

APPENDIX 1 Science Advice



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This document is approved and in pre-publication with CSAS. Please note that this document has not yet been published on the DFO CSAS website.

Newfoundland and Labrador Region

Canadian Science Advisory Secretariat

Arctic Region

Approved Pre-Publication Science Response 2026/nnn

STOCK UPDATE FOR NORTHERN SHRIMP (*PANDALUS BOREALIS*) IN THE NORTH AND SOUTH STOCK ASSESSMENT REGIONS FOR THE 2026-27 FISHING SEASON

CONTEXT

Fisheries and Oceans Canada's (DFO's) Fisheries Resource Management sector has requested an update of the Northern Shrimp (*Pandalus borealis*) stock in the North and South Stock Assessment Regions (NSAR and SSAR) as the basis for Science advice for the 2026 – 27 fishing season. The most recent stock assessment (March 2025) estimated that Northern Shrimp in both assessment regions would be in the Healthy Zone of the Precautionary Approach (PA) Framework, if the proposed Upper Stock Reference (USR) points were adopted by DFO Fisheries Resource Management. The status of Northern Shrimp in the NSAR and SSAR will be reassessed at the next full assessment.

This Fisheries Science Response is from the multi-regional (Newfoundland and Labrador and Arctic Regions) peer review meeting of March 10 - 11, 2026, on the Stock Update for Northern Shrimp (*Pandalus borealis*) in the North and South Stock Assessment Regions for the 2026-27 fishing season.

SCIENCE ADVICE

Status

- Stock status for the North Stock Assessment Region (NSAR) and the South Stock Assessment Region (SSAR) are not determined during interim-year updates.

Trends

- **NSAR:** The Spawning Stock Biomass (SSB) and Fishable Biomass (FB) indices were updated to 2025 and both increased from 2024. In the context of the overall trajectory of the stock, these interannual changes in the indices are consistent with the stock biomass remaining near their respective time-series averages.
- **SSAR:** The SSB and FB indices were updated to 2025 and both increased from 2024. In the context of the overall trajectory of the stock, these interannual changes in the indices are consistent with the stock biomass remaining near their respective time-series low levels.

Ecosystem and Climate Change Considerations

- In the southern portion of the NSAR and in the SSAR, the warm phase in ocean climate that started around 2020 continued in 2025.

- The biomass of key predatory fishes (Greenland Halibut, Atlantic Cod, and redfish) have increased in both assessment regions in the 2020s and remains high in 2025.
- The ecosystem biomass in the SSAR is at the highest level since the ecosystem collapse in the late 1980s and early 1990s, but remains below pre-collapse levels. These increases are driven by groundfish, with the community having returned to a groundfish-dominated structure.
- Based on information from Atlantic Cod and Greenland Halibut diets, the current shrimp biomass in the Division 2J3KL portion of the SSAR is estimated to be at or below the level of the pre-ecosystem collapse period.

Stock Advice

- **NSAR:** The preliminary exploitation rate index (ERI) was 13.3% in 2025/26. If the entire 2025/26 aggregated total allowable catch (TAC) for the management areas of this region is taken, the ERI will be 17.8%.
- **SSAR:** The preliminary ERI was 8.3% in 2025/26. If the entire 2025/26 aggregated TAC for the management areas of this region is taken, the ERI will be 15.8%.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

2024 (Johnson et al. In prep.¹)

Assessment Type

Interim-Year Update

Most Recent Assessment Date

1. Last Full Assessment: March 2025
2. Last Interim-Year Update: N/A (first time these stocks are updated using a new population structure)

Stock Assessment Approach

1. Broad category: Single stock assessment model
2. Specific category: Statistical catch-at-length

This assessment follows the framework of Johnson et al. (In prep.¹), which uses the Bayesian size structured Spatially Integrated Statistical Catch-at-Length/Size (SISCALS) model to determine stock status. See Procedure for Interim year updates section below for details on the update process. For interim updates, SISCALS is not run; instead, survey data from the DFO fall multispecies survey and the Northern Shrimp Research Foundation (NSRF)–DFO summer trawl survey were used to generate fishable biomass (FB) and spawning stock Biomass (SSB) survey indices for the North and South stock assessment regions (NSAR and SSAR). Fishery

¹ Johnson, S.D.N., Cox, S.P., Baker, K.D., Le Corre, N., Coffey, W., and Enright, D. In prep. A framework stock assessment for Canada's Northern Shrimp (*Pandalus borealis*) fishery off Newfoundland, Labrador, and Baffin Island. DFO Can. Sci. Advis. Sec. Res. Doc.

trends were evaluated using total allowable catch (TAC), commercial catch-to-date, and exploitation rate indices. All biomass indices reported in this update are derived from spatiotemporal models using survey data, which differs from SISCALS due to survey catchability and selectivity.

Ecosystem and Climate Change Assessment Approach

The physical environment was characterized by examining trends in ocean climate using oceanographic indicators, and the Newfoundland and Labrador Climate Index (NLCI). Food web components examined included lower trophic levels characterized using primary production and zooplankton indicators and status and trends of the fish community. The characterization of ecological and environmental interactions included fish diets, estimations of food consumption, modelling of shrimp biomass as a function of predators' diets, and the evaluation of changes in shrimp per capita production over time.

Stock Structure Assumption

Stock overview information: Baker et al. 2025; Johnson et al. (In prep.)¹.

A new understanding of Northern Shrimp stock structure in Atlantic and Arctic Canada, based upon their distribution, larval dispersal, gene flow, and life history traits, was adopted in December 2024. Therefore, in 2025 the spatial scale of assessment for Northern Shrimp changed from six assessment areas (i.e., Eastern Assessment Zone [EAZ], Western Assessment Zone [WAZ], and Shrimp Fishing Areas [SFAs] 4, 5, 6, and 7 [NAFO

Divisions 3LNO]) to two stock assessment regions (i.e., NSAR and SSAR) (Figure 1). NSAR combines the WAZ, EAZ, SFA 4, and the portion of SFA 5 north of the border between Northwest Atlantic Fisheries Organization (NAFO) Divisions 2H and 2J. SSAR combines SFAs 6 and 7, and the portion of SFA 5 south of the border between NAFO Divisions 2H and 2J.

Reference Points

Northern Shrimp reference points in the Precautionary Approach (PA) Framework were developed using a stock assessment model (SISCALS), and reflect estimated natural mortality and size at sex-transition from the most recent eight years (i.e., approximately one Northern Shrimp generation) (DFO 2025). Note that the stock status is not updated in interim-years.

Data

- NSRF-DFO collaborative annual trawl survey (2005 – 25)
- DFO-Newfoundland and Labrador (NL) fall multispecies trawl survey data (1995 – 2025)
- At-sea-observer data from commercial vessels (1979 – 2025)
- Commercial catch data from NL logbook databases (1998 – 2025)
- Commercial catch data from Canadian Atlantic Quota Report (CAQR) and Atlantic Quota Monitoring System (AQMS) (1977 – 2025). In 2003, the management year shifted from a calendar year to a fiscal year (April 1 – March 31)
- DFO-NL Ecosystem Research Program Indicators (1960 – 2025)
- Atlantic Zone Monitoring Program Indicators (1950 – 2025)
- NASA Moderate Resolution Imaging Spectroradiometer Aqua Ocean Color observation (2003 – 25)

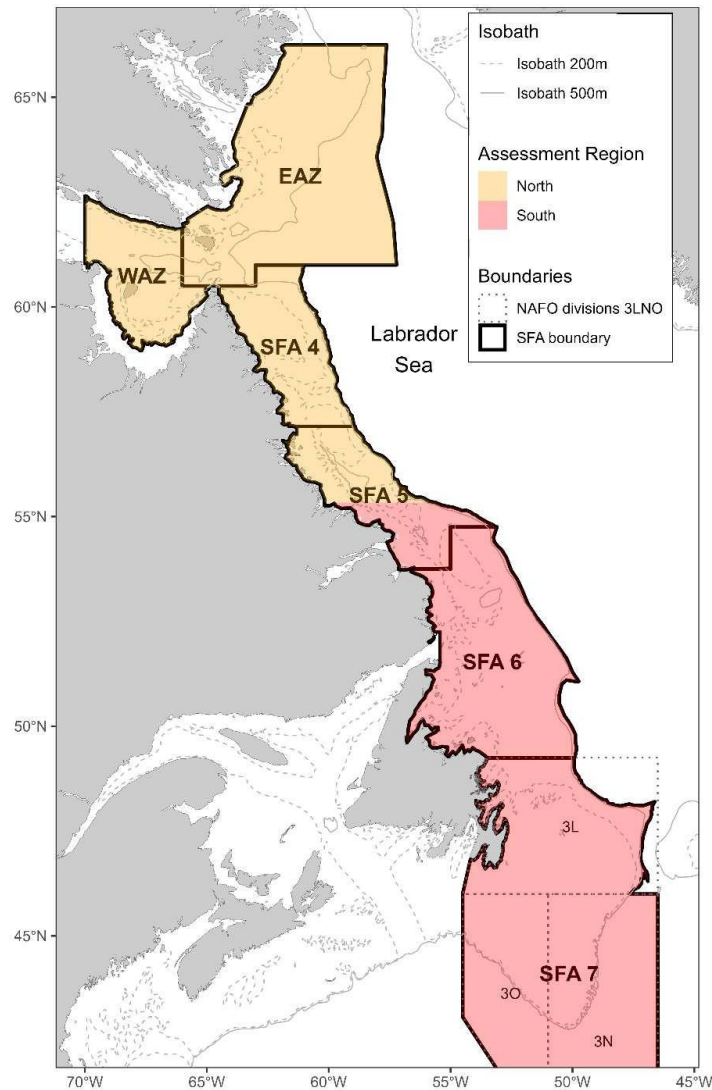


Figure 1. Map showing the six previously used shrimp fishing areas (EAZ, WAZ, SFAs 4–7) and the two stock assessment regions used in the assessment framework (North in yellow, and South in red).

Data changes:

This update applies the same data changes that were incorporated in the March 2025 assessment (DFO 2025).

Commercial catch data for 2025/26 are considered preliminary as the season is not closed until March 31, 2026; these data for 2024/25 are also preliminary pending possible revisions from outstanding catch logs. Data were pulled on February 5, 2026, for Newfoundland and Labrador and Arctic Regions. Catch data for 2023/24 and 2024/25 were revised to reflect updates from harvest activities that had not yet been reported at the time of the last assessment or update (Table 1).

The most recent three years (2023/24 to 2025/26) of at-sea observer program data and NL logbook data have been updated to reflect the most up-to-date information.

ASSESSMENT

Historical and Recent Stock Trajectory and Trends – North Stock Assessment Region

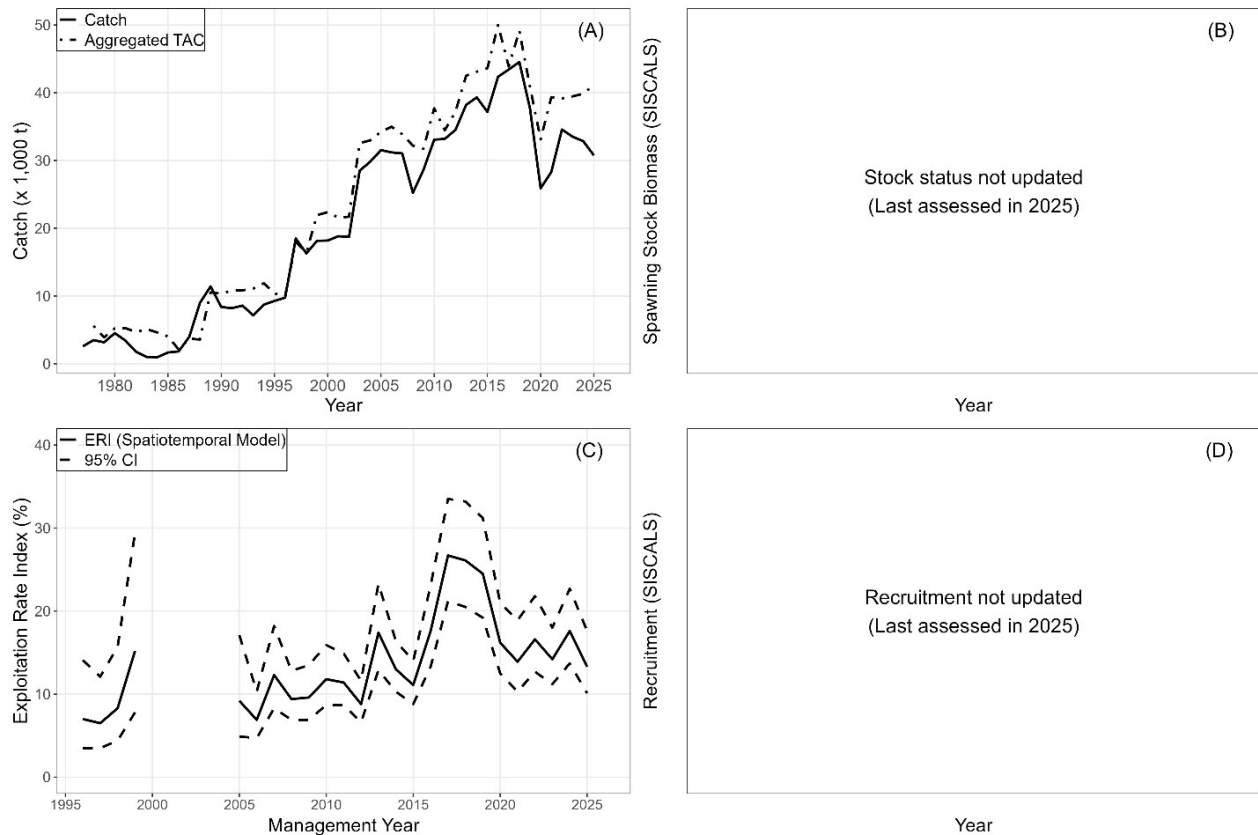


Figure 2. Northern Shrimp in the NSAR. (A) Catch (x 1,000 t) and aggregated Total Allowable Catch (x 1,000 t) (from the management areas in the NSAR) by year (data for 2024/25 – 2025/26 are preliminary), (B) SSB from SISCALS and stock status are not updated in an interim-year update, (C) Exploitation rate index (%) per management year based on catch and FB survey index from the same year, (D) Recruitment is not updated in an interim-year update. The most recent full stock assessment was conducted in 2025; see the corresponding [Science Advisory Report](#).

Fishery

Catch in the NSAR ranged between 984 t and 44,542 t from 1977 to 2025/26 (Figure 2a). The preliminary aggregated catch in 2025/26, as of February 5, 2026, was 30,765 t (75% of the aggregated total allowable catch [TAC] of 41,128 t) (Table 1).

Biomass

The SSB survey index in 2025 (150,000 t, Figure 3b) increased from 2024 (142,900 t), and remains above the time-series average. The FB survey index in 2025 (231,000 t, Figure 3b) increased from 2024 (186,300 t), but remains below the time-series average. In the context of

the overall trajectory of the stock, these interannual changes in the indices are consistent with the stock biomass remaining near their respective time-series averages.

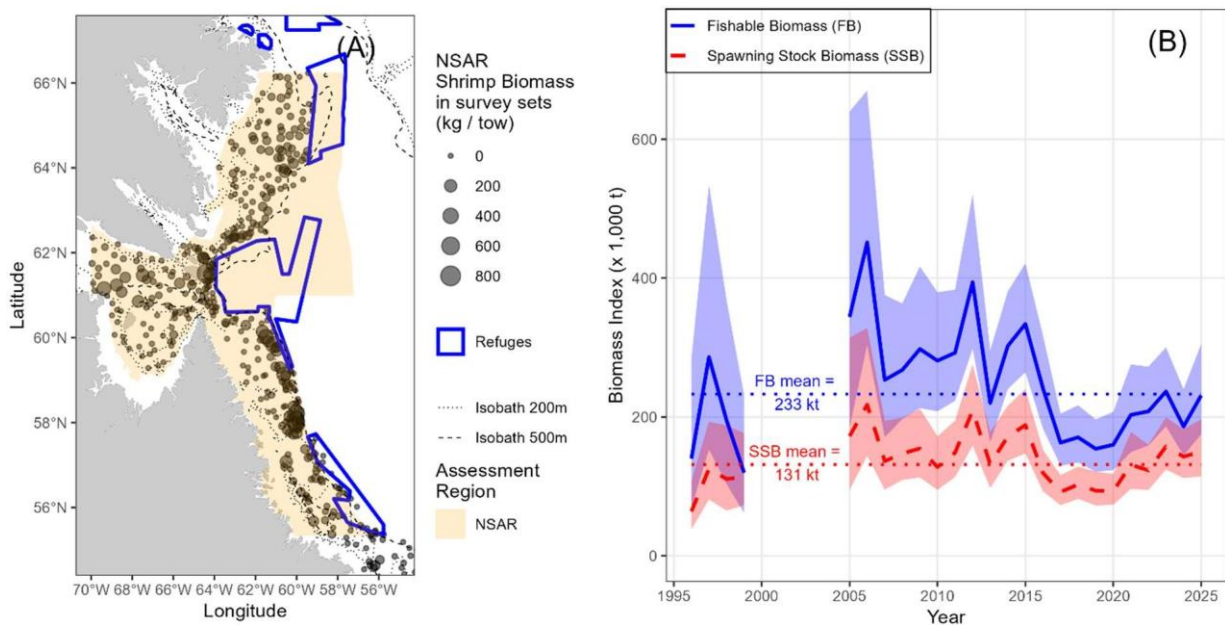


Figure 3. Additional indicators for Northern Shrimp in the NSAR. (A) Map of the survey catch of Northern Shrimp in 2025 (kg / tow), (B) FB (carapace length ≥ 17 mm – blue continuous line) and SSB (females of all sizes – red dashed line) survey indices (x 1,000 t). Horizontal dotted lines indicate long-term geometric mean and shaded areas indicate 95% confidence intervals around indices.

Biological Indicators

In 2025, the length at 50% transition to females returned to values consistent with previous years, following an unusually sharp decline in 2024 that fell below the prior time-series minimum. Median female and male carapace length in 2025 also returned to values consistent with previous years after reaching some of the lowest values observed in the time-series in 2024.

Exploitation

The exploitation rate index (ERI) ranged between 6.5% and 26.7% from 1996 to 2025/26 (Figure 2c). The preliminary ERI for 2025/26 was 13.3% with 75% of the aggregated TAC taken. Should the entire 2025/26 aggregated TAC of 41,128 t be taken, the ERI would be 17.8%.

Current Outlook

The stock status is not updated in interim-years.

Historical and Recent Stock Trajectory and Trends – South Stock Assessment Region

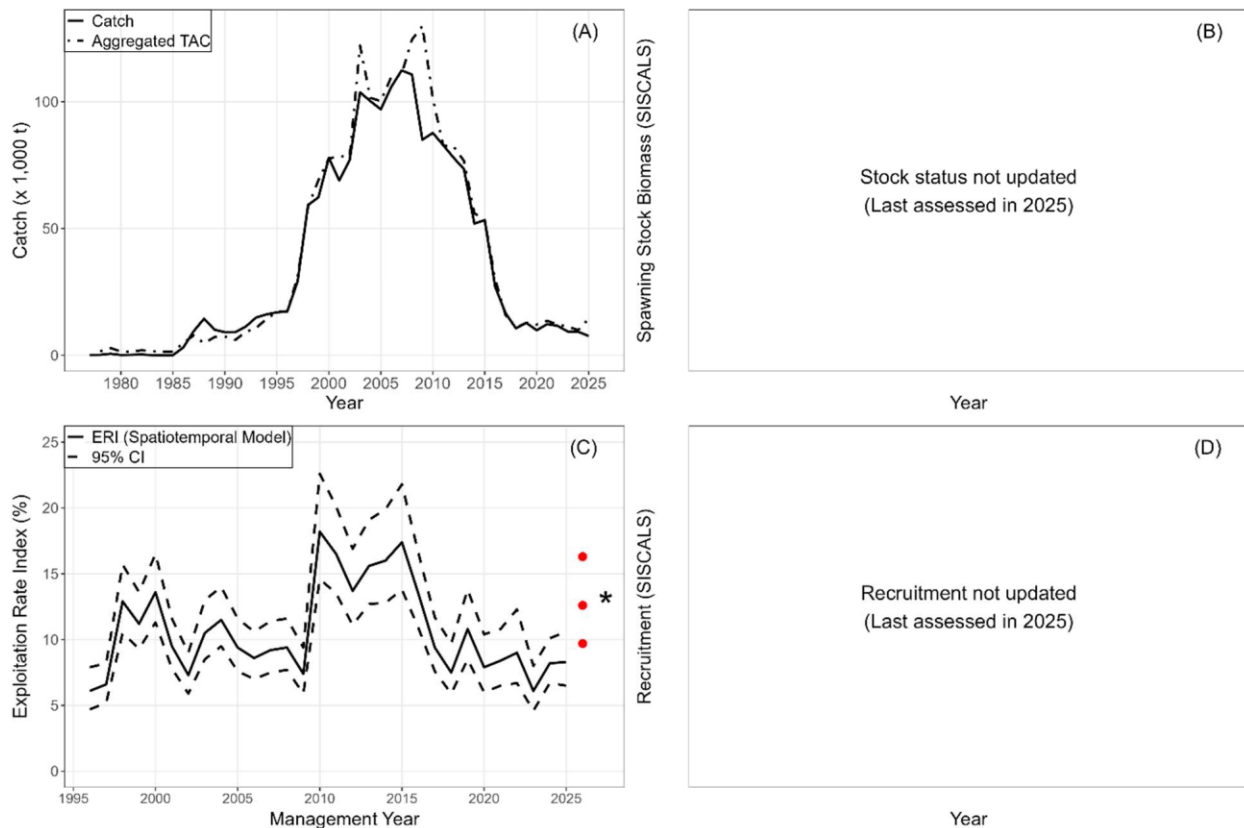


Figure 4. Northern Shrimp in the SSAR. (A) Catch (x 1,000 t) and aggregated Total Allowable Catch (x 1,000 t) (from the management areas in the SSAR) by year (data for 2024/25 – 2025/26 are preliminary), (B) SSB from SISCALS and stock status are not updated in an interim-year update, (C) Exploitation rate index (%) based on catch from a given management year (calendar year, or April 1–March 31 from 2003 onward) and FB survey index from the previous year (asterisk denotes 2026/27 projected ERI and red dots denote 95% confidence intervals considering the same aggregated TAC as in 2025/26), (D) Recruitment is not updated in an interim-year update. The most recent full stock assessment was conducted in 2025; see the corresponding [Science Advisory Report](#).

Fishery

Catch in the SSAR ranged between 15 t and 112,363 t from 1977 to 2025/26 (Figure 4a). The preliminary aggregated catch in 2025/26, as of February 5, 2026, was 7,563 t (53% of the aggregated TAC of 14,387 t) (Table 1).

Biomass

The SSB survey index in 2025 (73,400 t, Figure 5b) increased from 2024 (55,500 t), but remains below the time-series average and is around the lowest level in the survey time-series. The FB survey index in 2025 (114,500 t, Figure 5b) increased from 2024 (90,900 t), but remains below the time-series average and is around the lowest level in the survey time-series. In the context of the overall trajectory of the stock, these interannual changes in the indices are consistent with the stock biomass remaining near their respective time-series low levels.

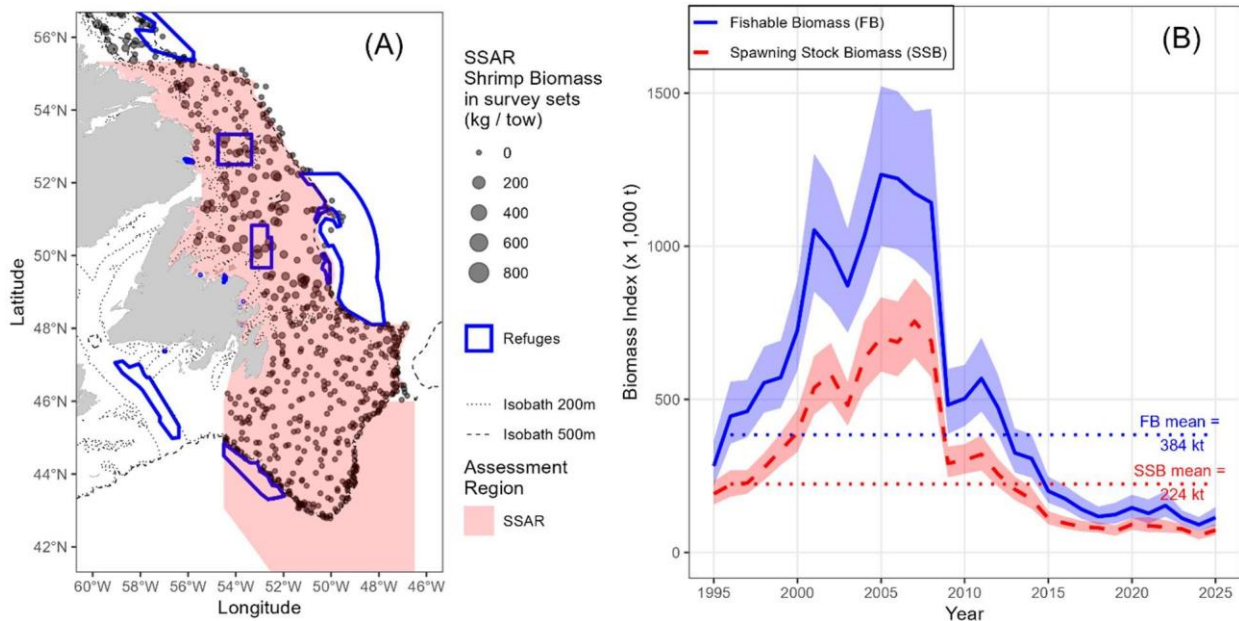


Figure 5. Additional indicators for Northern Shrimp in the SSAR. (A) Map of the survey catch of Northern Shrimp in 2025 (kg / tow), (B) FB (carapace length ≥ 17 mm – blue continuous line) and SSB (females of all sizes – red dashed line) survey indices (x 1,000 t). Horizontal dotted lines indicate geometric mean and shaded areas indicate 95% confidence intervals around indices.

Biological Indicators

In 2025, the length at 50% transition to female was similar to 2024. Median female and male carapace length in 2025 was similar to 2024.

Exploitation

The ERI ranged between 6.1% and 18.2% from 1996 to 2025/26 (Figure 4c). The preliminary ERI for 2025/26 was 8.3% with 53% of the aggregated TAC taken. Should the entire 2025/26 aggregated TAC of 14,387 t be taken, the ERI would be 15.8%.

Current Outlook

The stock status is not updated in interim-years.

History of TAC and Catch

With the change from six assessment areas (SFAs) to two stock assessment regions, SFA-specific TACs were summed for each stock assessment region into aggregated TACs for the purpose of understanding catch history (Le Corre et al. In press). The SFA 5 TAC was divided between the NSAR and SSAR each year based on the proportion of catch in each stock assessment region (i.e., SFA 5 North or South) within that year. The only exception was the final reported year (2025/26), which was incomplete because some logbooks had not yet been received and the fishing season does not close until March 31st; in that case, the previous year’s catch proportions were used to divide the SFA 5 catch and TACs.

The preliminary aggregated TAC within the NSAR increased from 39,848 t in 2024/25 to 41,128 t in 2025/26 (Table 1). The preliminary aggregated TAC within the SSAR increased from 9,931 t in 2024/25 to 14,387 t in 2025/26.

*Table 1. Nominal reported catches and aggregated TACs (t) for Northern Shrimp in the NSAR and SSAR over the last 10 years. Catches are based on AQMS data as of February 5, 2026 for the Arctic and Newfoundland and Labrador regions. *Catches for 2024/25 and 2025/26 are considered preliminary. ** TAC and Catch in Shrimp Fishing Area 5 were based on the values from SFA 5, split between the NSAR and SSAR according to the yearly proportion of catch in each stock assessment region, using observer data (Large Vessel: 2016/17 – 2025/26) and logbook data (Small Vessel: 2016/17 – 2025/26).*

Year	NSAR**		SSAR**	
	Catch (t)	Aggregated TAC (t)	Catch (t)	Aggregated TAC (t)
2016/2017	42,363	50,000	27,019	29,994
2017/2018	43,430	43,884	16,582	15,809
2018/2019	44,542	49,137	10,619	10,868
2019/2020	37,686	40,873	12,744	12,806
2020/2021	25,909	33,118	9,836	12,096
2021/2022	28,306	39,341	12,253	13,573
2022/2023	34,578	39,172	11,581	12,092
2023/2024	33,518	39,469	9,314	11,218
2024/2025*	32,859	39,848	9,213	9,931
2025/2026*	30,765	41,128	7,563	14,387

Ecosystem and Climate Change Considerations

Ecosystem considerations were summarized for the NL Bioregion (NAFO Divisions 2GHJ3KLNOPs), which includes the southern portion of the NSAR (NAFO Divisions 2GH), and the entirety of the SSAR (NAFO Divisions 2J3KLNO). Generally, there is less ecosystem information available for the NSAR, especially for the portion north of the NL Bioregion.

The ocean climate in the NL Bioregion has shown decadal-scale cold and warm phases. The warm phase that started around 2020 continued in 2025. Recent phytoplankton blooms have been early. Total zooplankton biomass has been improving since the lows in the early mid- 2010s.

Newfoundland and Labrador ecosystems collapsed in the late 1980s and early 1990s and was associated with extreme cold ocean conditions and ecosystem overfishing. Declines in biomass of groundfish were not compensated by increases in shellfish, with total biomass remaining below pre-collapse levels. Some rebuilding was observed between the mid-2000s and early 2010s, after which declines occurred. While these ecosystems continue experiencing overall lower productivity conditions relative to the pre-collapse period related to bottom-up processes (e.g., food limitation), improvements in total biomass have been observed since 2020 after the lows in the mid-2010s. These increases are driven by groundfish and not shellfish.

Shrimp remains an important forage species, especially in the northern areas, but its dominance in fish diets has decreased in the NL Bioregion. Key predatory fishes (Greenland Halibut, Atlantic Cod, and redfish) have increased in both assessment regions in the 2020’s. Although the cod levels observed in the NSAR remain low in comparison with the SSAR, and with other predators in the NSAR, its levels have increased and reached a time-series high in 2025.

Both fishing and fish predation have been potential drivers of the stock in Div. 2H, while fish predation has been the stronger potential stock driver in Div. 2J3KL. The fish predation mortality index on shrimp remains at a higher level in 2J3KL, and has increased to this level in Div. 2H in

recent years. This is consistent with the ecosystem in Div. 2H shifting to a finfish-dominated community structure.

Ocean climate controls productivity at the ecosystem level in the NL Bioregion, and where the ecosystem configuration associated with a warm ocean climate does not favor Northern Shrimp. The biomass of Shrimp in Div. 2J3KL has declined to levels similar or lower to the ones estimated for the 1980s before the ecosystem collapse.

PROCEDURE FOR INTERIM-YEAR UPDATES

During interim-year updates, assessment model (SISCALS) outputs and overall stock status are not updated. Stock status for the North Stock Assessment Region (NSAR) and the South Stock Assessment Region (SSAR) are only updated when the stock assessment model is run; it is not possible to determine stock status during interim-year stock updates. However, FB and SSB survey indices, estimated using spatiotemporal models, are updated for use in the harvest decision rules that are being tested via MSE. In addition, other biological indicators, ecosystem indices, fishery catch and TAC information, and exploitation rate indices are also updated.

OTHER MANAGEMENT QUESTIONS

Northern Shrimp continues to be managed at the SFA scale, with management recommendations informed by SSB and FB survey indices estimated at the stock assessment region level and applied within harvest decision rules to derive a stock assessment region harvest level (Johnson et al., In prep.²). The stock assessment region harvest level is then divided among management areas (i.e., the SFAs) using calculations informed by the spatial distribution of the FB survey index within each stock assessment region. More specifically, the FB spatiotemporal models were used to predict FB survey estimates at the scale of each management area across the time-series, expressed as proportions of the overall biomass within each stock assessment region (more details in Johnson et al., In prep.¹).

Caution is needed when interpreting single-year spatial patterns (Table 2 and Table 3). Shrimp can be transported great distances in a relatively short period of time in and out of management areas. This can cause fluctuations in biomass observed within and among management areas. It is one of the reasons that performing assessments at the SFA level is no longer how Northern Shrimp are assessed. Relative distribution among SFAs needs to be seen as a tool for informing spatial allocations of harvest level at the management area scale.

²Johnson, S.D.N., Cox, S.P., Baker, K.D., Le Corre, N., Fulton, S., Coffey, W., and Walkusz, W. In prep. Evaluating candidate harvest decision rules for Canada's Northern Shrimp (*Pandalus borealis*) fishery off Newfoundland, Labrador, and Baffin Island.. DFO Can. Sci. Advis. Sec. Res. Doc.

Table 2. Annual SSB and FB indices for NSAR ($\times 1,000$ t), and the annual relative biomass (%) representing the distribution of FB among management areas based on FB index spatial pattern.

Year	Biomass Indices		Relative biomass (%) based on FB distribution			
	SSB index (x 1,000 t)	FB index (x 1,000 t)	EAZ	WAZ	SFA 4	SFA 5N
2016	119.3	241.2	33.6	10.4	34.4	21.6
2017	92.0	162.9	25.5	7.6	41.1	25.8
2018	102.7	170.7	25.8	11.2	30.1	32.9
2019	93.8	154.1	35.7	21.0	26.8	16.5
2020	93.2	160.0	32.1	18.7	28.9	20.3
2021	131.2	203.0	21.0	12.6	45.7	20.6
2022	123.1	208.0	17.6	19.5	38.0	24.9
2023	157.5	236.7	26.4	16.1	32.5	24.9
2024	142.9	186.3	29.0	12.8	33.2	25.0
2025	150.0	231.0	19.3	28.8	37.6	14.3

Table 3. Annual SSB and FB indices for SSAR ($\times 1,000$ t), and the annual relative biomass (%) representing the distribution of FB among management areas based on FB index spatial pattern.

Year	Biomass Indices		Relative biomass (%) based on FB distribution				
	SSB index (x 1,000 t)	FB index (x 1,000 t)	SFA 5S	SFA 6	NAFO3L	NAFO3N	NAFO3O
2016	95.7	175.9	18.3	70.1	11.6	0	0
2017	84.4	140.8	24.8	70.1	5.1	0	0
2018	80.4	117.6	12.9	79.1	7.9	0	0
2019	69.9	123.9	15.5	74.5	9.9	0	0
2020	91.7	146.2	7.8	83.9	8.3	0	0
2021	87.6	128.0	8.2	74.1	17.7	0.1	0
2022	83.2	153.5	9.1	75.3	15.5	0.1	0
2023	76.9	112.1	9.8	82.5	7.5	0.1	0
2024	55.5	90.9	4.1	83.8	12.0	0.1	0
2025	73.4	114.5	5.7	87.7	6.6	0.1	0

SOURCES OF UNCERTAINTY

Interim-year updates involve several classes of uncertainty. For Northern Shrimp, the most relevant ones include:

- Observation uncertainty or measurement error associated with direct data inputs to the assessment such as catch, survey indices, length composition, and biological characteristics.
- The relative catchabilities for the four research vessels (Cape Ballard, Aqviq, Kinguk, and Katsheshuk II) that have been used throughout the time-series of the NSRF-DFO collaborative survey and the relative catchability between the vessels is unknown.
- The variability of Northern Shrimp's vertical distribution across space and time is unclear. Biomass estimates rely on bottom trawl surveys, which may miss shrimp which are higher in the water column, influencing observed fluctuations rather than population size.
- Environmental data in the NSAR lacks predation mortality indices, comprehensive physical ocean data, and pelagic production data, which are needed to include impacts of environmental conditions and predation in the NSAR and adopt an ecosystem approach to fisheries management.
- The assessment results assume consistent spatial patterns in fishery removals. Historically, allocations in the NSAR and SSAR have been made at the management-area level, which is

smaller than the stock assessment region scale. This approach has likely helped limit localized concentrations of fishing effort by distributing fishing activity across the management areas. It is unclear how changes in the distribution of fishing effort could impact the broader population.

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Aaron Adamack	DFO NL - Science
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SOURCES OF INFORMATION

- Baker, K.D., Le Corre, N., Bourret, A., Parent, G., Fulton, S., Duprey, N.M.T., and Cox, S. 2025. [Spatial stock structure of northern shrimp *Pandalus borealis* Krøyer, 1838 \(Decapoda: Caridea: Pandalidae\) in Canada's Northwest Atlantic](#). J. Crustacean Biol. 45(2).
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