured and weighed. A subsample would provide a clearer picture of the composition of tagged herring (fall vs. spring spawning herring).
- Participants wondered about the possibility of false detections, which could exist but were filtered out. There could also be instances of predation. It was pointed out that acoustic technology is highly conservative. The quality of the data is considered to be very good.
- It was noted that 3Pn could be explored more in the future. Data from other networks exist and could potentially be used.
- It appears that environmental conditions tend to affect the timing of migration, but not patterns of migration.
- Participants were reminded that the goal of the study was to figure out how to develop an approach for 4Sw in relation to 4R.
- Participants felt that the results provide useful information on the relationship between 4R and 4Sw for herring. There seemed to be evidence of a general north-south migration pattern. The telemetry data collected over the coming years will be used to validate this cyclic pattern of migration.
- The migration pattern appeared to be consistent with the data from the commercial fishery.
- Therefore, all agreed that it would be more appropriate to expand Division 4R to include Subdivision 4Sw in the stock assessment (NAFO 4RSw).

COMMERCIAL CATCH-AT-AGE

Manuelle Beaudry-Sylvestre gave a presentation on the revision process for the landings and commercial catch-at-age (CAAs) data for the Atlantic herring commercial fishery in NAFO Divisions 4RSw for the period 1973–2021. The following databases were available: ZIFF (1985–2021), DFO research document for 4R only (1973–1996), NAFO 21B (1960–2018). Developing the revised series for 4R and 4Sw consisted of three steps: 1) deciding which year of the ZIFF data to use as the first year for area 4R; 2) assessing the possibility of extending the 4R ZIFF series using NAFO B data; and 3) assembling the selected data sources into a continuous series for each NAFO subarea. It was noted that NAFO B data were not considered as they were incomplete. It was decided to extend the 4R ZIFF series (starting from 1993) using data from the DFO research document (1973–1992) instead of NAFO B data. The revised series for 4Sw starts from 1985 (ZIFF data). Another objective was to optimize the linkage between landings and samples by drawing on the 3Pn4RS cod assessment. The standardization of sample selection was reviewed, as were the CAA calculations, and a comparison with previous values was made. The results indicated that the automation of methods in R improved efficiency and reproducibility. No significant changes were observed in numbers-at-age, except for young year-classes. A future objective would be to incorporate these methods into the existing catchR package.

- Concerns were raised regarding the fact that NAFO B data had not been used.
- Although the length frequencies had been collected as usual, they were never used. It may be possible to look into the added value of dockside length frequencies.

- The approach used for the standardized proportions at age and year drew on the 3Pn4RS cod assessment framework, but in the case of herring, the spawning group was also considered in the proportions.
- Some questions were raised to clarify the figure showing the relative differences in numbers-at-age. There was some confusion as to how to interpret the figure.
- A decision was made to add the CAA values for 1965–1972 to the 4RSw landings for the period 1973–present by applying the proportions of landings per NAFO unit from the historical STATLANT data. A few years of 4Sw landings would also be added to the 4RSw CAA.
- It was agreed that the new method is transparent and reproducible. The equations are known, and the pairing of biological samples with landings strata according to a hierarchy of levels has merit.

ACOUSTIC SURVEY INDICES

The following presentation consisted of a review of the acoustic survey indices for Atlantic herring in NAFO areas 4RSw from 2009 to 2021. Under constant catchability (q) conditions, the abundance of each cohort should decline over time. As this was not the case, the population model, which had been calibrated with acoustic indices, was rejected in the 2020 assessment. Uncertainty was also observed in the analytical methods, survey catchability and biological sampling. An analytical procedure consisting of a set of five revisions was used to address these uncertainties. Changes between the original and revision 2 were negligible, except in 2010–2011 for spring spawners. Revision 3 resulted in an increase in fall spawners in 2009–2011 and 2019–2020 (summer), but a decline in 2017. Revision 4 resulted in a 2/3 decrease in all biomass estimates relative to those derived using the Foote equation (1987[1]). Revision 5 had a negligible impact. The results show that these revisions helped provide a better understanding of the uncertainties in the acoustic survey by moving away from a black box method. Revision 3 had the greatest impact on cohort tracking. The results suggest that the irregular patterns in the original catch curves were mainly due to time-varying survey catchability, an effect implied by the limited impact of our combined revisions. A key objective moving forward would be to incorporate the uncertainty into a population model as well as into science advisory reports.

- It was mentioned that the acoustics work done by the Norwegians had been considered and used in the new approach to be presented.
- Participants were reminded that the revisions are cumulative and not independent of each other.
- Regarding revision 1, it was asked whether a calculation of uncertainty had been performed. How should uncertainty be projected at each step?
- In revision 2, an attempt was made to estimate biomass for all strata that had not been covered in the survey. Some participants felt it would be better not to transform the variables and to use them on their natural scale instead. Would kriging be a better approach? The answer appeared to be no, given that the correlation between predicted and observed values was weak. Participants wondered whether there was a more suitable approach.

[1] Foote, K.G. 1987. Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. 82: 981-987.

Herring is highly unpredictable, which complicates matters. Predicted values largely underestimate what is observed.

- Revision 3 involved the use of an acoustic survey-specific decision tree for sample selection. It was pointed out that a good sample is one that has a good fit with the acoustic signal. There seemed to be some confusion as to how to choose the two samples at each level of aggregation. It was recommended that the methodology for sample selection be clarified and that the number of fish per sample be added as a prioritization criterion. It was also recommended that the structure of the decision tree be validated using available data.
- In revision 4, a significant difference was observed when the target strength equation by Foote (1987) was replaced with that of Ona (2003[2]). This change reduced absolute biomass considerably but did not affect relative biomass.
- It was noted that the main problem with the survey was the time-varying catchability. This would explain the unusual patterns in the catch curves. Participants said it was not surprising to see large confidence intervals, given the spatial variation between transects. It was specified that these intervals could not be interpreted as uncertainties. If they are included, it is important to provide a clear explanation of what they represent (i.e., variability in measured biomass between transects). The year effect for catchability could be examined more closely.

Revision 2 was reviewed again. Another model (glm) was used to fill in the missing values in the stratum-survey table. Although this still underestimated values, it did so to a lesser extent. The Gamma distribution seems to be more suitable than the lognormal model and does not require log transformation.

- Some participants felt that the effect of interactions would be very strong (compared to the year and stratum effects) and that it would explain much of the variance. The predictions from this model were not very good.
- However, some trends were still observed. While abundant strata remained that way and vice versa, the variability was significant. The average was not considered to be more useful.
- There doesn't seem to be a simple solution. There is an advantage to imputing values, but the uncertainty must be propagated.
- Additionally, the quality of the survey results would need to be quantified. Would this input be useful? The timing of the survey, which remained the same, seemed to be problematic. Should smaller areas (e.g., the north) be targeted and sampled more intensively? Some participants felt that this would only shift the problem. Others thought that this solution would be beneficial if the spawning grounds and spawning period could be targeted, which does not seem to be the case. It would also involve creating a new survey, which would be an enormous undertaking.
- As a short-term solution, it was suggested to better identify what information we have on age compositions and to see what could be used. Once the standard has been defined for each sample, the multivariate distance can be examined for each age composition. This would make it possible to assess the extent of errors, if any, and to take that into account in the model. One possible approach would be to identify the samples for which there is a good level of confidence and to examine how the results differ when we stray from them.

[2] Ona, E. 2003. An expanded target-strength relationship for herring, ICES J. Mar. Sci. 60(3): 493–499.

The commercial catch-at-age data is considered to be good and could be used to verify whether the main issue relates to catchability rather than sampling. An age-structured model would be useful.

CLASSIFICATION OF ACOUSTIC SIGNALS

Shani Rousseau presented a new acoustic data classification method, which would be used in the summer survey. The old method (1a) and the new method (1b) for revision 1 were compared. The main difference between revisions 1a and 1b stemmed from the classification of fish with swim bladders, which differs between the two methods. The method used in revision 1b results in a larger biomass estimate than the method used in revision 1a. The classification of herring (step 3) could result in a difference in biomass between the two methods. However, considering the very high proportion of herring relative to other fish species with swim bladders present in the study area, significant differences are not likely to occur. Although the exclusion threshold of 120 m does not aways exclude all acoustic signals from redfish, the quantities included are not great enough to cause an overestimate of biomass. The primary uncertainty therefore lies in the representativeness of biological samples. For the fall 2009–2022 series, classification would be performed using the revision 1a method. For the summer 2019+ series, classification would be performed using the revision 1b method. However, the classification of herring (step 3) would be done by manual review (expert scrutiny) for the 2019–2022 surveys, given that the species composition was not available.

- It was pointed out that, for practical reasons, the two vessels (acoustic and fishing) cannot follow too closely behind one another even though they are in the same area.
- Some participants mentioned that herring and capelin do not usually coexist. A “habitat” variable could be added to separate capelin from herring.
- Participants were reminded that the primary uncertainty lies in the representativeness of the biological samples.
- Concerns were raised regarding the exclusion threshold of 120 m. It was pointed out that this method would be applied in summer, which did not seem to be problematic.

CONCLUSION

In conclusion, the increased knowledge on the migration and mixing patterns of herring stocks in the northeastern GSL was highlighted.

Many aspects were also improved:

- Automation and standardization of data processing;
- Standardization of sample selection (commercial and acoustic);
- Review of biomass calculations in the acoustic survey;
- Review of number-at-age calculations (commercial and acoustic); and
- Standardization of the herring classification method.

This work enabled us to move away from a black box method and to reduce some of the uncertainty associated with the acoustic index.

According to the results obtained, two major sources of uncertainty need to be addressed in part 2 of the review of the assessment framework:

- Catchability
- Sample representativeness

The next steps are to consider other inputs (new and existing), including:

- The experimental gillnet survey in 4RS (2021–)
- Catch-at-age research from a commercial gillnet fishery in St. George's Bay (spring spawners only; 1985–2004)
- Catches-at-age from the bottom trawl survey in the northern GSL. It was noted that this survey did not adequately cover shallow waters and did not seem to be very useful; there was a lot of noise in the survey.

Regarding the acoustic survey:

- It was reiterated that the weather makes it difficult to carry out this survey in the fall.
- It was pointed out that the fishery operates when water temperatures in bays begin to get very cold (fall to early winter).
- The timing of the fishery and the tagging data seemed to be consistent.
- It was suggested that time-varying catchability be incorporated into the stock assessment model and that an observation error that varies according to the quality of the acoustic index be added.

Regarding the number-at-age from the acoustic survey, the following should be done:

- The selection of biological samples for estimating numbers-at-age should be improved;
- An acceptability threshold should be identified; and
- Numbers-at-age from problematic survey years should be removed from consideration.

Other comments were made:

- One possible approach would be to identify the samples for which there is a good level of confidence and to examine how the results differ when we stray from them. The commercial catch-at-age data was considered to be good and could be used to verify whether the main issue ultimately relates to catchability rather than sampling. An age-structured model would be useful.
- However, it may be necessary to take a step back to reflect on a different stock assessment approach.
- The change in stock definition requested by meeting participants, which would integrate Subdivision 4Sw into Division 4R for the stock assessment, could be addressed in a Science Response. This may be incorporated into the terms of reference for part 2 of the assessment framework for Atlantic herring stocks on the west coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4Rsw).

APPENDIX 1 — TERMS OF REFERENCE

Assessment Framework for Atlantic Herring (*Clupea harengus*) Stocks on the West Coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw): Part 1 - Review of Available Data for Modelling

Regional Peer Review – Quebec Region

April 4-5, 2023
Mont-Joli, Quebec

Chairperson: Jean-Martin Chamberland

Context

Atlantic herring (*Clupea harengus*) populations on the west coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw) are characterized by two spawning components. Spring spawners generally spawn in April and May, and fall herring, in August and September. Spring and fall spawning herring are considered separate stocks and are assessed separately.

A first series of acoustic surveys was carried out in the fall between 1991 and 2002. A second series of surveys was initiated in the fall of 2009 and continued until 2021. These surveys target aggregations of both spring and fall spawners as they congregate near shore to feed, before beginning their migration to their wintering grounds. A summer acoustic survey was also initiated in 2019 to target fall spawner aggregations during their spawning season. The data collected from these surveys are used to calculate biomass indices and age composition for the two spawning stocks.

The 2016 and 2018 assessments used a sequential population analysis (SPA) model to determine the status of the herring stocks on the west coast of Newfoundland (DFO 2016, 2018). The model used commercial fishery data and was calibrated with acoustic abundance indices. In 2020, concerns about certain aspects of the fall acoustic survey, particularly with respect to changes in catchability, led to the rejection of the SPA model as the basis for scientific advice, which resulted in the rejection of reference points and the precautionary approach (DFO 2021). During the 2020 assessment, it was determined that the review of the assessment framework was a priority.

This meeting is the first of two and will be used to review the available data in order to establish a new assessment model and propose a new sampling and estimation methodology for the acoustic survey abundance index.

Objectives

The objectives of this first part are:

- Present the results of the first year of the acoustic telemetry study on herring in the northern Gulf of St. Lawrence and discuss the implications for the definition of biological and fisheries management units.
- To examine the available data and methods for calculating inputs, which would be used in the west coast of Newfoundland herring stocks assessment model, including:
    - Catches at age in the commercial fishery;
    - Biomass index and numbers at age of acoustic surveys from 2009 to 2021.

- To present a new methodology for biological sampling and biomass estimation of the acoustic survey.

Expected Publications

- Proceedings
- Research Document

Expected Participation

- Fisheries and Oceans Canada (DFO): Ecosystems and Oceans Science, and Fisheries Management
- Fishing Industry
- Provincial representatives
- Academia
- Indigenous Communities / Organizations
- Environmental Non-governmental Organizations

References

DFO. 2016. Assessment of the West Coast of Newfoundland (Division 4R) herring stocks in 2015. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/024.

DFO. 2018. Assessment of the West Coast of Newfoundland (Division 4R) herring stocks in 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/036.

DFO. 2021. Assessment of the West Coast of Newfoundland (NAFO Division 4R) Herring Stock in 2019. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/005.

APPENDIX 2 — LIST OF PARTICIPANTS

Name	Affiliation	April 4	April 5
Adamack, Aaron	DFO — Science	x	x
Anderson, Sam	Barry Group	x	x
Barry, Bill	Barry Group	x	x
Barry, David	Barry Group	x	x
Beaudry-Sylvestre, Manuelle	DFO — Science	x	x
Benoît, Hugues	DFO — Science	x	x
Boudreau, Mathieu	DFO — Science	x	x
Carruthers, Erin	FFAW	x	x
Chamberland, Jean-Martin	DFO — Science	x	x
Cogliati, Karen	DFO — Science	x	x
Corbett, Emma	Prov. of NL	x	x
Cyr, Charley	DFO — Science	x	x
Desgagnés, Mathieu	DFO — Science	x	x
Dionne, Hélène	DFO — Science	x	x
Dubé, Sonia	DFO — Science	x	x
Dunne, Erin	DFO — Science	x	x
Émond, Kim	DFO — Science	x	x
Geoffroy, Maxime	Memorial University of Newfoundland	x	x
Landry, Lysandre	DFO — Science	x	-
Munden, Jenna	Herring Science Council	x	x
Nilo, Pedro	DFO — Science	x	x
Ouellette-Plante, Jordan	DFO — Science	x	-
Paquet, Frédéric	DFO — Science	x	x
Pellerin, Mathieu	DFO — Ressource management	x	x
Rolland, Nicolas	DFO — Science	x	x
Rousseau, Shani	DFO — Science	x	x
Senay, Caroline	DFO — Science	x	x
Smith, Andrew	DFO — Science	x	x
Turcotte, François	DFO — Science	x	x
Van Beveren, Elisabeth	DFO — Science	x	x
Zabihi-Seissan, Sanaollah	DFO — Science	x	x

APPENDIX 3 — AGENDA

Assessment Framework for Atlantic Herring Stocks on the West Coast of Newfoundland and the Lower North Shore of Quebec (NAFO Divisions 4RSw): Part 1 – Review of Available Data for Modelling

Regional Peer Review – Quebec Region

April 4-5, 2023

Day 1 – April 4, 2023

Time (EDT)	Topic
8:30	Chair introduction and Terms of reference
8:45	Round table
9:00	Introduction
9:15	Acoustic tagging
10:15	*Break*
10:30	Commercial catch-at-age
11:45	*Lunch Break*
12:45	Acoustic surveys indices (biomass and number-a- age)
15:45	End of day 1

Day 2 – April 5, 2023

Time (EDT)	Topic
8:30	Summary of day 1
8:45	Discussion on acoustic indices – follow up
9:30	Acoustic surveys: classification of acoustic signals
10:15	*Break*
10:30	Acoustic surveys: classification of acoustic signals
11:00	Conclusion