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Proceedings of the regional peer review meeting on the assessment of the Estuary and Gulf of St. Lawrence shrimp stocks

January 22–23, 2020
Mont-Joli, Quebec

Chairperson: Bernard Sainte-Marie
Editor: Sonia Dubé

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

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Foreword

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

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SUMMARY

This document contains the proceeding from the meeting held within the regional assessment process of the Estuary and Gulf of St. Lawrence Shrimp stocks. This review process was held on January 22–23, 2020 at the Maurice Lamontagne Institute in Mont-Joli. This meeting gathered more than fifty participants from sciences to management to industry. This proceeding contains the essential parts of the presentations and discussions held and relates the recommendations and conclusions that were presented during the review.

INTRODUCTION

The Quebec Region of Fisheries and Oceans Canada (DFO) is responsible for assessing the stocks of several exploited fish and invertebrate species in the Estuary and Gulf of St. Lawrence. Most of these stocks are assessed periodically within a regional advisory process, which is conducted at the Maurice Lamontagne Institute in Mont-Joli. This document consists of the proceedings of the meeting held on January 22–23, 2020, on the assessment of the Estuary and Gulf of St. Lawrence shrimp stocks.

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, the ultimate goal being to provide scientific advice on managing the shrimp stock in the Estuary and Gulf of St. Lawrence for the 2020 fishing season.

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 review 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 review (Appendices 1 and 2). The proceedings also list the recommendations made by the meeting participants.

CONTEXT

Meeting chairperson Bernard Sainte-Marie welcomes the participants. He goes over the scientific review's objectives and agenda. After the participants introduce themselves, the biologist in charge of the review, Hugo Bourdages, highlights the contribution of his collaborators. He began his presentation by recalling the key role of the northern shrimp as a forage species. He describes the meeting plan and the Terms of Reference. This review will be used to provide scientific advice for the 2020 fishing season.

A synopsis of the fishery management measures is given. There are four fishing areas (Estuary, Sept-Iles, Anticosti and Esquiman) and 109 licences (five provinces and seven First Nations). Each area is subject to catch monitoring through the application of a Total Allowable Catch (TAC). A reminder of the shrimp life cycle allows to situate the development stages in relation to the harvesting periods and the temperature profile at depth. The data used in the assessment come from the commercial fishery (1982–2019) and the DFO research survey (1990–2019).

ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

Environmental and ecosystem considerations were presented before any details of the assessment were given. Peter Galbraith presented a summary of the temperatures observed in the three layers of water (surface, cold intermediate and deep layers) in the Gulf of St. Lawrence. The area of seabed covered by waters warmer than 6˚C is still extensive in the Anticosti Channel, the Esquiman Channel and in the central Gulf and has increased considerably in the northwestern Gulf. Deep-water temperatures have reached the highest level in 100 years across the Gulf, at depths of 250 m and 300 m. Despite the warming trend male and female shrimp have been observed at the same depths year after year. Between 2009 and 2019, water temperatures at a depth of 300 m increased by 1 to 1.3°C, depending on the region. In 2019, male and female shrimp were found at bottom temperatures 1°C warmer than the average from 1990 to 2010. It was also mentioned that the cold intermediate layer is colder in the Esquiman and Anticosti areas, which could benefit these stocks.

Low dissolved oxygen levels were recorded in the Estuary and at the channel heads, where there are dense shrimp populations. The results of Denis Chabot's research suggest that the distribution of shrimp stocks is still influenced by depth and possibly by sediments more than by temperature. The results likely under-estimate the effect of hypoxia, considering that the observed warming of deep waters could increase the metabolism of shrimp and boost their oxygen consumption. A lower pH could amplify this effect. The combined influence of these environmental variables on the nutritional value and the organoleptic quality of the shrimp was also studied. It appears that higher water temperatures have a slight effect on nutritional quality but organoleptic quality remains unchanged.

Questions were raised about the ability of shrimp to adapt to climate change. Egg development time is influenced by water temperature and hatching of the eggs in spring must be synchronized with the phytoplankton bloom to ensure high larval survival. However, with the warming of the waters, the start of the phytoplankton bloom has been occurring earlier. Since eggs develop faster in warmer water, it has been hypothesized that the timing of shrimp maturation and spawning has shifted to an earlier point in time to match the phytoplankton bloom. The mechanisms responsible for this adjustment remain unknown.

Ecosystem changes have also been observed, including an increase in the abundance of deepwater redfish (*Sebastes mentella*). Thus, the warming of deep waters and predation by redfish appear to be important factors in the decline of northern shrimp. Consumption of shrimp by redfish from the strong 2011 to 2013 year classes could further increase pressure on shrimp stocks in the coming years. These conditions are not expected to improve in the short term.

According to research done by Marie-Julie Roux, water temperatures and fishing pressure appear to determine the distribution patterns of northern shrimp in the Estuary and Gulf of St. Lawrence and might explain the changes in distribution observed in recent years. The effect of temperature is predominant in Esquiman and Anticosti, whereas the effect of fishing is dominant in the Estuary and appears to be significant in Sept-Îles. While redfish biomass has little effect on distribution patterns, it appears to influence the likelihood of occurrence of shrimp in the fishery. Redfish biomass appears to explain the observed reduction in the biomass of the shrimp population in recent years. While the predominant effect of temperature on shrimp distribution has been emphasized, some industry members have noted changes in shrimp distribution since the arrival of the redfish. It was pointed out that this could be linked to water depth, a parameter that was not considered in the study. The higher temperatures would also cause the shrimp to congregate, possibly increasing their vulnerability to predation and to the fishery.

Lastly, the genomics research that is under way in the northwestern Atlantic will enable comparison of three genetically distinct populations with respect to their differing ability to adapt to temperature stress.

ASSESSMENT OF THE RESOURCE

BYCATCHES

Mr. Bourdages gives an overview of the following shrimp fishery bycatches: Greenland halibut, redfish, Atlantic cod, capelin, Witch flounder, American plaice and Atlantic halibut.

- A few clarifications on the at-sea observer program were made. It appears that the 5% coverage has not been achieved in recent years in some areas.
- The existence of a small fish protocol to limit by-catches of small fish (closure when 4–5% catches of small fish) was recalled.

COMMERCIAL FISHERY

For each area, Bourdages presented the commercial fishery indicators (landings, effort, catch per unit effort [CPUE], distribution of effort based on data from logbooks and VMS data, length frequencies and number per unit effort (NPUE). In 2019, preliminary landings for all the shrimp fishing areas totalled 16,161 t against a TAC of 17,335 t. The CPUE values for the commercial fishery decreased between 2014 and 2017. Since then, CPUE has stabilized in Sept-Îles, Anticosti and Esquiman and has increased in the Estuary. The CPUE values from recent years are comparable to those observed in the early 2000s.

- According to industry members, the use of the twin trawl remains marginal. Therefore, the increased effectiveness associated with this type of trawl should be negligible across the entire series.
- A contraction in the spatial distribution of fishing effort has been observed, along with the abandonment of certain traditional fishing areas. Southern Anticosti was given as an example. For some, the decrease in biomass observed in this region is linked to that in Sept-Îles. The possibility of predation by redfish was also mentioned.
- There is concern about the decrease in the size of female shrimp and the impact on reproductive potential. This decrease in size needs to be taken into consideration during the interpretation of indicators (CPUE and NPUE).

RESEARCH SURVEY

Bourdages presented the indicators from the DFO research survey (distribution, biomass, abundance of females, males and juveniles, length frequencies). In 2019, the biomass values estimated from the survey were similar or slightly higher than the 2018 estimates for Sept-Îles, Anticosti and Esquiman. The biomass values estimated since 2017 in these areas were low and comparable to the values from the early 1990s. In the Estuary, large interannual variations can be seen in the estimated biomass; the 2017 and 2018 values were among the lowest in the series (1990–2019) whereas the 2019 value was among the highest.

Northern shrimp is still widespread in the northern Gulf of St. Lawrence but since 2008 the research survey has shown a decreasing trend in the area in which northern shrimp are concentrated. This trend is reflected in commercial fishery data as well, with harvesters abandoning certain fishing grounds due to the low abundance of shrimp. The decreasing trend in the size of females and the low abundance of males observed in recent years indicate low stock productivity.

- Although the 2019 survey was incomplete, it was pointed out that the strata that were not covered in 2019 have little influence on the assessment of biomass, because shrimp abundance is always low in these strata.
- To reduce the uncertainty associated with the shrimp biomass in the Estuary, it was suggested that stations be added, which does not seem realistic in the present context. Instead it seems more appropriate to consider how to integrate data from the shallower water strata.
- It seems possible to link the abundance of juveniles (as reflected by the graph of the index of juveniles) to the abundance of juveniles that will recruit to the adult biomass several years later.
- The participants asked about the high biomass values estimated in 2003. This annual effect is observed in other species and should be taken with a grain of salt.

- Finally, the observed changes in the spatial distribution of the fishery appear to partly explain the recent differences between the fishery indices and the research survey indices. Clearly, the fishery concentrates its effort in the areas with the highest shrimp abundance.
- A comparison of the survey and the fishing sites suggests that a relatively small proportion of shrimp are present outside the fishing grounds, except in Anticosti. The proportion of the biomass estimated by the survey outside the fishing grounds has declined in recent years. If the survey is examined solely for the area fished, the survey CPUEs (area fished) are comparable to the fishery CPUEs.
- It is considered appropriate to review the boundaries of the management units taking into account the current situation of shrimp distribution.
- It would also be useful to better document historical changes in gear and technology in order to more effectively assess changes in catchability and effective effort over time. A number of industry members said that they are concerned about this aspect.

EXPLOITATION RATE

The exploitation rate indicator for Sept-Îles and Esquiman declined in 2019 and is comparable to the series average, whereas the indicator for Anticosti increased above the average in 2018 and 2019. In the Estuary, this indicator varies widely; in 2019, it reached the lowest value in the series.

PRECAUTIONARY APPROACH

The methodology used in the precautionary approach (PA) framework was presented. In 2019, the main stock status indicator increased slightly in Anticosti, Esquiman and Sept-Îles, but rose significantly in the Estuary. The indicator had declined sharply for all four stocks in previous years. In 2019, the Estuary, Anticosti and Esquiman stocks were in the healthy zone whereas the Sept-Îles stock remained in the cautious zone.

According to the guidelines established as part of the precautionary approach, the projected harvest levels for 2020 are 1,524 t for the Estuary, 5,123 t for Sept-Îles, 6,311 t for Anticosti and 6,142 t for Esquiman. Fisheries Management will set the TACs based on this information.

- In keeping with the precautionary approach, the main indicator gives equal weighting to the fishery indicators and the research survey indicators. It was emphasized that the survey makes it possible to carefully monitor population dynamics and that it may better represent stock status.
- It was suggested that historical values be presented in the graph of removals in relation to the stock status indicator.

COMPLEMENTARY RESEARCH

Research has been undertaken to examine the feasibility of using a risk-based approach to incorporate the effects of the observed ecosystem changes in the assessment of shrimp stocks and the formulation of the science advice. The approach presented by Marie-Julie Roux and Daniel Duplisea is based on analysis and risk management methods. The ecosystem changes influence the uncertainty associated with the data acquisition process (observation uncertainty) and the uncertainty associated with stock dynamics (process uncertainty). This approach makes it possible to assess resource status and to condition harvest advice by considering the state of the environment (favourable or unfavourable). A risk-based approach can be used with different levels of knowledge and data availability. For example, Marie-Julie Roux described a semi-

quantitative method that can be used to condition the harvest control rules so as to reduce removals where environmental conditions are unfavourable. As another example, Daniel Duplisea presented an approach based on the empirical relationship between shrimp stock productivity and certain environmental variables (e.g., bottom temperatures, predation), outlining the situations in which this approach would be useful.

- It was noted that this type of exercise is complex and that the relationships between stock productivity parameters and ecosystem variables are seldom robust over time.
- It should be understood that these studies are preliminary and given as an example, and that, for the time being, the results must be treated with caution.
- Care must be taken in selecting the reference period so as to ensure that it represents a period of stability. It is also important to carefully document inputs through effective data collection.
- The participants expressed satisfaction with the work accomplished while recognizing that there is still much to do. They agreed on the importance of continuing this work.

CONCLUSION

SUMMARY

The highlight were presented, and the participants commented on them. Clarifications were provided and some points were restructured.

- It was indicated that the first highlight concerning landings and the 2019 TAC should remain factual.
- After some discussion on the evolution of CPUEs, it was agreed to indicate that they decreased between 2014 and 2017.
- After several comments on the changes in biomass estimated by the survey, it was decided to conserve the first version of the highlight. “Estimated” biomass would still be used.
- In the highlight on projected harvest levels for 2020, it should be specified that the TAC will be established by Fisheries Management on the basis of this information.
- With regard to the highlight concerning the warming of waters, it should be made clear that this refers to the deep water layers. It was decided that the second sentence should be replaced by: “These conditions are not expected to improve in the short term.”
- In the highlight on recruitment, reference will be made to the low abundance of males (instead of recruitment), which seems more appropriate. In the second sentence, the wording will be changed to “indicates low productivity” from “affects productivity.”
- The participants decided to remove the last highlight which concerns the outlook, as it was considered too speculative.

INTERIM YEARS

The Estuary and Gulf of St. Lawrence Northern Shrimp stock is reviewed every two years. For the interim years, an update of the following indices is planned:

- Landings
- Summer fishery CPUE (male and female)

- Abundance index from the survey (male and female)
- Main stock status indicator
- Projected harvest

RESEARCH

Mr. Bourdages cites some recent publications[1] and briefly outlines DFO contributions as part of the Northern Shrimp strategic research plan (Appendix 3).

[1] Brosset, P., Bourdages, H., Blais, M., Scarratt, M., and Plourde, S. 2019. Local environment affecting northern shrimp recruitment: a comparative study of Gulf of St. Lawrence stocks. ICES J. Mar. Sci. 76(4): 974-986.

Tamdrari, H., Benoît, H., Hanson, J.M., Bourdages, H., and Brêthes, J.C. 2018. Environmental associations and assemblage structure of shrimp species in the Gulf of St. Lawrence (Canada) following dramatic increases in abundance. Mar. Ecol. Progr. Ser. 596: 95-112.

Ouellet, P., Chabot D. Calosi, P., Orr, D. and Galbraith, P.S. 2017. Regional variations in early life stages response to a temperature gradient in the northern shrimp Pandalus borealis and vulnerability of the populations to ocean warming. J. Exp. Mar. Biol. Ecol. 497, 50-60.

APPENDIX 1 – TERMS OF REFERENCE

Assessment of Estuary and Gulf of St. Lawrence shrimp stocks

Regional Peer Review - Quebec Region

January 22-23, 2020
Mont-Joli, QC

Chairperson: Bernard Sainte-Marie

Context

The Estuary and northern Gulf of St. Lawrence are divided in four shrimp fishing areas (SFA): Estuary (SFA 12), Sept-Iles (SFA 10), Anticosti (SFA 9) and Esquiman (SFA 8). Shrimp fishing is regulated by a number of management measures, including the setting of total allowable catches (TAC) in the four areas.

The key elements for the establishment of a precautionary approach (PA) were adopted in 2012. Reference points were determined and guidelines have been established to determine harvest based on the stock status main indicator and its position relative to healthy, cautious and critical zone classification.

Objectives

Provide scientific advice for the management of Northern Shrimp stocks in the Estuary and Gulf of St. Lawrence (SFA 8, 9, 10 and 12) for the 2020 fishing season. This advice shall include:

- Description of the biology of Gulf of St. Lawrence Northern shrimp and its distribution;
- A summary of oceanographic and ecosystem conditions in the Gulf;
- Analysis of commercial fishery data including landings, effort, catch per unit of effort and data from the commercial sampling program;
- Data analysis of the DFO research surveys in August in the estuary and northern Gulf.
- Update of the main stocks status indicator.
- A recommendation on harvest according to PA guidelines for the 2020 fishing season.
- Comment the outlook for stock abundance.
- Estimate by-catches during the directed fishery on Northern Shrimp.
- Identification and prioritization of research projects to be considered for the future.

Expected Publications

- CSAS Science Advisory Report on Estuary and Gulf of St. Lawrence shrimp.
- CSAS Research documents
- CSAS Proceedings summarizing discussions.

Participation

- Fisheries and Oceans Canada (DFO) (Science, and Ecosystems and Fisheries Management sectors)
- Fishing industry
- Provincial representatives
- Aboriginal Communities / Organizations

APPENDIX 2 – LIST OF PARTICIPANTS

Name	Affiliation	January 22	January 23
Alberio, Marco	UQAR	-	x
Cormier Baldwin, Johanne (tél)	MAAP – NB	x	x
Barria, Aura[2]	UQAR	-	x
Beauchamp, Brittany	DFO – Science	x	x
Beaulieu, Jérome	DFO – Fisheries Management	x	x
Bermingham, Tom	DFO – Science	x	x
Boissonneault, Maude	UQAR	x	x
Boudreau, Mathieu	DFO – Science	x	x
Bourdages, Hugo	DFO – Science	x	x
Bourdages, Yan	ACPG	x	-
Bowlby, Heather	DFO – Science	x	x
Brassard, Claude	DFO – Science	x	x
Brown-Vuillemin, Sarah	UQAR	x	x
Brulotte, Sylvie	DFO – Science	x	-
Bruneau, Benoît	DFO – Science	x	-
Calosi, Piero	UQAR	-	x
Cassista-Daros, Manon	DFO – Science	x	x
Castonguay, Martin	DFO – Science	x	x
Chabot, Denis	DFO – Science	x	-
Chamberland, Jean-Martin	DFO – Science	x	-
Couillard, Catherine	DFO – Science	x	x
Côté, Mario	Shrimper - ACPG	x	x
Dennis, Bill	FLR – NF	x	x
Desgagnés, Mathieu	DFO – Science	x	x
Dewland, Jennifer	PEI Fishermen's Association	x	x
Dubé, Sonia	DFO – Science	x	x
Duplisea, Daniel	DFO – Science	x	x
Dupuis, Vincent	ACPG	x	x
Élément, Patrice	ACPG	x	x
Faille, Geneviève	DFO – Science	x	-
Ferguson, Annie (tél)	MAAP – NB	x	x
Galbraith, Peter	DFO – Science	x	-
Gauthier, Johanne	DFO – Science	x	x
Gionet, Norbert	ACAG – FRAPP	x	x
Guscelli, Ella	UQAR	x	x
Isabel, Laurie	DFO – Science	x	x
Lacroix-Lepage, Claudie	DFO – Science	x	x
Lanteigne, Jean	FRAPP	x	x
Légère, Michel	ACAG – FRAPP	x	x
Lemire, Maryse	DFO – Fisheries Management	x	x
Marquis, Marie-Claude	DFO – Science	x	x
Méthot, Chantal	DFO – Science	x	x
Noisette, Fanny	UQAR – ISMER	x	x
Nozères, Claude	DFO – Science	x	x
Ouellette-Plante, Jordan	DFO – Science	x	x
Parent, Geneviève	DFO – Science	-	x
Pellerin, Mathieu	DFO – Fisheries Management	x	x
Pomerleau, Corinne	DFO – Science	x	x
Plourde, Stéphane	DFO – Science	x	x
Robichaud, Roger	DAAF – NB	x	x
Roussel, Eda	ACAG – FRAPP	x	x

Name	Affiliation	January 22	January 23
Roux, Marie-Julie	DFO – Science	x	x
Scallon-Chouinard, Pierre-Marc	DFO – Science	x	x
Sainte-Marie, Bernard	DFO – Science	x	x
Sandt-Duguay, Emmanuel	AGHAMM – GMRC	x	x
Senay, Caroline	DFO – Science	x	x
Soubirou, Marina	UQAR	x	-
Small, Daniel	UQAR	-	x
Spingle, Jason	FFAW – NL	x	x

APPENDIX 3 – STRATEGIC RESEARCH PLAN

DFO's contribution to the Northern Shrimp strategic research plan

Topic A. Shrimp productivity and sustainable harvesting

Sub-topic A1. The abundance of shrimp stocks in the Estuary and Gulf

- Status assessment of shrimp stocks by continued monitoring activities intended to calculate stock status indicators and determine the appropriate fishery catch shares consistent with the precautionary approach adopted in 2012 – DFO (Core Program)

Sub-topic A2. The trophic relationships between shrimp and its predators

- Study of diets of major groundfish - DFO (Core Program and Partnership Fund)

Sub-topic A3. Environmental factors influencing shrimp productivity

- Status assessment of the physical and biochemical oceanographic environment of the Gulf of St. Lawrence by continuing the Atlantic Zone Monitoring Program to detect, monitor and foresee changes in productivity and marine environment status – DFO (Core Program)
- Assessment of synergic effects of various environmental stressors combined with acidification on the physiology, growth and survival of invertebrates that are harvested commercially in the St. Lawrence – DFO (Strategic Program for Ecosystem-Based Research and Advice 2014–2017)
- Linking physiology to biogeography of Northern shrimp to facilitate adaptation to climate change – DFO (Strategic Program for Ecosystem-Based Research and Advice 2017-2020)
- PANOMICS: Integrating Genomics into Current and Future Spatial Management of Northern Shrimp along the Canadian Coast – DFO (Genomics Research and Development Initiative, 2019-2022)
- REDTANKS: understanding the environmental requirements and shrimp consumption of the redfish (*Sebastes* spp.) using tank experiments – DFO (Results Fund, 2019-2021)
- Ecosystem Approach, Shrimp Pilot Project – DFO (2019-2021)
- The Return of Groundfish to the Estuary and Northern Gulf of St. Lawrence – DFO (Partnerships Fund, 2017-2020)

Topic B. The impacts of the fishery on the ecosystem

Sub-topic B1. Vulnerable benthic habitats and communities

- Study of the distribution, spatial structure, reproduction, ecosystem function and vulnerability to trawling of sea pen fields in the Gulf of St. Lawrence in support of the "Eastern Canadian Coral and Sponge Conservation Strategy" – DFO (Strategic Program for Ecosystem-Based Research and Advice 2014–2017)

Sub-topic B2. Species not targeted by the fishery

- Assessment of the significance of shrimpers' bycatch by analyzing data from the At-Sea Observer Program activity monitoring – DFO (Core Program)