ASSESSMENT OF THE ESTUARY AND GULF OF ST. LAWRENCE (DIVISIONS 4RST) CAPELIN (*MALLOTUS VILLOSUS*) STOCK IN 2022 AND 2023

CONTEXT

The Fisheries Management Branch of Fisheries and Oceans Canada (DFO) requested that the 4RST capelin stock (IFMP) be assessed relative to reference points that are consistent with the DFO Precautionary Approach (DFO 2009), provide harvest advice, and inform on the current state of different indicators of stock health. This Science Advisory Report is from the February 27-28, 2024 regional peer review Stock Assessment of the Estuary and Gulf of St. Lawrence (4RST) in 2023. Additional publications from this meeting will be posted on the (DFO) Science Advisory Schedule as they become available.

SCIENCE ADVICE

Status

- Due to the absence of an approved Limit Reference Point (LRP), the stock status of 4RST capelin in 2022 and 2023 is uncertain.

Trends

- Since mid-2010, the index of mature biomass varied without a noticeable trend around the time series average (1995-2022).

- The index of fishing mortality was highly variable over the period 1996-2023 and was low in 2022 and 2023 relative to the time series.

Ecosystem and Climate Change Considerations

- Increasing water temperatures in the Gulf of St. Lawrence may negatively affect capelin habitat availability but impact on stock productivity remains uncertain.

Stock Advice

- The 2023 stock status of 4RST capelin is uncertain. However, given that the index of mature biomass has varied without trend since the mid-2010s and the index of fishing mortality was low with respect to the biology of the species, harvest levels attained since 1996 (741 to 11,825 t) are unlikely to pose a risk to the stock in 2024 and 2025.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

The assessment approach was adopted during the 2024 stock assessment (Boudreau et al. in prep.[1]).

Assessment Type

Full Assessment: Full peer-reviewed stock assessment

Most Recent Assessment Date

1. Last Full Assessment: 2022 (DFO 2022, Boudreau et al. 2023)

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)

The assessment approach adopted consists of the evaluation of recent trends in the mature biomass index along with the comparison of fishing mortality index with natural mortality typical of short-lived species like capelin. The mature biomass index for the 4RST capelin is obtained by combining the biomass derived from the mean number of mature capelin per tow in the bottom-trawl surveys conducted in the northern and southern Gulf of St. Lawrence.

Stock Structure Assumption

Stock overview information: The Atlantic Capelin found in the Arctic and Atlantic Oceans are divided into three distinct clades including the Northeast/Central Atlantic clade, the Arctic clade and the Northwest Atlantic clade. Within the Northwest Atlantic clade, three distinct haplotypes have been identified but all are found across the Newfoundland and Labrador Shelf, the Gulf of St. Lawrence, and into the upper St. Lawrence Estuary (Cayuela et al. 2020). Previous attempts to examine the stock structure of Capelin in the Northwest Atlantic including the Gulf of St. Lawrence have highlighted multiple instances of phenotypic variation between spawning sites for traits such as spawning behavior, diet, colour, morphology, number of vertebrae and other life-history traits (Templeman 1948; O'Boyle and Lett 1977; Sharp et al. 1978; Carscadden 1979; Carscadden and Misra 1979; Lambert and Bernier 1989; Dodson et al. 2007; Praebel et al. 2008; Kenchington et al. 2015). The structure of capelin populations in the Estuary and Gulf of St. Lawrence is not clearly defined, and capelin in Divisions 4RST are currently managed as a single stock.

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[1] Boudreau et al. In preparation. Capelin in the Estuary and Gulf of St. Lawrence (NAFO Divs. 4RST) in 2022 and 2023.

Reference Points

- Limit Reference Point (LRP): N/A. Empirically estimated candidate LRPs were evaluated but not adopted due to the uncertainty in the index of mature stock biomass estimated from the bottom trawl surveys.

- Upper Stock Reference (USR): N/A.

- Removal Reference (RR): N/A.

- Target (TRP): N/A.

Data

- Capelin annual landings from the directed fishery based on records contained in the Zonal Interchange File Format (ZIFF) database (1960 to 2023);

- Capelin relative abundance (mean number per tow) in the preferred and unfavorable thermal habitat in the bottom trawl surveys conducted in the northern and southern Gulf of St. Lawrence (1995 to 2023);

- Biological samples collected in the bottom trawl surveys (1995 to 2023);

Data changes: The vessel and gear used in the annual September sGSL trawl survey changed from CCGS Teleost using a Western IIA trawl to CCGS Capt. Jacques Cartier using a NEST trawl in 2023. The vessel used in the annual August survey in the nGSL also changed from the CCGS Teleost to CCGS John Cabot. Comparative fishing experiments were conducted in 2021 and 2022 to estimate differences in fishing efficiency between both survey new platforms. Non-negligeable length dependent differences in fishing efficiency were observed between platforms and the estimated conversion factors (Benoît and Yin 2023, Benoît and Yin 2024, in press.) were applied to capelin survey catch data to maintain the continuity of the surveys time-series.
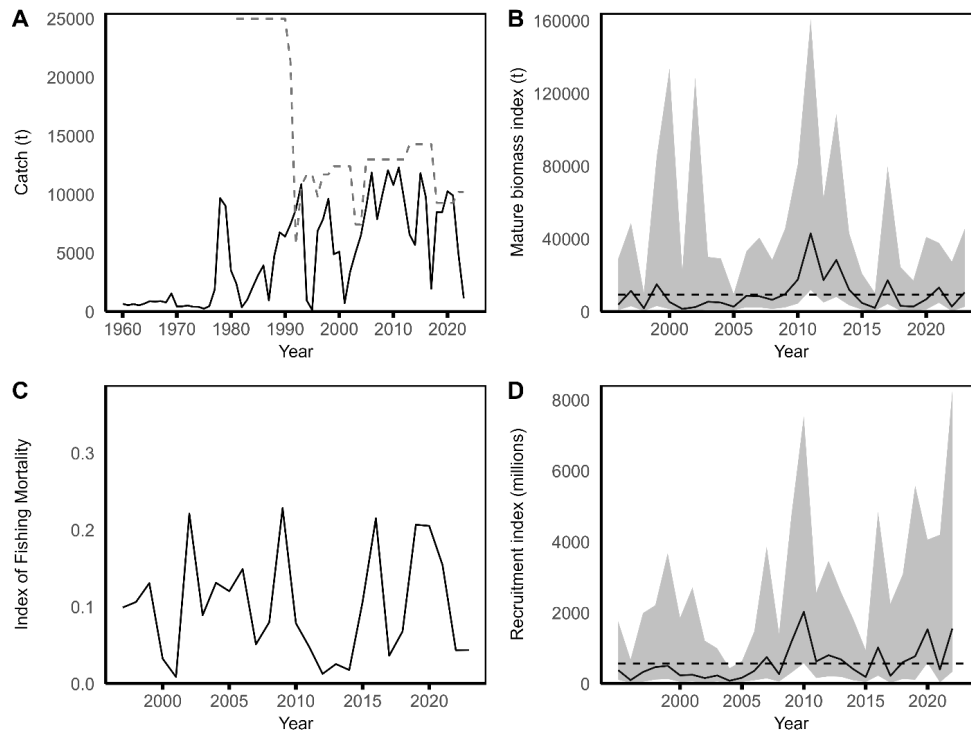
ASSESSMENT

Figure 1. (A) Catch (solid line) and total allowable catch (dashed line), (B) mature biomass index (solid line with 95% CI, metric tons) and time series average (dashed line), (C) index of fishing mortality and (D) recruitment index (solid line with 95% CI, numbers) and time series average (dashed line).

Historical and Recent Stock Trajectory and Trends

Mature Biomass Index

The time series of mature biomass estimated from the bottom trawl surveys index showed significant interannual variability and very large confidence intervals on annual estimates (Figure 1B). It is currently uncertain how much of the signal reflects true biological change rather than observation error.

The mature biomass index of the stock was mostly lower than average in the first decade (1995 to 2005). The highest values of the index were observed from 2010 to 2013. The stock biomass has been fluctuating around the time series average since then.

The mature biomass index in the northern Gulf of St. Lawrence survey has been constantly decreasing since 2017 whereas the index in the southern Gulf varied around the average of the time series with a marked increase for 2023.

Index of Fishing Mortality

The index of fishing mortality (Figure 1C) was based on the ratio of landings to the index of mature biomass (exploitation rates), assuming cautious survey catchability accepted in the previous assessment (DFO 2022), and natural mortality between the timing of the survey and the fishery. The index of fishing mortality was highly variable over the period 1996-2023 and was low in 2022 and 2023. Despite high variability and uncertainty in the time-series, there is evidence that landings are smaller than estimated consumption of mostly mature capelin by a

subset of predators implying that fishing mortality is considerably lower than natural mortality due to predation and other causes (Savenkoff et al. 2004, Ouellette-Plante et al. 2022). Furthermore, these estimates of fishing mortality are considerably lower than a range of plausible estimates of natural mortality (Chamberland et al. 2022, Boudreau et al. 2023) and accepted sustainable fishing mortality rates for small pelagic fish (Patterson 1992).

Recruitment

The recruitment index estimated from the bottom trawl surveys showed significant interannual variability without apparent trend (Figure 1D). Recruitment was generally lower than the time-series average in the first decade and relatively higher since the mid-2000s. It is currently still uncertain how much of the signal reflects true biological change rather than observation error.

History of Landings and TAC

The commercial fishery for 4RST capelin is co-managed by DFO's Newfoundland and Labrador, Gulf, and Quebec regions under an evergreen Integrated Fishery Management Plan (IFMP). The majority of the commercial fleet is based on the west coast of Newfoundland (NAFO Division 4R). Fishing seasons are generally short and coincide with the inshore capelin spring spawning migration. The total allowable catch (TAC) for 4RST capelin has rarely been limiting and landings have historically been market-driven (Figure 1A, Table 1). The TAC is currently split by fleet and NAFO Division. The 4R fixed gear fleet, which includes tuck seiners, has an allocation of 37.82% of the total TAC under a fully competitive quota. The 4R mobile gear fleet, includes large (vessel > 19.81 m (65 ft.)) and small (vessel < 19.81 m) purse seiners, each with an allocation of 24.15% of the total TAC. Small seiners are managed through individual quotas while larger seiners are managed as a competitive fishery. The allocation for 4ST is 13.88% of the total TAC and is managed as a competitive fishery across all gear types. All licence holders in 4R are required to have their catch monitored at dockside and the return of logbooks is mandatory.

Table 1. Management year landings by NAFO division, total landings and Total Allowable Catch (TAC) are listed in metric tons

Year	4R	4S	4T	Total landings	TAC
Average 1960-1980	1,245	103	338	1,686	-
Average 1981-1990	2,810	137	244	3,191	25,000
Average 1991-2000	5,730	332	210	6,273	11,940
Average 2001-2010	6,643	721	380	7,745	11,776
2011	9,890	974	1,449	12,314	13,000
2012	8,914	478	147	9,539	13,000
2013	6,350	236	0	6,587	14,300
2014	5,683	20	0	5,703	14,300
2015	11,361	107	357	11,825	14,300
2016	9,326	78	373	9,777	14,300
2017	1,945	19	1	1,965	14,300
2018	8,141	356	6	8,503	9,295
2019	7,569	427	490	8,487	9,295
2020	7,876	1,858	547	10,281	9,295
2021	8,013	1,733	188	9,934	9,295
2022	4,886	117	10	5,013	10,225

Year	4R	4S	4T	Total landings	TAC
2023	1,147	12	2	1,161	10,225

Ecosystem and Climate Change Considerations

The effects of the ecosystem on the stock were considered outside of the stock assessment approach and were not used to condition the stock indices.

Changes in climate and ecosystem variables may affect recruitment, survival and growth potential, but the magnitude and direction of these changes are uncertain. Capelin is a cold water species associated with the cold intermediate layer in the Gulf of St. Lawrence. Temperatures in this habitat have been increasing since 2019 and may negatively affect capelin habitat availability but impact on stock productivity remains uncertain.

Capelin can be an important prey for species such as Greenland Halibut (*Reinhardtius hippoglossoides*), Atlantic Cod (*Gadus morhua*), marine mammals and seabirds. The impacts of the downward trend in capelin abundance in the northern Gulf of St. Lawrence on its main predators remain uncertain.

PROCEDURE FOR INTERIM YEAR UPDATES

The stock is fully assessed every two years. No stock status update will be published in the interim year.

SOURCES OF UNCERTAINTY

The key indicators of stock state (mature biomass, recruitment and fishing mortality indices) were derived from bottom trawl surveys and are considered to have a high level of uncertainty due to the opportunistic nature of the data. This includes overall low and uncertain survey catchability, poor sampling in areas where the cold intermediate layer does not touch the bottom and timing of surveys about eight months prior to the start of the fishery. The presumed low fishing mortality rates depend on the assumption of low capelin catchability in the bottom trawl surveys. Cautious values accepted in the previous assessment were used but could not be validated. There is uncertainty surrounding the fraction of reproductive output that is being removed by the fishery as the fishery targets fish on the verge of spawning. Another source of uncertainty relates to the fact that the fishery, concentrated on the West coast of Newfoundland, has been linked to an index of biomass at the Gulf of St. Lawrence scale. There is therefore a risk of local depletion and this uncertainty has not been addressed for the moment.

Research Recommendations

Research recommendations that could improve the quality and confidence in the bottom trawl indices (mature biomass and recruitment) and support the development of reference points were identified and discussed.

• Use of complementary data collected during the bottom trawl surveys to validate the observed biomass trend of capelin caught in trawl sets. This include the analyses of stomach content data of predators for which capelin is an important component of their diet, the estimation of capelin biomass based on recordings of acoustic backscatter, and the possibility to track cohorts in the annual capelin number at age estimated from the lengths and ages of capelin sampled during the surveys.

- Improve our understanding of the interannual variability and the level of uncertainty associated with annual estimates. This includes accounting for the impact of diurnal vertical capelin migration on survey catchability, an impact assessment of few large capelin catches during certain years and the examination of interannual recurrence in locations of large catches which would suggest a structure that should be taken into account in the calculation of annual estimates.

- Identify the biotic and abiotic factors that influence productivity and annual variabilities in stock size in order to assess the risk and impacts of significant factors in relation to the ecosystem and climate changes.

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SOURCES OF INFORMATION

Benoît, H.P. and Yin, Y. 2023. Results of Comparative Fishing Between the CCGS Teleost Fishing the Western IIA Trawl and CCGS Capt. Jacques Cartier Fishing the NEST Trawl in the Southern Gulf of St. Lawrence in 2021 and 2022. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/083: xiv + 187 p.

Benoît, H.P., Yin, Y., and Bourdages, H. 2024. Results of Comparative Fishing Between the CCGS *Teleost* and CCGS *John Cabot* in the Estuary and Northern Gulf of St. Lawrence in 2021 and 2022. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/007. xvii + 229 p.

Boudreau, M., Chamberland, J.M., Girard, L., Boudreau, M., Benoît, H., Lehoux, C., Smith, A., Galbraith, P. and Plourde, S. 2023. Capelin in the Estuary and Gulf of St. Lawrence (NAFO Divs. 4RST) in 2021. DFO Can. Sci. Advis. Sec. Res. Doc. 2023/018. v + 51 p.

Carscadden, J.E. 1979. Capelin (*Mallotus villosus*) in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 1979/24. 13 p.

Carscadden, J.E. and Misra, R.K. 1979. Multivariate Analysis of Meristic Characters of Capelin (*Mallotus villosus*) in the Northwest Atlantic. ICNAF Res. Doc. 79/II/29. Serial No. 5355.

Cayuela, H., Rougemont, Q., Laporte, M., Mérot, C., Normandeau, E., Dorant, Y., Tørresen, O.K., Hoff, S.N.K., Jentoft, S., Sirois, P., Castonguay, M., Jansen, T., Præbel, K., Clément, M. and Bernatchez, L. 2020. Shared ancestral polymorphisms and chormosonal rearrangements as potential drivers of local adaptation in a marine fish. Mol. Ecol. 29 (13): 2379–2398.

Chamberland, J.-M., Plourde, S. and Benoît, H.B. 2022. Biological characteristics, factors affecting catchability, and abundances indices of Capelin in the southern and northern Gulf of St Lawrence multi species bottom trawl surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/77. iv + 41 p.

Dodson, J.J., Tremblay, S., Colombani, F., Carscadden, J.E. and Lecomte, F. 2007. Trans-Arctic dispersals and the evolution of a circumpolar marine fish species complex, the Capelin (*Mallotus villosus*). Mol. Ecol. 16: 5030–5043.

DFO. 2009. A fishery decision-making framework incorporating the precautionary approach. Last updated 2009-03-23.

DFO. 2022. Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin Stock in 2021. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/023.

DFO. 2023. Update of stock status indicators of the Estuary and Gulf of St. Lawrence (Divisions 4RST) capelin stock in 2022. DFO Can. Sci. Advis. Sec. Sci. Res. 2023/030.

Kenchington, E.L., Nakashima, B.S., Taggart, C.T. and Hamilton, L.C. 2015. Genetic structure of Capelin (*Mallotus villosus*) in the Northwest Atlantic Ocean. PLoS ONE. 10(3): e0122315. doi:10.1371/journal.pone.0122315

Lambert, J.-D. and Bernier, B. 1989. Observations on 4RST Capelin in the Gulf of St. Lawrence (A retrospective, 1984–1987). CAFSAC Res. Doc. 89/8. 33p.

O'Boyle, R.N. and Lett, P.F.K. 1977. Status of Capelin (*Mallotus villosus*) stocks in the Gulf of St. Lawrence. CAFSAC Res. Doc. 77/4.

Ouellette-Plante, J., Benoît, H., Plourde, S. and Chabot, D. 2022. Preliminary estimates of annual Capelin consumption by Atlantic Cod and Greenland Halibut. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/013. iv + 48 p.

Patterson, K. 1992. Fisheries for small pelagic species: an empirical approach to management targets. Rev. Fish Biol. Fish. 2(4): 321–338.

Præbel K., Westgaard, J.I., Fevolden, S.E., and Christiansen, J.S. 2008. Circumpolar genetic population structure of Capelin *Mallotus villosus*. Mar. Ecol. Prog. Ser. 360: 189–199.

Savenkoff, C., Grégoire, F. and Chabot, D. 2004. Main prey and predators of Capelin (*Mallotus villosus*) in the northern and southern Gulf of St. Lawrence during the mid-1980s and mid-1990s. Can. Tech. Rep. Fish. Aquat. Sci. 2551: vi + 30 p.

Sharp, J.C., Able, K.W., Leggett, W.C. and Carscadden. J.E. 1978. The utility of meristic and morphometric characters in the identification of Capelin (*Mallotus villosus*) stocks in Canadian Atlantic waters. J. Fish. Res. Board Can. 35: 124–130.

Templeman, W. 1948. The life history of the Capelin (*Mallotus villosus* O.F. Müller) in Newfoundland waters. St-John's NFLD: Newfoundland Government Laboratory. 151 p.

THIS REPORT IS AVAILABLE FROM THE:

Correct Citation for this Publication:

DFO. 2024. Assessment of the Estuary and Gulf of St. Lawrence (Divisions 4RST) Capelin
(*Mallotus villosus*) Stock in 2022 and 2023. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.
2024/021.

Aussi disponible en français :

*MPO. 2024. Évaluation du stock de capelan (*Mallotus villosus*) de l'estuaire et du golfe du
Saint-Laurent (divisions 4RST) en 2022 et 2023. Secr. can. des avis sci. du MPO. Avis Sci.
2024/021.*