

SUBMISSION TO THE
NUNAVUT WILDLIFE MANAGEMENT BOARD
AND NUNAVIK MARINE REGION WILDLIFE BOARD

FOR

Information:

Decision: X

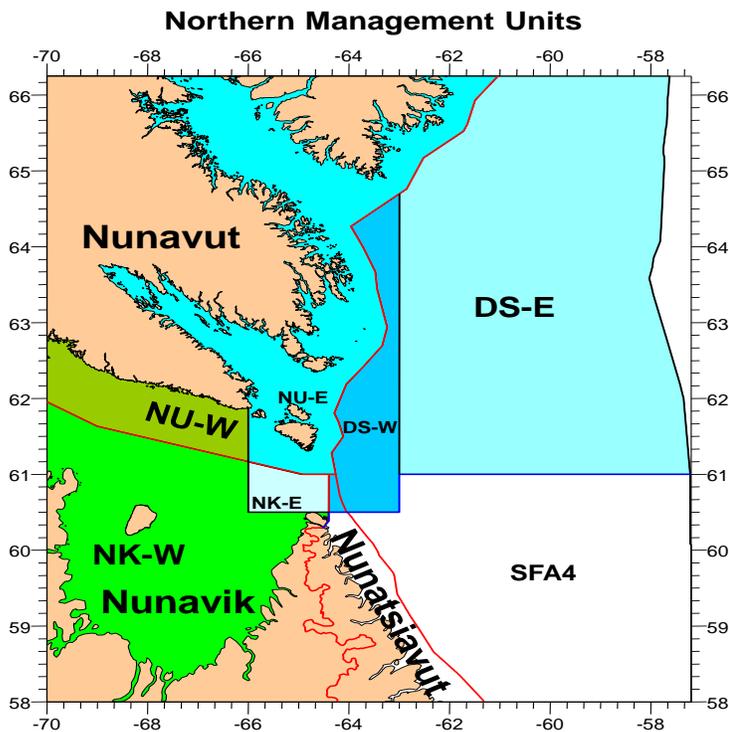
Recommendation: X

Issue: Upper Stock Reference: Precautionary Approach Framework for Northern (*Pandalus borealis*) and Striped (*P. montagui*) Shrimp in the Western and Eastern Assessment Zones

Map:

Blue areas – Eastern Assessment Zone

Green areas – Western Assessment Zone



Northern shrimp (*Pandalus borealis*)



Striped shrimp (*Pandalus montagui*)

Background

Further to briefing notes provided for information to the Nunavut Wildlife Management Board (NWMB) and the Nunavik Marine Region Wildlife Board (NMRWB) (the Boards) in December 2020 and March 2021, work has been conducted through the Northern Precautionary Approach Working Group (NPAWG) to develop advice on a Precautionary Approach (PA) Framework for stocks in the Western and Eastern Assessment Zones (WAZ and EAZ).

Further information on the composition of this working group and its purpose and objectives is outlined in the NPAWG: Status Report (February 2021) and was provided to the Boards at their regular meetings in March 2021 (Appendix 1).

The primary components of a complete PA Framework will include the Limit Reference Point (LRP) and Upper Stock Reference (USR) to define three stock status zones (Healthy, Cautious and Critical Zones), as well as harvest decision rules (HDRs) for each stock. Development of a PA Framework will serve to guide fisheries management decisions and contribute to sustainable management of *P. montagui* and *P. borealis* in these areas.

A summary of NPAWG discussions on the primary PA components with outcomes was presented by the Chair of NPAWG to the Northern Shrimp Advisory Committee (NSAC) on March 9, 2021. As outlined in the Status Report (February 2021), DFO Science has established LRPs for stocks in the WAZ and updated pre-existing LRPs for stocks in the EAZ. These LRPs are considered implemented and remain in effect until such a time as they are revised by DFO Science.

With support from NPAWG, advice on USRs for *P. montagui* and *P. borealis* stocks in the WAZ and EAZ is now available. DFO is seeking Board decisions and recommendations, as appropriate, to establish USRs that could be implemented in the 2021-22 fishery. This approach would implement a partial PA Framework while work on HDRs is ongoing. Recognizing the interrelationship between HDRs and reference points in achieving fisheries management objectives, as HDRs are developed, USRs would be reviewed to ensure compatibility.

Analysis and Recommendations

Through a series of working group sessions held from November 2020 to April 2021, members of the NPAWG have shown support for USRs established at **70% of the geometric mean of the Spawning Stock Biomass (SSB) index for the available time series, for each stock in the WAZ and EAZ. DFO effectively advances this as a recommendation for consideration by the Boards.** Recommended USR values (in tonnage) are shown for each stock at Table 1 and in figures at Appendix 2.

Through its deliberations, NPAWG considered USRs initially proposed by DFO Science at 80% of the geometric mean of the SSB index for the available time series (Appendix 3; Appendix 4). The proposed USRs are consistent with the DFO PA Policy in cases where

insufficient stock-specific information is available. USRs proposed at the 80% level were characterized as a starting point for further discussion by NPAWG, where the establishment of the USR remains a management decision, driven by productivity objectives for the stock, broader biological considerations and social and economic objectives for the fishery.

In supporting a slightly lower USR at 70%, NPAWG considered the high degree of year-to-year variability in stock status indicators (fishable and SSB) for *P. montagui* and *P. borealis*, recalling that no discernable trend has been observed for either species in the WAZ and EAZ. NPAWG considered that annual stock status (Healthy, Cautious or Critical Zone) was not likely to be affected by placement of the USR at a lower level, where the magnitude of year-to-year fluctuations in SSB for these stocks is typically greater than +/-10% (the difference between a USR at 70% or 80%).

From a socio-economic standpoint, industry has pointed to prospective harm to product marketability where stocks enter a Cautious Zone. Increasing the size of the Healthy Zone by establishing a lower USR (70%) could be a means to lessen the frequency of entering the Cautious Zone and avoid or forgo the associated negative financial impacts.

NPAWG acknowledged that establishing USRs at 70% would define the boundaries of a more narrow Cautious Zone and would leave less time for management to respond to stock declines towards the LRP. The working group discussed that this concern could be addressed by HDRs that prescribe more drastic responses to stock declines in the Cautious Zone (e.g., greater reductions in TAC, lower target exploitation rate, etc.).

It remains a policy priority for DFO to implement complete PA Frameworks that include reference points for each stock, enabling the Department to report on stock status through the annual Sustainability Survey for Fisheries. This is particularly pertinent in the case of EAZ stocks to ensure that USRs previously in place for a number of years are replaced.

Lastly, NPAWG industry members have supported and prioritized the establishment of a USR for *P. montagui* in the WAZ in an effort to satisfy a condition for Marine Stewardship Council (MSC) certification of this fishery. This MSC condition requires that reference points be established for this stock by 2021.

Table 1. Limit Reference Points and recommended Upper Stock Reference points for *P. borealis* and *P. montagui* in the Western and Eastern Assessment Zones.

Species	Western Assessment Zone (WAZ)		Eastern Assessment Zone (EAZ)	
	LRP (40%)	USR (70%)	LRP (40%)	USR (70%)
Northern Shrimp (<i>Pandalus borealis</i>)	4,100t *New	7,200t *New	15,800t *Updated	27,600t *Updated
Striped Shrimp (<i>Pandalus montagui</i>)	12,300t *New	21,500t *New	3,100t *Updated	5,400t *Updated

Summary of the Request

To implement a partial PA Framework for *P. borealis* and *P. montagui* stocks in the WAZ and EAZ for the 2021-22 fishery, decisions and recommendations from the Boards following matters are requested on the as soon as possible:

Western Assessment Zone:

1. Decisions on a USR for *P. borealis* and *P. montagui*, respectively.

Eastern Assessment Zone:

1. In the NU/NK E management units, decisions on a USR for *P. borealis* and *P. montagui*, respectively.
2. In the Davis Strait management units, recommendations on a USR for *P. borealis* and *P. montagui*, respectively.

Note: It is envisaged to establish a single USR for each stock for the entire assessment zone (i.e. established on an assessment zone rather than management unit scale), for which there was clear support within the NPAWG. Therefore, decisions and recommendations from NWMB and NMRWB must be compatible in order to be considered for implementation by the Minister of Fisheries and Oceans.

Prepared by: Courtney D’Aoust, Fisheries Resource Management, Fisheries and Oceans Canada

Date: May 7, 2021

Appendices

APPENDIX 1 – Northern Precautionary Approach Working Group: Status Report (February 2021)

APPENDIX 2 – (Figures 1 -4) Established Limit Reference Point and Recommended Upper Stock Reference for *P. borealis* and *P. montagui* in the Eastern and Western Assessment Zones.

APPENDIX 3 – [SUMMARY] DFO. 2020. Science Advice on Limit Reference Points for Northern Shrimp (*Pandalus Borealis*) and Striped Shrimp (*Pandalus Montagui*) in the Eastern and Western Assessment Zones. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/053.

APPENDIX 4 – [FULL PUBLICATION] DFO. 2020. Science Advice on Limit Reference Points for Northern Shrimp (*Pandalus Borealis*) and Striped Shrimp (*Pandalus Montagui*) in the Eastern and Western Assessment Zones. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/053.

Northern Precautionary Approach Working Group: Status Report

February 2021

Disclaimer: This report is intended to be a status report only and is not intended for use in decision making. A final NPAWG report will be prepared upon conclusion of working group sessions.

Composition & Structure

The Northern Precautionary Approach Working Group (NPAWG) was established in November 2020. The working group is composed of co-management partners, relevant industry stakeholders, provincial governments and officials from Fisheries and Oceans Canada (DFO). A complete list of NPAWG members is at Appendix 1.

Discussions of NPAWG have proceeded through a series of virtual meeting from November 2020 to February 2021. A consultation schedule is at Appendix 2.

Purpose & Objectives

The purpose of NPAWG is to provide advice on the primary components of a Precautionary Approach (PA) Framework for Northern shrimp (*Pandalus borealis*) and Striped shrimp (*P. montagui*) stocks in the Western Assessment Zone (WAZ), and an updated PA Framework for these stocks in the Eastern Assessment Zone (EAZ).

Consistent with the [Fishery Decision-Making Framework Incorporating the Precautionary Approach](#) (DFO, 2009) (referred to herein as DFO's PA Policy), the primary components of the PA Framework will include reference points to define three stock status zones (Healthy, Cautious and Critical Zones (Figure 1)) as well as a harvest strategy that may include Harvest Decision Rules (HDRs).

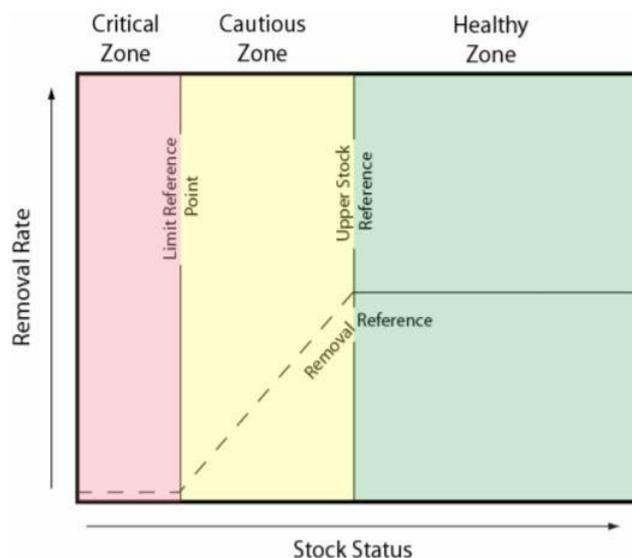


Figure 1. Fisheries management framework consistent with a precautionary approach.

A PA Framework for these stocks will serve to guide fisheries management decisions and contribute to sustainable management of the resource in these areas. In addition, efforts to develop a PA Framework for *P. montagui* in the WAZ, specifically developing a Limit Reference Point (LRP) and a Target Reference Point (TRP)), are directly related to conditions for Marine Stewardship Council (MSC) certification of this fishery.

Limit Reference Points (LRP)

Consistent with DFO’s PA Policy, LRPs are established by DFO Science as the point below which serious harm is occurring to the stock. In May 2020, a Canadian Science Advisory Secretariat (CSAS) peer review process was convened to establish LRPs for *P. borealis* and *P. montagui* stocks in the WAZ, and update existing LRPs for these stocks in the EAZ. Publications from this peer-review process were released in November 2020 and distributed to NPAWG members. A copy of the Science Advisory Report (2020/053) was provided to the NWMB and NMRWB for December 2020 and March 2021 Board meetings.

- [Terms of Reference](#)
- [Science Advisory Report 2020/053](#)
- [Research Document 2020/072](#)
- [Proceedings 2020/024](#)

LRPs developed through the May 2020 peer review process were established at 40% of the geometric mean of the Spawning Stock Biomass (SSB) index for the available time series (Table 1).

Table 1. *Limit Reference Points and proposed Upper Stock Reference points¹ for P. borealis and P. montagui in the Western and Eastern Assessment Zones.*

Species	Western Assessment Zone (WAZ)		Eastern Assessment Zone (EAZ)	
	LRP (40%)	USR ¹ (80%)	LRP (40%)	USR ¹ (80%)
Northern Shrimp <i>(Pandalus borealis)</i>	4,100t *New	8,200t	15,800t *Updated <i>(increase from 6,800t implemented in 2009)</i>	31,600 *Updated <i>(increase from 18,200 implemented in 2009)</i>
Striped Shrimp <i>(Pandalus montagui)</i>	12,300t *New	24,600t	3,100t *Updated <i>(increase from 2,300t implemented in 2009)</i>	6,100t *Updated <i>(no change from 6,100t implemented in 2009)</i>

¹ USRs indicated in Table 1 were proposed by DFO Science. USRs require Board decisions and recommendations (as appropriate) prior to being established.

NPAWG Discussion

Although the development of LRPs for shrimp stocks in the WAZ and EAZ does not fall within the scope of NPAWG purpose and objectives, the working group did discuss general concerns toward the established reference points. In a submission from the Canadian Association of Prawn Producers (CAPP) and a joint submission from the Nunavut Fisheries Association (NFA) and Northern Coalition (NC), industry maintained that environmental and population dynamics of Northern shrimp stocks had not been adequately examined in setting the LRPs. Further, members expressed concern for the level of precaution taken in setting LRPs and that these reference points should be implemented on a temporary basis only.

Officials from DFO discussed the level of available information (limited data time series) and degree of uncertainty as to the point below which serious harm may be occurring to these stocks, noting the consensus of the May 2020 CSAS participants to exercise greater precaution in setting the LRPs. Representatives from the Government of Quebec and Government of Nunavut expressed concern for lack of an established plan or committed funds that could provide additional data (specifically, environmental and ecosystem data) for the WAZ and EAZ that could mitigate uncertainty and potentially lead to revised reference points in the near term.

Outcome

LRPs are considered implemented and remain in effect until such a time as they are revised by DFO Science. Accordingly, no decisions or recommendations are to be sought from the NWMB or NMRWB, nor the Northern Shrimp Advisory Committee (NSAC) on these biological points.

Upper Stock Reference Points (USR)

Consistent with DFO's PA Policy, the USR is the stock level threshold below which removals must be progressively reduced in order to avoid reaching the LRP. The establishment of the USR is a management decision, driven by productivity objectives for the stock, broader biological considerations and social and economic objectives for the fishery. This decision is, therefore, informed by consultations with fishery and other interests, with advice and input from Science. NPAWG served as the body for this consultative process. USRs require Board decisions and recommendations (as appropriate) prior to being established by the Minister of Fisheries and Oceans Canada.

As part of the May 2020 CSAS peer review process, DFO Science also proposed USRs for stocks in the WAZ and proposed updated USRs for stocks in the EAZ. USRs were proposed at 80% of the geometric mean of the SSB index for the available time series (Table 1).

NPAWG Discussion

To a great extent, the working group discussed year-to-year variability in stock status indicators (fishable and SSB) for *P. borealis* and *P. montagui* in the WAZ and EAZ, recalling that no discernable trend has been observed for either species. Given influences beyond fishing mortality and the lack of trends that can be derived from a relatively limited time series, some NPAWG members felt that measures should be taken to mitigate the effects of this variability.

Measures discussed by the working group included the suggestion of a USR established at 70% of the geometric mean of the SSB index for the available time series. Some members proposed that averaging of multiple (2 or 3) SSB indices would be used to determine stock status relative to PA reference points. DFO Science maintained that the clearest and most recent expression of stock status is represented as a single data point, rather than an average. In reaction to this position, some working group members then proposed that a USR not be developed and instead NPAWG focus on a Target Reference Point (TRP) to satisfy MSC conditions. These measures would effectively reduce, or eliminate, the potential for stocks to enter a defined Cautious Zone. Industry members pointed to significant prospective harm to product marketability where stocks enter a Cautious Zone.

From DFO's perspective, stock status is exclusively within the Science sector's area of responsibility and a single-year value is the clearest expression of that status for a given point in time. Additionally, it was noted that USRs are an integral part of DFO's PA policy, primarily serving as a point sufficiently above the LRP "to provide an opportunity for the management system to recognize a declining stock status and sufficient time for management actions to have effect". In keeping with DFO's PA policy, the USR is critical in defining the boundary between the Healthy and Cautious Zones and DFO continues to report in this context through the annual [Sustainability Survey for Fisheries](#).

It remains a policy priority for the Department to establish complete PA Frameworks for Canada's fisheries that include a USR. The establishment of a TRP without an accompanying (or dual purpose) USR would represent a departure from this priority. This would be particularly pertinent in the EAZ where a USR has been in place for a number of years.

Outcome

NPAWG members have shown significant support for a USR established at 70% of the geometric mean of the SSB index for the available time series, for stocks in the WAZ and EAZ. Ongoing work to develop HDRs has considered the USR at this prospective level. Members continue to see the establishment of a USR as coupled with the development of HDRs given their combined effect on potential fishing opportunities and stock conservation.

Harvest Decision Rules (HDRs)

Consistent with DFO's PA Policy, pre-agreed Harvest Decision Rules (HDRs) and management actions for each zone within the PA Framework are essential components of a harvest strategy. HDRs prescribe harvest rates and possibly other management procedures for each zone or steps within a zone. HDRs have not been established for stocks in the WAZ. HDRs are established within the [Integrated Fisheries Management Plan \(Annex I\)](#) for stocks in the EAZ and remain in effect until these have been revised.

NPAWG Discussion

Through initial discussions had to date, NPAWG has explored ways in which HDRs could accommodate significant variability in biomass indices for *P. borealis* and *P. montagui* stocks in the WAZ and EAZ. Industry noted the objective to promote catch stability in the short term ahead of a desired review of PA reference points, and the general need for predictability in annual Total Allowable Catch (TAC) levels. A number of proposals were prepared by industry representatives and presented to the working group for consideration.

One proposed HDR approach looked to establish a baseline TAC that could remain constant, with a trigger to respond to an unusual change in biomass patterns observed over the time series. The proposed trigger would consider the three-year average of the SSB index relative to the half-way point of Cautious Zone, and if below, would result in significant reduction in the TAC.

A second proposal presented the option to consider biomass indices for each species as a combined total for the WAZ and EAZ as a means to reduce year-to-year variability. Exploitation rates (e.g. 20% exploitation rate in the Healthy Zone) could be applied to a three-year average of combined fishable biomass estimates to generate TAC levels for each species across a combined area. It was proposed that these TAC levels then be proportionally divided between the WAZ and EAZ.

The working group continues to consider industry proposed measures with possibility to suggest modifications or new approaches for consideration in future discussions.

Outcome

The development of HDRs for WAZ stocks and any possible revisions to existing HDRs for EAZ stocks is ongoing. Where a number of industry proposals have been brought forward to date, DFO is expected to present its response and/or additional option(s) for consideration by the working group in future sessions.

Other Areas of Discussion: Review Provision

Given the limited time series and uncertainty surrounding the stocks in the EAZ and WAZ, many group members stated a strong preference for a PA to be reviewed in the near-term (i.e., 2-5 years). Members suggested the benefit of doing so with the aid of additional survey results and, preferably, incremental science work that could provide some information related to environmental and ecological influences on these stocks.

NPAWG Discussion

DFO raised concern that a defined expiry date on a PA Framework is unlikely to be supported by DFO decision-makers and acknowledged that there could be implications for MSC certification for these fisheries in the event a PA Framework (including reference points) is not in place. The notion of a review after a certain time period was discussed.

DFO Science noted that the knowledge of these stocks is not likely to increase to an extent that could result in a different outcome in the development of a PA Framework to that being undertaken now. DFO proposed that the working group recommend a review of reference points (and any additional components of a PA Framework) in 4 or 5 years (i.e., 2025 or 2026), principally through the establishment of a committee to commence an initial review and to ultimately consider the merit of modifying the PA Framework at that time. Associated with the notion of available data for the WAZ and EAZ, NPAWG has noted the need for additional science to improve environmental knowledge.

Next Steps

NPAWG should reconvene to discuss on HDRs in mid-to-late March. Pending the outcomes of these sessions, DFO will seek decisions and recommendations from the NWMB and NMRWB on USRs and HDRs at the next opportunity.

Fisheries and Oceans Canada (DFO) Members

Derek Mahoney (Resource Management Operations (RMO), Ottawa) (*Chair*)
Courtney D'Aoust (RMO, Ottawa)
Leigh Edgar (RMO, Ottawa)
Christi Friesen (RM, Arctic)
Jeff Adam (RM, Arctic)
Sheri Friesen (RM, Arctic)
Felix Dionne (RM, Quebec)
Jérôme Beaulieu (RM, Quebec)
Martin Henri (RM, Newfoundland and Labrador)
Wojciech Walkusz (Science, Ontario & Prairie)
Krista Baker (Science, Newfoundland and Labrador)
Katherine Skanes (Science, Newfoundland and Labrador)
Brittany Beauchamp (Science, Ottawa)

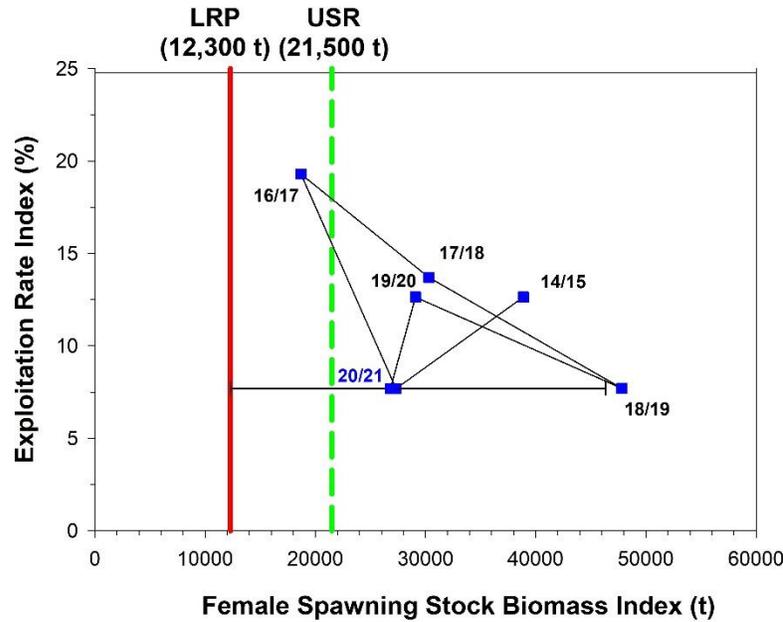
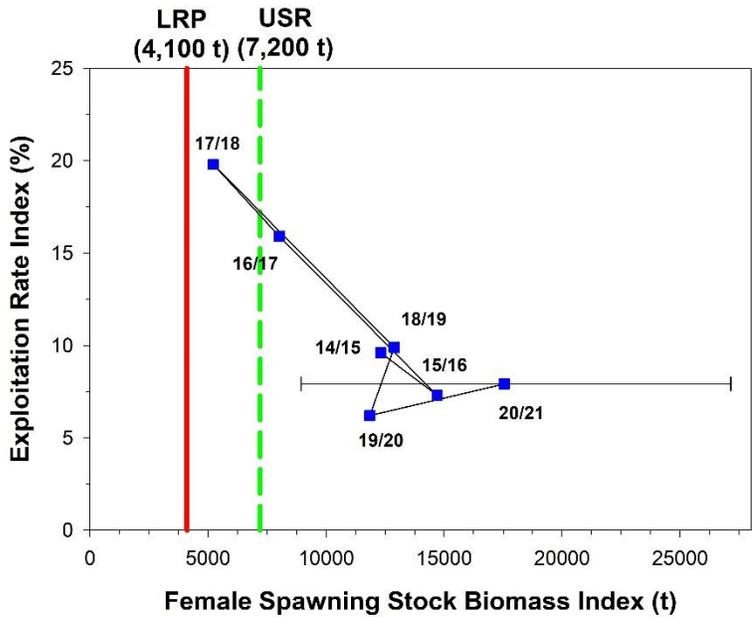
Non-DFO Members

Frankie Jean-Gagnon (Nunavik Marine Region Wildlife Board)
Amber Giles (Nunavut Wildlife Management Board)
Aaron Dale (Torngat Joint Fisheries Board)
Zoya Martin (Government of Nunavut)
Omar Sarr (Government of Quebec)
Todd Broomfield (Nunatsiavut Government)
Alastair O'Reilly (Northern Coalition)
Bruce Chapman (Canadian Association of Prawn Producers)
Tony Wright (Makivik Corporation)
Brian Burke (Nunavut Fisheries Association)

(APPENDIX 2)

Session Title	Objectives	Sub-group(s) to attend	Date & Time
USR 4: EAZ & WAZ stocks	Discuss reference points and harvest decision rules (Borealis + Montagui)	WAZ & EAZ	Thursday February 18 1 PM – 3 PM EST (2 hours)
USR 3: EAZ & WAZ stocks	Discuss reference points (Borealis + Montagui)	WAZ & EAZ	Friday February 5 9 AM – 11 AM EST (2 hours)
USR 2: EAZ & WAZ stocks	Discuss options for USRs (Borealis + Montagui)	WAZ & EAZ	Friday January 15 10 AM – 12PM EST (2 hours)
USR 1: EAZ stocks	Discuss options for USRs (Borealis + Montagui)	EAZ	Monday January 11 10 AM – 12PM EST (2 hours)
USR General	Discussion: Outcomes of CSAS peer-review Discuss key considerations for USRs	WAZ & EAZ	Thursday December 17 10 AM – 12PM EST (2 hours)
NPAWG Introductory Session	Welcome to NPAWG: Terms of Reference Introduction to the Precautionary Approach Framework Overview: CSAS peer-review outcomes (LRPs and USRs)	WAZ & EAZ	Monday November 30 10 AM – 12PM EST (2 hours)

APPENDIX 2



Figures 1 and 2. Newly established LRP for Northern Shrimp (left) and Striped Shrimp (right) in the WAZ. The LRP (red line) is calculated as 40% of the geometric mean of the SSB index and the recommended USR (dashed green line) calculated as 70% of the geometric mean of the SSB index. Blue symbols are annual stock status values, numbers indicate the fishing season.

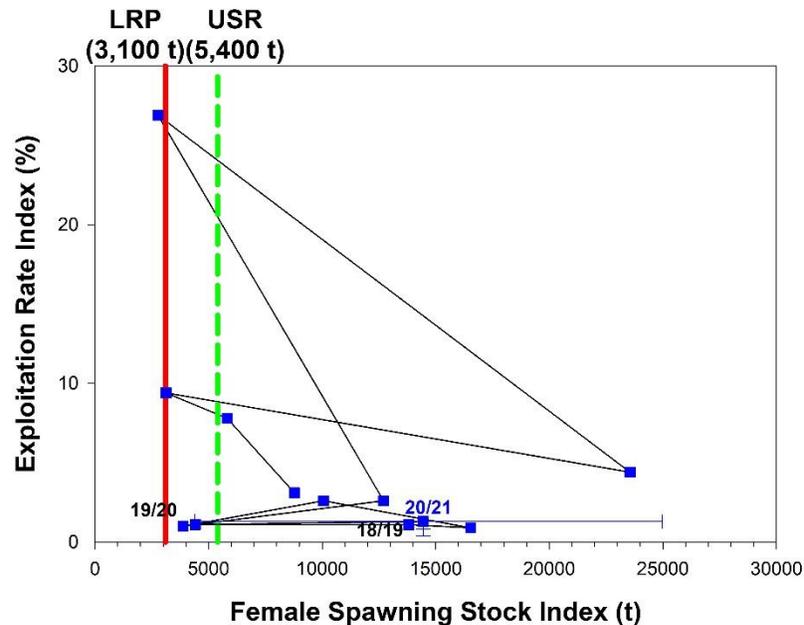
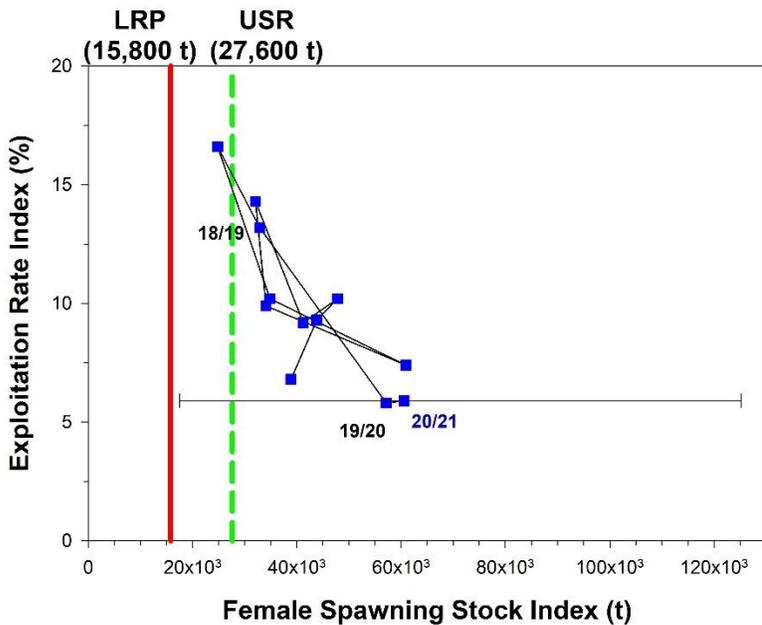


Figure 3 and 4. Newly established LRP for Northern Shrimp (left) and Striped Shrimp (right) in the EAZ. The LRP (red line) is calculated as 40% of the geometric mean of the SSB index and the recommended USR (dashed green line) calculated as 70% of the geometric mean of the SSB index. Blue symbols are annual stock status values, numbers indicate the fishing season.

SCIENCE ADVICE ON LIMIT REFERENCE POINTS FOR NORTHERN SHRIMP (*PANDALUS BOREALIS*) AND STRIPED SHRIMP (*PANDALUS MONTAGUI*) IN THE EASTERN AND WESTERN ASSESSMENT ZONES

Canadian Science Advisory (Science Advisory Report 2020/053)

SUMMARY

- The Precautionary Approach (PA) Framework for the Eastern Assessment Zone (EAZ) was established in 2009 on the basis of 3 years of survey data and the results of the *Precautionary Approach Workshop on Canadian Shrimp and Prawn Stocks and Fisheries* (DFO 2009b). The Western Assessment Zone (WAZ) PA Framework was deferred because of changes to the survey design in 2014 that reset the survey time series. The goals of this meeting were to establish the Limit Reference Point (LRP) and propose Upper Stock Reference Points (USR) for the WAZ and update the existing reference points for the EAZ.
- LRPs for Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montagui*) in both the WAZ and EAZ are newly established as 40%, and the proposed USRs as 80%, of the geometric mean of the spawning stock biomass (SSB) index. These calculations are consistent with guidance in the DFO PA Policy.
- In the WAZ, the newly established LRPs for Northern Shrimp (4,100 t) and Striped Shrimp (12,300 t) are based on a 6-year time series (2014–2019). Similarly, a newly proposed upper stock reference (USR) is provided for each species (8,200 and 24,600 t, respectively).
- In the EAZ, the updated LRP for Northern Shrimp (increase to 15,800 from 6,800 t) and the proposed USR (increase to 31,600 from 18,200 t) are based on an 11-year time series (2009–2019). Re-calculation of the LRP and proposed USR for Striped Shrimp in the EAZ resulted in 3,100 t (increase from 2,300 t) and 6,100 t (no change), respectively.
- The LRPs and proposed USRs are based on the best available scientific information, but do not incorporate environmental or ecosystem factors into their calculations. Information pertaining to these metrics are lacking.
- The PA reference points for the WAZ and EAZ should be re-examined when a population model is developed or relationships between stock productivity and environmental or ecosystem factors are sufficiently developed to inform stock assessments.



SCIENCE ADVICE ON LIMIT REFERENCE POINTS FOR NORTHERN SHRIMP (*PANDALUS BOREALIS*) AND STRIPED SHRIMP (*PANDALUS MONTAGUI*) IN THE EASTERN AND WESTERN ASSESSMENT ZONES



Top: Northern Shrimp (*Pandalus borealis*)
Bottom: Striped Shrimp (*Pandalus montagui*)
Photo: Fisheries Oceans Canada, Newfoundland
and Labrador Region.

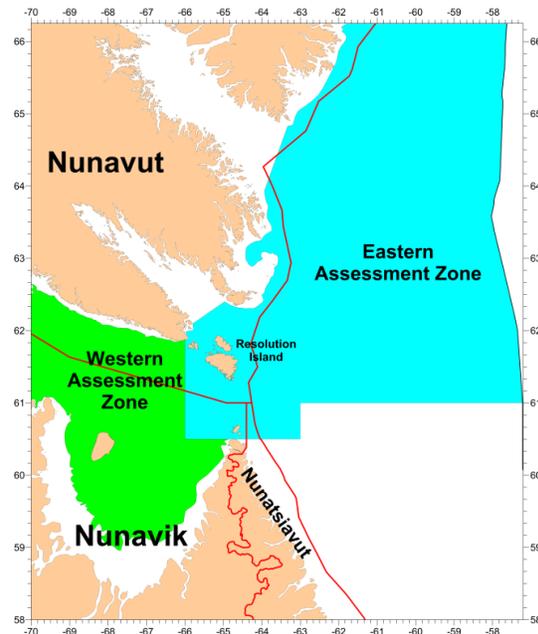


Figure 1. Eastern and Western Assessment Zones for shrimp fisheries in Arctic Region. Boundaries of the Nunavut, Nunavik and Nunatsiavut land claim areas are shown in red.

Context:

Fisheries and Oceans Canada's Fishery Decision-Making Framework Incorporating the Precautionary Approach describes a framework where reference points and harvest decision rules are used to make fisheries management decisions. The limit reference point (LRP) represents the stock status below which serious harm is likely occurring to the stock. The LRP is established based on biological criteria by Fisheries and Oceans Canada (DFO) Science. The Upper Stock Reference (USR) divides the Healthy Zone from the Cautious Zone and is established by DFO Resource Management in consultation with co-management partners, provincial and territorial governments, industry, and DFO Science, to enact harvest decision rules.

Since the reorganization of the Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montagui*) surveys conducted in the Arctic Region in 2014, the joint DFO-Northern Shrimp Research Foundation survey has covered the Western Assessment Zone (WAZ) and Eastern Assessment Zone (EAZ) survey areas annually with the same ship and gear (DFO 2020a). LRPs for the WAZ were developed in 2013, however, the restart of the time series in 2014 means they are no longer valid (DFO 2018a). Data points acquired since the new survey began will therefore be used to establish new reference points for

the WAZ. Reference points will also be updated for the EAZ since the original points were calculated from only three surveys (Siferd 2015), which no longer correspond to the assessment area boundaries (DFO 2019a).

DFO Resource Management has requested that Science establish LRPs consistent with the Precautionary Approach (PA) framework for Northern Shrimp and Striped Shrimp in order to determine the point below which serious harm may be occurring to the stock (i.e., the Critical Zone), and propose an USR. This Science Advisory Report is from the May 12–13, 2020 Meeting on Science Advice on Limit Reference Points for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the Eastern and Western Assessment Zones. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

SUMMARY

- The Precautionary Approach (PA) Framework for the Eastern Assessment Zone (EAZ) was established in 2009 on the basis of 3 years of survey data and the results of the *Precautionary Approach Workshop on Canadian Shrimp and Prawn Stocks and Fisheries* (DFO 2009b). The Western Assessment Zone (WAZ) PA Framework was deferred because of changes to the survey design in 2014 that reset the survey time series. The goals of this meeting were to establish the Limit Reference Point (LRP) and propose an Upper Stock Reference point (USR) for the WAZ and update the existing reference points for the EAZ.
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- The LRPs and proposed USRs are based on the best available scientific information, but do not incorporate environmental or ecosystem factors into their calculations. Information pertaining to these metrics are lacking.
- The PA reference points for the WAZ and EAZ should be re-examined when a population model is developed or relationships between stock productivity and environmental or ecosystem factors are sufficiently developed to inform stock assessments.

BACKGROUND

Canadian Precautionary Approach Framework and Limit Reference Points

In 2009, Fisheries and Oceans Canada (DFO) published the [Sustainable Fisheries Framework](#) that provides the basis for ensuring Canadian fisheries are conducted in a manner which supports conservation and sustainability. The framework is comprised of a number of policies for the conservation and sustainable use of fisheries resources including “[A Fishery Decision-Making Framework Incorporating the Precautionary Approach](#)” (DFO 2009a). The Precautionary

Approach (PA) Policy applies where decisions on harvest strategies or harvest rates for a stock are taken to determine Total Allowable Catch (TAC) or other measures to control harvests. This is the case for Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montagui*) stocks.

There are three components to the general decision framework for the PA:

1. Reference points and stock status zones;
2. Harvest strategy and harvest decision rules; and,
3. The need to take into account uncertainty and risk when developing reference points and developing and implementing decision rules.

The first component of the PA framework, reference points and status zones, is the subject of this advisory report. The PA is divided into three stock status zones: the Healthy, Cautious and Critical Zones (Figure 2). The Upper Stock Reference (USR) divides the Healthy Zone from the Cautious Zone and the Limit Reference Point (LRP) divides the Cautious Zone from the Critical Zone.

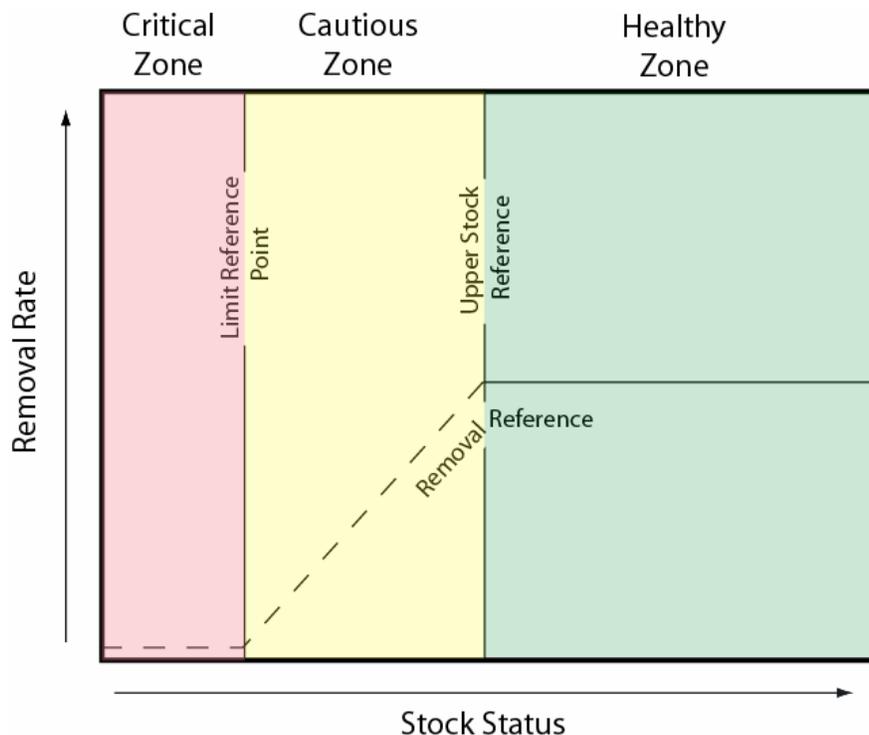


Figure 2. Elements of DFO's PA framework (from DFO 2009a).

The LRP is defined as the stock status *below which serious harm is being done to the stock*. However, a challenge in setting an LRP is identifying the threshold of where and when 'serious harm' occurs to the stock. This threshold is approximated based on the best available information, below which validation is exactly the situation to be avoided. LRP's are based on biological criteria and are established by DFO Science. In the Critical Zone, conservation/biological considerations are meant to be the primary drivers for management decision-making (as opposed to socio-economic factors) and there is to be no tolerance for preventable declines as the primary goal is to rebuild the stock out of the critical zone. Management actions pertaining to this zone are to promote stock growth and removals are to be kept to the lowest possible level regardless of the stock trajectory.

When establishing an LRP, the guidelines advise choosing a stock metric that can account for changing productivity, generally the spawning stock biomass. An LRP should be determined by accounting for periods of high and low productivity over as long a time-series as possible, and based on the best information available on stock biology and fishery characteristics while acknowledging limitations of the data. However, in some cases there may be insufficient information on which to base choices of stock-specific precautionary reference points and harvest rules. In these instances, DFO has a guideline of 40% LRP and 80% USR. The PA Policy states:

“In cases where insufficient stock-specific information is available, these reference points may be considered as the best available guidance for management and for assessing the stock in relation to sustainability. Actual reference points for a stock may use other metrics and be set lower or higher than these references but should be demonstrably appropriate for the stock and be consistent with the intent of the PA.”

Furthermore, while reference points should be reviewed periodically, neither the timeframe nor the triggers for review are specified in the PA Policy. Given that reference points have not been previously proposed for Northern Shrimp and Striped Shrimp in the Western Assessment Zone (WAZ; Figure 1) and that the current reference points in the Eastern Assessment Zone (EAZ) have been in place since 2009 (DFO 2009b), Resource Management has requested a review of the LRPs, and their rationales, to be carried out for these stocks.

Species Biology

Northern Shrimp is found in the Northwest Atlantic from Baffin Bay to the Gulf of Maine, while Striped Shrimp is found from Davis Strait south to the Bay of Fundy.

Both species of shrimp are protandric hermaphrodites. They function as males early in their lives then change sex and reproduce as females for the remainder of their lives. Females usually produce eggs once a year in the late summer-fall and carry them, attached to their abdomen, through the winter until the spring, when they hatch. Newly hatched shrimp spend three to four months as pelagic larvae. At the end of this period they settle at the bottom and take up the life style of the adults.

Recent research by Le Corre (2019, 2020) on the connectivity of management units via shrimp larval drift found that virtually the entire population of Northern Shrimp along the Canadian Atlantic coast (from Baffin Bay to the Scotian Shelf) is connected through larval drift processes with variable retention success in a given management zone. Also, larval drift was found to promote genetic homogeneity in areas with strong currents (Jorde et al. 2015). These findings improved our understanding of recruitment mechanisms and may in the future help to inform management of Canadian shrimp stocks.

Shrimp lifespan is uncertain but shrimp in the north are thought to live five to eight years. Growth rates and maturation are likely slower in the northern populations.

Fishery

The fishery began in the late 1970s in what is known as shrimp fishing area (SFA) 1. Exploratory fishing expanded into what is now the Davis Strait-East management unit (previously known as SFA 2) and then to areas southeast of Resolution Island in Hudson Strait. Quotas in these areas were based on fishery performance and not scientific survey data. In the mid-1990s, the fishery moved southeast of Resolution Island in SFA 2, where the main fishery

remains to date. Implementation of the Nunavut Agreement in 1999 shifted the main fishery east of the Nunavut Settlement Area.

Currently, the fishery in the EAZ and WAZ is managed by a TAC which is divided into individual quotas for 17 offshore licence holders and special allocations for Nunavut and Nunavik fishing interests. Changes to the management of the fishery in what were SFAs 2 and 3 created new SFAs and Management Units beginning with the 2013/14 fishing season (Figure 2). Nunavut Wildlife Management Board (NWMB) and Nunavik Marine Region Wildlife Board (NMRWB) advise on the allocation of quotas to Nunavut and Nunavik fishing interests, respectively. All fishing to date has been conducted by large vessels (> 100' overall length) with 100% At-Sea-Observer coverage.

Fishing gear in the EAZ and WAZ consists of single and, more recently, twin shrimp trawls requiring a minimum codend mesh size of 40 mm and separator grate (maximum 28 mm bar spacing). Since 2003, the management year has been April 1 to March 31. The fishing season is limited by the extent of sea ice, and is conducted between May and December in most years.

Northern Shrimp has been the main commercial species throughout the history of the shrimp fishery in this area. Historically, most of the harvest of Striped Shrimp occurred as by-catch in the directed Northern Shrimp fishery. Directed fishing for Striped Shrimp has become more important especially with quotas available in the Nunavut-West and Nunavik-West management units beginning with the 2013/14 fishing season.

Fishery catch per unit effort (CPUE) data are not considered to reflect stock status. Commercial fishing locations are not broadly distributed; fishing vessels target areas of high density. A mix of two shrimp species are disproportionally caught in the fishery and the composition of the two species in the catch determines which species is designated as directed, which biases CPUE calculations. Throughout the history of the fishery, economic factors (e.g., fuel prices, market price of shrimp) have influenced when and where the species are caught. In the EAZ, commercial vessel performance has changed over the years to target each species to achieve cleaner catches of just one species. Renewed effort in the WAZ is relatively recent. In some years, cleaner catches can be similarly achieved in the WAZ, however that varies in relation to the distribution of the two species.

ASSESSMENT

This is an assessment of LRPs for both Northern Shrimp and Striped Shrimp in the EAZ and WAZ (Figure 1). These two species have overlapping distributions, particularly in the Resolution Island area, resulting in an overlap of their fisheries. The total removal, both directed catch and by-catch, of each species is considered in the assessment.

DFO plans and the Northern Shrimp Research Foundation (NSRF) conducts annual surveys of the EAZ (Resolution Island Study Area; RISA-W, RISA-E and SFA 2EX) and WAZ (SFA 3) survey areas (Figure 3). Both species in the EAZ and WAZ were last assessed in 2019 (DFO 2019a) and updated in 2020 (DFO 2020a). Survey data in the EAZ are available for the period of 2006–2019, however, the first three years are not considered comparable with the rest of the series because of poor trawl performance, incomplete sampling coverage, and inconsistent timing, vessels, and gear (DFO 2018a). Therefore the first three years of data are excluded, and only 2009–2019 data are evaluated for the EAZ.

The WAZ (Figure 1) was surveyed biennially by DFO from 2007–2013. However, results could not be combined with the EAZ survey results because the surveys used different gear and occurred at different times of year. This prevented a comprehensive evaluation of the

distributions of shrimp and a more practical look at broader stock assessment over a larger spatial scale. In 2014, the NSRF was commissioned to take over the survey of the WAZ so that it is sampled in conjunction with the EAZ as a means to maintain consistent methods among management units. This action started a new time series for the WAZ. In 2019, the WAZ was surveyed for the sixth year in the new time series. The advice contained herein marks the first occasion that LRP have been developed in the WAZ.

Fishable and female spawning stock biomass (SSB) indices from scientific surveys form the basis of this assessment. Fishable biomass is based on male and female shrimp from the surveys with a carapace length greater than 17 mm; this represents shrimp that are large enough to be retained in commercial trawls. SSB is based on all female shrimp from the surveys regardless of size. Fishery data are used to determine the observed exploitation rate index, calculated as catch from the reporting records (Canadian Atlantic Quota Report; CAQR) divided by the fishable biomass index from the same year. The potential exploitation rate index is calculated to represent the exploitation rate if the entire TAC is taken. Bootstrapped 95% confidence intervals are included for each of the indices.

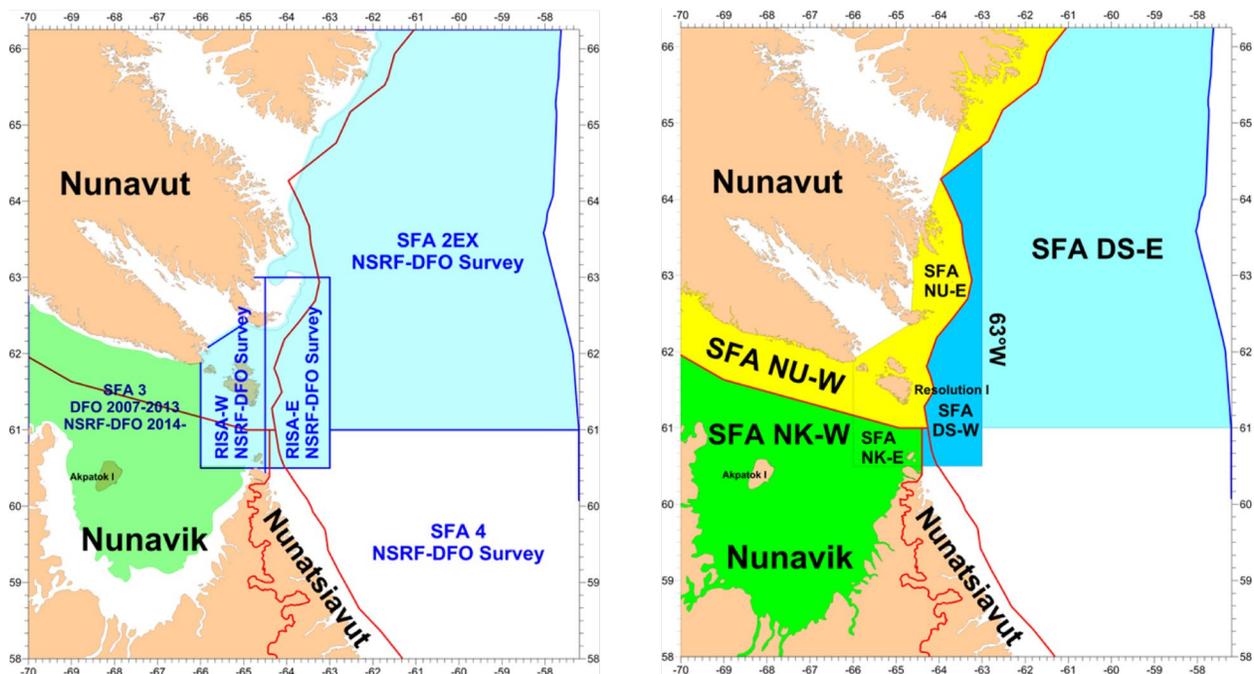


Figure 3. Locations of NSRF survey areas (left panel) within the Eastern (blue) and Western (green) Assessment Zones and the management units (right panel) referred to in this report. Shrimp Fishing Area (SFA), Exploratory (EX), Resolution Island Study Area (RISA), East (E), West (W), Nunavut (NU), Nunavik (NK) and Davis Strait (DS). Red lines show the borders of the Nunavut, Nunatsiavut and Nunavik Land Claims Areas.

For each assessment zone and shrimp fishery an LRP based on 30% and 40% of the SSB index was explored (Walkusz and Atchison 2020). Currently, a 30% LRP is being applied as a reference point by the Northwest Atlantic Fisheries Organization (NAFO) for the Northern Shrimp stock in SFA 1, which is adjacent to the EAZ. This was noted but not considered in-depth during a two-day workshop in 2008 among DFO-Science, DFO-Resource Management, co-management partners and stakeholders in an attempt to establish LRP in these shrimp fisheries (2009b). Additionally, LRP and the USRs were adopted at 30% and 80%, respectively, of the geometric mean of female SSB for both Northern and Striped Shrimp in

other southern SFAs. The SSB was deemed to be a suitable proxy for B_{MSY} . The contributing factors leading to the use of 30 and 80% were three years of survey data (2006–2008) in Shrimp Fishing Area 2, and that it was consistent with the approach taken by NAFO. LRPs have since gone unchanged in the EAZ (Siferd 2015).

Adopting a 30% LRP as part of the 2020 process would be consistent with NAFO approach and how shrimp fisheries are managed in the Newfoundland and Labrador Region. However, the use of a 30% LRP is unsubstantiated for the WAZ and EAZ based on the best available scientific information for these particular fisheries (Walkusz and Atchison 2020). Furthermore, an LRP of 40% is suggested in the DFO PA Policy (DFO 2009a) for instances of data deficiency and uncertainty. Establishing LRPs based on 40% average SSB for the WAZ and the EAZ was determined to be the best way forward based on the information available and recent decreases in stock productivity in southern SFAs (e.g., SFAs 4–6, DFO 2019b; SFAs 13–15, DFO 2019c). Uncertainty remains with respect to biomass variability as it relates to environmental conditions (e.g., temperature). Patchy shrimp population distributions have led to occasional large catches and fluctuations and increased variance in biomass estimates for each of the assessment zones in different years. Other SFAs have longer data sets and can justify using 30% LRPs, while the WAZ and EAZ have shorter data sets, large fluctuations in biomass indices and a lack of stock trends. Furthermore, Striped Shrimp in the EAZ appear to have recovered from biomass levels equivalent to an SSB level near the 40% LRP; below this point the ability of the stocks to recover is unknown (DFO 2020b). Similarly, it is not known to what extent Northern Shrimp can recover from below their lowest recorded biomass levels (comparatively higher than Striped Shrimp in the EAZ). When the PA framework for the EAZ was initially established using 30% LRPs, the reference points were based on three years of data, the geographic area of SFA 2 and a different survey range. It was recommended that the initial EAZ PA framework be revised as soon as possible (DFO 2020b). One of the potential options would be to move to a dynamic LRP, which follows the pattern of the stock. Since information on shrimp stocks is limited in the WAZ and EAZ, a fixed LRP is recommended. The PA framework may be revised in the future when more data on variables affecting shrimp stocks in the WAZ and EAZ become available.

The recommended reference points follow DFO's PA Policy (2009a) and include new data to update existing LRPs in the EAZ and establish new LRPs in the WAZ. The geometric mean of SSB was used as a proxy for B_{MSY} . Furthermore, this framework suggests a starting point for calculating USRs. Accordingly, the LRPs and proposed USRs were calculated at 40% and 80%, respectively, of the geometric mean of SSB for both Northern and Striped Shrimp (Figures 4 and 5).

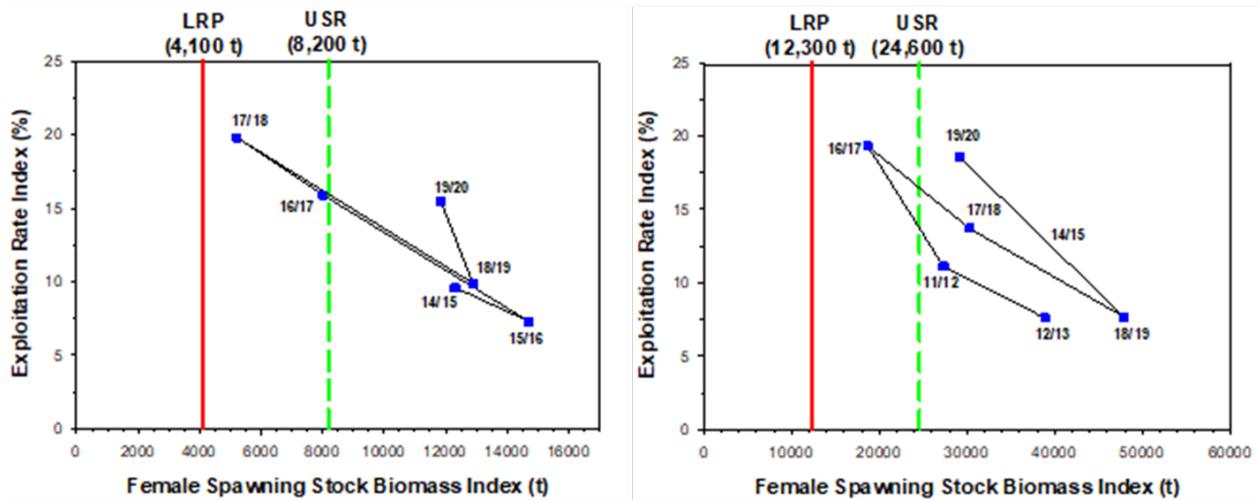


Figure 4. Newly established LRP for Northern Shrimp (left) and Striped Shrimp (right) in the WAZ. The LRP (red line) is calculated as 40% of the geometric mean of the SSB index and the proposed USR (dashed green line) calculated as 80% of the geometric mean of the SSB index. Blue symbols are annual stock status values, numbers indicate the fishing season.

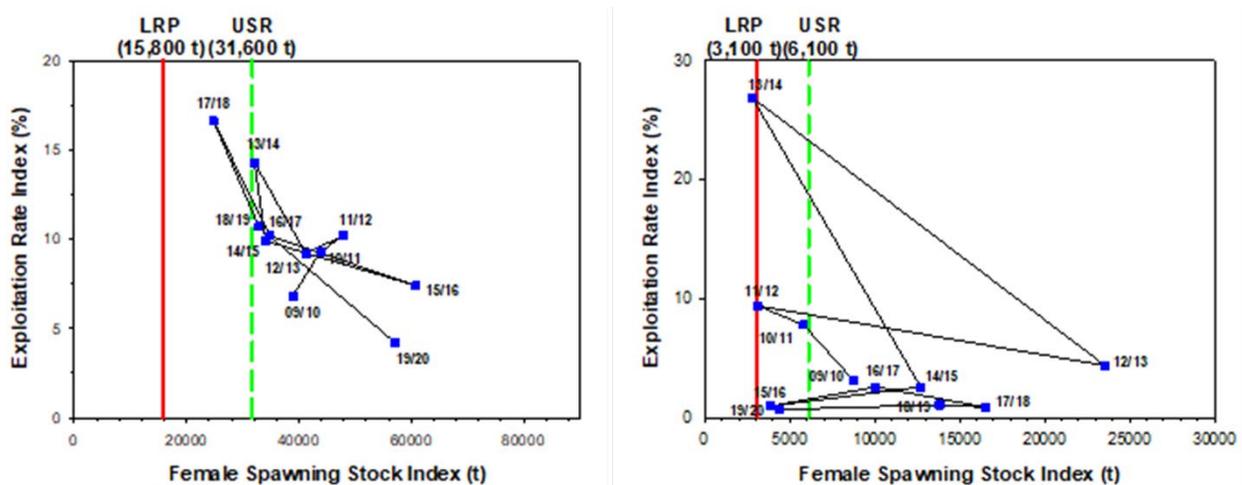


Figure 5. Updated LRP for Northern Shrimp (left) and Striped Shrimp (right) in the EAZ. The LRP (red line) is calculated as 40% of the geometric mean of the SSB index and the proposed USR (dashed green line) calculated as 80% of the geometric mean of the SSB index. Blue symbols are annual stock status values, numbers indicate the fishing season.

Sources of Uncertainty

The sources of uncertainty that were not quantitatively incorporated into the establishment of LRPs for Northern and Striped Shrimp stocks in the WAZ and EAZ, include:

- Despite having data on temperature preferences of the two shrimp species, the distribution, availability and dynamics of preferred habitats is lacking. Future efforts should focus on moving towards an Ecosystem Approach to Fisheries Management to address knowledge gaps and drivers of stock variability, such as: larval drift related to the connectivity between management zones (stocks), habitat spatiotemporal variability, and ecosystem linkages

(e.g., predator-prey interactions, oceanographic drivers). The lack of environmental information contributes to uncertainty.

- Given the short time series and the lack of observed trends, it is not feasible to identify periods of high productivity upon which to base reference points (as suggested in the DFO PA Policy).
- Trawls used in the survey are known to have a catchability less than one but the exact value is unknown. Therefore, the survey is an index of biomass and not an absolute estimate of the total biomass.
- Catch data are known; however, the total fishery-induced mortality is unknown (landed catch plus incidental mortality from trawling). Exploitation rates are a relative index rather than absolute.
- Survey of all stocks is completed in the middle of the fishing season. It is uncertain how much of the TAC has already been taken while the survey is ongoing. Results may be confounded by the timing of the survey and the concurrent level of harvest.
- It is uncertain to what extent these stocks have the capacity to recover from low levels of biomass. High biomass variability exhibited in these stocks can lead to their positioning within the proposed Cautious Zone of this PA framework. A longer time series and a better understanding of the drivers of stock variability may inform recovery potential.
- The stocks' natural mortality, including multi-species linkages, is currently unknown.
- Factors that may cause shrimp productivity to change are poorly understood within the WAZ and EAZ. For example, it is uncertain to what extent larval drift exists between these assessment zones, and to what extent shrimp productivity is impacted by their movements.
- Stocks of both species in both assessment zones exhibit relatively large inter-annual variability in biomass and no trends have been observed. The drivers leading to this variability are poorly understood.
- Northern and Striped Shrimp have populations spanning both assessment zones and their relative distributions are likely to change inter-annually. The stock structure of each species within and between assessment zones is unresolved. For example, it is possible there are multiple populations of the same species within a single assessment zone.
- DFO has recently discovered that a portion of what was previously identified as *P. montagui* from the Gulf and Scotian Shelf (Division 3PS) are in fact *Dichelopandalus leptocerus*. There remains uncertainty about whether this species has recently migrated to this area or may have been misidentified for several years. The same may be true in more northern areas including the WAZ and EAZ.

CONCLUSIONS AND ADVICE

The work described here represents new and updated science advice on reference points for the Northern and Striped Shrimp fisheries in the WAZ and EAZ. The advice is based on a traditional approach of calculating SSB from shrimp trawl surveys, and explores a time series of fishery-independent data. Data used to assess these fisheries are limited and highly variable, and currently no trends in stock status have been observed. Striped Shrimp in the EAZ have demonstrated an ability to recover from 40% of the SSB, the LRP, below which the ability of these stocks to recover is uncertain. Therefore, we recommend a PA consistent with DFO (2009a) that reflects insufficient stock-specific information: 40% LRP and 80% USR, with

respect to the geometric mean SSB index. These reference points represent the best available scientific information and constitute advice to management for assessing the stock in relation to sustainability.

In the WAZ, the newly established LRP and the proposed USR for Northern Shrimp and Striped Shrimp are based on a 6-year time series (2014–2019; Table 1). In the EAZ, the updated LRP and the proposed USR for Northern Shrimp and Striped Shrimp are based on an 11-year time series (2009–2019; Table 1).

Table 1. Established Limit Reference Points (LRPs) and proposed Upper Stock Reference points (USRs) for Northern Shrimp and Striped Shrimp in the Western Assessment Zone and Eastern Assessment Zone. Spawning stock biomass is reported in tonnes. Previous reference points are provided in parentheses.

Species	Western Assessment Zone		Eastern Assessment Zone	
	LRP	USR	LRP	USR
Northern Shrimp (<i>Pandalus borealis</i>)	4,100	8,200	15,800 (from 6,800)	31,600 (from 18,200)
Striped Shrimp (<i>Pandalus montagui</i>)	12,300	24,600	3,100 (from 2,300)	6,100 (no change)

The PA reference points for the WAZ and EAZ should be re-examined when a population model is developed or relationships between stock productivity and environmental or ecosystem factors are sufficiently developed to inform stock assessments.

OTHER CONSIDERATIONS

In general, management of key forage species, such as shrimp, under an ecosystem approach, requires the adoption of a conservative approach with lower fishing mortality reference points and higher biomass reference points than would be considered under a single species management approach.

In cases where insufficient stock-specific information is available, DFO’s PA Policy (2009a) suggests reference points that may be considered as the best available guidance for management and for assessing the stock in relation to sustainability. The 40% LRP and 80% USR provided as guidance are the results of reviews and meta-analyses across a wide variety of fish stocks. However, it is uncertain to what extent this standard can be applied to shrimp fisheries. Here, 40% LRP and 80% USR of the geometric mean SSB index have been used to inform reference points for shrimp fisheries in the WAZ and EAZ without demonstrable validation of stock productivity. Indeed, most larvae released in any management area end up as functioning adults in another management area (in other words, most adults in any management area originated elsewhere; Le Corre et al. 2020). This in and of itself is evidence that the SSB index within an individual management area does not provide a defensible measure of the future health within any individual management area.

The PA reference points in both the WAZ and EAZ are based on the best available scientific information and need to be re-evaluated with new and/or alternative methodologies when data are available to corroborate the advice contained herein. Actual reference points for a stock may use other metrics and be set lower or higher than these references but should be justified for the

stock and consistent with the intent of the PA. Ideally, more robust LRPs and associated PA frameworks should be considered by Science and Resource Management when additional data are available.

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SOURCES OF INFORMATION

This Science Advisory Report is from the May 12–13, 2020 Meeting on Science Advice on Limit Reference Points for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the Western and Eastern Assessment Zones. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

DFO. 2009a. [A fishery decision-making framework incorporating the precautionary approach](#). [online]. [accessed June 2020].

DFO. 2009b. [Proceedings of the Precautionary Approach Workshop on Shrimp and Prawn Stocks and Fisheries; November 26-27, 2008](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2008/031.

- DFO. 2018a. [Update of stock status indicators for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagu*, in the Western and Eastern Assessment Zones, February 2018](#). DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/012.
- DFO. 2018b. [Integrated Fisheries Management Plan \(IFMP\): Northern shrimp and striped shrimp – Shrimp fishing areas 0, 1, 4-7, the Eastern and Western Assessment Zones and North Atlantic Fisheries Organization \(NAFO\) Division 3M](#). Fisheries and Oceans Canada, Ottawa, ON. 84 p.
- DFO. 2019a. [Assessment of Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagu*, in the Eastern and Western Assessment Zones, February 2019](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/011.
- DFO. 2019b. [An Assessment of Northern Shrimp \(*Pandalus borealis*\) in Shrimp Fishing Areas 4– 6 and of Striped Shrimp \(*Pandalus montagu*\) in Shrimp Fishing Area 4 in 2018](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/027.
- DFO. 2019c. [Assessment of Northern Shrimp on the Eastern Scotian Shelf \(SFAs 13-15\)](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/013.
- DFO. 2020a. [Update of stock status indicators for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagu*, in the Western and Eastern Assessment Zones, January 2020](#). DFO Can. Sci. Advis. Sec. Sci. Resp. 2020/014. (Erratum: February 2020)
- DFO. 2020b. [Proceedings for the regional peer-review meeting on Science Advice on Limit Reference Points for Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagu*, in the Western and Eastern Assessment Zones; May 12–13, 2020](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2020/024.
- Jorde, P.E., Søvik, G., Westgaard, J.I. et al. 2015. Genetically distinct populations of northern shrimp, *Pandalus borealis*, in the North Atlantic: adaptation to different temperatures as an isolation factor. *Mol Ecol.* 24(8): 1742–1757.
- Jorde, P.E., Søvik, G., Westgaard, J.I., Albretsen, J., Andre, C., Hvingel, C., Johansen, T., Sandvik, A.D, Kingsley, M., And Jørstad, N.E. 2015. Genetically distinct populations of northern shrimp, *Pandalus borealis*, in the North Atlantic: adaptation to different temperatures as an isolation factor. *Mol Ecol.* 24(8): 1742–1757.
- Le Corre, N., Pepin, P., Han, G., Ma, Z., and Snelgrove, P.V.R. 2019. Assessing connectivity patterns among management units of the Newfoundland and Labrador shrimp population. *Fish. Oceanogr.* 28(2): 183–202.
- Le Corre, N., Pepin, P., Burmeister, A., Walkusz, W., Skanes, K., Wang, Z., Brickman, and D., Snelgrove, P.V.R. 2020. Larval connectivity of Northern Shrimp (*Pandalus borealis*) in the northwest Atlantic. *Can. J. Fish. Aqua. Sci.* 77 : 1332–1347.
- Siferd, T.D. 2015. [2015 Assessment of Northern Shrimp \(*Pandalus borealis*\) and Striped Shrimp \(*Pandalus montagu*\) in the Eastern and Western Assessment Zones \(SFAs Nunavut, Nunavik and Davis Strait\)](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2015/010. v + 70 p.
- Walkusz, W., and Atchison, S. 2020. [Information in support of establishing new Limit Reference Points for Northern Shrimp \(*Pandalus borealis*\) and Striped Shrimp \(*Pandalus montagu*\) stocks in the Western Assessment Zone and updating the existing Limit Reference Points for the Eastern Assessment Zones](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/072. iv + 26 p.

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