



# UPDATE OF STOCK STATUS INDICATORS FOR NORTHERN SHRIMP, *PANDALUS BOREALIS*, AND STRIPED SHRIMP, *PANDALUS MONTAGUI*, IN THE WESTERN AND EASTERN ASSESSMENT ZONES, JANUARY 2022

## Context

Fisheries and Oceans Canada (DFO) Resource Management has requested an update on the stock status of the two species of shrimp, Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*Pandalus montagui*), in the Western Assessment Zone (WAZ) and Eastern Assessment Zone (EAZ). The last Zonal Peer Review (ZPR) for the WAZ and EAZ, which fully assessed the stock status, took place in February 2021 (DFO 2021). The full assessments and the updates follow the framework developed in 2007 for Northern Shrimp off Labrador and the northeastern coast of Newfoundland (DFO 2007). The basis of this update is a series of previously reported fishery-independent surveys and fishery data, as well as new survey and catch data from the 2021/22 fishing season.

This Science Response Report results from the Regional Science Response Process (SRP) of January 27, 2022 for the Stock Status Update for Northern Shrimp (*Pandalus borealis*) and Striped Shrimp (*Pandalus montagui*) in the Eastern Assessment Zone and Western Assessment Zone, January 2022.

## Background

The EAZ and WAZ (Figure B1) were adopted in 2011 as the basis for assessing the status of shrimp in Shrimp Fishing Area (SFA) 2 and SFA 3 (DFO 2011). The combined boundary of the EAZ and WAZ is equivalent to the combined areas of SFAs 2 and 3 and their corresponding Management Units implemented in the 2013/14 fishing season.

Two exploitation rates are presented for each assessment zone and species because the total allowable catch (TAC) is not generally taken. Exploitation rate (ER) refers to the reported (realized) rate based on a reported catch in a given year, while the potential rate is calculated as though the TAC had been fully taken. Note that all interim catch estimates provided in this report have been obtained from the Atlantic Quota Monitoring System (AQMS), which replaced the Canadian Atlantic Quota Report (CAQR) in 2021. Given that the shrimp fisheries in the EAZ and WAZ operate on a fiscal calendar year from April 1 until March 31, all 2021/2022 catch estimates and ERs reported in this assessment should be considered preliminary.

In 2014, DFO's Central and Arctic Region (now the Arctic and Aquatic Research Division within the Ontario and Prairie Region) reorganized the surveys and stopped conducting the shrimp survey in the WAZ. Since then, the WAZ has been surveyed during the joint DFO-Northern Shrimp Research Foundation (NSRF) survey of the EAZ and SFA 4 (also known as NAFO 2G) areas so that all three areas are sampled with the same ship, comparable gear (i.e., a standard Campelen trawl in SFA 4 and a modified Campelen trawl in the EAZ/WAZ; Siferd and Legge 2014), and during the same time of year. While this resulted in restarting the WAZ time-series, the future benefits to the assessment of shrimp outweigh this near-term shortcoming. Sampling strategy, biomass indices, and upper and lower confidence intervals used in biomass and exploitation rate calculations followed accepted peer reviewed methodology (Siferd 2015).

Resource status in the EAZ and WAZ is evaluated within a Precautionary Approach (PA) Framework that was established in 2020 (DFO 2020). For both species of shrimp, the Limit Reference Point (LRP) was set at 40% of the geometric mean of the female spawning stock biomass (SSB) index and the preliminary (not yet finalized) Upper Stock Reference (USR) was proposed at 80% of the geometric mean of the female SSB index over a recent productive period. For the EAZ, the recent productive period used to calculate the geometric mean is 2009–2019. For the WAZ, the geometric mean is based on the 2014–2019 period given the previously mentioned change to the survey protocol prior to 2014 (DFO 2020).

## Analysis and Response

### Update of Indicators (catch records are preliminary as of January 7, 2022)

#### Eastern Assessment Zone – *Pandalus borealis*

##### *Fishery*

The preliminary total 2021/22 catch of *P. borealis* in the EAZ was 8,359 t, which is 74% of the TAC (Table A1, Figure B2).

##### *Biomass*

The fishable biomass index decreased for the second year in a row, by 37.8% from 2020 to 2021, and is now at 53,658 t (Table A2, Figure B3a). The female SSB index showed a second consecutive annual decrease, by 40.9% from 2020 to 2021, and is now at 35,792 t (Table A2, Figure B3b). Both indices fell below their respective long-term means in 2021.

##### *Exploitation*

The reported ER index for 2021/22 was 15.6% (Figure B4a). If the entire TAC were taken this fishing season the potential ER index for 2021/22 would be 21.1% (Figure B4b), which is above the long-term mean (14.7%).

##### *Current Outlook*

Despite the decline in the SSB index, based on the proposed USR, *P. borealis* in the EAZ still remains within the Healthy Zone of the PA Framework. Note, there is a possibility of transgressing into the Cautious Zone based on the confidence interval crossing the proposed USR (Figure B5).

#### Eastern Assessment Zone – *Pandalus montagui*

##### *Fishery*

The preliminary total 2021/22 catch of *P. montagui* in the EAZ was 582 t, which is 65% of the TAC (Table A1, Figure B6).

##### *Biomass*

The fishable biomass index decreased by 19.0% from 2020 to 2021, and is now at 15,225 t (Table A3, Figure B7a). The female SSB index showed a decrease, by 22.4 % from 2020 to 2021, and is now at 11,200 t (Table A3, Figure B7b). Both indices were close to their respective long-term means in 2021.

##### *Exploitation*

The reported ER index for 2021/22 was 3.8% (Figure B8a). If the entire TAC were taken this fishing season the potential ER index for 2021/22 would be 5.9% (Figure B8b), which is below the long-term mean (28.6%).

*Current Outlook*

Despite the decline in the SSB index, based on the proposed USR, *P. montagui* in the EAZ still remains within the Healthy Zone of the PA Framework. Note, there is a possibility of transgressing into the Cautious Zone based on the confidence interval crossing the proposed USR (Figure B9).

**Western Assessment Zone – *Pandalus borealis***

*Fishery*

The preliminary total 2021/22 catch of *P. borealis* in the WAZ was 1,248 t, which is 24% of the TAC (Table A1, Figure B10).

*Biomass*

The fishable biomass index decreased by 39.7% from 2020 to 2021, and is now at 19,784 t (Table A4, Figure B11a). The female SSB index showed a decrease, by 19.8% from 2020 to 2021, and is now at 14,082 t (Table A4, Figure B11b). Both indices were near their respective long-term means with the fishable biomass being slightly below the long-term mean and the female SSB being slightly above the long-term mean.

*Exploitation*

The reported ER index for 2021/22 was 6.3% (Figure B12a). As a consequence of the decline in the fishable biomass in 2021, if the entire TAC were taken this fishing season the potential ER index for 2021/22 would be 25.7% (Figure B12b), which is above the long-term mean (12.5%).

*Current Outlook*

Despite the decline in the SSB index, based on the proposed USR, *P. borealis* in the WAZ still remains within the Healthy Zone of the PA Framework. Note there is a possibility of transgressing into the Cautious Zone based on the confidence interval crossing the proposed USR (Figure B13).

**Western Assessment Zone – *Pandalus montagui***

*Fishery*

The preliminary total 2021/22 catch of *P. montagui* in the WAZ was 8,106 t, which is 86% of the TAC (Table A1, Figure B14).

*Biomass*

The fishable biomass index increased by 27.7% from 2020 to 2021, and is now at 65,026 t (Table A5, Figure B15a). The female SSB index showed an increase, by 39.5% from 2020 to 2021, and is now at 37,398 t (Table A5, Figure B15b). Both indices are above their respective long-term means in 2021.

*Exploitation*

The reported ER index for 2021/22 was 12.5% (Figure B16a). If the entire TAC were taken this fishing season the potential ER index for 2021/22 would be 14.6% (Figure B16b), which is near the long-term mean (14.5%).

*Current Outlook*

Based on the proposed USR, *P. montagui* in the WAZ is within the Healthy Zone of the PA Framework. Transgressing into the Cautious Zone is very unlikely based on the confidence interval not crossing the proposed USR (Figure B17).

## Conclusions

### Eastern Assessment Zone (EAZ)

#### *Pandalus borealis*

- In 2021, the fishable biomass and female SSB indices had relatively large decreases; both biomass indices fell below their long-term means in 2021. This follows 2020 in which a decrease in fishable biomass and a small increase in female SSB occurred.
- Based on the proposed USR the stock remains in the Healthy Zone of the PA Framework.
- The potential ER index for 2021/22 is 21.1%, which is above the long-term mean of the potential ER (14.7%).

#### *Pandalus montagui*

- In 2021, both the fishable biomass and female SSB indices decreased, but remained close to their long-term means.
- Based on the proposed USR the stock remains in the Healthy Zone of the PA Framework. Note that the interpretation of the stock status is complicated due to large fluctuations in stock biomass.
- The potential ER index for 2021/22 is 5.9%, which is below the long-term mean of the potential ER (28.6%).

### Western Assessment Zone (WAZ)

#### *Pandalus borealis*

- In 2021, the fishable biomass and female SSB indices decreased. The fishable biomass index in 2021 was close to the long-term series mean. The female SSB index was above the long-term series mean.
- Based on the proposed USR the stock remains in the Healthy Zone of the PA Framework.
- The potential ER index for 2021/22 is 25.7%, which is above the long-term mean of the potential ER (12.5%).

#### *Pandalus montagui*

- In 2021, both the fishable biomass and female SSB indices increased, which placed them above their respective time-series means.
- Based on the proposed USR the stock remains in the Healthy Zone of the PA Framework.
- The potential ER index for 2021/22 is 14.6%, which is near the long-term mean of the potential ER (14.5%).

## Contributors

- Colin Gallagher, DFO Science, Ontario and Prairie Region (Chair)
- Wojciech Walkusz, DFO Science, Ontario and Prairie Region
- Sheila Atchison, DFO Science, Ontario and Prairie Region
- Katherine Skanes, DFO Science, Newfoundland and Labrador Region
- Krista Baker, DFO Science, Newfoundland and Labrador Region
- William Coffey, DFO Science, Newfoundland and Labrador Region
- Mary Thiess, DFO Science, National Capital Region

- Nicholas Duprey, DFO Science, National Capital Region (written review only)
- Jennie Ryman, DFO Fisheries Management, Arctic Region
- Kailey Noonan, DFO Fisheries Resource Management, National Capital Region
- Derek Mahoney, DFO Fisheries Resource Management, National Capital Region
- Erika Parrill, DFO Fisheries Resource Management, National Capital Region (written review only)

### Approved by

Tricia Mitchell, Regional Director of Science, Ontario and Prairie Region

Lianne Postma, A/Division Manager, Arctic and Aquatic Research Division, Ontario and Prairie Region

(February 4, 2022) (Erratum: February 25, 2022)

### Sources of Information

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- Siferd, T., and Legge, G. 2014. [Modifications to the Campelen 1800 shrimp survey trawl](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2014/024. iv + 38 p.
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## Appendix A. Tables

Table A1. Nominal reported catches (t) for the Eastern Assessment Zone and Western Assessment Zone for *Pandalus borealis* and *Pandalus montagui*. Catch based on AQMS as of January 7, 2022 (denoted with a \*). Since the fishery is still open, the catch reported here are preliminary for 2021/22.

Year	Catch (t)			
	Eastern Assessment Zone		Western Assessment Zone	
	<i>P. borealis</i>	<i>P. montagui</i>	<i>P. borealis</i>	<i>P. montagui</i>
2021*	8,359	582	1,248	8,106
2020	6,165	447	1,438	7,841
2019	5,508	225	1,612	8,114
2018	6,198	234	1,307	5,531
2017	6,488	233	918	5,609
2016	6,667	358	643	5,660
2015	4,816	59	353	4,616
2014	4,972	401	847	5,836
2013	6,793	1,075	973	4,775
2012	5,555	1,173	13	1,105
2011	7,687	135	0	857
2010	6,908	483	57	345
2009	5,159	564	0	0
2008	5,184	808	0	0
2007	6,359	1,832	0	0
2006	6,028	925	0	0
2005	6,387	1,427	-	0
2004	5,842	2,301	-	0
2003	5,617	1,217	-	0
2002	5,695	3,081	-	0
2001	6,275	3,867	-	0
2000	5,718	4,238	-	0
1999	5,465	3,780	-	0
1998	5,372	3,360	-	0
1997	5,870	3,050	-	0
1996	3,467	3,058	-	0
1995	2,489	3,192	-	0
1994	456	154	-	0
1993	68	0	-	0
1992	1,210	1	-	0
1991	1,150	623	-	0
1990	1,634	174	-	5

*Table A2. Fishable and female spawning stock (SS) biomass estimates for Pandalus borealis in the Eastern Assessment Zone for the 2009–2021 surveys. LCL and UCL are the lower and upper 95% confidence limits, respectively. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2021	Fishable	-37.8	53,658	35,405	73,870
2020	Fishable	-9.4	86,211	26,090	170,892
2019	Fishable	102.8	95,138	48,333	146,788
2018	Fishable	19.6	46,900	36,344	58,928
2017	Fishable	-40.2	39,198	30,225	48,907
2016	Fishable	-17.0	65,570	42,137	93,569
2015	Fishable	56.5	78,984	50,852	106,962
2014	Fishable	1.5	50,458	38,914	62,340
2013	Fishable	-17.9	49,697	38,427	60,631
2012	Fishable	-22.9	60,534	43,074	79,960
2011	Fishable	10.5	78,530	23,900	135,037
2010	Fishable	-9.8	71,065	40,234	108,703
2009	Fishable	54.3	78,755	48,850	110,115
2021	Female SS	-40.9	35,792	23,322	48,492
2020	Female SS	5.9	60,531	17,534	125,168
2019	Female SS	74.0	57,143	28,420	87,654
2018	Female SS	32.4	32,842	23,548	44,126
2017	Female SS	-28.8	24,800	19,888	30,252
2016	Female SS	-42.8	34,827	24,220	46,979
2015	Female SS	78.7	60,869	33,379	88,386
2014	Female SS	6.3	34,069	25,157	43,000
2013	Female SS	-22.2	32,049	26,762	37,607
2012	Female SS	-13.8	41,190	29,498	54,383
2011	Female SS	9.1	47,807	13,470	82,926
2010	Female SS	12.7	43,800	19,025	79,665
2009	Female SS	40.5	38,856	23,122	56,820

*Table A3. Fishable and female spawning stock (SS) biomass estimates for Pandalus montagui in the Eastern Assessment Zone for the 2009–2021 surveys. LCL and UCL are the lower and upper 95% confidence limits, respectively. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2021	Fishable	-19.0	15,225	5,674	27,430
2020	Fishable	121.1	18,802	6,583	31,371
2019	Fishable	-59.3	8,503	3,930	13,948
2018	Fishable	-16.3	20,895	12,617	29,450
2017	Fishable	81.0	24,957	17,246	32,311
2016	Fishable	124.7	13,792	6,452	21,126
2015	Fishable	-63.0	6,137	3,445	8,629
2014	Fishable	371.0	16,600	11,203	22,084
2013	Fishable	-87.8	3,524	1,738	6,208
2012	Fishable	272.7	28,845	8,582	48,946
2011	Fishable	4.3	7,740	2,871	14,285
2010	Fishable	-52.7	7,423	5,714	9,290
2009	Fishable	6.9	15,679	6,190	29,774
2021	Female SS	-22.4	11,200 <sup>1</sup>	4,073	22,834
2020	Female SS	227.0	14,437	4,392	24,991
2019	Female SS	-68.0	4,415	1,742	7,275
2018	Female SS	-19.8	13,806	9,362	20,052
2017	Female SS	64.4	16,537	9,866	23,250
2016	Female SS	159.4	10,056	2,986	17,280
2015	Female SS	-69.5	3,877	2,085	5,452
2014	Female SS	357.1	12,696	8,834	16,622
2013	Female SS	-88.2	2,778	1,301	4,949
2012	Female SS	653.8	23,552	6,218	40,985
2011	Female SS	-46.3	3,124	1,599	4,721
2010	Female SS	-33.7	5,819	4,509	7,136
2009	Female SS	-17.7	8,776	4,205	13,955

<sup>1</sup> Erratum February 2022 – 112,00 corrected to 11,200

*Table A4. Fishable and female spawning stock (SS) biomass estimates for Pandalus borealis in the Western Assessment Zone for the 2014–2021 surveys. LCL and UCL are the lower and upper 95% confidence limits, respectively. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2021	Fishable	-39.7	19,784	11,230	29,631
2020	Fishable	61.1	32,835	14,867	52,744
2019	Fishable	-3.4	20,378	12,852	29,080
2018	Fishable	101.0	21,088	12,627	33,452
2017	Fishable	-20.0	10,487	5,073	17,185
2016	Fishable	-54.0	13,116	7,867	18,868
2015	Fishable	31.4	28,532	18,531	39,501
2014	Fishable	-1.3	21,713	14,353	31,046
2021	Female SS	-19.8	14,082	7,076	22,531
2020	Female SS	48.2	17,555	8,943	27,150
2019	Female SS	-8.1	11,845	7,529	16,299
2018	Female SS	147.0	12,884	7,121	19,203
2017	Female SS	-34.9	5,216	3,045	7,676
2016	Female SS	-45.5	8,015	4,780	11,590
2015	Female SS	19.5	14,710	9,270	20,379
2014	Female SS	25.8	12,309	8,792	16,398

*Table A5. Fishable and female spawning stock (SS) biomass estimates for Pandalus montagui in the Western Assessment Zone for the 2014–2021 surveys. LCL and UCL are the lower and upper 95% confidence limits, respectively. Year over year (YOY) change indicates the relative change in comparison to the previous year.*

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2021	Fishable	27.7	65,026	42,563	89,148
2020	Fishable	-20.8	50,911	22,199	90,802
2019	Fishable	-19.5	64,268	29,711	112,173
2018	Fishable	77.7	79,835	34,057	132,111
2017	Fishable	41.6	44,915	29,179	63,381
2016	Fishable	-42.5	31,724	19,507	44,908
2015	Fishable	-28.4	55,194	35,769	76,429
2014	Fishable	68.9	77,078	44,854	111,562
2021	Female SS	39.5	37,398	24,651	50,850
2020	Female SS	-7.8	26,811	12,310	46,349
2019	Female SS	-39.2	29,079	14,930	45,581
2018	Female SS	57.8	47,834	19,926	81,534
2017	Female SS	62.1	30,305	18,830	43,434
2016	Female SS	-31.6	18,691	11,090	27,334
2015	Female SS	-29.7	27,324	18,282	37,041
2014	Female SS	44.2	38,875	23,553	55,849

### Appendix B. Figures

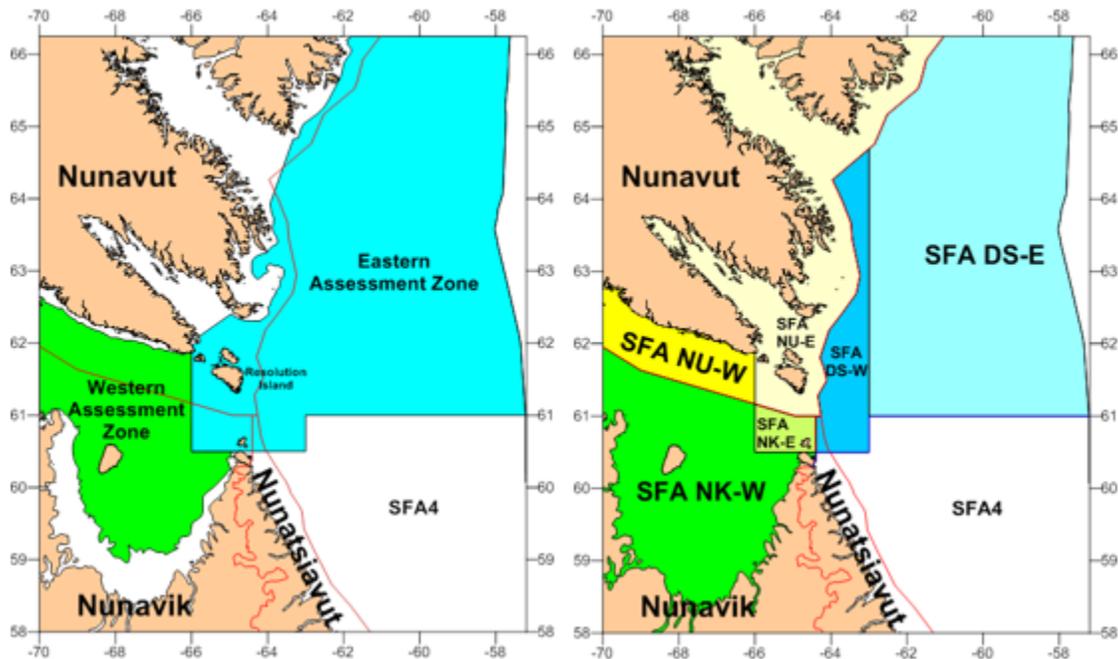


Figure B1. Location of the Western and Eastern assessment zones (left panel) and corresponding Shrimp Fishing Area (SFA) management units (right panel). Boundaries of the Nunavut (NU), Nunavik (NK) and Nunatsiavut Land Claims Areas are identified with red lines. Abbreviations for Davis Strait (DS), East (E) and West (W) are used.

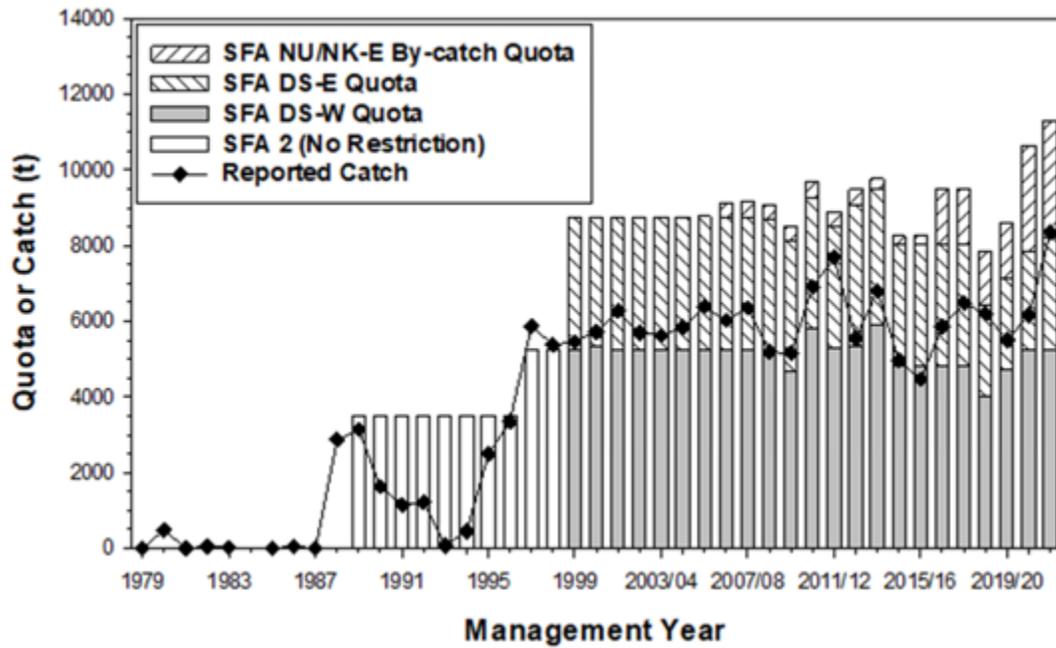


Figure B2. Eastern Assessment Zone *Pandalus borealis* TAC and catch recorded for 1979–2021/22 (AQMS as of January 7, 2022); since the fishery remains open until March 31, 2022, catch estimates are preliminary. Quota for 1999–2012/13 was renamed to correspond to new management areas.

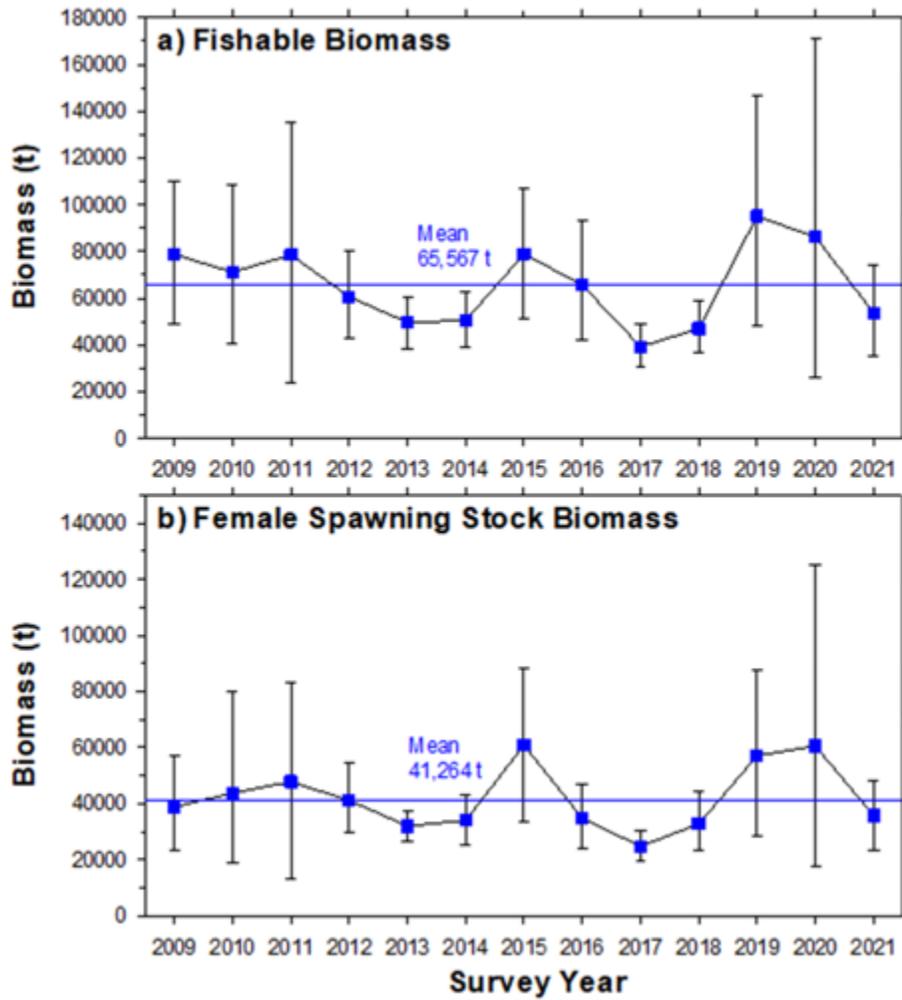


Figure B3. Eastern Assessment Zone *Pandalus borealis* a) fishable and b) female spawning stock biomass indices for the survey years 2009–2021. Error bars are 95% confidence ranges. Horizontal blue lines correspond to the long-term series mean.

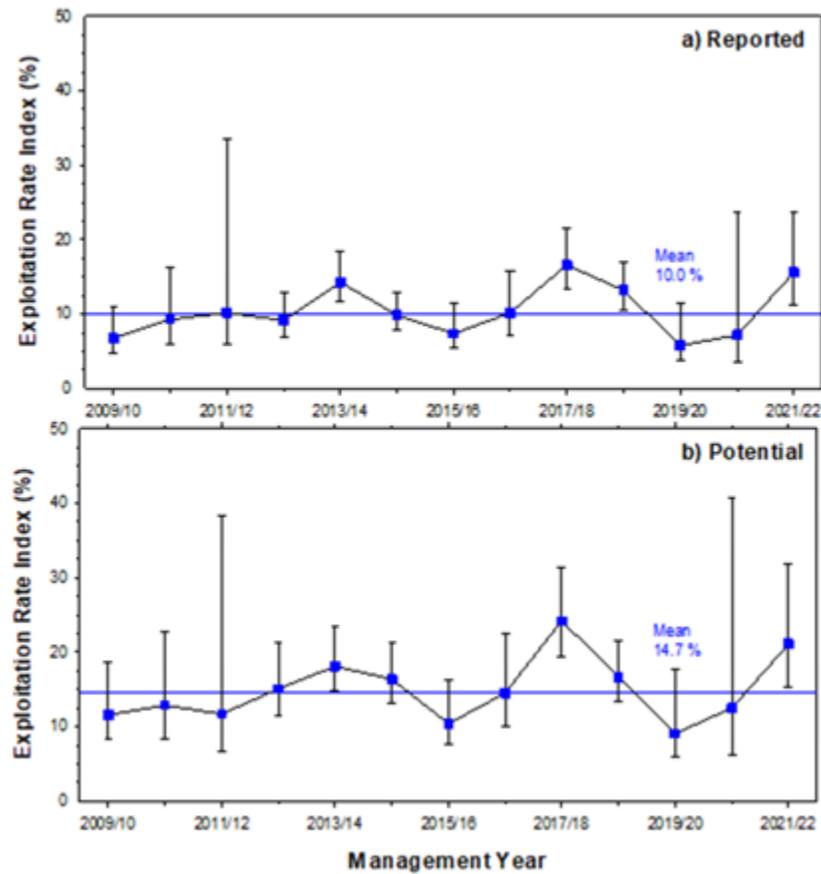


Figure B4. Eastern Assessment Zone *Pandalus borealis* a) reported and b) potential exploitation rate indices for the period of 2009/10–2021/22. Error bars are 95% confidence ranges. Horizontal blue lines correspond to the long-term series mean.

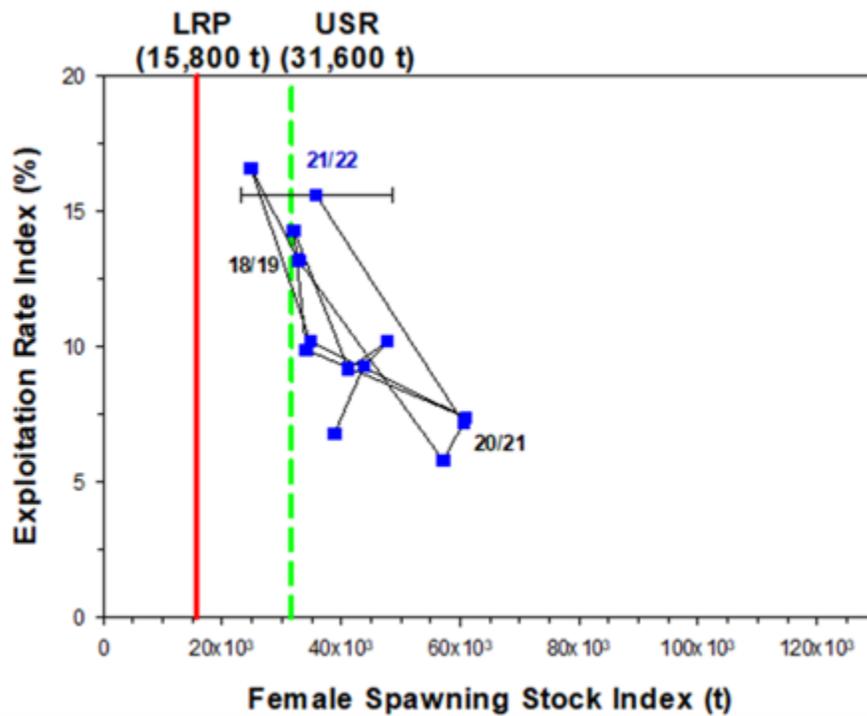


Figure B5. Eastern Assessment Zone trajectory of *Pandalus borealis* female spawning stock biomass index and exploitation rate in relation to reference points proposed in 2020 (DFO 2020). The dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female SSB indices from the 2009–2019 surveys. Since the USR has not been implemented and it is currently under consultation, final location of the dashed line is yet to be determined.

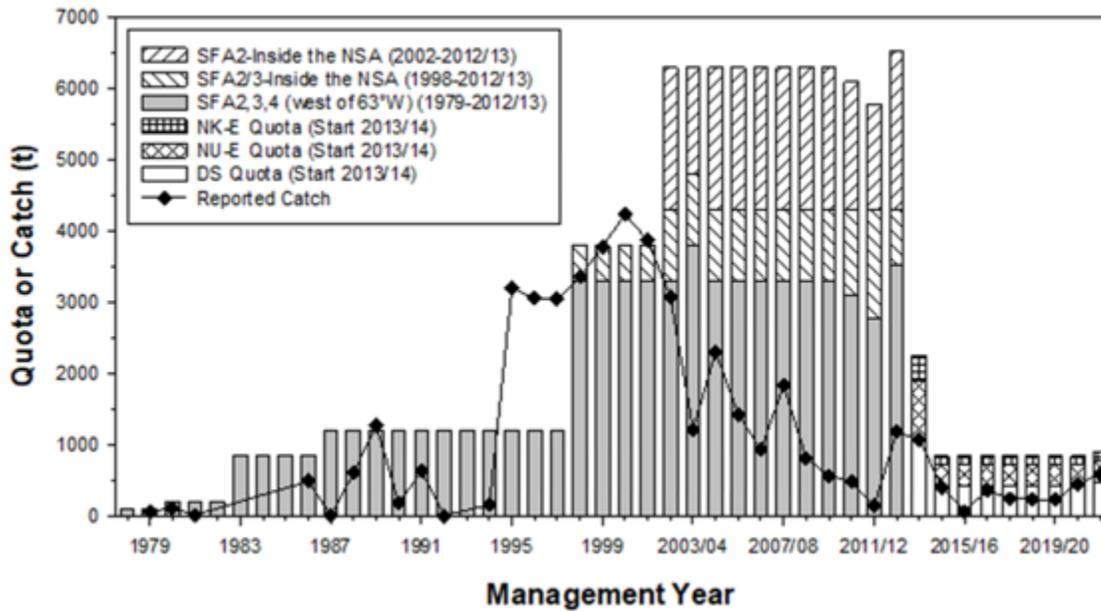


Figure B6. Eastern Assessment Zone *Pandalus montagui* TAC and catch recorded for 1979–2021/22 (AQMS as of January 7, 2022); since the fishery remains open until March 31, 2022, catch estimates are preliminary. Quota for 1999–2012/13 was renamed to correspond to new management areas.

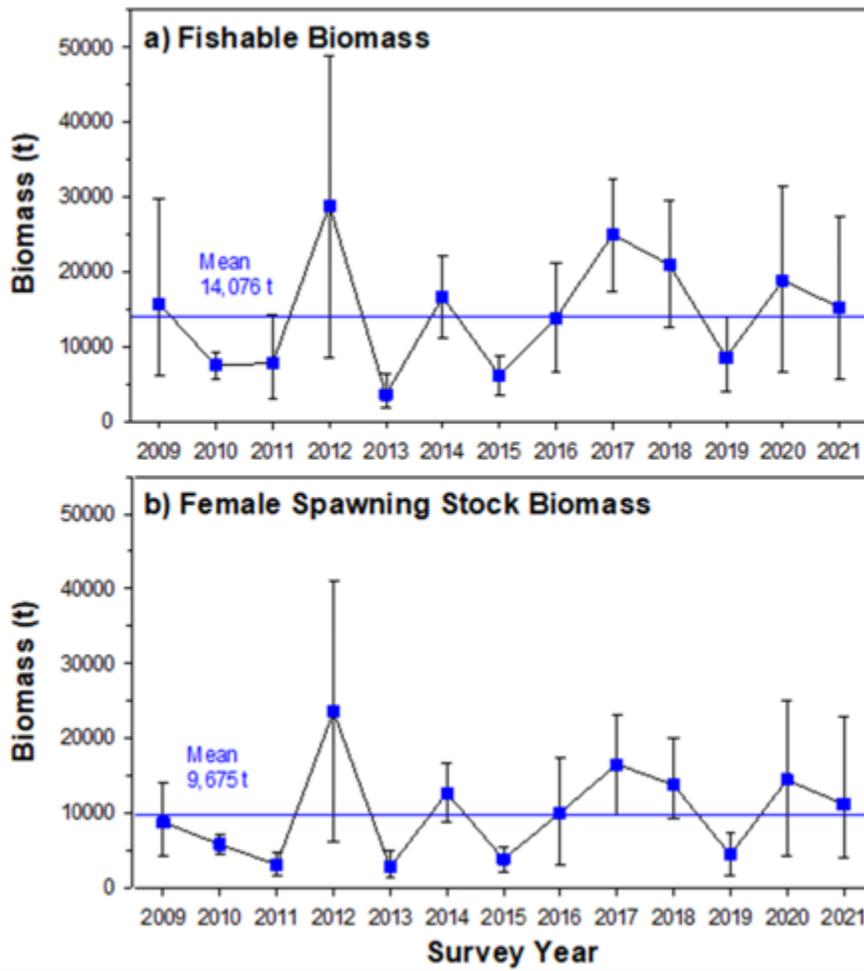


Figure B7. Eastern Assessment Zone *Pandalus montagu* a) fishable and b) female spawning stock biomass indices for the survey years 2009–2021. Error bars are 95% confidence ranges. Horizontal blue lines correspond to the long-term series mean.

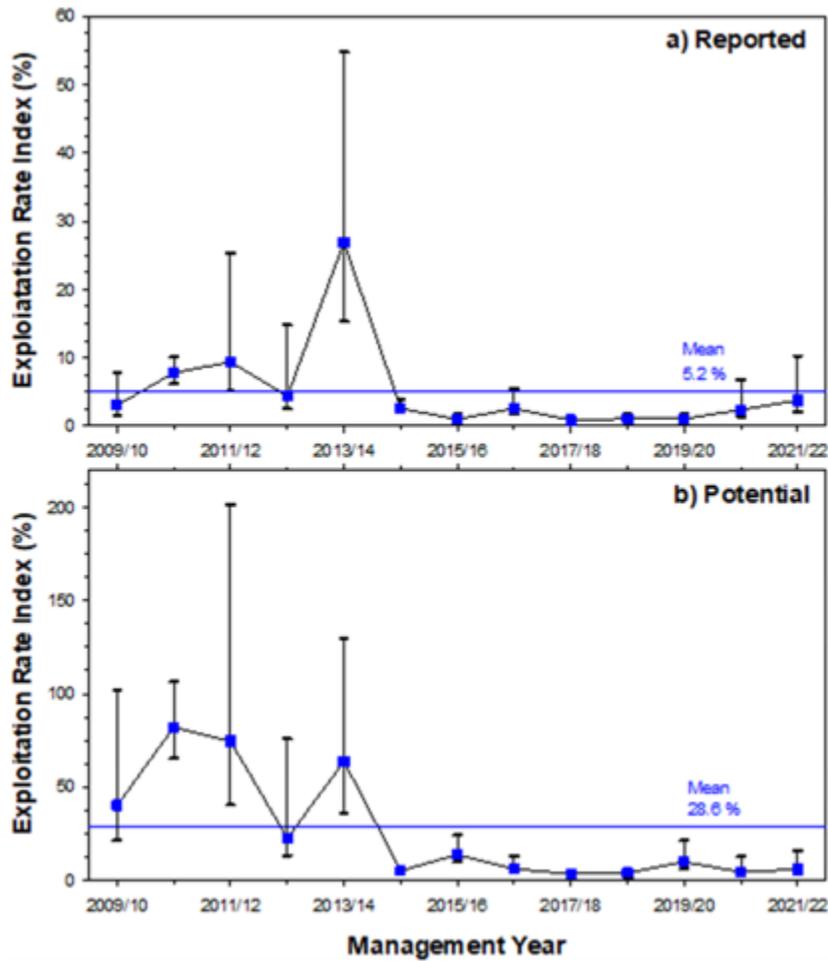


Figure B8. Eastern Assessment Zone *Pandalus montagui* a) reported and b) potential exploitation rate indices for the period of 2009/10–2021/22. Error bars are 95% confidence ranges. Horizontal blue lines correspond to the long-term series mean.

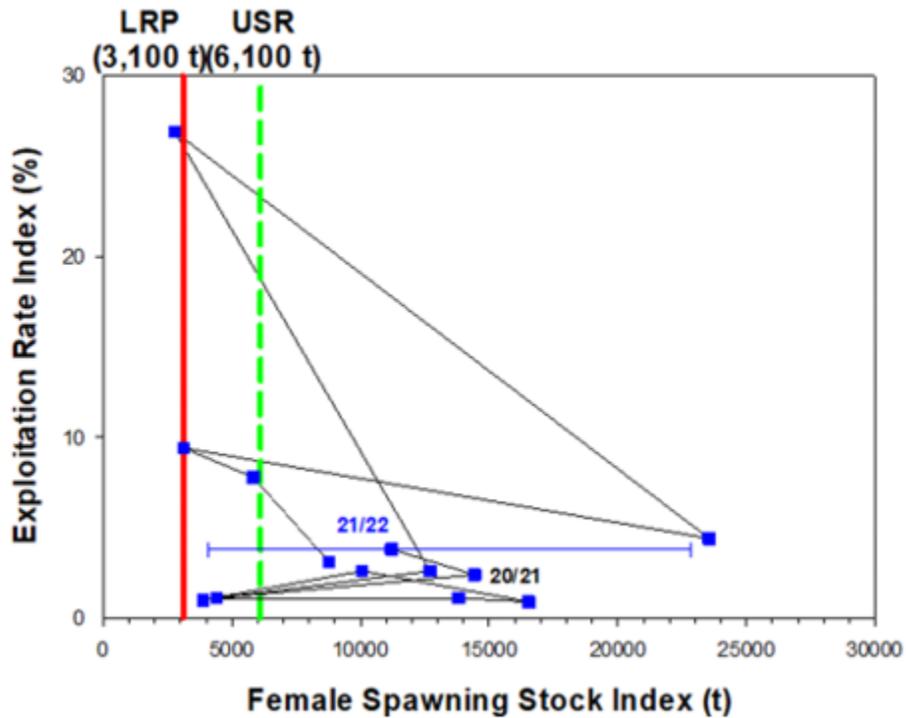


Figure B9. Eastern Assessment Zone trajectory of *Pandalus montagui* female spawning stock biomass index and exploitation rate in relation to reference points proposed in 2020 (DFO 2020). The dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female SSB indices from the 2009–2019 surveys. Since the USR has not been implemented and it is currently under consultation, final location of the dashed line is yet to be determined.

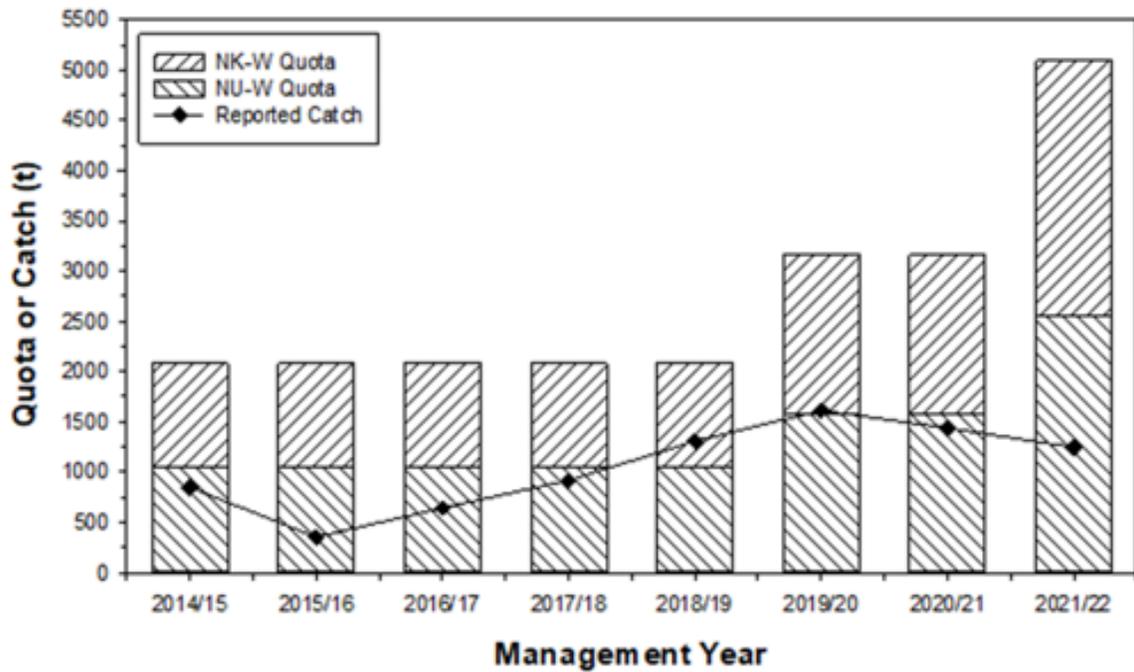


Figure B10. Western Assessment Zone *Pandalus borealis* TAC and catch recorded for 2014/15–2021/22 (AQMS as of January 7, 2022); since the fishery remains open until March 31, 2022, catch estimates are preliminary.

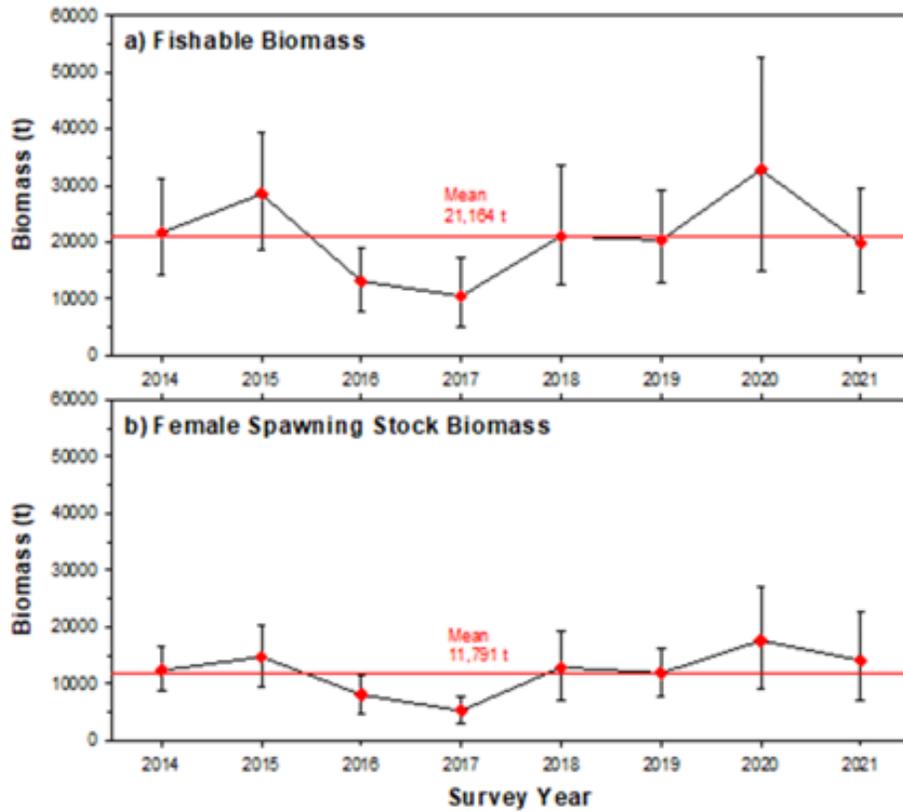


Figure B11. Western Assessment Zone *Pandalus borealis* a) fishable and b) female spawning stock biomass indices for the survey years 2014–2021. Error bars are 95% confidence ranges. Horizontal red lines correspond to the long-term series mean.

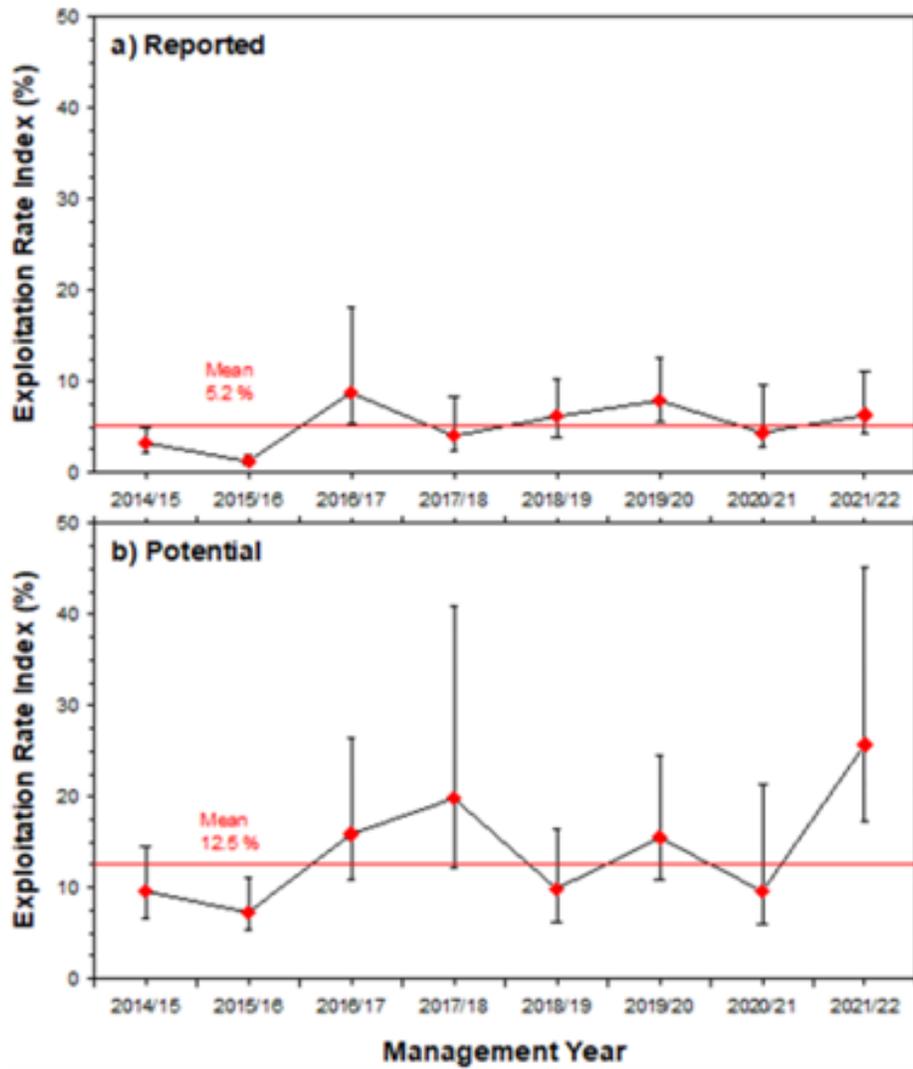


Figure B12. Western Assessment Zone *Pandalus borealis* a) reported and b) potential exploitation rate indices for the period of 2014/15–2021/22. Error bars are 95% confidence ranges. Horizontal red lines correspond to the long-term series mean.

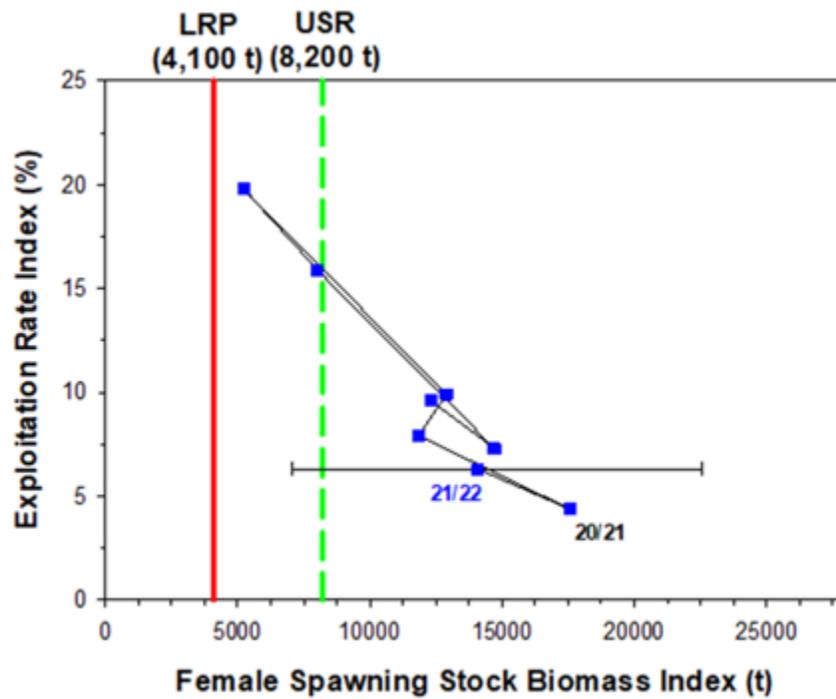


Figure B13. Western Assessment Zone trajectory of *Pandalus borealis* female spawning stock biomass index and exploitation rate in relation to reference points proposed in 2020 (DFO 2020). The dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female SSB indices from the 2014–2019 surveys. Since the USR has not been implemented and it is currently under consultation, final location of the dashed line is yet to be determined.

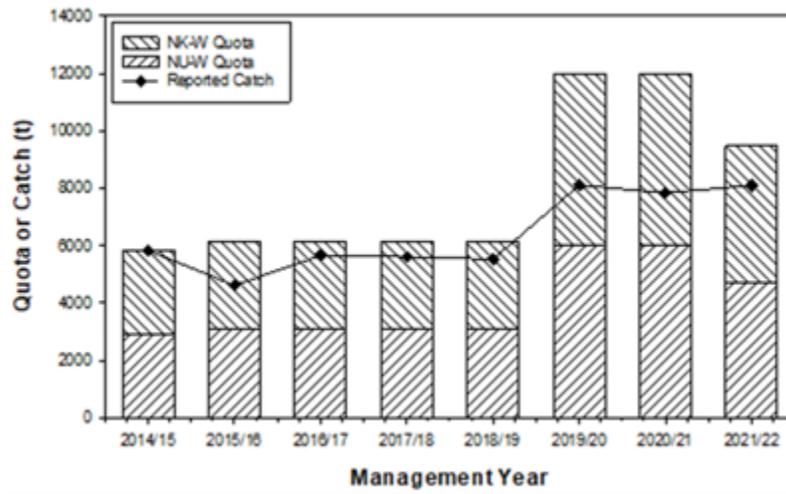


Figure B14. Western Assessment Zone *Pandalus montagui* TAC and catch recorded for 2014/15–2021/22 (AQMS as of January 7, 2022); since the fishery remains open until March 31, 2022, catch estimates are preliminary.

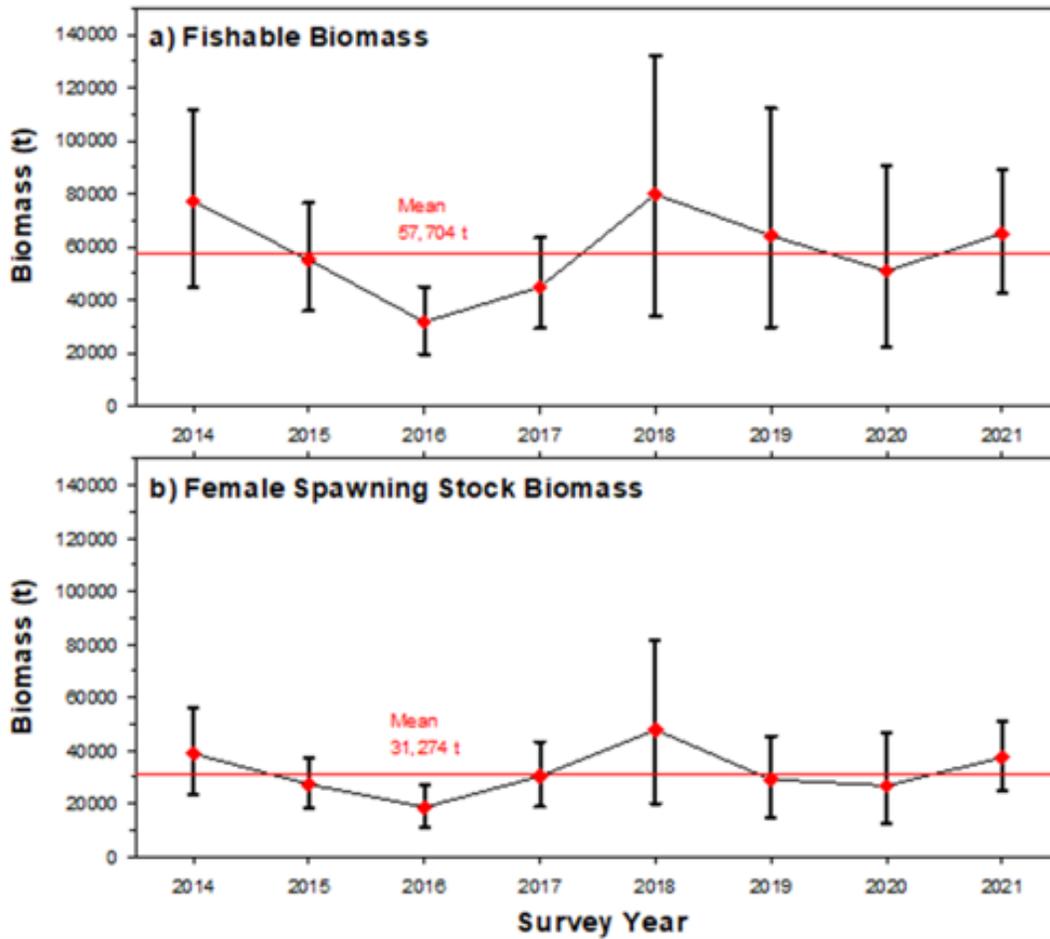


Figure B15. Western Assessment Zone *Pandalus montagui* a) fishable and b) female spawning stock biomass indices for the survey years 2014–2021. Error bars are 95% confidence ranges. Horizontal red lines correspond to the long-term series mean.

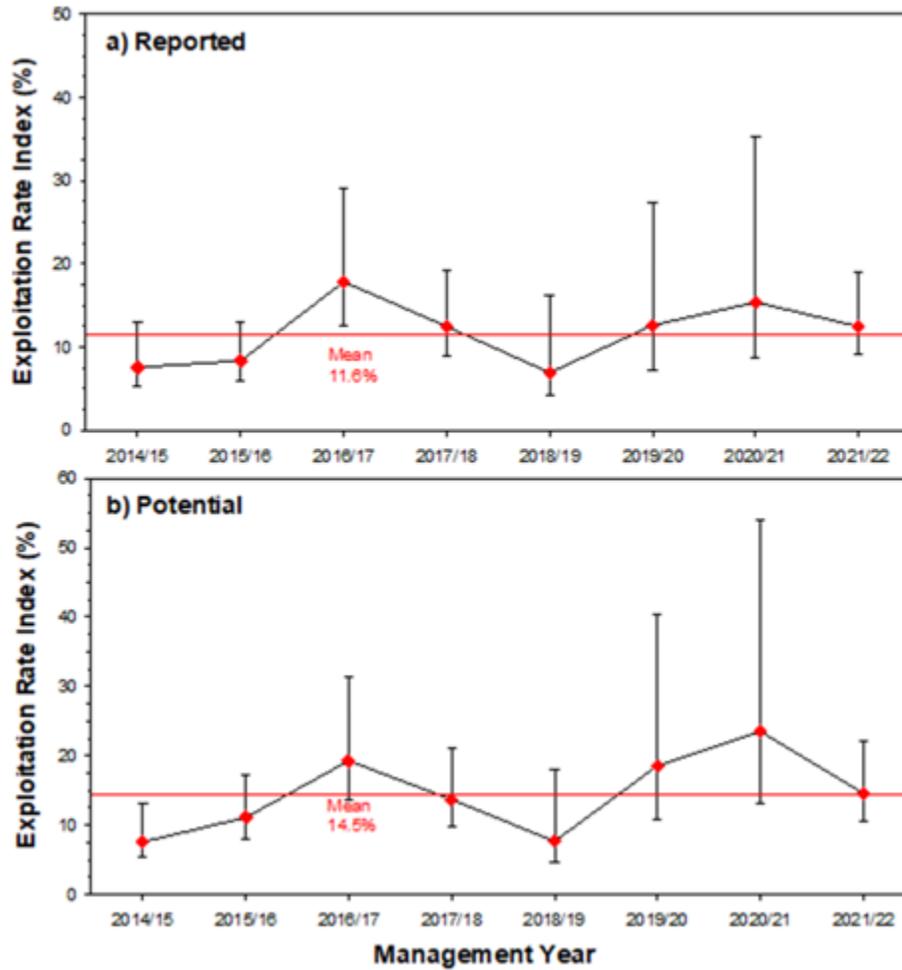


Figure B16. Western Assessment Zone *Pandalus montagui* a) reported and b) potential exploitation rate indices for the period of 2014/15–2021/22. Error bars are 95% confidence ranges. Horizontal red lines correspond to the long-term series mean.

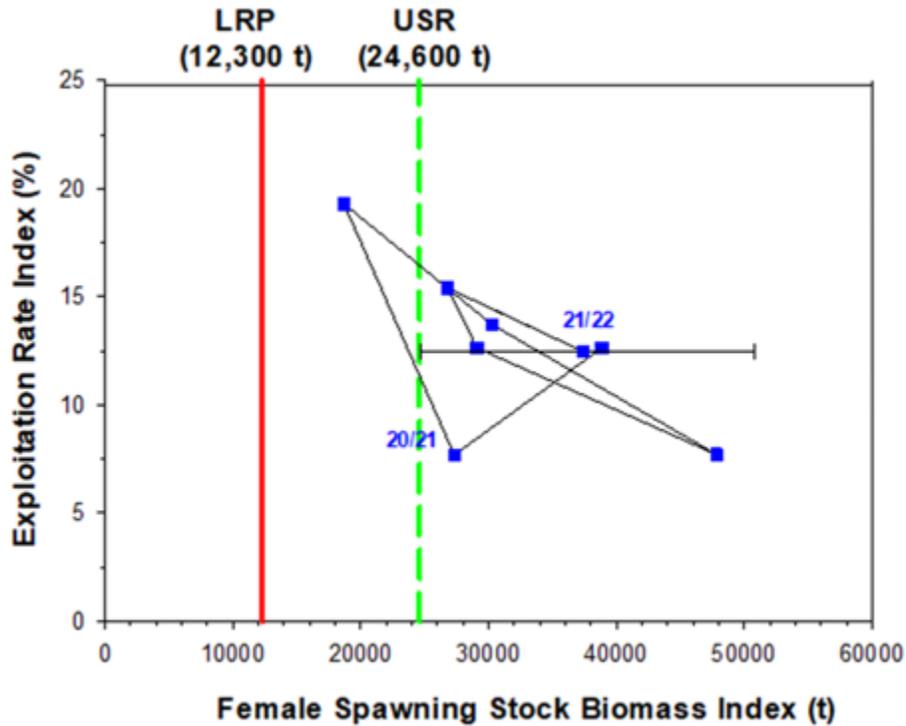


Figure B17. Western Assessment Zone trajectory of *Pandalus montagui* female spawning stock biomass index and exploitation rate in relation to reference points proposed in 2020 (DFO 2020). The dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female SSB indices from the 2014–2019 surveys. Since the USR has not been implemented and it is currently under consultation, final location of the dashed line is yet to be determined.

