



# NORTHEASTERN GULF OF ST. LAWRENCE (4RSW) ATLANTIC HERRING (*CLUPEA HARENGUS*) STOCK ASSESSMENT IN 2024

## CONTEXT

The Fishery Management branch of Fisheries and Oceans Canada (DFO) requested scientific advice on the status of the 4RSw spring- and fall-spawning herring stocks to inform decisions for the 2026-2027 and 2027-2028 management cycles. During a CSAS meeting held in April 2023, it was concluded that 4Sw should be assessed jointly with 4R, as evidence indicates that fish from these two regions belong to a single biological unit. The spring- and fall-spawning components, however, continue to be assessed separately. In December 2025, a second CSAS assessment framework review meeting was conducted, during which a new assessment model and limit reference point (LRP) were approved.

This Fisheries Science Advisory Report is from the regional peer review of January 28, 2026 on the Northeastern Gulf of St. Lawrence (4RSw) Atlantic Herring (*Clupea harengus*) Stock Assessment in 2024. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

## SCIENCE ADVICE

### Status

- The 2024 spawning stock biomass (SSB) of spring spawners is above the Limit Reference Point (LRP) with a very high probability (>99%), while the SSB of fall spawners is above the LRP with a high probability (84%).

### Trends

- SSB of spring spawners has increased steadily since 2020, following a period of historically low biomass throughout the 2010s.
- SSB of fall spawners increased from the 2022 historical low.
- Fishing mortality of spring spawners remained generally low to moderate (0.1-0.4) throughout most of the time series.
- Fishing mortality of fall spawners remained below 0.2 throughout most of the time series.
- Recruitment of spring spawners fluctuated without trend, with the most recent strong cohort originating in 2017.
- Recruitment of fall spawners fluctuated without trend, with strong year-classes becoming more frequent since the early 2000s.

## Ecosystem and Climate Change Considerations

- Shifts in migration timing and spatial distribution, reducing availability of herring to the survey, were linked to water temperature and zooplankton abundance. These shifts were incorporated into the assessment by modelling survey catchability as time-varying.
- Declines in fall and spring spawner weight-at-age and changes in maturation are likely driven in part by temperature increases. The contribution of these changes to the SSB were incorporated into the assessment.
- While the technical impact of these changes is accounted for in the assessment model, possible effects of these changes on total stock productivity cannot be quantified at the present.

## Stock Advice

- Available evidence (SSB relative to the LRP, exploitation rates, age compositions and recruitment) indicates that harvests within the range of 2015-2024 levels (4,135 to 19,933 t in 4R and 659 to 4,021 t in 4Sw) would be unlikely to cause the 4RSw spring- and fall-spawning stocks to decline to their LRPs by 2028.

## BASIS FOR ASSESSMENT

### Assessment Details

The stocks are assessed with a statistical catch-at-age model using a state-space framework (Woods Hole Assessment Model [WHAM], Stock and Miller 2021), reviewed and accepted at the assessment framework review meeting held on December 3-4, 2025.

The assessment relies on data through 2024 rather than 2025, as would typically be expected for science advice covering the 2026-2027 fishing seasons. This one-year offset reflects the late timing of the herring fishery, which often extends into December, and the requirement to provide advice early in winter (January), which precludes complete processing of data from the most recent year.

### Year Assessment Approach was Approved

2025 (Émond and Van Beveren in prep.<sup>1</sup>)

### Assessment Type

Full Assessment

### Most Recent Assessment Date

1. Last Full Assessment: 2022 (DFO 2022)
2. Last Interim-Year Update: 2024 (DFO 2024)

### Stock Assessment Approach

1. Broad category: single stock assessment model
2. Specific category: state-space age-structured model

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<sup>1</sup> Émond, K., and Van Beveren, E. In preparation. Framework review for Atlantic herring (*Clupea harengus*) in NAFO divisions 4RSw: Population Model and Limit Reference Point.

### Stock Structure Assumption

Acoustic tagging data and spatio-temporal patterns in commercial fishery landings and acoustic survey indices (DFO 2021; Santo et al. 2025) indicate extensive seasonal movements of herring between divisions 4Sw and 4R, primarily following a north-south migration pattern (Émond and Nilo 2025). These findings, which are consistent with an earlier study (McQuinn and Lefebvre 1995), provide strong evidence that herring in divisions 4R and 4Sw comprise a single biological unit and should therefore be assessed as a single stock.

Within division 4RSw, the herring population is composed of two spawning components: spring spawners, which typically spawn in April-May, and fall spawners, which spawn in August-September. These components can be genetically differentiated and are therefore assessed separately.

### Reference Points

- Limit Reference Point (LRP):  $B_{loss}$
- Upper Stock Reference (USR): N/A
- Removal Reference (RR): N/A
- Target Reference Point (TRP): N/A

### Data

- Commercial fishery landing data (1966-2024)
- Age and spawning component composition of commercial catches (1966-2024)
- Total biomass indices, and age and spawning component composition data from the summer acoustic survey in divisions 4RSw (2019-2024)
- Total biomass indices, and age and spawning component composition data from the fall acoustic survey in division 4R (1991-2022)
- Biological data by spawning component: maturity- and weight-at-age (1966-2024)

## ASSESSMENT

## Stock Status and Trends for Spring Spawners

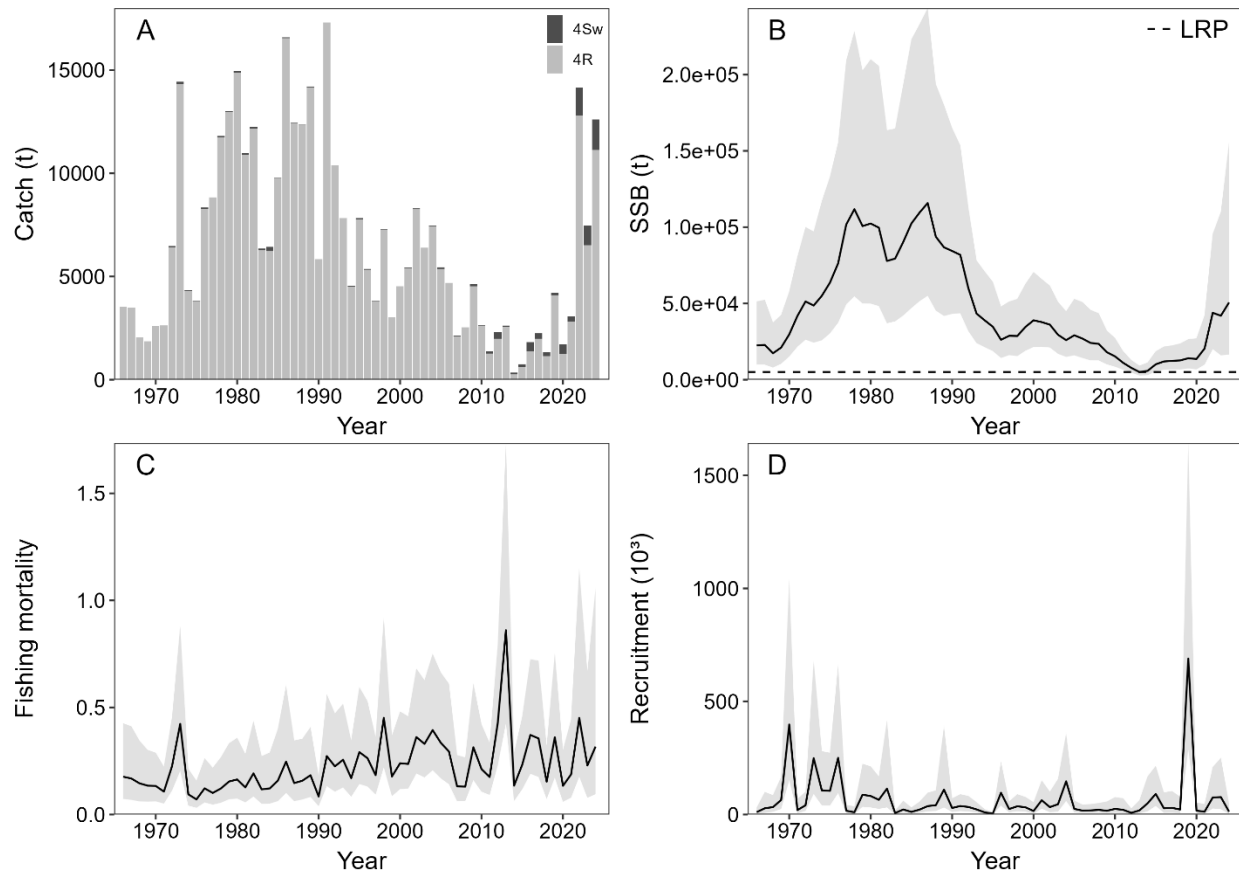


Figure 1. Status of the spring-spawning herring stock. (A) Total catch (t) in 4R and 4Sw, (B) May SSB (black line) with 95% confidence intervals (gray) in relation to the LRP (dashed horizontal line), (C) Fully-selected fishing mortality (black line) with 95% confidence intervals (gray), (D) Recruitment (thousands of age-2 fish, black line) with 95% confidence intervals (gray).

### Spawning Stock Biomass (SSB)

Following the historical low in 2013, SSB has been increasing overall, with a marked upward trend from 2020. SSB was estimated at 50,608 t in 2024 (95% CI: 16,501-155,214 t), well above the LRP (5,017 t; Figure 1B).

### Fishing Mortality (F)

Fully-selected  $F$  remained low to moderate over most of the time series (Figure 1C).  $F$  was generally below 0.2 during the 1970s and 1980s, with the exception of a peak of 0.42 in 1973.  $F$  increased slightly through the 1990s and 2000s, and reached a maximum of 0.86 in 2013 (95% CI: 0.43-1.74). Since then,  $F$  has fluctuated between 0.13 and 0.45.

$F$  estimates for this stock are generally lower than those reported for other herring stocks and are within or below  $F_{MSY}$  benchmarks reported for comparable small pelagic stocks (Sparholt et al. 2021; Northeast Fisheries Science Center 2025).

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**Recruitment**

Recruitment (age-2) was highly variable over time, punctuated by occasional strong year-classes (Figure 1D). The most recent notable event occurred in 2017 and represents the strongest recruitment in the entire time series. This exceptionally high 2017 cohort underlies the ongoing increase in SSB.

**Current Status**

The 2024 SSB is approximately 10 times higher than the LRP, placing the 4RSw spring-spawning stock at a very high probability (>99%) of being above the LRP. Because an Upper Stock Reference (USR) has not yet been defined, stock status is assessed solely relative to the LRP.

**Stock Status and Trends for Fall Spawners**

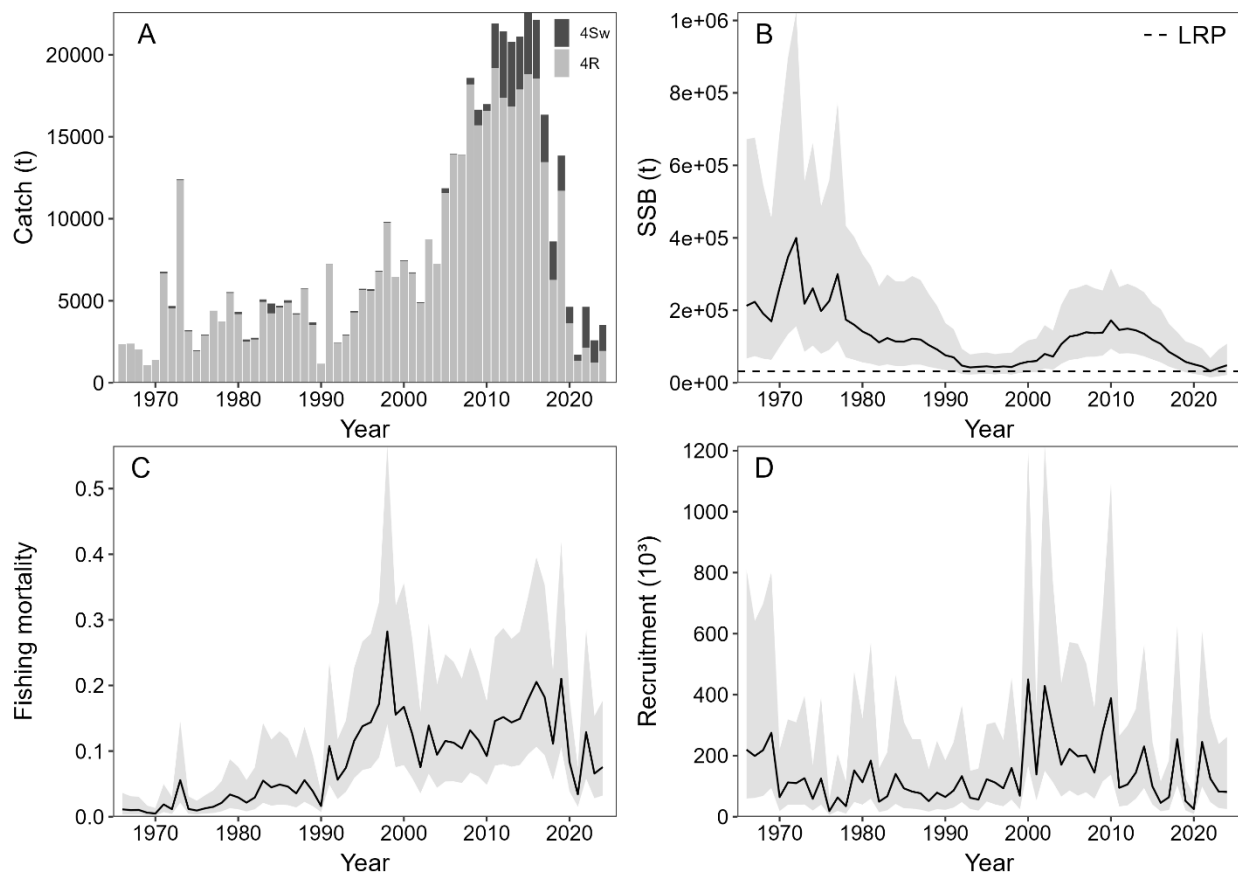


Figure 2. Status of the fall-spawning herring stock. (A) Total catch (t) in 4R and 4Sw, (B) August SSB (black line) with 95% confidence intervals (gray) in relation to the LRP (dashed horizontal line), (C) Fully-selected fishing Mortality (black line) with 95% confidence intervals (gray), (D) Recruitment (thousands of age-2 fish, black line) with 95% confidence intervals (gray).

**Spawning Stock Biomass (SSB)**

SSB approached the LRP during the 1990s and again in 2022 (Figure 2B). In 2023 and 2024, SSB increased, reaching 48,353 t in 2024 (95% CI: 21,736-107,567 t), equivalent to 1.5 times the LRP (32,007 t).

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**Fishing Mortality (F)**

Fully-selected F generally remained below 0.2 throughout most of the time series (Figure 2C). F increased gradually from the late 1960s to a peak in 1998 (0.28; 95% CI: 0.14-0.56), then declined through the 2000s and stabilized around the time-series average (Figure 2C). In 2022-2024, F remained relatively low (~0.07-0.13), comparable to levels seen in the early 1990s and early 2000s.

F estimates for this stock are generally lower than those reported for other herring stocks and are within or below  $F_{MSY}$  benchmarks reported for comparable small pelagic stocks (Sparholt et al. 2021; Northeast Fisheries Science Center 2025).

**Recruitment**

Recruitment (age-2) was highly variable over the time series, with strong year-classes occurring more frequently from the early 2000s onward (Figure 2D). The most recent strong recruitment event occurred in 2019 but has not yet translated into a notable increase in SSB.

**Current Status**

The 2024 SSB places the 4RSw fall-spawning stock above the LRP at a high probability (84%). In the absence of a defined USR, stock status is currently assessed solely relative to the LRP.

**History of Landings and TAC**

Herring stocks in NAFO division 4R and subdivision 4Sw are currently managed separately, with 4Sw managed as part of division 4S. The TAC for division 4R has been set at 20,000 t annually since 2003. In division 4S, the TAC was initially set at 1,000 t until 1991, increased to 4,000 t in 1992, and further raised to 4,500 t in 2019, while maintaining a 4,000 t limit in 4Sw to promote a more even distribution of fishing effort across division 4S. These TACs apply to total catches and do not distinguish between spawning components.

Preliminary landings in division 4R were estimated at 7,749 t in 2023 and 13,081 t in 2024, while landings in subdivision 4Sw were 2,297 t and 3,059 t, respectively (Table 1). Combined landings across the 4RSw area therefore totaled 10,046 t in 2023 and 16,140 t in 2024. Spring spawners accounted for approximately 75% of the landings in both years.

*Table 1. Summary of landings and TACs (tonnes) for NAFO Divisions 4R and 4Sw, including the 4RSw totals, for 1966-2024.*

Year	NAFO Division			TAC	
	4R	4Sw	4RSw (total)	4R	4Sw
Mean 1966-1976	8,547	108	8,615	No TAC	1,000
Mean 1977-1991	16,522	172	16,694	10,000-35,000	1,000
Mean 1992-2014	16,304	773	17,077	13,000-35,000	4,000
2015	19,419	3,932	23,352	20,000	4,000
2016	19,933	4,021	23,953	20,000	4,000
2017	15,438	3,136	18,574	20,000	4,000
2018	7,419	2,505	9,924	20,000	4,000
2019	15,806	2,259	18,065	20,000	4,000
2020	4,864	1,482	6,346	20,000	4,000
2021	4,135	659	4,795	20,000	4,000
2022	14,926	3,847	18,773	20,000	4,000
2023	7,749	2,297	10,046	20,000	4,000
2024	13,081	3,059	16,140	20,000	4,000

### **Ecosystem and Climate Change Considerations**

Recruitment was modeled as a time-varying process without explicitly linking it to environmental variables. Recruitment is a key driver of small pelagic fish dynamics and is strongly influenced by environmental conditions. Spawning success, for instance, is temperature-dependent, particularly during egg development (Burbank et al. 2023). Zooplankton community shifts may also affect herring recruitment: abundance of cold water copepods likely enhance spring spawner recruitment, whereas warmer conditions and higher late-season zooplankton abundance may favor fall spawners (Brosset et al. 2019).

Natural mortality was assumed constant, largely due to limited information and, to a lesser extent, technical constraints. Herring are however a key prey species for many fishes (Ouellette-Plante et al. 2020), marine mammals (Irani et al. 2025; Tessier-Larivière et al. 2026), and seabirds (Benoît and Rail 2016).

Somatic growth, expressed as weight-at-age, has declined over time. A comparative analysis of length-at-age for herring stocks across Atlantic Canada showed that this decline is widespread and associated with rising sea surface temperatures, suggesting that growth is unlikely to return to previous levels in the near future (Beaudry-Sylvestre et al. 2024). Maturation variability was also incorporated into the assessment, but changes were minimal, indicating that ecosystem effects on this process are unlikely to meaningfully affect stock resilience in the short term.

Changes in herring distribution and body condition may influence several productivity processes. Recent work on 4RSw herring links distribution shifts to thermal conditions and food availability, suggesting that environmental change may have altered migration timing (Rioux et al. in prep.<sup>2</sup>). Ecosystem-driven shifts in migration timing have affected observed biomass and were incorporated into the assessment model. However, the magnitude and direction of these effects on stock productivity remain uncertain. Body condition of both components has declined, but its influence on processes such as recruitment and natural mortality is still unclear.

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<sup>2</sup> Rioux, È., Émond, K., Lehoux, C., and Van Beveren, E. In preparation. Potential mechanisms behind changing survey catchability in 4RSw Atlantic herring.

## Stock Advice

Projections for the spring- and fall-spawning stocks are not yet available and will be developed for the next assessment in 2028. The approach used in previous assessments to providing science advice is used here as a transitional step.

Although 4R and 4Sw regions are now assessed as a single biological stock for both spawning components, they continue to be managed separately. As the precautionary approach for this stock is still under development, region-specific guidance is provided based on recent productivity trends and exploitation levels. Recent recruitment estimates indicate the potential for continued increases in SSB in the near term, while exploitation rates are expected to remain low under harvest levels similar to those observed in the recent past. Between 2015 and 2024, landings in 4R ranged from 4,135 to 19,933 t, and from 659 to 4,021 t in 4Sw (Table 1). Harvests within these ranges do not appear to have adversely affected either the spring- or fall-spawning components. Maintaining catches within these bounds therefore appears unlikely to cause the 4RSw spring- and fall-spawning stocks to decline to their LRPs by 2028.

## SOURCES OF UNCERTAINTY

Incorporating time-varying catchability to the fall acoustic survey addressed a major source of uncertainty identified in previous assessments. However, the covariate used to model this variation (temporal mismatch between the survey and the commercial fishery) may not accurately capture true variation in herring availability to the survey, and alternative covariates or formulations could lead to different perceived dynamics.

Several key parameters, including natural mortality and selectivity, are assumed constant across years. While this simplification is necessary given that catchability is already modeled as time-varying, it introduces uncertainty in model outputs. In particular, natural mortality may vary over time or among age classes in response to changes in predator abundance or environmental conditions. Model self-tests further indicated that the model exhibits a tendency to underestimate SSB, with estimated biases of 10.5% (95% CI: 6.0-15.0%) for spring spawners and 16.6% (95% CI: 6.9-26.4%) for fall spawners.

Because projections for the spring- and fall-spawning components are not yet available, the current advice is based on recent trends and assumptions about near-term stock dynamics under harvest levels similar to those observed in recent years. Although spring and fall spawners are assessed separately, they are exploited in a mixed fishery, with catches reflecting variable contributions from each component depending on their relative abundance, the timing of the fishery, and fishing location. Developing projections that adequately account for this mixed-fishery structure will require additional analyses to apportion future catches between spawning components.

A Precautionary Approach framework for the 4RSw herring stock remains under development. While LRP has been identified, other key elements, such as the USR, removal reference, and harvest control rules, have not yet been defined. The absence of these components limits the ability to translate stock status into tactical management advice and to formally evaluate risk under alternative management scenarios.

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