



ASSESSMENT OF NORTHERN SHRIMP (*PANDALUS BOREALIS*) AND STRIPED SHRIMP (*PANDALUS MONTAGUI*) IN THE EASTERN AND WESTERN ASSESSMENT ZONES, FEBRUARY 2021



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

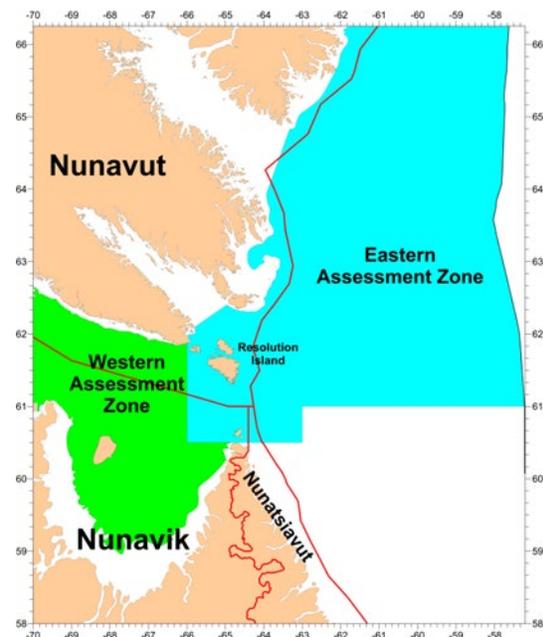


Figure 1. Eastern and Western Assessment Zones. Boundaries of the Nunavut, Nunavik and Nunatsiavut land claims areas are shown in red.

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 2019 (DFO 2019) with a stock status update in 2020 (DFO 2020a). Full assessments are carried out every two years with stock status updates in the intervening years.

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 2020b).

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

This Science Advisory Report is from the February 22–26, 2021 Zonal Advisory Meeting on the Assessment of Northern Shrimp in SFAs 4-6, EAZ & WAZ and of Striped Shrimp in SFA 4, EAZ & WAZ. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

SUMMARY

- The assessment includes the 2019 and 2020 survey and fishery data.
- It is recognized that the population of *Pandalus montagui* spans the area of the Eastern and Western Assessment Zones (EAZ, WAZ) and Shrimp Fishing Area (SFA) 4. Currently it is not known what the rates of exchange (export/import) are between these zones, therefore, understanding resource dynamics as a whole requires integrating information from all assessment areas.
- It is recognized that *P. borealis* are distributed broadly over the Northwest Atlantic Ocean, including the EAZ and WAZ, and that these areas are connected through larval dispersal, but rates of exchange of adults are less understood. These linkages need to be considered to interpret dynamics within and among assessment areas.
- In the EAZ the stocks are currently assessed with updated Limit Reference Points (LRPs) relevant to a Precautionary Approach (PA) Framework. Updated Upper Stock Reference (USRs) are currently being considered.
- In the WAZ the stocks are currently assessed with the LRPs (established *de novo* in 2020). USRs are currently being considered.

Eastern Assessment Zone – *Pandalus borealis*

- Total catch varied without trend around 6,000 t from 1997 through 2020/21. Catch statistics in 2020/21 are preliminary.
- The fishable biomass index was above the long term mean (63,486 t) and was 86,211 t in 2020.
- The female spawning stock biomass (SSB) was above the long term mean (39,659 t) and was 60,531 t in 2020.
- The reported exploitation rate index for 2020/21 was 5.9% with 48% of the Total Allowable Catch (TAC) taken. Based on the 2020/21 TAC of 10,653 t, the potential exploitation rate index was 12.5%.
- *Pandalus borealis* stock in the EAZ is currently well above the established LRP. Although there is currently no established USR, the stock is considered in a healthy state.

Eastern Assessment Zone – *Pandalus montagui*

- Total catch in 2020/21 was 267 t, 32% of the 840 t TAC. Catch statistics in 2020/21 are preliminary.
- The fishable biomass index is subject to considerable interannual variability potentially associated with resource distribution. Since 2017, it has generally been above the long term mean (14,076 t) and was 18,803 t in 2020. Fluctuations in fishable biomass may also differ across adjacent assessment areas within the same year for this stock.
- The female spawning stock biomass (SSB) index was above the long term mean (9,675 t) and was 14,437 t in 2020.
- The reported exploitation rate index for 2020/21 was 1.3% with 32% of the TAC taken. Based on the 2020/21 TAC of 840 t, the potential exploitation rate index was 4.5%.

- *Pandalus montagui* stock in the EAZ is currently well above the established LRP. Although there is currently no established USR and the stock biomass index is subject to considerable interannual variability, the stock is considered in a healthy state.

Western Assessment Zone – *Pandalus borealis*

- Total catch in 2020/21 was 625 t, which is 20% of the 3,163 t TAC. Catch statistics in 2020/21 are preliminary.
- The fishable biomass index in 2020 remained above the long term mean (19,219 t) and was 32,835 t.
- The female SSB index in 2020 remained above the long term mean (10,830 t) and was 17,555 t.
- The reported exploitation rate index for 2020/21 was 1.9% with 20% of the TAC taken. Based on the 2020/21 TAC of 3,163 t, the potential exploitation rate index was 9.6%.
- *Pandalus borealis* stock in the WAZ is currently well above the established LRP. Although there is currently no established USR, the stock is considered in a healthy state.

Western Assessment Zone – *Pandalus montagui*

- Total catch in 2020/21 was 3,917 t, which is 33% of the 11,975 t TAC. Catch statistics in 2020/21 are preliminary.
- Movement across management areas is suspected to contribute to interannual variability in the fishable biomass index. It was below the long term mean (56,609 t) and was 50,911 t in 2020.
- The SSB index was below the long term mean (31,640 t) and was 26,811 t in 2020.
- The reported exploitation rate index for 2020/21 was 7.7% with 33% of the TAC taken. Based on the 2020/21 TAC of 11,975 t, the potential exploitation rate index was 23.5%.
- Although there is currently no established USR for *Pandalus montagui* stock in the WAZ, the stock is above the established LRP relevant to a PA Framework.

BACKGROUND

Species Biology

Northern Shrimp (*Pandalus borealis*) is found in the Northwest Atlantic from Baffin Bay to the Gulf of Maine, while Striped Shrimp (*P. montagui*) is found from Davis Strait south to the Bay of Fundy. Both species have preferred depth and temperature ranges. *Pandalus montagui* prefers cooler water (-1 to 2 °C) than *P. borealis* (0 to 4 °C). In the assessment area, these cooler waters tend to occur at shallower depths. The bulk of the biomass of *P. borealis* is located at depths of 300–500 m, while *P. montagui* occur mainly at depths of 200–500 m. Northern Shrimp are associated with soft substrates whereas Striped Shrimp prefer harder bottoms. Since these two species' thermal preference and depth overlap, they are often found occupying the same locations.

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. Both species migrate upwards into the water column during the night. The

migration consists mainly of males and smaller females. Shrimp are opportunistic feeders on or near the sea floor and in the water column. 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. *Pandalus* shrimp are important forage species.

Fishery

The fishery is managed by a Total Allowable Catch (TAC) which is divided into quotas for the 17 offshore license holders and special allocations for Nunavut and Nunavik interests. Since 2013/14 fishing season, the fishery has been managed in new Shrimp Fishing Areas (SFAs) and Management Units (Figure 2). The 17 offshore license holders have access to fishing grounds in Davis Strait. Their quota is further subdivided by enterprise allocation with each receiving a 1/17 share per license. Nunavut and Nunavik each have quotas that can be fished anywhere within either of their two land claims areas. Nunavut also has quota that can be fished within management unit Davis Strait-East. Nunavut Wildlife Management Board (NWMB) and Nunavik Marine Region Wildlife Board (NMRWB) manage the sub-allocation of their quotas. All fishing to date has been conducted by large vessels with 100% observer coverage.

Fishing gear consists of single and, more recently, twin shrimp trawls requiring a minimum codend mesh size of 40 mm and Nordmøre 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.

Pandalus borealis has been the main commercial species throughout the history of the shrimp fishery in this area. Historically, most of the harvest of *P. montagui* occurred as by-catch in the directed *P. borealis* fishery. Directed fishing for *P. montagui* has become more important especially with new quotas available in areas Nunavut-West and Nunavik-West beginning with the 2013/14 fishing season. Additionally, recent increases in *P. montagui* biomass in the WAZ (i.e., in 2018), and the subsequent increase in the TAC, has increased the importance of this stock to the commercial fishery.

In general, the shrimp fishery began in the late 1970s in SFA 1. Exploratory fishing expanded into what is now Davis Strait-East management unit (previously 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 Land Claims Agreement in 1999 shifted the main fishery east of the Nunavut Settlement Area.

Fishery catch per unit effort (CPUE) data are not considered to reflect stock status. Commercial fishing locations are not broadly distributed, since fishing vessels target areas of high resource density. A mix of two shrimp species is targeted in the fishery and the composition of the two species in the catch determines which species is designated as directed, which biases CPUE calculations. Over the time period 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 both *P. borealis* and *P. montagui* 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.

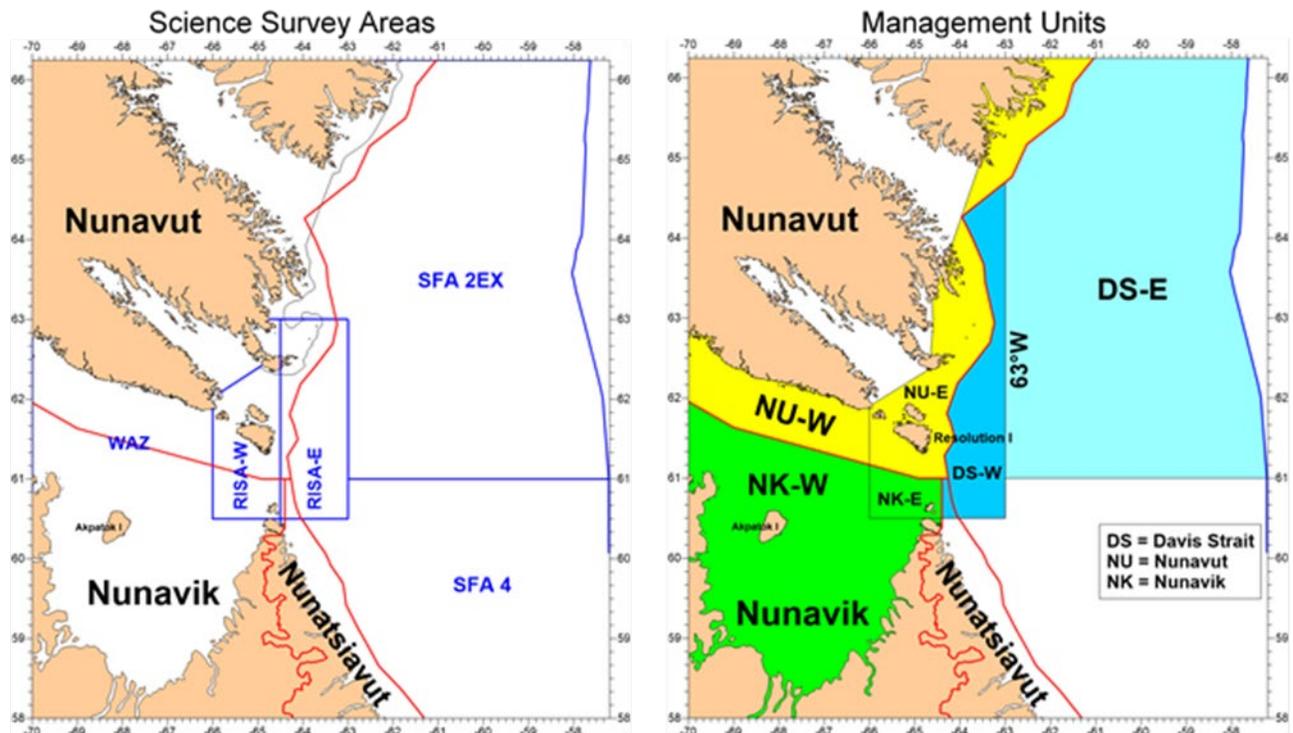


Figure 2. Location of the survey areas (left panel) within the Eastern and Western Assessment Zones (Figure 1) and the management units (right panel) referred to in this report. Shrimp Fishing Area (SFA), Exploratory (EX), Resolution Island Study Area (RISA), East (E), West (W), Nunavut (NU), Nunavik (NK) and Davis Strait (DS). Red line shows the borders of the Nunavut, Nunatsiavut and Nunavik Land Claims Areas.

Survey data, since the last full assessment, comes from the 2019 and 2020 Northern Shrimp Research Foundation (NSRF) surveys of the EAZ and WAZ (Figure 2). The EAZ, for the purpose of the survey, is divided into three areas: Resolution Island Study Area (RISA)-W, RISA-E and SFA 2EX. The WAZ is surveyed as a single unit.

Data collected between 2009 and 2020 are evaluated for the assessment in the EAZ.

The WAZ (Figure 2) was surveyed biennially by DFO from 2007–2013. Because the WAZ was surveyed by a different ship and gear and at a different time of year, it could not be combined with the survey results of the EAZ. This prevented a comprehensive evaluation of the distributions of shrimp and a more practical look at broader stock implications. 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 address these issues. This action started a new time series for the WAZ. In 2020, the WAZ was surveyed for the seventh year in the new time series.

The assessment follows the framework established by DFO (2007). Fishable and female spawning stock biomass (SSB) indices from scientific surveys form the basis of the assessment. Fishable biomass is based on male and female shrimp from the surveys with a carapace length greater than 17 mm. SSB is based on all female shrimp from the surveys regardless of size. The recruitment index was removed from the assessment starting in 2017 as too few recruitment-sized shrimp are caught in the trawl codend during the survey to produce a meaningful index. 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 was calculated assuming the entire TAC was taken. Bootstrapped 95% confidence intervals are included for each of the indices.

Until recently the status of the resource in the EAZ was assessed with a Precautionary Approach (PA) Framework (DFO 2009). Currently there is no complete PA Framework in the EAZ. Reference points that were set in 2009 were deemed outdated and were re-evaluated and updated in 2020 (DFO 2020b). For both species of shrimp the Limit Reference Point (LRP) was set at 40% and the preliminary Upper Stock Reference (USR) was proposed at 80% of the geometric mean of SSB for 2008–2019, respectively. There is an Integrated Fisheries Management Plan (IFMP; DFO 2018) in place for shrimp in the EAZ. Reference Points for the WAZ were developed in 2012, however, they were not applicable because 2014 was the start of a new survey time series. In 2020, new Reference Points were developed for the WAZ (DFO 2020b) with the same proxies as for the EAZ.

The WAZ was surveyed biennially with the Greenland Institute of Natural Resources' research vessel *Paamiut* using a Cosmos trawl from 2007–2013. The EAZ was surveyed with the commercial fishing vessels *Cape Ballard* from 2005 to 2011 and *Aqviq* in 2012 and 2013. Since 2014 both the EAZ and WAZ have been surveyed by commercial fishing vessels: the *Kinguk* in 2014, the *Katsheshuk II* in 2015 and 2020, and the *Aqviq* from 2016 to 2019. A standard Campelen trawl was used to sample the EAZ in 2006 and 2007. In 2008, to improve coverage and reduce the incidence of tear-ups in the RISA survey area, a modified Campelen trawl was developed (Siferd and Legge 2014) and first used. That same year, a standard Campelen trawl was used in the SFA 2EX survey area. The modified Campelen trawl has been used on all NSRF surveys in the EAZ (since 2008) and WAZ (since 2014). There has been no standardization between the Cosmos and the Campelen surveys.

Two additional aspects when interpreting the trawl survey data are worth noting. The first is the strong tidal currents in Hudson Strait, with speeds up to five knots, which could result in quick shifts in shrimp distribution and catchability. The second is that the near-bottom average water temperatures in the WAZ in 2016 and 2017 were the lowest in the survey time series, which might have influenced the spatial distribution of the resource in the area and may translate into biomass variability in the coming years.

In 2018, in order to protect coral and sponges habitats, the Government of Canada implemented a Marine Conservation Closure in Davis Strait (Davis Strait Closure). This closure has impacted the allocation of the sampling stations visited during the NSRF survey in 2020. As a consequence, five deep water strata had their sizes reduced in the EAZ (all in SFA 2EX). Overall the survey area of the EAZ in 2020 has been reduced by 12.7%. The re-analysis of the shrimp biomass using the revised area (reduction of strata due to Davis Strait Closure implementation) has shown minimal impact on the past years' results. Fishable biomass was lower by $\bar{x} = 1.5\%$ (range: 0.3–2.6%) for *P. borealis*. There was no biomass difference in *P. montagui*, as the location of the closure is outside of this species spatial range. Spawning stock biomass of *P. borealis* was lower by $\bar{x} = 1.9\%$ (range: 0.4–3.5%) with no difference in SSB observed for *P. montagui*. Thus, considering the negligible impact of the closure on biomass indices, it has been determined that there is no need to revise the Reference Points of the PA Framework in the EAZ.

Eastern Assessment Zone – *P. borealis*

Fishery

Catch has varied without trend around 6,000 t from 1997 through 2020/21 (Figure 3, Table 1). The total reported catch for 2020/21, based on the CAQR, as of February 2, 2021, was 5,119 t, 48% of the 10,653 t TAC.

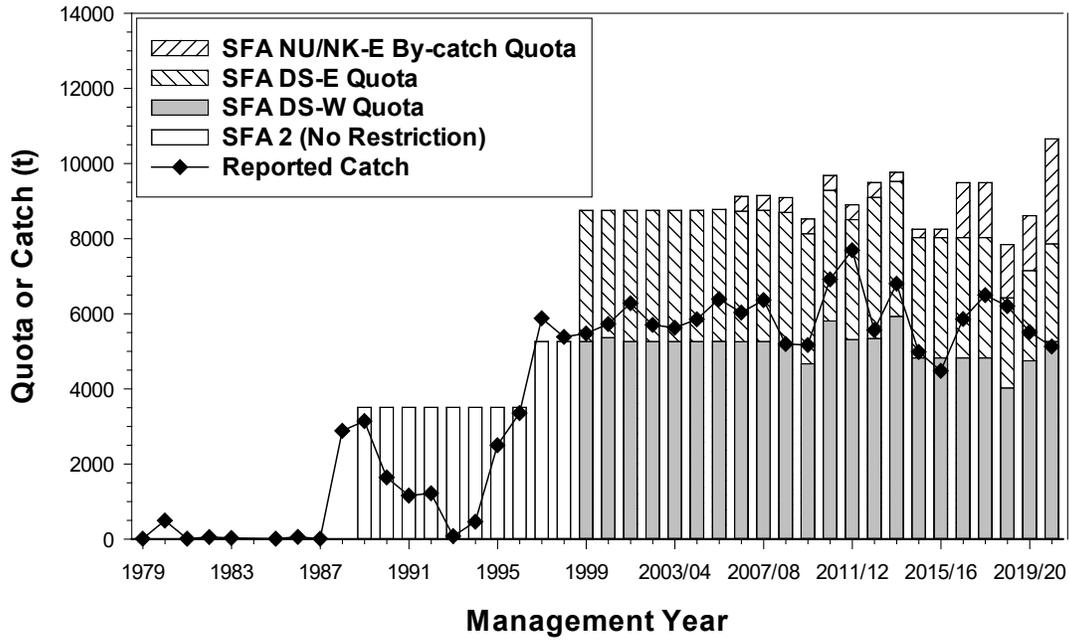


Figure 3. Eastern Assessment Zone *Pandalus borealis* Total Allowable Catch and catch reported by the Canadian Atlantic Quota Report (CAQR). CAQR records may be incomplete for 2020/21 (data as of February 2, 2021).

Biomass

The fishable biomass index was above the long term mean (63,486 t) and was 86,211 t in 2020 (Figure 4a, Table 2). The female SSB was above the long term mean (39,659 t) and was 60,531 t in 2020 (Figure 4b, Table 2).

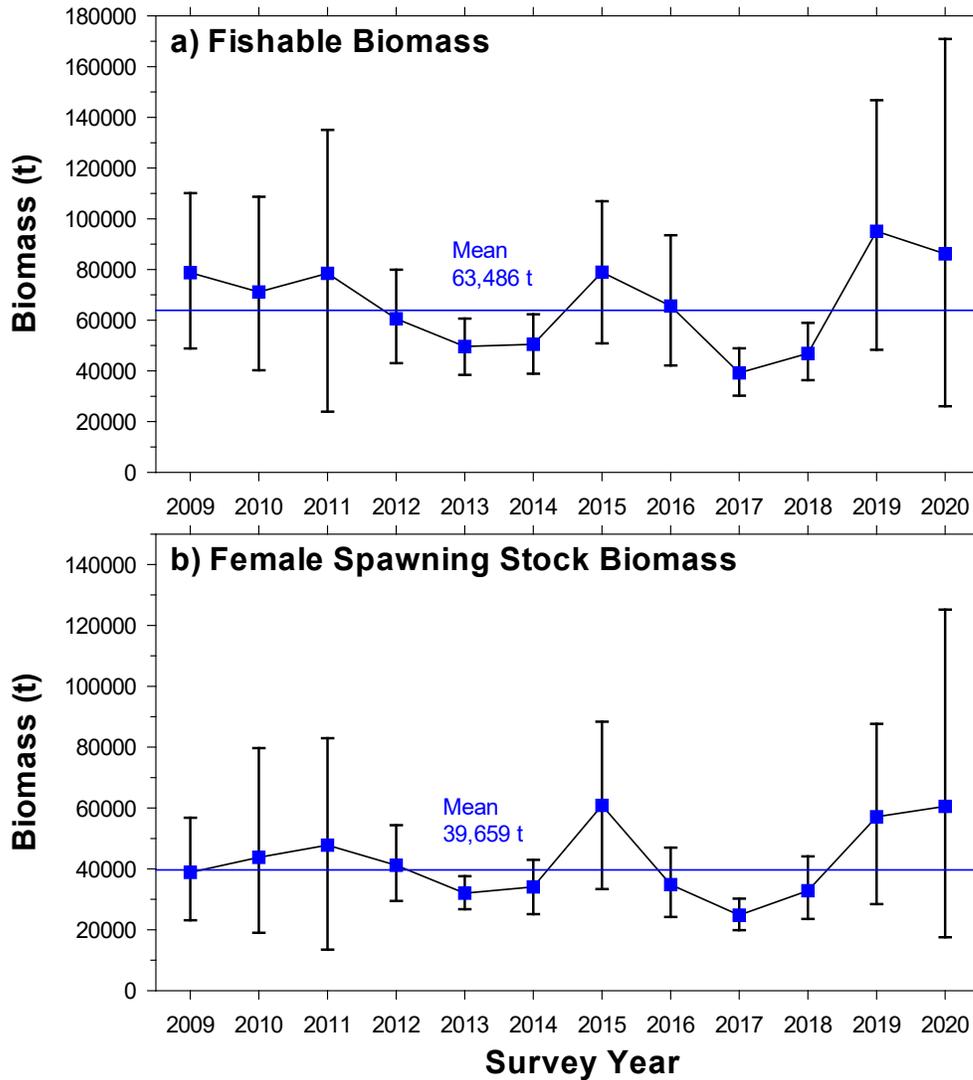


Figure 4. The Eastern Assessment Zone fishable and female spawning stock biomass indices of *Pandalus borealis* for the survey years 2009–2020. Error bars are 95% confidence ranges.

Exploitation

The reported exploitation rate index has varied without trend since 2009/10 and for 2020/21 it was 5.9% with 48% of the TAC taken (Figure 5a). Based on the 2020/21 TAC of 10,653 t, the potential exploitation rate index was 12.5% (Figure 5b).

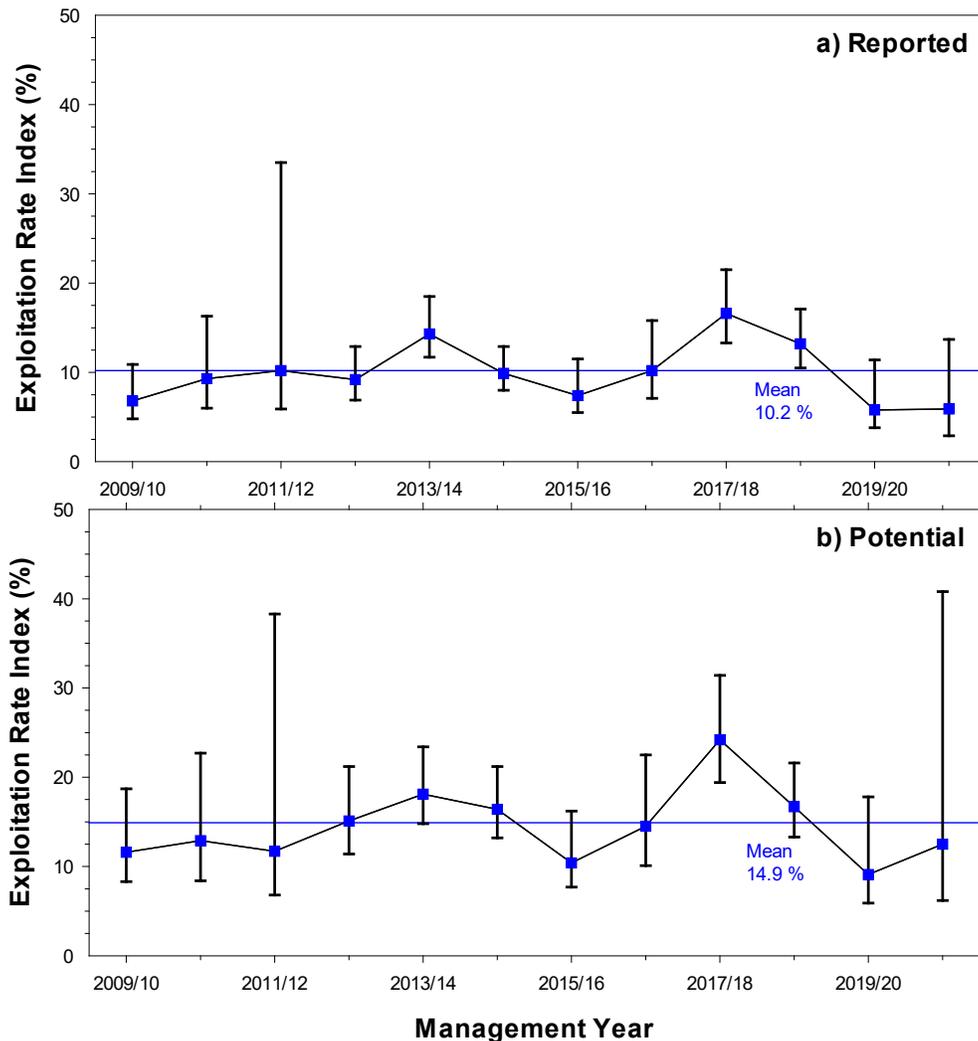


Figure 5. The Eastern Assessment Zone *Pandalus borealis* exploitation rate indices for management years 2009/10–2020/21; a) the reported rate, based on the catch taken and b) the potential rate if the TAC was taken. Error bars are 95% confidence ranges.

Current Outlook

Pandalus borealis stock in the EAZ is currently well above the established Limit Reference Point (LRP; Figure 6). Although there is currently no established Upper Stock Reference (USR), the stock is considered in a healthy state.

Should the USR be established at the proposed level suggested by Fisheries and Oceans Canada (DFO) Science sector (i.e., 80% of the geometric mean of the SSB; DFO 2020b), the stock would be placed well within the Healthy Zone of the PA Framework.

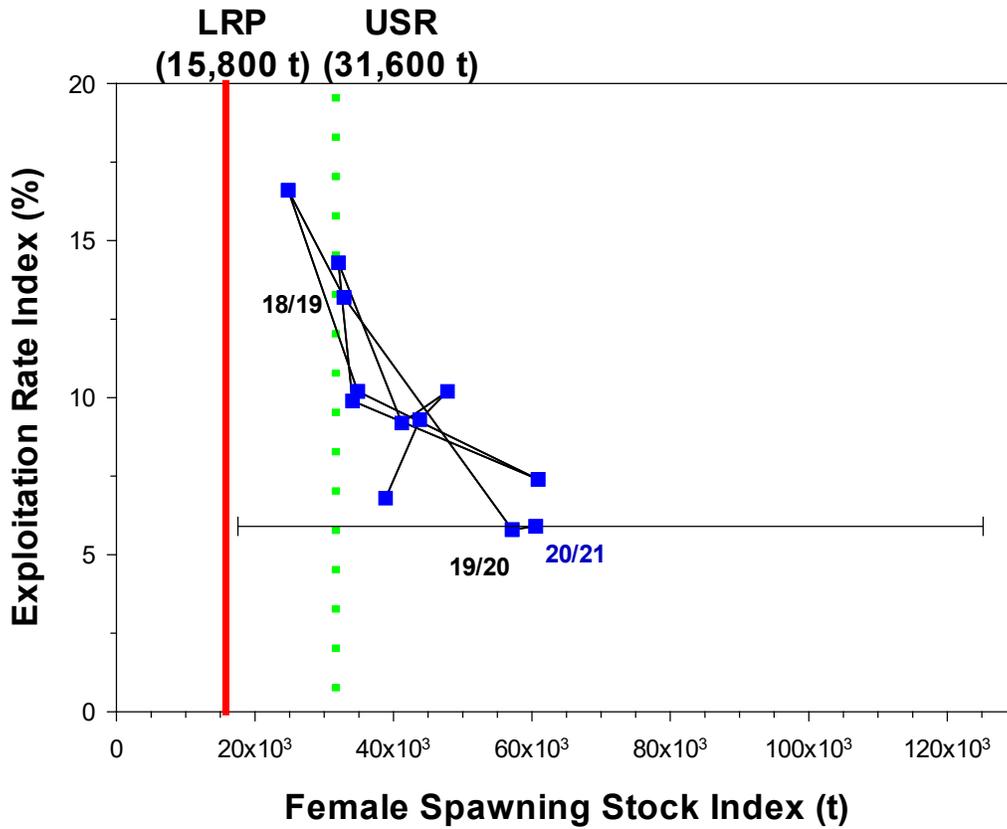


Figure 6. Eastern Assessment Zone trajectory of *Pandalus borealis* female spawning stock and exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020b). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line 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 implemented and it is currently being consulted, final location of the dashed line is yet to be determined.

Eastern Assessment Zone – *P. montagui*

Fishery

Total catch in 2020/21 was 267 t, 32% of the 840 t TAC (Figure 7, Table 1). Catch statistics in 2020/21 are preliminary and based on the CAQR data as of February 2, 2021.

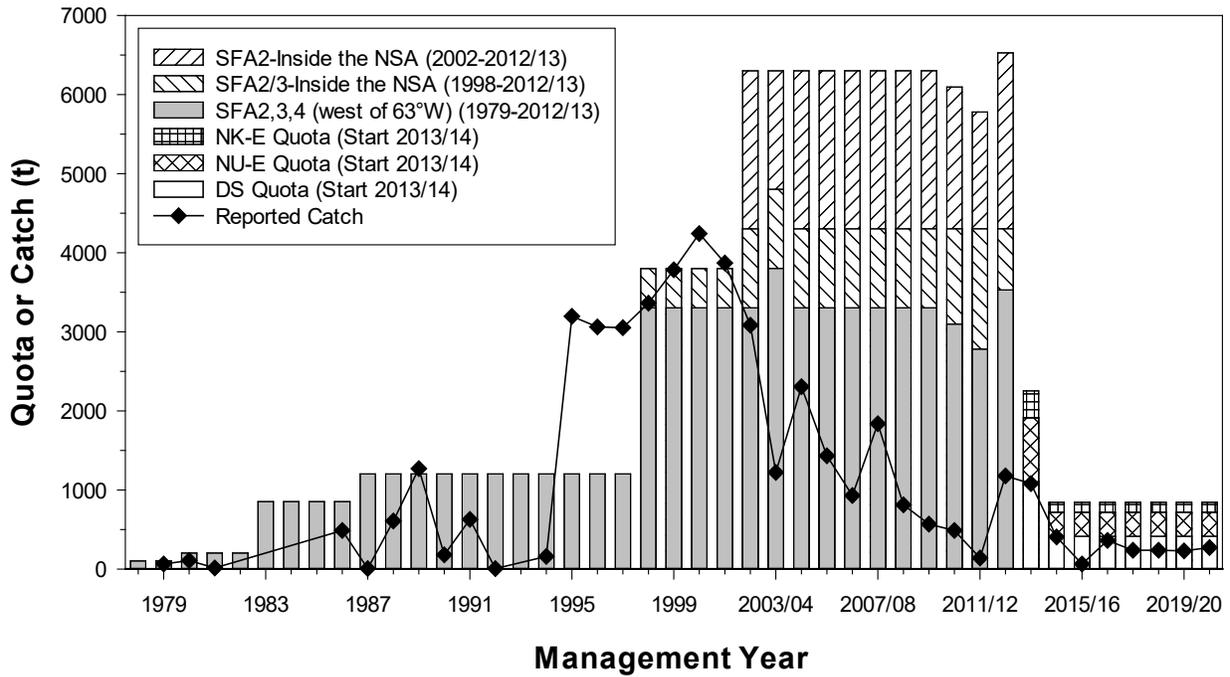


Figure 7. Eastern Assessment Zone *Pandalus montagui* Total Allowable Catch and catch reported in the Canadian Atlantic Quota Report (CAQR). CAQR records may be incomplete for 2020/21 (data as of February 2, 2021).

Biomass

The fishable biomass index of *P. montagui* in the EAZ is subject to considerable interannual variability potentially associated with resource distribution. Fluctuations in fishable biomass may also differ across adjacent assessment areas within the same year for this stock. Since 2017, it has generally been above the long term mean (14,076 t) and was 18,803 t in 2020 (Figure 8a, Table 3). The female SSB index was above the long term mean (9,675 t) and was 14,437 t in 2020 (Figure 8b, Table 3).

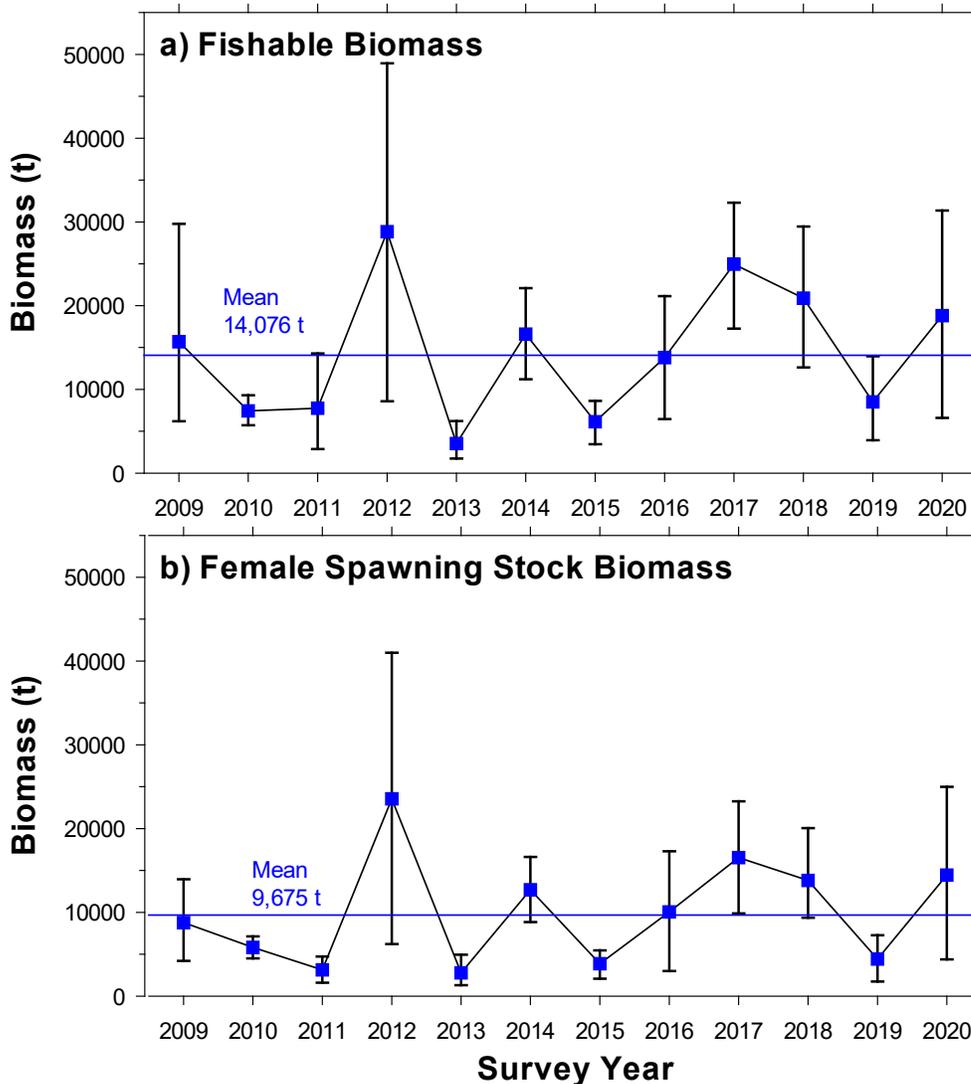


Figure 8. The Eastern Assessment Zone *Pandalus montagui* fishable and female spawning stock biomass indices for the survey years 2009–2020. Error bars are 95% confidence ranges.

Exploitation

The reported exploitation rate index for 2020/21 was 1.3% with 32% of the TAC taken (Figure 9a). Based on the 2020/21 TAC of 840 t, the potential exploitation rate index was 4.5% (Figure 9b).

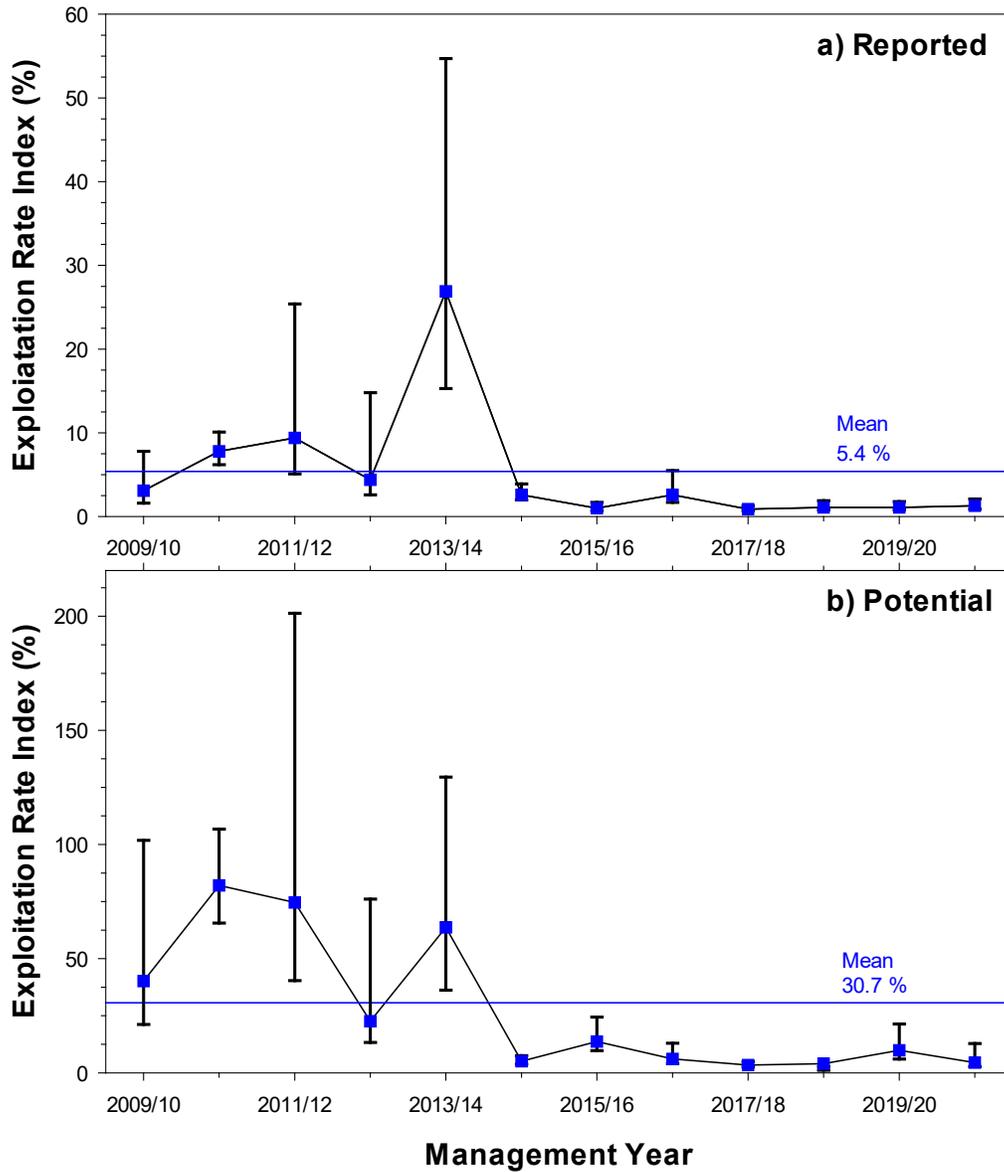


Figure 9. The Eastern Assessment Zone *Pandalus montagu* exploitation rate indices for management years 2009/10–2020/21; a) the reported rate, based on the catch taken and b) the potential rate if the Total Allowable Catch was taken. Error bars are 95% confidence ranges.

Current Outlook

Pandalus montagui stock in the EAZ is currently well above the established LRP (Figure 10). Although there is currently no established USR and the stock biomass index is subject to considerable interannual variability, the stock is considered in a healthy state.

Should the USR be established at the proposed level (i.e., 80% of the geometric mean of the SSB; DFO 2020b), the stock in 2020 would be placed well within the Healthy Zone of the PA Framework.

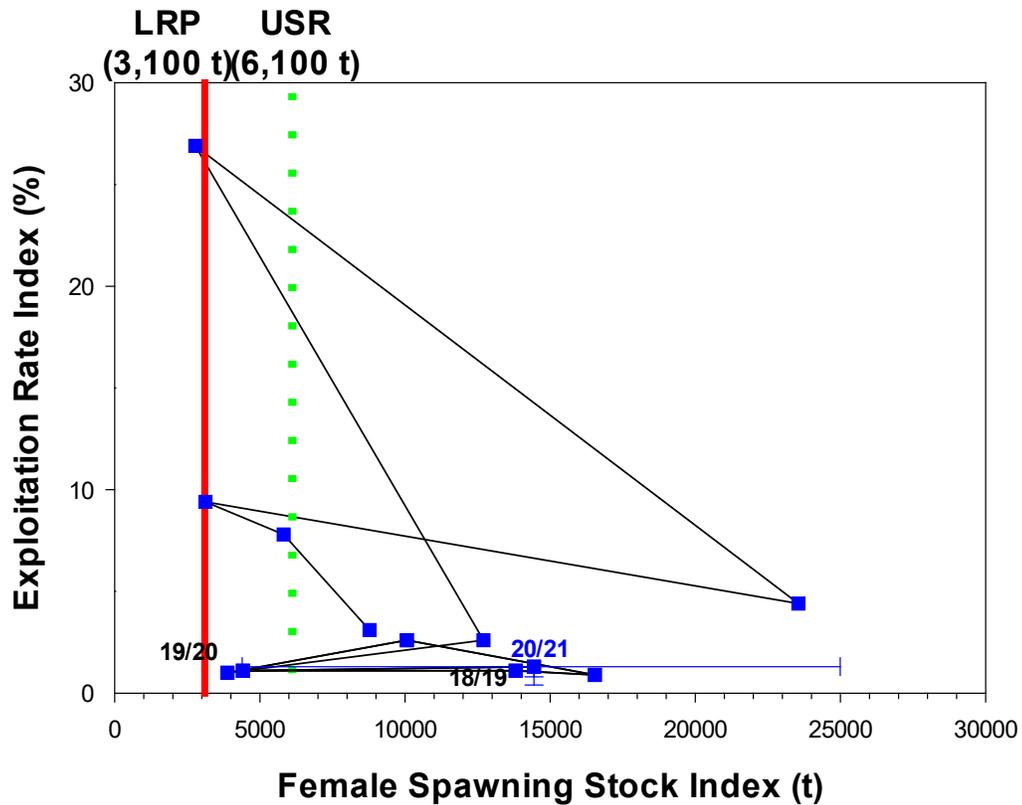


Figure 10. Eastern Assessment Zone trajectory of *Pandalus montagui* female spawning stock and exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO 2020b. Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2009–2019 surveys. Since the USR has not been implemented and it is currently being consulted, final location of the dashed line is yet to be determined.

Western Assessment Zone – *P. borealis*

Fishery

Total catch in 2020/21 was 625 t, which is 20% of the 3,163 t TAC (Figure 11, Table 1). Catch statistics in 2020/21 are based on the CAQR, as of February 2, 2021.

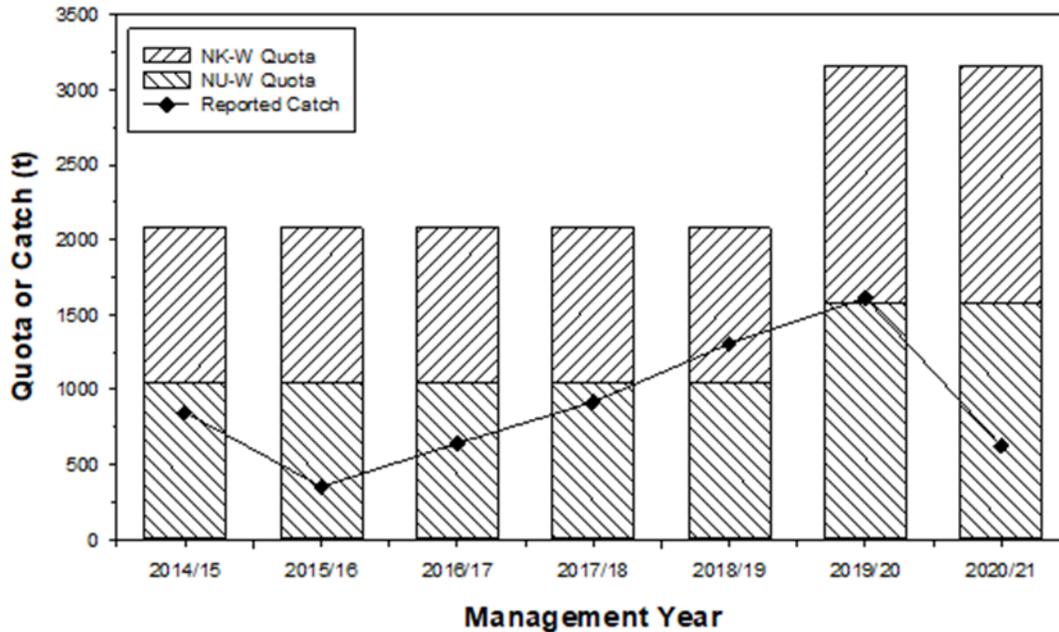


Figure 11. The Western Assessment Zone *Pandalus borealis* Total Allowable Catch and catch recorded in the Canadian Atlantic Quota Report (CAQR) for 2020/21. Catch records from CAQR as of February 2, 2021.

Biomass

Due to a change in survey methodology, the 2014 survey began a new time series. Thus, the 2020 survey was the seventh 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 2020 remained above the long term mean (19,219 t) and was 32,835 t (Figure 12a, Table 4). The female SSB index in 2020 remained above the long term mean (10,830 t) and was 17,555 t (Figure 12b, Table 4).

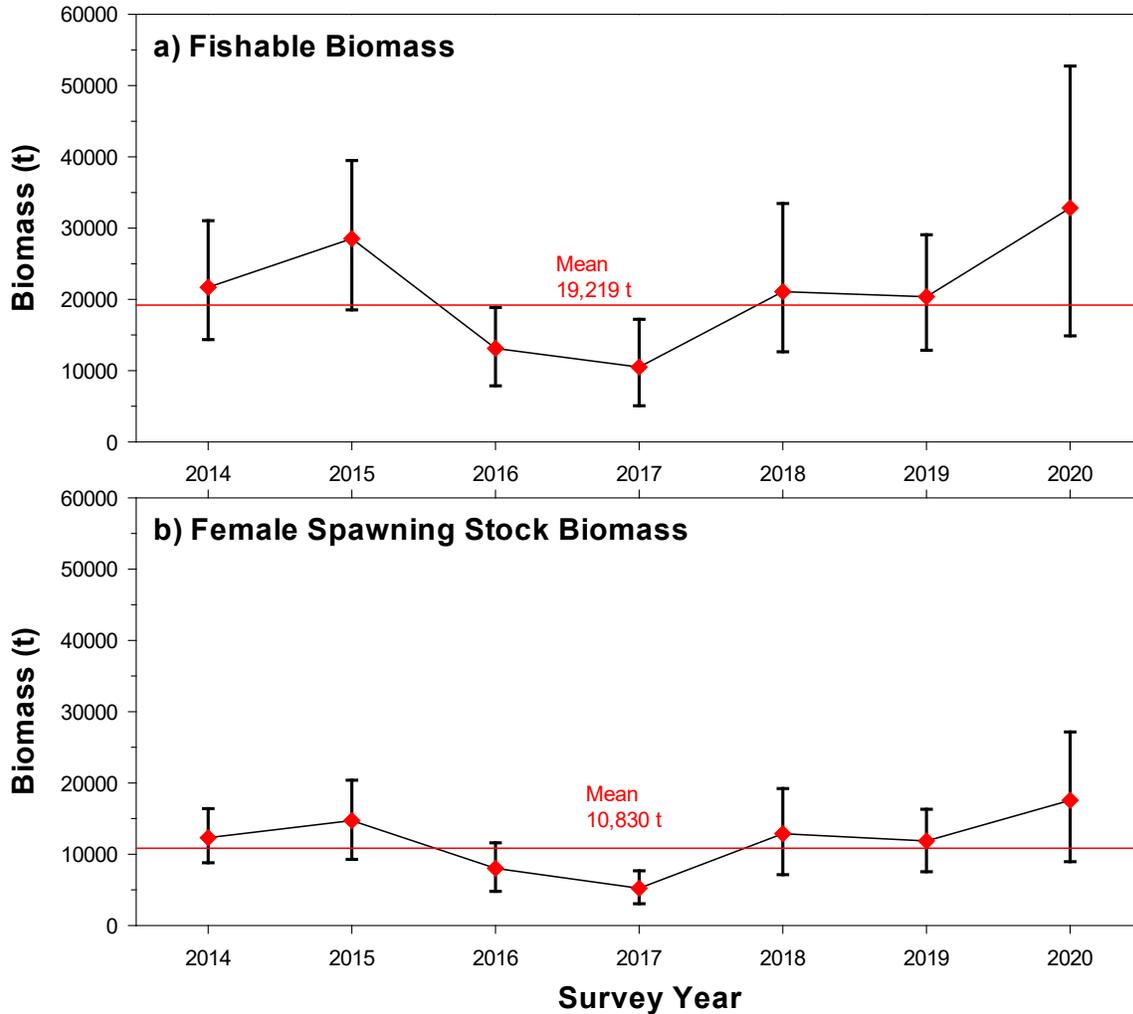


Figure 12. Western Assessment Zone *Pandalus borealis*, a) fishable biomass and b) female spawning stock biomass indices from the 2014–2020 Northern Shrimp Research Foundation-Fisheries and Oceans Canada (NSRF-DFO) surveys. Error bars are 95% confidence ranges.

Exploitation

The reported exploitation rate index for 2020/21 was 1.9% with 20% of the TAC taken (Figure 13a). Based on the 2020/21 TAC of 3,163 t, the potential exploitation rate index was 9.6% (Figure 13b).

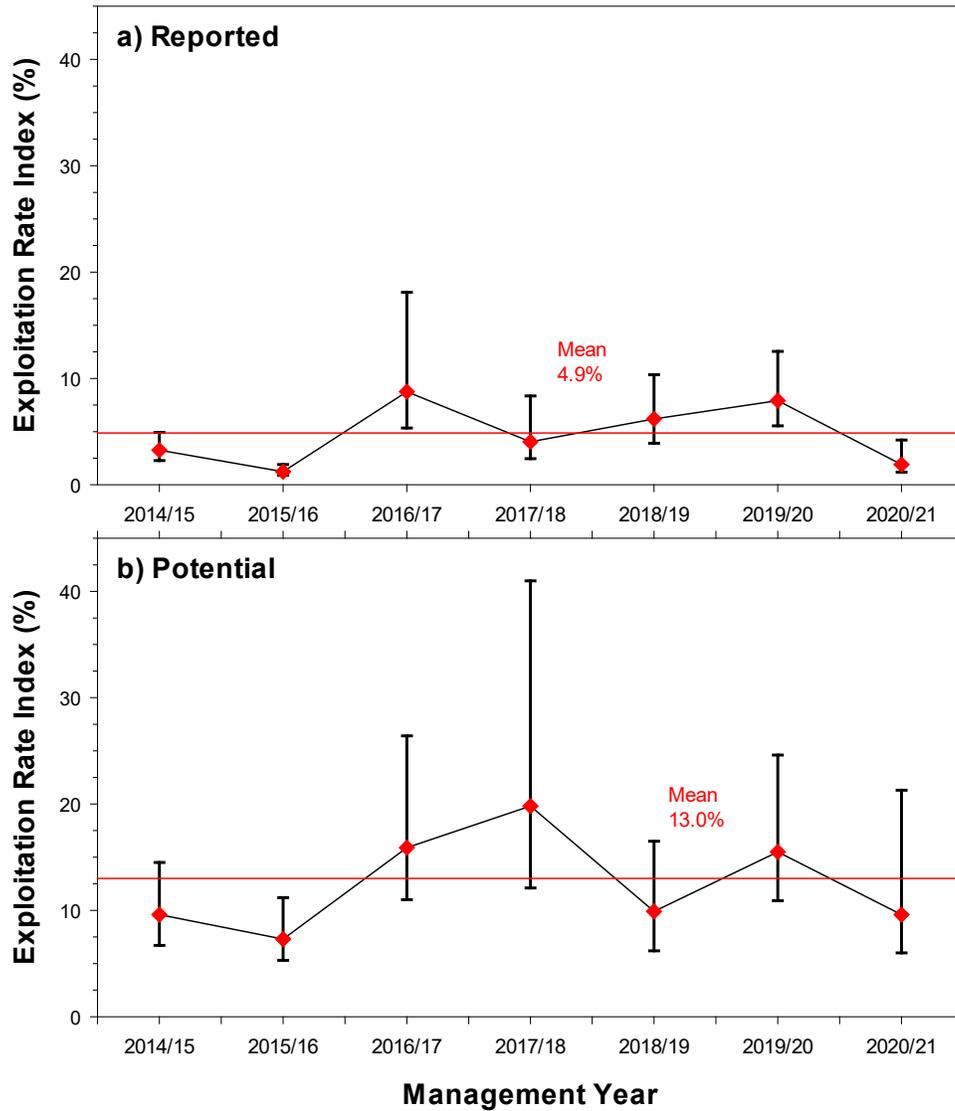


Figure 13. The Western Assessment Zone *Pandalus borealis* exploitation rate indices for the management years 2014/15–2020/21; a) reported rate, based on the Canadian Atlantic Quota Report catch and the b) potential rate if the entire Total Allowable Catch assigned to the zone was taken. Error bars are 95% confidence ranges.

Current Outlook

Pandalus borealis stock in the WAZ is currently well above the established LRP (Figure 14). Although there is currently no established USR, the stock is considered in a healthy state.

Should the USR be established at the proposed level (i.e., 80% of the geometric mean of the SSB; DFO 2020b), the stock in 2020 would be placed well within the Healthy Zone of the PA Framework.

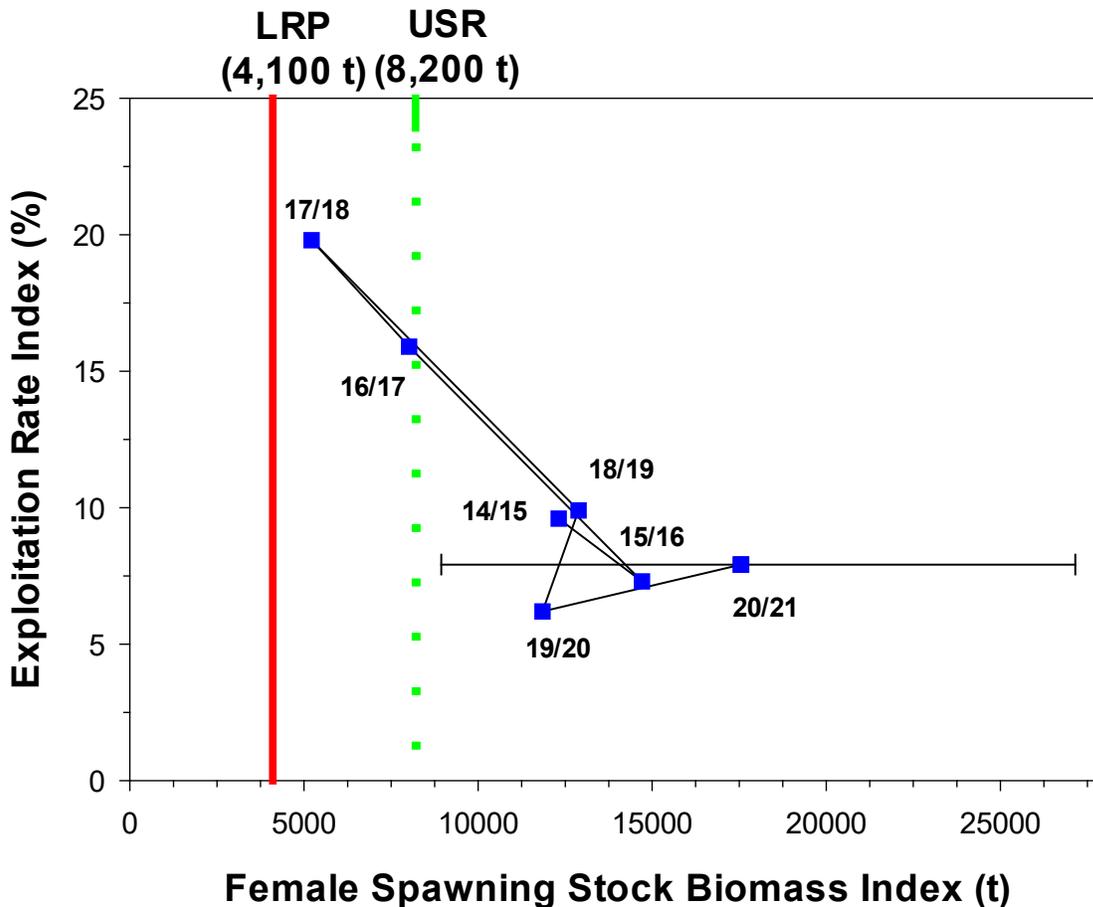


Figure 14. Western Assessment Zone trajectory of *Pandalus borealis* female spawning stock and exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO 2020b. Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys. Since the USR has not been implemented and it is currently being consulted, final location of the dashed line is yet to be determined.

Western Assessment Zone – *P. montagui*

Fishery

Total catch in 2020/21 was 3,917 t, which is 33% of the 11,975 t TAC (Figure 15, Table 1). Catch statistics in 2020/21 are preliminary.

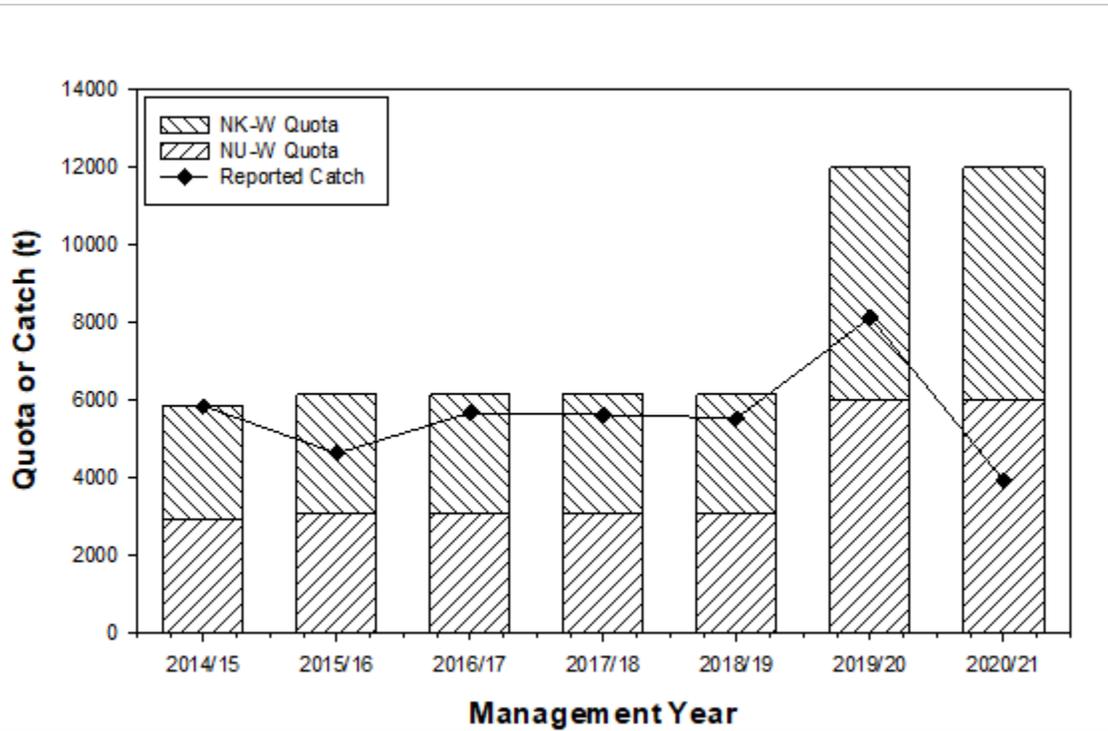


Figure 15. The Western Assessment Zone *Pandalus montagui* Total Allowable Catch and catch recorded in the Canadian Atlantic Quota Report (CAQR) for 2020/21. Catch records from CAQR as of February 2, 2021.

Biomass

Due to a change in survey methodology, the 2014 survey began a new time series. Thus, the 2020 survey was the seventh survey in the new time series. Since the start of the new series, the fishable biomass and SSB indices varied without trend. Movement across management areas is suspected to contribute to interannual variability in the fishable biomass index. The fishable biomass was below the long term mean (56,609 t) and was 50,911 t in 2020 (Figure 16a, Table 5). The SSB index was below the long term mean (31,640 t) and was 26,811 t in 2020 (Figure 16b, Table 5).

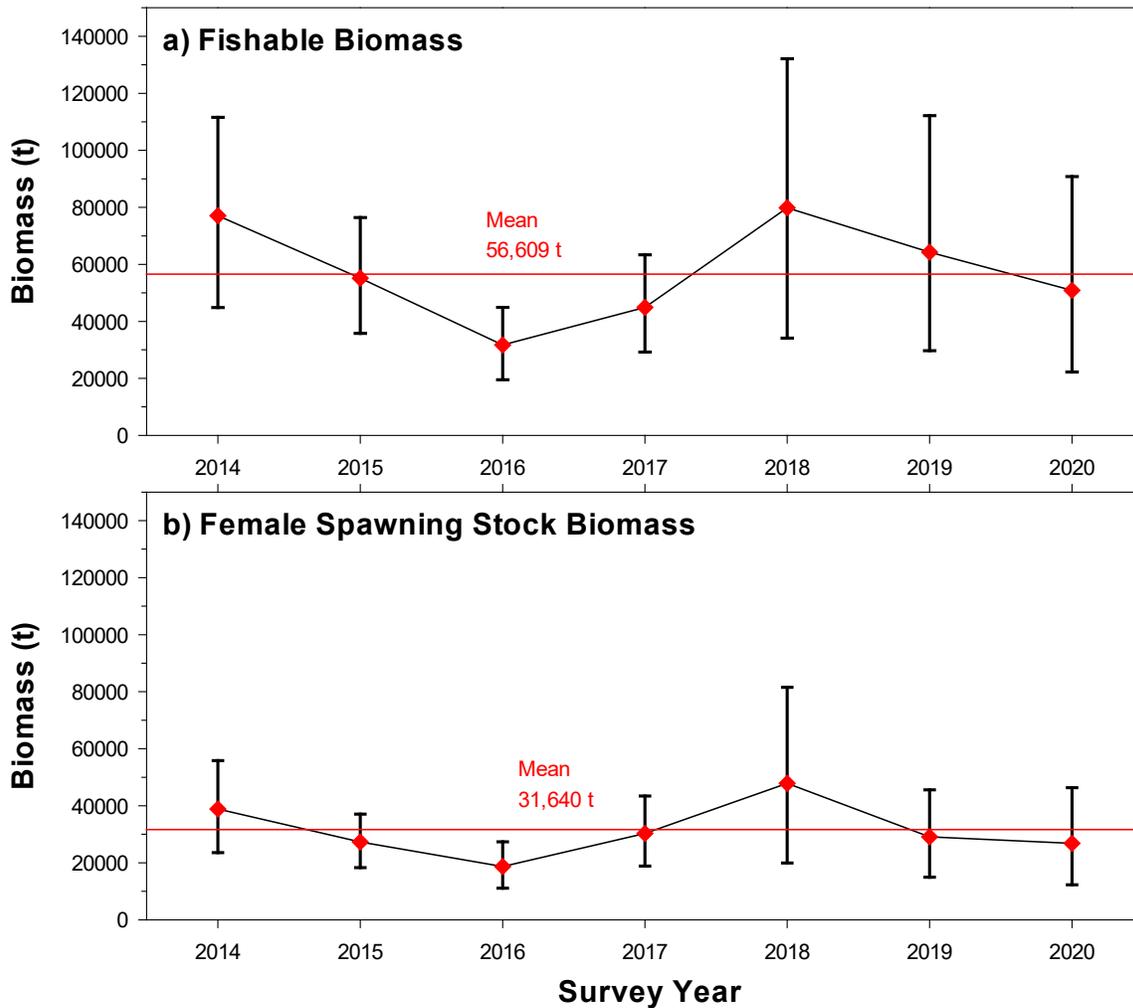


Figure 16. Western Assessment Zone *Pandalus montagui*, a) fishable biomass and b) female spawning stock biomass indices from the 2014–2020 Northern Shrimp Research Foundation-Fisheries and Oceans Canada (NSRF-DFO) surveys. Error bars are 95% confidence ranges.

Exploitation

The reported exploitation rate index for 2020/21 was 7.7% with 33% of the TAC taken (Figure 17). Based on the 2020/21 TAC of 11,975 t, the potential exploitation rate index was 23.5%.

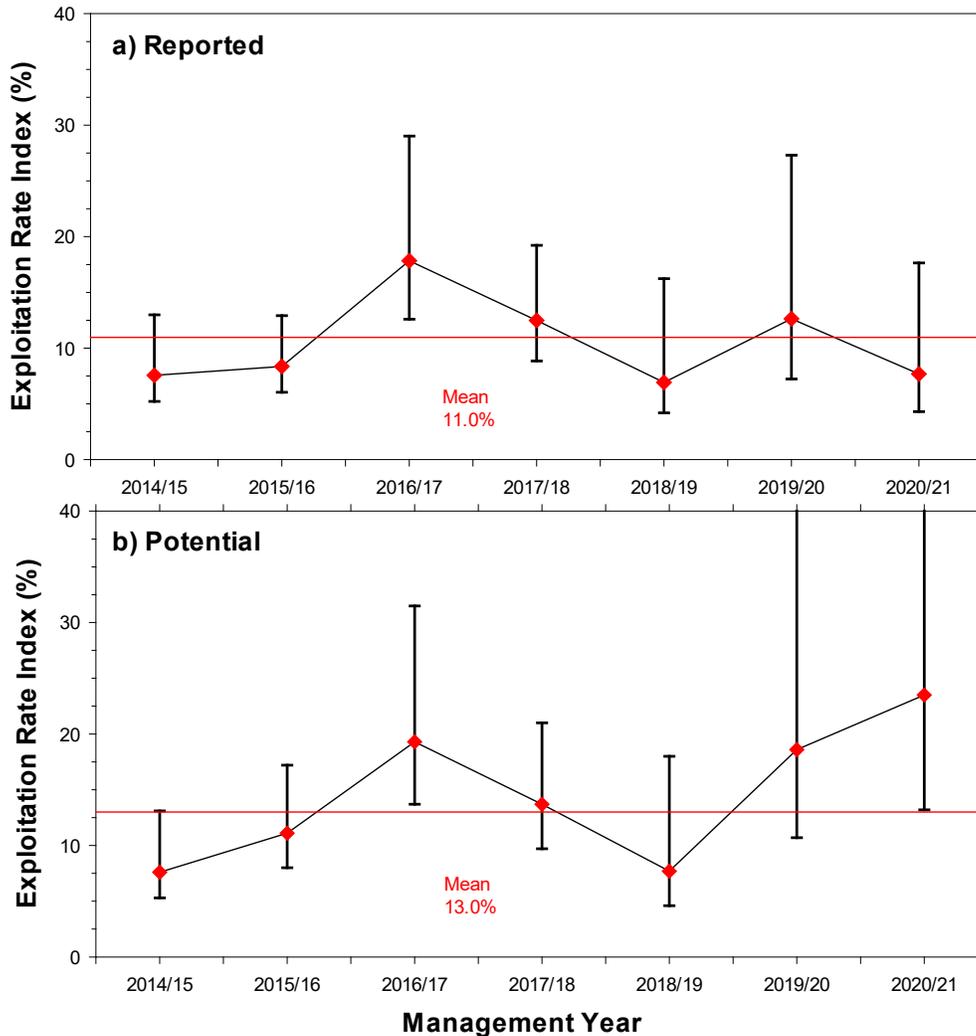


Figure 17. The Western Assessment Zone *Pandalus montaguui* exploitation rate indices for the management years 2014/15–2020/21; a) reported rate, based on the Canadian Atlantic Quota Report catch and the b) potential rate if the entire Total Allowable Catch assigned to the zone was taken. Error bars are 95% confidence ranges.

Current Outlook

Although there is currently no established USR for *Pandalus montaguui* stock in the WAZ, the stock is above the LRP relevant to a PA Framework (Figure 18).

Even though there were recently two years of SSB index declines, should the USR be established at the proposed level (i.e. 80% of the geometric mean of the SSB; DFO 2020b), the stock in 2020 would still be placed within the Healthy Zone of the PA Framework.

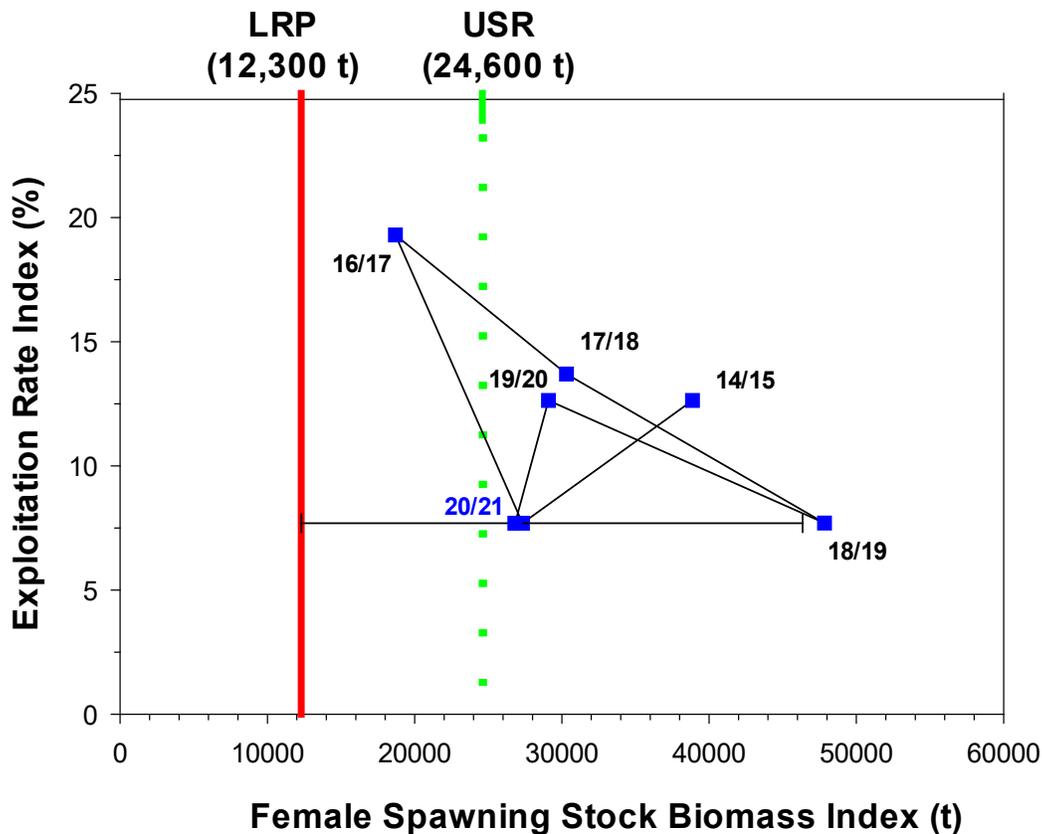


Figure 18. Western Assessment Zone trajectory of *Pandalus montagui* female spawning stock and exploitation rate in reference to Limit Reference Points (LRPs) calculated using the proxy developed in DFO (2020b). Dashed green line indicates the proposed Upper Stock Reference (USR) and the solid red line indicates the LRP, each referring to 80% and 40%, respectively, of the geometric mean of the female spawning stock biomass indices from the 2014–2019 surveys. Since the USR has not been implemented and it is currently being consulted, final location of the dashed line is yet to be determined.

Sources of Uncertainty

Hudson Strait is a highly dynamic system with strong tidal currents and mixing. Shrimp could be transported great distances in a relatively short period of time in and out of the WAZ, EAZ, and SFA 4 to the south. This is most likely the cause of the wide fluctuations in biomass seen in these areas. 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 at neap tides. 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 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). 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 commonality of the ships' dimensions, the relative catchability would be consistent among vessels. However, this was not empirically tested.

Additionally, drivers of stock variability are poorly understood and research is needed on foraging (e.g., zooplankton biomass estimates), predation (e.g., gut contents of shrimp predators), and ecosystem tracers (e.g., stable isotopes and fatty acids in various food chain elements).

Science Recommendations

- *Pandalus montagui* total biomass – combine EAZ/WAZ/SFA4 to seek the difference in biomass index confidence intervals when the index is computed as separate zones vs. entire area;
- Inter-regional stock level integration of the *P. borealis* biomass data (North-South integration);
- *Pandalus montagui*/*P. borealis* biomass relationships between EAZ/WAZ/SFA4 to seek evidence of local scale biomass export/import between the zones;
- Predator-prey dynamics – continue collection of data (in 2021), process existing samples (from 2020), analyze existing data sets (from 2019), publish compiled data (from 2018);
- Collect ancillary environmental data (seasonal aspect; grant application put forward to deploy moorings).

CONCLUSIONS AND ADVICE

Eastern Assessment Zone – *P. borealis*

Pandalus borealis stock in the EAZ is currently well above the established LRP. Although there is currently no established USR, the stock is considered in a healthy state. Based on the 2020/21 TAC of 10,653 t, the potential exploitation rate index was 12.5%.

Eastern Assessment Zone – *P. montagui*

Pandalus montagui stock in the EAZ is currently well above the established LRP. Although there is currently no established USR and the stock biomass index is subject to considerable interannual variability, the stock is considered in a healthy state. Based on the 2020/21 TAC of 840 t, the potential exploitation rate index was 4.5%.

Western Assessment Zone – *P. borealis*

Pandalus borealis stock in the WAZ is currently well above the established LRP. Although there is currently no established USR, the stock is considered in a healthy state. Based on the 2020/21 TAC of 3,163 t, the potential exploitation rate index was 9.6%.

Western Assessment Zone – *P. montagui*

Although there is currently no established USR for *Pandalus montagui* stock in the WAZ, the stock is above the established LRP relevant to a PA Framework. Based on the 2020/21 TAC of 11,975 t, the potential exploitation rate index was 23.5%.

MANAGEMENT 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. Keeping the exploitation rate at or below the base of 15% for the Healthy Zone of the IFMP PA framework is thought to be conservative and leaves sufficient forage in the water for predators.

Since the PA reference points for *P. borealis* and *P. montagui* in the EAZ were deemed no longer appropriate (DFO 2018), they were updated in May, 2020 (DFO 2020a); as a result, adopted LRPs are used in this report, while the USRs are still under consideration through the consultative process within the Northern Precautionary Approach Working Group (NPAWG).

LIST OF MEETING PARTICIPANTS

Name	Organization/Affiliation
Brian Healey	DFO Science, Newfoundland and Labrador Region
Brittany Beauchamp	DFO Science, National Capital Region
Brittany Pye	DFO Science, Newfoundland and Labrador Region
Christina Schaefer	DFO Science, Newfoundland and Labrador Region
Darrell Mallowney (Chair)	DFO Science, Newfoundland and Labrador Region
Darren Sullivan	DFO Science, Newfoundland and Labrador Region
David Belanger	DFO Science, Newfoundland and Labrador Region
Derek Osborne	DFO Science, Newfoundland and Labrador Region
Elizabeth Coughlan	DFO Science, Newfoundland and Labrador Region
Eugene Lee (Meeting Coordinator)	DFO Science, Newfoundland and Labrador Region
Frederic Cyr	DFO Science, Newfoundland and Labrador Region
Hannah Munro	DFO Science, Newfoundland and Labrador Region
Julia Pantin	DFO Science, Newfoundland and Labrador Region
Katherine Skanes (Stock Lead)	DFO Science, Newfoundland and Labrador Region
Kelly Dooley	DFO Science, Newfoundland and Labrador Region
Krista Baker	DFO Science, Newfoundland and Labrador Region
Kyle Lefort (Rapporteur)	DFO Science, Newfoundland and Labrador Region

Name	Organization/Affiliation
Manon Cassista-De Ros (Internal Reviewer)	DFO Science, Maritimes Region
Mariano Koen-Alonso	DFO Science, Newfoundland and Labrador Region
Nicholas LeCorre	DFO Science, Quebec Region
Roanne Collins	DFO Science, Newfoundland and Labrador Region
Sanaollah Zabihi-Seisson	DFO Science, Newfoundland and Labrador Region
Sheila Atchison	DFO Science, Ontario and Prairie Region
William Coffey	DFO Science, Newfoundland and Labrador Region
Wojciech Walkusz (Stock Lead)	DFO Science, Ontario and Prairie Region
Jennifer Duff	DFO Communications, Newfoundland and Labrador Region
Courtney D'Aoust	DFO Resource Management, National Capital Region
Christie Friesen	DFO Resource Management, Arctic Region
Martin Henri	DFO Resource Management, Newfoundland and Labrador Region
Robyn Morris	DFO Resource Management, Newfoundland and Labrador Region
Abe Solberg	Marine Institute Memorial University of Newfoundland
Arnault LeBris	Marine Institute Memorial University of Newfoundland
Raquel Ruiz	Marine Institute Memorial University of Newfoundland
Tyler Eddy	Marine Institute Memorial University of Newfoundland
Adam Mugeridge	Government of Nova Scotia
Alastair O'Reilly	Northern Coalition
Allister Russell	Fish, Food and Allied Workers Union, Harvester
Bobby Noble	Fish, Food and Allied Workers Union, Harvester
Brian Burke	Nunavut Fisheries Association
Brian McNamara	Newfoundland Resources Ltd.
Bruce Chapman	Canadian Association of Prawn Producers

Name	Organization/Affiliation
Claude Pelletier	Government of New Brunswick
Craig Taylor	Torngat Wildlife, Plants & Fisheries Secretariat
Derek Butler	Association of Seafood Producers
Derrick Dalley	Innu Nation, Newfoundland and Labrador
Dwan Street	Fish, Food and Allied Workers Union, Scientist
Erin Carruthers	Fish, Food and Allied Workers Union, Scientist
Frankie Jean-Gagnon	Nunavik Marine Wildlife Board
Joanne Bowers	Government of Prince Edward Island
Keith Watts	Torngat Fish Cooperation (NC)
Lisa Matchim	Torngat Secretariat
Nelson Bussey	Fish, Food and Allied Workers Union, Harvester
Nicole Rowsell	Government of Newfoundland and Labrador
Rob Coombs	NunatuKavut Community Council
Susanne Fuller	Oceans North
Todd Broomfield	Nunatsiavut Government
Tony Wright	Makivik Corporation
Zoya Martin	Government of Nunavut

SOURCES OF INFORMATION

This Science Advisory Report is from the February 22–26, 2021 Zonal Advisory Meeting on the Assessment of Northern Shrimp in SFAs 4-6, EAZ & WAZ and of Striped Shrimp in SFA 4, EAZ & WAZ. 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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APPENDIX 1. ANNUAL DATA TABLES

Table A1. Nominal reported catches (t) for the Eastern Assessment Zone and Western Assessment Zone for *Pandalus borealis* and *P. montagui*. *Catch based on CAQR as of 2 February 2021. Since the fishery is still open the catch is preliminary for 2020.

Year	Eastern Assessment Zone		Western Assessment Zone	
	<i>P. borealis</i>	<i>P. montagui</i>	<i>P. borealis</i>	<i>P. montagui</i>
2020*	5119	267	625	3917
2019	5508	225	1612	8114
2018	6198	234	1307	5531
2017	6488	233	918	5609
2016	6667	358	643	5660
2015	4816	59	353	4616
2014	4972	401	847	5836
2013	6793	1075	973	4775
2012	5555	1173	13	1105
2011	7687	135	0	857
2010	6908	483	57	345
2009	5159	564	0	0
2008	5184	808	0	0
2007	6359	1832	0	0
2006	6028	925	0	0
2005	6387	1427	-	0
2004	5842	2301	-	0
2003	5617	1217	-	0
2002	5695	3081	-	0
2001	6275	3867	-	0
2000	5718	4238	-	0
1999	5465	3780	-	0

Year	Eastern Assessment Zone		Western Assessment Zone	
	<i>P. borealis</i>	<i>P. montagui</i>	<i>P. borealis</i>	<i>P. montagui</i>
1998	5372	3360	-	0
1997	5870	3050	-	0
1996	33467	3058	-	0
1995	2489	3192	-	0
1994	456	154	-	0
1993	68	0	-	0
1992	1210	1	-	0
1991	1150	623	-	0
1990	1634	174	-	5
1989	3133	1265	-	10
1988	2873	603	-	13
1987	0	0	-	0
1986	50	483	-	0
1985	0	0	-	0
1984	0	0	-	0
1983	21	0	-	0
1982	46	0	-	0
1981	1	9	-	2
1980	487	103	-	3
1979	1	58	-	25

Table A2. Fishable and female spawning stock biomass estimates for *Pandalus borealis* in the Eastern Assessment Zone for the 2009–2020 surveys. LCL and UCL are the lower and upper 95% confidence limits. Year over year (YOY) change indicates the relative change in comparison to the previous year.

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2020	Fishable	-9.4	86211	26090	170892
2019	Fishable	102.8	95138	48333	146788
2018	Fishable	19.6	46900	36344	58928
2017	Fishable	-40.2	39198	30225	48907
2016	Fishable	-17.0	65570	42137	93569
2015	Fishable	56.5	78984	50852	106962
2014	Fishable	1.5	50458	38914	62340
2013	Fishable	-17.9	49697	38427	60631
2012	Fishable	-22.9	60534	43074	79960
2011	Fishable	10.5	78530	23900	135037
2010	Fishable	-9.8	71065	40234	108703
2009	Fishable	54.3	78755	48850	110115

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2020	Female SS	5.9	60531	17534	125168
2019	Female SS	74.0	57143	28420	87654
2018	Female SS	32.4	32842	23548	44126
2017	Female SS	-28.8	24800	19888	30252
2016	Female SS	-42.8	34827	24220	46979
2015	Female SS	78.7	60869	33379	88386
2014	Female SS	6.3	34069	25157	43000
2013	Female SS	-22.2	32049	26762	37607
2012	Female SS	-13.8	41190	29498	54383
2011	Female SS	9.1	47807	13470	82926
2010	Female SS	12.7	43800	19025	79665
2009	Female SS	40.5	38856	23122	56820

Table A3. Fishable and female spawning stock biomass estimates for *Pandalus montagu* in the Eastern Assessment Zone for the 2009–2020 surveys. LCL and UCL are the lower and upper 95% confidence limits. Year over year (YOY) change indicates the relative change in comparison to the previous year.

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2020	Fishable	121.1	18802	6583	31371
2019	Fishable	-59.3	8503	3930	13948
2018	Fishable	-16.3	20895	12617	29450
2017	Fishable	81.0	24957	17246	32311
2016	Fishable	124.7	13792	6452	21126
2015	Fishable	-63.0	6137	3445	8629
2014	Fishable	371.0	16600	11203	22084
2013	Fishable	-87.8	3524	1738	6208
2012	Fishable	272.7	28845	8582	48946
2011	Fishable	4.3	7740	2871	14285
2010	Fishable	-52.7	7423	5714	9290
2009	Fishable	6.9	15679	6190	29774
2020	Female SS	227.0	14437	4392	24991
2019	Female SS	-68.0	4415	1742	7275
2018	Female SS	-19.8	13806	9362	20052

Year	Biomass	YOY change (%)	Weight (tonne)		
			Mean	LCL	UCL
2017	Female SS	64.4	16537	9866	23250
2016	Female SS	159.4	10056	2986	17280
2015	Female SS	-69.5	3877	2085	5452
2014	Female SS	357.1	12696	8834	16622
2013	Female SS	-88.2	2778	1301	4949
2012	Female SS	653.8	23552	6218	40985
2011	Female SS	-46.3	3124	1599	4721
2010	Female SS	-33.7	5819	4509	7136
2009	Female SS	-17.7	8776	4205	13955

Table A4. Fishable and female spawning stock biomass estimates for *Pandalus borealis* in the Western Assessment Zone for the 2014–2020 surveys. Year over year (YOY) change indicates the relative change in comparison to the previous year. LCL and UCL are the lower and upper 95% confidence limits.

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2020	Fishable	61.1	32835	14867	52744
2019	Fishable	-3.4	20378	12852	29080
2018	Fishable	101.0	21088	12627	33452
2017	Fishable	-20.0	10487	5073	17185
2016	Fishable	-54.0	13116	7867	18868
2015	Fishable	31.4	28532	18531	39501
2014	Fishable	-1.3	21713	14353	31046
2020	Female SS	48.2	17555	8943	27150
2019	Female SS	-8.1	11845	7529	16299
2018	Female SS	147.0	12884	7121	19203
2017	Female SS	-34.9	5216	3045	7676
2016	Female SS	-45.5	8015	4780	11590
2015	Female SS	19.5	14710	9270	20379
2014	Female SS	25.8	12309	8792	16398

Table A5. Fishable and female spawning stock biomass estimates for *Pandalus montagui* in the Western Assessment Zone for the 2014–2020 surveys. Year over year (YOY) change indicates the relative change in comparison to the previous year. LCL and UCL are the lower and upper 95% confidence limits.

Year	Biomass	YOY change (%)	Weight (tonnes)		
			Mean	LCL	UCL
2020	Fishable	-20.8	50911	22199	90802
2019	Fishable	-19.5	64268	29711	112173
2018	Fishable	77.7	79835	34057	132111
2017	Fishable	41.6	44915	29179	63381
2016	Fishable	-42.5	31724	19507	44908
2015	Fishable	-28.4	55194	35769	76429
2014	Fishable	68.9	77078	44854	111562
2020	Female SS	-7.8	26811	12310	46349
2019	Female SS	-39.2	29079	14930	45581
2018	Female SS	57.8	47834	19926	81534
2017	Female SS	62.1	30305	18830	43434
2016	Female SS	-31.6	18691	11090	27334
2015	Female SS	-29.7	27324	18282	37041
2014	Female SS	44.2	38875	23553	55849

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Telephone: (204) 983-5232

E-Mail: csas-sccs@dfo-mpo.gc.ca

Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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