Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Quebec Region

Canadian Science Advisory Secretariat
Science Advisory Report 2025/036

ASSESSMENT OF SEA CUCUMBER STOCKS IN QUEBEC'S INSHORE WATERS IN 2023

*Figure 1. Sea Cucumber (*Cucumaria frondosa*).*
Photo: J.-P. Dallaire, DFO

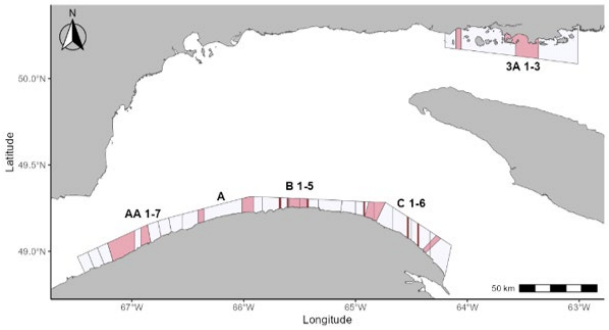

Figure 2. Sea cucumber fishing areas in Quebec

CONTEXT

The sea cucumber (*Cucumaria frondosa*) fishery is a recent activity in the Estuary and northern Gulf of St. Lawrence. Exploratory permits were issued for the coastal waters of the northern shore of the Gaspé Peninsula (Fishing areas A, B, and C) in 2008 and in the waters of the Mingan Archipelago (Fishing area 3) in 2009. An experimental licence was also issued for the waters of the Lower North Shore in 2017. The fishery transitioned to commercial status in areas B and C in 2024. The fishery is carried out either by diving or with a modified LGS-type dredge or a dredge designed specifically for sea cucumbers.

Stock assessments are carried out every three years to determine whether changes in the main stock indicators require modifications in management measures. The most recent assessment was conducted in 2021. The main stock assessment indicators are derived from fisheries logbook data, the sampling of landings in areas A, B, C and 3, the research survey conducted every 2 alternating between the Mingan Archipelago and the northern shore of the Gaspé Peninsula, as well as an annual post-season survey carried out by the Mi'gmaq Wolastoqey Indigenous Fisheries Management Association (MWIFMA) and the industry in areas B and C.

This Science Advisory Report is from the regional peer review on April 24, 2024, on Assessment of Sea Cucumber Stocks in Quebec's Inshore Waters. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The sea cucumber dredge fishery in Quebec began in 2008 and remained in the exploratory stage in fishing areas 3, B, and C in 2023. Mean annual landings during the

2021–2023 period totalled 879 t, 50% of which came from the Gaspé Peninsula's north shore and 50% from the Mingan Archipelago.

- In 2022, dockside monitoring of the size structure of sea cucumbers based on eviscerated mass replaced the less reliable length-based measurements used for over a decade.
- Size at maturity based on eviscerated mass was determined for both male and female sea cucumbers in the Mingan Archipelago region (Fishing area 3) and could inform future management measures to protect the reproductive potential of the stock.

Mingan Archipelago

Fishing Area 3

- Since 2018, the authorized fishing effort has been set at 120 days. From 2021 to 2023, mean annual landings were 442 t, which is comparable to those for the 2017–2020 period (466 t). Landings in 2023 were among the highest values in the time series. The fishing effort from 2021 to 2023 (77 days) was also consistent with the effort of 79 days from 2017 to 2020.
- The mean catch per unit effort (CPUE) in 2021–2023 was 128 kg/t·m, representing a slight increase compared with the mean of 118 kg/t·m from 2017 to 2020.
- Measurements of eviscerated mass taken in 2022 and 2023 indicated that the majority of landed sea cucumbers were mature individuals.

Gaspé Peninsula

Fishing Area B

- The total allowable catch (TAC) has been set at 325 t annually since 2017 and was fully used from 2021 to 2023 with mean annual landings of 322 t during that period. Annual fishing effort remained similar to the effort employed from 2017 to 2020.
- The mean CPUE from 2021 to 2023 was 135 kg/t·m, representing a slight increase from the mean of 125 kg/t·m from 2017 to 2020.
- Measurements of eviscerated masses taken in 2023 indicated that the majority of landed sea cucumbers were mature individuals.

Fishing Area C

- The TAC has been set at 271.7 t every year since 2020 and was not fully exploited between 2021 and 2023 owing to socio-economic factors. Mean annual landings during that period were 64 t. Fishing effort declined by 70% compared with the effort from 2017 to 2020.
- The CPUE has been increasing in the past three years (2021–2023), with the mean CPUE during that period (64 kg/t·m) being slightly greater than that from 2017 to 2020 (56 kg/t·m).
- Measurements of eviscerated masses taken in 2023 indicated that the majority of landed sea cucumbers were mature individuals.

Fishery-independent surveys

- In 2022, Fisheries and Oceans Canada (DFO) conducted a research survey in Fishing Area 3. From 2013 to 2023, MWIFMA carried out post-season surveys in Fishing Areas B and C.
- The DFO survey conducted in Fishing Area 3 revealed a decreasing gradient in sea cucumber densities from west to east in the study area. Individuals sampled at stations in the eastern portions of the study area also tended to show greater variability in mean eviscerated masses and a wider range of values than those sampled in the west.
- According to the results of the MWIFMA post-season survey from 2021 to 2023, sea cucumber abundance and biomass in Fishing Areas B and C were higher at sites that had not been dredged in more than four years compared with those that were actively fished.

Perspectives for the 2024 to 2026 fishing seasons

- In Fishing Area 3, maintaining annual fishing efforts similar to those observed from 2021 to 2023 may be able to support similar yields over the next three years.
- In Fishing Area B, given the conservation measures implemented, including protected areas and depth restrictions, maintaining landings near the mean levels from 2021 to 2023 is not expected to significantly impact sea cucumber abundance across the area over the next three years.
- In Fishing Area C, the low volume of landings from 2021 to 2023 creates considerable uncertainty in the monitoring of the resource, and the current status of the sea cucumber population in this area is unclear. It is recommended that stock indicators continue to be monitored until the next assessment.

INTRODUCTION

Biology

Sea cucumbers (holothurians) are a broadly distributed class of echinoderms that play a vital ecological role in benthic communities. Among them, the sea cucumber (*Cucumaria frondosa*; subsequently referred to as sea cucumber; Figure 1) is one of the most abundant species in the temperate waters of the Arctic and North Atlantic Oceans. It is found in most inshore habitats in the Estuary and Gulf of St. Lawrence (GSL). Juvenile sea cucumbers are typically found at depths of less than 10 m, but then migrate slowly to depths of up to 60 m, although they can sometimes be found at depths of over 400 m. Although generally sedentary, the species can adjust its buoyancy, allowing it to be carried long distances by currents to avoid adverse environmental conditions and predation (Hamel et al. 2019).

In the Saint Lawrence Estuary, spawning occurs in mid-June, coinciding with the spring bloom (Hamel and Mercier 1995; Gianasi et al. 2020; Couillard et al. 2021). The age and size at sexual maturity remain uncertain owing to the lack of reliable aging methods and the high variability in individual size and weight (Gianasi et al. 2020; Couillard et al. 2021). However, Hamel and Mercier (1996) have suggested that sexual maturity may be reached after approximately three years. Larval development lasts roughly 6.5 weeks, from egg fertilization to larval settlement on the seabed (Hamel and Mercier 1995; Hamel and Merci 1996; So et al. 2010; Gianasi et al. 2020).

Fishery

Sea cucumber harvesting began in the 1970s off the east coast of North America and in the 1990s in Canadian waters. In Canada, the species is fished in the Bay of Fundy, off the Scotian Shelf, on St. Pierre Bank and in the Estuary and Gulf of St. Lawrence. In the GSL, sea cucumber has been actively fished since 2008, using scuba diving and, more commonly, specially designed dredges.

Since the fishery's inception, the management units (fishing areas) for the species in Quebec's inshore waters have undergone several changes (Figure 2). The first sustained fishing attempts took place in 2008 in what is now known as Fishing Area C, along the north shore of the Gaspé Peninsula. The following year, the fishery expanded westward to Fishing Areas A and B and then to Fishing Area 3 in the waters surrounding the Mingan Archipelago on the North Shore. Over time, Fishing Area 3 was subdivided, reaching a total of 17 sub-areas (3A1–3A17) in 2022. In 2015, areas B and C were further divided into five and six sub-areas, respectively (B1–B5 and C1–C6), to spread the distribution of fishing effort. In 2018, Fishing Area AA (AA1–AA7) was established west of Fishing Area A. In 2017, an experimental fishing licence was issued for the Lower North Shore of Quebec. In 2023, the 17 sub-areas in Fishing Area 3 (3A1–3A17) were consolidated into three larger sub-areas (3A, 3B and 3 C).

Additional management measures include restrictions on gear and depth, a limited number of permits, the establishment of protected and fishery closure areas, a legal minimum size of 114 mm, dockside monitoring, logbook requirements, partial at-sea observer coverage, the use of vessel monitoring systems (VMS), and a total allowable catch (TAC) in areas AA, A, B, and C. Fishing Area 3, in contrast, is managed through a fixed number of allowable fishing days. In 2023, two fishing permits were issued in area 3, while four permits were issued in various locations along the Gaspé Peninsula (areas B and C).

Impact of dredges on habitat and biodiversity

The use of dredges on the seabed impacts habitat quality and the structure of benthic communities (Campagna et al. 2005; DFO 2021; St. Pierre et al. 2021). In 2021, DFO conducted a study comparing the effects of two types of sea cucumber dredges on benthic communities in areas A, B, and C (St-Pierre et al. 2021). The results showed that protected areas and sites closed to harvesting for four to six years supported higher sea cucumber abundance and biomass compared with actively fished sites. The study also indicated that species larger than 5 cm could recover from dredging within four to six years, while the recovery of the community structure of smaller species could take longer.

ASSESSMENT

Data

The data on landings, fishing effort, and CPUE used in this assessment come from harvesters' logbooks and processors' sales slips. Size structure data for the species were obtained through DFO's commercial dockside sampling program and at-sea observer program. Additional biological data, such as size structure, density and bycatch, were collected through post-season industry surveys, research projects between DFO and the industry, and scientific surveys conducted by DFO.

Landings

In Quebec, total landings increased from 201 t in 2008 to 1 816 t in 2014. However, a sharp decline occurred in 2015, when no fishing activity took place in Fishing Area B. Since 2016, mean annual landings stabilized at 1 034 t (Figure 3).

Dive fishery

The first sea cucumber dive fishery took place in 2009 in area A. Nine days of fishing yielded 23 t in landings. Since then, area A has remained inactive, as it is only accessible to dive licence holders. More recently, small-scale trial dive fisheries were conducted in areas B and AA in 2017 and 2018. However, these efforts ceased in 2018 owing to low profitability and technical challenges associated with dive harvesting.

Dredge fishery

Between 2021 and 2023, mean annual landings reached 879 t (Figure 3) and were evenly distributed between the Mingan Archipelago (50%, Fishing Area 3) and the Gaspé Peninsula's north shore (50%, Fishing Areas B (36.6 %) and Fishing Area C (13.0%)).

In Fishing Area 3, landings remained below 400 t until 2013. Subsequently, landings were consistently higher, averaging 459 t from 2014 to 2023. Annual landings across area 3 from 2021 to 2023 were 416 t, 385 t, and 527 t, respectively (Figure 3).

In Fishing Area B, landings increased annually from 2009 to a peak of 608 t in 2014, surpassing the TAC of 600 t. Following a reduction in the size of the fishing area in 2015, the TAC was lowered to 350 t and divided among the five newly created sub-areas. There was no fishery in 2015, and the TAC was further reduced to 325 t in 2017. From 2017 to 2023, landings stabilized at a mean of 321 t. From 2021 to 2023, TACs were either nearly reached or slightly exceeded in each sub-area.

In Fishing Area C, annual landings rose gradually from 201 t in 2009 to 792 t in 2014, nearing the TAC of 800 t. Following the division of area C into six sub-areas in 2015 and the associated reduction in the size of the harvestable area, the TAC was lowered from 382 t in 2015 to 352 t in 2017 and 271.8 t in 2020. Between 2015 and 2020, landings decreased significantly, averaging 315 t. In 2021, landings fell to a low of 81 t, but rebounded to 164 t in 2023. That year, the TACs in sub-areas C1, C4, and C5 were close to being fully used at 81%, 98%, and 94% respectively, while lower proportions were fished in sub-units C2, C3 and, C6, at 13%, 40% and 44% respectively (Figure 3).

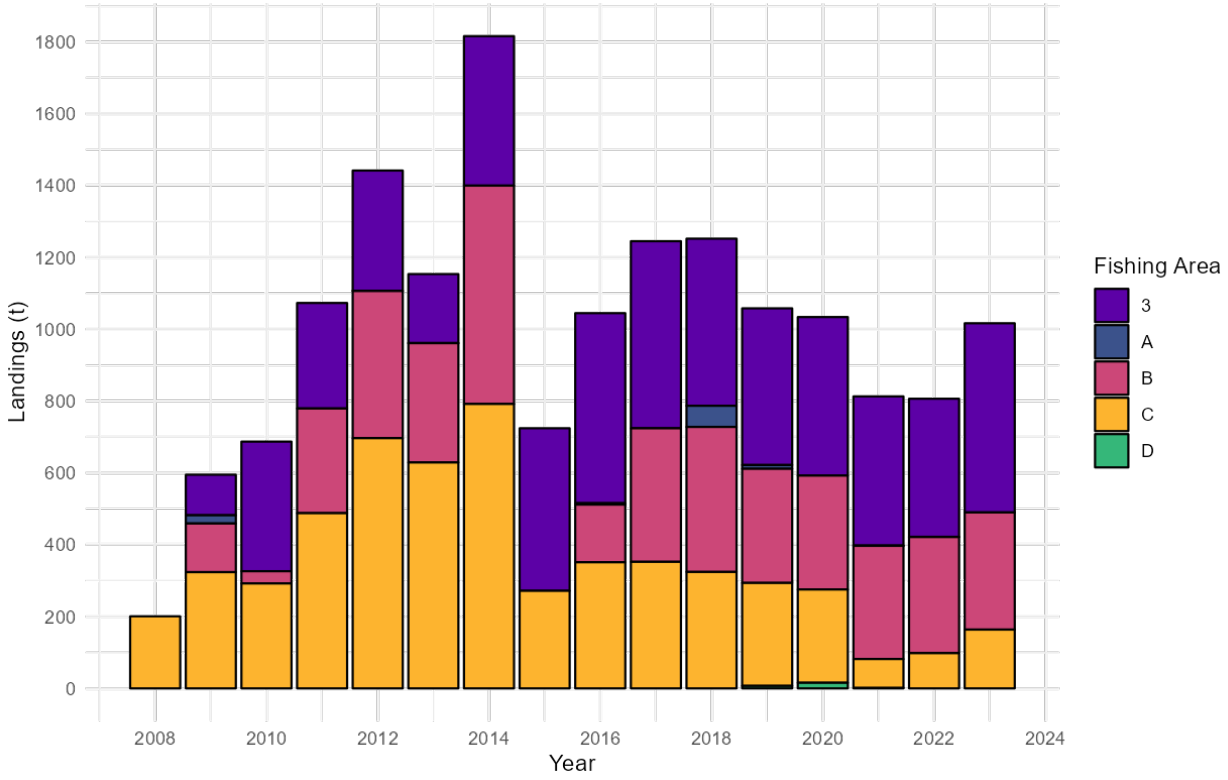

Figure 3. Annual landings (t) of sea cucumber by Fishing Area from 2008 to 2023, with landings in area 3 shown in purple; Areas A and AA in blue; Area B in pink; Area C, in orange; and Area D (Lower North Shore), in green.

Effort

Between 2021 and 2023, the mean fishing effort declined across all units compared with 2017–2020. Specifically, effort decreased from 3,738 tow·m to 3,519 tow·m (-6%) in area 3, from 2,583 tow·m to 2,333 kg/ tow·m (-10%) in area B, and from 5,374 tow·m to 1,625 tow·m (-70%) in area C.

Catch per unit effort (CPUE)

In contrast to effort, CPUE increased across all actively harvested areas from 2017–2020 to 2021–2023 (Figure 4). Mean CPUE rose from 118 kg/tow·m to 128 kg/tow·m (+8%) in Uareanit 3, from 125 kg/tow·m to 135 kg/tow·m (+8%) in area B, and from 56 kg/tow·m to 64 kg/tow·m (+14%) in area C.

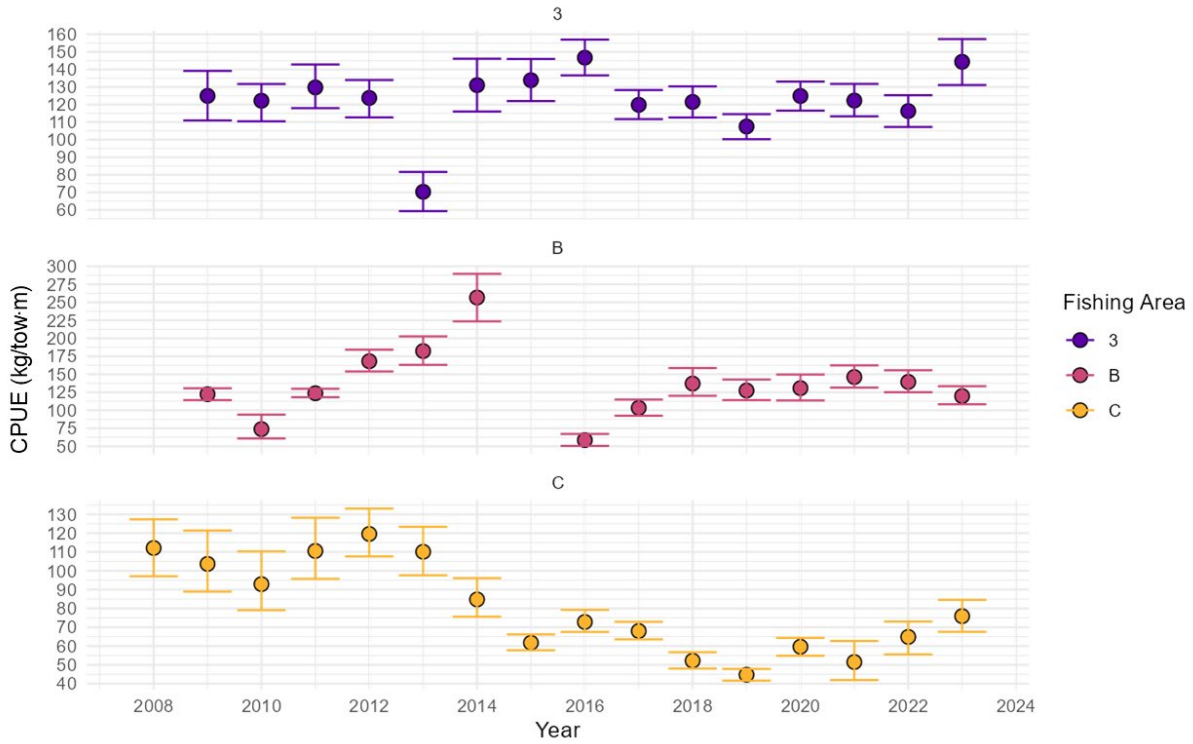

Figure 4. Annual mean CPUE (kg/tow·m) by management unit with 95% confidence intervals.

Size structures

The eviscerated masses of sea cucumbers harvested by the dredge fishery were sampled in 2022 and 2023 in areas 3, B, and C. Size at maturity, based on eviscerated mass, was determined for males and females in area 3 and could serve as a baseline for determining measures to protect the reproductive potential of sea cucumbers in this area. The mass at which 99% of females would have had the opportunity to reproduce at least once before being caught was 94.6 g (83.9–114.4 g). These results, combined with the measurements of eviscerated masses obtained by DFO's dockside sampling program, indicated that most of the sea cucumbers landed in areas B and C in 2023, and those landed in area 3 in 2022 and 2023, were mature individuals (Table 1).

Table 1. Mean eviscerated masses (g), with standard deviations (SD) of sea cucumbers sampled in DFO's dockside monitoring program in 2022 and 2023 in fishing areas (F. A.) 3, B, and C. Sample size (N) and the number of samples (N sample) are also shown.

Year	*F. A.*	N	N sample	Mean	S. D.
2022	3	399	3	238.31	60.61
2022*	B	200	2	209.31	55.42
2022*	C	384	4	242.61	52.36
2023	3	200	2	184.28	42.09
2023	B	400	4	159.53	37.80
2023	C	300	3	224.69	46.58

* The dissection protocol was not properly applied in areas B and C in 2022.

Research surveys

DFO survey

In October 2022, DFO conducted a research survey in the inshore waters around the Mingan Archipelago. Sea cucumber densities observed varied by sub-area (Figures 5 and 6). Sea cucumbers were harvested at most of the sampling stations (139/165 stations), with a mean of 38 specimens per station (min. 0; max. 371). The mean density in the study area as a whole was 53.17 individuals/1,000 m^2 (95% CI: 41.06–66.56 individuals/1,000 m^2). Density by sub-area ranged from 3.45 individuals/1,000 m^2 in sub-area 3A10 to 134.23 individuals/1,000 m^2 in sub-area 3A14. The survey also showed a decreasing density gradient from west to east (Figures 5 and 6). No clear relationship was found between sea cucumber density, depth, or bottom temperature (Figure 7).

Biological measurements were taken during the survey on 1 419 specimens. The mean eviscerated mass per sub-area ranged from 0.16 kg (95% CI: 0.15–0.18 kg) in sub-area 3A6 to 0.28 kg (95% CI: 0.25–0.31 kg) in sub-area 3A11 (Figure 8). Values for mean eviscerated masses were similar across the different depth strata, at 0.21 kg, 0.22 kg, 0.23 kg, 0.21 kg, 0.21 kg, and 0.21 kg for the 10–19 m, 20–29 m, 30–39 m, 40–49 m, and 50+ m strata respectively. Specimens sampled from the eastern portions of the survey area appeared to have more variability and a wider range of values than those sampled in the west (Figure 8).

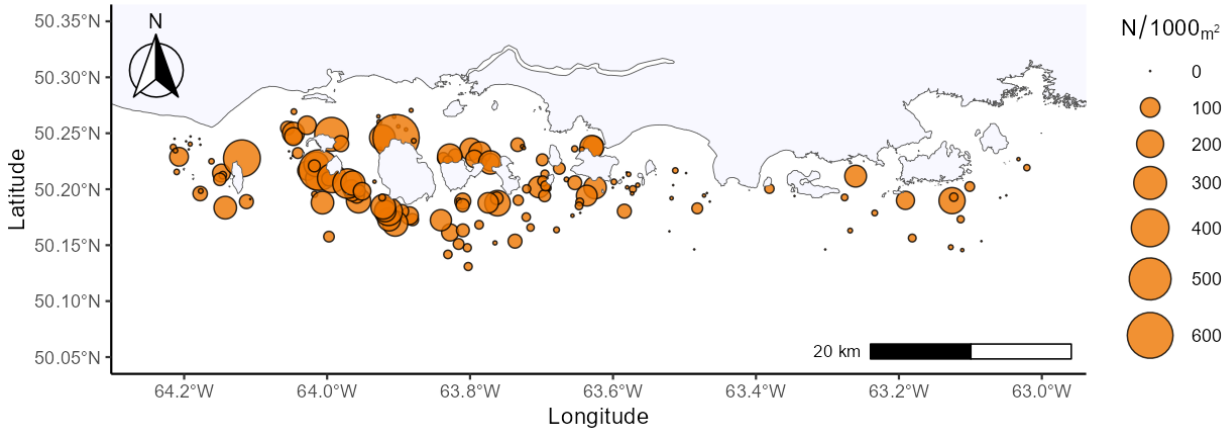

Figure 5. Sea cucumber densities (N/1,000 m^2) observed in the 2022 survey in the inshore waters around the Mingan Archipelago (fishing area 3).

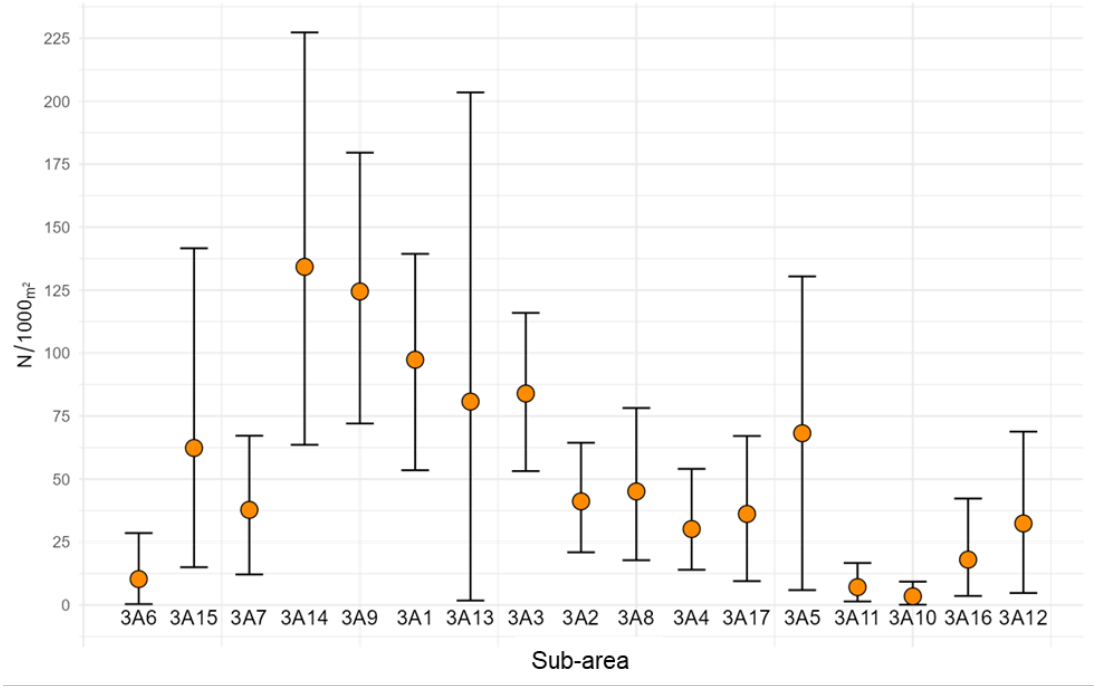

Figure 6. Mean sea cucumber densities (N/1,000 m²) and associated 95% confidence intervals, observed in the 2022 survey by sub-area (from the westernmost strata (left) to the easternmost strata (right)). The sub-area names (3A1–3A17) are listed below the figure.

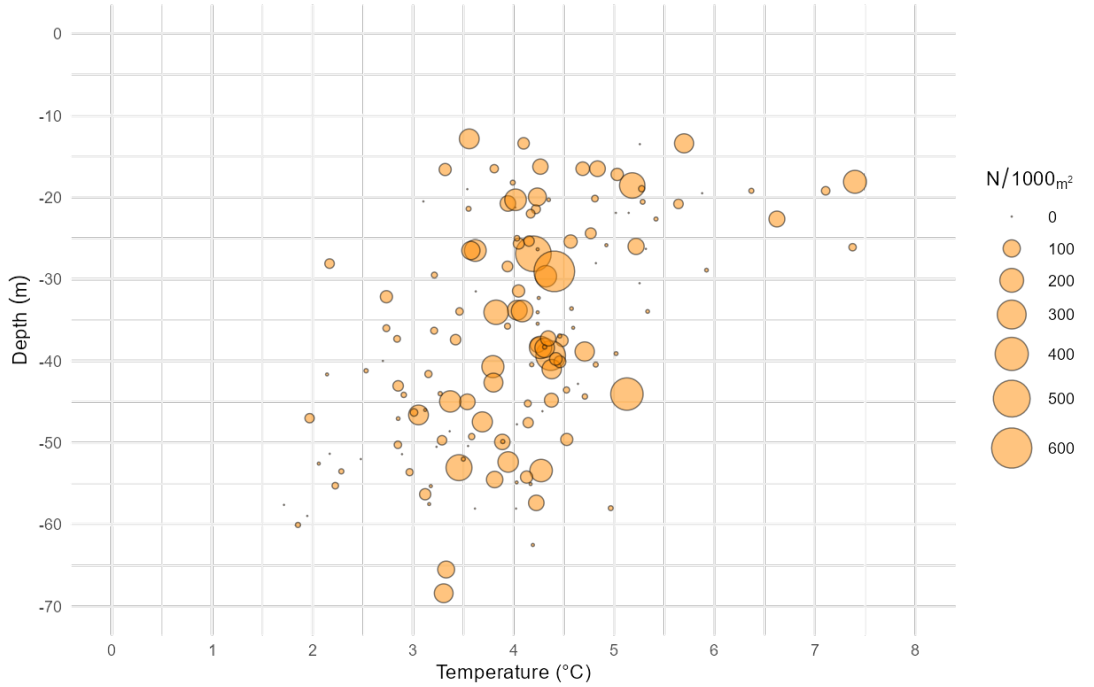

Figure 7. Sea cucumber densities (N/1,000 m²) per station observed in the 2022 survey by depth (m) and bottom temperature (°C).

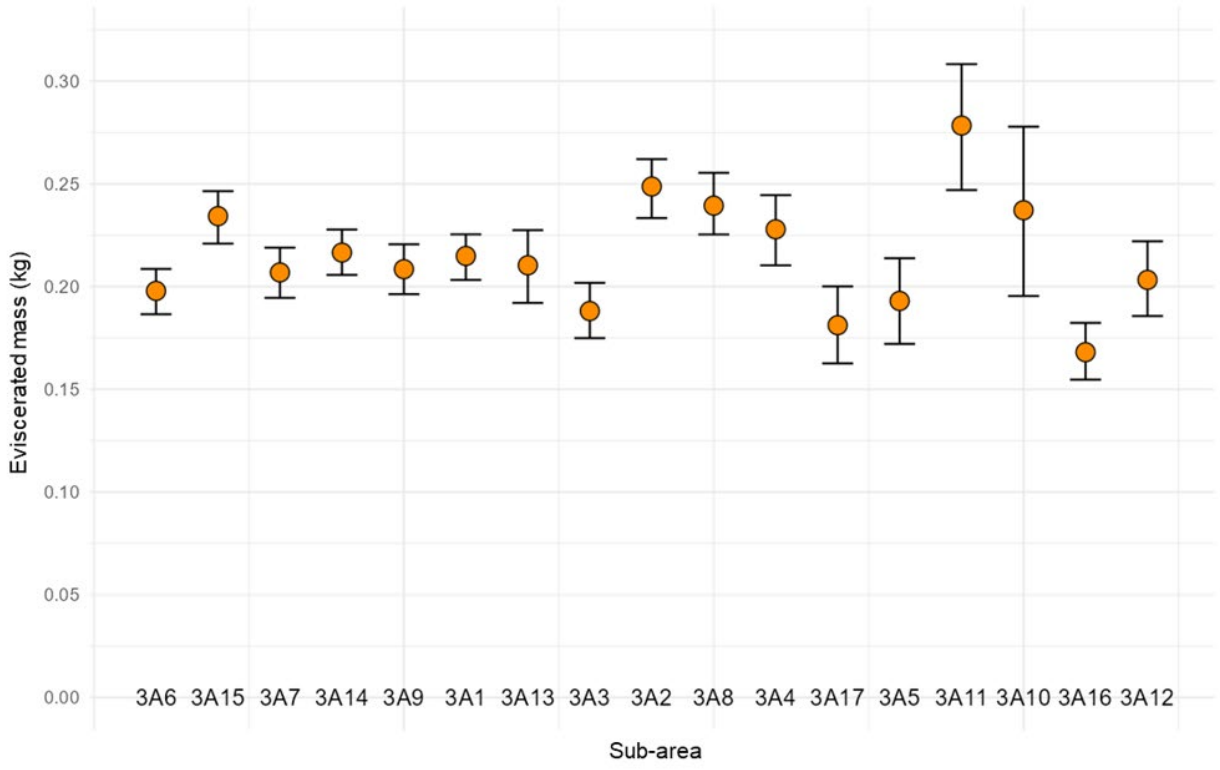

Figure 8. Average eviscerated masses of sea cucumbers (kg) and associated 95% confidence intervals, observed in the 2022 survey by sub-area (from the westernmost strata (left) to the easternmost strata (right)).

Post-season surveys

Since 2013, the MWIFMA has conducted post-season surveys in areas B and C using dredges. The purpose of the surveys was to compare yields in fished sites with respect to yields in unfished sites, protected areas, and closed sites. The objectives were also to monitor the medium- and long-term impacts of dredging on benthic communities. Fixed stations targeting the 32–42 m isobath exploited by the fishery have been sampled annually since 2016 (M.-H. Rondeau, MWIFMA, unpublished data). Results from the post-season survey for the 2021–2023 period show that sea cucumber abundance and biomass in areas B and C were higher at sites where dredge fishing had not been carried out for more than four years than at sites that had been fished with this gear during the current year. These findings align with those of St-Pierre et al. (2021), who also reported greater sea cucumber abundance and biomass in unfished and protected areas in areas B and C than in actively fished areas.

Sources of Uncertainty

This assessment relies largely on the quality of the indices derived from logbook and purchase slip data, the at-sea observer program, the post-season surveys off the Gaspé Peninsula, a single 2018 research survey along the Gaspé Peninsula's north shore and one survey conducted in the Mingan Archipelago in 2022, as well as from biological samples collected in DFO's dockside sampling program. Given that the actual exploitation rate is unknown, it is difficult to adjust effort, quotas, and other management strategies to ensure a sustainable harvest.

Fishing gear used for sea cucumber harvesting has changed over time and varies across regions and permit holders. As a result, differences in the estimated CPUE values between units and years could be due in part to these gear differences. In addition, variations in fishing techniques, such as dredging speed, cable length, towing direction relative to the current, tow duration, time of day, and the use of different vessels, may also affect the estimation of CPUE values. Consequently, interannual variations in CPUE values can largely be due to whether harvesters do not visit the same sites from year to year, if their fishing technique changes, or if their experience differs from that of other harvesters.

Along with differences in fishing methods, incomplete or missing information in logbooks also increases uncertainty. The way that effort is recorded in logbooks, representing the number of hours fished, varies among harvesters, and could either be the total duration of the fishing trip or the time during which the gear is actively fishing. Since effort is critical to estimating CPUE, standardizing how it is reported is necessary to improve the reliability of this metric. However, using the number of tows to standardize CPUE along with standardizing the dredge width to 1 m, is still prone to imprecision if tow lengths vary over time. A more reliable estimate of CPUE could be achieved by contacting harvesters directly and by using data from the at-sea observer program and the Vessel Monitoring System (VMS).

The sea cucumber's unique biology also makes it difficult to monitor stock status. The mean length of individuals measured at sea or dockside is directly influenced by the technique used by the sampler to ensure that all individuals sampled are sufficiently contracted, as well as by the time elapsed between capture and measurement. Recent work (Couillard et al. 2021) showed that the measurement of length and mass in individual sea cucumbers is strongly influenced by capture and handling conditions, which could also affect CPUE and landings values.

These different sources of uncertainty limit the ability to interpret the stock indicators and could therefore result in a poor fit between the conclusions of this advice and the actual status of sea cucumber stocks.

CONCLUSION

Given that the sea cucumber fishery is relatively recent, the existing knowledge on the exploitation of this species remains incomplete or insufficient, making it difficult to establish sustainable exploitation rates and reference points. Consequently, management measures for each area should be periodically reassessed in light of new insights. In the absence of improved information, any increase in fishing effort should be done gradually and only considered when catches and stock status indicators remain stable or show positive trends over multiple years.

In Fishing Area 3, the mean CPUE for 2021–2023 showed a slight increase compared with the 2017–2020 period. However, the effects of the establishment of new sub-areas and protected areas are still too recent to assess their impact on the distribution of fishing effort and stock status. Maintaining annual effort near the levels observed from 2021 to 2023 could help sustain yields over the next three years.

In Fishing Area B, the mean CPUE for 2021–2023 showed a slight increase over that for 2017–2020. Considering the existing conservation measures, maintaining landings at levels similar to those from 2021 to 2023 is unlikely to significantly affect sea cucumber abundance in the area as a whole over the next three years.

In Fishing Area C, despite an increase in CPUE over the past three years, the low volume of landings during this period introduced significant uncertainty into the monitoring of the resource.

Consequently, the current status of the sea cucumber in this area is unclear. Continued monitoring of stock indicators is recommended until the next assessment.

OTHER CONSIDERATIONS

Most commercial sea cucumber fisheries around the world are dive fisheries. Despite the rudimentary methods available to commercial divers, several stocks have collapsed and show no significant signs of recovery, which suggests that sea cucumber species react poorly to high fishing pressure. Consequently, a more precautionary approach to the *Cucumaria frondosa* fishery is critical.

Our knowledge of many aspects of the species, particularly its biology and ecology, is inadequate or insufficient and must be improved. Therefore, efforts must be focused on determining the spawning period in our waters, the minimum density required to ensure adequate reproductive success, growth rates, size at sexual maturity, exploitation rates, spatial and temporal dynamics and the impact of fishing gear on the benthic community, as well as on developing more reliable biometric indicators.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Arseneault, Line	Fisher Area 3
Belley, Rénald	DFO – Science
Bermingham, Tom	DFO – Science
Bernier, Denis	DFO – Science
Boulay, Catherine	DFO – Fisheries Management
Burnsed, Christina	Micmacs of Gesgapegiag Band
Cervello, Gauthier	DFO – Science
Couillard, Catherine	DFO – Science
Cyr, Charley	DFO – Science
De Carufel, Valérie	DFO – Science
Gianasi, Bruno	DFO – Science
Lague, Lydia	DFO – Fisheries Management
Loboda, Sarah	DFO – Science
Marcoux, Guylaine	DFO – Fisheries Management
Nadalini, Jean-Bruno	DFO – Science
Myles, Geneviève	Association des capitaines propriétaires de la Gaspésie
Ouellette-Plante, Jordan	DFO – Science
Paquette, Laurence	DFO – Science
Rochette, Mona	DFO – Science
Rondeau, Marie-Hélène	Association de gestion halieutique autochtone Mi'gmaq et Wolastoqey
Roy, Marie-Josée	DFO – Fisheries Management
Roy, Virginie	DFO – Science
Sandt-Duguay, Emmanuel	Association de gestion halieutique autochtone Mi'gmaq et Wolastoqey
Sean Anne-Sara	DFO – Science
Sean-Fortin, David	DFO – Science
Shaw, Ghislain	Gespeg First Nation

Name	Affiliation
Sigouin, Evelyne	Association de gestion halieutique autochtone Mi'gmaq et Wolastoqey
Smith, Andrew	DFO – Science
Tamdrari Hacène	DFO – Science
Vigneault, Guy	Shipek

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THIS REPORT IS AVAILABLE FROM THE:

Center for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
850 route de la mer
Mont-Joli, QC
G5H 3Z4

E-Mail: dfo.csaquebec-quebeccas.mpo@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-5087
ISBN 978-0-660-77952-2 Cat. No. Fs70-6/2025-036E-PDF

Correct Citation for this Publication:

DFO. 2025. Assessment of Sea Cucumber Stocks in Quebec's Inshore Waters in 2023. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2025/036.

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