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Results of soft-shell clam (*Mya arenaria*) surveys from 2016 to 2020 on the Upper North Shore and update of surveys from 2001 to 2014 in Quebec

Sylvie Brulotte

Fisheries and Oceans Canada
Maurice Lamontagne Institute
850, route de la Mer, P.O. Box 1000
Mont-Joli, Québec, G5H 3Z4

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Canada

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

Soft-shell clam (*Mya arenaria*) is found throughout Quebec's coastline. Quebec's coastal zone is divided into shellfish areas, which are grouped into three major regions: the North Shore, Gaspé–Lower St. Lawrence and the Magdalen Islands. Clam beds in 28 shellfish areas on the Upper North Shore were surveyed from 2016 to 2020. The results—including the area of the beds, density (number/m^2) and yield (g/m^2) of sub-legal-size (20–50 mm) and legal-size (≥ 51 mm) clams, harvestable area, biomass of clams ≥ 51 mm, size structure, sediment grain size and associated species counts—are provided for all those surveys. In addition, an update of the results of surveys from 2001 to 2014 is provided.

Shellfish beds varie from 0.004 km^2 (Batture aux Gibiers Est) to 5.99 km^2 (Pointe-aux-Outardes Ouest). The preferred habitat of soft-shell clams is a mixture of mud and sand sediments in varying proportions. The average density of clams 20–50 mm varies greatly from one bed to another, from 0 (Batture aux Gibiers Est) to 277 clams/m^2 (Anse du Colombier). The average densities of clams ≥ 51 mm ranged from 2 (Pointe aux Vaches) to 79 clams/m^2 (Rivière Blanche). Values greater than 45 clams/m^2 were observed in Rivière Blanche, Îlets Jérémie and Réserve Pessamit Sud. Such values were never obtained during previous surveys from 2001 to 2014 in Quebec.

Within each shellfish area, the harvestable area is delineated by a minimum of three contiguous stations with a density of legal-size clams ≥ 16 clams/m^2, based on the premise that harvesters target locations with sufficient density of clams. With this premise, four shellfish areas do not have a harvestable area, whereas others have harvestable areas between 0.03 km^2 (Batture à Théophile) and 2.37 km^2 (Pointe-aux-Outardes Ouest). The mean density of clams ≥ 51 mm over the harvestable area varies from 17 clams/m^2 (Batture à Théophile) to 98 clams/m^2 (Rivière Blanche). The average yield of clams ≥ 51 mm varies from 338 g/m^2 (Batture à Théophile) to 2,843 g/m^2 (Rivière Blanche). The highest harvestable biomasses were obtained in Pointe-aux-Outardes Ouest and Réserve Pessamit Sud.

These results were compared with those of previous surveys conducted on the same beds. In general, the densities of clams ≥ 51 mm are similar or higher to those in the surveys from 2002 to 2014. However, comparison with surveys conducted from 1967 to 1970 shows that recent densities are lower for several areas.

INTRODUCTION

Soft-shell clams (*Mya arenaria*)—also referred to as long-neck or steamer clams, or just clams—occur throughout the coastal waters of North America and Europe (Bousfield 1964; Abgrall et al. 2010). 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), the Gulf of St. Lawrence and Chaleur Bay. It is distributed mainly in the midlittoral zone[1] to a maximum depth of 10 m in the infralittoral zone. It is an endobenthic organism that lives buried in loose sand and mud sediments, mainly in protected areas such as bays, river estuaries and barachois (Belding 1930; Abraham and Dillon 1986; Newell and Hidu 1986; Brulotte and Giguère 2003; Roy et al. 2003; Giguère et al. 2008). Lavoie (1967) mentions that pure sand, gravel and cobble are not suitable substrates to support a soft-shell clam population. The species is sedentary and lives in beds or aggregations of varying size (Brousseau 1978; Strasser et al. 1999). Soft-shell clams are filter feeders that consume algae, plankton, bacteria and suspended particles in the water (Matthiessen 1960; Abraham and Dillon 1986; Newell and Hidu 1986; Christian et al. 2010; Mason Webber et al. 2021). They have separate sexes and usually have an even sex ratio (Brousseau 1978; Roseberry et al.1991; Blaise et al. 1999; Brulotte and Giguère 2007). In Quebec, the mean size at which 50% of the individuals are sexually mature is 38–46 mm (Brulotte and Giguère 2007). There is generally only one spawn (or several partial spawns) a year, occurring mainly from May to July (Roseberry et al. 2006; Brulotte et Giguère 2007; St-Onge 2013). Gametes are released into the water, where oocytes are fertilized. After a pelagic larval stage lasting about 5 weeks, the larva metamorphoses, takes the adult form, and settles on the seabed (Brousseau 1978; Abraham and Dillon 1986; Abgrall et al. 2010). In Quebec, these juveniles bury themselves in the sediment or adhere to the substrate mainly in July and August (Brulotte et al. 2012). Recruitment is variable from year to year (MacKenzie and McLaughlin 2000; Brulotte et al. 2012, 2015) and depends on the timing of spawning, environmental conditions (e.g., temperature, current) and the mortality and dispersal rate of larvae and juveniles (Belding 1930; Brousseau 1978; Abraham and Dillon 1986; Strasser et al. 1999; Garcia et al. 2003; Abgrall et al. 2010; Mason Webber 2021). In Quebec, soft-shell clams take 5 to 7 years to reach the minimum legal size of 51 mm (Lavoie 1969a; Lamoureux 1977; Mercier et al. 1978; Procéan 1993). They can reach a size of just over 110 mm over a typical lifespan of 10 to over 17 years (Belding 1930; Feder and Paul 1974; Brousseau 1978; Abraham and Dillon 1986; Maximovich and Guerassimova 2003; Abgrall et al. 2010).

Quebec's coastal area was divided into 352 shellfish harvest areas[2] in 2020, making it possible to monitor and control the quality of the water and shellfish present (CSSP 2020; ECCC 2020). Shellfish areas are grouped into 11 major regions, the main ones being the Magdalen Islands (50 areas), the Lower St. Lawrence (67 areas), Gaspé (78 areas), the Upper North Shore (55 areas), the Middle North Shore (60 areas) and the Lower North Shore (22 areas). They are managed under the Canadian Shellfish Sanitation Program (CSSP), which classifies and determines the status of each area annually. The various possible classifications are: approved (A); conditionally approved, closed from June 1 to September 30 of each year (CA); conditionally approved with a conditional management plan, due to the risk of overflow at a

[1] The midlittoral zone, or intertidal zone, corresponds to the shore zone between the high and low tide marks. Its upper end is delimited by the mean level of high spring tides, and its lower end by the mean low water neaps.

[2] Excluding aquaculture sites, main outfalls and overflows.

water filtration plant (CA-CMP); and prohibited (P). Clam harvesting is allowed in areas with A, CA and CA-CMP statuses. In 2020, there were 71 areas where harvesting was authorized: 23 areas in the Magdalen Islands, 3 in the Lower St. Lawrence, 3 in Gaspé, 23 in the Upper North Shore, 15 in the Middle North Shore and 4 in the Lower North Shore.

Soft-shell clam harvesting is a very popular activity among the populations of Quebec's coastal areas, since the resource is easily accessible and can collected without the use of specialized equipment. Recreational harvesting has been practiced for many years in Quebec, and commercial harvesting has been documented since 1917 (DFO 2020). The minimum legal size has been 51 mm (2 inches) since at least 1990. Since most harvesting is done on the lower part of the intertidal zone and at the beginning of the subtidal zone, it is only possible at low tide, mainly during large spring tides. These tides occur about twice a month and last for about a week. In addition, harvesting takes place mainly in the spring and fall (Brulotte 2011). In summer, several shellfish areas are closed due to their CA status and the presence of biotoxins.

Commercial landings of soft-shell clams came almost exclusively from the Magdalen Islands during the period of 1920-1950 (Figure 1). Beginning in 1954, landings from the Magdalen Islands considerably dropped, and the Gaspé–Lower St. Lawrence and North Shore regions took over. Since the end of the 1960s, most of the commercial harvesting has been done on the North Shore. Quebec landings fluctuated between 90 and 820 t from 1917 to 1999. They reached a peak of 1,207 t in 2000 and dropped drastically to 11 t in 2011. This led to the closure of processing plants in the North Shore, particularly in Forestville. Since then, annual landings have remained lower than 85 t.

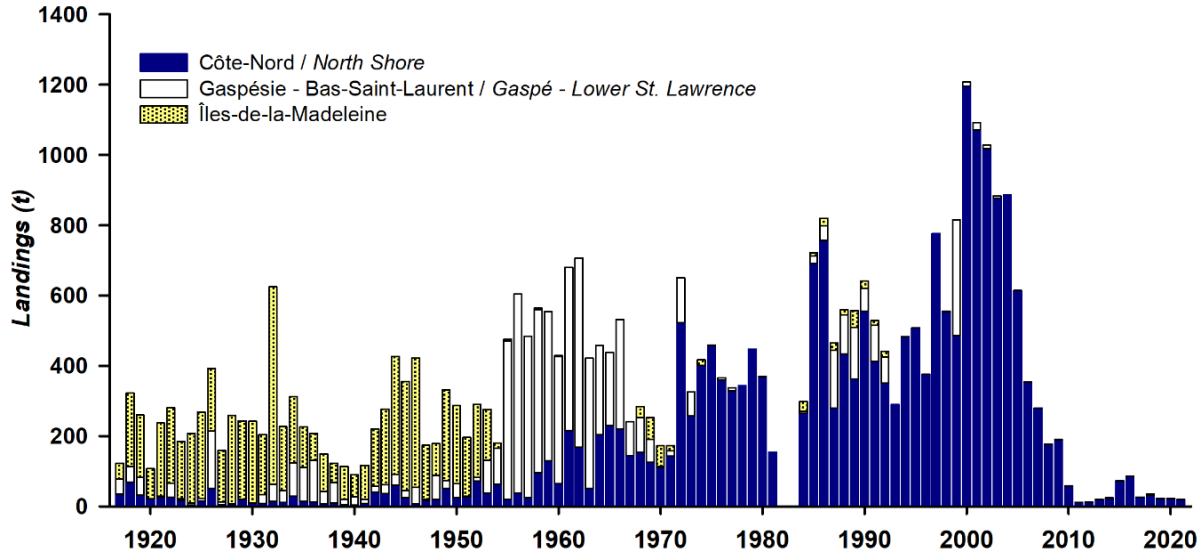

Figure 1. Annual commercial landings of soft-shell clams by region of Quebec.

Over the years, surveys have been carried out in Quebec, mainly in the 1960s by the teams of Lavoie and Lamoureux from Quebec's Ministry of Industry and Commerce at the time (Lavoie 1967, 1968, 1969a, 1969b, 1970a, 1970b; Lamoureux 1975a, 1975b). The purpose of these surveys was to evaluate beds with commercial harvesting potential. Subsequently, other surveys were conducted on a smaller scale, and some beds were revisited to assess their condition following commercial harvesting (Lamoureux 1974, 1977; Giguère and Lamoureux 1978; Mercier et al. 1978; Bourget and Messier 1983; Desrosiers and Brêthes 1984; Tremblay 1990; Procéan 1993; Beaulieu and Mathieu 1998; Robineau 2011).

Since the early 2000s, several other surveys have been conducted in Quebec by Fisheries and Oceans Canada (DFO) and partners to document the status of soft-shell clam beds (Brulotte and Giguère 2003; Roy et al. 2003; Brulotte et al. 2006; Giguère et al. 2007, 2008; Brulotte 2011, 2018).

Stock assessment for soft-shell clam is conducted every 3 years by DFO Québec. The most recent assessment took place on February 25, 2020, in Mont-Joli, Québec. In support of the Science Advisory Report (DFO 2020) and the Research Document associated (Brulotte 2020), this study provides detailed information on the techniques, analyses and results of clam surveys conducted on the Upper North Shore from 2016 to 2020, as well as updated results of surveys since 2001.

MATERIALS AND METHODS

SURVEYS FROM 2016 TO 2020 IN THE UPPER NORTH SHORE

All areas on the Upper North Shore open to clam harvesting (A, CA and CA-CMP statuses) were surveyed from 2016 to 2019, i.e., 23 shellfish harvest areas. Five areas with a prohibited status were surveyed in 2019 and 2020. From west to east, these areas are (Figure 2 and Appendices 1 and 2):

- Pointe aux Vaches (N-01.1.2),
- Baie des Petites Bergeronnes (N-01.1.4),
- Baie des Grandes Bergeronnes (N-01.2.1),
- Batture à Théophile (N-01.2.2),
- Baie des Escoumins (N-02.1),
- 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),
- Rivière Blanche (N-04.3),
- 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),
- Réserve Pessamit Nord (N-05.1.3.2),
- 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),
- Franquelin (N-08.2), and
- Baie Saint-Nicolas (N-08.3).

These areas were initially visited to determine the location and approximate extent of the beds, which made it possible to target the areas to be surveyed. The same methodology was used for each survey. A systematic sampling grid covering the entire bed was used to locate the stations. The distance between sampling stations differed according to the bed and occasionally between different portions of the same bed (Table 1). The number of sampling stations also varied according to the area and the sampling grid (Table 1). A 0.25 m^2 quadrat was used to delineate the sampling area at each station. Sediments were collected using a shovel or a Venturi suction system (Brulotte and Giguère 2003) to a depth of approximately 30 cm. The contents of the quadrat were sieved through 10 mm mesh (Table 1). All clams were counted and measured (anteroposterior length ± 1 mm; Appendix 3). Other living species present were identified and counted. The only exception to this protocol was in Réserve Pessamit Nord, where a 6 mm mesh was used for sieving.

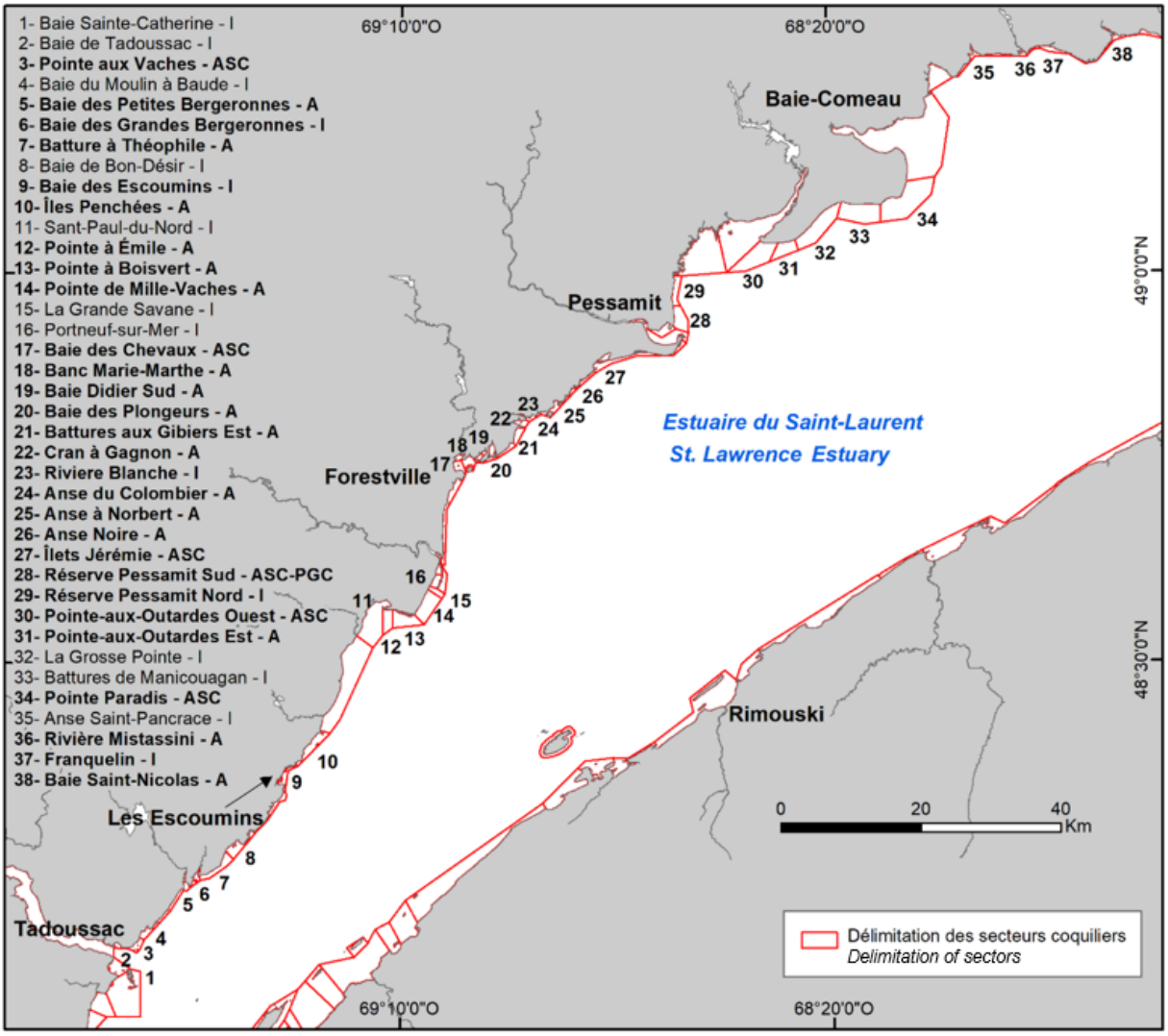

Figure 2. Location of the main shellfish areas on the Upper North Shore and their status according to the 2020 Canadian Shellfish Sanitation Program.(A = approved, CA = conditionally approved, CA-CMP = conditionally approved with a conditional management plan and P = prohibited). Shellfish areas in bold were surveyed from 2016 to 2020.

Table 1. General information for each shellfish area surveyed from 2016 to 2020 on the Upper North Shore. Name of the area, sampling year, sampling grid, mesh size of the sieve used, number of stations visited, number of stations surveyed, and number of sediment samples collected.

Shellfish area	Year	Grid	Sieve	Stations visited	Stations surveyed	Sediment
Pointe aux Vaches	2018	62 m by 65 m	10 mm	51	45	13
Baie des Petites Bergeronnes	2018	100 m by 100 m	10 mm	64	61	0
Baie des Grandes Bergeronnes	2020	80 m by 80 m	10 mm	150	150	36
Batture à Théophile	2018	100 m linéaire	10 mm	52	52	11
Baie des Escoumins	2020	80 m by 75 m	10 mm	93	93	23
Îles Penchées	2018	80 m by 85 m and 65 m by 75 m	10 mm	109	83	23
Pointe à Émile	2018	150 m by 200 m and 75 m by 200 m	10 mm	77	72	12
Pointe à Boisvert	2017	150 m by 150 m and 109 m by 109 m	10 mm	197	139	23
Pointe de Mille-Vaches	2018	65 m by 100 m	10 mm	222	178	35
Baie des Chevaux	2017	100 m by 100 m	10 mm	151	146	0
Banc Marie-Marthe	2016	75 m by 75 m	10 mm	115	110	38
Baie Didier Sud	2018	75 m by 75 m	10 mm	123	112	22
Baie des Plongeurs	2016	75 m by 75 m	10 mm	106	106	30
Batture aux Gibiers Est	2018	65 m by 65 m	10 mm	42	21	7
Cran à Gagnon	2017	75 m by 75 m	10 mm	69	69	0
Rivière Blanche	2020	60 m by 60 m	10 mm	84	84	21
Anse du Colombier	2017	65 m by 65 m	10 mm	57	51	12
Anse à Norbert	2018	85 m by 85 m and 60 m by 60 m	10 mm	93	66	18
Anse Noire	2018	60 m by 60 m	10 mm	49	27	10
Îlets Jérémie	2017	75 m by 75 m	10 mm	174	97	21
Réserve Pessamit Sud	2018	150 m by 150 m and 105 m by 105 m	10 mm	113	113	0
Réserve Pessamit Nord	2019	150 m by 150 m and 75 m by 75 m	6 mm	311	284	55
Pointe-aux-Outardes Ouest	2017	150 m by 190 m	10 mm	249	242	50
Pointe-aux-Outardes Est	2018	150 m by 190 m	10 mm	162	143	26
Pointe Paradis	2019	125 m by 125 m	10 mm	206	198	40
Rivière Mistassini	2018	75 m by 75 m	10 mm	83	74	20
Franquelin	2020	75 m by 75 m	10 mm	98	95	21
Baie Saint-Nicolas	2018	85 m by 85 m and 65 m by 65 m	10 mm	87	74	22

Each sampling station was assigned according to the following criteria :

- Sampled station: Sediment and biota were sampled.
- Compact clay: Sediment consists of compact clay. Clams cannot burrow in such a habitat; station not sampled.
- Backshore: Station is located on the beach. No clams are present; station not sampled.
- Rocky habitat: Habitat is unsuitable for clams; station not sampled.
- Too deep: Water depth is too deep for harvesting (more than 0.6–0.7 m of water), even during spring tides; station cannot be sampled.
- Other unsuitable habitats: Three shellfish areas (Pointe à Boisvert, Pointe de Mille-Vaches and Îlets Jérémie) have various habitats that are unsuitable for clam.
- Extensive coverage by eelgrass (*Zostera marina*): The area to be sampled is covered by at least 80% eelgrass. It is very difficult to dig up sediment and clams (usually little or no clams); station not sampled.

Depending on the shellfish areas, the intertidal zone habitat can be quite heterogeneous. On occasion, some stations were moved slightly to allow sampling, for example to avoid the presence of rocks.

Sediments were visually assessed at each station. In addition, a sediment sample was collected using a 5 cm (2 inch) ABS pipe to a depth of 20–30 cm at approximately one quarter of the stations sampled per bed (Table 1). The location of the sediment samples was chosen to cover the different types of sediments. These samples were used to determine the grain size of the sediments in the clam beds. The methodology used for the surveys conducted from 2016 to 2018 is based on that of Walton and is described in Brulotte and Giguère (2003). For the surveys conducted in 2019 and 2020, the methodology is different and is based on analysis of the coarse portion by sieving and of the fine portion by laser (Eshel et al. 2004; Coulombier et al. 2012). No sediment samples were taken from the Baie des Petites Bergeronnes, Baie des Chevaux, Cran à Gagnon and Réserve Pessamit Sud, since the grain size of these areas had been analyzed during previous surveys. In general, the agreement between the visual assessment and the results of the grain size analysis is above 85% to 90%.

Contents of clay and silt (particles < 63 µm), sand (≥ 63 µm to < 2 mm), gravel (≥ 2 mm to < 64 mm) and cobble (≥ 64 mm to < 256 mm)[3] were calculated from the dry weight of each category relative to the total dry weight of the sample and are expressed as a percentage. The sediment classes used, whether for visual assessment or grain size analysis, are mud, sandy mud, muddy sand, sand, gravelly sand and mixed sediment, according to the criteria in Table 2. At some stations, when the sediments consisted of compact clay, the class noted was clay. Compact clay is distinguished from mud by its nearly 100% clay content and lack of silt, but mainly by its density. Compact clay is a dense sediment in which clams cannot burrow, whereas mud is a much looser sediment.

[3] Adaptation of the Wentworth grain-size classification by Blott and Pye (2001).

Table 2. Sediment classification, based on contents (%) of clay/silt, sand and gravel/cobble, used for visual assessment and grain size analysis of sediments.

Sediment	Clay and silt	Sand	Gravel and cobble
Mud	≥ 80	< 10	< 10
Sandy mud	30–79	20–69	< 10
Muddy sand	10–29	70–89	< 10
Sand	< 10	> 90	< 10
Gravelly sand	< 10	70–89	10–29
Mixed sediment[1]	x	x	≥ 30

[1] Sediment composed of at least 30% gravel and cobble, mixed with sand, clay and silt.

A subsample of clams was collected from each harvest area for biometric analyses and consisted of two clams per 1 mm length increment. First, the fresh whole weight (±0.1 g) of each clam was measured. Then, the subsample was frozen for more detailed analyses in the laboratory. After thawing, each clam was numbered and measured for anteroposterior length (±1 mm, Appendix 3), maximum width at the hinge (±1 mm), maximum thickness (±1 mm) and weight (thawed whole weight, ±0.1 g). Viscera[4] (±0.0001 g) and shells (±0.1 g) were oven dried at 70 °C for 120 hours and 24 hours, respectively, and weighed. The viscera were then combusted in a muffle furnace at 450 °C for 24 hours. The dry viscera weight used in the allometric relationships refers to the weight of the dry viscera minus the weight of the ash. The shells were kept for possible age reading. Allometric relationships between shell width or thickness and length were calculated from a linear relationship, $y = ax + b$ (Appendix 4). For weight-length relationships, the linear relationship was established using log-transformed data (ln). The allometric relationships obtained between fresh or thawed whole weight and length were used to calculate yields (g/m^2). For the surveys conducted from 2016 to 2020, yields were calculated using fresh weights (Appendices 4 and 5).

Clams were grouped into two size classes: sub-legal size (20–50 mm) and legal size (≥ 51 mm). The mesh size used during sieving affects the minimum length of clams retained by the sieve. For a 10 mm mesh size, clams ≥ 20 mm are considered retained, while for a 6–7 mm mesh size, clams ≥ 11 mm are retained.

A shellfish bed is defined as a suitable habitat for clam establishment and survival with a density of at least 1 clam/m^2. The area of the clam bed is a minimum estimate of its actual area, as small clams are not retained by the 10 mm mesh size. The presence of all clam sizes collected (≥ 6 mm) was used to delineate the bed, which means that some stations on the periphery have no clams ≥ 20 mm. However, this means that clams 6–19 mm are included in the bed, mainly for beds where the quantity of clams < 30 mm is significant, such as those of Réserve Pessamit Nord (and use of a 6 mm mesh size) and Franquelin. The area of each bed was therefore estimated by summing the sampling interval (distance between stations in m^2) of the surveyed stations. Stations without clams (≥ 6 mm) located on the periphery of the sampled area were excluded from the calculation. Stations referred to as “enclaved”, which are located closer to the center of the area and have no clams (maximum of two consecutive stations without clams), were included in the estimation of area, density and yield of the beds.

In some parts of the bed, such as the southern parts of the Pointe de Mille-Vaches and Pointe Paradis, clams were more sparsely distributed, i.e., one or two stations with clams surrounded by several stations without clams. The area of the bed was estimated by adding up only the

[4] For clams, viscera are defined as all internal organs, including the gonad and muscles, except the shell.

stations with clams. For beds that had been already surveyed from 2002 to 2014 (Baie des Petites Bergeronnes, Pointe à Émile, Baie des Chevaux, Cran à Gagnon, Anse Noire, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est), the area was estimated based on the results of all surveys. In the Anse Noire, the area of the bed located in the far west goes slightly beyond the boundaries of the shellfish area. In this particular case, the estimated bed area includes the portion located outside the boundaries.

The harvestable area is defined by a minimum of three contiguous stations with a density of legal-size clams ≥ 16 clams/m^2, based on the premise that harvesters target locations with sufficient density of these clams to make the time spent harvesting worthwhile (Brulotte 2020; DFO 2020). Usually, high-density stations are found in the same location on the bed. However, this area may occasionally include a few enclaved stations with lower density, which allows for some continuity of the harvestable area.

Densities and yields are averaged over the harvestable area and are presented with its standard error (used as an index of population variation). The harvestable commercial biomass (t) is calculated by multiplying the yield of clams ≥ 51 mm within the harvestable area by the size of the harvestable area. The variables presented for each shellfish area are:

- the total area,
- the average density and yield of clams 20–50 mm and ≥ 51 mm in the shellfish area,
- the harvestable area, and
- the average density and yield and biomass of clams ≥ 51 mm over the harvestable area.

In addition, the size structure of clams by shellfish area is presented using a histogram. The average sizes of clams ≥ 20 mm and clams ≥ 51 mm are provided along with their standard deviation (used as an index of sample variation). The various statistical analyses were performed using SAS (version 9.4).

In 2018, clams were harvested to assess their health status (diseases) and the presence of pathogens and microplastics in the organism. The areas selected were intended to cover the entire territory and target locations that may be contaminated. The areas selected were:

- Pointe aux Vaches: located at the mouth of the Saguenay River and in the far west of the territory;
- Pointe de Mille-Vaches: located between two major rivers;
- Réserve Pessamit Sud: located near a wastewater treatment plant; and
- Baie Saint-Nicolas: located in the far east of the territory and at the mouth of a river.

A sample of 60 commercial-size clams was kept for each of the areas targeted. The analyses were carried out by the team of Michelle Maillet and Rémi Sonier of the Aquaculture and Coastal Ecosystems Section of DFO – Gulf Region (Moncton, New Brunswick). The protocol is provided in Appendix 6.

UPDATE OF SURVEY RESULTS FROM 2001 TO 2014

Several clam surveys have been conducted in Quebec since 2001 by DFO and partners (Brulotte and Giguère 2003; Roy et al. 2003; Brulotte et al. 2006; Giguère et al. 2007, 2008; Brulotte 2011, 2018). These surveys are listed in Appendix 2. Their basic information, including the sampling grid, mesh size and number of stations surveyed, is provided in Appendix 7, and their rough location is provided in Figure 3. The methodology used is similar to that described for surveys conducted from 2016 to 2020. The results of these various surveys were reworked

to better match the data provided for the recent Upper North Shore surveys to enable comparison between the different regions of Quebec. These new results (area, density and yield) may differ slightly from those provided in the original publications. In addition, a harvestable area was calculated for all harvest area. For these surveys, yields were calculated using thawed weight, except for Pointe à Émile and Anse Noire in 2003, which were calculated using fresh weight.

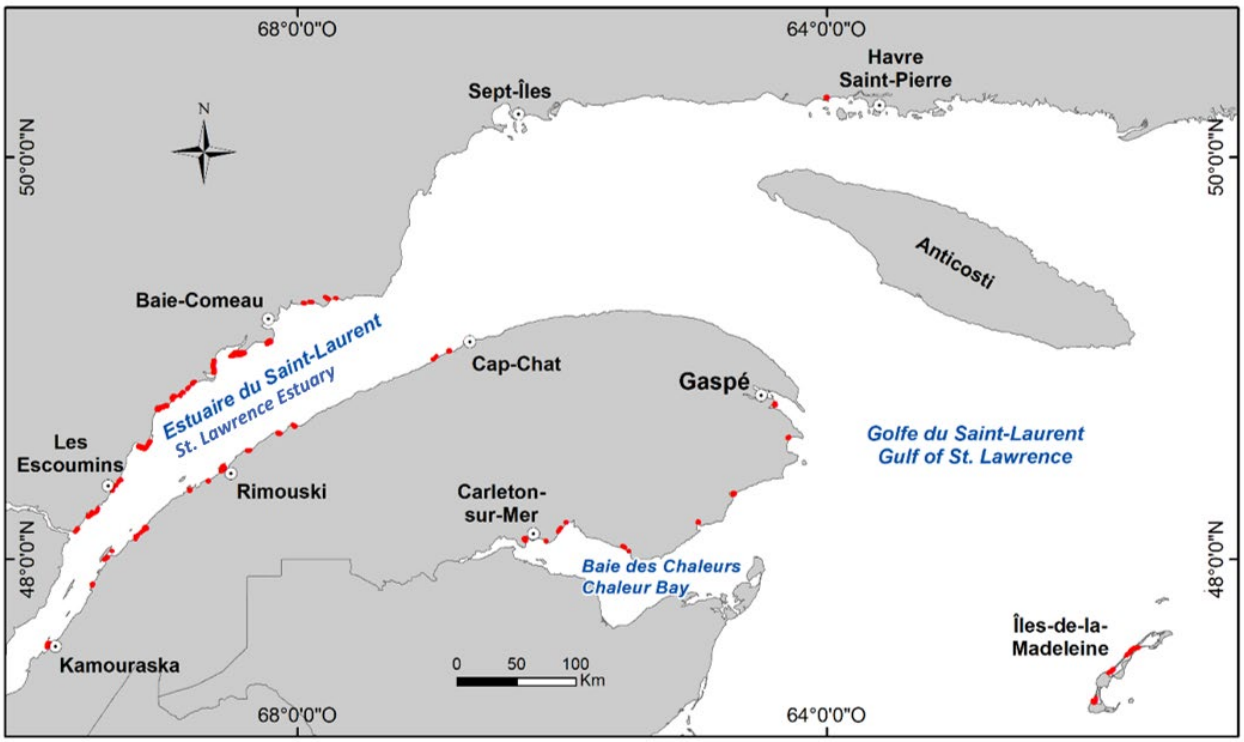

Figure 3. Location of soft-shell clam surveys (red dot) conducted in Quebec since 2001.

Two other shellfish areas were surveyed; the results will be provided for the first time in this document:

- The Bonaventure Ouest bed (shellfish areas G-10.4.1 and G-10.4.2), surveyed in 2009 and 2011 in connection with a spring recreational harvest that took place in 2009 and 2010.
- The bed located at the mouth of Mingan River (straddling shellfish areas N-18.3.1, N-18.3.2 and N-18.3.3), surveyed in 2007 as a follow-up to intensive commercial harvesting in 2002 and 2003 at the aquaculture area located in shellfish area N-18.3.2.

The latter bed was surveyed in 2001 (Brulotte and Giguère 2003). The protocol was the same as that described in the previous section. The sieve used had a mesh size of 6 mm, and no clam subsamples were collected (Appendix 7). For Bonaventure, a few grain size samples were collected. Yields were calculated using the 2002 thawed live weight-length relationship for Bonaventure and the 2001 thawed weight–length relationship for Mingan.

COMPARISON BETWEEN YEARS

It is possible to compare the results between survey years for several beds in order to assess the biomass over time with or without recreational and commercial harvesting. The results of eight areas surveyed from 2001 to 2014 were compared with those of 2016–2020, namely the following areas (Figure 2 and Appendix 2):

- Baie des Petites Bergeronnes (2008 and 2018),
- Pointe à Émile (2003 and 2018),
- Baie des Chevaux (2002 and 2017),
- Cran à Gagnon (2007 and 2017),
- Anse Noire (2003 and 2018),
- Réserve Pessamit Sud (2005, 2010, 2014 and 2018),
- Pointe-aux-Outardes Ouest (2003 and 2017), and
- Pointe-aux-Outardes Est (2004 and 2018).

Robineau (2011) conducted a few surveys on the Upper North Shore in the summer of 2009 to assess the spatial variability of clam populations between 1967 and 2009. With these data, it was possible to compare four other sectors: Rivière Blanche (2009 and 2020), Anse du Colombier (2009 and 2017), Anse à Norbert (2009 and 2018) and Îlets Jérémie (2009 and 2017). The results of these surveys are presented in this document in order to compare the densities obtained recently with those of 2009. The methodology used by Robineau (2011) is similar to that used by DFO.

A comparison of densities for clams 20–50 mm and of densities and yields for clams ≥ 51 mm was made between years for these areas, except for the 2009 surveys, where only the density of the two size classes could be calculated. Comparisons were made with non-parametric Wilcoxon-Mann-Whitney tests (two groups) or Kruskal-Wallis tests (≥ three groups), with the year factor and a significance threshold of 0.05. Regardless of the area, the results used for comparison were calculated on a common area for the different surveys of one bed.

For the comparison of results between years, the yields calculated from thawed weights were used (only yields measured before 2016), except for Pointe à Émile and Anse Noire, where fresh weights were used.

SURVEYS FROM 1967 TO 1970 ON THE UPPER NORTH SHORE

The vast majority of commercially viable clam beds on the Upper North Shore were surveyed from 1967 to 1977 by Lavoie (1969a, 1969b, 1970a, 1970b). These campaigns (historical surveys) are intended to assess changes that occurred in the location and extent of the deposits and to allow a comparison of the densities obtained at that time with the current situation. The areas covered are:

- Baie du Moulin à Baude,
- Baie des Petites Bergeronnes,
- Baie des Grandes Bergeronnes,
- Batture à Théophile,
- Baie des Escoumins (two beds),
- Îles Penchées (two beds),
- Pointe à Émile,
- Pointe à Boisvert (two beds),
- Pointe de Mille-Vaches (two beds),

- Baie des Chevaux,
- Banc Marie-Marthe,
- Baie Didier Sud,
- Baie des Plongeurs,
- Rivière Blanche,
- Anse du Colombier,
- Anse à Norbert,
- Îlets Jérémie (two beds),
- Réserve Pessamit Sud,
- Réserve Pessamit Nord (two beds),
- Pointe-aux-Outardes Ouest, and
- Pointe-aux-Outardes Est.

The information available in Lavoie's documents is generally limited to summary tables of the results and maps of the rough location of the sites surveyed. However, we were able to obtain the raw data (clam counts per station) from these surveys (P. Archambault, Université Laval, Québec).

The sampling methodology used at that time was quite similar to the one used by DFO since 2001, i.e., using a systematic grid with a sampling interval varying from 50 to 100 m between transects or stations, depending in the beds, and a 0.25 m^2 quadrat, except at Pointe-aux-Outardes Ouest and Est, where the distance between transects was 500 m. However, the location of the stations was not georeferenced (use of a compass).

The outlines of the beds surveyed at that time were roughly traced on the electronic maps (ArcGIS, ArcMap) currently used based on the maps provided in the paper documents. This made it possible to assess the overlap of recently surveyed stations with the outline of historically surveyed beds.

It was possible to compare densities of legal-size clams between years using the non-parametric Wilcoxon-Mann-Whitney test with the year factor and a significance threshold of 0.05. Only stations from the recent surveys located on historical beds were used to calculate current densities. For some areas, the recent surveys did not completely cover the historical beds. In order to have a better correspondence between the surveyed areas, some stations from the 1967–1970 surveys were excluded from the calculation of densities.

RESULTS

SURVEYS FROM 2016 TO 2020 ON THE UPPER NORTH SHORE

All maps presented in this document were produced using ArcGIS (ArcMap version 10.7.1). The results of the surveys are presented by shellfish area..

The first series of maps shows the habitat surveyed (Appendix 8). It shows the location of all the stations visited, whether or not they were sampled. These maps include stations located on the backshore, rocky habitats, stations where the sediment consists exclusively of compact clay,

eelgrass beds, other unsuitable habitats and stations that could not be sampled because the depth was too great (too much water), as well as sampled stations.

The other two sets of maps, inserted in the text by shellfish area, show clam densities and yields for two size classes, clams ≥ 20 mm (red circle: total density; green circle: total yield) and clams ≥ 51 mm (white circle), using two superimposed circles with a size proportional to the density or yield, as the case may be. The difference between the two circles gives an indication of the density or yield of clams 20–50 mm. For example, when the red portion is absent at a station, the total density (≥ 20 mm) is approximately equal to the density of legal-size clams. Circle size is comparable between areas. The beds are roughly delineated on the density and sediment maps, and the harvestable area is delineated on the yield maps.

A series of maps, inserted in the text by shellfish area, present the sediment classification obtained by grain size analyses and visual assessment. The symbols used for the different sediment categories are the same for the grain size analyses (grain size) and the visual assessment (visual), but those for the grain size analyses are slightly larger.

Another series of maps, provided in the appendix, were produced to show the distribution of three bivalve species (*Macoma balthica*, *Mesodesma* ssp. and *Mytilus* ssp.) and of eelgrass. Finally, the last series of maps, provided in the appendix by shellfish harvest area, shows the locations of the historical beds (1967–1970) and the stations surveyed in 2016–2020 in order to see the concordance between the current and historical beds.

Size structures were compiled by shellfish harvest area and are presented by 1 mm length class. Numbers were standardized for a sample area of 100 m^2 to allow comparisons. The scale of the Y axis differs occasionally to better represent the size structures.

Pointe aux Vaches, area N-01.1.2

Pointe aux Vaches is part of the Saguenay–St. Lawrence Marine Park (Figure 2). The bed is located in the centre-east of the tidal flats (Appendix 8A). This area was surveyed over 2 days in September 2018. The sampling grid was 62 m by 65 m (Table 1). Fifty-one stations were visited, including four that were not sampled (one on the backshore, two in rocky habitat and one in which the sediment was compact clay) (Appendix 8A).

Of the 45 stations sampled, only 16 had clams. The bed has an area of 0.08 km^2. The average density of clams ≥ 20 mm in Pointe aux Vaches is 8.2 clams/m^2, and the maximum density is 36 clams/m^2. Stations with clams are distributed throughout the surveyed area (Figure 4). The majority of clams are between 20 and 50 mm, with an average density of 6.1 clams/m^2 (Figure 4 and Table 3). The average density of clams ≥ 51 mm is only 2.1 clams/m^2. Legal-size clams are found at stations closer to the coast. The average yield of clams 20–50 mm is 27 g/m^2, and that of clams ≥ 51 mm is 86 g/m^2 (Figure 5 and Table 3). Of the 28 shellfish areas surveyed from 2016 to 2020, the density and average yield of both size classes in Pointe aux Vaches are among the lowest values (Table 3).

No station has a density of clams ≥ 51 mm greater than or equal to 16 clams/m^2. Therefore, there is no harvestable area in Pointe aux Vaches (Table 4).

Only 44 clams (19 to 77 mm) were measured during the survey (Table 5). The average size of clams ≥ 20 mm was 41 mm. No mode is visible in the size structure, given the low number of clams collected (Figure 6).

In total, 13 sediment samples were collected, nine of which were within the delineated bed (Figure 7 and Table 1). The grain size analysis shows that sediments are mainly composed of muddy sand and gravelly sand (Table 6). Visual examination of the other stations shows that

the sediments are mostly gravelly sand and sand (Table 6). The overall composition is therefore mainly gravelly sand (43%), along with sand (24%) and muddy sand (24%). One station is sandy mud, and another is mixed sediment (Table 6). The various sediments are distributed throughout the bed (Figure 7).

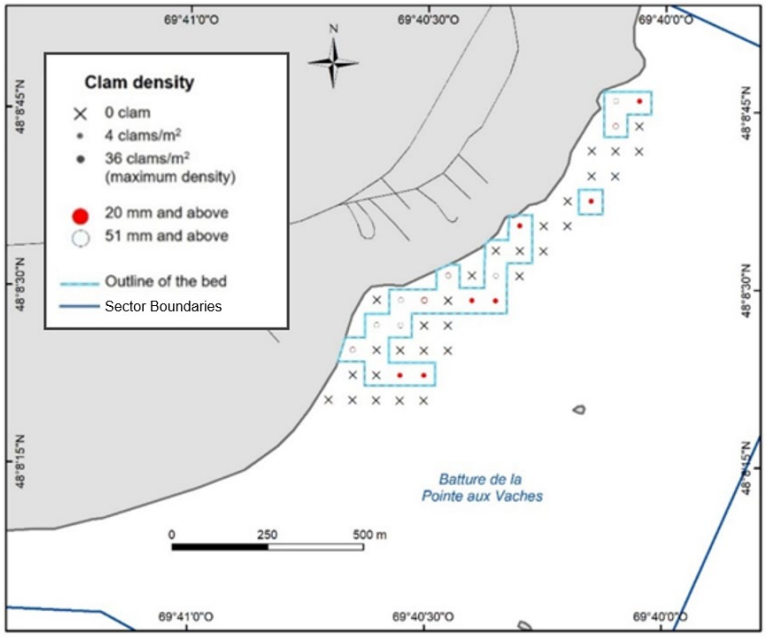

Figure 4. Soft-shell clam density by size class and by station in Pointe aux Vaches shellfish area (N-01.1.2) on the Upper North Shore surveyed in 2018.

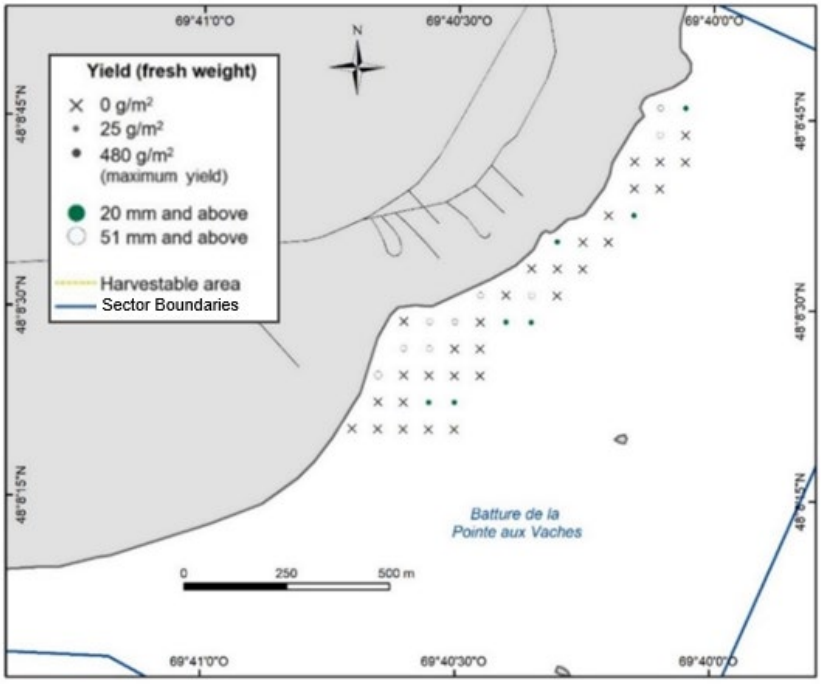

Figure 5. Soft-shell clam yield by size class and by station in Pointe aux Vaches shellfish area (N-01.1.2) on the Upper North Shore surveyed in 2018.

Table 3. Total area (km^2), number of stations in the bed, average density (number/m^2 ± standard error) and average yield (g/m^2 ± standard error) of soft-shell clams by size class for the 28 shellfish areas on the Upper North Shore surveyed from 2016 to 2020.

Shellfish area	Total area	Stations	Density 20–50 mm	Density ≥ 51 mm	Yield 20–50 mm	Yield ≥ 51 mm
Pointe aux Vaches	0.08	21	6.1 ± 1.7	2.1 ± 0.7	27 ± 8	86 ± 26
Baie des Petites Bergeronnes	0.60	60	30.6 ± 6.4	36.3 ± 4.0	259 ± 46	1,149 ± 121
Baie des Grandes Bergeronnes	0.87	136	76.4 ± 6.4	38.4 ± 4.5	649 ± 56	1,048 ± 141
Batture à Théophile	0.24	47	146.5 ± 22.2	5.4 ± 1.1	942 ± 118	109 ± 22
Baie des Escoumins	0.44	74	10.7 ± 1.5	26.8 ± 4.2	90 ± 14	1,079 ± 184
Îles Penchées	0.45	70	47.2 ± 5.6	10.4 ± 2.3	336 ± 45	283 ± 63
Pointe à Émile	1.16	63	23.4 ± 5.7	8.8 ± 1.4	182 ± 40	232 ± 38
Pointe à Boisvert	1.14	79	25.5 ± 8.5	3.6 ± 0.5	60 ± 15	126 ± 17
Pointe de Mille-Vaches	0.54	83	25.2 ± 5.4	13.5 ± 2.2	157 ± 33	379 ± 55
Baie des Chevaux	1.45	142	117.1 ± 10.8	21.6 ± 3.6	629 ± 65	598 ± 106
Banc Marie-Marthe	0.48	84	16.5 ± 4.0	29.8 ± 2.6	154 ± 31	1,220 ± 100
Baie Didier Sud	0.51	90	78.6 ± 8.4	22.4 ± 4.3	693 ± 79	671 ± 137
Baie des Plongeurs	0.50	89	178.0 ± 16.5	32.1 ± 4.6	1,491 ± 132	902 ± 136
Batture aux Gibiers Est	0.004	1	0	32.0	0	796
Cran à Gagnon	0.38	65	71.0 ± 10.8	29.3 ± 4.4	685 ± 94	974 ± 147
Rivière Blanche	0.25	69	175.7 ± 28.6	78.5 ± 11.5	1,461 ± 221	2,281 ± 354
Anse du Colombier	0.15	36	276.5 ± 44.6	38.9 ± 6.3	1,496 ± 246	1,034 ± 159
Anse à Norbert	0.17	39	49.5 ± 13.2	23.0 ± 4.2	334 ± 93	653 ± 110
Anse Noire	0.10	26	99.6 ± 16.3	21.8 ± 5.0	815 ± 142	567 ± 138
Îlets Jérémie	0.42	74	120.3 ± 28.2	54.0 ± 8.6	727 ± 154	1,452 ± 235
Réserve Pessamit Sud	1.43	108	24.2 ± 4.0	49.2 ± 7.6	152 ± 28	1,744 ± 234
Réserve Pessamit Nord	1.34	178	11.0 ± 2.0	6.0 ± 1.4	52 ± 14	203 ± 37
Pointe-aux-Outardes Ouest	5.99	206	8.8 ± 2.5	19.0 ± 1.9	44 ± 9	848 ± 80
Pointe-aux-Outardes Est	1.82	63	2.8 ± 0.8	7.0 ± 1.4	29 ± 8	226 ± 50
Pointe Paradis	1.48	95	15.6 ± 2.5	3.0 ± 0.4	79 ± 12	84 ± 12
Rivière Mistassini	0.37	66	40.0 ± 8.4	18.5 ± 2.9	317 ± 69	562 ± 95
Franquelin	0.24	42	18.2 ± 5.0	31.1 ± 6.5	97 ± 28	1,319 ± 233
Baie Saint-Nicolas	0.35	56	122.5 ± 22.2	22.4 ± 3.8	673 ± 116	662 ± 118

Table 4. Total area (km^2), harvestable area (km^2) and number of stations, average density (number/m^2 ± standard error), average yield (g/m^2 ± standard error) and biomass (t) of clams ≥ 51 mm on the harvestable area for the 28 shellfish areas on the Upper North Shore surveyed from 2016 to 2020.

shellfish area	Total area	Harvestable area	Stations	Density	Yield	Biomass
Pointe aux Vaches	0.08	0	0	-	-	0
Baie des Petites Bergeronnes	0.60	0.55	55	39.2 ± 4.1	1,243 ± 125	683.7
Baie des Grandes Bergeronnes	0.87	0.60	94	54.5 ± 5.8	1,489 ± 187	893.4
Batture à Théophile	0.24	0.03	6	17.3 ± 4.2	338 ± 83	10.1
Baie des Escoumins	0.44	0.19	31	54.0 ± 7.2	2,078 ± 307	394.8
Îles Penchées	0.45	0.15	23	26.7 ± 5.4	742 ± 144	111.3
Pointe à Émile	1.16	0.26	16	25.4 ± 2.3	674 ± 68	175.2
Pointe à Boisvert	1.14	0	0	-	-	0
Pointe de Mille-Vaches	0.54	0.16	25	36.1 ± 5.1	913 ± 122	145.9
Baie des Chevaux	1.45	0.48	48	60.6 ± 8.0	1,679 ± 246	805.9
Banc Marie-Marthe	0.48	0.32	57	39.2 ± 3.0	1,573 ± 115	503.4
Baie Didier Sud	0.51	0.17	30	56.5 ± 10.0	1,723 ± 325	292.9
Baie des Plongeurs	0.50	0.32	56	49.4 ± 6.2	1,390 ± 188	444.8
Batture aux Gibiers Est	0.004	0	0	-	-	0
Cran à Gagnon	0.38	0.22	39	48.0 ± 5.7	1,587 ± 189	349.1
Rivière Blanche	0.25	0.20	55	97.8 ± 13.2	2,843 ± 411	568.6
Anse du Colombier	0.15	0.12	28	49.2 ± 6.9	1,292 ± 175	155.0
Anse à Norbert	0.17	0.12	27	33.3 ± 5.1	936 ± 130	112.3
Anse Noire	0.10	0.04	10	40.4 ± 7.9	1,098 ± 235	43.9
Îlets Jérémie	0.42	0.26	47	81.2 ± 11.8	2,172 ± 325	564.7
Réserve Pessamit Sud	1.43	0.88	69	78.9 ± 10.7	2,789 ± 316	2,454.3
Réserve Pessamit Nord	1.34	0.10	17	54.2 ± 10.4	1,514 ± 244	151.4
Pointe-aux-Outardes Ouest	5.99	2.37	83	38.3 ± 3.7	1,537 ± 142	3,642.7
Pointe-aux-Outardes Est	1.82	0.34	12	26.2 ± 3.7	876 ± 153	297.8
Pointe Paradis	1.48	0	0	-	-	0
Rivière Mistassini	0.37	0.17	31	35.3 ± 4.6	1,086 ± 154	184.6
Franquelin	0.24	0.10	17	56.4 ± 11.9	2,345 ± 352	234.5
Baie Saint-Nicolas	0.35	0.15	28	39.3 ± 5.5	1,044 ± 152	156.6

Table 5. Average (± standard deviation) and median size of clams ≥ 20 mm, average size (± standard deviation) of clams ≥ 51 mm, size range and number of clams measured in the 28 shellfish areas on the Upper North Shore surveyed from 2016 to 2020.

Shellfish area	Average size Clams ≥ 20 mm	Median size Clams ≥ 20 mm	Average size Clams ≥ 51 mm	Range (mm)	Number
Pointe aux Vaches	41 ± 18	35	69 ± 6	19–77	44
Baie des Petites Bergeronnes	50 ± 14	52	61 ± 7	18–84	1,026
Baie des Grandes Bergeronnes	45 ± 12	45	58 ± 6	16–89	4,016
Batture à Théophile	35 ± 8	35	53 ± 2	16–59	1 835
Baie des Escoumins	56 ± 15	58	64 ± 9	16–96	725
Îles Penchées	39 ± 12	38	57 ± 5	6–71	1,072
Pointe à Émile	42 ± 12	42	57 ± 5	16–74	559
Pointe à Boisvert	31 ± 13	26	63 ± 8	12–83	716
Pointe de Mille-Vaches	45 ± 14	45	61 ± 8	17–93	822
Baie des Chevaux	37 ± 13	35	59 ± 8	10–98	5,499
Banc Marie-Marthe	56 ± 15	57	65 ± 10	13–97	1,009
Baie Didier Sud	42 ± 11	41	58 ± 6	15–89	2,349
Baie des Plongeurs	40 ± 10	39	57 ± 5	13–81	4,898
Batture aux Gibiers Est	57 ± 4	57	57 ± 4	52–63	8
Cran à Gagnon	44 ± 12	44	58 ± 6	15–93	1,721
Rivière Blanche	45 ± 12	44	59 ± 7	14–96	4,501
Anse du Colombier	36 ± 11	34	57 ± 7	14–99	3,020
Anse à Norbert	43 ± 13	43	59 ± 6	15–79	780
Anse Noire	40 ± 11	40	56 ± 5	15–71	807
Îlets Jérémie	42 ± 15	42	60 ± 7	14–86	3,385
Réserve Pessamit Sud	55 ± 17	58	65 ± 9	17–99	2,034
Réserve Pessamit Nord	43 ± 18	44	63 ± 10	9–104	1,689
Pointe-aux-Outardes Ouest	57 ± 20	60	69 ± 11	9–105	1,477
Pointe-aux-Outardes Est	58 ± 11	58	63 ± 8	8–95	160
Pointe Paradis	38 ± 13	36	60 ± 9	12–94	474
Rivière Mistassini	44 ± 13	44	59 ± 8	13–88	1,003
Franquelin	55 ± 20	58	68 ± 10	12–102	561
Baie Saint-Nicolas	38 ± 13	36	58 ± 6	16–86	2,046

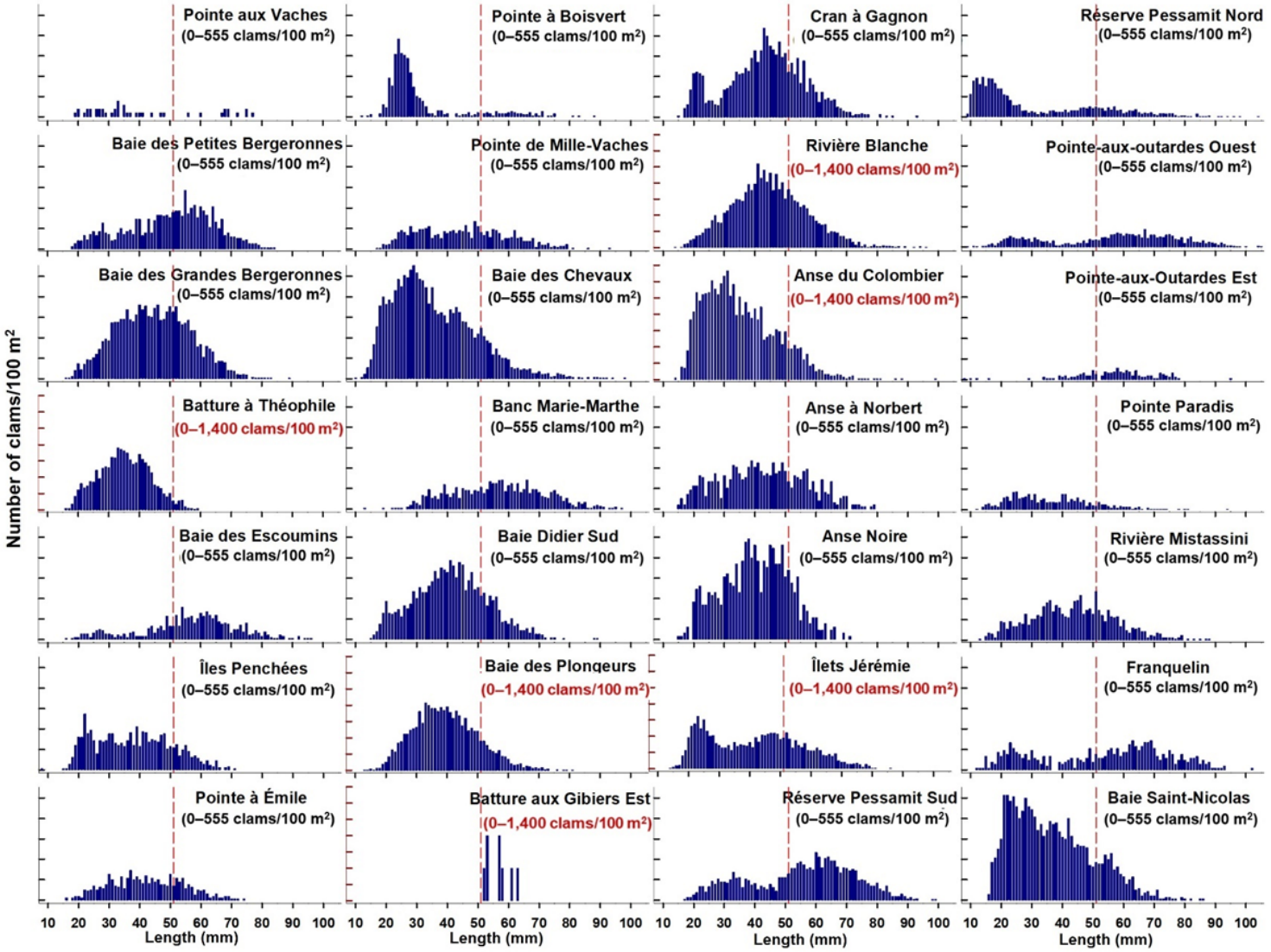

Figure 6. Size structure of soft-shell clams in the 28 shellfish areas on the Upper North Shore surveyed from 2016 to 2020.The value in parentheses indicates the scale of the Y axis; there are two possible Y scales, 0–555 and 0–1.400 clams/100 m². The vertical, red dashed line indicates the minimum legal size of 51 mm.

Table 6. Results of grain size analyses and visual assessment (in number of stations) and total compilation (%) by sediment category in clam beds in the 28 shellfish areas on the Upper North Shore surveyed from 2016 to 2020.

Sector	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	Gs	Mix	M	Sm	Ms	S	Gs	Mix	M	Sm	Ms	S	Gs	Mix
Pointe aux Vaches	0	1	4	0	3	1	0	0	1	5	6	0	0	4.8	23.8	23.8	42.9	4.8
Baie des Petites Bergeronnes	-	-	-	-	-	-	4	10	11	11	16	8	6.7	16.7	18.3	18.3	26.7	13.3
Baie des Grandes Bergeronnes	0	11	14	1	5	5	21	13	20	11	16	19	15.4	17.6	25.0	8.8	15.4	17.6
Batture à Théophile	1	6	2	0	2	0	9	4	11	10	2	0	21.3	21.3	27.7	21.3	8.5	0
Baie des Escoumins	1	8	2	2	4	3	5	0	8	27	1	13	8.1	10.8	13.5	39.2	6.8	21.6
Îles Penchées	0	16	4	2	0	0	2	14	21	7	4	0	2.9	42.9	35.7	12.9	5.7	0
Pointe à Émile	1	4	2	3	1	0	16	9	10	13	1	3	27.0	20.6	19.0	25.4	3.2	4.8
Pointe à Boisvert	0	0	4	8	2	0	1	1	8	53	2	0	1.3	1.3	15.2	77.2	5.1	0
Pointe de Mille-Vaches	0	0	4	16	3	1	0	0	1	57	1	0	0	0	6.0	88.0	4.8	1.2
Baie des Chevaux[3]	-	-	-	-	-	-	104	17	8	10	0	0	74.8	12.2	5.8	7.2	0	0
Banc Marie-Marthe	1	4	5	14	5	0	4	11	28	11	1	0	6.0	17.9	39.3	29.8	7.1	0
Baie Didier Sud	9	5	3	1	1	0	52	10	8	1	0	0	67.8	16.7	12.2	2.2	1.1	0
Baie des Plongeurs	5	14	4	4	0	0	32	17	11	2	0	0	41.6	34.8	16.9	6.7	0	0
Batture aux Gibiers Est	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cran à Gagnon	-	-	-	-	-	-	25	23	14	2	1	0	38.5	35.4	21.5	3.1	1.5	0
Rivière Blanche	0	9	7	2	1	0	26	11	3	9	1	0	37.7	29.0	14.5	15.9	2.9	0
Anse du Colombier	0	3	3	3	1	0	11	5	7	2	1	0	30.6	22.2	27.8	13.9	5.6	0
Anse à Norbert	0	4	3	4	0	0	2	6	7	12	1	0	5.1	25.6	25.6	41.0	2.6	0
Anse Noire	0	6	1	1	1	1	4	0	7	2	2	1	15.4	23.1	30.8	11.5	11.5	7.7
Îlets Jérémie	0	2	5	8	3	0	7	3	5	41	0	0	9.5	6.8	13.5	66.2	4.1	0
Réserve Pessamit Sud	-	-	-	-	-	-	0	2	1	103	2	0	0	1.9	0.9	95.4	1.9	0
Réserve Pessamit Nord[3]	0	2	1	35	0	0	1	8	14	116	0	0	0.6	5.6	8.5	85.3	0	0
Pointe-aux-Outardes Ouest	1	3	5	8	22	3	14	4	4	123	16	3	7.3	3.4	4.4	63.6	18.4	2.9
Pointe-aux-Outardes Est	0	0	0	4	5	1	0	0	0	52	1	0	0	0	0	88.9	9.5	1.6
Pointe Paradis	0	2	7	10	2	0	1	4	19	49	1	0	1.1	6.3	27.4	62.1	3.2	0
Rivière Mistassini	1	5	1	1	7	4	4	2	14	10	11	6	7.6	10.6	22.7	16.7	27.3	15.2
Franquelin[3]	0	0	0	7	6	0	0	0	0	26	0	3	0	0	0	78.6	14.3	7.1
Baie Saint-Nicolas	1	5	4	0	5	4	11	6	2	12	4	2	21.4	19.6	10.7	21.4	16.1	10.7

[1] Sediment category: M = Clay and silt, Sm = Sandy mud, Ms = Muddy sand, S = Sand, Gs = Gravelly sand, Mix = Mixed sediment (mixture of gravel, sand and clay), see Table 2 for further information.

[2] Compilation calculated over all stations, grain size analysis and visual assessment, by sediment category.

[3] There is one station where the sediment category information is missing.

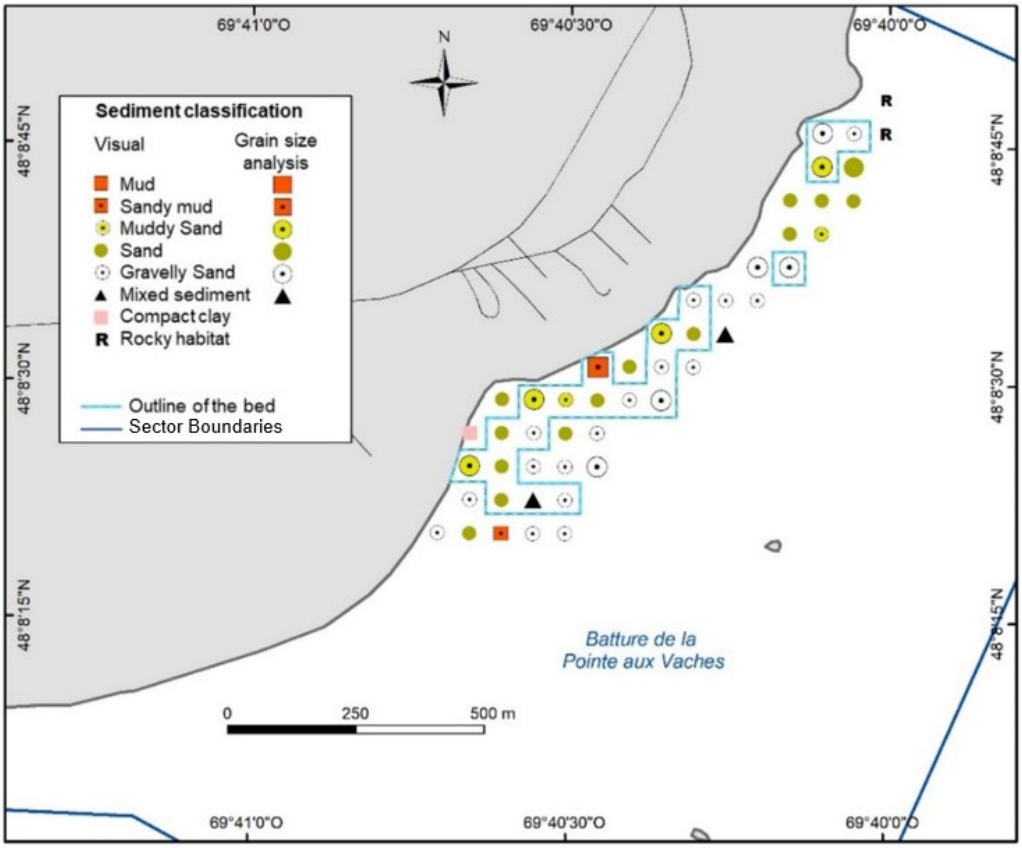

Figure 7. Sediment classification (grain size analysis and visual assessment) by station in Pointe aux Vaches shellfish area (N-01.1.2) on the Upper North Shore surveyed in 2018.

Baie des Petites Bergeronnes, area N-01.1.4

Baie des Petites Bergeronnes area is located in the territory of the Saguenay–St. Lawrence Marine Park (Figure 2). It was surveyed over 2 days in September 2018 with a sampling grid of 100 m by 100 m (Table 1). The survey covers the entire bay (Appendix 8B). Three stations were not sampled because they were located in the river channel (too much water), for a total of 61 stations sampled.

The area of the clam bed is estimated at 0.60 km^2. Clams were observed at all 60 stations included in the bed. The average density of clams ≥ 20 mm on the Baie des Petites Bergeronnes bed is 66.9 clams/m^2, with a maximum density of 300 clams/m^2 (Figure 8 and Table 3). The average densities of clams 20–50 mm and clams ≥ 51 mm are similar at 30.6 and 36.3 clams/m^2, respectively. However, the average yield of clams 20–50 mm is much lower than that of legal-size clams. It is 259 g/m^2 for 20–50 mm and 1,149 g/m^2 for clams ≥ 51 mm (Figure 9 and Table 3). Clams 20–50 mm are found mainly in the western and eastern parts of the bay, while legal-sized clams are found almost everywhere.

Harvestable area is estimated at 0.55 km^2 and includes 55 stations (Figure 9). It covers almost the entire bay and is one of the highest values among the 2016–2020 surveys (Table 4). The average density of clams ≥ 51 mm in the harvestable area is 39.2 clams/m^2, and the average yield is 1,243 g/m^2 (Table 4). The harvestable biomass is estimated at 684 t.

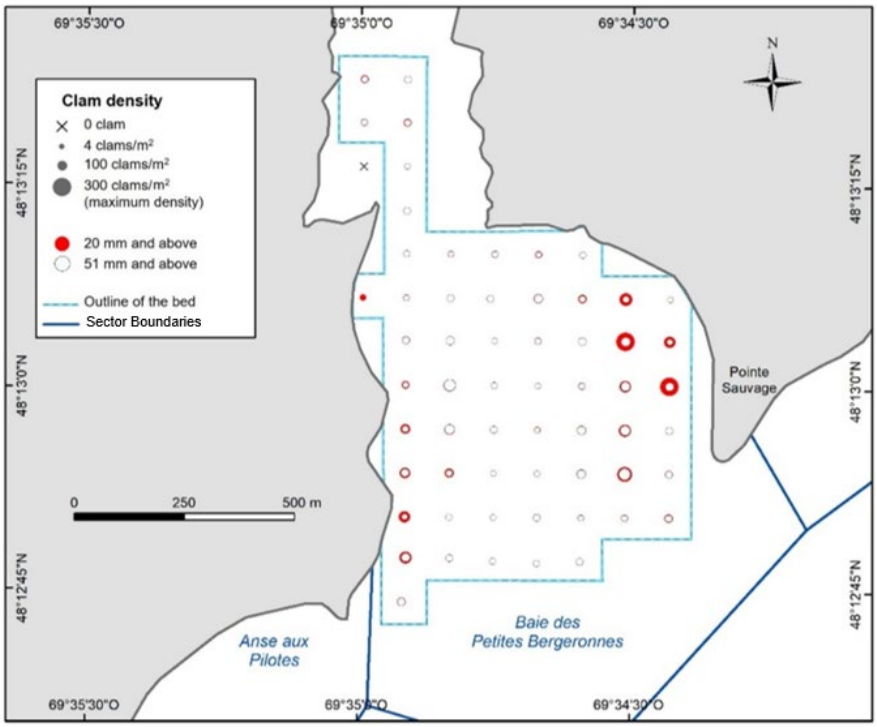

Figure 8. Soft-shell clam density by size class and by station in Baie des Petites Bergeronnes shellfish area (N-01.1.4) on the Upper North Shore surveyed in 2018.

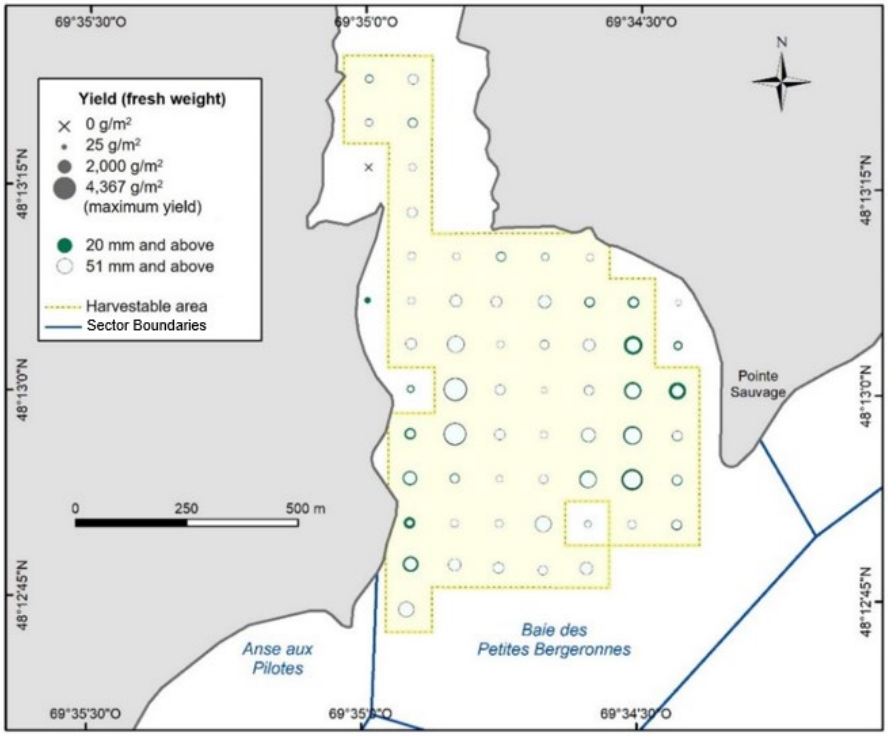

Figure 9. Soft-shell clam yield by size class and by station in Baie des Petites Bergeronnes shellfish area (N-01.1.4) on the Upper North Shore surveyed in 2018.

Clams ranging from 18 to 84 mm were collected from Baie des Petites Bergeronnes, for a total of 1,026 clams measured (Table 5). The average size of clams ≥ 20 mm is 50 mm. The size structure shows a mode around 46–62 mm (Figure 6).

No grain size analysis was carried out in 2018, since this bed was already surveyed in 2008; at that time, 18 samples were collected and analyzed (Appendix 7). In 2008, sediments were composed mainly of gravelly sand (63%), muddy sand (22%) and mixed sediment (13%), along with some sand (Appendices 9 and 10). In 2018, the visual assessment shows that all sediment categories are still present, with a preponderance of gravelly sand (Table 6 and Figure 10). Stations with more muddy sediments are found in the north-central part of the bed.

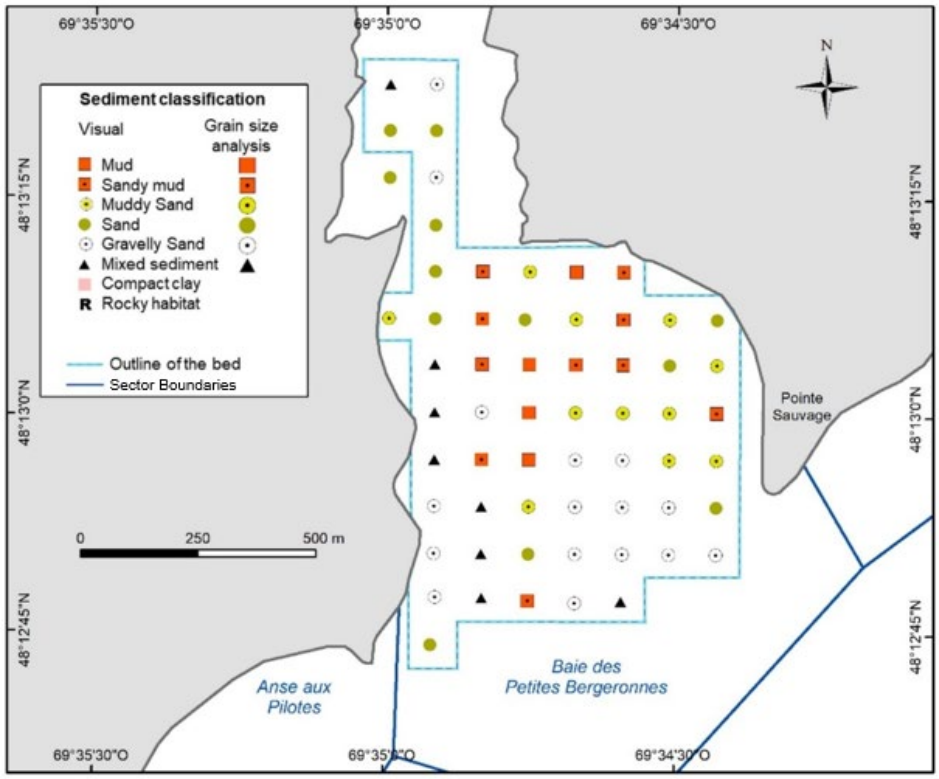

Figure 10. Sediment classification (visual assessment) by station in Baie des Petites Bergeronnes shellfish area (N-01.1.4) on the Upper North Shore surveyed in 2018.

Baie des Grandes Bergeronnes, area N-01.2.1

Baie des Grandes Bergeronnes juxtaposes the Baie des Petites Bergeronnes to the east (Figure 2). The survey took 6 days in September 2020 and used a sampling grid of 80 m by 80 m (Table 1). It covered almost the entire bay; only a small portion to the southeast was not covered (Appendix 8C). All the stations on the original grid were sampled, for a total of 150 stations.

The area of the clam bed is estimated at 0.87 km^2 and includes 136 stations (Table 3). Thirteen stations without clams were retained in the delineation of the bed to ensure some continuity of the bed. The average density of clams ≥ 20 mm is estimated at 114.8 clams/m^2, with a maximum density of 464 clams/m^2. Clams 20–50 mm dominate with an average density of 76.4 clams/m^2, while the density of clams ≥ 51 mm is 38.4 clams/m^2 (Figure 11 and Table 3). The average yield of clams 20–50 mm is 649 g/m^2, almost half that of legal-size clams, with 1,048 g/m^2 (Figure 12 and Table 3). The maximum yield reaches 12,560 g/m^2, the second

highest value among the 2016–2020 surveys. Clams 20-50 mm and ≥ 51 mm are found throughout the bay. However, the stations with the highest densities and yields of legal-size clams are located in the northern portion of the bay.

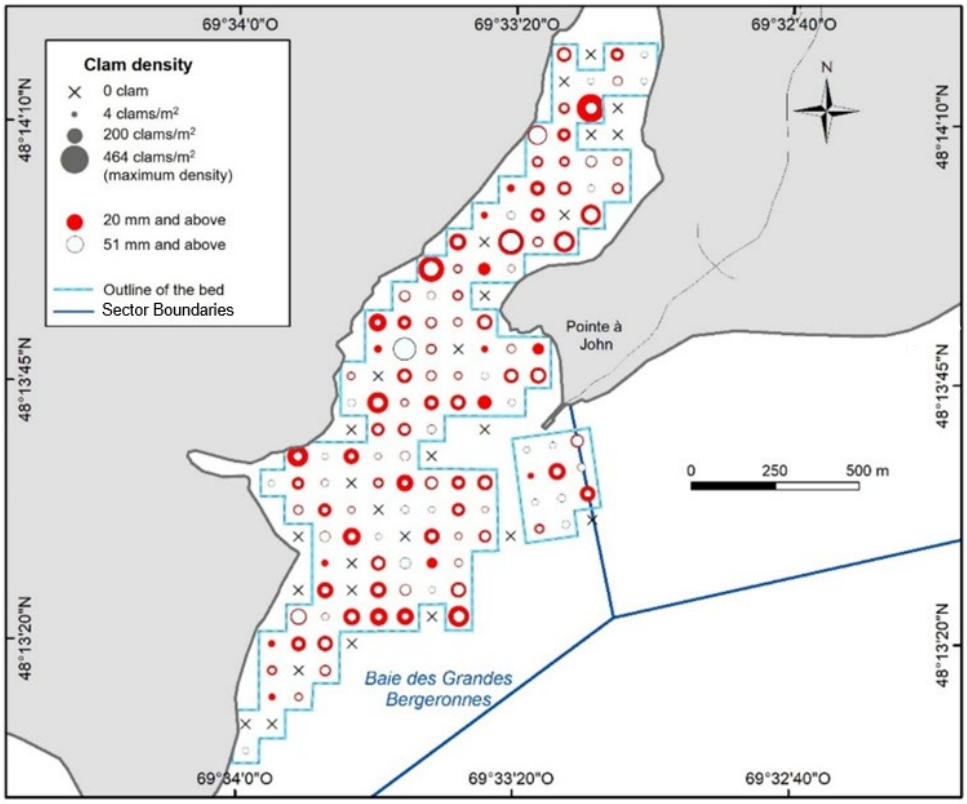

Figure 11. Soft-shell clam density by size class and by station in Baie des Grandes Bergeronnes shellfish area (N-01.2.1) on the Upper North Shore surveyed in 2020.

The harvestable area is estimated at 0.60 km^2 and includes 94 stations (Table 4 and Figure 12). This area is among the largest of the 2016–2020 surveys. The average density of clams ≥ 51 mm is 54.5 clams/m^2, and the average yield is 1,489 g/m^2. The harvestable biomass is estimated at 894 t, which is among the highest values in the 2016–2020 surveys.

Over 4,000 clams were collected and measured (Table 5). Their size ranged from 16 to 89 mm. The average size of clams ≥ 20 mm is 45 mm. For the size structure, there is a broad mode forming a plateau between 36 and 52 mm (Figure 6).

In total, 36 sediment samples were collected, all distributed over the bed (Figure 13 and Table 1). The grain size analyses shows that sediments are composed mainly of muddy sand and sandy mud, as well as gravelly sand and mixed sediment (Figure 13 and Table 6). The visual assessment of the sediments shows a preponderance of mud, muddy sand, mixed sediment and gravelly sand (Figure 13 and Table 6). All sediment categories are present in this bed, with no defined distribution pattern. Muddy sand dominates with 25% of observations, and sand is the least present with 9%.

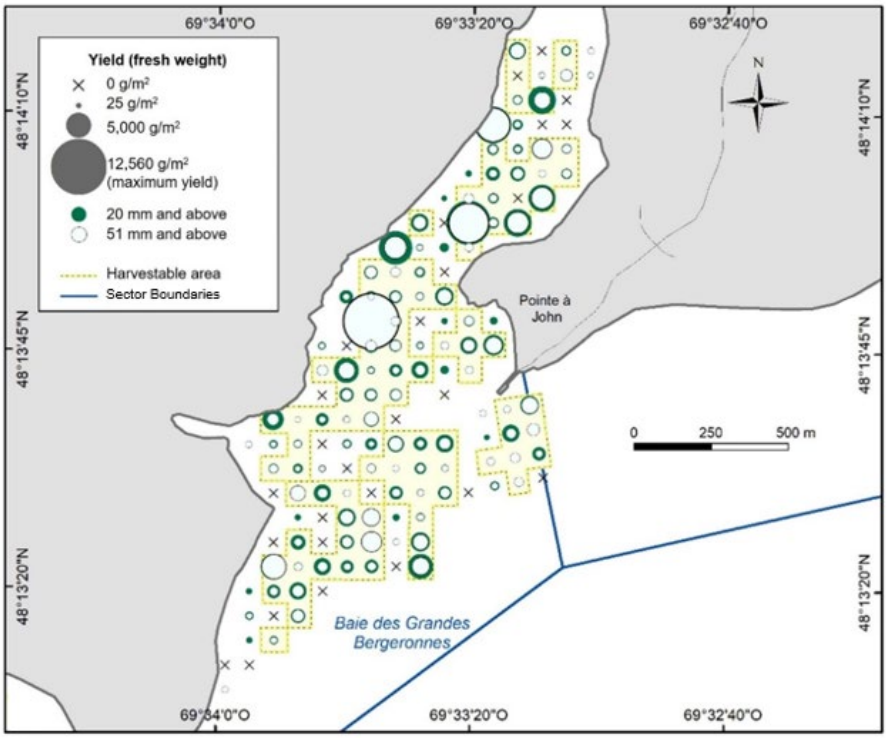

Figure 12. Soft-shell clam yield by size class and by station in Baie des Grandes Bergeronnes shellfish area (N-01.2.1) on the Upper North Shore surveyed in 2020.

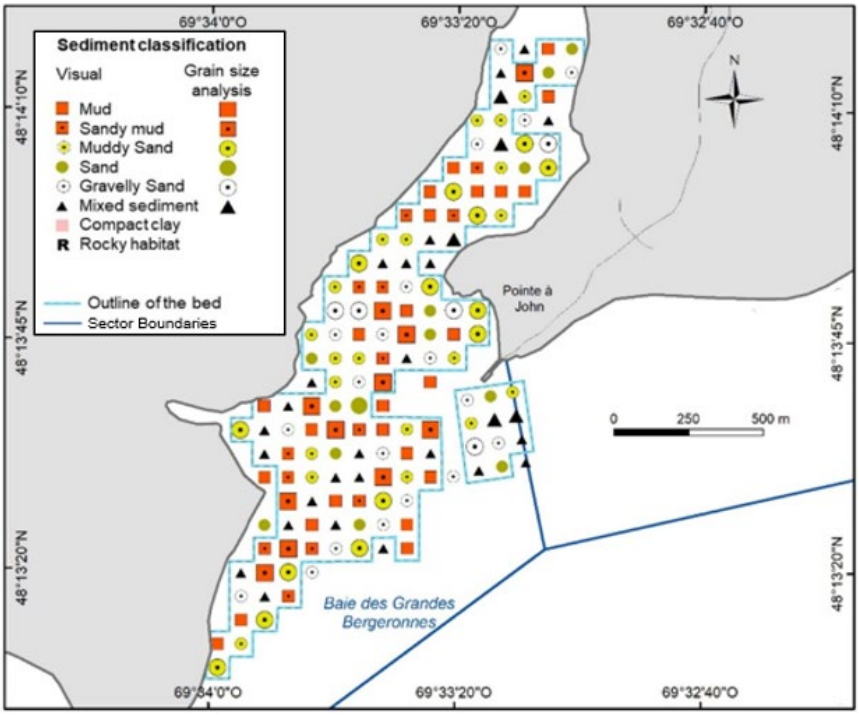

Figure 13. Sediment classification (grain size analysis and visual assessment) by station in Baie des Grandes Bergeronnes shellfish area (N-01.2.1) on the Upper North Shore surveyed in 2020.

Batture à Théophile, area N-01.2.2

Batture à Théophile follows the Baie des Grandes Bergeronnes and is located on the Batture du Bon-Désir (Figure 2 and Appendix 8D) in the Saguenay–St. Lawrence Marine Park. It was surveyed over 2 days in May 2018. In this particular case, the survey was conducted in a linear fashion, parallel to the shoreline, with a distance of 100 m between stations, since the habitat suitable for clams was found in a strip about 50 m wide along the shoreline (Table 1 and Appendix 8D). All the stations on the original grid were sampled, for a total of 52 stations.

The area of the clam bed is estimated at 0.24 km^2 and includes 47 stations (Table 3). Three stations without clams were retained in the delineation of the bed. The average density of clams ≥ 20 mm in the bed is 151.9 clams/m^2, with a maximum density of 676 clams/m^2. Clams 20–50 mm strongly dominate, with an average density of 146.5 clams/m^2 (Figure 14 and Table 3). The density of clams ≥ 51 mm is only 5.4 clams/m^2. The density of clams 20–50 mm is among the highest values in the 2016–2020 surveys, while the density of legal-size clams is among the lowest values. The average yield of clams 20–50 mm reaches 942 g/m^2, and that of legal-size clams is only 109 g/m^2 (Figure 15 and Table 3). The average yield of clams 20–50 mm is among the highest values in the 2016–2020 surveys, but that of legal-size clams is among the lowest values. Sub-legal-size clams are found throughout, but densities are highest in the eastern portion. Legal-size clams are found mainly in the central and western portions of the bed.

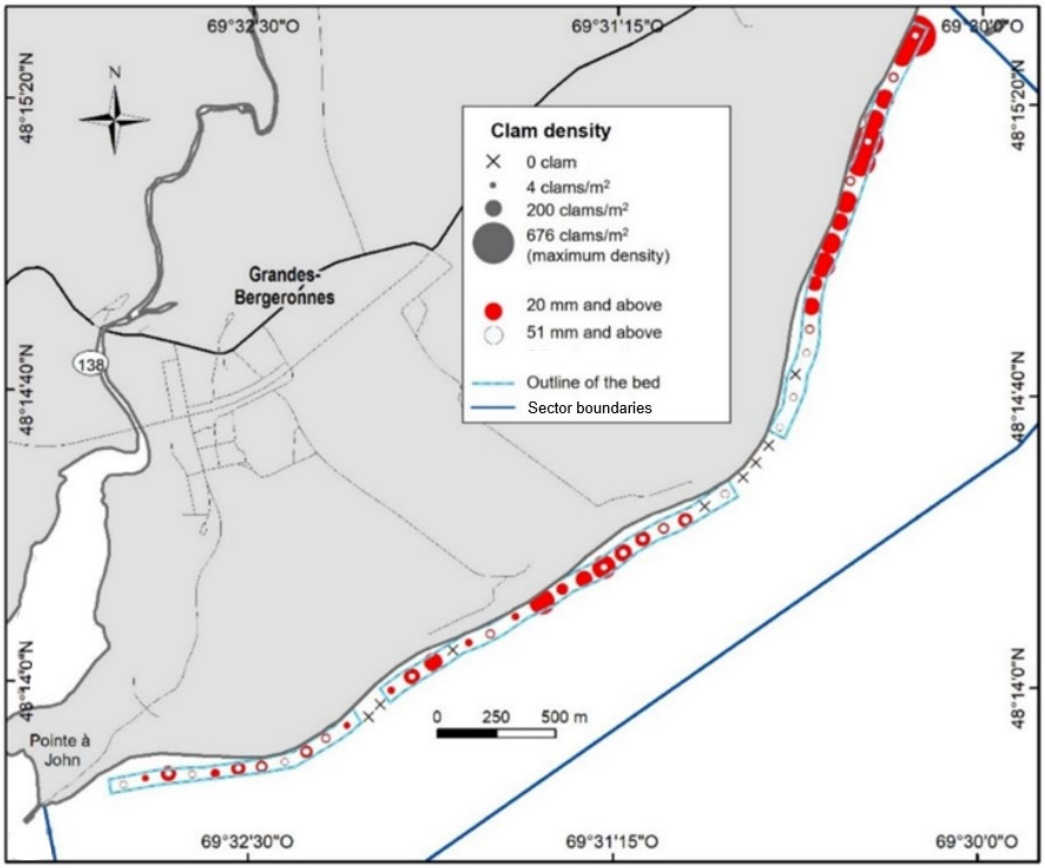

Figure 14. Soft-shell clam density by size class and by station in Batture à Théophile shellfish area (N-01.2.2) on the Upper North Shore surveyed in 2018.

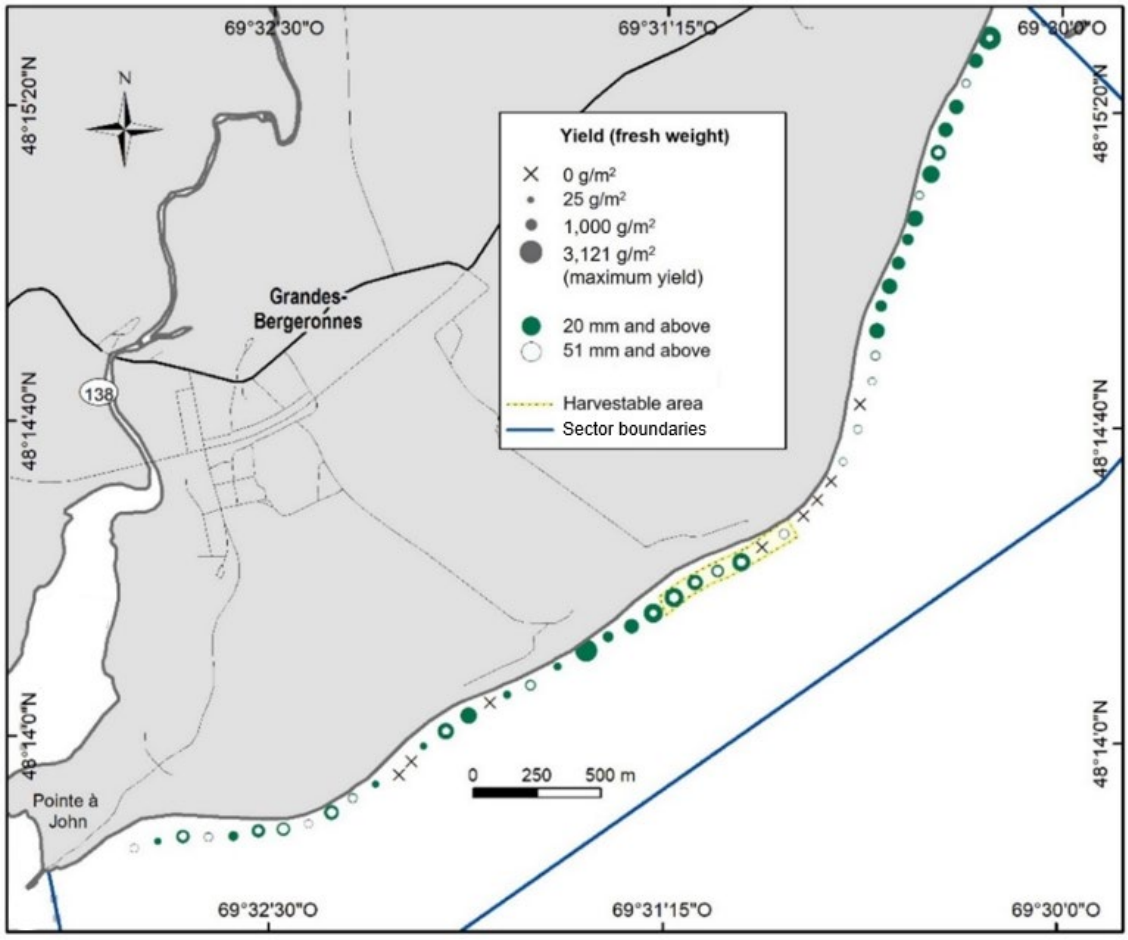

Figure 15. Soft-shell clam yield by size class and by station in Batture à Théophile shellfish area (N-01.2.2) on the Upper North Shore surveyed in 2018.

The harvestable area is estimated at only 0.03 km^2 (six stations) (Figure 15). The average density of clams ≥ 51 mm in that area is 17.3 clams/m^2, and the average yield is 338 g/m^2 (Table 4). The harvestable biomass for this shellfish harvest area is estimated at 10 t. All these values are among the lowest in the 2016–2020 surveys.

In total, 1,835 clams were measured during the survey, and size ranged from 16 to 59 mm (Table 5). The average size of clams ≥ 20 mm is 35 mm. The size structure shows a majority of sub-legal-size clams and very few clams ≥ 51 mm (Figure 6). The mode is around 33–40 mm.

In total, 11 sediment samples were collected, all distributed over the bed (Figure 16 and Table 1). The grain size analyses show that sediments are mainly composed of sandy mud, along with muddy sand, gravelly sand and mud (Figure 16 and Table 6). Visual assessment of the sediment at the remaining stations shows a preponderance of muddy sand and sand (Figure 16 and Table 6). All sediment categories are present in this bed, except for mixed sediment. Mud, sandy mud, muddy sand and sand are found in similar proportions, ranging from 21% to 28%, and gravelly sand has a lower frequency, with 9%. The northeastern portion of the area is dominated by muddy sediments, while the rest of the bed is mostly sandy sediments.

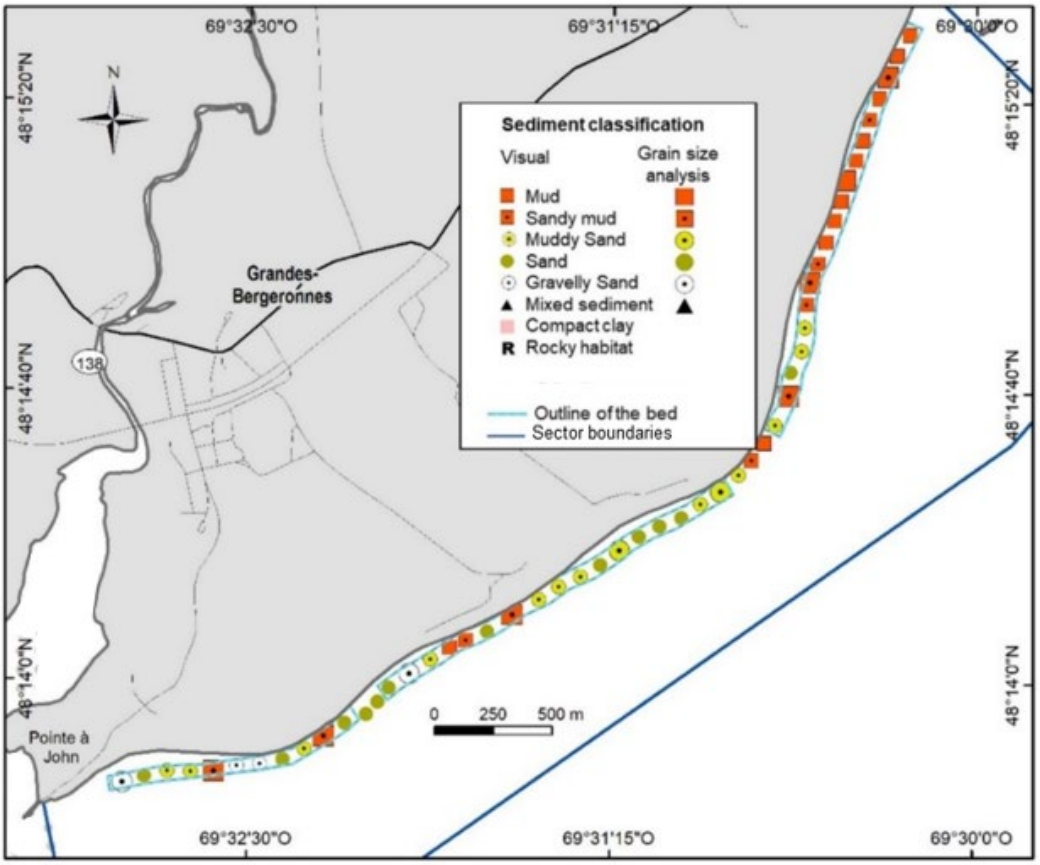

Figure 16. Sediment classification (grain size analysis and visual assessment) by station in Batture à Théophile shellfish area (N-01.2.2) on the Upper North Shore surveyed in 2018.

Baie des Escoumins, area N-02.1

Baie des Escoumins is located opposite the municipality of Les Escoumins and is the first shellfish area outside the Marine Park (Figure 2). The survey took 3 days in August 2020 and used a sampling grid of 80 m by 75 m (Table 1). It covered the Baie des Escoumins, Baie Saint-Onge and a large part of Grande Batture des Escoumins (Appendix 8E). The northeastern portion of the area was not surveyed. All the stations on the original grid were sampled, for a total of 93 stations. Four beds were surveyed: two in Baie des Escoumins (Bed 1 to the north and Bed 2 to the south of the bay, separated by the river channel), a small bed of three stations in the southwest of Baie Saint-Onge (Bed 3), and a final bed on the Grande Batture des Escoumins (Bed 4).

The area of the clam beds is estimated at 0.44 km^2 and includes 74 stations (Table 3). The delineation of the beds retained three stations without clams and one station with clams < 20 mm. The surveyed portion north of Bed 4 has a sparser distribution, and a few enclaved stations were retained in the bed. The average density of clams ≥ 20 mm over all beds is 37.5 clams/m^2, with a maximum density of 202 clams/m^2 (Figure 17 and Table 3). Clams ≥ 51 mm dominate with an average density of 26.8 clams/m^2, while that of clams 20–50 mm is 10.7 clams/m^2. The average yield of clams 20–50 mm is 90 g/m^2, but that of legal-size clams reaches 1,079 g/m^2 (Figure 18 and Table 3). The maximum yield is 7,488 g/m^2. Clams 20-50 mm are found almost everywhere in the four beds. The stations with the highest densities and highest yields of clams ≥ 51 mm are located on beds 1 and 2.

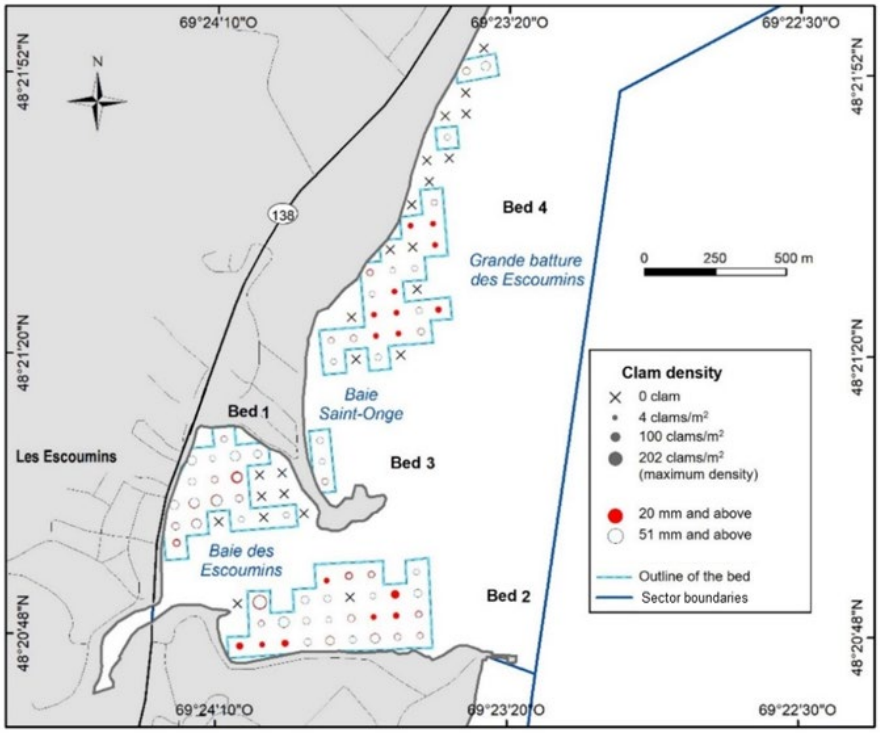

Figure 17. Soft-shell clam density by size class and by station in Baie des Escoumins shellfish area (N-02.1) on the Upper North Shore surveyed in 2020.

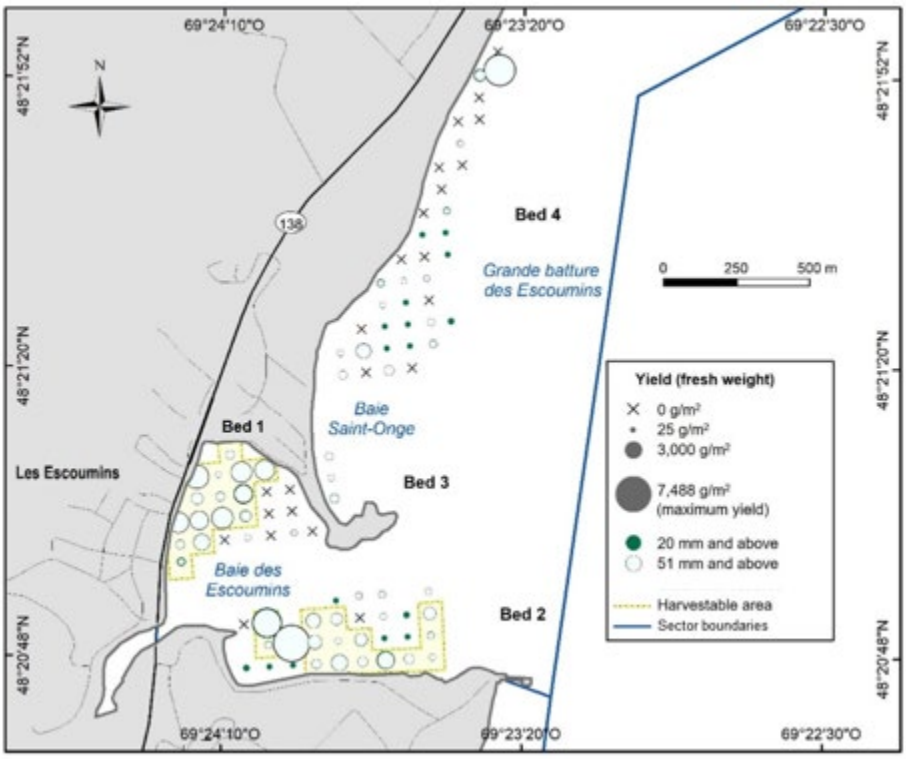

Figure 18. Soft-shell clam yield by size class and by station in Baie des Escoumins shellfish area (N-02.1) on the Upper North Shore surveyed in 2020.

A harvestable area is present only on the two beds of Baie des Escoumins and includes 31 stations (Figure 18). The total harvestable area for this area is estimated at 0.19 km^2. The average density of clams ≥ 51 mm over the harvestable area is 54.0 clams/m^2, and the average yield is 2,078 g/m^2. This yield is among the highest values in the 2016–2020 surveys (Table 4). The harvestable biomass is estimated at 395 t.

Across all four beds, 725 clams were measured and had sizes ranging from 16 to 96 mm (Table 5). The average size of clams ≥ 20 mm is 56 mm, which is among the highest values obtained for all 2016–2020 surveys. The size structure shows a mode around 54–62 mm (Figure 6).

In total, 23 sediment samples were collected, 20 of which are distributed over the beds (Figure 19 and Table 1). The grain size analysis shows that the sediments are composed mainly of sandy mud, along with all other categories (Figure 19 and Table 6). The visual assessment of the sediments shows a marked preponderance of sand, followed by mixed sediment, muddy sand, mud and gravelly sand (Figure 19 and Table 6). Sand dominates with 39% of observations, followed by mixed sediment with 22% of observations. The other sediment categories account for between 7% and 13% of observations. All sediment categories are present with no defined distribution pattern.

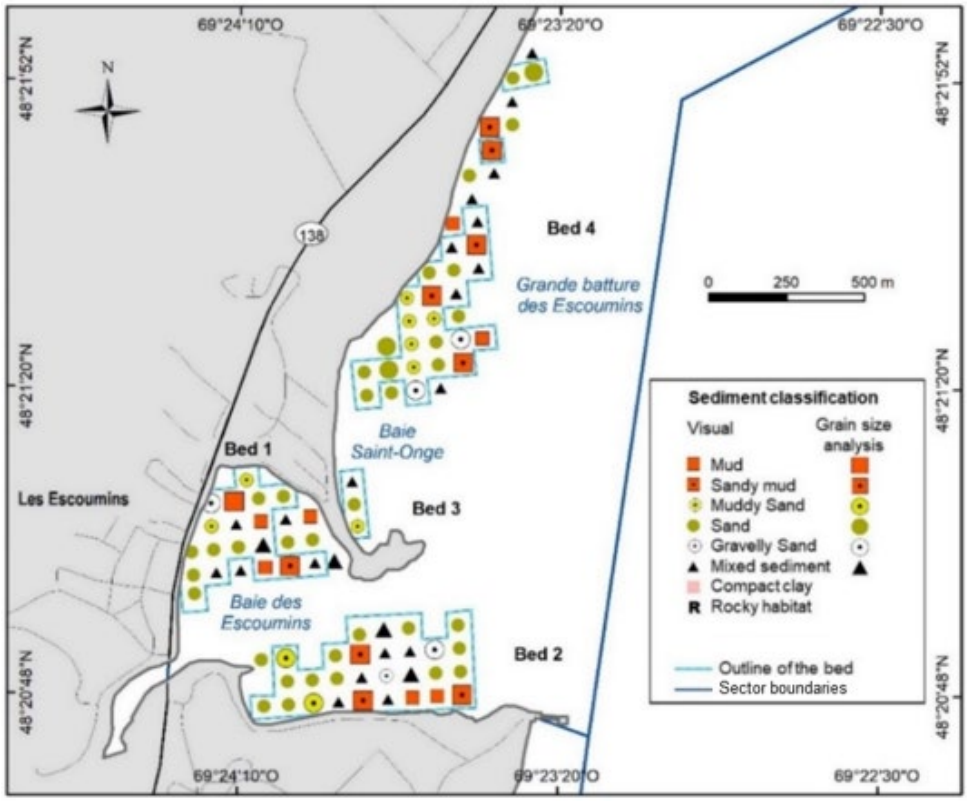

Figure 19. Sediment classification (grain size analysis and visual assessment) by station in Baie des Escoumins shellfish area (N-02.1) on the Upper North Shore surveyed in 2020.

Îles Penchées, area N-02.2

Îles Penchées was surveyed over 4 days in May and June 2018 (Figure 2). The northeast portion of the area was not surveyed (Appendix 8F). The sampling grid used varied slightly depending on the bed, i.e., 65 m by 75 m for Bed 1 (located completely to the west of the area) and 80 m by 85 m for the other two beds (Bed 2 located in the centre in Baie à Thibault and

Bed 3 further to the east) (Table 1 and Appendix 8F). In total, 109 stations were visited, but only 83 were sampled. Twenty-one stations had rocky sediments not conducive to soft-shell clams, and the other five stations were located on the beach.

The area of the three clam beds is estimated at 0.45 km^2 and includes 70 stations (Table 3). The largest bed is Bed 2, located in the centre (Figure 20). One station without clams was retained in the delineation of the beds (Bed 1). The average density of clams ≥ 20 mm over all the beds is 57.6 clams/m^2, with a maximum density of 252 clams/m^2 (Figure 20 and Table 3). Clams 20–50 mm dominate with an average density of 47.2 clams/m^2, while the density of clams ≥ 51 mm is 10.4 clams/m^2. The average yield of clams 20–50 mm is 336 g/m^2 and is similar to that of legal-size clams, which is 283 g/m^2 (Figure 21 and Table 3). The maximum yield of clams ≥ 20 mm is 4,656 g/m^2. Clams of both size classes are found almost everywhere in the three beds. However, the highest yields of clams ≥ 51 mm are found on the southern tip of Bed 3.

The total harvestable area is estimated at 0.15 km^2 and includes 23 stations (Table 4). Each bed has a harvestable area (Figure 21). The average density of clams ≥ 51 mm over the harvestable area is 26.7 clams/m^2, and the average yield is 742 g/m^2 (Table 4). The harvestable biomass is estimated at 111 t. These three values are among the lowest observed during the 2016–2020 surveys.

Across the three beds, 1,072 clams were measured and ranged in size from 6 to 71 mm (Table 5). The average size of clams ≥ 20 mm is 39 mm. The size structure shows a broad plateau from about 21 to 48 mm (Figure 6).

In total, 23 sediment samples were collected, 22 of which are distributed over the beds (Figure 22 and Table 1). The grain size analysis shows that the sediments are composed mainly of sandy mud (Figure 22 and Table 6). Visual assessment of the sediments shows a marked preponderance of muddy sand and sandy mud. Only mixed sediment is absent from the observations. In the bed, sandy mud dominates with 43% of observations, followed closely by muddy sand with 36%. Sand and muddy sand dominate in Bed 1, but sandy mud and muddy sand dominate in the other two beds.

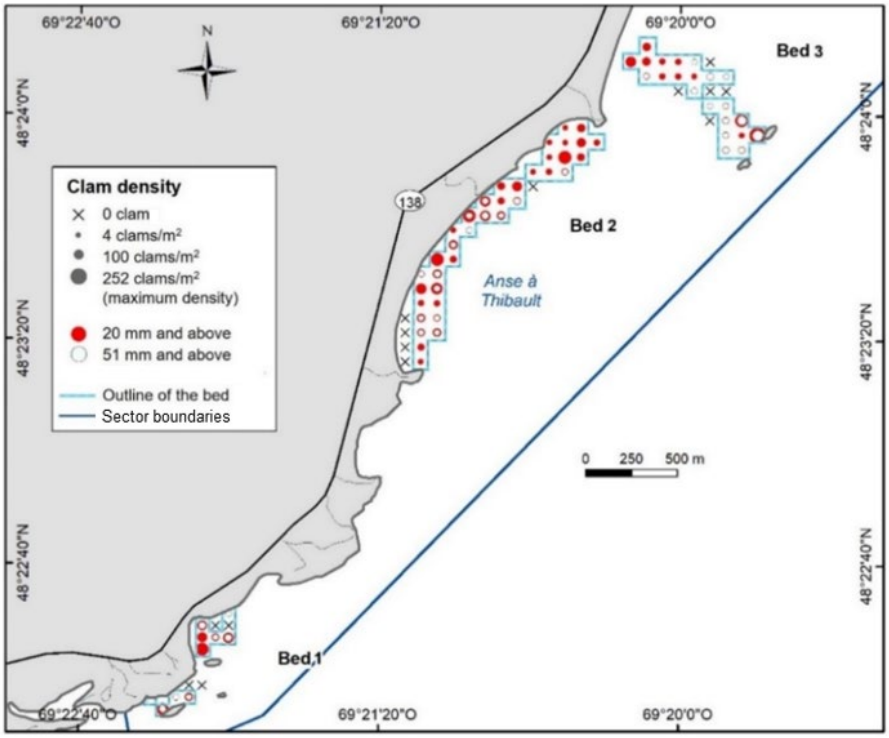

Figure 20. Soft-shell clam density by size class and by station in Îles Penchées shellfish area (N-02.2) on the Upper North Shore surveyed in 2018.

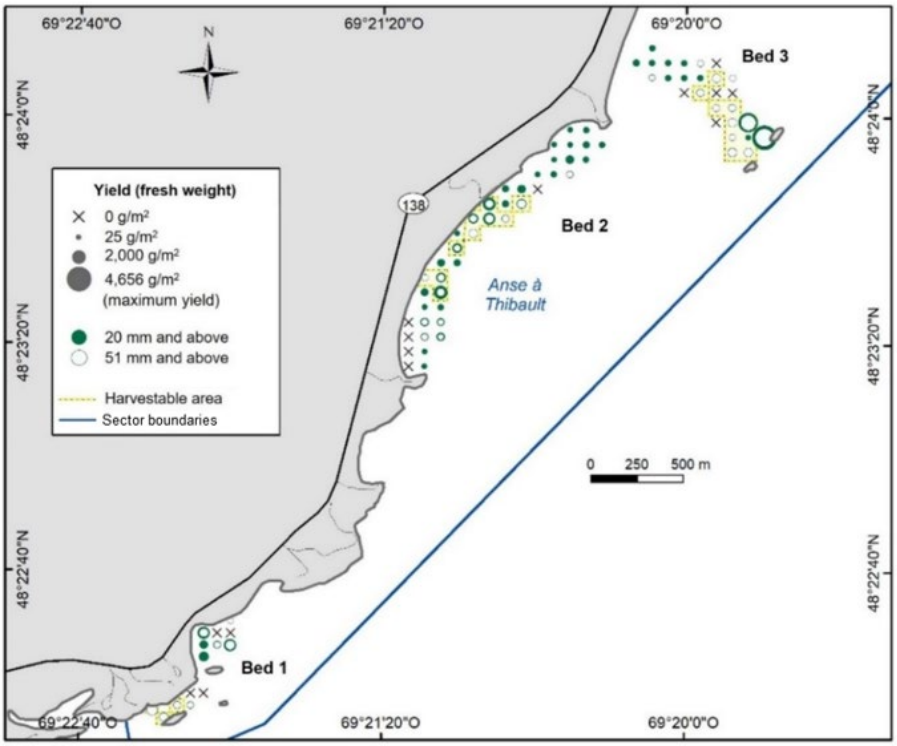

Figure 21. Soft-shell clam yield by size class and by station in Îles Penchées shellfish area (N-02.2) on the Upper North Shore surveyed in 2018.

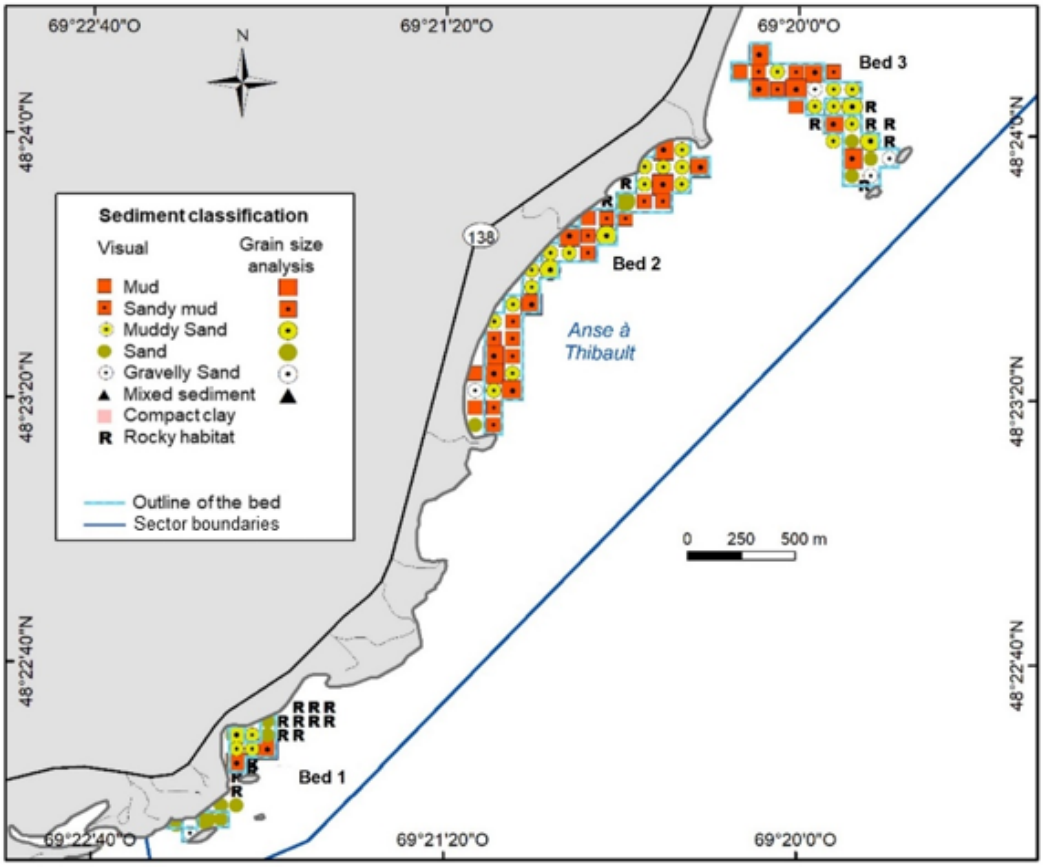

Figure 22. Sediment classification (grain size analysis and visual assessment) by station in Îles Penchées shellfish area (N-02.2) on the Upper North Shore surveyed in 2018.

Pointe à Émile, area N-03.1.2

Pointe à Émile is located in the municipality of Longue-Rive, near the hamlet of Pointe-à-Boisvert (Figure 2 and Appendix 8G). This area is located in Baie des Mille-Vaches and it was surveyed over 6 days during in June, July and August 2018. Two sampling grids were used. First, a wider grid of 150 m by 200 m covered the entire area, then a smaller grid of 75 m by 200 m was applied in the most interesting area of the bed (Table 1 and Appendix 8G). Seventy-seven stations were visited, of which 72 were sampled. Two stations were located on the beach, two stations had rocky sediments, and one station was too deep; these stations were not sampled.

The area of the clam bed is estimated at 1.16 km^2 and includes 63 stations (Table 3 and Figure 23). Four stations without clams were retained in the delineation of the bed. Two of the stations have a rocky habitat, and two stations located at the western edge of the area have only clams < 20 mm. The bed is split nearly in two by a central area that appears to have little interest for clams. The average density of clams ≥ 20 mm is 32.2 clams/m^2, with a maximum density of 356 clams/m^2 (Figure 23 and Table 3). Clams 20–50 mm dominate with an average density of 23.4 clams/m^2, while the density of clams ≥ 51 mm is 8.8 clams/m^2. The average yield of clams 20–50 mm is 182 g/m^2, and that of legal-size clams is slightly higher at 232 g/m^2 (Figure 24 and Table 3). The maximum yield of clams ≥ 20 mm is 2,131 g/m^2. Both clam size classes are distributed throughout the bed.

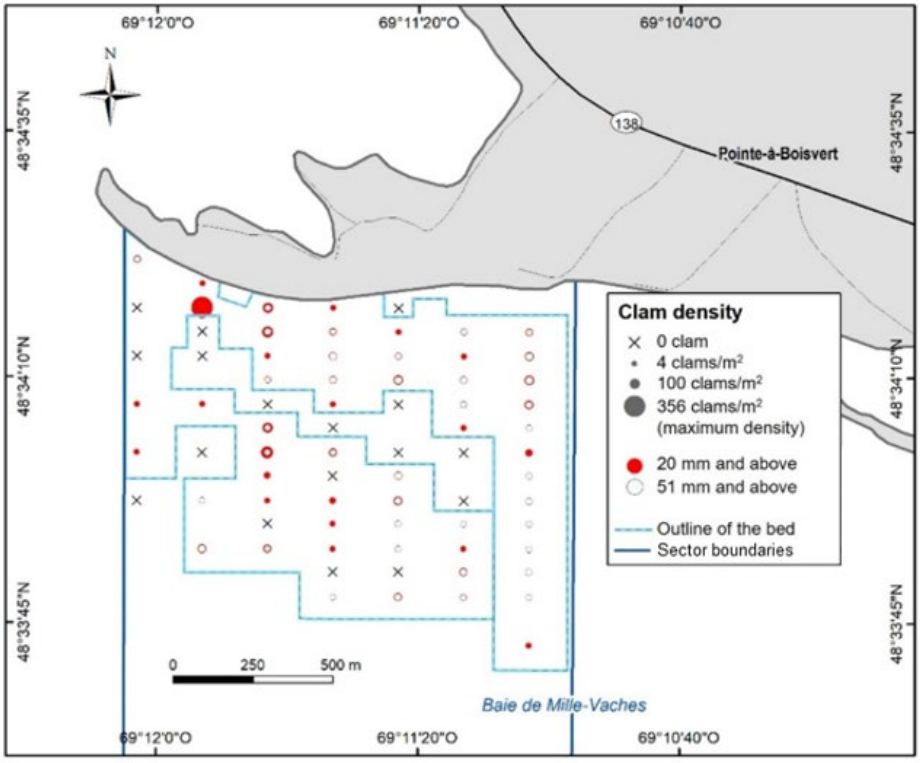

Figure 23. Soft-shell clam density by size class and by station in Pointe à Émile shellfish area (N-03.1.2) on the Upper North Shore surveyed in 2018.

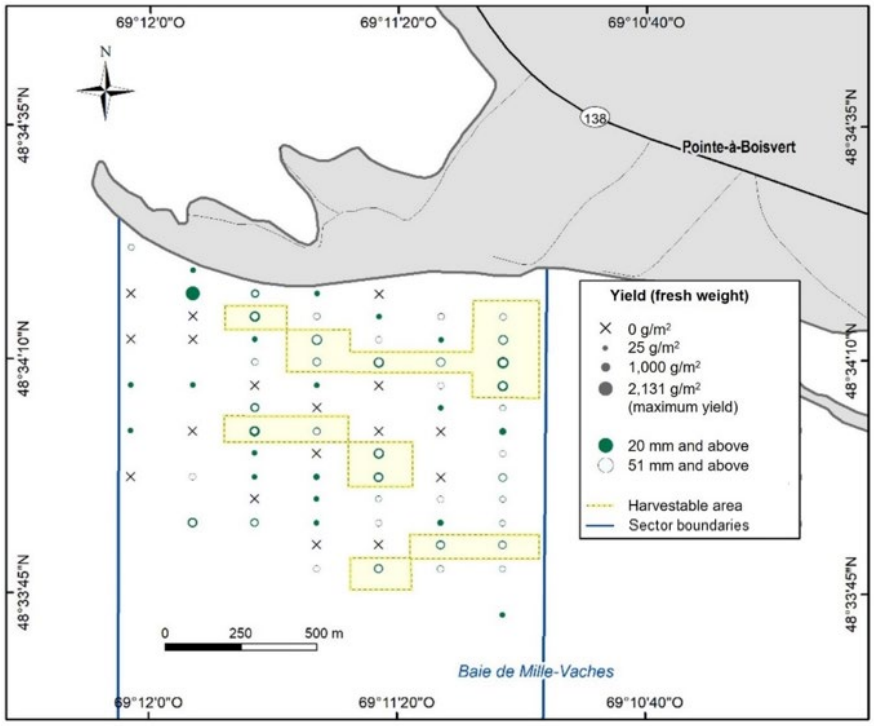

Figure 24. Soft-shell clam yield by size class and by station in Pointe à Émile shellfish area (N-03.1.2) on the Upper North Shore surveyed in 2018.

Despite the fairly large area of Pointe à Émile bed, the harvestable area is estimated at only 0.26 km^2 and includes 16 stations (Table 4 and Figure 24). The average density of clams ≥ 51 mm over this area is 25.4 clams/m^2, and the average yield is 674 g/m^2. These values are among the lowest observed in 2016–2020 (Table 4). The harvestable biomass is estimated at 175 t.

In total, 559 clams were measured with clams ranging in size from 16 to 74 mm (Table 5). The average size of clams ≥ 20 mm is 42 mm. The size structure shows a plateau that ranges from approximately 37 to 44 mm (Figure 6).

Twelve sediment samples were collected, one of which is located outside the bed (Figure 25 and Table 1). The grain size analyses show that sediments are composed of sandy mud, sand and muddy sand (Figure 25 and Table 6). However, visual assessment of the sediments shows a preponderance of mud and sand, followed closely by muddy sand and sandy mud. All types of sediment are present in this bed. Together, the two types of information show that mud and sand dominate with 27% and 25% of observations, respectively, followed by sandy mud with 21% and muddy sand with 19%. Mud is mainly present in the southwestern portion of the bed, and sand is mainly present in the northeastern portion.

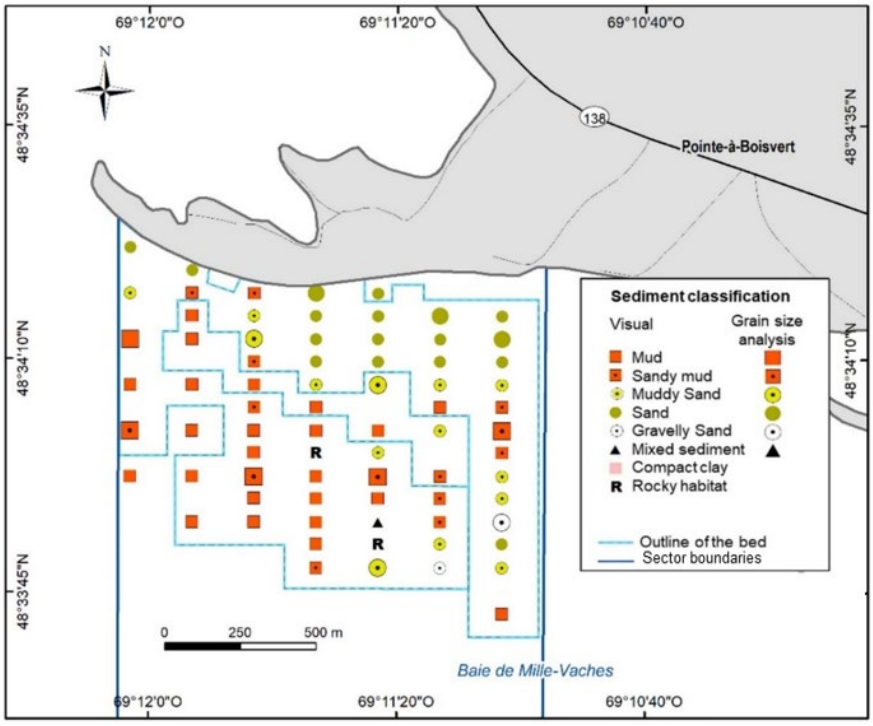

Figure 25. Sediment classification (grain size analysis and visual assessment) by station in Pointe à Émile shellfish area (N-03.1.2) on the Upper North Shore surveyed in 2018.

Pointe à Boisvert, area N-03.2.1

Pointe-à-Boisvert area is adjacent to Pointe à Émile. It is therefore also located in Baie des Mille-Vaches in the municipality of Longue-Rive, near the hamlet of Pointe-à-Boisvert (Figure 2 and Appendix 8H). The entire area was surveyed over 8 days in July and August 2017. Two sampling grids were used. Initially, a wider grid of 150 m by 150 m was used to cover the entire area (Table 1 and Appendix 8H). Stations were then placed in a staggered pattern on the first grid over the most interesting part of the bed, for a sampling grid of 109 m by 109 m. In total, 197 stations were visited, of which 139 were sampled. The entire southeastern portion of the

area lacks suitable clam habitat (51 stations). In addition, sampling excluded six stations located on the beach (mixed sediment) and one station that was too deep (too much water).

The clam bed in this area is estimated at 1.14 km^2 and includes 79 stations (Table 3 and Figure 26). This bed is a continuation of the one in Pointe à Émile. Four stations without clams were retained in the delineation of the bed; two enclaved stations to the south and two other stations to the east were included in the bed. The vast majority of the stations located seaward had no clams. The average density of clams ≥ 20 mm is 29.1 clams/m^2, with a maximum density of 585 clams/m^2 (Figure 26 and Table 3). Clams 20–50 mm strongly dominate with an average density of 25.5 clams/m^2. The average density of clams ≥ 51 mm, 3.6 clams/m^2, is among the lowest values observed during the 2016–2020 surveys. The average yield of clams 20–50 mm is 60 g/m^2, and the average yield of legal-size clams is 126 g/m^2 (Figure 27 and Table 3). The maximum yield of clams ≥ 20 mm is 1,410 g/m^2. The density and yield of legal-size clams are among the lowest values observed during the 2016–2020 surveys. Clams 20–50 mm are mainly found closer to the shoreline, while legal-size clams are distributed throughout the bed.

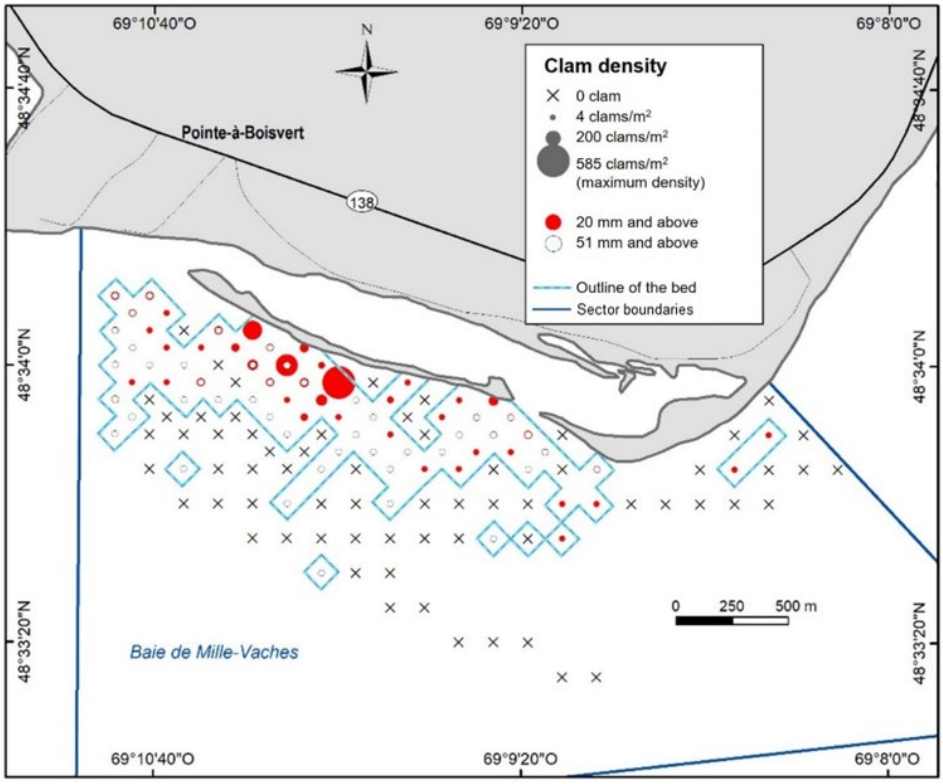

Figure 26. Soft-shell clam density by size class and by station in Pointe à Boisvert shellfish area (N-03.2.1) on the Upper North Shore surveyed in 2017.

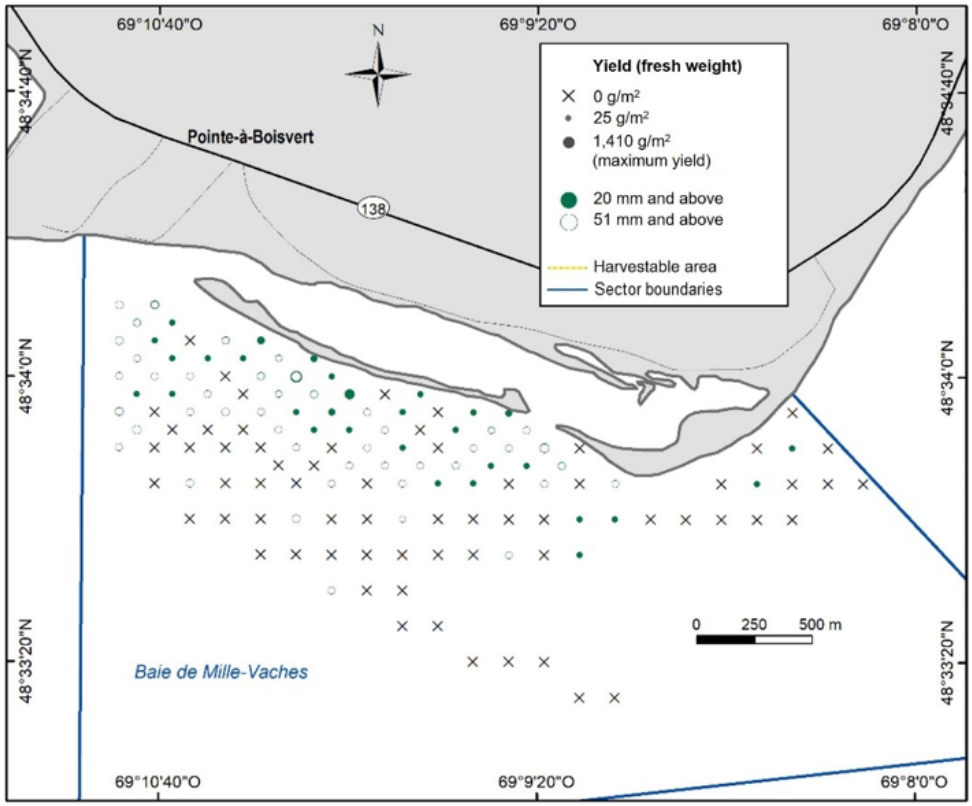

Figure 27. Soft-shell clam yield by size class and by station in Pointe à Boisvert shellfish area (N-03.2.1) on the Upper North Shore surveyed in 2017.

Only two stations had a density of clams ≥ 51 mm greater than 16 clams/m^2. According to the criteria listed above, there is therefore no harvestable area in Pointe-à-Boisvert (Table 4 and Figure 27).

In total, 716 clams were measured. The size of these clams ranged from 12 to 83 mm (Table 5). The average size of clams ≥ 20 mm is 31 mm. The size structure shows a significant mode around 23–27 mm (Figure 6). The majority of clams collected from this bed are between 19 and 33 mm.

There were 23 sediment samples collected, nine of which were located outside the bed (Figure 28 and Table 1). The grain size analyses show that sediments are mostly sand, with some muddy sand and gravelly sand (Figure 28 and Table 6). The visual assessment of the sediments also shows a marked preponderance of sand. All types of sediment are present in this bed, except for mixed sediment. Together, the two types of information show that sand accounts for 77% of the sediments in the bed, along with muddy sand (15%) and gravelly sand (5%) and a little mud and sandy mud. The muddy sediments are located in the western portion of the bed, while sand dominates elsewhere.

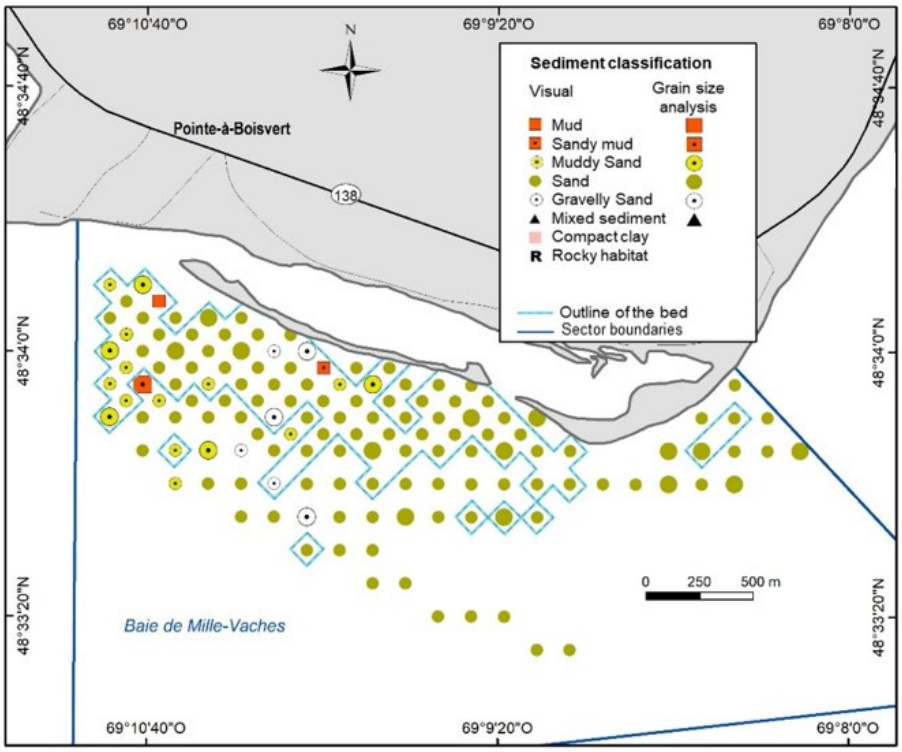

Figure 28. Sediment classification (grain size analysis and visual assessment) by station in Pointe à Boisvert shellfish area (N-03.2.1) on the Upper North Shore surveyed in 2017.

Pointe de Mille-Vaches, area N-03.2.2

Pointe de Mille-Vaches is the third area located in the municipality of Longue-Rive (Figure 2 and Appendix 8I). It is adjacent to Pointe-à-Boisvert to the northeast. It is a very large area, about 4 km long, located on the Banc de Portneuf. Almost the entire area was surveyed (except for the westernmost section) over 9 days in August, September and October 2018. A sampling grid of 65 m by 100 m was used (Table 1 and Appendix 8I). In total, 222 stations were visited, of which 178 were sampled. There were 16 stations with unsuitable habitat for clams: 10 were located on the beach with mixed sediments, and three were too deep (too much water) to be sampled. There is also an eelgrass bed in the northeast portion of the area that was not sampled (15 stations).

The clam bed in this area is estimated at 0.54 km^2 and includes 83 stations (Table 3 and Figure 29). There are few clams in the central and southern portion of the area, and several enclaved stations were included in the bed. In addition, four stations without clams were retained in the delineation of the bed. The average density of clams ≥ 20 mm is 38.7 clams/m^2, with a maximum density of 306 clams/m^2 (Figure 29 and Table 3). Clams 20–50 mm dominate with an average density of 25.2 clams/m^2, and the density of clams ≥ 51 mm is 13.5 clams/m^2. The average yield of clams 20–50 mm is 157 g/m^2, and the average yield of legal-size clams is 379 g/m^2 (Figure 30 and Table 3). The maximum yield of clams ≥ 20 mm is 3,215 g/m^2. Clams 20–50 mm are found mostly to the north of the bed near the shoreline. Legal-size clams are distributed throughout the bed, with slightly higher densities in the north.

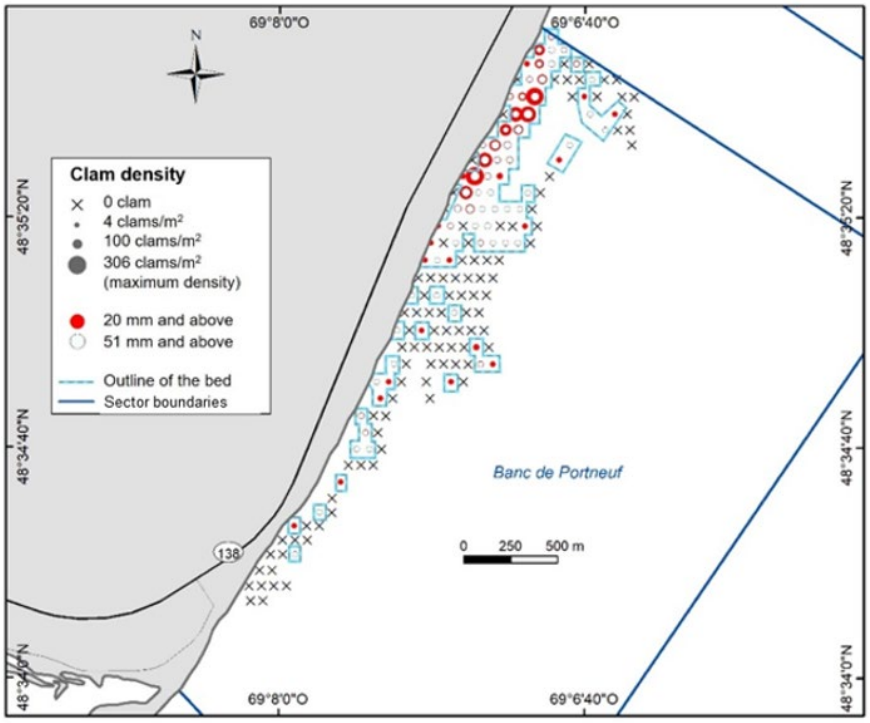

Figure 29. Soft-shell clam density by size class and by station in Pointe de Miille-Vaches shellfish area (N-03.2.2) on the Upper North Shore surveyed in 2018.

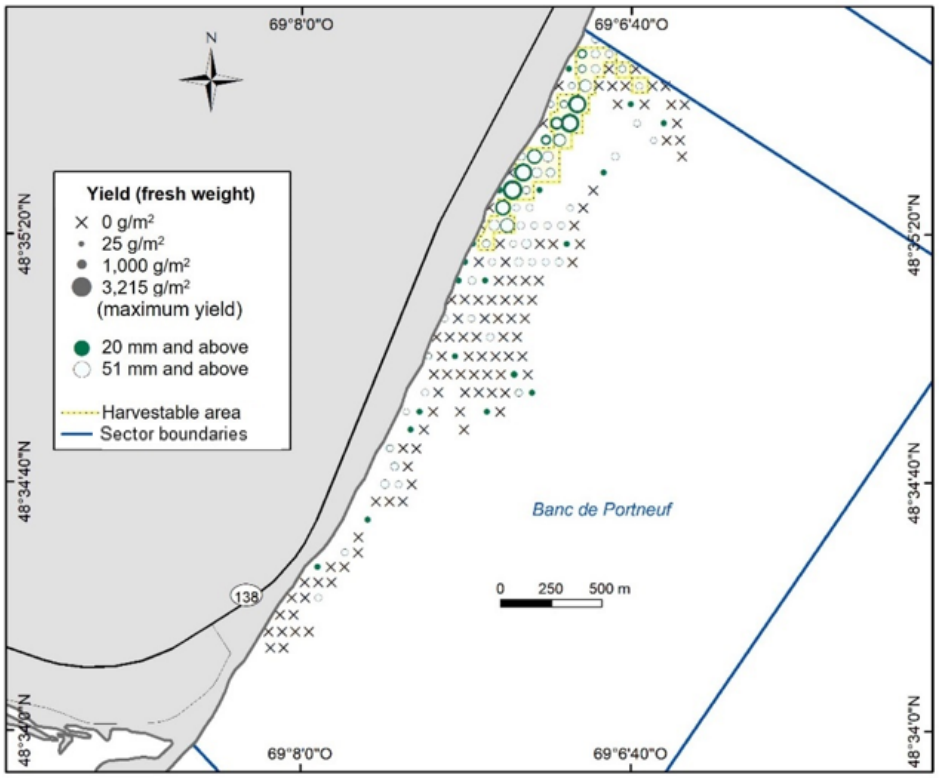

Figure 30. Soft-shell clam yield by size class and by station in the Pointe de Mille-Vaches shellfish area (N-03.2.2) on the Upper North Shore surveyed in 2018.

The harvestable area of the Pointe de Mille-Vaches bed is estimated at 0.16 km^2 and includes 25 stations (Table 4 and Figure 30). This harvestable area is located in the northeastern portion of the bed. The average density of clams ≥ 51 mm is 36.1 clams/m^2, and the average yield is 913 g/m^2. This yield is among the lowest values observed during the 2016–2020 surveys. The harvestable biomass is estimated at 146 t for this bed.

In total, 822 clams were measured. The size of these clams ranges from 17 to 93 mm (Table 5). The average size of clams ≥ 20 mm is 45 mm. The size structure shows a broad plateau from 24 to 54 mm (Figure 6).

Thirty-five sediment samples were collected, 24 of which were located in the bed (Figure 31 and Table 1). The grain size analyses show that sediments are mostly sand, with some muddy sand and gravelly sand (Figure 31 and Table 6). The visual assessment shows that the sediments are almost exclusively sand. The types of sediment present in this bed are sand (88%), muddy sand (6%) and gravelly sand (5%). There is only one mention of mixed sediment (1%).

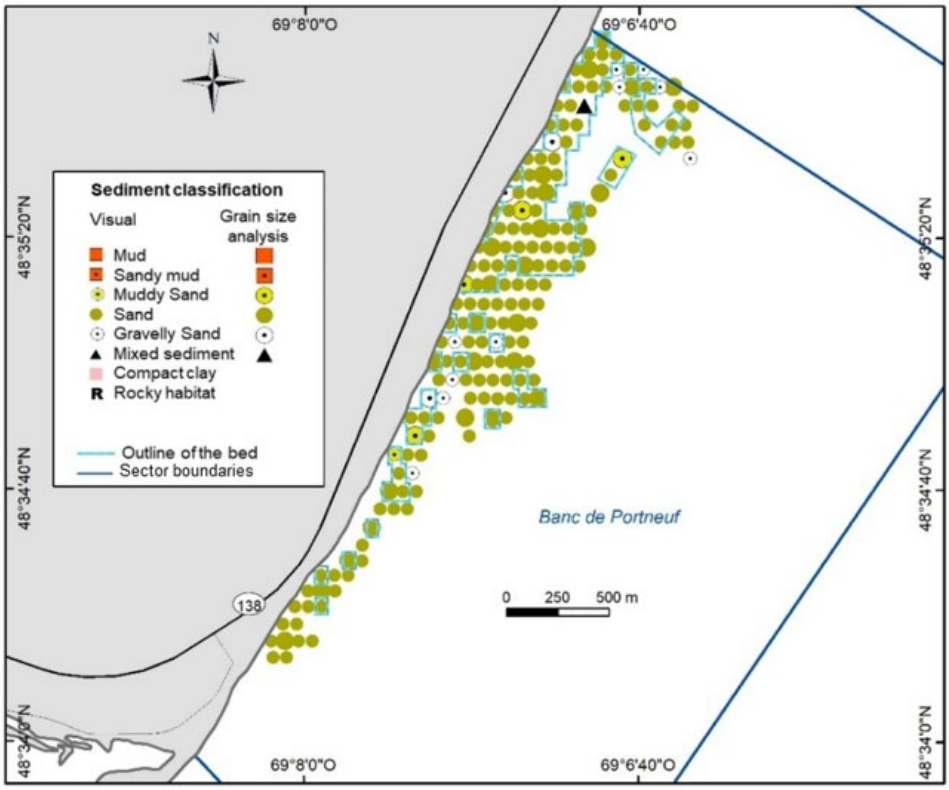

Figure 31. Sediment classification (grain size analysis and visual assessment) by station in Pointe de Mille-Vaches shellfish area (N-03.2.2) on the Upper North Shore surveyed in 2018.

Baie des Chevaux, area N-04.1.1.1

Baie des Chevaux is located in Baie Laval in the municipality of Forestville (Figure 2 and Appendix 8J). The area was surveyed over 5 days in October and November 2017 and April and June 2018; however, the majority of the survey was conducted in 2017. A sampling grid of 100 m by 100 m was used (Table 1 and Appendix 8J). In total, 151 stations were visited, of which 146 were sampled. There were four stations to the south with unsuitable clam habitat and one station with compact clay.

The area of the clam bed is estimated at 1.45 km^2 and includes 142 stations (Table 3 and Figure 32). This is one of the largest clam beds surveyed in 2016–2020. The delineation of the bed considers the results of the 2002 survey (Giguère et al. 2008). The bed therefore includes five stations without clams located on its southern periphery. In addition, the bed delineation retained one station with clams smaller than 20 mm, one station without clams, and one station with compact clay sediments. The average density of clams ≥ 20 mm is 138.7 clams/m^2, with a maximum density of 838 clams/m^2 (Figure 32 and Table 3). This maximum value is among the highest obtained during the 2016–2020 surveys. Clams 20–50 mm strongly dominate with an average density of 117.1 clams/m^2. The average density of clams ≥ 51 mm is 21.6 clams/m^2. The average yield of clams 20–50 mm is 629 g/m^2, a value similar to that of legal-size clams of 598 g/m^2 (Figure 33 and Table 3). The maximum yield of clams ≥ 20 mm is 7,508 g/m^2. Clams 20–50 mm are found almost everywhere in the bed. However, legal-size clams are concentrated in the central-eastern part of the bed.

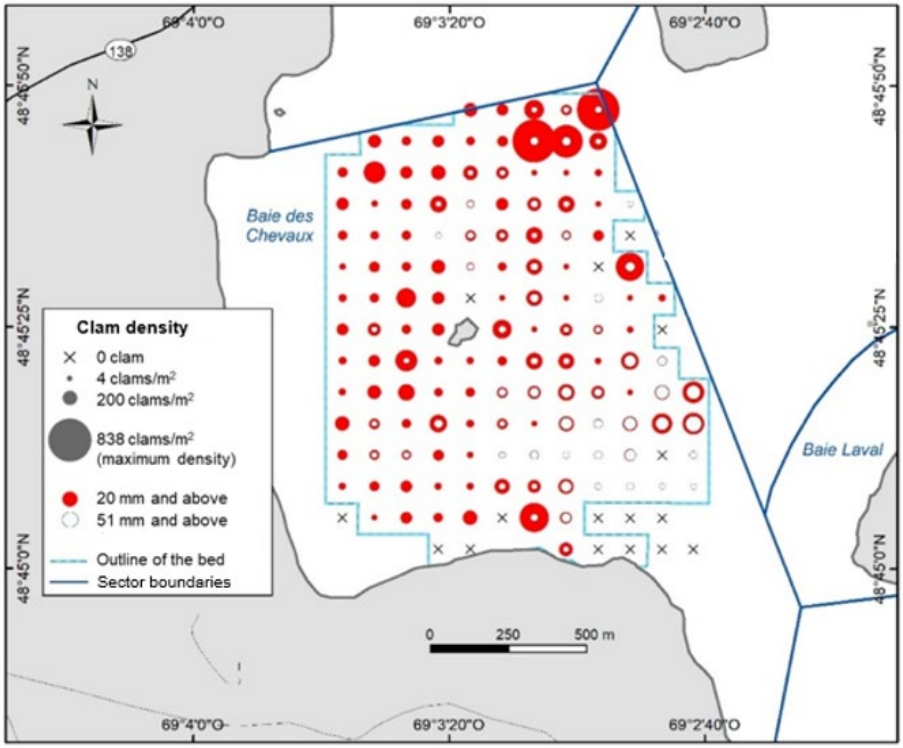

Figure 32. Soft-shell clam density by size class and by station in Baie des Chevaux shellfish area (N-04.1.1.1) on the Upper North Shore surveyed in 2017.

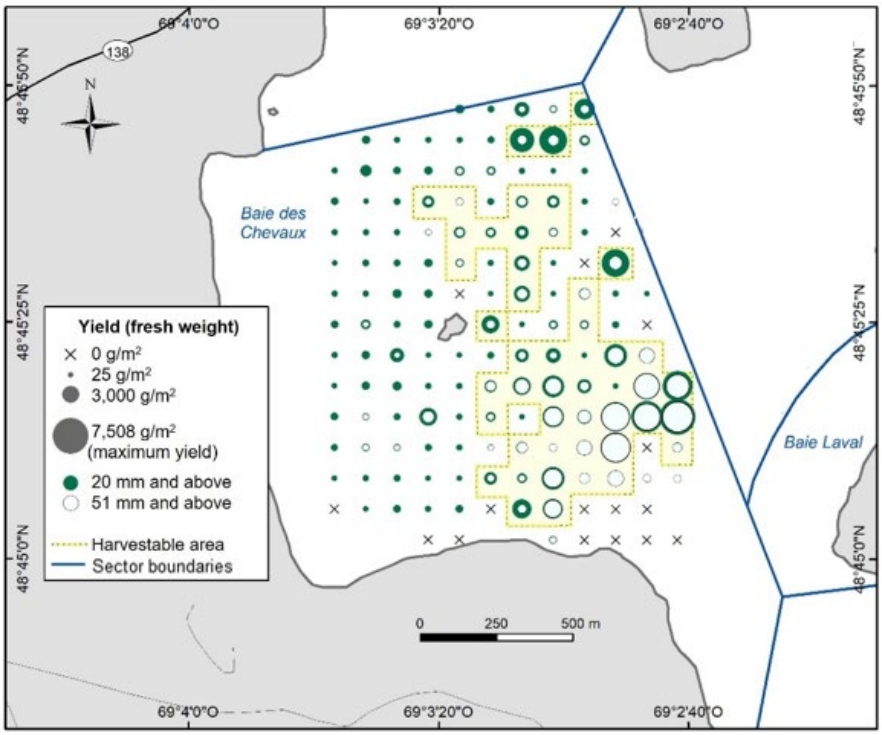

Figure 33. Soft-shell clam yield by size class and by station in Baie des Chevaux shellfish area (N-04.1.1.1) on the Upper North Shore surveyed in 2017.

The harvestable area of Baie des Chevaux bed is estimated at 0.48 km^2 and includes 48 stations (Table 4 and Figure 33). This harvestable area is located in the eastern half of the bed. The average density of clams ≥ 51 mm is 60.6 clams/m^2, and the average yield is 1,679 g/m^2. The harvestable biomass is estimated at 806 t. This density and biomass are among the highest values in the 2016–2020 surveys.

An impressive 5,499 clams were measured (Table 5). The size of these clams ranged from 10 to 98 mm. The average size of clams ≥ 20 mm is 37 mm. The size structure shows a mode at 29 mm, but the density of clams 15–35 mm is high (Figure 6).

No grain size analysis was conducted in 2017, since this bed was previously surveyed in 2002 and 71 samples were collected from the bed and analyzed at that time (Appendix 7). In 2002, the sediments were composed mainly of sandy mud (44%) and muddy sand (41%), with some sand, mud and gravelly sand (Appendices 9 and 11). In 2017, the visual assessment showed that the sediment consisted of mud (75%), sandy mud (12%), sand (7%) and muddy sand (6%) (Figure 34 and Table 6). The sandy sediments are found almost exclusively in the southeastern portion of the bed.

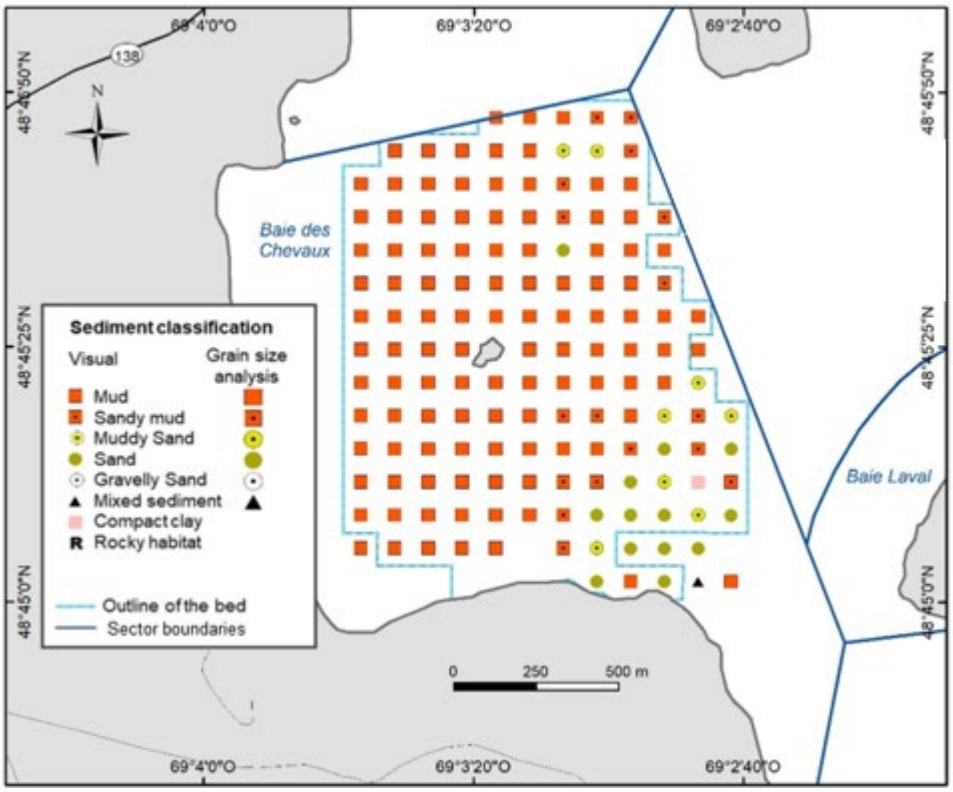

Figure 34. Sediment classification (visual assessment) by station in Baie des Chevaux shellfish area (N-04.1.1.1) on the Upper North Shore surveyed in 2017.

Banc Marie-Marthe, area N-04.1.2.1

Banc Marie-Marthe is located on the east side of Baie Laval (Figure 2 and Appendix 8K). The Rivière Laval channel separates this area from the Baie des Chevaux. The Banc Marie-Marthe was surveyed in 7 days over the months of October 2016 and April 2017; however, the majority of the survey was conducted in 2016. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8K). Only the western part of the area was surveyed. In total, 115 stations were visited, of which 110 were sampled. There were five stations with compacted clay that were not sampled.

The area of the clam bed is estimated at 0.48 km^2 and includes 84 stations (Table 3 and Figure 35). The bed includes two stations without clams. The average density of clams ≥ 20 mm is 46.3 clams/m^2, with a maximum density of 361 clams/m^2 (Figure 35 and Table 3). The density of clams 20–50 mm is 16.5 clams/m^2, and that of clams ≥ 51 mm is 29.8 clams/m^2. The average yield of clams 20–50 mm is 154 g/m^2, but that of legal-size clams reaches 1,220 g/m^2 (Figure 36 and Table 3). The maximum yield of clams ≥ 20 mm is 5,204 g/m^2. Clams 20–50 mm are rather rare in the bed, while legal-size clams are present almost everywhere.

The harvestable area of Banc Marie-Marthe bed is estimated at 0.32 km^2 and includes 57 stations (Table 4 and Figure 36). This harvestable area covers the entire western portion of the bed. The average density of clams ≥ 51 mm is 39.2 clams/m^2, and the average yield is 1,573 g/m^2. The harvestable biomass is estimated at 503 t.

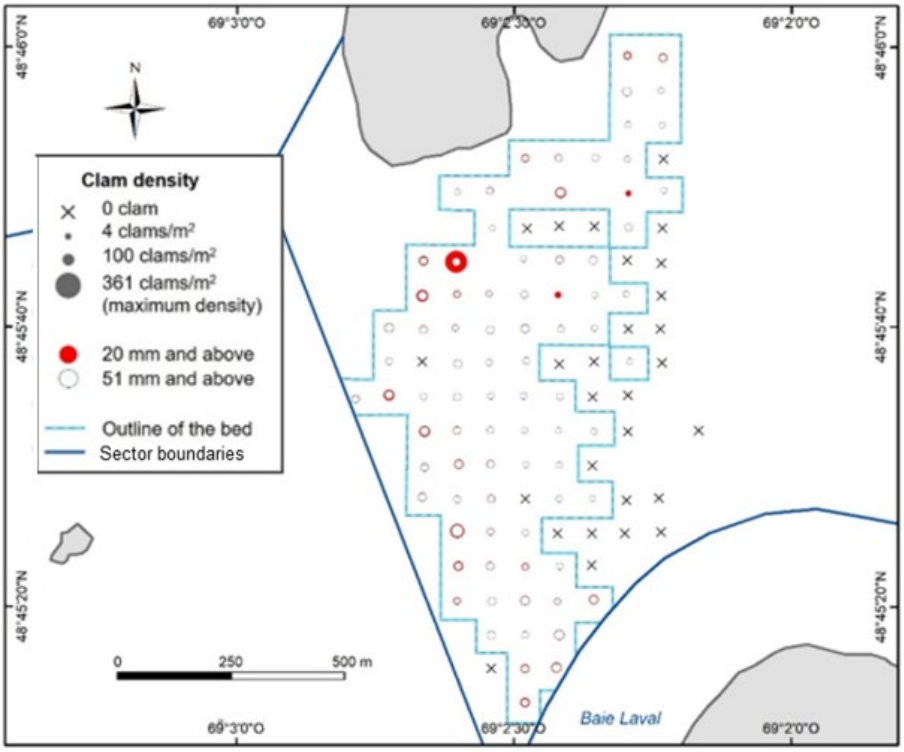

Figure 35. Soft-shell clam density by size class and by station in Banc Marie-Marthe shellfish area (N-04.1.2.1) on the Upper North Shore surveyed in 2016.

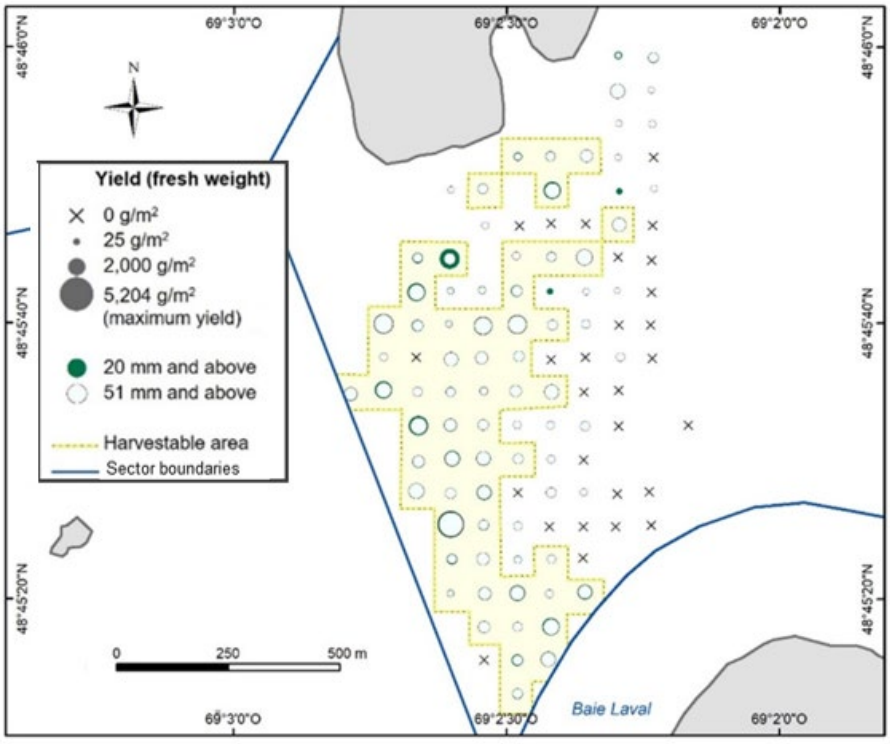

Figure 36. Soft-shell clam yield by size class and by station in Banc Marie-Marthe shellfish area (N-04.1.2.1) on the Upper North Shore surveyed in 2016.

In total, 1,009 clams were measured, ranging in size from 13 to 97 mm (Table 5). The average size of clams ≥ 20 mm is 56 mm. The highest densities are between 54 and 66 mm (Figure 6).

There were 38 sediment samples collected, nine of which were located outside the bed (Figure 37 and Table 1). The grain size analysis shows that the sediments in the bed are mostly sand, along with some muddy sand, gravelly sand and sandy mud (Figure 37 and Table 6). The visual assessment shows a dominance of muddy sand, along with sand and sandy mud. The sediment types present on this site are therefore muddy sand (39%), sand (30%) and sandy mud (18%), with some gravelly sand and mud. The muddier sediments (mud and sandy mud) are found in the northern portion of the bed and at the southwestern end.

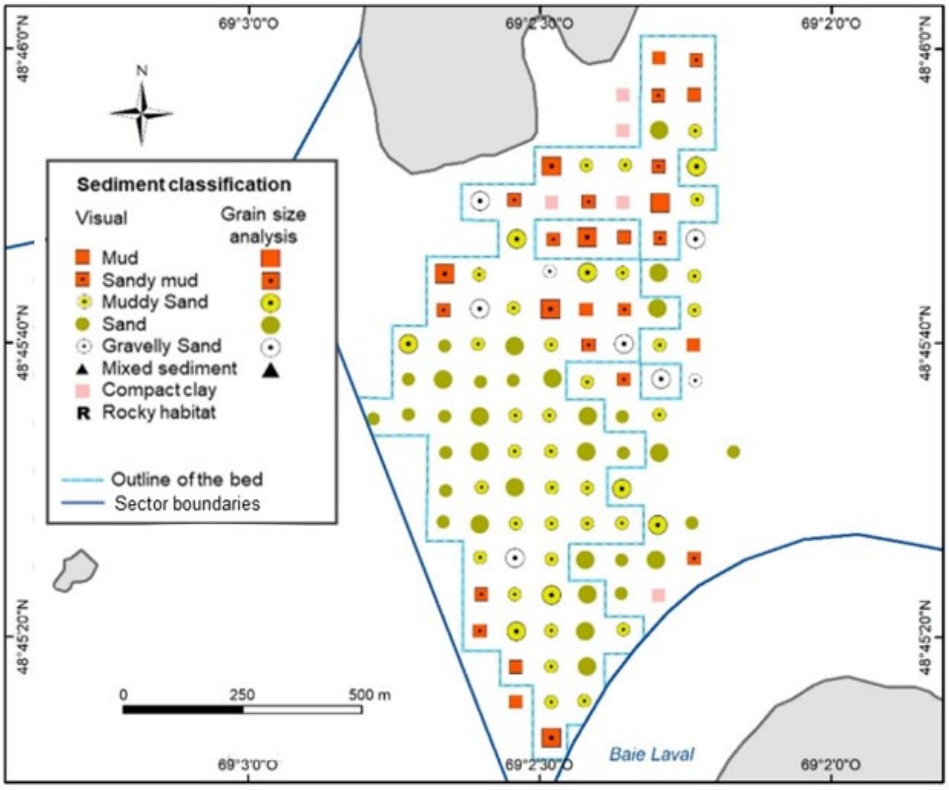

Figure 37. Sediment classification (grain size analysis and visual assessment) by station in Banc Marie-Marthe shellfish area (N-04.1.2.1) on the Upper North Shore surveyed in 2016.

Baie Didier Sud, area N-04.1.2.2

Baie Didier Sud opens into Baie Laval on the east side (Figure 2 and Appendix 8L). This area was surveyed in 5 days over the months of October 2017 and April and May 2018. The majority of the survey was conducted in 2018. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8L). In total, 123 stations were visited, of which 112 were sampled. There were nine stations located to the south that were too deep, one station with a rocky sediment and one station located on the beach that could not be sampled. The sampling grid covered most of the area, except for the southern part, which was too deep.

The area of the clam bed is estimated at 0.51 km^2 and includes 90 stations (Table 3 and Figure 38). Five stations without clams were retained in the delineation of the bed. The average density of clams ≥ 20 mm is 101.0 clams/m^2, with a maximum density of 444 clams/m^2 (Figure 38 and Table 3). The density of clams 20–50 mm is 78.6 clams/m^2, and that of clams ≥ 51 mm is lower with 22.4 clams/m^2. The average yield of clams 20–50 mm is 693 g/m^2, a yield

similar to that of legal-size clams of 671 g/m^2 (Figure 39 and Table 3). The maximum yield of clams ≥ 20 mm is 7,787 g/m^2 for this bed. Clams of both size classes are distributed throughout the bed, with higher densities in the south.

The harvestable area of Baie Didier Sud bed is estimated at 0.17 km^2 and includes 30 stations (Table 4 and Figure 39). Two harvestable areas were delineated, one on the southwest side and the other in the central-eastern part of the bed. The average density of clams ≥ 51 mm is 56.5 clams/m^2, and the average yield is 1,723 g/m^2 for the entire harvestable area. The harvestable biomass for this bed is estimated at 293 t.

In total, 2,349 clams were measured. The size of these clams ranged from 15 to 89 mm (Table 5). The average size of clams ≥ 20 mm is 42 mm. The size structure shows a mode around 38–45 mm (Figure 6).

Twenty-two sediment samples were collected from this bed, including three stations not located in the bed (Figure 40 and Table 1). The grain size analyses show that the sediments consist mainly of mud and sandy mud, along with some muddy sand, sand and gravelly sand (Figure 40 and Table 6). The visual assessment shows a dominance of mud, along with sandy mud and muddy sand. All of this information combined shows that the sediments present on this bed consist of 68% mud, 17% sandy mud, 12% muddy sand, along with some sand and gravelly sand. The muddy sand and sandy sediments are found to the south of the bed.

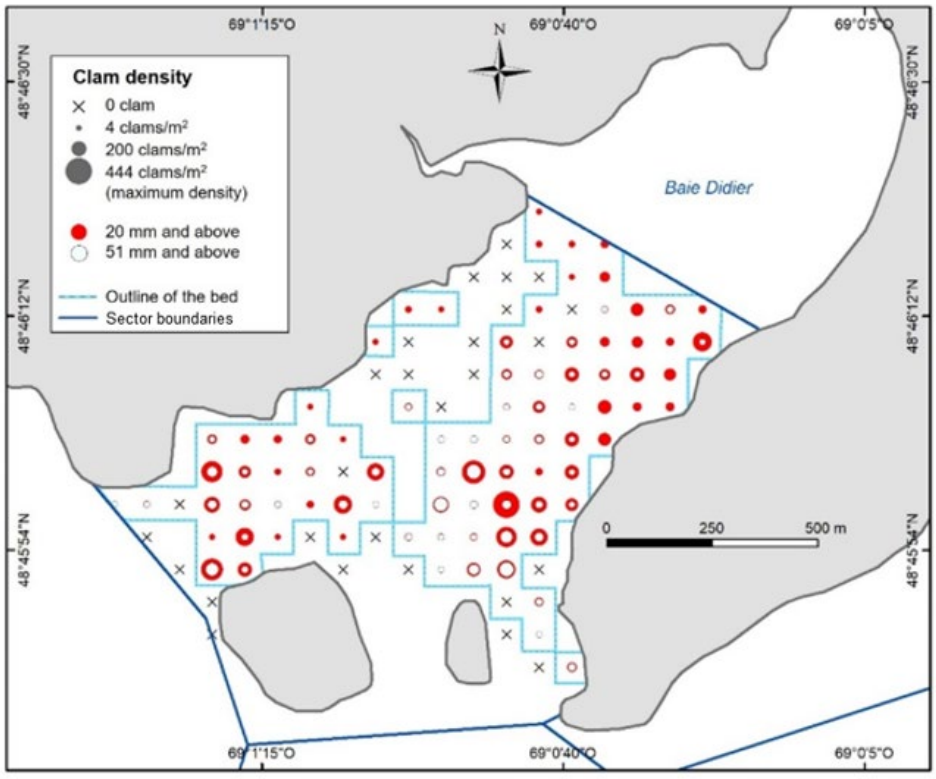

Figure 38. Soft-shell clam density by size class and by station in Baie Didier Sud shellfish area (N-04.1.2.2) on the Upper North Shore surveyed in 2018.

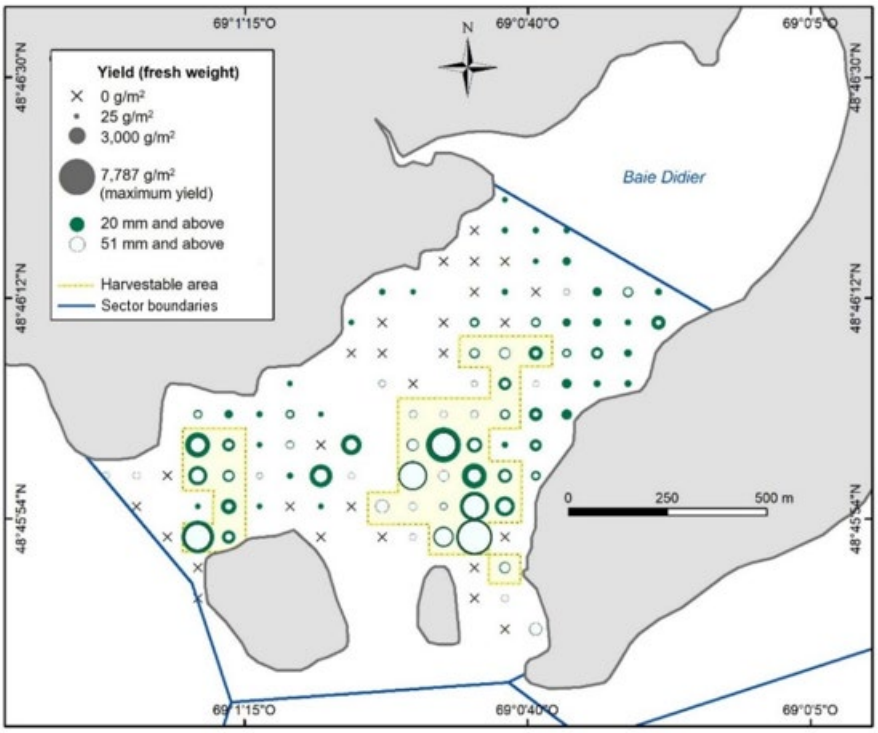

Figure 39. Soft-shell clam yield by size class and by station in Baie Didier Sud shellfish area (N-04.1.2.2) on the Upper North Shore surveyed in 2018.

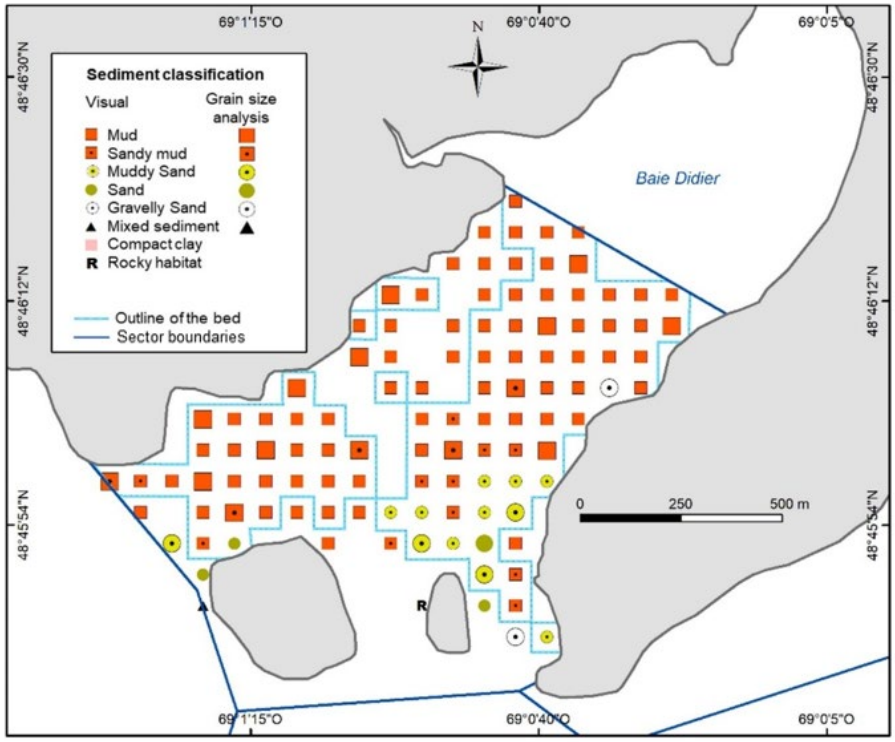

Figure 40. Sediment classification (grain size analysis and visual assessment) by station in Baie Didier Sud shellfish area (N-04.1.2.2) on the Upper North Shore surveyed in 2018.

Baie des Plongeurs, area N-04.1.3

Baie des Plongeurs is located just east of Baie Didier (Figure 2 and Appendix 8M). This area was surveyed in 8 days spread over the months of November 2016 and April 2017. The majority of the survey was conducted in 2016. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8M). All 106 stations in the sampling plan were sampled. Sampling covered only the central part of the area.

The area of the bed is estimated at 0.50 km^2 and includes 89 stations (Table 3 and Figure 41). Only one station without clams was retained in the delineation of the bed. The average density of clams ≥ 20 mm is 210.1 clams/m^2, with a maximum density of 804 clams/m^2 (Figure 41 and Table 3). The density of clams 20–50 mm is 178.0 clams/m^2, and that of clams ≥ 51 mm is lower with 32.1 clams/m^2. The average yield of clams 20–50 mm is 1,491 g/m^2, and the average yield of legal-size clams is 902 g/m^2 (Figure 42 and Table 3). The maximum yield of clams ≥ 20 mm is 9,837 g/m^2 for this bed. The average density and yield of clams 20–50 mm are among the highest values observed during the 2016–2020 surveys. Clams 20–50 mm are mostly found around the perimeter of the bed, with the central portion being less densely populated. Clams ≥ 51 mm are distributed throughout the bed.

The harvestable area of the Baie des Plongeurs bed is estimated at 0.32 km^2 and includes 56 stations (Table 4 and Figure 42). Several harvestable areas were delineated in this bed. The average density of clams ≥ 51 mm is 49.4 clams/m^2, and the average yield is 1,390 g/m^2 for the entire harvestable area. The harvestable biomass is estimated at 445 t.

In total, 4,898 clams were measured and ranged in size from 13 to 81 mm (Table 5). The average size of clams ≥ 20 mm is 40 mm. The size structure shows a mode around 31–41 mm (Figure 6). The size structure is very similar to that of Baie Didier Sud, but with much higher densities for all sizes (the Y-axis scale differs between the two areas).

Thirty sediment samples were collected, three of which are not located in the bed (Figure 43 and Table 1). The grain size analyses show that sediments are composed of sandy mud, along with mud, muddy sand and sand (Figure 43 and Table 6). The visual assessment shows a dominance of mud and sandy mud, along with muddy sand. The sediment types present in this bed are mud (42%), sandy mud (35%) and muddy sand (17%), along with some sand (7%). The sandy sediments are found mainly to the south of the bed.

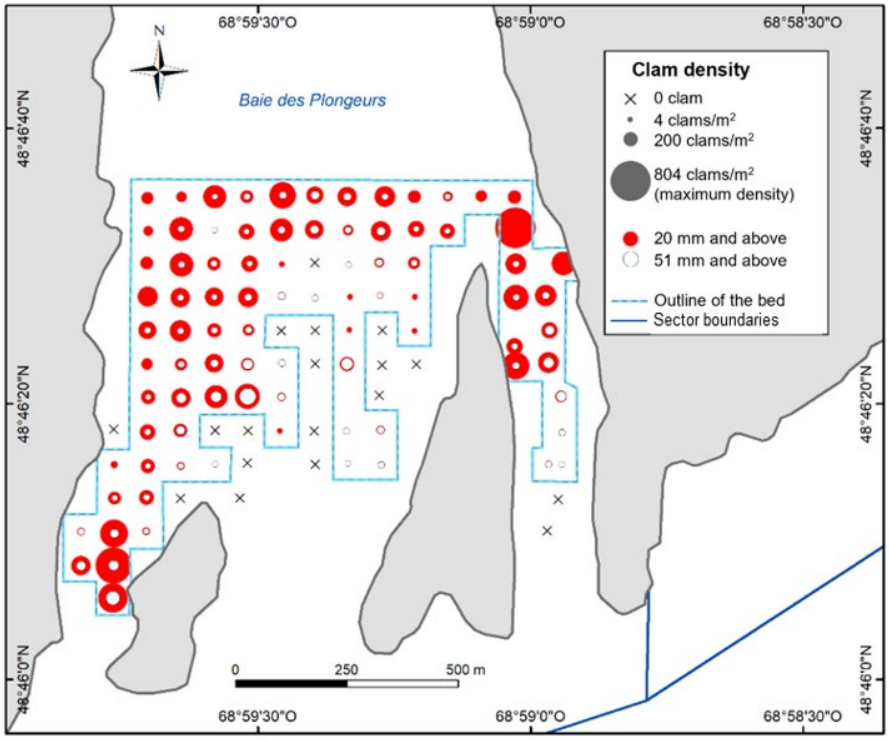

Figure 41. Soft-shell clam density by size class and by station in Baie des Plongeurs shellfish area (N-04.1.3) on the Upper North Shore surveyed in 2016.

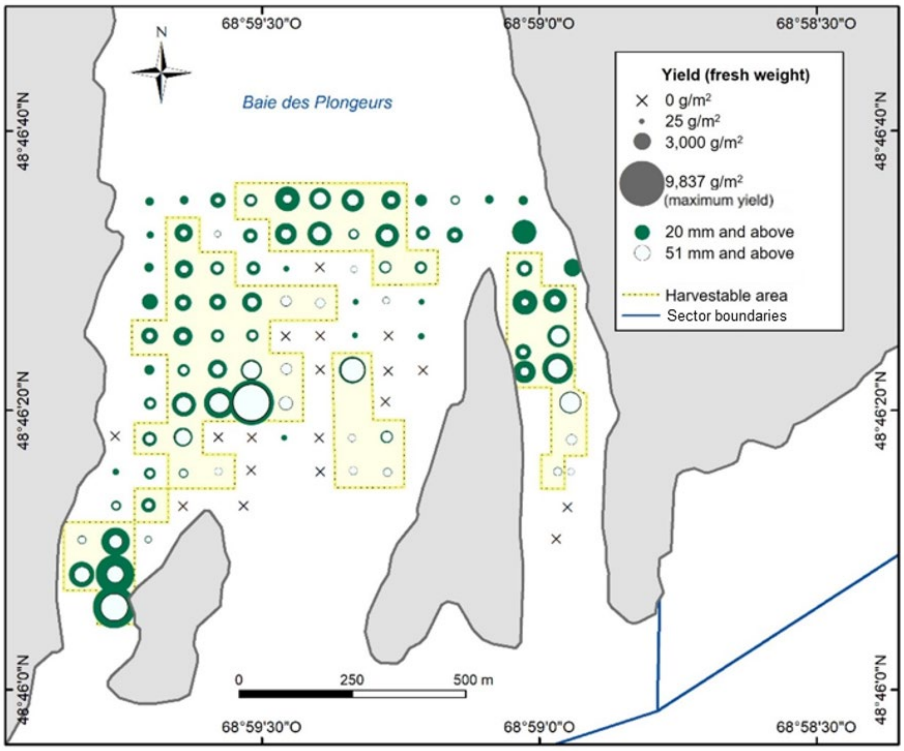

Figure 42. Soft-shell clam yield by size class and by station in Baie des Plongeurs shellfish area (N-04.1.3) on the Upper North Shore surveyed in 2016.

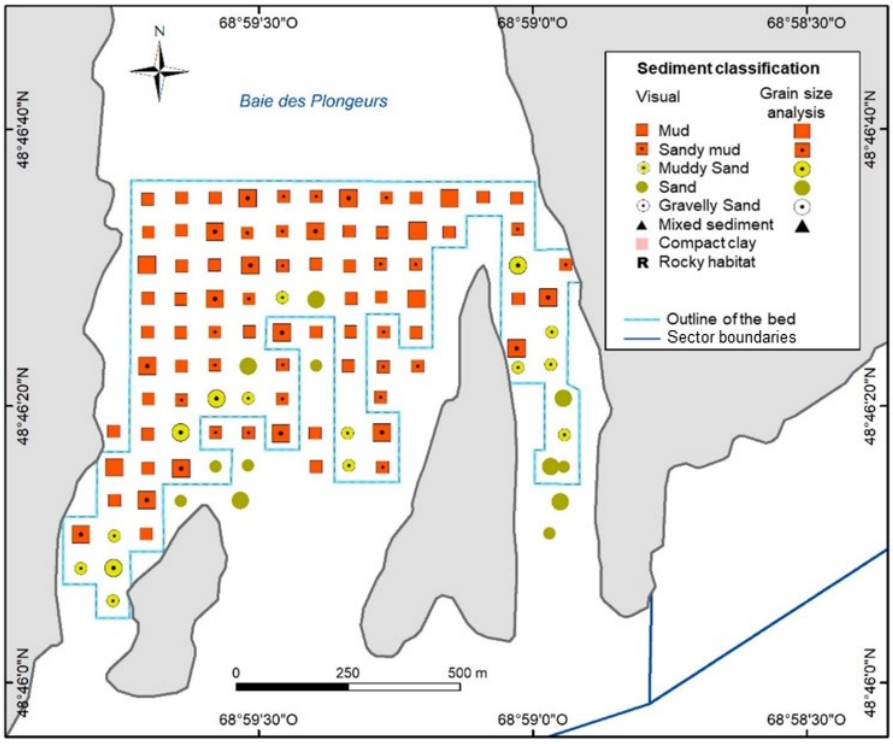

Figure 43. Sediment classification (grain size analysis and visual assessment) by station in Baie des Plongeurs shellfish area (N-04.1.3) on the Upper North Shore surveyed in 2016.

Batture aux Gibiers Est, area N-04.2.1.2

Batture aux Gibiers Est is located a few kilometers east of the Baie des Plongeurs, near the village of Saint-Marc-de-Latour (Figure 2). This area was surveyed in 1 day in August 2018. A sampling grid of 65 m by 65 m was used, (Table 1 and Appendix 8N). The sampling plan contained 42 stations, but only 21 could be sampled. Twelve of the stations were rocky habitats, five were located on the beach, and four others were too deep; these stations were not sampled.

Clams were collected at only one station out of the 21 sampled, so the bed area in this area is 0.004 km^2 (Table 3 and Figure 44). No sub-legal-size clams were harvested. The density of clams ≥ 51 mm is 32.0 clams/m^2, and the yield is 796 g/m^2 (Figures 44 and 45 and Table 3).

Since there was only one station with a density of clams ≥ 51 mm greater than or equal to 16 clams/m^2, there is no harvestable area in the Batture aux Gibiers Est area (Table 4).

Eight clams were measured, and their sizes ranged from 52 to 63 mm (Table 5). The average size of these clams is 57 mm. Because of the small number of clams measured, the size structure does not provide any additional information (Figure 6).

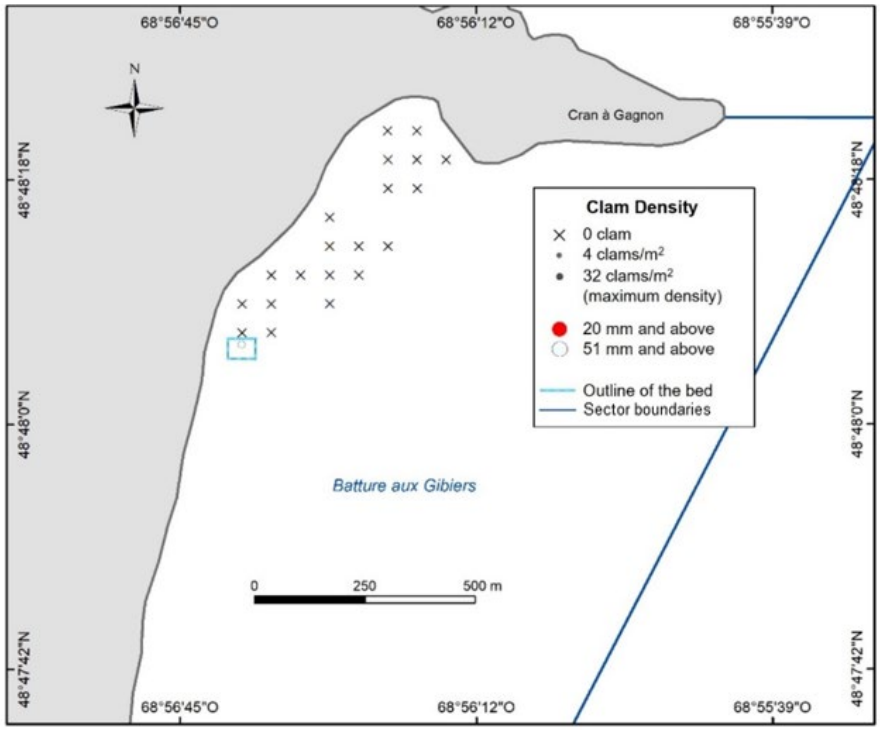

Figure 44. Soft-shell clam density by size class and by station in Batture aux Gibiers Est shellfish area (N-04.2.1.2) on the Upper North Shore surveyed in 2018.

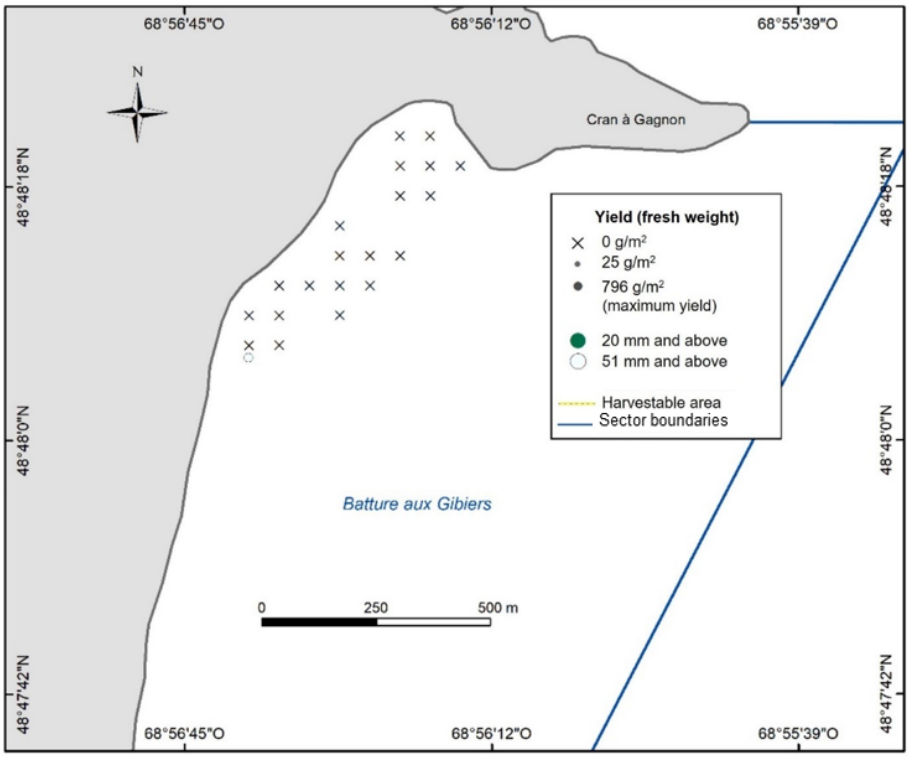

Figure 45. Soft-shell clam yield by size class and by station in Batture aux Gibiers Est shellfish area (N-04.2.1.2) on the Upper North Shore surveyed in 2018.

Seven sediment samples were collected during the sampling, but none were in the bed (Figure 46). All of the observations collected in the sampled portion of this area show that almost all of the sediments were sand, with only one mention of gravelly sand.

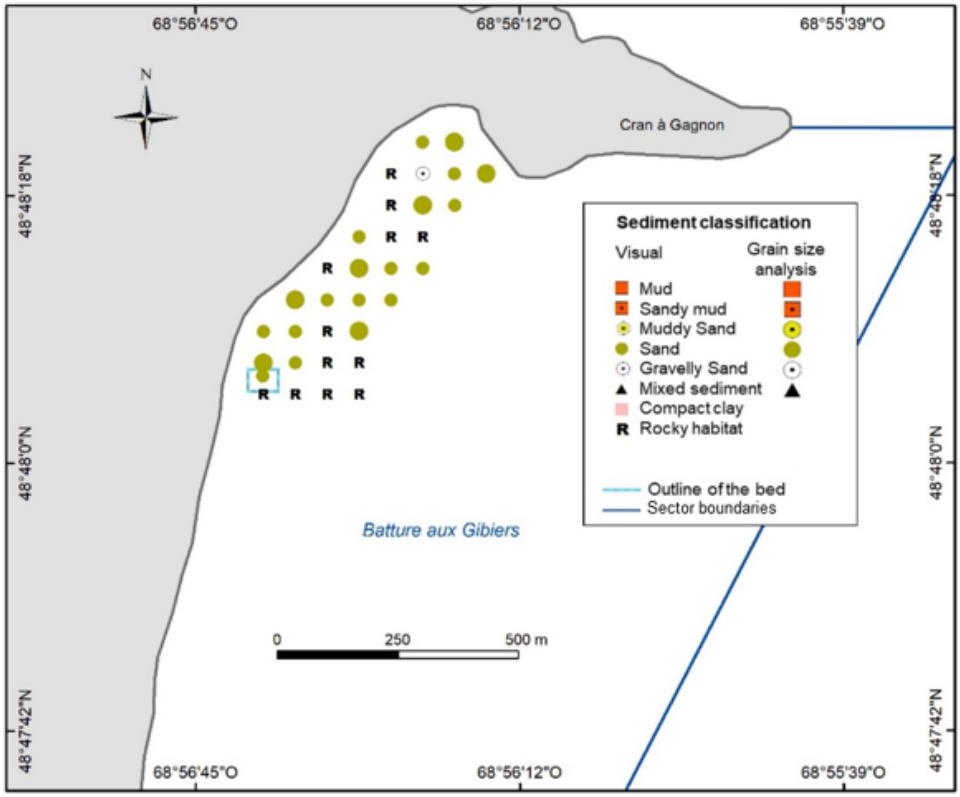

Figure 46. Sediment classification (grain size analysis and visual assessment) by station in Batture aux Gibiers Est shellfish area (N-04.2.1.2) on the Upper North Shore surveyed in 2018.

Cran à Gagnon, area N-04.2.2

Cran à Gagnon area is located in Baie Blanche, near the village of Saint-Marc-de-Latour (Figure 2). This area was surveyed in 4 days during July and August 2017. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8O). Only the western portion of the area, located in the bottom of Baie Blanche, was surveyed. All 69 stations in the sampling plan were sampled.

The area of the Cran à Gagnon bed is estimated at 0.38 km^2 and includes 65 of the sampled stations (Table 3 and Figure 47). The area of the bed was delineated based on the 2007 and 2017 surveys, which explains why 10 stations without clams were retained in the delineation of the bed, including a few on the periphery. The average density of clams ≥ 20 mm is 100.3 clams/m^2, with a maximum density of 492 clams/m^2 (Figure 47 and Table 3). The density of clams 20–50 mm is 71.0 clams/m^2, and that of clams ≥ 51 mm is lower with 29.3 clams/m^2. The average yield of clams 20–50 mm is 685 g/m^2, and the average yield of legal-size clams is 974 g/m^2 (Figure 48 and Table 3). The maximum yield of clams ≥ 20 mm is 7,043 g/m^2 for this bed. Clams 20–50 mm are found mainly on the northern and western part of the bed. Clams ≥ 51 mm are distributed throughout the bed, with higher densities in the northern portion.

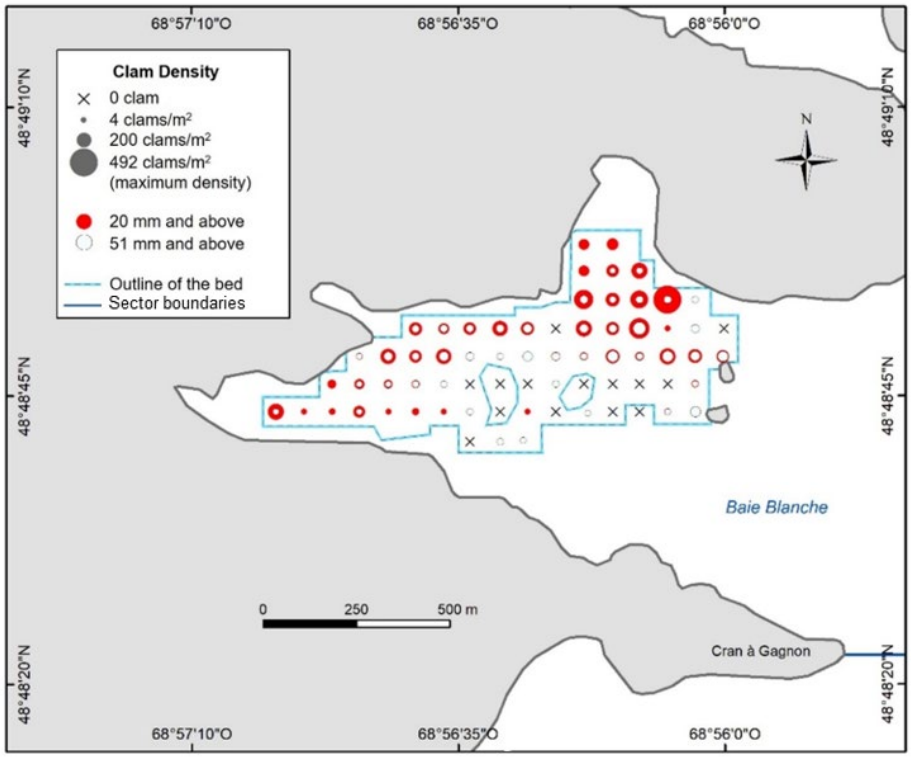

Figure 47. Soft-shell clam density by size class and by station in Cran à Gagnon shellfish area (N-04.2.2) on the Upper North Shore surveyed in 2017.

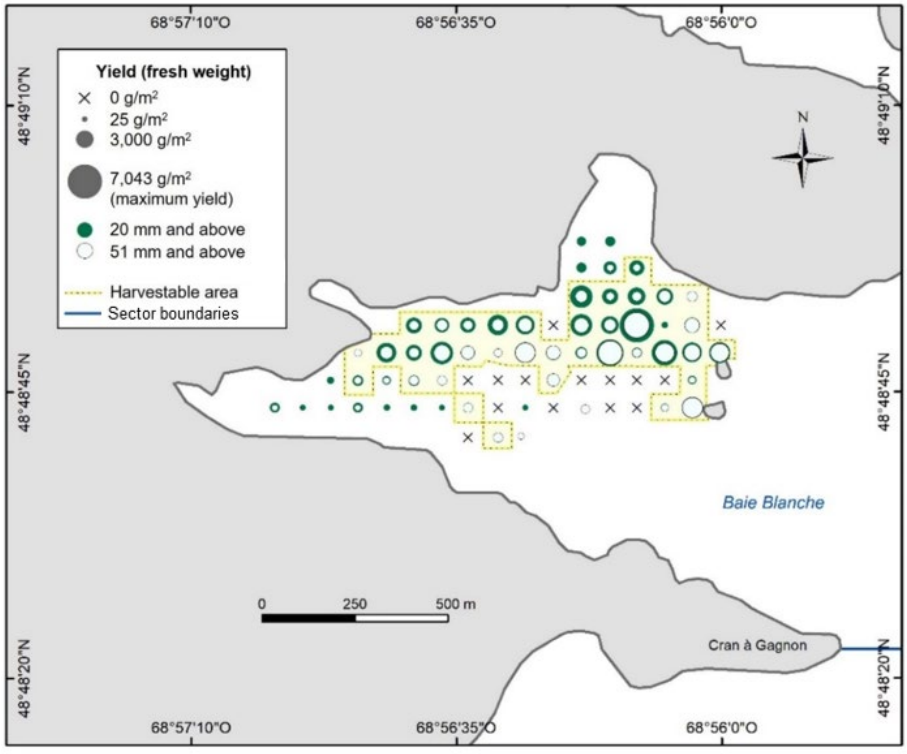

Figure 48. Soft-shell clam yield by size class and by station in Cran à Gagnon shellfish area (N-04.2.2) on the Upper North Shore surveyed in 2017.

The harvestable area of the Cran à Gagnon bed is estimated at 0.22 km^2 and includes 39 stations (Table 4 and Figure 48). The average density of clams ≥ 51 mm is 48.0 clams/m^2, and the average yield is 1,587 g/m^2 over the harvestable area. The harvestable biomass for this bed is estimated at 349 t.

In total, 1,721 clams were measured (Table 5). The size of these clams ranged from 15 to 93 mm. The average size of clams ≥ 20 mm is 44 mm. The size structure shows a primary mode around 42–48 mm, with a secondary mode at 20–23 mm (Figure 6).

No grain size analysis was carried out in 2017, since this bed was already surveyed in 2007. At that time, 58 samples were collected and analyzed, including 54 in the bed (Appendix 7). In 2007, the sediments were composed mainly of sandy mud (39%), muddy sand (32%) and mud (23%) (Appendices 9 and 12). In 2017, the visual assessment showed approximately the same proportions in a slightly different order, i.e., a dominance of mud (39%), sandy mud (35%) and muddy sand (22%) (Table 6 and Figure 49). There were also a few observations of sand and gravelly sand. Stations with muddy sand and sandy sediments are found to the east of the bed.

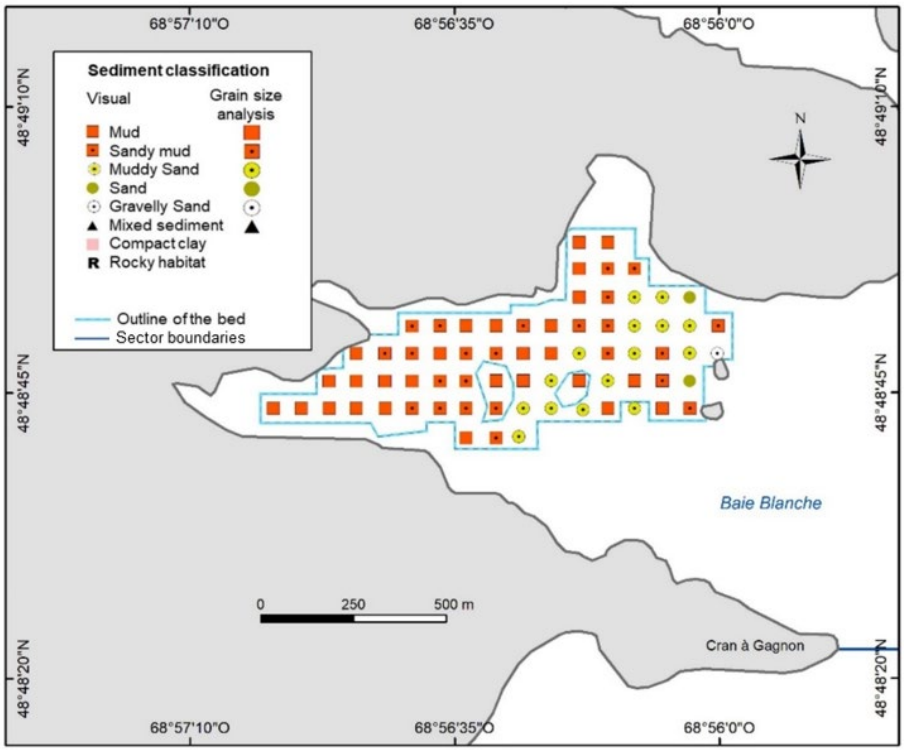

Figure 49. Sediment classification (visual assessment) by station in Cran à Gagnon shellfish area (N-04.2.2) on the Upper North Shore surveyed in 2017.

Rivière Blanche, area N-04.3

Rivière Blanche follows Cran à Gagnon (Figure 2 and Appendix 8P). Only the estuary portion of Rivière Blanche, in the west, was surveyed. This area was surveyed over 3 days in August 2020. A sampling grid of 60 m by 60 m was used (Table 1 and Appendix 8P). All 84 stations in the sampling plan were sampled.

The area of bed is estimated at 0.25 km^2 and includes 69 stations (Table 3 and Figure 50). Only one station without clams was retained in the delineation of the bed. The average density of clams ≥ 20 mm is 254.2 clams/m^2, with a maximum density of 1,134 clams/m^2 (Figure 50 and

Table 3). The density of clams 20–50 mm is 175.7 clams/m^2, and that of clams ≥ 51 mm is lower with 78.5 clams/m^2. The average yield of clams 20–50 mm is 1,461 g/m^2, and that of legal-size clams reaches 2,281 g/m^2 (Figure 51 and Table 3). The maximum yield of clams ≥ 20 mm is 17,806 g/m^2 for this bed. All of these density and yield values are among the highest values observed during the 2016–2020 surveys. In addition, the average densities and yields of clams ≥ 51 mm and the maximum yield are the highest values. Clams 20–50 mm are found almost everywhere in the bed, and high densities are found mainly in the centre. Clams ≥ 51 mm are also distributed throughout the bed. The highest densities and yields are found in the central-northern portion of the bed.

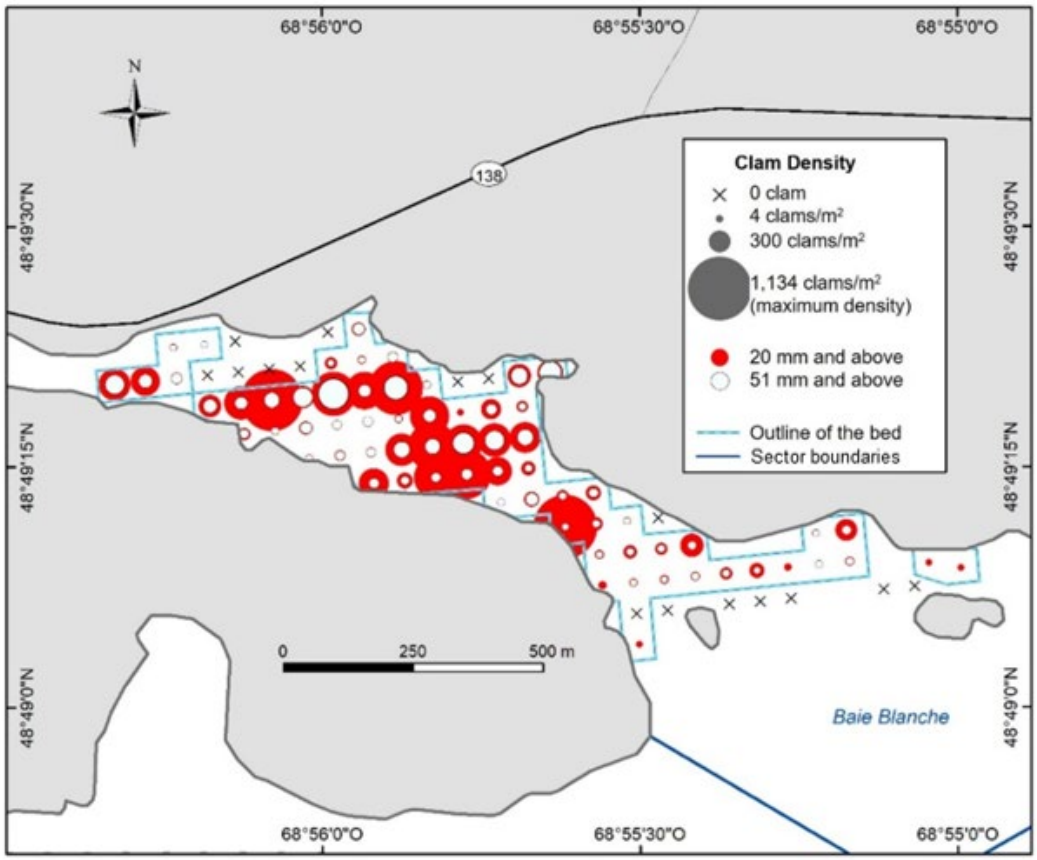

Figure 50. Soft-shell clam density by size class and by station in Rivière Blanche shellfish area (N-04.3) on the Upper North Shore surveyed in 2020.

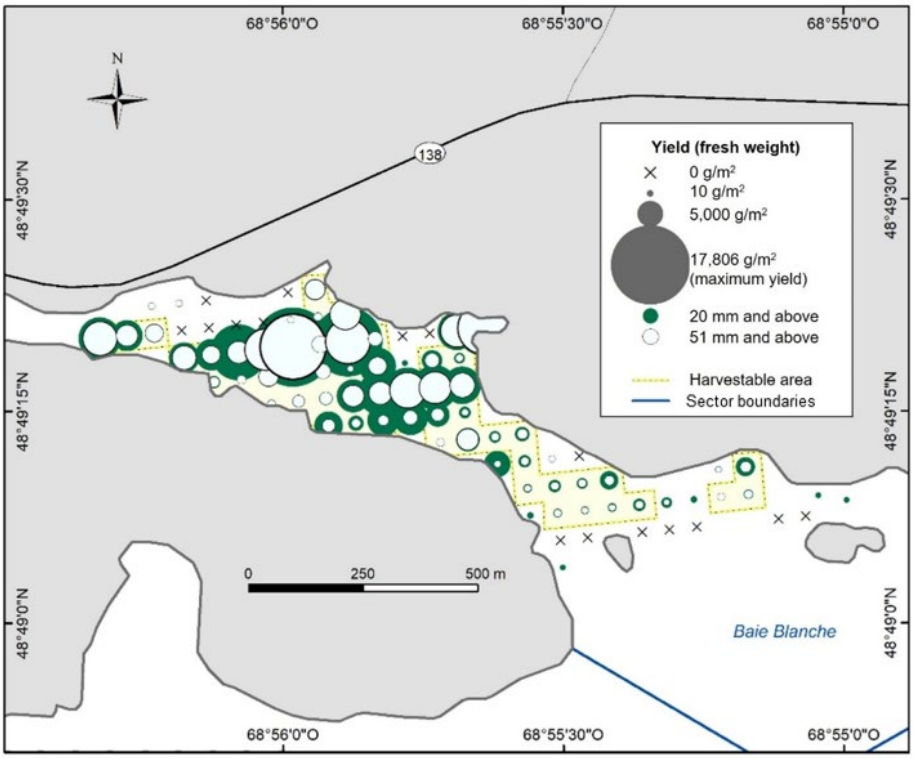

Figure 51. Soft-shell clam yield by size class and by station Rivière Blanche shellfish area (N-04.3) on the Upper North Shore surveyed in 2020.

The harvestable area of the Rivière Blanche bed is estimated at 0.20 km^2 (55 stations), which is almost the entire bed (Table 4 and Figure 51). The average density of clams ≥ 51 mm is 97.8 clams/m^2, and the average yield is 2,843 g/m^2 for the entire harvestable area. This density and yield are the highest values obtained during the 2016–2020 surveys. The harvestable biomass for this bed is estimated at 569 t.

In total, 4,501 clams were measured during sampling (Table 5). The size of these measured clams ranged from 14 to 96 mm. The average size of clams ≥ 20 mm is 45 mm. The size structure shows a mode around 41–43 mm (Figure 6).

Twenty-one sediment samples were collected during the survey, 19 of which are located in the bed (Figure 52 and Table 1). The grain size analyses show that sediments consist mainly of sandy mud and muddy sand (Figure 52 and Table 6). The visual assessment shows a dominance of mud, along with sandy mud and sand. The types of sediment present on this site are mud (38%), sandy mud (29%), sand (16%), muddy sand (14%) and some gravelly sand. The sandy sediments are found mainly to the northwest of the bed.

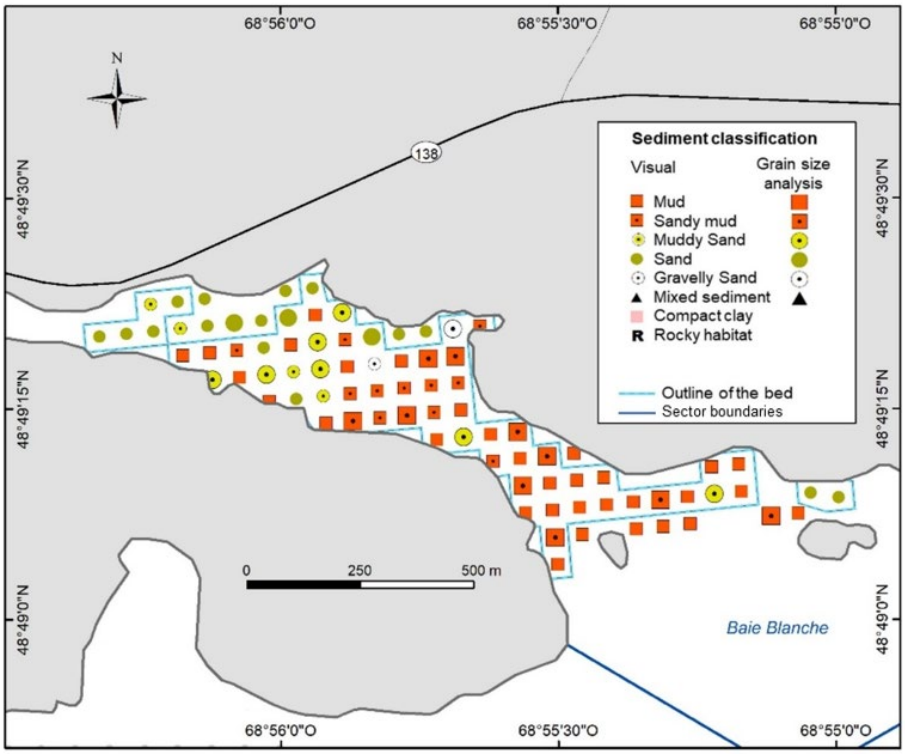

Figure 52. Sediment classification (grain size analysis and visual assessment) by station in Rivière Blanche shellfish area (N-04.3) on the Upper North Shore surveyed in 2020.

Anse du Colombier, area N-04.4.1

Anse du Colombier is adjacent to Rivière Blanche and is located near the municipality of Cap Colombier (Figure 2). The eastern part of Anse du Colombier was surveyed in 2 days in September 2017. A sampling grid of 65 m by 65 m was used (Table 1 and Appendix 8Q). Of the 57 stations in the sampling plan, 51 were sampled. Three stations were too deep, two stations were located on the beach, and one station had rocky habitat.

The area of the bed is estimated at 0.15 km^2 and includes 36 stations (Table 3 and Figure 53). Only one station without clams was retained in the delineation of the bed. The average density of clams ≥ 20 mm is 315.4 clams/m^2, with a maximum density of 862 clams/m^2 (Figure 53 and Table 3). The density of clams 20–50 mm is 276.5 clams/m^2, and that of clams ≥ 51 mm is much lower with 38.9 clams/m^2. The average yield of clams 20–50 mm is 1,496 g/m^2, and that of legal-size clams reaches 1,034 g/m^2 (Figure 54 and Table 3). The maximum yield of clams ≥ 20 mm is 6,343 g/m^2 for this bed. The average density and yield values for clams 20–50 mm and the maximum density are among the highest values observed during the 2016–2020 surveys. Clams 20–50 mm are found in the eastern half of the bed. Clams ≥ 51 mm are distributed throughout.

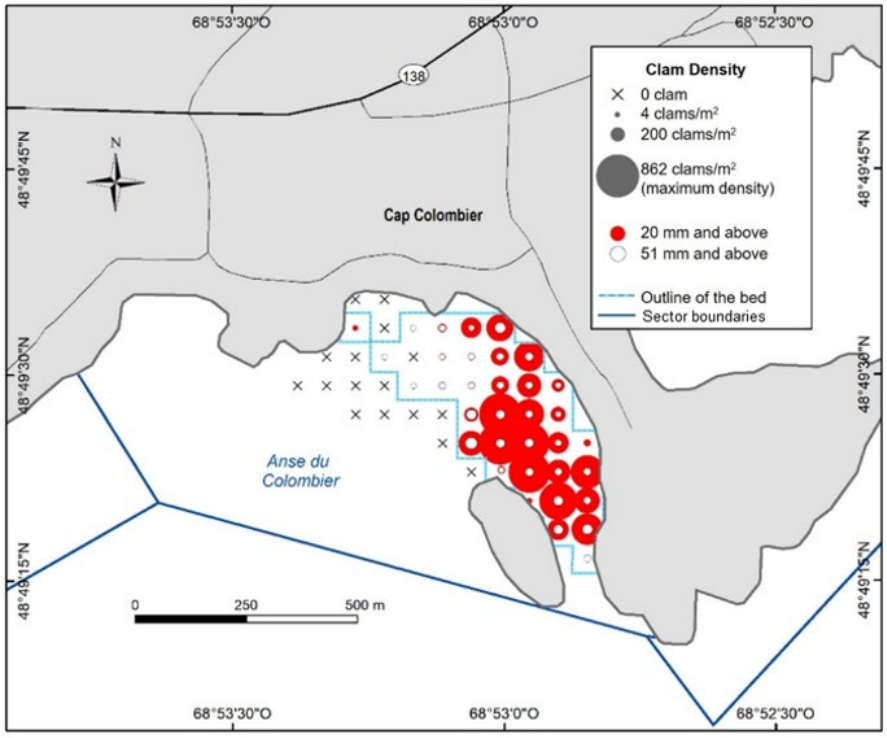

Figure 53. Soft-shell clam density by size class and by station in Anse du Colombier shellfish area (N-04.4.1) on the Upper North Shore surveyed in 2017.

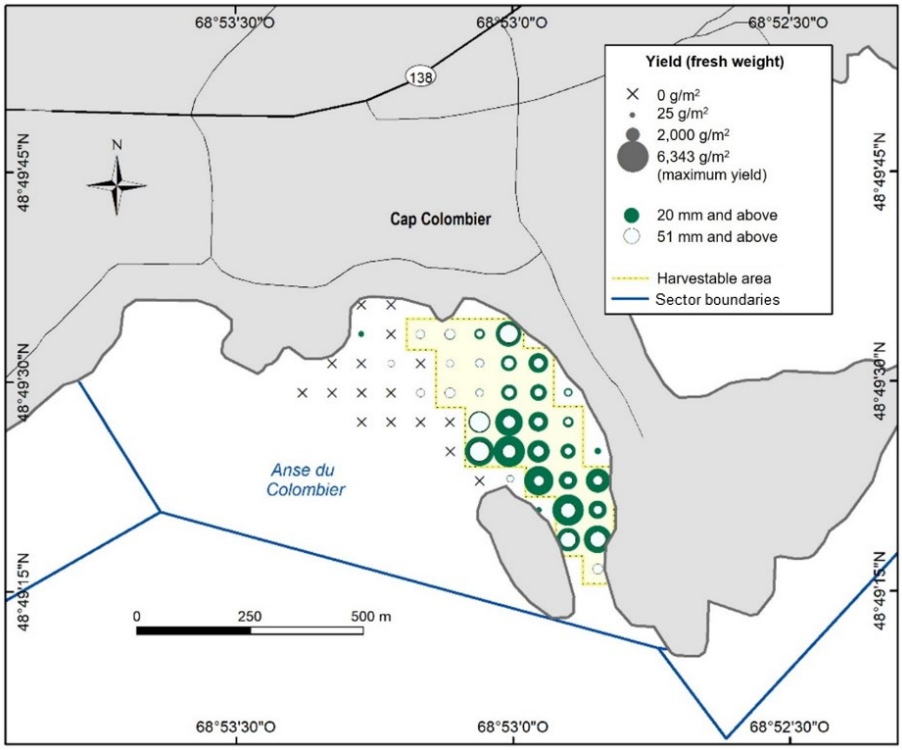

Figure 54. Soft-shell clam yield by size class and by station in Anse du Colombier shellfish area (N-04.4.1) on the Upper North Shore surveyed in 2017.

The harvestable area of Anse du Colombier bed is estimated at 0.12 km^2 (28 stations), which is almost the entire bed (Table 4 and Figure 54). The average density of clams ≥ 51 mm is 49.2 clams/m^2, and the average yield is 1,292 g/m^2 for the entire harvestable area. The harvestable biomass is estimated at 155 t.

In total, 3,020 clams were measured (Table 5). Size ranged from 14 to 99 mm. The average size of clams ≥ 20 mm is 36 mm, which is among the lowest values obtained during the 2016–2020 surveys. The size structure shows a mode around 31-33 mm (Figure 6).

Twelve sediment samples were collected during the survey, 10 of which were located in the bed (Figure 55 and Table 1). The grain size analyses show that the sediments in the bed are made up of equal parts of sandy mud, muddy sand and sand, with some gravelly sand (Figure 55 and Table 6). The visual assessment shows a dominance of mud, followed by muddy sand and sandy mud. The sediment types present on this site are mud (31%), muddy sand (28%), sandy mud (22%), sand (14%) and gravelly sand (6%). The sandy sediments are found mainly in the western part of the bed.

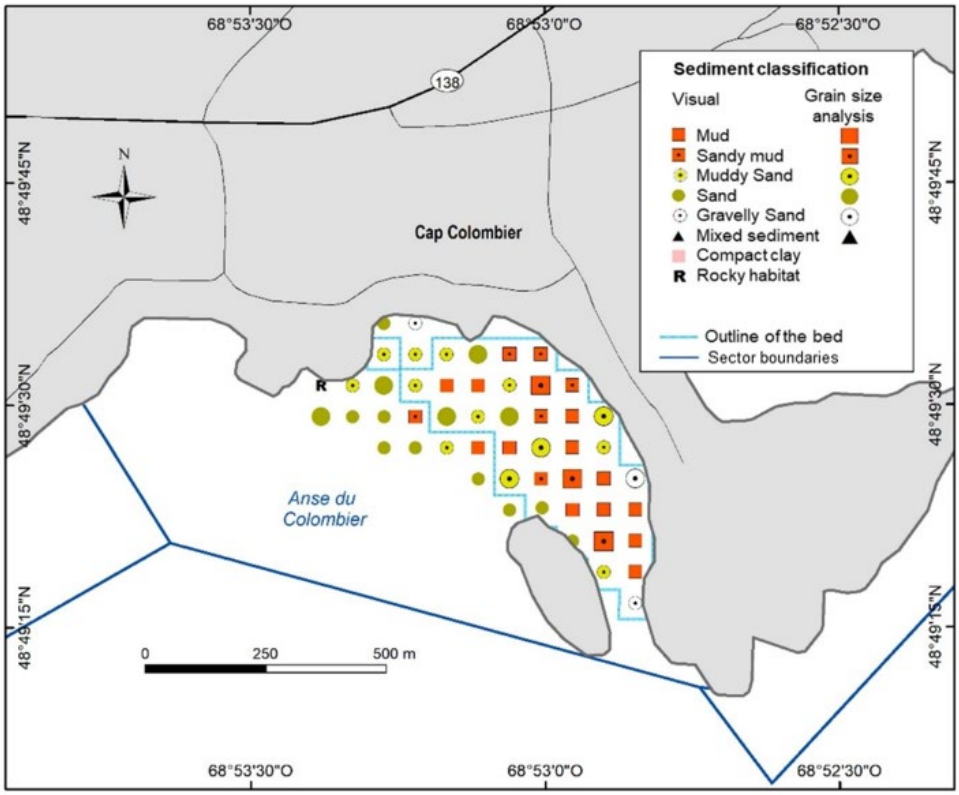

Figure 55. Sediment classification (grain size analysis and visual assessment) by station in Anse du Colombier shellfish area (N-04.4.1) on the Upper North Shore surveyed in 2017.

Anse à Norbert, area N-04.4.2

Anse à Norbert is adjacent to Anse du Colombier area (Figure 2). It is the central part of the area (at Havre Colombier and Anse à Norbert) that was surveyed over 3 days in May 2018 (Appendix 8R). Two sampling grids were used to cover this bed (Table 1). First, a wider grid of 85 m by 85 m covered the entire portion to be surveyed. Then, a smaller grid of 60 m by 60 m was applied in the most interesting area of the bed. In total, 93 stations were used, but only 66 were sampled. Thirteen stations were located on the beach (including one on land), 10 stations were too deep, and four stations had rocky habitat.

The area of the Anse à Norbert bed is estimated at 0.17 km^2 and includes 39 stations (Table 3 and Figure 56). Only one station without clams was retained in the delineation of the bed. The average density of clams ≥ 20 mm is 72.5 clams/m^2, with a maximum density of 414 clams/m^2 (Figure 56 and Table 3). The density of clams 20–50 mm is 49.5 clams/m^2, and that of clams ≥ 51 mm is lower with 23.0 clams/m^2. The average yield of clams 20–50 mm is 334 g/m^2, and that of legal-size clams reaches 653 g/m^2 (Figure 57 and Table 3). The maximum yield of clams ≥ 20 mm is 4,387 g/m^2. Clams 20–50 mm are found at the northwest and southeast ends of the bed, while clams ≥ 51 mm are distributed throughout.

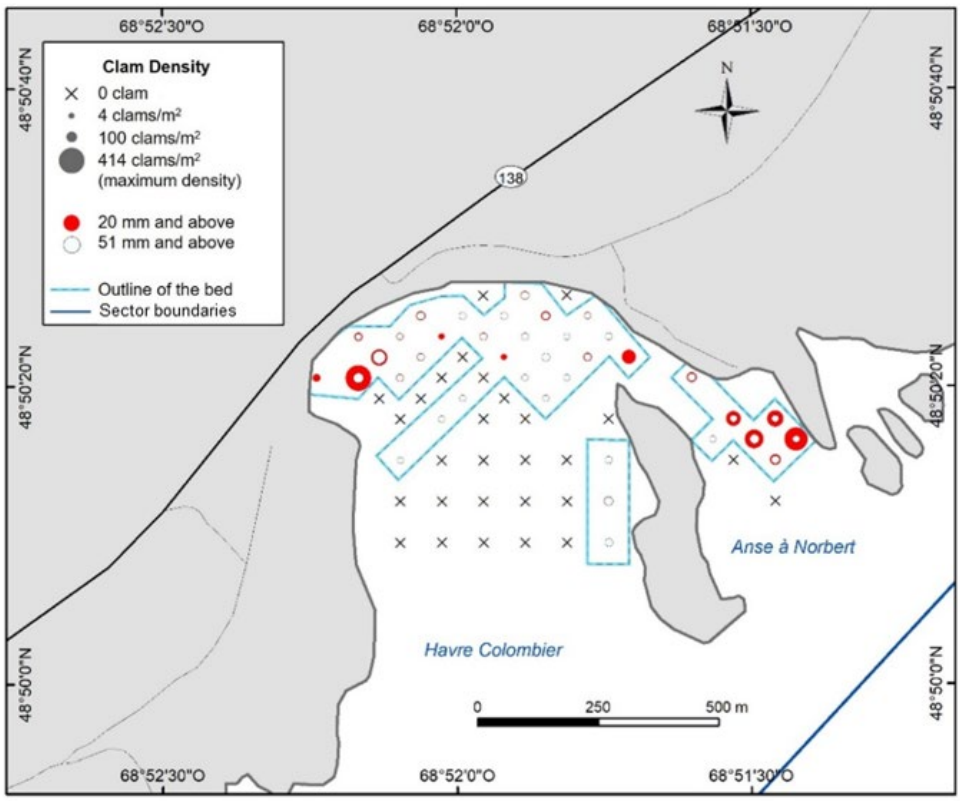

Figure 56. Soft-shell clam density by size class and by station in Anse à Norbert shellfish area (N-04.4.2) on the Upper North Shore surveyed in 2018.

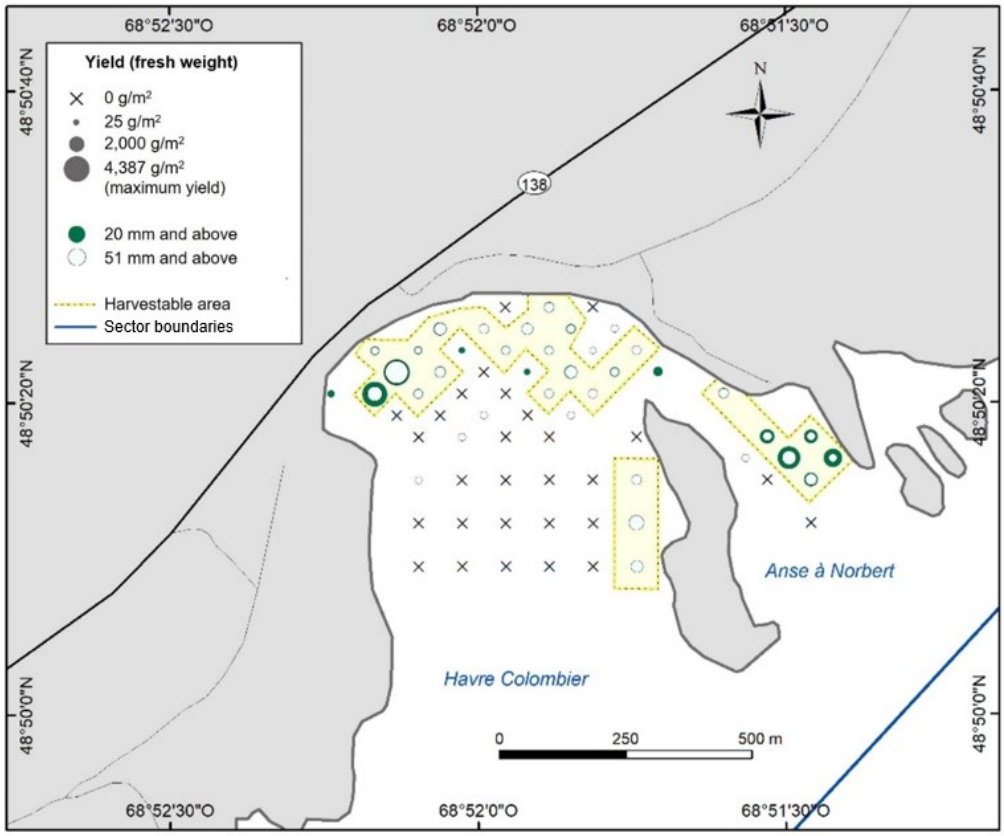

Figure 57. Soft-shell clam yield by size class and by station in Anse à Norbert shellfish area (N-04.4.2) on the Upper North Shore surveyed in 2018.

The harvestable area of the Anse à Norbert bed is estimated at 0.12 km^2 (27 stations), which is almost the entire bed (Table 4 and Figure 57). The average density of clams ≥ 51 mm is 33.3 clams/m^2, and the average yield is 936 g/m^2. The harvestable biomass is estimated at 112 t, which is among the lowest values obtained during the 2016–2020 surveys.

In total, 780 clams were measured (Table 5). Size ranged from 15 to 79 mm. The average size of clams ≥ 20 mm is 43 mm. The size structure shows some main modes between 34 and 49 mm (Figure 6).

Eighteen sediment samples were collected during the survey, 11 of which were located in the bed (Figure 58 and Table 1). The grain size analyses show that sediments are composed almost equally of sandy mud, sand and muddy sand (Figure 58 and Table 6). However, the visual assessment shows a dominance of sand, followed by muddy sand and sandy mud. The types of sediment present in this bed are sand (41%), muddy sand (26%), sandy mud (26%), mud (5%) and gravelly sand (3%). The muddy sediments are mainly found at the northwest and southeast ends of the bed.

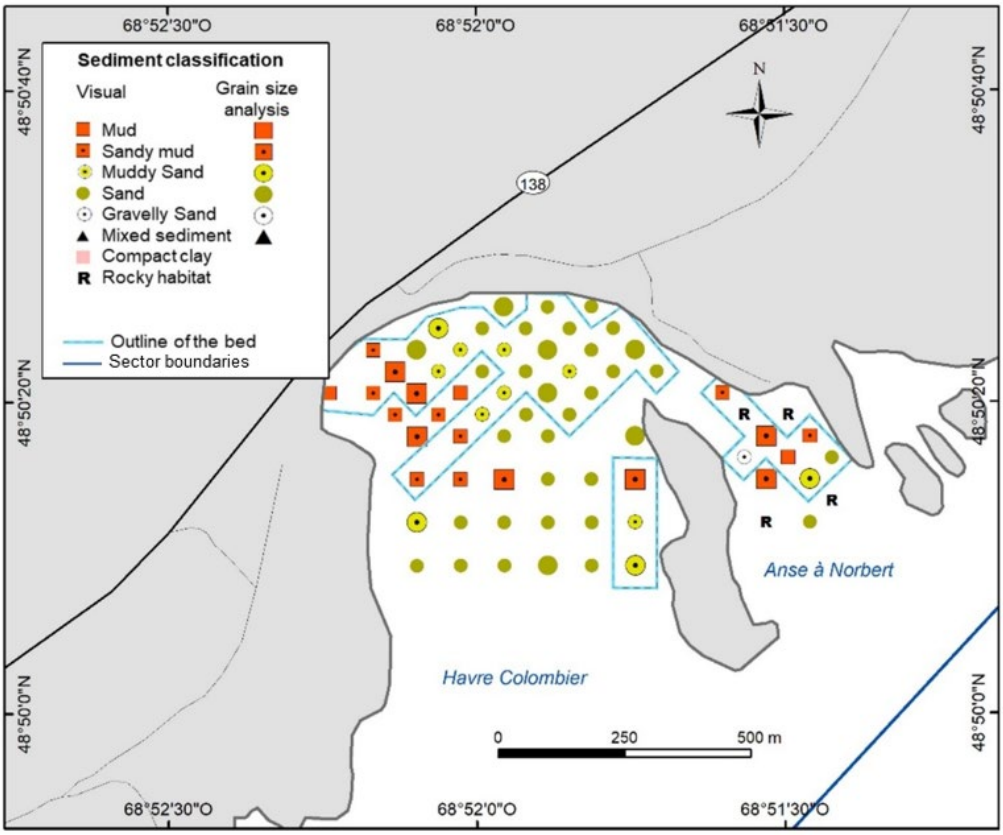

Figure 58. Sediment classification (grain size analysis and visual assessment) by station in Anse à Norbert shellfish area (N-04.4.2) on the Upper North Shore surveyed in 2018.

Anse Noire, area N-04.5.1

Anse Noire follows Anse à Norbert area (Figure 2). Two beds were targeted during the survey. The Anse Noire is located at the western end of the area (Bed 1) and extends slightly into Anse à Norbert. The second bed is located approximately in the centre of the area in Anse aux Bouleaux (Appendix 8S). The two beds were surveyed over 2 days in June 2018. A sampling grid of 60 m by 60 m was used (Table 1 and Appendix 8S). In total, 49 stations were laid out; however, only 27 were sampled. Twelve stations were located on the beach (some on land), eight stations had rocky habitat, and two stations were too deep.

The total area of the two beds in Anse Noire is estimated at 0.10 km^2 and includes 26 stations (Table 3 and Figure 59). Only one station without clams was retained in the delineation of Bed 1, since clams were collected there in 2003 (previous survey). The average density of clams ≥ 20 mm is 121.4 clams/m^2, with a maximum density of 420 clams/m^2 (Figure 59 and Table 3). The density of clams 20–50 mm is 99.6 clams/m^2, and that of clams ≥ 51 mm is lower with 21.8 clams/m^2. The average yield of clams 20–50 mm is 815 g/m^2, and that of legal-size clams reaches 567 g/m^2 (Figure 60 and Table 3). The maximum yield of clams ≥ 20 mm is 4,914 g/m^2 for these beds. Both clam size classes are distributed throughout the beds.

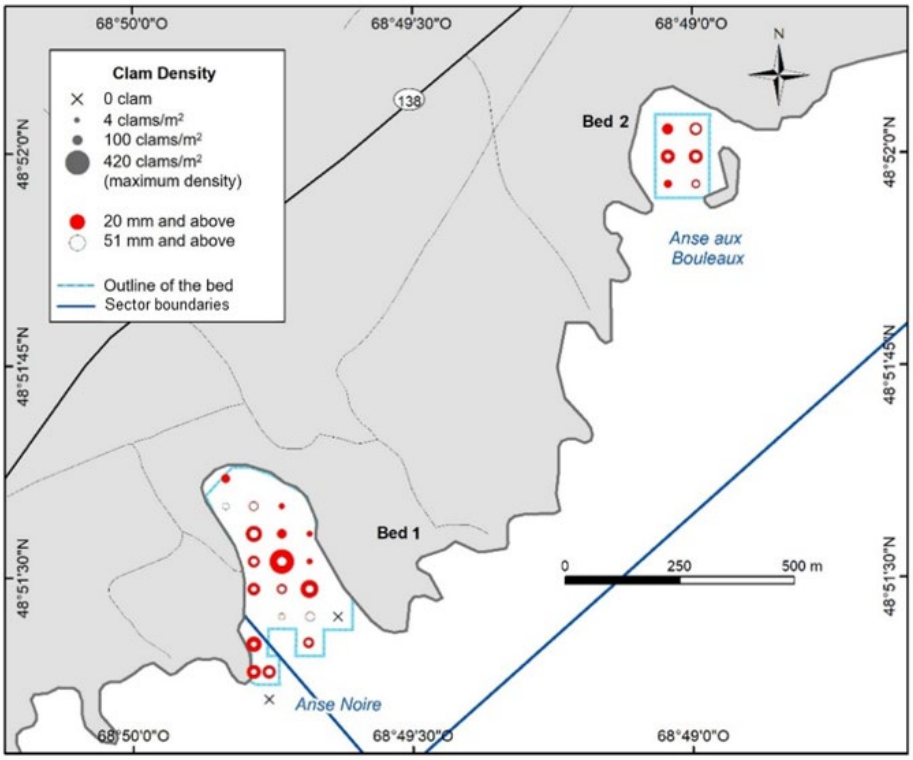

Figure 59. Soft-shell clam density by size class and by station in Anse Noire shellfish area (N-04.5.1) on the Upper North Shore surveyed in 2018.

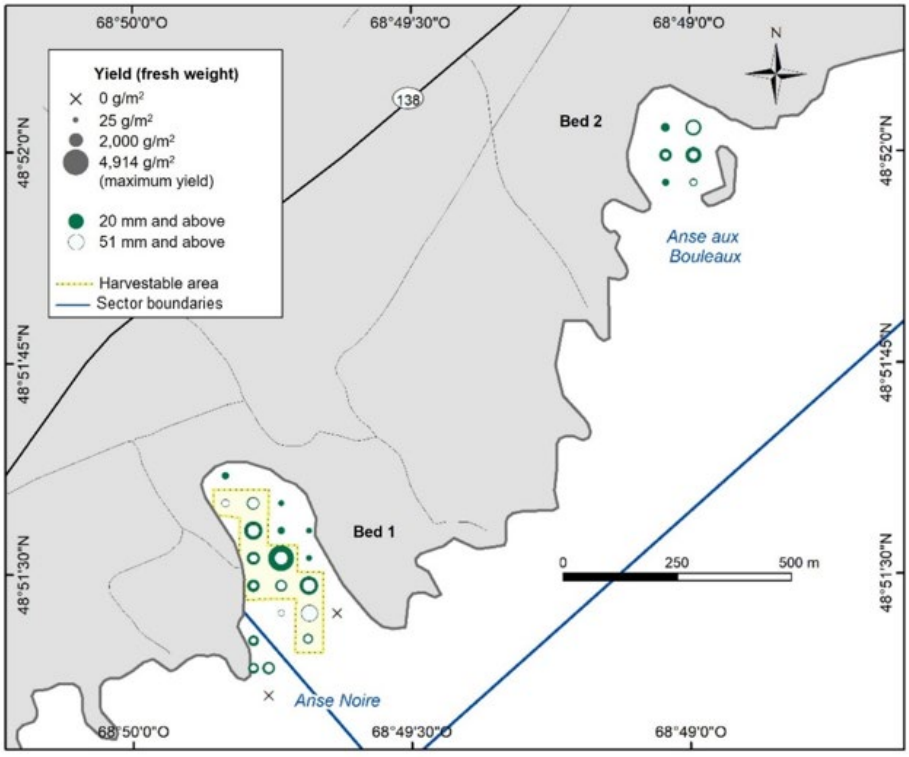

Figure 60. Soft-shell clam yield by size class and by station in Anse Noire shellfish area (N-04.5.1) on the Upper North Shore surveyed in 2018.

The harvestable area of the two beds is estimated at only 0.04 km^2 (10 stations) and is found exclusively on Bed 1, located in Anse Noire (Table 4 and Figure 60). For the bed located in Anse aux Bouleaux, only two stations have a density of clams ≥ 51 mm greater than 16 clams/m^2. The average density of clams ≥ 51 mm is 40.4 clams/m^2, and the average yield is 1,098 g/m^2 over the harvestable area. The harvestable biomass is estimated at 44 t. Despite interesting yields, the harvestable biomass is among the lowest values observed during the 2016–2020 surveys, mainly due to the small harvestable area of this bed.

In total, 807 clams were measured (Table 5). Size range from 15 to 71 mm. The average size of clams ≥ 20 mm is 40 mm. The size structure shows two main modes, located between 36 and 49 mm (Figure 6).

Ten sediment samples were collected during the survey, all of which were found in the beds (Figure 61 and Table 1). The grain size analyses show that the sediments are mostly made up of sandy mud (Figure 61 and Table 6). However, the visual assessment shows a dominance of muddy sand and mud. The types of sediment present in these beds are muddy sand (31%), sandy mud (23%), mud (15%), sand (11%), gravelly sand (11%) and mixed sediment (8%). Muddy sediments are found mainly on Bed 2 in Anse aux Bouleaux, while sandy sediments are found mainly on Bed 1 in Anse Noire.

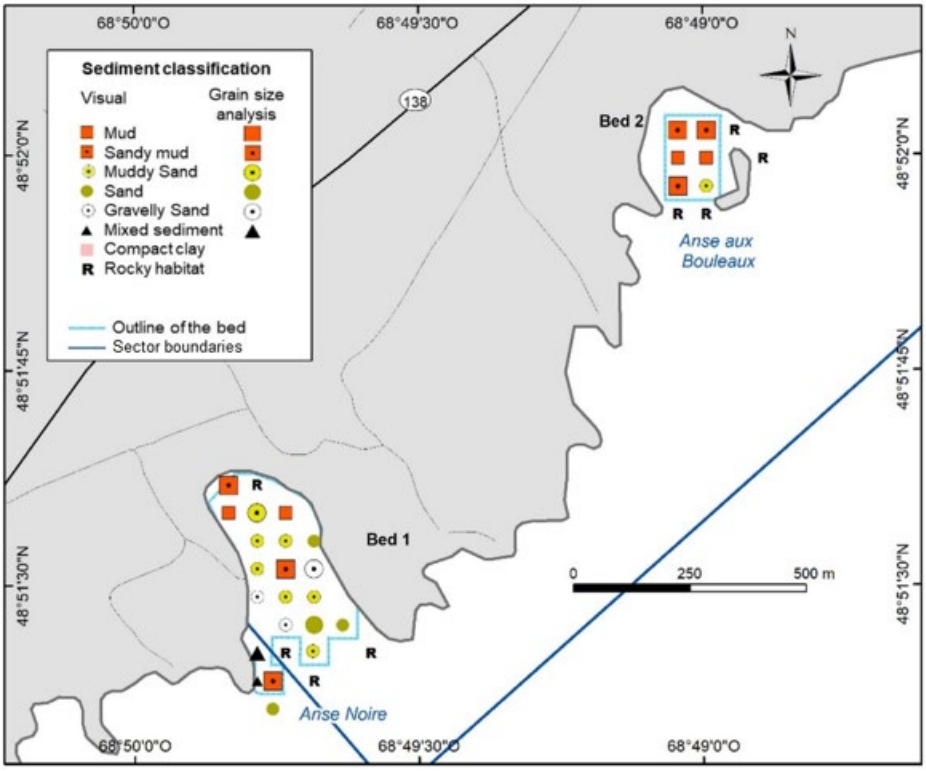

Figure 61. Sediment classification (grain size analysis and visual assessment) by station in Anse Noire shellfish area (N-04.5.1) on the Upper North Shore surveyed in 2018.

Îlets Jérémie, area N-04.5.2

Îlets Jérémie is a vast area that follows Anse Noire (Figure 2). Only the east part of Baie des Îlets Jérémie was surveyed. This area was sampled over 5 days in October and November 2017. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8T). There were 174 stations in the sampling plan, 97 of which were sampled. Most of the stations that could not be sampled were located in the northern part of the bay at the mouth of the river. This

area is rather swampy, and clams are found almost exclusively in the channels. Forty-seven stations did not have suitable clam habitat, 21 stations were located on the beach (some on land), eight stations were too deep, and finally one station had rocky habitat.

The area of the bed is estimated at 0.42 km^2 and includes 74 stations (Table 3 and Figure 62). Three stations without clams were retained in the delineation of the bed. The northern portion is sparser, and the bed includes only stations with clams. The average density of clams ≥ 20 mm is 174.3 clams/m^2, with a maximum density of 1,618 clams/m^2 (Figure 62 and Table 3). The density of clams 20–50 mm is 120.3 clams/m^2, and that of clams ≥ 51 mm is 54.0 clams/m^2. The average yield of clams 20–50 mm is 727 g/m^2, and that of legal-size clams reaches 1,452 g/m^2 (Figure 63 and Table 3). The maximum yield of clams ≥ 20 mm is 12,163 g/m^2 for this bed. The average density and yield of clams ≥ 51 mm and the maximum density and yield are among the highest values observed during the 2016–2020 surveys. Clams 20–50 mm are found throughout, but high densities are mainly on the southern part of the bed and at a few stations to the north. Clams ≥ 51 mm are distributed throughout, but the highest densities and yields are found in the southern and northern parts of the bed.

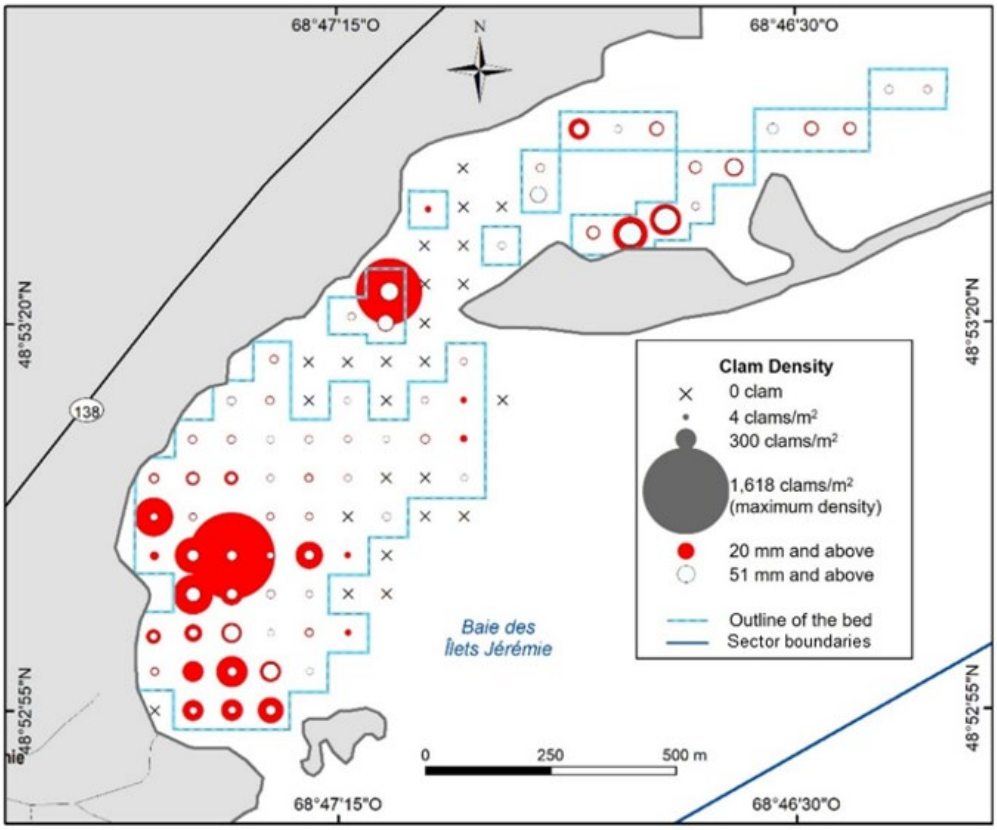

Figure 62. Soft-shell clam density by size class and by station in Îlets Jérémie shellfish area (N-04.5.2) on the Upper North Shore surveyed in 2017.

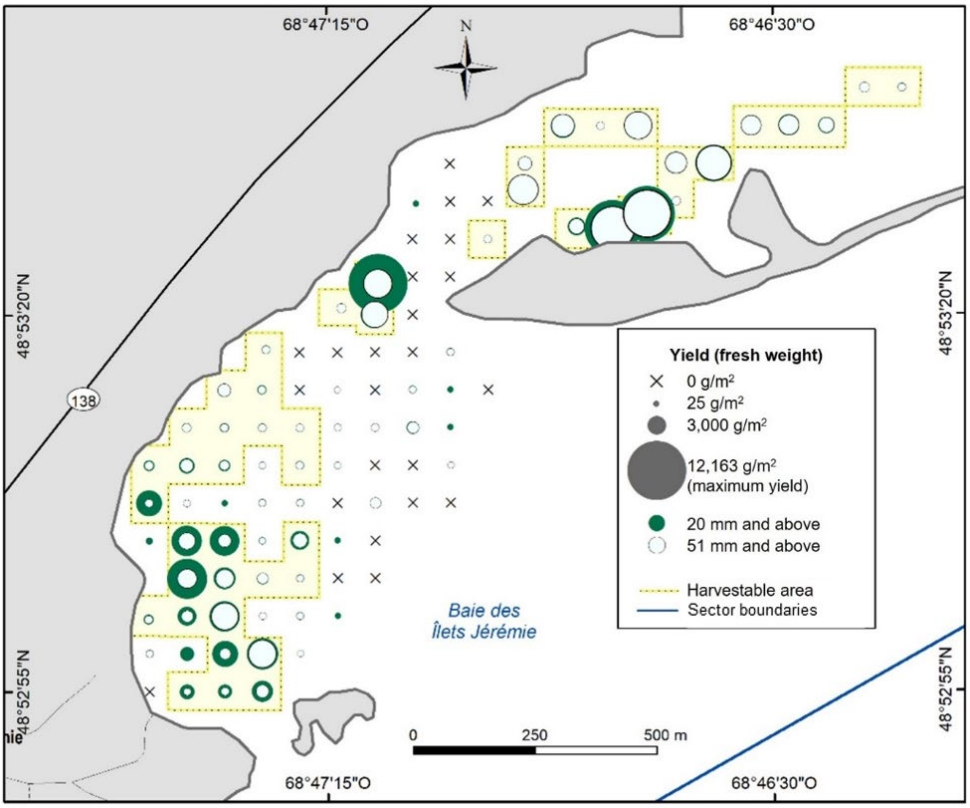

Figure 63. Soft-shell clam yield by size class and by station in Îlets Jérémie shellfish area (N-04.5.2) on the Upper North Shore surveyed in 2017.

The harvestable area of Îlets Jérémie bed is estimated at 0.26 km^2 and includes 47 stations (Table 4 and Figure 63). The average density of clams ≥ 51 mm is 81.2 clams/m^2, and the average yield is 2,172 g/m^2 for the entire harvestable area. These values are among the highest obtained in 2016–2020. The harvestable biomass is estimated at 565 t.

In total, 3,385 clams were measured, with size ranging from 14 to 86 mm (Table 5). The average size of clams ≥ 20 mm is 42 mm. The size structure shows a first mode around 21–26 mm and a second, smaller mode around 4,652 mm (Figure 6).

Twenty-one sediment samples were collected during the survey, 18 of which were located in the bed (Figure 64 and Table 1). The grain size analyses show that the sediments consist mainly of sand and muddy sand in the bed (Figure 64 and Table 6). The visual assessment shows a marked dominance of sand, along with mud, muddy sand and sandy mud. The types of sediment present in this bed are sand (66%), muddy sand (13%), mud (10%), sandy mud (7%) and gravelly sand (4%). The muddy sediments are found at the southwest and northeast ends of the bed.

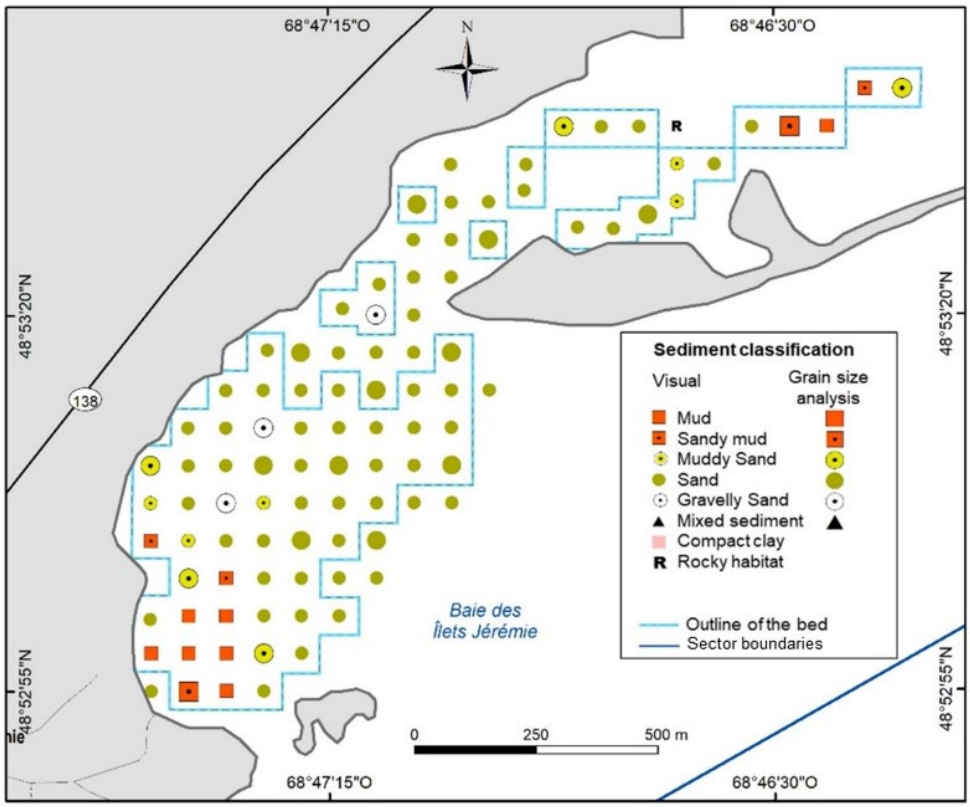

Figure 64. Sediment classification (grain size analysis and visual assessment) by station in Îlets Jérémie shellfish area (N-04.5.2) on the Upper North Shore surveyed in 2017.

Réserve Pessamit Sud, area N-05.1.3.1

Réserve Pessamit Sud is located at the mouth of Rivière Betsiamites, near the municipality of Pessamit (Figure 2 and Appendix 8U). Sampling was conducted over 3 days in August and October 2018. The first survey was done in 2005 and was repeated in 2010 and 2014. During these surveys, two sampling grids were used. The same sampling design was repeated for the 2018 survey (Table 1 and Appendix 8U). First, a wider grid of 150 m by 150 m covered the entire portion to be surveyed. Then, a smaller grid of 105 m by 105 m was applied in the most interesting area of the bed. All 113 stations in the sampling plan were sampled. The northern part of the area was not surveyed in 2018. However, half of this part was covered during the 2005 survey (Giguère et al. 2008), and the other portion was covered in 2019 (data not shown). Despite the presence of clams in this northern portion, the commercially harvested bed is located in the portion surveyed in 2010 and 2014, and the same sampling plan was repeated in 2018.

The area of the bed is estimated at 1.43 km^2 and includes 108 of the sampled stations (Table 3 and Figure 65). The area of the bed was delineated based on the 2005, 2010, 2014 and 2018 surveys, which is why several stations without clams were retained in the delineation of the bed, including a few in the periphery. The average density of clams ≥ 20 mm is 73.4 clams/m^2, with a maximum density of 616 clams/m^2 (Figure 65 and Table 3). The density of clams 20–50 mm is 24.2 clams/m^2, and that of clams ≥ 51 mm is higher with 49.2 clams/m^2. The average yield of clams 20–50 mm is 152 g/m^2, and that of legal-size clams reaches 1,744 g/m^2 (Figure 66 and Table 3). The maximum yield of clams ≥ 20 mm is 12,686 g/m^2 for this bed. The average density and yield of clams ≥ 51 mm and the maximum yield are among the highest values obtained

during the 2016–2020 surveys. Both clam size classes are found throughout the bed. Densities and yields of clams ≥ 51 mm are highest in the southern half of the bed.

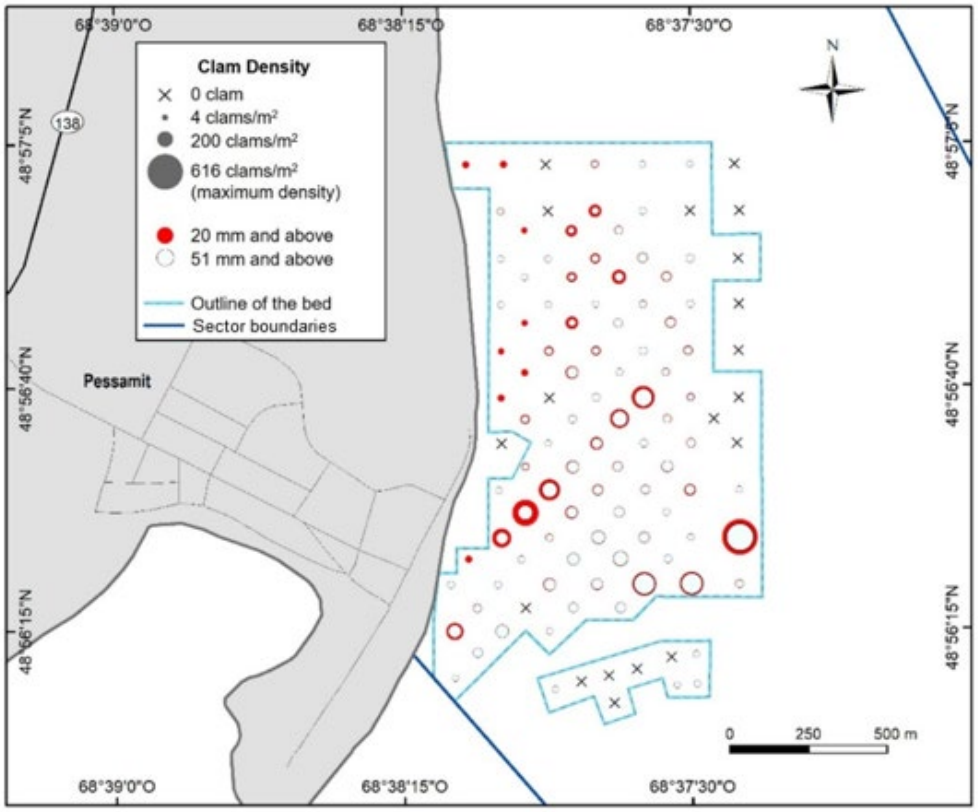

Figure 65. Soft-shell clam density by size class and by station in Réserve Pessamit Sud shellfish area (N-05.1.3.1) on the Upper North Shore surveyed in 2018.

The harvestable area of Réserve Pessamit Sud was estimated at 0.88 km^2 in 2018 and includes 69 stations (Table 4 and Figure 66). This is the second largest value for the 2016–2020 surveys. The average density of clams ≥ 51 mm is 78.9 clams/m^2, and the average yield is 2,789 g/m^2 for the entire harvestable area. Both values are among the highest in the 2016–2020 surveys. The harvestable biomass is estimated at 2,454 t. Given the large area and the high yield of legal-size clams, the biomass is the second highest value in the 2016–2020 surveys.

In total, 2,034 clams were measured (Table 5). Clam size ranged from 17 to 99 mm. The average size of clams ≥ 20 mm is high, at 55 mm. The size structure shows a primary mode around 60–64 mm, with a secondary mode at 32–35 mm (Figure 6). In contrast to the vast majority of beds surveyed in 2016–2020, densities of legal-size clams are higher than those of clams 20–50 mm.

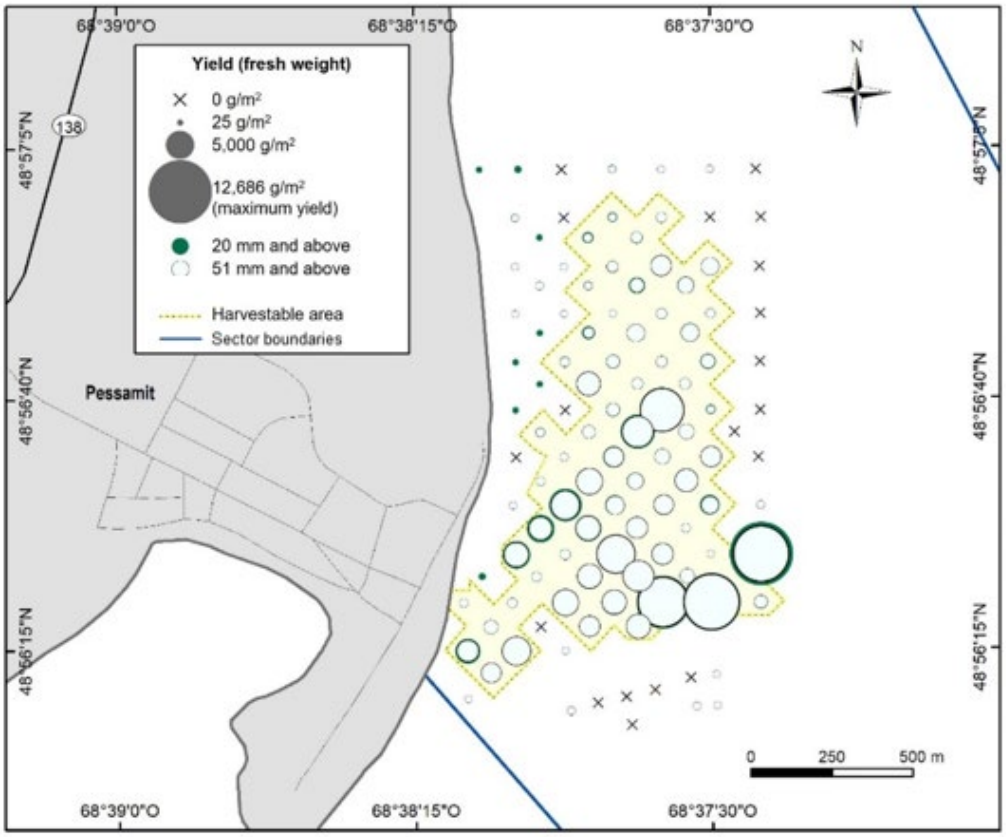

Figure 66. Soft-shell clam yield by size class and by station in Réserve Pessamit Sud shellfish area (N-05.1.3.1) on the Upper North Shore surveyed in 2018.

No grain size analysis was carried out in 2018, since this bed was previously surveyed and, in 2010, 54 samples were collected and analyzed, including 52 in the bed (Appendix 7). At that time, the sediments were composed mainly of sand (48%) and gravelly sand (44%) (Appendices 9 and 13). In 2018, the percentages obtained with the visual assessment were slightly different, with a dominance of sand (95%), along with some sandy mud, gravelly sand and muddy sand (Table 6 and Figure 67).

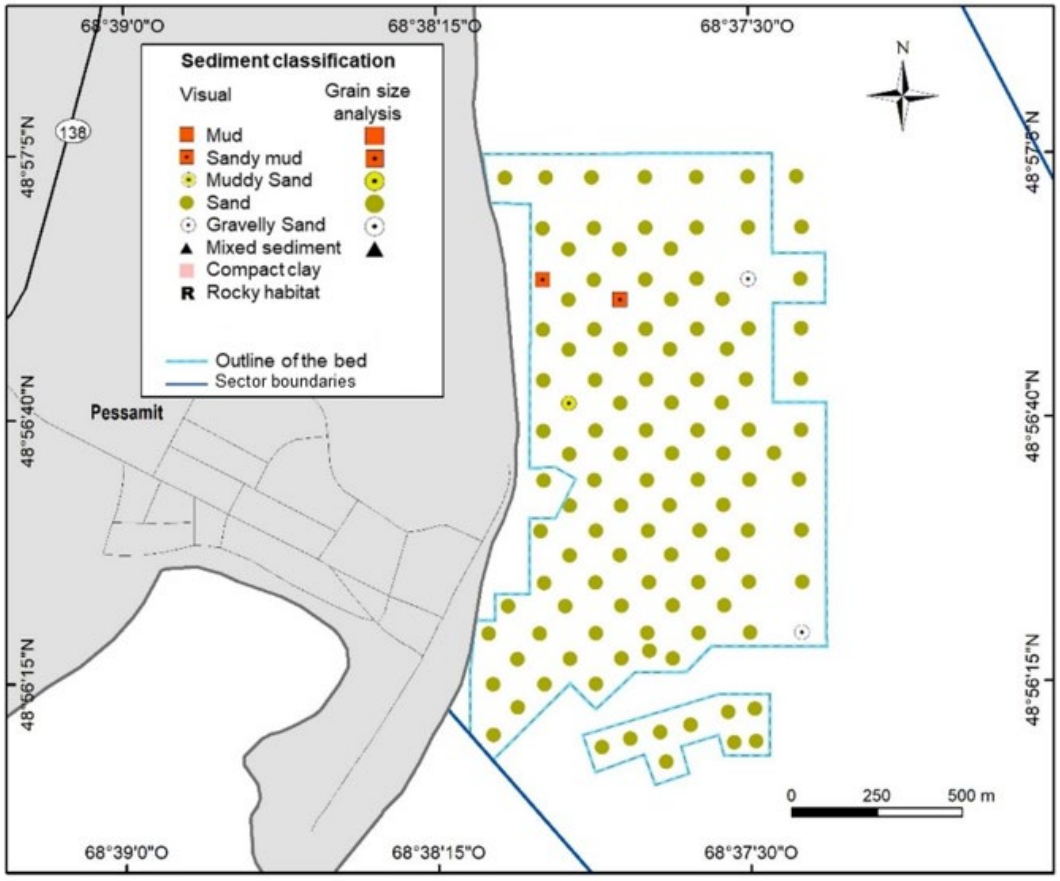

Figure 67. Sediment classification (visual assessment) by station in Réserve Pessamit Sud shellfish area (N-05.1.3.1) on the Upper North Shore surveyed in 2018.

Réserve Pessamit Nord, area N-05.1.3.2

Réserve Pessamit Nord is located just north of Réserve Pessamit Sud, in Baie aux Outardes (Figure 2 and Appendix 8V). This area was surveyed over 11 days in August, September and October 2019. Two sampling grids were (Table 1 and Appendix 8V). First, a wider grid of 150 m by 150 m was used to cover the entire area. Then, a smaller grid of 75 m by 75 m was applied in the most interesting areas. Of the 311 stations planned, 284 were sampled. The majority of the stations not sampled were too deep (20 stations). There were also four stations with rocky habitat and three stations with compacted clay sediment.

The clam bed is mainly located in the north-central portion of the area. The distribution of clams in the southern portion of the area is sparser. The area of the bed is estimated at 1.34 km^2 and includes 178 stations (Table 3 and Figure 68). Exceptionally for this area, the sieve used had a 6 mm mesh size, which means that 35 stations included in the delineation of the bed only have clams under 20 mm. In addition, 12 stations without clams were retained, one of which is a rocky habitat. In the southern portion, the bed includes only stations with clams. The average density of clams ≥ 20 mm is only 17.0 clams/m^2, with a maximum density of 318 clams/m^2 (Figure 68 and Table 3). The density of clams 20–50 mm is 11.0 clams/m^2, and that of clams ≥ 51 mm is 6.0 clams/m^2. The average yield of clams 20–50 mm is 52 g/m^2, and that of legal-size clams is 203 g/m^2 (Figure 69 and Table 3). The maximum yield of clams ≥ 20 mm is 4,993 g/m^2 for this bed. The density of clams ≥ 51 mm and the yield of clams 20-50 mm are among the lowest values during the 2016–2020 surveys. Clams 20-50 mm are found throughout

the bed, but the highest densities are observed at the northernmost part of the bed. Clams ≥ 51 mm are found almost everywhere, but more sparsely.

The harvestable area of Réserve Pessamit Nord is estimated at only 0.10 km^2 and includes 17 stations (Table 4 and Figure 69). There are three small harvestable areas, two in the north and one in the south. The average density of clams ≥ 51 mm is 54.2 clams/m^2, and the average yield is 1,514 g/m^2 for the entire harvestable area. The harvestable biomass is estimated at only 151 t.

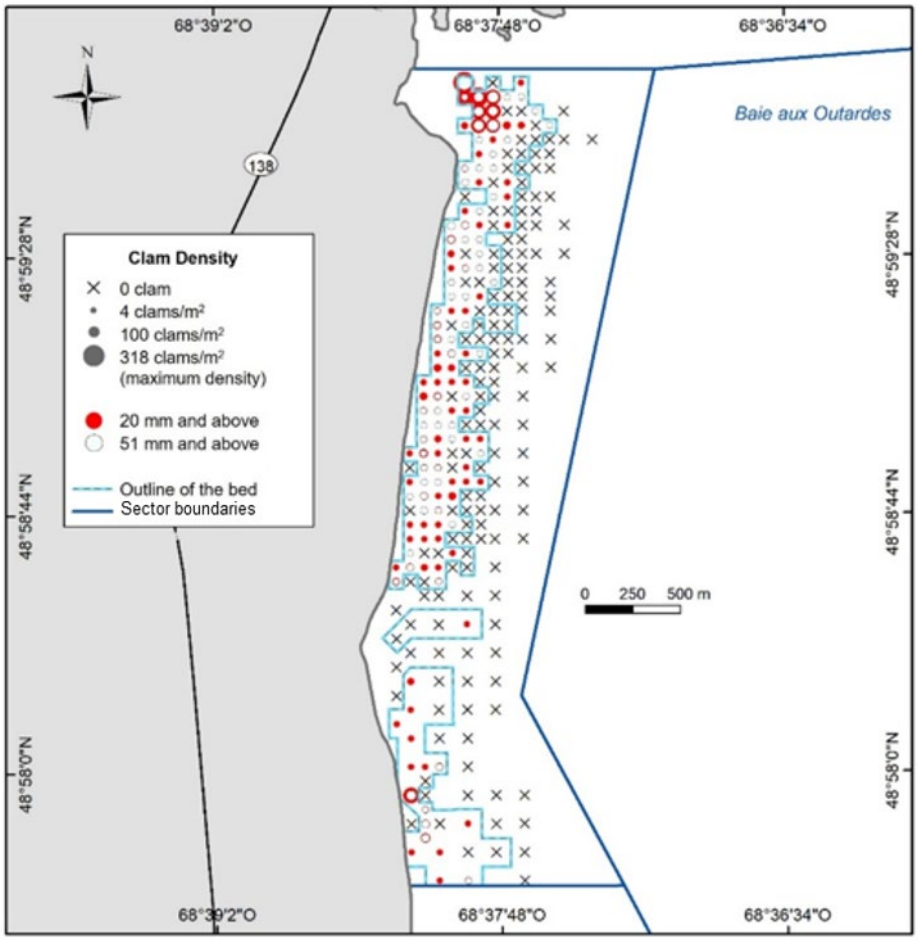

Figure 68. Soft-shell clam density by size class and by station in Réserve Pessamit Nord shellfish area (N-05.1.3.2) on the Upper North Shore surveyed in 2019.

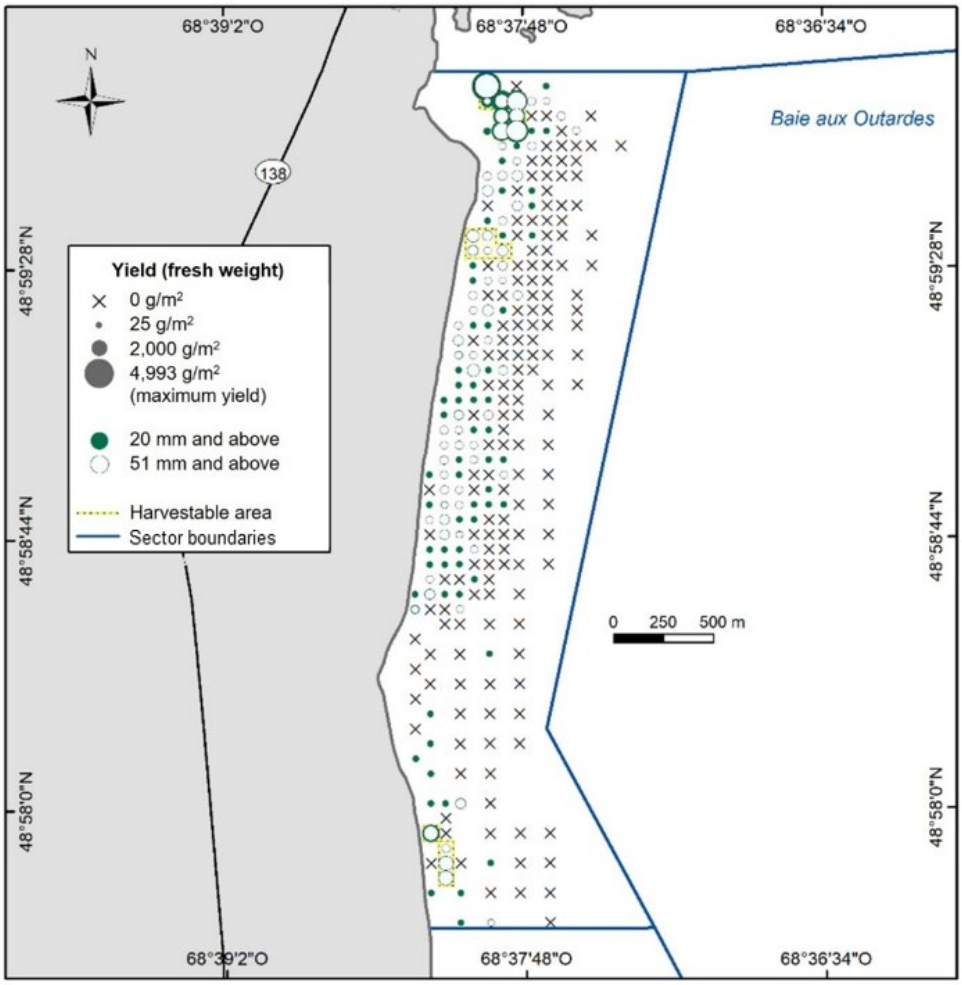

Figure 69. Soft-shell clam yield by size class and by station in Réserve Pessamit Nord shellfish area (N-05.1.3.2) on the Upper North Shore surveyed in 2019.

In total, 1,689 clams were measured (Table 5). The size of these clams ranged from 9 to 104 mm. The average size of clams ≥ 20 mm is 43 mm. The size structure shows a mode around 11–18 mm because of the mesh size used (Figure 6).

Fifty-five sediment samples were collected during the survey, 38 of which were located in the bed (Figure 70 and Table 1). The grain size analyses show that the sediments consist almost exclusively of sand (Figure 70 and Table 6). The visual assessment also shows a marked dominance of sand, along with muddy sand, sandy mud and some mud. The types of sediment present in this bed are sand (85%), muddy sand (8%), sandy mud (6%) and mud (1%). Sand dominates over the entire bed, and the few observations of muddy sediments are found mainly in the northern portion of the bed.

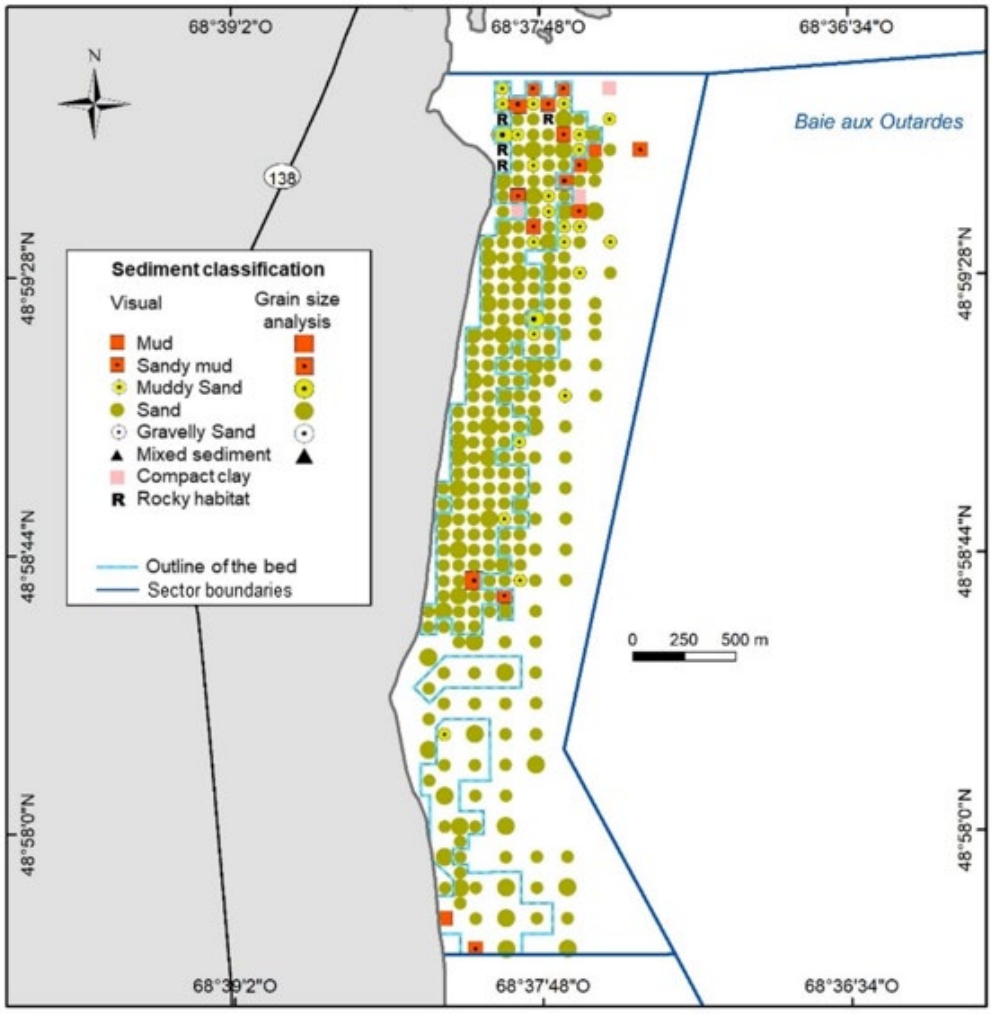

Figure 70. Sediment classification (grain size analysis and visual assessment) by station in Réserve Pessamit Nord shellfish area (N-05.1.3.2) on the Upper North Shore surveyed in 2019.

Pointe-aux-Outardes Ouest, area N-06.1.1

Pointe-aux-Outardes Ouest area is located at the outlet of Rivière aux Outardes, opposite the municipality of Pointe-aux-Outardes (Figure 2 and Appendix 8W). This entire area was surveyed over 15 days in August, September and October 2017 and in May and June 2018. The majority of the stations were surveyed in 2017. A sampling grid of 150 m by 190 m was used (Table 1 and Appendix 8W). Of the 249 stations in the sampling plan, 242 were sampled. Five stations had compacted clay sediment, and the other two were too deep.

The area of the bed is estimated at 5.99 km^2 and includes 206 stations (Table 3 and Figure 71). This is the largest clam bed surveyed to date on the Upper North Shore. This bed was first surveyed in 2003 (6 mm mesh size). The delineation of the bed therefore considers the results obtained during the two surveys. This explains why 44 stations without clams were kept in the delineation of this bed. Some of these are located in the periphery, including four stations with compact clay that were not sampled. In addition, one station with clams < 20 mm was retained in the delineation of the bed. The average density of clams ≥ 20 mm is 27.8 clams/m^2, with a maximum density of 480 clams/m^2 (Figure 71 and Table 3). The density of clams 20-50 mm is

only 8.8 clams/m^2, and that of clams ≥ 51 mm is 19.0 clams/m^2. The average yield of clams 20–50 mm is 44 g/m^2, and that of legal-size clams is 848 g/m^2 (Figure 72 and Table 3). The maximum yield of clams ≥ 20 mm is 6,470 g/m^2 for this bed. The average density and yield of clams 20–50 mm are among the lowest values observed during the 2016–2020 surveys. Clams 20–50 mm are found mostly in the southwest and east of the bed, while clams ≥ 51 mm are distributed throughout.

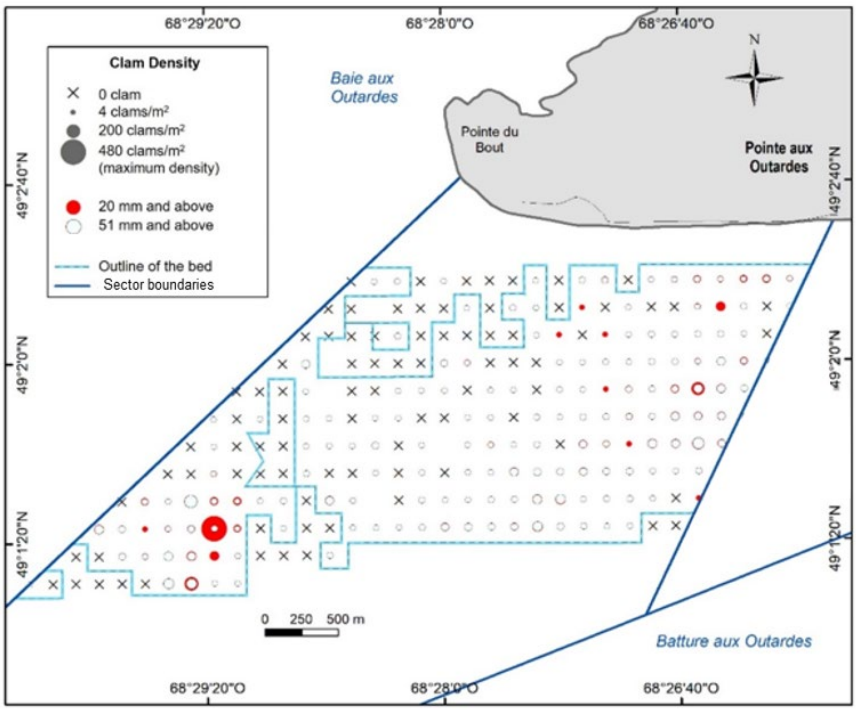

Figure 71. Soft-shell clam density by size class and by station in Pointe-aux-Outardes Ouest shellfish area (N-06.1.1) on the Upper North Shore surveyed in 2017.

The harvestable area of the Pointe-aux-Outardes Ouest bed is estimated at 2.37 km^2 (83 stations), which is nearly half of the bed area (Table 4 and Figure 72). This is the largest harvestable area among the 2016–2020 surveys. The average density of clams ≥ 51 mm is 38.3 clams/m^2, and the average yield is 1,537 g/m^2 for the entire harvestable area. Given the large harvestable area of this bed, the harvestable biomass reaches 3,643 t, which is the highest value obtained among the 2016–2020 surveys.

In total, 1,477 clams were measured . Clam size ranged from 9 to 105 mm (Table 5). The largest clam was collected from this bed. The average size of clams ≥ 20 mm is at 57 mm, which is among the largest sizes obtained during the 2016–2020 surveys. The size structure shows a mode around 22–27 mm and a broad plateau at 54–76 mm (Figure 6).

Fifty sediment samples were collected during the survey, including 42 from the bed (Figure 73 and Table 1). The grain size analyses show that all types of sediment were observed on this bed, but gravelly sand dominates (Figure 73 and Table 6). The visual assessment shows a marked predominance of sand, along with mainly gravelly sand and mud. The types of sediment present in this bed are sand (64%), gravelly sand (18%), mud (7%), muddy sand (4%), sandy mud (3%) and mixed sediment (3%). Muddy sediment is found almost exclusively in the northwestern part of the bed.

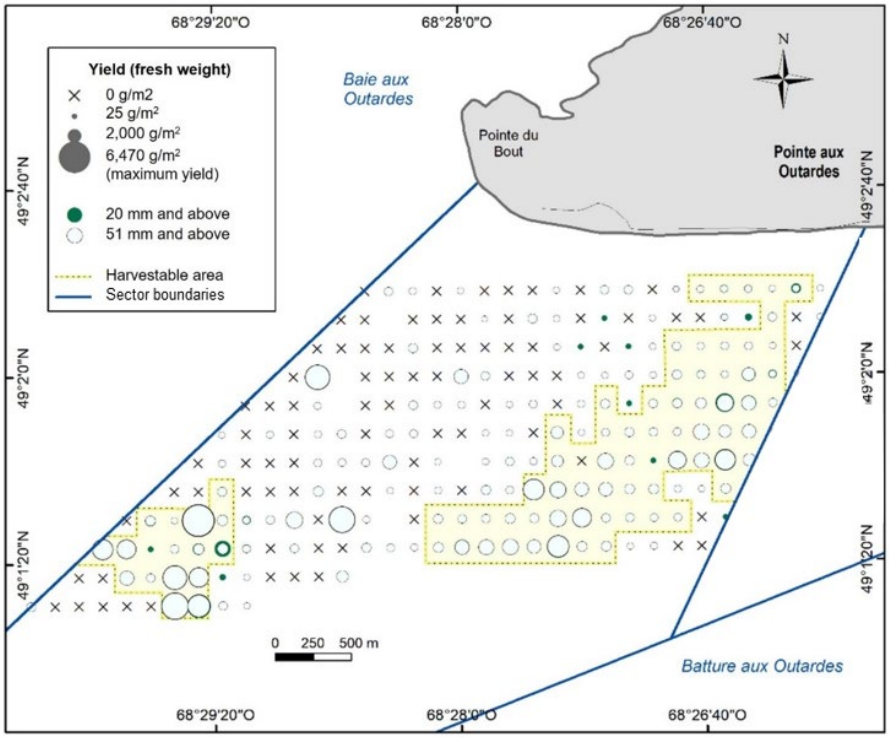

Figure 72. Soft-shell clam yield by size class and by station in Pointe-aux-Outardes Ouest shellfish area (N-06.1.1) on the Upper North Shore surveyed in 2017.

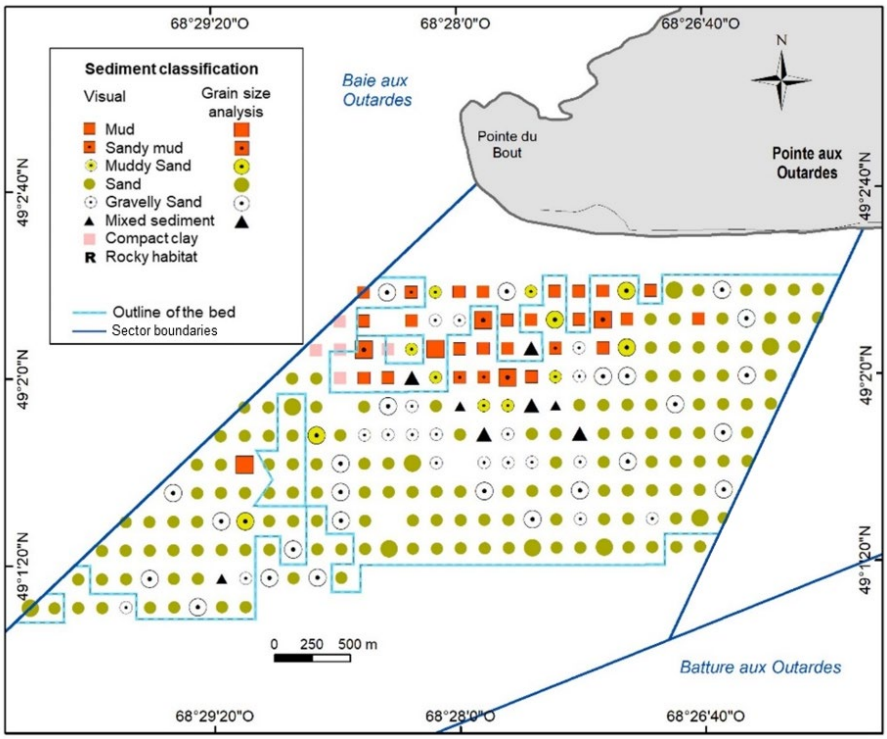

Figure 73. Sediment classification (grain size analysis and visual assessment) by station in Pointe-aux-Outardes Ouest shellfish area (N-06.1.1) on the Upper North Shore surveyed in 2017.

Pointe-aux-Outardes Est, area N-06.1.2

Pointe-aux-Outardes Est follows Pointe-aux-Outardes Ouest area (Figure 2 and Appendix 8X). This bed was examined separately since it is located in another shellfish area, but in fact there is only one clam bed that overlaps the two areas. The Pointe-aux-Outardes Est bed covers the central-eastern part of Batture aux Outardes. This area was surveyed in its entirety over 10 days in August, September and October 2018 and in May 2019. The majority of the stations were surveyed in 2018. A sampling grid of 150 m by 190 m was used (Table 1 and Appendix 8X). Of the 162 stations in the sampling plan, 143 were sampled. The 19 stations not sampled were all too deep.

The area of the bed is estimated at 1.82 km^2 and includes 63 stations (Table 3 and Figure 74). This bed was first surveyed in 2004 (6 mm mesh size). The delineation of the bed considers the results obtained during the two surveys. This explains why 24 stations without clams were kept in the delineation of this bed, mainly located at the eastern edge of the bed, along with one station with only clams < 20 mm. The average density of clams ≥ 20 mm is 9.8 clams/m^2, with a maximum density of 76 clams/m^2 (Figure 74 and Table 3). The density of clams 20-50 mm is only 2.8 clams/m^2, and that of clams ≥ 51 mm is 7.0 clams/m^2. The average yield of clams 20–50 mm is 29 g/m^2, and that of legal-size clams is 226 g/m^2 (Figure 75 and Table 3). The maximum yield of clams ≥ 20 mm is 2,109 g/m^2 for this bed. The average density and yield of clams 20–50 mm are among the lowest values observed during the 2016–2020 surveys. Clams 20–50 mm are found mostly in the northern part of the bed, while clams ≥ 51 mm are distributed throughout.

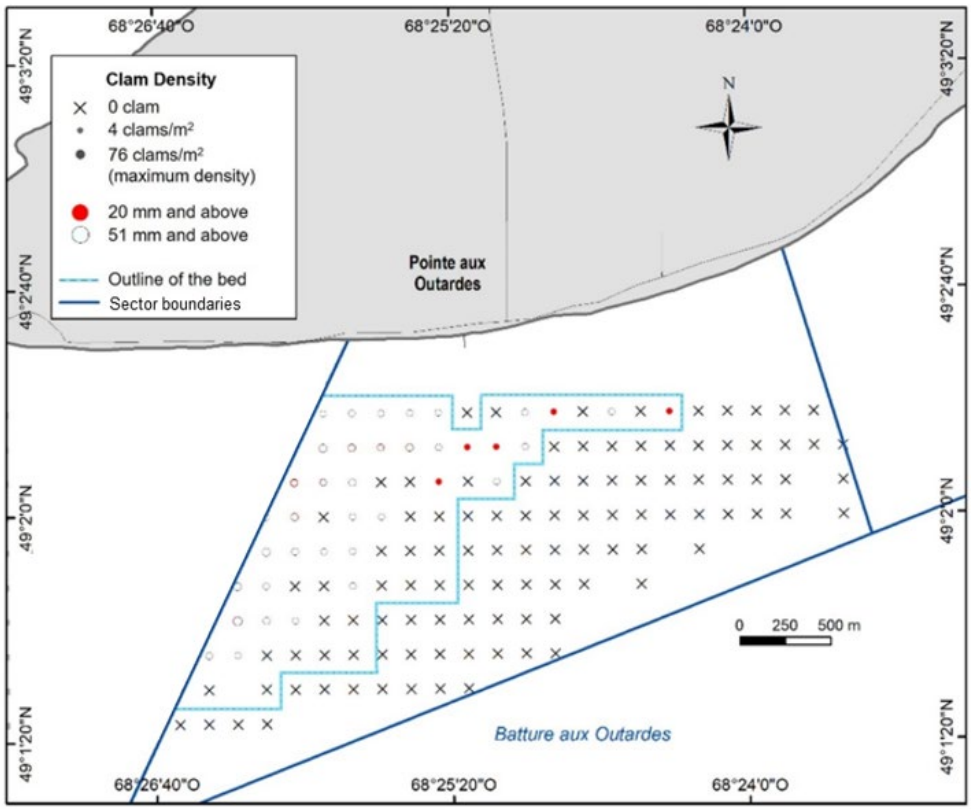

Figure 74. Soft-shell clam density by size class and by station in Pointe-aux-Outardes Est shellfish area (N-06.1.2) on the Upper North Shore surveyed in 2018.

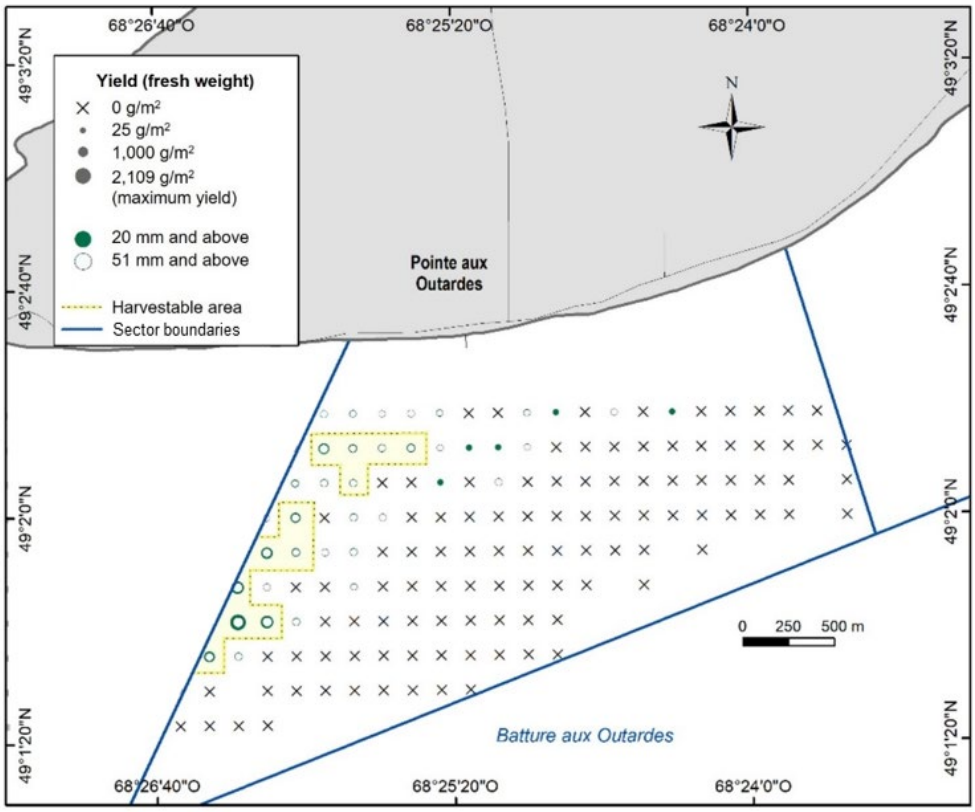

Figure 75. Soft-shell clam yield by size class and by station in Pointe-aux-Outardes Est shellfish area (N-06.1.2) on the Upper North Shore surveyed in 2018.

The harvestable area of the Pointe-aux-Outardes Est is estimated at only 0.34 km^2 (12 stations), which is a small proportion of the total bed area (Table 4 and Figure 75). The average density of clams ≥ 51 mm is 26.2 clams/m^2, and the average yield is 876 g/m^2 for the entire harvestable area. These values are among the lowest obtained during the 2016–2020 surveys. The harvestable biomass is estimated at only 298 t.

In total, 160 clams were measured (Table 5). The size ranged from 8 to 95 mm. The average size of clams ≥ 20 mm is very high at 58 mm, which is the largest value obtained during the 2016–2020 surveys. The size structure shows a weak plateau around 57–64 mm (Figure 6).

Of the 26 sediment samples collected during the survey, only 10 were in the bed (Figure 76 and Table 1). The grain size analyses show that gravelly sand and sand dominate, along with some mixed sediment (Figure 76 and Table 6). The visual assessment almost exclusively shows sand. The sediment types present on this bed are sand (89%), gravelly sand (9%) and mixed sediment (2%). The more gravelly sediments are found mainly at the western limit of the bed.

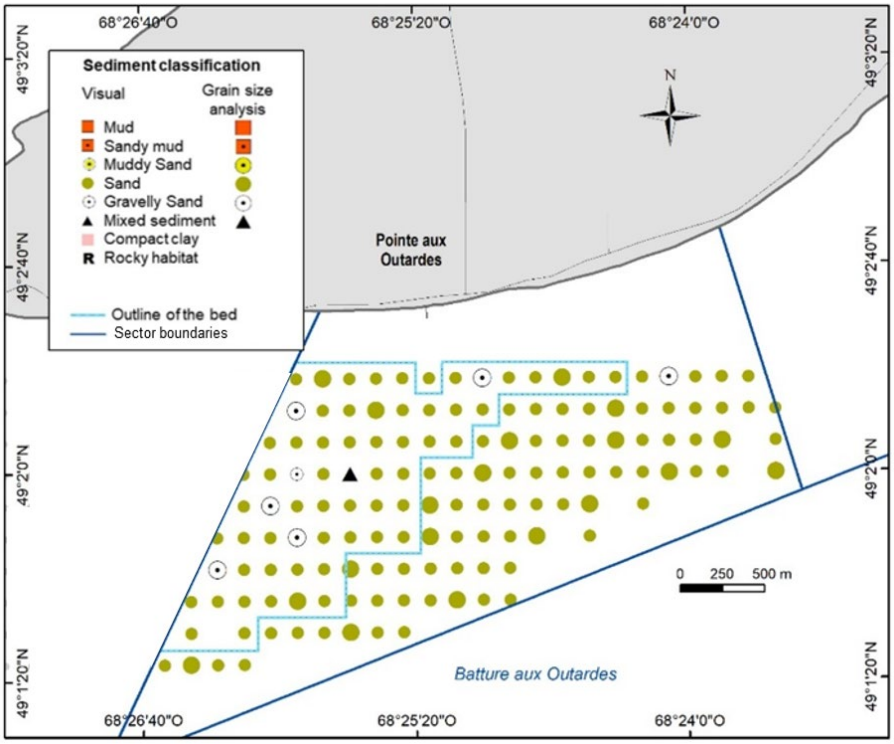

Figure 76. Sediment classification (grain size analysis and visual assessment) by station in Pointe-aux-Outardes Est shellfish area (N-06.1.2) on the Upper North Shore surveyed in 2018.

Pointe Paradis, area N-06.3

To the east of Batture aux Outardes is Batture de Manicouagan, part of which is covered by the Pointe Paradis shellfish area (Figure 2 and Appendix 8Y). This is a large area, of which only the western part, located at Anse à la Peinture, was surveyed. Sampling was conducted over 7 days in July, August and September 2019. A sampling grid of 125 m by 125 m was used (Table 1 and Appendix 8Y). Of the 206 stations in the sampling plan, 198 were sampled. There were four stations that were too deep, three stations located on the beach, and one station with a significant proportion of eelgrass. A more central area was not sampled, possibly because it was too deep.

The area of the bed is estimated at 1.48 km^2 and includes 95 of the sampled stations (Table 3 and Figure 77). This bed is one of the largest surveyed from 2016 to 2020. The clam bed is mainly located in the northern portion, and the distribution of clams in the southern portion is sparser. The delineation of the bed retained 10 stations with no clams and eight stations with only clams < 20 mm, mostly located at the edge of the bed. In the southern portion, the bed includes only stations with clams. The average density of clams ≥ 20 mm is only 18.6 clams/m^2, with a maximum density of 136 clams/m^2 (Figure 77 and Table 3). The density of clams 20–50 mm is 15.6 clams/m^2, and that of clams ≥ 51 mm is only 3.0 clams/m^2. The average yield of clams 20–50 mm is 79 g/m^2, and that of legal-size clams is 84 g/m^2 (Figure 78 and Table 3). The maximum yield of clams ≥ 20 mm is 772 g/m^2 for this bed. The density and yield of clams ≥ 51 mm, as well as the maximum yield, are among the lowest values obtained during the 2016–2020 surveys. Clams 20–50 mm are found mainly on the northern part of the bed, while clams ≥ 51 mm are distributed throughout.

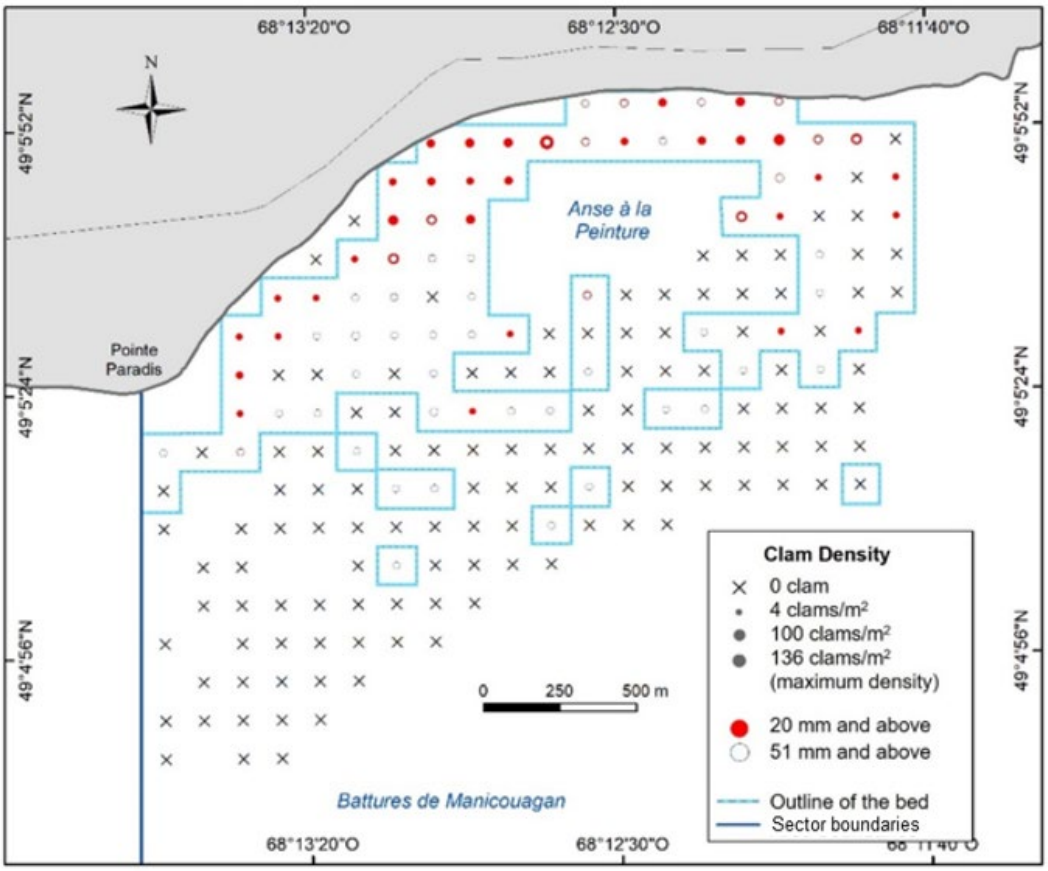

Figure 77. Soft-shell clam density by size class and by station in Pointe Paradis shellfish area (N-06.3) on the Upper North Shore surveyed in 2019.

There is no harvestable area on the Pointe Paradis (Table 4 and Figure 78). Only three stations have a density of clams ≥ 51 mm greater than 16 clams/m^2 and these stations are scattered over the bed.

In total, 474 clams were measured (Table 5). The size ranged from 12 to 94 mm. The average size of clams ≥ 20 mm is 38 mm. The size structure shows a weak plateau around 21–31 mm (Figure 6).

In total, 40 sediment samples were collected during the survey, of which only 21 were located in the bed (Figure 79 and Table 1). The grain size analyses show that the sediments consist mainly of sand and muddy sand, with some sandy mud and gravelly sand (Figure 79 and Table 6). The visual assessment shows the same trends, with the addition of some mud. The sediment types present in this bed are 62% sand, 27% muddy sand, 6% sandy mud, 3% gravelly sand and 1% mud. The muddier sediments (mud, sandy mud and muddy sand) are found throughout the bed, but mostly in the north.

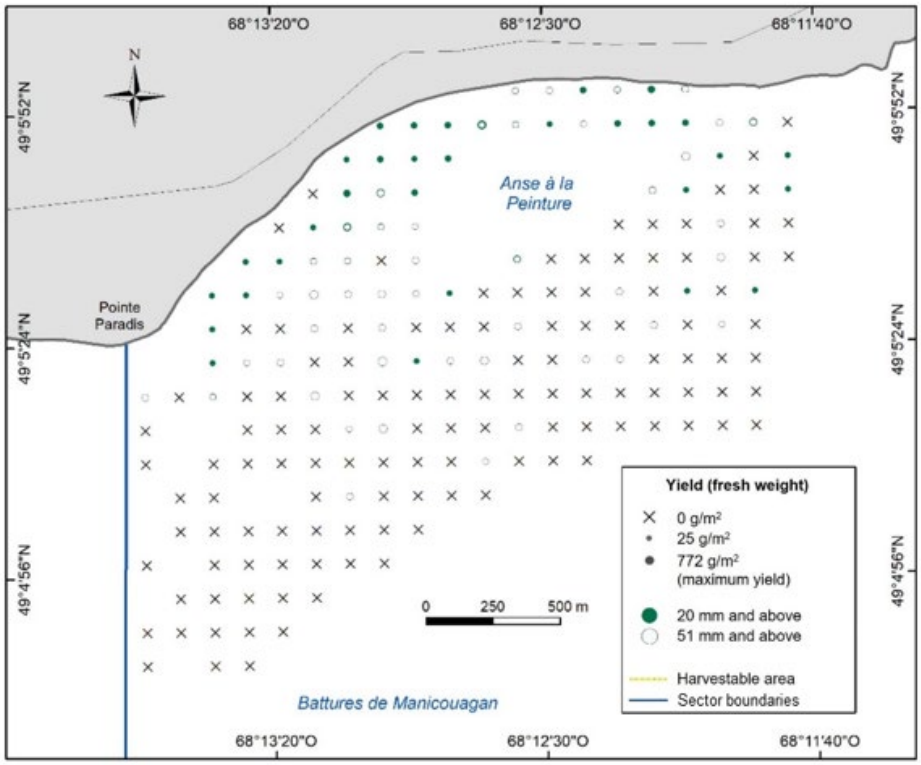

Figure 78. Soft-shell clam yield by size class and by station in Pointe Paradis shellfish area (N–06.3) on the Upper North Shore surveyed in 2019.

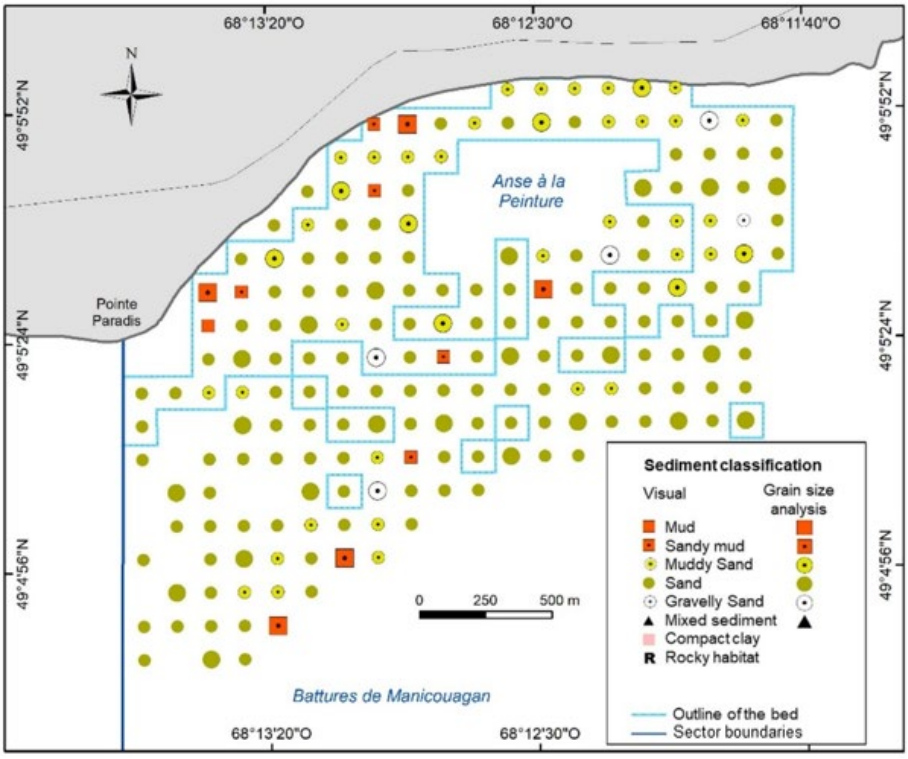

Figure 79. Sediment classification (grain size analysis and visual assessment) by station in Pointe Paradis shellfish area (N-06.3) on the Upper North Shore surveyed in 2019.

Rivière Mistassini, area N-08.1.3

Rivière Mistassini is located further east, in the Rivière Mistassini estuary, near the municipality of Mistassini (Figure 2 and Appendix 8Z). The mouth of the river is divided in two by a portion of land, creating a small bay to the west. This area was surveyed over 3 days in July 2018. A sampling grid 75 m by 75 m was used (Table 1 and Appendix 8Z). In total, 83 stations were included in the sampling plan, of which 74 were sampled. There were five stations that had rocky habitat, two stations located on the beach and two stations that were too deep.

The area of the bed is estimated at 0.37 km^2 and includes 66 stations (Table 3 and Figure 80). Two stations without clams with rocky habitat (not sampled) were retained in the delineation of the bed. The average density of clams ≥ 20 mm is 58.5 clams/m^2, with a maximum density of 562 clams/m^2 (Figure 80 and Table 3). The density of clams 20–50 mm is 40.0 clams/m^2, and that of clams ≥ 51 mm is lower, with 18.5 clams/m^2. The average yield of clams 20–50 mm is 317 g/m^2, and that of legal-size clams is 562 g/m^2 (Figure 81 and Table 3). The maximum yield of clams ≥ 20 mm is 6,327 g/m^2. Clams 20–50 mm are less abundant in the southern part of the bed, while clams ≥ 51 mm are found almost everywhere.

The harvestable area is estimated at 0.17 km^2 and includes 31 stations (Table 4 and Figure 81). The average density of clams ≥ 51 mm is 35.3 clams/m^2, and the average yield is 1,086 g/m^2 for the entire harvestable area. The harvestable biomass is estimated at 185 t.

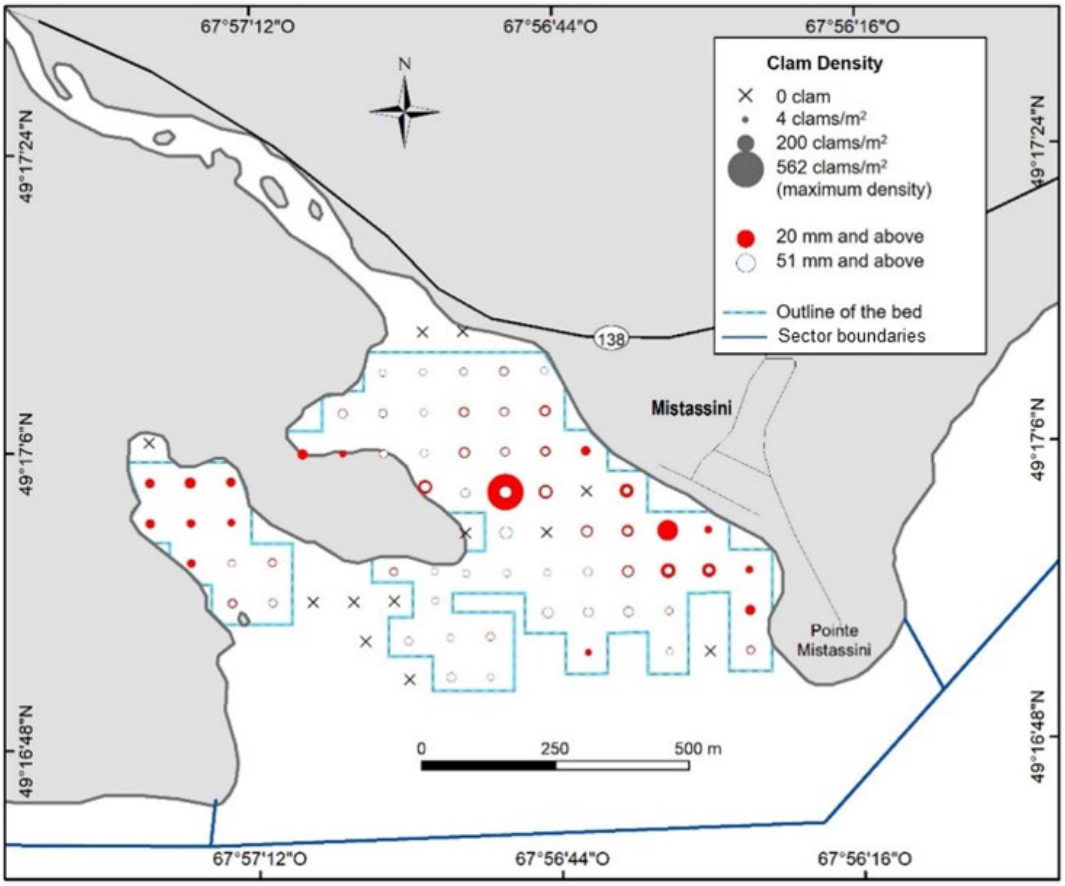

Figure 80. Soft-shell clam density by size class and by station in Rivière Mistassini shellfish area (N-08.1.3) on the Upper North Shore surveyed in 2018.

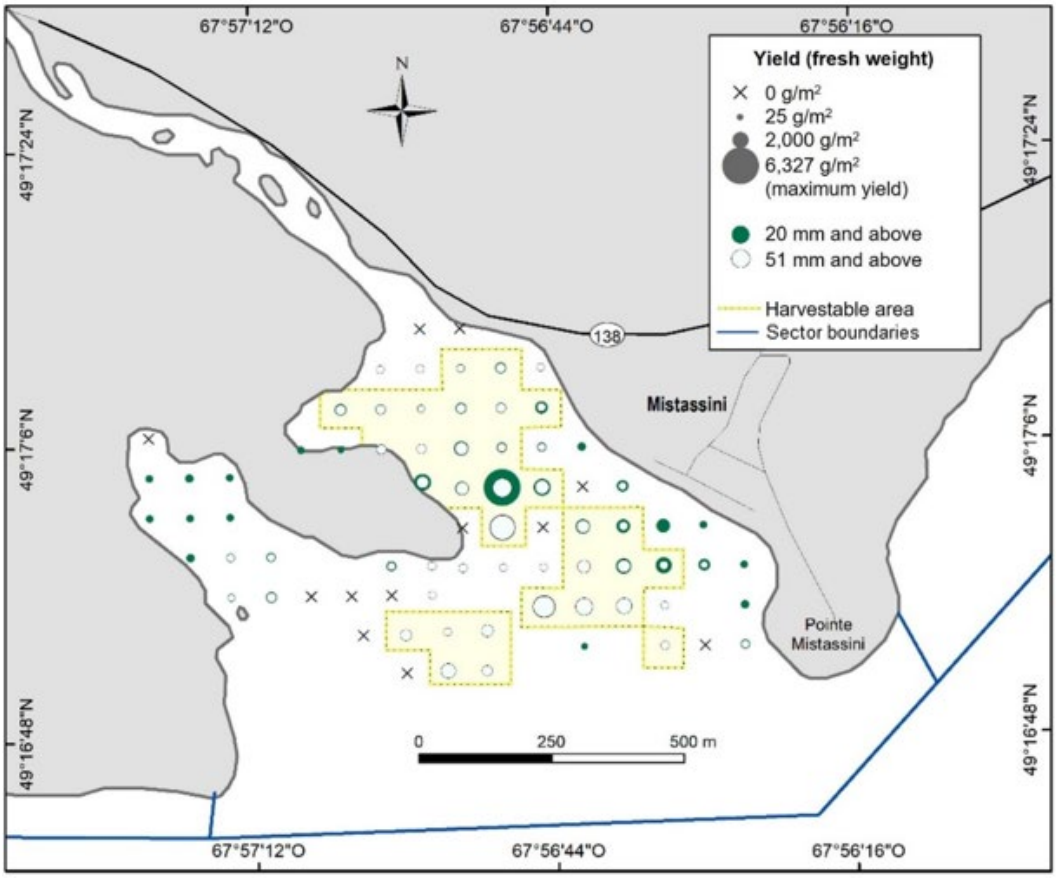

Figure 81. Soft-shell clam yield by size class and by station in Rivière Mistassini shellfish area (N-08.1.3) on the Upper North Shore surveyed in 2018.

In total, 1,003 clams were measured (Table 5). Clam size ranged from 13 to 88 mm. The average size of clams ≥ 20 mm is 44 mm. The size structure shows some modes located between 35 and 51 mm (Figure 6).

In total, 20 sediment samples were collected during the survey, only one of which is located outside the bed (Figure 82 and Table 1). All types of sediments were observed (Figure 82 and Table 6). Grain size analyses show a predominance of gravelly sand, sandy mud and mixed sediment. The visual assessment shows a dominance of muddy sand, gravelly sand and sand. The sediment types present on this bed are gravelly sand (27%), muddy sand (23%), sand (17%), mixed sediment (15%), sandy mud (11%) and mud (8%). The small bay to the west has more muddy sediments, and the southeastern portion of the bed has gravelly sediments.

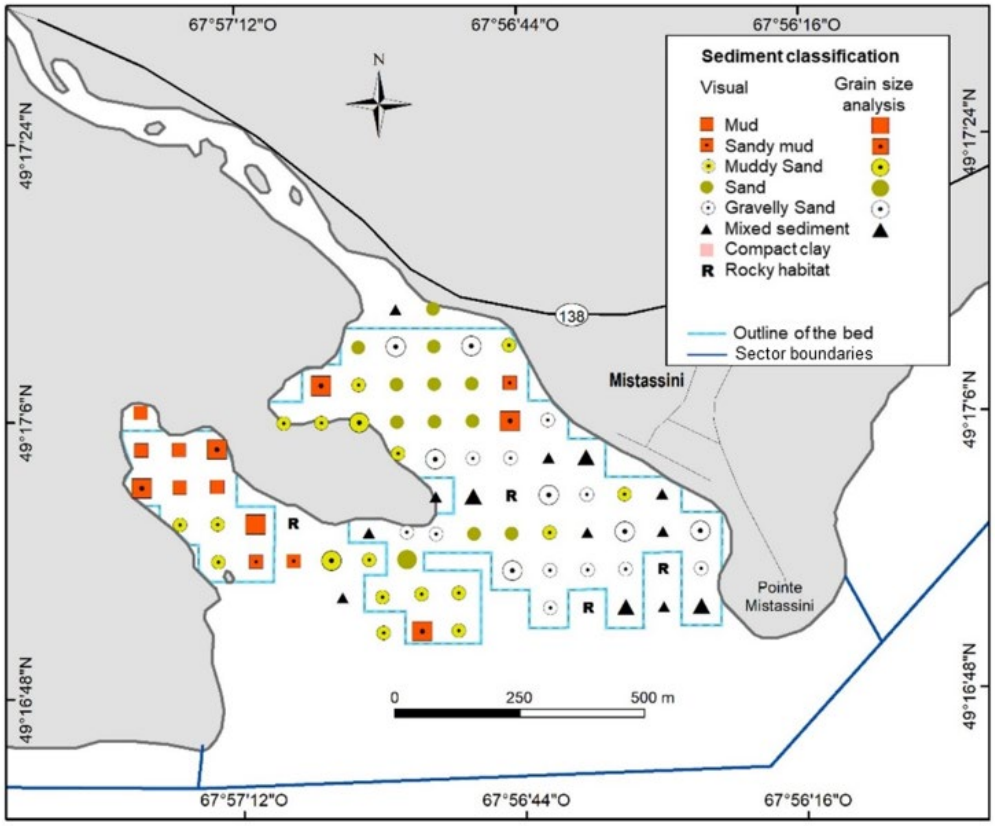

Figure 82. Sediment classification (grain size analysis and visual assessment) by station in Rivière Mistassini shellfish area (N-08.1.3) on the Upper North Shore surveyed in 2018.

Franquelin, area N-08.2

Franquelin is adjacent to Rivière Mistassini on the west side (Figure 2). It is a very large area, and only the western portion located opposite the municipality of Franquelin was surveyed over 3 days in September 2020. A sampling grid of 75 m by 75 m was used (Table 1 and Appendix 8AA). In total, 98 stations were visited, three of which were too deep to be sampled.

The clam bed is estimated at 0.24 km^2 and includes 42 stations (Table 3 and Figure 83). The bed contains one station with no clams and three stations with only clams < 20 mm. The average density of clams ≥ 20 mm is 49.3 clams/m^2, with a maximum density of 292 clams/m^2 (Figure 83 and Table 3). The density of clams 20–50 mm is 18.2 clams/m^2, and that of clams ≥ 51 mm is 31.1 clams/m^2. The average yield of clams 20–50 mm is 97 g/m^2, but the yield of legal-size clams reaches 1,319 g/m^2, which is one of the highest values among those in the 2016–2020 surveys (Figure 84 and Table 3). The maximum yield of clams ≥ 20 mm is 7,929 g/m^2. Clams 20–50 mm are present mostly in the centre of the bed, while legal-size clams are distributed throughout.

The harvestable area is estimated at 0.10 km^2 and includes 17 stations (Table 4 and Figure 84). This small harvestable area is located on the western portion of the bed. The average density of clams ≥ 51 mm is 56.4 clams/m^2, and the average yield is 2,345 g/m^2, which is among the highest values obtained in 2016–2020. The harvestable biomass is estimated at only 235 t, given its small area.

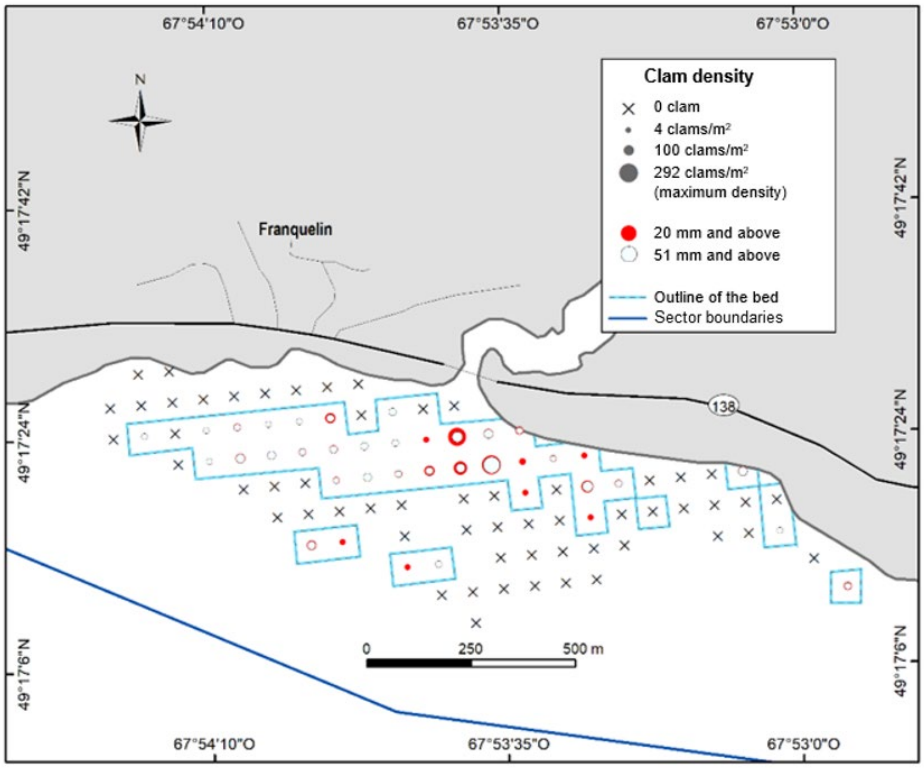

Figure 83. Soft-shell clam density by size class and by station in Franquelin shellfish area (N-08.2) on the Upper North Shore surveyed in 2020.

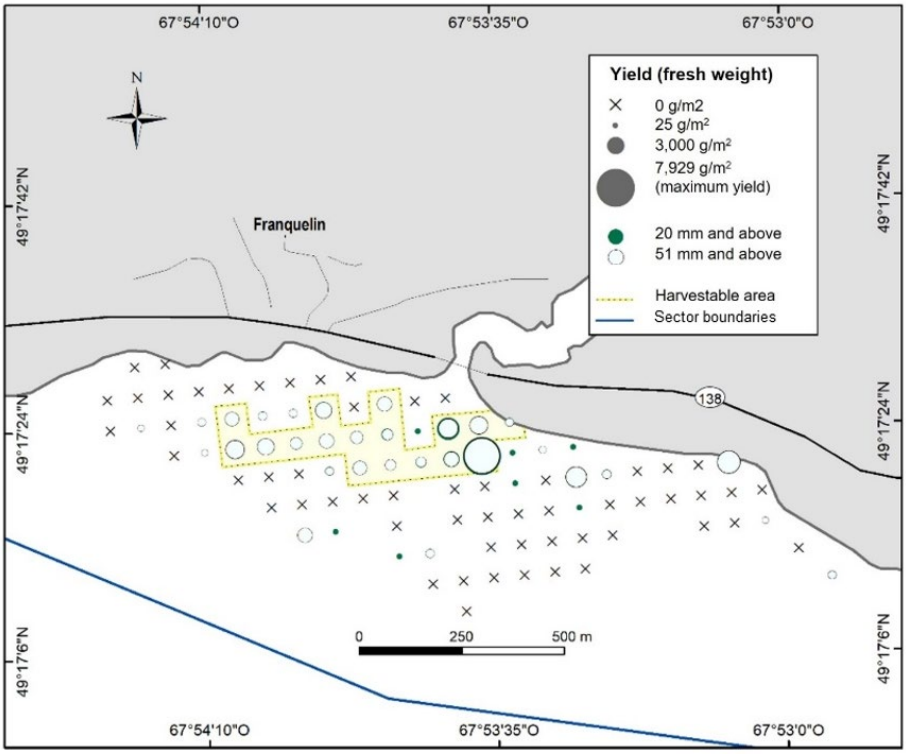

Figure 84. Soft-shell clam yield by size class and by station in Franquelin shellfish area (N-08.2) on the Upper North Shore surveyed in 2020.

In total, 561 clams were measured, ranging in size from 12 to 102 mm (Table 5). The average size of clams ≥ 20 mm is 55 mm. The size structure shows two modes, one around 21–24 mm and the second around 62–69 mm (Figure 6).

In total, 21 sediment samples were collected, 13 of which are located in the bed (Figure 85 and Table 1). Grain size analyses show that sediments consist of sand and gravelly sand in roughly the same proportions (Figure 85 and Table 6). The visual assessment also shows a dominance of sand, with some observations of mixed sediment. The sediment types present on this bed are sand (79%), gravelly sand (14%) and mixed sediment (7%). There is no clear pattern in the distribution of the different sediment categories in the bed.

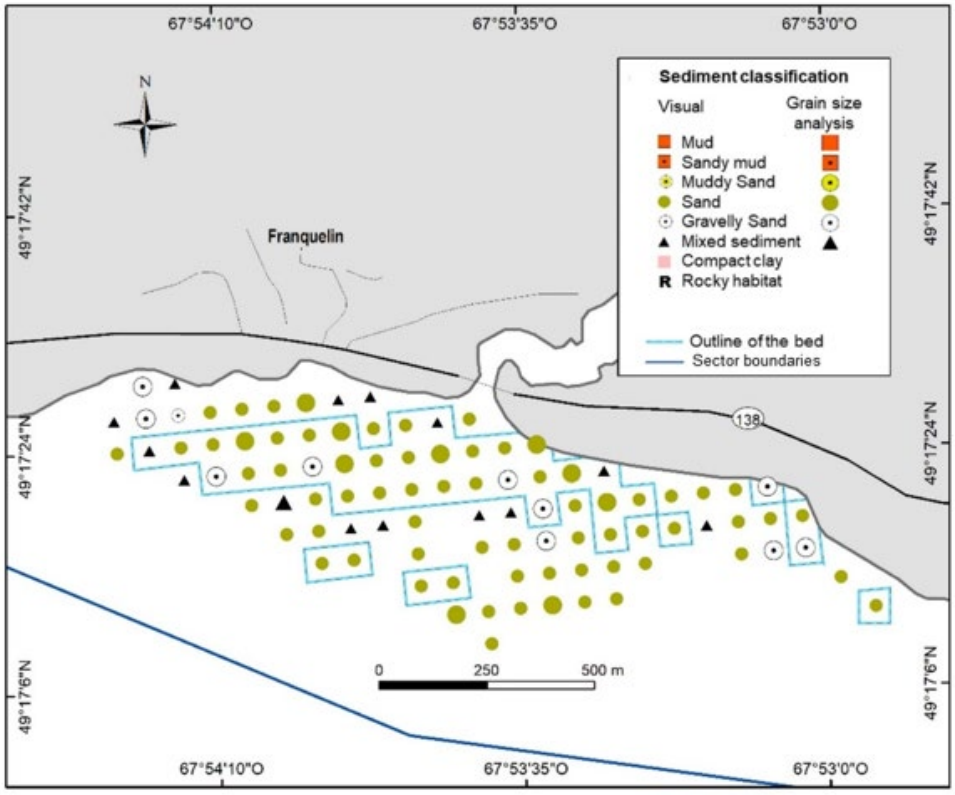

Figure 85. Sediment classification (grain size analysis and visual assessment) by station in Franquelin shellfish area (N-08.2) on the Upper North Shore surveyed in 2020.

Baie Saint-Nicolas, area N-08.3

Baie Saint-Nicolas is the easternmost area in the 2016–2020 survey series (Figure 2). It is a large area, and three beds were surveyed. The first two beds are located in Grande Baie Saint-Nicolas, namely Bed 1 (located in Anse à Ouellet) and Bed 2 (located in the estuary of Rivière Saint-Nicolas) (Appendix 8BB). Bed 3 is located slightly further east in Petite Baie Saint-Nicolas (Appendix 8CC). All of the beds were surveyed over 6 days during the months of June, July and August 2018. Two sampling grids were used: a grid of 85 m by 85 m used to cover Beds 1 and 3 and the northern half of Bed 2, and a grid of 65 m by 65 mm for the southern half of Bed 2 (Table 1 and Appendices 8BB and 8CC). In total, 87 stations were visited, of which 74 were sampled. There were 11 stations that were too deep and two stations with rocky habitat.

The total area of the beds is estimated at 0.35 km^2 and includes 56 stations (Table 3 and Figure 86). One station without clams was retained in the delineation of Bed 3. The average

density of clams ≥ 20 mm is 144.9 clams/m^2, with a maximum density of 708 clams/m^2 (Figure 86 and Table 3). Clams 20–50 mm strongly dominate with an average density of 122.5 clams/m^2, and the density of clams ≥ 51 mm is 22.4 clams/m^2. The average yield of clams 20–50 mm is 673 g/m^2, a value similar to that of legal-size clams of 662 g/m^2 (Figure 87 and Table 3). The maximum yield of clams ≥ 20 mm is 4,143 g/m^2. Clams 20–50 mm are present throughout beds 1 and 2, with much lower densities in Bed 3. The highest densities were obtained in the northern part of Bed 2. Legal-size clams are found throughout the three beds.

The harvestable area is estimated at 0.15 km^2 and includes 28 stations (Table 4 and Figure 87). Only beds 1 and 2 have harvestable areas (Figure 87A). The average density of clams ≥ 51 mm is 39.3 clams/m^2, and the average yield is 1,044 g/m^2. The harvestable biomass is estimated at 157 t for the entire area.

In total, 2,046 clams were measured. Clam size ranged from 16 to 86 mm (Table 5). The average size of clams ≥ 20 mm is 38 mm. The size structure shows a mode at 21–29 mm, but the density of clams from 15 mm to about 40 mm is high (Figure 6).

There were 22 sediment samples collected, 19 of which were located in the beds (Figure 88 and Table 1). Grain size analyses show that the sediments are composed of sandy mud, gravelly sand, muddy sand and mixed sediment in similar proportions (Figure 88 and Table 6). The visual assessment shows a dominance of sand and mud, along with sandy mud and gravelly sand. All sediment categories were observed. The sediments present on these beds are 21% sand, 21% mud, 20% sandy mud, 16% gravelly sand, 11% muddy sand and 11% mixed sediment. The muddy sediments are found in Bed 1 and on the northern part of Bed 2. The more gravelly sediments are mainly found in the southernmost part of Bed 2 and in Bed 3.

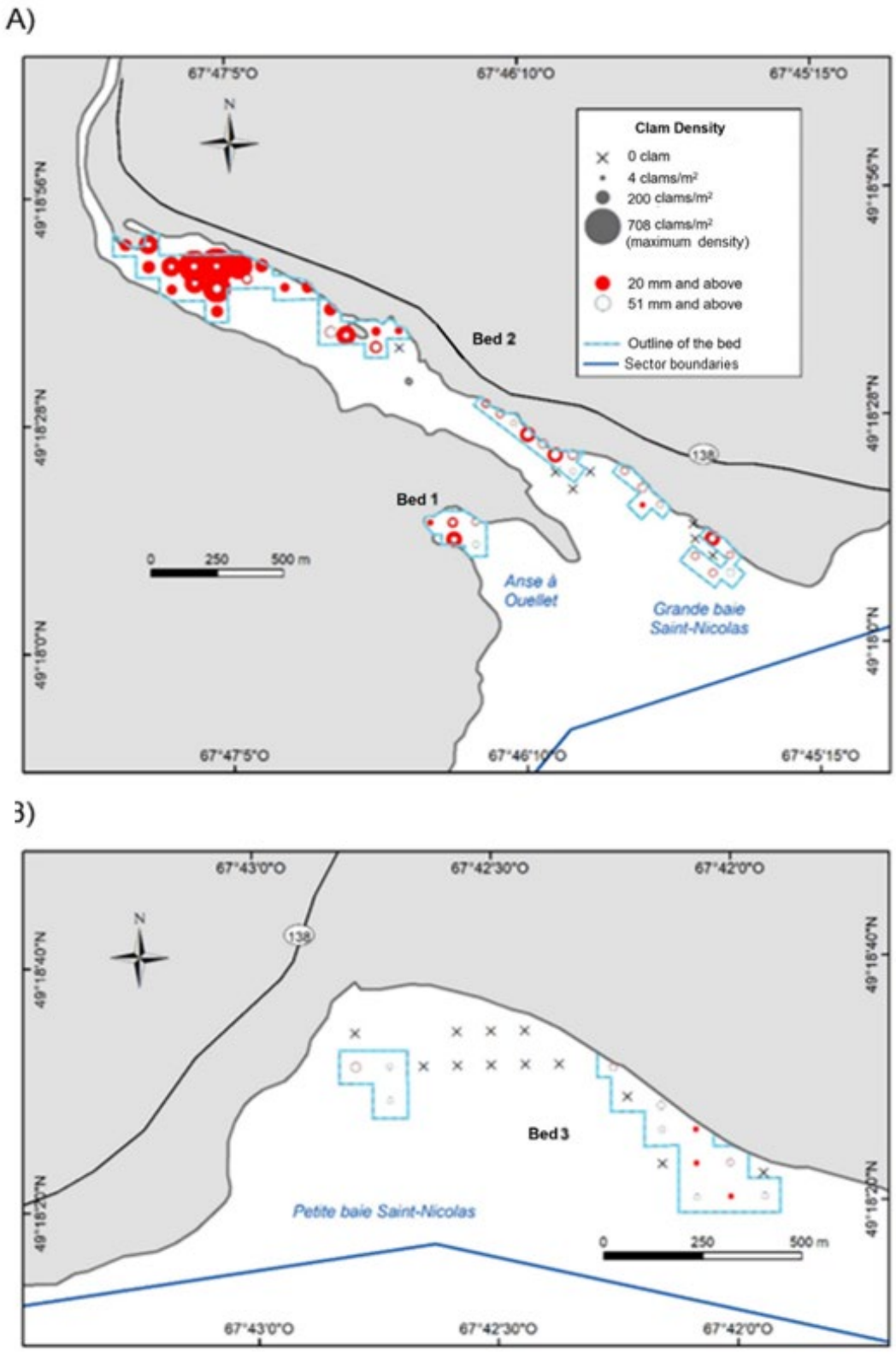

Figure 86. Soft-shell clam density by size class and by station in Baie Saint-Nicolas shellfish area (N-08.3) on the Upper North Shore surveyed in 2018. (A) western portion and (B) eastern portion.

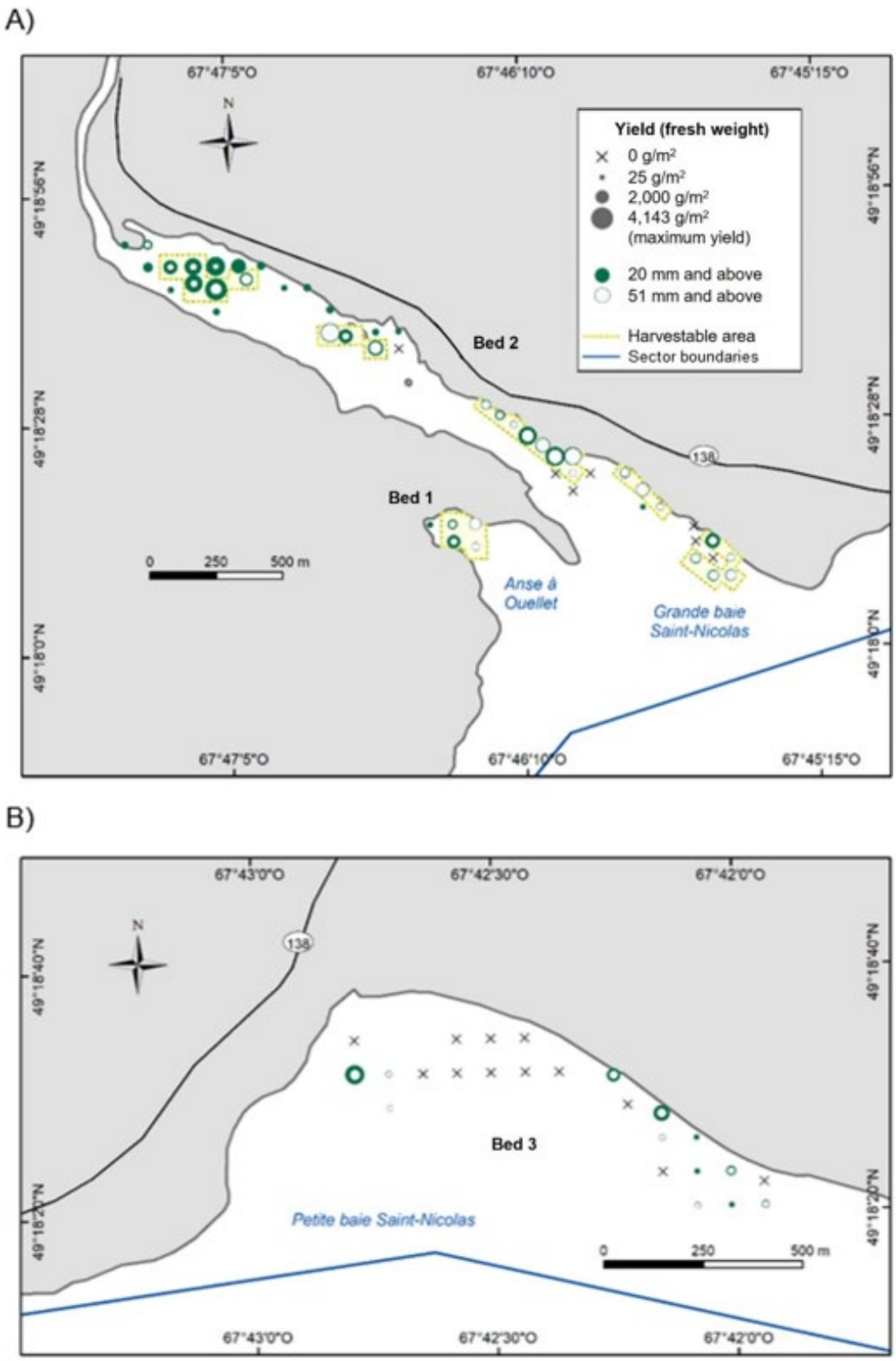

Figure 87. Soft-shell clam yield by size class and by station in Baie Saint-Nicolas shellfish area (N-08.3) on the Upper North Shore surveyed in 2018.(A) western portion and (B) eastern portion.

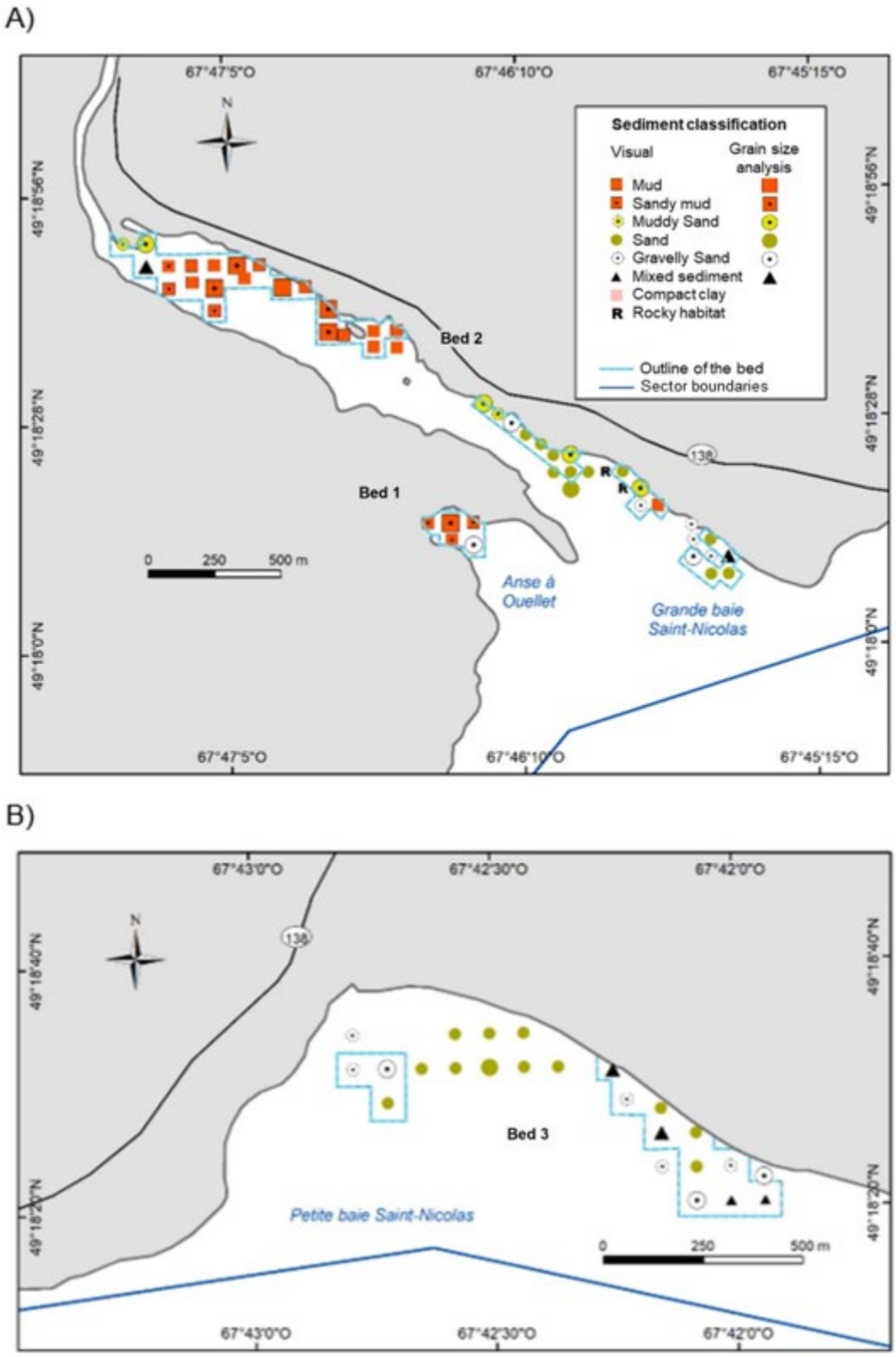

Figure 88. Sediment classification (grain size analysis and visual assessment) by station in Baie Saint-Nicolas shellfish area (N-08.3) on the Upper North Shore surveyed in 2018. (A) western portion and (B) eastern portion.

COMPILATION OF SURVEY RESULTS FROM 2016 TO 2020

Area, density and yield

In total, 28 shellfish areas were surveyed from 2016 to 2020 on the Upper North Shore, for a total of 36 clam beds. Four areas have more than one bed: Baie des Escoumins (4 beds), Îles Penchées (3 beds), Anse Noire (2 beds) and Baie Saint-Nicolas (3 beds). Commercial or recreational clam harvesting has been prohibited in five of these beds since 2010 (Restricted[5] or Prohibited status in the CSSP classification), namely Baie des Grandes Bergeronnes, Baie des Escoumins, Rivière Blanche, Pessamit Nord Reserve and Franquelin (Brulotte 2011, 2018, 2020). There has been no commercial harvesting in the Pointe aux Vaches, Baie des Petites Bergeronnes, Batture à Théophile, Pointe à Émile, Pointe de Mille-Vaches, Pointe Paradis and Rivière Mistassini areas since 2010 (Brulotte 2020). However, there may have been some recreational harvesting in these areas. Finally, only recreational harvesting is permitted for a few weeks in the spring in Baie des Petites Bergeronnes.

Total area of beds

Results show that the area of clam beds varies greatly from one area to another (Figure 89 and Table 3). It ranges from 0.004 km^2 at Battures aux Gibiers Est to 5.99 km^2 at Pointe-aux-Outardes Ouest, for a total area of 22.93 km^2 and an average of 0.82 km^2. However, in reality, there are eight areas with an area of more than 1 km^2, and the others are generally under 0.50 km^2. Moreover, these values are considered conservative, since it does not account for the juvenile clams that are present and not retained by the sieve used (< 20 mm for a 10 mm mesh and < 10 mm for a 6 mm mesh). In addition, some small beds may have gone unnoticed, especially in large areas such as Franquelin and Baie Saint-Nicolas.

The average density of legal-size clams (≥ 51 mm) also varies considerably between areas, ranging from 2 to 79 clams/m^2 (Figure 90 and Table 3). The average value is 24 clams/m^2 for all areas surveyed from 2016 to 2020. The three highest values were observed in the following areas (in descending order): Rivière Blanche (79 clams/m^2), Îlets Jérémie (54 clams/m^2) and Réserve Pessamit Sud (49 clams/m^2). The three lowest values were observed in Pointe à Boisvert (4 clams/m^2), Pointe Paradis (3 clams/m^2) and Pointe aux Vaches (2 clams/m^2).

The average density of sub-legal-size clams (20–50 mm) varies between areas, from 0 to 277 clams/m^2, with an average value of 65 clams/m^2 (Figure 90 and Table 3). The highest values were observed in the Anse du Colombier (277 clams/m^2), Baie des Plongeurs (178 clams/m^2) and Rivière Blanche (176 clams/m^2) areas. Except for Batture aux Gibiers Est, where the bed includes only one station without any sub-legal-size clams, average densities of less than 15 sub-legal-size clams/m^2 were observed in Réserve Pessamit Nord (11 clams/m^2), Baie des Escoumins (11 clams/m^2), Pointe aux Outardes Ouest (9 clams/m^2), Pointe aux Vaches (6 clams/m^2) and Pointe aux Outardes Est (3 clams/m^2).

The average density of clams ≥ 20 mm reached more than 200 clams/m^2 in the Anse du Colombier, Rivière Blanche and Baie des Plongeurs areas, but was lower than 25 clams/m^2 in Pointe Paradis, Réserve Pessamit Nord, Pointe-aux-Outardes Est and Pointe aux Vaches (Figure 90 and Table 3). The mean value of this density is 89 clams/m^2 for all areas.

[5] Status changed to Prohibited as of 2020, allowed commercial harvesting on the condition that the clams be processed in a depuration plant before being marketed.

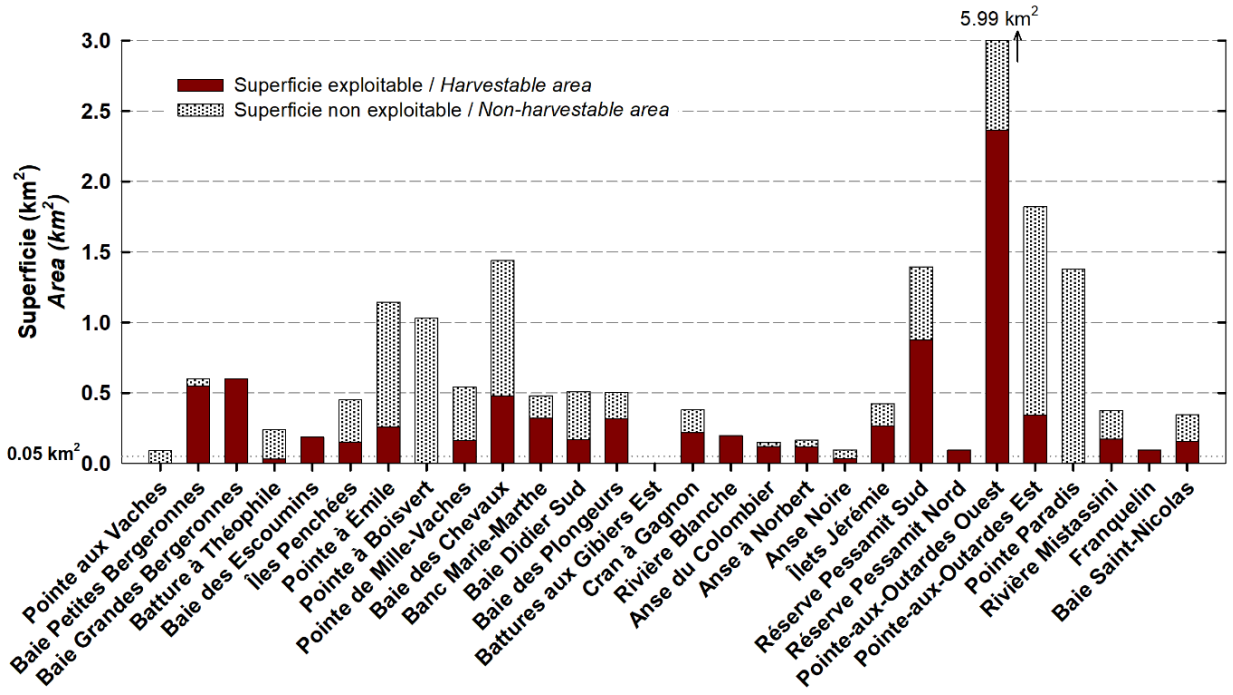

Figure 89. Harvestable and non-harvestable area of soft-shell clam beds for the 28 shellfish areas surveyed on the Upper North Shore from 2016 to 2020.

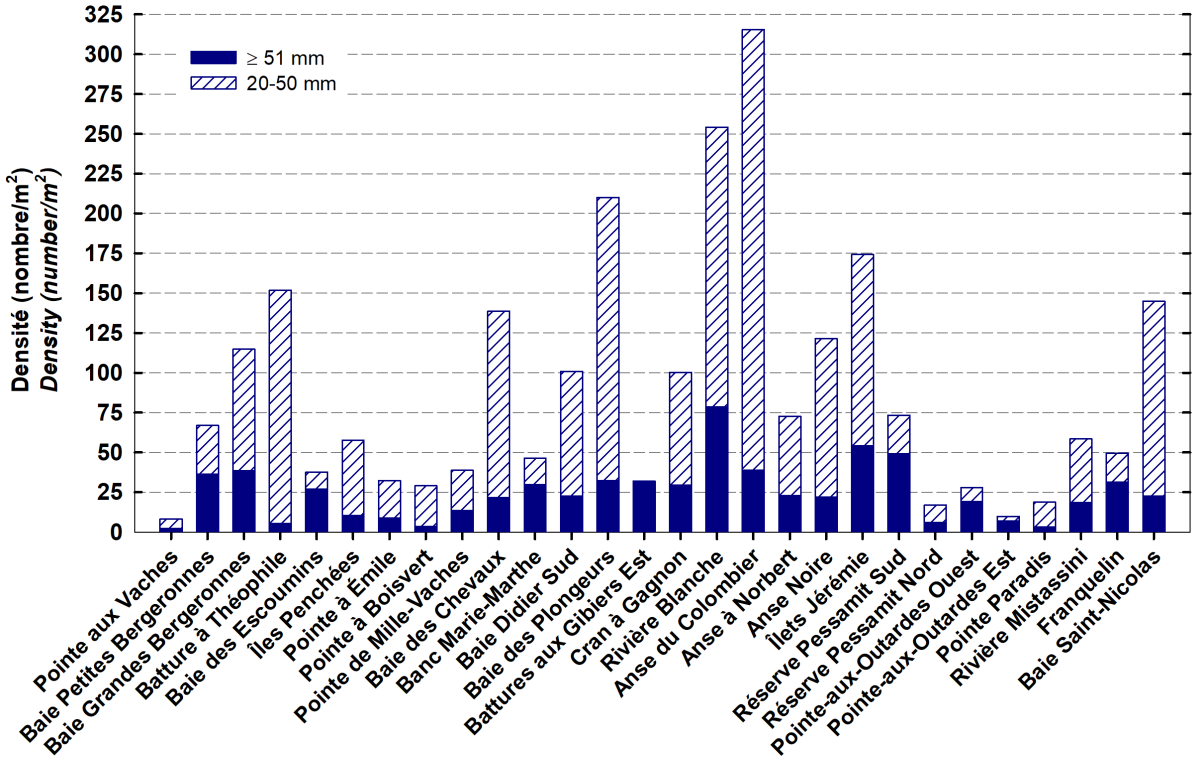

Figure 90. Density of soft-shell clams ≥ 51 mm and 20–50 mm over the total area of the clam beds for the 28 shellfish areas surveyed on the Upper North Shore from 2016 to 2020.

It is important to note that, in most cases, the density of sub-legal-size clams is at least twice that of legal-size clams (Figure 90 and Table 3). This situation ensures the renewal of legal-size clams while considering losses due to natural mortality and incidental mortality from commercial fishing (Lavoie 1969b; Mercier et al. 1978; Witherspoon 1982; Biorex 1992). There are six cases where the density of legal-size clams is clearly higher than that of sub-legal-size clams: Baie des Escoumins, Banc Marie-Marthe, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest, Pointe aux Outardes Est and Franquelin.

The yield integrates the density of the clams and their size, since the weight of a clam is proportional to its size. The yield of legal-size clams in the beds varies from 84 to 2,281 g/m^2, for an average yield of 715 g/m^2 for all areas (Figure 91 and Table 3). Four areas have yields of more than 1,250 g/m^2, namely Rivière Blanche, Réserve Pessamit Sud, Îlets Jérémie and Franquelin. However, three areas have yields of less than 125 g/m^2, namely Batture à Théophile, Pointe aux Vaches and Pointe Paradis.

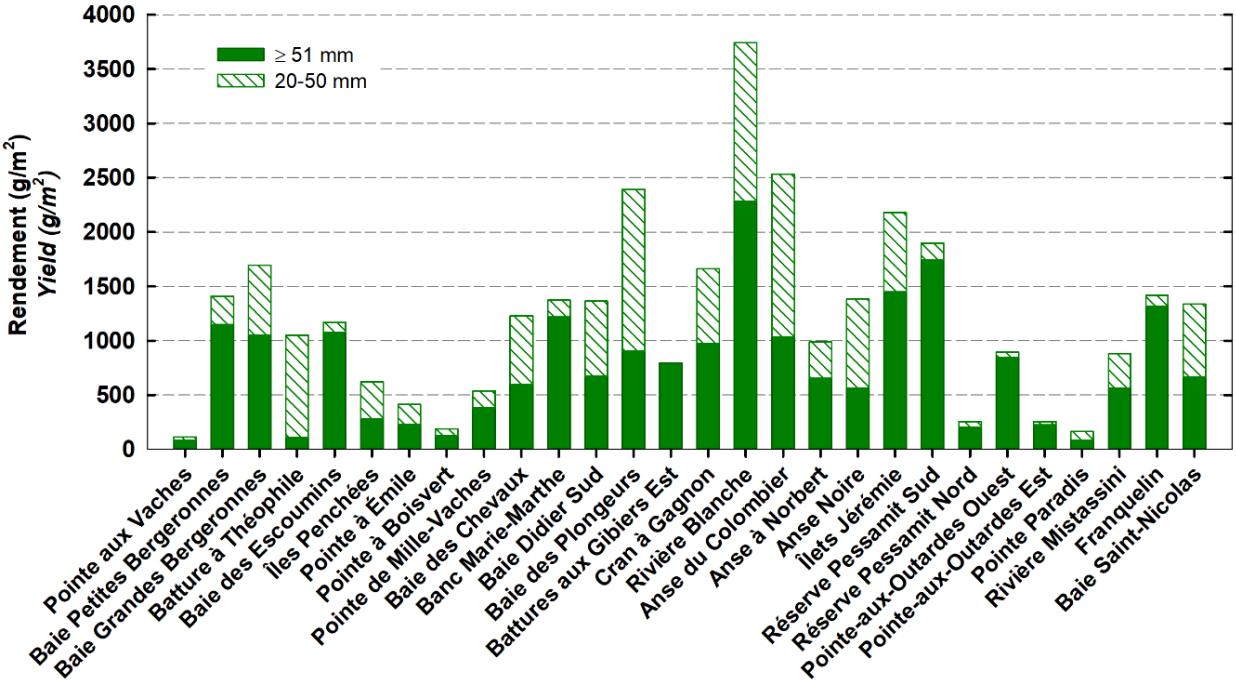

Figure 91. Yield of soft-shell clams ≥ 51 mm and 20–50 mm over the total area of the clam beds for the 28 shellfish areas surveyed on the Upper North Shore from 2016 to 2020.

Harvestable area of the beds

The delineation of harvestable areas makes it possible to determine tthe area (density of legal-size clams ≥ 16 clams/m^2) that will be used for commercial harvesting. Areas with low densities of legal-size clams or areas occupied mainly by sub-legal-size clams will not be of interest to harvesters. It also allows for a more accurate assessment of the biomass that will be available for harvesting. It should be noted, however, that the harvestable area and estimated biomass are valid only at the time of the survey. Any alterations to the density and yield of legal-size clams due to changes in the harvesting rate or the environment, such as climate change, could affect the harvestable area and the biomass estimate.

Four areas have no harvestable area, since the clam density per station does not exceed 16 clams/m^2 or there are less than three contiguous stations with such a density. These are Pointe aux Vaches, Pointe à Boisvert, Battures aux Gibiers Est and Pointe Paradis (Figure 89

and Table 4). The other areas have a harvestable area of between 0.03 and 2.37 km^2, for a total of 8.27 km^2 for all the beds surveyed in 2016–2020. However, harvesting is prohibited in some of these areas, leaving a total of 7.10 km^2 available on the Upper North Shore. The minimum area that can support commercial harvesting is probably between 0.01 and 0.1 km^2. Based on current data, the area deemed acceptable for commercial harvesting has been set at 0.05 km^2 on the Upper North Shore (Brulotte 2020; DFO 2020). Two areas have an area smaller than this, namely Batture à Théophile (0.03 km^2) and Anse Noire (0.04 km^2). The other areas have a harvestable area of between 0.12 and 2.37 km^2. The area with the largest harvestable area is undoubtedly Pointe-aux-Outardes Ouest (2.37 km^2), followed by the Réserve Pessamit Sud (0.88 km^2), Baie des Grandes Bergeronnes (0.60 km^2), Baie des Petites Bergeronnes (0.55 km^2) and Baie des Chevaux (0.48 km^2).

The average density of clams ≥ 51 mm on the harvestable area varies from 17 to 98 clams/m^2, and the average is 47 clams/m^2 (Table 4 and Figure 92). The areas with the highest values are Rivière Blanche (98 clams/m^2), Îlets Jérémie (81 clams/m^2), Réserve Pessamit Sud (79 clams/m^2) and Baie des Chevaux (61 clams/m^2). Clam harvesting is prohibited in the Rivière Blanche area. The lowest densities, below 30 clams/m^2, are found in the Îles Penchées, Pointe-aux-Outardes Est, Pointe à Émile and Batture à Théophile areas.

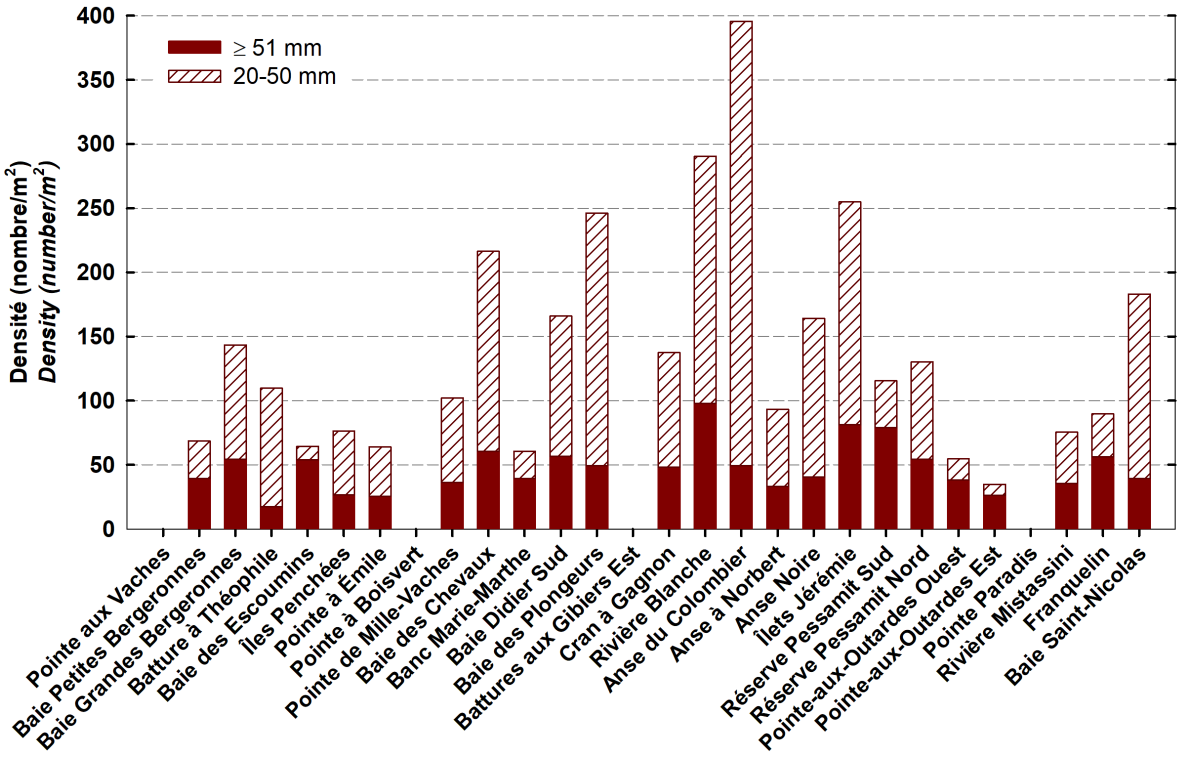

Figure 92. Density of soft-shell clams ≥ 51 mm and 20–50 mm over the harvestable area of the beds for the 28 shellfish areas surveyed on the Upper North Shore from 2016 to 2020.

The average yield of clams ≥ 51 mm over the harvestable area ranges from 338 to 2,843 g/m^2, with an average of 1,457 g/m^2 (Table 4 and Figure 93). Generally, high yields are associated with high densities. The areas with yields of over 2,000 g/m^2 are Rivière Blanche, Réserve Pessamit Sud, Franquelin, Îlets Jérémie and Baie des Escoumins. Soft-shell clam harvesting is prohibited in three of these areas, namely Rivière Blanche, Franquelin and Baie des Escoumins.

The commercial biomass calculated on the harvestable area varies greatly from one area to another, since it depends on yield and area (Table 4). The highest harvestable biomasses were

obtained in the Pointe-aux-Outardes Ouest area, with 3,643 t, and Réserve Pessamit Sud, with 2,454 t. These numbers were highest in the former because of its large area and the latter because of its high yield and its area. For the other areas, the biomass decreases sharply and varies between 10 t (Batture à Théophile) and 893 t (Baie des Grandes Bergeronnes), for an average of 331 t per area without the two highest values.

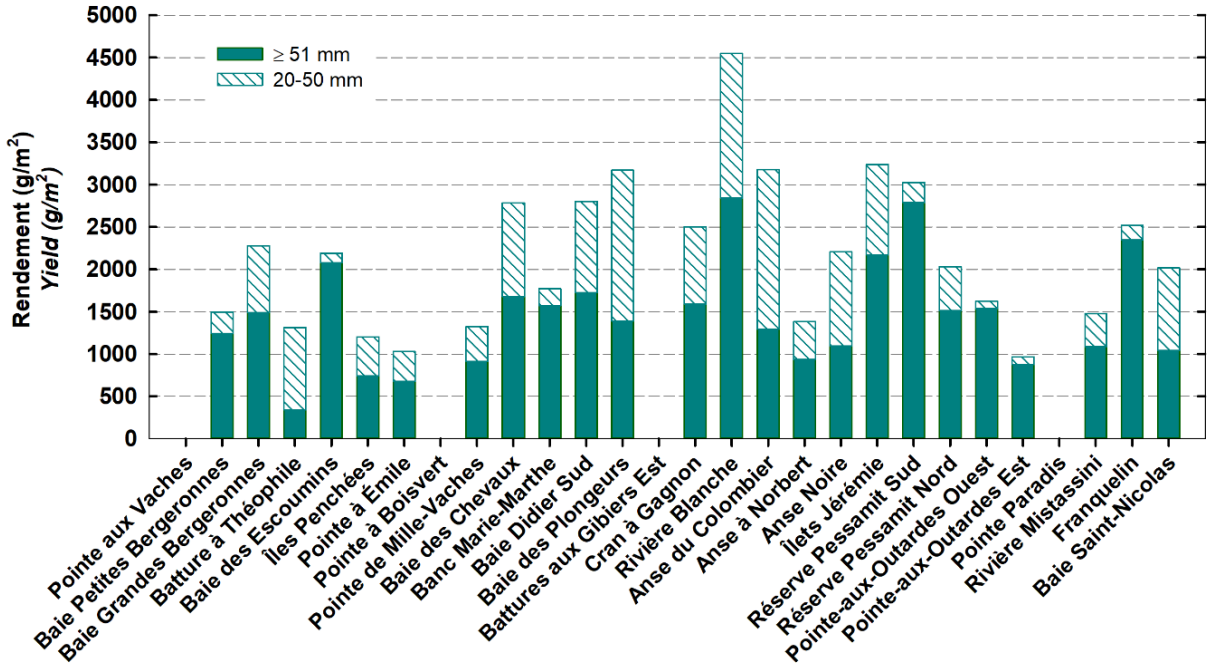

Figure 93. Yield of soft-shell clams ≥ 51 mm and 20–50 mm on the harvestable area of the beds for the 28 shellfish areas surveyed from 2016 to 2020 in the Upper North Shore.

Sustainable exploitation rate indicators

Values for some variables were slightly modified this fiscal year, and five shellfish areas (Baie des Grandes Bergeronnes, Baie des Escoumins, Rivière Blanche, Réserve Pessamit Nord and Franquelin) were added to what was presented during the peer review in February 2020 (Brulotte 2020; DFO 2020). Therefore, it is necessary to update the data that encompass all of the information used to determine the TAC for shellfish harvest areas on the Upper North Shore (Table 7). The appropriate exploitation rate for soft-shell clam populations on the Upper North Shore was estimated to be 5% (Brulotte 2020; DFO 2020).

Certain indicators were used to assess the potential of beds to support commercial and recreational harvesting and to justify reducing the exploitation rate when necessary. The first indicator is the size of the harvestable area, which should be 0.05 km^2 or larger. Four shellfish areas have no harvestable area: Pointe aux Vaches, Pointe à Boisvert, Batture aux Gibiers Est and Pointe Paradis (Table 7). Batture à Théophile and Anse Noire are the other shellfish harvest areas that do not meet this criterion. For these two areas, the exploitation rate must be minimized.

Table 7. Results of surveys conducted from 2016 to 2020 in 28 shellfish areas on the Upper North Shore.Bed area (km²), harvestable area (km²), average density (number/m²) of soft-shell clams 20–50 mm over all beds, average density (number/m²), average yield (kg/m²) and biomass (t) of soft-shell clams ≥ 51 mm in the harvestable area, and the potential harvest (t) calculated using exploitation rates of 5% and 2.5%.

Shellfish harvest area	Surface area	Harvestable area	Density 20–50 mm	Density ≥ 51 mm	Yield ≥ 51 mm	Biomass ≥ 51 mm	t 5%	t 2.5%
Pointe aux Vaches	0.08	**0**[1]	**6.1**[1]	-	-	-	0	-
Baie des Petites Bergeronnes	0.60	0.55	30.6	39.2	1,243	684	34[2]	-
Baie des Grandes Bergeronnes	0.87	0.60	76.4	54.5	1,489	893	0[3]	
Batture à Théophile	0.24	**0.03**[1]	146.5	17.3	338	10	0	-
Baie des Escoumins	0.44	0.19	**10.7**[1]	54.0	2,078	395	0[3]	
Îles Penchées	0.45	0.15	47.2	26.7	742	111	6	-
Pointe à Émile	1.16	0.26	23.4	25.4	674	175	9	4
Pointe à Boisvert	1.14	**0**[1]	25.5	-	-	-	0	-
Pointe de Mille-Vaches	0.54	0.16	25.2	36.1	913	146	7	-
Baie des Chevaux	1.45	0.48	117.1	60.6	1,679	806	40	-
Banc Marie-Marthe	0.48	0.32	16.5	39.2	1,573	503	25	13
Baie Didier Sud	0.51	0.17	78.6	56.5	1,723	293	15	-
Baie des Plongeurs	0.50	0.32	178.0	49.4	1,390	445	22	-
Battures aux Gibiers Est	0.004	**0**[1]	**0**[1]	-	-	-	0	-
Cran à Gagnon	0.38	0.22	71.0	48.0	1,587	349	17	-
Rivière Blanche	0.25	0.20	175.7	97.8	2,843	569	0[3]	-
Anse du Colombier	0.15	0.12	276.5	49.2	1,292	155	8	-
Anse à Norbert	0.17	0.12	49.5	33.3	936	112	6	-
Anse Noire	0.10	**0.04**[1]	99.6	40.4	1,098	44	0	-
Îlets Jérémie	0.42	0.26	120.3	81.2	2,172	565	28	-
Réserve Pessamit Sud	1.43	0.88	24.2	78.9	2,789	2,454	123	-
Réserve Pessamit Nord	1.34	0.10	**11.0**[1]	54.2	1,514	151	0[3]	-
Pointe-aux-Outardes Ouest	5.99	2.37	**8.8**[1]	38.3	1,537	3,643	182	91
Pointe-aux-Outardes Est	1.82	0.34	**2.8**[1]	26.2	876	298	15	7
Pointe Paradis	1.48	**0**[1]	15.6	-	-	-	0	-
Rivière Mistassini	0.37	0.17	40.0	35.3	1,086	185	9	5
Franquelin	0.24	0.10	18.2	56.4	2,345	235	0[3]	-
Baie Saint-Nicolas	0.35	0.15	122.5	39.3	1,044	157	8	-

[1] Values in bold and red represent areas where indicators do not meet the minimum criteria, i.e., a harvestable area of 0.05 km² and a density of 15 clams/m² for soft-shell clams 20–50 mm.
[2] Recreational harvesting only.
[3] Commercial and recreational soft-shell clam harvesting is prohibited in these shellfish harvest areas.

The second indicator is the density of soft-shell clams 20–50 mm in all beds, which must be ≥15 clams/m^2. When this indicator is not met, the exploitation rate must be reduced by half. The areas affected are Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est (Table 7). The Baie des Escoumins and Réserve Pessamit Nord shellfish areas would also have been affected in the same manner, but harvesting is prohibited in these areas. Although the Banc Marie-Marthe shellfish area has a density above 15 clams/m^2, its density is only 16.5 clams/m^2. It is therefore recommended that the exploitation rate in this area be reduced to 2.5%.

Lastly, the exploitation rate of 5% defined for soft-shell clam beds on the Upper North Shore appears to be too high for the Pointe à Émile and Rivière Mistassini areas. Since the proposed TAC is higher than the commercial landings observed between 2000 and 2005 (Brulotte 2020; DFO 2020), it is suggested that the exploitation rate be reduced to 2.5% for both of these areas (Table 7).

Sediments

At least 50% of the sediments in all soft-shell clam beds surveyed between 2016 and 2020 were composed of a mix of sand and mud (Figure 94 and Table 6). Three beds stand out with a fairly high proportion of more gravelly sediment (between 40% and 48%), namely Pointe aux Vaches, Rivière Mistassini and Baie des Petites Bergeronnes. Sand predominates in several beds. Proportions of over 60% were observed in the following beds (listed in descending order): Réserve Pessamit Sud, Pointe-aux-Outardes Est, Pointe de Mille-Vaches, Réserve Pessamit Nord, Franquelin, Pointe à Boisvert, Îlets Jérémie, Pointe-aux-Outardes Ouest and Pointe Paradis. Most of these beds, except for Îlets Jérémie, are located on extensive tidal flats exposed to the wind.

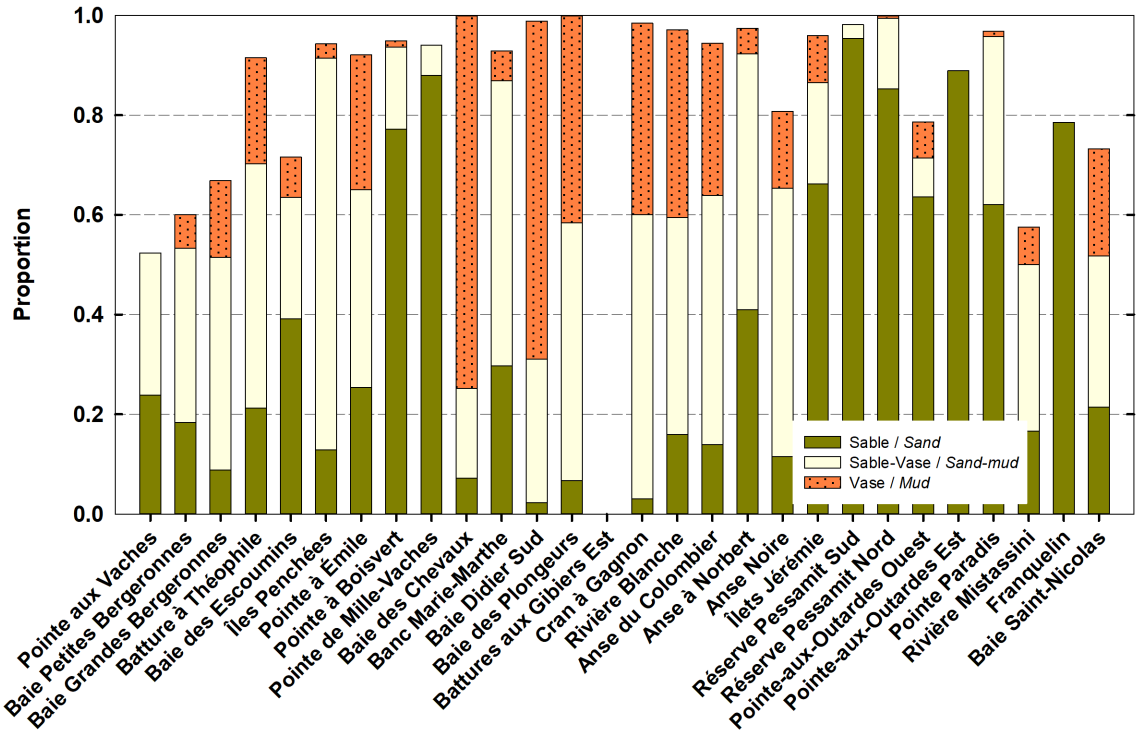

Figure 94. Proportion of different sediments in soft-shell clam beds for the 28 shellfish areas surveyed from 2016 to 2020 on the Upper North Shore.The Sand-Mud category includes sandy mud and muddy sand, but the gravelly sand and mixed categories are not represented).

Furthermore, Baie des Chevaux and Baie Didier Sud have sediments consisting of over 65% mud. Mud and sand-mud sediments dominate (> 60%) the following beds: Cran à Gagnon, Baie des Plongeurs, Îles Penchées, Rivière Blanche, Anse Colombier, Batture à Théophile, Anse Noire, Pointe à Émile and Banc Marie-Marthe. Most of these beds, except for Îles Penchées, Batture à Théophile and Pointe à Émile, are located in bays and coves that provide shelter from the winds.

There are four beds where all categories of sediment are present. There is a certain dominance of sand in two of the beds (Baie des Escoumins and Anse à Norbert), while none of the sediment categories are predominant in the other two beds (Baie des Grandes Bergeronnes and Baie Saint-Nicolas).

It is difficult to relate sediment grain size to bed location. Caron (1991) states that sediments in bays exposed to prevailing winds have a coarser grain size than sediments in more sheltered bays. However, this generalization must take into account the presence of rivers and their flows, as noted in Giguère et al. (2007). Beds located in river estuaries—such as Baie des Petites Bergeronnes, Baie des Grandes Bergeronnes, Rivière Mistassini and Baie Saint-Nicolas in part, which seem to be fairly well protected from prevailing winds and storm-force winds—have more gravelly sediments or a mixture of all sediment categories. In general, beds located on open tidal flats exposed to S, SE, E and sometimes NE winds have sediments that consist mainly of sand (Pointe à Boisvert, Pointe de Mille-Vaches, Réserve Pessamit Sud, Réserve Pessamit Nord, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est, Pointe Paradis and Franquelin). Beds in more sheltered locations have mud, sandy mud and muddy sand sediments (Baie des Chevaux, Banc Marie-Marthe, Baie Didier Sud, Baie des Plongeurs, Cran Gagnon, Rivière Blanche, Anse du Colombier, Anse Noire). However, there are exceptions in all cases. Moreover, as some authors have indicated (Lavoie 1970a, 1970b; Leblanc and Miron 2005; Giguère et al. 2007), soft-shell clam beds are not necessarily uniform landscapes; there are numerous obstacles or shelters, such as islets, depressions, marine plants (e.g., eelgrass), boulders, and rocks of various dimensions that change the sediment grain size distribution on a small scale. Lamoureux (1975a) and Roseberry (1988) state that soft-shell clams are often found near the edges of boulders, where looser sediments are often found. This pattern was observed previously in the Cran à Gagnon bed (Brulotte, DFO Quebec Region, unpublished data).

It is even more difficult to relate types of sediment to soft-shell clam density. In general, the highest densities (or yields) of legal-size soft-shell clams from the surveys conducted from 2016 to 2020 were found at stations where the sediments consisted of muddy sand, sand or gravelly sand. At stations with mud and sandy mud sediments, soft-shell clams 20–50 mm often predominate (there are few, if any, legal-size soft-shell clams). However, soft-shell clams of both size classes were found in all sediment types (mud, sandy mud, muddy sand, sand, gravelly sand and mixed) at various densities, depending on the area. No soft-shell clams were found at compact clay stations, stations on the beach (no or insufficient immersion time) or stations with coarser sediments (rocky habitat). Roy et al. (2003) reported that there were no soft-shell clams at gravel stations and low densities at mixed sediment stations. Lavoie (1967) indicated that pure sand, gravel and cobble are not suitable substrates for supporting a soft-shell clam population. According to Newell and Hidu (1986) and Abraham and Dillon (1986), soft-shell clams can burrow into and live in soft mud, sand, compact clay and coarse gravel as well as in between pebbles.

Other authors have observed a wide variability in soft-shell clam density and size structure on a small scale (Roseberry 1988; Brulotte and Giguère 2003). Observations from various surveys of soft-shell clam beds conducted between 2001 and 2008 in Quebec showed that few legal-size clams were found in loose surface sediments (5–10 cm) overlying a much more compact layer

at depth (Brulotte, DFO Quebec Region, unpublished data). This type of habitat limits the burrowing of large soft-shell clams.

More detailed studies of currents and winds in the different beds are required to better understand the dynamics that link bed location, sediment composition and soft-shell clam distribution. In addition, other factors such as the abundance and quality of food also have an impact on soft-shell clam density.

Associated species

Seventeen (17) taxa besides the soft-shell clam were observed in surveys conducted between 2016 and 2020 (Appendix 14). The most common taxa were the bivalves *Macoma balthica*, *Mesodesma* ssp. (*M. arctatum* and *M. deauratum*) and *Mytilus* ssp. (*M. edulis* and *M. trossulus*); and polychaetes (Polychaeta). Other taxa observed were *Zostera marina* eelgrass; nemertean worms (Nemertea); bivalves *Cyrtodaria siliqua* and *Ensis Leei*; gastropods *Buccinum undatum*, Littorinidae, Naticidae, Nudibranchia and *Testudinalia testudinalis*; the crab *Cancer irroratus*; the shrimp *Crangon septemspinosa*; barnacles (Cirripedia); the sea urchin *Strongylocentrotus droebachiensis*; and the fish *Ammodytes americanus*.

Soft-shell clam beds on the Upper North Shore are part of the *Macoma balthica* boréo-Atlantic community described for the soft sediments of the St. Lawrence Estuary (Desrosiers and Brêthes 1984; Roseberry 1988; Caron et al. 1996). *M. balthica*, soft-shell clams, polychaetes and some gastropods are predominant in this community. In addition, *Mytilus* ssp. are well represented on more rocky substrates.

In this study, the presence of soft-shell clams was not associated with *M. balthica* as often as we would have expected. Given that the size of *M. balthica* rarely exceeds 25–30 mm in the Estuary and that a 10 mm mesh size was used in nearly all of the surveys between 2016 and 2020, a significant portion of individuals were not collected by the sieve. This fact should be considered when interpreting the results. Previous surveys (using a 6 mm mesh size) carried out in the Pointe à Émile (2003), Baie des Chevaux (2002), Cran à Gagnon (2007), Anse Noire (2003), Réserve Pessamit Sud (2005 and 2010), Pointe-aux-Outardes Ouest (2003) and Pointe-aux-Outardes Est (2004) shellfish harvest areas all showed a higher occurrence of *M. balthica* in soft-shell clam beds (Giguère et al. 2008).

Macoma balthica was observed in all shellfish areas except for Batture aux Gibiers Est and Pointe-aux-Outardes Est (Appendices 14 to 42). In the case of Batture aux Gibiers, soft-shell clams were found at only one station; therefore, it is not surprising that *M. balthica* was absent. In 2004, *M. balthica* was found in the Pointe-aux-Outardes Est bed (Giguère et al. 2008). It was also observed at several stations in the Pointe-aux-Outardes Ouest bed in 2017. The absence of this species in 2018 in the Pointe-aux-Outardes Est bed appears to be related to the sieve used. As mentioned previously, there were fewer occurrences of *M. balthica* than soft-shell clams in most beds.

The bivalve *Mesodesma* ssp. is generally present along the edges of clam beds in sandier sediments (Appendices 14 to 42). When soft-shell clams and *Mesodesma* co-occur, densities of *Mesodesma* are low. However, there are some areas where *Mesodesma* was observed at almost all of the stations sampled, i.e., Banc Marie-Marthe, Réserve Pessamit Nord, Pointe-aux-Outardes Est and Franquelin (Appendices 25, 36, 38 and 41). Sediments in these last three shellfish areas consist of sand almost exclusively (Figures 70, 76 and 85). In contrast, the sediments in Banc Marie-Marthe are a mixture of mainly muddy sand, sand and sandy mud (Figure 37 and Table 6).

Unlike *L. balthica* and *Mesodesma* ssp., the mussel (*Mytilus* ssp.) is not a bivalve that burrows into sediments. Instead, it attaches itself to hard sediments, such as large cobbles, rocks or boulders. It can therefore be found alongside soft-shell clams where such rocks are present in the bed. Mussels were observed in all shellfish areas, except Batture à Théophile (Appendices 14 to 42). However, its occurrence is generally low. The highest occurrences (32–46% of stations) were observed in the Baie des Petites Bergeronnes, Baie des Grandes Bergeronnes, Îles Penchées, Banc Marie-Marthe, Rivière Mistassini and Baie Saint-Nicolas shellfish areas.

Polychaetes were observed in all of the shellfish areas (Appendix 14). Although the sampling method used was not the most suitable for polychaetes, polychaete occurrence in each shellfish area was generally high (over 40% of stations).

Predators of soft-shell clams are numerous and vary depending on the size of the clam (Belding 1930; Abraham and Dillon 1986; Abgrall et al. 2010). Larvae and juveniles (which burrow at shallow depths) are the most vulnerable to predation. Brousseau and Baglivo (1988) and Gray et al. (1998) state that adult soft-shell clams have a refuge size from certain predators, mainly via their burrowing depth. The main predators of soft-shell 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 (Belding 1930; Villemure and Lamoureux 1975; Abraham and Dillon 1986; Newell and Hidu 1986; Abgrall et al. 2010).

Among the species present on the Upper North Shore, the following are potential predators of soft-shell clams: nemertean worms, Naticidae, certain polychaetes (e.g., *Allita virens* [previously *Nereis virens*]), *Cancer irroratus* and *Crangon septemspinosa* (Brulotte 2020; DORIS 2021). These species, with the exception of polychaetes, are not typically found in soft-shell clam beds on the Upper North Shore (Appendix 14). Nemertean worms were observed in two locations, Banc Marie-Marthe and Baie des Plongeurs, with occurrences at three or four stations. Naticidae gastropods were only observed in Franquelin at one station. The polychaete *Allita virens* was only identified in Banc Marie-Marthe and Baie des Plongeurs, but polychaetes were generally not identified to species. The most common predator is the crab *Cancer irroratus*, which was observed in 12 shellfish areas, with occurrences at one to six stations. The shrimp *Crangon septemspinosa* was observed in eight shellfish areas at one to three stations, except in the Réserve Pessamit Nord shellfish area, where the species was observed at 70 stations.

The only fish species observed was the American sand lance, *Ammodytes americanus*, which has a tendency to burrow into sandy sediments. This species was collected in nine shellfish areas, with occurrences at one to nine stations (Appendix 14). Eight of these areas have sediments that are primarily composed of sand: Pointe à Boisvert, Pointe de Mille-Vaches, Batture aux Gibiers Est, Réserve Pessamit Sud, Réserve Pessamit Nord, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est and Pointe Paradis. The only shellfish areas missing from this list are Îlets Jérémie and Franquelin; thus, the sand lance is present in all areas where sand is dominant. Looking at the overall proportion (across all stations sampled) and not only at each bed, we can see that Batture aux Gibiers Est has a proportion of 87% sand. However, Sand Lance were also observed at a station in Anse du Colombier, where sand accounts for a much lower proportion of sediments.

Clam health

The conclusion of the report provided by Michelle Maillet (DFO, Gulf Region) states that the clams harvested in 2018 in the Pointe aux Vaches, Pointe de Mille-Vaches, Réserve Pessamit

Sud and Baie Saint-Nicolas shellfish areas were generally healthy (Appendix 6). Unfortunately, the analyses on the presence of microplastics in the digestive system could not be completed.

COMPARISON OF RESULTS BETWEEN YEARS

It is possible to compare the results of recent surveys with those from surveys conducted between 2002 and 2014 for 12 shellfish areas on the Upper North Shore. The average density or average yield of soft-shell clams ≥ 51 mm increased significantly compared with previous surveys in the Baie des Petites Bergeronnes, Pointe à Émile, Cran à Gagnon, Rivière Blanche, Anse du Colombier, Anse à Norbert, Îlets Jérémie and Réserve Pessamit Sud shellfish areas (Table 8). Although the densities and yields were not significantly different, there was still an increase between years in Baie des Chevaux and Anse Noire. However, the densities and yields of legal-size soft-shell clams were similar between years in Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est.

Table 8. Survey year, number of stations, average density (number/m^2 ± standard error, average yield (g/m^2 ± standard error) of soft-shell clams by size class and comparison (Wilcoxon-Mann-Whitney non-parametric test) of results from year to year for 12 shellfish areas on the Upper North Shore.

Sector	Year	Number	Density 20–50 mm		Density ≥ 51 mm		Yield[1] ≥ 51 mm	
			Average	P > |Z|	Average	P > |Z|	Average	P > |Z|
Baie des Petites Bergeronnes	2008 2018	34 34	22.0 ± 3.7 40.9 ± 9.8	0.3988	12.4 ± 2.6 34.5 ± 5.1	**0.0002**[2]	303 ± 66 920 ± 144	**< 0.0001**[2]
Pointe à Émile	2003 2018	14 19	83.7 ± 14.7 37.8 ± 17.4	**0.0065**[2]	1.9 ± 1.1 8.0 ± 2.7	0.0571	34 ± 20 227 ± 80	**0.0430**[2]
Baie des Chevaux	2002 2017	71 121	125.3 ± 14.0 119.1 ± 10.5	0.1010	9.3 ± 2.2 22.3 ± 3.9	0.7547	229 ± 52 561 ± 106	0.5514
Cran à Gagnon	2007 2017	58 59	80.3 ± 10.3 76.8 ± 11.6	0.3505	9.8 ± 1.6 28.8 ± 4.5	**0.0053**[2]	264 ± 47 833 ± 129	**0.0029**[2]
Rivière Blanche	2009[3] 2020	43 34	61.3 ± 7.8 201.4 ± 46.9	0.9836	11.7 ± 2.6 91.5 ± 18.7	**< 0.0001**[2]	- -	-
Anse du Colombier	2009[3] 2017	33 23	122.7 ± 15.0 363.0 ± 56.6	**0.0012**[2]	5.0 ± 1.2 42.3 ± 6.6	**< 0.0001**[2]	- -	-
Anse à Norbert	2009[2] 2018	27 22	12.1 ± 5.3 30.5 ± 15.1	0.1134	2.7 ± 1.1 20.8 ± 7.1	**0.0017**[2]	- -	-
Anse Noire	2003 2018	22 16	75.4 ± 14.0 82.4 ± 24.0	0.6784	6.6 ± 2.3 24.8 ± 7.1	0.0604	150 ± 52 672 ± 201	0.0585
Îlets Jérémie	2009[3] 2017	93 51	76.7 ± 11.0 129.1 ± 36.3	0.2796	7.9 ± 1.5 28.8 ± 6.3	**0.0003**[2]	- -	-
Réserve Pessamit Sud[4]	2005 2010 2014 2018	105 108 106 108	53.5 ± 18.5 24.3 ± 6.3 28.9 ± 6.2 24.2 ± 4.0	0.1927	18.1 ± 3.6 12.5 ± 2.0 12.7 ± 2.5 49.2 ± 7.6	**< 0.0001**[2]	511 ± 86 376 ± 55 398 ± 73 1 624 ± 218	**< 0.0001**[2]
Pointe-aux-Outardes Ouest	2003 2017	218 156	6.3 ± 1.2 4.1 ± 0.9	0.5906	13.8 ± 1.2 18.7 ± 2.2	0.6111	684 ± 56 768 ± 84	0.8954
Pointe-aux-Outardes Est	2004 2018	41 41	18.9 ± 3.6 2.3 ± 1.0	**< 0.0001**[2]	11.4 ± 2.9 7.6 ± 1.9	0.2207	314 ± 75 237 ± 65	0.2293

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

[2] Values in bold represent variables (by shellfish harvest area) where there is a significant difference between years (P < 0.05).

[3] Results from Robineau (2011).

[4] Results of the Kruskal-Wallis non-parametric test (P > χ^2).

In contrast, the density of clams 20–50 mm was more variable between stations and from year to year. For most of the shellfish areas compared, there was no significant difference between years. However, the density of soft-shell clams increased significantly in Anse du Colombier, whereas it decreased in Pointe à Émile and Pointe-aux-Outardes Est (Table 8).

Twenty (20) of the shellfish areas surveyed between 2016 and 2020 were also visited in 1967–1970 (Lavoie 1969a, 1969b, 1970a, 1970b), in addition to the Baie du Moulin à Baude area, which was last surveyed in 2002 (Giguère et al. 2008). Maps indicating the locations of historical soft-shell clam beds and densities of clams ≥ 51 mm at each station from recent surveys are provided in Appendices 43 to 63 for each of these 21 shellfish areas. Although the location of the beds has generally remained unchanged, the boundaries of the beds may have shifted. On the one hand, the locations of soft-shell clam beds in the following six shellfish areas have remained nearly identical (i.e., densities of legal-size clams are located in the same place as in the historical beds): Baie du Moulin à Baude (Appendix 43), Baie des Chevaux (Appendix 52), Rivière Blanche (Appendix 56), Anse du Colombier (Appendix 57), Îlets Jérémie (Appendix 59) and Pointe-aux-Outardes Est (Appendix 63). On the other, the location of the bed in the Batture à Théophile area is not the same at all (Appendix 46). The recent survey covers a narrow strip along the entire coastline, whereas the historical bed is wider and located only at the southwestern end.

In some cases, the recent beds are more extensive than the historical ones. The most obvious example is Baie des Petites Bergeronnes, where the historical bed covers only a small area on the east-central side, while the current bed extends over the entire bay (Appendix 44). The current bed in Baie des Grandes Bergeronnes is longer and extends over the entire bay, unlike the historical bed, which only covers the center of the bay (Appendix 45). In the Baie Didier Sud shellfish area, the historical bed does not include the western portion of the bay (Appendix 54). In Baie des Plongeurs, the historical bed does not include the eastern portion of the bay (Appendix 55). The current bed in Pointe-aux-Outardes Ouest extends farther offshore and to the west (Appendix 62).

It is worrisome to note that there are four areas where the current beds are much smaller than the historical ones, i.e., in Pointe à Boisvert (Appendix 50), Pointe des Mille-Vaches (Appendix 51), Banc Marie-Marthe (Appendix 53) and Réserve Pessamit Nord (Appendix 61).

The five remaining shellfish areas are a mix of all of the situations described above. In the Baie des Escoumins, the location of the current north bed in the bay is similar to that of the historical bed (Appendix 47). The bed on the south side of the bay was not surveyed by Lavoie. The current bed at Grande Batture des Escoumins is much smaller than its historical counterpart. In the Îles Penchées, the small bed located in the southwest of the area was not surveyed by Lavoie either (Appendix 48). The boundaries of the central bed are fairly similar to the historical bed, whereas the north bed is currently less extensive and not necessarily located in the same place as its historical counterpart. The bed in the Pointe à Émile is currently not as wide as its historical counterpart but extends slightly farther west (Appendix 49). In Anse à Norbert, the historical bed does not include the eastern and southeastern portions of the current bed (Appendix 58). The historical bed also appears to be in a slightly more southerly location than the current bed. Lastly, the historical bed in Réserve Pessamit Sud extends farther north (portion partly surveyed in 2005 with minimal resources [Giguère et al. 2008]) and east, but the current bed extends slightly farther southwest (Appendix 60).

In terms of comparing densities of clams ≥ 51 mm between the two survey series (same area), there is no significant difference between years in Baie du Moulin à Baude (MD), Baie des Petites Bergeronnes (RL), Baie des Grandes Bergeronnes (SB), Batture à Théophile (GB), Baie des Escoumins (north bed in the bay [EG]), Baie Didier Sud (BD), Baie des Plongeurs (BP),

Rivière Blanche (BB), Îlets Jérémie (IJ-1 and IJ-2) and Réserve Pessamit Nord (north bed BM-3) (Table 9). For all other beds, the density from historical surveys was significantly higher than in recent surveys, i.e., in Baie des Escoumins (ES), Îles Penchées (JL and DT), Pointe à Émile (PB-1), Pointe à Boisvert (PB-1 and PB-2), Pointe de Mille-Vaches (PB-4), Baie des Chevaux (BL), Banc Marie-Marthe (BL), Anse du Colombier (CC), Anse à Norbert (AF), Réserve Pessamit Sud (BM-1), Réserve Pessamit Nord (BM-1 and BM-2), Pointe-aux-Outardes Ouest (PO-1) and Pointe-aux-Outardes Est (PO-1).

Table 9. Comparison of densities (number/m^2 ± standard error) of soft-shell clams ≥ 51 mm between surveys conducted in 1967–1970 and 2016–2020 for 21 shellfish areas on the Upper North Shore.The identifiers (Identif.) used for beds in 1967–1970 (reference indicated in parentheses) and the number of stations used in the comparison are also given.

Sector	Identif.[1]	1967–1970 Density	1967–1970 Number	2016–2020[2] Density	2016–2020[2] Number	Wilcoxon[3] P > |Z|
Baie du Moulin à Baude[2]	MD (a)	24.9 ± 3.6	72	36.7 ± 6.8	45	0.4638
Baie des Petites Bergeronnes	RL (b)	42.2 ± 8.1	9	67.8 ± 11.3	9	0.1831
Baie des Grandes Bergeronnes	SB (b)	33.5 ± 4.4	41	33.5 ± 6.8	60	0.1641
Batture à Théophile	GB (b)	11.8 ± 2.6	16	8.0 ± 2.4	11	0.3388
Baie des Escoumins	EG (b)	14.1 ± 2.2	19	43.1 ± 11.0	16	0.1420
	ES (b)	31.1 ± 3.1	135	6.7 ± 3.3	27	**< 0.0001**
Îles Penchées	JL (b)	27.4 ± 5.7	19	9.5 ± 2.8	16	**0.0065**
	DT (b)	17.4 ± 3.5	41	4.9 ± 2.6	14	**0.0187**
Pointe à Émile + Pointe à Boisvert	PB-1 (b)	29.8 ± 2.1	204	6.0 ± 0.9	124	**< 0.0001**
Pointe à Boisvert	PB-2 (b)	3.6 ± 0.7	11	0	8	**0.0009**
Pointe de Mille-Vaches	PB-4 (b)	38.1 ± 3.6	101	8.2 ± 1.5	132	**< 0.0001**
Baie des chevaux + Banc Marie-Marthe	BL (c)	59.5 ± 5.2	149	29.0 ± 3.0	199	**< 0.0001**
Baie Didier Sud	BD (c)	28.7 ± 7.2	22	29.1 ± 7.2	45	0.7392
Baie des Plongeurs	BP (c)	26.9 ± 5.0	32	31.4 ± 5.4	67	0.7777
Rivière Blanche	BB (c)	57.7 ± 8.0	71	73.9 ± 13.0	55	0.6217
Anse du Colombier	CC (c)	47.0 ± 4.9	43	34.3 ± 6.6	28	**0.0330**
Anse à Norbert	AF (c)	10.8 ± 1.9	40	5.2 ± 1.6	29	**0.0290**
Îlets Jérémie	IJ-1 (c)	27.4 ± 3.2	119	28.3 ± 6.1	60	0.0975
	IJ-2 (c)	57.0 ± 8.0	24	117.5 ± 27.0	15	0.0584
Réserve Pessamit Sud + Réserve Pessamit Nord	BM-1 (c)	33.6 ± 3.4	117	30.8 ± 6.4	98	**0.0404**
Réserve Pessamit Nord	BM-2 (c)	13.3 ± 2.4	24	1.2 ± 0.5	53	**< 0.0001**
	BM-3 (c)	28.0 ± 10.3	13	37.0 ± 20.2	4	0.5626
Pointe-aux-Outardes Ouest + Pointe-aux-Outardes Est	PO-1 (d)	17.5 ± 1.8	151	10.1 ± 1.3	137	**< 0.0001**

[1] References: a = Lavoie 1969a; b = Lavoie 1969b; c = Lavoie 1970a; and d = Lavoie 1970b.

[2] All recent surveys were conducted between 2016 and 2020, except in Baie du Moulin à Baude, which was surveyed in 2002.

[3] Values in bold represent variables (by shellfish harvest area) where there is a significant difference between years ($P < 0.05$).

This situation is not really surprising. Commercial harvesting has taken place primarily on the North Shore since 1971, and most of these landings come from the Upper North Shore (Figure 1). Biorex (1992) reports that landings recorded in 1986 were a record high in Quebec at the time. Subsequently, intensive commercial harvesting took place in most of the Upper North Shore beds from the late 1990s up until 2005 (Figure 1; Brulotte 2020). On another note, Villemure and Lamoureux (1975) reported that while digging is the main method used to harvest soft-shell clams on the Upper North Shore, dredges were used around 1973 on the beds in Portneuf-sur-Mer (Pointe à Émile, Pointe à Boisvert and Pointe de Mille-Vaches). All of the above may be reasons why the densities of legal-size soft-shell clams are currently lower in several beds.

However, the situation seems to be more worrisome in the Pointe à Émile, Pointe à Boisvert and Pointe de Mille-Vaches shellfish areas, where the current density of legal-size clams is nearly five times lower than the value obtained by Lavoie.

CONCLUSION

Surveys of soft-shell clam beds conducted from 2016 to 2020 provided a broad overview of the current status of soft-shell clam populations on the Upper North Shore. In general, soft-shell clam beds are found all along the coast, mainly in bays and mouths of rivers (wherever sediments are suitable). The size of these beds ranges from 0.004 to 5.99 km^2. Some beds overlap two shellfish areas, such as in the case of Pointe à Émile and Pointe à Boisvert (total area of 2.3 km^2), and Baie des Chevaux and Banc Marie-Marthe (total area of 1.9 km^2). The Pointe-aux-Outardes bed, which stretches across Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est, is undoubtedly the largest, totaling 7.8 km^2. However, for management-related reasons, these beds are regulated by shellfish area.

Preferred habitat of soft-shell clams consists of muddy, sandy mud, muddy sand and sandy sediments in varying proportions, and occasionally gravelly sand. Soft-shell clams are mainly associated with *Macoma balthica*, *Mesodesma* ssp., *Mytilus* ssp. and polychaetes. The most commonly observed predators are the decapods *Cancer irroratus* and *Crangon septemspinosa*.

Average densities of clams 20–50 mm vary greatly from one bed to another, with values ranging from 2.8 to 276.5 clams/m^2. This does not include Batture aux Gibiers Est, where this class is absent. In numerous beds, clams 20–50 mm account for over half of individuals. However, they were less abundant in Baie des Escoumins, Banc Marie-Marthe, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest, Pointe-aux-Outardes Est and Franquelin shellfish areas. The results of DFO surveys carried out from 2002 to 2014 on the Upper North Shore indicate that, at the time of the surveys, there were only two cases among the eleven surveys conducted in which the density of soft-shell clams 20–50 mm was lower than the density of clams ≥ 51 mm, i.e., in Baie du Moulin à Baude and Pointe-aux-Outardes Ouest (Appendix 64). This was also the case for surveys conducted from 2001 to 2011 in the other regions (Appendix 64).

The indicator for the average density of clams 20–50 mm describes the status of pre-recruitment to the fishery. To support the clam fishery, it is important to ensure that there is a certain quantity of clams present in the beds to ensure the renewal of the commercially harvestable clam population while also accounting for mortality. The reasons for the low density of clams 20–50 mm relative to the density of legal-size clams observed in some beds are unknown, but they do not seem to be related to harvesting, given that some of the target areas have not been harvested (commercially or recreationally) since at least 2010. Is this a stable situation that is not of concern for these shellfish areas? Is this an occasional situation dependent on sporadic recruitment? Is it related to sandy sediments, which make it more

difficult for juveniles to settle? Since the causes are unknown, caution must be exercised in the exploitation of these beds.

The average densities of legal-size clams from the surveys conducted between 2016 and 2020 also vary greatly from bed to bed, ranging from 2.1 to 78.5 clams/m^2. Densities higher than 45 clams/m^2 were observed in Rivière Blanche, Îlets Jérémie and Réserve Pessamit Sud shellfish areas. Such values have never been seen in other surveys conducted in Quebec from 2001 to 2014, either on the North Shore or in other regions (Appendix 64). Average densities of more than 20 clams/m^2 were observed in about half of the surveys conducted between 2016 and 2020. Such values have sometimes been obtained in soft-shell clam beds in other regions (Appendix 64). The soft-shell clam beds on the Upper North Shore may be the most productive beds in Quebec.

Of the 28 shellfish areas surveyed from 2016 to 2020, 24 had a harvestable area ranging from 0.03 to 2.37 km^2. However, some of these areas are too small to allow the commercial fishery operation, e.g., in Batture à Théophile (0.03 km^2) and Anse Noire (0.04 km^2). Conversely, other shellfish areas such as Pointe-aux-Outardes Ouest (2.47 km^2) and Réserve Pessamit Sud (0.88 km^2) have large harvestable areas. The estimated harvestable areas in previous surveys conducted on the Upper North Shore (2002–2014) are smaller than the boundaries of current areas, except in Pointe-aux-Outardes Est, where it is similar (Appendix 65 and Table 4). In addition, the Réserve Pessamit Sud has been surveyed four times since 2005. From 2005 to 2014, the harvestable area was stable at around 0.4–0.6 km^2 during a period of regular commercial harvesting, which lasted until at least 2010 (Brulotte 2020). However, in 2018, the harvestable area was estimated to be 0.88 km^2, pointing to an expansion of the soft-shell clam population in this bed.

The principle of the harvestable area makes it possible to evaluate the current status of the population and identify which beds could support commercial and recreational harvesting. The criteria used to define the harvestable areas of beds on the Upper North Shore may need to be adjusted for other regions in Quebec, given the high productivity of several beds on the Upper North Shore. Using the same criteria, harvestable areas were estimated for all 30 surveys conducted since 2001 in the Magdalen Islands, Chaleur Bay, Lower St. Lawrence and Middle North Shore regions (Appendix 65). In these other regions of Quebec, only 15 shellfish areas have a harvestable area (0.05–0.83 km^2). This type of information is useful for better targeting beds that have the potential for soft-shell clam harvesting.

In addition to the harvestable area, estimates of the density and yield of legal-size clams and, most importantly, an estimate of the biomass available for the commercial and recreational harvesting for each shellfish areas have been calculated. The available biomass is highly variable between shellfish areas since it incorporates the variables of density, the size of clams ≥ 51 mm (or yield) and the size of the harvestable area. Four shellfish areas surveyed between 2016 and 2020 had a biomass greater than 800 t: Pointe-aux-Outardes Ouest, Réserve Pessamit Sud, Baie des Grandes Bergeronnes and Baie des Chevaux (Table 4). The other areas on the Upper North Shore with a harvestable area had biomasses ranging from 10 to 684 t. In the other regions of Quebec, similar biomass values (24–476 t) were obtained in the 15 shellfish harvest areas with a harvestable area (Appendix 65). Lastly, this estimate of the biomass available for harvesting can be used to determine a suitable maximum annual harvest level (or a TAC) for each shellfish harvest area, to ensure that soft-shell clams on the Upper North Shore are sustainably harvested (DFO 2020; Brulotte 2020).

Since 2010 and the closure of processing plants on the Upper North Shore, soft-shell clam landings and fishing effort in the commercial fishery (and possibly the recreational fishery) have declined significantly (Brulotte 2020; DFO 2020). This has allowed soft-shell clam populations

on the Upper North Shore to recover to some degree, resulting in an increase in the densities of clams ≥ 51 mm and the harvestable areas of numerous beds. This was confirmed by comparing surveys conducted between 2002 and 2010 (years of heavy harvesting) with recent surveys. However, the comparison with previous years (1967–1970) clearly shows that in several beds, the current area has decreased and that current densities of soft-shell clams ≥ 51 mm are lower than historical densities.

Furthermore, the return of favourable harvesting conditions appears to be more problematic in some areas such as Pointe à Boisvert and Pointe de Mille-Vaches. These two areas were heavily exploited as early as 1985 and in the early 2000s (Gosselin 1988; Biorex 1992; Procéan 1995; Brulotte 2020; DFO 2020). Although almost no commercial harvesting has taken place in these shellfish areas since then, there is no harvestable area in these two beds, according to the recent surveys.

Frequent mixing of sediments on tidal flats, particularly those with sandy sediments, can make it difficult for young clams to settle and burrow (Newell and Hidu 1982; Hidu and Newell 1989; Hunt and Mullineaux 2002; St-Onge and Miron 2007) and can compromise recruitment and, in turn, recruitment to the fishery. Several authors have stated that processes related to pre- and post-establishment of juvenile benthic invertebrates, such as transport (passive movement), have a notable influence on the distribution and abundance of adults (Dunn et al. 1999; Snelgrove et al. 1999; Hunt 2005; LeBlanc and Miron 2005). Sediment samples collected during surveys on the Upper North Shore show that roughly 10 beds consist primarily 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 Pointe de Mille-Vaches, Réserve Pessamit Sud, Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est. Therefore, in the context of environmental change, caution must continue to be exercised. The increased frequency of storm surges, shoreline erosion and decreased ice cover are environmental phenomena that could have a negative impact on soft-shell clam populations, the recovery of certain beds and recruitment to the population.

Lastly, given that the source of larvae/juveniles for all soft-shell clam beds on the Upper North Shore has not been determined, it is recommended that the reproductive potential of each shellfish area be preserved to ensure the renewal capacity of each bed (Brulotte 2020; DFO 2020). The density of sexually mature soft-shell clams (> 40 mm) is important, since an adequate density allows the meeting of gametes released into the water and ensures successful reproduction. Although the minimum density required for soft-shell clams is not known, it can be assumed that 16 legal-size clams/m^2 is a good minimum density.

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APPENDICES

Appendix 1. List of shellfish areas (number and name) on the Upper North Shore (includes part of the Charlevoix region) in geographic order from west to east, 2020 classification based on the Canadian Shellfish Sanitation Program, soft-shell clam subarea and total allowable catch (TAC) in effect in 2019 and 2021.

Number	Name	Classification[1]	Subarea	TAC (t) 2019	TAC (t) 2021
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]	Prohibited	1A	-	-
N-01.1.1	Baie de Tadoussac	Prohibited	1A	-	-
N-01.1.2	Pointe aux Vaches	CA	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]	Prohibited	1A	-	-
N-01.2.2	Batture à Théophile	Approved	1A	0.4	0.4
N-01.3	Baie de Bon-Désir	Prohibited	1A	-	-
N-02.1	Baie des Escoumins2	Prohibited	1A	-	-
N-02.2	Îles Penchées	Approved	1A	5	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	1
N-03.2.1	Pointe à Boisvert	Approved	1A	20	0.5
N-03.2.2	Pointe de Mille-Vaches	Approved	1A	20	6
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	20
N-04.1.1.2	Mouths of Rivière Laval and Ruisseau Jean Raymond	Prohibited	1A	-	-
N-04.1.2.1	Banc Marie-Marthe	Approved	1A	30	12
N-04.1.2.2	Baie Didier Sud	Approved	1A	4	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	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	0.5
N-04.2.2	Cran à Gagnon	Approved	1A	5	5
N-04.3	Rivière Blanche	Prohibited	1A	-	-
N-04.4.1	Anse du Colombier	Approved	1A	10	7
N-04.4.2	Anse à Norbert	Approved	1A	1	1

Number	Name	Classification[1]	Subarea	TAC (t) 2019	TAC (t) 2021
N-04.5.1	Anse Noire	Approved	1A	1	0.5
N-04.5.2	Îlets Jérémie	CA	1A	15	15
N-04.6	Pointe à Michel	Prohibited	1A	-	-
N-05.1.1	Banc des Blancs	Prohibited	1A	-	-
N-05.1.2	Pointe de Betsiamites	Prohibited	1C	-	-
N-05.1.3.1	Réserve Pessamit Sud	CA-CMP	1C	50	50
N-05.1.3.2	Réserve Pessamit Nord[2]	Prohibited	1C	-	-
N-05.2.1	Ragueneau Ouest	Prohibited	1C / 1B[3]	-	-
N-05.2.2	Ragueneau Est	Prohibited	1B	-	-
N-06.1.1	Pointe-aux-Outardes Ouest	CA	1B	] 30[4]	30
N-06.1.2	Pointe-aux-Outardes Est	Approved	1B		7
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	3
N-08.2	Franquelin	Prohibited	1B	-	-
N-08.3	Baie Saint-Nicolas	Approved	1B	1	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 (2020). CA = conditionally approved, closed from June 1 to September 30 of each year; CA-CMP = approved with a conditional management plan.

[2] Harvesting permitted between 1999 and 2019 on the condition that the soft-shell clams undergo depuration at a processing plant.

[3] Shellfish area split between two subareas, with roughly ¾ located in subarea 1C and ¼ in subarea 1B, with Rivière aux Rosiers as the dividing line.

[4] Total TAC of 30 t for Pointe-aux-Outardes Ouest and Est.

Appendix 2. Shellfish areas (name and number) in Quebec where soft-shell clam beds have been surveyed since 2001 by DFO and its partners, listed by region, with the survey year and associated publication.

Magdalen Islands

Shellfish area	Area number	Year	Publication
Havre-aux-Basques	A-18.1 and A-18.2	2001	Brulotte et al. 2006
Lagune du Havre-aux-Maisons Nord	A-15.1.2	2003	Brulotte et al. 2006
Dune du Nord	A-10.2	2003	Brulotte et al. 2006
Pointe-aux-Loups	A-10.1.4	2003	Brulotte et al. 2006
Dune du Sud	A-10.1.3 et A-11	2003	Brulotte et al. 2006

Chaleur Bay

Shellfish area	Area number	Year	Publication
Bassin de la rivière Nouvelle	G-02.2	2002	Roy et al. 2003
Carleton Centre	G-03.1	2002	Roy et al. 2003
Clapperton	G-04.2	2002	Roy et al. 2003
Pointe Verte	G-06.1 and G-05	2001	Roy et al. 2003
Bonaventure	G-10.4.1 and G-10.4.2[1]	2002	Roy et al. 2003
	G-10.4.2	2009 and 2011	Present document
Bonaventure Est	G-10.4.3	2002	Roy et al. 2003
Barachois de Port-Daniel	G-20.2	2002	Roy et al. 2003
Baie du Grand-Pabos	G-21.2	2002	Roy et al. 2003
Estuaire de la rivière Malbaie	G-22.6	2002	Roy et al. 2003
Estuaire de la rivière Saint-Jean	G-24.2.2	2002	Roy et al. 2003

Lower St. Lawrence and Gaspé North

Shellfish area	Area number	Year	Publication
Kamouraska	K-01	2005	Giguère et al. 2007
Anse au Persil	B-01.3	2005	Giguère et al. 2007
Île Verte	B-02.4	2005	Giguère et al. 2007
Batture de Tobin	B-02.9	2005	Giguère et al. 2007
Îlets D'Amours	B-03.1	2005	Giguère et al. 2007
Pointe des Riou	B-03.2	2005 and 2006	Giguère et al. 2007
Baie du Ha! Ha!	B-03.5	2005	Giguère et al. 2007
Baie Hâtée	B-04.1	2005	Giguère et al. 2007
Rimouski	B-04.1	2005 and 2006	Giguère et al. 2007
Anse aux Coques	B-05[2]	2005	Giguère et al. 2007
Baie Mitis	B-06.2	2005	Giguère et al. 2007
Anse du Petit Mitis	B-06.3	2005	Giguère et al. 2007
Petits-Méchins	B-09.2	2005	Giguère et al. 2007
Capucins	B-10.1	2005 and 2006	Giguère et al. 2007

Upper North Shore

Shellfish area	Area number	Year	Publication
Pointe aux Vaches	N-01.1.2	2018	Present document
Baie du Moulin à Baude	N-01.1.3	2002	Giguère et al. 2008
Baie des Petites Bergeronnes	N-01.1.4	2008 and 2018	Giguère et al. 2008 and present document
Baie des Grandes Bergeronnes	N-01.2.1	2020	Present document
Batture à Théophile	N-01.2.2	2018	Present document
Baie des Escoumins	N-02.1	2020	Present document
Îles Penchées	N-02.2	2018	Present document
Pointe à Émile	N-03.1.2	2003 and 2018	Giguère et al. 2008 and present document
Pointe à Boisvert	N-03.2.1	2017	Present document
Pointe de Mille-Vaches	N-03.2.2	2018	Present document
Baie des Chevaux	N-04.1.1.1	2002 and 2017	Giguère et al. 2008 and present document
Banc Marie-Marthe	N-04.1.2.1	2016	Present document
Baie Didier Sud	N-04.1.2.2	2018	Present document
Baie des Plongeurs	N-04.1.3	2016	Present document
Batture aux Gibiers Est	N-04.2.1.2	2018	Present document
Cran à Gagnon	N-04.2.2	2007 and 2017	Giguère et al. 2008 and present document
Rivière Blanche	N-04.3	2009 and 2020	Robineau 2011 and present document
Anse du Colombier	N-04.4.1	2009 and 2017	Robineau 2011 and present document
Anse à Norbert	N-04.4.2	2009 and 2018	Robineau 2011 and present document
Anse Noire	N-04.5.1[3]	2003 and 2018	Giguère et al. 2008 and present document
Îlets Jérémie	N-04.5.2	2009 and 2017	Robineau 2011 and present document
Réserve Pessamit Sud	N-05.1.3.1	2005, 2010, 2014 and 2018	Giguère et al. 2008, Brulotte 2011, Brulotte 2018 and present document
Réserve Pessamit Nord	N-05.1.3.2	2019	Present document
Pointe-aux-Outardes Ouest	N-06.1.1	2003 and 2017	Giguère et al. 2008 and present document
Pointe-aux-Outardes Est	N-06.1.2	2004 and 2018	Giguère et al. 2008 and present document
Pointe Paradis	N-06.3	2019	Present document
Rivière Mistassini	N-08.1.3	2018	Present document
Franquelin	N-08.2	2020	Present document
Baie Saint-Nicolas	N-08.3	2018	Present document

Middle North Shore

Shellfish area	Area number	Year	Publication
Mingan	N-18.3.1, N-18.3.2 and N-18.3.3	2001 and 2007	Brulotte and Giguère 2003 and present document

[1] The bed overlaps slightly with the extreme western part of adjacent shellfish area G-10.4.3.

[2] Since 2008, this shellfish area has been grouped with four other areas under B-05 (B-05.1, B-05.2, B-05.3, B-05.4 and B-05.5); before that it was designated as area B-05.3.

[3] A small portion of the bed located west of Anse Noire straddles area N-04.4.2.

Appendix 3. Identification of the anteroposterior length of a soft-shell clam, equal to the longest shell measurement (Photo S. Brulotte DFO).

Appendix 4. Parameters of allometric relations between different variables (width [mm], thickness [mm], fresh whole weight (g), thawed whole weight [g], dry viscera weight [g], dry shell weight [g], and length [mm]) for soft-shell clams, by shellfish area surveyed from 2016 to 2020 on the Upper North Shore and value estimated for a 51 mm long soft-shell clam, for each dependent variable.

Width

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	y = 0.634 x – 0.905	0.992	24	31.4 mm
Baie des Petites Bergeronnes	y = 0.607 x + 1.067	0.988	120	32.0 mm
Baie des Grandes Bergeronnes	y = 0.580 x + 1.802	0.980	123	31.4 mm
Batture à Théophile	y = 0.620 x + 0.658	0.984	80	32.3 mm
Baie des Escoumins	y = 0.617 x + 0.403	0.981	123	31.9 mm
Îles Penchées	y = 0.637 x + 0.087	0.979	260	32.6 mm
Pointe à Émile	y = 0.591 x + 1.176	0.978	103	31.3 mm
Pointe à Boisvert	y = 0.614 x – 0.663	0.987	101	30.6 mm
Pointe de Mille-Vaches	y = 0.602 x – 0.530	0.979	122	30.2 mm
Baie des Chevaux	y = 0.603 x + 0.363	0.986	142	31.1 mm
Banc Marie-Marthe	y = 0.603 x + 0.716	0.974	106	31.5 mm
Baie Didier Sud	y = 0.615 x + 1.228	0.986	133	32.6 mm
Baie des Plongeurs	y = 0.594 x + 1.766	0.981	145	32.0 mm
Cran à Gagnon	y = 0.610 x + 1.350	0.971	111	32.5 mm
Rivière Blanche	y = 0.618 x – 0.032	0.987	147	31.5 mm
Anse du Colombier	y = 0.631 x – 0.411	0.987	119	31.8 mm
Anse à Norbert	y = 0.607 x + 0.544	0.981	109	31.5 mm
Anse Noire	y = 0.623 x + 0.723	0.976	135	32.5 mm
Îlets Jérémie	y = 0.579 x + 1.036	0.986	249	30.6 mm
Réserve Pessamit Sud	y = 0.587 x + 0.585	0.987	151	30.5 mm
Réserve Pessamit Nord	y = 0.622 x – 0.476	0.986	152	31.2 mm
Pointe-aux-Outardes[1]	y = 0.581 x + 0.906	0.987	316	30.5 mm
Pointe Paradis	y = 0.599 x + 0.408	0.989	111	31.0 mm
Rivière Mistassini	y = 0.607 x + 0.962	0.986	180	31.9 mm
Franquelin	y = 0.596 x + 0.002	0.987	141	30.4 mm
Baie Saint-Nicolas	y = 0.610 x + 0.665	0.974	278	31.8 mm

Thickness

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	y = 0.384 x – 0.793	0.951	22	18.8 mm
Baie des Petites Bergeronnes	y = 0.388 x + 0.049	0.974	120	19.9 mm
Baie des Grandes Bergeronnes	y = 0.388 x + 0.213	0.965	123	20.0 mm
Batture à Théophile	y = 0.362 x + 0.488	0.960	80	19.0 mm
Baie des Escoumins	y = 0.417 x – 1.297	0.966	123	19.9 mm
Îles Penchées	y = 0.400 x – 0.451	0.960	261	20.0 mm
Pointe à Émile	y = 0.371 x + 0.207	0.950	96	19.1 mm
Pointe à Boisvert	y = 0.406 x – 1.731	0.976	101	19.0 mm
Pointe de Mille-Vaches	y = 0.392 x – 1.798	0.950	122	18.2 mm
Baie des Chevaux	y = 0.379 x – 0.585	0.963	140	18.8 mm
Banc Marie-Marthe	y = 0.395 x – 0.619	0.958	106	19.6 mm
Baie Didier Sud	y = 0.376 x + 0.610	0.968	133	19.8 mm
Baie des Plongeurs	y = 0.380 x + 0.909	0.970	145	20.3 mm
Cran à Gagnon	y = 0.399 x – 0.111	0.949	111	20.2 mm
Rivière Blanche	y = 0.418 x – 1.174	0.977	147	20.1 mm
Anse du Colombier	y = 0.400 x – 0.883	0.974	120	19.5 mm
Anse à Norbert	y = 0.380 x – 0.475	0.969	109	18.9 mm

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Anse Noire	y = 0.405 x – 0.628	0.966	158	20.0 mm
Îlets Jérémie	y = 0.362 x – 0.056	0.980	248	18.4 mm
Réserve Pessamit Sud	y = 0.382 x – 1.023	0.965	151	18.5 mm
Réserve Pessamit Nord	y = 0.408 x – 1.859	0.970	152	18.9 mm
Pointe-aux-Outardes[1]	y = 0.383 x – 1.217	0.964	316	18.3 mm
Pointe Paradis	y = 0.358 x – 0.409	0.974	111	17.8 mm
Rivière Mistassini	y = 0.391 x – 0.344	0.962	180	19.6 mm
Franquelin	y = 0.382 x – 0.792	0.972	141	18.7 mm
Baie Saint-Nicolas	y = 0.397 x – 0.744	0.957	260	19.5 mm

Fresh whole weight

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	ln(y) = 3.027 ln(x) – 9.119	0.986	24	16.2 g
Baie des Petites Bergeronnes	ln(y) = 3.022 ln(x) – 8.999	0.992	120	17.9 g
Baie des Grandes Bergeronnes	ln(y) = 2.975 ln(x) – 8.813	0.991	123	17.9 g
Batture à Théophile	ln(y) = 2.958 ln(x) – 8.760	0.988	80	17.7 g
Baie des Escoumins	ln(y) = 3.239 ln(x) – 9.858	0.986	123	17.8 g
Îles Penchées	ln(y) = 3.125 ln(x) – 9.323	0.987	260	19.4 g
Pointe à Émile	ln(y) = 3.052 ln(x) – 9.106	0.984	104	18.1 g
Pointe à Boisvert	ln(y) = 3.236 ln(x) – 9.940	0.983	99	16.2 g
Pointe de Mille-Vaches	ln(y) = 3.142 ln(x) – 9.640	0.979	122	15.1 g
Baie des Chevaux	ln(y) = 3.059 ln(x) – 9.219	0.994	140	16.6 g
Banc Marie-Marthe	ln(y) = 3.123 ln(x) – 9.404	0.989	130	17.7 g
Baie Didier Sud	ln(y) = 2.988 ln(x) – 8.777	0.988	117	19.5 g
Baie des Plongeurs	ln(y) = 2.973 ln(x) – 8.706	0.989	120	19.7 g
Cran à Gagnon	ln(y) = 3.205 ln(x) – 9.566	0.984	113	20.8 g
Rivière Blanche	ln(y) = 3.146 ln(x) – 9.505	0.991	148	17.6 g
Anse du Colombier	ln(y) = 3.162 ln(x) – 9.569	0.992	120	17.5 g
Anse à Norbert	ln(y) = 3.145 ln(x) – 9.538	0.991	109	16.9 g
Anse Noire	ln(y) = 3.155 ln(x) – 9.448	0.988	158	19.3 g
Îlets Jérémie	ln(y) = 2.954 ln(x) – 8.841	0.995	132	16.0 g
Réserve Pessamit Sud	ln(y) = 3.115 ln(x) – 9.517	0.989	150	15.3 g
Réserve Pessamit Nord	ln(y) = 3.274 ln(x) – 10.109	0.987	146	15.9 g
Pointe-aux-Outardes[1]	ln(y) = 3.128 ln(x) – 9.536	0.994	203	15.8 g
Pointe Paradis	ln(y) = 3.188 ln(x) – 9.788	0.987	111	15.6 g
Rivière Mistassini	ln(y) = 3.100 ln(x) – 9.276	0.989	179	18.4 g
Franquelin	ln(y) = 3.080 ln(x) – 9.313	0.992	120	16.4 g
Baie Saint-Nicolas	ln(y) = 3.128 ln(x) – 9.401	0.984	275	18.1 g

Thawed whole weight

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	ln(y) = 3.131 ln(x) – 9.580	0.979	24	15.4 g
Baie des Petites Bergeronnes	ln(y) = 3.118 ln(x) – 9.483	0.990	120	16.1 g
Baie des Grandes Bergeronnes	ln(y) = 3.106 ln(x) – 9.455	0.989	123	15.7 g
Batture à Théophile	ln(y) = 3.094 ln(x) – 9.447	0.983	80	15.2 g
Baie des Escoumins	ln(y) = 3.325 ln(x) – 10.291	0.983	123	16.1 g
Îles Penchées	ln(y) = 3.230 ln(x) – 9.846	0.985	261	17.3 g
Pointe à Émile	ln(y) = 3.125 ln(x) – 9.500	0.979	103	16.2 g
Pointe à Boisvert	ln(y) = 3.346 ln(x) – 10.503	0.990	101	14.2 g
Pointe de Mille-Vaches	ln(y) = 3.213 ln(x) – 10.006	0.980	122	13.8 g
Baie des Chevaux	ln(y) = 3.112 ln(x) – 9.544	0.989	136	14.7 g

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Banc Marie-Marthe	ln(y) = 3.251 ln(x) – 10.043	0.983	99	15.5 g
Baie Didier Sud	ln(y) = 3.112 ln(x) – 9.360	0.989	132	17.8 g
Baie des Plongeurs	ln(y) = 3.114 ln(x) – 9.397	0.985	126	17.2 g
Cran à Gagnon	ln(y) = 3.304 ln(x) – 10.106	0.975	111	17.9 g
Rivière Blanche	ln(y) = 3.192 ln(x) – 9.775	0.992	147	16.0 g
Anse du Colombier	ln(y) = 3.202 ln(x) – 9.819	0.992	120	16.0 g
Anse à Norbert	ln(y) = 3.171 ln(x) – 9.720	0.991	109	15.6 g
Anse Noire	ln(y) = 3.220 ln(x) – 9.848	0.985	158	16.7 g
Îlets Jérémie	ln(y) = 3.109 ln(x) – 9.536	0.993	249	14.7 g
Réserve Pessamit Sud	ln(y) = 3.199 ln(x) – 9.945	0.988	151	13.9 g
Réserve Pessamit Nord	ln(y) = 3.295 ln(x) – 10.297	0.988	152	14.2 g
Pointe-aux-Outardes[1]	ln(y) = 3.192 ln(x) – 9.893	0.990	284	14.3 g
Pointe Paradis	ln(y) = 3.221 ln(x) – 10.035	0.991	112	13.8 g
Rivière Mistassini	ln(y) = 3.228 ln(x) – 9.916	0.985	180	16.1 g
Franquelin	ln(y) = 3.177 ln(x) – 9.806	0.991	141	14.6 g
Baie Saint-Nicolas	ln(y) = 3.280 ln(x) – 10.143	0.979	277	15.7 g

Dry viscera weight

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	ln(y) = 3.366 ln(x) – 13.292	0.971	24	0.95 g
Baie des Petites Bergeronnes	ln(y) = 3.240 ln(x) – 13.161	0.976	120	0.66 g
Baie des Grandes Bergeronnes	ln(y) = 3.351 ln(x) – 13.731	0.955	115	0.57 g
Batture à Théophile	ln(y) = 3.012 ln(x) – 12.634	0.962	80	0.45 g
Baie des Escoumins	ln(y) = 3.532 ln(x) – 14.223	0.978	120	0.72 g
Îles Penchées	ln(y) = 3.328 ln(x) – 13.381	0.964	260	0.74 g
Pointe à Émile	ln(y) = 3.364 ln(x) – 13.423	0.969	102	0.82 g
Pointe à Boisvert	ln(y) = 3.305 ln(x) – 13.112	0.988	101	0.89 g
Pointe de Mille-Vaches	ln(y) = 3.637 ln(x) – 14.347	0.980	121	0.95 g
Baie des Chevaux	ln(y) = 3.464 ln(x) – 13.725	0.985	140	0.90 g
Banc Marie-Marthe	ln(y) = 3.290 ln(x) – 12.890	0.979	105	1.05 g
Baie Didier Sud	ln(y) = 3.282 ln(x) – 12.997	0.983	118	0.91 g
Baie des Plongeurs	ln(y) = 3.297 ln(x) – 12.921	0.983	145	1.05 g
Cran à Gagnon	ln(y) = 3.505 ln(x) – 13.811	0.975	105	0.97 g
Rivière Blanche	ln(y) = 3.389 ln(x) – 13.562	0.985	136	0.79 g
Anse du Colombier	ln(y) = 3.511 ln(x) – 13.820	0.959	120	0.98 g
Anse à Norbert	ln(y) = 3.534 ln(x) – 14.209	0.978	109	0.73 g
Anse Noire	ln(y) = 3.236 ln(x) – 13.023	0.973	148	0.74 g
Îlets Jérémie	ln(y) = 3.153 ln(x) – 12.732	0.985	240	0.71 g
Réserve Pessamit Sud	ln(y) = 3.449 ln(x) – 13.801	0.983	151	0.79 g
Réserve Pessamit Nord	ln(y) = 3.425 ln(x) – 13.652	0.981	142	0.83 g
Pointe-aux-Outardes[1]	ln(y) = 3.182 ln(x) – 12.869	0.969	308	0.70 g
Pointe Paradis	ln(y) = 3.288 ln(x) – 13.367	0.983	111	0.65 g
Rivière Mistassini	ln(y) = 3.282 ln(x) – 13.338	0.972	179	0.65 g
Franquelin	ln(y) = 3.313 ln(x) – 13.437	0.982	136	0.66 g
Baie Saint-Nicolas	ln(y) = 3.414 ln(x) – 13.874	0.956	278	0.64 g

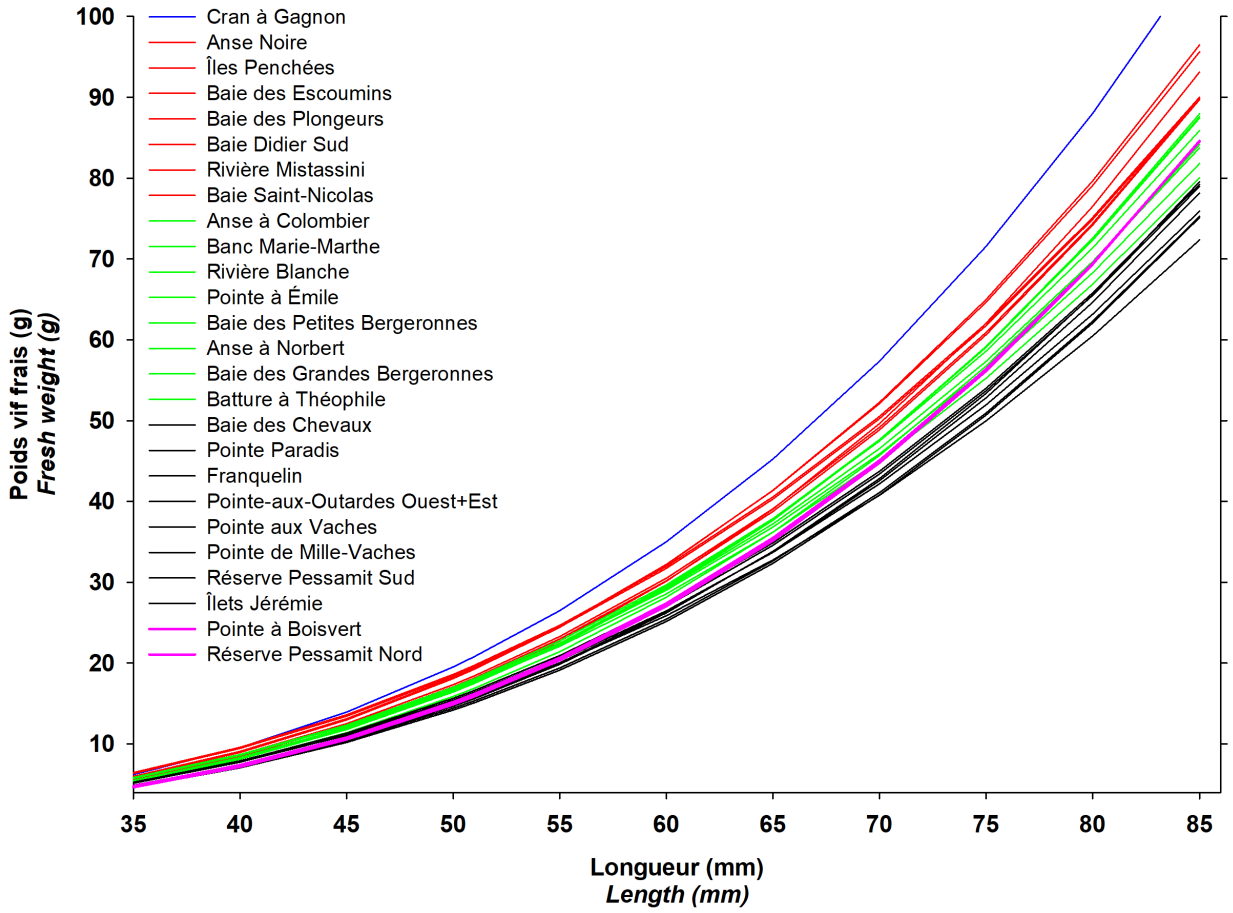
Dry shell weight

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Pointe aux Vaches	ln(y) = 3.145 ln(x) – 10.503	0.971	24	6.4 g
Baie des Petites Bergeronnes	ln(y) = 3.137 ln(x) – 10.415	0.974	120	6.8 g
Baie des Grandes Bergeronnes	ln(y) = 3.148 ln(x) – 10.441	0.980	115	6.9 g

Shellfish area	Equation	R squared	# of individuals	Value at 51 mm
Batture à Théophile	ln(y) = 3.045 ln(x) – 10.052	0.981	80	6.8 g
Baie des Escoumins	ln(y) = 3.438 ln(x) – 11.594	0.972	120	6.8 g
Îles Penchées	ln(y) = 3.227 ln(x) – 10.728	0.973	261	7.1 g
Pointe à Émile	ln(y) = 3.061 ln(x) – 10.138	0.964	102	6.7 g
Pointe à Boisvert	ln(y) = 3.327 ln(x) – 11.430	0.978	100	5.2 g
Pointe de Mille-Vaches	ln(y) = 3.251 ln(x) – 11.206	0.969	122	4.8 g
Baie des Chevaux	ln(y) = 3.021 ln(x) – 10.116	0.982	142	5.8 g
Banc Marie-Marthe	ln(y) = 3.184 ln(x) – 10.630	0.977	106	6.6 g
Baie Didier Sud	ln(y) = 3.011 ln(x) – 9.817	0.984	133	7.5 g
Baie des Plongeurs	ln(y) = 3.013 ln(x) – 9.850	0.985	145	7.4 g
Cran à Gagnon	ln(y) = 3.259 ln(x) – 10.818	0.970	111	7.4 g
Rivière Blanche	ln(y) = 3.163 ln(x) – 10.541	0.985	136	6.7 g
Anse du Colombier	ln(y) = 3.225 ln(x) – 10.863	0.984	120	6.1 g
Anse à Norbert	ln(y) = 3.179 ln(x) – 10.675	0.984	109	6.2 g
Anse Noire	ln(y) = 3.280 ln(x) – 10.968	0.980	158	6.9 g
Îlets Jérémie	ln(y) = 3.090 ln(x) – 10.339	0.987	249	6.1 g
Réserve Pessamit Sud	ln(y) = 3.199 ln(x) – 10.866	0.981	151	5.5 g
Réserve Pessamit Nord	ln(y) = 3.302 ln(x) – 11.272	0.977	142	5.5 g
Pointe-aux-Outardes[1]	ln(y) = 3.221 ln(x) – 10.881	0.985	316	6.0 g
Pointe Paradis	ln(y) = 3.253 ln(x) – 11.088	0.980	112	5.5 g
Rivière Mistassini	ln(y) = 3.278 ln(x) – 10.970	0.978	180	6.8 g
Franquelin	ln(y) = 3.336 ln(x) – 11.328	0.983	136	6.0 g
Baie Saint-Nicolas	ln(y) = 3.304 ln(x) – 11.085	0.974	276	6.7 g

[1] The samples collected in the Pointe-aux-Outardes Ouest and Pointe-aux-Outardes Est were combined, since there is only one soft-shell clam bed and it straddles the two areas.

Appendix 5. Allometric relation between soft-shell clam live weight and length for 28 shellfish areas derived for surveys conducted from 2016 to 2020 on the Upper North Shore.



Note: The different shellfish areas were divided into 5 groups (colour) to facilitate their graphical representation. However, no link, geographic or otherwise, was found between the areas in a given group.

Appendix 6. Report on the analyses conducted on soft-shell clams from Pointe aux Vaches, Pointe de Mille-Vaches, Réserve Pessamit Sud and Baie Saint-Nicolas shellfish areas to assess clam health.Received May 5, 2020.

Internal report on the health status of soft-shell clams (*Mya arenaria*) from four shellfish areas on the Upper North Shore, Quebec

- **Michelle Maillet and Rémi Sonier Ph.D**., (DFO, Gulf Region (Moncton, NB), Aquaculture and Coastal Ecosystems Section)
- **With the collaboration of Sylvie Brulotte** (DFO, Quebec Region, Demersal and Benthic Science Branch) and **Pierre Kaltenback** (Pro Faune)

BACKGROUND

The soft-shell clam (*Mya arenaria*) is a commercially harvested species that is found in the waters of the Gulf of St. Lawrence. Together, the soft-shell clam and the quahog (*Mercrenaria mercenaria*), account for a wild fishery of regional and national importance which is worth close to $86,786 (DFO 2018).

A number of bivalve species, including soft-shell clams, are vulnerable to predators, environmental factors and certain diseases. This report summarizes the results of disease screening of soft-shell clam specimens from the Upper North Shore, Quebec, more specifically, from Pointe aux Vaches, Pointe de Mille-Vaches, Réserve Pessamit Sud and Baie Saint-Nicolas. These shellfish areas were selected because their locations are believed to be affected by anthropogenic factors to a greater extent than other shellfish areas.

Laboratory processing of specimens

In August and September, 2018, sixty soft-shell clams were collected from each of the sampling sites. The specimens were transported in coolers aboard buses within three days of collection to ensure that they would be delivered alive. They were processed within 24 hours after their receipt at the Gulf Fisheries Centre laboratory. The clams were measured and dissected. A tissue slice 4 to 5 mm thick was collected, ensuring that each slice contained a section of the gills, the digestive gland, the gonads and the mantle. Following staining, the tissues were examined under the microscope at 10×, 20×, 40× and 100x magnification (with oil as needed) in order to identify diseases, parasites and pathogens.

RESULTS

Table A. Information compiled and results of the health analysis of soft-shell clams collected in 2018 in four shellfish areas on the Upper North Shore.

Information	Pointe aux Vaches	Pointe de Mille-Vaches	Réserve Pessamit Sud	Baie Saint-Nicolas
Sampling date (2018)	Sept 23.	Sept. 23	Sept. 23	Aug. 14
Average size ± SD (mm)	61.6 ± 8.5	53.1 ± 6.6	56.6 ± 5.6	52.8 ± 4.9
Number of males	27/58	29/60	24/60	26/60
Number of females	31/58	31/60	36/60	34/60
Gonad maturity index	4	4	4	4
Stomach contents	18/58	30/60	24/60	14/60
Hemocyte infiltration	5/58	19/60	10/60	17/60
Diapedesis	1/58	0/60	0/60	0/60
Metaplasia	0/58	0/60	0/60	0/60
Rickettsia-like organisms (RLO)	22/58	5/60	26/60	18/60
Ciliates	1/58	0/60	0/60	0/60

Definition of terms and values

Gametogenesis index:

0 = Underdeveloped gametes with no distinction between male and female.

1 = Start of development, where sexual differentiation occurs.

2 = The gonads fill with gametes of average maturity.

3 = The gonads are full of fully mature gametes.

4 = The gametes have been or are being released. Residual gametes are also present after release.

Hemocyte infiltration:

0 = Indicates no infiltration.

1 = Minimal infiltration, about 25% to 50% of the tissue on the slide shows infiltration. This can be associated with heavy feeding and is fairly common in a healthy population.

2 = More than 50% of tissues exhibit infiltration, possibly due to physiological or environmental stress or pathogenicity.

Systematic (extending through tissues) and focal (an aggregation of hemocytes caused by a pathogen). As a rule, infiltration is an immunological response.

Diapedesis:

Hemocyte migration across the wall of the intestine or stomach. This mechanism removes harmful elements such as parasites, heavy metals and excess metabolic products.

Metaplasia:

Change in the shape of the digestive tubules caused by stress, such as during periods of starvation and during the winter. The shape of the tubule epithelial cells changes during the stages of digestion.

Rickettsia-like organisms (RLO):

Group of intracellular organisms. In Quebec, a low level of mortality is associated with these organisms. They are not uncommon.

Ciliates:

Organisms found in bivalves that have ciliated structures or membranes. When their numbers are low, these organisms have no adverse effects on affected bivalves.

CONCLUSION

A gametogenesis index of 4 indicates that a natural reproductive cycle occurred during the preceding months (Table A).

The type of infiltration found in soft-shell clam specimens from the Upper North Shore corresponds to level 1 consistently (Table A), with no sign of pathogenicity. Level 1 infiltration is very common in healthy bivalves.

No diapedesis or metaplasia was observed in Upper North Shore soft-shell clams, except one case of diapedesis at Pointe aux Vaches (Table A). No ciliates were observed, with one exception at Pointe aux Vaches.

In the past few years, non-organic “structures” have been observed in bivalves, more specifically, in the stomach contents and even beyond the stomach lumen. More detailed analyses are required to determine the exact composition of these structures, but they may be microplastics. In the case of specimens from the Upper North Shore, these non-organic structures were found at all sites sampled (Table A).

In conclusion, the soft-shell clams collected from the Upper North Shore in 2018 were generally healthy.

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Appendix 7. General information for each of the shellfish areas surveyed from 2001 to 2014 in Quebec (grouped by region), specifically the area name, year of sampling, sampling grid, sieve mesh size, number of stations visited, number of stations surveyed, and number of sediment samples collected.

Magdalen Islands

Shellfish area and year	Grid	Sieve	Stations visited	Stations surveyed[1]	Sediment
Havre-aux-Basques 2001	150 m by 170 m	3 mm	130	98	0
Havre-aux-Maisons Nord 2003	100 m by 100 m and 50 m by 100 m	6 mm	145	145	72
Dune du Nord 2003	50 m by 100 m	6 mm	89	89	47
Pointe-aux-Loups 2003	50 m by 100 m	6 mm	108	108	55
Dune du Sud 2003	100 m by 100 m	6 mm	45	45	23

Chaleur Bay

Shellfish areaand year	Grid	Sieve	Stations visited	Stations surveyed[1]	Sediment
Bassin de la rivière Nouvelle 2002	63 m by 63 m	7 mm	358	305	0
Carleton 2002	50 m by 50 m	7 mm	55	42	0
Clapperton 2002	15 m by 100 m	7 mm	212	132	0
Pointe Verte 2001	50 m by 67 m	7 mm	70	60	0
Bonaventure 2002	15 m by 100 m, 70 m by 70 m, 15 m by 50 m, etc.	7 mm	241	147	0
Bonaventure 03/2009	200 m by 150 m and 100 m by 150 m	6 mm	71	43	0
Bonaventure 09/2009	135 m by 135 m	6 mm	34	32	7
Bonaventure 2011	135 m by 135 m	6 mm	33	32	0
Bonaventure Est 2002	33 m by 85 m	7 mm	41	13	0
Barachois de Port-Daniel 2002	50 m by 50 m	7 mm	206	151	0
Baie du Grand-Pabos 2002	63 m by 63 m and 10 m by 63 m	7 mm	226	160	0
Estuaire de la rivière Malbaie 2002	63 m by 63 m	7 mm	136	82	0
Estuaire de la rivière Saint-Jean 2002	63 m by 63 m	7 mm	196	132	0

Bas-Saint-Laurent et Gaspésie Nord

Shellfish areaand year	Grid	Sieve	Stations visited	Stations surveyed[1]	Sediment
Kamouraska 2005	135 m by 200 m	Visual[2]	111	111	0
Anse au Persil 2005	135 m by 200 m	Visual	34	34	0
Île Verte 2005	125 m by 200 m	Visual	40	40	0
Batture de Tobin 2005	150 m by 200 m and 80 m by 80 m	Visual	53	53	0
Îlets D'Amours 2005	200 m linear	Visual	11	11	0
Pointe des Riou 2006	150 m by 150 m	6 mm	102	99	0
Baie du Ha! Ha! 2005	200 m by 130 m and100 m by 130 m	Visual	47	47	0
Baie Hâtée 2005	125 m by 100 m and 85 m by 100 m	Visual	38	38	0
Rimouski 2006	175 m by 175 m	6 mm	159	159	0
Anse aux Coques 2005	200 m by 115 m	Visual	27	27	0
Baie Mitis 2005	175 m by 150 m and 120 m by 120 m	Visual	61	61	0
Anse du Petit Métis 2005	200 m by 145 m	Visual	31	31	0
Petits-Méchins 2005	195 m linear	Visual	16	16	0
Capucins 2006	75 m by 75 m	6 mm	122	118	0

Haute-Côte-Nord

Shellfish areaand year	Grid	Sieve	Stations visited	Stations surveyed[1]	Sediment
Baie du Moulin à Baude 2002	60 m by 120 m	6 mm	86	86	82
Baie des Petites Bergeronnes 2008	100 m by 100 m	10 mm	51	35	18
Pointe à Émile 2003	100 m by 200 m	6 mm	20	20	0
Baie des Chevaux 2002	150 m by 200 m and 75 m by 100 m	6 mm	76	73	73
Cran à Gagnon 2007	75 m by 75 m	1 mm	91	62	58
Anse Noire 2003	50 m by 50 m	6 mm	24	24	0
Réserve Pessamit Sud 2005	150 m by 150 m and 105 m by 105 m	6 mm	125	125	0
Réserve Pessamit Sud 2010	150 m by 150 m and 105 m by 105 m	6 mm	113	113	54
Réserve Pessamit Sud 2014	150 m by 150 m and 105 m by 105 m	6 mm	113	111	0
Pointe-aux-Outardes Ouest 2003	150 m by 200 m, 78 m by 100 m and 140 m by 200 m	6 mm	290	282	52
Pointe-aux-Outardes Est 2004	140 m by 200 m	6 mm	50	48	0

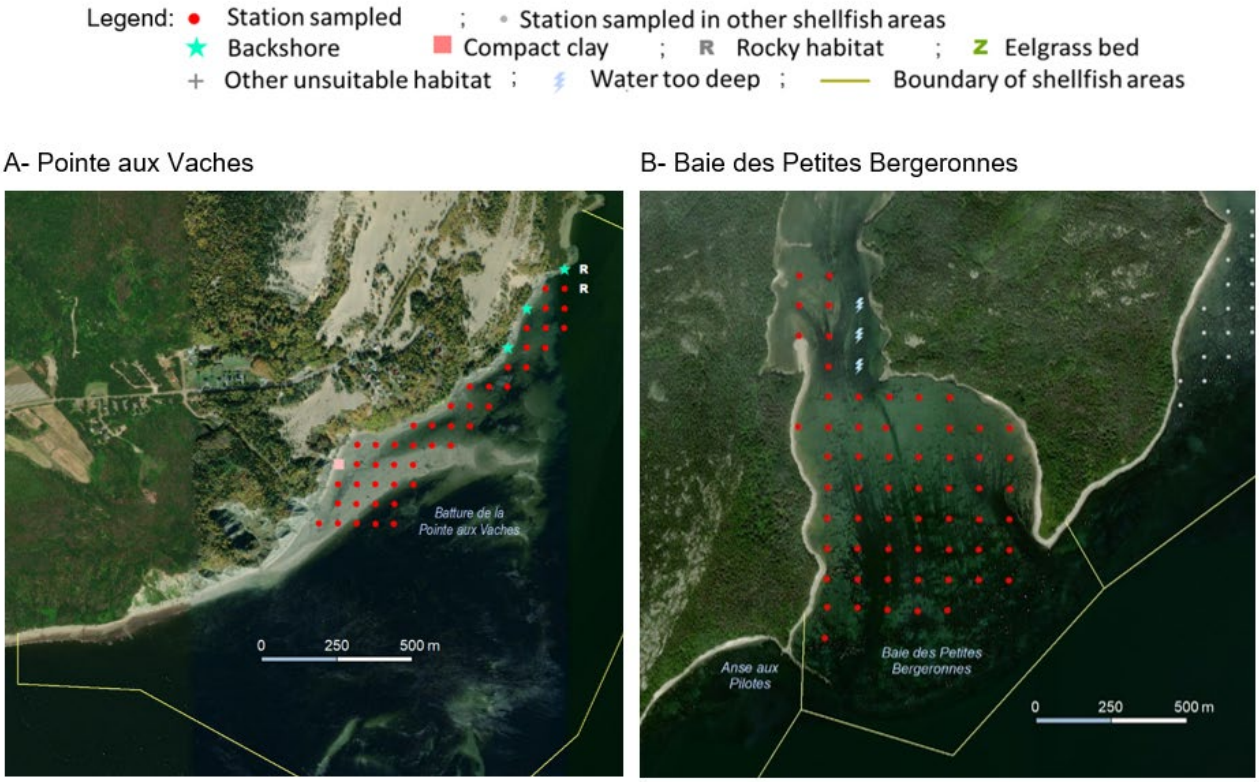
Moyenne-Côte-Nord

Shellfish areaand year	Grid	Sieve	Stations visited	Stations surveyed[1]	Sediment
Mingan 2001	100 m par 200 m, 100 m par 100 m et 50 m par 50 m, etc.	7 mm	83	83	39
Mingan 2007	90 m par 90 m	6 mm	59	59	0

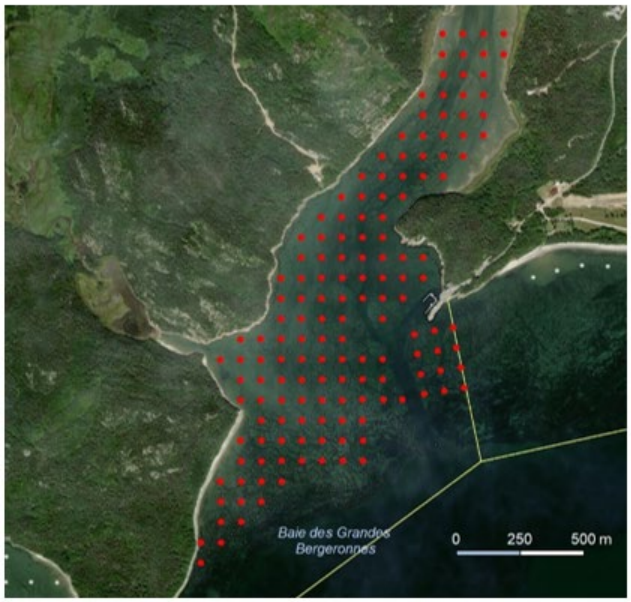
[1] Does not include stations surveyed to assess densities by kriging (1 m by 1 m or 5 m by 5 m sampling grid).

[2] Sorted visually.

Appendix 8. Map showing the locations of the stations visited, for each shellfish area, during the surveys of soft-shell clam beds on the Upper North Shore conducted from 2016 to 2020.Source of basemap: ArcGIS online (ESRI, Maxar, GeoEye, Earthstar Geographics, CNSE/Airbus DS, USDA, USGS, AeroGRID, IGN and the GIS user community).



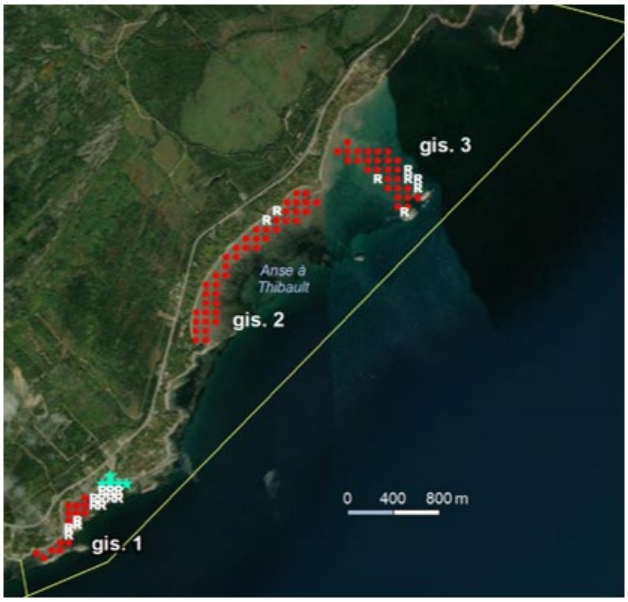
C- Baie des Grandes Bergeronnes



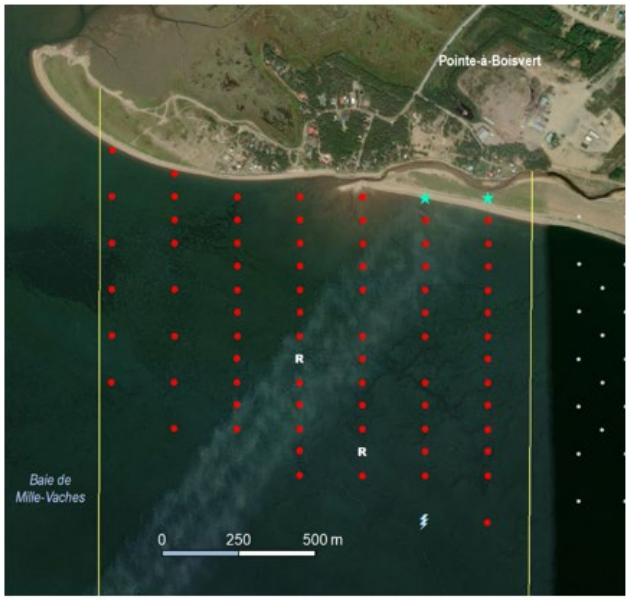
D- Batture à Théophile

E- Baie des Escoumins

F- Îles Penchées



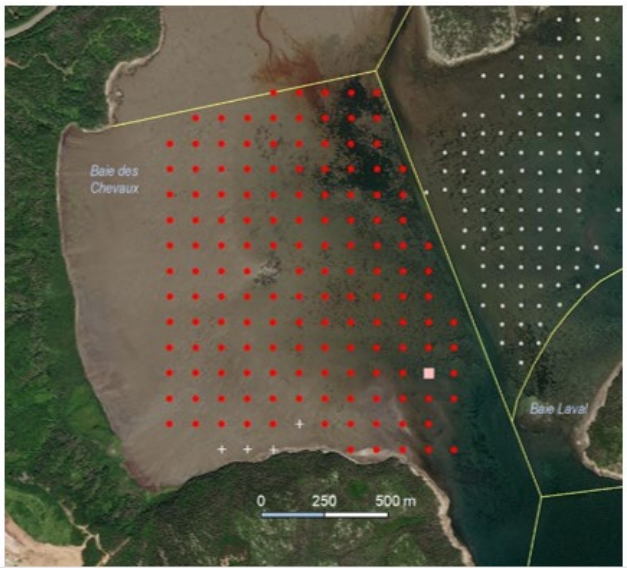
G- Pointe à Émile



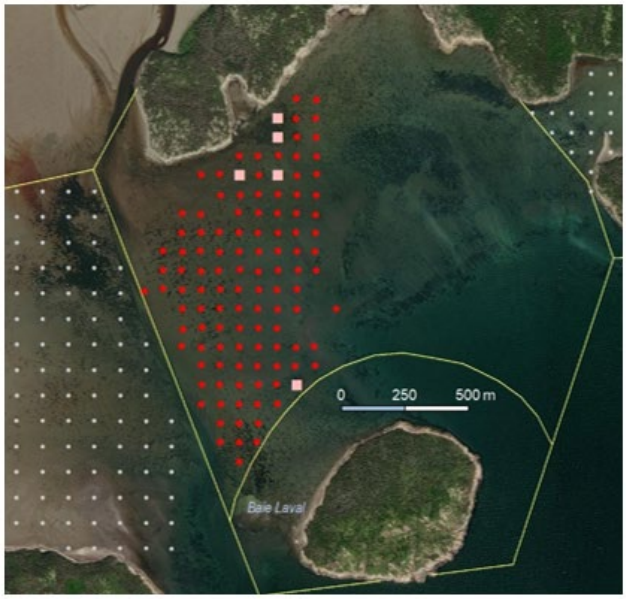
H- Pointe à Boisvert

I- Pointe de Mille-Vaches

J- Baie des Chevaux

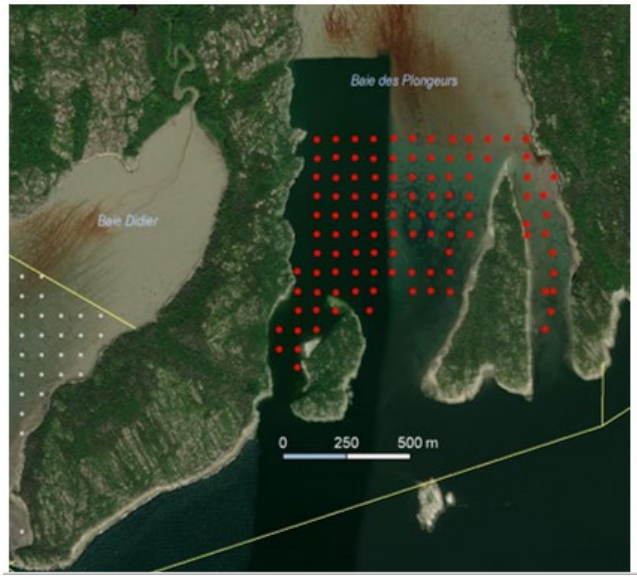


K- Banc Marie-Marthe



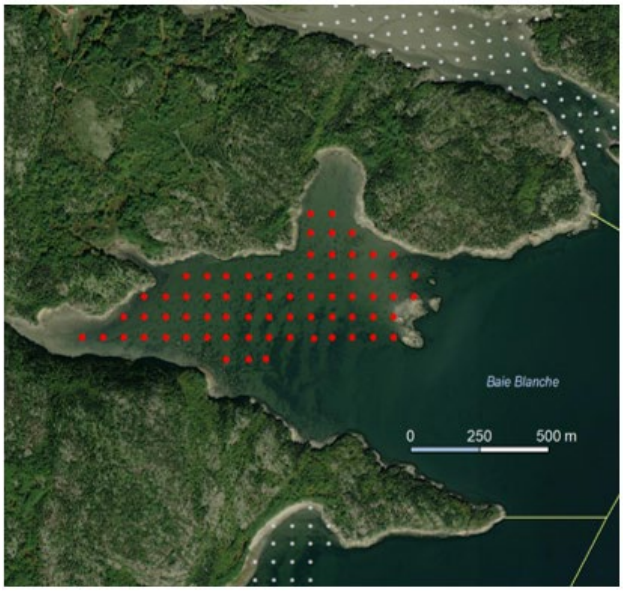
L- Baie Didier Sud

M- Baie des Plongeurs

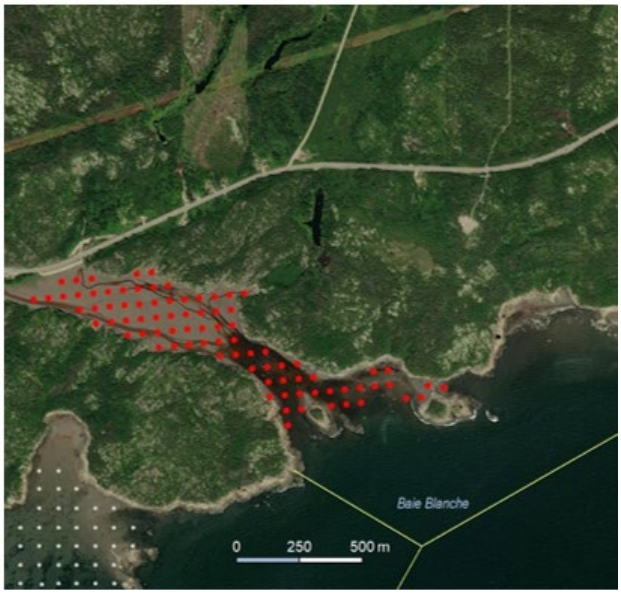


N- Batture aux Gibiers Est

O- Cran à Gagnon



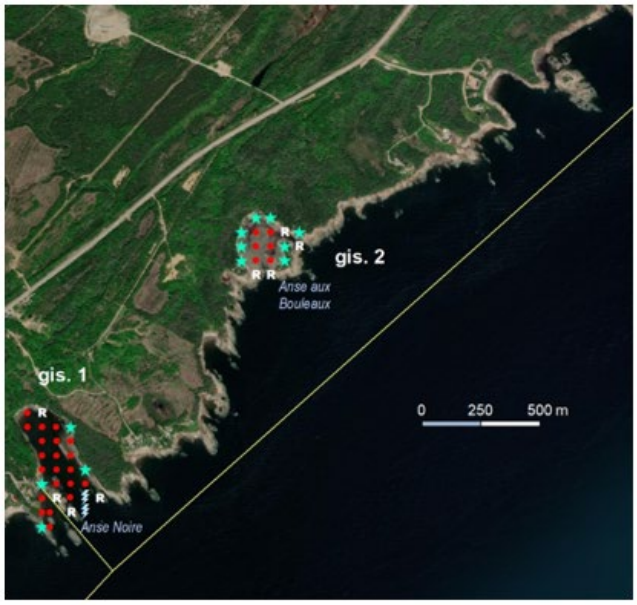
P- Rivière Blanche



Q- Anse du Colombier

R- Anse à Norbert

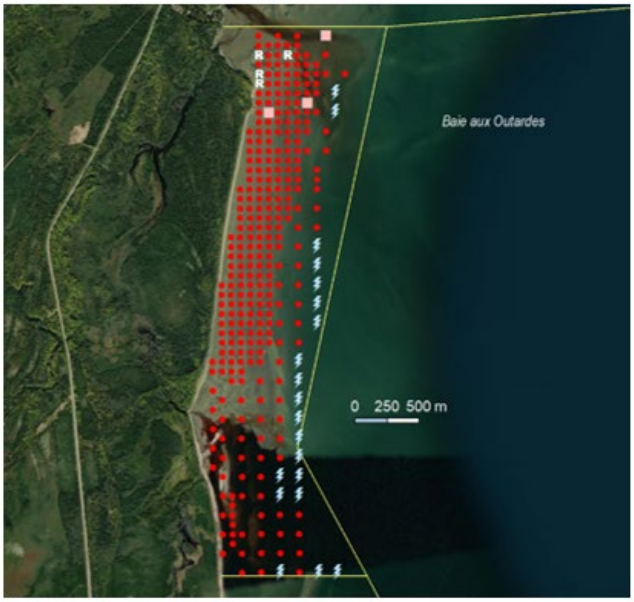
S- Anse Noire



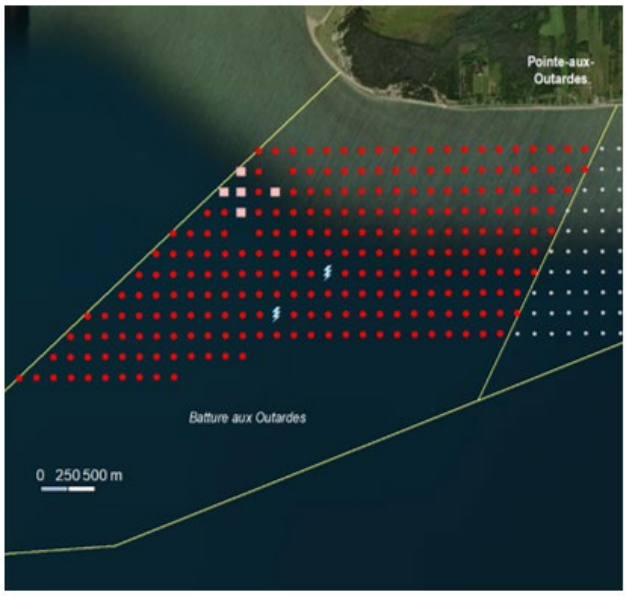
T- Îlets Jérémie

U- Réserve Pessamit Sud

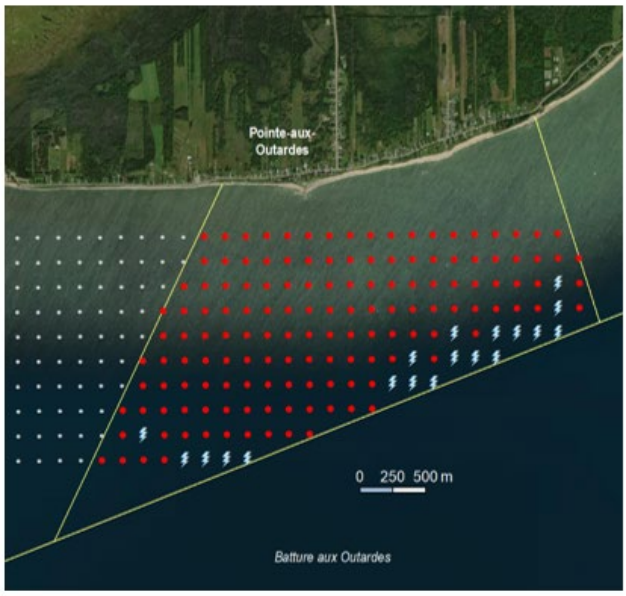
V- Réserve Pessamit Nord



W- Pointe-aux-Outardes Ouest



X- Pointe-aux-Outardes Est

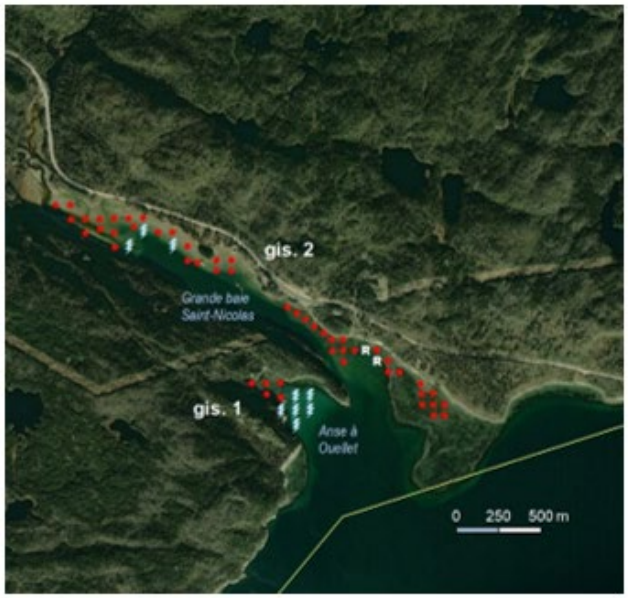


Y- Pointe Paradis

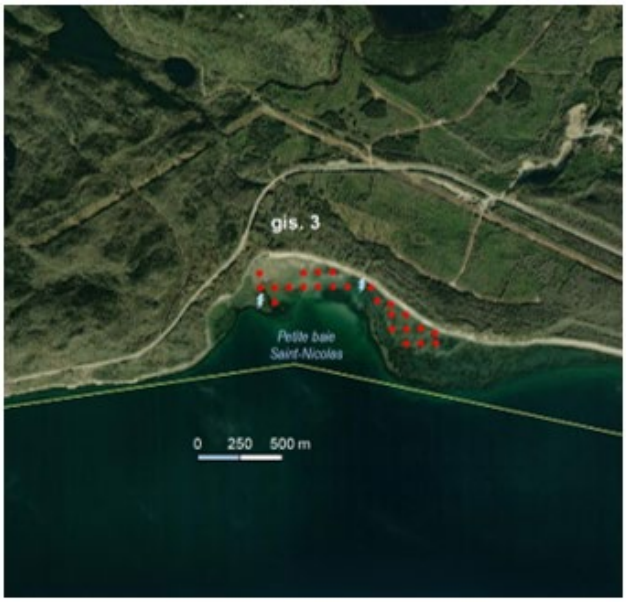
Z- Rivière Mistassini

AA- Franquelin

BB- Baie Saint-Nicolas portion ouest



CC- Baie Saint-Nicolas portion est



Appendix 9. Results (in number of stations) of grain size analysis and visual assessment and total compilation (%) by sediment category for stations surveyed on soft-shell clam beds, by shellfish area, from 2001 to 2014 in Quebec (grouped by region).

Magdalen Islands

Shellfish area	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M
Havre-aux-Basques 2001	-	-	-	-	-	-	0	0	1	88	9	0	0	0	1.0	89.8	9.2	0
Havre-aux-Maisons Nord 2003	0	0	0	62	1	0	0	0	0	56	8	0	0	0	0	92.9	7.1	0
Dune du Nord 2003	0	0	0	45	0	0	0	0	0	40	0	0	0	0	0	100	0	0
Pointe-aux-Loups 2003	0	0	0	55	0	0	0	0	0	52	0	1	0	0	0	99.1	0	0.9
Dune du Sud 2003	0	0	0	23	0	0	0	0	0	19	0	1	0	0	0	97.7	0	2.3

Chaleur Bay

Shellfish area	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	M	Sm	Ms	Sm	M	Sm	Ms	M	M	Sm	Ms	S	M	Sm
Bonaventure 2009-2011[2 3]	0	0	2	4	1	0	2	18	14	4	4	1	4.0	36.0	32.0	16.0	10.0	2.0

Lower St. Lawrence and Gaspé North

Shellfish area	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M
Kamouraska 2005	-	-	-	-	-	-	8	13	8	3	22	15	11.6	18.8	11.6	4.3	31.9	21.7
Anse au Persil 2005	-	-	-	-	-	-	2	1	6	0	2	0	18.2	9.1	54.5	0	18.2	0
Île Verte 2005	-	-	-	-	-	-	0	1	29	2	0	0	0	3.1	90.6	6.3	0	0
Batture de Tobin 2005	-	-	-	-	-	-	0	1	16	2	1	0	0	5.0	80.0	10.0	5.0	0
Îlets D'Amours 2005	-	-	-	-	-	-	0	3	0	0	1	1	0	60.0	0	0	20.0	20.0
Pointe des Riou 2006	-	-	-	-	-	-	0	5	35	3	10	3	0	8.9	62.5	5.4	17.9	5.4
Baie du Ha! Ha! 2005	-	-	-	-	-	-	1	0	15	0	3	4	4.3	0	65.2	13.0	17.4	0
Baie Hâtée 2005	-	-	-	-	-	-	1	1	5	5	2	0	7.1	7.1	35.7	35.7	14.3	0
Rimouski 2006	-	-	-	-	-	-	26	13	40	16	44	6	17.9	9.0	27.6	11.0	30.3	4.1
Anse aux Coques 2005	-	-	-	-	-	-	0	0	0	5	0	1	0	0	0	83.3	0	16.7
Baie Mitis 2005	-	-	-	-	-	-	5	20	9	5	0	2	12.2	48.8	22.0	12.2	0	4.9
Anse du Petit Métis 2005	-	-	-	-	-	-	1	4	6	0	1	0	8.3	33.3	50.0	0	8.3	0
Petits-Méchins 2005	-	-	-	-	-	-	0	0	0	0	0	1	-	-	-	-	-	-
Capucins 2006[2]	-	-	-	-	-	-	9	5	58	5	14	1	9.8	5.4	63.0	5.4	15.2	1.1

Upper North Shore

Shellfish area	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M
Baie du Moulin à Baude 2002	0	0	3	27	35	1	0	0	0	0	0	1	0	0	4.5	40.3	52.2	3.0
Baie des Petites Bergeronnes 2008[2]	0	0	4	1	8	4	0	0	3	0	12	0	0	0	21.9	3.1	62.5	12.5
Pointe à Émile 2003	-	-	-	-	-	-	5	6	2	4	0	0	29.4	35.3	11.8	23.5	0	0
Baie des Chevaux 2002	3	31	29	7	1	0	-	-	-	-	-	-	4.2	43.7	40.8	9.9	1.4	0
Cran à Gagnon 2007[2]	10	22	18	3	1	0	3	0	0	0	0	0	22.8	38.6	31.6	5.3	1.8	0
Anse Noire 2003	-	-	-	-	-	-	7	11	0	0	3	1	31.8	50.0	0	0	13.6	4.5
Réserve Pessamit Sud 2005	-	-	-	-	-	-	0	4	20	70	11	0	0	3.8	19.0	66.7	10.5	0
Réserve Pessamit Sud 2010[2]	0	1	1	25	23	2	-	-	-	-	-	-	0	1.9	1.9	48.1	44.2	3.8
Pointe-aux-Outardes Ouest 2003[2]	0	1	0	22	16	0	0	15	10	15	83	8	0	9.4	5.9	21.8	58.2	4.7
Pointe-aux-Outardes Est 2004	-	-	-	-	-	-	0	0	0	9	30	2	0	0	0	22.0	73.2	4.9

Middle North Shore

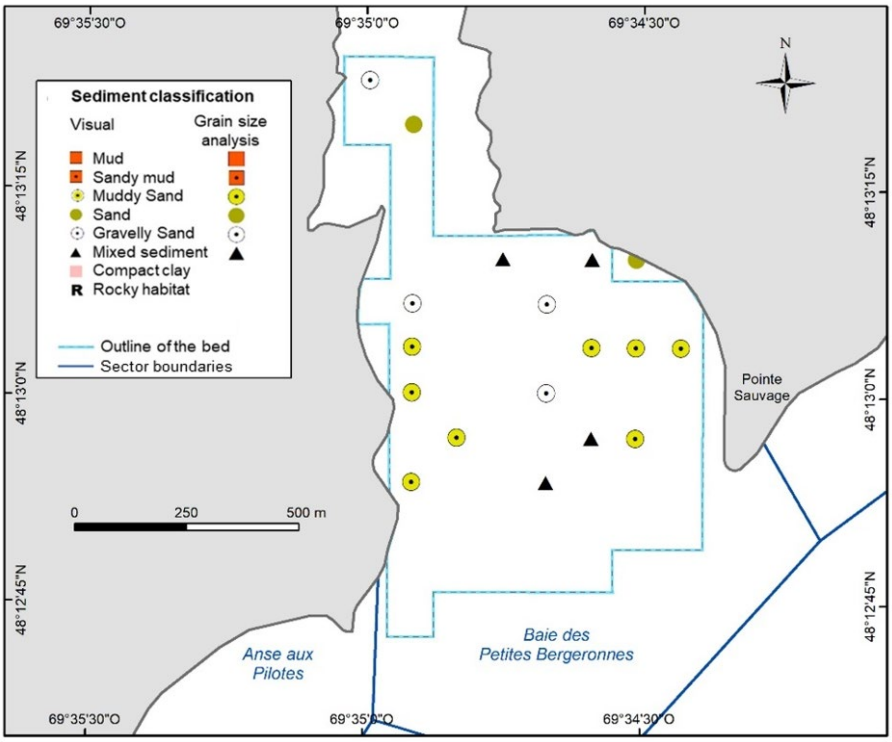
Shellfish area	Grain size analysis[1]						Visual assessment[1]						Total (%)[2]					
	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M	M	Sm	Ms	S	Gs	M
Mingan 2001	0	0	0	13	3	1	0	0	10	19	10	0	0	0	17.9	57.1	23.2	1.8
Mingan 2007	-	-	-	-	-	-	0	0	6	26	9	0	0	0	14.6	63.4	22.0	0

[1] Sediment category: M = Clay and silt, Sm = Sandy mud, Ms = Muddy sand, S = Sand, Gs = Gravelly sand, Mix = Mixed sediment (mixture of gravel, sand and clay), see Table 2 for further information.

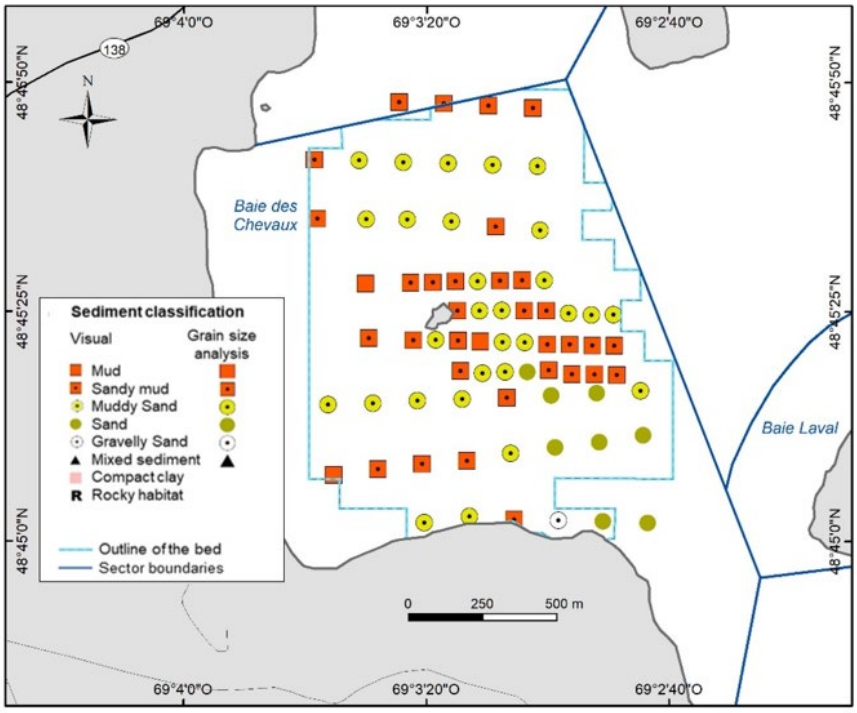
[2] Compilation calculated based on all stations, Grain size analyses and visual assessment, by sediment category. By default, the information on sediment category is available for all stations surveyed. There are a few exceptions where information is missing for some stations. Here is the list of exceptions: Capucins (98% of stations), Bonaventure (89% of stations), Baie des Petites Bergeronnes (94% of stations), Cran à Gagnon (98% of stations), Réserve Pessamit Sud 2010 (48% of stations) and Pointe-aux-Outardes Ouest (72% of stations).

[3] Value calculated based on all information (non-redundant) collected from 2009 to 2011.

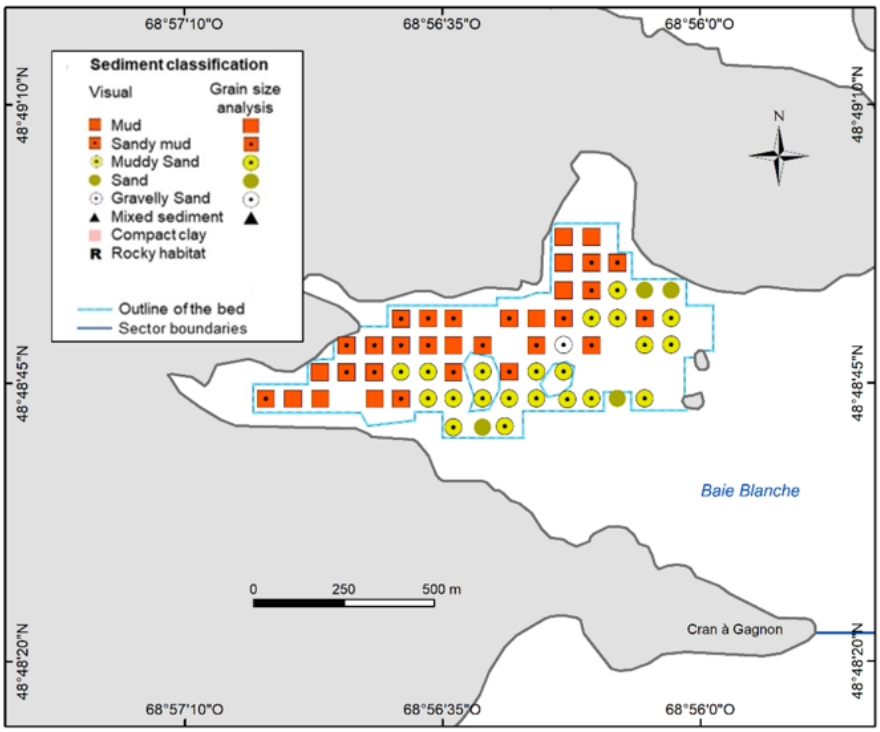
Appendix 10. Sediment classification (grain size analysis), by station, in Baie des Petites Bergeronnes N-01.1.4 shellfish area on the Upper North Shore surveyed in 2008.



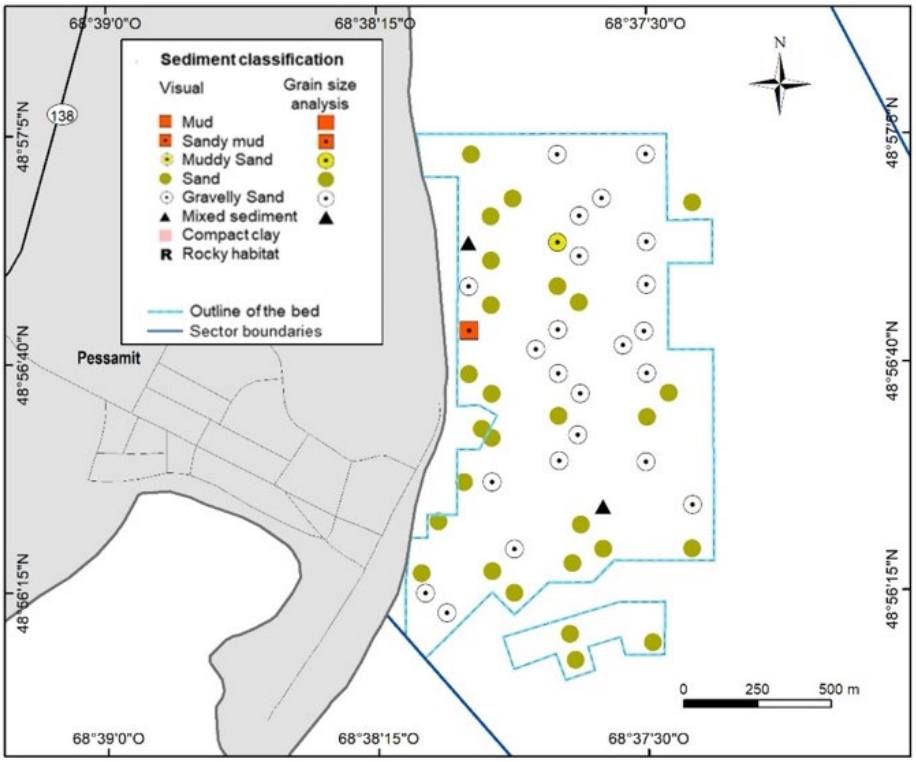
Appendix 11. Sediment classification (grain size analysis), by station, in Baie des Chevaux N-04.1.1.1 shellfish area on the Upper North Shore surveyed in 2002.



Appendix 12. Sediment classification (grain size analysis), by station, in Cran à Gagnon N-04.2.2 shellfish area on the Upper North Shore surveyed in 2007.



Appendix 13. Sediment classification (grain size analysis), by station, in Réserve Pessamit Sud N-05.1.3.1 shellfish area on the Upper North Shore surveyed in 2010.



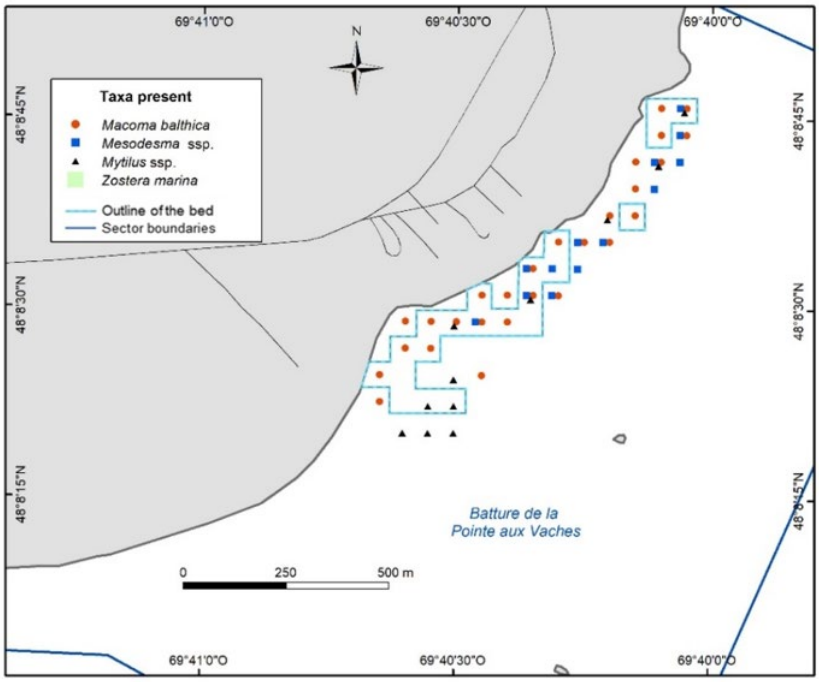
Appendix 14. Number of stations (No.) and occurrence (number of stations where species was observed) of associated species observed during the surveys of 28 shellfish areas conducted from 2016 to 2020 on the Upper North Shore.

Shellfish area	No.	Mya[1]	Mac[1 2]	Meso[1 2]	Mytil[1 2]	Cyrto[1]	Ensis[1]	Gast[1]	Poly[1]	Canc[1]	Crang[1]	Ammo[1]	Zost[1 2]	Other[1]
Pointe aux Vaches	45	16	27	13	11	0	0	0	19	0	0	0	0	0
Baie des Petites Bergeronnes	61	60	13	0	28	0	0	0	29	0	0	0	0	0
Baie des Grandes Bergeronnes	150	123	22	1	53	0	0	0	69	0	1	0	0	0
Batture à Théophile	52	44	8	0	0	0	0	0	13	0	0	0	0	1
Baie des Escoumins	93	71	33	2	21	0	0	0	9	0	0	0	1	0
Îles Penchées	86	69	23	0	28	0	0	0	58	4	0	0	0	0
Pointe à Émile	74	59	10	1	18	0	0	2	42	5	0	0	8	0
Pointe à Boisvert	139	75	66	42	5	0	0	0	79	6	0	1	0	0
Pointe de Mille-Vaches	193	79	151	16	15	0	5	1	110	0	0	2	32	0
Baie des Chevaux	148	135	61	7	35	0	0	0	68	1	0	0	4	0
Banc Marie-Marthe	110	82	85	62	36	0	0	2	82	1	1	0	4	3
Baie Didier Sud	112	85	44	3	22	0	0	1	71	0	0	0	0	0
Baie des Plongeurs	106	88	72	4	27	0	0	2	70	2	1	0	0	4
Batture aux Gibiers Est	22	1	0	0	2	0	0	0	7	0	0	1	0	0
Cran à Gagnon	69	55	12	0	4	0	0	0	26	2	0	0	0	0
Rivière Blanche	84	68	48	0	17	0	0	0	12	0	2	0	11	0
Anse du Colombier	51	35	25	0	3	0	0	0	22	0	0	1	0	0
Anse à Norbert	66	38	39	21	3	1	1	1	32	0	0	0	0	0
Anse Noire	27	25	12	2	3	0	0	0	11	0	0	0	0	0
Îlets Jérémie	97	73	46	17	6	0	0	0	16	0	1	0	0	0
Réserve Pessamit Sud	113	94	39	28	22	0	0	0	35	0	0	9	0	0
Réserve Pessamit Nord	285	178	270	163	1	0	1	1	154	0	70	6	0	0
Pointe-aux-Outardes Ouest	246	163	40	36	45	0	0	0	116	1	0	7	13	0
Pointe-aux-Outardes Est	143	39	0	132	33	0	0	0	96	2	1	2	5	0
Pointe Paradis	199	85	11	68	11	0	2	0	84	5	3	2	40	0
Rivière Mistassini	78	64	23	2	28	0	0	0	11	1	0	0	1	0
Franquelin	95	41	26	43	18	0	0	1	9	0	0	0	0	0
Baie Saint-Nicolas	76	55	15	9	24	0	1	9	28	1	0	0	2	1

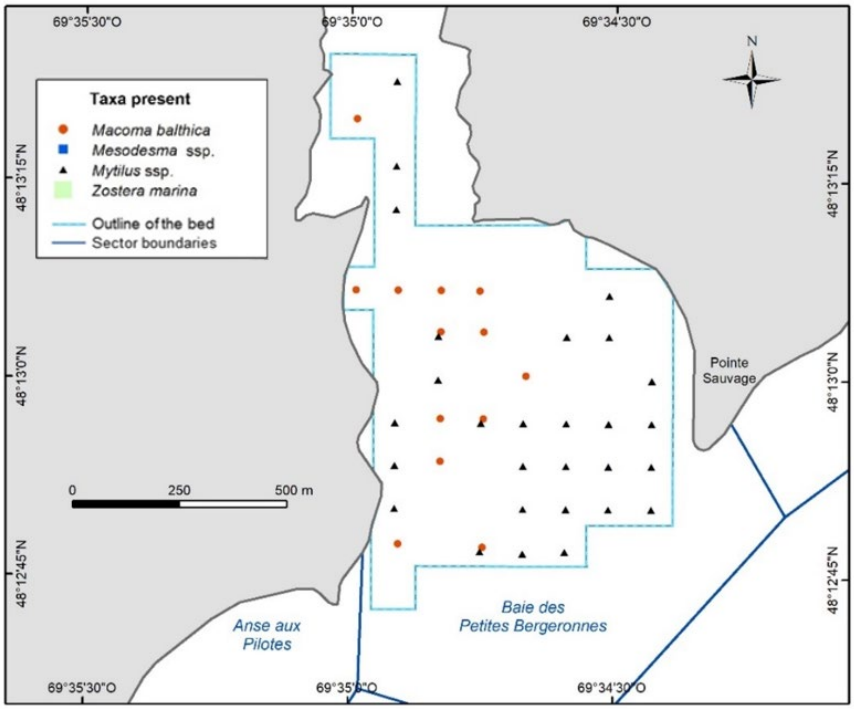
[1] The species observed are, in order listed: *Mya arenaria*, *Macoma balthica*, *Mesodesma* ssp., *Mytilus* ssp., *Cyrtodaria siliqua*, *Ensis leei*, Gastropoda (includes *Buccinum undatum*, Littorinidae, Naticidae, Nudibranchia and *Testudinalia testudinalis*), Polychaeta, *Cancer irroratus*, *Crangon septemspinosa*, *Ammodytes americanus*, *Zostera marina* and Other species (includes Nemertea, Cirripedia and *Strongylocentrotus droebachiensis*).

[2] The occurrences by station of these four species are shown on maps for each shellfish area in Appendices 15 to 42.

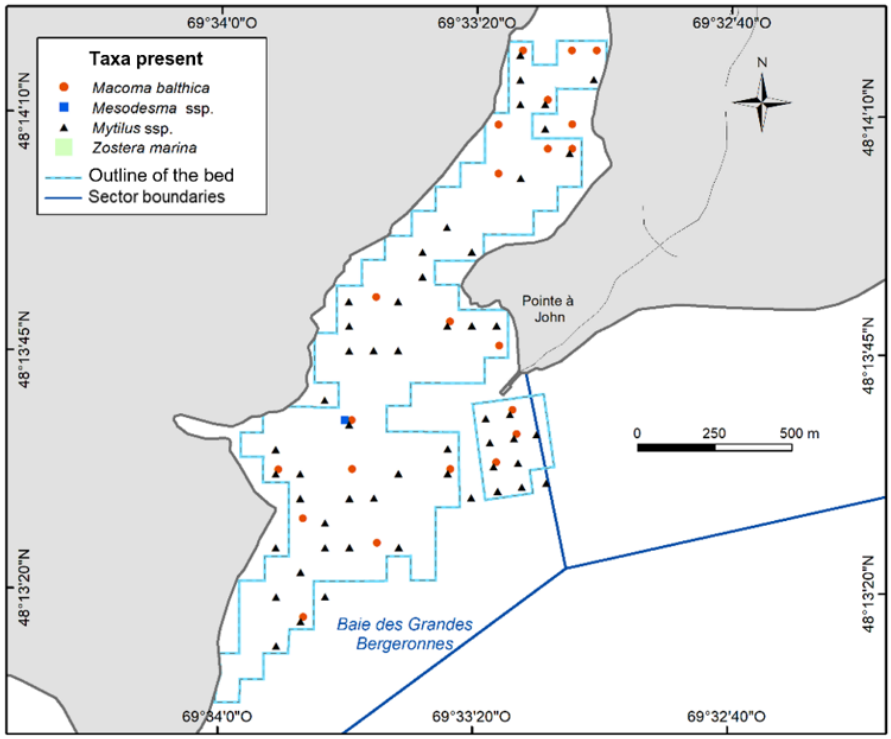
Appendix 15. Occurrence, by station, of Macoma balthic*a,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe aux Vaches N-01.1.2 shellfish area on the Upper North Shore surveyed in 2018.*



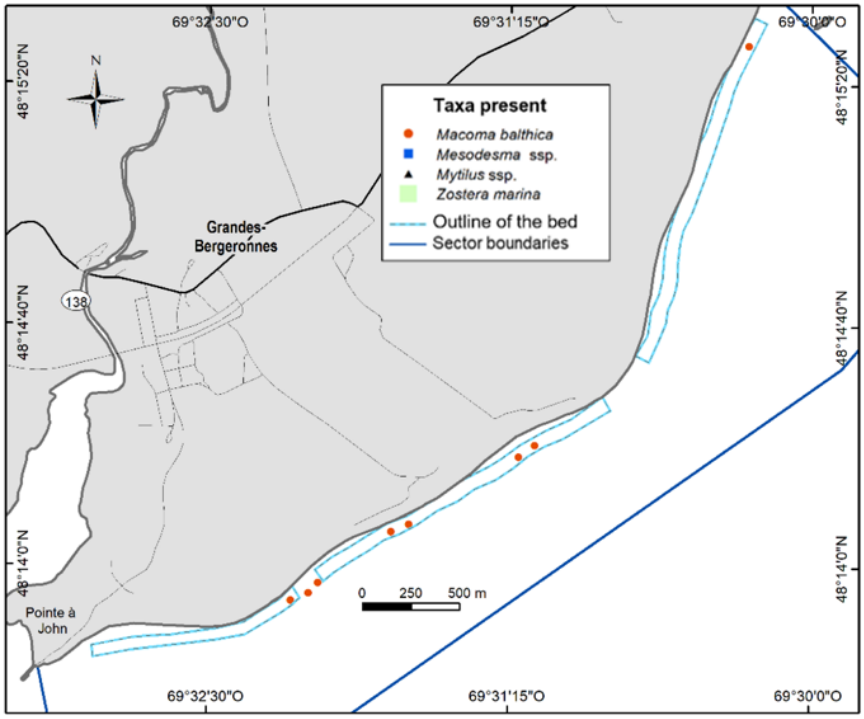
Appendix 16. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie des Petites Bergeronnes N-01.1.4 shellfish area on the Upper North Shore surveyed in 2018.*



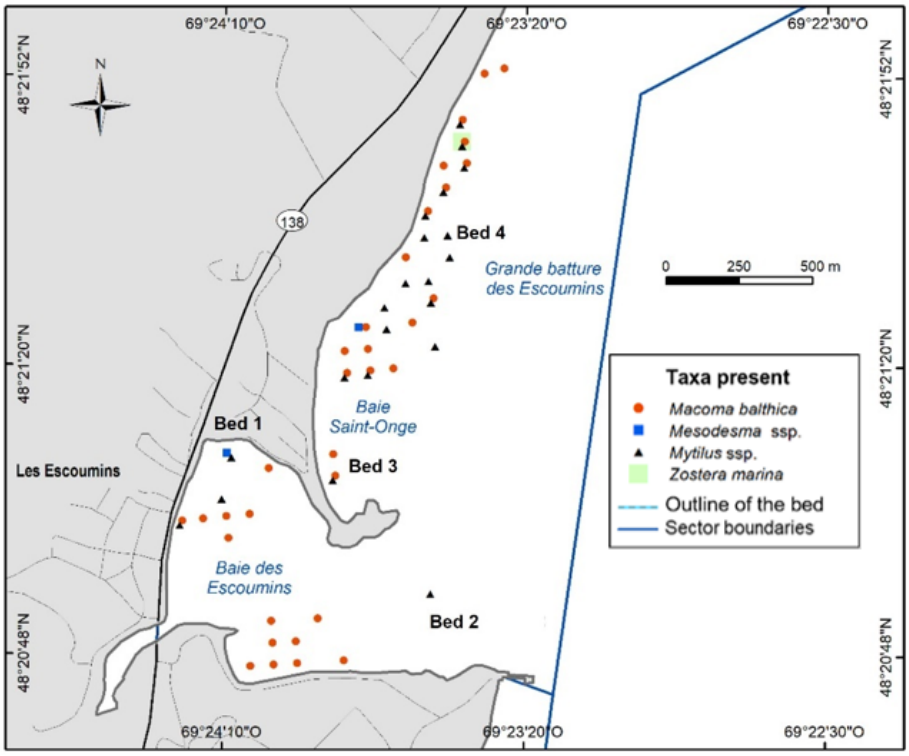
Appendix 17. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie des Grandes Bergeronnes N-01.2.1 shellfish area on the Upper North Shore surveyed in 2020.*



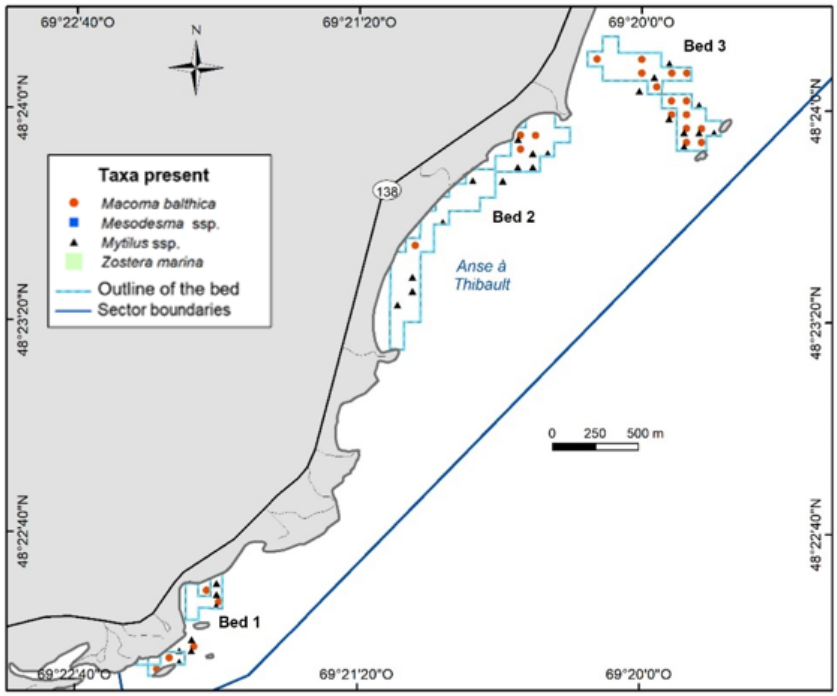
Appendix 18. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Batture à Théophile N-01.2.2 shellfish area on the Upper North Shore surveyed in 2018.*



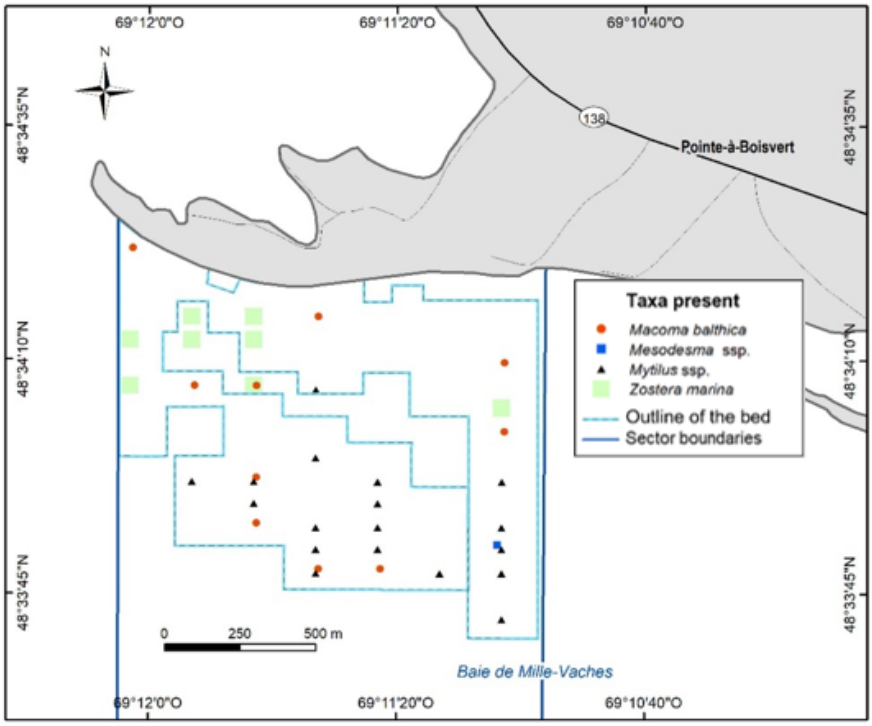
Appendix 19. Occurrence, by station, of Macoma balthica, Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie des Escoumins N-02.1 shellfish area on the Upper North Shore surveyed in 2020.*



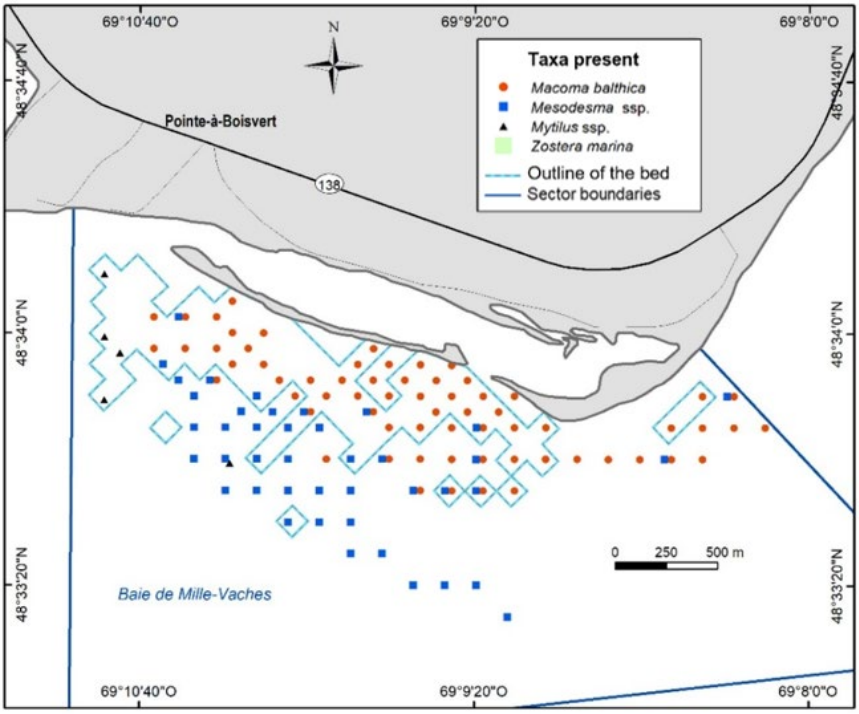
Appendix 20. Occurrence, by station, of Macoma balthica, Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Îles Penchées N-02.2 shellfish area on the Upper North Shore surveyed in 2018.*



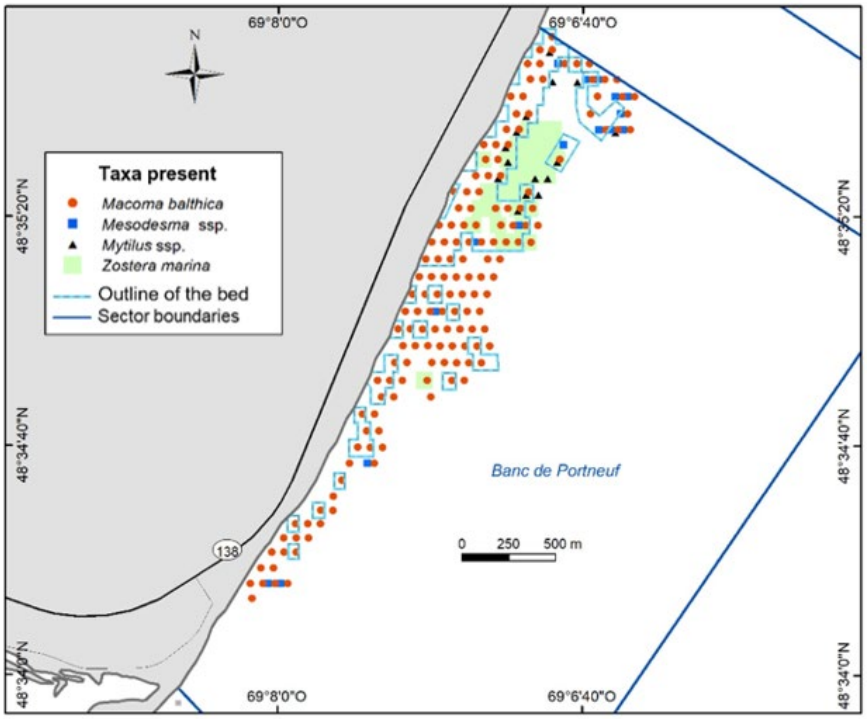
Appendix 21. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *Pointe à Émile N-03.1.2 shellfish area on the Upper North Shore surveyed in 2018.*



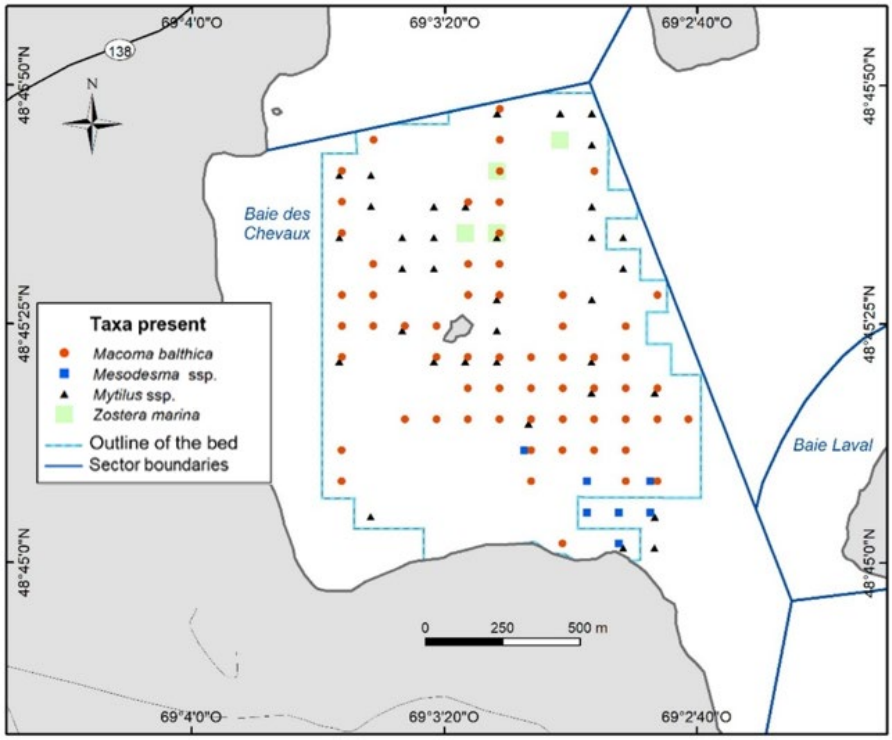
Appendix 22. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe à Boisvert N-03.2.1 shellfish area on the Upper North Shore surveyed in 2017.*



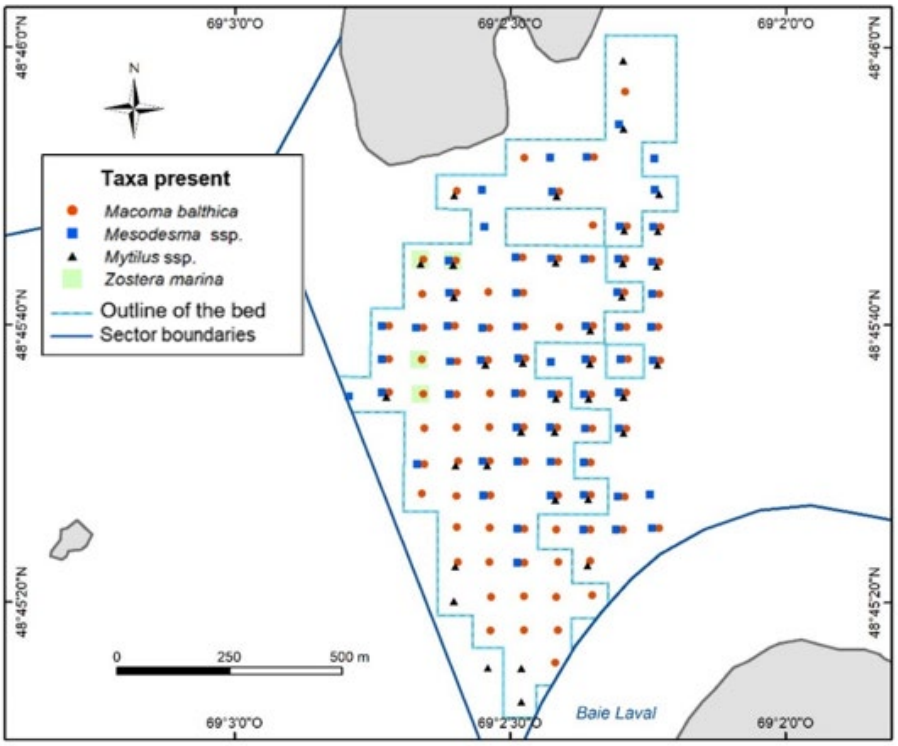
Appendix 23. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe de Mille-Vaches N-03.2.2 shellfish area on the Upper North Shore surveyed in 2018.*



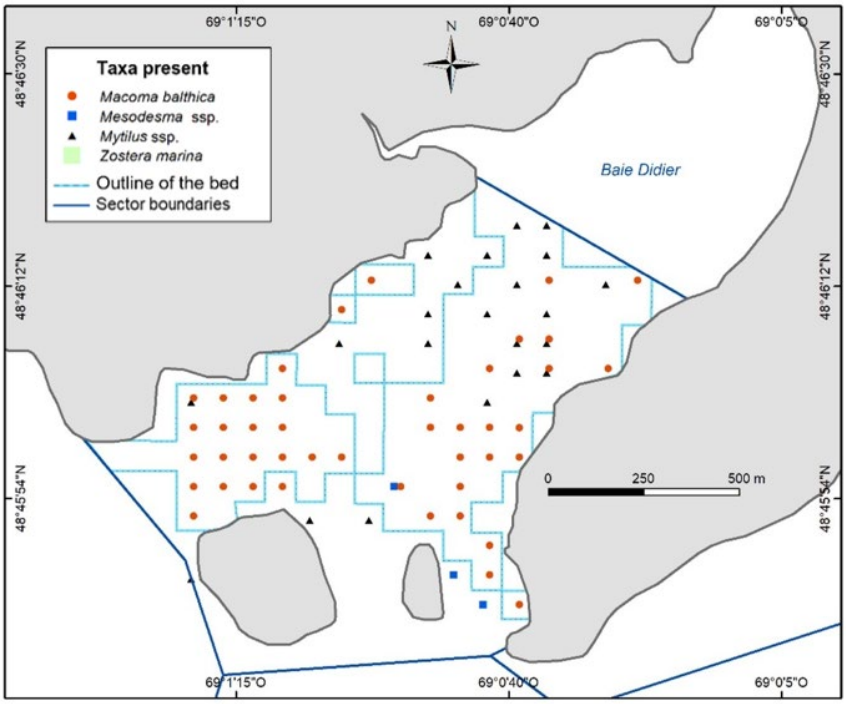
Appendix 24. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie des Chevaux N-04.1.1.1 shellfish area on the Upper North Shore surveyed in 2017.*



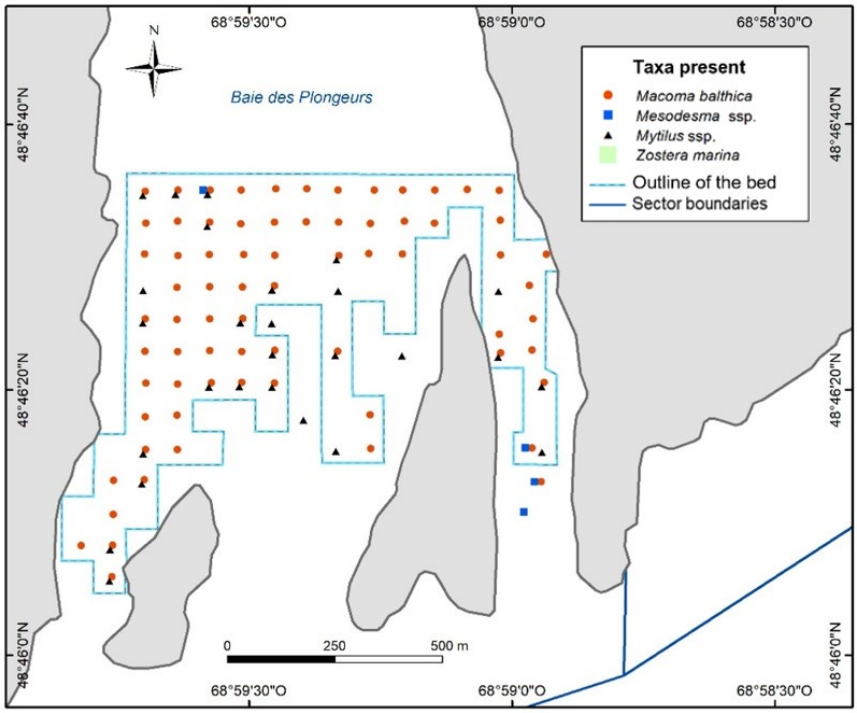
Appendix 25. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Banc Marie-Marthe N-04.1.2.1 shellfish area on the Upper North Shore surveyed in 2016.*



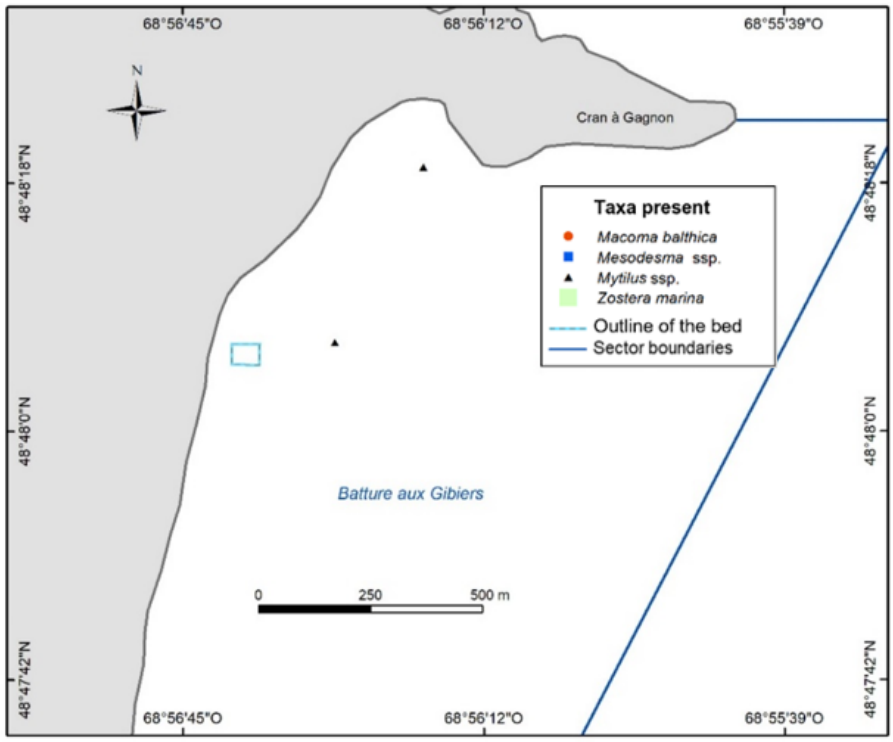
Appendix 26. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie Didier Sud N-04.1.2.2 shellfish area on the Upper North Shore surveyed in 2018.*



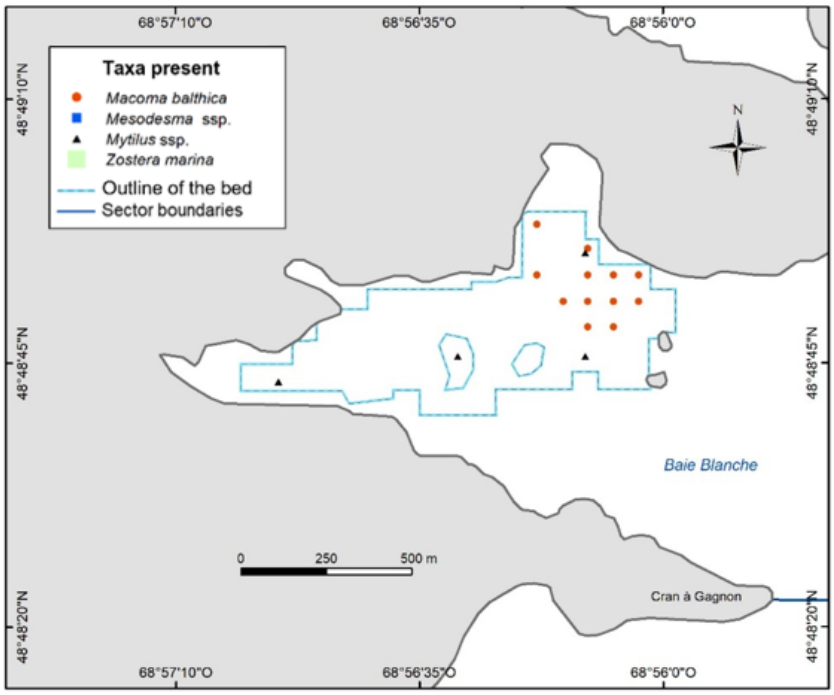
Appendix 27. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie des Plongeurs N-04.1.3 shellfish area on the Upper North Shore surveyed in 2016.*



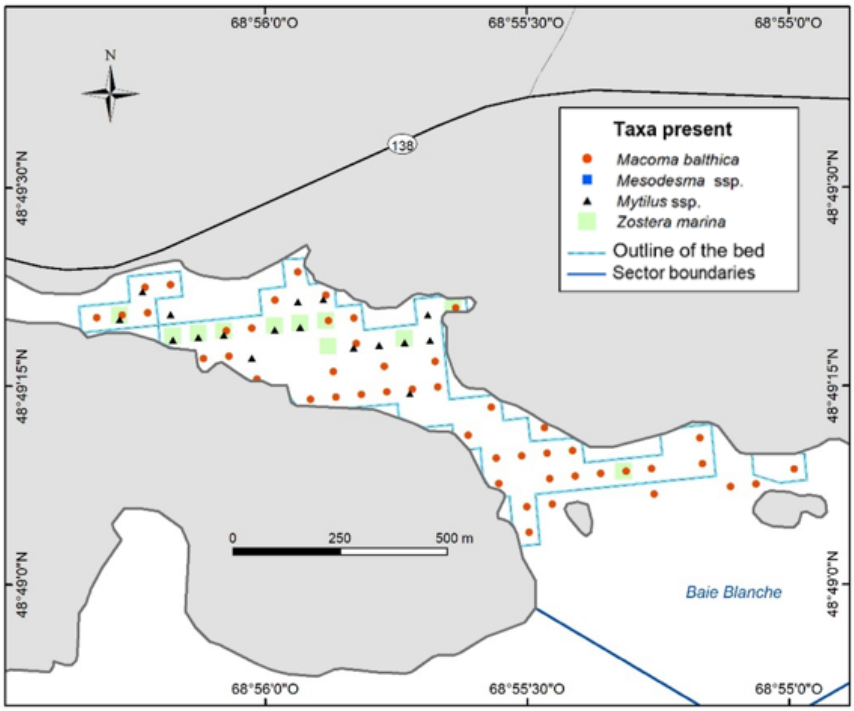
Appendix 28. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Batture aux Gibiers Est N-04.2.1.2 shellfish area on the Upper North Shore surveyed in 2018.*



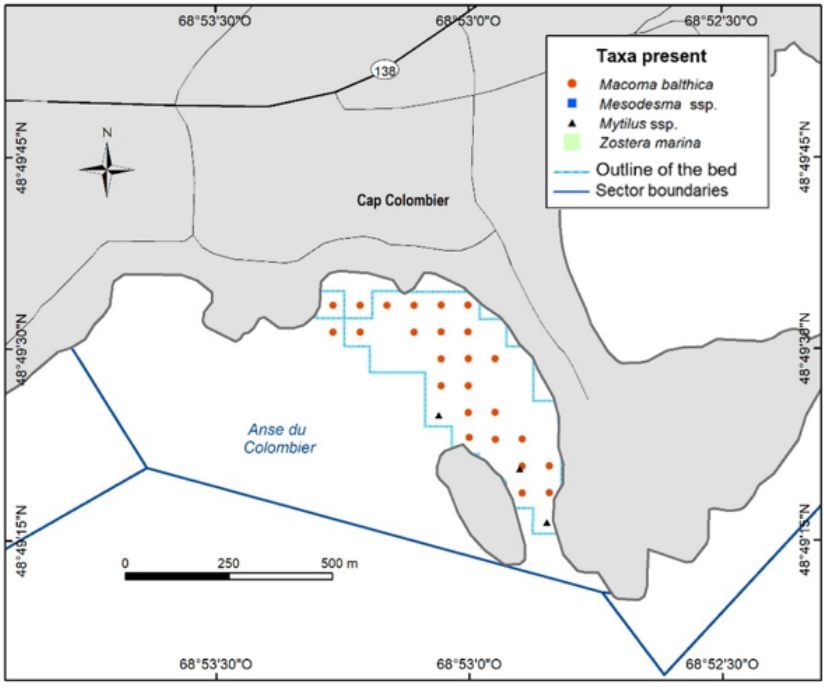
Appendix 29. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Cran à Gagnon N-04.2.2 shellfish area on the Upper North Shore surveyed in 2017.*



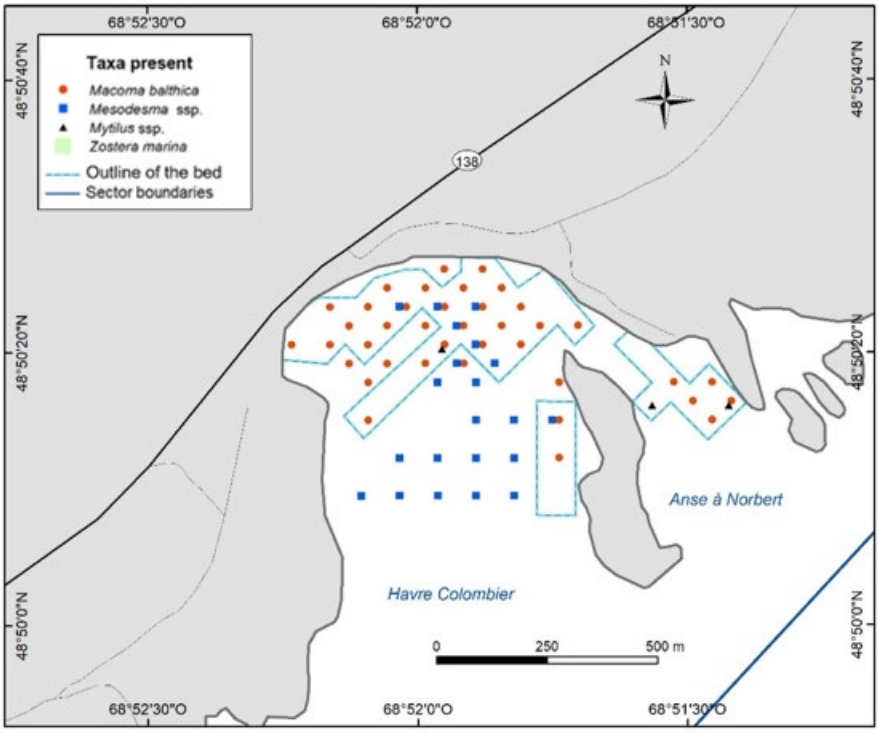
Appendix 30. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Rivière Blanche N-04.3 shellfish area on the Upper North Shore surveyed in 2020.*



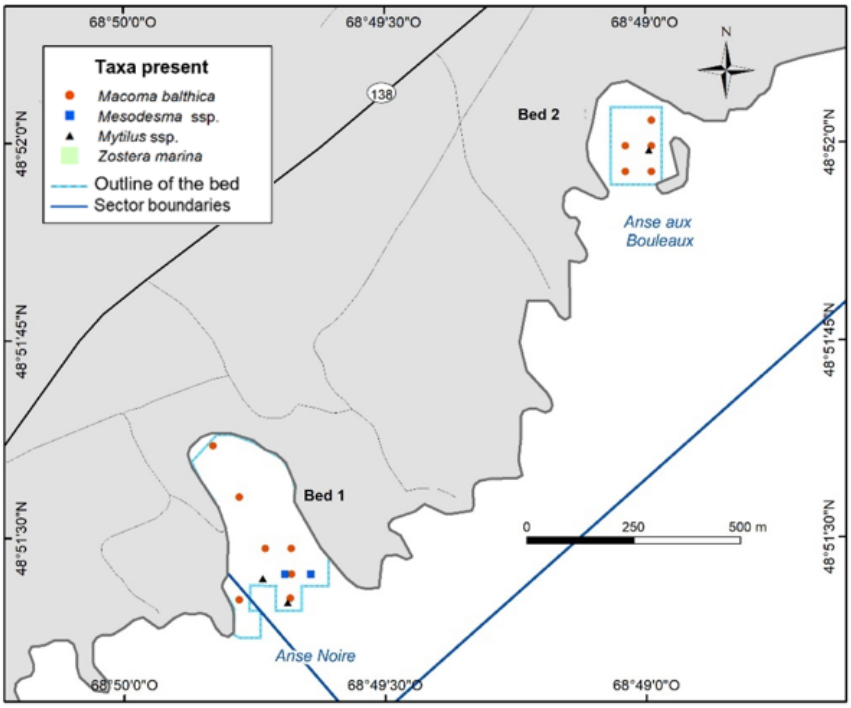
Appendix 31. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Anse du Colombier N-04.4.1 shellfish area on the Upper North Shore surveyed in 2017.*



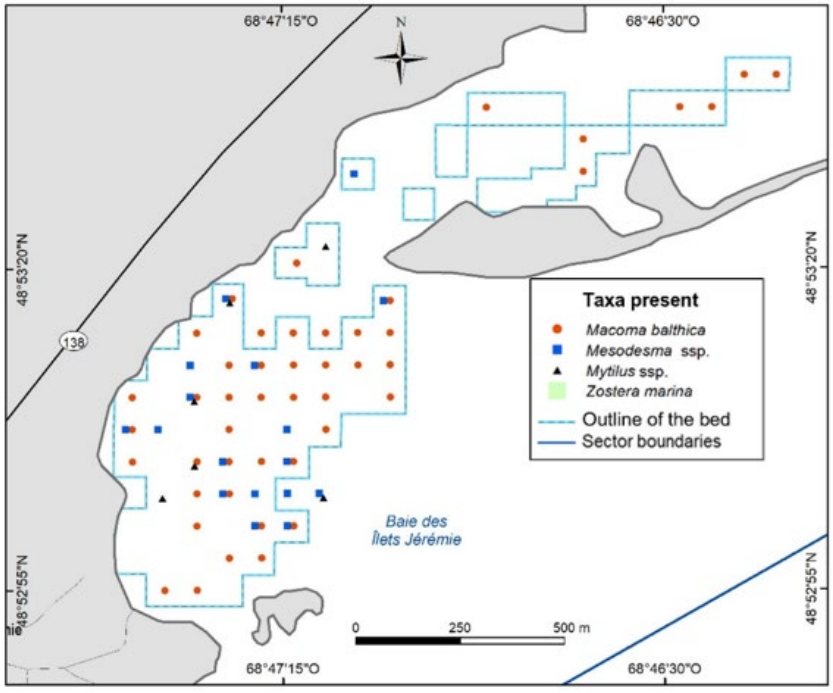
Appendix 32. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Anse à Norbert N-04.4.2 shellfish area on the Upper North Shore surveyed in 2018.*



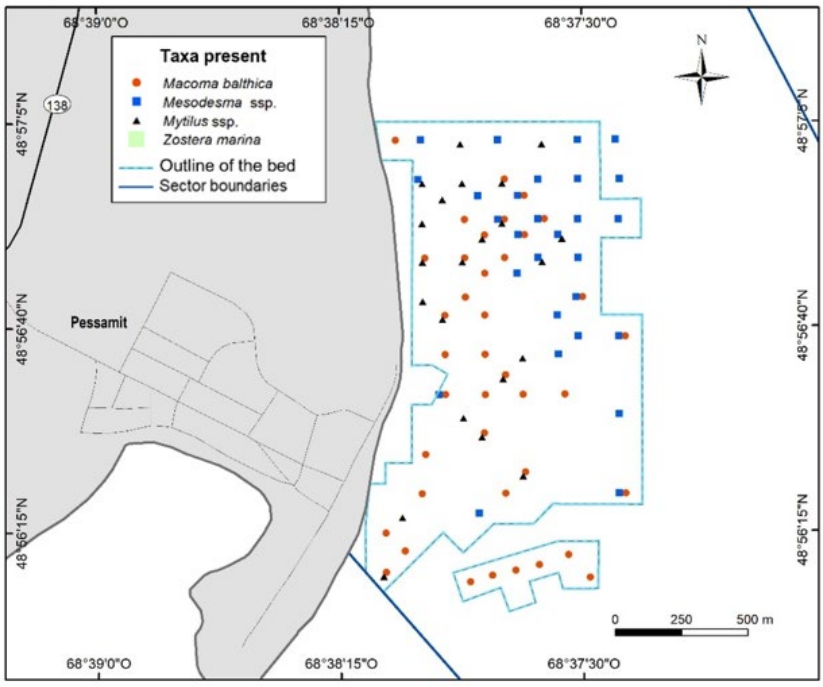
Appendix 33. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Anse Noire N-04.5.1 shellfish area on the Upper North Shore surveyed in 2018.*



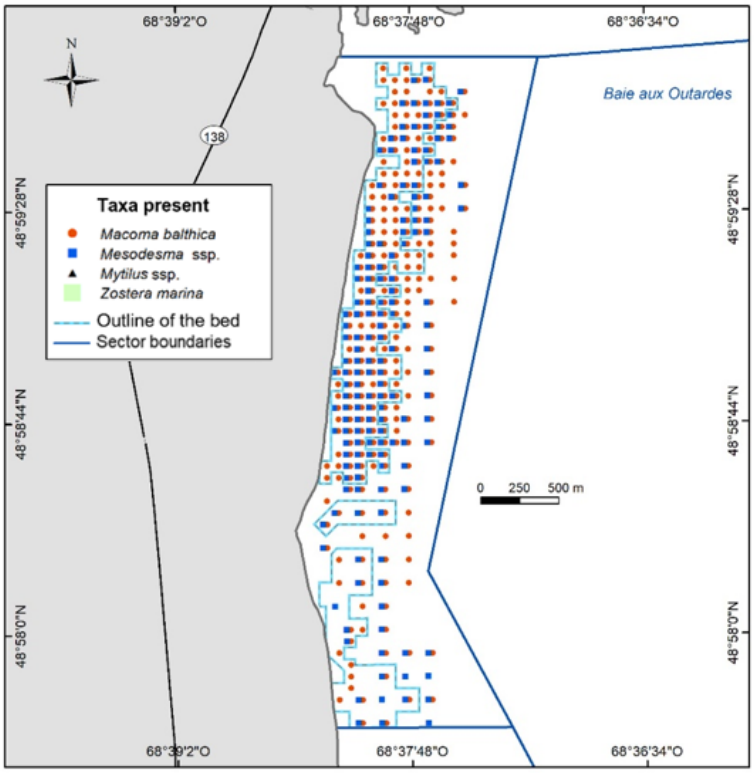
Appendix 34. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Îlets Jérémie N-04.5.2 shellfish area on the Upper North Shore surveyed in 2017.*



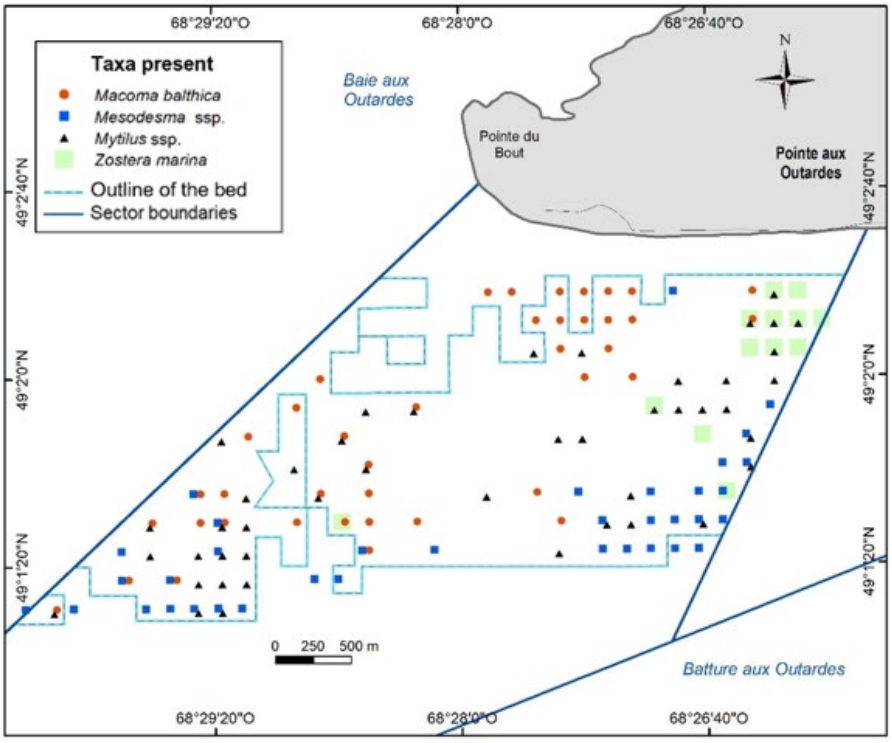
Appendix 35. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Réserve Pessamit Sud N-05.1.3.1 shellfish area on the Upper North Shore surveyed in 2018.*



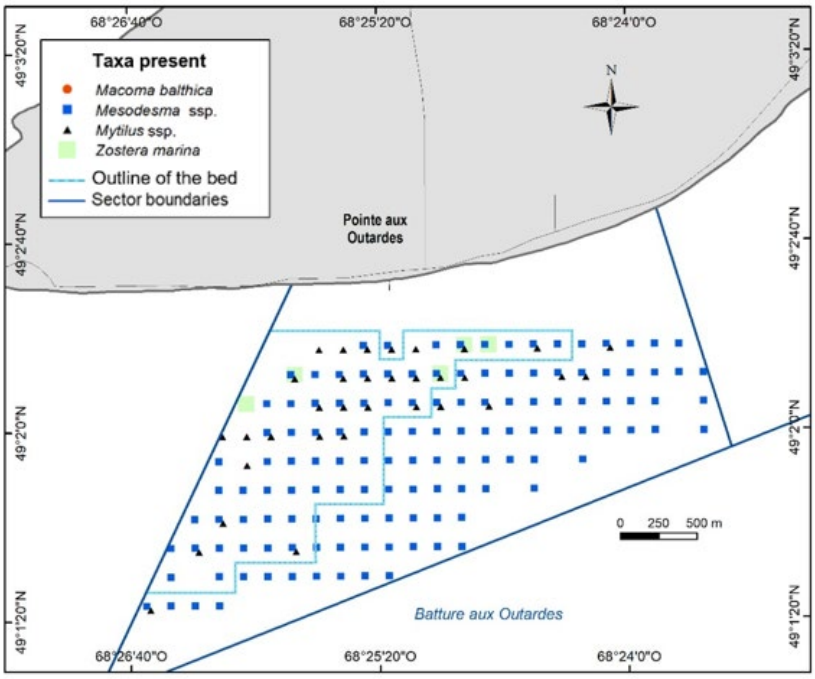
Appendix 36. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Réserve Pessamit Nord N-05.1.3.2 shellfish area on the Upper North Shore surveyed in 2019.*



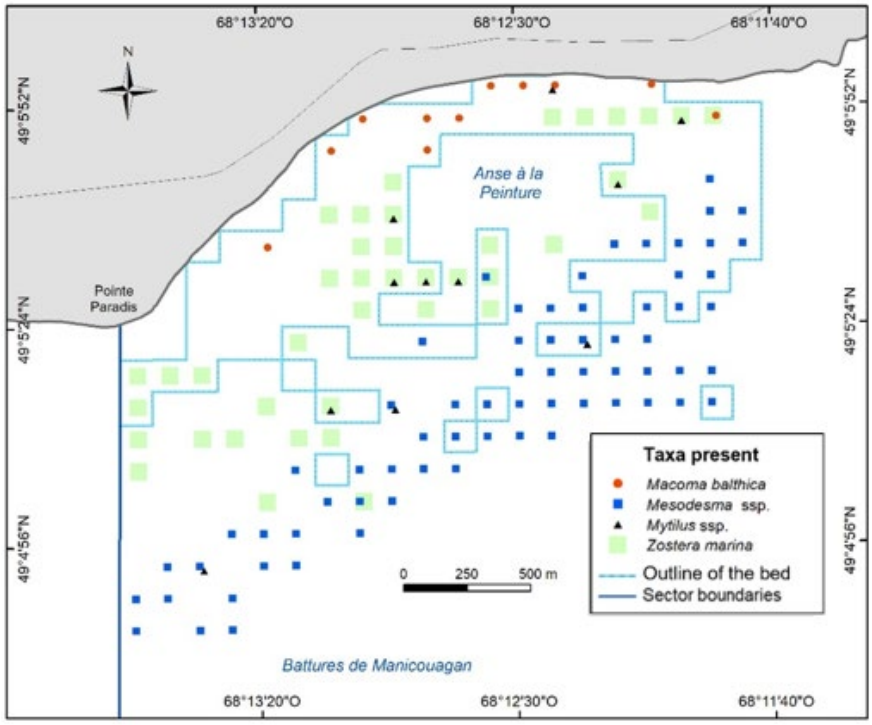
Appendix 37. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe-aux-Outardes Ouest N-06.1.1 shellfish area on the Upper North Shore surveyed in 2017.*



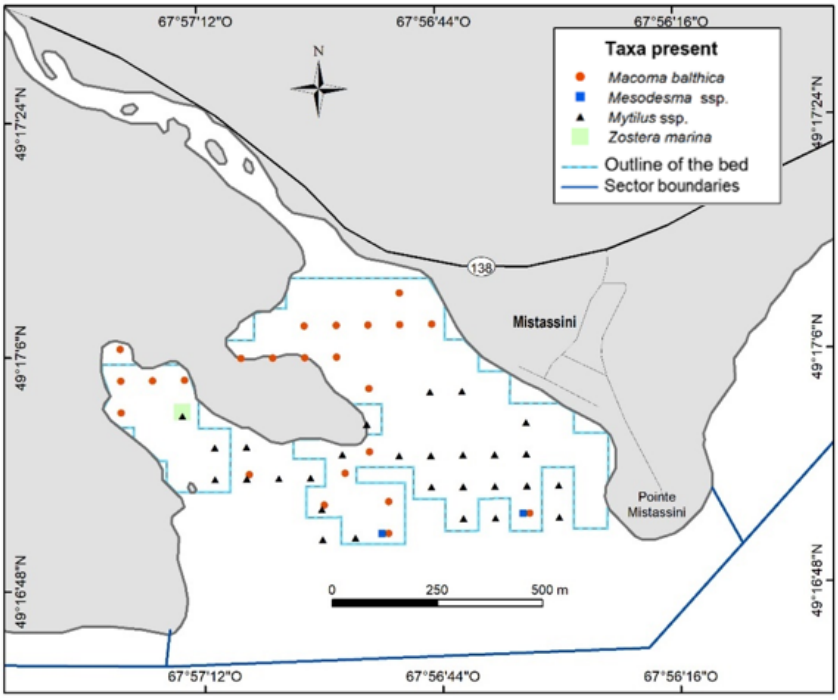
Appendix 38. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe-aux-Outardes Est N-06.1.2 shellfish area on the Upper North Shore surveyed in 2018.*



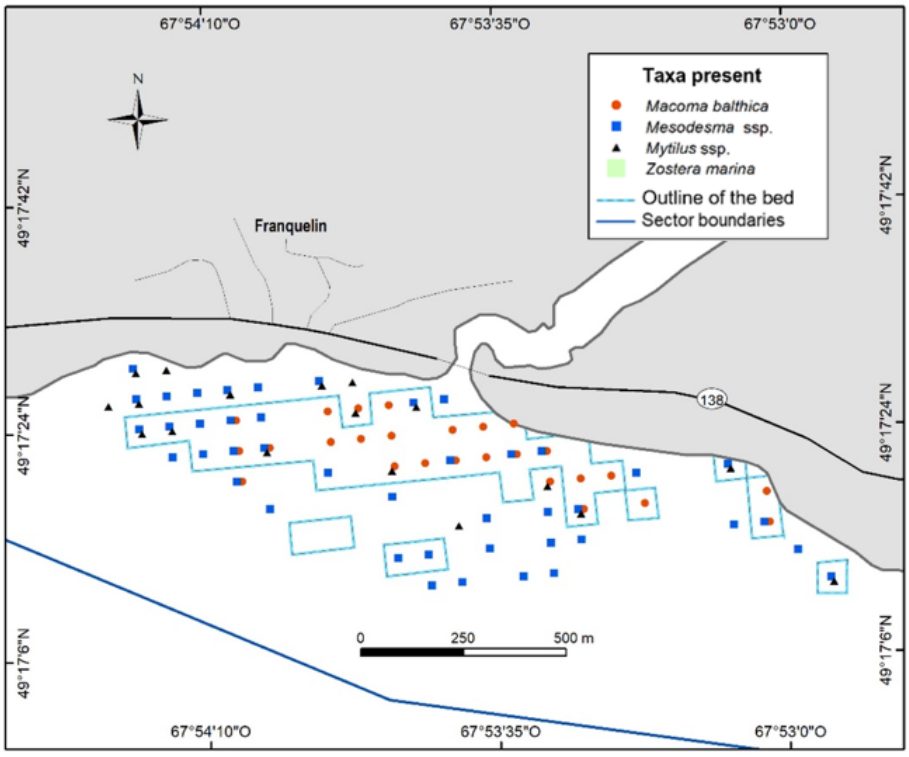
Appendix 39. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Pointe Paradis N-06.3 shellfish area on the Upper North Shore surveyed in 2019.*



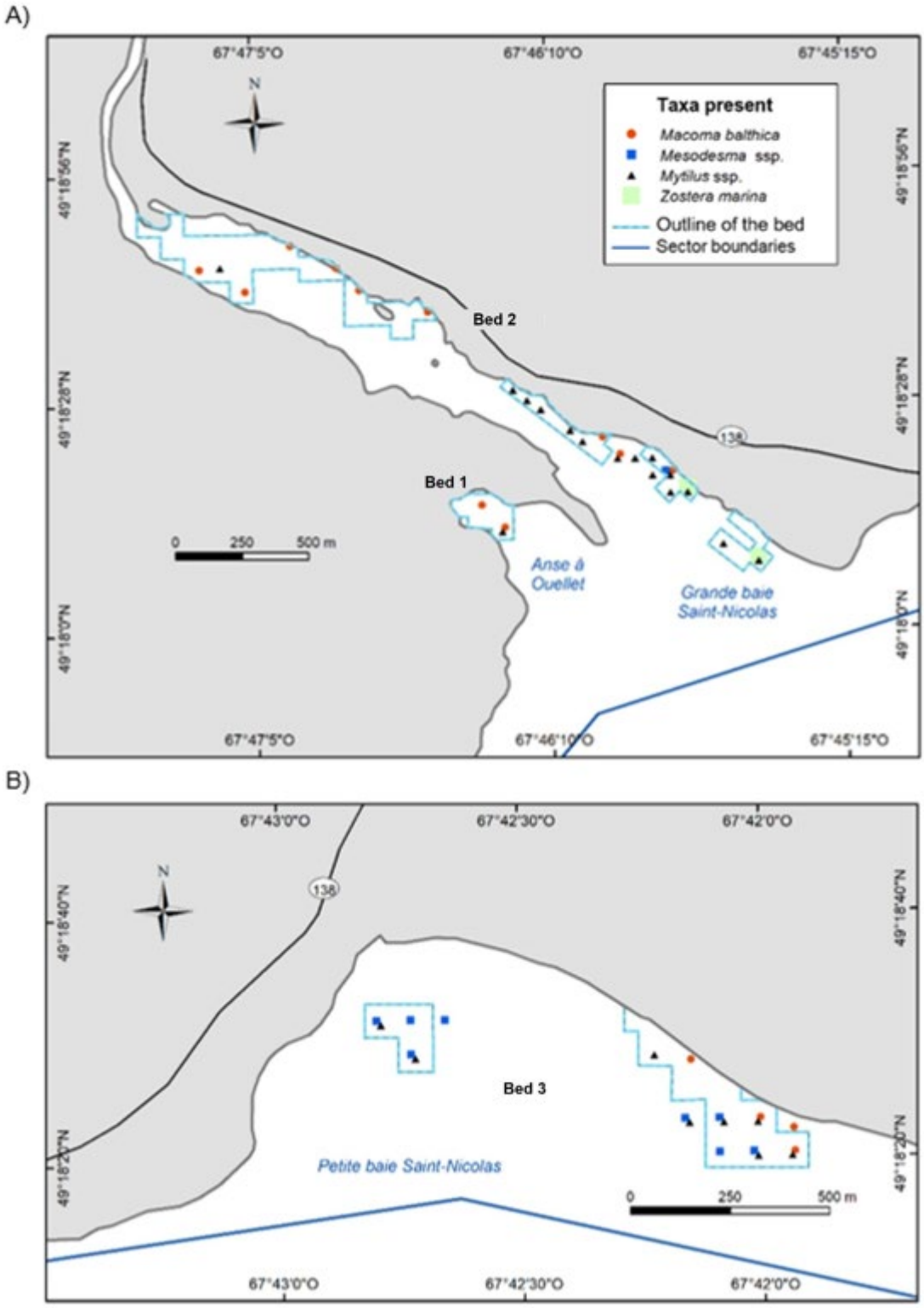
Appendix 40. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Rivière Mistassini N-08.1.3 shellfish area on the Upper North Shore surveyed in 2018.*



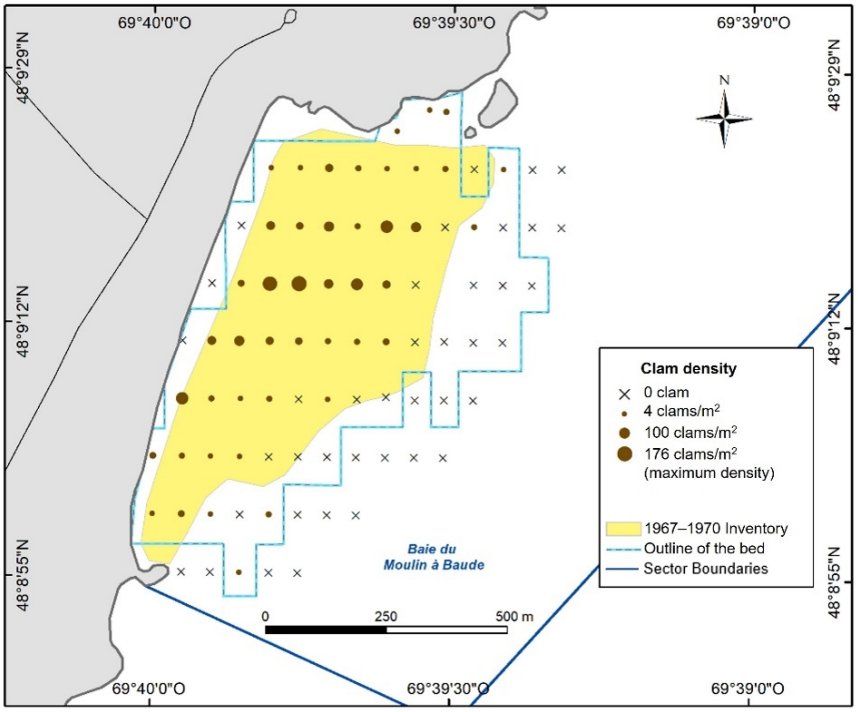
Appendix 41. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Franquelin N-08.2 shellfish area on the Upper North Shore surveyed in 2020.*



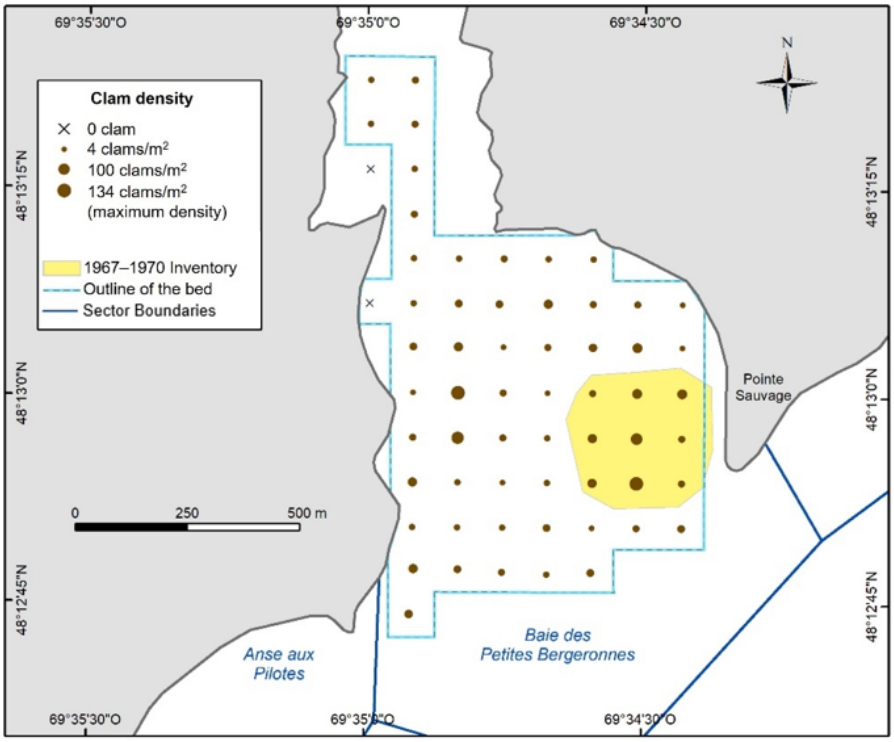
Appendix 42. Occurrence, by station, of Macoma balthica*,* Mesodesma *ssp.,* Mytilus *ssp. and* Zostera marina *in Baie Saint-Nicolas N-08.3 shellfish area on the Upper North Shore surveyed in 2018, A) western portion and B) eastern portion.*



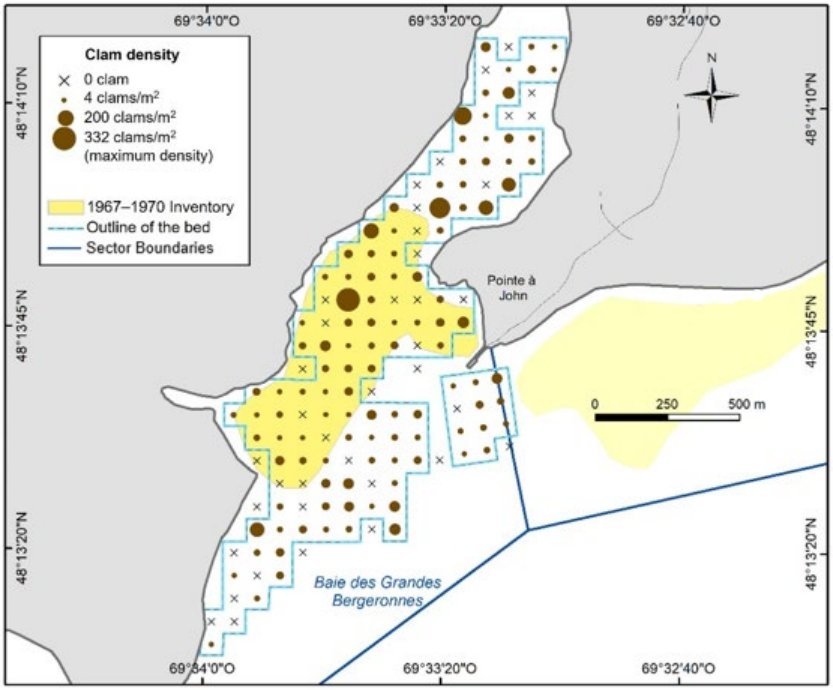
Appendix 43. Rough delineation of the soft-shell clam bed (MD) surveyed in 1967 (Lavoie 1969a) and density of clams ≥ 51 mm, by station, in Baie du Moulin à Baude N-01.1.3 shellfish area on the Upper North Shore surveyed in 2002 (Giguère et al. 2008).



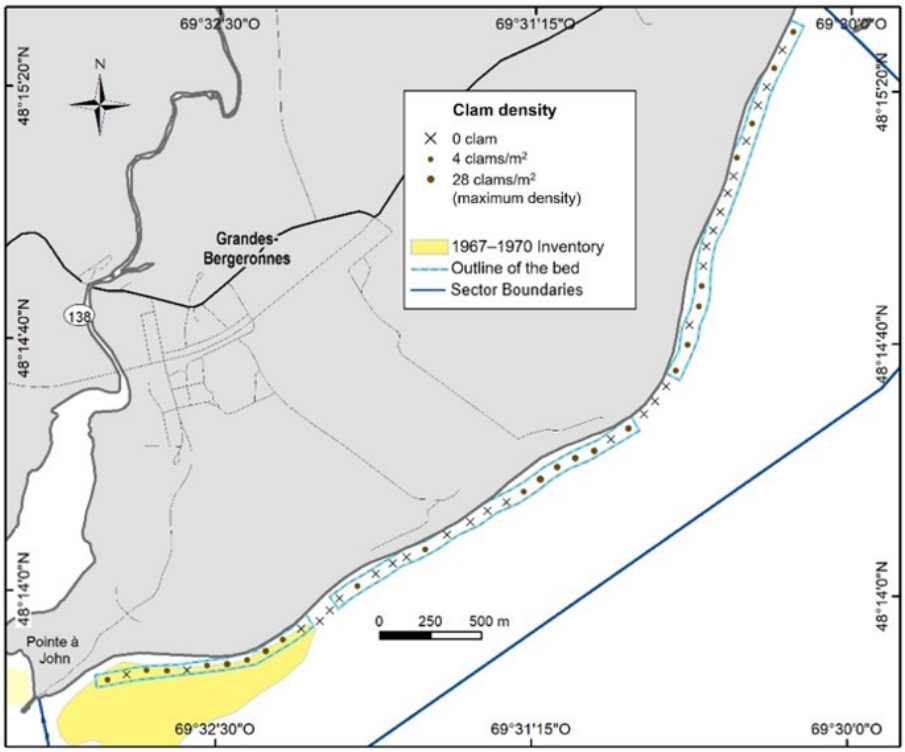
Appendix 44. Rough delineation of the soft-shell clam bed (RL) surveyed in1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Baie des Petites Bergeronnes N-01.1.4 shellfish area on the Upper North Shore surveyed in 2018.



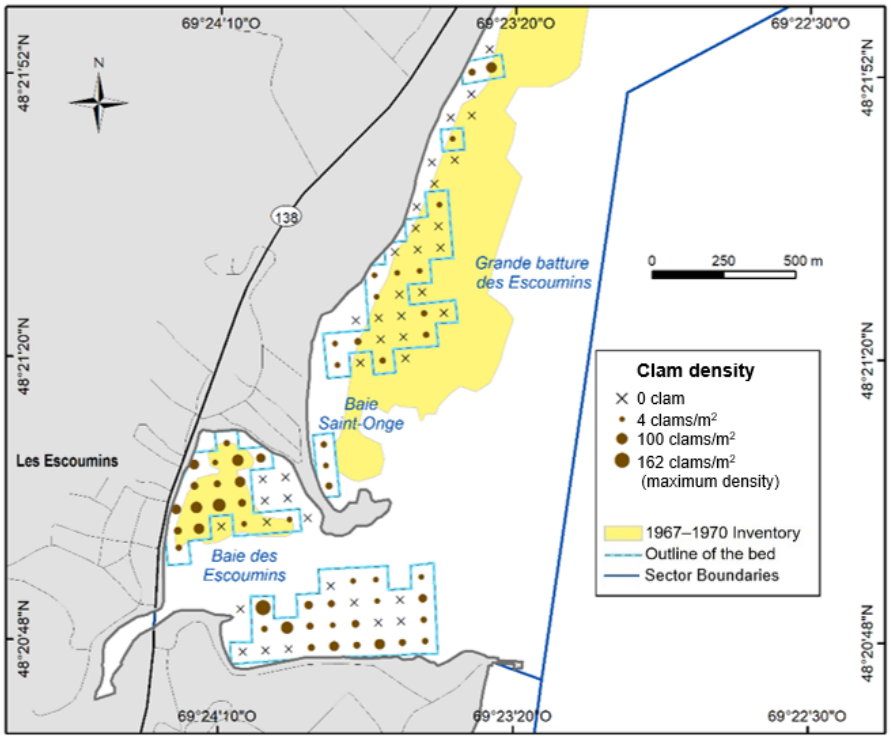
Appendix 45. Rough delineation of the soft-shell clam bed (SB) surveyed in1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Baie des Grandes Bergeronnes N-01.2.1 on the Upper North Shore surveyed in 2020.



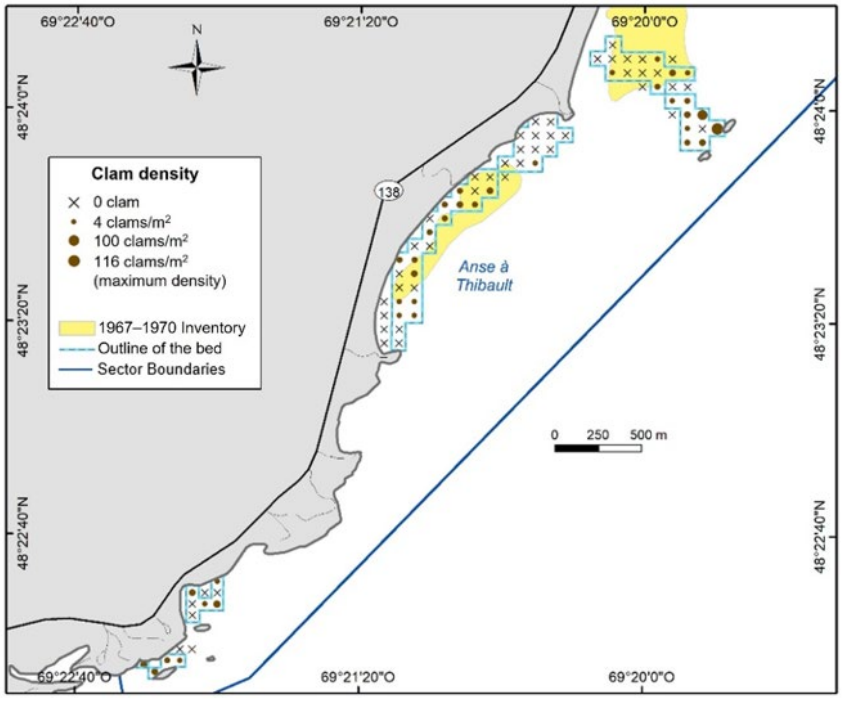
Appendix 46. Rough delineation of the soft-shell clam bed (GB) surveyed in1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Batture à Théophile N-01.2.2 shellfish area on the Upper North Shore surveyed in 2018.



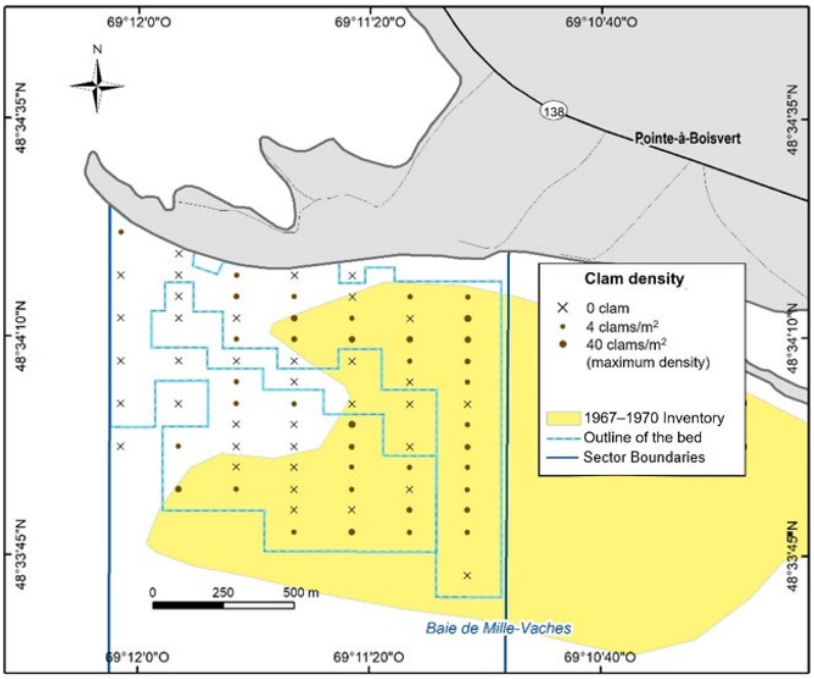
Appendix 47. Rough delineation of the soft-shell clam bed (EG and ES) surveyed in 1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Baie des Escoumins N-02.1 shellfish area on the Upper North Shore surveyed in 2020.



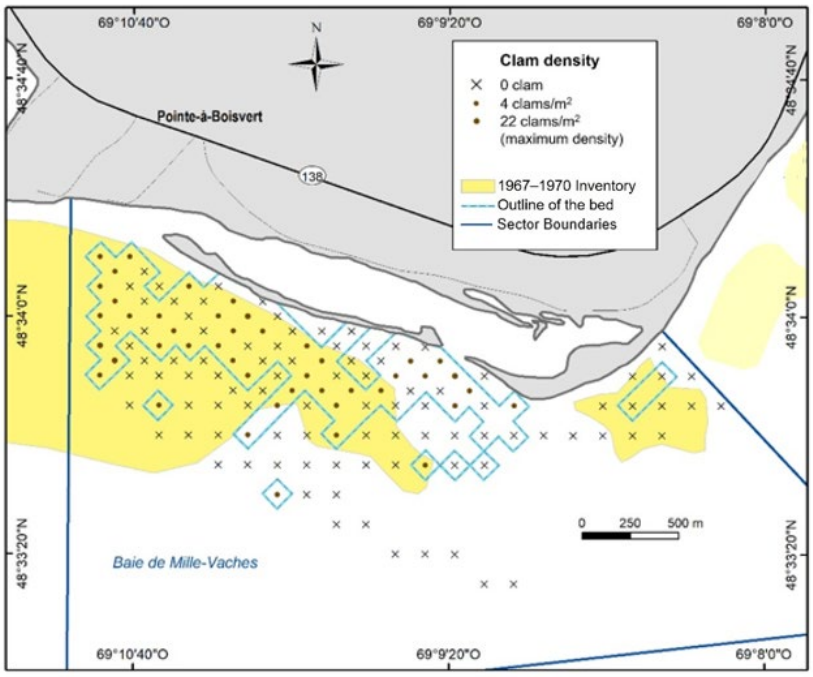
Appendix 48. Rough delineation of the soft-shell clam bed (DT and JL) surveyed in 1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Îles Penchées N-02.2 shellfish area on the Upper North Shore surveyed in 2018.



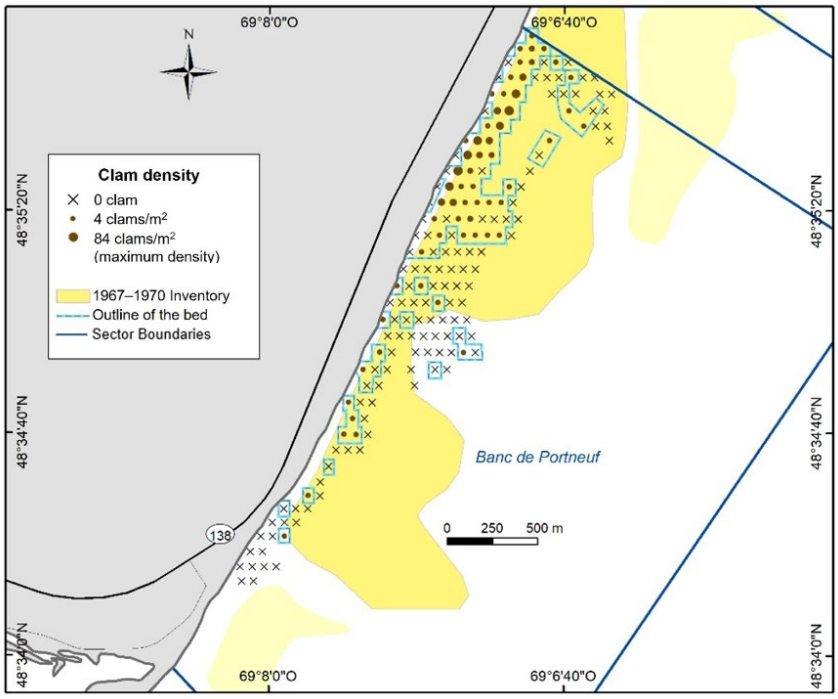
Appendix 49. Rough delineation of the soft-shell clam bed (PB-1) surveyed in 1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Pointe à Émile N-03.1.2 shellfish area on the Upper North Shore surveyed in 2018.



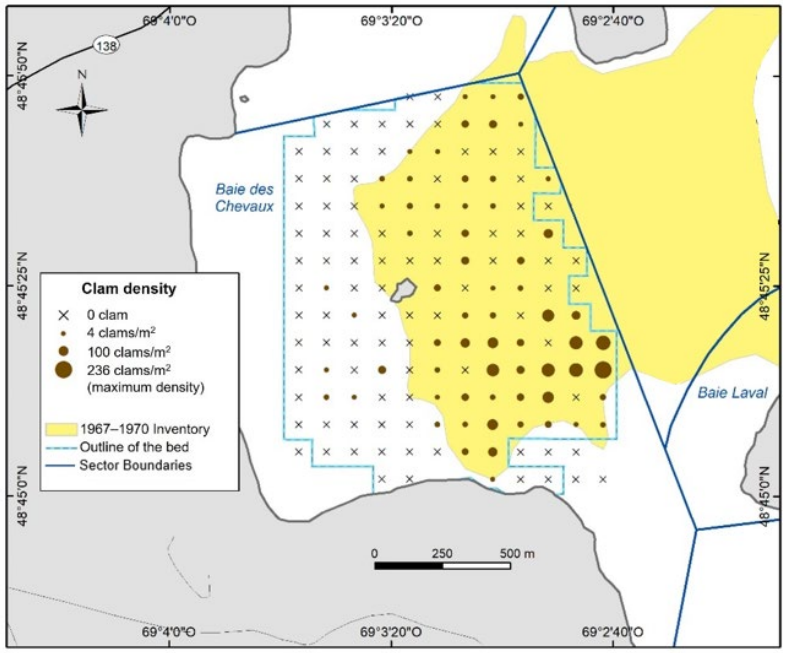
Appendix 50. Rough delineation of the soft-shell clam bed (PB-1 continued and PB-2) surveyed in 1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Pointe à Boisvert N-03.2.1 shellfish area on the Upper North Shore surveyed in 2017.



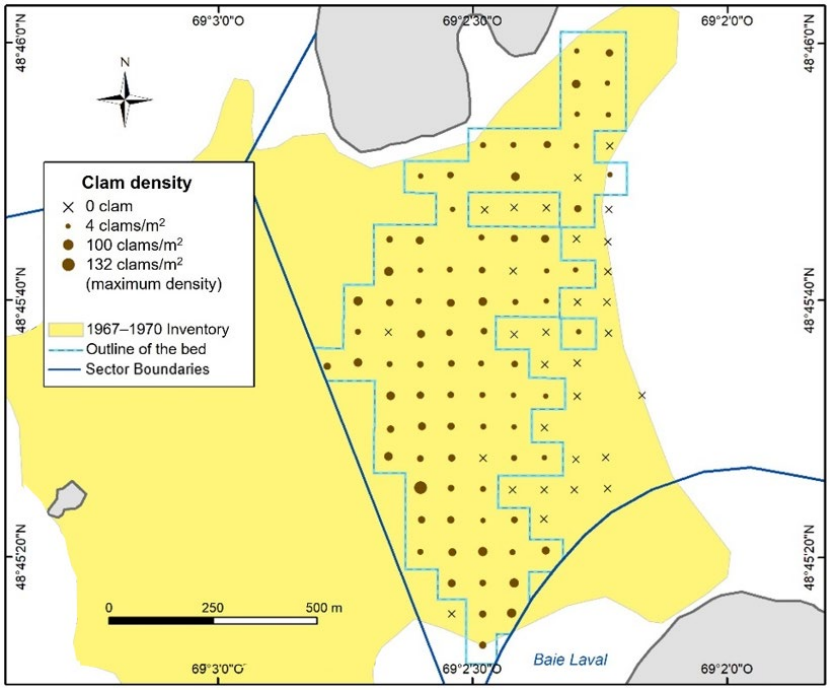
Appendix 51. Rough delineation of the soft-shell clam bed (PB-4) surveyed in1968 (Lavoie 1969b) and density of soft-shell clams ≥ 51 mm, by station, in Pointe de Mille-Vaches N-03.2.2 shellfish area on the Upper North Shore surveyed in 2018.



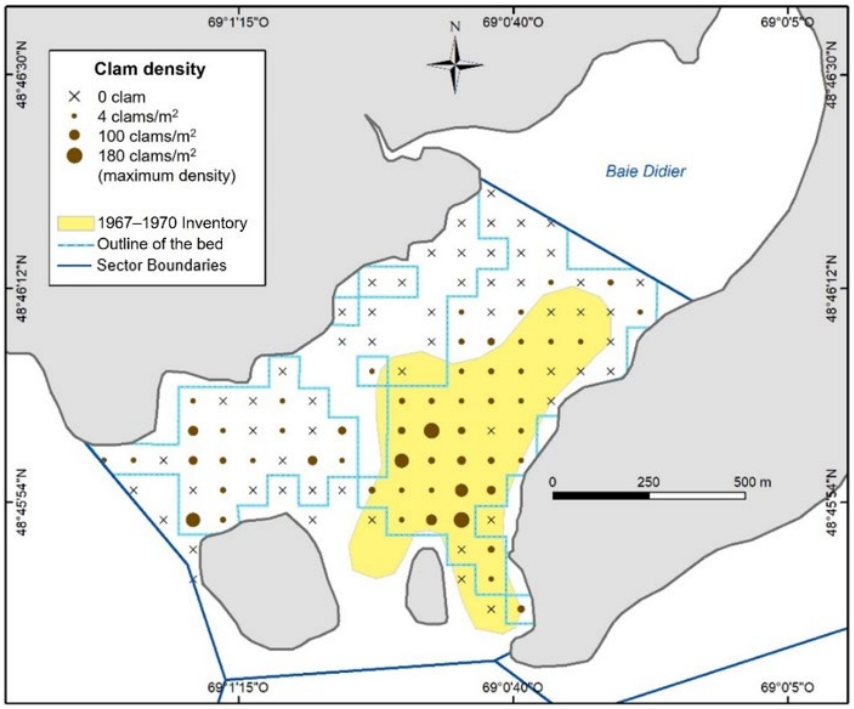
Appendix 52. Rough delineation of the soft-shell clam bed (BL) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Baie des Chevaux N-04.1.1.1 shellfish area on the Upper North Shore surveyed in 2017.



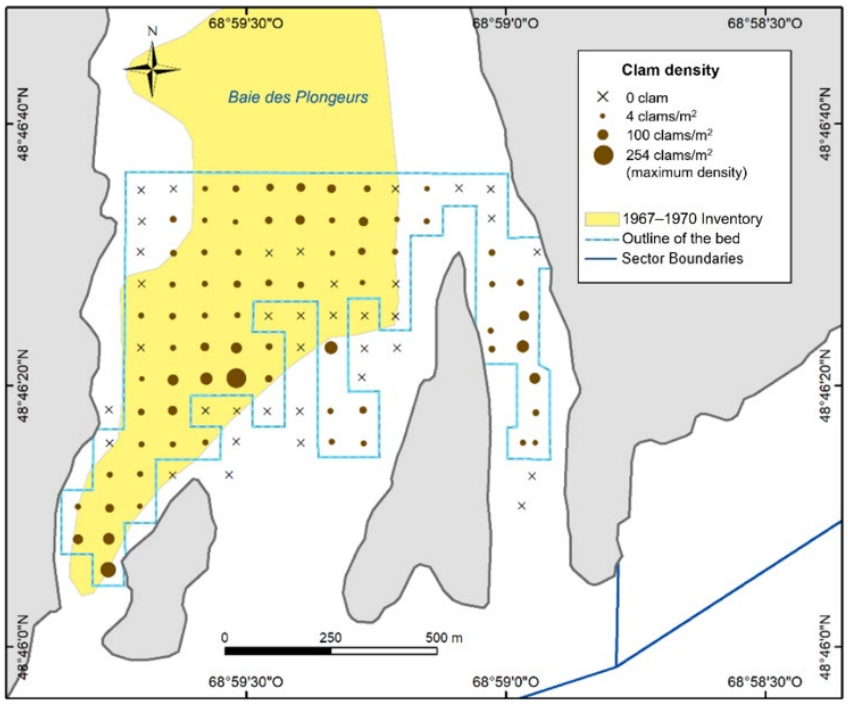
Appendix 53. Rough delineation of the soft-shell clam bed (BL suite) surveyed in1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Banc Marie-Marthe N-04.1.2.1 shellfish area on the Upper North Shore surveyed in 2016.



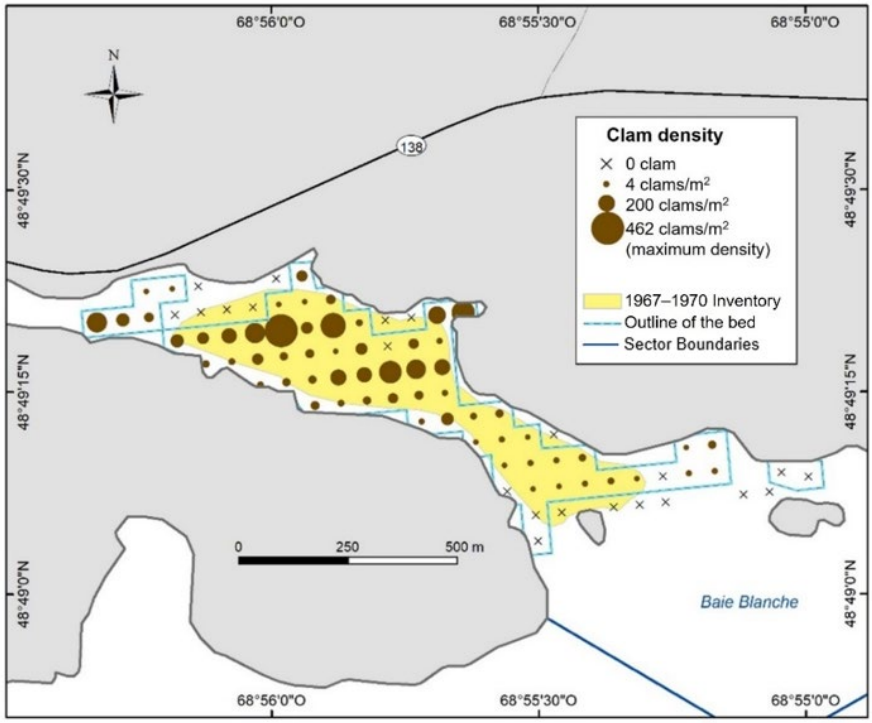
Appendix 54. Rough delineation of the soft-shell clam bed (BD) surveyed in1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51, by station, in Baie Didier Sud N-04.1.2.2 shellfish area on the Upper North Shore surveyed in 2018.



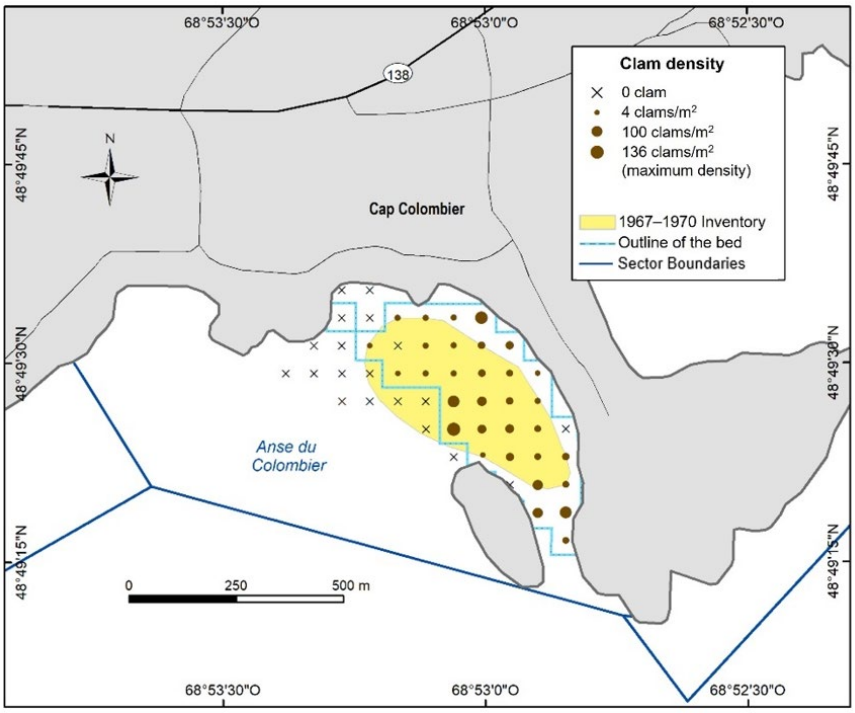
Appendix 55. Rough delineation of the soft-shell clam bed (BP) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Baie des Plongeurs N-04.1.3 shellfish area on the Upper North Shore surveyed in 2016.



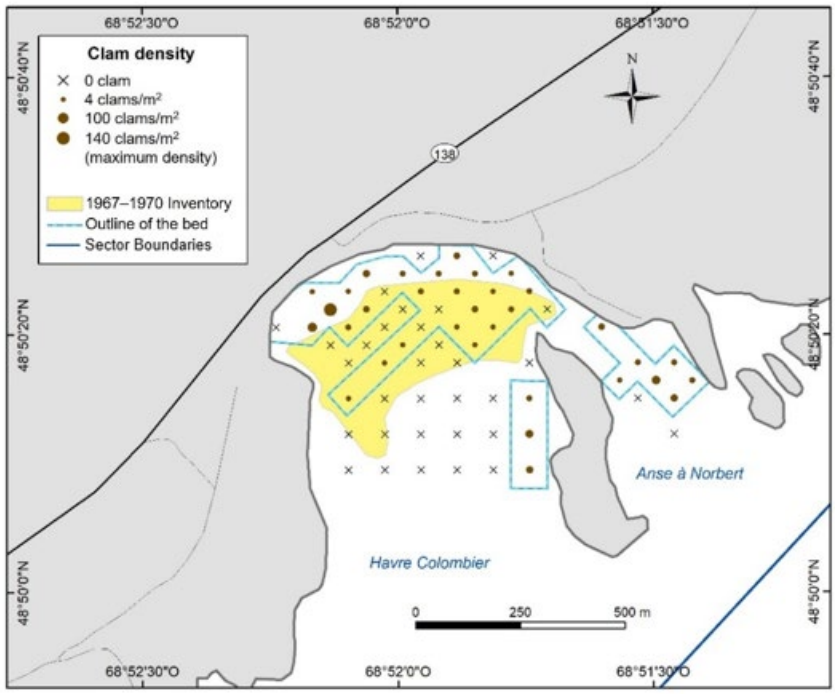
Appendix 56. Rough delineation of the soft-shell clam bed (BB) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Rivière Blanche N-04.3 shellfish area on the Upper North Shore surveyed in 2020.



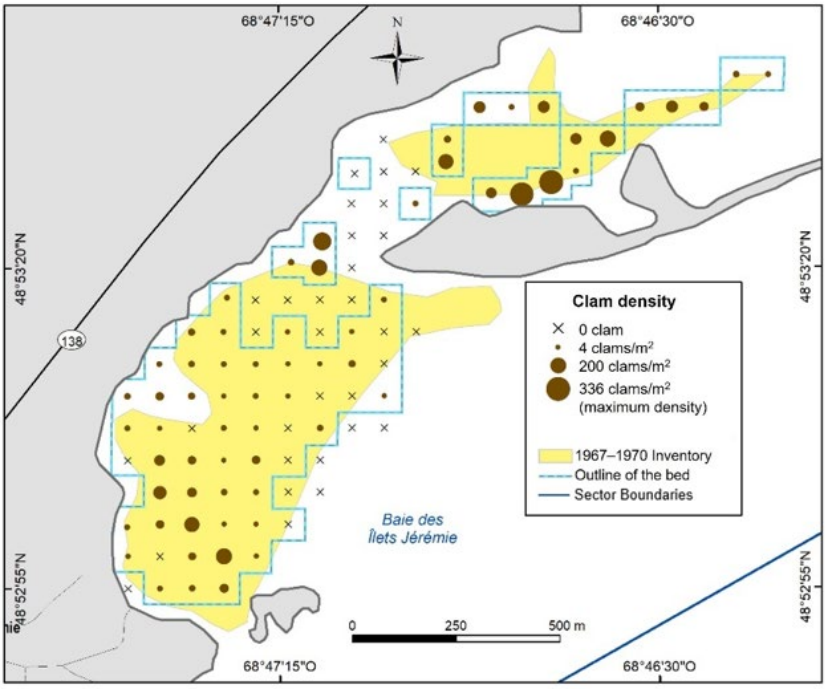
Appendix 57. Rough delineation of the soft-shell clam bed (CC) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Anse du Colombier N-04.4.1 shellfish area on the Upper North Shore surveyed in 2017.



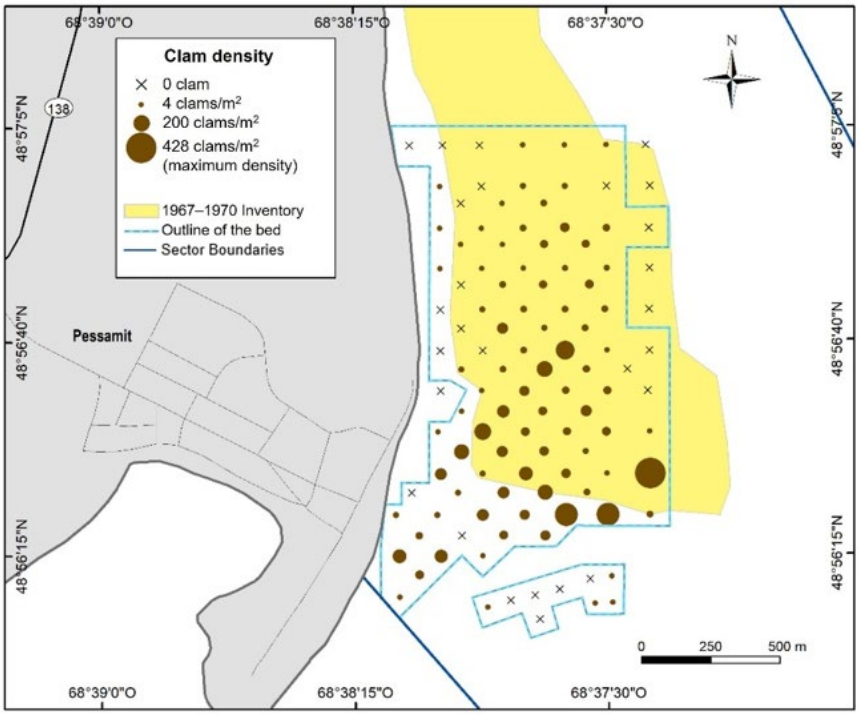
Appendix 58. Rough delineation of the soft-shell clam bed (AF) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Anse à Norbert N-04.4.2 shellfish area on the Upper North Shore surveyed in 2018.



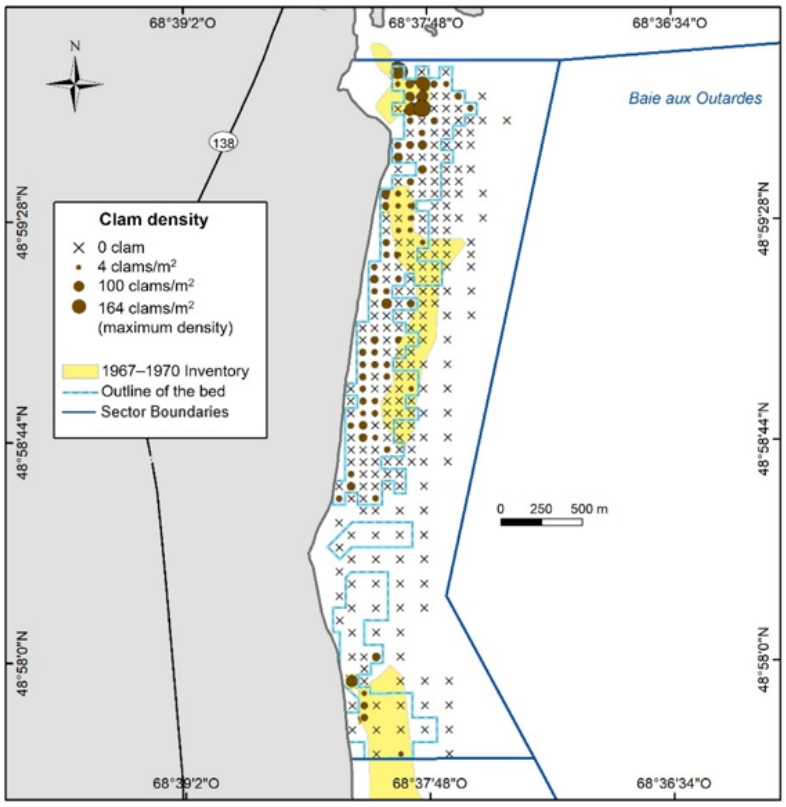
Appendix 59. Rough delineation of the soft-shell clam bed (IJ-1 and IJ-2) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Jérémie N-04.5.2 shellfish area on the Upper North Shore surveyed in 2017.



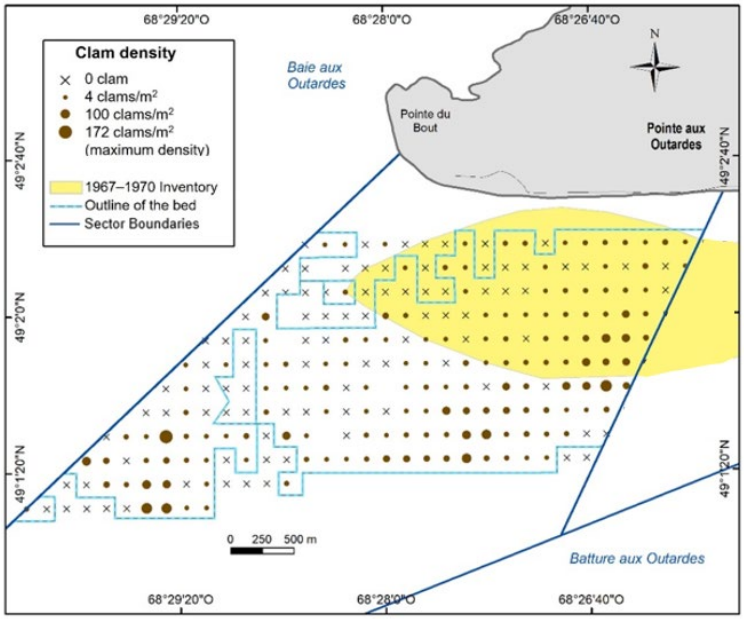
Appendix 60. Rough delineation of the soft-shell clam bed (BM-1) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Réserve Pessamit Sud N-05.1.3.1 shellfish area on the Upper North Shore surveyed in 2018.



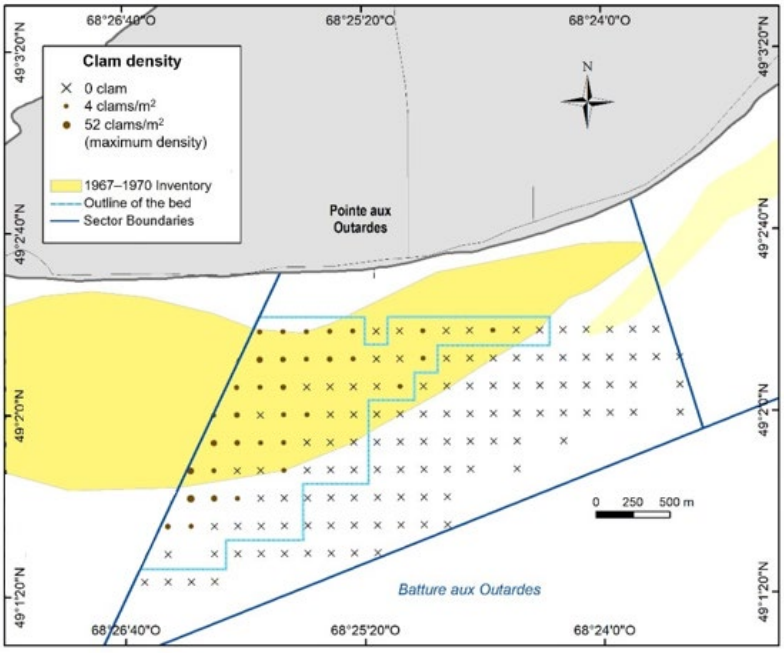
Appendix 61. Rough delineation of the soft-shell clam bed (BM-1 suite and BM-2) surveyed in 1969 (Lavoie 1970a) and density of soft-shell clams ≥ 51 mm, by station, in Réserve Pessamit Nord N-05.1.3.2 shellfish area on the Upper North Shore surveyed in 2019.



Appendix 62. Rough delineation of the soft-shell clam bed (PO-1) surveyed in 1970 (Lavoie 1970b) and density of soft-shell clams ≥ 51 mm, by station, in Pointe-aux-Outardes Ouest N-06.1.1 shellfish area on the Upper North Shore surveyed in 2017.



Appendix 63. Rough delineation of the soft-shell clam bed (PO-1 suite) surveyed in 1970 (Lavoie 1970b) and density of soft-shell clams ≥ 51 mm, by station, in Pointe-aux-Outardes Est N-06.1.2 shellfish area on the Upper North Shore surveyed in 2018.



Appendix 64. Total area (km^2), number of stations, average density (number/m^2 ± standard error) and average yield (g/m^2 ± standard error) of soft-shell clams by size class in all beds, by shellfish area surveyed from 2001 to 2014 in Quebec (grouped by region).

Magdalen Islands

Shellfish area	Surface area	Stations	Average density			Average yield[1]	
			11–19 mm	20–50 mm	≥ 51 mm	20–50 mm	≥ 51 mm
Havre-aux-Basques 2001	2.22	98	98.9 ± 16.1	102.6 ± 10.5	0.1 ± 0.1	266 ± 28	1 ± 1
Havre-aux-Maisons Nord 2003	1.13	127	23.7 ± 3.1	83.3 ± 9.9	6.2 ± 1.7	238 ± 30	114 ± 35
Dune du Nord 2003	0.43	85	33.5 ± 7.4	50.1 ± 5.1	0	88 ± 9	0
Pointe-aux-Loups 2003	0.54	108	104.4 ± 15.6	40.6 ± 4.2	7.5 ± 1.0	100 ± 12	115 ± 15
Dune du Sud 2003	0.42	43	32.5 ± 6.6	50.5 ± 9.4	6.4 ± 1.3	154 ± 28	122 ± 27

Chaleur Bay

Shellfish area	Surface area	Stations	Average density			Average yield[1]	
			11–19 mm	20–50 mm	≥ 51 mm	20–50 mm	≥ 51 mm
Bassin de la rivière Nouvelle 2002	1.12	282	8.8 ± 0.8	44.3 ± 2.7	9.6 ± 0.8	213 ± 14	175 ± 15
Carleton 2002	0.06	23	9.2 ± 1.8	12.3 ± 2.7	1.7 ± 0.7	69 ± 18	35 ± 15
Clapperton 2002	0.03	23	3.5 ± 0.6	3.5 ± 1.2	1.0 ± 0.5	14 ± 6	20 ± 8
Pointe Verte 2001	0.16	47	11.1 ± 2.2	23.5 ± 4.1	2.3 ± 0.7	119 ± 23	46 ± 13
Bonaventure 2002	0.43	111	3.9 ± 0.8	6.6 ± 1.1	4.9 ± 0.9	49 ± 8	150 ± 27
Bonaventure 03/2009	0.43	29	2.6 ± 1.0	11.8 ± 4.0	12.7 ± 2.0	90 ± 29	518 ± 71
Bonaventure 09/2009	0.43	27	0.7 ± 0.3	2.8 ± 1.2	2.8 ± 1.2	12 ± 6	148 ± 49
Bonaventure 2011	0.43	28	0.9 ± 0.4	2.6 ± 1.4	5.9 ± 3.7	17 ± 12	256 ± 150
Bonaventure Est 2002	0.01	3	0	4.0 ± 0.0	0	10 ± 6	0
Barachois de Port-Daniel 2002	0.37	148	10.8 ± 1.1	54.1 ± 4.2	17.3 ± 2.1	332 ± 27	376 ± 52
Baie du Grand-Pabos 2002	0.40	128	6.3 ± 0.9	33.5 ± 3.6	10.7 ± 1.7	180 ± 21	229 ± 39
Estuaire de la rivière Malbaie 2002	0.33	83	19.6 ± 2.7	54.6 ± 5.7	37.7 ± 4.1	313 ± 34	1,131 ± 125
Estuaire de la rivière Saint-Jean 2002	0.41	104	26.7 ± 3.2	66.1 ± 6.6	16.9 ± 2.2	247 ± 25	374 ± 54

Lower St. Lawrence and Gaspé North

Shellfish area	Surface area	Stations	Average density			Average yield[1]	
			11–19 mm	20–50 mm	≥ 51 mm	20–50 mm	≥ 51 mm
Kamouraska 2005	1.86	69	19.9 ± 4.0	38.4 ± 4.9	0	91 ± 11	0
Anse au Persil 2005	0.30	11	2.3 ± 2.3	88.6 ± 18.3	0	382 ± 109	0
Île Verte 2005	0.80	32	5.5 ± 2.2	39.1 ± 8.6	14.8 ± 3.1	234 ± 55	319 ± 72
Batture de Tobin 2005	0.53	20	1.4 ± 1.3	33.8 ± 6.1	4.3 ± 2.2	149 ± 44	79 ± 40
Îlets D'Amours 2005	0.10	5	5.0 ± 5.0	75.0 ± 28.5	5.0 ± 5.0	415 ± 177	100 ± 100
Pointe des Riou 2006	1.31	56	2.6 ± 0.7	9.2 ± 1.4	1.1 ± 0.3	37 ± 6	26 ± 7
Baie du Ha! Ha! 2005	0.43	23	0.8 ± 0.9	43.2 ± 9.4	5.3 ± 2.9	258 ± 64	123 ± 67
Baie Hâtée 2005	0.13	14	0	30.6 ± 8.4	23.5 ± 5.8	210 ± 77	1,009 ± 299
Rimouski 2006	4.44	145	26.2 ± 2.9	50.3 ± 4.5	4.9 ± 0.7	251 ± 25	121 ± 18
Anse aux Coques 2005	0.14	6	0	8.3 ± 5.3	20.8 ± 7.7	102 ± 65	678 ± 299
Baie Mitis 2005	0.96	41	6.9 ± 3.8	87.3 ± 16.4	21.0 ± 5.8	532 ± 90	546 ± 135
Anse du Petit Métis 2005	0.35	12	6.3 ± 4.5	110.4 ± 33.4	29.2 ± 7.4	822 ± 263	919 ± 307
Petits-Méchins 2005	0.01	1	0	25.0	0	84	0
Capucins 2006	0.53	94	47.4 ± 6.8	53.4 ± 6.2	9.1 ± 2.1	302 ± 40	233 ± 58

Upper North Shore

Shellfish area	Surface area	Stations	Average density			Average yield[1]	
			11–19 mm	20–50 mm	≥ 51 mm	20–50 mm	≥ 51 mm
Baie du Moulin à Baude 2002	0.49	67	14.7 ± 3.0	7.6 ± 1.6	25.9 ± 5.0	28 ± 6	805 ± 143
Baie des Petites Bergeronnes 2008	0.60	34	0.6 ± 0.3	22.0 ± 3.7	12.4 ± 2.6	205 ± 35	303 ± 66
Pointe à Émile 2003	1.16	17	100.8 ± 21.0	78.8 ± 12.4	1.5 ± 0.9	373 ± 83	28 ± 17
Baie des Chevaux 2002	1.45	71	38.0 ± 4.1	125.3 ± 14.0	9.3 ± 2.2	683 ± 86	229 ± 52
Cran à Gagnon 2007	0.38	58	13.2 ± 2.1	80.3 ± 10.3	9.8 ± 1.6	479 ± 61	264 ± 47
Anse Noire 2003	0.08	22	36.9 ± 8.0	75.4 ± 14.0	6.6 ± 2.3	467 ± 96	150 ± 52
Réserve Pessamit Sud 2005	1.43	105	24.0 ± 7.6	53.5 ± 18.5	18.1 ± 3.6	226 ± 66	511 ± 86
Réserve Pessamit Sud 2010	1.43	108	5.7 ± 1.2	24.3 ± 6.3	12.5 ± 2.0	150 ± 44	376 ± 55
Réserve Pessamit Sud 2014	1.43	106	18.7 ± 4.1	28.9 ± 6.2	12.7 ± 2.5	107 ± 24	398 ± 73
Pointe-aux-Outardes Ouest 2003	5.99	235	5.8 ± 1.2	5.9 ± 1.1	14.0 ± 1.2	25 ± 6	686 ± 54
Pointe-aux-Outardes Est 2004	1.82	41	66.0 ± 9.6	18.9 ± 3.6	11.4 ± 2.9	73 ± 17	314 ± 75

Middle North Shore

Shellfish area	Surface area	Stations	Average Density			Average Yield[1]	
			11-19 mm	20-50 mm	≥ 51 mm	20-50 mm	≥ 51 mm
Mingan 2001	0.32	56	3.2 ± 1.2	39.3 ± 8.0[2]	25.7 ± 4.9[3]	165 ± 32	695 ± 142[4]
Mingan 2007	0.32	41	5.7 ± 1.8	36.6 ± 9.6[2]	15.4 ± 4.5[3]	197 ± 60	333 ± 91[4]

[1] Yield calculated from the thawed weight, except in the case of Anse Noire and Pointe à Émile 2003 (fresh weight).

[2] Result of the comparison of densities of soft-shell clams 20–50 mm (same surface area) with the Wilcoxon-Mann-Whitney non-parametric test, P > |Z| = 0.0953.

[3] Result of the comparison of densities of soft-shell clams ≥ 51 mm (same surface area) with the Wilcoxon-Mann-Whitney non-parametric test, P > |Z| = 0.0070.

[4] Result of the comparison of yields of soft-shell clams ≥ 51 mm (same surface area) with the Wilcoxon-Mann-Whitney non-parametric test, P > |Z| = 0.0038.

Appendix 65. Total surface area (km^2), harvestable area (km^2), number of stations, average density (number/m^2 ± standard error), average yield (g/m^2 ± standard error) and biomass (t) of soft-shell clams ≥ 51 mm in the harvestable area, by shellfish area, surveyed from 2001 to 2014 in Quebec (grouped by region).

Magdalen Islands

Shellfish area	Total surface area	Harvestable surface area	Stations	Density	Yield[1]	Biomass
Havre-aux-Basques 2001	2.22	0	-	-	-	0
Havre-aux-Maisons Nord 2003	1.13	0.10	17	23.4 ± 3.3	423 ± 67	40.2
Dune du Nord 2003	0.43	0	-	-	-	0
Pointe-aux-Loups 2003	0.54	0.12	23	21.3 ± 2.5	321 ± 40	36.9
Dune du Sud 2003	0.42	0.05	5	22.8 ± 3.7	484 ± 98	24.2

Chaleur Bay

Shellfish area	Total surface area	Harvestable surface area	Stations	Density	Yield[1]	Biomass
Bassin de la rivière Nouvelle 2002	1.12	0.38	95	21.3 ± 1.5	388 ± 30	146.4
Carleton 2002	0.06	0	-	-	-	0
Clapperton 2002	0.03	0	-	-	-	0
Pointe Verte 2001	0.16	0	-	-	-	0
Bonaventure 2002	0.43	0	-	-	-	0
Bonaventure 2009 à 2011	0.43	0	-	-	-	0
Bonaventure Est 2002	0.01	0	-	-	-	0
Barachois de Port-Daniel 2002	0.37	0.16	62	36.6 ± 3.9	809 ± 101	125.4
Baie du Grand-Pabos 2002	0.40	0.10	24	31.8 ± 5.3	700 ± 131	66.7
Estuaire de la rivière Malbaie 2002	0.33	0.26	65	47.1 ± 4.6	1,419 ± 139	366.2
Estuaire de la rivière Saint-Jean 2002	0.41	0.20	50	31.3 ± 3.6	693 ± 92	137.5

Lower St. Lawrence and Gaspé North

Shellfish area	Total surface area	Harvestable surface area	Stations	Density	Yield[1]	Biomass
Kamouraska 2005	1.86	0	-	-	-	0
Anse au Persil 2005	0.30	0	-	-	-	0
Île Verte 2005	0.80	0.38	15	30.0 ± 3.6	643 ± 96	241.1
Batture de Tobin 2005	0.53	0	-	-	-	0
Îlets D'Amours 2005	0.10	0	-	-	-	0
Pointe des Riou 2006	1.31	0	-	-	-	0
Baie du Ha! Ha! 2005	0.43	0	-	-	-	0
Baie Hâtée 2005	0.13	0.07	8	39.8 ± 4.6	1,488 ± 322	107.1
Rimouski 2006	4.44	0.83	27	19.1 ± 2.0	470 ± 56	388.6
Anse aux Coques 2005	0.14	0	-	-	-	0
Baie Mitis 2005	0.96	0.33	14	56.5 ± 11.8	1,434 ± 248	476.0
Anse du Petit Métis 2005	0.35	0.23	8	43.8 ± 6.3	1,378 ± 363	139.7
Petits-Méchins 2005	0.01	0	-	-	-	0
Capucins 2006	0.53	0.11	20	38.0 ± 6.5	979 ± 198	110.1

Upper North Shore

Shellfish area	Total surface area	Harvestable surface area	Stations	Density	Yield[1]	Biomass
Baie du Moulin à Baude 2002	0.49	0.19	26	61.6 ± 9.1	1,888 ± 246	353.5
Baie des Petites Bergeronnes 2008	0.60	0.14	14	24.3 ± 4.5	598 ± 119	83.7
Pointe à Émile 2003	1.16	0	-	-	-	0
Baie des Chevaux 2002	1.45	0.21	19	33.9 ± 7.2	868 ± 173	182.2
Cran à Gagnon 2007	0.38	0.10	18	23.1 ± 2.8	619 ± 89	62.7
Anse Noire 2003	0.08	0.02	6	20.7 ± 5.1	459 ± 112	6.9
Réserve Pessamit Sud 2005	1.43	0.57	45	38.7 ± 7.6	1,018 ± 175	575.3
Réserve Pessamit Sud 2010	1.43	0.40	32	35.8 ± 4.7	990 ± 127	394.7
Réserve Pessamit Sud 2014	1.43	0.45	40	33.7 ± 5.7	1,022 ± 168	462.5
Pointe-aux-Outardes Ouest 2003	5.99	1.86	83	26.3 ± 2.2	1,263 ± 103	2,348.3
Pointe-aux-Outardes Est 2004	1.82	0.36	13	29.7 ± 6.9	817 ± 162	297.3

Middle North Shore

Shellfish area	Total surface area	Harvestable surface area	Stations	Density	Yield[1]	Biomass
Mingan 2001	0.32	0.23	37	40.8 ± 6.7	1,099 ± 199	247.3
Mingan 2007	0.32	0.10	12	42.3 ± 12.4	883 ± 244	85.8

[1] Yield calculated from the thawed weight, except in the case of Anse Noire and Pointe à Émile 2003 (fresh weight).