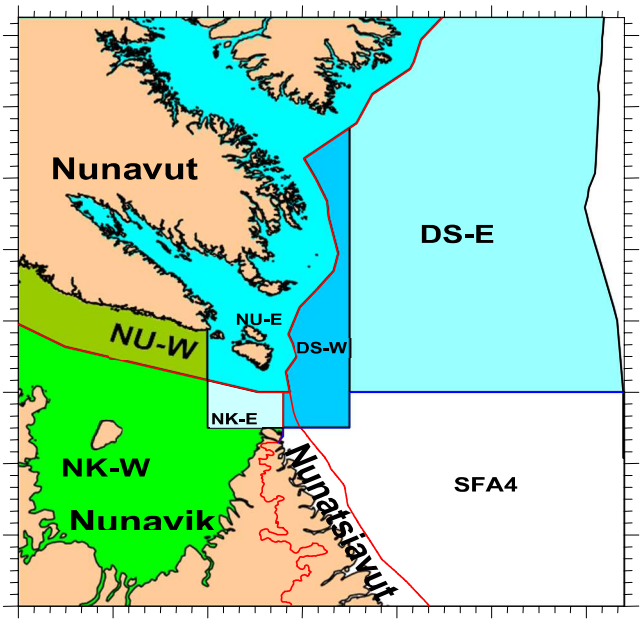
SUBMISSION TO THE
NUNAVUT WILDLIFE MANAGEMENT BOARD
AND NUNAVIK MARINE REGION WILDLIFE BOARD

FOR

Information: **Decision: X** **Recommendation: X**

Issue: Total Allowable Catch levels for Northern (*Pandalus borealis*) and Striped (*Pandalus montagui*) Shrimp for the 2023-24 season 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

Fisheries and Oceans Canada (DFO) submitted a briefing note to the Nunavut Wildlife Management Board (NWMB) and the Nunavik Marine Region Wildlife Board (NMRWB) (the Boards) *For Information* in March 2023 to mark an upcoming request for their decisions and recommendations on 2023-24 Total Allowable Catch (TAC) and harvest levels for two species of shrimp in the Western Assessment Zone (WAZ) and Eastern Assessment Zone (EAZ).

Science results from the 2022 DFO-Northern Shrimp Research Foundation multi-species survey are now available with results of the Canadian Science Advisory Secretariat (CSAS) peer review from the week of February 13, 2023, provided at Appendix 1. A meeting of the Northern Shrimp Advisory Committee (NSAC) occurred on April 4-5, 2023. A summary of these consultations is provided at Appendix 5.

This briefing note presents the Boards with the information necessary to provide decisions and advice to the Minister of Fisheries and Oceans Canada for 2023-24 fisheries in the WAZ and EAZ. Recognizing that fishing may begin in these areas as early as May 2023, advice is requested as soon as possible.

WESTERN ASSESMENT ZONE (WAZ)

Fishery Profile

The fishery for *P. borealis* and *P. montagui* in the WAZ operates April 1 – March 31. Harvesting activity typically commences in May/June, subject to ice conditions.

The WAZ is divided into two management units, Nunavut West (NU-W) and Nunavik West (NK-W) (see map). These management units are located entirely within the Nunavut Settlement Area (NSA) and Nunavik Marine Region (NMR), respectively. The NWMB and NMRWB make decisions on management measures within their respective land claim areas and may make recommendations for adjacent management units.

P. borealis and *P. montagui* allocations in the NU-W management unit have been allocated to Nunavut fishing interests. Similarly, allocations in the NK-W management unit have been allocated to Nunavik fishing interests. Although no formal sharing arrangement exists, harvest level decisions in NU-W and NK-W have historically resulted in equal distribution of the overall TAC for each stock. A standing joint decision made by the NWMB and NMRWB on July 13, 2022, supports harvesting of these species in either management unit, regardless of land claim boundaries.

A quota and catch history profile for the WAZ is provided at Appendix 4.

Precautionary Approach (PA) Framework

Work continues on the development of a Precautionary Approach (PA) framework for *P. borealis* and *P. montagui* in the WAZ.

Limit Reference Points (LRPs) are established for each *P. borealis* and *P. montagui* stocks at 40% of the geometric mean of the Spawning Stock Biomass (SSB) index for the available time series (2014-2019). DFO Science has proposed an Upper Stock Reference (USR) point for each stock at 80% of the geometric mean of the same SSB index[1].

Through a series of working group sessions from November 2020 to February 2021, the Northern Precautionary Approach Working Group (NPAWG) considered a potential USR at 70% of the geometric mean of the SSB index for each stock. DFO sought decisions and recommendations from the NWMB and NMRWB on USRs for EAZ and WAZ stocks in March 2021. In June 2021, the Boards rejected this request until such time that a PA Framework, including Harvest Decision Rules (HDRs), can be presented as a full and

[1] LRPs for WAZ stocks were established through a CSAS peer-review process in May 2020 (Science Advisory Report 2020/053). USRs have not yet been established. Use of proposed USRs are for illustrative purposes, to help inform 2023-24 TAC decisions.

comprehensive amendment to the Integrated Fisheries Management Plan (IFMP) for this fishery. HDRs that could prescribe exploitation rates (ER) and other management measures in each the Healthy, Cautious and Critical Zones are currently under development and are not yet available for the WAZ.

Relative to the established LRP and proposed USR developed by DFO Science, both *P. borealis* and *P. montagui* stocks in the WAZ would be situated high in the Healthy Zone.

Science Advice

Nine years of data are now available in the time series for the WAZ that began in 2014. A summary of the CSAS peer-review from February 2023 is at Appendix 1. Stock status indicators for *P. borealis* and *P. montagui* in the WAZ (2019-2022) are at Appendix 2.

P. borealis and *P. montagui* stocks have shown signs of high volatility, with no clear indication of mechanisms driving year-to-year fluctuations in biomass. Currently, DFO Science cannot detect trends for either stock.

For ***P. borealis***, the 2022 survey indicates a Fishable Biomass (FB) increase of 19.9% from the 2021 survey. The Spawning Stock Biomass (SSB) increased by 12.9% from the previous year's survey. *[FB 23,939t; SSB 15,899t]*

For ***P. montagui***, the 2022 survey indicates a FB increase of 61.1% from the 2021 survey. The SSB increased by 63.3% from the previous year's survey. *[FB 104,737t; SSB 61,058t]*

2023-24 Management Considerations

For ***P. borealis***, the current SSB is in the Healthy Zone, at 194% of the proposed USR developed by DFO Science. No HDRs have been established for WAZ stocks.

The 2022-23 TAC was 3,958t. A rollover of the TAC in 2023-24 would result in a potential ER of 16.5%. Maintaining the target 20% ER from 2022-23 would result in a TAC of 4,788t (an increase of 830t or approximately 21%) which is slightly above the maximum past ER of 19.8%. A 15% TAC increase would result in a TAC of 4,552t (potential ER 19.0%. Scenarios are illustrated below.

Scenario *(P. borealis)*	TAC	ER	% change in TAC from previous year
Rollover TAC	3,958t	16.5%	0%
Maintain ER	4,788t	20.0%	+21.0%
15% TAC increase	4,552t	19.0%	+15.0%
Maximum past ER	4,740t	19.8%	+19.8%

For ***P. montagui***, the current SSB is in the Healthy Zone, at 248% of the proposed USR developed by DFO Science. No HDRs have been established for WAZ stocks.

The 2022-23 TAC was 12,096t. A rollover of the TAC in 2023-24 would result in a potential ER of 11.5%. Maintaining the 18.6% potential ER for the fourth consecutive year would result in a TAC of 19,481t (an increase of 7,385t or approximately 61.1%). Any increase in TAC for 2023-24 would represent the highest TAC levels for *P. montagui* to date. Scenarios are illustrated below.

Scenario *(P. montagui)*	TAC	ER	% change in TAC from previous year
Rollover TAC	12,096t	11.5%	0%
Maintain ER	19,481t	18.6%	+61.1%
15% TAC increase	13,910t	13.3%	+15.0%
Maximum past ER	20,214t	19.3%	+67.1%

Recommendation: No HDRs currently exist for stocks in the WAZ. HDRs may be proposed in future, pending outcomes of NPAWG discussions.

The Department maintains its view from 2022-23 that the Boards could continue to establish an overall TAC (combined for NU-W and NK-W) with a potential ER that falls within the range where each stock has shown an ability to recover:

- *P. borealis* - 7.3% - 19.8% ER
- *P. montagui* - 7.0% - 19.3% ER

Other key considerations may include historic catch levels for the respective stocks, and industry's capacity to prosecute the full extent of substantial TAC increases (Appendix 4).

Summary of Request

Western Assessment Zone:

1. Decisions on harvest levels for *P. borealis* and *P. montagui* in the NU-W (within the NSA) and NK-W (within the NMR) management units, respectively.

2. Recommendations on the overall TAC for *P. borealis* and *P. montagui* in the WAZ.

Summary of requested decisions and recommendations, WAZ.

Area (Management Unit)	***P. borealis***	***P. montagui***
NSA (NU W)	Harvest level decision NWMB *(Recommendation NMRWB)*	Harvest level decision NWMB *(Recommendation NMRWB)*
NMR (NK W)	Harvest level decision NMRWB *(Recommendation NWMB)*	Harvest level decision NMRWB *(Recommendation NWMB)*
TOTAL (WAZ)	*TAC recommendation (combined total of decisions) NWMB and NMRWB*	*TAC recommendation (combined total of decisions) NWMB and NMRWB*

EASTERN ASSESMENT ZONE (EAZ)

Fishery Profile

The fishery for *P. borealis* and *P. montagui* in the EAZ operates April 1 – March 31. Harvesting activity typically commences in May/June, subject to ice conditions.

The EAZ is divided into four management units, Nunavut East (NU-E), Nunavik East (NK-E), and the offshore Davis Strait West (DSW) and Davis Strait East (DSE) areas (see map). These management units are located partially within and adjacent to the NSA and NMR. The NWMB and NMRWB make decisions on management measures within their respective land claims areas and may make recommendations for the adjacent Davis Strait management units.

P. borealis and *P. montagui* allocations in the NU-E management unit have been allocated to Nunavut fishing interests. Similarly, allocations in the NK-E management unit have been allocated to Nunavik fishing interests. Although no formal sharing arrangement exists, DFO observes a long-standing distribution of allocations between NU-E and NK-E management units at 80-20 per cent for *P. borealis*; and approximately 70-30 per cent for *P. montagui*. A standing joint decision made by the NWMB and NMRWB on July 13, 2022, supports harvesting of these species in either management unit, regardless of land claim boundaries.

P. borealis allocations in the Davis Strait East management units have been to Nunavut fishing interests and the offshore fleet, with Nunavik fishing interests also having access in Davis Strait West. *P. montagui* is a bycatch species in the offshore Davis Strait areas only.

There are no pre-existing arrangements for the distribution of quota between management units in the EAZ. However, allocation of quotas between the settlement areas (NU/NK-E) and the offshore Davis Strait areas must distribute fishing effort throughout the Zone and avoid concentrated effort in a single productive area (e.g. Resolution Island).

A quota and catch history profile for the EAZ is provided at Appendix 4.

Precautionary Approach Framework

A PA Framework that includes HDRs currently exists for *P. borealis* and *P. montagui* in the EAZ. Work is ongoing to review this framework and potential updates could be developed by the NPAWG.

DFO Science updated the LRPs for each *P. borealis* and *P. montagui* stocks to 40% of the geometric mean of the SSB index for the available time series (2009-2019), an increase from

30%. DFO Science has proposed a USR for each stock at 80% of the geometric mean of the SSB index[2].

Relative to the updated LRP and proposed USR developed by DFO Science, the *P. borealis* stock would be situated in the Cautious Zone of an updated PA Framework and the *P. montagui* stock would be situated in the Healthy Zone.

Science Advice

Thirteen years of data are now available in the time series for the EAZ. A summary of the CSAS peer-review from February 2023 is at Appendix 1. Stock status indicators for *P. borealis* and *P. montagui* in the EAZ (2019-2022) are at Appendix 3.

P. borealis and *P. montagui* stocks have shown signs of high volatility, with no clear indication of mechanisms driving year-to-year fluctuations in biomass. DFO Science cannot detect trends for either stock at this time.

For ***P. borealis***, the 2022 survey indicates a FB decrease of 29.8% from the 2021 survey. The SSB also decreased by 32.1% from the previous year's survey. These are the lowest biomasses observed in the time series and mark a third consecutive year of decline. *[FB 36,911t; SSB 23,771t]*

For ***P. montagui***, the 2022 survey indicates a slight FB decrease of 5.9% from the 2021 survey. The SSB also decreased by 6.9% from the previous year's survey. *[FB 14,325t; SSB 10,428t]*

2023-24 Management Considerations

For ***P. borealis***, the current SSB is 75% of the proposed USR developed by DFO Science and lands just above the midpoint of the Cautious Zone. Current HDRs for the upper half of the Cautious Zone indicate that ERs should not significantly exceed 15%. HDRs also note that year-to-year changes in TAC may exceed the general limit of 15% of the previous TAC in cases where the stock is declining precipitously (greater than 25% decline). The 2022 survey marks two consecutive years of precipitous FB decline for *P. borealis*.

The 2022-23 TAC was 10,732t. A rollover of the current TAC in 2023-24 would result in a potential ER of 29.1%. Maintaining the target 20% ER from 2022-23 would result in a TAC of 7,382t (a decrease of 3,350t or -31.2%). Given the modest TAC reduction (-12.4%) taken in 2022-23 in response to the precipitous stock decline of -40.5%, a more substantial TAC decrease would be required in 2023-24 to lower the potential ER to within the range of 15-20%, to align

[2] LRPs for EAZ stocks were updated through a CSAS peer-review process in May 2020 (Science Advisory Report 2020/053). USRs have not yet been established. Use of proposed USRs are for illustrative purposes, to help inform 2023-24 TAC decisions.

with HDRs and support continued Marine Stewardship Council certification for this stock. Scenarios are illustrated below.

Scenario *(P. borealis)*	TAC	ER	% change in TAC from previous year
Rollover TAC*	*10,732t*	*29.1%*	*0%*
Maintain ER	7,382t	20.0%	-31.2%
15% ER	5,537t	15.0%	-48.4%

** Illustrative, not recommended given high potential ER while in the Cautious Zone.*

For ***P. montagui****,* although there was a slight decline in FB and SSB, the current SSB is in the Healthy Zone, at 171% of the proposed USR developed by DFO Science. In the application of current HDRs, establishing a TAC at a maximum potential 20% ERs for stocks in the Healthy Zone does not represent a conservation concern. However, HDRs also note that year-to-year changes in TAC should generally not exceed 15% of the previous TAC (unless there has been a precipitous decline, i.e. greater than 25%, which is not the case for *P. montagui* in 2022).

The TAC was set at 840t from 2014 to 2020, with a series of increases towards 1,400t in 2022-23. A rollover of the current TAC in 2023-24 would result in a potential ER of 9.8%. Maintaining the 9.2% ER would result in a TAC decrease to 1,318t. A 15% TAC increase would result in a TAC of 1,610t (potential ER 11.2%) Scenarios are illustrated below.

Scenario *(P. montagui)*	TAC	ER	% change in TAC from previous year
Rollover TAC	1,400t	9.8%	0%
15% TAC increase	1,610t	11.2%	+15.0%

Recommendation:

For ***P. borealis***, it is recommended to decrease the TAC to achieve a potential ER in the range of 15-20% to align with HDRs for stocks in the Cautious Zone. Although this would require a substantial TAC decrease (greater than 31.2%), this recommendation considers three consecutive years of decline, the most recent two of which have been precipitous, and the lowest biomass levels observed in the time series.

For ***P. montagui****,* it is recommended to increase the TAC by 15%. This recommendation follows a substantial TAC increase taken in 2022-23 (+45.1%) and represents a further step to address industry concerns that the *P. montagui* TAC (a bycatch limit in Davis Strait E/W) is too limiting relative to the target species *P. borealis*. A TAC increase pursues higher exploitation in the Healthy Zone that would be more appropriate for the directed fishery in NU/NK-E.

Summary of Request

Eastern Assessment Zone:

1. Decisions on harvest levels for *P. borealis* and *P. montagui* in the NU E (within the NSA) and NK E (within the NMR) management units, respectively.

2. Recommendations on the distribution of the TAC for *P. borealis* between the Davis Strait management units (DS W and DS E). Recommendations on *P. borealis* allocations in Davis Strait management units.

3. Recommendations on the overall TAC for *P. borealis* and *P. montagui* in the EAZ, respectively.

Summary of requested decisions and recommendations, EAZ.

Area (Management Unit)	***P. borealis***	***P. montagui***
NSA (NU E)	Harvest level decision NWMB *(Recommendation NMRWB)*	Harvest level decision NWMB *(Recommendation NMRWB)*
NMR (NK E)	Harvest level decision NMRWB *(Recommendation NWMB)*	Harvest level decision NMRWB *(Recommendation NWMB)*
DS E	TAC distribution and allocation recommendation NWMB & NMRWB	TAC recommendation NWMB & NMRWB
DS W	TAC distribution and allocation recommendation NWMB & NMRWB	
TOTAL (EAZ)	*TAC Recommendation NWMB & NMRWB*	*TAC Recommendation NWMB & NMRWB*

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Date: April 11, 2023

APPENDIX 1

ASSESSMENT OF NORTHERN SHRIMP (PANDALUS BOREALIS) AND STRIPED SHRIMP (PANDALUS MONTAGUI) IN THE EASTERN AND WESTERN ASSESSMENT ZONES, FEBRUARY 2023

SUMMARY

- The last full assessment was completed in 2021. This assessment has updated the stock status for *Pandalus borealis and P. montagui* in the Eastern Assessment Zone (EAZ) and Western Assessment Zone (WAZ), to incorporate survey and fishery data from the last two years. Limited predator-prey information, potential redfish competition, and oceanographic data were reviewed for additional ecosystem context.
- *Pandalus borealis* and *P. montagui* are distributed broadly over the Northwest Atlantic Ocean. The associated assessment areas, including the EAZ, WAZ and Shrimp Fishing Area 4 (SFA4), are connected through larval dispersal, but rates of exchange of adults are less understood. These linkages need to be considered to interpret fluctuations in biomass within and among assessment areas, even within the same year.
- The ocean climate in the NW Atlantic experiences fluctuations at decadal time scales, with potential impacts on availability of optimal Pandalid habitat and/or predator-prey interactions in the EAZ/WAZ. In 2022, bottom temperatures in the EAZ were lower than the 2006–2021 average for the first time since 2017, but they remained relatively high in the WAZ after the record high in 2021.
- The emergence of a large biomass of juvenile redfish in the EAZ over the last three years may have indirect (competition) and/or direct (future predation) impacts on the shrimp population. The magnitude and duration of these impacts are unknown.
- In both the EAZ and WAZ the stocks are currently assessed relative to established Limit Reference Points (LRPs) and previously proposed Upper Stock Reference points (USRs) in accordance with DFOs Precautionary Approach (PA) Framework.

Eastern Assessment Zone – *Pandalus borealis*

- Total catch varied without trend around 6,000 t from 1997 through 2022/23. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 declined to the lowest value in the time series (36,911 t). This was below both the long term mean (2009–2021; 63,642 t) and reference period mean (2009–2019; 62,849 t).
- The female spawning stock biomass index (SSB) in 2022 declined to the lowest value in the time series (23,771 t). This was below both the long term mean (2009–2021; 40,374 t) and reference period mean (2009–2019; 39,459 t).
- Both the reported and potential exploitation rates were the highest in the time series. The reported exploitation rate index for 2022/23 was 19.4% with 67% of the Total Allowable Catch (TAC) taken. Should the entire 2022/23 TAC of 10,732 t be taken, the potential exploitation rate index would be 29.1%.

- *Pandalus borealis* stock in the EAZ is currently above the established LRP (15,800 t), but below the proposed USR. Based on the proposed USR of 31,600 t, this would place the stock in the cautious zone with a 98.3% probability.

Eastern Assessment Zone – *Pandalus montagui*

- Total catch in 2022/23 was 1,419 t, 101.4% of the 1,400 t TAC. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 was 14,325 t. This was above both the long term mean (2009–2021; 12,397 t) and reference period mean (2009–2019; 11,715 t).
- The female spawning stock biomass index (SSB) in 2022 was 10,428 t, above both the long term mean (2009–2021; 8,267 t) and reference period mean (2009–2019; 7,644 t).
- The reported exploitation rate index for 2022/23 was 9.9% with 101.4% of the TAC taken.
- *Pandalus montagui* stock in the EAZ is currently well above the established LRP (3,100 t) and the proposed USR (6,100 t). This would place the stock in the healthy zone with a 93.1% probability.

Western Assessment Zone – *Pandalus borealis*

- Total catch in 2022/23 was 318 t, which is 8.0% of the 3,958 t TAC. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 was 23,939 t. This was above the long term mean (2014–2021; 19,994 t) and reference period mean (2014–2019; 18,223 t).
- The female SSB index in 2022 was 15,899 t, above both the long term mean (2014–2021; 11,402 t) and reference period mean (2014–2019; 10,243 t).
- The reported exploitation rate index for 2022/23 was 1.3% with 8.0% of the TAC taken. Should the entire 2022/23 TAC of 3,958 t be taken, the potential exploitation rate index would be 16.5%.
- *Pandalus borealis* stock in the WAZ is currently well above the established LRP (4,100 t) and the proposed USR (8,200 t). This would place the stock in the healthy zone with a 98.8% probability.

Western Assessment Zone – *Pandalus montagui*

- Total catch in 2022/23 was 11,195 t, which is 92.6% of the 12,096 t TAC. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 was 104,737 t and was the highest in the time series. This is well above the long term mean (2014–2021; 56,440 t) and reference period mean (2014–2019; 56,079 t).
- The female SSB index in 2022 was 61,058 t, above both the long term mean (2014–2021; 30,937 t) and reference period mean (2014–2019; 30,698 t).
- The reported exploitation rate index for 2022/23 was 10.7% with 92.6% of the TAC taken. Should the entire 2022/23 TAC of 12,096 t be taken, the potential exploitation rate index would be 11.5%.

- *Pandalus montagui* stock in the WAZ is currently well above the established LRP (12,300 t) and the proposed USR (24,600 t). This would place the stock in the healthy zone with a >99.9% probability.

APPENDIX 2

Table 1. Stock status indicators for *P. borealis* and *P. montagui* in the WAZ (2019-2022).

P. borealis				
	2023-24	**2022-23**	**2021-22**	**2020-21**
Total Allowable Catch (TAC) (t)	*TBD*	3,958	5,090	3,163
% Change TAC	*TBD*	-22.2	60.9	0.0
Fishable Biomass (FB)*	23,939	19,967[3]	34,929[4]	20,378
Spawning Stock Biomass (SSB)*	15,899	14,083	17,555	11,845
Potential Exploitation Rate	*TBD*	19.8	14.6	15.5
% Change FB	19.9	-42.8	71.4	-3.4
% Change SSB	12.9	-19.8	48.2	-8.1

P. montagui				
	2023-24	**2022-23**	**2021-22**	**2020-21**
Total Allowable Catch (t)	*TBD*	12,096	9,470	11,975
% Change TAC	*TBD*	27.7	-20.9	0.0
FB*	104,737	65,026	50,911	64,268
SSB*	61,058	37,398	26,811	29,079
Potential Exploitation Rate	*TBD*	18.6	18.6	18.6
% Change FB*	61.1	27.7	-20.8	-19.5
% Change SSB*	63.3	39.5	-7.8	-39.2

**Biomass indices reflect the prior year's survey (e.g. 2023-24 indices are reflective of the Fall 2022 survey.*

[3] FB value updated 2023, affects associated potential ER.
[4] FB value updated 2023, affects associated potential ER.

APPENDIX 3

Table 1. Stock status indicators for *P. borealis* and *P. montagui* in the EAZ (2019-2022).

P. borealis				
	2023-24	**2022-23**	**2021-22**	**2020-21**
Total Allowable Catch (TAC) (t)	*TBD*	10,732	12,251	10,653
% Change TAC	*TBD*	-12.4	15.0	23.7
Fishable Biomass (FB)*	36,911	52,617[5]	88,361	95,138
Spawning Stock Biomass (SSB)*	23,771	35,000	59,935	57,143
Potential Exploitation Rate	*TBD*	20.4	13.9	11.2
% Change FB	-29.8	-40.5	-7.1	102.9
% Change SSB	-32.1	-41.6	4.9	74.0

P. montagui				
	2023-24	**2022-23**	**2021-22**	**2020-21**
Total Allowable Catch (t)	*TBD*	1,400	965	840
% Change TAC	*TBD*	45.1	14.9	0.0
FB*	14,325	15,225	18,802	8,503
SSB*	10,428	11,200	14,437	4,415
Potential Exploitation Rate	*TBD*	9.2	5.1	9.9
% Change FB*	-5.9	-19.0	121.1	-59.3
% Change SSB*	-6.9	-22.4	227.0	-68.0

**Biomass indices reflect the prior year's survey (e.g. 2023-24 indices are reflective of the Fall 2022 survey.*

[5] FB value updated 2023, affects associated potential ER.

APPENDIX 4

		2019/20		2020/21		2021/22		2022/23	
Species	**Management unit_Fleet/Interest**	**Quota**	**Catches**	**Quota**	**Catches**	**Quota**	**Catches**	**Quota**	**Catches (Preliminary)**
P. borealis	DSW_Offshore	4,737	4,511	5,250	4,980	5,250	4,145	4,884	4,253
	DSE_Offshore	802	4	1,000	11	1,150	1	1,008	0
	DSE_Nunavut	1,604	0	1,604	35	1,845	0	1,616	0
	DSW_Nunavut	1,084	976	1,778	1,185	2,753	3,413	2,155	1,428
	DSW_Nunavik	120	0	197	0	305	0	239	141
	NU-E_Nunavut	210	4	659	420	758	212	664	624
	NK- E_Nunavik	53	13	165	167	190	259	166	181
	TOTAL	***8,610***	***5,508***	***10,653***	***6,648***	***12,251***	***8,029***	***10,732***	***6,626***
P. montagui	NU-E_Nunavut	301	76	301	168	346	146	574	429
	NK-E_Nunavik	129	0	129	178	148	128	252	235
	DS E/W_Offshore (bycatch)	410	150	410	96	471.5	779	574	474
	TOTAL	***840***	***225***	***840***	***348***	***965.5***	***1,053***	***1,400***	***1,139***
P. borealis	NU-W_Nunavut	1,582	1,236	1,582	785	2,545	637	1,976	320
	NK-W_Nunavik	1,582	375	1,582	652	2,545	539	1,976	492
	TOTAL	***3,163***	***1,612***	***3,163***	***1,438***	***5,090***	***1,175***	***3,958***	***812***
P. montagui	NU-W_Nunavut	5,988	4,131	5,988	3,871	4,735	2,996	6,048	4,364
	NK-W_Nunavik	5,988	3,983	5,988	3,970	4,735	4,743	6,048	6,044
	TOTAL	***11,975***	***8,114***	***11,975***	***7,841***	***9,470***	***8,838***	***12,096***	***10,407***

APPENDIX 5

Consultation Summary: Northern Shrimp Advisory Committee (April 4-5, 2023)
2023-24 Total Allowable Catches for Northern and Striped Shrimp in the WAZ and EAZ

A meeting of the Northern Shrimp Advisory Committee (NSAC) took place on April 4, 2023. The Department held a post-meeting with Indigenous participants on April 5, 2023. Meetings were well attended by groups that have direct interests in the Western and Eastern Assessment Zones (WAZ and EAZ), namely:

- Nunavut Wildlife Management Board (NWMB)
- Nunavut Fisheries Association (NFA)
- Torngat Fish Producers Co-Op
- Qikiqtaaluk Corporation (QC)
- Northern Coalition
- NunatuKavut Community Council (NCC)
- Innu Nation
- Torngat Joint Fisheries Board
- Nunatsiavut Government (NG)
- Baffin Fisheries Coalition (BFC)
- Makivik Corporation

Other participants at NSAC included representatives of the offshore fleet, individual licence holders, provincial government representatives, and Oceans North (non-governmental organization). Staff from the Nunavik Marine Region Wildlife Board (NMRWB) were not in attendance at the Indigenous post-meeting, but did attend NSAC on April 4, 2023.

The Department sought views on Total Allowable Catches (TACs) for *Pandalus borealis* and *P. montagui* in the EAZ at the main NSAC table, with discussions on WAZ TACs reserved for the Indigenous post-meeting. DFO reminded NSAC participants of the NWMB and NMRWB's (the Boards') decision-making role in WAZ, and decision and advice role in the EAZ.

The Department encouraged Nunavut and Nunavik industry to make their views on TACs known to their respective Boards as part of the upcoming joint hearing process on 2023-24 TACs for Northern and Striped shrimp in the WAZ and EAZ. NFA members and Makivik Corporation confirmed their intent to submit a joint recommendation through this process in the coming weeks.

Eastern Assessment Zone

Northern shrimp (P. borealis):

- Canadian Association of Prawn Producers (CAPP) applied their proposed Harvest Decision Rule (HDR) developed in 2022 with support of the Northern Coalition and NFA, to recommend a TAC of 8,687t (potential ER 23.5%).
    - The proposed approach to setting TACs responds only partially to year-to-year changes in biomass (pursuing only 50% of the targeted change in TAC) in the

first year, with opportunity for further response in the following year.

- Northern Coalition supported the proposed TAC of 8,687t and called for reconsideration and feedback to industry's 2022 HDR proposal.
- NFA recommended to maintain the 20% ER with TAC 7,382t, noting it would accept a 15% ER (TAC 5,537t) that is aligned with ERs for Cautious Zone stocks. NFA noted that its support for lower ERs, however, should not be interpreted as foregoing higher ER in some future circumstance.
- Members pointed to consistently low catch rates in the Davis Strait East management unit, such that potential ERs for the EAZ are an overestimation that would not be realized.
- Members were critical of the current HDR that indicates changes in the TAC should generally not exceed 15% of the previous TAC, unless the stock is declining precipitously (a unidirectional rule for increasing TAC).
    - Members were concerned for the number of years needed to make progress towards/return to target exploitation levels as the biomass increases.
- NFA observed patterns of increasing and decreasing biomass over the time series that might suggest a biomass increase can be expected in the coming years.
    - DFO, echoed by Oceans North, noted risk in anticipating such a pattern will continue and risk of a delayed management response under this assumption.
- BFC pressed that any discussion of biomass decline to the lowest levels in the time series should be considered in the context of similarly low levels in 2017 or 2013, after which the biomass increased.
- Participants discussed the potential impacts of an increasing biomass of redfish (*Sebastes* sp.) on the *P. borealis* stock in terms of competition for food (plankton), and potential for future predation on shrimp by redfish.

Striped shrimp (P. montagui):

- CAPP proposed that the TAC for *P. montagui* include an 920t bycatch allowance for the offshore fleet in the Davis Strait management units, calculated as 49% of a recommended TAC of 1,920t. It was proposed that this allowance be static to promote year-to-year stability.
- BFC did not support the idea of a static allowance in the case where other interests would see their share fluctuate with overall TAC changes.
- NFA supported a 15% ER, upwards to 20% ER, as being appropriate for a Healthy Zone stock.

<u>Western Assessment Zone</u>

Northern shrimp (P. borealis):

- QC supported a potential ER of 20% (TAC 4,788t).

Striped shrimp (P. montagui):

- No specific TAC levels were recommended.

Management Measures:

- Makivik Corporation revisited a request to allow crossing between the management units of NK-E and NK-W in a single tow. This request stems from challenges in accessing large shrimp aggregations situated on the management line.
    - DFO reiterated the need to accurately report catches as per conditions of licence, and confirmed that the management unit line aligns with stock assessment boundaries.
    - DFO clarified that crossing between management units within the same assessment zone is currently permitted, where removals are attributed to the same overall TAC.
    - Makivik Corporation called for continued discussion towards a solution, with possibilities including a defined subset of quota for which crossing management unit lines can occur, or changing of the management unit lines to avoid this problem area.
- Members pointed to considerable delays in final TAC decisions and the implications of these delays in terms of limited time to harvest quotas. DFO and Board staff were encouraged to explore ways to minimize these delays and tighten decision timelines where possible.

Access and Allocations:

- Following a statement from the Northern Shrimp Research Foundation (NSRF) offered at NSAC on April 4, members inquired about a possible re-allocation of *P. borealis* quota in Shrimp Fishing Area 4 that is currently used to fund science survey work in SFA 4 and the EAZ, and facilitates survey work in the WAZ.
    - Makivik Corporation and NFA members stressed the importance of continued science information provided through the NSRF survey to inform management decisions.
    - Members clarified that WAZ survey work was funded from Nunavut and Nunavik fishing interests directly, rather than from SFA 4 quota.
    - NCC expressed concern for SFA 4 quota that effectively funds EAZ surveys.

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Arctic Region and Ontario and Prairie Region

Canadian Science Advisory Secretariat
Science Advisory Report 2023/013

ASSESSMENT OF NORTHERN SHRIMP (*PANDALUS BOREALIS*) AND STRIPED SHRIMP (*PANDALUS MONTAGUI*) IN THE EASTERN AND WESTERN ASSESSMENT ZONES, FEBRUARY 2023

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

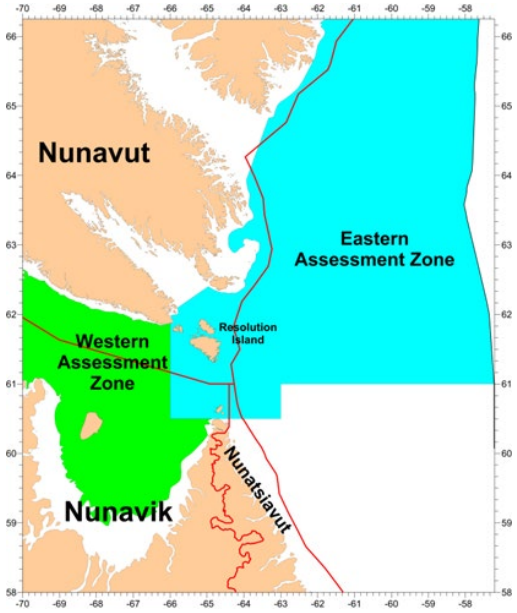

Figure 1. Eastern and Western Assessment Zones. Boundaries of the Nunavut, Nunavik and Nunatsiavut land claims areas are shown in red.

Context:

*Fisheries and Oceans Canada (DFO) Resource Management (RM) has requested Science advice on the status of the two species of shrimp, Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*Pandalus montagui*) in the waters adjacent to Nunavut and Nunavik. Both species in the Eastern and Western Assessment Zones (EAZ and WAZ) were last fully assessed in 2021 (DFO 2021) with a stock status update in 2022 (DFO 2022). Full assessments are carried out every two years with stock status updates in the intervening years. The next full assessment is scheduled for 2025.*

This assessment follows the framework developed in 2007 for Northern Shrimp off Labrador and the northeastern coast of Newfoundland (DFO 2007). Updates of Reference Points for the EAZ and establishment of new Reference Points for the WAZ took place in 2020 (DFO 2020).

A series of fishery-independent surveys and fishery data formed the basis of the current assessment.

*This Science Advisory Report is from the February 15–16, 2023 regional peer review on the Stock Assessment of Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montagui*) in the Eastern Assessment Zone and Western Assessment Zone for the 2023-24 fishing season. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

March 2023

Canada

SUMMARY

- The last full assessment was completed in 2021. This assessment has updated the stock status for *Pandalus borealis and P. montagui* in the Eastern Assessment Zone (EAZ) and Western Assessment Zone (WAZ), to incorporate survey and fishery data from the last two years. Limited predator-prey information, potential redfish competition, and oceanographic data were reviewed for additional ecosystem context.
- *Pandalus borealis* and *P. montagui* are distributed broadly over the Northwest Atlantic Ocean. The associated assessment areas, including the EAZ, WAZ and Shrimp Fishing Area 4 (SFA4), are connected through larval dispersal, but rates of exchange of adults are less understood. These linkages need to be considered to interpret fluctuations in biomass within and among assessment areas, even within the same year.
- The ocean climate in the NW Atlantic experiences fluctuations at decadal time scales, with potential impacts on availability of optimal Pandalid habitat and/or predator-prey interactions in the EAZ/WAZ. In 2022, bottom temperatures in the EAZ were lower than the 2006–2021 average for the first time since 2017, but they remained relatively high in the WAZ after the record high in 2021.
- The emergence of a large biomass of juvenile redfish in the EAZ over the last three years may have indirect (competition) and/or direct (future predation) impacts on the shrimp population. The magnitude and duration of these impacts are unknown.
- In both the EAZ and WAZ the stocks are currently assessed relative to established Limit Reference Points (LRPs) and previously proposed Upper Stock Reference points (USRs) in accordance with DFOs Precautionary Approach (PA) Framework.

Eastern Assessment Zone – *Pandalus borealis*

- Total catch varied without trend around 6,000 t from 1997 through 2022/23. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 declined to the lowest value in the time series (36,911 t). This was below both the long term mean (2009–2021; 63,642 t) and reference period mean (2009–2019; 62,849 t).
- The female spawning stock biomass index (SSB) in 2022 declined to the lowest value in the time series (23,771 t). This was below both the long term mean (2009–2021; 40,374 t) and reference period mean (2009–2019; 39,459 t).
- Both the reported and potential exploitation rates were the highest in the time series. The reported exploitation rate index for 2022/23 was 19.4% with 67% of the Total Allowable Catch (TAC) taken. Should the entire 2022/23 TAC of 10,732 t be taken, the potential exploitation rate index would be 29.1%.
- *Pandalus borealis* stock in the EAZ is currently above the established LRP (15,800 t), but below the proposed USR. Based on the proposed USR of 31,600 t, this would place the stock in the Cautious zone with a 98.3% probability.

Eastern Assessment Zone – *Pandalus montagui*

- Total catch in 2022/23 was 1,419 t, 101.4% of the 1,400 t TAC. Catch statistics in 2022/23 are preliminary.

- The fishable biomass index in 2022 was 14,325 t. This was above both the long term mean (2009–2021; 12,397 t) and reference period mean (2009–2019; 11,715 t).
- The female spawning stock biomass index (SSB) in 2022 was 10,428 t, above both the long term mean (2009–2021; 8,267 t) and reference period mean (2009–2019; 7,644 t).
- The reported exploitation rate index for 2022/23 was 9.9% with 101.4% of the TAC taken.
- *Pandalus montagui* stock in the EAZ is currently well above the established LRP (3,100 t) and the proposed USR (6,100 t). This would place the stock in the Healthy zone with a 93.1% probability.

Western Assessment Zone – *Pandalus borealis*

- Total catch in 2022/23 was 318 t, which is 8.0% of the 3,958 t TAC. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 was 23,939 t. This was above the long term mean (2014–2021; 19,994 t) and reference period mean (2014–2019; 18,223 t).
- The female SSB index in 2022 was 15,899 t, above both the long term mean (2014–2021; 11,402 t) and reference period mean (2014–2019; 10,243 t).
- The reported exploitation rate index for 2022/23 was 1.3% with 8.0% of the TAC taken. Should the entire 2022/23 TAC of 3,958 t be taken, the potential exploitation rate index would be 16.5%.
- *Pandalus borealis* stock in the WAZ is currently well above the established LRP (4,100 t) and the proposed USR (8,200 t). This would place the stock in the Healthy zone with a 98.8% probability.

Western Assessment Zone – *Pandalus montagui*

- Total catch in 2022/23 was 11,195 t, which is 92.6% of the 12,096 t TAC. Catch statistics in 2022/23 are preliminary.
- The fishable biomass index in 2022 was 104,737 t and was the highest in the time series. This is well above the long term mean (2014–2021; 56,440 t) and reference period mean (2014–2019; 56,079 t).
- The female SSB index in 2022 was 61,058 t, above both the long term mean (2014–2021; 30,937 t) and reference period mean (2014–2019; 30,698 t).
- The reported exploitation rate index for 2022/23 was 10.7% with 92.6% of the TAC taken. Should the entire 2022/23 TAC of 12,096 t be taken, the potential exploitation rate index would be 11.5%.
- *Pandalus montagui* stock in the WAZ is currently well above the established LRP (12,300 t) and the proposed USR (24,600 t). This would place the stock in the Healthy zone with a > 99.9% probability.

BACKGROUND

This document provides an overview of the assessment for *P. borealis* and *P. montagui* in the Eastern (EAZ) and Western (WAZ) Assessment Zones (Figure 1). The two species have overlapping distributions, particularly in the Resolution Island area, resulting in an overlap of

their fisheries. The assessment follows the framework established by DFO (2007); catch data from scientific surveys is spatially expanded to produce an abundance index for the fishable (FB) and female spawning stock biomass (SSB). Both male and female shrimp with a carapace length greater than 17 mm are considered in the calculation of fishable biomass, while female shrimp of any size form the basis of the SSB index. A detailed description of the survey history, survey design, and biomass calculations can be found in (Fulton et al. in prep.[1]). Stock updates were last provided in 2022 (DFO 2022) and the last full assessment was conducted in 2021 (DFO 2021). Since the last full assessment, new data from the 2021 and 2022 Northern Shrimp Research Foundation (NSRF) surveys of the EAZ and WAZ are included.

Fisheries in the Eastern and Western Assessment Zones are managed pursuant to an Integrated Fisheries Management Plan (2018). Reference points aligned with DFO's Precautionary Approach Framework (DFO 2009) were set for the EAZ in 2009, but later updated when more survey data was available (DFO 2020). For both species of shrimp in the EAZ, the Limit Reference Point (LRP) was set at 40% of the geometric mean of the SSB for 2009–2019; 15,800 t for *P. borealis* and 3,100 t for *P. montagui*. The Upper Stock Reference (USR) was proposed by Science at 80% of the geometric mean of the SSB (2009–2019); 31,600 t for *P. borealis* and 6,100 t for *P. montagui*. Reference Points for the WAZ were developed in 2012, however, they were not implemented because 2014 was the start of a new survey time series. In 2020, new Reference Points were developed for the WAZ using the same proxies as for the EAZ and a time series covering 2014–2019 (DFO 2020) (LRP = 4,100 t for *P. borealis* and 12,300 t for *P. montagui*; proposed USR = 8,200 t for *P. borealis* and 24,600 t for *P. montagui)*. Reference period mean values used in this assessment correspond to 2009–2019 and 2014–2019 period in the EAZ and WAZ, respectively.

In addition to an index of abundance from the scientific survey, fishery data are used to determine the observed and potential exploitation rate indices. Observed (reported) exploitation rates are calculated as catch from the reporting records (Atlantic Quota Management System; AQMS) divided by the fishable biomass index from the same year. Potential exploitation rates assume the entire quota was removed. The total removal, both directed catch and reported by-catch, of each species is considered in the assessment.

ASSESSMENT

The fishery catch, biomass indices, exploitation rate indices and current outlook using the precautionary approach are presented below for each species and assessment area. Although not quantified, other linkages need to be considered to interpret fluctuations in biomass within and among assessment areas, even within the same year. *Pandalus borealis* and *P. montagui* are distributed broadly over the Northwest Atlantic Ocean. The associated assessment areas, including the EAZ, WAZ and Shrimp Fishing Area 4 (SFA4), are connected through larval dispersal, but rates of exchange of adults are less understood.

[1] Fulton, S., Walkusz, W., Atchison, S., and Cyr, F. In preparation. Information to support the assessment of Northern Shrimp, *Pandalus borealis*, and Striped Shrimp, *Pandalus montagui*, in the Eastern and Western Assessment Zones, February 2023. DFO Can. Sci. Advis. Sec. Res. Doc.

Eastern Assessment Zone – *P. borealis*

Fishery

Catch has varied without trend around 6,000 t from 1997 through 2022/23 (Figure 2b, Table 1). The total reported catch for 2022/23, based on the AQMS, as of January 20, 2023, was 7,145 t, 66.6% of the 10,732 t TAC.

Biomass

The fishable biomass index in 2022 declined to the lowest value in the time series (36,911 t; Figure 2a, Table 2). This was below both the long term mean (2009–2021; 63,642 t) and reference period mean (2009–2019; 62,849 t). The female spawning stock biomass index (SSB) in 2022 also declined to the lowest value in the time series (23,771 t; Figure 2a, Table 2). This was below both the long term mean (2009–2021; 40,374 t) and reference period mean (2009–2019; 39,459 t).

Exploitation

Both the reported and potential exploitation rates were the highest in the time series. The reported exploitation rate index for 2022/23 was 19.4% with 66.6% of the Total Allowable Catch (TAC) taken (Figure 2c). Should the entire 2022/23 TAC of 10,732 t be taken the potential exploitation rate index would be 29.1%.

Current Outlook

The *P. borealis* stock in the EAZ is currently above the established LRP (15,800 t), but below the proposed USR (Figure 2d). Should the USR be established at the proposed level of 31,600 t suggested by Fisheries and Oceans Canada (DFO) Science sector (i.e., 80% of the geometric mean of the SSB index; DFO 2020), this would place the stock in the Cautious zone of the PA Framework with a 98.3% probability.

Eastern Assessment Zone – *P. montagui*

Fishery

Total catch in 2022/23 was 1,419 t, 101.4%% of the 1,400 t TAC (Figure 3b, Table 1). Catch statistics in 2022/23 are preliminary and based on the AQMS data as of January 20, 2023.

Biomass

The fishable biomass index in 2022 was 14,325 t (Figure 3a, Table 3). This was above both the long term mean (2009–2021; 12,397 t) and reference period mean (2009–2019; 11,715 t). The female spawning stock biomass index in 2022 was 10,428 t, above both the long term mean (2009–2021; 8,267 t) and reference period mean (2009–2019; 7,644 t).

Exploitation

The reported exploitation rate index for 2022/23 was 9.9% with 101.4% of the TAC taken (Figure 3c).

Current Outlook

The *P. montagui* stock in the EAZ is currently well above the established LRP (3,100 t) and the proposed USR (6,100 t; Figure 3d). Should the USR be established at the Science Sector proposed level of 6,100 (i.e., 80% of the geometric mean of the SSB; DFO 2020), the stock in 2022 would be placed well in the Healthy zone of the PA Framework with a 93.1% probability.

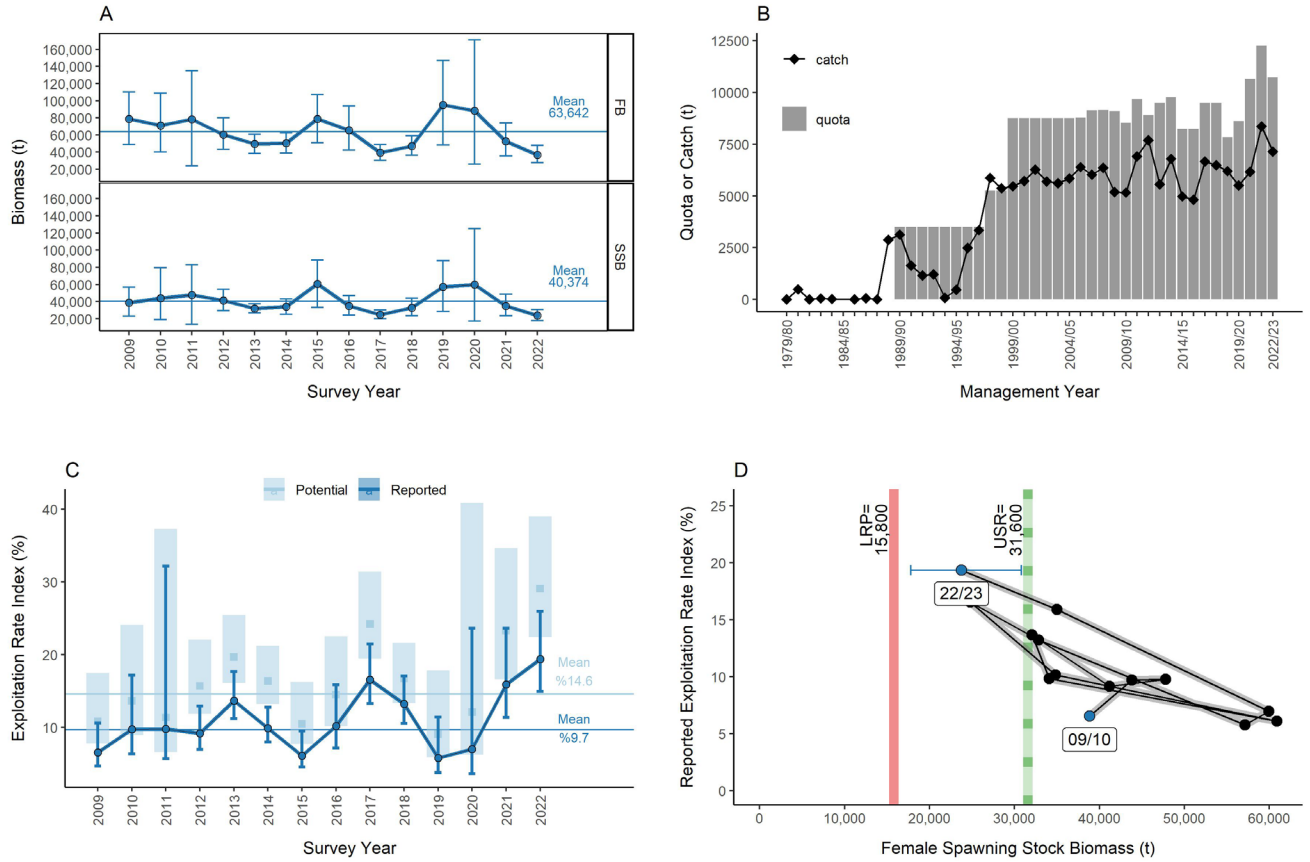

Figure 2. Pandalus borealis *in the Eastern Assessment Zone: A: Fishable (FB, top) and female spawning stock biomass (SSB; bottom) indices for the survey years 2009–2022. Error bars are bootstrapped 95% confidence range and horizontal lines are long term (2009–2021) geometric means; B: Total Allowable Catch (grey bars) and reported catch from DFO harvest records (black line). Harvest records may be incomplete for 2022/23 (data as of January 20, 2023); C: Exploitation rate indices for management years 2009/10–2022/23 at the reported rate based on the total catch (blue line) and at the potential rate if the TAC was fully harvested (blue shading). Error bars based on bootstrapped 95% confidence ranges of the fishable biomass and lines are long term (2009–2021) geometric means; D: Female spawning stock biomass and reported exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to the 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2009–2019 surveys. Since the USR has not been formally accepted, final location of the dashed line is yet to be determined.*

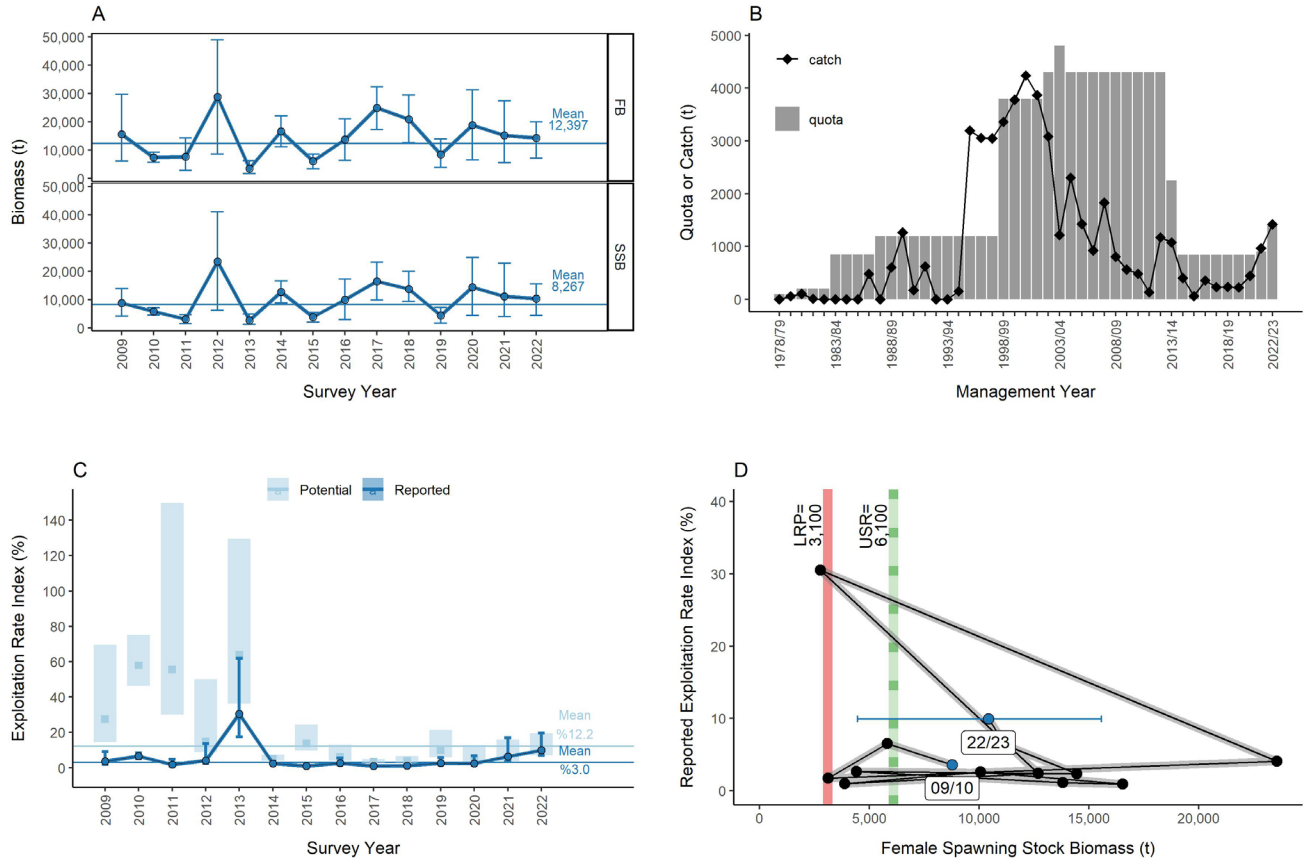

Figure 3. Pandalus montagui *in the Eastern Assessment Zone. A: Fishable (FB, top) and female spawning stock biomass (SSB; bottom) indices for the survey years 2009–2022. Error bars are bootstrapped 95% confidence range and horizontal lines are long term (2009–2021) geometric means; B: Total Allowable Catch (grey bars) and reported catch from DFO harvest records (black line). Harvest records may be incomplete for 2022/23 (data as of January 20, 2023); C: Exploitation rate indices for management years 2009/10–2022/23 at the reported rate based on the total catch (blue line) and at the potential rate if the TAC was fully harvested (blue shading). Error bars based on bootstrapped 95% confidence ranges of the fishable biomass and lines are long term (2009–2021) geometric means; D: Female spawning stock biomass and reported exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to the 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2009–2019 surveys. Since the USR has not been formally accepted, final location of the dashed line is yet to be determined.*

Western Assessment Zone – *P. borealis*

Fishery

Total catch in 2022/23 was 318 t, which is 8.0% of the 3,958 t TAC (Figure 4b, Table 1). Catch statistics in 2022/23 are based on the AQMS, as of January 20, 2023.

Biomass

Due to a change in survey methodology, the 2014 survey began a new time series. Thus, the 2022 survey was the ninth survey in the new time series. Since the start of the new series both the fishable biomass and SSB indices varied without a trend. The fishable biomass index in 2022 was 23,939 t (Figure 4a, Table 4). This was above the long term mean (2014–2021; 19,994 t) and reference period mean (2014–2019; 18,223 t). The female SSB index in 2022 was 15,899 t, above both the long term mean (2014–2021; 11,402 t) and reference period mean (2014–2019; 10,243 t).

Exploitation

The reported exploitation rate index for 2022/23 was 1.3% with 8.0% of the TAC taken (Figure 4c). Should the entire 2022/23 TAC of 3,958 t be taken, the potential exploitation rate index would be 16.5% (Figure 4c).

Current Outlook

The *P. borealis* stock in the WAZ is currently well above the established LRP (4,100 t) and the proposed USR (8,200 t; Figure 4d). Should the USR be established at the proposed level (i.e., 80% of the geometric mean of the SSB index; DFO 2020), this would place the stock in the Healthy zone of the PA Framework with a 98.8% probability.

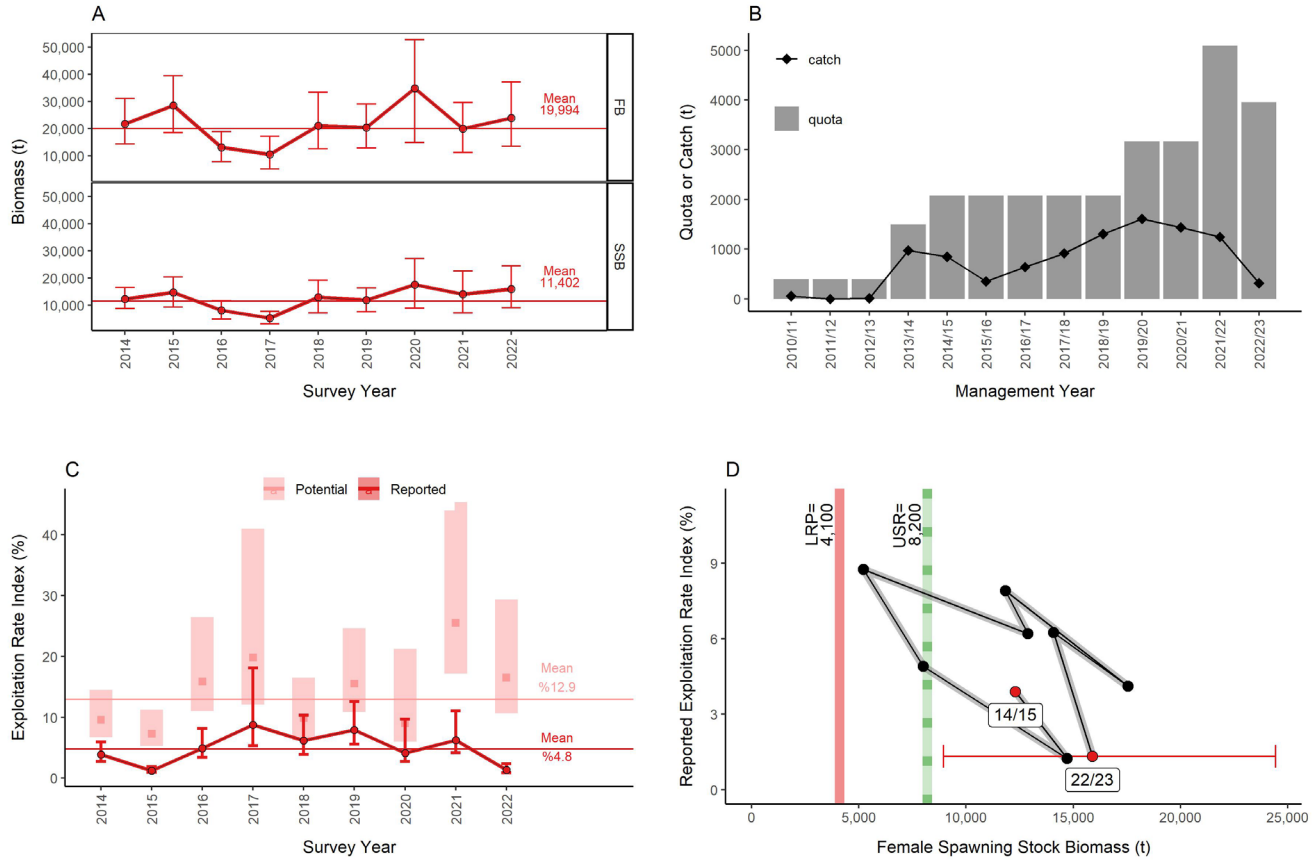

Figure 4. Pandalus borealis *in the Western Assessment Zone. A: Fishable (FB, top) and female spawning stock biomass (SSB; bottom) indices for the survey years 2014–2022. Error bars are bootstrapped 95% confidence range and horizontal lines are long term (2014–2021) geometric means; B: Total Allowable Catch (grey bars) and reported catch from DFO harvest records (black line). Harvest records may be incomplete for 2022/23 (data as of January 20, 2023); C: Exploitation rate indices for management years 2010/11–2022/23 at the reported rate based on the total catch (red line) and at the potential rate if the TAC was fully harvested (red shading). Error bars based on bootstrapped 95% confidence ranges of the fishable biomass and lines are long term (2014–2021) geometric means; D: Female spawning stock biomass and reported exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to the 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys. Since the USR has not been formally accepted, final location of the dashed line is yet to be determined.*

Western Assessment Zone – *P. montagui*

Fishery

Total catch in 2022/23 was 11,195 t, which is 92.6% of the 12,096 t TAC and the highest reported catch in the time series (Figure 5b, Table 1). Catch statistics in 2022/23 are based on the AQMS, as of January 20, 2023.

Biomass

Due to a change in survey methodology, the 2014 survey began a new time series. Thus, the 2022 survey was the ninth survey in the new time series. Since the start of the new series, the fishable biomass and SSB indices varied without trend. The fishable biomass index in 2022 was 104,737 t and was the highest in the time series (Figure 5a, Table 5). This is well above the long term mean (2014–2021; 56,440 t) and reference period mean (2014–2019; 56,079 t). The female SSB index in 2022 was 61,058 t, above both the long term mean (2014–2021; 30,937 t) and reference period mean (2014–2019; 30,698 t).

Exploitation

The reported exploitation rate index for 2022/23 was 10.7% with 92.6% of the TAC taken (Figure 5c). Should the entire 2022/23 TAC of 12,096 t be taken, the potential exploitation rate index would be 11.5%.

Current Outlook

The *P. montagui* stock in the WAZ is currently well above the established LRP (12,300 t) and the proposed USR (24,600 t; Figure 5d). Should the USR be established at the proposed level (i.e., 80% of the geometric mean of the SSB index; DFO 2020), the stock in 2022 would be placed within the Healthy zone of the PA Framework with a > 99.9% probability.

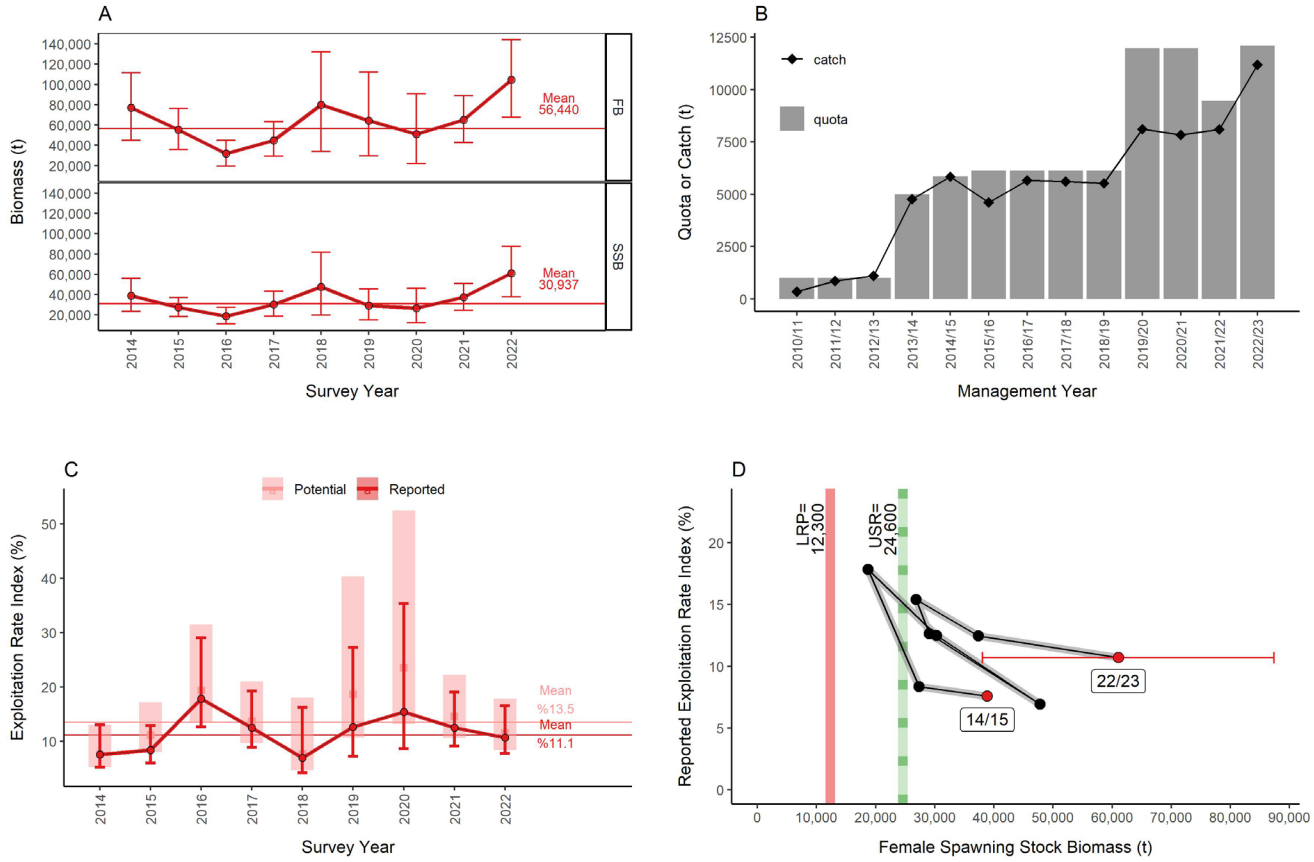

Figure 5. Pandalus montagui *in the Western Assessment Zone. A: Fishable (FB, top) and female spawning stock biomass (SSB; bottom) indices for the survey years 2014–2022. Error bars are bootstrapped 95% confidence range and horizontal lines are long term (2014–2021) geometric means; B: Total Allowable Catch (grey bars) and reported catch from DFO harvest records (black line). Harvest records may be incomplete for 2022/23 (data as of January 20, 2023); C: Exploitation rate indices for management years 2010/11–2022/23 at the reported rate based on the total catch (red line) and at the potential rate if the TAC was fully harvested (red shading). Error bars based on bootstrapped 95% confidence ranges of the fishable biomass and lines are long term (2014–2021) geometric means; D: Female spawning stock biomass and reported exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to the 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys. Since the USR has not been formally accepted, final location of the dashed line is yet to be determined.*

Ancillary Ecosystem Information

It is believed that the available shrimp habitat is shaped, to a great extent, by the oceanographic conditions present in the area. The ocean climate in the NW Atlantic experiences fluctuations at decadal time scales, with potential impacts on availability of optimal Pandalid habitat and/or predator-prey interactions in the EAZ/WAZ. In 2022, bottom temperatures in the EAZ were lower than the 2006–2021 average for the first time since 2017, while in the WAZ, they remained higher than the average after the record high observed in 2021. Additionally, other drivers of stock variability are poorly understood and research is needed on foraging (e.g., water column productivity estimates), predation (e.g., gut contents of shrimp predators), and ecosystem tracers (e.g., stable isotopes and fatty acids to connect various food chain elements). The emergence of a large biomass of juvenile redfish in the EAZ over the last three years has been identified as one such driver that may have indirect (competition) and/or direct (future predation) impacts on the shrimp population. The magnitude and duration of these impacts are currently not known. Quantification of *P. montagui* and *P. borealis* as a prey species in the EAZ and WAZ is ongoing. A qualitative overview of gut data from six predator taxa collected between 2018 and 2021 provided a preliminary look at potential trends in predator size and species that may consume higher proportions of Pandalid shrimp. This information can be used to inform ongoing data collection in order to target specific questions instead of the current exploratory approach.

Sources of Uncertainty

Due to challenges with vessel logistics, the number of stations sampled in the 2022 NSRF survey was reduced. A reduction in number of sets fished occurred in the WAZ. Although the minimum of two sets per strata was achieved, the reduction of samples in areas of high variability impacts the characterization of sample variance and resulting confidence intervals.

Hudson Strait is a highly dynamic system with strong tidal currents and mixing. With speeds up to five knots, the strong currents could result in quick shifts in shrimp distribution and catchability. Shrimp could be transported great distances in a relatively short period of time in and out of the WAZ, EAZ, and SFA4 to the south. This is most likely the cause of the wide fluctuations in biomass observed within and among assessment areas, even within the same year. Assessing only a subset of a larger population is a source of uncertainty in determining the true status of a resource.

Experimental work done by DFO in 2007 in the Resolution Island area suggests that survey results may be affected by the tidal cycle. In order to reduce the impact of the tidal currents, the surveys were conducted near neap tides as much as possible. However, the survey is conducted around the clock, so strong tidal currents would still be present and may result in either an over- or underestimate of biomass.

Trawls used in the survey are known to have a catchability coefficient 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 is known; however, the total fishery-induced mortality is unknown (landed catch plus incidental mortality from trawling). Thus, exploitation rates are a relative index rather than absolute.

Four research vessels (*Cape Ballard*, *Aqviq*, *Kinguk*, *Katsheshuk II*) have been used throughout the time series in the EAZ and WAZ. Expert opinion was that, given the similarity in the ships' dimensions and use of standardized gear, the relative catchability would be consistent among vessels. However, this assumption has not been empirically tested.

Research Recommendations

- Re-calculate *P. borealis* and *P. montagui* total biomass for the entire study area by combining EAZ/WAZ/SFA4 to investigate the difference in biomass index confidence intervals when the index is computed as separate zones *vs*. over the entire area;
- Investigate *P. montagui and P. borealis* total biomass time series for potential relationships between assessment areas (EAZ/WAZ/SFA4) for evidence of local scale biomass export/import between the zones over time;
- Continue to investigate potential predator-prey dynamics by continuing collection of samples in 2023, processing existing samples (from 2020–2022), analyzing existing data sets (from 2018–2021), and publishing compiled data (from 2019/20);
- Quantify juvenile redfish impact on shrimp stock through estimates of redfish biomass, their feeding preferences, and their role in the food web;
- Continue to collect ancillary environmental data (Project funding obtained, moorings deployed in summer 2022, and data retrieval set for summer 2023).

CONCLUSIONS AND ADVICE

Eastern Assessment Zone – *P. borealis*

The *P. borealis* stock in the EAZ is currently above the established LRP (15,800 t), but below the proposed USR. Based on the proposed USR of 31,600 t, this would place the stock in the Cautious zone with a 98.3% probability. Should the entire 2022/23 TAC of 10,732 t be taken the potential exploitation rate index would be 29.1%.

Eastern Assessment Zone – *P. montagui*

The *P. montagui* stock in the EAZ is currently well above the established LRP (3,100 t) and the proposed USR (6,100 t). This would place the stock in the Healthy zone with a 93.1% probability. Based on the 2022/23 TAC of 1,400 t, the exploitation rate index was 9.9% with 101.4% of the TAC taken.

Western Assessment Zone – *P. borealis*

The *P. borealis* stock in the WAZ is currently well above the established LRP (4,100 t) and the proposed USR (8,200 t). This would place the stock in the Healthy zone with a 98.8% probability. Should the entire 2022/23 TAC of 3,958 t be taken the potential exploitation rate index would be 16.5%.

Western Assessment Zone – *P. montagui*

The *P. montagui* stock in the WAZ is currently well above the established LRP (12,300 t) and the proposed USR (24,600 t). This would place the stock in the Healthy zone with a > 99.9% probability. Should the entire 2022/23 TAC of 12,096 t be taken the potential exploitation rate index would be 11.5%.

OTHER CONSIDERATIONS

In general, management of key forage species, such as shrimp, under an ecosystem approach requires adoption of a conservative approach with lower fishing mortality reference points and

higher biomass reference points than those that would be adopted under a single species management approach. Management considerations should refer to the IFMP for Northern and Striped shrimp (DFO 2018) for options of exploitation rates.

The PA reference points for *P. borealis* and *P. montagui* were updated in May 2020 (DFO 2020), providing the established LRPs and proposed USRs that are used in this report. It is important to note that the proposed USRs are still under consideration through the consultative process within the Northern Precautionary Approach Working Group (NPAWG) and will not be considered established until that process is complete.

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SOURCES OF INFORMATION

This Science Advisory Report is from the February 15–16, 2023 regional peer review on the Stock Assessment of Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*P. montagui*) in the Eastern Assessment Zone and Western Assessment Zone for the 2023-24 fishing season. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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