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Science Response 2025/015

QUEBEC NORTH SHORE (4S) HERRING (*CLUPEA HARENGUS*) STOCKS UPDATE IN 2024

CONTEXT

The Fisheries Management Branch of Fisheries and Oceans Canada (DFO) initially requested a full stock assessment of the herring (*Clupea harengus*) stocks of Quebec's North Shore (Integrated Fisheries Management Plan). However, this assessment was canceled to allow for a revision of the assessment framework. To determine whether recent changes in stock status require adjustments to the management plan for the 2025 and 2026 fishing seasons, an update of main indicators for the status of the two spawning herring stocks in Quebec's North Shore was conducted in 2024.

This Science Response is from the February 28, 2025 regional peer review on the Quebec North Shore (4S) Herring (*Clupea harengus*) Stocks Update in 2024.

SCIENCE ADVICE

Status

- In the absence of reference points, it is not possible to determine the status of the Quebec North Shore herring stocks under the precautionary approach framework.

Trends

- Strong cohorts, observed in spring spawners in 2017 and fall spawners in 2016, entered the fishery in 2019 and remained dominant in commercial catches and research surveys until 2024.

- New recruitment events occurred in 2019 for fall spawners and in 2020 for spring spawners.

- Since 2022, the total biomass of the spring spawning stock, as estimated during the summer acoustic survey in 4Sw, has increased, while that of the fall spawning stock has remained relatively stable.

- The proportion of spring spawners in commercial catches and research surveys has increased since 2019.

Ecosystem and Climate Change Considerations

- Rising water temperatures and changes in zooplankton dynamics in the Gulf of St. Lawrence could negatively affect herring condition and recruitment, but the impact on stock productivity remains uncertain.

Stock Advice

- Catch-at-age from the commercial fishery and research surveys follow the progression of the 2016 fall spawning stock and the 2017 spring spawning stock cohorts until 2024, suggesting low overall mortality.

- After a period of low stock status in the mid-2000s and during the 2010s, the spring spawning stock is showing signs of improvement since 2019.

- Maintaining the current TAC of 4,500 t should not pose a significant short-term risk to the two herring spawning stocks off the North Shore of Quebec.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

2011 (Grégoire and Beaulieu 2011)

Assessment Type

Interim Year Update

Most Recent Assessment Date

1. Last Full Assessment: 2021 (DFO 2021)
2. Last Interim Year Update: 2023 (DFO 2023)

Assessment Approach

1. Broad category: index-based (trends in empirical indices only)
2. Specific category: index-based (including fishery-dependent and fishery-independent indices)

Stock Structure Assumption

The structure of herring stocks is complex, and interactions between local and neighboring populations in Quebec's North Shore remain poorly understood. Differences observed in the age composition of herring stocks in the eastern and western parts of division 4S suggest that these two regions may contain distinct populations (Trudeau and McQuinn 1986). Furthermore, an acoustic telemetry study conducted in 2021-2022 in the northeastern Gulf of St. Lawrence revealed extensive movement and mixing between herring stocks in unit area 4Sw and division 4R (west coast of Newfoundland). These findings challenge the current distinction between these stocks and suggest that it may be more appropriate to consider them as a single unit for future stock assessments (Émond and Nilo 2025). Herring populations in Quebec's North Shore consist of two spawning components: spring spawners, which typically spawn in April-May, and fall spawners, which spawn in August-September. These two groups are genetically distinct and are assessed separately.

Reference Points

- Limit Reference Point (LRP): N/A
- Upper Stock Reference (USR): N/A

- Removal Reference (RR): N/A

- Target Reference Point (TRP): N/A

Data

- Commercial fishery landing data (1985-2024)

- Age composition of commercial catches (1985-2024)

- Recruitment index estimated from the age composition of commercial catches (1985-2021)

- Total biomass index and age-specific abundances from the summer acoustic survey in unit area 4Sw (2019-2024)

- Total biomass index and age-specific abundances from the fall acoustic survey in unit area 4Sw (2009-2022)

Data changes: The improvement and standardization of analytical methods for the summer acoustic survey (Rousseau and Émond 2024) and fall acoustic survey (Beaudry-Sylvestre et al. 2024) resulted in a revision of the biomass index.

ASSESSMENT

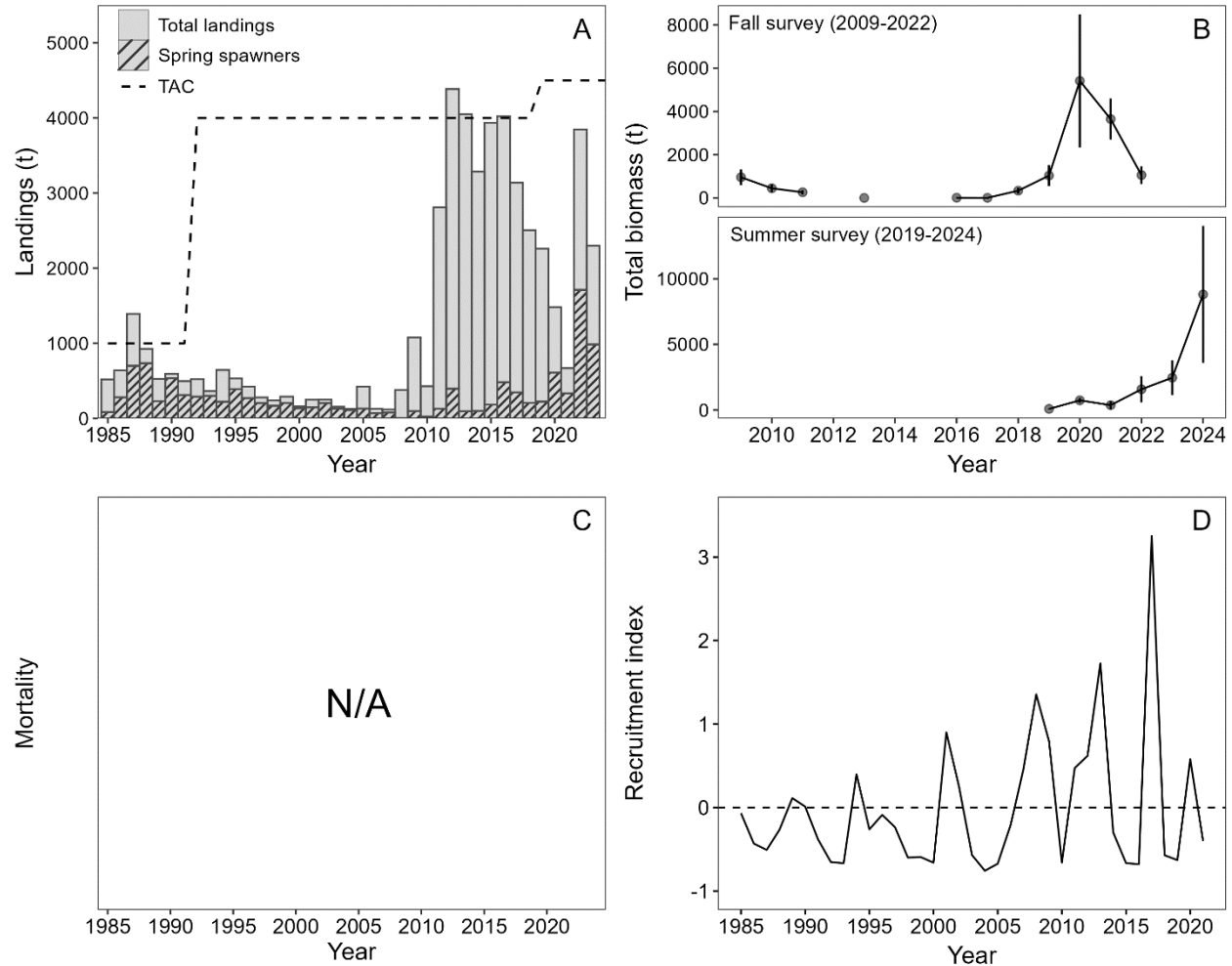## Status and Trends of the Spring Spawning Stock

Figure 1. Status of the spring spawning stock. (A) Total catches, estimated catches of spring spawners, and total allowable catch (TAC), (B) Total biomass indices (with standard errors) from summer and fall acoustic surveys, (C) Mortality data not available (N/A), (D) Recruitment index (solid line) and time series average (dotted line).

Landings

The proportion of spring-spawning herring in landings fluctuated greatly between 1985 and 2007, ranging from 16.5% to 90.4% (Figure 1A). Between 2008 and 2019, this proportion declined rapidly, averaging only 7%. Since 2020, an increase has been observed, with spring spawners accounting for nearly 50% of landings.

In 2023, spring-spawning herring catches were largely dominated by the 2017 cohort, which represented 83.3% of the individuals caught. In 2024, this cohort remained the most abundant in landings (36.4%), followed by the more recent 2020 cohort (28.2%). The 2017 cohort has notably been dominant in commercial catches of spring spawners since 2019.

Total Biomass

Since 2022, the total biomass of spring-spawning herring estimated in the summer survey has been increasing, reaching 8,807 t (± 5,228 t) in 2024 (Figure 1B). Since the survey only covers a small portion of the stock's distribution area, this value is considered a minimum estimate of the amount of fish available at the time of the survey.

The proportion of spring spawners observed in the fall acoustic survey has significantly increased, rising from an average of 7.7% between 2009 and 2018 to 45.5% between 2019 and 2022. In the summer survey, this proportion is lower, with an average of 28.0% of the estimated biomass between 2019 and 2024.

In 2023, biomass estimates of spring spawners in the summer acoustic survey were predominantly composed of fish from the 2017 cohort (78.4%). In 2024, the 2017 cohort remained dominant (50.6%), but the more recent 2020 cohort was also well represented (32.6%). As with commercial fishery catches, the dominance of the 2017 cohort has been observed in acoustic surveys since 2019.

Recruitment

The recruitment index, defined as the proportion of ages 3 to 5 in commercial catches lagged by 3 years to match with the year of birth, provides an approximate estimate of when recruitment peaks occurred. Between 1985 and 2024, strong cohorts appeared regularly at intervals of 5 to 7 years (Figure 1D). Recent recruitment events occurred in 2017 and 2020, with the 2017 cohort notably standing out due to its significantly larger magnitude compared to the others.

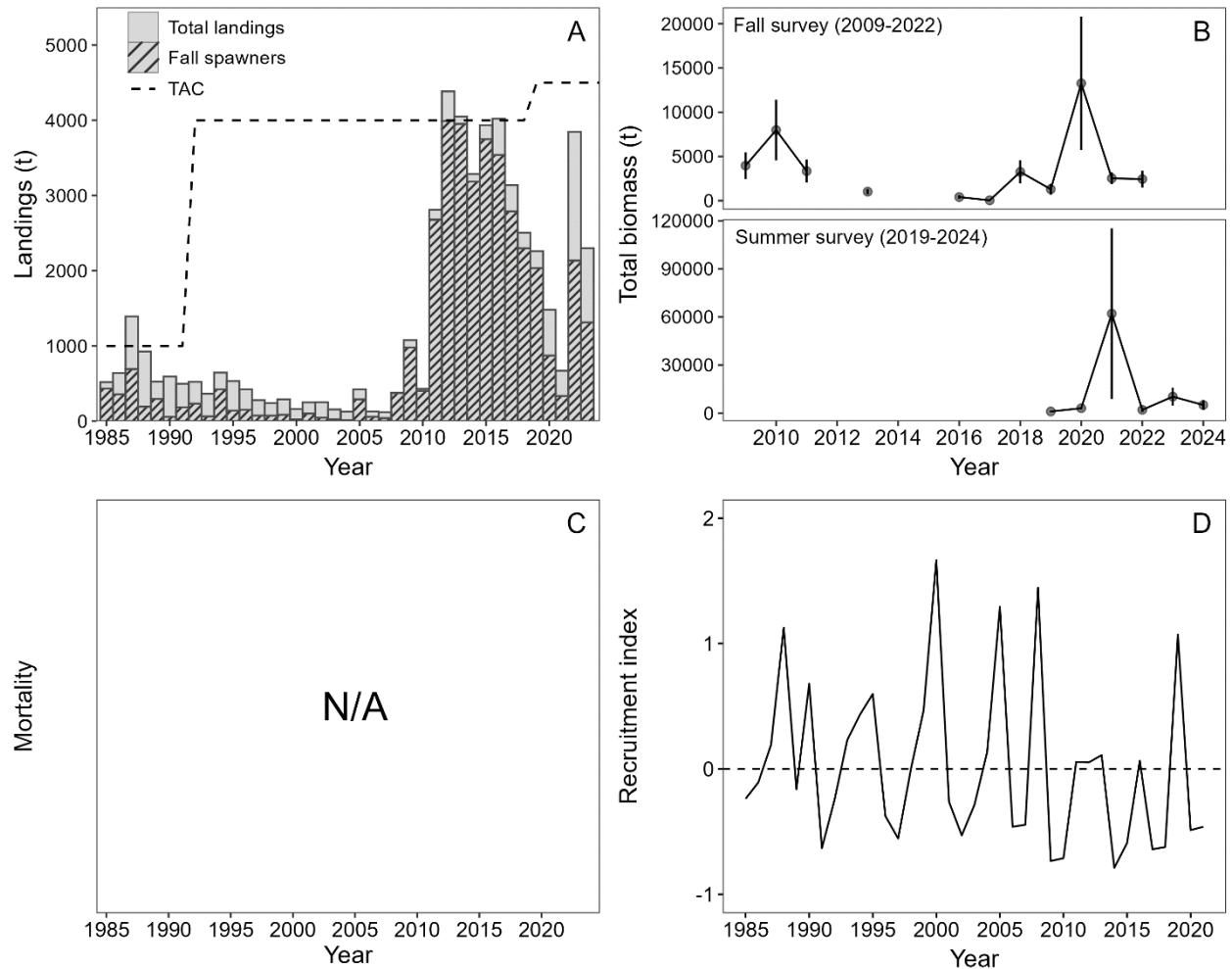## Status and Trends of the Fall Spawning Stock

Figure 2. Status of the fall spawning stock. (A) Total catches, estimated catches of fall spawners, and total allowable catch (TAC), (B) Total biomass indices (with standard errors) from summer and fall acoustic surveys, (C) Mortality data not available (N/A), (D) Recruitment index (solid line) and time series average (dotted line).

Landings

Between 2008 and 2019, fall spawners dominated commercial catches, accounting for an average of 93% of total landings (Figure 2A). Starting in 2020, this proportion declined, with spring and fall spawners now being represented in nearly equal proportions in landings. In 2023 and 2024, fall spawners made up 57.1% and 51.7% of landings, respectively.

In 2023 and 2024, landings of fall spawners were primarily composed of individuals from the 2016 (15.6-36.2%) and 2019 (21.3-42.7%) cohorts. In 2024, a notable proportion of individuals from the 2017 cohort (18.8%) was also observed. While the 2016 cohort dominated catches in 2023, the 2019 cohort was the most abundant in 2024.

Total biomass

Except for 2021, when the estimated biomass of fall spawners reached an exceptionally high level (62,066 t ± 53,243 t), biomass observed in the summer acoustic survey fluctuated between 2019 and 2024 without a clear trend, ranging from 1,048 t to 10,305 t (Figure 2B).

In 2023, biomass estimates for fall spawners were largely dominated by the 2016 cohort, which accounted for 66.4% of the total. In 2024, while the 2016 cohort remained predominant (30.6%), the more recent 2019 cohort showed a notable increase, accounting for 38.7% of the biomass. Since 2019, the 2016 cohort has consistently remained abundant in both summer and fall acoustic surveys.

Recruitment

Like the spring spawning stock, the fall spawning stock is characterized by the periodic occurrence of dominant cohorts (Figure 2D). Recent recruitments occurred in 2016 and 2019, with the 2019 cohort standing out for its relatively higher strength compared to the 2016 cohort.

History of Landings and TAC

Since the early 1970s, the commercial herring fishery on Quebec's North Shore has been managed under a preventive TAC due to insufficient data on stock abundance, structure, and dynamics needed to establish a formal TAC. Initially set at 1,000 t until 1991, the TAC was increased to 4,000 t in 1992. In 2019, it was raised to 4,500 t, while maintaining a 4,000 t limit in unit area 4Sw to better distribute fishing effort across division 4S. The TAC applies to total catches without distinguishing between spawning groups. The main fishing gears used are purse seine, trap, and gillnet. There is no gear-specific TAC allocation, and the fishery operates as a competitive fishery. A minimum legal catch size of 26.5 cm is in effect, except for gillnet catches, which are exempt.

Commercial herring landings on Quebec's North Shore have increased significantly since 2011 (Table 1). Since 2008, the majority of catches have come almost exclusively from unit area 4Sw in 4S-east. From 1985 to 2007, most landings were from the gillnet fishery. However, between 2008 and 2010, as fishing effort shifted eastward in division 4S, the purse seine fishery gradually replaced the gillnet fishery and now accounts for more than 98% of catches. In 2023 and 2024, herring landings on Quebec's North Shore, including both spawning groups, reached 2,300 t and 2,996 t, respectively, representing 51% and 67% of the TAC.

Table 1. Landings by year and by sector (4S-east: 4Ss, 4Sv, 4Sw, and 4Sx; 4S-west: 4Si, 4Sy, and 4Sz), with total landings and the total allowable catch (TAC) indicated in metric tons.

Year	4S-west	4S-east	Total	TAC
Mean 1985-1991	366	362	364	1,000
Mean 1992-1998	301	129	215	4,000
Mean 1999-2005	102	135	119	4,000
2006	70	58	129	4,000
2007	51	69	120	4,000
2008	5	375	380	4,000
2009	3	1,075	1,078	4,000
2010	5	425	430	4,000
2011	6	2,805	2,810	4,000
2012	2	4,383	4,385	4,000
2013	2	4,047	4,049	4,000
2014	1	3,285	3,286	4,000
2015	0	3,934	3,934	4,000
2016	1	4,021	4,022	4,000
2017	0	3,137	3,137	4,000
2018	0	2,505	2,506	4,000
2019	0	2,259	2,260	4,500
2020	0	1,482	1,482	4,500
2021	2	668	670	4,500
2022	0	3,847	3,847	4,500
2023	3	2,297	2,300	4,500
2024	0	2,996	2,996	4,500

Ecosystem and Climate Change Considerations

The increase in water temperature in the Gulf of St. Lawrence has led to changes in the composition and abundance of zooplankton species in recent years. One of the dominant species, *Calanus finmarchicus*, has declined significantly and has been partly replaced by smaller species such as *Pseudocalanus* spp. These changes could influence the productivity of herring stocks, whose primary food source is zooplankton. However, the extent of this impact on stock productivity remains uncertain.

The decline of large copepods such as *C. finmarchicus* in favor of smaller species like *Pseudocalanus* spp. may be contributing to a reduction in the weight-at-age and condition index of herring (MPO 2021; Émond et al. 2024). Indeed, *Pseudocalanus*, which is less energy-rich than larger calanoids, may limit the net energy gain of herring during years when it dominates the zooplankton community.

Changes in zooplankton dynamics may also influence herring recruitment. The abundance of cold-water copepods with high energy content (e.g., *C. finmarchicus* and *C. hyperboreus*) is likely to favor the recruitment of spring spawners, while warmer waters and higher zooplankton abundance later in the fall are expected to benefit fall spawners.

SOURCES OF UNCERTAINTY

Acoustic surveys are the primary source of independent fishery data used to assess the status of herring stocks on Quebec's North Shore. However, changes in survey catchability over time, variations in survey coverage and sampling effort, as well as the substantial movement of herring between the 4Sw and 4R areas, introduce considerable uncertainty into the time series. This limits our ability to compare results across years and assess long-term biomass trends.

The biological sampling used to separate acoustic biomass between spring and fall spawners and convert it into age-specific abundances has been conducted with different gears over the years. Some of the samples were obtained from the commercial fishery or other DFO research surveys. Using commercial fishery samples compromises the statistical independence of acoustic samples from the fishery data and introduces additional uncertainty into the survey results.

The assessment of herring stocks in division 4S relies in part on samples obtained from the annual commercial fishery. Since 2007, this fishery has been concentrated almost exclusively in the eastern area of 4S, making the biological sampling unrepresentative of the entire division. Moreover, the low number of spring spawners in commercial samples from 2008 to 2018 has prevented a reliable estimation of the age composition of these catches, thus hindering the tracking of spring spawner cohorts during this period.

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SOURCES OF INFORMATION

Beaudry-Sylvestre, M., Rousseau, S., and Émond, K. 2024. Acoustic Survey Index Revision and Standardization for the Atlantic Herring (*Clupea harengus*) 2009-2021 Fall Series in NAFO Divisions 4RSw. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/026. iv + 32 p.

DFO. 2021. Assessment of the Quebec North Shore (Division 4S) herring stocks in 2020. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/037.

DFO. 2023. Update of stock status indicators for Quebec North Shore (Division 4S) herring in 2022. DFO Can. Sci. Advis. Sec. Sci. Resp. 2023/032.

Émond, K., Dionne, H., Beaudry-Sylvestre, M., Paquet, F., Rousseau, S., Lehoux, C., and Nilo, P. 2024. Assessment of the West Coast of Newfoundland (NAFO Division 4R) Atlantic Herring (*Clupea harengus*) Stocks in 2021. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/004. xi + 93 p.

Émond, K., and Nilo, P. 2025. Preliminary Results from an Acoustic Telemetry Study on Atlantic Herring in the Northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2025/029. iv + 24 p.

Grégoire, F., and Beaulieu, J.-L. 2011. Atlantic herring (*Clupea harengus harengus* L.) on the Quebec North Shore (NAFO Division 4S) in 2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/019. vi + 102 pp.

Rousseau, S., and Émond, K. 2024. Design and Analytical Methodology for the Atlantic Herring (*Clupea harengus*) Summer Acoustic Survey in NAFO Divisions 4RSw (2019-2023). DFO Can. Sci. Advis. Sec. Res. Doc. 2024/061. iv + 30 p.

Trudeau, C., and McQuinn, I. H. 1986. Fishery and biological characteristics of the 4S herring stocks in 1985. CAFSAC Res. Doc. 86/77.