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Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2023/040

Quebec Region

Proceedings of the Regional Peer Review on the Scallop Stock Assessment in Quebec Coastal Waters (Management Units 15 to 20)

**March 8-9, 2023
Mont-Joli, QC**

**Chairpersons: Hacène Tamdrari and Charley Cyr
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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

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Department of Fisheries and Oceans, 2023
ISSN 1701-1280

ISBN 978-0-660-67978-5 Cat. No. Fs70-4/2023-040E-PDF

Correct citation for this publication:

DFO. 2023. Proceedings of the Regional Peer Review on the Scallop Stock Assessment in Quebec Coastal Waters (Management Units 15 to 20); March 8-9, 2023. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2023/040.

Aussi disponible en français :

DFO. 2023. Compte rendu de l'examen par les pairs régional sur l'évaluation des stocks de pétoncle des eaux côtières du Québec (unités de gestion 15 à 20); du 8 au 9 mars 2023. Secr. can. des avis sci. du MPO. Compte rendu 2023/040.

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SUMMARY

This document outlines the proceedings of the regional peer review meeting on the assessment of the Quebec coastal waters scallop stocks. This meeting, which was held on March 8-9, 2023 at the Maurice Lamontagne Institute in Mont-Joli, brought together about thirty participants from science, management and industry. These proceedings detail the essential parts of the presentations and discussions held during the meeting, as well as the recommendations and conclusions made.

INTRODUCTION

The Quebec Region of Fisheries and Oceans Canada (DFO) is responsible for assessing several stocks of fish and invertebrate species harvested in the Estuary and Gulf of St. Lawrence. Most of these stocks are periodically assessed as part of a regional advisory process that is conducted at the Maurice Lamontagne Institute in Mont-Joli. This document outlines the proceedings of the meeting on the assessment of the Quebec coastal waters scallop stocks held on March 8-9, 2023.

The objective of the meeting was to determine whether there were any changes in the resource's status and whether adjustments were required to the management plans based on the chosen conservation approach, with the ultimate goal being to provide a science advisory report on the management of the Quebec coastal waters scallop stocks for the 2023 to 2025 fishing seasons.

These proceedings report on the main points discussed in the presentations and deliberations stemming from the activities of the regional stock assessment committee. The regional peer review meeting is a process open to all participants who are able to provide a critical outlook on the status of the assessed resources. Accordingly, participants from outside DFO are invited to take part in the committee's activities within the defined framework for this meeting (Appendices 1 and 2). The proceedings also list the recommendations made by the meeting participants.

ASSESSMENT

The meeting co-chair, Charley Cyr, went over the peer review process and objectives. The participants were then asked to introduce themselves. The assessment biologist, Rénaud Belley, presented the terms of reference, highlighted the contributions of the collaborators, and reviewed the summary of the 2020 Science Advisory Report. He outlined some aspects of scallop biology, in this case involving two species, the sea scallop and the Iceland scallop. He also provided an overview of the dredge fishery, which is carried out in 24 fishing areas divided among three regions: North Shore (13 fishing areas), Magdalen Islands (5 fishing areas) and Gaspé Peninsula (6 fishing areas). He briefly described the management measures in place, which vary widely from one fishing area to another. The information sources used to calculate the indicators consist of commercial fishery statistics (logbooks, Vessel Monitoring System [VMS], purchase slips, at-sea and dockside sampling), scientific surveys and research projects.

From 2020 to 2022, Quebec's average annual scallop landings totaled 56.4 t of meat, a 26 % decrease from 2016–2019. Fishing effort dropped by 25% on the same period. Sixty-seven % of the landings were from the Magdalen Islands, 31% from the North Shore and 2% from the Gaspé Peninsula.

The indicators were reviewed in the case of fishing areas with significant fishing effort, specifically areas 16E, 16F, 16A1 (North Shore), 19A (Gaspé Peninsula) and 20A (Magdalen Islands).

NORTH SHORE (AREAS 15, 16 AND 18)

Indicators

Annual landings averaged 17.2 t for the period 2020-2022 and consisted primarily of Iceland scallops. They decreased by 32% compared to 2016-2019, while fishing effort fell by 44%. From

2020 to 2022, there was no fishing effort in areas 16A2, 16C, 16D, 16G, 16H, 16I, 18A and 18D and very little in areas 15 and 16B.

Since 2013 in area 16E, landings have been less than 16 t compared to levels that were generally above 50 t prior to 2007. Since 2008, fishing has been concentrated mainly on bed D south of Grande Île where recruitment was very good in previous years. The latest research surveys show that the density of non-commercial-size scallop remains below the reference mean despite an increase in 2022. The density of commercial-size scallops remains among the lowest values in the historical series and below the reference mean. A rebuilding plan is being developed for Area 16E

Since 2009 in area 16F, landings have been less than 5 t compared to levels higher than 25 t prior to 2007. Since 2011, fishing has been concentrated primarily on bed C. The 2022 research survey showed that the density of commercial- and non-commercial-size scallops were among the lowest and below the series average in their historical series. Reduced fishing effort in recent years does not appear to have led to an increase in densities. Based on the low recruitment observed in the research survey, an increase in densities of commercial-size scallops is not expected in the short term. A rebuilding plan is being developed for this area.

The fishery in area 16A1 resumed in 2017, concentrating on the Île Rouge bed. The TAC has been adjusted to 8.72 t in 2020. Because the bed is located at the western edge of the known distribution of scallops and is geographically isolated, it is likely to be more vulnerable to overharvesting. Commercial catch per unit effort (CPUE) was relatively high in 2020 and 2022, reaching the reference mean in 2020 and exceeding it in 2022. The current fishing effort on this bed should be sustainable by the time of the next assessment.

- In Area 16E, an increase in bottom temperatures in the month of August has been noted over the years. Values in recent years were above average. Having an indicator of temperature as a function of depth could be useful, particularly at depths where scallops are found.
- Some participants emphasized the strong recruitment on bed D in 2022.

Assessment model and proposed limit reference point

For Area 16E, a new surplus production model was presented, along with the data used, assumptions, model fits to the data, process errors and residuals. Of the three options presented, the participants chose to use the one that maximized the data while having “very good” to “acceptable” diagnostics. Output from this model indicates that the stock biomass has decreased, reaching 99.69 t in 2022, the lowest level ever recorded. A limit reference point has been set to 40% of the theoretical biomass maximum sustainable yield (B_{MSY}), or 182.8 t. The stock has been in the critical zone of the precautionary approach since 2008. Predictions based on the scenario with average landings of 9.89 t in the last two years were optimistic.

- It was noted that the model estimates the environment’s maximum carrying capacity and the production surplus is based on this maximum capacity. A penalty can be applied to the production curve where there is reduced recruitment.
- It was mentioned that commercial CPUE was not used in the model because of the problem of CPUE hyperstability. If CPUE were used, it would have to be by bed. Some participants felt that it was not relevant to integrate CPUE, given the efficiency of the fishers.
- This type of model is also limited by its assumption of the environment’s stability.
- Participants were reminded that the suggestion had been made to use the biomass of commercial-size scallops in grams (of muscle) per m².

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- What M consists of was clarified: it is the parameter for the shape of the surplus production curve. Natural mortality is considered in the intrinsic population growth rate (r).
 - It was noted that the model already considers all individuals via r , so commercial biomass was the focus for now.
 - No retrospective patterns were observed for the chosen model. The model seemed to respond well when some years were removed.
 - Finally, there was consensus on the surplus production model presented and the LRP chosen. This approach can also be applied to Area 16F.

Research project: Spatial variation in the biological characteristics of Iceland scallops caught in Quebec

Catherine Couillard presented the preliminary results of a research project aimed at better understanding variations in the biological characteristics (scallop condition, and shell shape and state) of Iceland scallops and their impact on stock status and productivity. Among the results, it was observed that, in Area 16E in June 2021, the muscle weight of scallops with a shell height of 85 mm varied by 16% between beds, being higher in the islands (bed Q) and lower outside the islands. In the islands, gonad maturation was also most advanced, and shells were deepest and widest. However, barnacle infestation rates and shell density were highest on bed D, outside the islands. In general, the presence of barnacles did not appear to affect muscle or gonad condition, except in a small number of severely infested scallops. Moreover, since 2003–2004, the distribution of barnacle infestations has shifted. They were initially centred in the islands (bed Q), but have spread outside the islands (beds D and F), where they are now more severe. In 2019–2021, large-scale spatial patterns (between the Quebec and Nunavut fishing areas) were observed in rates of infestation by barnacles and shell-boring worms and in shell densities. The most severe infestations by shell-boring worms and the least-dense shells were observed in Nunavut, while the most severe infestations by barnacles and the densest shells were found in Area 16E. The link between these observations and environmental conditions will be explored.

- A review of the literature suggests that the presence of barnacles may protect scallops from predation by crabs and lobsters, although perhaps not from starfish. However, barnacles may hinder scallop movement.
- It was noted that volume (which can be calculated using shell width, depth and height) is an interesting variable, as it is less influenced in the short term by environmental conditions than muscle or gonad weights.
- The participants wondered about the choice of datasets on barnacle infestation rates (e.g. research cruises, shell collections) in order to be able to incorporate the most appropriate datasets.
- The participants also wondered about the mechanism by which barnacles spread (e.g. boats, chemical signals from barnacles that attract other barnacles).
- The thickening of the shells of barnacle-infested scallops has been observed. It is not known whether this is a direct or indirect effect of barnacle infestations or a consequence of environmental conditions.
- Given that the specific biological characteristics of scallops, including muscle weight per scallop and the timing of reproduction, vary based on the bed and are linked in particular to

environmental pressures at the scale of the bed, management by bed seemed to be more appropriate.

Research project: Using larval and post-larval shell markings to better understand the spatial and temporal variability of Iceland scallop recruitment

The research project presented by Gauthier Cervello focused on the use of larval and post-larval shell markings to better understand the spatial and temporal variability of Iceland scallop recruitment in Areas 16E and 16F. The results indicated that Area 16F had a higher density of juveniles attached to collectors, particularly on bed C. Lipid profiles indicated that the juveniles with the highest meat yield at harvest were found in Area 16F. Larvae and juveniles in this area may have access to high-quality food and consume more diatoms and dinoflagellates. Juveniles collected in the more inland portion of Area 16E appear to begin growing earlier because primary production is not synchronous between Areas 16F and 16E. Juveniles collected in the autumn of 2022 in all sectors had weaker larval and benthic growth than those collected in the autumn of 2021, which may be related to the colder temperatures measured in 2022. Winter does not select for larger egg sizes. Winter would seem to select for larvae that are larger at benthic settlement. Larvae that have accumulated more lipid reserves in autumn would be better able to survive in winter .

- Some participants asked up to what size shells could be measured. Shells can be about 3 cm maximum, but after that, it erodes.
- The same exercise for lipid analyses was planned for 2022, enabling comparison between a warm year and a cold one.

Research project: Genomics of Iceland scallop populations in the Atlantic Ocean

Geneviève Parent's presentation focused on the genomics of Iceland scallop populations in the Atlantic Ocean. The results revealed the presence of two populations, one that is more northerly (Nunavut) and one that is more southerly (Gulf of St. Lawrence). Both populations are present around Blanc Sablon. The most plausible evolutionary scenario would be post-glacial colonization from two refugia associated with this sector. Interbreeding between the two populations is infrequent. Work was in progress on the morphological differentiation of the two populations.

- Blanc Sablon is a mixing area between north and south.
- There was a consensus that there is sufficient gene flow in the Gulf of St. Lawrence (GSL) so that there would be no sub-components.
- The participants asked about the possibility of finer-scale differentiation in the GSL. It was noted that the differentiation between the two populations (Nunavut and GSL) was already small.
- It was added that some markers may be potentially under selection, or potentially adaptive. However, this needs to be proven. Is it really possible to associate a phenotype with a genotype?

Summary and recommendations – North Shore

Participants commented on the summary. Only comments on the content are reported.

- For the key point on North Shore landings, it was suggested that the average landed value (17.2 t) be indicated.

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- Some key points were moved so that they could be integrated with their specific area.

Area 16E

- In the key point on the latest research surveys that indicated that the density of non-commercial-size scallops remained below average, it was stated that strong cohorts of small scallops were observed on bed D in 2022. The consensus was that the density of commercial-size scallops remained among the lowest values in the historical series and below the reference mean (1990–2019).
- A key point referring to the new surplus production model was added, indicating that stock biomass was decreasing and had reached 99.69 t in 2022, the lowest level ever recorded.
- The next key point was regarding the LRP. The participants agreed on the importance of specifying its value. The key point was worded to read that the LRP had been set to 40% of the B_{MSY} , or 182.8 t. The stock has been in the critical zone of the precautionary approach since 2008.
- The participants agreed on the content and structure of the last key points for Area 16E, one to focus on the exploitation rate, which was deemed to be higher than what the stock could support. Another key point would be more specific and involve the protection of bed D, while the final key point, which stated that the stock was in the critical zone, would mention that a rebuilding plan was being developed for Area 16E.
- In the end, these key points were worded as follows:
- The exploitation rate estimated by the model indicates that fishing effort would be greater than the level the stock has been able to withstand since 1990, with the exception of 2010 and 2014.
- Minimizing fishing effort on bed "D" would favour the survival of strong cohorts of small scallop observed during the survey in 2022.
- Since the stock is in the critical zone, a rebuilding plan is being developed for Area 16E.

Area 16F

- For the key point on the 2022 research survey, the participants agreed to say that the densities of commercial- and non-commercial-size scallops were among the lowest in, and below the average for, the historical series.
- The participants did not believe that current densities could be maintained in this area with the same level of effort as in the last three years. Rather, they believed that the reduction in fishing effort in recent years did not likely lead to an increase in densities.
- The participants finally agreed to formulate the last key point as follows: Reduced fishing effort in recent years does not appear to have led to an increase in densities. Based on the low recruitment observed in the research survey, an increase in densities of commercial-size scallops is not expected in the short term. A rebuilding plan is being developed for area 16F.

Area 16A1

- For the key point on the resumption of the fishery in this area in 2017, it was decided to shorten this point by including only the essential information. It would simply be stated that this bed was unable to support an annual exploitation level of about 10 t from 1998 to 2002. The TAC was adjusted to 8.72 t in 2020 to address this concern. It is likely that this bed is more vulnerable to overharvesting because it is located at the western edge of the known distribution of scallops and is geographically isolated.

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- It was decided not to include any key points from the genetic study.
 - The participants agreed with the idea that the current effort would be sustainable. A final key point was added as follows: Commercial catch per unit effort (CPUE) was relatively high in 2020 and 2022, reaching the reference mean in 2020 and exceeding it in 2022. The current fishing effort on this bed should be sustainable by the time of the next assessment.

GASPÉ PENINSULA (AREAS 17, 18, 19)

Indicators

Landings reached more than 60 t prior to 2001, and then gradually declined to totals below 2 t per year since 2018. Fishing effort has also declined and is now very low compared to what it was in the 1990s. Scallop landings have increased by 38% while fishing effort has decreased by 2% in 2020-2022 compared to 2016-2019. Since 2014, the fishery in this region has been concentrated mainly in Area 19A despite a modest resumption of fishing in area 18B1 in 2022. From 2020 to 2022, there was no fishing effort in Areas 17A1, 17A2, 18B2 and 18C, and very little effort in Area 18B1.

In area 19A, landings and fishing effort were very low between 2020 and 2022. Over the last nine years, fishing effort has been concentrated on two beds, leaving a number of beds unharvested. In 2017, the CPUE fell to the lowest value in the historical series, but it has been on the rise since then. The average CPUE for the past three years is above the historical average. The current fishing effort on these two beds should be sustainable until the next assessment.

- It was noted that there is only one fisher in Area 19A.
- Fishers seem to be targeting sea scallops rather than Iceland scallops, which occur at greater depths.

Summary and recommendations – Gaspé Peninsula

The participants made a few comments on the summary. Only comments on the content are reported.

- In the first key point on landings, it was suggested that the emphasis be placed on the fact that the fishing effort is at very low levels compared to what it was historically. The participants decided not to indicate that landings are mainly made up of sea scallops, as this is presumed. This information would be included in the Science Advisory Report.
- It was decided to create a sub-section for Area 19A.
- The key point on the current fishing effort deployed on the two beds in Area 19A should state that this effort should be sustainable by the next assessment. The phrase “there is a high probability” was to be removed.

MAGDALEN ISLANDS (AREA 20)

Indicators

In Area 20A, Sea scallop landings and CPUEs increased sharply in 2007 and have remained relatively high since then. Fishing effort is distributed evenly across all beds. The 2021 and 2022 research surveys indicate that densities of scallop of all size classes (commercial ≥ 100 mm,

pre-recruit 85-99 mm, pre-recruit 70-84 mm and < 70 mm) are high and close to the maximum historical values.

- Looking at the VMS data, the participants wondered about the dredging effort. This fishing pattern was confirmed not to be new. It is normal to have hot spots. Having these VMS data was considered useful. It was suggested that this map be superimposed on the density indices from the research surveys.
- The participants wondered about the density indices in the western part, which appeared to be lower.
- Dredging was noted to be more selective now. The changes took place about 10 years ago. The CPUE in recent years was likely not affected.

Decision rules

Decision rules for determining annual fishing effort have been in place since 2010. Effort is calculated using CPUE values derived from logbook data and research survey abundance indices. The 2022 CPUE places the stock in the high CPUE zone, and the density indicators are all above the 85th percentiles of the historical series. For 2023, fishing effort is at the maximum level established under the decision rules for Area 20A, i.e., 430 days at sea. The short- and medium-term outlook for the stock in Area 20A is very encouraging.

- A reminder of the background for the development of this approach appeared to be necessary.
- Some participants considered the maximum level to be set too high (430 days at sea). However, all these years later, this approach seemed to be working well.
- It was noted that perhaps a constant effort should be applied (e.g. 230 days).

Summary and recommendation – Magdalen Islands

The participants made a few comments. Only comments on the content are reported.

- In the key point on the research surveys, it was decided to move the information on the strong 40–65 mm cohort observed in 2022 to the last key point, which reads as follows: The short- and medium-term outlook for the stock in Area 20A is very encouraging. High abundances of 85–99 mm scallops were observed across all beds; these scallops will be available to the fishery in 2023. In addition, a strong cohort of 40–65 mm scallops has been observed in the Centre beds and will recruit to the fishery within 3–4 years. Some kind of protection would be beneficial for maximizing their survival.
- As for the key point on the decision rules, the sentence stating that fishing effort is to be reviewed annually after the indicators are updated was removed. Participants added that the 2022 CPUE placed the stock in the high CPUE zone and the density indicators are all above the 85th percentiles of the historical series.

CONCLUSION

MONITORING INDICATORS FOR THE MAGDALEN ISLANDS

The indicators to be monitored during the intervening years for the Magdalen Islands are as follows:

- Landings

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- CPUEs from logbooks
 - Abundance index from research surveys (commercial and non-commercial)
 - Update of fishing effort in the Magdalen Islands on the basis of these indicators (for seasons 2023 to 2025)

RESEARCH ACTIVITIES

Research priorities were established, including:

- Development of a rebuilding plan for areas 16E and 16F.
- Development of a stock assessment model for area 16F and proposed reference points.
- Expérience en bassins sur les effets de l'acidification et de la température (David Drolet).
- Several research projects are continuing in 2023 for areas 16EF:
 - Catherine Couillard and her teams: scallop condition and shell shape;
 - Virginie Roy and her team: new method for determining scallop age, growth, recruitment, environmental conditions from the shells, sexual maturity and maturity ogives, population genetics (collaboration with Geneviève Parent and Gregory Puncher).

APPENDIX 1 - TERMS OF REFERENCE

Stock Assessment of Scallop in Quebec Inshore Waters

Regional Peer Review – Quebec Region

March 8-9, 2023

Mont-Joli, Québec

Chairpersons: Hacène Tamdrari and Charley Cyr

Context

In the Gulf of St. Lawrence, two species of scallops are commercially fished, namely the sea scallop (*Placopecten magellanicus*) and the Iceland scallop (*Chlamys islandica*). The scallop fishery is an inshore fishery using the Digby dredge and catches are landed mostly as meat (muscle). Given the difficulty in visually distinguishing between the meat of the two species, commercial fishing statistics are presented regardless of the species. However, catches in any one area usually consist of just one species.

Quebec waters are divided into 24 fishing areas to which access is limited to a small number of fishermen. Fishing effort is controlled by a fishing season and catches are limited by quotas or by a limited number of fishing days.

At the request of the Fisheries Management Branch, resource assessment is done every three years. The last scallop stock review was done in 2020. The objective of the review is to determine whether changes that have occurred in the stock status necessitate adjustments to management plans based on the conservation approach used.

Objectives

Provide scientific advice on the management of scallop stocks in Quebec's inshore waters (management units 15 to 20) for the 2023-2025 fishing seasons. This advice shall include:

- Description of the biology of scallop and its distribution in Quebec's coastal waters;
- Description of the fishery including landings, fishing effort and management measures specific to the fishing areas;
- Analysis of catch per unit effort from the fishery;
- Analysis of data from the commercial at-sea and dockside sampling program;
- Analysis of data gathered during research surveys in unit 16E, 16F (Mingan), and 20 (Magdalen Islands);
- Presentation of significant environmental data for these species in actively fished areas;
- Presentation of a stock assessment model for Area 16E and a suggested limit reference point (LRP) for this area (TBC);
- Presentation of the most recent knowledge from Iceland scallop research projects;
- A review of the decision rule for the adjustment of fishing effort in the Magdalen Islands;
- Identification of indicators to follow the stock status during the years without a formal stock assessment;
- The identification and prioritization of research projects to be considered for the future;
- Perspectives for the 2023-2025 fishing seasons.

Expected Publications

- Science Advisory Report
- Research Document
- Proceedings

Expected Participation

- Fisheries and Oceans Canada (DFO) (Science, and Ecosystems and Fisheries Management sectors)
- Fishing industry
- Provincial representatives
- Aboriginal communities/organizations
- External experts

APPENDIX 2 - LIST OF PARTICIPANTS

Name	Affiliation	March 8	March 9
Arseneault, Line	Fisher North Shore	X	X
Arseneault, Lionel	Fisher North Shore	X	X
Belley, Rénaud	DFO – Science	X	X
Bermingham, Tom	DFO – Science	X	X
Bois, Samantha	ACPG	X	X
Boudreau, Mathieu	DFO – Science	X	-
Boudreau, Sophie	DFO – Science	X	-
Bourdages, Hugo	DFO – Science	X	X
Cervello, Gauthier	DFO – Science	X	-
Chlebak, Ryan	DFO – Science Ottawa	X	X
Couillard, Catherine	DFO – Science	X	X
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De Carufel, Valérie	DFO – Science	X	X
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Duplisea, Daniel	DFO – Science	-	X
Gianasi, Bruno	DFO – Science	X	-
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Lacasse, Olivia	DFO – Science	X	X
Nozères, Claude	DFO – Science	X	-
Parent, Geneviève	DFO – Science	X	-
Poitevin, Pierre	UQAR	X	X
Poulin, Jean-Michel	DFO – Fisheries Management	X	X
Roy, Marie-Josée	DFO – Fisheries Management	X	X
Sean, Anne-Sara	DFO – Science	X	X
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Smith, Andrew	DFO – Science	X	X
Tamdrari, Hacène	DFO – Science	X	X