



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Ecosystems and
Oceans Science

Sciences des écosystèmes
et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2024/069

Quebec Region

Stock Assessment of Atlantic Surfclam (*Spisula solidissima*) of the Îles-de-la-Madeleine in 2023

Bruno L. Gianasi and Brigitte Desrosiers

Maurice Lamontagne Institute
Fisheries and Oceans Canada
850, route de la Mer
Mont-Joli, Québec, G5H 3Z4

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

[http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca](http://www.dfo-mpo.gc.ca/csas-sccs/csas-sccs@dfo-mpo.gc.ca)



© His Majesty the King in Right of Canada, as represented by the Minister of the
Department of Fisheries and Oceans, 2024

ISSN 1919-5044

ISBN 978-0-660-73956-4 Cat. No. Fs70-5/2024-069E-PDF

Correct citation for this publication:

Gianasi, B. L. and Desrosiers, B. 2024. Stock Assessment of Atlantic Surfclam (*Spisula solidissima*) of the Îles-de-la-Madeleine in 2023. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/069. ix + 42 p.

Aussi disponible en français :

Gianasi, B. L. et Desrosiers, B. 2024. Évaluation du stock de mactre de l'Atlantique (*Spisula solidissima*) des Îles-de-la-Madeleine en 2023. Secr. can. des avis sci. du MPO. Doc. de rech. 2024/069. ix + 43 p.

TABLE OF CONTENTS

ABSTRACT	ix
INTRODUCTION	1
DISTRIBUTION AND BIOLOGY OF THE ATLANTIC SURFCLAM	1
GEOGRAPHIC DISTRIBUTION	1
GROWTH AND LENGTH-AGE RELATIONSHIP	1
REPRODUCTION	2
ENVIRONMENTAL CONDITIONS	2
DESCRIPTION OF THE FISHERY	2
MANAGEMENT MEASURES	3
Commercial hydraulic dredging	3
Commercial and recreational hand harvesting	4
MATERIALS AND METHODS	4
DATA SOURCES	4
Purchase slips	4
Logbooks	4
Commercial catch sampling program	4
DELINEATION OF BEDS	5
STOCK STATUS INDICATORS	5
Landings	5
Fishing effort	5
Catch per unit effort (CPUE)	5
Size structure	6
Bed exploitation indices	6
RESULTS	6
GENERAL INFORMATION	6
COMMERCIAL HYDRAULIC DREDGING	7
Shifts between beds	7
Landings and fishing effort by sub-area	7
Catch per unit effort by bed	7
Area dredged by bed	8
Size structure by bed	8
COMMERCIAL HAND HARVESTING	9
Dive harvesting	9
Onshore harvesting (hand digging)	9
CONCLUSIONS AND CONSIDERATIONS	10
HYDRAULIC DREDGE FISHERY	10
HAND DIGGING	10
ACKNOWLEDGEMENTS	10
REFERENCES CITED	11
TABLES	14

FIGURES	27
---------------	----

LIST OF TABLES

Table 1. Estimated shell width and thickness, live wet weight, age, weight of 300 surfclams, and number of surfclams required for a 66 kg basket, based on the anteroposterior length of Atlantic surfclams from the Îles-de-la-Madeleine.	14
Table 2. Fishing seasons by year and sub-area for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.	14
Table 3. Total allowable catch (t) and effort restriction (days) by sub-area, for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.	15
Table 4. Number of Atlantic surfclams measured in the dredge fishery by sub-area, bed and year under the DFO commercial catch sampling program (2004–2023) and At-Sea Observer Program (2005–2018).	16
Table 5. Number of Atlantic surfclams measured from the commercial dive fishery and onshore (hand digging) harvesting under DFO’s commercial catch sampling program, by shellfish area and year.	17
Table 6. Positions (UTM zone 20N, CRS 32620) of sites used to monitor the non-standardized catch per unit effort (CPUE) in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.	18
Table 7. Number of licences issued annually by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.	18
Table 8. Annual landings (t) by sub-area (5A1 and 5B1) and bed (CGE, East and North), and total landings by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.	19
Table 9. Annual fishing effort (days) by sub-area (5A1 and 5B1) and bed (CGE, East and North), and total fishing effort by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.	20
Table 10. Annual mean non-standardized catch per unit effort (CPUE) (kg/h·m or kg/h) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and bed (CGE, East or North) or shellfish area for the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine.	21
Table 11. Annual mean standardized catch per unit effort (CPUE) (kg/h·m or kg/h) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and bed (CGE, East or North) or shellfish area for the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine.	22
Table 12. Estimated total area (km ²) of known Atlantic surfclam beds in the Îles-de-la-Madeleine, based on logbooks (2002 onward), at-sea sampling (2005 to 2018) and research surveys (2007 and 2012).	23
Table 13. Area (km ²) and proportion (%) of the estimated total area of each bed dredged in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.	23
Table 14. Annual mean size (anteroposterior length in mm) of landed Atlantic surfclams (measured at dockside) by fishing type (dredging and hand harvesting) and bed (CGE, East and North) or shellfish area in the commercial fishery in the Îles-de-la-Madeleine.	24
Table 15. Annual landings (t) by shellfish area for commercial dive harvesting of Atlantic surfclams in the Îles-de-la-Madeleines.	25

Table 16. Annual landings (t) by shellfish area for commercial onshore harvesting (hand digging) of Atlantic surfclams in the Îles-de-la-Madeleine.....26

LIST OF FIGURES

Figure 1. Boundaries of management sub-areas (5A1, 5A2, 5B1 and 5B2), location of exclusion areas and refuge area (A-08.4), and known distribution of the Atlantic surfclam in the Îles-de-la-Madeleine.	27
Figure 2. Von Bertalanffy growth curves for Atlantic surfclams harvested in Eastern Canada in various studies.	28
Figure 3. Morphometric relationship between live wet weight and anteroposterior length of Atlantic surfclams harvested in the Îles-de-la-Madeleine in 2013 and 2014 (Brulotte 2016).	28
Figure 4. Boundaries of the sub-areas (5A1, 5A2, 5B1 and 5B2) for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.	29
Figure 5. Location of the three known Atlantic surfclam beds (CGE, East and North) exploited by the commercial dredge fishery in the Îles-de-la-Madeleine.	29
Figure 6. The location of the main shellfish harvesting areas where the Atlantic surfclam is hand collected in the Îles-de-la-Madeleine.	30
Figure 7. Fishing locations (positions at start of fishing day, shown as white dots) since 2002, and location of sites (black squares) used to monitor non-standardized catch per unit effort (CPUE) in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine, on the CGE and North beds (orange polygons, sub-areas 5A1 and 5B1).	31
Figure 8. Annual landings (t) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and by sub-area in the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine.	32
Figure 9. Location of commercial Atlantic surfclam dredging (fishing positions at start of day, shown as black dots) from 2002 to 2023 in sub-areas 5A1 and 5B1 (orange polygons) in the Îles-de-la-Madeleine.	33
Figure 10. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the Chenal de la Grande-Entrée (CGE) bed, in sub-area 5A1 in the Îles-de-la-Madeleine.	34
Figure 11. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the North bed, in sub-areas 5A1 and 5B1 in the Îles-de-la-Madeleine.	35
Figure 12. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the East bed, in sub-area 5A1 in the Îles-de-la-Madeleine.	36
Figure 13. Changes in the non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery at the monitoring sites in the North (sub-areas 5A1 and 5B1) and CGE beds.	37
Figure 14. Size structure (anteroposterior length) of Atlantic surfclams landed by bed (CGE, East and North) and number of surfclams measured during the Îles-de-la-Madeleine commercial dredge fishery.	38
Figure 15. Landings (t), effort (fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dive fishery in shellfish areas A-09.5 and A-12.1 in the Îles-de-la-Madeleine.	39

Figure 16. Size structure (anteroposterior length) of Atlantic surfclams landed by shellfish area and number of surfclams measured during the Îles-de-la-Madeleine commercial diving fishery.40

Figure 17. Landings (t), effort (fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) for commercial onshore harvesting (hand digging) of Atlantic surfclams in shellfish areas A-09.5, A-12.1, A-17.1 and A-17.4 in the Îles-de-la-Madeleine.41

Figure 18. Size structure (anteroposterior length) of Atlantic surfclams landed by shellfish area and number of surfclams measured during the Îles-de-la-Madeleine commercial hand digging fishery.42

ABSTRACT

Quebec's Atlantic surfclam fishery is confined to the Îles-de-la-Madeleine. Commercial fishing is carried out from vessels in coastal waters using hydraulic clam dredges or by hand harvesting, either by digging by hand or by diving in lagoons and along the coast. Hand harvesting is well established in both the recreational and commercial fisheries in the Îles-de-la-Madeleine. However, the scope of recreational harvesting on the islands is poorly known.

Three surfclam beds were delineated in sub-areas 5A1 and 5B1 based on the location of commercial dredging. The Chenal de la Grande-Entrée (CGE) and East beds are in sub-area 5A1, while the North bed straddles sub-areas 5A1 and 5B1. The fishery initially exploited the CGE and East beds, but expanded to the North bed when the latter was discovered in the 2000s. From 2012 to 2018, the fishery was concentrated mainly in the North bed, but resumed in the CGE bed in 2019. From 2021 to 2023, the fishery operated in both the North and CGE beds.

The total allowable catch (TAC) has not been reached in sub-areas 5A1 and 5B1 since 2019, and average landings in 2021–2023 (177 t) remained below the historical average (193 t, 2002–2020). The decline in landings is partly due to the fluctuating number of active harvesters (between two and four) in recent years. When the fishery resumed on the CGE bed in 2019, the non-standardized catch per unit effort (CPUE) was high (337 kg/h·m). The average for the last three years (232 kg/h·m) is still above the historical average (176 kg/h·m, 2002–2020), but shows a downward trend. The CPUE for the North bed was high in 2021 (330 kg/h·m), but has been falling since then, and the 2021–2023 average (215 kg/h·m) is slightly below the historical average (233 kg/h·m, 2002–2020). Although the size of landed surfclams has remained stable (130 mm), exceeding the minimum legal size of 90 mm, the drop in landings and CPUE values in recent years suggests that removal rates may be too high in sub-areas 5A1 and 5B1.

Landings from commercial hand harvesting (dive fishing and hand digging) varied with the fishing effort. Non-standardized CPUEs in the dive fishery were slightly above the reference mean in sub-area A-12.1, but below it in A-9.5. For onshore harvesting (i.e., hand digging), CPUEs in A-09.5 increased relative to their respective historical means. The average size of landed clams was around 130 mm for dive harvesting and 120 mm for onshore harvesting.

INTRODUCTION

Fisheries and Oceans Canada (DFO) has conducted a review and assessment of the Îles-de-la-Madeleine Atlantic surfclam stock every three years since 2009, with few exceptions. The most recent review was on February 29, 2024. In support of that review (DFO 2024), this document presents the data, techniques, analyses and findings of the resource assessment following the 2023 fishing season.

DISTRIBUTION AND BIOLOGY OF THE ATLANTIC SURFCLAM

GEOGRAPHIC DISTRIBUTION

The Atlantic surfclam occurs along the Atlantic coast of North America, from Gaspé Bay in the Gulf of St. Lawrence to Cape Hatteras in North Carolina (Bousfield 1964, FAO 2019). This endobenthic bivalve prefers soft substrates of medium-grained sand and gravel, or mixed sand, mud and gravel substrates (Medcof and MacPhail 1955, Yancey and Welch 1968, Fréchette and Giguère 1986). Burial depth varies with siphon length, and larger individuals are found deeper in the sediment. Surfclams are planktivorous, using their inhalant siphon to feed by filtering small organisms suspended in the water (Cargnelli et al. 1999).

Surfclam habitat extends from the upper reaches of the infralittoral zone to a depth of 60 m (Caddy et al. 1974, Jones et al. 1983). According to information from logbooks, exploratory fisheries and research surveys (Brulotte 2013), the Atlantic surfclam is found primarily at depths from 0 m to 30 m in the Îles-de-la-Madeleine (Figure 1).

The surfclam is a sedentary species that occurs in relatively large aggregations called beds. Adults are found at water temperatures of 1 °C to 25 °C; temperatures above 28 °C can be lethal (Merrill and Ropes 1969, Snelgrove et al. 1998, Cargnelli et al. 1999).

On the Atlantic east coast, the main predators of the Atlantic surfclam are the northern moon snail (*Euspira heros*), rock crab (*Cancer irroratus*), sand shrimp (*Crangon septemspinosa*), sea stars, various groundfish species such as *Gadus morhua*, and seabirds (Yancey and Welch 1968, Caddy et al. 1974, Mackenzie et al. 1985, Stehlik 1993, Dietl and Alexander 1997, Cargnelli et al. 1999).

GROWTH AND LENGTH-AGE RELATIONSHIP

The anteroposterior length–age relationship calculated in the Îles-de-la-Madeleine in 2012 and 2013 shows rapid growth during the first seven to eight years, followed by a sharp decline (Brulotte 2016 and Figure 2). The Atlantic surfclam reaches a size of 76 mm (the minimum legal size from 2002 to 2013) in four to five years and 90 mm (the minimum legal size from 2014 onward) in five to six years. On the basis of the individuals harvested in 2012 and 2013, the oldest individuals harvested are likely 25 years old. These results are similar to those obtained in 1986 by Gendron (1988) in the Îles-de-la-Madeleine; however, Roberts (1981) reported a higher growth rate in the Northumberland Strait off Prince Edward Island (Figure 2).

According to the literature, the Atlantic surfclam could have a lifespan of at least 30 years and could reach a maximum size of 226 mm (Ropes and Ward 1977, Jones et al. 1978, Ropes 1980, Fay et al. 1983, Sephton and Bryan 1990, Weinberg 1999, NOAA 2019). In several regions, the Atlantic surfclam typically lives to an age of 15 to 25 years. The maximum size observed to date in the Îles-de-la-Madeleine is 184 mm, in 2016.

Width, thickness and live weight values for various shell lengths are shown in Table 1, based on morphometric relationships calculated in 2012–2013 in the Îles-de-la-Madeleine (Brulotte 2016 and Figure 3). For example, an individual that measures 130 mm (the average size of landed surfclams) is about 12–13 years old and weighs 375 g (Brulotte 2016).

REPRODUCTION

The Atlantic surfclam is a dioecious species, meaning that it has separate sexes but is not sexually dimorphic. According to Sephton and Bryan (1990), surfclams reach sexual maturity at four years. In the Îles-de-la-Madeleine, a four-year-old surfclam measures between 55 mm and 85 mm (Brulotte 2016 and Figure 2). According to Giguère et al. (2005), surfclams harvested in the Îles-de-la-Madeleine measuring between 75 mm and 92 mm were all sexually mature. These authors also reported that the gonads are fully ripened by mid-May and spawning takes place mainly in July and August.

The gametes are released into the water, where the oocytes are fertilized (Ropes 1978). The fertilized eggs develop into larvae, which are pelagic. The duration of the larval phase depends on water temperature: about 35 days at 14 °C or 19 days at 22 °C (Loosanoff and Davis 1963, Fay et al. 1983). After metamorphosis, which occurs when the larvae reach a length of approximately 300 µm, the juveniles settle to the bottom and begin their benthic life stage (Ropes 1980, Fay et al. 1983).

ENVIRONMENTAL CONDITIONS

The Îles-de-la-Madeleine are at the northern limit of the Atlantic surfclam's range (FAO 2019). Any change in the water temperature at depths between 0 m and 50 m could impact the species' distribution and abundance. In recent years, average sea surface temperatures in the Magdalen Shallows in August and September have been similar to or higher than the mean (Galbraith et al. 2022). The Atlantic surfclam is a warm-water species, and this observed warming could extend its range into somewhat deeper water (25–35 m) and increase its productivity in the Îles-de-la-Madeleine. However, it could also reduce the species' presence in lagoons, where temperatures could become too high at certain times of the year (Weinberg 2005). It is clear that climate change will have an impact on the Atlantic surfclam distribution in the relatively short term (Munroe et al. 2016, Hofmann et al. 2018, Timbs 2018).

DESCRIPTION OF THE FISHERY

The Atlantic surfclam fishery in Quebec is confined to the Îles-de-la-Madeleine. Commercial dredging, which is limited mainly to the eastern part of the Îles-de-la-Madeleine, is conducted from vessels in coastal waters using a New England hydraulic dredge (Lambert and Goudreau 1996). Hand harvesting is carried out by divers or onshore harvesters using hand tools; this fishery takes place in a number of shellfish areas in lagoons and along the coast, on both a recreational and commercial basis.

Exploratory fisheries using hydraulic dredges were carried out in the Îles-de-la-Madeleine in 1948–1949, and in 1978, 1984 and 1985 (Medcof and MacPhail 1955, Bernier and Poirier 1979, Bio-Conseil Inc. 1986, Fréchette and Giguère 1986, Giguère et al. 2005), at depths of less than 15 m. These activities resulted in only two small surfclam beds being located: one at the entrance to Chenal du Havre aux Maisons (roughly in line with shellfish area A-16.1.2) and the other along Dune du Sud, near shellfish area A-12.1 (Giguère et al. 2005). Two hydraulic dredge exploratory licences were issued in 1986, resulting in total landings of 46.5 t in 1986 and less than 1 t in 1987 (Gendron 1988). In 1986, the performance of the fishery plummeted during

the fishing season, from 189 kg/h·m in July to 55 kg/h·m in December, and it was concluded that these two beds could not support long-term commercial harvesting.

Nevertheless, some harvesters continued to explore the area with mechanical gear, and a more intensive fishery began in the late 1990s, mainly at the entrance to Chenal de la Grande Entrée (at the northeastern end of shellfish area A-12.1). In the fall of 2001, an advisory committee was created and, in March 2002, the first management plan was implemented for the commercial dredge fishery. At that time, hand harvesting by divers and onshore harvesters was unregulated. It was not until 2023, when the *Atlantic Fishery Regulations, 1985*, were amended, that a more effective framework was established for managing recreational harvests of Atlantic surfclam, as well as of several other mollusc species. This framework designated authorized gear, minimum legal sizes and daily catch limits. An initial management plan was established in the spring of 2005 to regulate commercial and recreational hand harvesting of Atlantic surfclams in the Îles-de-la-Madeleine.

MANAGEMENT MEASURES

Commercial hydraulic dredging

Commercial hydraulic dredging was initially concentrated on the eastern side of the Îles-de-la-Madeleine, in an area within current sub-area 5A1. To encourage exploration of all of area 5, it was divided into two sub-areas in 2005, into three sub-areas in 2008, and ultimately into four sub-areas in 2011, namely 5A1, 5A2, 5B1 and 5B2 (Figure 4 and Table 2). Despite these incentives, sub-areas 5A2 and 5B2 remained lightly fished. The boundaries of sub-areas 5A1 and 5B1 were slightly modified in the northern part of the Îles-de-la-Madeleine in 2013 (Brulotte 2013). The various monitoring indicators presented here have all been recalculated to take into account the new sub-area boundaries.

Three Atlantic surfclam beds in the Îles-de-la-Madeleine have been delineated using fishing positions recorded in logbooks since 2002. Their boundaries are adjusted to take account of the new data from each stock assessment, by using ArcGIS software to create polygons around the georeferenced positions where hydraulic dredge fishing has taken place since 2002. The three known surfclam beds on the Îles-de-la-Madeleine are the Chenal de la Grande-Entrée (CGE) bed and the East bed, which are in sub-area 5A1, and the North bed, which straddles sub-areas 5A1 and 5B1 (Figure 5).

Most of the current management measures for the dredge fishery in the Îles-de-la-Madeleine were in place by 2002. They include the requirement to complete a logbook, a maximum dredge width of 2.13 m, and minimum spacing of 3.175 cm between dredge bars. The fishing season varies slightly from year to year, but typically runs from late March to late December; the fishery is closed during the spawning period (July and August) in sub-areas 5A1, 5A2 and 5B1 (Brulotte 2013 and Table 2).

There are four commercial hydraulic dredge licences. Since 2016, they have included individual transferable quotas (ITQs). Beginning in 2005, dredging in lagoons was prohibited, and shellfish area A-08.4 was designated as a refuge closed to all commercial and recreational fishing (Figure 1). In 2011, exclusion areas were added to protect lobster habitat, mainly north of the Îles-de-la-Madeleine (DFO 2011 and Figure 1). From 2005 to 2018, DFO required 5% observer coverage under the At-Sea Observer Program, but at-sea observer coverage ended in 2019.

A total allowable catch (TAC) for the dredge fishery was introduced in 2002 (Brulotte 2013). Since 2013, the TAC has been set at 125 t in 5A1, 55 t in 5A2 and 113 t in 5B1; in 5B2, fishing effort is limited to 12 fishing days (Table 3). Lastly, since 2015, dockside weighing has been mandatory for all landings in the dredge fishery.

The minimum legal size was 76 mm from 2002 to 2013, but was increased to 90 mm in 2014.

Commercial and recreational hand harvesting

Hand harvesting is carried out with hand tools, and either involves digging for clams on shore or diving for them underwater; this practice is authorized in a number of shellfish areas in the lagoons and along the coast (Figure 6). From 2005 to 2013, the minimum legal size was 76 mm for both commercial and recreational harvesters; in 2014, it was increased to 90 mm. The other management measures have remained unchanged since their implementation in 2005. The fishing season for hand harvesting extends from mid-January to late December, between sunrise and sunset. Hand harvesting may be carried out commercially or recreationally, but a commercial licence is required for the harvest or sale of more than 300 surfclams per day. There is currently no restriction on the number of licences that may be issued. Hand harvesters with a commercial licence are required to complete a logbook. There is no maximum catch limit for hand digging by onshore harvesters, but the commercial dive fishery has been subject to a maximum daily limit of 680 kg since 2016.

The harvesting grounds in and around the Îles-de-la-Madeleine are divided into approximately 50 shellfish areas, nearly half of which are open (approved or conditionally approved) to hand harvesting of molluscs. Hand harvesting of Atlantic surfclams is mainly concentrated in about 10 areas (Figure 6). The Canadian Shellfish Sanitation Program (CSSP 2019) regularly issues guidelines on the status of shellfish areas. Fishers and hand harvesters must ensure that shellfish areas are open before they begin harvesting.

MATERIALS AND METHODS

DATA SOURCES

Commercial fishery data are taken from three different sources: purchase slips, logbooks and commercial catch sampling.

Purchase slips

Purchase slips are completed by the buyer and provide official figures on surfclam landings sold to a processing facility. Data for the current year are generally considered preliminary, because the data from some of the logbooks may not yet be entered at the time of analysis. Data are validated annually by DFO-Science to eliminate or correct outliers (effort, location, etc.).

Logbooks

Harvesters in the dredge fishery must fill out a logbook daily, providing the following information, among others: fisher identification number (FIN), vessel registration number (VRN), landing date, catch date, fishing position (start and end of the day), fishing sub-area, number of dredging hours and landed weight.

For commercial hand harvesting, fishers must complete the logbook after each fishing day, indicating their name, FIN, harvesting date, shellfish area visited, total quantity fished, duration of harvesting (in hours), the type of fishing (hand digging onshore or diving) and the number of hand harvesters present.

Commercial catch sampling program

Since 2005, the DFO commercial catch sampling program has gathered data to measure the size structure of surfclam landings. Sampling is done either at the dock or at the plant. Typically,

10 samples per fishing type are collected annually under the sampling program. Since 2004, one sample has corresponded to about 150 measured surfclams. Tables 4 and 5 show the number of surfclams measured by sub-area, bed, shellfish area and year. The size of Atlantic surfclams is based on the anteroposterior length of the shell (mm).

DELINEATION OF BEDS

Three main fishing areas or beds—CGE, East and North (Figure 5)—were delineated based on the daily fishing positions recorded in commercial dredge fishery logbooks (2002 onward), tow positions provided by at-sea sampling (2005 to 2018) and comments from fishers. The area of the beds is adjusted on the basis of the new data from each stock assessment by creating polygons around the georeferenced positions where fishing has taken place.

The area of the known beds available to the fishery was estimated using the Kernel Density tool (ArcGIS 10.0, available with the Spatial Analyst licence), as described in Trottier and Goudreau (2015). The calculated area ($\pm 0.5 \text{ km}^2$) corresponds to the minimum area in which 95% of the fishing positions are distributed. Exclusion areas (under lobster habitat protection) were subtracted from the final areas.

STOCK STATUS INDICATORS

The commercial fishing indicators used to assess the Atlantic surfclam stock include annual landings, fishing effort, catch per unit effort (CPUE) and size structure of landings. For the commercial dredge fishery, the exploitation index was also used.

Landings

Annual landings, expressed in tonnes (t) of live weight, consist of the total landings from all commercial fishing activities, and are compiled by fishing type (dredging, hand harvesting by divers, and hand harvesting by onshore harvesters) and by year. For dredging, official landings from 2002 to 2014 were estimated on the basis of the number of baskets landed multiplied by the mean weight of one basket (54 kg per basket from 2002 to 2011 and 66 kg per basket from 2012 to 2014). The increase in basket weight was necessary because, over the years, harvesters had been filling their baskets a little more. Since 2015, dockside weighing has been mandatory for dredge fishery landings. In the hand harvest, various types of pails or bins are used. The mean weight of surfclams was measured for each container type and is used to estimate landings.

Fishing effort

Fishing effort is expressed in days and is the sum of all fishing days of each harvester, regardless of the time spent fishing. Total effort is the sum of all fisher-days by fishing type.

Catch per unit effort (CPUE)

The non-standardized CPUE is calculated on the basis of the number of hours fished each day as recorded in the logbooks and is expressed in kilograms of live weight per fishing hour and per metre of gear width (kg/h·m) for dredging, and in kilograms of live weight per fishing hour (kg/h) for hand harvesting. CPUEs are usually standardized (PROC MIXED, SAS version 9.3, values were first transformed to natural log) to take into consideration the effect of certain variables on catch rate (Gavaris 1980). For the dredge fishery, the CPUEs are standardized by bed, taking into account the following variables: year, fishing month and fisher identification number (FIN). The calculation only includes harvesters who have been active for at least three years. For hand harvesting, CPUEs are standardized by the type of harvesting—diving or

onshore harvesting—for the main shellfish areas, considering the year and FIN. Harvesters must have made at least 30 trips to be included.

During the 2012 stock assessment, the CPUE values for the dredge fishery were analyzed to determine the impact of changing the conversion factor used to estimate basket weight and to ensure that CPUEs were comparable across the entire time series (Brulotte 2013). The analysis results showed that these adjustments had little impact on overall interannual trends for standardized CPUEs.

Given the low numbers of active dredge harvesters and experienced hand harvesters in recent years, it was agreed at the 2019 and 2024 peer review meetings that the non-standardized CPUE would be used to calculate fishery performance. Accordingly, this document uses mainly non-standardized CPUEs, although standardized CPUEs have not been eliminated, given their validity.

Size structure

Size structures are aggregated by fishing type, bed or shellfish area and by year, to obtain the annual size structure of surfclam landings. The figures are aggregated to ensure each sample has the same weighting (thereby eliminating the effect of the variation in the number of surfclams measured).

The length of landed surfclams is shown by year, and by bed or shellfish area, using a boxplot. The bar inside the box represents the median, the bottom and top of the box represent the 25th and 75th percentiles, the vertical lines at either end of the box (the whiskers) represent the range of the values, and points beyond the whiskers represent outliers.

Bed exploitation indices

Each year, the dredge fishery typically targets new portions of beds, i.e., harvesters travel within a bed and explore new fishing sites. To identify variations in the CPUE, monitoring was conducted using small areas fished in the North bed, one in sub-area 5A1 and the other in sub-area 5B1, and in the CGE bed (Figure 7 and Table 6). Observations were selected from the daily positions (start and end) recorded by the harvesters in their logbooks. The resulting annual non-standardized CPUEs are shown using a boxplot.

The bed exploitation index is estimated by using the proportion of each bed that is dredged annually relative to the total known area of the bed. The area dredged annually was calculated by multiplying the dredging duration recorded in the logbooks by the dredge width and an average tow speed of 1,519 m/h (0.8 knots). This average speed was calculated using at-sea sampling data from 2006 to 2018 that was verified by harvesters. The formula for calculating the exploitation index is as follows:

$$\text{Index (\%)} = \frac{\text{area dredged annually}}{\text{total known area}} \times 100$$

RESULTS

GENERAL INFORMATION

Four harvesters were active in the hydraulic dredge fishery in sub-areas 5A1 and 5B1 between 2002 and 2018. However, since 2019, the number of active harvesters in this fishery has fluctuated between two and four (Table 7).

From 2002 to 2004, commercial Atlantic surfclam landings in the Îles-de-la-Madeleine hovered around 110 t; these landings came exclusively from dredge fishing in the CGE and East beds (Figure 8 and Table 8). Subsequently, landings gradually increased to reach nearly 290 t in 2009. This increase was primarily due to the start of harvesting in the part of the North bed that is in sub-area 5B1. Between 2012 and 2018, total commercial landings ranged from 242.9 t to 304.0 t annually (Table 8). Since 2019, average landings have totalled 177 t, below the historical average (193 t, 2002–2020).

The monitoring of commercial hand harvesting has been possible since 2005, with the introduction of a logbook requirement in this fishery. Annual landings are variable, as they are dependent on fishing effort (Figure 8 and Table 8). Between 2021 and 2023, the average landings in the dive fishery (37 t) and for onshore harvesting (14 t) remained above their respective historical averages (22 t and 11 t respectively, 2002–2020).

Landings and effort data in the following sections are presented by sub-area since management measures are specific to each sub-area. However, CPUE data and size structures are presented by bed to better document changes over the years in each of the beds.

COMMERCIAL HYDRAULIC DREDGING

Shifts between beds

The commercial hydraulic dredge fishery initially exploited the CGE and East beds and then expanded to the North bed when the latter was discovered in the early 2000s (Figure 9). Between 2012 and 2018, harvesting focused mainly on the North bed, but resumed in the CGE bed in 2019. From 2021 to 2023, the fishery operated in both the Nord and CGE beds. The East bed remains very lightly fished (Figure 9 and Table 8).

Landings and fishing effort by sub-area

Over the years, total landings in sub-area 5A1 have ranged between 65.9 t and 133.6 t (Figure 8 and Table 8). The TAC of 125 t was either reached or slightly exceeded from 2002 to 2018, but has not been attained since 2019. Annual landings in 2023 (65.9 t) were the lowest in the time series. The fishing effort in 5A1 peaked (50–65 days) at the beginning of the fishery, but has dropped significantly since 2011. In 2023, the effort was 20 days, one of the lowest values in the time series (Table 9).

Prior to 2008, sub-area 5B1 was fished only occasionally (Figure 9). Harvesting in the portion of the North bed in sub-area 5B1 did not really begin until 2009, with landings of 160.3 t (Table 8). Since 2009, annual landings in 5B1 have ranged from 65 t to 160.3 t. In 2023, landings were the lowest (65 t) in the time series. Fishing effort ranged between 18 and 53 days from 2009 to 2022. In 2023, it dropped to 17 days, one of the lowest values in the time series (Table 9).

Catch per unit effort by bed

CPUE, dredged area and size structure data are shown by bed, to better assess the status of each bed.

The non-standardized CPUE in the CGE bed has varied over the years. Between 2002 and 2007, it was around 100 kg/h·m, but it rose from 138 kg/h·m to 255 kg/h·m between 2008 and 2012 (Figure 10 and Table 10). Between 2013 and 2018, this bed was not fished, as the fishery was concentrated mainly in the North bed. In 2019, fishing resumed in the CGE bed, with a high CPUE of 347 kg/h·m recorded that year. This increase suggests that the period without

harvesting was beneficial for the reestablishment of clam populations. However, since 2019, the CPUE has fallen, reaching 153 kg/h·m in 2023 (Figure 10).

Exploitation of the North bed began in 2004, but did not really pick up until 2009, when it was discovered that the North bed extended into 5B1; the CPUE reached 233 kg/h·m that year (Figure 11 and Table 10). After peaking at 383 kg/h·m in 2012, the CPUE has shown a general downward trend. Between 2021 and 2023, the mean CPUE was 215 kg/h·m, slightly below the reference mean of 233 kg/h·m.

The East bed was exploited mainly between 2002 and 2010, generating non-standardized CPUEs ranging from 94 kg/h·m to 185 kg/h·m. However, harvesting has been sporadic since 2011 (Figure 12 and Table 10).

Standardized CPUE values are shown in Table 11. However, insufficient data were available to calculate the standardized CPUEs for some years.

Tracking changes in CPUEs over the years is useful at sites that have been fished for a number of years, given that harvesters are continuing to look for new fishing sites. Two monitoring sites in the North bed were selected for this purpose, one in sub-area 5A1 and the other in sub-area 5B1, as well as one site in the CGE bed (Figures 7 and 13).

CPUE values at the site in sub-area 5A1 in the North bed fluctuated between 200 kg/h·m and 400 kg/h·m between 2010 and 2021 (Figure 13). This site was not fished in 2022 or 2023. CPUE values at the site in sub-area 5B1 in the North bed were stable between 2010 and 2021, ranging between 200 kg/h·m and 400 kg/h·m. However, the CPUE fell sharply in 2022 and 2023 to values around 100 kg/h·m. In the CGE bed, CPUE values have been decreasing, falling from 500 kg/h·m to 100 kg/h·m in recent years (Figure 13).

Area dredged by bed

In 2023, the total area of all beds in sub-areas 5A1 and 5B1 was estimated to be 40.1 km² (Table 12). The areas of the CGE and East beds have increased slightly, from 4 km² and 11 km² respectively in 2002–2018 to 5.1 km² and 14.1 km² in 2021 onwards. The total area of the North bed, estimated at 10 km² in 2009, increased to 21.5 km² in 2018, as a result of the exploitation of new fishing sites (Figure 9). The number and area of known beds depend on harvesters' exploration activities. Currently, sub-areas 5A1 and 5A2 may be well known, but exploration continues in sub-areas 5B1 and 5B2 (Figure 9).

From 2002 to 2008, between 9% and 13% of the known area of the CGE and East beds was being dredged in some years (Table 13). Exploitation of the North bed intensified after 2009 and, between 2009 and 2019, between 5% and 7% of the bed's known area was dredged according to estimates. In recent years, the area dredged in the North bed has decreased, but has increased in the CGE bed, with the resumption of fishing in this bed in 2019. From 2021 to 2023, between 2% and 3% of the known area of the North bed was dredged, and between 7% and 10% of the known area of the CGE bed (Table 13).

Size structure by bed

The average size of surfclams measured each year in dockside and at-sea sampling are shown in Table 14, and size structures by bed are shown in Figure 14.

The size structures of surfclam landings in the last five years are fairly similar (Figure 14). Few surfclams smaller than 90 mm are harvested or landed. In addition, harvesters report that they do minimal sorting of their catches and that processing plants prefer surfclams larger than 100 mm. The 2014 increase in the minimum legal size to 90 mm has had little impact on

average size, due to the fact that, since 2007, landed surfclams have typically been larger than 100 mm.

COMMERCIAL HAND HARVESTING

Hand harvesting of Atlantic surfclams takes place in about 10 shellfish areas. However, harvesting occurs more regularly in A-09.5 (mainly islets B and C) and A-09.1 (in the Lagune de la Grande Entrée), along Plage de la Dune du Sud (A-12.1), in the Chenal du Havre aux Maisons (A-16.1.2), in the Parc de Gros-Cap campground (A-16.2.1.1) and along the Plage de La Martinique (A-17.1) and the Sandy Hook dune (A-17.4) in Baie de Plaisance (Figure 6).

Since 2010, the number of licences issued has ranged between 52 and 77 for dive fishing and between 47 and 103 for onshore fishing (Table 7). However, the number of active licences remains very low. In 2023, latent effort (the ratio of unused licences to the total number of licences issued) was 88% for dive fishing and 69% for onshore fishing (Table 7). Although the fishing season runs from mid-January to late December, the actual fishing season is shorter, typically from mid-March to early October.

Since 2005, annual landings by the commercial hand harvest fishery have ranged from 11.5 t to 58.5 t (Table 8), and fishing effort has ranged from 105 to 299 days (Table 9).

Dive harvesting

Since 2005, landings from commercial dive harvesting have varied considerably from year to year, ranging from 1.5 t to 47.3 t depending on divers' fishing effort (Table 8). The variations in landings paralleled those in fishing effort (Table 9). Annual landings by the dive fishery in the last three years (2021–2023) averaged 36.7 t, representing 91 days of fishing effort. These landings came mainly from shellfish area A-12.1 and, to a lesser extent, shellfish areas A-09.5, A-16.2.1.1 and A-17.1 (Table 15).

In shellfish area A-12.1, non-standardized CPUE values for commercial dive harvesting remained above 80 kg/h between 2007 and 2009 (Figure 15 and Table 10). CPUE values then fell, but stabilized at around 50–65 kg/h in 2010–2014. After reaching a historic low in 2015 at 39.6 kg/h, values stabilized at near the mean in the following years. The mean CPUE for the last three years (72 kg/h) is slightly higher than the reference mean (69 kg/h, Figure 15).

In general, CPUE values for shellfish area A-09.5 were lower than those for A-12.1. The mean CPUE for the last three years (46 kg/h) is below the reference mean (54 kg/h), despite a marked increase in 2023 (Figure 15).

Surfclams harvested by divers and measured at landing were large (Figure 16 and Table 14). Since 2010, landings have contained few individuals smaller than 100 mm. The average size of landed surfclams from shellfish area A-12.1 was between 129 mm and 145 mm. Over the last three years, the average size of landed surfclams has been around 130 mm, with some slight variations. The average size of landed surfclams from shellfish area A-09.5, around 112 mm, is slightly smaller than those from shellfish area A-12.1. However, it is worth noting that, in these areas, the number of samples collected and the number of surfclams measured were sometimes low (Figure 16).

Onshore harvesting (hand digging)

Annual landings from commercial onshore harvesting are highly variable, ranging from 0.2 t to 21.1 t (Table 8), with an average of 14.0 t in the last three years. Since monitoring began, commercial landings have come mainly from shellfish area A-09.5 (Table 16). However,

landings from shellfish areas A-12.1, A-17.1 and A-17.4 have increased somewhat in recent years (Figure 17).

Landings varied with fishing effort. Effort in all shellfish areas ranged between 64 and 189 days per year (Figure 17 and Table 9).

In shellfish area A-09.5, non-standardized CPUE values were relatively high between 2005 and 2009, at around 30 kg/h. CPUEs then fell, with values estimated at around 20 kg/h between 2010 and 2016. Since 2017, CPUE values have increased to roughly 30 kg/h. In the last three years, the mean CPUE has been 33 kg/h, well above the historical mean (Figure 17 and Table 10). CPUE values have also been increasing in shellfish areas A-12.1, A-17.1 and A-17.4 (Figure 17).

The surfclams landed in this fishery have the smallest mean size among the three commercial surfclam fisheries (Table 14). The 2014 increase in the minimum legal size to 90 mm has had a noticeable effect on size structures and mean sizes (Figure 18). There is a great deal of variability in size structures and mean sizes between years and between shellfish areas. Across all shellfish areas, the mean size ranged from 117 mm to 121 mm in the last three years (Figure 18).

CONCLUSIONS AND CONSIDERATIONS

HYDRAULIC DREDGE FISHERY

Since 2019, TACs for the hydraulic dredge fishery in sub-areas 5A1 and 5B1 have not been reached. The drop in landings is partly attributable to the decline in the number of active fisherman. The decline in landings and CPUE in recent years suggests that removal rates may be too high in sub-areas 5A1 and 5B1, despite the movement of fisherman between different beds (CGE and North).

HAND DIGGING

Whereas the scope of recreational harvesting is not well known, reported commercial landings vary and depend on the fishing effort.

For dive harvesting, non-standardized CPUE values in the two most heavily fished shellfish areas (A-09.5 and A-12.1) were slightly above the reference mean in A-12.1, but below the mean in A-9.5. For onshore harvesting, CPUEs in A-09.5 have increased relative to the historical average. The average size of landed surfclams is around 130 mm in the dive fishery and around 120 mm for onshore harvesting. According to this data, landings from clam digging fishery can be maintained at this level.

ACKNOWLEDGEMENTS

We would like to thank the technical support and sampling team and DFO's commercial catch sampling program, as well as Sophie Boudreau, Michelle Langford, Louise Girard, Denis Bernier, Caroline Vanier, and the contract employees who collected the data. In addition, our thanks go to the staff of the Fisheries Management Branch – Statistics and Licensing Division in Quebec City and at the area offices. We would also like to thank all of the harvesters involved in the commercial Atlantic surfclam fishery. Lastly, special thanks go to Charley Cyr and Virginie Roy for reviewing this document.

REFERENCES CITED

- Bernier, L. and Poirier, L. 1979. Évaluation sommaire du stock de mactres de l'Atlantique, *Spisula solidissima* Dillwyn, des Îles-de-la-Madeleine (Golfe du Saint-Laurent). MICQ, D.G.P.M., Cahier d'Information No 92. 42 p.
- Bio-Conseil, Inc. 1986. Pêche exploratoire à la palourde (*Spisula solidissima*) aux Îles-de-la-Madeleine, automne 1985. Rapport final, Québec. 9 p.
- Bousfield, E.L. 1964. Coquillages des côtes canadiennes de l'Atlantique. Musée national du Canada, Ottawa, 89 p.
- Brulotte, S. 2013. [Évaluation des stocks de la mactre de l'Atlantique, *Spisula solidissima*, des eaux côtières des Îles-de-la-Madeleine – méthodologies et résultats](#). Secr. can. de consult. sci. du MPO. Doc. de rech. 2013/082. x + 58 p.
- Brulotte, S. 2016. [Évaluation des stocks de la mactre de l'Atlantique, *Spisula solidissima*, des Îles-de-la-Madeleine, Québec en 2015 – méthodologie et résultats](#). Secr. can. de consult. sci. du MPO. Doc. de rech. 2016/074. x + 51 p.
- Caddy, J.F., Chandler, R.A. and Wilder, D.G. 1974. Biology and commercial potential of several underexploited molluscs and crustaceans on the Atlantic coast of Canada. Federal-Provincial Fisheries Committee. Meeting on Utilization of Atlantic Resources, Montréal, February 5-7 1974. 111 p.
- Cargnelli, L.M., Griesbach, S.J., Packer, D.B. and Weissberger, E. 1999. Essential fish habitat source document: Atlantic surfclam, *Spisula solidissima*, life history and habitat characteristics. NOAA Tech. Memo. NMFS-NE-142. 13 p.
- CSSP. 2019. [Canadian Shellfish Sanitation Program](#). Government of Canada
- DFO. 2011. [Identification of Atlantic surfclam fishing areas off Grosse-Île \(Magdalen Islands, Quebec\) to avoid impacting lobster habitat](#). DFO Can. Sci. Advis. Sec. Sci. Resp. 2011/006.
- DFO. 2024. [Assessment of the Îles-de-la-Madeleine Atlantic Surfclam Stock in 2023](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2024/025.
- Dietl, G.P. and Alexander, R.R. 1997. Predator-prey interactions between the naticids *Euspira heros* Say and *Neverita duplicata* Say and the Atlantic surfclam *Spisula solidissima* Dillwyn from Long Island to Delaware. J. Shellfish Res. 16 : 413-422.
- FAO (Food and Agriculture Organization of the United Nations). 2019. [Fisheries and Department. Species fact sheets, *Spisula solidissima* \(Dillwyn, 1817\)](#). (consulted February 2, 2019).
- Fay, C.W., Neves, R.J. and Pardue, G.B. 1983. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic) surf clam. U.S. Fish and Wildlife Service, Division of Biological Services, FWS/OBS-82/11.13. U.S. Army Corps of Engineers, TR EL-82-4. 23 p.
- Fréchette, M. and Giguère, M. 1986. Rapport sur une pêche exploratoire à la palourde aux Îles-de-la-Madeleine. MPO. Rapport interne. 12 p.
- Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. 37 : 2272-2275.
- Galbraith, P.S., Chassé, J., Dumas, J., Shaw, J.-L., Caverhill, C., Lefavre, D. and Lafleur, C. 2022. [Physical Oceanographic Conditions in the Gulf of St. Lawrence during 2021](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2022/034. iv + 83 p.

-
- Gendron, L. 1988. [Exploitation et état du stock de mactres \(*Spisula solidissima*\) des Îles-de-la-Madeleine en 1986](#). Rap. manus. can. sci. halieut. aquat. 1993 : v + 17 p.
- Giguère, M., Brulotte, S., Paille, N. and Fortin, J. 2005. [Mise à jour des connaissances sur la biologie et l'exploitation de la mactre de l'Atlantique \(*Spisula solidissima*\) aux Îles-de-la-Madeleine](#). Rapp. tech. can. sci. halieut. aquat. 2587 : ix + 32 p.
- Hofmann, E.E., Powell, E.N., Klinck, J.M., Munroe, D.M., Mann, R., Haidvogel, D.B., Narvarz, D.A., Zhang, X. and Kuyendall, K.M. 2018. An overview of factors affecting distribution of the Atlantic Surfclam (*Spisula solidissima*), as continental shelf biomass dominant, during a period of climate change. J. Shellfish Res. 37(4) : 821-831.
- Jones, D.S., Thompson, I. and Ambrose, W. 1978. Age and growth rate determinations for the Atlantic surf clam *Spisula solidissima* (bivalvia: mactracea), based in internal growth lines in shell cross-sections. Mar. Biol. 47 : 63-70.
- Jones, D.S., Williams, D.F. and Arthur, M.A. 1983. Growth history and ecology of the Atlantic surf clam, *Spisula solidissima* (Dillwyn), as revealed by stable isotopes and annual shell increments. J. Exp. Mar. Biol. Ecol. 73 : 225-242.
- Lambert, J. and Goudreau, P. 1995. [Performance de la drague hydraulique de type Nouvelle-Angleterre pour la récolte de la mactre de Stimpson \(*Mactromeris polynyma*\)](#). Rapp. can. ind. sci. halieut. aquat. 235 : vii + 28 p.
- Loosanoff, V.L. and Davis, H.C. 1963. Rearing of bivalve mollusks. In Advances in Marine Biology, Vol. 1. Édité par F.S. Russel. Acad. Press, New York. p. 1-136.
- Mackenzie, C.L. Jr., Radosh, D.J. and Reid, R.N. 1985. Densities, growth, and mortalities of juveniles of the surf clam (*Spisula solidissima*) (Dillwyn) in the New York Bight. J. Shellfish Res. 5 : 81-84.
- Medcof, J.C. and MacPhail, J.S. 1955. Survey of bar clam resources of the Maritimes provinces. Fish. Res. Board Can. Bull. 102, 6 p.
- Merrill, A.S. and Ropes, J.W. 1969. The general distribution of the surf clam and ocean quahog. Proc. Nat. Shellfisheries Ass. 59 : 40-45.
- Munroe, D.M., Narvaez, D.A., Hennen, D., Jacobson, L., Mann, R., Hofmann, E.E., Powell, E.N. and Klinck, J.M. 2016. Fishing and bottom water temperature as drivers of change in maximum shell length in Atlantic surfcalms (*Spisula solidissima*). Estuar. Coast. Shelf Sci. 170 : 112-122.
- NOAA Fishwatch. 2019. [Atlantic Surfclam, *Spisula solidissima*](#).
- Roberts, G. 1981. Dynamics of an exploited population of bar clam, *Spisula solidissima*. Can. Manuscr. Rep. Fish. Aquat. Sci. 1607: iv + 13 p.
- Ropes, J.W. 1978. Biology and distribution of surf clams (*Spisula solidissima*) and ocean quahogs (*Arctica islandica*) of the northeast coast of the United States. In Proceedings of northeast clam industries: Management for the future. April 27-28, 1978. Hyannis, MA. p. 47-66.
- Ropes, J.W. 1980. Biological and fisheries data on the Atlantic surf clam, *Spisula solidissima* (Dillwyn). U.S. Natl Mar. Fish. Serv. Northeast Fish. Cent. Sandy Hook Lab Tech. Ser. Rep. No. 24. 88 p.
- Ropes, J.W. and Ward, G.E. Jr. 1977. The Atlantic coast surf clam fishery-1974. Mar. Fish. Rev. 39(5) : 18-23.
-

-
- Sephton T.W. and Bryan, C.F. 1990. Age and growth rate determinations for the Atlantic surf clam, *Spisula solidissima* (Dillwyn, 1817), in Prince Edward Island, Canada. J. Shellfish. Res. 9 : 177-185.
- Snelgrove, P.V.R., Grassle, J.P and Butman, C.A. 1998. Sediment choice by settling larvae of the bivalve, *Spisula solidissima* (Dillwyn), in flow and still water. J. Exp. Mar. Biol. Ecol. 231 : 171-190.
- Stehlik, L.L. 1993. Diets of the brachyuran crabs *Cancer irroratus*, *C. borealis*, and *Ovalipes ocellatus* in the New York Bight. J. Crust. Biol. 13(4) : 723-735.
- Timbs, J. 2018. Spatial distribution and stock-recruitment analysis of the Atlantic Surfclam, *Spisula solidissima*, in the Mid-Atlantic Bight and on Georges bank. Thesis (M.Sc.), University of Southern Mississippi, The Aquila Digital Community. 91 p.
- Trottier, S. and Goudreau, P. 2015. [Évaluation des stocks de mactre de Stimpson \(*Mactromeris polynyma*\) des eaux côtières du Québec en 2014](#). Secr. can. de consult. sci. du MPO. Doc. de rech. 2015/063. ix + 72 p.
- Weinberg, J.R. 1999. Age-structure, recruitment, and adult mortality in populations of the Atlantic surfclam, *Spisula solidissima*, from 1978 to 1997. Mar. Biol. 134 : 113-125.
- Weinberg, J.R. 2005. Bathymetric shift in the distribution of Atlantic surfclams: response to warmer ocean temperature. ICES J. Mar. Sci. 62 : 1444-1453.
- Yancey, R.M. and Welch, W.R. 1968. The Atlantic coast surf clam, with a partial bibliography. U.S. Fish. Wildlife Serv. Circ. 288. 14 p.

TABLES

Table 1. Estimated shell width and thickness, live wet weight, age, weight of 300 surfclams, and number of surfclams required for a 66 kg basket, based on the anteroposterior length of Atlantic surfclams from the Îles-de-la-Madeleine.

Length (mm)	Width (mm)	Thickness (mm)	Live weight (g)	Age (years)	300 surfclams ¹ (kg)	66 kg ² (number)
76	57	34	77	4-5	23	851
90	67	40	127	5-6	38	519
100	73	44	173	6-7	52	381
110	80	48	229	7-8	69	289
120	87	52	296	9-10	88	224
130	94	56	375	11-13	112	177
135	97	58	419	13-15	125	159

¹ Maximum daily limit for recreational harvesters.

² Estimated weight of a basket used mainly in diving.

Data source: Brulotte 2016

Table 2. Fishing seasons by year and sub-area for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.

Year	Sub-area	Fishing season (dd/mm)
2008	5A1 5A2 5B	5A1 and 5A2 : 07/04 to 05/07 and 01/09 to 13/12 5B : 07/04 to 13/12
2009	5A1 5A2 5B	5A1 and 5A2 : 06/04 to 04/07 and 01/09 to 12/12 5B : 06/04 to 12/12
2010 ¹	5A1 5A2 5B	5A1 and 5A2 : 29/03 to 01/07 and 01/09 to 11/12 5B : 01/09 to 11/12
2011	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 28/03 to 02/07 and 01/09 to 31/12 5B2 : 11/04 to 31/12
2012	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 26/03 to 30/06 and 01/09 to 31/12 5B2 : 26/03 to 31/12
2013 ²	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 25/03 to 29/06 and 02/09 to 31/12 5B2 : 25/03 to 31/12
2014	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 24/03 to 28/06 and 01/09 to 31/12 5B2 : 24/03 to 31/12
2015	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 29/03 to 03/07 and 30/08 to 31/12 5B2 : 29/03 to 31/12
2016	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 21/03 to 02/07 and 29/08 to 31/12 5B2 : 21/03 to 31/12
2017	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 20/03 to 01/07 and 27/08 to 31/12 5B2 : 20/03 to 31/12
2018	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 26/03 to 01/07 and 27/08 to 31/12 5B2 : 26/03 to 31/12
2019	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 25/03 to 01/07 and 27/08 to 31/12 5B2 : 25/03 to 31/12
2020	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 23/03 to 01/07 and 27/08 to 31/12 5B2 : 23/03 to 31/12
2021	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 15/03 to 30/06 and 01/09 to 31/12 5B2 : 15/03 to 31/12
2022	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 15/03 to 30/06 and 01/09 to 31/12 5B2 : 15/03 to 31/12
2023	5A1 5A2 5B1 5B2	5A1, 5A2 and 5B1 : 01/03 to 30/06 and 01/09 to 31/12 5B2 : 01/03 to 31/12

¹ Area 5B is divided into two sub-areas: 5B1 and 5B2.

² The boundary between 5A1 and 5B1 was changed.

Table 3. Total allowable catch (t) and effort restriction (days) by sub-area, for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.

Year	Area 5			
	5A		5B	
	5A1	5A2	5B1	5B2
2008	113 t	55 t	-	
2009	113 t	55 t	-	
2010	125 t	55 t	100 t or 36 days	
2011	125 t	55 t	100 t or 36 days	12 days
2012	125 t	55 t	100 t or 36 days	12 days
2013	125 t or 44 days	55 t	113 t or 36 days	12 days
2014	125 t or 44 days	55 t	113 t or 36 days	12 days
2015	125 t or 44 days	55 t	113 t or 36 days	12 days
2016	125 t or 44 days	55 t	113 t or 36 days	12 days
2017	125 t or 44 days	55 t	113 t or 36 days	12 days
2018	125 t or 44 days	55 t	113 t or 36 days	12 days
2019	125 t or 44 days	55 t	113 t or 36 days	12 days
2020	125 t or 44 days	55 t	113 t or 36 days	12 days
2021	125 t or 44 days	55 t	113 t or 36 days	12 days
2022	125 t or 44 days	55 t	113 t or 36 days	12 days
2023	125 t or 44 days	55 t	113 t or 36 days	12 days

Table 4. Number of Atlantic surfclams measured in the dredge fishery by sub-area, bed and year under the DFO commercial catch sampling program (2004–2023) and At-Sea Observer Program (2005–2018).

Year	Dockside sampling					At-sea sampling		
	Sub-area		Bed			Bed		
	5A1	5B1	CGE	Est	Nord	CGE	Est	Nord
2004	1102	-	-	1102	-	-	301	-
2005	498	117	-	165	333	-	-	1723
2006	1293	-	217	204	872	-	1747	1120
2007	1036	-	175	661	200	-	245	-
2008	746	304	-	746	-	-	-	2725
2009	703	1346	-	537	1512	-	-	1406
2010	1066	646	-	-	1536	-	-	2221
2011	466	1184	-	-	1650	-	-	779
2012	1451	621	300	-	1772	-	-	534
2013	858	774	-	-	1632	-	-	958
2014	1053	482	-	150	1385	-	-	1196
2015	760	790	-	-	1550	-	-	1543
2016	449	1094	-	-	1543	-	-	952
2017	904	601	-	-	1505	-	-	606
2018	451	1022	-	-	1473	-	-	-
2019	910	599	140	-	1216	-	-	-
2020	624	-	332	-	302	-	-	-
2021	963	638	309	-	1292	-	-	-
2022	791	770	946	155	460	-	-	-
2023	620	679	620	-	679	-	-	-

Table 5. Number of Atlantic surfclams measured from the commercial dive fishery and onshore (hand digging) harvesting under DFO's commercial catch sampling program, by shellfish area and year.

Year	Diving		Hand digging			
	A-09.5	A-12.1	A-09.5	A-16.2 ¹	A-17.1	A-17.4
2004	-	-	1645	-	-	-
2005	139	575	2121	-	-	-
2006	158	670	1263	-	-	-
2007	-	2022	1082	947	-	-
2008	-	2144	1811	271	58	-
2009	185	786	694	-	105	-
2010	-	1590	1434	-	261	-
2011	508	1115	1183	-	-	-
2012	-	1370	575	97	150	-
2013	-	1568	-	951	337	-
2014	-	860	-	197	431	153
2015	-	-	300	150	753	300
2016	-	1399	150	643	282	300
2017	-	943	-	1445	150	-
2018	-	617	150	627	-	374
2019	306	781	-	747	286	304
2020	-	2114	926	1628	526	-
2021	-	1234	-	154	463	155
2022	155	803	313	316	189	159
2023	-	770	310	165	307	-

¹ Shellfish area A-16.2.1.1.

Table 6. Positions (UTM zone 20N, CRS 32620) of sites used to monitor the non-standardized catch per unit effort (CPUE) in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine. See Figure 7 for the location of the monitoring sites in each bed.

Bed	Sub-area	Latitude (N)	Longitude (W)
Nord	5A1	5277359 to 5278610	622675 to 621347
Nord	5B1	5279251 to 5280226	618291 to 617057
CGE	5A1	5267940 to 5266893	605948 to 607343

Table 7. Number of licences issued annually by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.

Year	Dredge			Diving			Hand digging		
	Issued	Active	% active	Issued	Active	% active	Issued	Active	% active
2002	4	4	100	-	3	-	-	-	-
2003	4	4	100	-	-	-	-	-	-
2004	4	4	100	-	-	-	-	-	-
2005	4	4	100	-	6	-	-	30	-
2006	4	4	100	-	3	-	-	38	-
2007	4	4	100	-	6	-	-	40	-
2008	4	4	100	-	3	-	-	27	-
2009	4	4	100	-	6	-	-	21	-
2010	4	4	100	-	17	-	-	31	-
2011	4	4	100	-	5	-	-	14	-
2012	4	4	100	-	17	-	-	15	-
2013	4	5	125	52	20	38	103	23	22
2014	4	4	100	52	23	44	88	16	18
2015	4	4	100	58	7	12	81	14	17
2016	4	4	100	68	21	31	73	17	23
2017	4	4	100	77	22	29	66	17	26
2018	4	4	100	69	12	17	57	14	25
2019	4	4	100	69	11	16	51	14	27
2020	4	3	75	63	7	11	48	12	25
2021	4	3	75	68	9	13	45	10	22
2022	4	4	100	67	7	10	47	17	36
2023	4	2	50	63	8	13	47	17	36

Table 8. Annual landings (t) by sub-area (5A1 and 5B1) and bed (CGE, East and North), and total landings by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.

Year	Dredge (t)					Hand harvesting (t)			Total (t)	
	5A1	5B1	CGE	EST	Nord	Total	Diving	Hand digging	Total	Quebec
2002	107.6	-	11.1	96.0	0.5	107.6	2.8	-	2.8	110.4
2003	115.0	-	32.7	78.9	3.4	115.0	-	-	-	115.0
2004	111.9	-	25.7	70.1	16.1	111.9	-	-	-	111.9
2005	106.7	17.8	3.6	4.0	63.5	125.3	3.6	13.6	17.2	142.4
2006	107.8	-	22.6	7.3	77.9	107.8	1.5	21.1	22.6	130.4
2007	118.8	5.6	5.8	7.9	35.6	124.4	18.0	0.2	18.2	142.6
2008	119.5	32.4	8.1	92.9	41.8	158.6	5.3	10.1	15.4	174.1
2009	109.9	160.3	0.3	44.9	190.7	270.7	13.4	6.2	19.6	290.3
2010	124.3	97.2	0.0	3.9	188.2	221.6	26.7	10.7	37.4	259.0
2011	102.1	122.6	5.1	-	219.5	227.4	7.4	8.1	15.5	242.9
2012	107.3	128.7	-	-	230.1	236.1	12.2	8.1	20.3	256.4
2013	131.7	114.8	-	-	246.5	246.5	28.7	13.0	41.7	288.2
2014	130.2	115.2	-	5.3	240.1	246.2	37.1	8.9	46.0	292.2
2015	126.4	115.0	-	-	241.4	241.4	5.9	11.5	17.4	258.8
2016	122.8	118.2	-	-	241.0	245.4	47.3	11.2	58.5	304.0
2017	122.9	110.8	-	-	233.7	233.7	40.4	0.9	41.3	275.0
2018	119.5	110.2	-	-	229.7	229.7	39.3	6.1	45.4	275.1
2019	133.6	104.4	52.4	-	185.6	238.0	4.0	7.5	11.5	249.6
2020	85.5	87.9	75.6	-	97.9	173.6	44.4	10.3	54.6	228.2
2021	120.0	97.3	96.0	5.1	116.2	217.4	46.7	5.5	52.2	269.6
2022	95.2	87.6	77.4	4.5	63.8	183.1	27.2	17.4	44.5	227.6
2023	65.9	65.0	36.0	-	68.0	130.9	36.3	19.2	55.5	186.5

Table 9. Annual fishing effort (days) by sub-area (5A1 and 5B1) and bed (CGE, East and North), and total fishing effort by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) for the Atlantic surfclam fishery in the Îles-de-la-Madeleine.

Year	Dredge (days)					Hand harvesting (days)			
	5A1	5B1	CGE	Est	Nord	Total	Diving	Hand digging	Total
2002	65	-	6	57	2	65	-	-	-
2003	64	-	21	42	1	64	-	-	-
2004	64	-	18	39	7	64	-	-	-
2005	31	12	2	11	18	43	19	114	133
2006	55	-	15	5	35	55	11	189	200
2007	62	4	3	37	23	66	67	159	226
2008	42	13	4	32	14	55	21	92	113
2009	43	53	10	21	62	96	40	65	105
2010	34	28	2	1	52	62	140	142	282
2011	25	36	2	-	59	61	38	83	121
2012	16	24	2	-	38	40	61	98	159
2013	21	20	-	-	41	41	130	132	262
2014	23	18	-	2	39	41	150	106	256
2015	26	19	-	-	45	45	45	140	185
2016	22	18	-	-	40	40	158	141	299
2017	25	26	-	-	51	51	166	116	282
2018	21	23	-	-	44	44	157	83	240
2019	33	26	13	-	46	59	151	91	242
2020	23	20	19	-	24	43	132	104	236
2021	33	27	27	1	32	60	118	64	182
2022	23	25	19	1	19	48	66	153	219
2023	20	17	10	-	12	37	88	172	260

Table 10. Annual mean non-standardized catch per unit effort (CPUE) (kg/h·m or kg/h) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and bed (CGE, East or North) or shellfish area for the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine.

Year	Dredge (kg/h·m)			Hand harvesting (kg/h)					
	CGE	Est	Nord	Diving		Hand digging			
				A-09.5	A-12.1	A-09.5	A-12.1	A-17.1	A-17.4
2002	116.9	128.9	-	-	-	-	-	-	-
2003	108.9	114.4	-	-	-	-	-	-	-
2004	85.3	94.1	155.4	-	-	-	-	-	-
2005	114.3	163.6	203.4	54.6	51.6	32.8	15.7	32.8	7.4
2006	109.3	133.0	131.8	34.0	61.1	30.9		11.5	16.0
2007	120.5	109.0	84.9	-	83.6	29.4		18.8	-
2008	138.6	130.3	131.5	31.9	131.9	31.9		26.9	-
2009	197.6	123.1	233.6	-	96.9	29.8	18.9	20.2	-
2010	186.7	185.1	241.9	47.8	58.6	19.1	35.7	22.5	-
2011	203.4	-	279.9	-	56.4	22.0	30.8	17.8	-
2012	255.5	-	382.7	56.7	53.3	18.3	21.3	22.7	-
2013	-	-	355.1	70.1	66.9	22.5	35.7	20.7	17.3
2014	-	196.8	326.9	61.2	59.1	21.6	28.8	31.8	13.9
2015	-	-	255.1	65.3	39.6	23.5	25.9	18.3	10.4
2016	-	-	296.6	56.8	75.3	21.4	23.2	25.1	16.9
2017	-	-	276.1	47.3	64.8	23.7	29.1	20.9	12.9
2018	-	-	272.3	67.2	72.2	27.0	30.3	15.1	15.2
2019	346.9	-	238.9	56.7	73.8	34.5	38.4	20.0	13.2
2020	305.0	-	288.6	51.5	61.5	30.1	31.6	19.5	12.5
2021	298.7	204.0	330.1	34.8	58.8	31.3	45.0	20.8	17.0
2022	243.5	133.1	171.0	35.6	77.6	32.8	47.6	25.7	16.7
2023	152.8	-	144.6	68.8	78.1	33.3	31.0	27.1	14.3

Table 11. Annual mean standardized catch per unit effort (CPUE) (kg/h·m or kg/h) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and bed (CGE, East or North) or shellfish area for the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine. See Table 10 for non-standardized CPUE values.

Year	Dredge (kg/h·m)			Hand harvesting (kg/h)					
	CGE	Est	Nord	Diving		Hand digging			
				A-09.5	A-12.1	A-09.5	A-16.2.1.1	A-17.1	A-17.4
2002	-	153.0	-	-	-	-	-	-	-
2003	67.4	138.4	-	-	-	-	-	-	-
2004	67.5	114.4	147.7	-	-	-	-	-	-
2005	-	207.8	203.6	-	38.0	34.7	-	6.5	-
2006	80.3	-	144.8	-	34.5	31.0	-	10.7	-
2007	-	122.8	106.3	-	54.8	28.4	22.4	15.7	-
2008	-	136.8	178.3	-	74.7	32.1	20.4	10.6	-
2009	115.0	132.2	190.5	-	63.0	27.4	18.7	11.7	-
2010	-	-	230.1	-	46.6	16.5	11.1	10.0	-
2011	-	-	215.9	-	34.9	18.8	10.0	13.1	-
2012	-	-	295.8	-	45.8	16.0	-	12.1	-
2013	-	-	282.7	-	53.8	19.9	14.9	18.0	-
2014	-	-	263.1	-	52.1	18.5	20.0	11.8	-
2015	-	-	243.1	-	39.5	17.9	21.4	15.3	-
2016	-	-	265.3	-	54.6	19.1	22.1	23.8	-
2017	-	-	242.1	-	63.6	22.4	16.7	21.9	-
2018	-	-	244.2	-	89.2	26.1	18.4	30.6	-
2019	431.0	-	203.2	-	93.7	29.1	20.9	31.7	-
2020	281.1	-	234.1	-	83.7	25.8	19.6	25.2	-
2021	328.8	-	247.9	-	81.6	27.0	-	-	-
2022	236.7	-	180.7	-	93.1	27.6	22.8	33.3	-
2023	193.7	-	185.2	-	98.4	29.8	31.8	30.5	-

Table 12. Estimated total area (km²) of known Atlantic surfclam beds in the Îles-de-la-Madeleine, based on logbooks (2002 onward), at-sea sampling (2005 to 2018) and research surveys (2007 and 2012). See Figure 9 for the locations used by the fishery in each bed over the years.

Périod ¹	CGE	Est	Nord			Total
			5A1	5B1	Total	
2002-2009	4.0	11.0	6.5	3.5	10.0	25.0
2002-2012	4.0	11.0	8.0	5.5	13.5	28.5
2002-2015	4.0	11.0	9.0	8.0	17.0	32.0
2002-2018	4.0	11.0	11.5	10.0	21.5	36.5
2002-2021	5.1	13.5	11.5	10.0	21.5	40.1
2002-2023	5.1	14.1	11.5	10.0	21.5	40.1

¹ The period refers to the years used to calculate the surface area.

Table 13. Area (km²) and proportion (%) of the estimated total area of each bed dredged in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.

Yeare	CGE		Est		Nord - 5A1		Nord - 5B1		Nord - total	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
2002	0.1	3.3	1.1	10.4	-	-	-	-	-	-
2003	0.5	12.7	1.1	9.6	-	-	-	-	-	-
2004	0.4	11.2	1.1	10.3	-	-	-	-	-	-
2005	0.05	1.2	0.4	3.3	0.5	4.4	-	-	0.5	2.4
2006	0.4	9.0	0.1	0.8	0.9	7.7	-	-	0.9	4.1
2007	0.1	1.9	1.1	10.1	0.6	5.2	-	-	0.6	2.8
2008	0.1	2.9	1.1	10.1	0.2	1.9	0.3	2.8	0.5	2.4
2009	0.3	6.3	0.7	6.3	0.3	3.0	1.3	12.6	1.6	7.5
2010	0.04	0.9	0.03	0.3	0.8	6.6	0.6	5.9	1.3	6.3
2011	0.04	1.1	-	-	0.5	4.5	0.8	7.9	1.3	6.1
2012	0.03	0.9	-	-	0.4	3.7	0.5	5.4	1.0	4.5
2013	-	-	-	-	0.5	4.7	0.6	6.2	1.2	5.4
2014	-	-	0.04	0.4	0.7	6.0	0.6	5.6	1.2	5.8
2015	-	-	-	-	0.8	6.9	0.6	6.5	1.4	6.7
2016	-	-	-	-	0.7	5.9	0.6	5.6	1.2	5.8
2017	-	-	-	-	0.7	6.0	0.7	6.8	1.4	6.4
2018	-	-	-	-	0.7	5.9	0.7	6.7	1.4	6.3
2019	0.2	4.6	-	-	0.6	5.3	0.6	6.5	1.3	5.8
2020	0.4	8.5	-	-	0.1	0.5	0.5	5.0	0.6	2.6
2021	0.5	9.0	-	-	0.2	1.8	0.4	4.3	0.6	3.0
2022	0.5	10.0	0.05	0.4	0.0	0.3	0.6	6.4	0.7	3.1
2023	0.4	7.5	-	-	0.0	0.2	0.5	4.7	0.5	2.3

Table 14. Annual mean size (anteroposterior length in mm) of landed Atlantic surfclams (measured at dockside) by fishing type (dredging and hand harvesting) and bed (CGE, East and North) or shellfish area in the commercial fishery in the Îles-de-la-Madeleine.

Year	Dredge			Diving		Hand digging				
	CGE	Est	Nord	A-09.5	A-12.1	A-09.5	A-12.1	A-16.2 ¹	A-17.1	A-17.4
2004	-	109.3	-	-	-	86.4	-	-	-	-
2005	-	101.8	114.6	101.9	125.3	88.5	-	-	-	-
2006	122.2	115.2	111.9	103.4	131.1	93.7	-	-	-	-
2007	126.5	125.4	116.1	-	128.8	96.8	-	118.2	-	-
2008	-	121.4	-	-	135.8	98.0	-	119.4	122.5	-
2009	-	125.2	120.6	123.6	133.9	91.9	-	-	115.6	-
2010	-	-	122.9	-	133.0	98.7	-	-	104.3	-
2011	-	-	126.3	124.7	132.2	94.6	-	-	-	-
2012	126.5	-	130.3	-	130.7	106.5	107	93.2	94.3	-
2013	-	-	130.7	-	128.6	-	114	94.4	103.8	-
2014	-	133.0	132.1	-	144.0	-	112	101.2	119.4	103.6
2015	-	-	133.4	-	-	108.5	-	110.4	121.0	106.7
2016	-	-	137.2	-	145.5	120.1	117	116.8	115.1	111.1
2017	-	-	134.5	-	130.7	-	-	113.2	119.3	-
2018	-	-	136.5	-	131.6	108.0	122	103.6	-	119.9
2019	138.0	-	135.9	119.8	128.7	-	-	109.4	124.2	106.6
2020	121.8	-	130.9	-	125.7	108.9	-	107.3	115.2	-
2021	133.3	-	130.0	-	129.0	-	-	109.9	117.3	103.9
2022	131.5	123.8	132.1	111.6	132.0	116.7	-	119.0	117.3	129.1
2023	136.5	-	135.1	-	129.3	126.1	-	124.6	120.6	-

¹ Shellfish area A-16.2.1.1.

Table 15. Annual landings (t) by shellfish area for commercial dive harvesting of Atlantic surfclams in the Îles-de-la-Madeleines.

Year	A-05	A-09.1	A-09.5	A-10.1.4	A-11	A-12.1	A-16.2.1.1	A-17.1
2005	-	-	0.4	0.6	-	2.6	-	-
2006	-	0.6	0.1	-	-	0.3	-	0.4
2007	-	0.3	-	-	-	16.4	0.6	0.7
2008	-	-	0.7	-	-	4.6	-	-
2009	-	0.3	-	-	-	13.1	0.1	-
2010	-	-	5.0	-	-	21.7	-	-
2011	-	-	-	-	-	7.4	-	-
2012	2.0	-	1.0	-	0.2	9.0	-	-
2013	-	0.2	2.0	-	-	26.4	< 0.1	-
2014	-	4.7	4.2	-	-	27.9	-	-
2015	-	-	1.3	-	-	4.6	-	-
2016	-	0.3	10.9	-	0.3	34.1	1.3	< 0.1
2017	-	-	2.6	0.4	-	34.0	3.3	0.1
2018	-	-	10.7	-	-	27.3	0.5	0.8
2019	-	-	3.2	-	-	36.3	0.5	-
2020	-	-	3.0	-	-	40.8	-	0.4
2021	-	-	1.3	-	-	44.9	-	0.1
2022	-	-	0.4	-	-	26.5	-	-
2023	-	-	6.1	-	-	25.4	-	0.4

Table 16. Annual landings (t) by shellfish area for commercial onshore harvesting (hand digging) of Atlantic surfclams in the Îles-de-la-Madeleine.

Year	A-09.1	A-09.3	A-09.5	A-10.1.2	A-10.1.4	A-10.2	A-11	A-12.1	A-14.3	A-16.1.2	A-16.2.1.1	A-17.1	A-17.4
2005	0.5	0.5	12.3	-	-	-	-	0.1	-	0.1	-	< 0.1	< 0.1
2006	1.5	0.5	18.6	0.1	-	-	-	-	0.1	< 0.1	-	0.3	0.1
2007	0.7	-	13.5	-	-	-	-	-	0.2	0.1	1.4	0.3	-
2008	0.6	-	8.2	0.2	-	-	-	-	0.2	-	0.6	0.3	-
2009	0.7	-	4.7	-	-	-	-	0.2	-	< 0.1	0.1	0.4	-
2010	0.4	-	8.3	< 0.1	-	< 0.1	-	1.9	-	< 0.1	< 0.1	0.1	< 0.1
2011	-	-	7.2	-	-	-	-	0.8	-	< 0.1	-	0.1	-
2012	-	-	6.1	-	0.3	-	0.3	1.2	-	0.1	0.1	0.1	-
2013	0.2	-	9.4	-	0.1	-	-	1.9	-	0.1	0.2	0.2	0.9
2014	-	-	6.3	-	< 0.1	-	-	0.9	-	-	0.3	0.2	1.4
2015	-	-	8.0	-	-	-	-	0.9	-	-	1.6	0.5	0.5
2016	-	-	6.6	-	-	-	0.1	1.2	-	-	2.1	0.2	1.0
2017	0.4	-	4.8	-	-	-	-	1.3	-	-	1.3	0.4	0.8
2018	-	-	3.2	-	-	-	-	1.0	-	-	0.8	0.6	0.4
2019	-	-	3.9	-	-	-	0.2	1.0	-	-	0.9	0.8	0.6
2020	-	-	7.1	-	-	-	-	1.1	-	-	0.7	0.6	0.3
2021	-	-	3.3	-	-	-	0.6	0.5	-	-	-	-	1.0
2022	-	-	9.0	-	-	-	-	3.5	-	-	1.2	2.1	1.1
2023	-	-	11.2	-	-	-	-	0.5	-	0.4	< 0.1	4.3	0.5

FIGURES

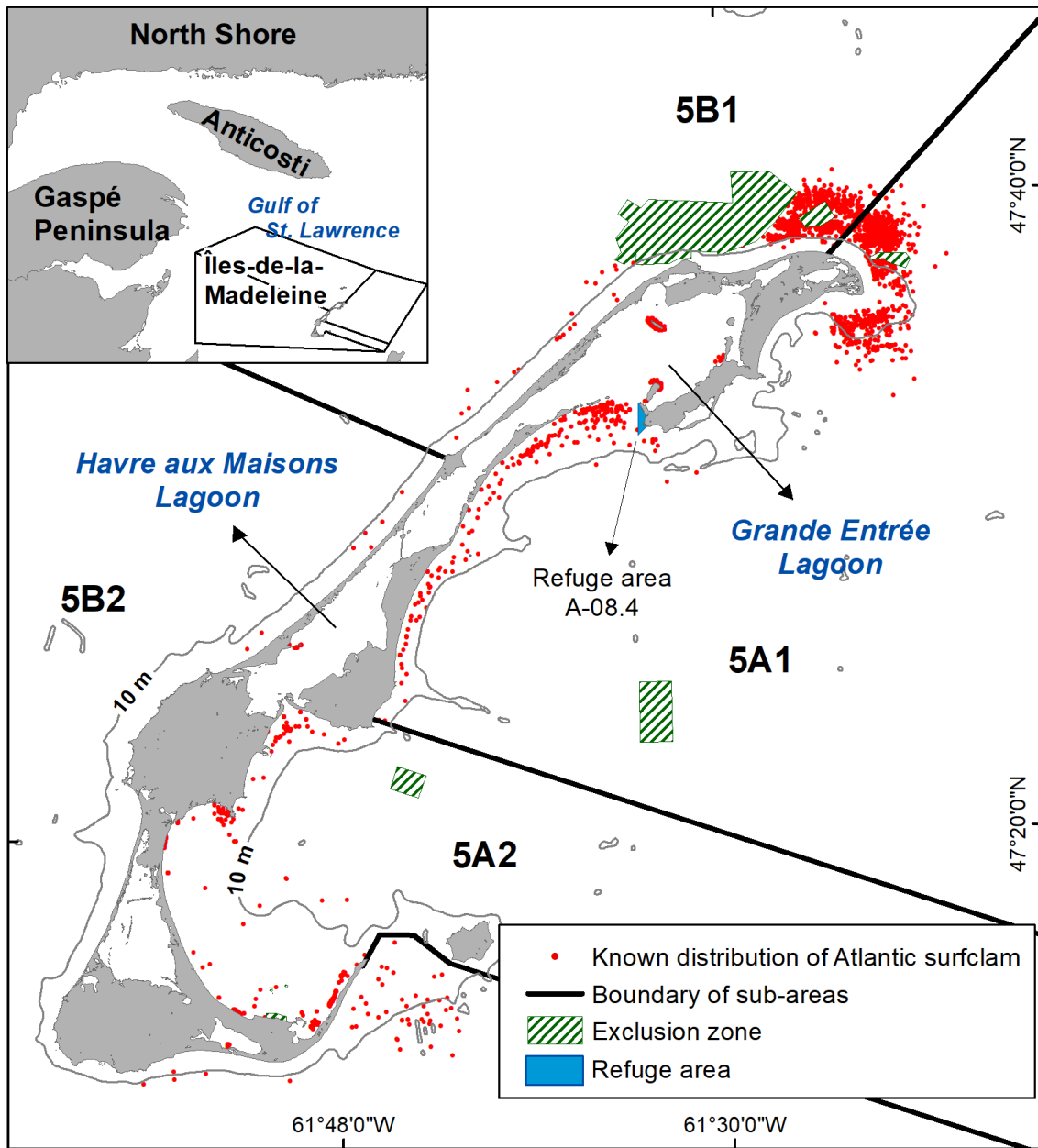


Figure 1. Boundaries of management sub-areas (5A1, 5A2, 5B1 and 5B2), location of exclusion areas and refuge area (A-08.4), and known distribution of the Atlantic surfclam in the Îles-de-la-Madeleine. Information sources: logbooks, at-sea sampling (2005 to 2018), research surveys (2007 and 2012) and exploratory fisheries (1978, 1984 and 1985).

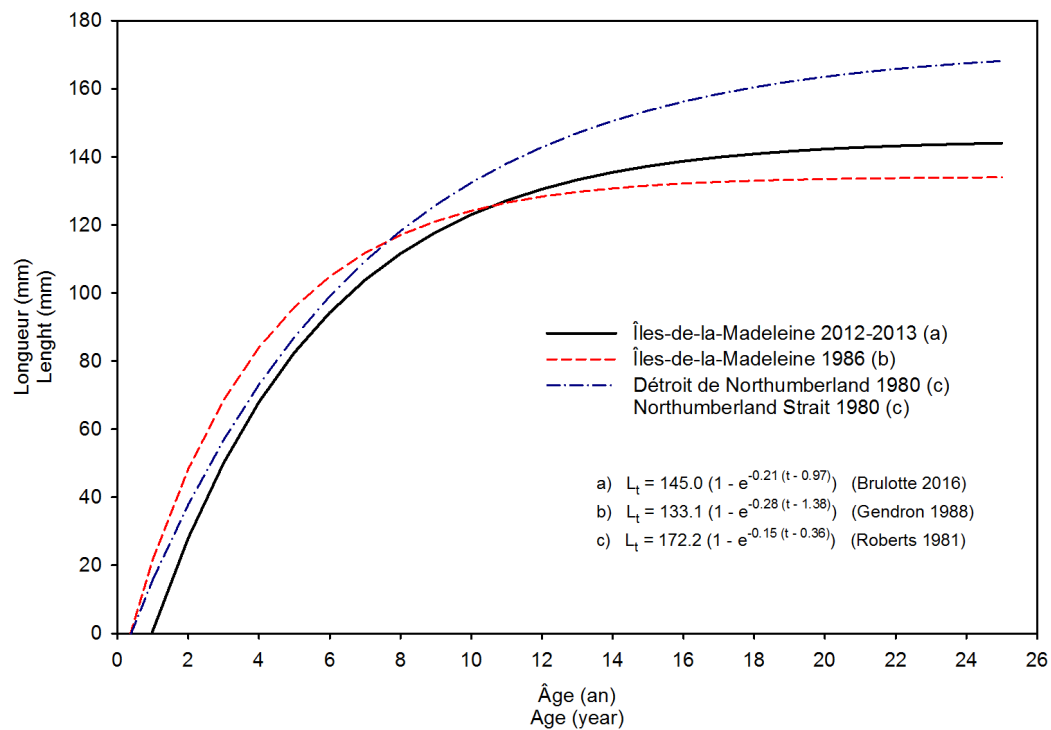


Figure 2. Von Bertalanffy growth curves for Atlantic surfclams harvested in Eastern Canada in various studies.

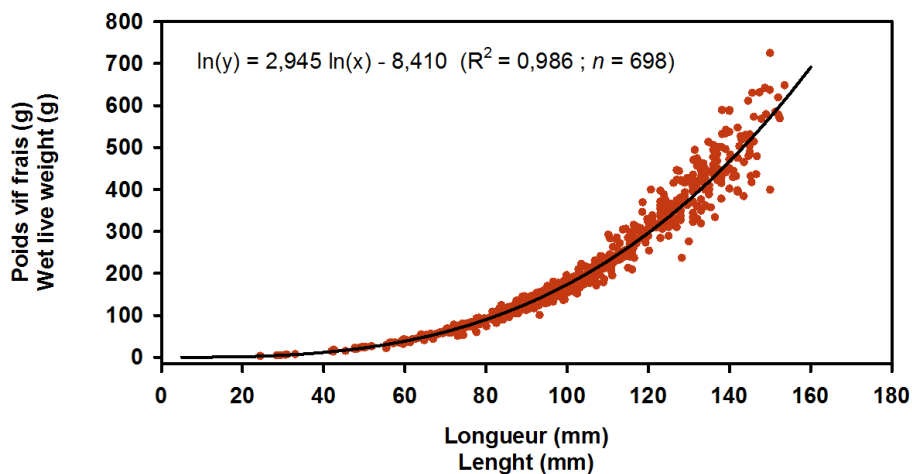


Figure 3. Morphometric relationship between live wet weight and anteroposterior length of Atlantic surfclams harvested in the Îles-de-la-Madeleine in 2013 and 2014 (Brulotte 2016).

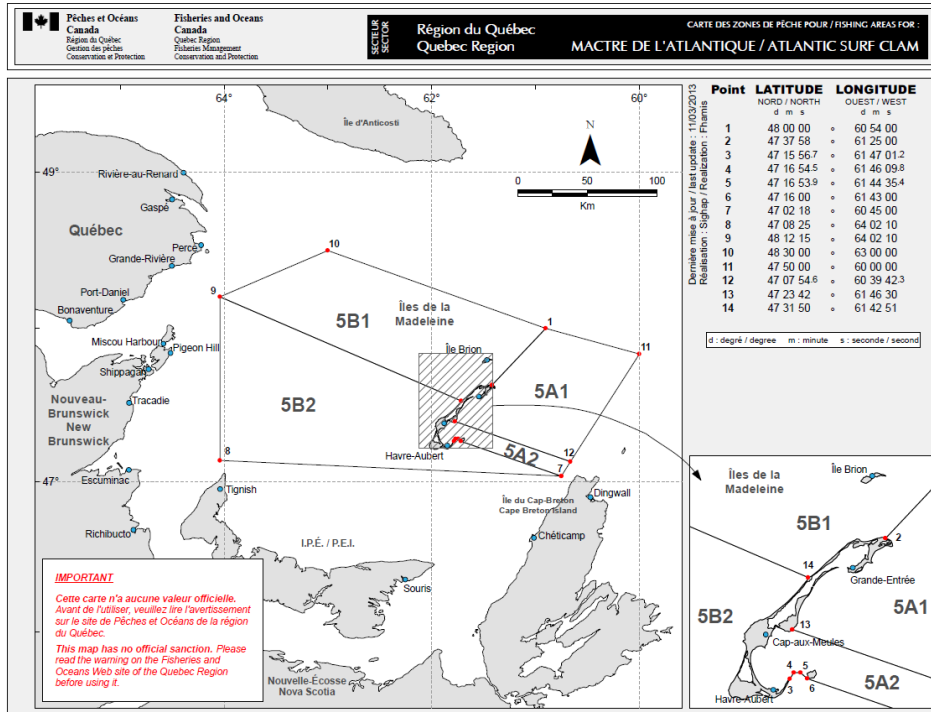


Figure 4. Boundaries of the sub-areas (5A1, 5A2, 5B1 and 5B2) for the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine.

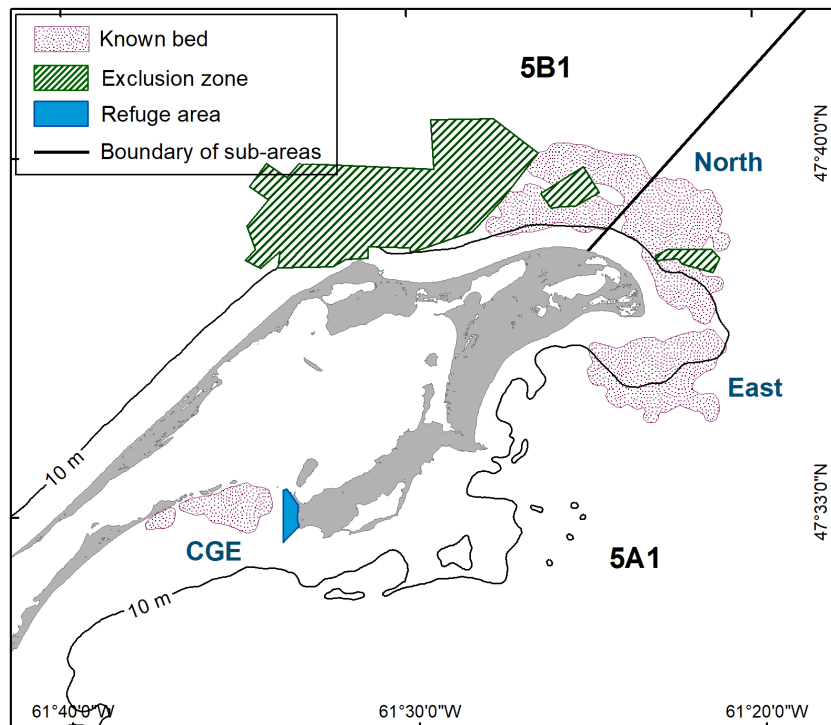


Figure 5. Location of the three known Atlantic surfclam beds (CGE, East and North) exploited by the commercial dredge fishery in the Îles-de-la-Madeleine. The CGE and East beds are in sub-area 5A1, and the North bed straddles sub-areas 5A1 and 5B1.

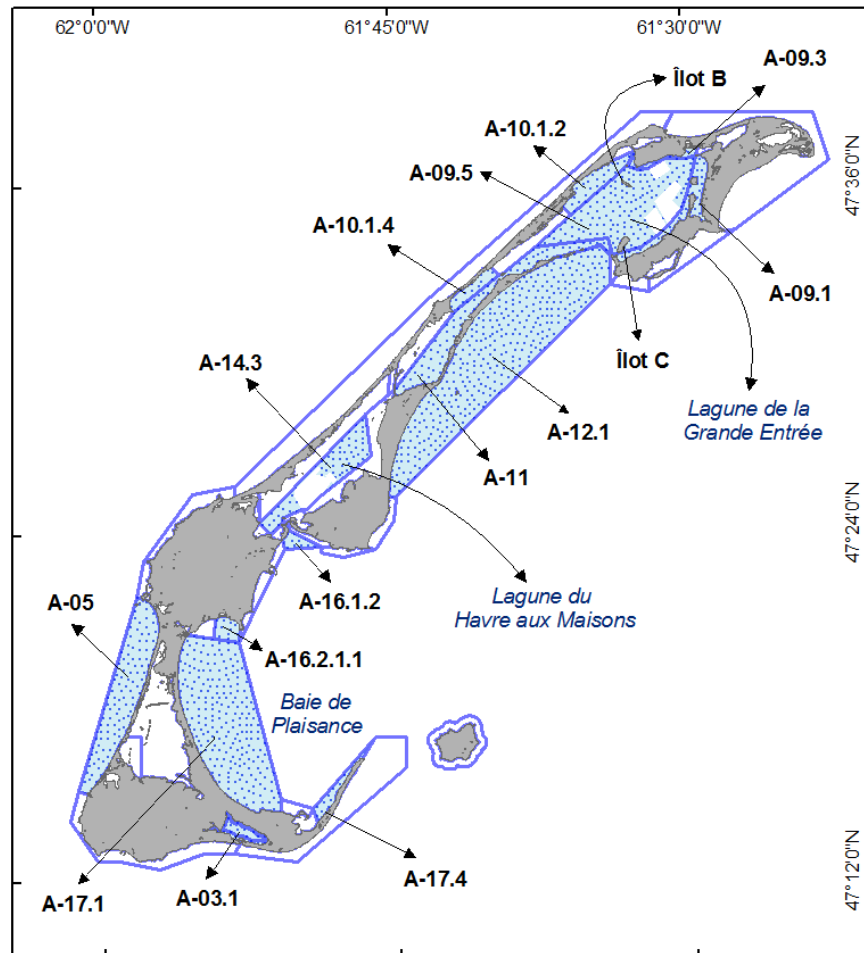


Figure 6. The location of the main shellfish harvesting areas where the Atlantic surfclam is hand collected in the Îles-de-la-Madeleine.

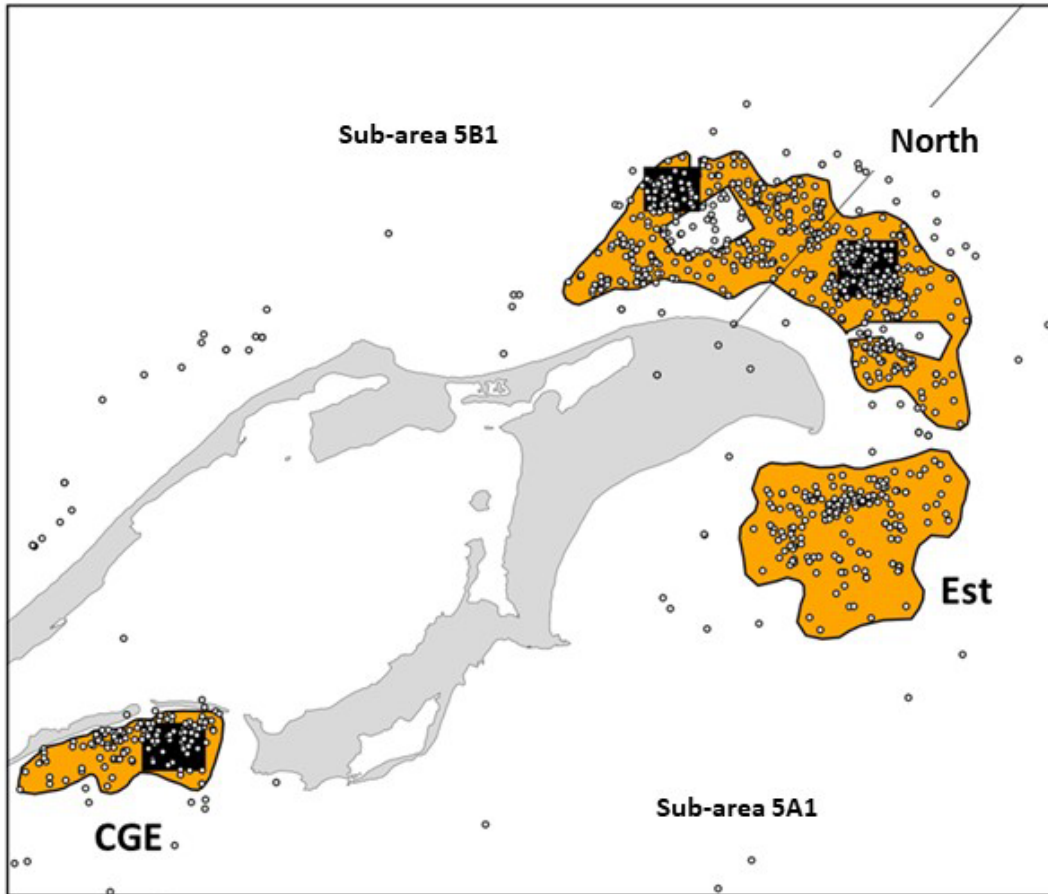


Figure 7. Fishing locations (positions at start of fishing day, shown as white dots) since 2002, and location of sites (black squares) used to monitor non-standardized catch per unit effort (CPUE) in the commercial Atlantic surfclam dredge fishery in the Îles-de-la-Madeleine, on the CGE and North beds (orange polygons, sub-areas 5A1 and 5B1). The white polygons represent exclusion areas (Figures 1 and 5).

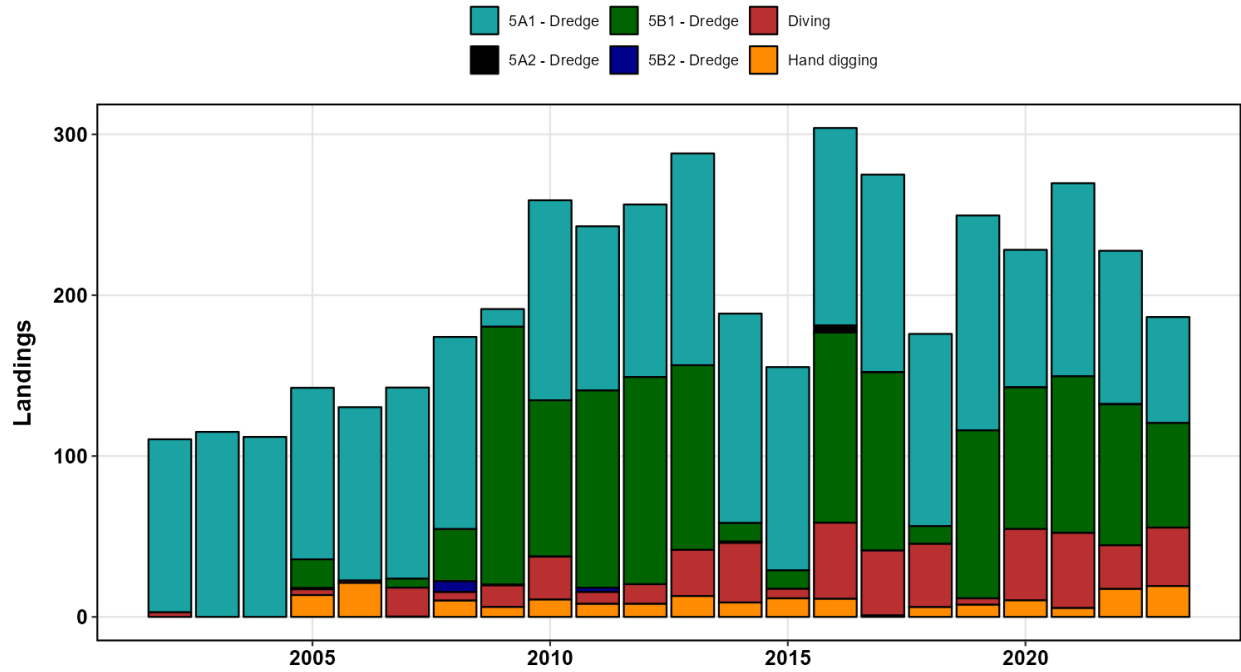


Figure 8. Annual landings (t) by fishing type (dredging, dive harvesting and onshore harvesting [hand digging]) and by sub-area in the commercial Atlantic surfclam fishery in the Îles-de-la-Madeleine.

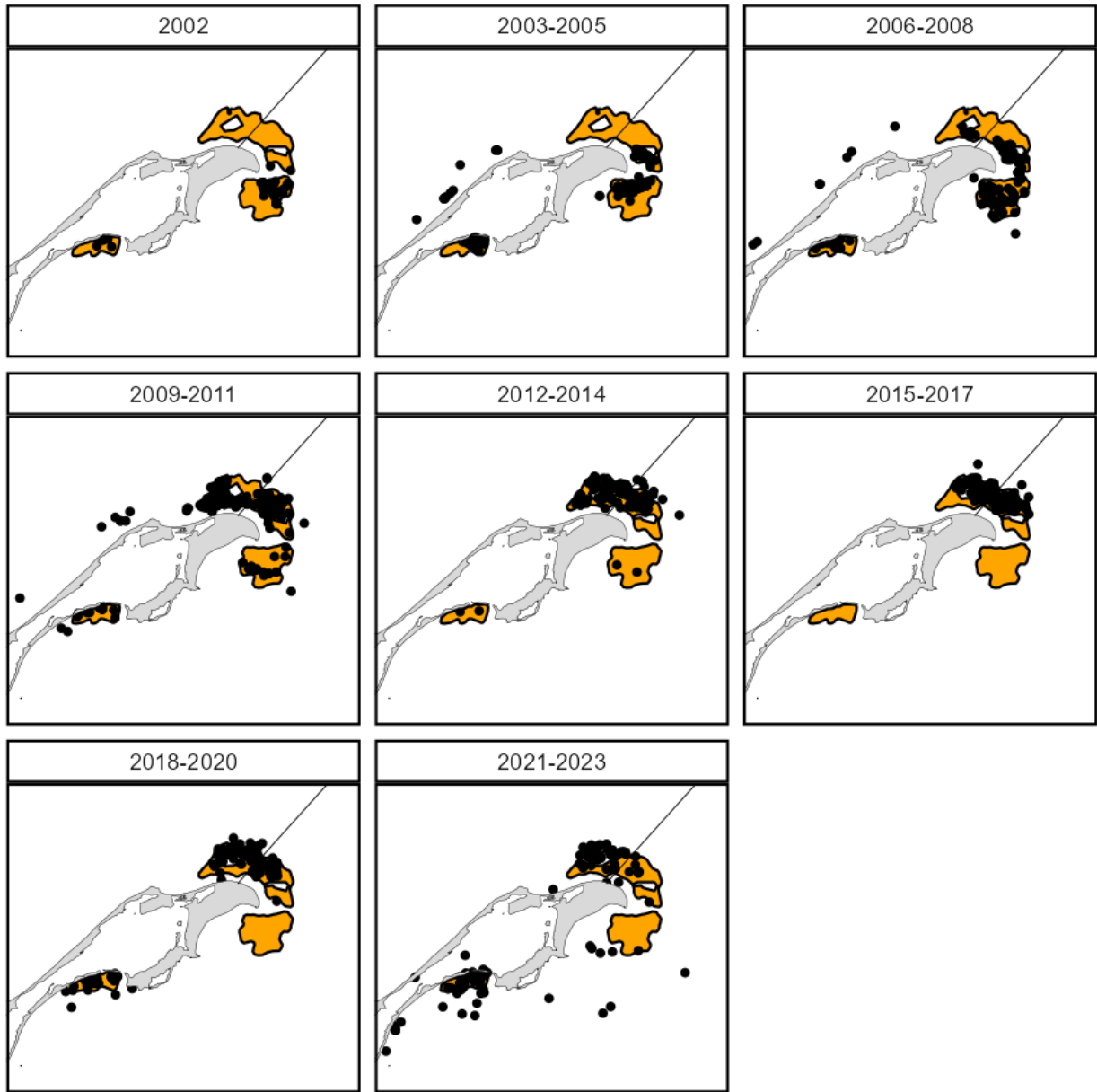


Figure 9. Location of commercial Atlantic surfclam dredging (fishing positions at start of day, shown as black dots) from 2002 to 2023 in sub-areas 5A1 and 5B1 (orange polygons) in the Îles-de-la-Madeleine.

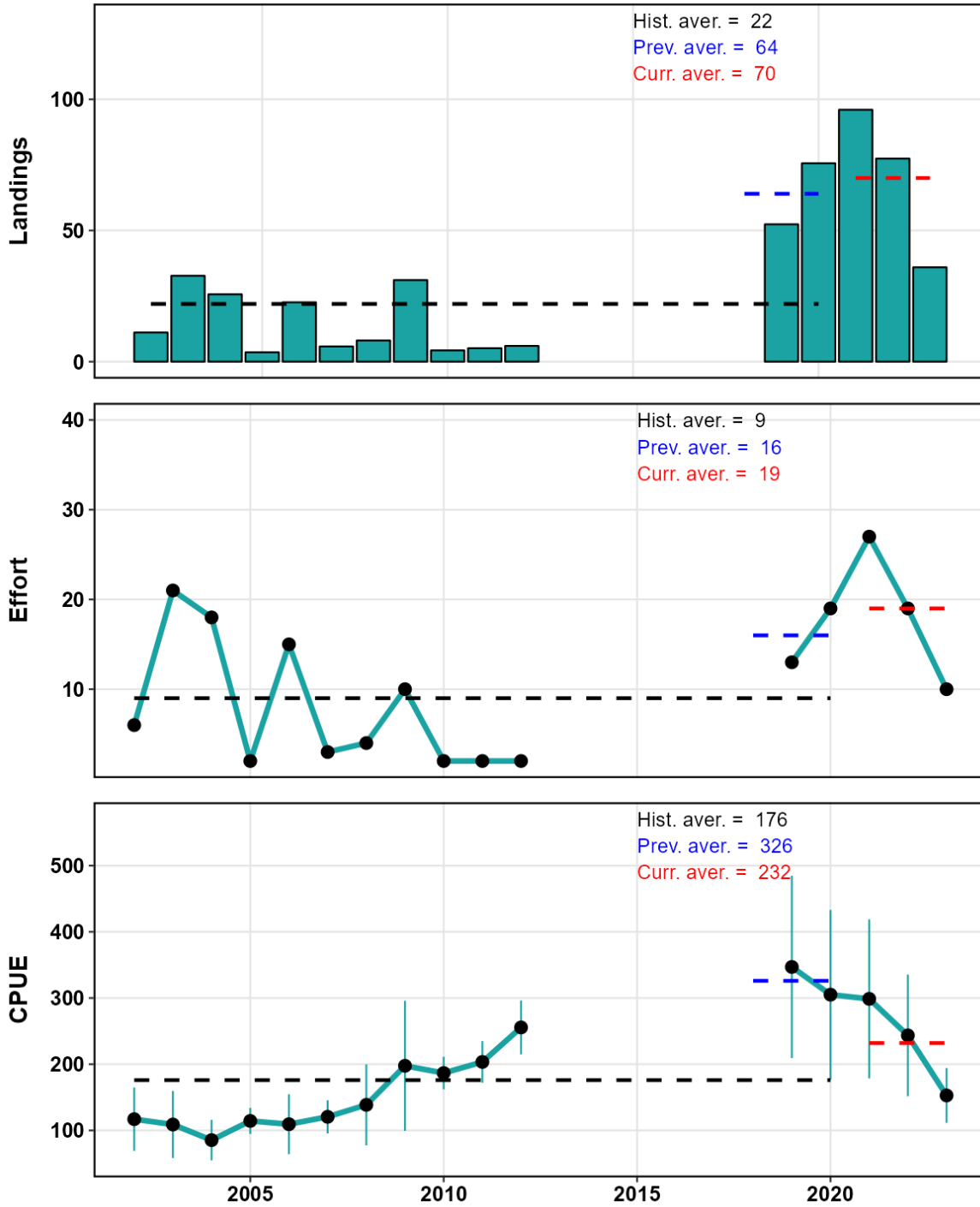


Figure 10. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the Chenal de la Grande-Entrée (CGE) bed, in sub-area 5A1 in the Îles-de-la-Madeleine. The different dashed lines indicate the historical average (hist. aver.), the average for the previous assessment period (prev. aver.) and the average for the current assessment period (cur. aver.).

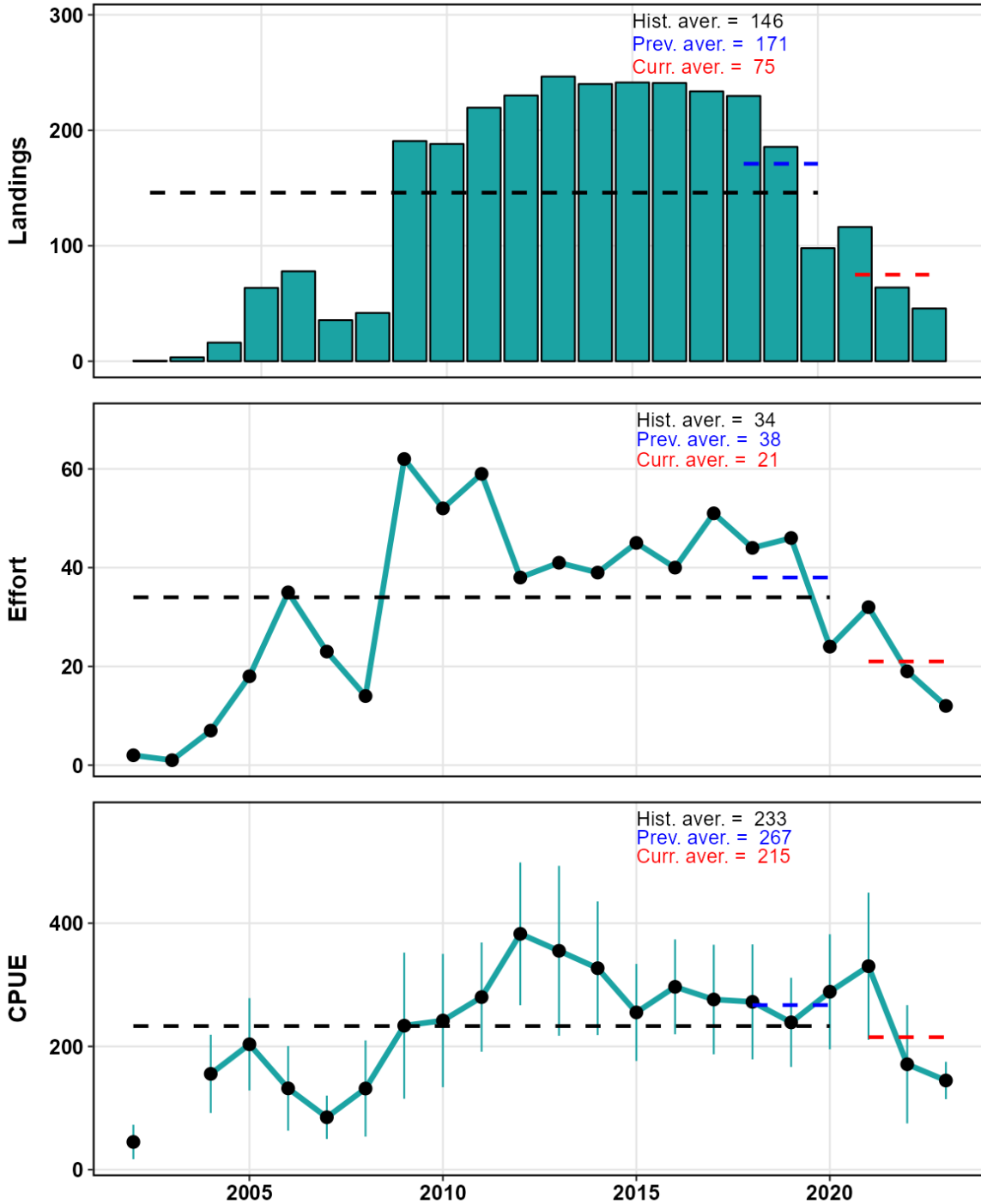


Figure 11. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the North bed, in sub-areas 5A1 and 5B1 in the Îles-de-la-Madeleine. The different dashed lines indicate the historical average (hist. aver.), the average for the previous assessment period (prev. aver.) and the average for the current assessment period (cur. aver.).

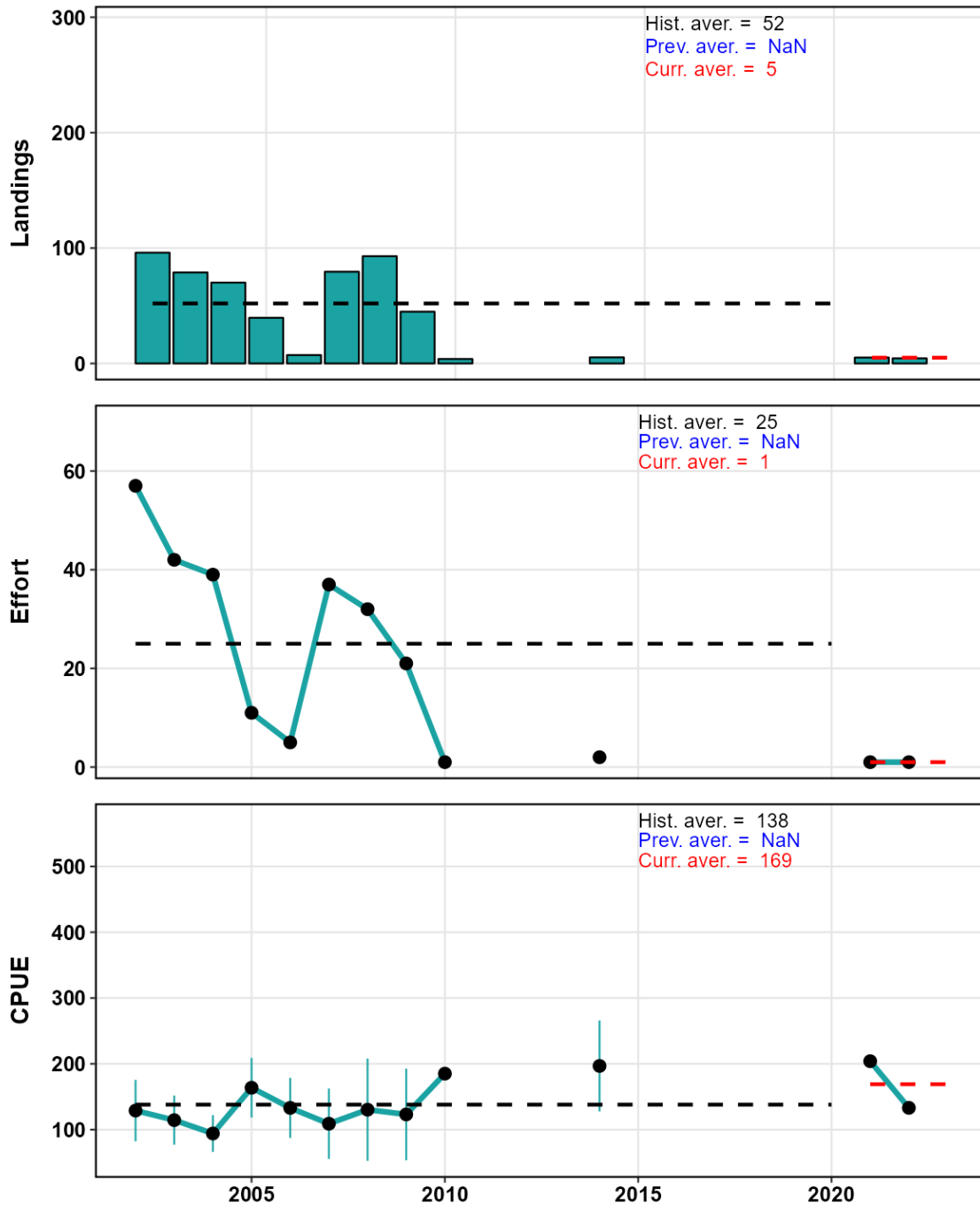


Figure 12. Annual landings (t), annual effort (number of fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery in the East bed, in sub-area 5A1 in the Îles-de-la-Madeleine. The different dashed lines indicate the historical average (hist. aver.), the average for the previous assessment period (prev. aver.) and the average for the current assessment period (cur. aver.). NaN: no data available.

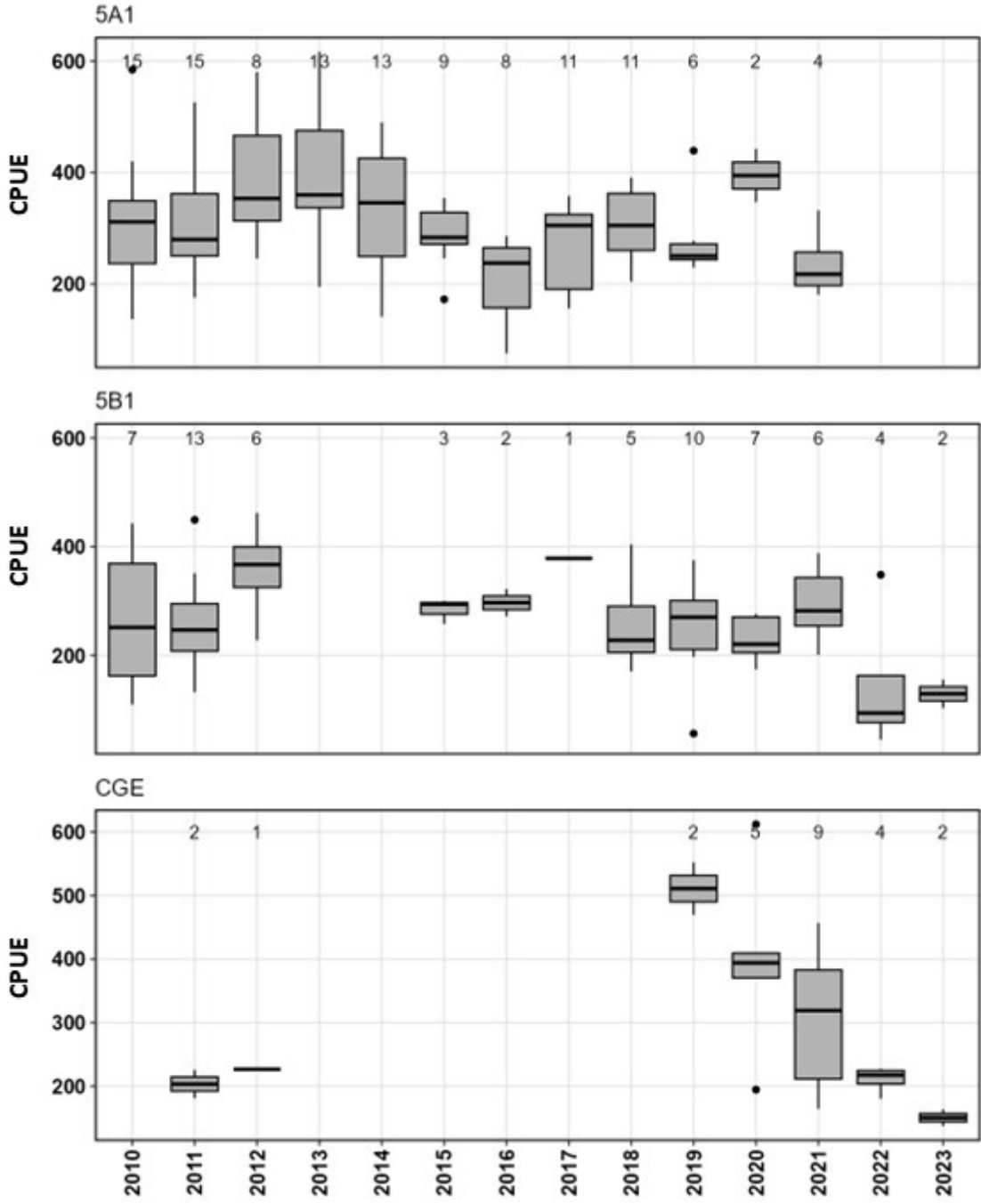


Figure 13. Changes in the non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dredge fishery at the monitoring sites in the North (sub-areas 5A1 and 5B1) and CGE beds. The values across the top of each graph indicate the number of logbook observations used in calculating the CPUE. See Figure 7 for the location of monitoring sites in each bed.

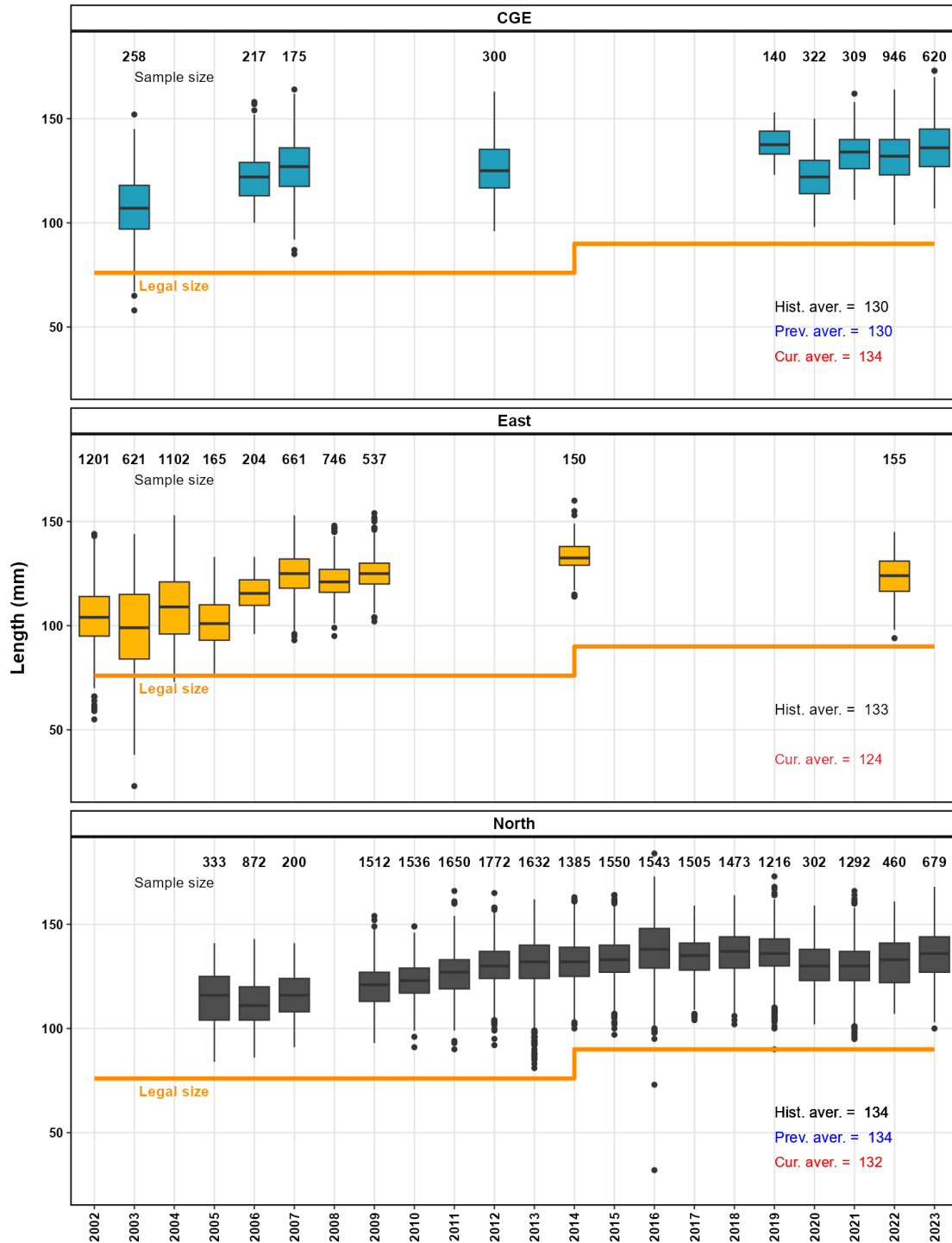


Figure 14. Size structure (anteroposterior length) of Atlantic surfclams landed by bed (CGE, East and North) and number of surfclams measured during the Îles-de-la-Madeleine commercial dredge fishery. The historical average size (hist. aver.), the average size from the previous assessment (prev. aver.) the average size for the current assessment (cur. aver.) are presented as well as the legal minimum size (orange line).

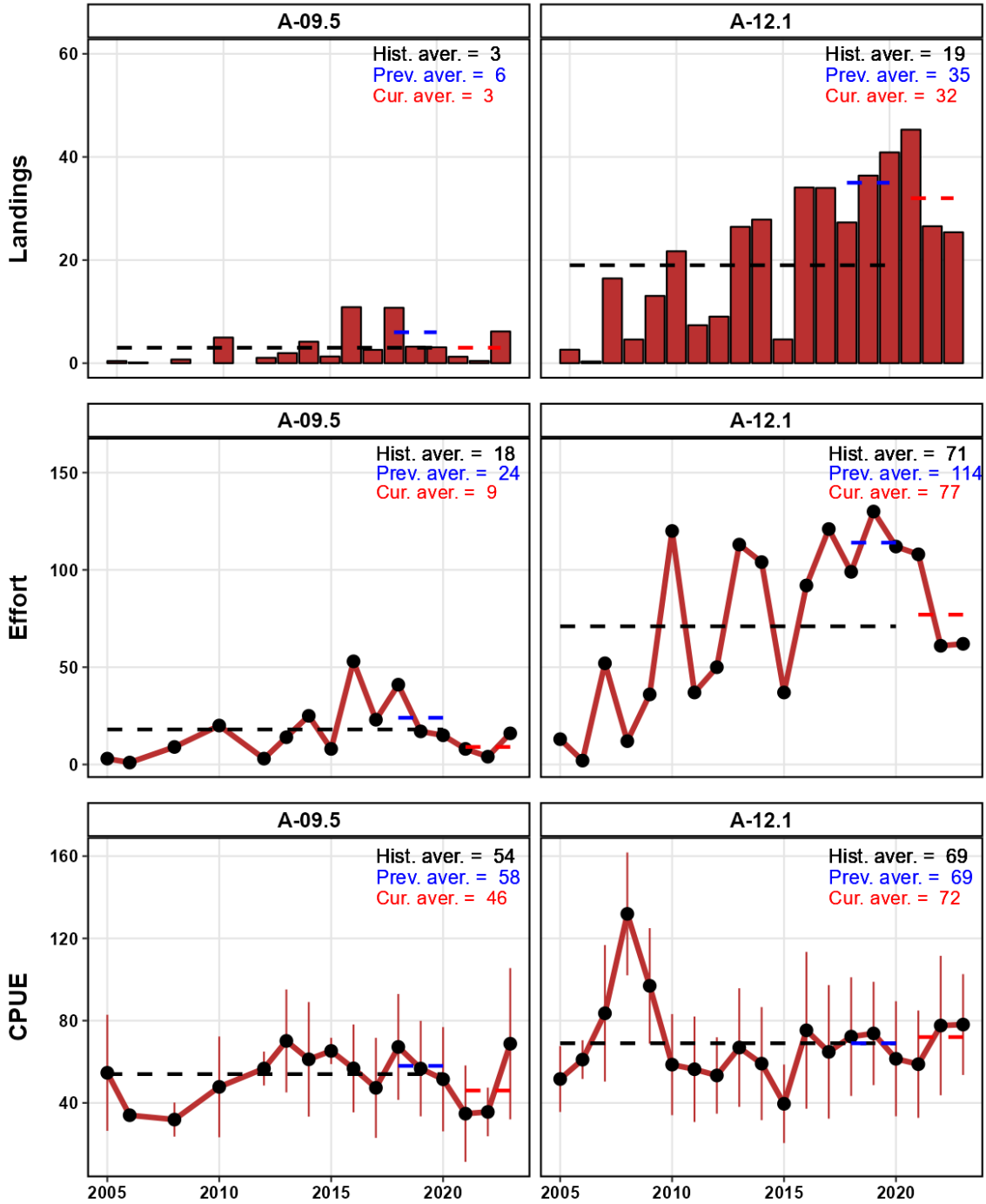


Figure 15. Landings (t), effort (fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) in the commercial Atlantic surfclam dive fishery in shellfish areas A-09.5 and A-12.1 in the Îles-de-la-Madeleine. The different dashed lines indicate the historical average (hist. aver.), the average for the previous assessment period (prev. aver.) and the average for the current assessment period (cur. aver.).

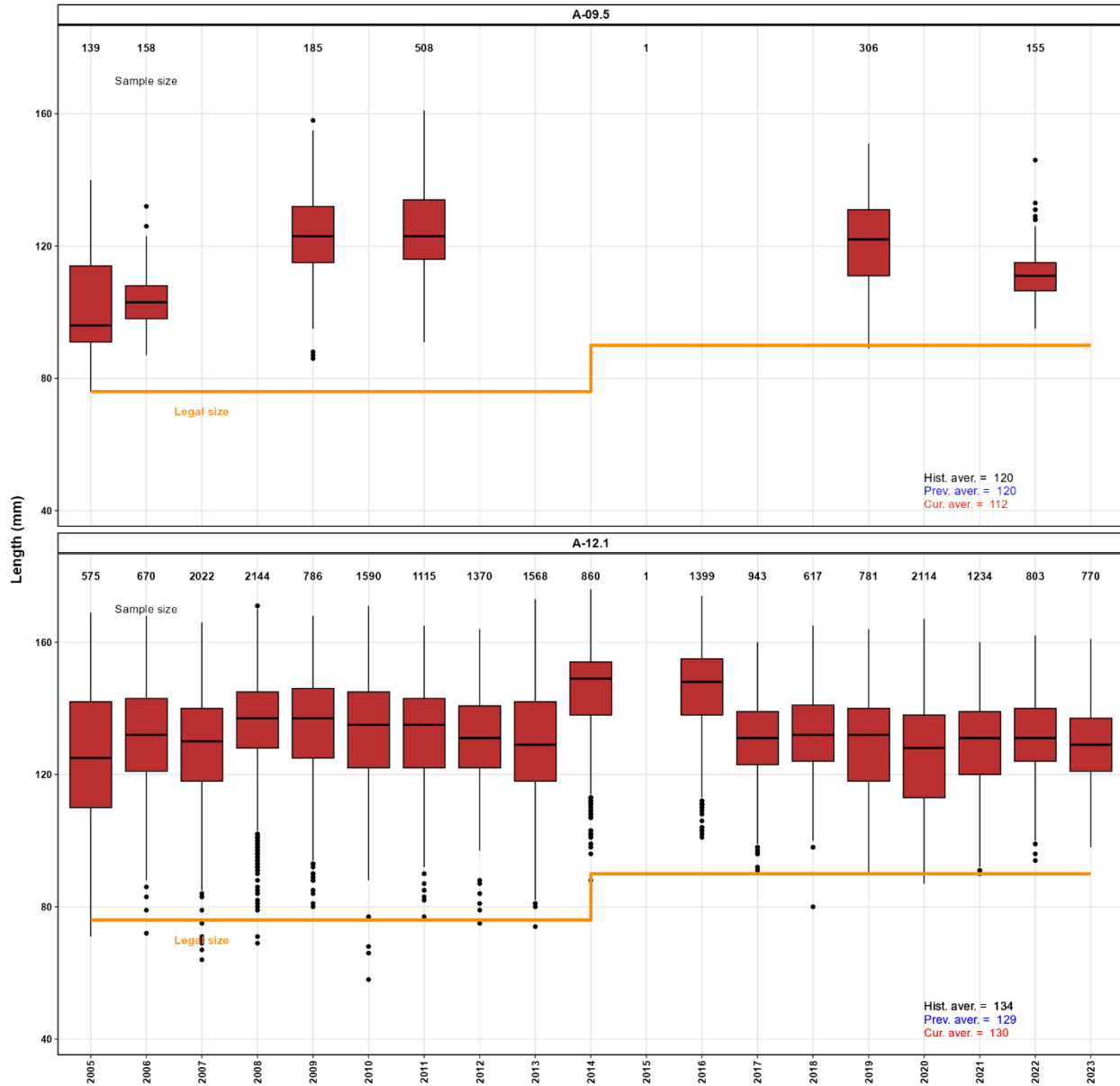


Figure 16. Size structure (anteroposterior length) of Atlantic surfclams landed by shellfish area and number of surfclams measured during the Îles-de-la-Madeleine commercial diving fishery. The historical average size (hist. aver.), the average size from the previous assessment (prev. aver.) the average size for the current assessment (cur. aver.) are presented as well as the legal minimum size (orange line).

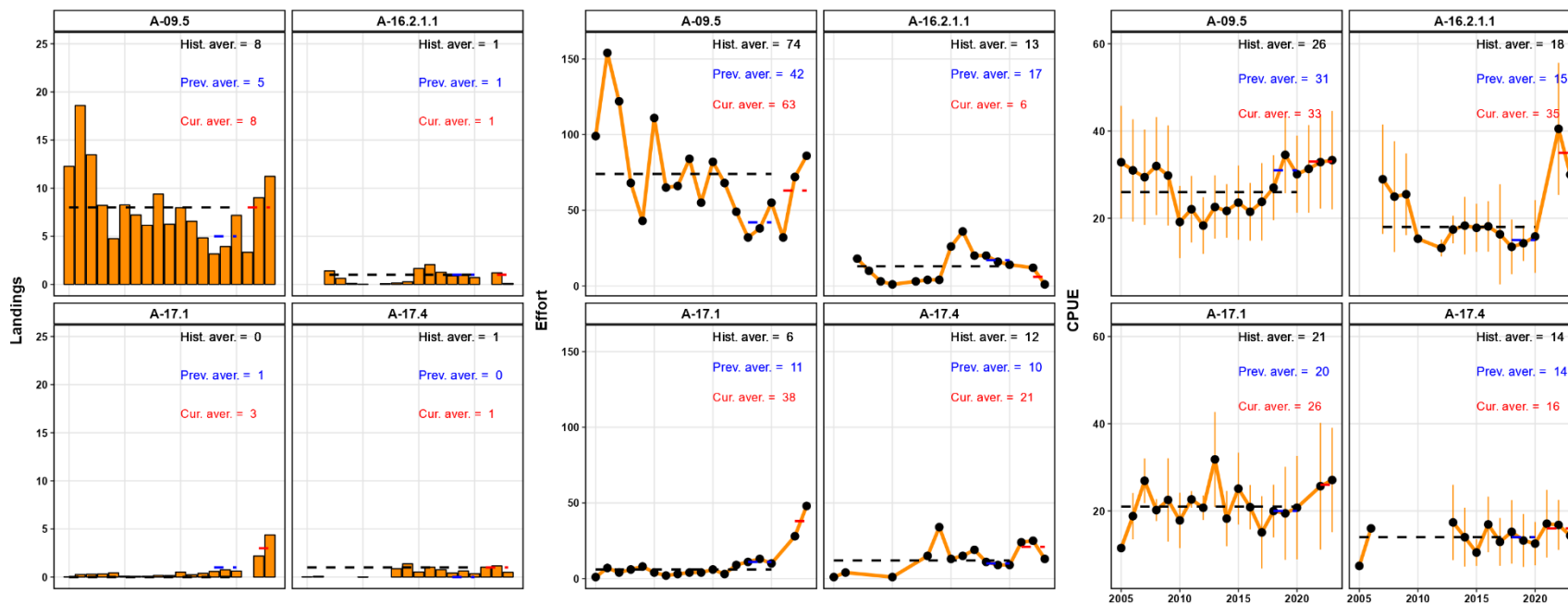


Figure 17. Landings (t), effort (fishing days) and non-standardized catch per unit effort (CPUE in kg/h·m) for commercial onshore harvesting (hand digging) of Atlantic surfclams in shellfish areas A-09.5, A-12.1, A-17.1 and A-17.4 in the Îles-de-la-Madeleine. The different dashed lines indicate the historical average (hist. aver.), the average for the previous assessment period (prev. aver.) and the average for the current assessment period (cur. aver.).

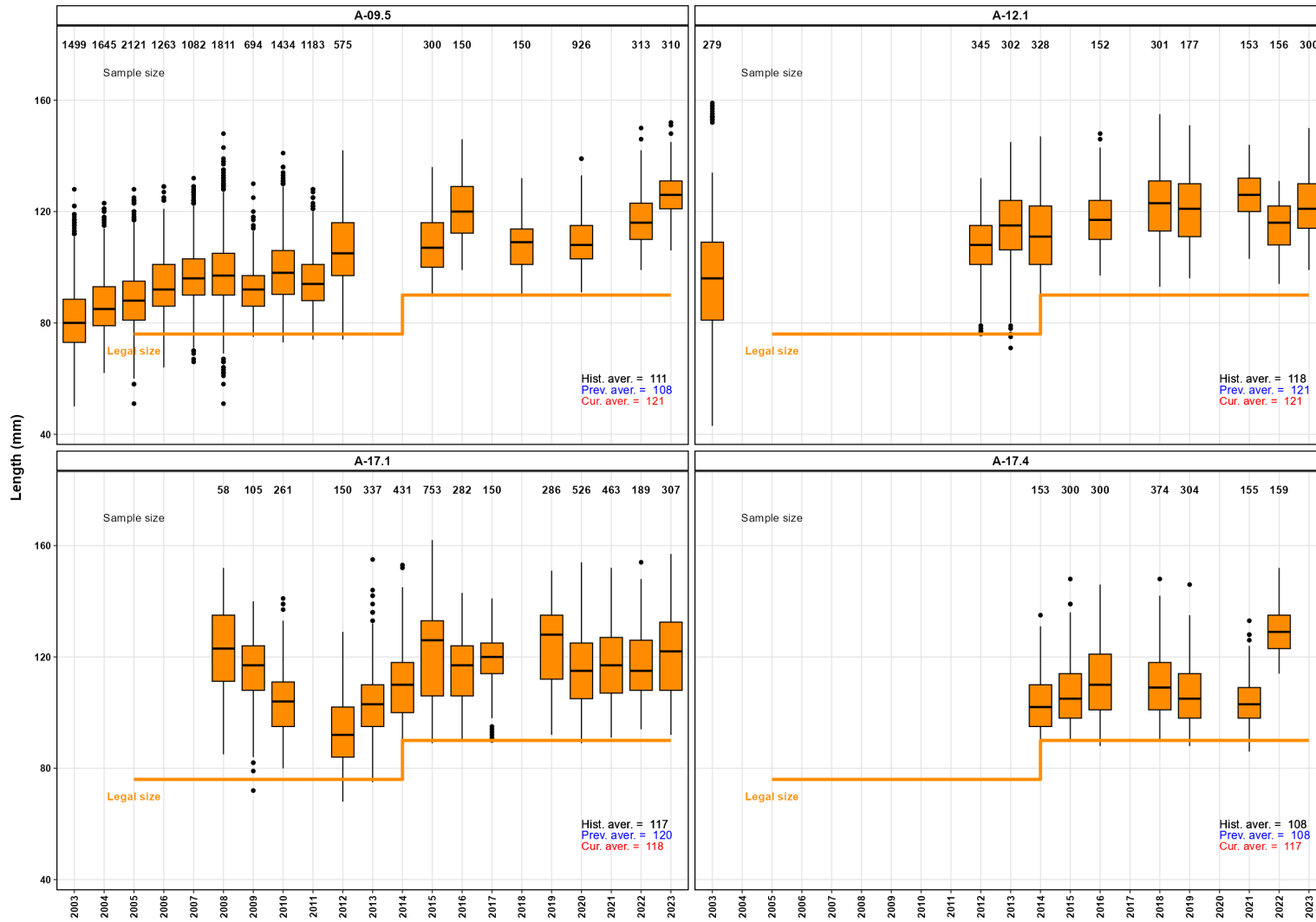


Figure 18. Size structure (anteroposterior length) of Atlantic surfclams landed by shellfish area and number of surfclams measured during the Îles-de-la-Madeleine commercial hand digging fishery. The historical average size (hist. aver.), the average size from the previous assessment (prev. aver.) the average size for the current assessment (cur. aver.) are presented as well as the legal minimum size (orange line).