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Assessment of Softshell Clam (*Mya arenaria*) Stocks of Québec's Inshore Waters in 2019 – Methodology and Results

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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.

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ABSTRACT

The softshell clam (*Mya arenaria*) is found all along Québec's coastlines, where it is harvested recreationally and commercially. Since 2008, harvesting has been performed exclusively with hand tools. For management purposes, Québec's coastal areas are divided into shellfish harvest areas in three main regions: the North Shore, Gaspé–Lower St. Lawrence, and the Îles-de-la-Madeleine. Recreational harvesting is carried out in all three regions, while commercial harvesting is limited to the Upper North Shore and the Îles-de-la-Madeleine. Commercial landings on the Îles-de-la-Madeleine have been small (< 3 t) for a number of years, and the current commercial fishery is limited almost exclusively to the Upper North Shore.

Commercial landings on the Upper North Shore reached a peak in 2000, at 1,173 t, and then declined rapidly, with average landings of 26 t recorded in 2017–2019. Total allowable catches (TACs) are not fully utilized owing to the low fishing effort. Commercial landings come mainly from 10 shellfish harvest areas. Since 2017, the average size of landed clams has ranged between 65 mm and 74 mm in the six areas sampled, with sub-legal size clams (< 51 mm) making up only a very small proportion of landings.

In all, 23 shellfish harvest areas on the Upper North Shore were surveyed from 2016 to 2019; eight of these had been previously covered in surveys from 2002 to 2014. Commercial density (i.e., the density of legal-size clams) increased substantially in five of these eight areas. However, the current area of some of these beds is much smaller than that measured in surveys from 1967 to 1977. Indicators used for assessing softshell clam stocks in the shellfish areas surveyed in 2016–2019 include harvestable area, density of 20–50 mm clams, density of legal-size clams (≥ 51 mm) and commercial biomass.

In order to protect the reproductive potential of each shellfish harvest area, it is recommended that the exploitation rate be limited to a maximum of 5% of the commercial biomass. However, at a 5% exploitation rate, certain shellfish areas could be more vulnerable to a loss of reproductive potential. Therefore, it is suggested that this rate be adjusted downward for shellfish areas with a harvestable area of less than 0.05 km² and an average density of sub-legal size clams (20–50 mm) of less than 15 clams/m². The suggested exploitation rates apply to all removals (from both commercial and recreational harvests).

INTRODUCTION

Softshell clams (*Mya arenaria*)—also referred to as long-neck or steamer clams, or just clams—occur just about everywhere along Québec's coastline, particularly in river estuaries and bays. Although the recreational harvesting of softshell clams has a long history in Québec, it is poorly documented. However, data on commercial softshell clam landings in the estuary and Gulf of St. Lawrence and Chaleur Bay have been collected since 1917. The resource was exploited extensively at the end of the Second World War, when the species was used as bait by cod fishermen (Lamoureux 1977). Processing of softshell clams in Québec probably dates back to 1944 (Lamoureux 1977). Beginning in the 1990s, most landings from Québec were exported to the Maritime provinces and United States in the form of frozen clam meat (Comité côtier Les Escoumins à la Rivière Betsiamites 2001). However, since 2011, commercial landings have mainly supplied local markets. Softshell clams are harvested primarily with hand tools (shovel, pitchfork, clam fork, etc.).

Fisheries and Oceans Canada (DFO) conducts a review and assessment of softshell clam stocks in Québec every three years. The most recent review was held on February 25, 2020, in Mont-Joli, Québec. This document presents the data, techniques, analyses, and findings of this resource assessment following the 2019 fishing season, in support of the Science Advisory Report (DFO 2020). Although some of the results of the surveys conducted from 2016 to 2019 are presented here, a second research document will describe all these survey results in detail.

BACKGROUND

Harvesting softshell clams is very popular among people in the maritime regions of Québec, because the resource is easily accessible and can be harvested without the use of specialized equipment. Commercial and recreational harvesting take place on the same coastal territory. These two activities are practiced at low tide, primarily during spring tides. Maritime Québec is divided into three large regions: the North Shore, Gaspé–Lower St. Lawrence and the Îles-de-la-Madeleine. Only the North Shore region is divided into three fishing areas: Area 1 (sub-areas 1A, 1B and 1C) corresponds to the Upper North Shore, Area 2 to the Middle North Shore and Area 3 to the Lower North Shore (Appendix 1). In addition, these three fishing areas have been carved up into a large number of shellfish harvest areas. The fishing areas are management units, while the shellfish harvest areas are currently considered as stocks.

SHELLFISH HARVEST AREAS

The coastal zones of Québec have been divided up into several hundred shellfish harvest areas, in order to monitor and manage water quality and the shellfish in these areas. Shellfish areas are managed under the Canadian Shellfish Sanitation Program (CSSP), which determines the classification (status) of each area annually. Three federal government departments and agencies are responsible for running the CSSP: Environment and Climate Change Canada (ECCC), the Canadian Food Inspection Agency (CFIA) and DFO. ECCC is in charge of monitoring bacteriological water quality in the shellfish areas, identifying and evaluating pollution sources and classifying shellfish harvest areas on the basis of water quality analyses. The CFIA regulates the processing, packaging, labelling and storage of shellfish, in order to prevent its contamination and spoilage in accordance with federal standards, in addition to maintaining a biotoxin surveillance program in shellfish harvest areas. Lastly, DFO regulates licences, harvesting locations and periods, and the minimum legal size of harvested shellfish for stock management purposes. DFO also monitors harvesting activities in areas considered to be

contaminated, or likely to be contaminated, in order to protect the public from the health risks associated with these foods.

Along with closure due to water contamination, some shellfish areas may also be closed for varying periods of time owing to the presence of biotoxins or to conserve shellfish stocks.

In 2019, there were 350 shellfish harvest areas¹ and 49 shellfish culture operations in Québec, with some shellfish areas containing more than one softshell clam bed (ECCC 2019, CSSP 2020). Québec's shellfish areas are distributed among the Îles-de-la-Madeleine (48), Gaspé (113), Lower St. Lawrence (34) and North Shore (148) regions, as well as other regions (7) such as the Saguenay River. Possible classification categories under the CSSP include approved (A), conditionally approved (CA, closed from June 1 to September 30 of each year), conditionally approved with a conditional management plan (CA-CMP, due to the risk of an overflow at a water filtration plant), restricted (R) and prohibited (P). Recreational and commercial harvesting of softshell clams is limited to shellfish areas with an A, CA or CA-CMP status. However, commercial harvesters can exploit shellfish areas with a restricted status on the condition that the softshell clams undergo depuration treatment at a processing plant before they are marketed (referred to as the "depuration fishery" in the rest of this document). Quebec has not had a depuration facility since 2010. No harvesting is allowed in areas with a prohibited status.

In Québec, 69 shellfish areas with an A status; 11 areas with a CA status; and 1 area with a CA-CMP status were open to softshell clam harvesting in 2019. In all, 31 of these areas were in the Îles-de-la-Madeleine, 6 in the Gaspé–Lower St. Lawrence region and 44 on the North Shore. In 2019, the Upper North Shore had 66 shellfish areas: 18 with an A status, 5 with a CA status, 1 with a CA-CMP status, 4 with an R status and 38 with a P status (Figure 1 and Appendix 2).

Over the years, some shellfish harvest areas have been subdivided into smaller areas to fine-tune their classification, resulting in the creation of new areas. For example, since 2005, the Pointe-aux-Outardes shellfish area (N-06.1²) has been subdivided into a western (Pointe-aux-Outardes Ouest, N-06.1.1) and eastern (Pointe-aux-Outardes Est, N-06.1.2) section. Until 2019, these two areas were dealt with together as area N-06.1 but, beginning in 2020, they will be handled separately. Other areas that have been subdivided include Baie Didier (N-04.1.2.2), divided in 2009 into southern and northern portions, Baie Didier Sud (N-04.1.2.2) and Baie Didier Nord (N-04.1.2.3) respectively; Battures aux Gibiers (N-04.2.1), divided in 2016 into western and eastern portions, Battures aux Gibiers Ouest (N-04.2.1.1) and Battures aux Gibiers Est (N-04.2.1.2) respectively; Ragueneau (N-05.2), divided in 2005 into western and eastern portions, Ragueneau Ouest (N-05.2.1) and Ragueneau Est (N-05.2.2) respectively; and Baie St-Ludger (N-06.2), divided in 2006 into La Grosse Pointe (N-06.2.1) and Battures de Manicouagan (N-06.2.2). Shellfish areas are usually subdivided to allow harvesting to be maintained in one part of the area, and to limit it (CA) or prohibit it in the other.

¹ Excluding areas around the pumping station overflows (OF) in Baie des Escoumins, and the main sewage outfalls (MSO) in Baie de Port-Daniel, Baie Sainte-Catherine, Pointe-au-Bouleau and Batture aux Alouettes.

² The number in parentheses is the identification number for the shellfish harvest area (Appendix 2).

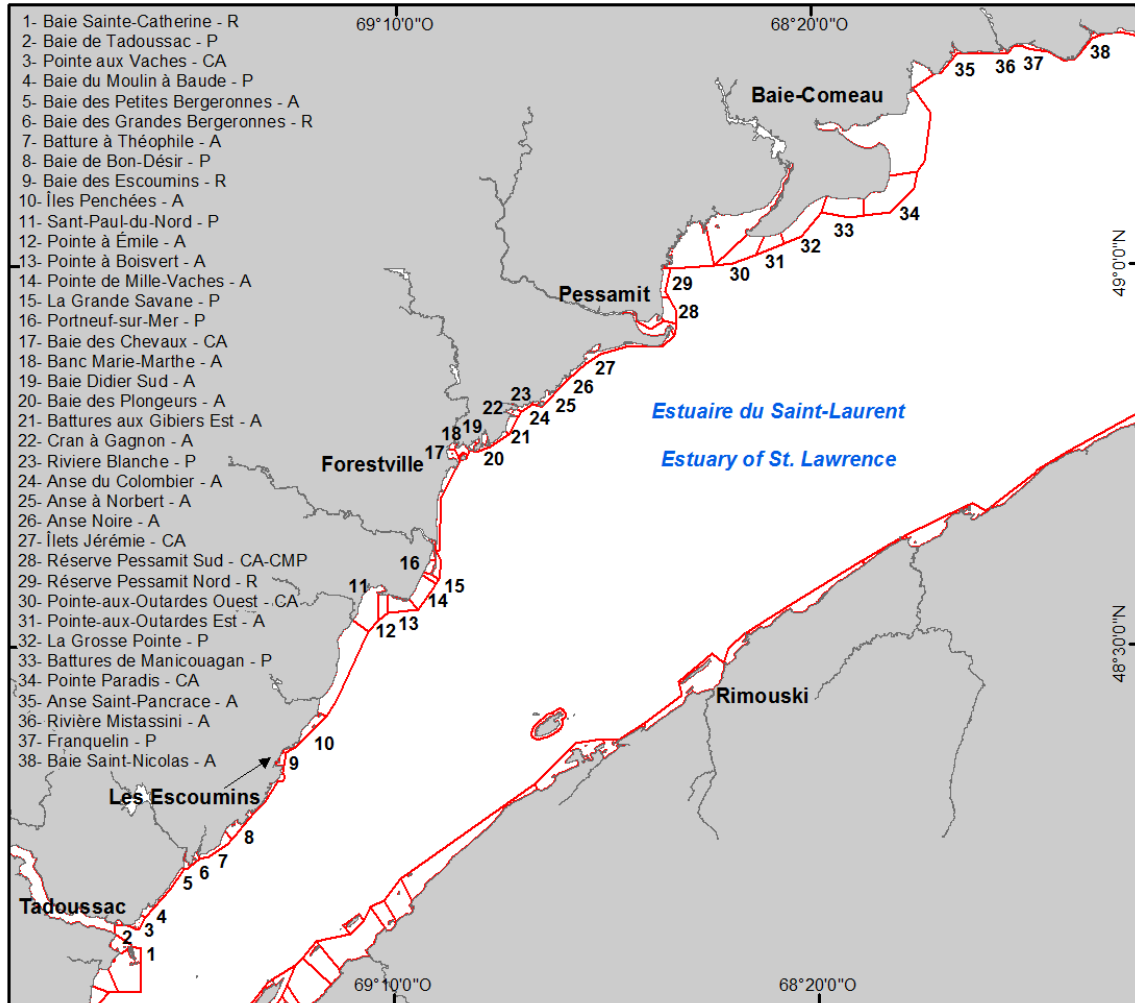


Figure 1. Location of the main shellfish areas on the Upper North Shore and their 2019 classification (status) under the Canadian Shellfish Sanitation Program (CSSP) (A = approved, CA = conditionally approved, CA-CMP = conditionally approved with conditional management plan, R = restricted and P = prohibited).

MANAGEMENT MEASURES

In Québec, the minimum legal size for softshell clams has been 51 mm since at least 1990, for all types of harvesting. Since 2002, recreational and commercial harvesting has been done exclusively on foot with hand tools (clam fork, shovel, etc.), except on the Middle North Shore (Area 2), where two commercial hydraulic dredge harvesting licences are authorized, and at aquaculture facilities, where the use of hydraulic rakes is permitted. Manual commercial harvesting is allowed on the Upper North Shore and in the Îles-de-la-Madeleine, while only recreational harvesting is permitted in other regions of Québec.

Since 2004, various management measures have been implemented to better control the manual commercial harvest (Appendix 3). In addition to a minimum legal size and restrictions on the type of fishing gear used, additional measures have been introduced on the Upper North Shore: the reorganization of fishing areas into sub-areas (Appendix 1), a fishing season, a maximum number of licences in sub-areas 1A and 1B, a participation clause and a prohibition on discards of large softshell clams (≥ 51 mm) in the water. In addition, harvesters are required

to wear a safety vest displaying their licence number while harvesting, and to complete a logbook. Since the creation of sub-area 1C in 2008, the Innu community of Pessamit has managed harvesting in this sub-area; this Indigenous community holds a communal commercial licence. Two other measures went into effect in 2008: (1) harvesters are only allowed to harvest in the sub-area where they reside; and (2) a limited fishing season, extending from mid-March to the end of October, was instituted. Since 2009, the Baie des Chevaux, Banc Marie-Marthe, Baie Didier Sud, Baie des Plongeurs and Cran à Gagnon shellfish areas in fishing sub-area 1A have been reserved exclusively for commercial harvesting. Two areas—Baie Didier Sud and Baie des Plongeurs—were closed from 2010 to 2015 to preserve beds' reproductive potential. Since 2015, the Baie des Petites Bergeronnes shellfish area, located in the Saguenay–St. Lawrence Marine Park, has been open for a few weeks in spring for recreational harvesting. Lastly, since 2015, total allowable catches (TAC) for commercial harvesting have been in place in 20 shellfish harvest areas on the Upper North Shore (Appendix 2).

In Area 2 on the North Shore, regulations exclusively target commercial fishing with mechanical gear, for which there are two non-transferable licences. Harvesters are allowed to use a single dredge with a maximum width of 1.52 m, and are required to fill out a logbook. The TAC is 68 t. However, mechanized softshell clam harvesting has not been carried out in this area since 2008.

Since 2005, commercial harvesters in the Îles-de-la-Madeleine have been required to complete a logbook and the commercial manual harvesting season there extends from March 1 to December 31. There are no limits on the number of licences issued; in 2019, there were seven active licences.

Since 2004, recreational harvesters in Québec have only been allowed to harvest 300 softshell clams a day (equivalent to between 5 kg and 15 kg a day, depending on the size of the clams). Any person wishing to harvest more than the daily limit or sell their catch must obtain a commercial licence.

The manual harvesting season is limited by the inaccessibility of coastal habitats. Since harvesting is primarily done in the lower portion of the intertidal zone, it can only be carried out at low tide, mainly during spring tides. Spring tides only occur roughly twice a month and last close to a week. Harvesting is mostly done in spring and fall (Brulotte 2011). In summer, a number of shellfish areas are closed due to their CA status and to the presence of biotoxins.

BIOLOGY

Softshell clams (*Mya arenaria*) are bivalve molluscs found in North American and European inshore waters (Abgrall et al. 2010). In the western Atlantic, softshell clams range from Labrador to Cape Hatteras, North Carolina (Bousfield 1964). This species occurs in the St. Lawrence estuary (beginning at Baie-Saint-Paul on the north shore and Saint-Rock-des-Aulnaies on the south shore), Gulf of St. Lawrence and Chaleur Bay. It is found mainly in the intertidal zone (the area covered by water at high tide and exposed at low tide) and in the subtidal zone to a depth of 10 m.

The softshell clam is an endobenthic organism that lives buried in soft sediments of mud and sand, mainly in protected locations such as bays, river estuaries and barachois (partly cut-off tidal ponds). It is a sedentary species that occurs in beds, or aggregations, of various sizes.

Softshell clams are filter feeders that consume algae, plankton and suspended particles in the water. A 25–30 mm clam likely filters around 2.5 litres of water an hour in summer (Newell et al. 1983). Softshell clams are dioecious, with separate sexes, and usually have an even sex ratio (Brousseau 1978, Roseberry et al. 1991, Blaise et al. 1999, Brulotte and Giguère 2007). The

mean size at which 50% of individuals are sexually mature (L_{50}) is 38–39 mm in Québec (Brulotte and Giguère 2007). The lowest value for L_{50} , 28–29 mm, was observed in the Havre aux Maisons lagoon in the Îles-de-la-Madeleine and the highest, 45–46 mm, at Pointe-aux-Outardes on the Upper North Shore. In addition, the L_{50} value is lower in softshell clams occupying the top part of the foreshore than those in the bottom part. Fecundity (number of ova, or eggs, produced) increases exponentially with length in softshell clams (Brousseau 1978). The number of eggs produced per female can range from 120,000 to 5 million, depending on the female's size and environmental conditions (Abgrall et al. 2010). There is generally only one spawn (or several partial spawns) a year, occurring mainly in June and July (Roseberry et al. 1991, Gauthier-Clerc et al. 2006, Brulotte and Giguère 2007, St-Onge 2013). The gametes are released into the water, where the ova are fertilized. After a pelagic larval stage lasting roughly five weeks (the duration of which depends on such factors as water temperature and food availability), the young clam metamorphoses (i.e., takes on adult form) and settles on the bottom, mainly in July and August. Recruitment to the adult population varies from year to year (Brulotte et al. 2012 and 2015), and depends on factors such as the synchronization of spawning in both sexes, physical conditions (temperature, current, etc.) and mortality and dispersal rates in larvae and juveniles (Brousseau 1978, Abraham and Dillon 1986, Strasser et al. 1999, Garcia et al. 2003, Abgrall et al. 2010).

The softshell clam populations in the estuary and northern Gulf of St. Lawrence differ genetically from those in the Îles-de-la-Madeleine and southern Gulf (St-Onge 2013). Under certain favorable conditions such as the presence of physical barriers, larval clams may remain at their spawning site (St-Onge et al. 2015). Despite this finding, we do not have any specific information on the source of recruitment to the population in each softshell clam bed in Québec. Consequently, each bed's reproductive potential must be protected.

The growth of softshell clams varies as a function of immersion time, the quality of the site where the clam has burrowed (physical variables such as water temperature) and the productivity of the surrounding environment. In Québec, softshell clams grow quickly in spring and summer, and slower in fall, and cease growing altogether in winter. At metamorphosis, the clams measure roughly 0.3 mm but can reach 2 mm to 8 mm by fall (Brulotte et al. 2012 and 2015). In tank experiments, 15–20 mm growth was achieved during the second growing season and slightly less in the third (Brulotte 2018); subsequently, growth ranged from 0 mm to 5 mm a year. In Québec, softshell clams require five to seven years to reach the minimum legal size of 51 mm (Lavoie 1969a, Lamoureux 1977, Mercier et al. 1978, Newell and Hidu 1982, Procéan 1993). The maximum size is slightly over 110 mm.

Clams can be dislodged from the substrate by waves, storms, or harvesting activities. The time it takes dislodged clams to bury themselves again affects mortality (e.g., owing to predation) and dispersal (e.g., by currents). According to tank and field tests, burrowing time is mainly influenced by the size of the clam and water temperature (Pariseau 2003, Pariseau et al. 2007, Brulotte 2018). Clams in the 15–20 mm length class bury themselves faster than those in the 35–40 mm class. In addition, burrowing time is inversely proportional to water temperature. At 20°C, a 15–20 mm clam takes roughly one hour to completely bury itself, but over seven hours at 5°C. Burial depth is one to two times the length of the clam (Nadeau and Myrand 2006). Juveniles (< 10 mm) bury themselves in the first few centimeters of sediment, which makes them more susceptible to being dislodged. Experiments on sandflats and mudflats show that the rate of dispersal (or loss) over a year is influenced by clam size and the type of sediment (Hunt and Mullineaux 2002, St-Onge and Miron 2007, and S. Brulotte, DFO, Mont-Joli, Québec, unpublished data). The highest mortality rates have been recorded in small individuals (< 20 mm) buried in sandy sediments.

Predators of softshell clams are numerous and vary depending on the size of the clam (Abgrall et al. 2010). Larvae and juveniles (which bury at shallow depths) are the most vulnerable to predation (Abraham and Dillon 1986). The main predators of softshell clams include some species of seabirds (e.g., gulls [*Larus* sp.]), fish (e.g., winter flounder [*Pseudopleuronectes americanus*]), crustaceans (e.g., rock crab [*Cancer irroratus*]), certain gastropods (e.g., moon snail [*Euspira heros*]), nemertean worms and polychaetes (Villemure and Lamoureux 1975, Abraham and Dillon 1986, Newell and Hidu 1986, Abgrall et al. 2010).

MATERIALS AND METHODS

COMMERCIAL HARVESTING

Data on the commercial softshell clam fishery come from three different sources: logbooks, purchase slips and the DFO's commercial catch sampling program. Logbooks, instituted in 2004–2005 for manual harvesting, are completed daily by the harvester, and provide information such as the harvester's name and identification number, date and duration of harvesting (hours), weight of the harvest and the shellfish area visited. The purchase slip is completed by the purchaser and provides the official landing figures when the softshell clams are sold to the processing plant.

The figures on annual landings by region from 1917 to 1992 presented in this document were taken from Bérubé (1990), Bérubé and Yergeau (1992) and DFO (2000). Since 1993, information on the commercial fishery has come from ZIFF (Zonal Exchange File Format) files, compiled by DFO's Regional Science Branch. Every fall, fishery statistics are updated for the current year and the two previous years; the data for the current and previous years are considered preliminary. Data are validated annually to eliminate or correct outliers (effort, location, etc.).

Since 2004, the DFO's commercial catch sampling program has allowed the size structure of landed softshell clams to be described. This sampling is usually done at the processing plant. For logistical reasons, the program is limited to the most heavily harvested areas. Owing to the absence of harvesting or to low landings in recent years, sampling may not have been carried out in some areas or during some years. One sample corresponds to roughly 150 measured softshell clams.

Commercial fishery indicators used in assessing the softshell clam stocks in each shellfish harvest area include landings, fishing effort, size structure, the average size of clams landed, and the proportion of sub-legal size clams in landings.

Landings, expressed in metric tonnes (t) of live weight, correspond to the official data available and do not include unreported fishing activities. Since 2002, commercial landings have been compiled by shellfish harvest area but previously were compiled by port of landing (e.g., Saint-Marc-de-Latour, Saint-Paul-du-Nord, Forestville) or by region.

Unreported fishing activities are estimated annually (based on supplementary purchase slips, or SPSs) by DFO fishery officers, among other parties. These estimates correspond to seafood sold directly to the public, kept for personal consumption or processed by fishers/harvesters (or used for bait), as well as the estimated recreational harvest. The 2018 and 2019 estimates were not yet available when this document was written.

Fishing effort is expressed in vendor-days rather than harvester-days, since the actual number of individuals involved in the softshell clam fishery is unknown. Although prohibited, it is common practice for harvesters on the Upper North Shore to get together in groups of two or three to dig for softshell clams. Furthermore, the harvester/vendor ratio may have changed over

the years, particularly between the early 2000s when exploitation was intensive and recent years. However, fishing effort is generally expressed in harvester-days in the Réserve Pessamit Sud area; in depuration areas, which have stricter controls on harvesting; and on the Îles-de-la-Madeleine.

Normally, a harvesting activity lasts from 4 to 6 hours, or the duration of low tide. Occasionally, harvesters manage to work during two low-tide periods in a single day (the first in the early morning and the second in the evening). In some shellfish areas, the evening's harvest is frequently recorded in the same logbook as the following day's harvest, even though this is not legal. In this case, the number of hours is usually adjusted to correspond to two tide periods. Logbooks from all years (2004–2019) were reviewed in 2019 to detect these cases, with landings divided by two to obtain data (landings and effort) per tide period.

Landings and fishing effort are used to calculate the catch per unit effort (CPUE), expressed in kg/vendor-day. The uncertainty over fishing effort (number of harvesters involved) also affects CPUE values. Since the closure of the Upper North Shore processing plants, new harvesters have entered the fishery, particularly in sub-areas 1A and 1C, resulting in a great deal of variability in CPUE values. For both of these reasons, annual variations observed in CPUE values are not used to describe the status of the different stocks.

In softshell clams, the size, or length (mm), is defined as the maximum anteroposterior length of the shell (Appendix 4). The size structures of landed clams (sampled at the processing plant) are compiled by shellfish area and by year. The figures are aggregated to ensure that each sample has the same weighting (thereby eliminating the effect of the variation in the number of clams measured). The average size of landed clams is calculated by shellfish area and by year. The proportion (%) of sub-legal size clams in landings is calculated on the basis of annual age structures by shellfish area. The reference average was calculated using the 2004–2018 period.

RESEARCH SURVEYS

2016–2019 surveys

All shellfish areas open for softshell clam harvesting (approved and conditionally approved status) on the Upper North Shore were surveyed from 2016 to 2019, or a total of 23 shellfish harvest areas.³ They include, from west to east (Figure 1): Pointe aux Vaches (N-01.1.2), Baie des Petites Bergeronnes (N-01.1.4), Batture à Théophile (N-01.2.2), Îles Penchées (N-02.2), Pointe à Émile (N-03.1.2), Pointe à Boisvert (N-03.2.1), Pointe de Mille-Vaches (N-03.2.2), Baie des Chevaux (N-04.1.1.1), Banc Marie-Marthe (N-04.1.2.1), Baie Didier Sud (N-04.1.2.2), Baie des Plongeurs (N-04.1.3), Battures aux Gibiers Est (N-04.2.1.2), Cran à Gagnon (N-04.2.2), Anse du Colombier (N-04.4.1), Anse à Norbert (N-04.4.2), Anse Noire (N-04.5.1), Îlets Jérémie (N-04.5.2), Réserve Pessamit Sud (N-05.1.3.1), Pointe-aux-Outardes Ouest (N-06.1.1), Pointe-aux-Outardes Est (N-06.1.2), Pointe Paradis (N-06.3), Rivière Mistassini (N-08.1.3) and Baie Saint-Nicolas (N-08.3).

First, the less well-known shellfish areas were visited to determine the location and approximate size of the beds, which allowed the beds to be surveyed to be targeted. The same methodology was employed throughout the surveys. A systematic sampling grid covering the entire bed was used to determine the location of sampling stations. The sampling interval (distance between stations) varied depending on the bed, and occasionally between different portions of the same

³ Excluding the Anse Saint-Pancrace (N-08.1.2) shellfish area, which was the only approved shellfish area that was not surveyed, since it has had no recorded softshell clam landings since 2002.

bed. A 0.25-m² quadrat was used as the area to be sampled at each station. Sediments were collected with a shovel or a Venturi suction system (Brulotte and Giguère 2003) to a depth of at least 30 cm. The contents of the quadrat were sieved through 10-mm mesh. All clams were counted and measured, and the other living organisms present were identified and counted.

A stratified random subsample (two clams collected per 1-mm length increment) was taken in each shellfish area and preserved for morphometric analyses in the laboratory (length [± 0.1 mm], fresh weight [± 0.1 g] and thawed weight [± 0.01 g]). The linear relations obtained between fresh or frozen weight and length were used in the yield calculations (g/m² or kg/m²). In the case of the surveys done between 2016 and 2019, yields were calculated using fresh weight (unless otherwise specified).

Clams were assigned to two size classes: sub-legal size clams (20–50 mm) and legal-size clams (≥ 51 mm). Owing to the mesh size used in sieving, clams < 20 mm were not included in the density (number/m²) and yield calculations. The average density and yield in each shellfish area was calculated on the basis of all the beds in the shellfish area, and shown with the standard error. Commercial biomass (t) was determined by multiplying the average yield of clams ≥ 51 mm by the harvestable area of the shellfish area.

The size of each bed was estimated by totaling the intervals (distance between stations in m²) between the stations surveyed. Stations without clams located on the periphery of the sampled area were excluded from the calculations. So-called enclosed stations (i.e., those located closer to the center of the sampled area) with no clams were retained to estimate the area, density and yield of beds.

The harvestable area is defined by a minimum of three contiguous stations with a density of legal-size clams ≥ 16 clams/m². Usually, stations with a high density of clams are found in the same part of a bed. However, the harvestable area may occasionally include several enclosed stations with less density, ensuring a certain continuity in the harvestable area.

Indicators for shellfish areas calculated from the survey results are the total area of beds in the shellfish area, harvestable area of these beds, average density of 20–50 mm clams in all beds in the shellfish area, and average density and biomass of clams ≥ 51 mm in the harvestable area.

2002–2014 surveys

From 2002 to 2014, DFO carried out a number of surveys of softshell clam beds on the Upper North Shore in collaboration with its partners. The eight shellfish harvest areas covered are (Figure 1): Baie des Petites Bergeronnes (2008), Pointe à Émile (2003), Baie des Chevaux (2002), Cran à Gagnon (2007), Anse Noire (2003), Réserve Pessamit Sud (2005, 2010 and 2014), Pointe-aux-Outardes Ouest (2003–2004⁴) and Pointe-aux-Outardes Est (2004). The methods used in the surveys and detailed results are described in Giguère et al. (2008), Brulotte (2011) and Brulotte (2018).

Densities of 20–50 mm clams, densities of clams ≥ 51 mm, and yields of clams ≥ 51 mm were compared by year in these eight shellfish areas. Comparisons were carried out using the Kruskal-Wallis nonparametric test, with a significance level of 0.05. The results used in the comparison were obtained from similar areas every year in each shellfish area.

⁴ Survey conducted over two years, one portion in 2003 and the other in 2004.

Yields over the years were compared using frozen weight (the only type of yield measured before 2016), except in the Pointe à Émile and Anse Noire shellfish areas, where only fresh weight was measured in the 2003 surveys.

1967–1977 surveys

The vast majority of commercially viable softshell clam beds on the Upper North Shore were surveyed from 1967 to 1977 (Lavoie 1969a, 1969b, 1970a and 1970b, Lamoureux 1974; Mercier et al. 1978). Data from this early series of surveys (historical surveys) are useful in evaluating changes that have occurred in the location and size of beds and, to a certain extent, in comparing historical densities and yields with current ones.

The methodology used in these surveys is quite different from the methods that DFO has been using since 2002. Furthermore, the information available in these documents is generally limited to summary tables of the results and maps of the locations of the sites surveyed, and does not include the number of stations surveyed or results by station. Therefore, statistical tests could not be used to compare densities and yields between years.

Since the results of the 1967–1977 surveys are in bushels per acre, these values all had to be converted into numbers/m² (whenever possible) and into kg/m². A conversion factor of 27.2 kg (60 lbs.) per bushel was used. Using maps provided in the historical documents, the outlines of the beds surveyed at that time were transferred onto the electronic charts (ArcGIS, ArcMap) used currently. This method allowed stations surveyed in 2016–2019 that fall within the boundaries of the historical beds (1967–1977) to be selected.

Only the aforementioned stations (i.e., those located within the boundaries of historical beds) were used to compare current densities and yields with those in 1967–1977. The index of agreement between the boundaries of historical beds and the location of recent surveys was calculated. The higher the percentage of agreement, the better the coverage of historical beds.

The relative differences (%) between density and yield values in 2016–2019 and 1967–1977 (reference value) were calculated. Differences of over 50% (absolute values) were considered important enough to be highlighted.

RESULTS

COMMERCIAL HARVESTING

From 1917 until the mid-1950s, commercial landings of softshell clams came almost exclusively from the Îles-de-la-Madeleine (Figure 2). Subsequently, landings from the islands declined and were replaced by those from the Gaspé–Lower St. Lawrence and North Shore regions. Since the late 1960s, the commercial harvest has taken place primarily on the North Shore. Landings in Québec fluctuated between 90 t and 820 t from 1917 to 1999. They reached a peak in 2000 at 1,207 t and then declined sharply afterwards, plummeting to 11 t in 2011. Since then, annual landings have remained low, at under 90 t (until 2019).

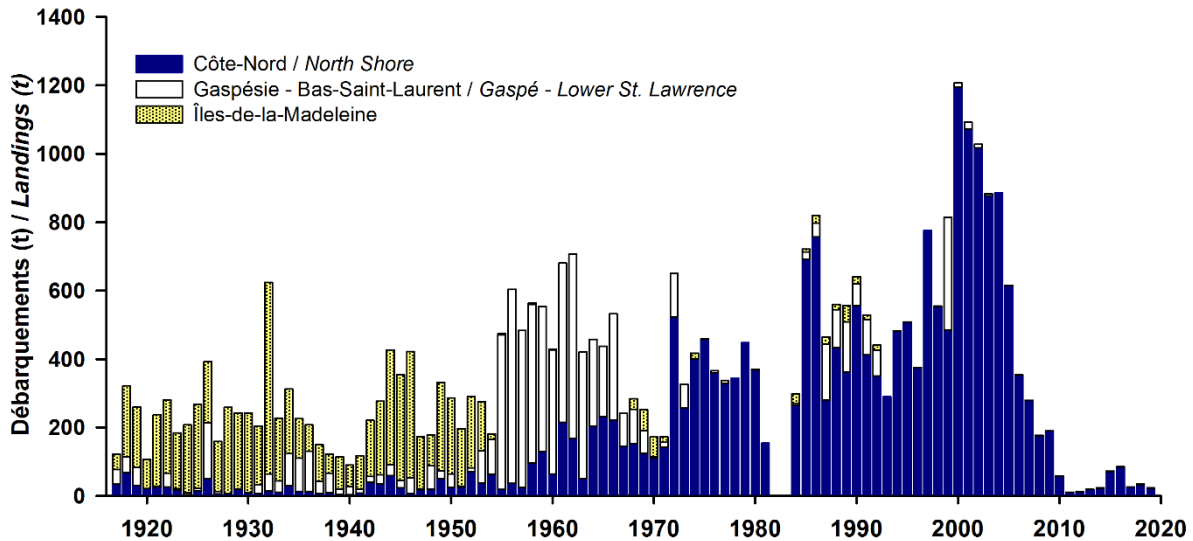


Figure 2. Annual commercial landings of softshell clams in Québec by region.

Since 1993, commercial harvesting has taken place primarily on the Upper North Shore (Appendix 5), although the Îles-de-la-Madeleine fishery experienced a certain resurgence beginning in 2005. However, annual landings on the Îles-de-la-Madeleine have remained low, between 0.1 t and 2.8 t (Table 1, Figure 2 and Appendix 5). The Middle North Shore and the Gaspé–Lower St. Lawrence region have not seen any commercial harvests since 2008 (Appendix 5) and none have been reported on the Lower North Shore since 1985. Consequently, most of the information in this document deals with the Upper North Shore, although data from other regions are presented in some tables, figures and appendices.

From 1984 to 1999, landings from the Upper North Shore fluctuated between 265 t and 757 t (Figure 3 and Appendix 5). They reached a peak of 1,173 t in 2000 and then declined significantly afterward, to only 11 t in 2011. The small landings (< 90 t) in the last ten years are likely due to the absence of processing plants from 2010 to 2014 and since 2017⁵ (Figure 3 and Table 1). Between 2017 and 2019, annual landings averaged 26 t, and came mostly from the Pointe-aux-Outardes Ouest shellfish area. Since TACs were instituted in 2015, they have only been fully utilized in Cran à Gagnon in 2015 and in Cran à Gagnon, Anse à Norbert and Anse Noire in 2016 (Table 1).

⁵ A processing plant in Forestville was open from the spring of 2015 to the fall of 2016.

Table 1. Commercial landings of softshell clams (t) from 2002 to 2019, Total Allowable Catch (TAC, t live weight) in 2019 by sub-area and shellfish harvest area on the Upper North Shore, and cumulative landings (t) by region (Upper North Shore and its sub-areas and Îles-de-la-Madeleine and for Québec as a whole.

Sub-Area, Area or region	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	TAC
1A- Baie des Petites Bergeronnes	15.5	31.7	26.4	115.5	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Grandes Bergeronnes ¹	-	22.2	100.1	-	75.0	27.8	14.4	18.2	-	-	-	-	-	-	-	-	-	-	-
1A- Batture à Théophile	< 0.1	-	-	-	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4
1A- Baie des Escoumins ¹	-	-	-	-	-	61.6	10.7	21.8	-	-	-	-	-	-	-	-	-	-	-
1A- Îles Penchées	5.4	4.5	6.6	1.9	5.9	-	-	-	-	-	-	-	-	-	0.3	-	-	-	5
1A- Pointe à Émile	-	2.3	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
1A- Pointe à Boisvert	125.1	48.5	23.5	20.6	12.3	4.2	1.5	0.5	-	-	0.1	-	-	-	-	-	-	0.4	20
1A- Pointe de Mille-Vaches	31.9	137.4	62.4	19.6	7.6	2.2	0.1	-	-	-	-	-	-	-	-	-	-	-	20
1A- Baie des Chevaux	81.6	58.6	44.7	26.7	10.3	3.6	4.7	2.7	1.1	0.7	1.8	2.2	0.6	2.4	10.5	3.0	2.3	3.1	20
1A- Banc Marie-Marthe	232.8	117.5	48.8	11.5	13.1	11.1	13.1	12.1	1.4	0.7	0.3	1.0	2.1	16.4	18.8	2.6	1.3	0.9	30
1A- Baie Didier Sud	3.5	19.1	11.8	7.8	4.6	2.4	0.2	0.7	C ²	C	C	C	C	C	2.2	-	0.7	0.4	4
1A- Baie des Plongeurs	30.2	17.4	27.4	31.6	18.4	3.6	0.5	-	C	C	C	C	C	C	3.3	1.2	3.8	0.2	10
1A- Battures aux Gibiers Est	1.7	2.5	0.5	-	-	-	0.4	-	-	-	-	-	-	-	1.2	-	-	-	0.5
1A- Cran à Gagnon	27.0	14.2	7.3	3.3	1.6	1.9	1.3	0.1	-	-	< 0.1	< 0.1	0.4	8.4 ³	5.3 ³	1.1	0.4	0.1	5
1A- Rivière Blanche ¹	-	24.0	5.3	-	-	13.0	10.7	10.6	-	-	-	-	-	-	-	-	-	-	-
1A- Anse du Colombier	10.0	17.0	22.7	21.6	5.3	3.7	3.0	2.1	-	-	-	< 0.1	0.1	2.1	3.6	0.5	0.5	< 0.1	10
1A- Anse à Norbert	13.3	0.4	1.3	0.2	1.7	0.6	0.2	-	0.1	-	-	0.1	0.1	-	1.0 ³	-	-	-	1
1A- Anse Noire	3.8	2.2	4.4	3.8	1.6	1.0	< 0.1	0.2	-	-	-	-	-	< 0.1	1.0 ³	-	-	-	1
1A- Îlets Jérémie	30.8	23.0	29.9	34.9	8.9	11.8	8.3	10.8	8.5	-	0.1	< 0.1	0.4	0.1	6.1	-	-	-	15
1B- Pointe-aux-Outardes Ouest ⁴	149.6	154.2	136.3	60.1	61.9	24.1	14.3	7.8	-	7.0	5.7	6.1	17.5	16.8	19.4	17.3	22.9	16.1	30 ⁴
1B- Pointe-aux-Outardes Est ⁴	-	-	-	19.3	8.6	7.0	11.6	19.6	8.5	2.6	3.3	8.1	1.7	5.4	7.4	-	0.3	0.2	-
1B- Rivière Mistassini	3.8	3.2	1.6	4.7	5.4	-	-	0.1	-	-	-	-	-	-	-	-	-	-	3
1B- Baie Saint-Nicolas	10.0	14.6	10.5	16.9	9.4	-	-	-	-	-	-	1.1	0.1	-	0.1	-	-	-	1
1C- Réserve Pessamit Sud	153.5	129.2	304.3	214.5	99.7	98.4	80.2	82.5	37.8	-	0.5	-	-	20.6	4.7	-	-	-	50
1A and 1B- Other sectors ⁵	-	15.3	10.0	-	1.4	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Upper North Shore	929.6	859.1	886.2	614.4	353.7	278.6	176.2	189.6	57.4	11.0	12.0	18.6	23.0	72.2	85.0	25.7	32.2	21.3	-
Sub-area 1A	612.7	498.5	318.2	298.9	92.2	46.2	34.3	29.1	11.1	1.4	2.4	3.3	3.7	29.3	53.4	8.4	9.0	5.0	-
Sub-area 1B	163.4	172.0	148.3	101.0	86.8	31.0	25.9	27.5	8.5	9.6	9.0	15.2	19.3	22.2	26.9	17.3	23.2	16.3	-
Sub-area 1C	153.5	129.2	304.3	214.5	99.7	98.4	80.2	82.5	37.8	-	0.5	-	-	20.6	4.7	-	-	-	-
Depuration ¹	-	59.4	115.4	-	75.0	103.0	35.8	50.5	-	-	-	-	-	-	-	-	-	-	-
Îles-de-la-Madeleine	-	-	-	0.1	0.4	0.5	1.0	0.5	0.9	0.1	0.8	1.2	1.3	0.8	0.7	0.9	2.8	2.3	-
Québec⁶	1,027.8	883.4	886.2	614.9	354.1	279.7	177.2	190.1	58.3	11.0	12.7	19.7	24.2	73.0	85.7	26.6	35.0	23.6	-

¹ Area with restricted or prohibited status (depuration fishery from 2002 to 2009).

² C = Shellfish area closed for conservation purposes.

³ TAC fully fished.

⁴ In 2005, the Pointe-aux-Outardes shellfish area was split into Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est. Since 2015, the combined TAC for both areas has been 30 t.

⁵ Baie Sainte-Catherine (depuration fishery), Saint-Paul-du-Nord, La Grosse Pointe and Franquelin (depuration fishery).

⁶ Includes all commercial landings in Québec (North Shore, Gaspé–Lower St. Lawrence, and the Îles-de-la-Madeleine).

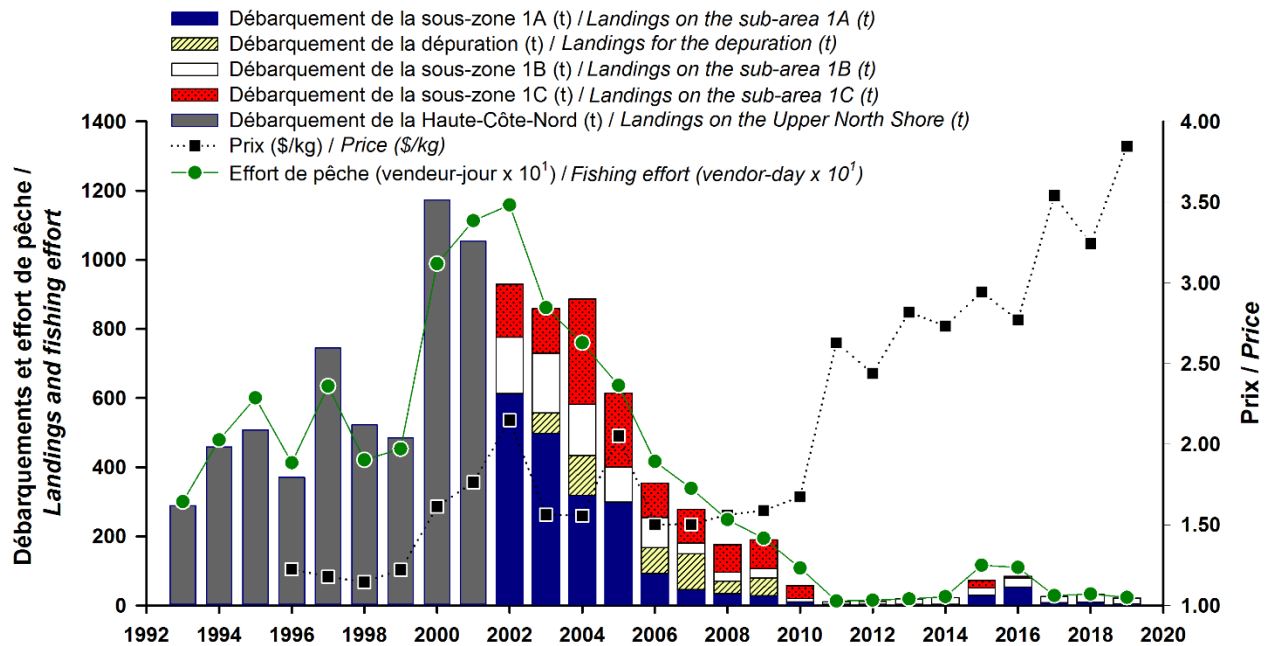


Figure 3. Annual commercial landings of softshell clams by sub-area (including landings in the deuration fishery), and average price and fishing effort for the Upper North Shore as a whole, 1993–2019.

When the deuration facility in Les Escoumins was in operation (1999 to 2009), restricted and prohibited shellfish areas provided a certain portion of the commercial harvest (Figure 3 and Table 1). Softshell clams from these areas underwent deuration treatment at the facility before being sold. This treatment consisted in keeping clams in deuration tanks containing sterilized seawater until all the bacteria in their flesh were eliminated. The quantity of clams that went through this plant before 2002 is unknown. Beginning in 2002, information from these shellfish areas was always handled separately under the “deuration” category, owing to the different harvesting conditions in these areas (limited accessibility and the fact that the deuration facility was responsible for monitoring the harvest). Most of these shellfish areas were located in sub-area 1A (Table 1).

Commercial harvesting in approved and conditionally approved areas is the industry’s main source of supply. However, to meet its needs, particularly from 2003 to 2009, the industry turned to shellfish areas that could be exploited using deuration (Figure 3). Daily catches in 2007 in some of these areas provide a better understanding of commercial harvesters’ behavior (Brulotte 2011). In the beginning, landings were large, up to 140 kg/harvester-day, but declined after a few days; below a certain threshold (around 80–90 kg/harvester-day), harvesters would move on to a new patch, until all the commercially viable portions of the bed had been harvested. From a broader perspective, this tendency of harvesters to move around, coupled with a low CPUE, could explain why certain shellfish areas were abandoned after one or two years of intensive harvesting, for example, Baie des Grandes Bergeronnes, Pointe à Boisvert and Banc Marie-Marthe (Table 1).

The average price per kilogram (live weight) of softshell clams from the Upper North Shore ranged from \$1.14 to \$1.22 from 1996 to 1999 (Figure 3). Subsequently, prices increased, remaining between \$1.50 and \$1.76 from 2000 to 2010, except in 2002 and 2005 when they were slightly above \$2.00. Beginning in 2011, prices rose gradually, reaching \$3.85 in 2019.

Overall, a fairly close relation is found between fishing effort and the volume of landings on the Upper North Shore (Figure 3). However, the decline in landings that began in 2001 preceded a

sharp drop in effort that started in 2003. In 2001 and 2002, despite increased prices and increased effort, landings fell, suggesting that softshell clam populations were overexploited in the early 2000s. Moreover, the figures for effort presented—particularly those before 2008—are likely minimum values, given the uncertainty surrounding this variable (vendor-days versus harvester-days). Consequently, the increase in fishing effort observed beginning in 2000 was probably actually greater. Subsequently, effort declined steadily, dropping from 11,586 vendor-days in 2002 to 130 vendor-days in 2011 (Table 2). The average annual effort for the 2017–2019 period was 283 vendor-days.

Since 2004, DFO has been able to determine the number of active commercial harvesters (vendors) (Table 3). As stated previously, fishing effort fell substantially between 2002 and 2011, which dovetails with a decline in the number of active harvesters during this period. In 2004, the Upper North Shore had 230 active harvesters, but only 65 in 2009 and 6 in 2011 (lowest value of the series). Since then, the number of active harvesters has remained low, varying between 14 and 97.

The downturn in landings, observed from 2001, is likely due mainly to the decline in the resource and harvesters' resulting lack of interest in the fishery. Owing to intensive exploitation from 1997 to 2005, landings in a number of shellfish areas, including Pointe de Mille-Vaches, Pointe à Boisvert, Baie des Chevaux, Banc Marie-Marthe, Réserve Pessamit Sud and Pointe-aux-Outardes (Ouest and Est), continued to plunge (Table 1), suggesting that beds were overexploited. The same phenomenon was observed in the depuration fishery from 2005 to 2009. The overall situation led to the closure of two softshell clam processing plants on the Upper North Shore in the spring of 2010.

The significance of the recreational harvest must not be overlooked, however. Estimates of unreported fishing activities (SPSs) on the Upper North Shore from 2001 to 2017, including the recreational harvest, range from 1.5 t to 818.7 t (Appendix 5), with an average of 36.6 t between 2012 and 2017. However, precise information on the recreational harvest by shellfish area would be needed to obtain a better estimate of the total harvest.

Since 2010, commercial landings of softshell clams have come primarily from 10 shellfish areas: Baie des Chevaux, Banc Marie-Marthe, Baie Didier Sud, Baie des Plongeurs, Cran à Gagnon, Anse du Colombier and Îlets Jérémie in sub-area 1A; Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est in sub-area 1B; and Réserve Pessamit Sud in sub-area 1C (Table 1). In general, the same trends can be observed at the individual shellfish area level as in the Upper North Shore as a whole: a significant decline in landings and effort from 2002 to 2011, followed by a stable trend (Tables 1 and 2). On one or more occasions from 2002 to 2005, annual landings exceeded 100 t in the Baie des Petites Bergeronnes, Baie des Grandes Bergeronnes, Pointe à Boisvert, Pointe de Mille-Vaches, Banc Marie-Marthe, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est and Réserve Pessamit Sud shellfish areas. Since 2010, annual landings by shellfish area have all been under 10 t, with three exceptions (Table 1). In 2010, the Innu community of Pessamit obtained authorization to sell its catch to New Brunswick with no obligation to process the clams; landings were 37.8 t. In 2015 and 2016, when the processing plant at Forestville was open, landings were slightly greater (as much as 21 t) in the Baie des Chevaux, Banc Marie-Marthe and Réserve Pessamit Sud shellfish areas. Lastly, landings in Pointe-aux-Outardes Ouest have ranged from 16.1 t to 22.9 t since 2014.

Table 2. Commercial fishing effort (vendor-days) for softshell clams by sub-area and by shellfish area on the Upper North Shore and cumulative effort by region (Upper North Shore and its sub-areas, and the Îles-de-la-Madeleine) and for Québec as a whole, 2002 to 2019.

Sub-area, Area or Region	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1A- Baie des Petites Bergeronnes	200	369	283	1,050	-	-	9	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Grandes Bergeronnes ¹	-	41	193	-	621	276	137	178	-	-	-	-	-	-	-	-	-	-
1A- Batture à Théophile	1	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Escoumins ¹	-	-	-	-	-	458	124	200	-	-	-	-	-	-	-	-	-	-
1A- Îles Penchées	79	72	92	36	98	-	-	-	-	-	-	-	-	-	4	-	-	-
1A- Pointe à Émile	-	64	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1A- Pointe à Boisvert	2,425	861	379	298	231	77	50	6	-	-	7	-	-	-	-	-	-	10
1A- Pointe de Mille-Vaches	390	1,640	802	294	152	39	2	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Chevaux	744	575	423	220	121	43	65	25	14	9	33	25	9	26	120	26	26	23
1A- Banc Marie-Marthe	2,293	1,089	438	117	149	139	144	111	10	10	13	21	29	160	209	38	21	10
1A- Baie Didier Sud	57	212	123	83	51	26	4	7	C ²	C	C	C	C	C	19	-	10	3
1A- Baie des Plongeurs	405	207	285	278	266	62	5	-	C	C	C	C	C	C	27	12	26	3
1A- Battures aux Gibiers Est	24	25	12	-	-	-	5	-	-	-	-	-	-	-	9	-	-	-
1A- Cran à Gagnon	336	194	77	61	33	33	20	2	-	-	1	1	6	95	65	17	1	2
1A- Rivière Blanche ¹	-	105	22	-	-	133	108	99	-	-	-	-	-	-	-	-	-	-
1A- Anse du Colombier	177	205	245	211	87	72	53	31	-	-	-	1	3	34	78	12	12	1
1A- Anse à Norbert	140	5	17	2	27	11	4	-	2	-	-	4	5	-	28	-	-	-
1A- Anse Noire	45	32	53	34	28	17	1	7	-	-	-	-	-	2	10	-	-	-
1A- Îlets Jérémie	335	264	270	284	87	132	77	84	51	-	2	3	5	1	45	-	-	-
1B- Pointe-aux-Outardes Ouest ³	-	-	-	608	496	243	265	90	-	78	58	53	178	149	262	180	221	172
1B- Pointe-aux-Outardes Est ⁴	1,655	1,230	1,301	213	109	100	218	297	79	33	36	69	19	55	104	-	14	8
1B- Rivière Mistassini	39	22	9	41	53	-	-	1	-	-	-	-	-	-	-	-	-	-
1B- Baie Saint-Nicolas	76	147	100	123	64	-	-	-	-	-	-	12	2	-	3	-	-	-
1C- Réserve Pessamit Sud	2,165	1,158	2,448	2,409	1,468	1,514	1,192	894	927	-	5	-	-	644	118	-	-	-
1A and 1B- Other sectors ⁴	-	97	19	-	13	11	-	-	-	-	-	-	-	-	-	-	-	-
Upper North Shore	11,586	8,614	7,598	6,362	4,167	3,386	2,483	1,942	1,083	130	155	189	256	1,166	1,101	285	331	232
Sub-area 1A	7,651	5,835	3,506	2,968	1,343	651	439	273	77	19	56	55	57	318	614	105	96	52
Sub-area 1B	1,770	1,399	1,410	985	735	343	483	298	79	111	94	134	199	204	369	180	235	180
Sub-area 1C	2,165	1,158	2,448	2,409	1,468	1,514	1,192	894	927	-	5	-	-	644	118	-	-	-
Depuration ¹	-	222	234	-	621	878	369	477	-	-	-	-	-	-	-	-	-	-
Îles-de-la-Madeleine	-	-	-	5	36	26	55	47	28	8	32	40	62	56	54	50	147	160
Québec⁵	12,142	8,751	7,598	6,368	4,203	3,413	2,538	1,989	1,111	138	187	229	318	1,222	1,155	335	478	392

¹ Restricted or prohibited area (depuration fishery from 2002 to 2009).

² C = area closed for conservation purposes.

³ The Pointe-aux-Outardes shellfish area was split into Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est in 2005.

⁴ Baie Sainte-Catherine (depuration fishery), Saint-Paul-du-Nord, La Grosse Pointe and Franquelin (depuration fishery).

⁵ Commercial fishing effort is shown for Québec as a whole (North Shore, Gaspé–Lower St. Lawrence and the Îles-de-la-Madeleine).

Table 3. Number of active commercial harvesters (vendors) in the commercial softshell clam fishery from 2004 to 2019 by sub-area (S-area), in the depuration fishery (Dep.) and for the Upper North Shore as a whole.

S-area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1A	137	125	77	37	33	22	9	2	10	11	11	19	44	12	12	7
1B	90	76	57	27	26	17	4	4	4	7	6	6	18	6	15	12
1C ¹	46	61	51	35	33	21	63	0	1	0	0	72	24	0	0	0
Dép.	25	0	27	23	19	19	0	0	0	0	0	0	0	0	0	0
Total	230	217	170	105	94	65	76	6	14	17	17	97	82	18	27	19

¹ Estimate is based on the maximum number of vendors in a single day.

Owing to the meagre fishing effort in recent years, the number of samples per shellfish area and the number of softshell clams measured annually under DFO's commercial catch sampling program have sometimes been quite small (Appendices 6 and 7). The average size of clams landed in all areas surveyed from 2004 to 2019 is shown in Table 4; size structures in the ten main shellfish areas are presented in Appendices 8, 9, 10, 11 and 12.

In general, the average size of the softshell clams sampled varies not only by shellfish area, but also by year (Table 4). Before 2010, the average size was frequently less than 60 mm, particularly in sub-area 1A. Furthermore, in 2010, the Baie Didier Sud and Baie des Plongeurs shellfish areas were closed for conservation purposes due to average landed clam sizes under 55 mm. Shellfish areas with the greatest average clam sizes include Banc Marie-Marthe, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est and Réserve Pessamit Sud; since 2011, this group has also included Baie des Chevaux, Baie Didier Sud and Baie des Plongeurs. The closure of the fishery in the aforementioned two shellfish areas allowed clams to grow and led to an increase in the average landed clam size. In recent years, the smallest average sizes (58 mm) have been observed in the Îles Penchées, Anse du Colombier and Anse Noire shellfish areas. The average size in the six areas sampled from 2017 to 2019 ranged from 65 mm to 74 mm.

A high percentage of sub-legal size clams (< 51 mm) in landings would likely be an indication that legal-size clams are scarce and that harvesters are falling back on smaller clams. A high percentage of small clams corresponds to small average sizes (Tables 4 and 5). Before 2010, this figure was sometimes over 30% (Table 5). In recent years, it has usually remained under 5% or thereabouts. Values of 10–12% were observed in the Anse du Colombier, Anse Noire and Îles Jérémie shellfish areas in 2015 and 2016.

RESEARCH SURVEYS

In all, 23 approved or conditionally approved shellfish areas were surveyed from 2016 to 2019. According to the results of these surveys, the size of softshell clam beds is highly variable among shellfish areas, ranging from 0.004 km² in Battures aux Gibiers Est to 5.96 km² in Pointe-aux-Outardes Ouest (Figure 4 and Table 6). The total area of beds in these 23 areas is 19.46 km², representing an average size of 0.85 km² per shellfish area.

Table 4. Average size (mm) of softshell clams landed from 2004 to 2019 and average reference size (Avg) for the 2004–2018 period by sub-area and by shellfish area on the Upper North Shore.

Shellfish area and sub-area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg
1A- Baie Sainte-Catherine ¹	-	-	-	59	-	-	-	-	-	-	-	-	-	-	-	-	59
1A- Baie des Petites Bergeronnes	-	-	-	-	59	-	-	-	-	-	-	-	-	-	-	-	59
1A- Baie des Grandes Bergeronnes ¹	-	-	57	60	56	63	-	-	-	-	-	-	-	-	-	-	59
1A- Baie des Escoumins ¹	-	-	-	65	63	64	-	-	-	-	-	-	-	-	-	-	64
1A- Îles Penchées	-	-	-	-	-	-	-	-	-	-	-	-	58	-	-	-	58
1A- Pointe à Boisvert	56	59	61	60	58	-	-	-	67	-	-	-	-	-	-	-	60
1A- Pointe de Mille-Vaches	64	69	57	66	58	-	-	-	-	-	-	-	-	-	-	-	63
1A- Baie des Chevaux	55	62	58	59	59	56	-	-	67	-	-	60	65	-	72	-	61
1A- Banc Marie-Marthe	63	60	60	64	62	62	-	-	-	-	-	65	65	67	74	73	64
1A- Baie Didier Sud	-	-	50	53	-	52	-	-	-	-	-	-	61	-	72	71	57
1A- Baie des Plongeurs	54	53	50	54	50	-	-	-	-	-	-	-	64	69	71	-	58
1A- Battures aux Gibiers Est	-	-	-	-	-	-	-	-	-	-	-	-	64	-	-	71	64
1A- Cran à Gagnon	-	-	49	57	60	58	-	-	-	-	-	59	62	-	-	-	57
1A- Rivière Blanche ¹	-	-	-	58	58	60	-	-	-	-	-	-	-	-	-	-	59
1A- Anse du Colombier	-	-	57	-	53	57	58	-	-	-	-	58	58	-	-	-	57
1A- Anse à Norbert	52	-	-	-	52	-	-	-	-	-	-	-	60	-	-	-	55
1A- Anse Noire	-	-	-	-	-	-	-	-	-	-	-	-	58	-	-	-	58
1A- Îlets Jérémie	71	-	-	-	55	56	64	-	-	-	-	-	61	-	-	-	61
1B- Pointe-aux-Outardes Ouest	74	73	73	74	78	71	75	74	69	64	66	69	72	66	65	67	71
1B- Pointe-aux-Outardes Est	-	-	64	65	66	71	65	-	-	66	-	66	67	-	-	-	66
1B- Rivière Mistassini	-	-	57	-	-	-	-	-	-	-	-	-	-	-	-	-	57
1B- Baie Saint-Nicolas	-	53	53	-	-	-	-	-	-	-	-	-	60	-	-	-	55
1C- Réserve Pessamit Sud	67	62	65	61	58	59	62	-	-	-	-	65	74	-	-	-	64

¹ Restricted or prohibited area (deputation fishery from 2002 to 2009).

Table 5. Proportion (%) of landed softshell clams under the minimum legal size (< 51 mm) from 2004 to 2019 and average reference value (Avg) for the 2004–2018 period by sub-area and by shellfish area on the Upper North Shore.

Shellfish area and sub-area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg
1A- Baie Sainte-Catherine ¹	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	7
1A- Baie des Petites Bergeronnes	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	6
1A- Baie des Grandes Bergeronnes ¹	-	-	13	7	16	8	-	-	-	-	-	-	-	-	-	-	11
1A- Baie des Escoumins ¹	-	-	-	2	2	11	-	-	-	-	-	-	-	-	-	-	5
1A- Îles Penchées	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	7
1A- Pointe à Boisvert	24	15	13	14	25	-	-	-	0	-	-	-	-	-	-	-	15
1A- Pointe de Mille-Vaches	3	1	24	3	9	-	-	-	-	-	-	-	-	-	-	-	8
1A- Baie des Chevaux	24	9	24	9	10	17	-	-	0	-	-	7	2	-	0	-	10
1A- Banc Marie-Marthe	17	23	30	10	11	7	-	-	-	-	-	1	2	0	0	0	10
1A- Baie Didier Sud	-	-	61	35	-	45	-	-	-	-	-	-	4	-	0	0	29
1A- Baie des Plongeurs	24	34	56	32	57	-	-	-	-	-	-	-	1	0	0	-	26
1A- Battures aux Gibiers Est	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	0	3
1A- Cran à Gagnon	-	-	61	14	5	17	-	-	-	-	-	4	1	-	-	-	17
1A- Rivière Blanche ¹	-	-	-	20	17	8	-	-	-	-	-	-	-	-	-	-	15
1A- Anse du Colombier	-	-	17	-	33	13	3	-	-	-	-	12	10	-	-	-	15
1A- Anse à Norbert	46	-	-	-	39	-	-	-	-	-	-	-	3	-	-	-	29
1A- Anse Noire	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	10
1A- Îlets Jérémie	0	-	-	-	21	22	1	-	-	-	-	-	10	-	-	-	11
1B- Pointe-aux-Outardes Ouest	1	1	1	2	0	6	< 1	< 1	1	3	4	5	2	4	2	3	2
1B- Pointe-aux-Outardes Est	-	-	4	5	8	8	2	-	-	5	-	5	8	-	-	-	6
1B- Rivière Mistassini	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	20
1B- Baie Saint-Nicolas	-	38	39	-	-	-	-	-	-	-	-	-	9	-	-	-	29
1C- Réserve Pessamit Sud	7	21	10	13	21	16	9	-	-	-	-	3	0	-	-	-	11

¹ Restricted or prohibited area (deputation fishery from 2002 to 2009).

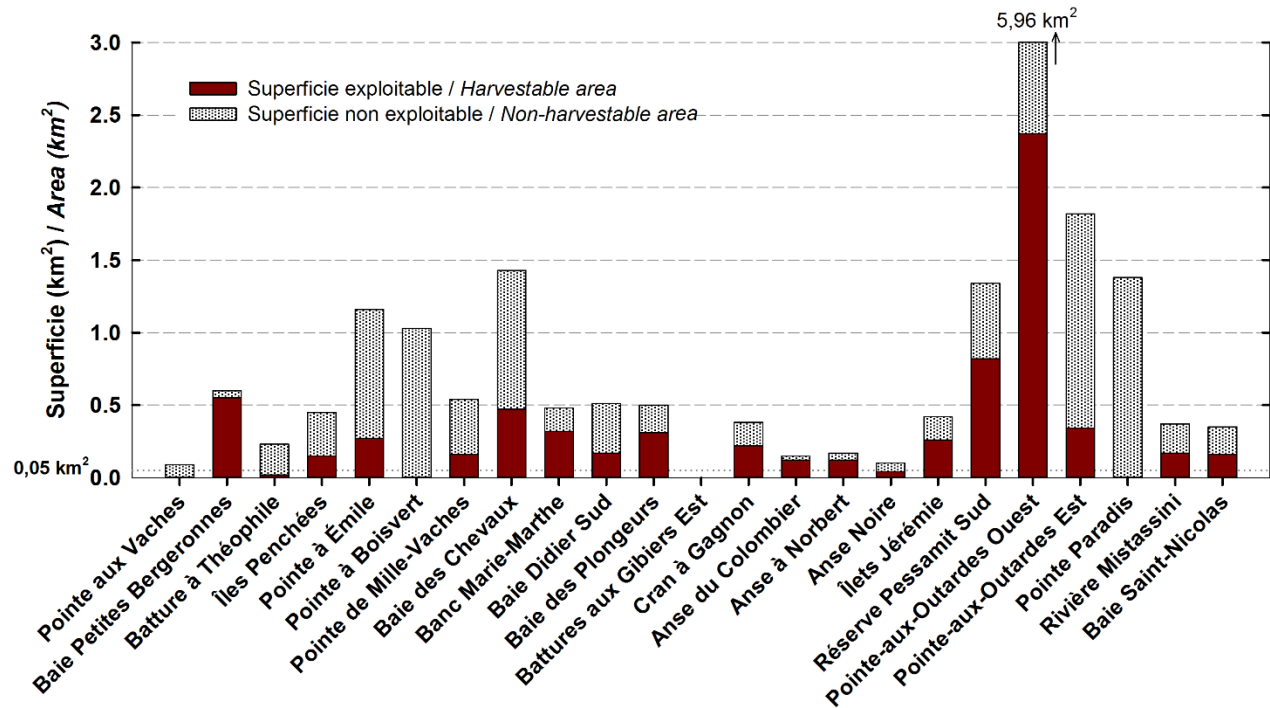


Figure 4. Harvestable and non-harvestable areas of softshell clam beds by shellfish area surveyed from 2016 to 2019 on the Upper North Shore.

The density of legal-size softshell clams (≥ 51 mm) in the 2016–2019 surveys was used as the chief criterion for defining harvestable area. Harvestable area is the first indicator used to assess the status of softshell clam stocks in each shellfish area. In the commercial fishery, harvesters target locations with a sizeable density of legal-size clams to ensure that their harvest is profitable. The density of sexually mature softshell clams (45 mm) is also important, since an adequate density allows the meeting of the male and female gametes released in the water and ensures reproductive success; however, the minimum density required in the species is not known. For these reasons, a minimum value of 16 clams/m² was deemed appropriate⁶.

Four shellfish areas have no harvestable area, owing to the fact that the maximum density of legal-size clams is less than 6 clams/m² or fewer than three sampling stations are present: Pointe aux Vaches, Pointe à Boisvert, Battures aux Gibiers Est and Pointe Paradis (Figure 4 and Table 6). The harvestable area calculated for the other shellfish areas ranges from 0.02 km² to 2.37 km², totaling 7.04 km². The conservation objective for these stocks is to preserve the reproductive potential of each bed while allowing recreational and commercial exploitation, which requires a minimum harvestable area of probably between 0.01 km² and 0.1 km². On the basis of current knowledge, the harvestable area required for exploitation on the Upper North Shore has been set at 0.05 km². Two shellfish areas have a harvestable area smaller than that: Batture à Théophile (0.02 km²) and Anse Noire (0.04 km²). The other shellfish areas have a harvestable area between 0.12 km² and 2.37 km².

⁶This assumes a minimum density of four clams per 0.25-m² quadrat (sampling area at each station).

Table 6. Results of softshell clam surveys conducted from 2016 to 2019 in certain Upper North Shore shellfish areas: area of beds (km²); harvestable area (km²); average density (number/m²) of 20–50 mm softshell clams in all beds; and average density (number/m²), average yield (kg/m²) and biomass (t) of softshell clams ≥ 51 mm in the harvestable area. Maximum commercial landings (t) observed between 2002 and 2005, the total allowable catch (TAC, t) in effect in 2019 and potential removals (t) calculated using an exploitation rate of 10%, 5% and 2.5% are also provided for each shellfish area.

Shellfish area	Area of beds	Harvestable area	Density 20–50 mm	Density ≥ 51 mm	Yield ≥ 51 mm	Biomass ≥ 51 mm	Maximum landing	2019 TAC	10%	5%	2.5%
Sub-area 1A											
Pointe aux Vaches	0.09	0¹	5.8¹	-	-	-	0	-	0	0	-
Baie Petites Bergeronnes	0.60	0.55	30.6	39.2	1.24	682	115	-	68	34	-
Batture à Théophile	0.23	0.02¹	146.5	22.0	0.43	9	0,9	0,4	1	0	-
Îles Penchées	0.45	0.15	47.2	26.7	0.74	111	7	5	11	6	-
Pointe à Émile	1.16	0.27	23.9	24.7	0.65	176	2	1	18	9	4
Pointe à Boisvert	1.03	0¹	28.0	-	-	-	125	20	0	0	-
Pointe de Mille-Vaches	0.54	0.16	25.2	35.6	0.91	146	137	20	15	7	-
Baie des Chevaux	1.43	0.47	118.8	61.3	1.70	799	82	20	80	40	-
Banc Marie-Marthe	0.48	0.32	16.5	39.2	1.57	502	233	30	50	25	13
Baie Didier Sud	0.51	0.17	78.6	56.5	1.72	292	19	4	29	15	-
Baie des Plongeurs	0.50	0.31	178.0	47.8	1.34	415	32	10	42	21	-
Battures aux Gibiers Est	0.004	0¹	0¹	-	-	-	3	0,5	0	0	-
Cran à Gagnon	0.38	0.22	71.0	48.0	1.59	350	27	5	35	17	-
Anse du Colombier	0.15	0.12	276.5	49.2	1.29	155	23	10	15	8	-
Anse à Norbert	0.17	0.12	49.5	33.3	0.94	113	13	1	11	6	-
Anse Noire	0.10	0.04¹	99.6	40.4	1.10	44	4	1	4	0	-
Îlets Jérémie	0.42	0.26	120.3	81.2	2.17	564	35	15	56	28	-
Sub-area 1B											
Pointe-aux-Outardes Ouest	5.96	2.37	8.9¹	38.3	1.54	3,650	~100] ³⁰	365	182	91
Pointe-aux-Outardes Est	1.82	0.34	2.8¹	26.2	0.86	292	~50		29	15	7
Pointe Paradis	1.38	0¹	16.6	-	-	-	0	-	0	0	-
Rivière Mistassini	0.37	0.17	40.0	35.3	1.09	185	5	3	19	9	5
Baie Saint-Nicolas	0.35	0.16	122.5	37.7	1.00	160	17	1	16	8	-
Sub-area 1C											
Réserve Pessamit Sud	1.34	0.82	24.0	79.5	2.81	2,304	304	50	230	115	-

¹ Values in bold and red identify shellfish areas where the indicators are below the minimum criteria, i.e., a harvestable area of 0.05 km² and a density of sub-legal size clams (i.e., 20–50 mm) of 15 clams/m².

The second indicator used to assess the status of softshell clam stocks is the average density of 20–50 mm clams, which corresponds to the level of pre-recruitment to the fishery in the beds surveyed in 2016–2019. To support the fishery, it is important to make sure that a certain quantity of clams are present in the beds to ensure the renewal of the commercial population. The average density of 20-50 mm clams in all the beds in each shellfish area surveyed ranged from 2.8 to 276.5 clams/m², except in the Battures aux Gibiers Est shellfish area, where this density was null (Figure 5 and Table 6). The average for all shellfish areas surveyed was 66.6 clams/m². Typically, the density of 20–50 mm clams is greater than that of legal-size clams (Figure 5). However, the inverse situation was found in a few shellfish areas: Banc Marie-Marthe, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est. However, according to the results of the 2002–2014 surveys, there was only one case in the ten surveys presented in which the density of 20–50 mm clams was less than that of ≥ 51 mm clams, in Pointe-aux-Outardes Ouest (Table 7). The reasons for this situation are not known, although a few hypotheses have been proposed, such as sporadic recruitment and the

presence of sandy sediments, which make it more difficult for juveniles to burrow. The fact remains that this situation is worrisome in terms of the population's capacity for renewal. Since the causes are unknown, as a precautionary measure, a minimum average density of sub-legal size clams of 15 clams/m² has been chosen as the criterion for adequate pre-recruitment. In four shellfish areas, the values for this metric do not meet the criterion: Pointe aux Vaches, Battures aux Gibiers Est, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est (Table 6). In addition, in two areas, values slightly exceed the criterion: Banc Marie-Marthe with 16.5 clams/m² and Pointe Paradis with 16.6 clams/m². The other shellfish areas had density values between 23.9 and 276.5 clams/m².

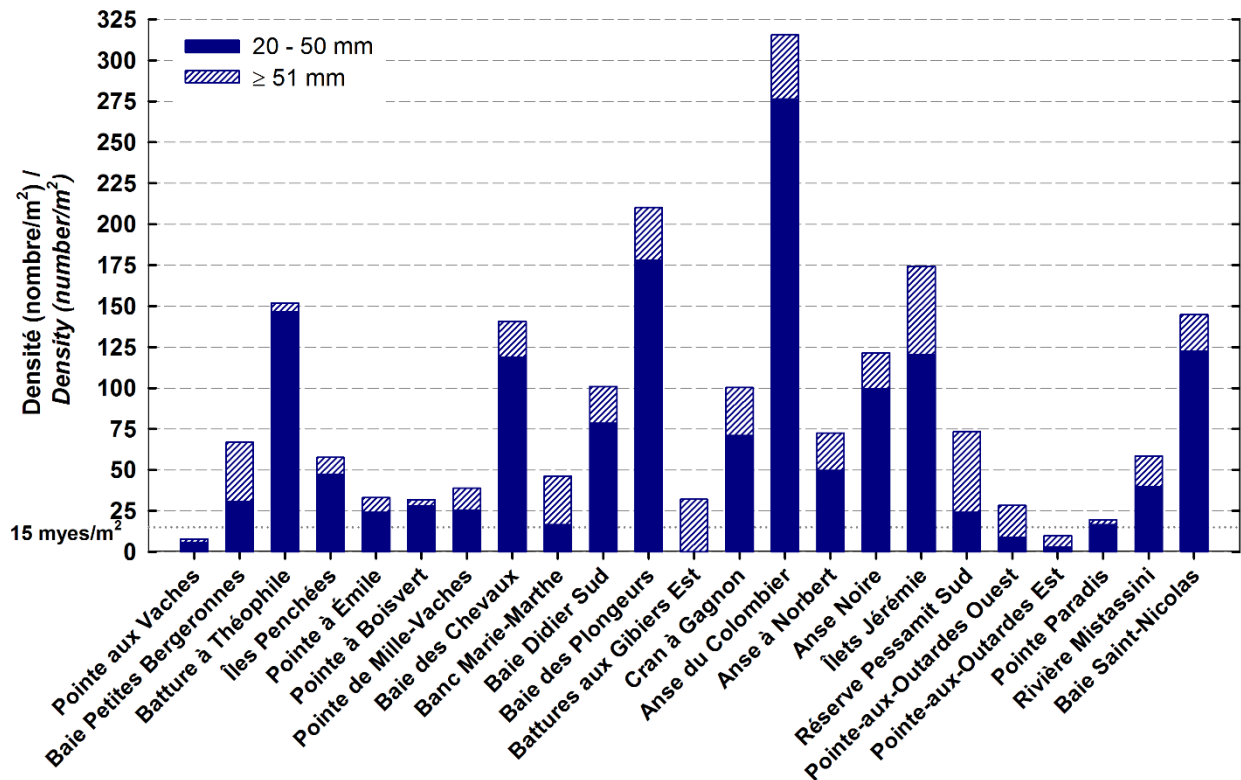


Figure 5. Density of sub-legal size (20–50 mm) and legal-size (≥ 51 mm) softshell clams, based on the total area of the beds, in each shellfish area surveyed from 2016 to 2019 on the Upper North Shore.

Other indicators used to assess these softshell clam stocks include average density, average yield, and the biomass of legal-size clams in the harvestable area. Values for average density varied between 22.0 and 81.2 clams/m², with an average of 43.3 clams/m² (Table 6 and Figure 6). The areas with the highest values were Îlets Jérémie, Réserve Pessamit Sud and Baie des Chevaux. Those with the lowest values (less than 25 clams/m²) included Batture à Théophile and Pointe à Émile, as well as Îles Penchées and Pointe-aux-Outardes Est, which had slightly better average densities (< 27 clams/m²).

The average yield of legal-size clams in the harvestable area ranged from 0.43 to 2.81 kg/m², with an average of 1.30 kg/m² (Table 6). In general, high yields are associated with high densities of legal-size clams. The shellfish areas with the highest yields were Réserve Pessamit Sud, Îlets Jérémie, Baie Didier Sud and Baie des Chevaux, with values ≥ 1.7 kg/m².

Commercial biomass by shellfish area (calculated based on the harvestable area) was highly variable, since it is a function of yield and area (Table 6). The highest biomass values were recorded in Pointe-aux-Outardes Ouest (3,650 t) and Réserve Pessamit Sud (2,304 t)—the first

owing to its large harvestable area and the second, to its high yields and its large area. Estimated values for commercial biomass in the other shellfish areas were significantly lower, ranging from 9 t (Batture à Théophile) to 799 t (Baie des Chevaux). The average commercial biomass in all the shellfish areas surveyed was 576 t.

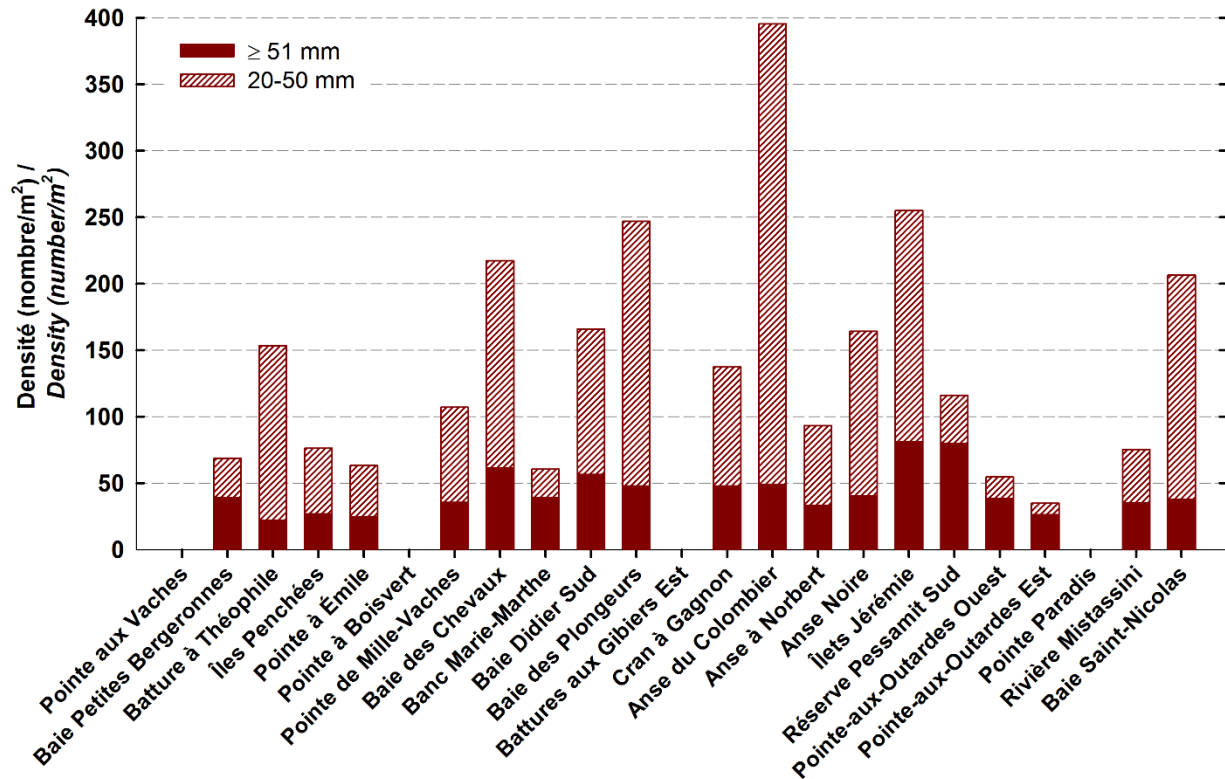


Figure 6. Density of legal-size (≥ 51 mm) and sub-legal size (20–50 mm) softshell clams, based on the harvestable area of the beds, in each shellfish area surveyed from 2016 to 2019 on the Upper North Shore.

The results of recent surveys (2016–2019) and those conducted from 2002 to 2014 can be compared in eight shellfish areas (10 surveys). The estimated average density and average yield of clams ≥ 51 mm were significantly higher in 2016–2019 compared to 2002–2014 in the Baie des Petites Bergeronnes, Pointe à Émile, Cran à Gagnon, Anse Noire and Réserve Pessamit Sud shellfish areas (Table 7 and Appendix 13). The results for these two variables were similar for Baie des Chevaux, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est in both sets of surveys. However, the density of 20–50 mm softshell clams was lower in the most recent set of surveys in the Pointe à Émile, Baie des Chevaux, and Pointe-aux-Outardes Est shellfish areas; no significant difference was found for the other five shellfish areas (Table 7).

A total of 17 shellfish areas surveyed in 2016–2019 were also covered in the 1967–1977 surveys (Lavoie 1969b, 1970a and 1970b, Mercier et al. 1978). Although the location of the beds has generally remained similar between the two periods, in some cases, the correspondence (i.e., the agreement index) between bed locations is poor—less than 55% in the case of the Batture à Théophile, Pointe Paradis and Pointe de Mille-Vaches shellfish areas (Table 8). The beds in these areas are actually much smaller now than they were at the time of the 1967–1977 surveys. In contrast, other beds appear to be larger now than they were during 1967–1977, primarily in the Baie des Petites Bergeronnes and Pointe-aux-Outardes Ouest shellfish areas. In addition, a few small beds were sampled in 1967–1977 but not in 2016–2019,

in the Îles Penchées and Pointe de Mille-Vaches shellfish areas. Another factor that must be taken into account is the number of sampling stations used in calculating current densities and yields (Table 8). Using fewer than 10 stations could make it risky to interpret the results, for example, in the Pointe à Boisvert (PB-2) shellfish area.

Table 7. Comparison of results (\pm standard error) between years by shellfish harvest area in the Upper North Shore obtained in surveys of softshell clam beds from 2002 to 2018.

Shellfish area	Year	Clam density 20–50 mm (number/m ²)		Clam density ≥ 51 mm (number/m ²)		Clam Yield ≥ 51 mm (g/m ²) ¹	
Baie des Petites Bergeronnes	2008	22.0 ± 3.7	-	12.4 ± 2.6	b ²	303 ± 66	b ²
	2018	31.8 ± 7.8	-	35.8 ± 4.6	a	1,013 ± 133	A
Pointe à Émile	2003	78.8 ± 12.4	a ²	1.5 ± 0.9	b	28 ± 17	B
	2018	37.0 ± 16.6	b	8.0 ± 2.6	a	224 ± 77	A
Baie des Chevaux	2002	125.3 ± 14.0	a	9.3 ± 2.2	-	229 ± 52	-
	2017	118.8 ± 10.8	b	22.0 ± 3.6	-	544 ± 96	-
Cran à Gagnon	2007	80.3 ± 10.3	-	9.8 ± 1.6	b	264 ± 47	B
	2017	71.0 ± 10.8	-	29.3 ± 4.4	a	853 ± 129	A
Anse Noire	2003	75.4 ± 14.0	-	6.6 ± 2.3	b	150 ± 52	B
	2018	97.4 ± 20.6	-	22.8 ± 5.8	a	605 ± 164	A
Réserve Pessamit Sud	2005	55.5 ± 18.6	-	18.0 ± 3.5	b	508 ± 85	B
	2010	23.7 ± 6.2	-	12.3 ± 2.0	b	372 ± 54	B
	2014	28.7 ± 6.2	-	12.4 ± 2.4	b	389 ± 72	B
	2018	24.0 ± 4.0	-	49.2 ± 7.7	a	1,623 ± 220	A
Pointe-aux-Outardes Ouest	2003	6.0 ± 1.1	-	13.6 ± 1.2	-	673 ± 55	-
	2017	7.6 ± 3.1	-	19.0 ± 2.2	-	783 ± 85	-
Pointe-aux-Outardes Est	2004	18.9 ± 3.6	a	11.4 ± 2.9	-	314 ± 75	-
	2017	2.3 ± 1.0	b	7.6 ± 1.9	-	237 ± 65	-

¹ Yield calculated on the basis of thawed weight, except in the Pointe à Émile and Anse Noire shellfish areas, where fresh weight was used.

² Results of the comparison of densities or yields between years by shellfish area using the Kruskal-Wallis nonparametric test. Different letters indicate statistically different values; the absence of a letter indicates that values are statistically similar.

In ten shellfish areas, densities and/or yields of legal-size softshell clams were higher in 1967–1977 than in 2016–2019 (difference of more than 50%): Îles Penchées, Pointe à Émile, Pointe à Boisvert, Pointe de Mille-Vaches, Baie des Chevaux, Banc Marie-Marthe, Anse à Norbert, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est and Pointe Paradis (Table 8). Conversely, four shellfish areas had higher yields of these clams in 2016–2019 than they did in 1967–1977: Baie des Petites Bergeronnes, Baie Didier Sud, Baie des Plongeurs and Îlets Jérémie.

Table 8. Results (density and yield of legal-size softshell clams ≥ 51 mm]) in surveys conducted in 1967–1977 and 2016–2019, by shellfish area on the Upper North Shore. The identifiers (Identif.) used for beds in 1967–1977 (and reference in parentheses), correspondence (Corr.) between beds surveyed in 1967–1977 and 2016–2019 (i.e., agreement index) and the number of stations surveyed in 2016–2019 used in the comparison are also provided.

Shellfish area	Identif. ¹	Corr.	Number of stations	Density (clams/m ²)		Yield (g/m ²)	
				1967–1977	2016–2019	1967–1977	2016–2019
B. Petites Bergeronnes	RL (a)	100% ²	10	48	64	907	1 798 ³
Pointe à Boisvert	PB-2 (a)	100%	8	3	0	214	0
Anse du Colombier	CC (b)	100%	26	42	32	960	842
Anse à Norbert	AF (b)	100%	34	12 ³	6	471 ³	194
Baie Didier Sud	BD (b)	95%	44	28	29	584	909 ³
Îlets Jérémie	IJ-1 (b)	95%	56	26	27	666	675
Pointe-aux-Outardes Ouest + Est	PO-1 (c)	85% ²	166	-	8	768 ³	272
Réserve Pessamit Sud	BM-1 (b)	85%	119	31	36	1 446	1 292
Îlets Jérémie	IJ-2 (b)	85%	17	51	112 ³	826	3 312 ³
Pointe à Émile + Pointe à Boisvert	PB-1 (a e)	80%	131	35 ³	6	901 ³	171
Îles Penchées	JL (a)	75%	13	46 ³	13	620	345
Baie des chevaux + Banc Marie-Marthe	BL (b)	75%	119	60 ³	29	1 404	913
Baie des Plongeurs	BP (b)	70%	69	25	32	527	900 ³
Pointe de Mille-Vaches	PB-4 (a e)	40%	139	38 ³	8	1 202 ³	219
Pointe Paradis	AA (d)	25%	182	-	1	155 ³	41
Batture à Théophile	GB (a)	15% ⁴	13	15	7	264	141

¹ References: a = Lavoie 1969b; b = Lavoie 1970a; c = Lavoie 1970b; d = Lamoureux 1974; e = Mercier 1978.

² The bed inventoried in 1967–1977 is restricted to a small portion compared to the current bed, i.e. about 10% for Baie des Petites Bergeronnes and 40% for Pointe-aux-Outardes Ouest.

³ The values in bold and red identify the highest value, representing a difference of greater than 50% between the two sets of surveys (the 1967–1977 survey is used as the reference value).

⁴ Since, in this shellfish area, the 2018 survey was run in a linear fashion parallel to the coastline.

EXPLOITATION RATE

Various indices of the relative exploitation rate were calculated for a number of Upper North Shore shellfish areas between 2002 and 2016 (DFO 2017, Brulotte 2018). In general, exploitation rate indices estimated for the 2002–2007 period on the basis of available commercial biomass and landings were 15% higher. These years correspond to a time when extensive harvesting was being carried out on the Upper North Shore, which was followed by a steep drop in landings. According to the recommendations in the 2017 Science Advisory Report (DFO 2017), annual removals should not exceed 10% of the commercial biomass for the Upper North Shore softshell clam populations.

As previously mentioned, the high level of commercial landings observed from 2000 to 2005 is not sustainable for these populations. The objective should therefore be removals that result in a decrease in the exploitation rate. On the basis of the results of the 2016–2019 surveys, with an exploitation rate of 10% of the commercial biomass, authorized removals would be equal to or greater than the maximum landings observed up until 2005 for several shellfish areas (Table 6). Consequently, it is preferable to limit the exploitation rate to a maximum of 5%. This maximum exploitation rate is particularly important given that removals in the recreational clam fishery are unknown and therefore not taken into account in the calculation of the exploitation

rate. In addition, it is recommended that the reproductive potential of each shellfish area be protected, given the lack of specific information on the source of recruitment to the population in the various beds. This exploitation rate should apply to all removals, whether by the commercial or recreational fishery.

The exploitation rate should be adjusted downward in accordance with the harvestable area and should be minimal in shellfish areas with a harvestable area of less than 0.05 km². According to the results of the 2016–2019 surveys, this applies to the Pointe aux Vaches, Batture à Théophile, Pointe à Boisvert, Battures aux Gibiers Est, Anse Noire and Pointe Paradis shellfish areas.

The density of 20–50 mm softshell clams, which represent pre-recruitment to the fishery, should also be taken into account in adjusting the exploitation rate. Consequently, the exploitation rate should be limited to a maximum of 2.5% in shellfish areas where the average density of these clams in all beds is less than 15 clams/m². The two shellfish areas that would be affected by this measure are Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est. The Banc Marie-Marthe shellfish area, with a density of 16.5 clams/m², could also be included in this group.

Lastly, the exploitation rate should be limited to a maximum of 5% in the other shellfish areas, namely Baie des Petites Bergeronnes, Îles Penchées, Pointe à Émile, Pointe de Mille-Vaches, Baie des Chevaux, Baie Didier Sud, Baie des Plongeurs, Cran à Gagnon, Anse du Colombier, Anse à Norbert, Îlets Jérémie, Réserve Pessamit Sud, Rivière Mistassini and Baie Saint-Nicolas. The Pointe à Émile and Rivière Mistassini shellfish areas could benefit from a reduction in their exploitation rate to 2.5%, since the application of the 5% rate would result in greater removals than those observed prior to 2006.

Despite the recommended decrease in the exploitation rate to a maximum of 5%, the total TACs proposed (425 t) greatly exceed the total TACs in effect in 2019 (256.9 t) (Table 6).

OTHER CONSIDERATIONS

Since 2010, softshell clam landings and fishing effort on the Upper North Shore have been low, owing mainly to the closure of processing plants. In the vast majority of shellfish areas, TACs have not been fully utilized since 2015 (Table 1). The decline in harvesting seems to have enabled stocks to recover in some shellfish areas, as shown by the results of recent surveys. However, the return of favorable harvesting conditions appears to be more problematic in some areas such as Pointe à Boisvert and Pointe de Mille-Vaches. Almost no commercial harvesting has taken place in these two shellfish areas since the early 2000s, when they were heavily exploited (Table 1).

Frequent sediment agitation on the flats, particularly those with sandy sediments, can make it more difficult for young clams to settle and burrow and can compromise recruitment to the population and, in turn, recruitment to the fishery on these beds. Sediment samples taken during surveys show that roughly ten beds consist mainly of sandy sediments. However, only a few beds are more vulnerable to this phenomenon, due to their greater exposure to storm-force winds (E and NE), primarily located in the Pointe de Mille-Vaches, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est shellfish areas. Therefore, in the context of environmental change, caution must continue to be exercised. The increased frequency of storm surges, bank erosion and decreased ice cover are environmental phenomena that could have a negative impact on softshell clam populations, the recovery of certain beds and recruitment to the population.

In addition, we do not have specific information on the source of recruitment to the population in the various beds on the Upper North Shore. Recruitment is variable from year to year and the

time required for softshell clams to reach legal size ranges from five to seven years in Québec. For all these reasons, caution must continue to be exercised in the exploitation of this species.

In addition, burrowing speed in softshell clams decreases sharply with a drop in water temperature. This phenomenon is amplified by clam size, with the largest clams burrowing more slowly than the smallest ones. In addition, the water temperature in the first few meters from the surface is closely linked to air temperature (Galbraith et al. 2019). Therefore, to reduce the incidental mortality in sub-legal size softshell clams caused by the commercial and recreational fishery, all harvesting should be prohibited when the air temperature is ≤ 0 °C. This last measure will prevent clams from being stranded at the surface of the bed when the water is cold, thus reducing mortality.

A total of 23 approved or conditionally approved shellfish areas were surveyed from 2016 to 2019. However, some shellfish areas on the Upper North Shore that have been closed to shellfish harvesting for a number of years contain softshell clam beds of various sizes, although they have not been surveyed recently. Some of these shellfish areas were commercially exploited (deuration fishery) from at least 2002 to 2009 (Table 1) or were surveyed previously (Lavoie 1969a, 1969b, 1970a and 1970b, Lamoureux 1974, Mercier et al. 1978, Giguère et al. 2008). These areas include Baie Sainte-Catherine (P-01.1), Baie de Tadoussac (N-01.1.1), Baie du Moulin à Baude (N-01.1.3), Baie des Grandes Bergeronnes (N-01.2.1), Baie de Bon-Désir (N-01.3), Baie des Escoumins (N-02.1), Saint-Paul-du-Nord (N-03.1.1), La Grande Savane (N-03.2.3), Portneuf-sur-Mer (N-03.2.4), Rivière Blanche (N-04.3), Réserve Pessamit Nord (N-05.1.3.2), La Grosse Pointe (N-06.2.1), Battures de Manicouagan (N-06.2.2) and Franquelin (N-8.2) (Figure 1). It would be interesting to find out the status of the softshell clam populations in the beds in these shellfish areas in order to obtain an overall picture of the situation on the Upper North Shore.

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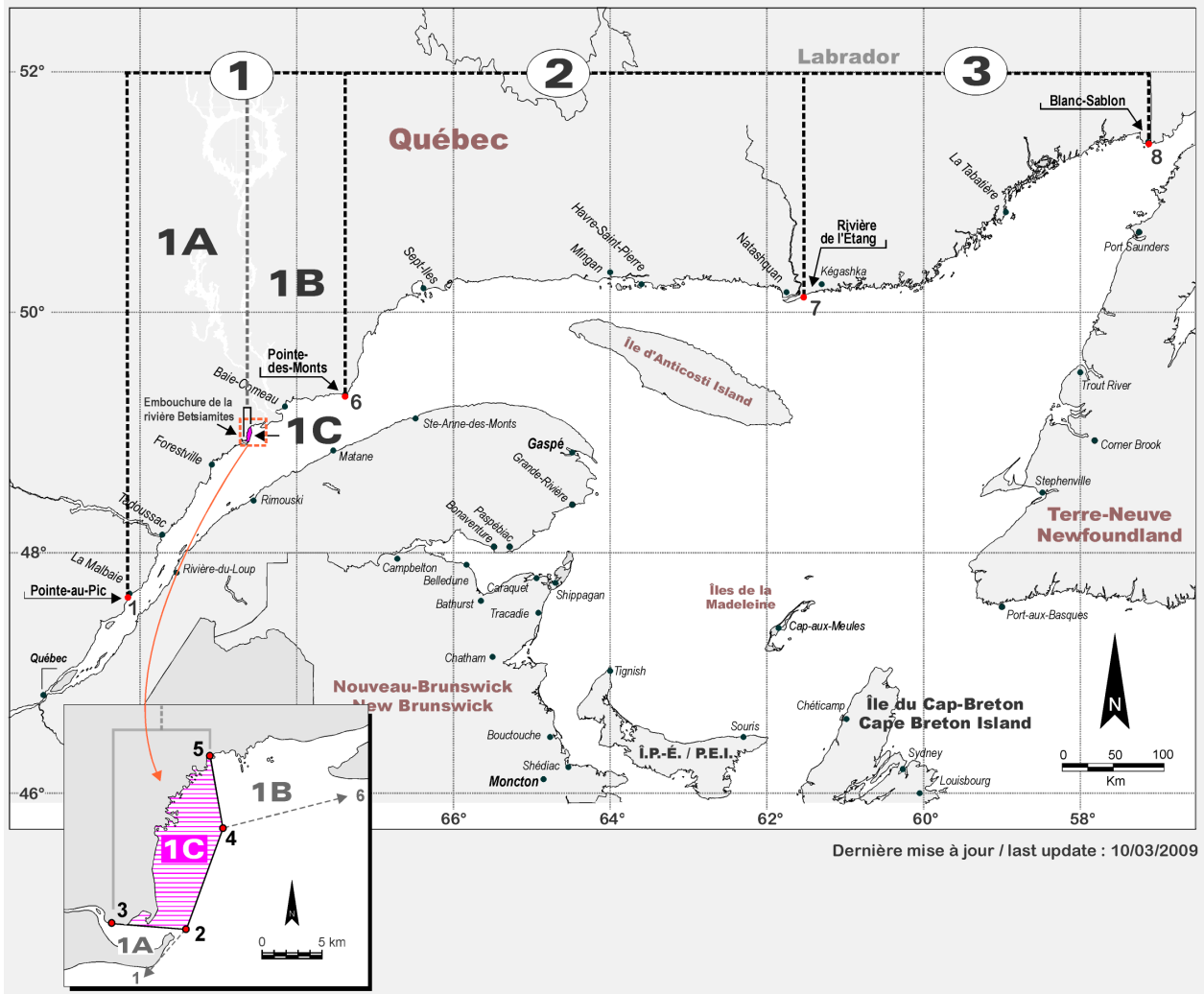
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APPENDICES

Appendix 1. Management areas and sub-areas for the commercial softshell clam fishery in Québec.



Appendix 2. List of shellfish harvest areas (name and number) on the Upper North Shore, in geographic order from west to east; classification (status) in 2019 under the Canadian Shellfish Sanitation Program, softshell clam fishing sub-area, and Total Allowable Catch (TAC) in effect in 2019.

Number	Name	Classification¹	Sub-area	TAC (t)
P-03	La Malbaie	Prohibited	1A	-
P-02.3	Anse d'Herbe / Saint-Fidèle	Prohibited	1A	-
P-02.2	Port au Saumon	Prohibited	1A	-
P-02.1	Port au Persil	Prohibited	1A	-
P-01.6	Rivière-Noire / Pointe aux Quilles	Prohibited	1A	-
P-01.5	Baie des Rochers	Prohibited	1A	-
P-01.4.2	Anse du Chafaud aux Basques	Prohibited	1A	-
P-01.4.1	La Petite Crique	Prohibited	1A	-
P-01.3	La batture aux Alouettes	Prohibited	1A	-
P-01.2	Pointe-au-Bouleau / Pointe aux Alouettes	Prohibited	1A	-
P-01.1	Baie Sainte-Catherine ²	Restricted	1A	-
N-01.1.1	Baie de Tadoussac ²	Prohibited	1A	-
N-01.1.2	Pointe aux Vaches	CA ³	1A	-
N-01.1.3	Baie du Moulin à Baude	Prohibited	1A	-
N-01.1.4	Baie des Petites Bergeronnes	Approved	1A	-
N-01.2.1	Baie des Grandes Bergeronnes ²	Restricted	1A	-
N-01.2.2	Batture à Théophile	Approved	1A	0,4
N-01.3	Baie de Bon-Désir	Prohibited	1A	-
N-02.1	Baie des Escoumins ²	Restricted	1A	-
N-02.2	Îles Penchées	Approved	1A	5
N-02.3	Baie des Bacon	Prohibited	1A	-
N-03.1.1	Saint-Paul-du-Nord	Prohibited	1A	-
N-03.1.2	Pointe à Émile	Approved	1A	1
N-03.2.1	Pointe à Boisvert	Approved	1A	20
N-03.2.2	Pointe de Mille-Vaches	Approved	1A	20
N-03.2.3	La Grande Savane	Prohibited	1A	-
N-03.2.4	Portneuf-sur-Mer	Prohibited	1A	-
N-03.2.5	Sainte-Anne-de-Portneuf	Prohibited	1A	-
N-03.2.6	Banc de Portneuf	Prohibited	1A	-
N-03.3	Forestville	Prohibited	1A	-
N-04.1.1.1	Baie des Chevaux	CA	1A	20
N-04.1.1.2	Mouth of Laval River and Jean Raymond Creek	Prohibited	1A	-
N-04.1.2.1	Banc Marie-Marthe	Approved	1A	30
N-04.1.2.2	Baie Didier Sud	Approved	1A	4
N-04.1.2.3	Baie Didier Nord	Prohibited	1A	-
N-04.1.2.4	Île Laval	Prohibited	1A	-
N-04.1.3	Baie des Plongeurs	Approved	1A	10
N-04.2.1.1	Battures aux Gibiers Ouest	Prohibited	1A	-
N-04.2.1.2	Battures aux Gibiers Est	Approved	1A	0,5
N-04.2.2	Cran à Gagnon	Approved	1A	5
N-04.3	Rivière Blanche ²	Prohibited	1A	-
N-04.4.1	Anse du Colombier	Approved	1A	10
N-04.4.2	Anse à Norbert	Approved	1A	1
N-04.5.1	Anse Noire	Approved	1A	1
N-04.5.2	Îlets Jérémie	CA	1A	15
N-04.6	Pointe à Michel	Prohibited	1A	-
N-05.1.1	Banc des Blancs	Prohibited	1A	-

Number	Name	Classification ¹	Sub-area	TAC (t)
N-05.1.2	Pointe de Betsiamites	Prohibited	1C	-
N-05.1.3.1	Réserve Pessamit Sud	CA-CMP ⁴	1C	50
N-05.1.3.2	Réserve Pessamit Nord	Restricted	1C	-
N-05.2.1	Ragueneau Ouest	Prohibited	1C / 1B ⁵	-
N-05.2.2	Ragueneau Est	Prohibited	1B	-
N-06.1.1	Pointe-aux-Outardes Ouest	CA	1B] 30 ⁶
N-06.1.2	Pointe-aux-Outardes Est	Approved	1B	
N-06.2.1	La Grosse Pointe	Prohibited	1B	-
N-06.2.2	Battures de Manicouagan	Prohibited	1B	-
N-06.3	Pointe Paradis	CA	1B	-
N-07	Rivière Manicouagan	Prohibited	1B	-
N-08.1.1	Baie des Anglais	Prohibited	1B	-
N-08.1.2	Anse Saint-Pancrace	Approved	1B	-
N-08.1.3	Rivière Mistassini	Approved	1B	3
N-08.2	Franquelin ²	Prohibited	1B	-
N-08.3	Baie Saint-Nicolas	Approved	1B	1
N-09.1.1	Baie des Molson	Prohibited	1B	-
N-09.1.2	Godbout	Prohibited	1B	-
N-09.1.3	Pointe-des-Monts	Prohibited	1B	-

¹ Reference: ECCC 2019.

² Harvesting allowed between 1999 and 2009 on condition that clams undergo depuration treatment at the processing plant.

³ CA = conditionally approved, closed from June 1 to September 1 of each year.

⁴ CA-CMP = conditionally approved with a conditional management plan.

⁵ Shellfish area split between two sub-areas, with roughly $\frac{3}{4}$ located in sub-area 1C and $\frac{1}{4}$ in sub-area 1B, with Rivière aux Rosiers as the dividing line.

⁶ Total TAC of 30 t for Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est.

Appendix 3. Softshell clam management measures (minimum legal size [mm], gear allowed, sub-areas, fishing season, maximum number of licences authorized, mandatory safety vest, obligation to complete a logbook (LB), prohibition on discarding softshell clams ≥ 51 mm and participation clause [kg]) for the manual commercial harvest on the Upper North Shore (Area 1) from 2004 to 2019.

Year	Legal size	Gear	Sub-area	Season	Licences	Safety vest	LB	discarding	Participation clause
2004	51	manual	A and B ¹	02/18 to 12/17	-	✓	✓	✓	1361
2005	51	manual	A and B	03/06 to 12/17	300 ²	✓	✓	✓	680
2006	51	manual ³	A and B	03/12 to 12/24	300	✓	✓	✓	680
2007	51	manual	A and B	03/17 to 12/21	175 ⁴	✓	✓	✓	680
2008	51	manual ⁵	A, B and C ⁶	03/21 to 10/31	150 ⁷	✓	✓	✓	680
2009	51	manual	A, B and C	03/25 to 10/31	150	✓	✓	✓	680
2010	51	manual	A, B and C	03/14 to 10/31	150	✓	✓	✓	454
2011	51	manual	A, B and C	03/18 to 10/31	150	✓	✓	✓	454
2012	51	manual	A, B and C	03/19 to 10/31	150	✓	✓	✓	454
2013	51	manual	A, B and C	03/15 to 11/30	150	✓	✓	✓	454
2014	51	manual	A, B and C	03/14 to 10/31	150	✓	✓	✓	454
2015	51	manual	A, B and C	03/14 to 10/31	150	✓	✓	✓	454
2016	51	manual	A, B and C	03/08 to 10/31 ⁸	136 ⁹	✓	✓	✓	454 ¹⁰
2017	51	manual	A, B and C	03/12 to 10/31	136	✓	✓	✓	454 ¹⁰
2018	51	manual	A, B and C	03/03 to 10/31	136	✓	✓	✓	454 ¹⁰
2019	51	manual	A, B and C	03/14 to 10/31	136	✓	✓	✓	454 ¹⁰

¹ Sub-area 1A: Pointe-au-Pic to Pointe à Michel; sub-area 1B: Pointe à Michel to Pointe des Monts.

² For all of area 1, including one communal licence.

³ Sub-area 1A: only short clam forks.

⁴ 100 licences in sub-area 1A and 75 licences in 1B (including one communal licence).

⁵ Sub-areas 1A and 1C: only short clam forks (longer forks allow softshell clams in the water to be harvested).

⁶ Sub-area 1A: Pointe-au-Pic to the mouth of Betsiamites River; sub-area 1B: Rivière aux Rosiers to Pointe des Monts; sub-area 1C: Mouth of the Betsiamites River to Rivière aux Rosiers (see Appendix 1).

⁷ 85 licences in sub-area 1A, 64 licences in sub-area 1B and one communal licence in sub-area 1C.

⁸ Exceptions: Baie Didier Sud opens from August 1 to 8, 2016 and Baie des Plongeurs opens from June 2 to 9 and from July 18 to 29, 2016.

⁹ 85 licences in sub-area 1A, 50 licences in sub-area 1B and one communal licence in sub-area 1C.

¹⁰ Participation clause implemented only if the number of licences issued make up 75% of the maximum number of licences authorized.

Appendix 4. Identification of the anteroposterior length of a softshell clam, equal to the longest shell measurement (Photograph by S. Brulotte, DFO).



Anteroposterior length

Appendix 5. Annual commercial landings (t) of softshell clams per region and in Québec as a whole and estimated removals (t) from unreported fishing activities (SPSs) in Québec as a whole and on the Upper North Shore (UNS) from 1984 to 2019.

Year	Upper North Shore	Middle North Shore	Gaspé – Lower St. Lawrence	Îles-de-la-Madeleine	Québec	SPSs	
						Québec	UNS
1984 ¹	265	0	6	28	299	-	-
1985	692	0	21	9	722	-	-
1986	757	0	41	22	820	-	-
1987	280	0	164	21	465	-	-
1988	418	16	111	15	560	-	-
1989	363	0	146	48	557	-	-
1990	462	93	65	20	640	-	-
1991	355	58	103	13	529	-	-
1992	333	13	75	15	436	-	-
1993	289.3	0.8	0	0	290.0	13.4	1.4
1994	458.7	23.9	0.5	0.2	483.3	50.0	-
1995	507.7	0.5	0.1	0.3	508.7	538.8	197.0
1996	371.1	4.5	0	0.3	376.0	170.2	70.3
1997	744.8	31.6	0	0	776.4	238.4	87.5
1998	522.4	31.8	0.7	0	554.8	244.6	112.8
1999	485.3	0.2	329.4	0	814.9	495.1	-
2000	1,172.8	22.7	12.0	0	1,207.5	775.5	-
2001	1,053.8	18.2	21.1	0	1,093.1	1,007.2	818.7
2002	929.6	87.9	10.3	0	1,027.8	803.1	772.0
2003	859.1	18.1	6.2	0	883.4	393.3	272.2
2004	886.2	0	0	0	886.2	381.5	181.4
2005	614.4	0	0.4	0.1	614.9	325.8	125.8
2006	353.7	0	0	0.4	354.1	272.4	72.4
2007	278.6	0.5	0	0.5	279.7	235.9	37.7
2008	176.2	0	0	1.0	177.2	173.5	23.9
2009	189.6	0	0	0.5	190.1	157.8	25.7
2010	57.4	0	0	0.9	58.3	113.8	7.8
2011	11.0	0	0	0.1	11.0	94.1	1.5
2012	12.0	0	0	0.8	12.7	100.3	23.5
2013	18.6	0	0	1.2	19.7	87.8	36.5
2014	23.0	0	0	1.3	24.2	97.5	44.7
2015	72.2	0	0	0.8	73.0	84.3	41.4
2016	85.0	0	0	0.7	85.7	88.4	48.8
2017	25.7	0	0	0.9	26.6	55.3	24.5
2018	32.2	0	0	2.8	35.0	-	-
2019	21.3	0	0	2.3	23.6	-	-

¹ Landings for the years from 1984 to 1992 were taken from Bérubé (1990), Bérubé and Yergeau (1992) and DFO (2000).

Appendix 6. Number of softshell clam samples taken from landings from 2004 to 2019 by sub-area and shellfish harvest area and total number of samples taken from the Upper North Shore under the DFO's commercial catch sampling program.

Shellfish area and sub-area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1A- Baie Sainte-Catherine ¹	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Petites Bergeronnes	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Grandes Bergeronnes ¹	-	-	7	9	3	11	-	-	-	-	-	-	-	-	-	-
1A- Baie des Escoumins ¹	-	-	-	19	6	15	-	-	-	-	-	-	-	-	-	-
1A- Îles Penchées	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
1A- Pointe à Boisvert	2	2	8	5	3	-	-	-	1	-	-	-	-	-	-	-
1A- Pointe de Mille-Vaches	6	5	5	2	1	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Chevaux	1	2	2	3	3	2	-	-	1	-	-	2	6	-	3	-
1A- Banc Marie-Marthe	3	2	5	9	7	14	-	-	-	-	-	28	8	1	1	1
1A- Baie Didier Sud	-	-	2	4	-	1	-	-	-	-	-	-	5	-	1	1
1A- Baie des Plongeurs	1	7	6	5	1	-	-	-	-	-	-	-	4	3	4	-
1A- Battures aux Gibiers Est	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
1A- Cran à Gagnon	-	-	3	2	5	1	-	-	-	-	-	7	9	-	-	-
1A- Rivière Blanche ¹	-	-	-	6	5	18	-	-	-	-	-	-	-	-	-	-
1A- Anse du Colombier	-	-	2	-	10	3	1	-	-	-	-	4	4	-	-	-
1A- Anse à Norbert	1	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-
1A- Anse Noire	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
1A- Îlets Jérémie	1	-	-	-	3	7	4	-	-	-	-	-	4	-	-	-
1B- Pointe-aux-Outardes Ouest	4	22	16	7	5	6	16	2	5	2	7	7	11	8	5	6
1B- Pointe-aux-Outardes Est	-	-	6	8	13	9	2	-	-	4	-	7	4	-	-	-
1B- Rivière Mistassini	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
1B- Baie Saint-Nicolas	-	2	4	-	-	-	-	-	-	-	-	-	1	-	-	-
1C- Réserve Pessamit Sud	6	15	20	24	22	21	23	-	-	-	-	20	1	-	-	-
Upper North Shore	18	79	109	122	108	123	64	4	12	12	14	89	80	12	14	9

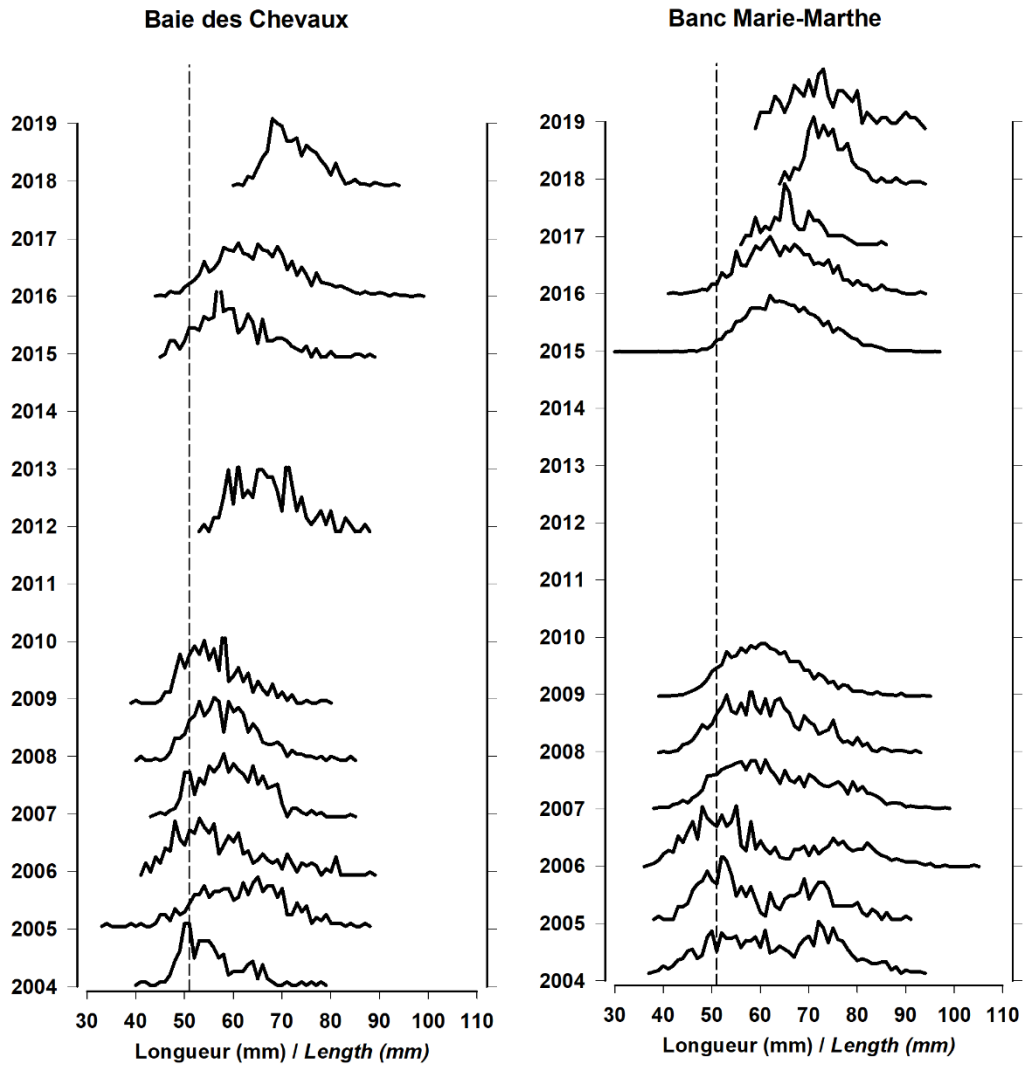
¹ Restricted or prohibited shellfish area (depuration fishery from 2002 to 2009).

Appendix 7. Number of softshell clams measured upon landing from 2004 to 2019 by sub-area and shellfish harvest area on the Upper North Shore under the DFO's commercial catch sampling program.

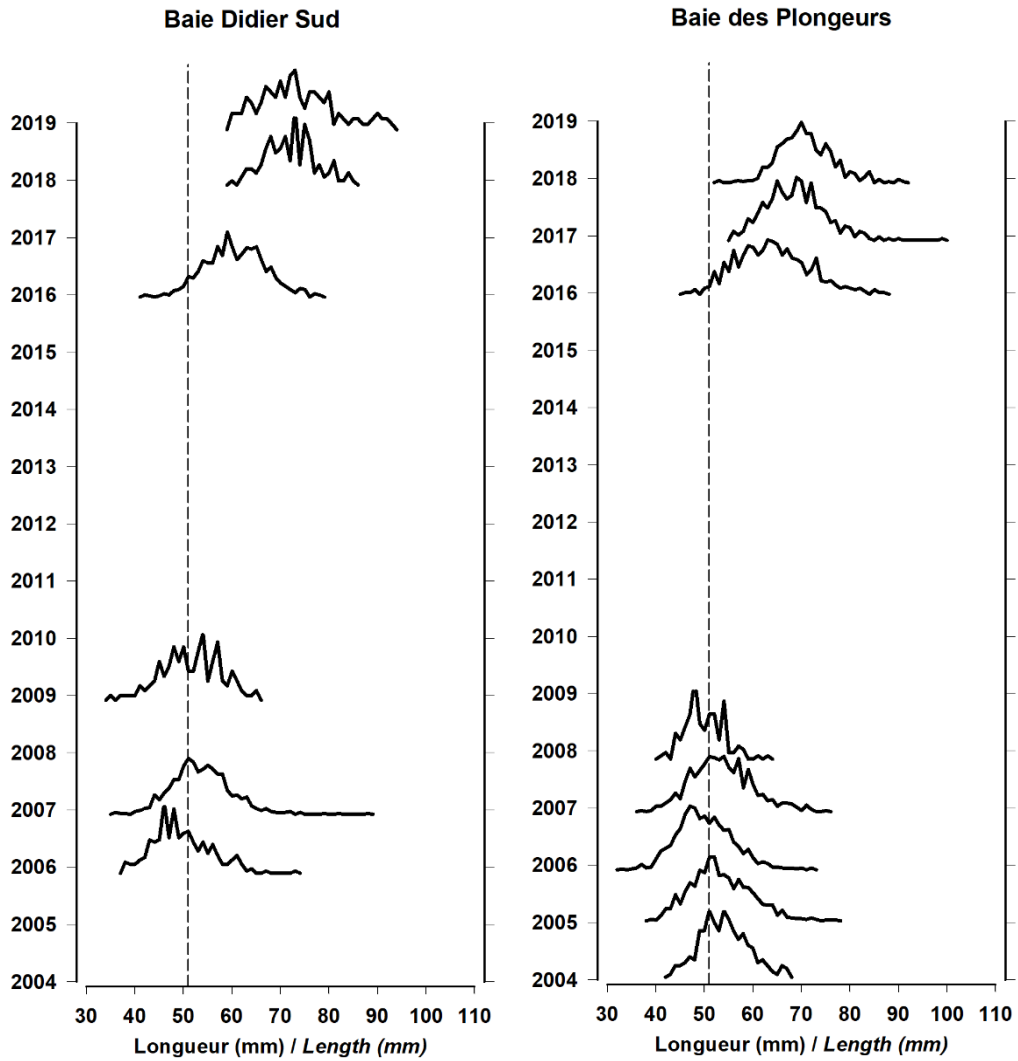
Shellfish area and sub-area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1A- Baie Sainte-Catherine ¹	-	-	-	598	-	-	-	-	-	-	-	-	-	-	-	-
1A- Baie Petites Bergeronnes	-	-	-	-	300	-	-	-	-	-	-	-	-	-	-	-
1A- Baie Grandes Bergeronnes ¹	-	-	1,075	1,354	452	1,654	-	-	-	-	-	-	-	-	-	-
1A- Baie des Escoumins ¹	-	-	-	2,842	900	2,255	-	-	-	-	-	-	-	-	-	-
1A- Îles Penchées	-	-	-	-	-	-	-	-	-	-	-	-	151	-	-	-
1A- Pointe à Boisvert	515	314	1,231	749	451	-	-	-	160	-	-	-	-	-	-	-
1A- Pointe de Mille-Vaches	1,637	792	761	300	150	-	-	-	-	-	-	-	-	-	-	-
1A- Baie des Chevaux	178	316	305	452	450	300	-	-	134	-	-	304	905	-	450	-
1A- Banc Marie-Marthe	773	316	759	1,351	1,054	2,121	-	-	-	-	-	4,221	1,205	150	300	150
1A- Baie Didier Sud	-	-	299	600	-	150	-	-	-	-	-	-	757	-	150	150
1A- Baie des Plongeurs	250	1,129	904	748	151	-	-	-	-	-	-	-	603	450	593	-
1A- Battures aux Gibiers Est	-	-	-	-	-	-	-	-	-	-	-	-	150	-	-	151
1A- Cran à Gagnon	-	-	450	300	760	150	-	-	-	-	-	1,052	1,358	-	-	-
1A- Rivière Blanche ¹	-	-	-	908	775	2,727	-	-	-	-	-	-	-	-	-	-
1A- Anse du Colombier	-	-	306	-	1,512	450	156	-	-	-	-	605	602	-	-	-
1A- Anse à Norbert	263	-	-	-	150	-	-	-	-	-	-	-	454	-	-	-
1A- Anse Noire	-	-	-	-	-	-	-	-	-	-	-	-	454	-	-	-
1A- Îlets Jérémie	252	-	-	-	449	1,220	618	-	-	-	-	-	602	-	-	-
1B- Pointe-aux-Outardes Ouest	1,044	3,476	2,424	1,199	756	894	2,469	300	750	300	997	1,220	1,651	1,200	1,050	900
1B- Pointe-aux-Outardes Est	-	-	912	1,058	1,935	1,359	308	-	-	600	-	1,258	601	-	-	-
1B- Rivière Mistassini	-	-	152	-	-	-	-	-	-	-	-	-	-	-	-	-
1B- Baie Saint-Nicolas	-	313	601	-	-	-	-	-	-	-	-	-	150	-	-	-
1C- Réserve Pessamit Sud	2,126	2,446	3,036	3,618	3,321	3,191	3,547	-	-	-	-	3,032	150	-	-	-

¹ Restricted or prohibited shellfish area (deputation fishery from 2002 to 2009).

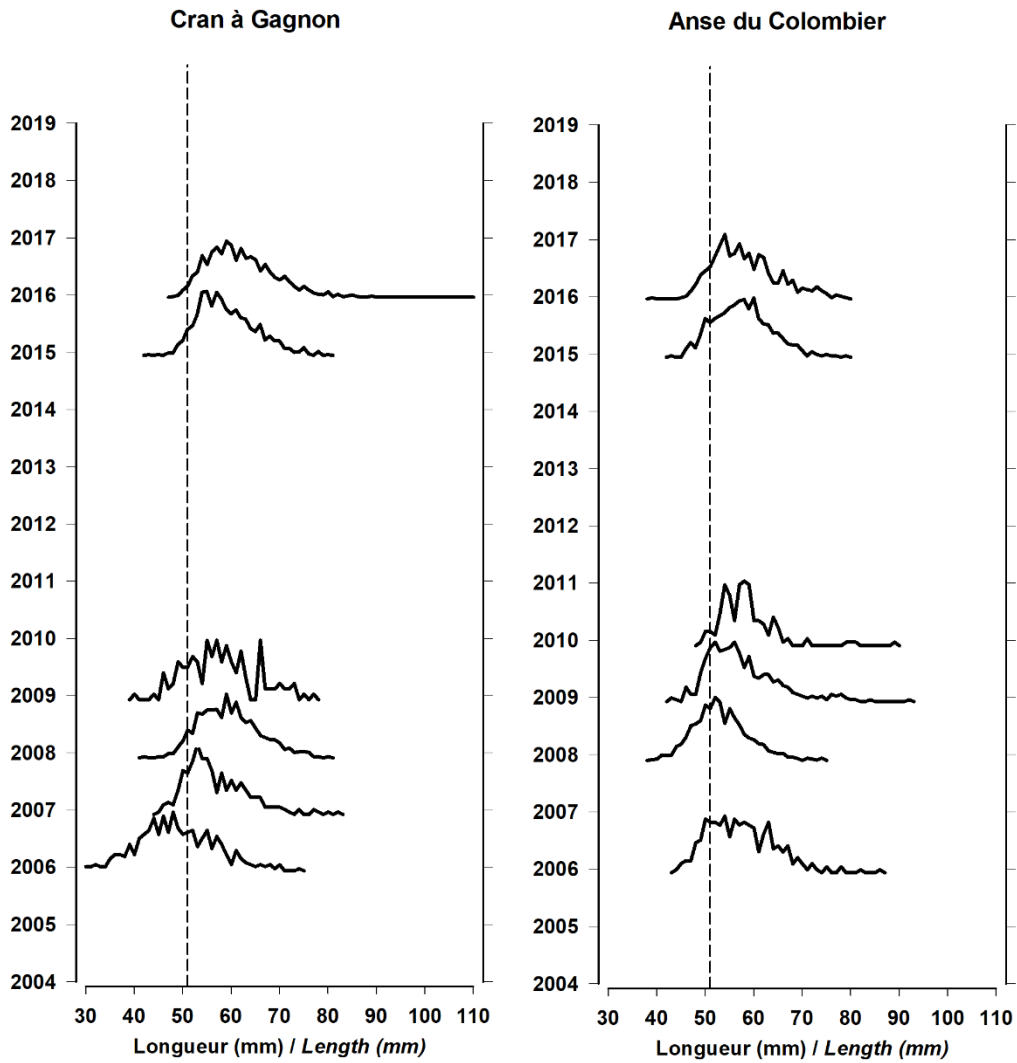
Appendix 8. Size structure of softshell clams landed (%) from 2004 to 2019 in the Baie des Chevaux and Banc Marie-Marthe shellfish areas in sub-area 1A of the Upper North Shore. The dotted vertical line shows the minimum legal size of 51 mm.



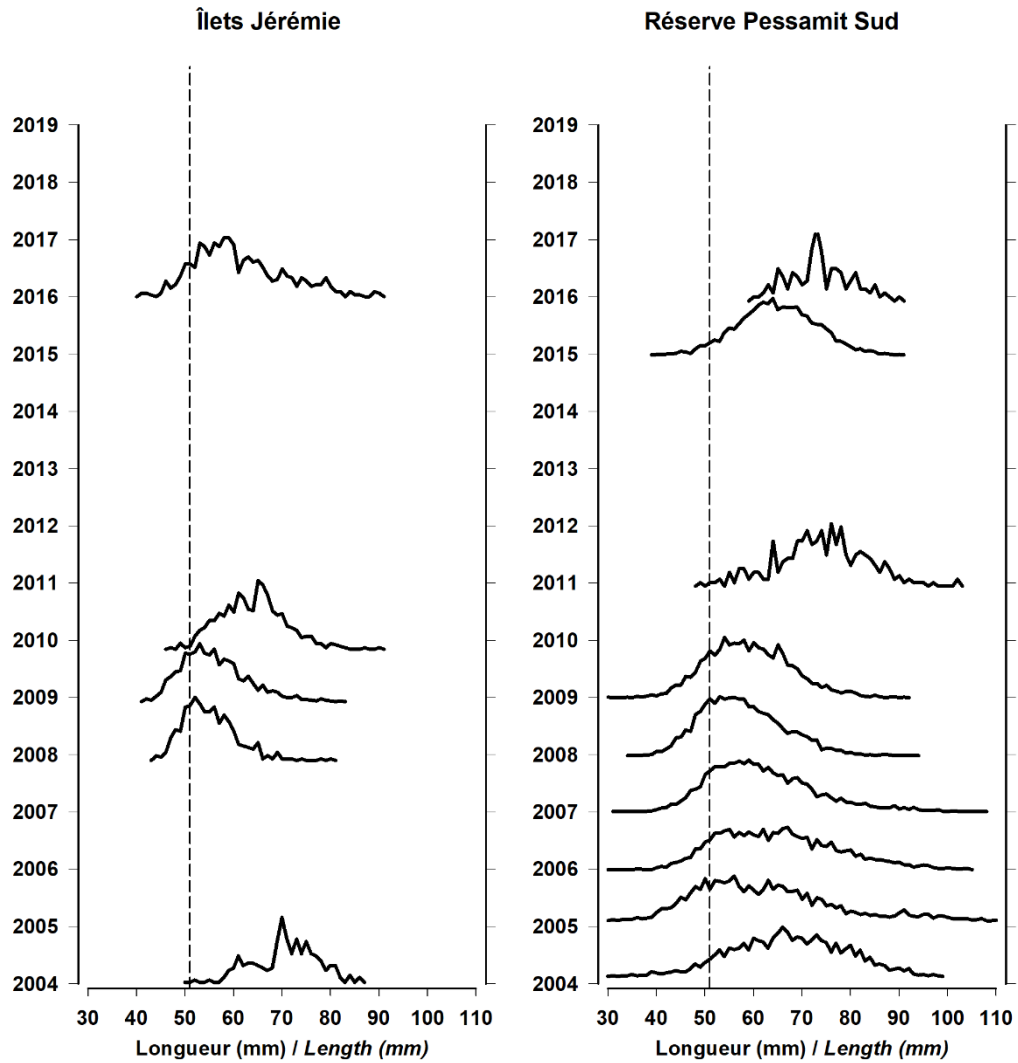
Appendix 9. Size structure of softshell clams landed (%) from 2004 to 2019 in the Baie Didier Sud and Baie des Plongeurs shellfish areas in sub-area 1A of the Upper North Shore. The dotted vertical line shows the minimum legal size of 51 mm.



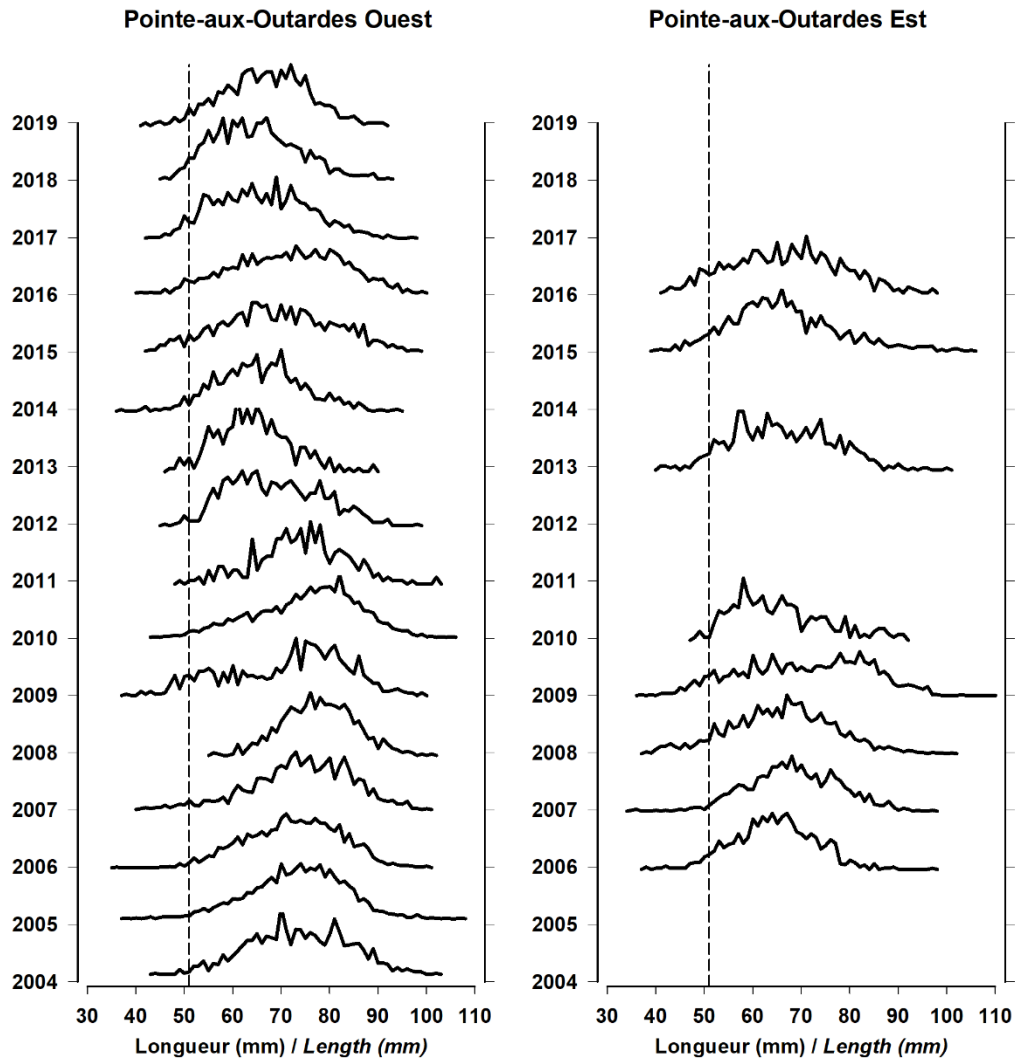
Appendix 10. Size structure of softshell clams landed (%) from 2004 to 2019 in the Cran à Gagnon and Anse du Colombier shellfish areas in sub-area 1A of the Upper North Shore. The dotted vertical line shows the minimum legal size of 51 mm.



Appendix 11. Size structure of softshell clams landed (%) from 2004 to 2019 in the Îlets Jérémie shellfish area in sub-area 1A and the Réserve Pessamit Sud shellfish area in sub-area 1C of the Upper North Shore. The dotted vertical line shows the minimum legal size of 51 mm.



Appendix 12. Size structure of softshell clams landed (%) from 2004 to 2019 in the Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est shellfish areas in sub-area 1B of the Upper North Shore. The dotted vertical line shows the minimum legal size of 51 mm.



Appendix 13. Results of comparisons, using the Kruskal-Wallis nonparametric test, of (A) densities of sub-legal size softshell clams (20–50 mm); (B) densities of legal-size softshell clams (≥ 51 mm); and (C) yields of legal-size softshell clams between years by shellfish harvest area on the Upper North Shore.

A) Density (number/m²) of sub-legal size softshell clams

Shellfish area	Year	Number of stations	Sum of scores	Mean score	Chi-square	DF	Pr > Chi-square
Baie Petites Bergeronnes	2008	34	1,695.0	41.3	0.1880	1	0.6646
	2018	45	1,800.0	39.0			
Pointe à Émile	2003	17	420.5	24.7	8.8661	1	0.0029
	2018	20	282.5	14.1			
Baie des Chevaux	2002	71	8,353.5	117.7	3.9021	1	0.0482
	2017	140	14,012.5	100.1			
Cran à Gagnon	2007	58	3,879.0	66.9	2.0635	1	0.1509
	2017	65	3,747.0	57.7			
Anse Noire	2003	22	454.5	20.7	0.2176	1	0.6408
	2018	20	448.5	22.4			
Réserve Pessamit Sud	2005	105	24,380.5	232.2	4.7300	3	0.1927
	2010	108	22,261.5	206.1			
	2014	106	21,064.0	198.7			
	2018	108	23,672.0	219.2			
Pointe-aux-Outardes Ouest	2003	220	40,447.5	183.9	1.0952	1	0.2953
	2017	155	30,052.5	193.9			
Pointe-aux-Outardes Est	2004	41	2,234.5	54.5	28.3102	1	< 0.0001
	2017	41	1,168.5	28.5			

B) Density (number/m²) of legal-size softshell clams

Shellfish area	Year	Number of stations	Sum of scores	Mean score	Chi-square	DF	Pr > Chi-square
Baie Petites Bergeronnes	2008	34	923.0	27.1	18.8940	1	< 0.0001
	2018	45	2,237.0	49.7			
Pointe à Émile	2003	17	254.5	15.0	5.7464	1	0.0165
	2018	20	448.5	22.4			
Baie des Chevaux	2002	71	7,736.5	109.0	0.2894	1	0.5906
	2017	140	14,629.5	104.5			
Cran à Gagnon	2007	58	3,086.0	53.2	6.9746	1	0.0083
	2017	65	4,540.0	69.8			
Anse Noire	2003	22	386.0	17.5	5.2244	1	0.0223
	2018	20	517.0	25.8			
Réserve Pessamit Sud	2005	105	22,345.5	212.8	29.0997	3	< 0.0001
	2010	108	20,298.5	187.9			
	2014	106	20,015.0	188.8			
	2018	108	28,719.0	265.9			
Pointe-aux-Outardes Ouest	2003	220	40,507.5	184.1	0.6959	1	0.4042
	2017	155	29,992.5	193.5			
Pointe-aux-Outardes Est	2004	41	1,827.0	44.6	1.5118	1	0.2189
	2017	41	1,576.0	38.4			

C) Yield (kg/m²) of legal-size softshell clams

Shellfish area	Year	Number of stations	Sum of scores	Mean score	Chi-square	DF	Pr > Chi-square																																																																																								
Baie Petites Bergeronnes	2008	34	890.5	26.2	21.6546	1	< 0.0001																																																																																								
	2018	45	2,269.5	50.4				Pointe à Émile	2003	17	251.0	14.8	6.3347	1	0.0118	2018	20	452.0	22.6	Baie des Chevaux	2002	71	7,830.0	110.3	0.6027	1	0.4376	2017	140	14,536.0	103.8	Cran à Gagnon	2007	58	3,049.5	52.6	7.9849	1	0.0047	2017	65	4,576.5	70.4	Anse Noire	2003	22	386.0	17.5	5.2097	1	0.0225	2018	20	517.0	25.8	Réserve Pessamit Sud	2005	105	21,735.0	207.0	34.9911	3	< 0.0001	2010	108	20,199.0	187.0	2014	106	20,011.0	188.8	2018	108	29,433.0	272.5	Pointe-aux-Outardes Ouest	2003	220	41,118.0	186.9	0.0556	1	0.8137	2017	155	29,382.0	189.6	Pointe-aux-Outardes Est	2004	41	1,825.0	44.5	1.4567	1	0.2275
Pointe à Émile	2003	17	251.0	14.8	6.3347	1	0.0118																																																																																								
	2018	20	452.0	22.6				Baie des Chevaux	2002	71	7,830.0	110.3	0.6027	1	0.4376	2017	140	14,536.0	103.8	Cran à Gagnon	2007	58	3,049.5	52.6	7.9849	1	0.0047	2017	65	4,576.5	70.4	Anse Noire	2003	22	386.0	17.5	5.2097	1	0.0225	2018	20	517.0	25.8	Réserve Pessamit Sud	2005	105	21,735.0	207.0	34.9911	3	< 0.0001	2010	108	20,199.0	187.0		2014	106	20,011.0	188.8				2018	108	29,433.0	272.5	Pointe-aux-Outardes Ouest	2003	220	41,118.0	186.9	0.0556	1	0.8137	2017	155	29,382.0	189.6	Pointe-aux-Outardes Est	2004	41	1,825.0	44.5	1.4567	1	0.2275	2017	41	1,578.0	38.5				
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	2010	108	20,199.0	187.0																																																																																											
	2014	106	20,011.0	188.8																																																																																											
	2018	108	29,433.0	272.5				Pointe-aux-Outardes Ouest	2003	220	41,118.0	186.9	0.0556	1	0.8137	2017	155	29,382.0	189.6	Pointe-aux-Outardes Est	2004	41	1,825.0	44.5	1.4567	1	0.2275	2017	41	1,578.0	38.5																																																																
Pointe-aux-Outardes Ouest	2003	220	41,118.0	186.9	0.0556	1	0.8137																																																																																								
	2017	155	29,382.0	189.6				Pointe-aux-Outardes Est	2004	41	1,825.0	44.5	1.4567	1	0.2275	2017	41	1,578.0	38.5																																																																												
Pointe-aux-Outardes Est	2004	41	1,825.0	44.5	1.4567	1	0.2275																																																																																								
	2017	41	1,578.0	38.5																																																																																											