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Gulf Region

Canadian Science Advisory Secretariat
Science Advisory Report 2024/020

SOUTHERN GULF OF ST. LAWRENCE (CFAS 12, 12E, 12F, 19) SNOW CRAB (*CHIONOECETES OPILIO*) STOCK ASSESSMENT IN 2023

CONTEXT

The Fisheries and Harbour Management Branch of Fisheries and Oceans Canada (DFO) has requested an assessment of the southern Gulf of St. Lawrence snow crab (*Chionoecetes opilio*) stock for Crab Fishing Areas (CFA) 12, 12E, 12F and 19. This Science Advisory Report is from the regional peer review of January 23-24th, 2024 on the Southern Gulf of St. Lawrence (CFAs 12, 12E, 12F, 19) Snow Crab Stock Assessment in 2023. 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 2023 southern Gulf of St. Lawrence snow crab commercial biomass index, estimated at 67,703 tonnes (t), is above the Upper Stock Reference (USR) with very high likelihood, placing the stock in the Healthy Zone of the Precautionary Approach (PA) Framework.

Trends

- Following a period of high levels from 2018 to 2022, the commercial biomass index decreased by 21% in 2023.
- Pre-recruits to the fishery decreased to below the time series (1997-2023) average in 2023.
- Female spawning stock indices have increased since 2006 and have remained at high levels in 2023.
- The population recruitment index was at the highest recorded level in 2021, but has decreased in 2023 to the time series average.

Ecosystem and Climate Change Considerations

There is continued evidence of warming conditions in the southern Gulf of St. Lawrence that can impact snow crab population dynamics and distribution; and the mechanisms require further investigation.

Stock Advice

- Based on the harvest decision rule, the 2023 commercial biomass index corresponds to a target exploitation rate of 38.59% and a catch option of 26,126 t for the 2024 southern Gulf of St. Lawrence fishery.

- A risk analysis indicates that this catch option would result in a very high likelihood that the commercial stock would remain in the Healthy Zone of the PA after the 2024 fishery.

BASIS FOR ASSESSMENT

Year Assessment Approach was Approved: November 21-25, 2011 (DFO 2012a)

Assessment Type: Full Assessment

Most Recent Assessment Date: January 25-26, 2023 (DFO 2023)

Assessment Details

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

Stock Structure Assumption

- Snow crab in the southern Gulf of St. Lawrence is considered as a single biological stock unit. The snow crab trawl survey covers the majority of crab habitat (Surette and Chassé 2023).

Reference Points

- Limit Reference Point (LRP): 10,000 t of residual commercial crab biomass (DFO 2012b).
- Upper Stock Reference (USR): 41,400 t of total commercial crab biomass (DFO 2012b).

Harvest Decision Rule

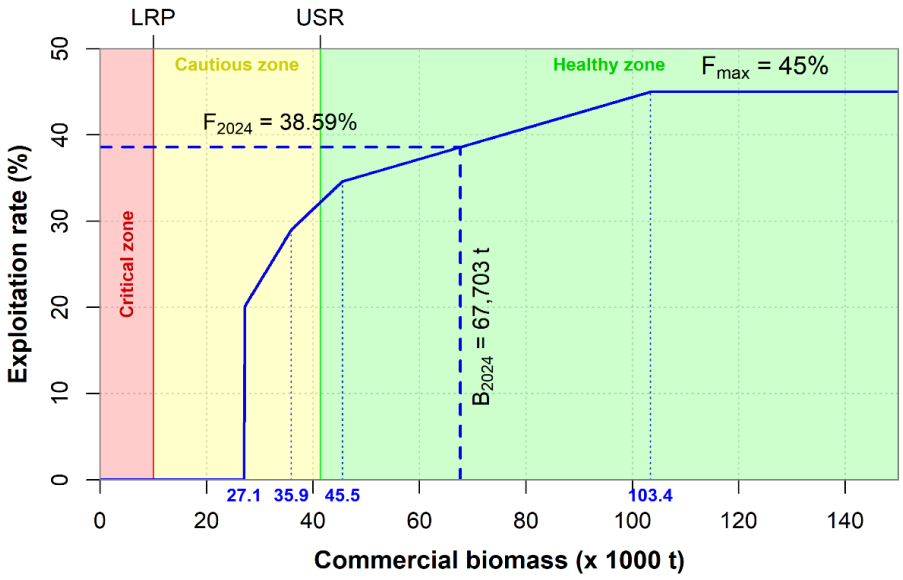

Figure 1. Harvest decision rule used for the southern Gulf of St. Lawrence snow crab fishery (DFO 2014), which maps the commercial biomass index to a target exploitation rate (solid blue line). The red line shows the limit reference point (LRP) for residual commercial biomass and the green line shows the upper stock reference (USR) point for commercial biomass. F_{max} represents the maximum allowed exploitation rate. The blue dashed line shows the projected commercial biomass for 2024 and its corresponding target exploitation rate. Dotted blue lines indicate inflection points in the harvest decision rule.

Data

- Commercial landings/sales slips: 1967-2023.
- Fishery logbooks: 1987-2023.
- Snow crab trawl survey: 1997-2023.
- Oceanographic data from September research vessel (RV) survey: 1971-2023.

Data changes:

- Survey design changes in 2006 and 2012, including expansion of the survey area and survey station redistribution.
- The survey vessel was changed in 1999, 2003, 2013 and 2019 with likely changes in survey catchability.

ASSESSMENT

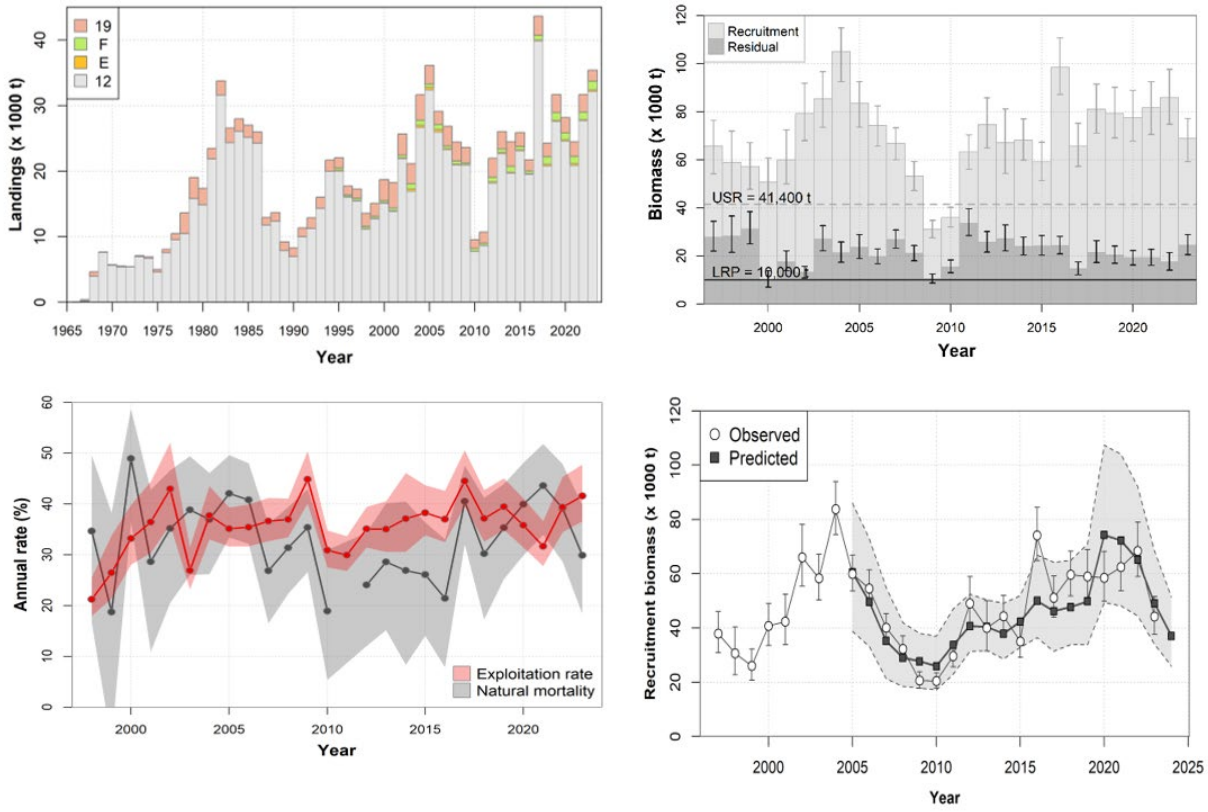

Figure 2. (Top left) Annual landings (in tonnes) of snow crab in the southern Gulf of St. Lawrence by fishing area, (Top right) Annual commercial recruitment and residual biomass in relation to the Upper Stock Reference (USR) (dashed line) and Limit Reference Points (LRP) (solid line), (Bottom left) Natural mortality and exploitation rate for commercial snow crab, (Bottom right) Observed (open circles and 95% confidence interval error bars) and predicted (black squares and shaded 95% confidence intervals) commercial crab recruitment by survey year.

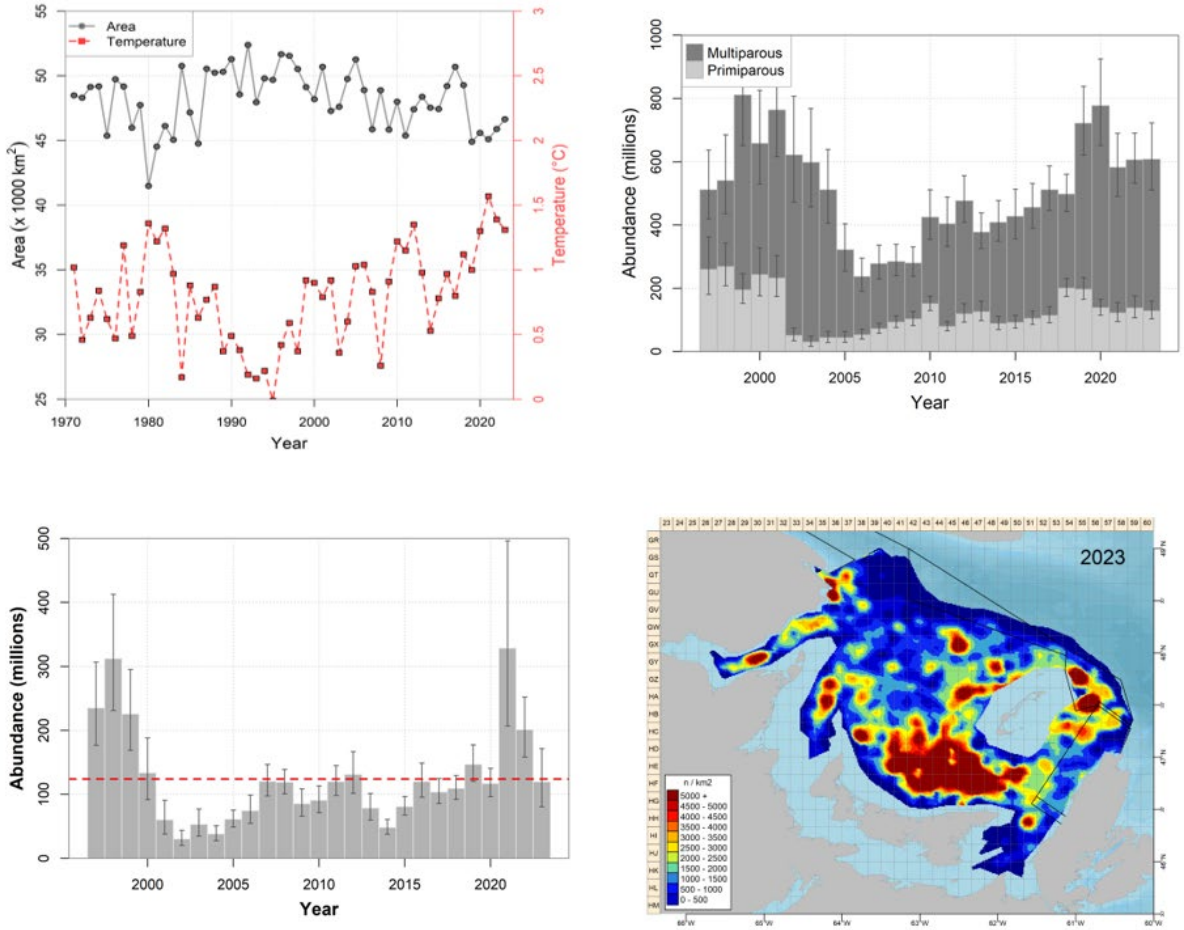

Figure 3. (Top left) Surface area within the polygon used for the biomass estimation and with bottom temperatures between -1 °C to 3 °C, an index of snow crab habitat, along with the mean temperature within the area .(Top right) Annual abundance (in millions; means with 95% confidence intervals) of primiparous and multiparous female snow crab and (Bottom left) small male crabs (instar VIII, 34 to 44 mm of carapace width), based on the trawl survey data. The red dashed line shows the average for the series. (Bottom right) Density (number per km^2) contours of commercial crab in the southern Gulf of St. Lawrence in 2023.

Historical and Recent Stock Trajectory and Trends

Biomass: Following a period of high levels since 2018, the commercial biomass index decreased by 21% in 2023 compared to 2022. The 2023 southern Gulf of St. Lawrence snow crab commercial stock biomass, estimated at 67,703 t, is still well above the USR, placing the stock in the Healthy Zone of the PA. The residual component of the biomass is 24,393 t which is also well above the LRP (Figure 2, Top right). The density of commercial snow crab in the southern Gulf of St. Lawrence in 2023 is presented in Figure 3 (Bottom right).

Abundance: After a period of high abundance in the early 2000's, the female spawning stock declined to low levels in 2006 and has gradually increased to high levels and presently stands at 607 million in 2023 (Figure 3, Top right).

Natural Mortality: Over the time series, natural mortality varied from 19% to 50%, with an average of 33%. In recent years, natural mortality stood at about 40% from 2020 to 2022 but has decreased to 30% in 2023 (Figure 2, Bottom left).

Recruitment: Population recruitment indices, which were at record levels in 2021, have decreased to average levels in 2023 (Figure 3, Bottom left). After a period of high fishery recruitment, there was a 35% decrease in 2023. A fishery recruitment model is projecting a further 17% decrease in 2024 (Figure 2, Bottom right).

History of Fishery Management

Snow crab has been commercially exploited in the southern Gulf of St. Lawrence since the mid-1960s. There are currently four Crab Fishing Areas (CFAs) in the southern Gulf of St. Lawrence: 12, 12E, 12F and 19, with CFA 12 being the largest by area, number of participants, and landings (Table 1). Management of these fisheries is based on quota and effort controls (trap allocations, trap dimensions and seasons). Only hard-shelled males larger than 95 mm carapace width are commercially exploited and landing of female crab is prohibited.

Local area closures during the fishing season occur when 1) the proportion of soft-shelled crab exceeds 20% in monitored catches, or 2) North Atlantic Right Whales (NARW) are detected in a given area. Local area closures can result in significant displacement of fishing effort.

Historical and Recent Landings, Effort and Catch Per Unit Effort (CPUE)

Snow crab landings from the southern Gulf of St. Lawrence were low in the early 1970s but increased more than threefold from 1975 to 1982. There were four periods of high landings (exceeding 20,000 t): 1981 to 1986, 1994 and 1995, 2002 to 2009, and the current period, from 2012 to 2023, the longest in the series (Table 1, Figure 2, Top left).

In recent years, CPUE values in CFA 12 ranged from 44.1 kilograms per trap haul (kg/th) in 2020 to 72.2 kg/th in 2023, among the highest in the series. Similarly, CPUE values 12E and 12F increased to their highest values in 2023, at 79.1 kg/th and 96.9 kg/th, respectively. The CPUE value for CFA 19 was 140.6 kg/th in 2023, the third highest in recent years. CPUE values for CFA 19 are typically much higher than those of other CFAs.

Table 1. Landings, fishing effort and catch per unit effort from logbooks in the southern Gulf of St. Lawrence snow crab, Chionoecetes opilio*, fisheries (Crab Fishing Areas 12, 12E, 12F and 19) from 2017-2023 (note: landings for 2023 are preliminary).*

Year	Landings (t)					Effort (number of trap hauls)				Catch per unit effort (kg/trap haul)			
	12	12E	12F	19	Total	12	12E	12F	19	12	12E	12F	19
2017	39,825	203	684	2,944	43,656	553,125	3,333	9,421	20,616	72.0	60.9	72.6	142.8
2018	20,769	260	1,183	2,048	24,260	469,887	5,579	17,120	13,120	44.2	46.6	69.1	156.1
2019	27,554	224	1,166	2,763	31,707	496,468	3,415	18,083	24,518	55.5	65.7	64.5	112.7
2020	24,554	234	1,084	2,284	28,156	556,780	5,098	22,168	22,458	44.1	45.9	45.2	101.7
2021	21,423*	223	592	2,241	24,479	363,136	5,314	18,612	18,384	57.4	55.7	59.1	121.0
2022	27,620*	197	1,173	2,671	31,661	537,820	2,509	15,240	23,690	51.4	78.5	76.5	112.6
2023	32,084*	291	1,329	1,700	35,404	444,480	3,678	13,718	12,088	72.2	79.1	96.9	140.6

**Total landings in CFA 12 include landings allocated to CFAs 12E (2021, 2022, 2023) and 12F (2021) that were fished in CFA 12.*

Projections for 2024 southern Gulf of St. Lawrence snow crab fishery

Table 2. Risk analysis for different catch options for the 2024 southern Gulf of St. Lawrence snow crab fishery showing the probability that the residual commercial biomass (B_{res}) would be below limit reference point (LPR), the probability that the total commercial biomass (B) would be below the upper stock reference (USR), and the expected biomass for the 2024 survey. In bold is the catch option corresponding to an exploitation rate of 38.59%, the rate as per the harvest decision rule.

Catch option (t)	Probability B_{res} < LRP B < USR		Predicted survey biomass for 2024 (t)
23,000	0.0%	0.8%	56,333 (43,811 – 71,558)
24,000	0.1%	1.3%	55,333 (42,811 – 70,558)
25,000	0.3%	2.1%	54,333 (41,811 – 69,558)
26,000	0.9%	3.2%	53,333 (40,811 – 68,558)
26,126	**1.1%**	**3.4%**	**53,207 (40,685 – 68,432)**
27,000	2.6%	4.7%	52,333 (39,811 – 67,558)
28,000	6.1%	6.7%	51,333 (38,811 – 66,558)
29,000	12.2%	9.2%	50,333 (37,811 – 65,558)
30,000	21.5%	12.4%	49,333 (36,811 – 64,558)

Ecosystem and Climate Change Considerations

Water temperature can affect moulting, reproduction, and movement of snow crab. Bottom temperatures over most of the southern Gulf of St. Lawrence are typically between -1 and 3 °C. Overall, bottom temperatures for the southern Gulf of St. Lawrence during 2023 were still much warmer than normal (1991-2020). In CFA 12, temperatures were 0.5 to 1 °C (or more) above normal. Very few areas had below normal temperatures in 2023.

The surface area with bottom temperatures between -1 and 3 °C in September, and within the polygon used for the estimation of the commercial biomass, rose slightly in 2023 but remained low (Figure 3, Top left). The average temperature within that area (1.3 °C) is still well above the long-term average (1991-2020) but decreased by 0.1 °C from 2022. The 2023 average temperature is the sixth highest of the 1971-2022 time series.

SOURCES OF UNCERTAINTY

The southern Gulf of St. Lawrence snow crab survey was developed to provide quality abundance and biomass indices: it uses a bottom trawl with high catchability for commercial crab, contains a fairly large number stations which are sampled annually, and a sampling area that covers most of the crabs' habitat. Changes in sampling design and fishing protocols have led to improvements in the survey over the years. However these changes, particularly the expansion of the survey area, the relocation of survey stations and variations in the survey's timing, may have led to variations in survey catchability. In addition, trawl catchability is known to vary with bottom type, sea conditions, current, vessel type, trawling speed and trawl symmetry.

Fishery pre-recruits (R-4, R-3, R-2) have decreased substantially from 2020 to 2022. R-3s and R-2s continued their downward trend in 2023 and are now below average levels. Despite the decrease in R-2s from 2020 to 2023, R-1s remained relatively stable, with the first significant decrease only appearing in 2023. Thus, a disconnect exists between R-1s and R-2s in recent years. Furthermore, skip-moulting proportions among R-2s are high in 2023. This adds to the

prediction uncertainty in the fishery recruitment model, which neither accounts for annual variations in mortality, nor accounts for variations in skip-moulting rates.

There is continued evidence of warming conditions in the southern Gulf of St. Lawrence that can impact snow crab population dynamics and distribution, in the short to long-term. Although some of these aspects are regularly monitored as part of annual assessments, the mechanisms require further investigation. The collapse of the Eastern Bering Sea snow crab stock in 2021 provides a cautionary tale on how quickly stock status can change. Before the collapse, assessment biologists reported record levels of recruits in 2018, which decreased substantially in 2019 and were at minimal levels in 2021. These decreases coincided with a marine heat wave resulting in a substantial decrease of the cold pool from 2018 to 2021.

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SOURCES OF INFORMATION

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*MPO. 2024. Évaluation du stock de crabe des neiges (*Chionoecetes opilio*) en 2023 dans le sud du golfe du Saint-Laurent (ZPC 12, 12E, 12F, 19). Secr. can. des avis sci. du MPO. Avis sci. 2024/020.*