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Assessment of the whelk fishery in Quebec's inshore waters – methodology and results

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Foreword

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

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ABSTRACT

The Waved Whelk, *Buccinum undatum*, is a gastropod mollusc that is found along the coasts of the Estuary and Gulf of St. Lawrence. In Québec, whelk growth is fairly slow and it can reach a shell height of 120–130 mm. Its life span is approximately 15 years.

There are 15 whelk fishing areas in Québec waters. The whelk fishery uses traps and focuses essentially on *Buccinum undatum*, although some other species of *Buccinum* are present. The fishery is regulated by the number of licences, the number of traps and the minimum legal size of 70 mm. Quotas on landings are in place in six areas. The stock status is determined primarily based on commercial fishery indicators.

In 2017, whelk landings totalled 1,329 t in Québec. A total of 77% of these landings were from the North Shore (areas 1 to 9), 8% from the Gaspé Peninsula–Lower St. Lawrence (areas 11 to 14) and 15% from the Îles-de-la-Madeleine (area 15). Landings increased in most fishing areas compared to 2014 and TACs, when present, have been reached only in fishing area 12. In 2017, catches per unit effort (CPUE) were above their reference average in areas 1, and 2, close to their average in areas 4, 6, 7, 12, 13 and 15 and under their average in areas 3, 5 and 8. In the last three areas, CPUEs measured in 2017 were among the lowest values observed since 2001. Mean sizes have been roughly stable in all areas since 2011. In 2017, the proportion of whelk measuring less than the legal limit (< 70 mm) in landings was less than 4% everywhere except in areas 1 (12%), 2 (6%) and 8 (7%).

The research survey shows that in 2017 in areas 1 and 2, the density of whelks (≥ 70 mm) was higher than in previous years (2005 to 2015). However, the density of whelks of 20 to 69 mm was around the average. The whelk densities obtained during the 2016 survey in the Îles-de-la-Madeleine were low. The highest densities were observed in fishing areas. Boring polychaetes would be responsible for the weakening of the shell whelks.

INTRODUCTION

The commercial whelk fishery began in the Estuary and Gulf of St. Lawrence in the 1940s (D'Amours et al. 1983). Landings remained between 100 t and 350 t until 1985, buoyed by the arrival of new processors in the mid-1960s. The fishery expanded along the North Shore in the early 1990s and began in the Îles-de-la-Madeleine in 2003; harvesting in the Gaspé–Lower St. Lawrence region has increased in intensity since 2005. In the late 1990s, several stakeholders (industry, fishers and managers) expressed concern about the uncontrolled development of this fishery in Québec, eventually leading to the introduction of various management measures in 1999.

There are 15 whelk fishing areas in Québec waters. Areas 1 to 9 are along the North Shore, areas 11 to 14 in the Gaspé Peninsula–Lower St. Lawrence, and area 15 around the Îles-de-la-Madeleine (Figure 1). Area 10 is under the joint responsibility of Gaspé Peninsula and Îles-de-la-Madeleine. The whelk fishery is an inshore fishery which is carried out with conical traps.

Fisheries and Oceans Canada (DFO) conducts a review and assessment of the whelk fishery in the inshore waters of Québec every three years. The most recent review was conducted on February 21, 2018. In support of this review (DFO 2018), this document presents the data, techniques, analyses, and findings of this assessment following the 2017 fishing season. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada Science Advisory Schedule as they become available.

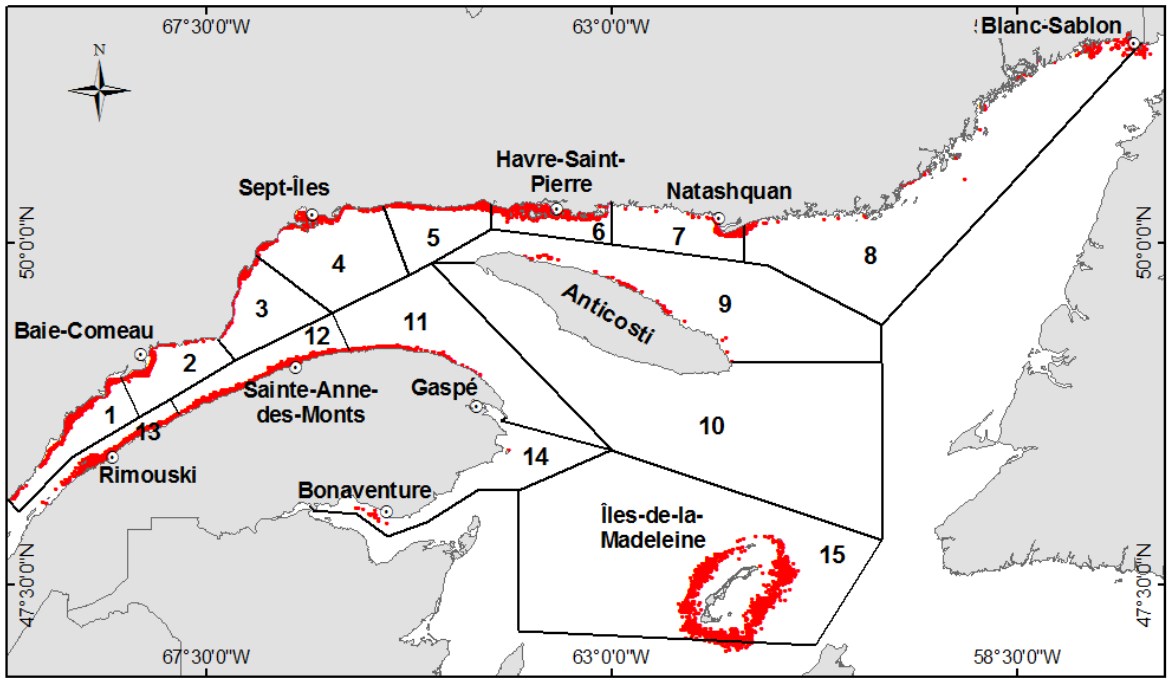

Figure 1. Whelk fishing areas and known Buccinum undatum *distribution in the Estuary and Gulf of St. Lawrence (source: logbooks, commercial sampling program, research surveys and exploratory fisheries).*

BIOLOGY

The Waved Whelk, *Buccinum undatum*, is a gastropod mollusc found along the western Atlantic coast from New Jersey to Labrador, including the Estuary and Gulf of St. Lawrence (Bousfield

1964). It is very common in cold waters, from the tidal level to depths of 30 m or more (Figure 1). Whelk is an opportunistic carnivorous predator and a carrion feeder (Himmelman and Hamel 1993). It feeds mostly on invertebrates, primarily Polychaeta, Molluscs and Echinodermata (Hamel 1989, Fahy 2001, Morel and Bossy 2004). Whelk detects their prey through waterborne odours, making it vulnerable to baited fishing gear. Whelk's ability to detect prey is therefore highly influenced by current strength and direction. When food or predators are present, whelk can move at a rate of 2 to 15 cm/min over a distance of several tens of metres (Himmelman 1988, Sainte-Marie 1991, Lapointe and Sainte-Marie 1992, Giguère et al. 2007).

In the St. Lawrence, whelk growth is slow (Jalbert et al. 1989, Gendron 1992). It can reach a 120–130 mm shell height size. Its longevity is estimated to around 15 years (Jalbert 1986, Gunnarsson and Einarsson 1995, Kenchington and Glass 1998).

Whelk species are dioecious, having two separate sexes and the ova are fertilized internally. Along the North Shore and the Gaspé, mating occurs in May and June (Boivin et al. 1985, Martel et al. 1986a, Himmelman and Hamel 1993). Eggs are laid two to three weeks after mating, mostly in June and July. Egg laying is generally communal, with females congregating at a site to lay their eggs. Eggs are enclosed in chitin capsules clumped together in a mass several centimetres wide attached to the substrate. Several females can lay their eggs on the same mass, at a rate of about 140 capsules per female (Martel 1985). Each capsule contains an average of 2,700 eggs (Martel et al. 1986b). There is no planktonic larval stage. Young whelks grow directly in the capsules. In the Estuary and northern Gulf of St. Lawrence, juveniles are 2–3 mm long when they emerge from the capsules after five to eight months of development, from November to February. About 30 juveniles can emerge from each capsule (Martel et al. 1986b).

Adults lead a rather sedentary life. They spend most of their time immobile and half buried in sediment (Hamel 1989). Evidence suggests that this behaviour, together with the absence of a larval phase, limits mixing with neighbouring populations and the possibility of rapidly recolonizing overexploited sites (Caddee et al. 1995, Nasution and Roberts 2004).

The commercial whelk fishery focuses essentially on the Waved Whelk. A few other species of *Buccinum* inhabit the Estuary and Gulf of St. Lawrence. During the research surveys carried out in the Haute-Côte-Nord region (Upper North Shore) and in the Îles-de-la-Madeleine, the species *B. glaciale*, *B. totteni*, *B. scalariforme* and *B. undatum* (WoRMS 2018) were found along with some individuals that could not be identified to the species level[1] (Appendices 1 and 2). However, the main species is *B. undatum*, which accounted for more than 90% of the whelks collected during the research surveys.

MATERIAL AND METHODS

COMMERCIAL FISHERY

The commercial whelk fishery data come from three separate sources: purchase receipts, logbooks and commercial catch sampling. The information collected through purchase receipts and logbooks is provided to us in a ZIFF file (Zonal Interchange Format File). Purchase receipt is completed by the buyer and provide official whelk landing figures. Landings used in this paper

[1] Identifying species in the genus *Buccinum* is fairly complex (given the presence of several species, similar species in different regions, and possibly hybrids), an in-depth genetic study is needed to clarify the situation.

do not include estimates for unreported landings. Whelk logbooks, introduced in 2001, are updated by fishermen on a daily basis. They provide various information including: the fisherman's identification, landing dates, trap haul dates, fishing location (first and last trap haul), fishing area, number of trap hauls, trap soak time and total weight landed.

The DFO commercial whelk sampling program has been in operation in Québec since 1987. Samples are collected dockside or at the plant to describe the size structure of landed individuals.

Commercial fishery indicators used to assess whelk by fishing area are:

- Landings in tonnes (t) of live weight;
- Fishing effort in number of trap hauls;
- Standardized catch per unit effort (CPUE) in kilograms of live weight per trap haul (kg/trap);
- Average (mm) and median size (mm) of landed whelk;
- Percentage (%) of sub-legal size whelk (< 70 mm) in landings.

Data for the current year are generally considered preliminary, because a small percentage of logbook data may not have been entered yet at the time of analysis. Data are validated annually to eliminate outliers (effort, location, etc.). Annual landings are the aggregate of all commercial fishing activities. Fishing effort has been compiled from logbooks since 2002[2]. Because the number of trap hauls per fishing activity is not always known, a correction factor is required to provide an estimate of the total number of trap hauls per area and per year. A rule of three is used to calculate this factor using the sum of landings with their known effort and total landings by area, year and month.

CPUE is calculated for each observation (departure date, location and fisherman). CPUE were standardized to account for the effect of trap soak times on catches (Gavaris 1980). The following variables were standardized (PROC MIXED, SAS version 9.4, values previously converted to natural logarithm) by fishing area: soak times (from 24 to 192 hours), month and year. The effect of these variables is significant in all areas. When the number of observations was < 10 (zone-year), these cases were not used to calculate standardized CPUE. The confidence interval for the average annual CPUE per area is 95%.

Appendix 3 provides the number of samples from the landed commercial catch sampling program by fishing area and year for the commercial whelk fishery. Since 2004, a sample has contained about 150 measured whelks (Appendix 4). In the case of whelk, size is defined as shell height and is measured to the nearest mm (Appendix 5). Whelk size structures are aggregated by year to calculate an annual size structure by fishing area. The figures are aggregated to ensure each sample has the same weighting (does not depend on the number of individuals measured). Size structures are presented in a bubble chart where bubble size is proportional to frequency (%) by 1 mm size class over which average size is superimposed with a 95% confidence interval.

The reference average of landings and CPUE are calculated for each fishing area for the period 2001 to 2016, and fishing effort is calculated for the period 2002 to 2016. Because the Îles-de-la-Madeleine fishery started in 2003, the reference period for fishing effort is 2003 to 2016 and

[2] The 2001 effort data are partial, making it difficult to estimate total effort, but these data were used to calculate CPUE.

that of the CPUE, from 2003 to 2013, so as to not include the very low values seen since 2014.[3] The reference average sizes are calculated for the period 2005 to 2016 by area. The relative difference between the value of the 2017 indicator and the reference average is calculated as follows:

$$\text{Relative difference} = \frac{\text{2017 value - Reference average}}{\text{Reference average}} \times 100$$

In addition, the position of the annual value can be compared to the reference average using the 95% confidence intervals. If the reference average is included in the confidence interval of the value, the value is considered similar to the average, otherwise the value is either above or below average.

Where there are fewer than three active fishermen, landing and fishing effort values are not presented in this paper in order to keep the information confidential unless the fishermen concerned have given their permission.

RESEARCH

Growth in tanks

Following the Haute-Côte-Nord research survey in 2015, whelks ≥ 70 mm were kept in tanks at the Maurice Lamontagne Institute. Shortly after the whelks were received, egg masses were found on the walls of the tanks. Young whelks emerged from the eggs at the end of December 2015. These young whelks were then transferred to round 60-litre tanks in an open system with filtered seawater circulating at a rate of 3 L/min. Whelk density was reduced in accordance with whelk growth. In March 2018, there were about 100 individuals per tank. From the time of hatching to April 2018, the whelks were fed twice a week with pellets for young fish (Skretting, St. Andrews NB, Canada). Since April 2018, their main source of food has been pieces of mussel, shrimp or fish. The whelks have been measured regularly since they hatched.

Haute-Côte-Nord Survey

A research survey has been conducted every two years in late July since 2005 in the Forestville, Pointe-aux-Outardes and Baie-Comeau sites along the Haute-Côte-Nord and in Fishing Areas 1 and 2 (Appendix 6). This survey was put in place in 2005 following intensive fishing in the early 2000s in Areas 1 and 2. The three sites covered by the survey were determined based on the distribution of commercial fishing effort from 2001 to 2004 (Brulotte 2015). In recent years, fishing effort has decreased significantly at Pointe-aux-Outardes whereas harvesting in the Forestville and Baie-Comeau sites has continued at the same level (Appendix 6).

The survey is conducted usually between July 17 and August 2 with a Digby scallop dredge and its four baskets are lined with 19 mm Vexar™ netting. A fixed-station sampling design was used to cover the three sites, at depths ranging from 5 m to 40 m (Appendix 6). Since 2007, the sampling plan has consisted of 55 stations off Forestville, 26 off Pointe-aux-Outardes and 11 off Baie-Comeau. During dredging, start and end positions are noted to calculate the distance dredged for each station. The area covered at each station is the product of basket

[3] The average is influenced to a great extent by the extreme values.

width (4 x 0.76 m) and distance. The average tow distance was 308 ± 27 m[4] in 2015 and 295 ± 41 m in 2017.

All individuals of the genus *Buccinum* (a few species were present) are harvested, identified to species, counted, and measured (shell height to the nearest mm). A stratified subsample (2 whelks per mm of height) was stored by site, species and year for analysis. Individuals were kept frozen until they were tested in the laboratory. All *Buccinum undatum* egg masses have been counted and individual weights measured.

Different variables are compiled on the individuals collected (sub-sample). A sequential number was assigned to each individual. The height (0.1 mm), width and minimum width (Appendix 5) as well as live weight (0.01 g) and sex of each individual were measured. The operculum was retained for age readings.

Due to the size of the mesh used to line dredge baskets, whelks less than 20 mm were not included in density and yield calculations. Whelks were divided into two size classes: sub-legal size individuals from 20 mm to 69 mm and legal size individuals ≥ 70 mm. The weight-height relationship, estimated from measurements of individuals in the stored subsample, was used to calculate the weight of each individual harvested (Appendix 7). Density (number/100 m^2) and yield (g/100 m^2) were calculated at each station for each size class by *Buccinum* species and for egg masses. Given that the commercial fishery includes all *Buccinum*, regardless of species, annual density and yield averages (± standard error) were calculated for each site for all whelk species. A nonparametric test (Kruskal-Wallis test) was used to compare annual density results by site. The Tukey test was used for post hoc comparisons. Size structure histograms are presented by year and site.

Îles-de-la-Madeleine Survey

A research survey was conducted in the Îles-de-la-Madeleine in 2016 following a request from DFO management. This survey had two main goals:

- assess the distribution of whelks at fishing sites, but also outside the usual fishing depths
- determine the cause of the embrittlement of whelk shells, a problem detected by a fisher in 2015.

Four sites were selected for the survey (Appendix 8). A systematic sampling plan was used at each site, for a total of 111 stations at depths between 30 m and 50 m. The survey took place from August 20 to 28, 2016. A Digby scallop dredge was used with its four baskets lined with 19 mm Vexar™ netting. The sampling protocol was essentially the same as that used on the Haute-Côte-Nord: identification of the *Buccinum* species, measurement of all whelks, counting, and weighing of all *Buccinum* egg masses.

All the whelks collected were frozen for more detailed laboratory analyses, including the characterization of lesions that may be causing shell embrittlement. A protocol was developed to assess lesion presence and severity and to determine the cause (Couillard et al. 2018).

Determination of age and growth

Whelk age can be determined by counting the growth rings on the operculum (Boivin et al. 1985, Gendron 1992). However, care must be taken because whelks can lose their operculum and the operculum can regenerate. First, the operculum must be removed and

[4] Average ± standard error.

cleaned. The internal face (attached to the foot) of the operculum is then stained with a 0.2% methylene blue solution. The rings are counted on transparent slides using a binocular microscope.

The von Bertalanffy growth curve (Ricker 1980) is used. It is based on shell height versus age, using the following equation:

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

Where: L_t = shell height (mm) at age t
L_∞ = shell height (mm) at infinity (maximum asymptotic size)
K = Brody growth coefficient
t = whelk age (number of growth rings)
t_0 = theoretical age when height equals 0 mm

Growth curves were calculated by fishing area, with Area 1 consisting of the Forestville and Pointe-aux-Outardes sites combined. In addition, data from the last two surveys (2015 and 2017) were used to determine the curves for the Haute-Côte-Nord.

MANAGEMENT MEASURES OF THE COMMERCIAL FISHERY

Various management measures have been put in place since 1999 (Appendix 9). Fishing effort has been controlled in all areas by a fishing season of about six months, number of licences and number and size of traps and introducing a landings quota in Areas 1, 2, 11, 12, 13 and 15. Active management measures for 2017 are presented in Appendix 10.

The total number of licences issued is controlled, but inactive fishermen sometimes outnumber active fishermen, creating a high potential effort that could become problematic in some areas. Steps have been taken to reduce the number of licences (e.g. licence buy-backs). As a result, the total number of licences has decreased from 281 in 1999 to 249 in 2014 and to 240 in 2017. However, there were only 81 active licences in 2017 (Appendix 10). The number of traps allocated to inactive fishermen was also reduced in 1999 and 2006 in order to decrease potential effort (Appendix 9). In 2017, the number of authorized traps varied between 50 and 175 traps per licence (Appendix 10). Some Aboriginal band councils may hold several licences. In 2017, the total number of authorized traps for all licences ranged from 550 to 6,400 traps per fishing area, while the number of traps in use or active was lower, from 200 to 1,700 traps per fishing area. (Appendix 10) In 2017, between 17% and 83% of traps were active depending on the fishing area.

Total allowable catches (TACs) are in effect in Areas 1 and 2 along the North Shore, in Areas 11, 12 and 13 of the Gaspé–Lower St. Lawrence and in Area 15 of the Îles-de-la-Madeleine (Appendices 9 and 10). They were respectively 491, 109, 11, 46, 82 and 376 t in 2017. Finally, the minimum legal size has been 70 mm in all areas since 2005 (Appendix 9).

COMMERCIAL FISHERY RESULTS

Area 10 has not been fished since 1997 (Figure 2 and Appendix 11), and there were a few days of fishing in areas 9, 11 and 14 in recent years. It is therefore impossible to determine the status of the resource in these areas.

From 2015 to 2017, the distribution of commercial fishing effort was generally uniform in the main fishing areas, with the exception of Areas 7 and 8 where fishing was carried out primarily near Natashquan and Blanc-Sablon (Figure 2).

From 1991 to 1998, annual landings ranged from 493 t to 1,032 t and were primarily from the North Shore (Figure 3 and Appendix 11). Landings subsequently peaked at 2,000 t in 2003 with the beginning of the fishery in the Îles-de-la-Madeleine. Subsequently, landings decreased mainly along the North Shore followed by stabilization. Since 2009, landings have fluctuated between 937 t and 1,484 t. In 2017, they were 1,329 t, and 77% were from the North Shore, 8% from the Gaspé–Lower St. Lawrence and 15% from the Îles-de-la-Madeleine. Landings in 2016 and 2017 increased in most fishing areas relative to 2014. Over the last three years, the TAC, where applicable, was reached only in Area 12.

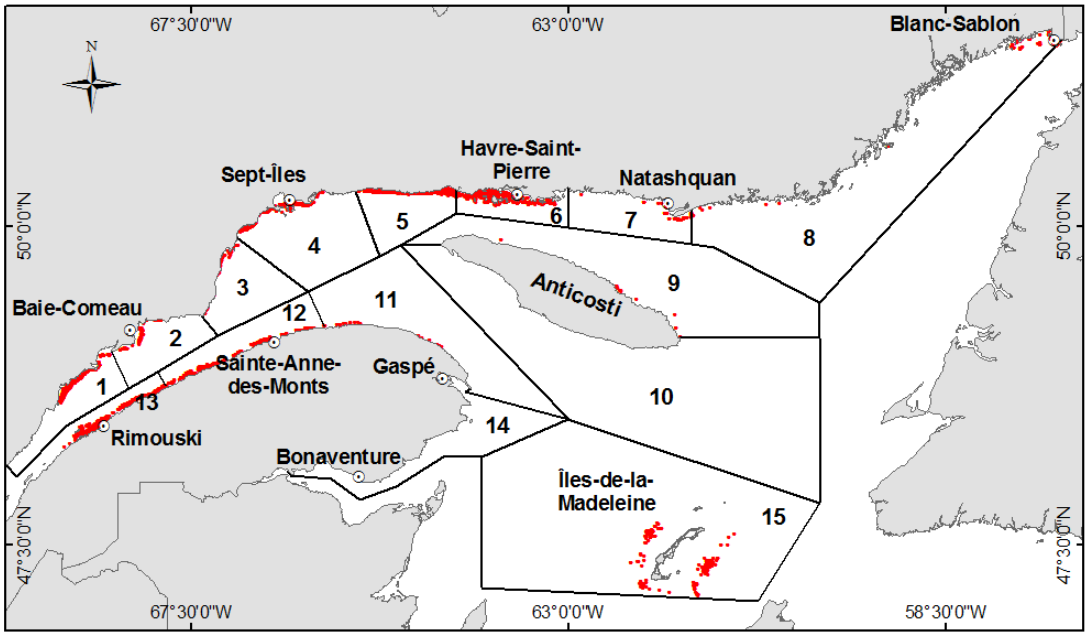

Figure 2. Location of the commercial whelk fishery from 2015 to 2017.

Fishing effort measured in number of trap hauls for the whole fishing season has only been available since 2002. Changes in landings since 2002 are largely attributable to changes in fishing effort (Figure 4 and Appendix 12). Overall effort reached a maximum value of 385,800 trap hauls in 2003. Effort subsequently declined to 206,200 trap hauls in 2008. Effort has since ranged from 167,200 to 261,900 trap hauls per year. In 2017, there were 212,400 trap hauls, a 15% decrease in effort compared to average along the North Shore, 36% in the Gaspé–Lower St. Lawrence and 23% in the Îles-de-la-Madeleine.

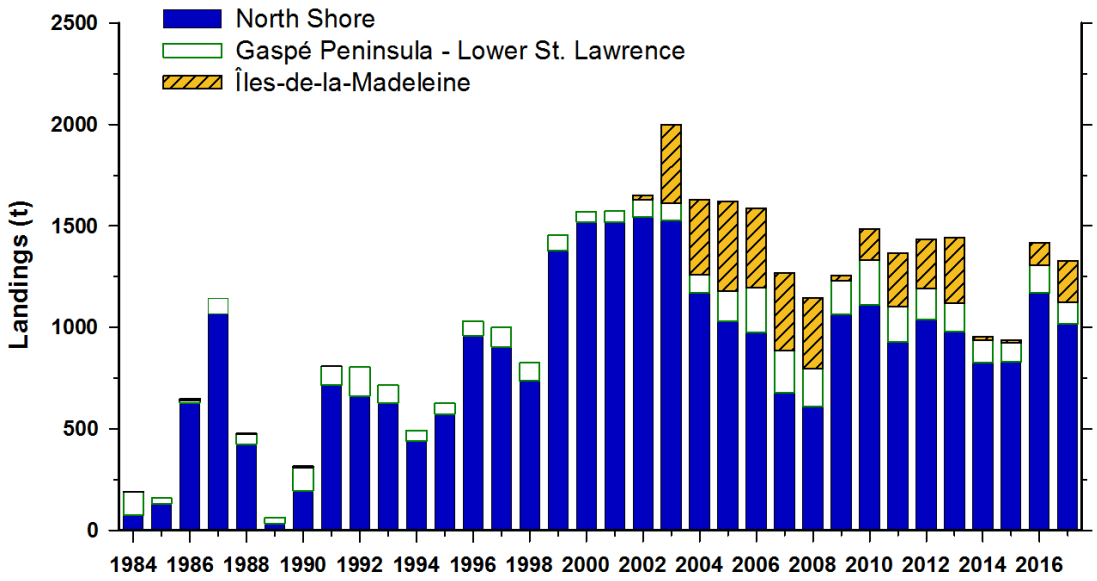

Figure 3. Annual whelk landings by region from 1984 to 2017.

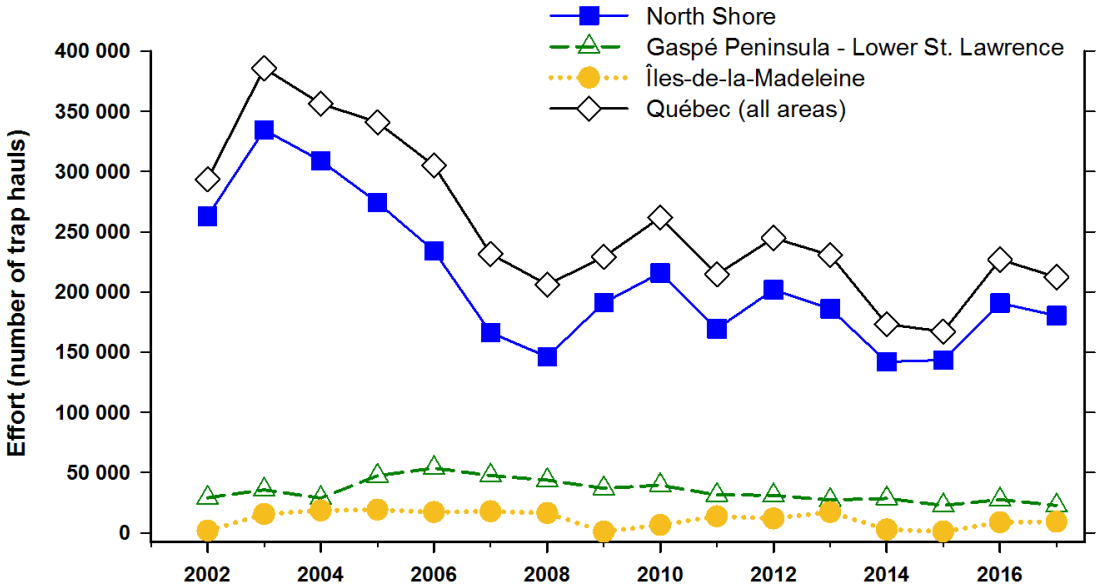

Figure 4. Annual fishing effort for the commercial whelk fishery by region and for all of Québec from 2002 to 2017.

NORTH SHORE

Fishing Area 1

Fishing Area 1 extends from Pointe Rouge (Tadoussac) to Pointe du Bout at Pointe-aux-Outardes (Figure 5). For several years, commercial fishing has been concentrated mainly in the central-eastern portion of the area. In 2017, there were 5 active licences in this area for 650 traps out of a total of 11 licences issued and 1,300 traps authorized under current management measures (Appendix 10).

Landings greater than 500 t were recorded in 2000, 2001 and 2002 (Figure 6 and Appendix 11). A preventive 491 t TAC was introduced in 2003 to limit exploitation in this area. The TAC has never been caught. Between 2004 and 2015, landings have ranged from 114 t to 300 t. Over the past two years, landings have increased to 428 and 378 t respectively. In 2017, Area 1 produced 28% of Québec landings.

Fishing effort decreased from close to 50,700 trap hauls in 2002 to 19,000 trap hauls in 2015 (Figure 6 and Appendix 12). Effort was 27,100 trap hauls in 2016 and 25,000 trap hauls in 2017. Changes in landings are largely attributable to changes in fishing effort.

From 2001 to 2004, CPUE declined from 12.8 to 6.5 kg/trap, the lowest value in the series (Figure 7 and Appendix 13). Subsequently, CPUE were fairly stable and ranged from 6.7 to 8.7 kg/trap until 2012. Since 2013, the CPUE values have been high and have exceeded the 2001-2016 reference average. They have reached levels comparable to those obtained in 2001 and 2002. In 2017, the CPUE was 15.4 kg/trap.

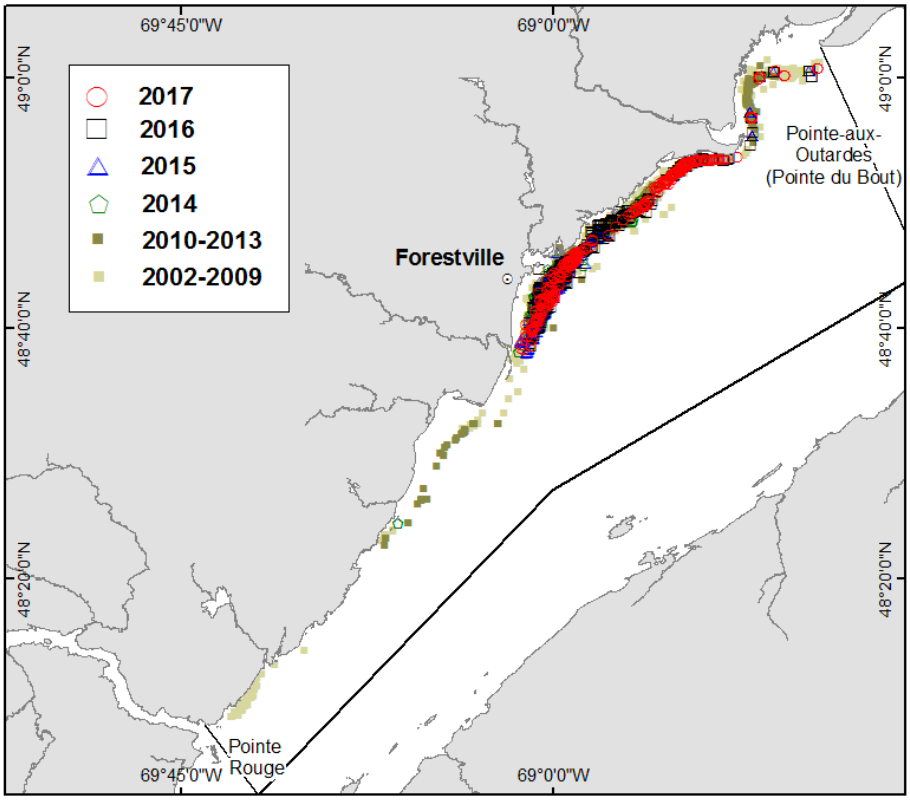

Figure 5. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 1.

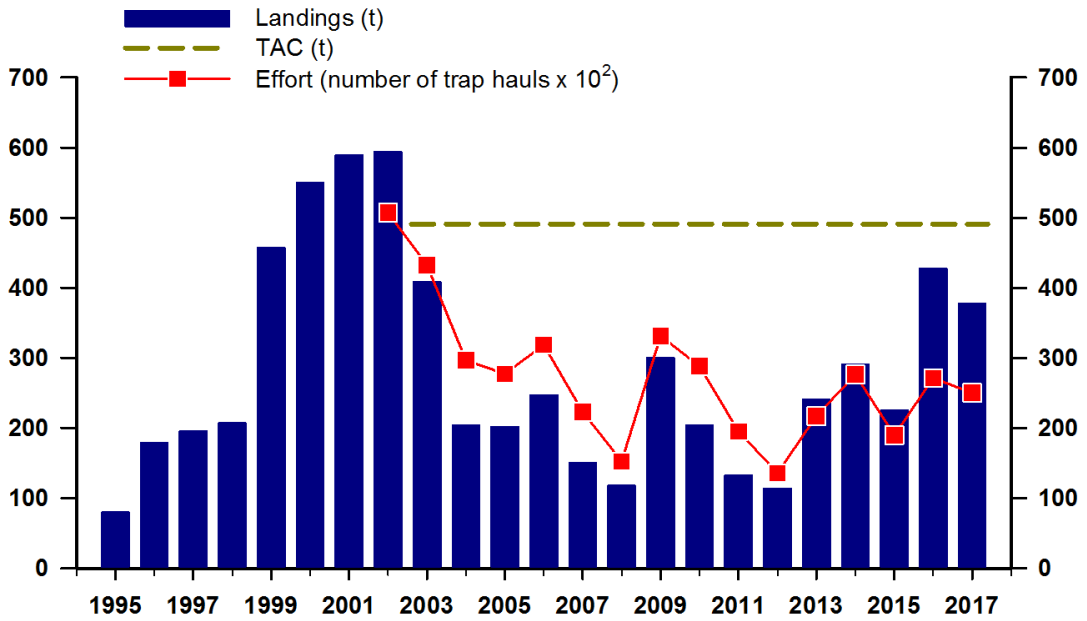

Figure 6. Whelk landings, total allowable catch (TAC) and fishing effort from 1995 to 2017 in Fishing Area 1.

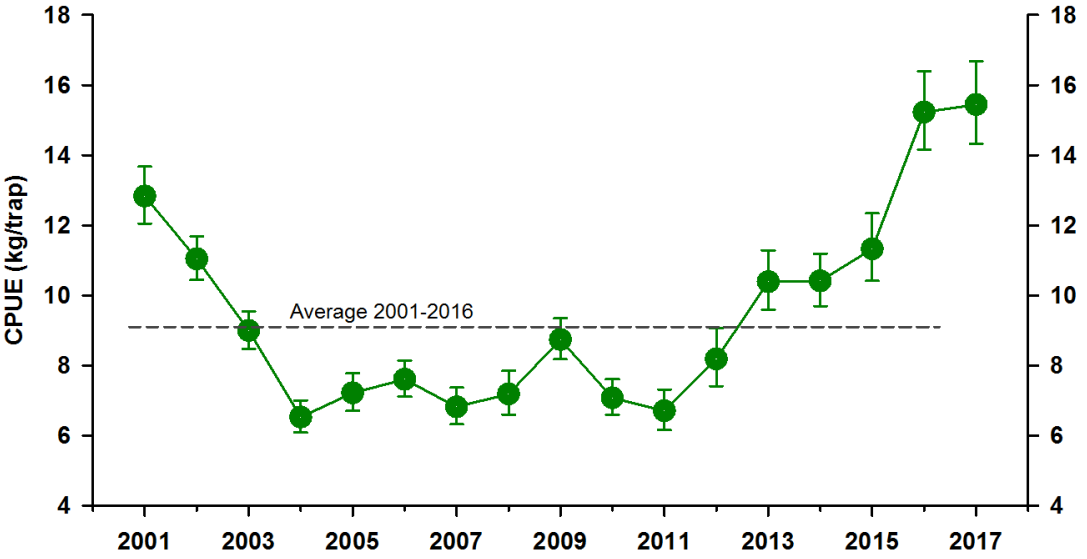

Figure 7. Standardized catch per unit effort (CPUE ± 95% confidence interval) in the commercial whelk fishery from 2001 to 2017 in Fishing Area 1.

Since 2007, the average size of landed whelk has been similar to or higher than 2005–2017 reference average (Figure 8 and Appendix 14). In 2017, the average size was 78 mm, similar to the reference average but this average is low compared to other fishing areas. Since 2010, whelk landings contained between 7% and 12% sub-legal size individuals (Figure 8 and Appendix 15). Since 2006, landed whelk size structures have been very consistent from year to year (Figure 11 and Appendix 15).

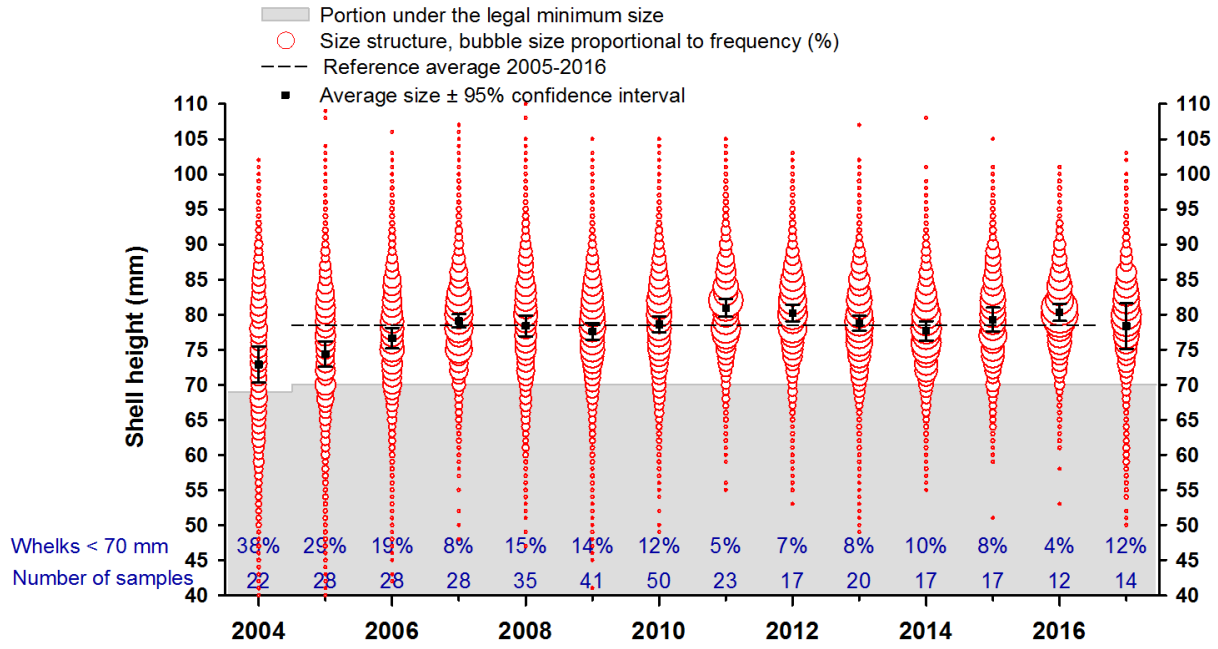

Figure 8. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 1.

Fishing Area 2

Fishing Area 2 extends from the Pointe du Bout at Pointe-aux-Outardes to Pointe-des-Monts (Figure 9). In recent years, fishing has been concentrated in the Baie-Comeau area. Two or three licences have been active since 2007. In 2017, there were two active licences for 200 traps out of a total of 6 licences issued and 550 authorized traps (Appendix 10).

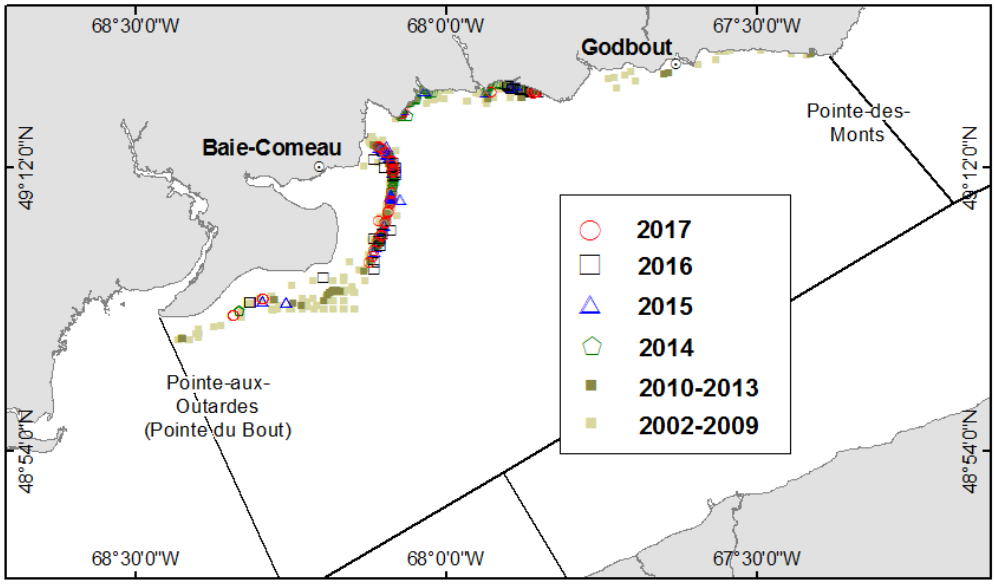

Figure 9. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 2.

Landings from this area were quite high from 2000 to 2003 with values ranging from 119 t to 207 t (Appendix 11). Subsequently, landings decreased. A preventive 109 t TAC was introduced in 2003 to limit landings. This TAC was caught only once, in 2003. Landings and fishing effort in recent years are confidential, given the low number of active fishermen. The 2001–2016 reference average of landings were 70 t and reference average of effort was 6,900 trap hauls (Appendices 11 and 12).

The 2001-2016 reference average of CPUE for this area is 10.1 kg/trap (Figure 10 and Appendix 13). Since 2010, the annual CPUE is generally similar to or greater than the reference average. The 2017 CPUE is the highest of the series at 13.8 kg/trap.

Landed whelk size structures in recent years vary not significantly from year to year (Figure 11). The 2005–2016 reference average size for this area was 77 mm. This average is similar to area 1 but lower than other areas (Appendix 14). Since 2014, the proportion of sub-legal size whelk in landings has been between 2% and 8%, a marked improvement over previous years (Appendix 15).

Fishing Area 3

The boundaries of Fishing Area 3 extend from Pointe-des-Monts in the west to Pointe Jambon in the east (Figure 12). The areas near Baie-Trinité and east of Rivière-Pentecôte have been the most visited since 2014. The number of active fishermen is usually low. In 2017, there were 3 active licences for 350 traps out of a total of seven licences issued and 850 authorized traps (Appendix 10).

Landings peaked at 52 t in 2001 (Figure 13 and Appendix 11). Then, they have decreased to less than 10 t in recent years. The 2001–2016 reference average of landings was 18 t for this area. The fishing effort has also been low since 2013; it was 1,000 trap hauls in 2017 (Figure 13 and Appendix 12).

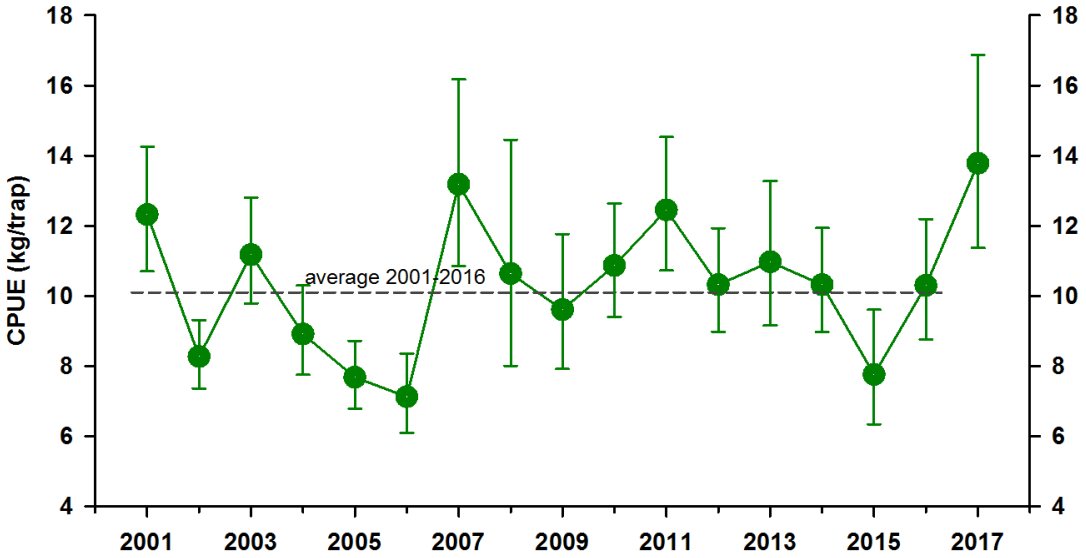

Figure 10. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 2.

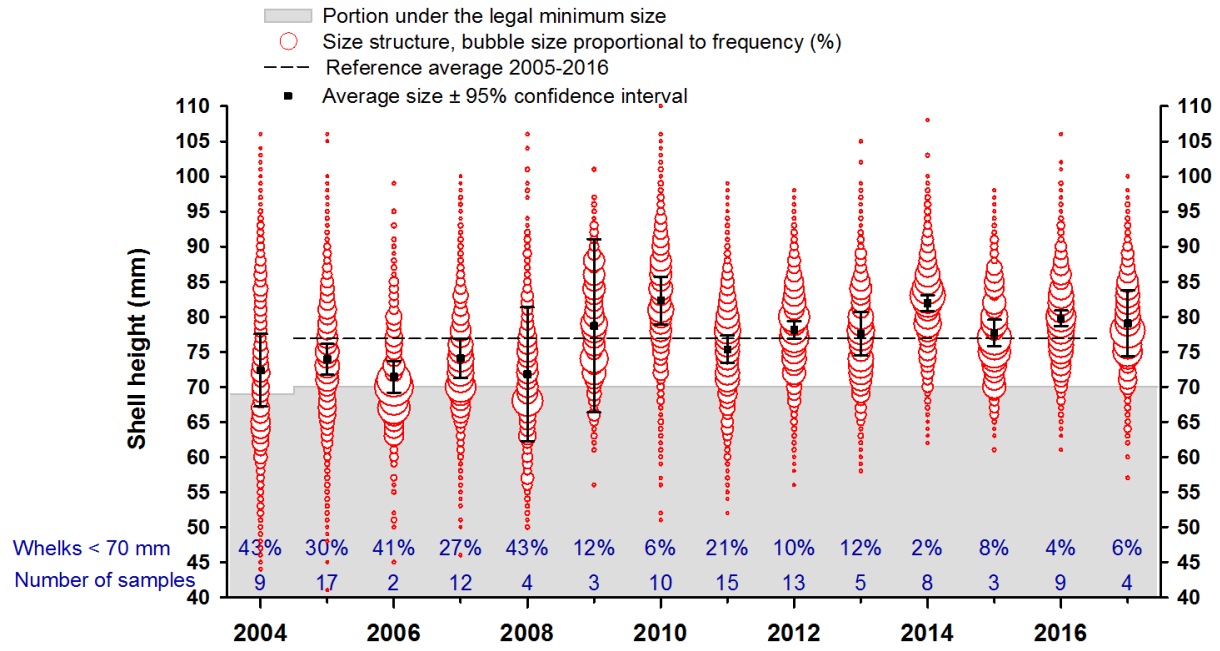

Figure 11. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 2.

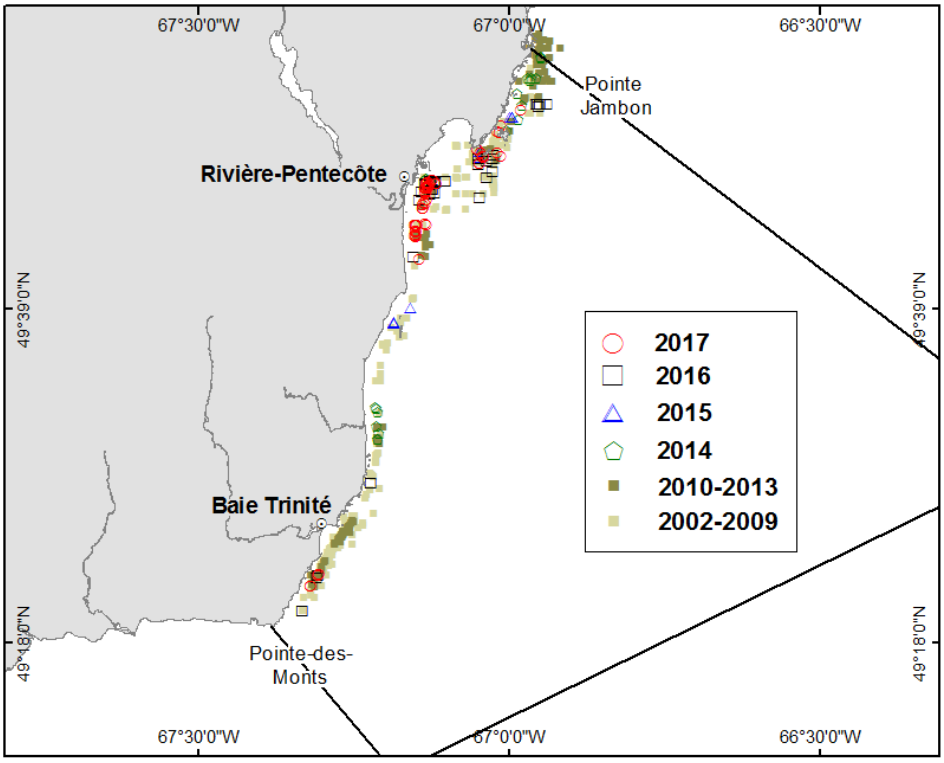

Figure 12. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 3.

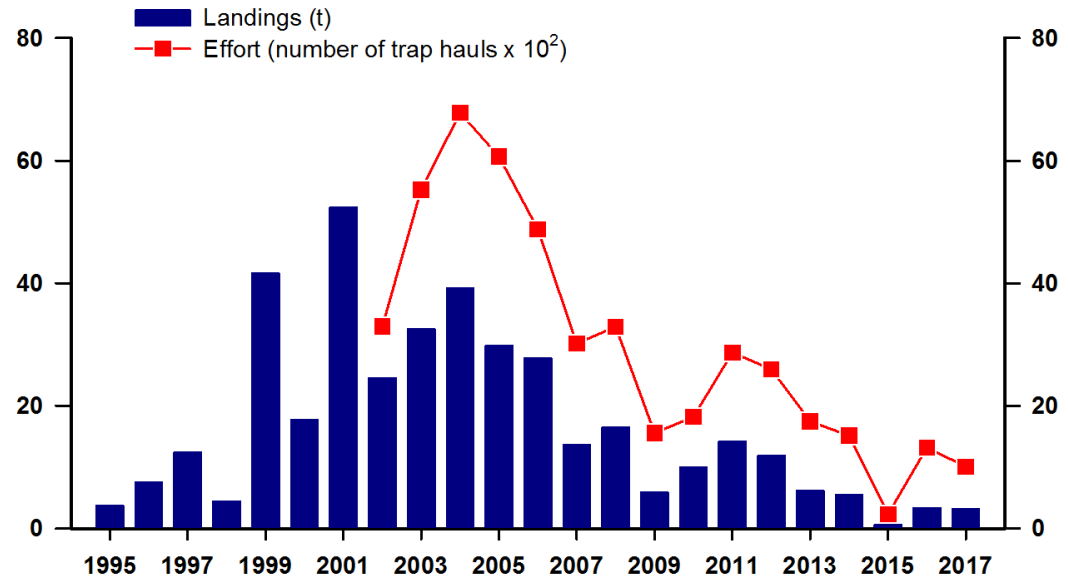

Figure 13. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 3.

Since 2010, the average CPUE values have declined to 1.9 kg/trap in 2017, the lowest value in the series (Figure 14 and Appendix 13). The values have been below the reference average for 2001-2016 (4.6-kg/trap) since 2011.

In this area, landed whelk sampling is sporadic. The most recent sampling campaign was in 2015 and 2016 and the average size was 95 mm and 97 mm with less than 1% sub-legal size whelk in landings (Figure 15 and Appendices 14 and 15).

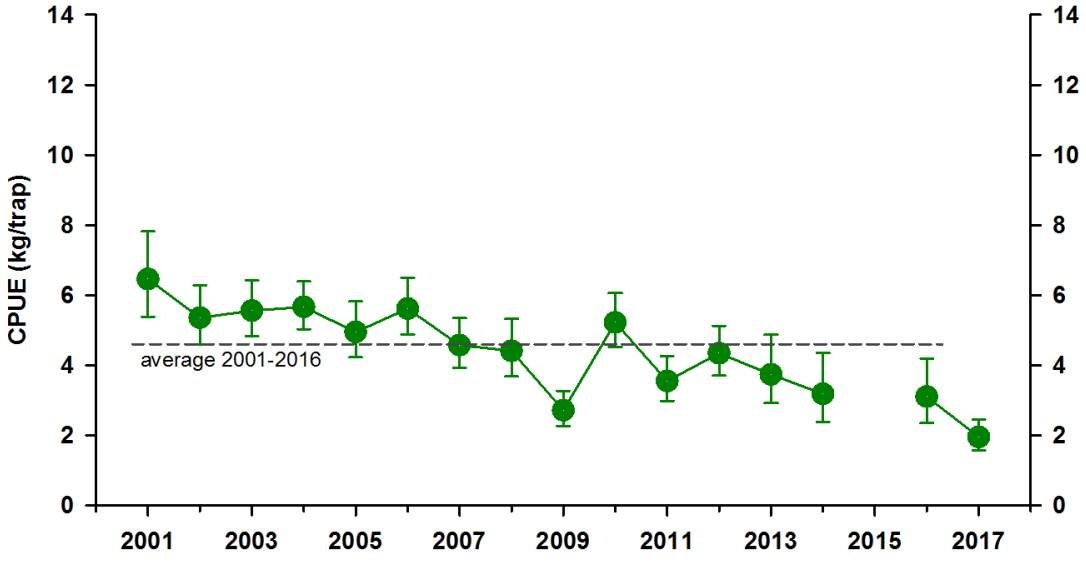

Figure 14. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 3.

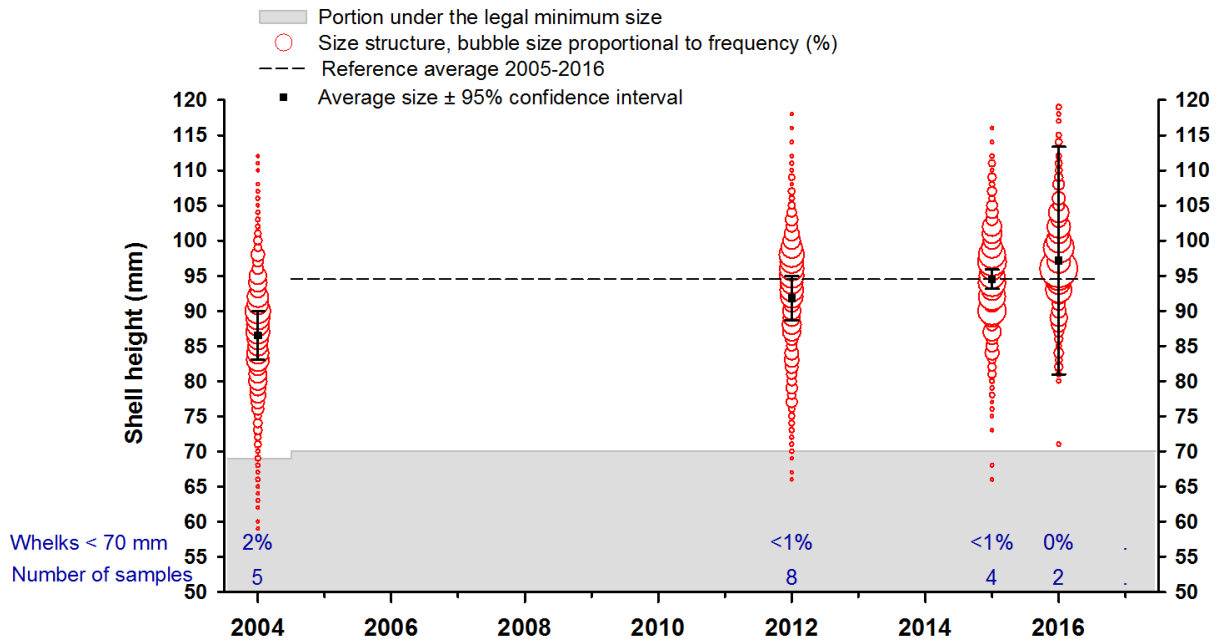

Figure 15. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2016 in Fishing Area 3.

Fishing Area 4

Fishing Area 4 extends from Pointe Jambon to Cap du Cormoran (Rivière-au-Tonnerre) (Figure 16). In recent years, the commercial fishery has covered the central portion of the area in the Moisie Bay sector and farther west fairly well. In 2017, there were 12 active licences for 1,250 traps out of a total of 28 licences issued and 2,559 authorized traps (Appendix 10).

From 2001 to 2004, landings exceeded 142 t and declined thereafter (Figure 17 and Appendix 11). Since 2008, annual landings have remained between 40 t and 82 t. In 2017, it was 57 t in 2017.

Fishing effort peaked in 2003 and 2004 with over 50,000 trap hauls (Figure 17 and Appendix 12). Subsequently, fishing effort decreased. There were 13,100, 12,100 and 17,400 trap hauls in 2015, 2016 and 2017.

CPUE were fairly stable from 2002 to 2010 at around 3 kg/trap (Figure 18 and Appendix 13). Between 2012 and 2016, CPUE have been above the 2001–2016 3.6 kg/trap reference average. In 2017, the CPUE was 3.2 kg/trap lightly under the reference average.

Since 2009, the average size of landed whelk increased to 97 mm in 2017 (Figure 19 and Appendix 14). Size structures are varied with maximum sizes occasionally reaching 120 mm. In the last three years, sub-legal size whelk accounted for less than 1% of landings (Figure 19 and Appendix 15).

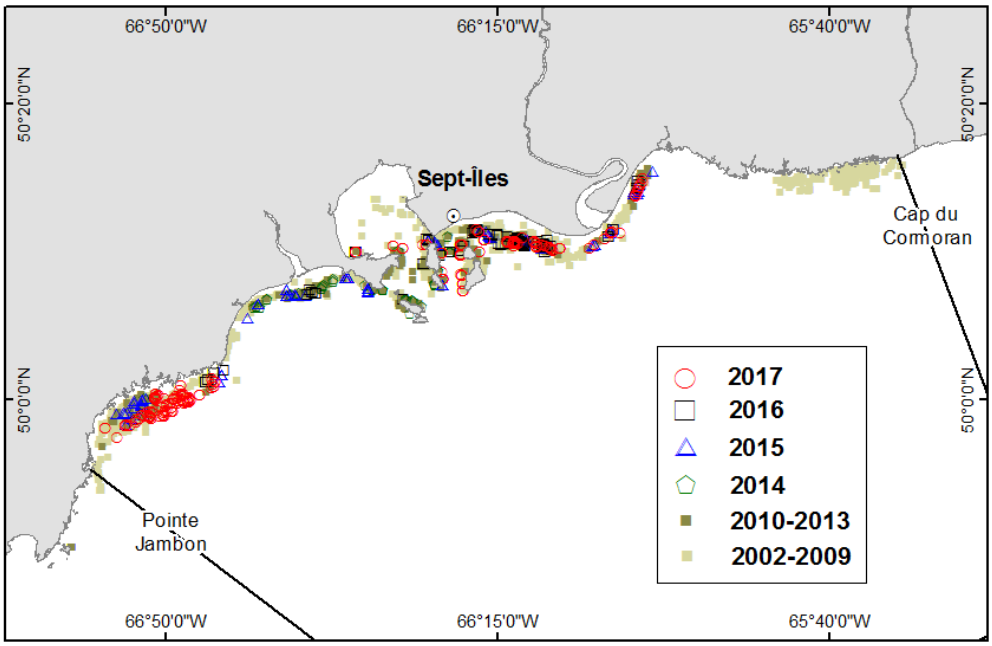

Figure 16. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 4.

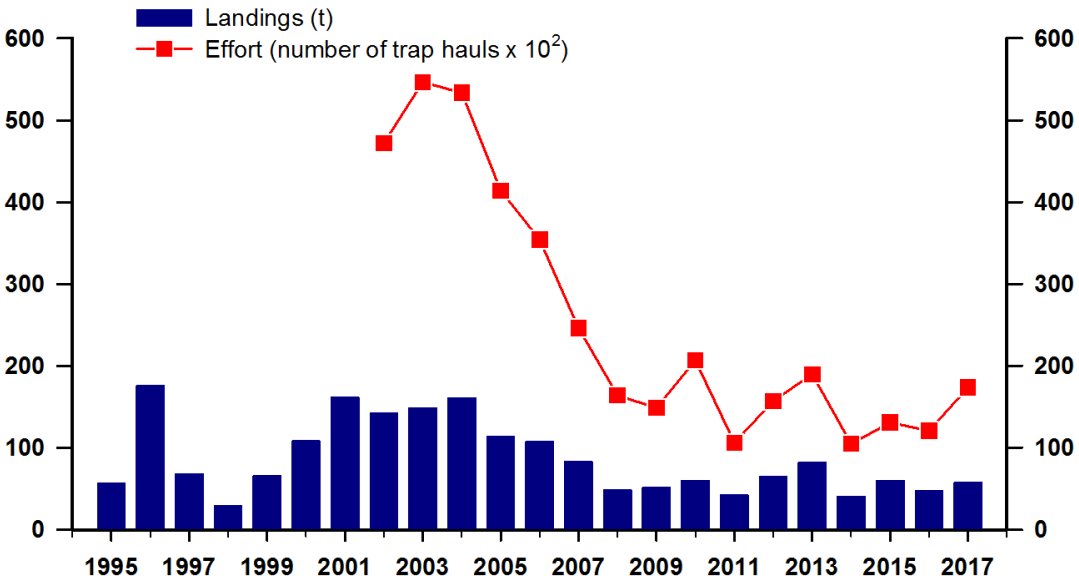

Figure 17. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 4.

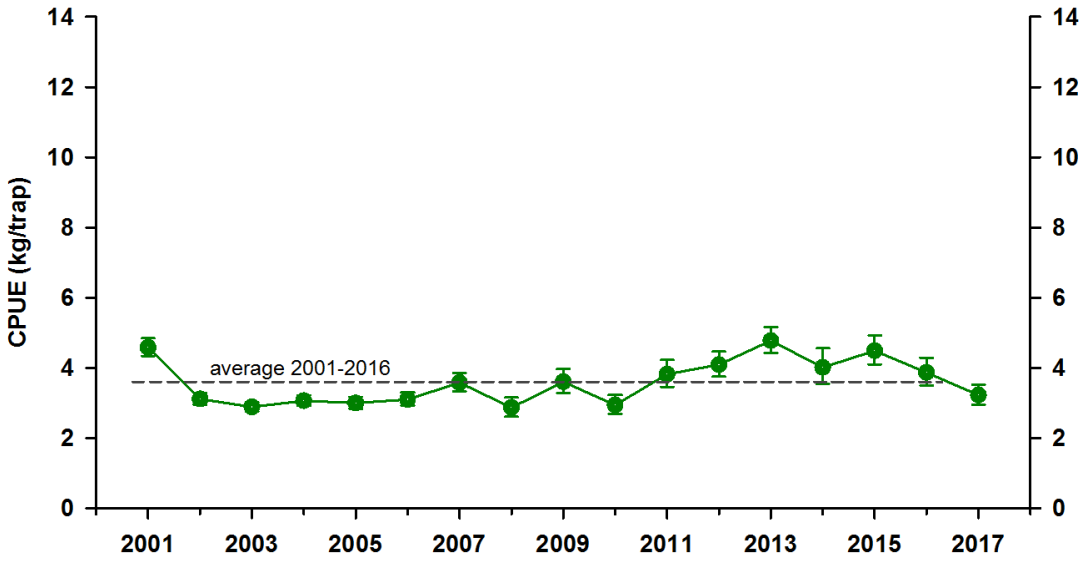

Figure 18. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 4.

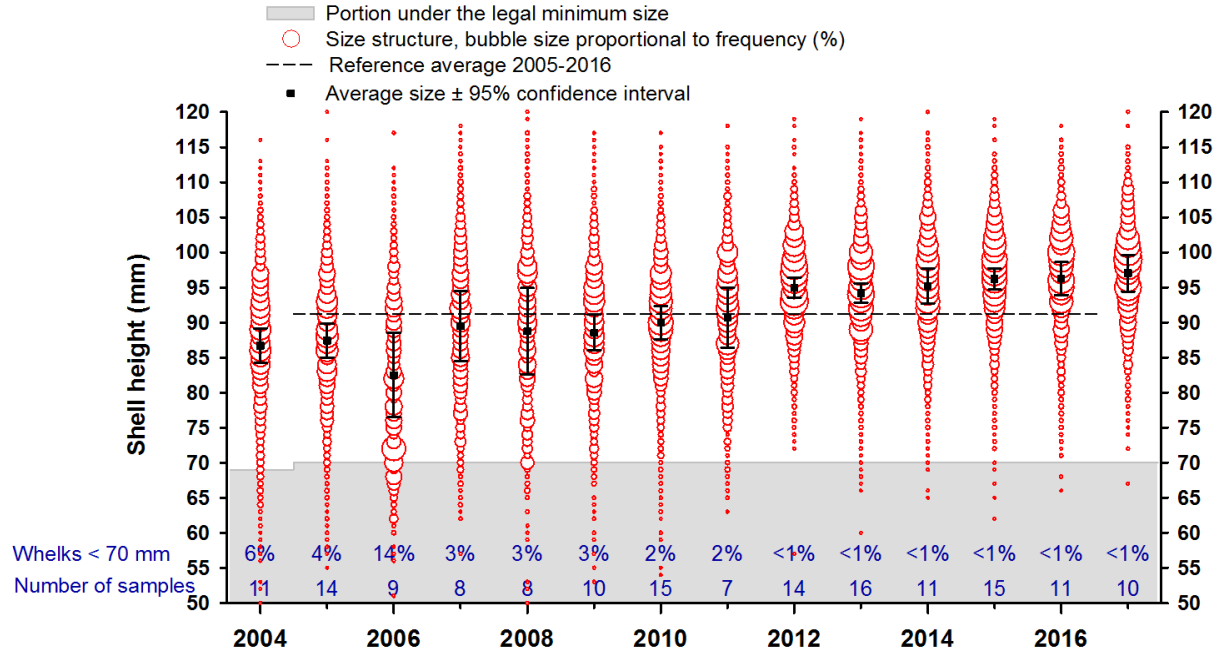

Figure 19. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2016 in Fishing Area 4.

Fishing Area 5

Fishing Area 5 extends from Cap du Cormoran (Rivière-au-Tonnerre) to Rivière Saint-Jean (Figure 20). The fishing effort covers most of the area. In 2017, there were 5 active licences for 650 traps out of a total of 17 licences issued and 1,750 authorized traps (Appendix 10).

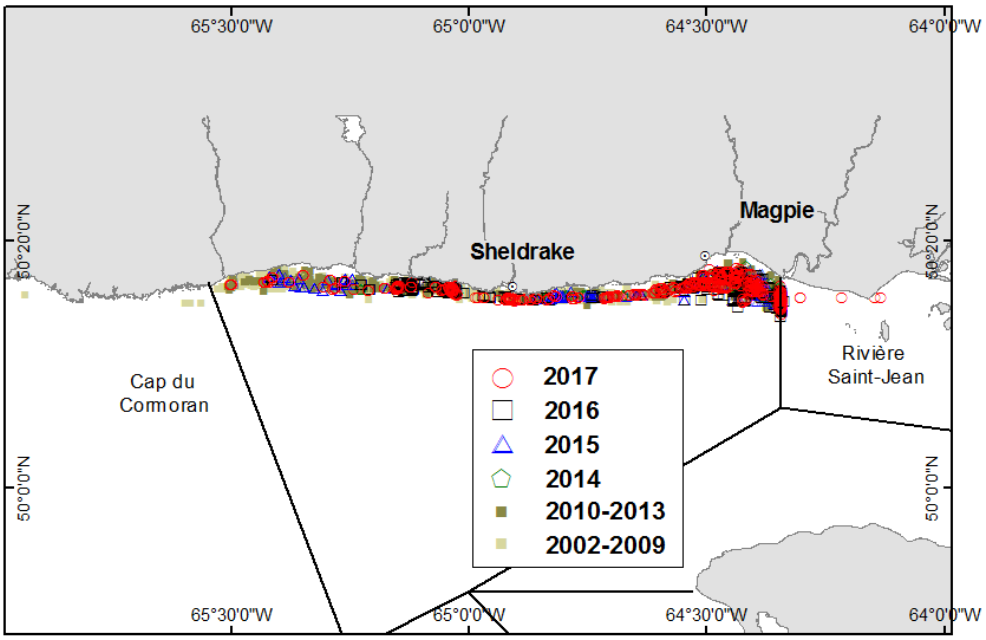

Figure 20. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 5.

Landings peaked at 493 t in 1999 (Figure 22 and Appendix 11). From 2003 to 2008, they decreased from 385 t to 146 t. Subsequently, landings ranged from 250 t to 409 t. Since 2014, landings are under 160 t. In 2017, landings in Area 5 accounted for 11% of all whelk landings in Québec.

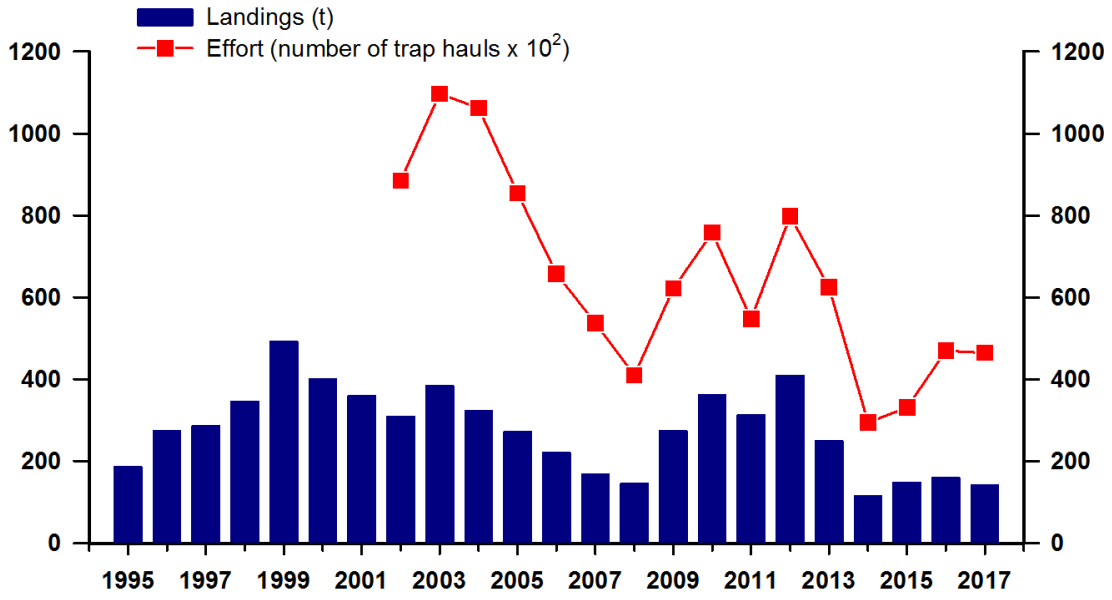

Figure 21. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 5.

Since 2002, changes in landings have been largely attributable to changes in fishing effort (Figure 21 and Appendix 12). Effort peaked in 2003 and 2004 with over 100,000 trap hauls and remained between 40,900 and 85,400 trap hauls until 2013. The lowest value was obtained in 2014 with 29,400 trap hauls, rising to 46,400 trap hauls in 2017.

From 2004 to 2008, CPUE were low, below 4 kg/trap, and then increased to 6.4 kg/trap in 2011 but since then, CPUE are decreasing (Figure 22 and Appendix 13). Average CPUE for 2017 was 3.3 kg/trap, the lowest value from the series.

The average size of landed whelk has been gradually increasing since 2007 (Figure 23 and Appendix 14). In 2014, it was 94 mm. The percentage of sub-legal size whelk in landings has remained below 5% since 2008 (Figure 23 and Appendix 15).

Fishing Area 6

The boundaries of Area 6 extend from Rivière Saint-Jean in the west to baie de la Grande Hermine in the east (Figure 24). Commercial fishing covers almost the entire area except the far eastern portion. In 2017, there were 11 active licences for 1,200 traps out of a total of 15 licences issued and 1,450 authorized traps (Appendix 10).

Between 2001 and 2008, landings ranged from 152 t to 282 t (Figure 25 and Appendix 11). Since 2009, landings ranged from 270 t to 366 t. In 2017, landings reached 307 t and accounted for 23% of total Québec landings.

The largest fishing effort occurred from 2003 to 2005, with over 89,100 trap hauls in 2004 (Figure 25 and Appendix 12). Subsequently, effort remained stable between 60,000 and 65,000 trap hauls annually. Over the past two years, effort has exceeded 70,000 trap hauls. Changes in landings are largely related to changes in fishing effort.

The lowest CPUE values were obtained for the period 2003 to 2008, including the minimum CPUE of 3.3 kg/trap in 2005 (Figure 26 and Appendix 13). Since 2011, CPUE values have remained around 5 kg/trap. In 2017, the CPUE was 4.7 kg/trap, a value similar to the 2001-2016 reference average.

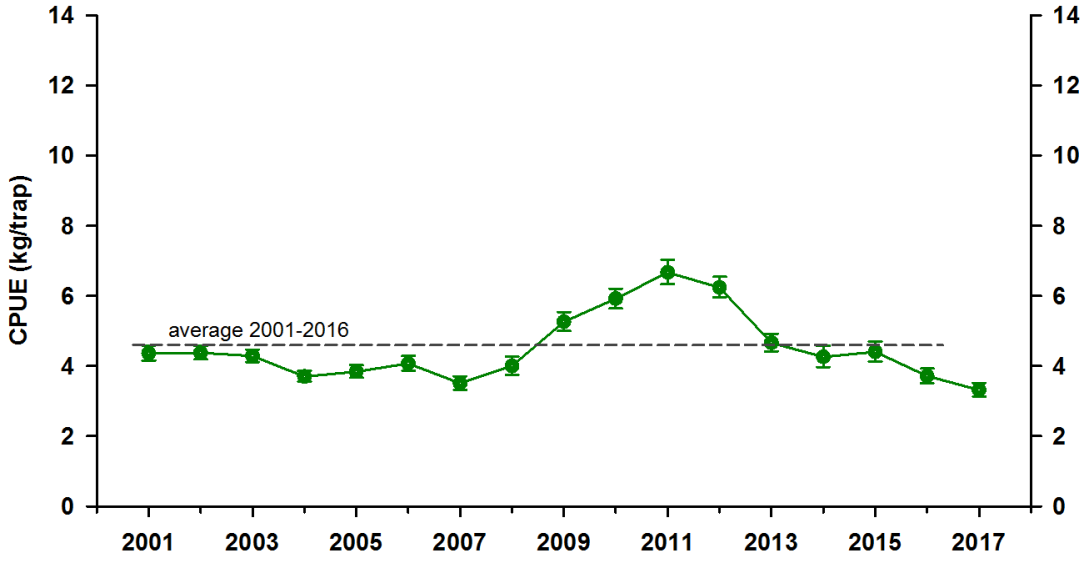

Figure 22. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 5.

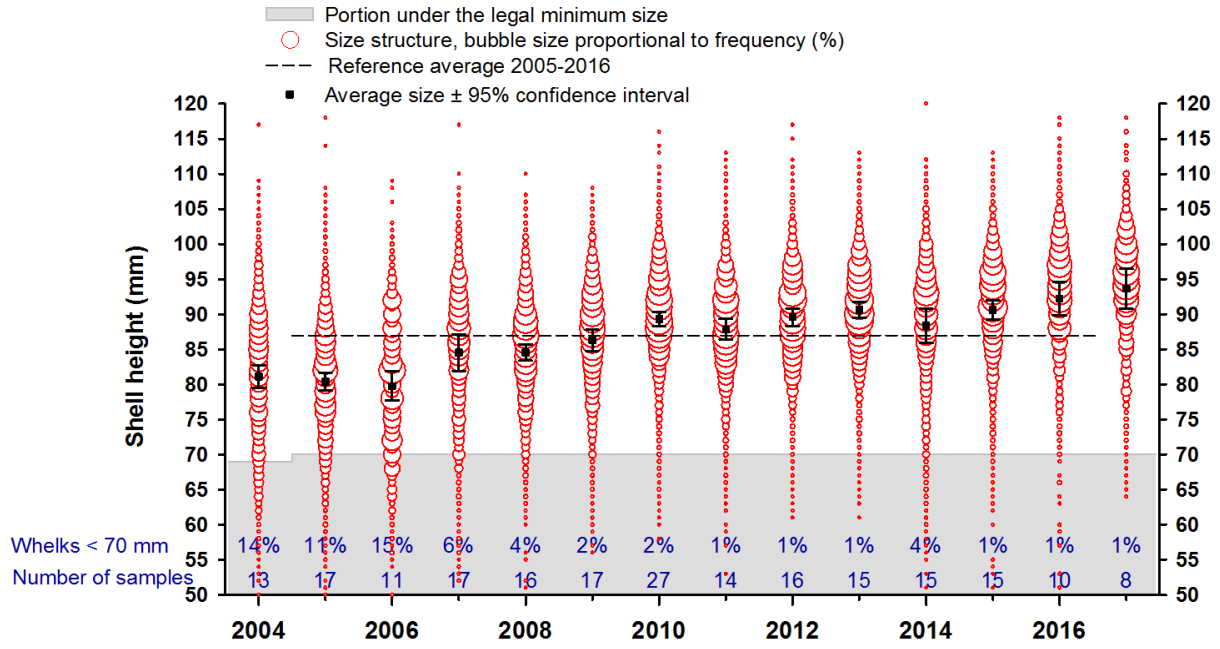

Figure 23. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 5.

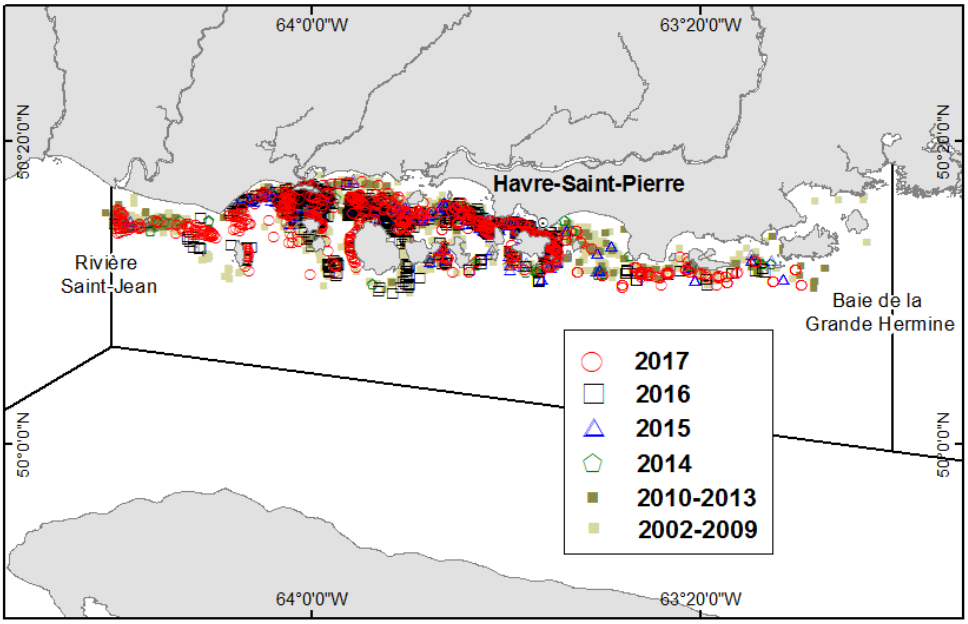

Figure 24. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 6.

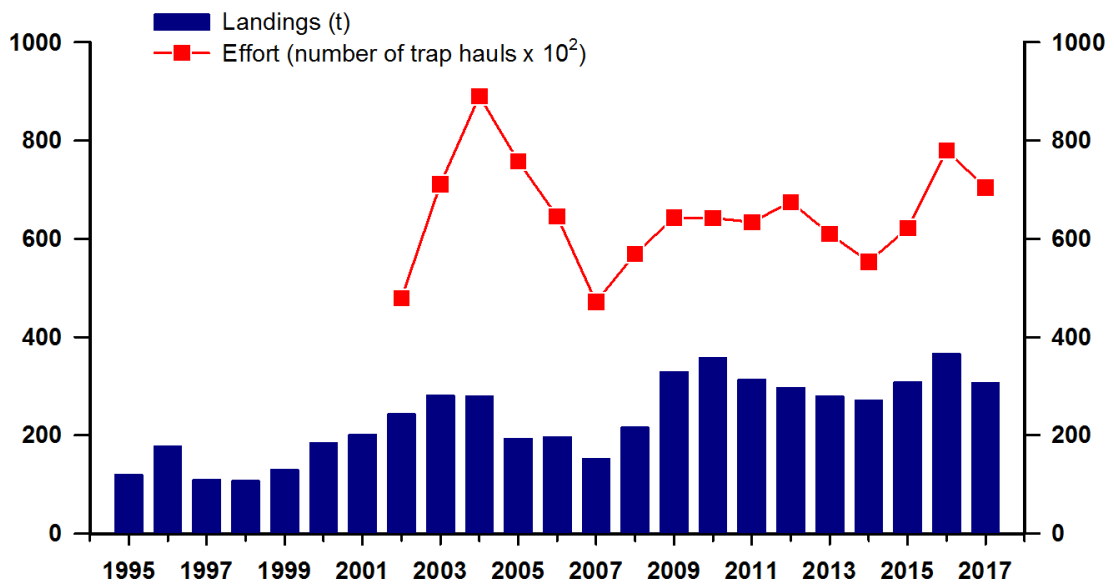

Figure 25. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 6.

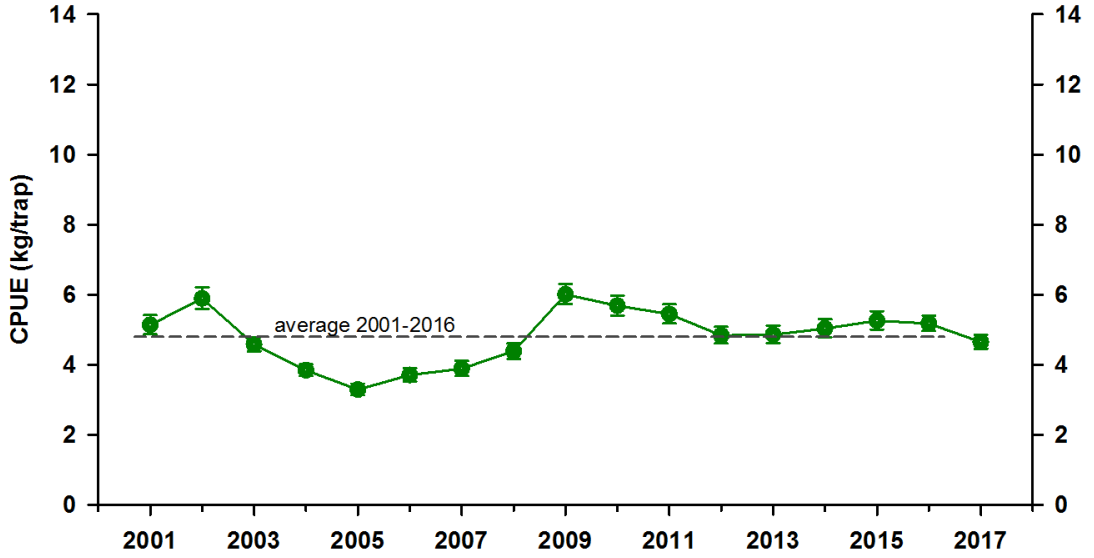

Figure 26. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 6.

Since 2010, the average annual size of landed whelk is around 88 mm, slightly above the 2005-2016 reference average (Figure 27 and Appendix 14). The percentage of sub-legal size whelks in landings has remained below 4% since 2010 except in 2016 with 6% (Figure 27 and Appendix 15). Since 2010, the size structures of landed whelk have been quite consistent.

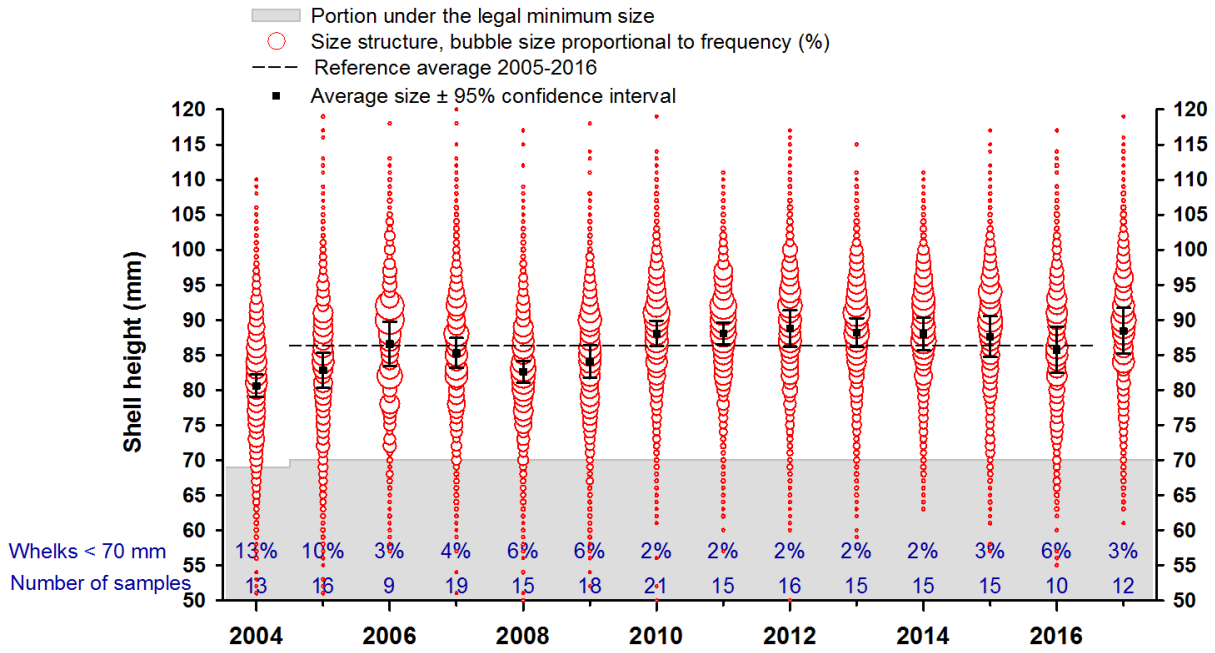

Figure 27. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 6.

Fishing Area 7

Fishing Area 7 extends from baie de la Grande Hermine to Rivière de l'Étang (Figure 28). However, the commercial fishery is conducted only near Natashquan. Since 2008, there have been two or three active licences. In 2017, there were 2 active licences for 300 traps out of a total of 6 licences issued and 600 authorized traps (Appendix 10).

Since 2010, landings have ranged from 22 to 76 t, with landings being related to fishing effort (Figure 29 and Appendices 11 and 12).

CPUE vary somewhat from year to year (Figure 30 and Appendix 13). Over the past two years, the annual CPUE was over the reference average 2001-2016, with values of 8.1 kg/trap in 2016 and 5.6 kg/trap in 2017.

Since 2014, the high variance in average size was attributable to the small number of samples (Figure 31 and Appendix 14). In 2017, the average size was 91 mm. Since 2011, the proportion of sub-legal size whelks in landings has been below 5% (Figure 31 and Appendix 15).

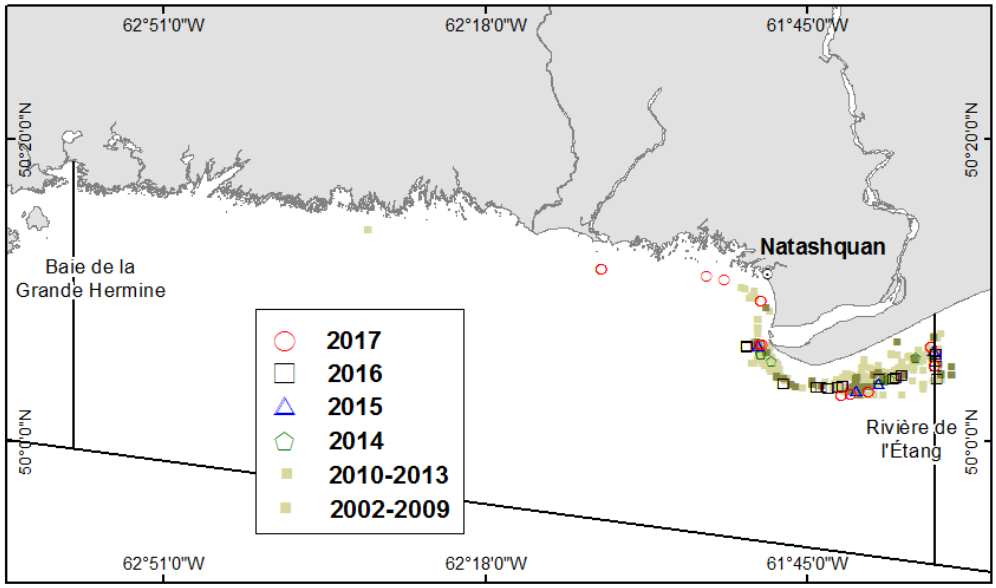

Figure 28. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 7.

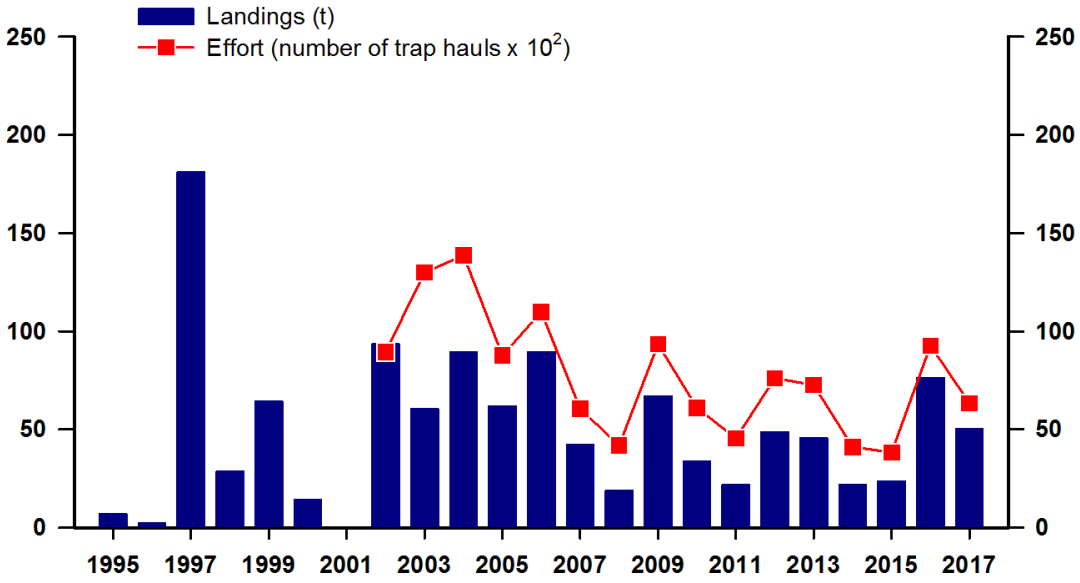

Figure 29. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 7.

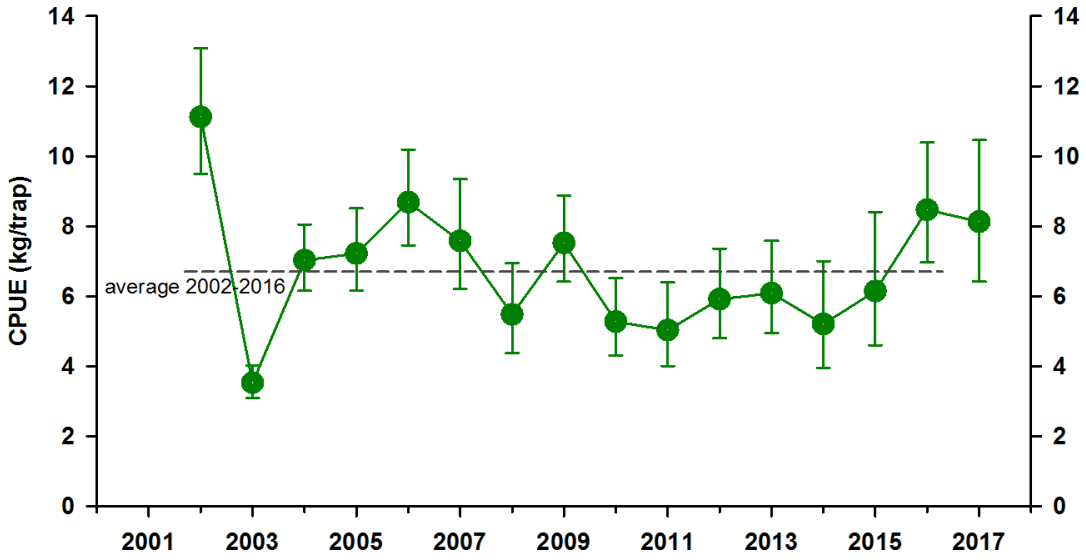

Figure 30. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 7.

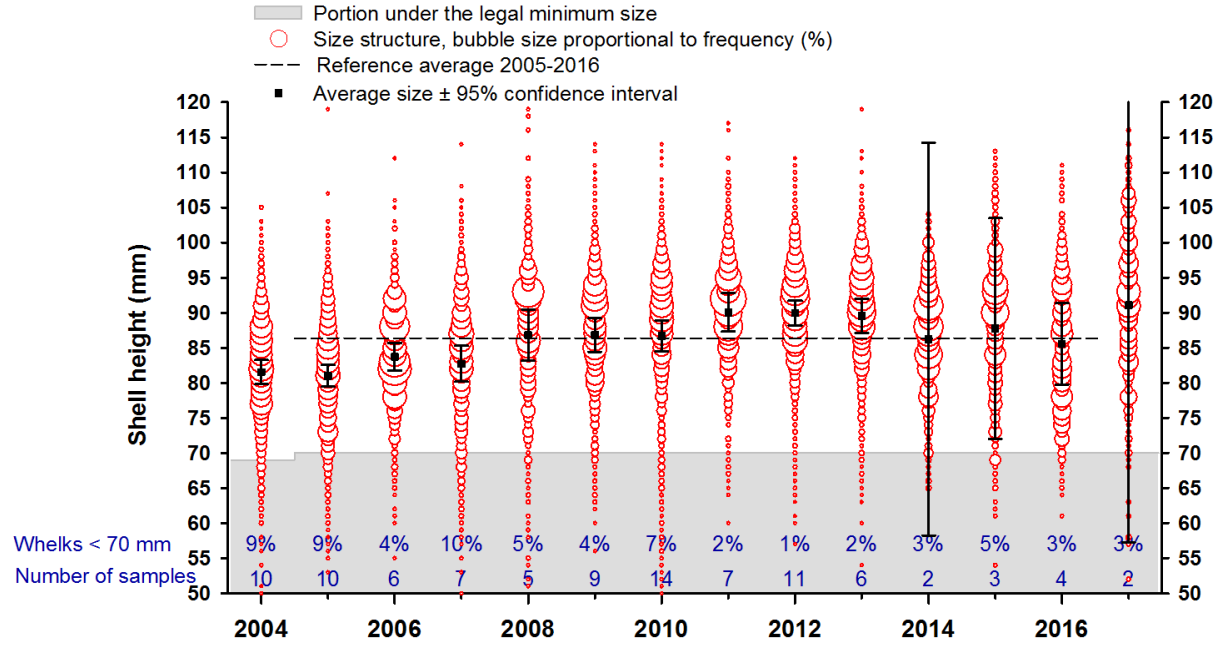

Figure 31. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 7.

Fishing Area 8

Fishing Area 8 is the largest fishing area in Québec, extending from Rivière de l'Étang to Blanc-Sablon (Figure 32). The commercial fishery is primarily concentrated in the Blanc-Sablon area. However, some fishing activities have been made in the western portion of the area in recent years. In 2017, there were 17 active licences for 1,700 traps out of a total of 64 licences issued and 6,400 authorized traps (Appendix 10).

Landings from Area 8 are highly variable from year to year and highly dependent on fishing effort (Figure 33 and Appendices 11 and 12). However, there has been a slight increase in effort since 2014 for stable landings. Maximum landings of just over 80 t were recorded in 1995, 1996 and 2003. Since 2011, landings were between 21 and 36 t. In 2017, landings were 30 t for a fishing effort of 10,200 trap hauls.

CPUE in this area fluctuate around the 2001–2016 4.1 kg/trap reference average (Figure 34 and Appendix 13). But since 2013, the CPUE is down to 3.4 kg/trap in 2016 and 2017. This value is the lowest in the series.

The average size of landed whelk was low in this area due to the high percentage of sub-legal size whelk in landings (Figure 35 and Appendices 14 and 15). The 2005–2016 reference average was 75 mm, only a few millimetres above the minimum legal size. However, the average size has increased since 2015, reaching 80 mm in 2017. From 2005 to 2014, the percentage of sub-legal size whelk in landings ranged from 19 to 40% (Figure 35 and Appendix 15). The situation has improved and a percentage of less than 10% has been observed in 2015, 2016 and 2017.

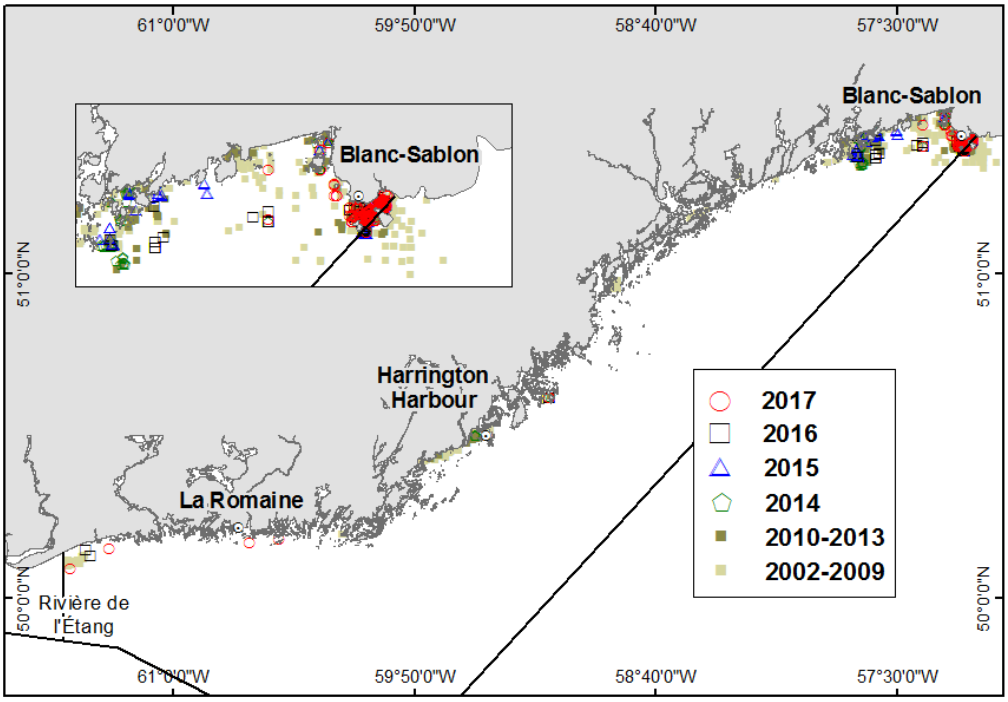

Figure 32. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 8.

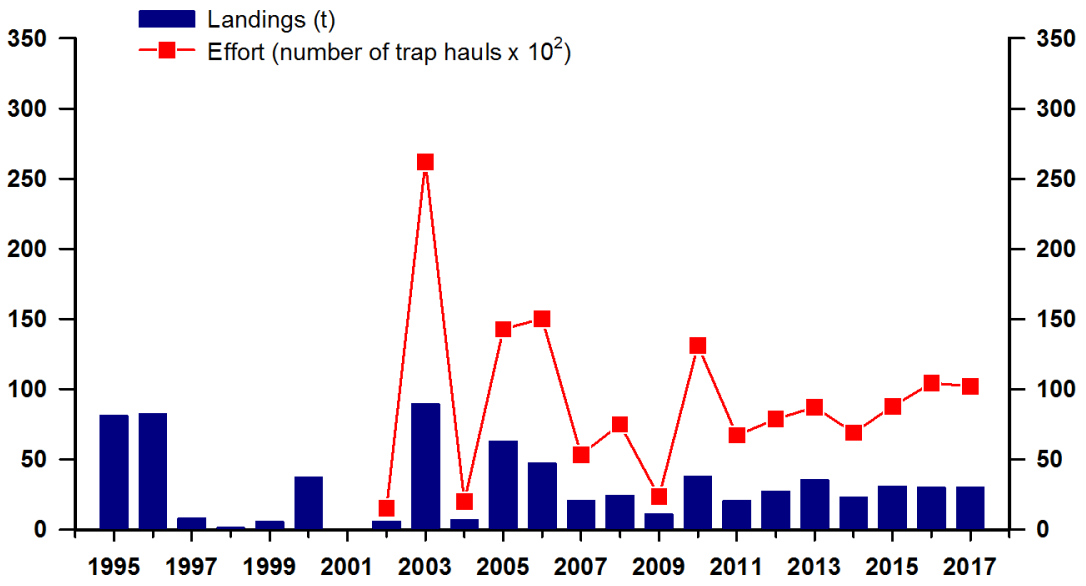

Figure 33. Whelk landings and fishing effort from 1995 to 2017 in Fishing Area 8.

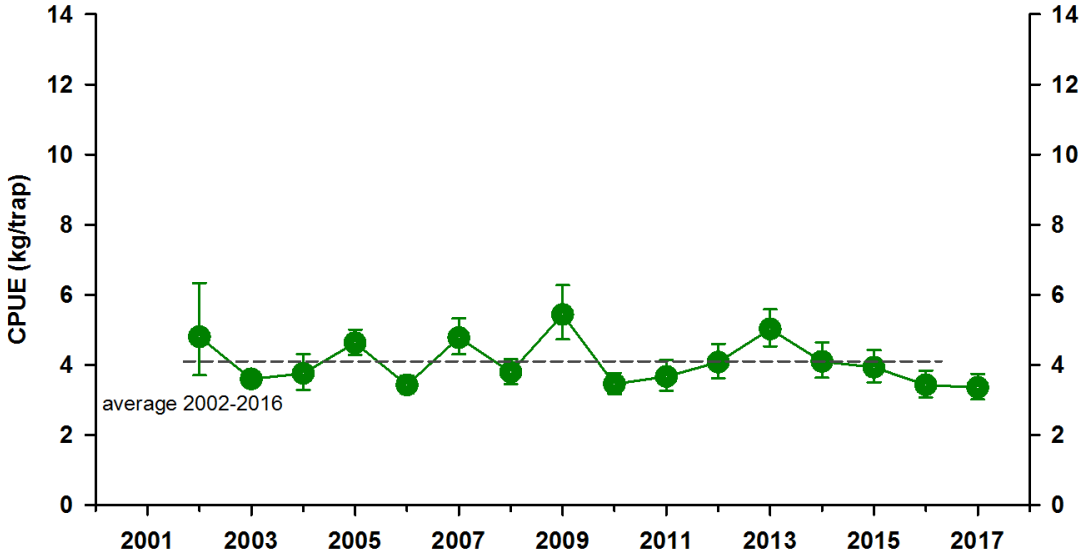

Figure 34. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 8.

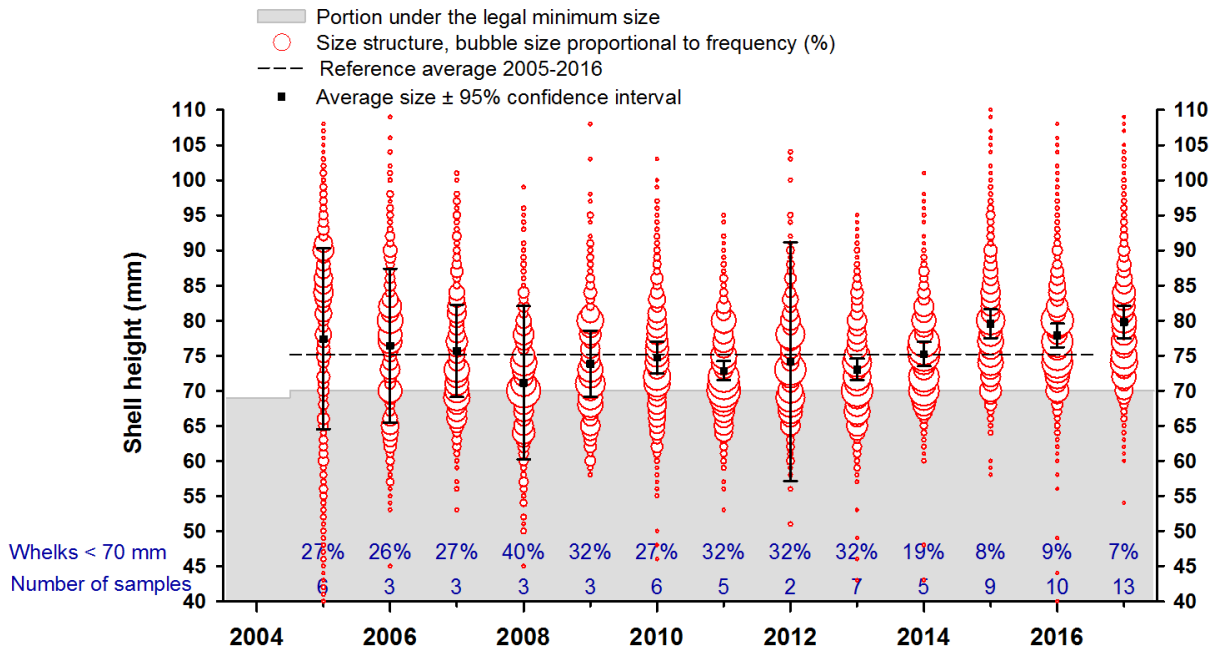

Figure 35. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2005 to 2017 in Fishing Area 8.

GASPÉ–LOWER ST. LAWRENCE

Fishing Area 12

Fishing Area 12 extends from Rivière Tartigou to Pointe de Chasse (Rivière-à-Claude) on the north shore of the Gaspé Peninsula (Figure 36). The commercial fishery covers most of the area. In 2017, there were 9 active licences for 1,000 traps out of a total of 34 licences issued and 2,875 authorized traps (Appendix 10).

From 2005 to 2011, landings remained stable between 84 t and 150 t (Figure 37 and Appendix 11). Landings peaked in 2006. A 128 t TAC was introduced in 2010 and slightly exceeded (129 t) the same year. It was raised to 135 t in 2012 and was decreased to 46 t in 2015 (Appendix 9). The TAC has been reached in the last three years.

Fishing effort reached the maximum value of 36,900 trap hauls in 2006 and then decreased until 2014 to 18,800 trap hauls (Figure 37 and Appendix 12). Following a decrease of the TAC in 2015, the effort was 14,400 trap hauls in 2015, 14,700 trap hauls in 2016 and 11,900 trap hauls in 2017.

A minimum CPUE of 2.5 kg/trap was observed in 2003 and 2014 (Figure 38 and Appendix 13). In 2015, there is an increase in CPUE that was close to the reference average of 3.7 kg/trap. The CPUE in 2017 was 4.4 kg/trap.

Since 2012, average sizes of landed whelk have been similar to or above the 2005–2016 88 mm reference average (Figure 39 and Appendix 14). The average size was 91 mm in 2017. Size structures have been very similar since 2012. The proportion of sub-legal size whelk has been less than 3% in landings since 2013 (Figure 39 and Appendix 15).

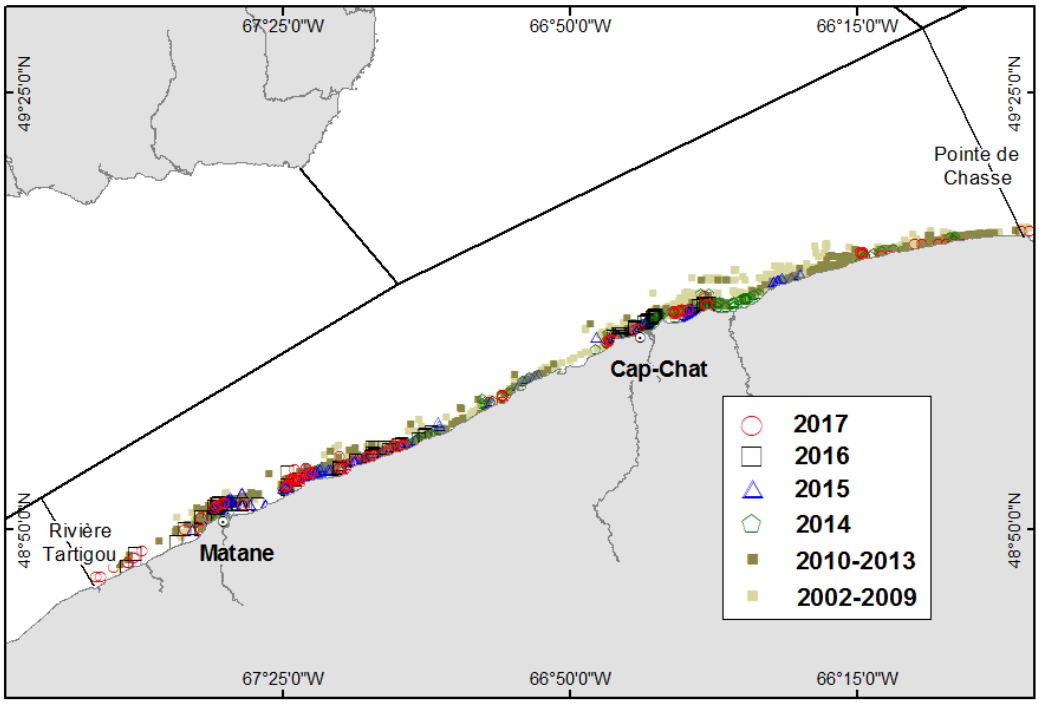

Figure 36. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 12.

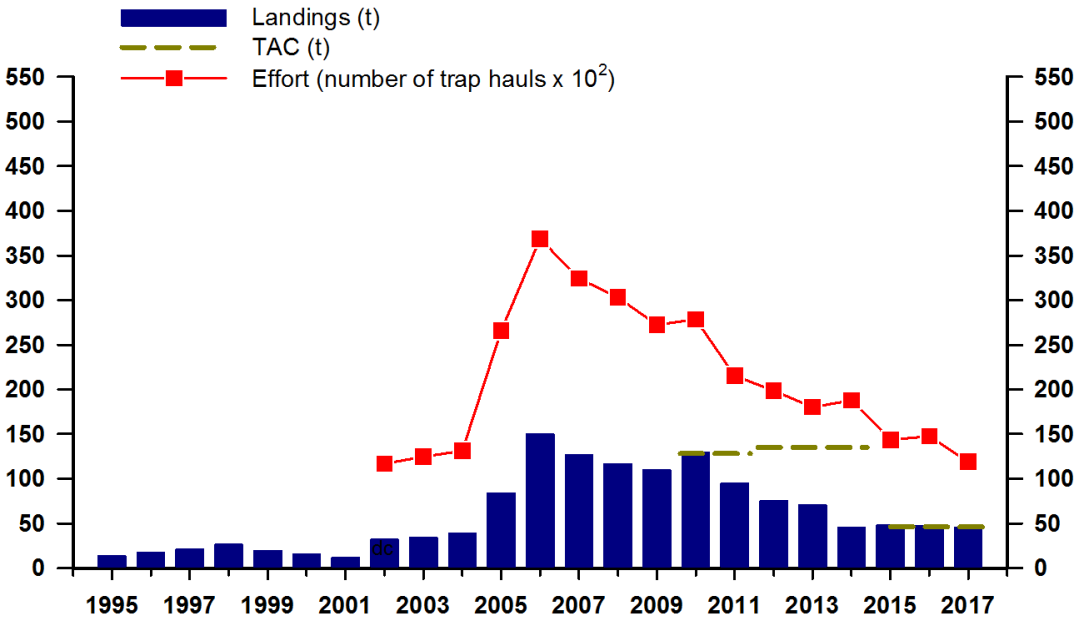

Figure 37. Whelk landings, total allowable catch (TAC) and fishing effort from 1995 to 2017 in Fishing Area 12.

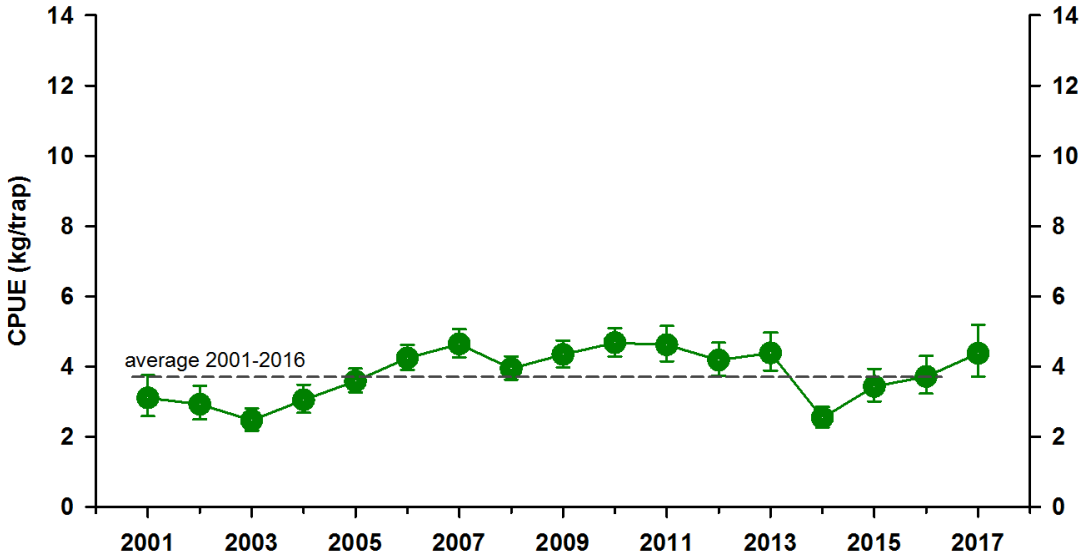

Figure 38. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 12.

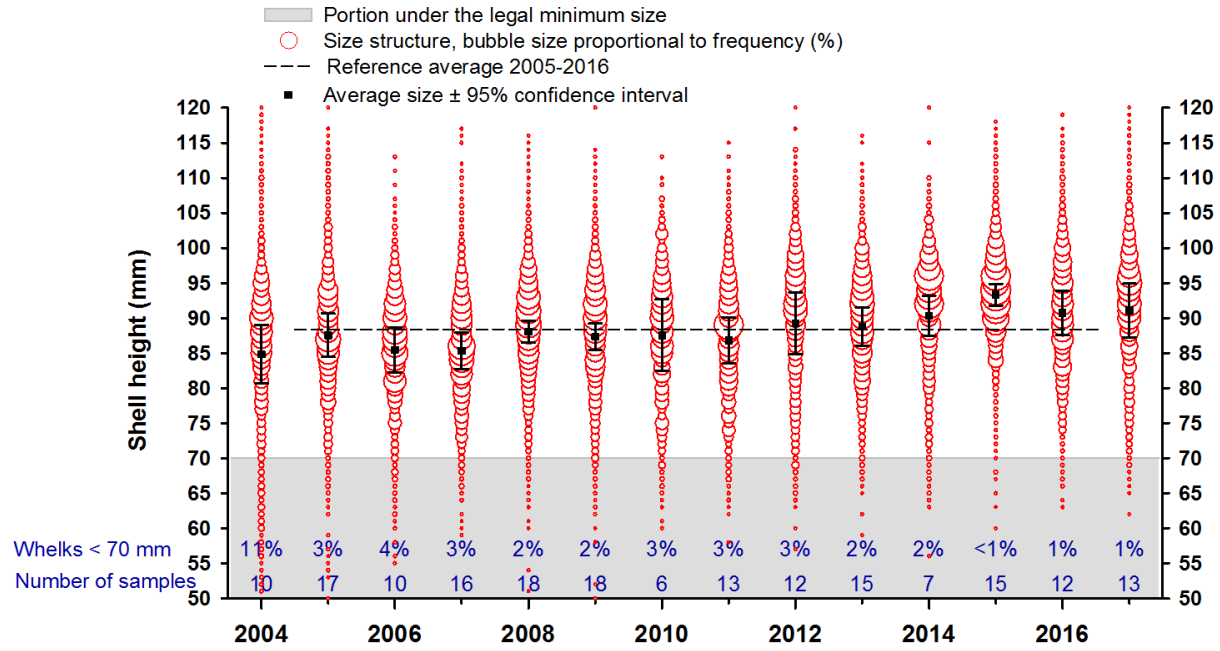

Figure 39. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2005 to 2017 in Fishing Area 12.

Fishing Area 13

The western boundary of Fishing Area 13 is the eastern point of Île d'Orléans, from this boundary to Pointe Rouge (Tadoussac), the Area covers both shores of the Estuary of St. Lawrence (Figures 2 and 5). It then extends from the southern side of the Estuary to Rivière Tartigou (Figure 40). The commercial fishery exclusively covers the eastern portion of the area, starting at the Bic archipelago (near Rimouski). In 2017, there were 4 active licences for 425 traps out of a total of 11 licences issued for 1,050 authorized traps (Appendix 10).

From 1995 to 2006, landings were less than 35 t (Figure 41 and Appendix 11). Later, there was an increase in landings with the discovery of new sites by fishermen. In 2010, the area was subdivided into 13a (eastern portion) and 13b (west of the Bic archipelago). An initial TAC was established for each of these subareas, 59 t in 13a and 50 t in 13b, to encourage fishermen to explore the western portion of the area (Appendix 9). In 2010, after the TAC was caught in 13a, some fishermen made trips to subarea 13b, but landings were disappointing, and the whelks were small. At the end of June 2010, an additional 41 t TAC was allocated for subarea 13a. In 2011, the two subareas were consolidated and a 73 t TAC was allocated to the eastern portion, with landings remaining unrestricted in the western portion of the area. In 2012, the TAC was increased to 82 t and subareas were eliminated. In 2016 the TAC was reached and landings were 59 t in 2017.

Fishing effort has ranged from 8,500 to 12,400 trap hauls since 2007 (Figure 41 and Appendix 12). The fishing effort reached a peak of 12,700 trap hauls in 2016. Landings generally follow changes in fishing effort.

From 2001 to 2005, CPUE values were the lowest in the series, around 4 kg/trap (Figure 42 and Appendix 13). Subsequently, CPUE gradually increased to 8.3 and 8.8 kg/trap in 2010 and 2011, well above the 2001–2016 reference average. From 2012 to 2014, CPUE were above average, but in 2015 and 2016, CPUE was around the reference average with values between 5.4 and 5.8 kg/trap. The 2017 CPUE, however, was higher at 6.7 kg/trap.

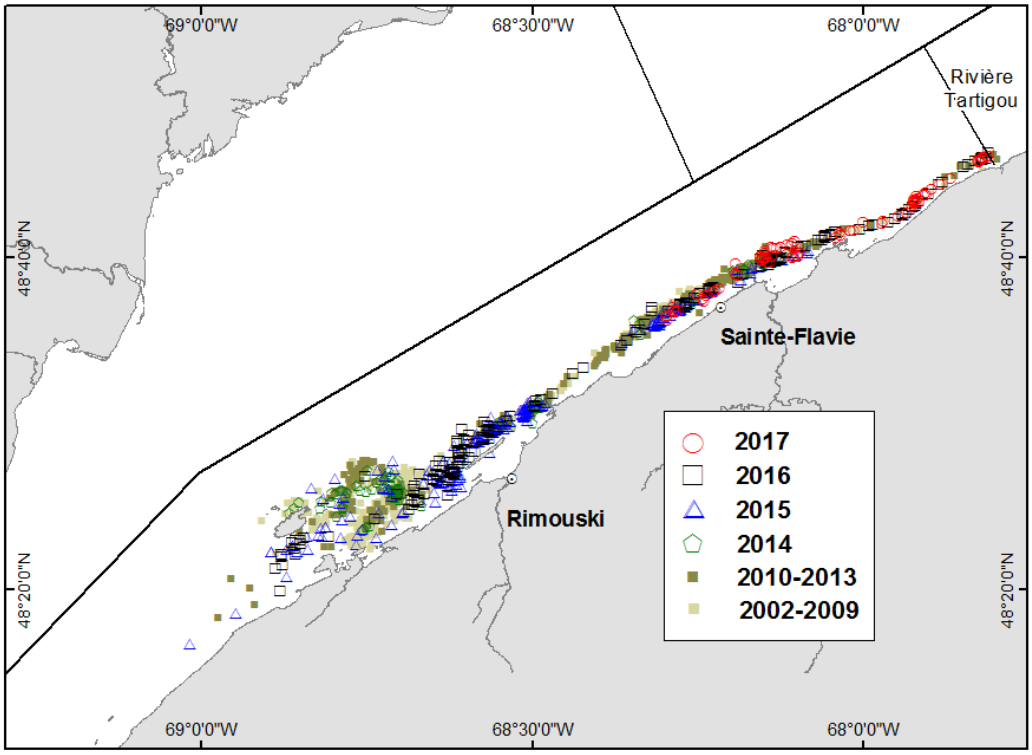

Figure 40. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 13.

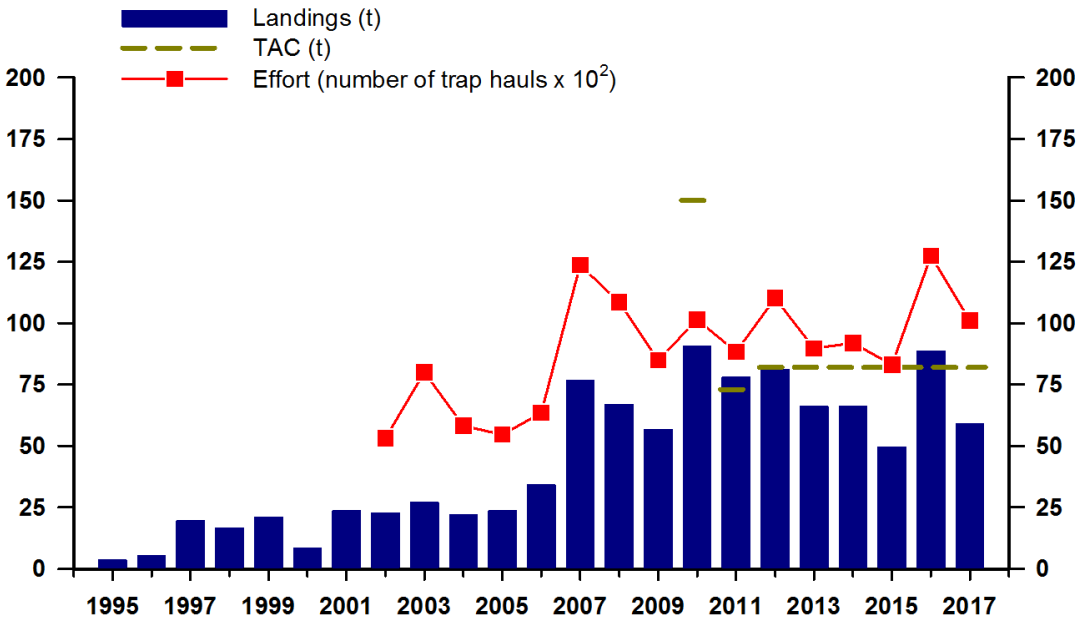

Figure 41. Whelk landings, total allowable catch (TAC) and fishing effort from 1995 to 2017 in Fishing Area 13.

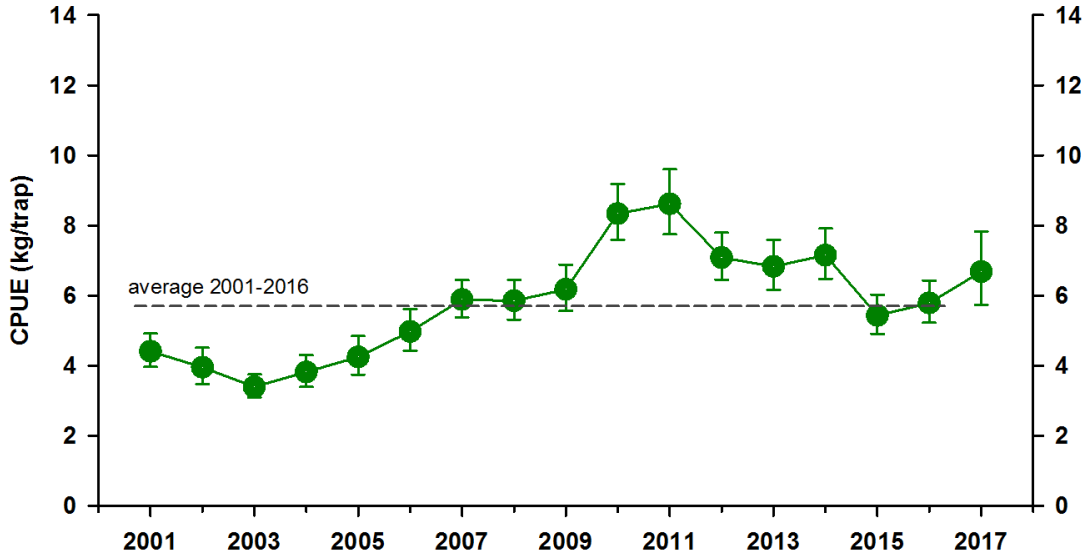

Figure 42. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2001 to 2017 in Fishing Area 13.

The average size of landed whelk increased from 70 mm in 2004 to 87 mm in 2007, possibly as a result of the exploitation of new sites (Figure 43 and Appendix 14). Since then, average size has ranged from 83 mm to 89 mm with values similar to or above the 2005–2016 reference average. Size structures have been similar in recent years. The proportion of sub-legal size whelk in landings has been below 2% since 2010 (Figure 43 and Appendix 15).

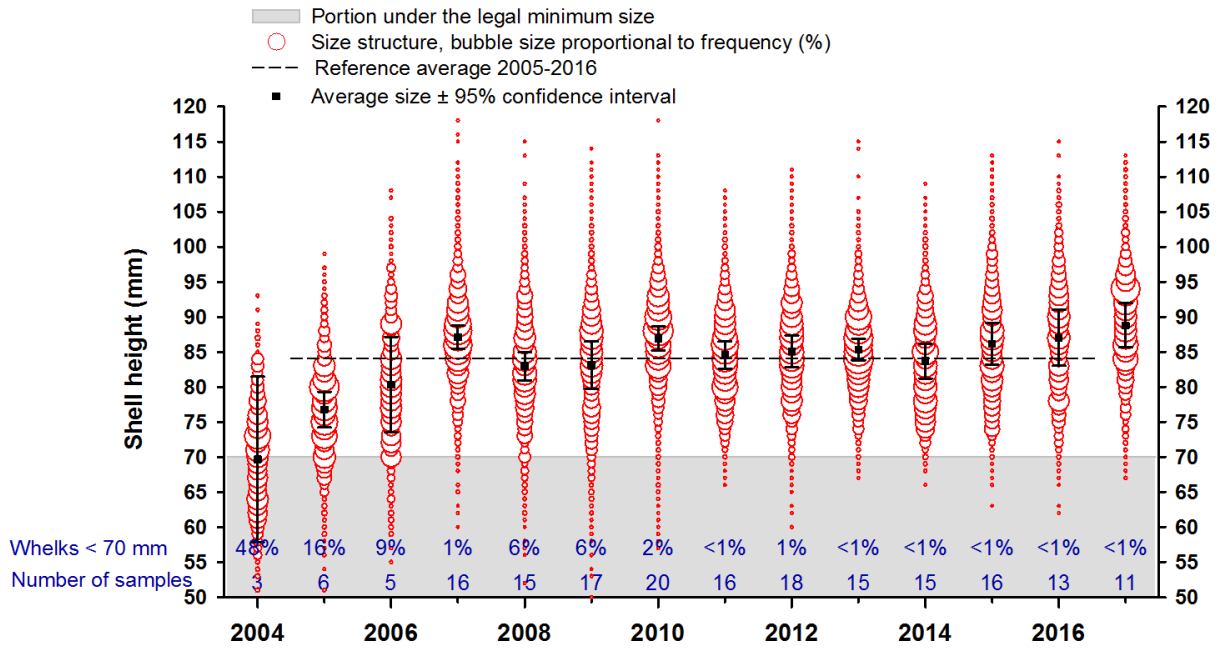

Figure 43. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 13.

ÎLES-DE-LA-MADELEINE

Fishing Area 15

Fishing Area 15 covers the entire coastal area around the Îles-de-la-Madeleine (Figure 44). Commercial fishing gained momentum in 2003. Every year, fishermen travel extensively in search of good fishing areas. In 2008, the area was slightly enlarged to the south, which explains why few trips were made outside Area 15. In 2009, the area boundaries were brought back to their original location. In 2017, there were 9 active licences for 900 traps out of a total of 11 licences issued and 1,100 authorized traps (Appendix 10). A management measure was added in 2011, allowing fishermen to use 150 traps each, provided they restrict their fishing season to between August and November, but few fishermen have used this clause to date.

In 2004, the area was divided into two subareas, with subarea 15a covering the portion that was already being exploited (southern portion), and a 400 t TAC was allocated to this subarea (Appendix 9). The Area was subdivided to better distribute the fishing effort around the Islands. In 2006, because this measure had been successful and at the fishermen's request, the two subareas were regrouped, and a 450 t TAC was allocated to Area 15 as a whole. The TAC was reduced to 376 t in 2012. The Area 15 TAC is divided equally among the 11 licence holders, which may explain why the TAC has not been reached since 2006.

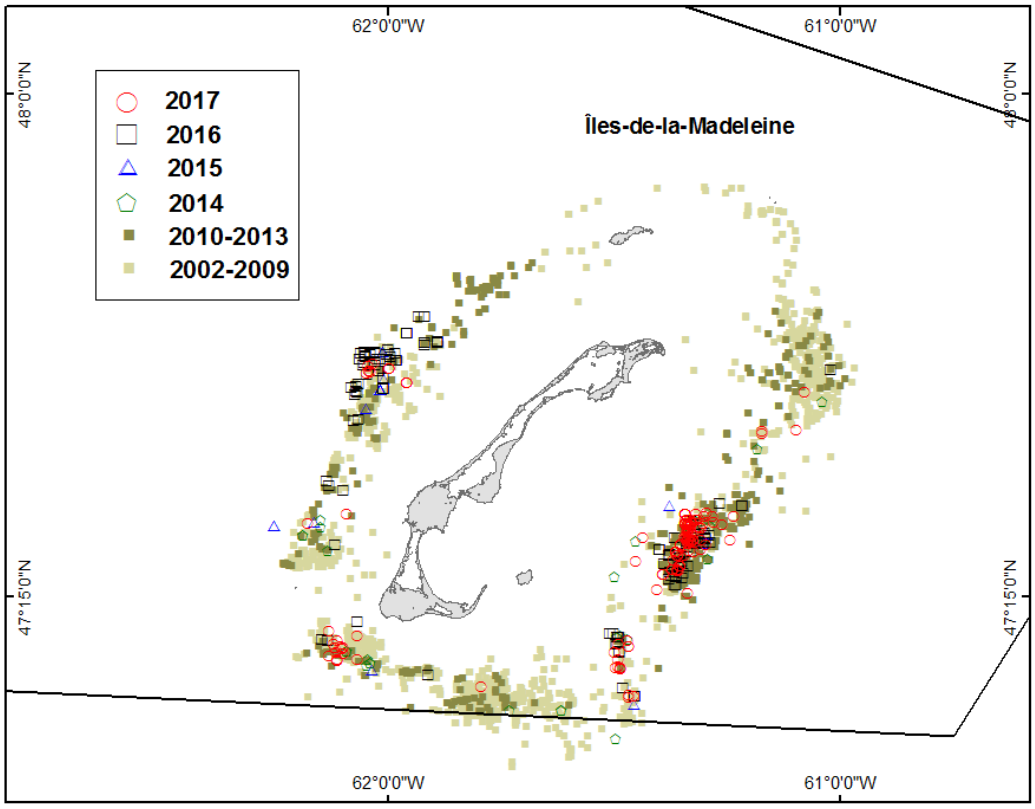

Figure 44. Distribution of commercial whelk fishing effort from 2002 to 2017 in Fishing Area 15.

From 2003 to 2008, landings ranged from 352 t to 442 t (Figure 45 and Appendix 11). In 2009, only two licences were active because of the low price offered by processing plants. From 2010 to 2013, landings increased from 150 t to 327 t. In 2014 and 2015, whelks were very scarce and only a few fishermen were active generating landings of 15 and 11 t respectively. There was some recovery in the commercial fishery in 2016, landings were 111 t in 2016 and 204 t in 2017.

From 2003 to 2008, fishing effort changed little from 15,500 to 19,200 trap hauls (Figure 45 and Appendix 12). Since then, the effort has been more variable and is primarily related to the number of active fishermen. In 2016 and 2017, fishing effort was 8,700 and 9,300 trap hauls.

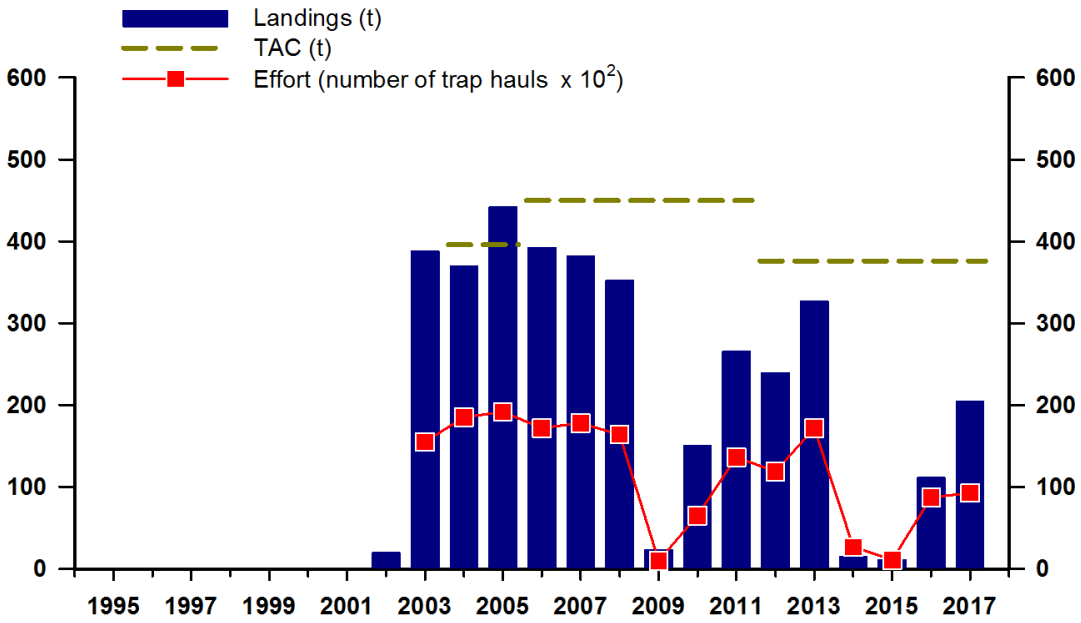

Figure 45. Whelk landings, total allowable catch (TAC) and fishing effort from 2002 to 2017 in Fishing Area 15.

From 2003 to 2013, CPUE in this area were the highest in Québec (Appendix 13). They generally ranged around 20 kg/trap (Figure 46). From 2011 to 2013, there was a slight decrease in CPUE with values around 18 kg/trap, below the reference average. In 2014, the average CPUE was only 4.7 kg/trap, by far the lowest value in the series. In 2015, there were few active fishermen, hence the lack of a standardized CPUE value. In 2016, CPUE was higher than in 2014, but remained low for this area. In 2017, CPUE was 17.3 kg/trap, a value similar to those from 2011 to 2013.

The 2013 CPUE did not foreshadow such a sharp decline in CPUE in 2014 (Figure 46). Environmental conditions in the Îles-de-la-Madeleine during the 2014 season, such as abnormally cold temperatures at fishing sites from April to August (Galbraith et al. 2015), could be responsible for the low yields. However, CPUE remained low in 2015. There was some increase in 2017, but not in the whole area (Figure 47 and Appendix 16). CPUE remained low in the southern part of the Islands, which explains why the fishery occurred mainly in the west and east of the Islands in 2016 and 2017 (Figure 44).

Since 2008, the average size of landed whelk has exceeded 81 mm (Figure 48 and Appendix 14). Size structures have changed little since 2008 except in 2014 and 2015 possibly due to lack of samples. The percentage of sub-legal whelk in landings has been below 3% since 2008 except in 2013 where it was 7% (Figure 48 and Appendix 15).

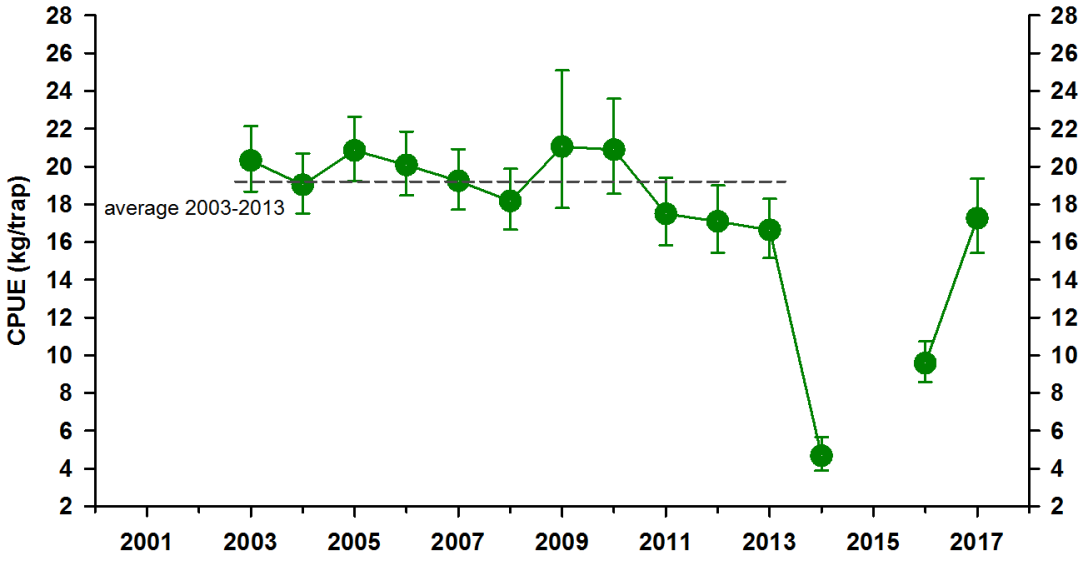

Figure 46. Annual average of standardized catch per unit effort (CPUE ± 95% confidence interval) and reference average in the commercial whelk fishery from 2003 to 2017 in Fishing Area 15.

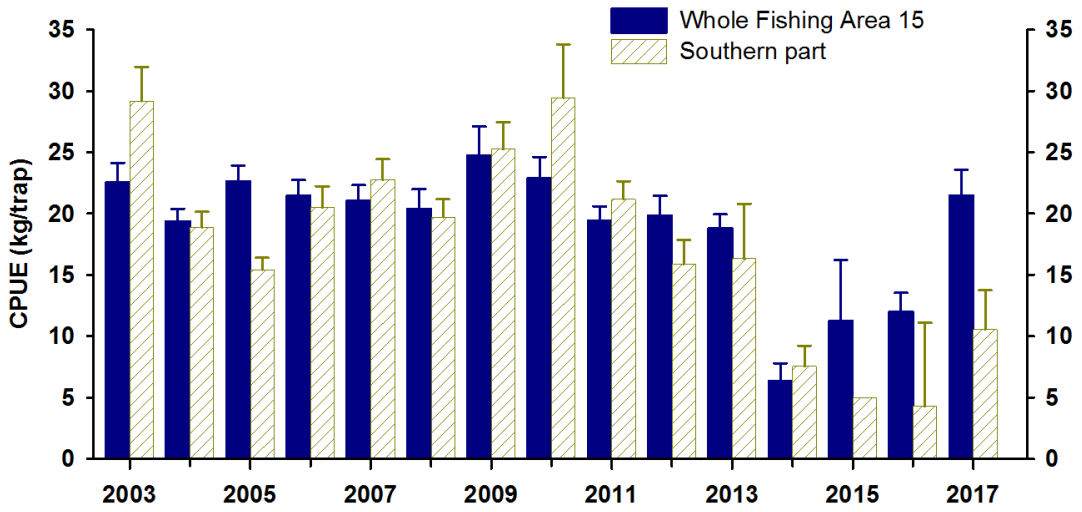

Figure 47. Annual average of not standardized catch per unit effort (CPUE ± 95% confidence interval) on the southern part and on the whole Fishing Area 15 from 2003 to 2017.

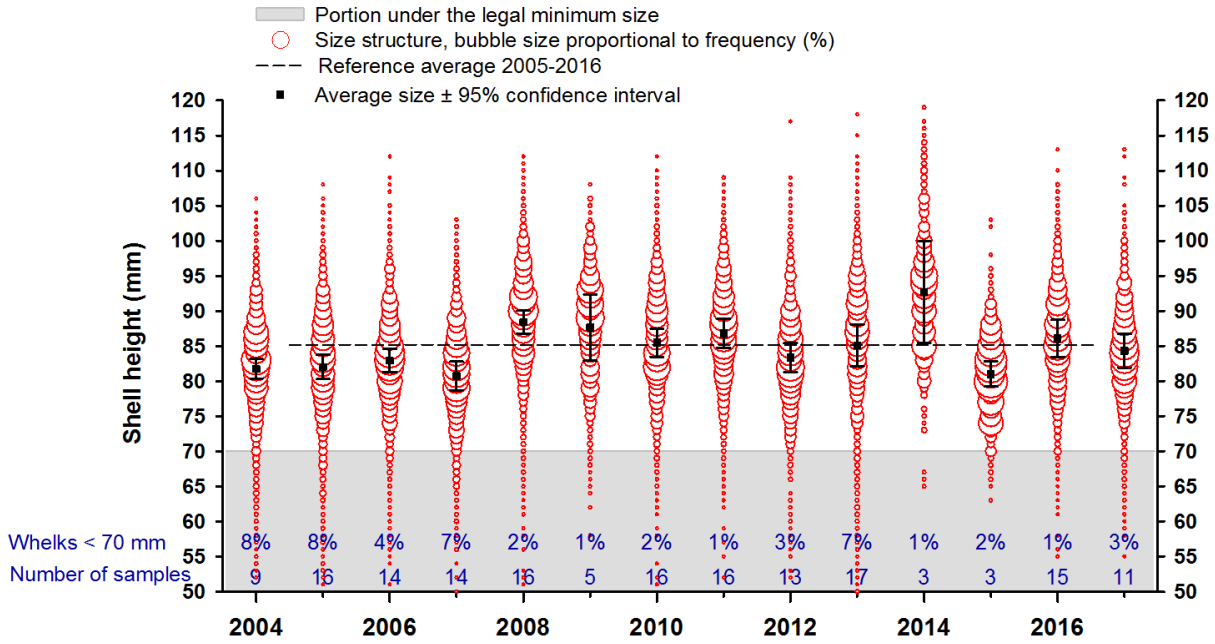

Figure 48. Size structure, average size, reference average, percentage of sub-legal size whelk and number of samples harvested per year of whelks landed during commercial fishing from 2004 to 2017 in Fishing Area 15.

RESEARCH

GROWTH IN TANKS

Based on results obtained in tanks from 2015 to 2018, annual growth (height) was approximately 8 mm in the first year, and 4 mm in the second year (Figure 49). There is considerable variability among individuals, however, with sizes ranging from 6.8 mm to 24.8 mm after two years of growth. Another tank-based study, carried out between 2000 and 2003, showed that growth varied according to the initial size of the individuals (Brulotte 2012). The results of a tagging-recapture study conducted in Fishing Area 1 in 2001-2002 showed the following increases after one year: 9 mm in whelks initially 45 to 54 mm; 4 to 6 mm in whelks initially 55 to 69 mm; and 1 to 2 mm in whelks ≥ 70 mm.

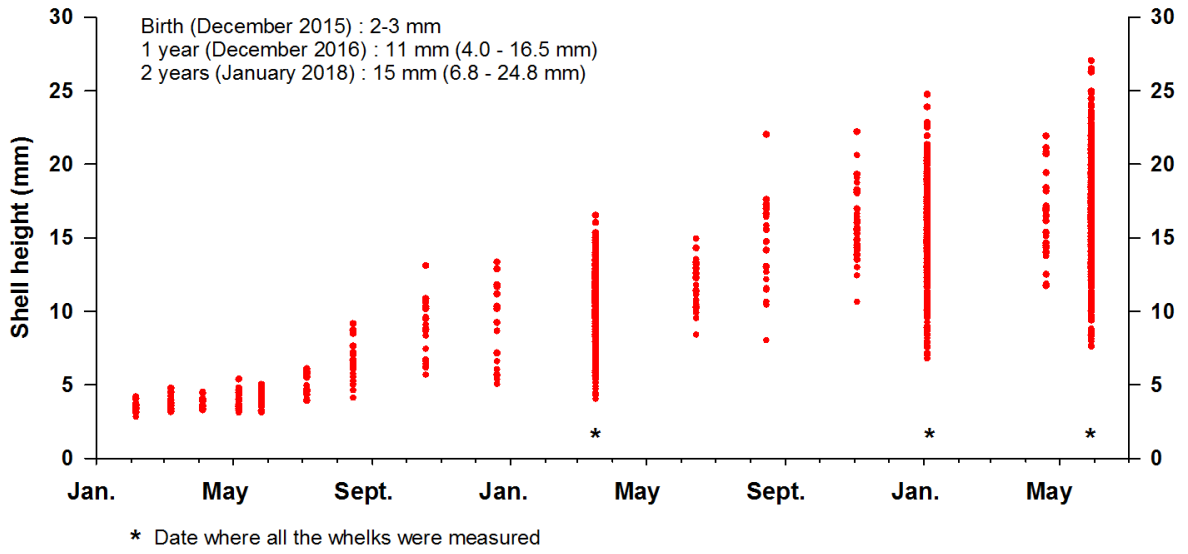

Figure 49. Shell height of Buccinum undatum *kept in tanks from hatching.*

HAUTE-CÔTE-NORD SURVEY

The average relative densities of whelks by size class, site, and year are presented in Table 1, along with the results of the density comparison test. Densities and yields of whelks and egg masses per station from the 2015 survey are found in Appendices 17 and 18, and those from the 2017 survey are found in Appendices 19 and 20. Maps of whelk densities calculated from 2005 to 2017 are provided in Figure 50 for Forestville, in Figure 51 for Pointe-aux-Outardes, and in Figure 52 for Baie-Comeau. In general, average total densities (whelks ≥ 20 mm) were of the same order of magnitude in Forestville and Pointe-aux-Outardes (3 to 16 whelks/100 m^2 per station) and higher in Baie-Comeau (16 to 59 whelks/100 m^2).

In Forestville, total densities differed significantly between years (Chi^2 = 130.75 and P < 0.0001); they were higher in 2013, 2015, and 2017, and lower in 2005, 2007, and 2009 (Table 1). In Pointe-aux-Outardes, total densities also differed between years (Chi^2 = 24.83 and P = 0.0004); densities were significantly higher in 2011 than in 2005, 2007, and 2009. However, in Baie-Comeau (Chi^2 = 9.002 and P = 0.1735) there was no difference between years (Table 1).

For whelks of legal size (≥ 70 mm), the year of the survey was a significant factor in relation to the densities at Forestville (Chi^2 = 188.925 and P < 0.0001), at Pointe-aux-Outardes (Chi^2 = 39.273 and P < 0.0001) and at Baie-Comeau (Chi^2 = 21.532 and P = 0.0015). Densities for 2017 were higher at all sites (Table 1).

For whelks of sub-legal size (20 to 69 mm), the densities differed significantly between years at Forestville (Chi^2 = 102.466 and P < 0.0001) and at Pointe-aux-Outardes (Chi^2 = 19.537 and P = 0.0033) but not at Baie-Comeau (Chi^2 = 12.089 and P = 0.0600). At Forestville, the densities were significantly higher in 2011, 2013, and 2015 than in other years (Table 1). At Pointe-aux-Outardes, the densities obtained in 2011 were significantly higher than those of other years. Densities observed in 2017 were about average in all sites.

Average whelk yields according to the size class and egg mass values recorded during the various research surveys are presented in Table 2. As in the case for densities, yields in were much higher Baie-Comeau than in the other two sites, and average yields sometimes exceeded 1,000 g/100 m^2. At Forestville and Pointe-aux-Outardes, average yields ranged from 200 to 500 g/100 m^2.

Egg masses were much more abundant in the Pointe-aux-Outardes and Baie-Comeau sites, with average densities ranging from 0.6 to 4.2 masses/100 m^2, compared to Forestville where average densities ranged from 0.01 to 0.04 mass/100 m^2 (Table 1).

However, the average weight of the egg masses varied considerably interannually for each site as well as between the sites, with values ranging from 51 to 222 g/egg mass (Table 2).

At Forestville, the size structure of the legal-size whelk population changed little between years, with a maximum size of around 100 mm (Figure 53). However, the proportion of sub-legal size whelks was much more variable. Whelks measuring 40–69 mm were abundant in 2011, 2013, and 2015. In 2017, a good portion of these whelks reached the legal size. The same pattern is observed for age structure, with modes corresponding to age 3 and 4 from 2011 to 2015, and a mode at age 7 in 2017 (Figure 53).

At Pointe-aux-Outardes, size structure is more variable between years (Figure 54). Young whelks were abundant in 2011, but much less so for the other years of the survey. Size structure was similar in 2015 and 2017. Maximum sizes exceed 105 mm. The age structures of the last three surveys are similar with a mode at age 7 (Figure 54).

At Baie-Comeau, size structures are similar for the last three surveys, with whelks measuring 60–75 mm being the most abundant (Figure 55). However, the median size increased between 2013 and 2017. Whelks smaller than 60 mm increased in abundance in the surveys between 2005 and 2011. The maximum size rarely exceeds 98 mm. Age structure differed between the years, but the mode was generally 7 years (Figure 55).

Growth curves calculated for Area 1 (grouping of FOR and PAO sectors) and Area 2 are very similar (Figure 56). The maximum size is 127 mm in both areas. The minimum legal size should be reached at about 6 years.

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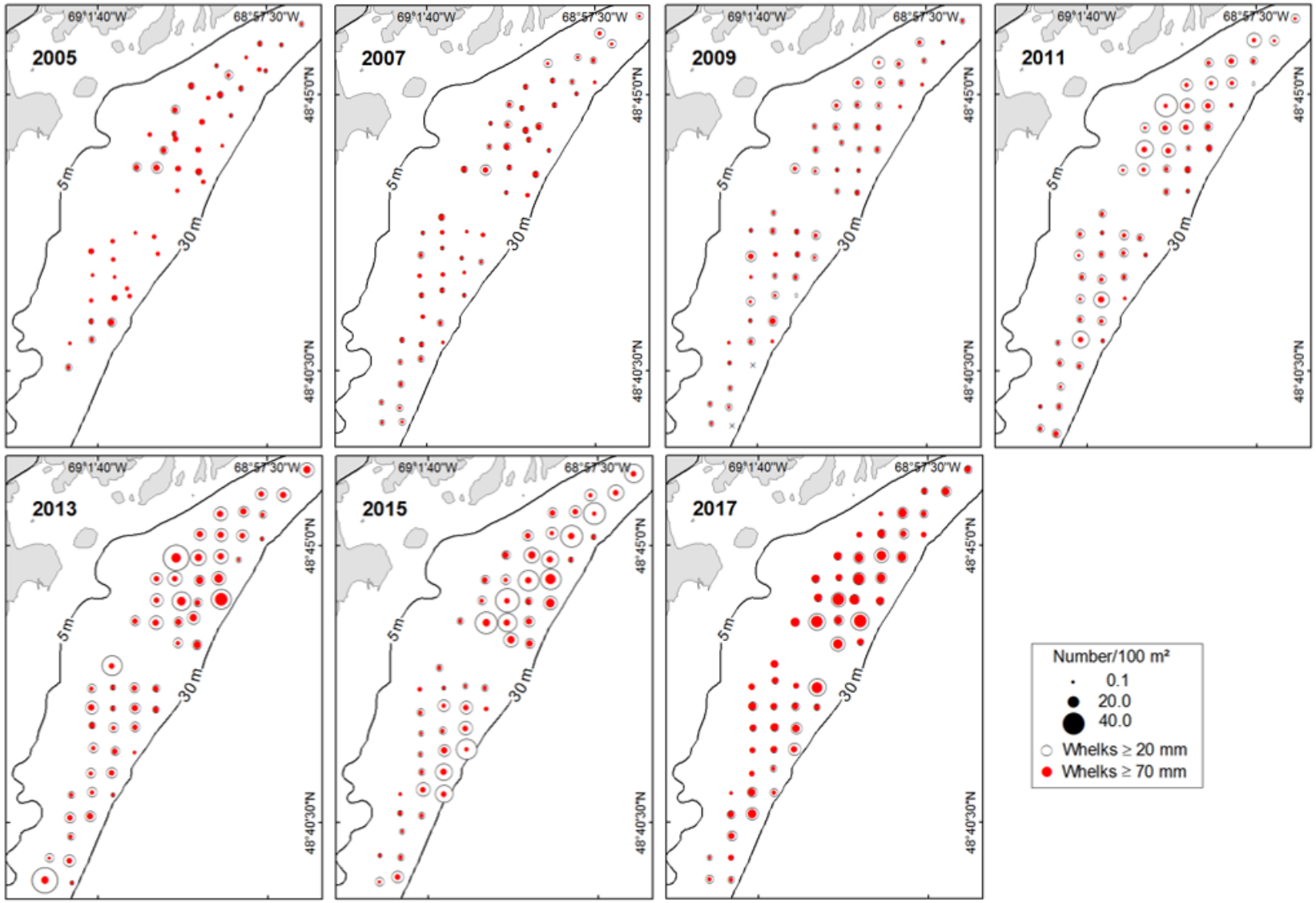

Figure 50. Density (number/100 m^2) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Forestville from 2005 to 2017.

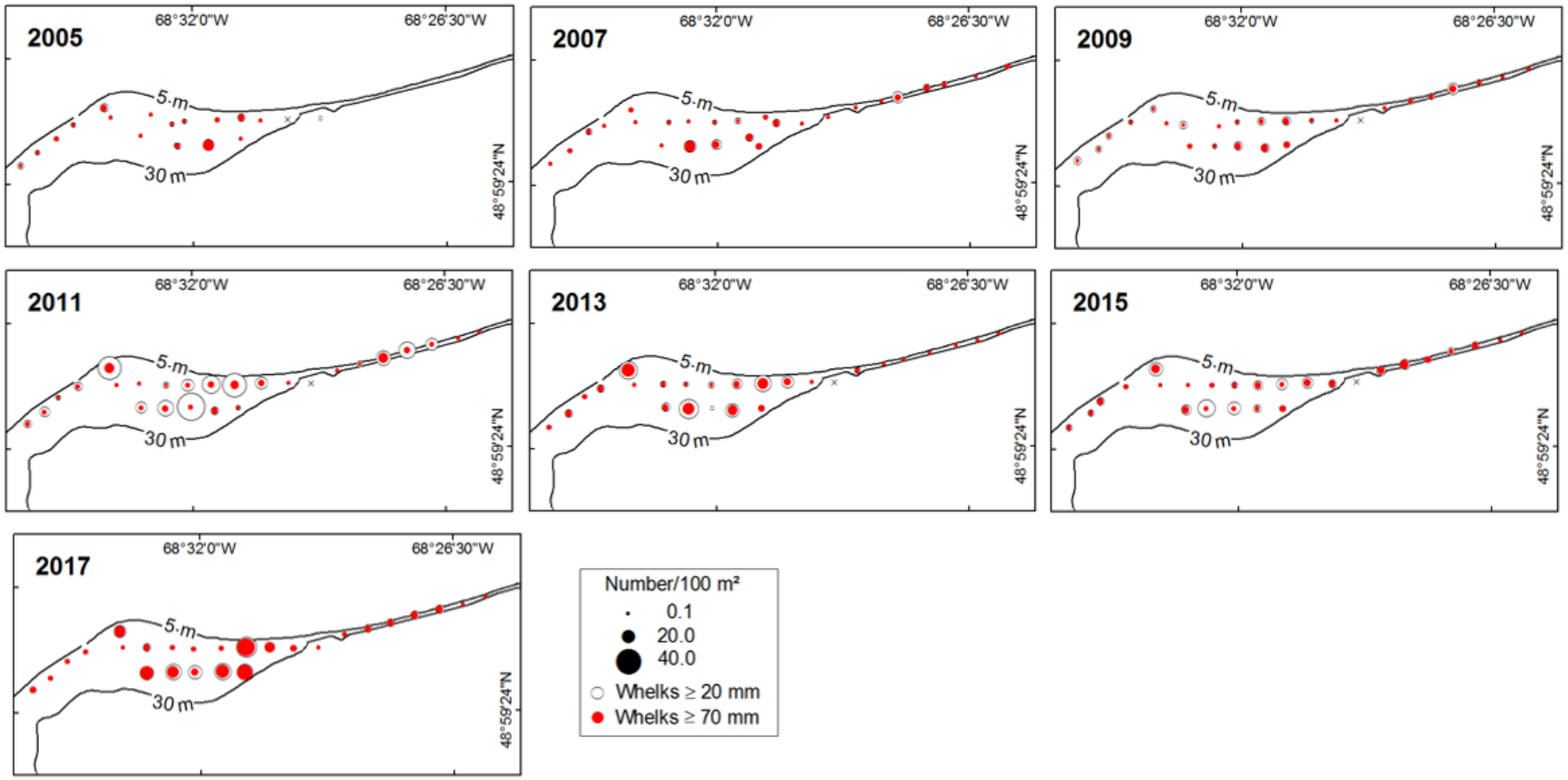

Figure 51. Density (number/100 m²) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Pointe-aux-Outardes from 2005 to 2017.

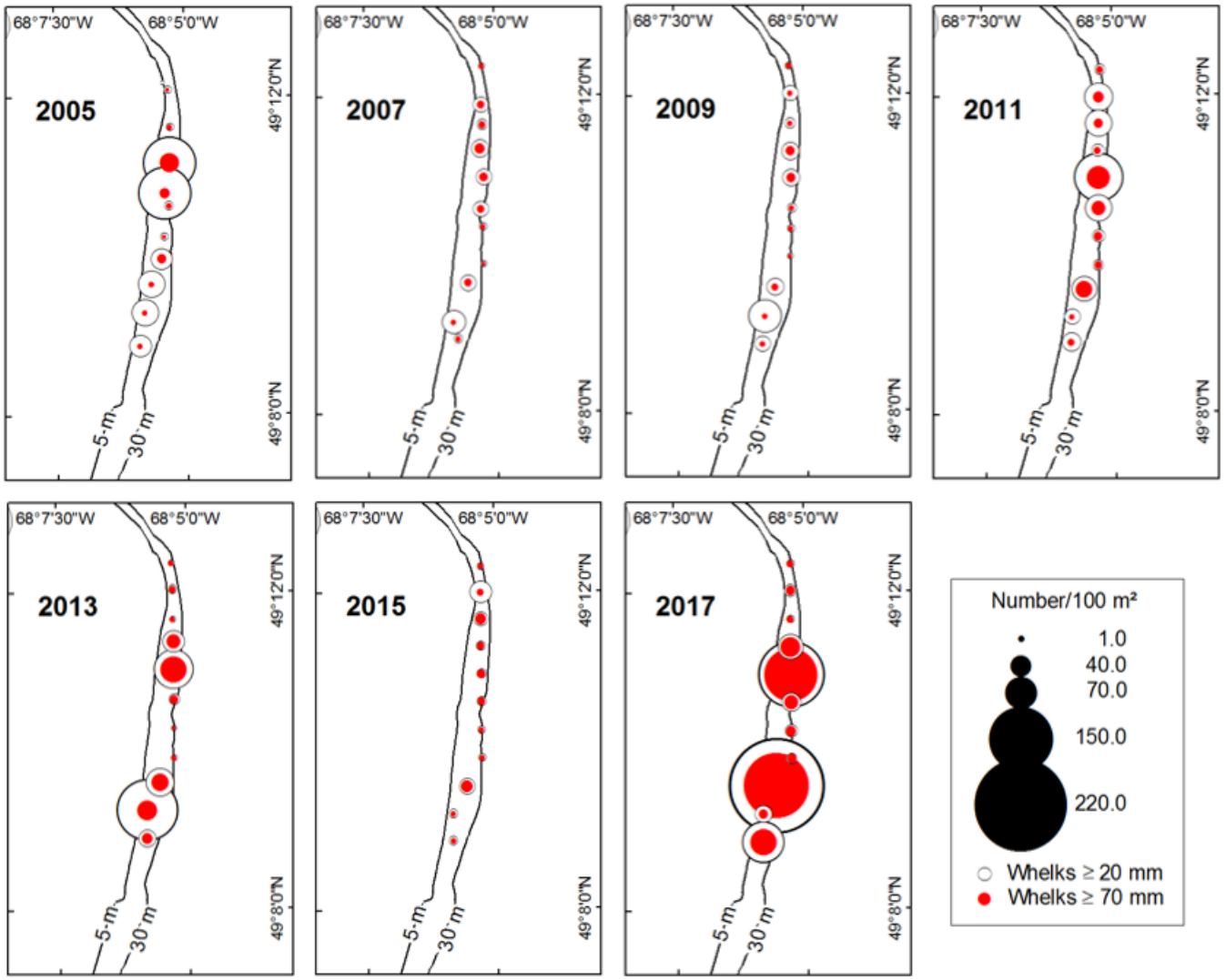

Figure 52. Density (number/100 m^2) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Baie-Comeau from 2005 to 2017.

Table 1. Average whelk density (number/100 m^2 ± standard error) by size class and egg mass by site and year in research surveys in Haute-Côte-Nord.

Site and Year	Whelk Size Class[1]			Egg mass
	≥ 20 mm	≥ 70 mm	20-69 mm	
Forestville				
2005	6.6 ± 0.5 c	3.3 ± 0.3 cd	3.3 ± 0.4 b	0.02 ± 0.01
2007	5.5 ± 0.4 c	2.4 ± 0.2 d	3.1 ± 0.3 b	-
2009	6.5 ± 0.5 c	1.9 ± 0.2 d	4.7 ± 0.4 b	0.01 ± 0.01
2011	12.2 ± 1.0 b	2.9 ± 0.2 d	9.3 ± 0.9 a	0.02 ± 0.01
2013	15.6 ± 1.1 ab	5.6 ± 0.4 b	10.0 ± 0.8 a	0.01 ± 0.01
2015	16.2 ± 1.5 a	4.6 ± 0.4 bc	11.6 ± 1.3 a	0.04 ± 0.01
2017	15.0 ± 0.8 ab	10.2 ± 0.5 a	4.8 ± 0.4 b	0.03 ± 0.01
Pointe-aux-Outardes				
2005	3.3 ± 0.8 b	1.9 ± 0.7 c	1.4 ± 0.3 b	1.0 ± 0.3
2007	4.2 ± 0.8 b	2.8 ± 0.6 bc	1.4 ± 0.3 b	-
2009	4.7 ± 0.7 b	2.0 ± 0.4 c	2.7 ± 0.5 b	1.1 ± 0.4
2011	12.0 ± 2.3 a	3.3 ± 0.6 bc	8.6 ± 1.9 a	1.4 ± 0.6
2013	6.8 ± 1.6 ab	3.9 ± 1.0 ac	2.9 ± 0.7 b	1.5 ± 0.5
2015	9.5 ± 1.1 ab	6.0 ± 0.5 ab	3.5 ± 0.8 b	1.0 ± 0.2
2017	8.9 ± 1.6 ab	7.1 ± 1.3 a	1.8 ± 0.5 b	1.3 ± 0.5
Baie-Comeau				
2005	42.7 ± 12.7 a	7.8 ± 3.3 b	35.0 ± 10.2 a	1.5 ± 2.2
2007	21.7 ± 4.1 a	6.4 ± 1.3 b	15.3 ± 3.6 a	-
2009	24.3 ± 5.5 a	6.0 ± 1.3b	18.3 ± 5.3 a	0.6 ± 0.2
2011	41.7 ± 8.2 a	16.4 ± 4.0 ab	25.3 ± 5.0 a	4.2 ± 1.9
2013	36.2 ± 12.9 a	17.9 ± 5.3 ab	18.4 ± 8.6 a	1.6 ± 0.6
2015	16.7 ± 3.3 a	8.8 ± 1.5 b	7.9 ± 2.9 a	2.2 ± 0.8
2017	59.1 ± 20.5 a	41.9 ± 14.8 a	17.2 ± 6.1a	1.7 ± 0.8

[1] Like letters identify similar densities between years by size class and site.

Table 2. Average whelk yield (g/100 m^2 ± standard error) by size class and egg mass, and average individual weight (g ± standard error) of egg masses by site and year during research surveys in Haute-Côte-Nord.

Site and Year	Whelk Size Class Yield			Egg mass	
	≥ 20 mm	≥ 70 mm	20-69 mm	Yield	Average Weight
Forestville					
2005	255 ± 19	199 ± 15	57 ± 6	-	-
2007	174 ± 11	127 ± 9	47 ± 4	0.7 ± 0.3	-
2009	170 ± 14	108 ± 10	61 ± 5	0.4 ± 0.2	51 ± 14
2011	290 ± 20	166 ± 11	124 ± 11	3.9 ± 1.7	222 ± 71
2013	499 ± 37	315 ± 24	183 ± 17	1.6 ± 0.9	133 ± 65
2015	452 ± 35	255 ± 21	197 ± 19	6.5 ± 2.5	148 ± 40
2017	718 ± 37	588 ± 33	129 ± 10	6.5 ± 3.6	151 ± 49
Pointe-aux-Outardes					
2005	159 ± 49	125 ± 47	34 ± 6	-	-
2007	197 ± 38	160 ± 33	37 ± 8	90 ± 27	-
2009	175 ± 30	126 ± 23	49 ± 10	73 ± 32	69 ± 5
2011	337 ± 59	193 ± 36	145 ± 30	106 ± 54	77 ± 4
2013	304 ± 71	233 ± 57	71 ± 16	107 ± 37	55 ± 8
2015	432 ± 38	360 ± 33	73 ± 13	83 ± 20	79 ± 11
2017	482 ± 87	434 ± 81	48 ± 11	102 ± 43	72 ± 7
Baie-Comeau					
2005	1,223 ± 404	397 ± 164	826 ± 259	-	-
2007	650 ± 109	312 ± 62	338 ± 67	37 ± 18	-
2009	677 ± 118	324 ± 67	353 ± 78	42 ± 17	72 ± 13
2011	1,468 ± 326	862 ± 208	606 ± 138	554 ± 283	130 ± 6
2013	1,527 ± 491	974 ± 286	552 ± 241	269 ± 120	136 ± 35
2015	640 ± 95	462 ± 75	179 ± 37	247 ± 100	101 ± 19
2017	2,820 ± 977	2,270 ± 793	550 ± 200	157 ± 76	77 ± 18

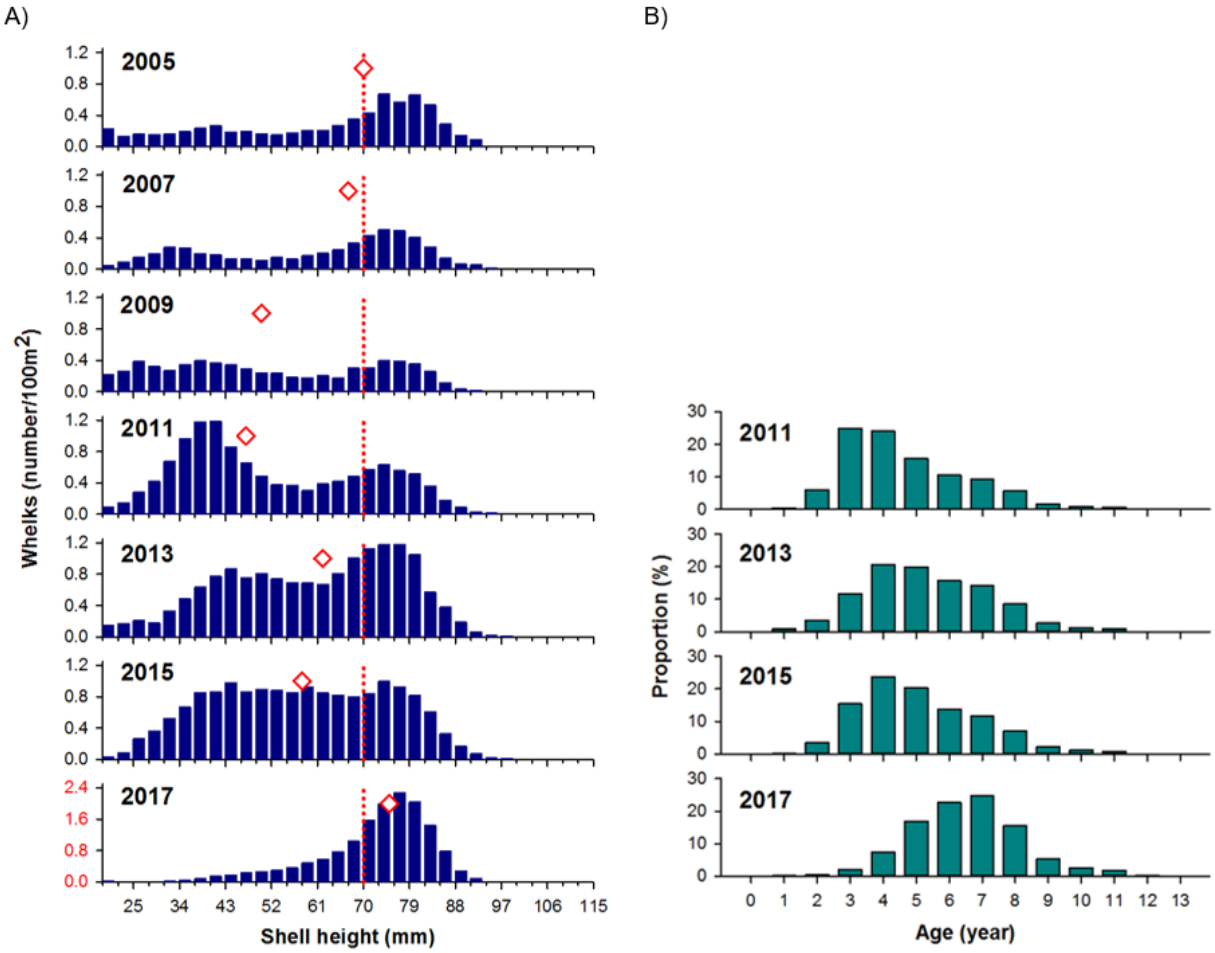

Figure 53. A) Whelk size structure and median size (red diamond) and B) age structure obtained from Forestville research surveys from 2005 to 2017. The vertical line in the right panel (A) represents the minimum legal size of 70 mm.

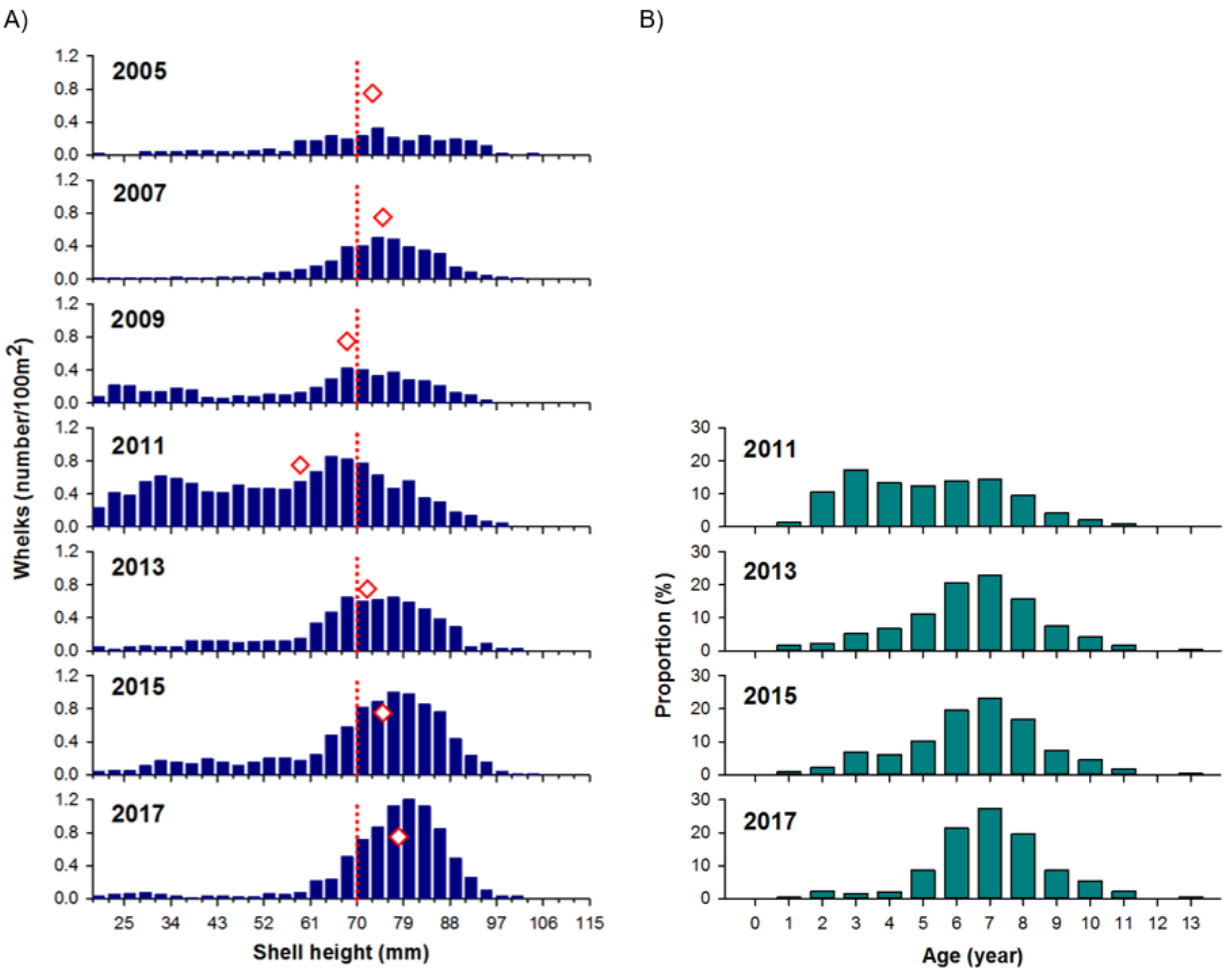

Figure 54. A) Whelk size structure and median size (red diamond) and B) age structure obtained from Pointe-aux-Outardes research surveys from 2005 to 2017. The vertical line in the right panel (A) represents the minimum legal size of 70 mm.

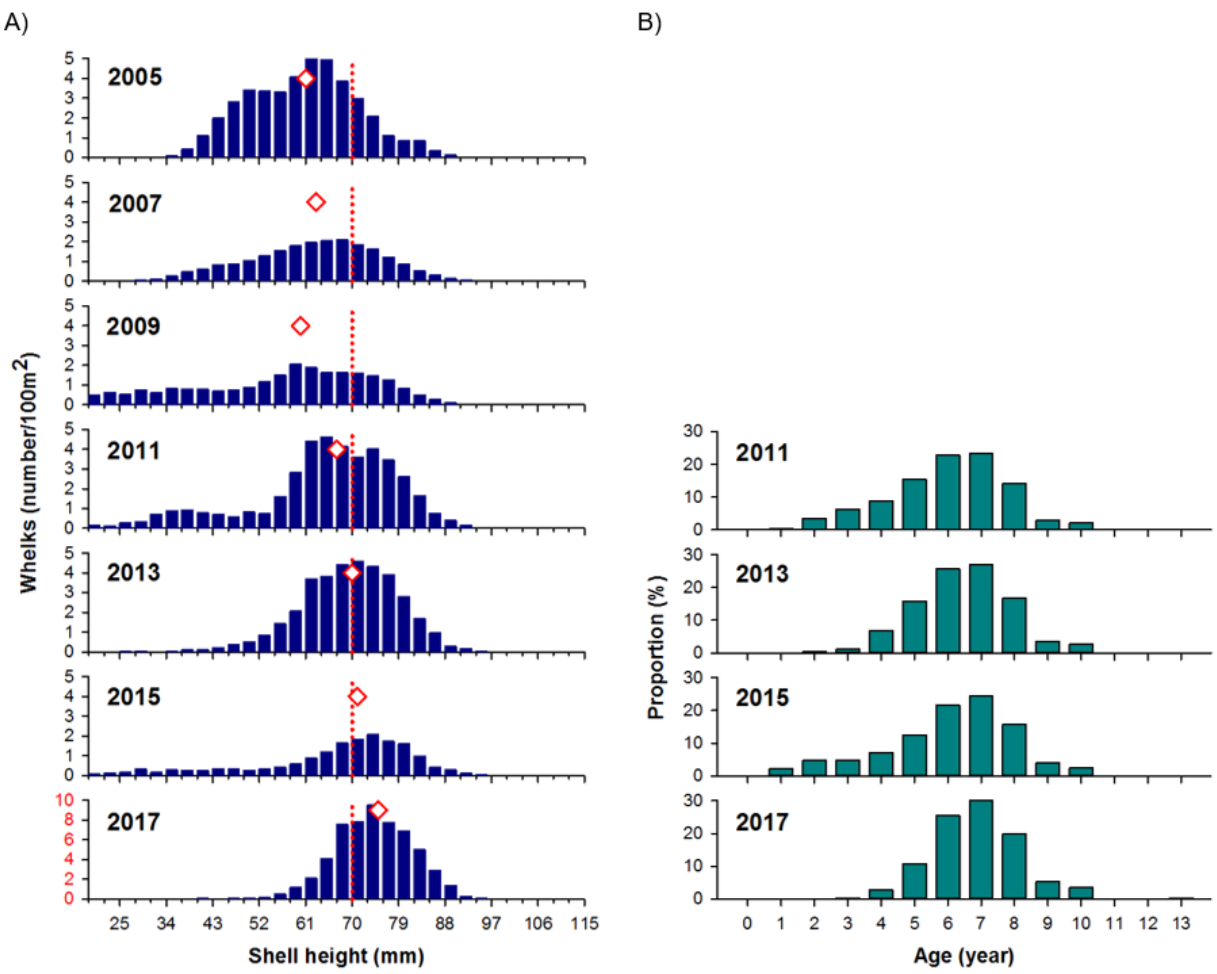

Figure 55. A) Whelk size structure and median size (red diamond) and B) age structure obtained from Baie-Comeau research surveys from 2005 to 2017. The vertical line in the right panel (A) represents the minimum legal size of 70 mm.

ÎLES-DE-LA-MADELEINE SURVEY

Of the 111 stations included in the 2016 sampling plan, only 82 could be covered because of the inclement weather, dredge related issues (unsuitable substrate and seabed elevation differences), etc. The average distance travelled to each station was 469 ± 89 m. Whelks were harvested at 70 stations (Figure 57 and Appendix 21). At the stations with whelks, densities were quite low, ranging from 0.07 to 6.74 whelks/100 m^2. The highest densities were observed in fishing sectors.

The average densities calculated for all stations with whelks were 0.53 individual/100 m^2 for whelks ≥ 70 mm, and 0.45 individual/100 m^2 for whelks measuring 20 to 69 mm, for a total of about 1 whelk/100 m^2 (Table 3).

The average yield calculated for all stations (all sites) with whelks was 45.6 g/100 m^2 (Table 3). The density of *B. undatum* egg masses was 0.08 mass/100 m^2 for all stations (Table 3 and Appendix 22). The average weight of an egg mass was 162 g. *Buccinum* egg masses other than those of *B. undatum* were observed at sites 2 (1 station) and 4 (10 stations).

The size structure shows a range of sizes from 15 to 110 mm with a predominance of legal-sized individuals (Figure 58). Individuals aged 3 to 9 were more predominant (Figure 58).

The growth curve calculated for the Îles-de-la-Madeleine shows a maximum size of 130 mm, slightly greater than that for the Haute-Côte-Nord (Figure 56). The minimum legal size of 70 mm should be reached at 5-6 years.

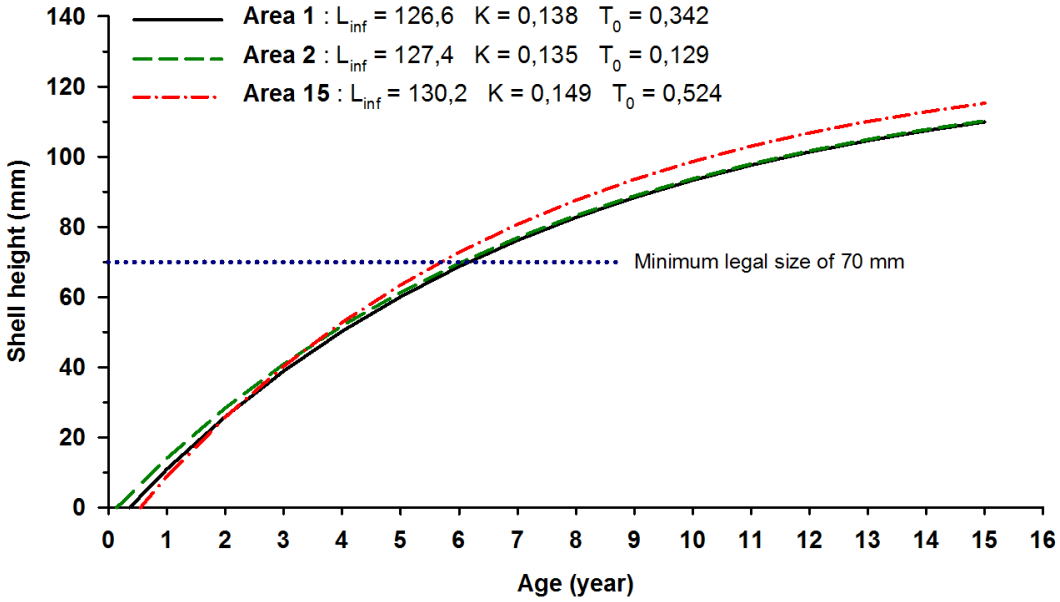

Figure 56. Von Bertalanffy growth curve for Buccinum undatum *by fishing area for the Haute-Côte-Nord and the Îles-de-la-Madeleine.*

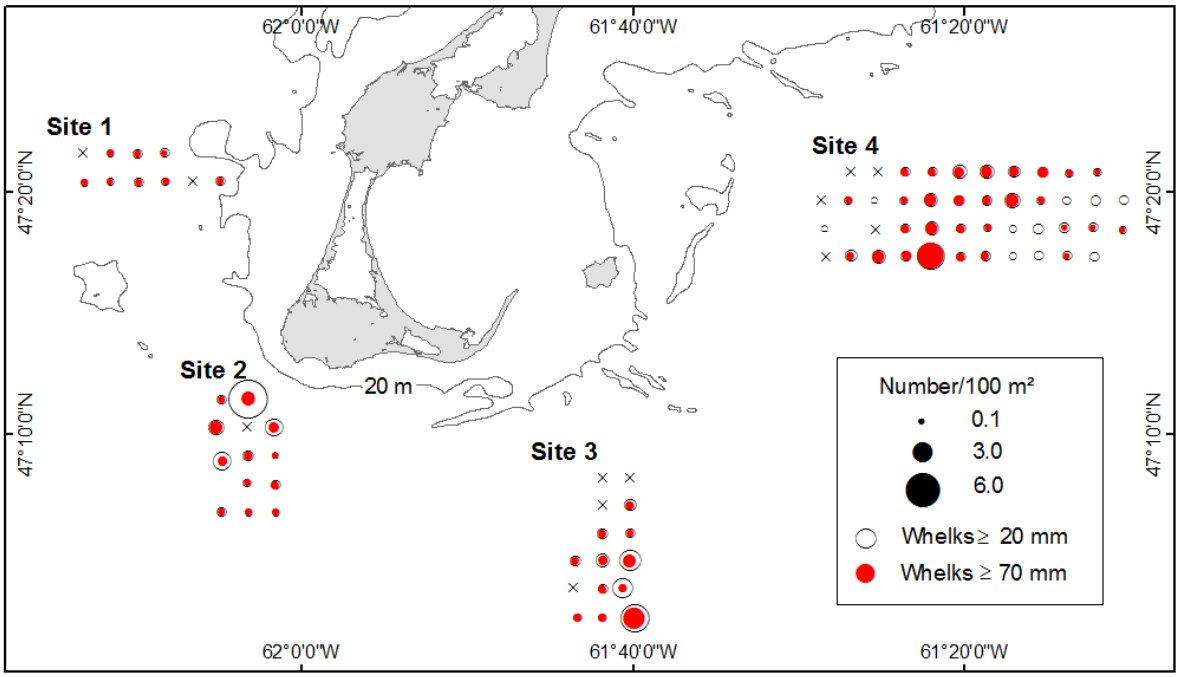

Figure 57. Density (number/100 m²) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Îles-de-la-Madeleine in 2016.

Table 3. Average density and yield (± standard error) of whelks by size class when present and egg masses per site during the research survey in the Îles-de-la-Madeleine in 2016.

Site	Size Class	Density (number/100 m^2)	Yield (g/100 m^2)	Number of station with whelk out of total station
1	≥ 20 mm	0.40 ± 0.08	14.66 ± 2.40	8/10
	≥ 70 mm	0.19 ± 0.03	9.81 ± 1.74	
	20-69 mm	0.22 ± 0.07	4.85 ± 1.57	
	Egg masses	0.02 ± 0.01	4.83 ± 4.34	
2	≥ 20 mm	1.39 ± 0.54	52.75 ± 14.79	12/13
	≥ 70 mm	0.56 ± 0.15	39.75 ± 10.61	
	20-69 mm	0.83 ± 0.43	13.00 ± 5.82	
	Egg masses	0.03 ± 0.02	8.89 ± 8.40	
3	≥ 20 mm	1.53 ± 0.41	68.56 ± 21.58	11/15
	≥ 70 mm	0.82 ± 0.26	58.61 ± 19.95	
	20-69 mm	0.71 ± 0.21	9.95 ± 2.83	
	Egg masses	0.10 ± 0.05	10.31 ± 6.73	
4	≥ 20 mm	0.82 ± 0.12	43.22 ± 9.94	39/44
	≥ 70 mm	0.51 ± 0.12	37.51 ± 10.10	
	20-69 mm	0.31 ± 0.04	5.72 ± 0.76	
	Egg masses	0.11 ± 0.03	19.19 ± 5.76	
Total	≥ 20 mm	0.98 ± 0.13	45.57 ± 7.07	70/82
	≥ 70 mm	0.53 ± 0.09	38.04 ± 6.76	
	20-69 mm	0.45 ± 0.09	7.53 ± 1.20	
	Egg masses	0.08 ± 0.02	14.18 ± 3.63	

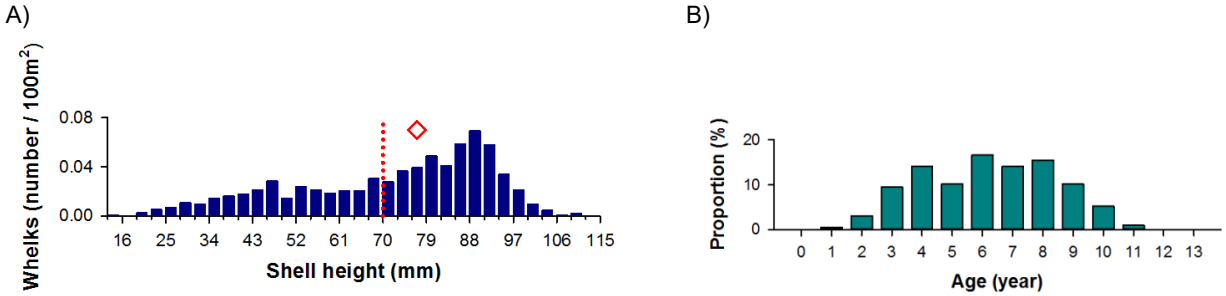

Figure 58. A) Size structure of the whelks and median size (red diamond) and B) age structure obtained from the research survey in the Îles-de-la-Madeleine in 2016. The vertical line in the right panel (A) represents the minimum legal size of 70 mm.

Laboratory examination of the *Buccinum undatum* shells collected during the survey showed that borer polychaetes were the main cause of the lesions (Couillard et al. 2018). Several polychaete species were identified, with *Polydora websteri* being the most common. The lesions observed included burrows (tunnels), ulcers, scars, and broken shells (Figure 59). According to the findings of Couillard et al. (2018), the prevalence and severity of lesions increased with whelk size, and whelks ≥ 80 mm were more severely affected. In addition, sites 3 and 4 (southwestern region) appeared to be the most affected.

According to the preliminary results collected from 2015 to 2017 in various fishing areas, whelks from other areas have a much lower infestation rate and lesion severity than those in the Îles-de-la-Madeleine.

A) Erosion spot without shell (mother-of-pearl) exposure (arrow)

B) Erosion spot with shell (mother-of-pearl) exposure (arrow)

C) Shell perforation during harvest

D) Burrows visible on shell cross sections (arrows)

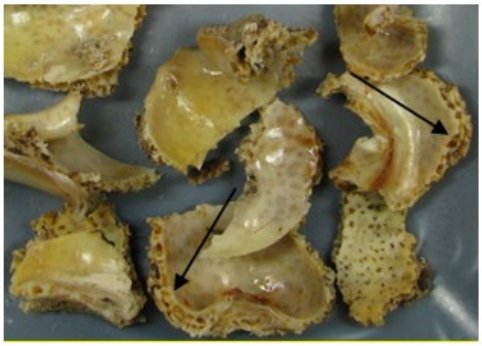

Figure 59. Photographs showing shell lesions in whelks harvested in the Îles-de-la-Madeleine in 2016 (Photographs: C. Turbide DFO 2016 and B. Desrosiers DFO 2017).

Further studies will be needed to assess the impact of this type of infestation on *B. undatum* (somatic conditions, reproduction and mortality) and to better understand the interactions between this infestation, environmental factors, and human activities.

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APPENDICES

Appendix 1. Average density (number/100 m^2) and number of individuals harvested (in parentheses) for the various Buccinum *species of ≥ 20 mm and relative proportion (%) of* B. undatum *(density) of all* Buccinum *by site and by year in the Haute-Côte-Nord and Îles-de-la-Madeleine research surveys.*

Site and Year	Density and Number					Proportion (%)
	B. undatum	***B. totteni***	***B. glaciale***	***B. scalariforme***	***Buccinum* sp.**	
Forestville						
2009	6.421 (3,494)	0.073 (40)	0.022 (11)	0.002 (1)	0.002 (1)	98.5%
2011	11.832 (6,241)	0.281 (132)	0.059 (30)	0	0.002 (1)	97.2%
2013	15.404 (7,783)	0.162 (81)	0.052 (26)	0.002 (1)	0.002 (1)	98.6%
2015	16.083 (8,200)	0. 037 (19)	0.054 (27)	0.002 (1)	0	99.4%
2017	14.916 (7,332)	0.004 (2)	0.054 (28)	0.004 (2)	0.004 (2)	99.6%
Pointe-aux-Outardes						
2009	4.561 (1,109)	0.181 (42)	0	0.004 (1)	0	96.1%
2011	11.911 (2,912)	0.029 (7)	0	0.015 (3)	0	99.6%
2013	6.827 (1,605)	0.004 (1)	0	0.004 (1)	0	99.9%
2015	9.520 (2,159)	0.021 (5)	0	0	0	99.8%
2017	8.866 (1,733)	0.009 (2)	0	0	0.015 (3)	99.7%
Baie-Comeau						
2009	24.201 (2,437)	0.040 (5)	0	0.010 (1)	0	99.8%
2011	41.683 (4,396)	0.046 (5)	0	0	0.010 (1)	99.9%
2013	36.217 (3,297)	0	0	0	0.011 (1)	100%
2015	16.715 (1,475)	0.012 (1)	0	0	-	99.9%
2017	59.143 (5,640)	0	0	0	-	100%
Îles-de-la-Madeleine						
2016	0.982 (823)	0.065 (63)	0	0.026 (28)	0.007 (7)	90.9%

Appendix 2. Photographs of the various Buccinum *species observed since 2009 in the Haute-Côte-Nord and Îles-de-la-Madeleine research surveys, and an example of an unidentified* Buccinum *(photographers: M. Boudreau DFO 2010 and S. Brulotte DFO 2015).*

B. undatum *B. totteni* *B. glaciale* *B. scalariforme* *Buccinum* sp.

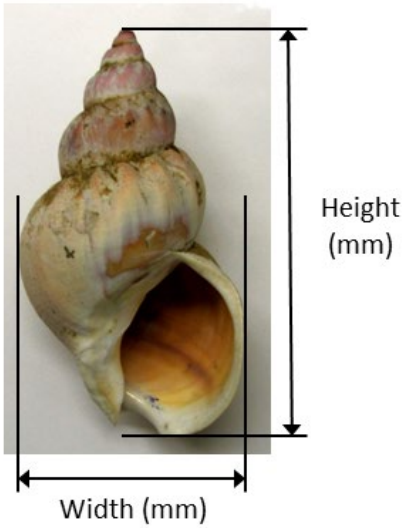
Appendix 3. Number of whelk specimens collected by region, Fishing Area and year as part of DFO's landed commercial catch sampling program.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine
	1	2	3	4	5	6	7	8	12	13	15
1987	0	0	0	12	0	5	0	0	0	3	0
1988	0	0	0	5	5	1	0	3	0	1	4
1989	0	0	0	2	0	0	0	0	0	2	2
1990	0	0	1	7	0	0	0	0	0	0	0
1991	0	0	0	17	8	6	0	0	0	0	0
1992	0	0	0	11	10	0	0	6	0	0	0
1993	0	0	0	4	1	4	0	2	12	0	0
1994	2	0	0	6	1	5	0	3	0	10	0
1995	6	0	0	8	6	6	0	11	0	10	0
1996	0	0	0	5	0	5	0	3	0	16	0
1997	4	4	0	4	3	4	0	1	0	12	0
1998	10	3	2	6	8	8	3	1	1	3	0
1999	3	4	3	6	9	9	7	5	0	5	0
2000	9	5	2	4	5	6	2	2	3	7	0
2001	10	6	5	10	8	8	0	0	4	7	0
2002	4	4	2	11	2	3	2	1	5	7	1
2003	2	5	0	12	10	12	6	5	6	5	8
2004	22	9	5	11	13	13	10	0	10	3	9
2005	28	17	0	14	17	16	10	6	17	6	16
2006	28	2	0	9	11	9	6	3	10	5	14
2007	28	12	0	8	17	19	7	3	16	16	14
2008	35	4	0	8	16	15	5	3	18	15	16
2009	42	2	0	10	17	18	9	3	18	17	5
2010	50	10	0	15	27	21	14	6	6	20	16
2011	23	15	0	7	14	15	7	5	13	16	16
2012	17	13	8	14	16	16	11	2	12	18	13
2013	20	5	0	16	15	15	6	7	15	15	17
2014	17	8	0	11	15	15	2	5	7	15	3
2015	17	3	4	15	15	15	3	9	15	16	5
2016	12	9	2	11	10	10	4	10	12	13	15
2017	14	4	0	10	8	12	2	13	13	11	11

Appendix 4. Number of whelks measured by region, Fishing Area and year through DFO's landed commercial catch sampling program.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine
	1	2	3	4	5	6	7	8	12	13	15
1995	650	-	-	831	628	601	-	1,213	-	1,000	-
1996	-	-	-	640	-	507	-	351	-	1,646	-
1997	448	485	-	420	301	381	-	101	1,216	-	-
1998	1,051	373	193	640	828	839	315	101	97	301	-
1999	314	409	310	615	928	920	712	545	-	663	-
2000	1,090	644	226	397	516	669	195	203	307	421	-
2001	1,079	615	497	1,043	802	819	-	-	389	515	-
2002	409	4,444	207	1,156	2,284	3,185	203	133	622	906	120
2003	219	4,380	-	1,256	1,021	1,208	602	536	755	940	-
2004	5,178	1,832	1,252	2,771	3,304	3,282	2,514	-	1,766	725	2,341
2005	4,347	2,879	-	2,154	2,567	2,473	1,513	876	2,600	984	2,837
2006	4,538	385	-	1,359	1,645	1,351	919	489	1,724	839	2,323
2007	4,449	2,162	-	1,213	2,580	2,936	1,055	500	2,753	2,634	2,324
2008	5,754	621	-	1,209	2,423	2,257	754	519	2,808	2,439	2,699
2009	6,690	344	-	1,543	2,553	2,698	1,364	484	2,832	2,627	794
2010	7,837	1,537	-	2,309	4,134	3,232	2,153	1,023	935	3,056	2,559
2011	3,631	2,337	-	1,040	2,116	2,283	1,123	882	1,950	2,409	2,503
2012	2,571	1,963	1,207	2,130	2,443	2,437	1,658	318	1,802	2,703	1,977
2013	3,008	756	-	2,431	2,269	2,263	907	1,126	2,251	2,250	2,626
2014	2,555	1,465	-	1,659	2,246	2,228	300	778	1,050	2,250	462
2015	2,556	675	584	2,261	2,250	2,254	453	1,430	2,250	2,400	820
2016	1,802	1,650	285	1,659	1,501	1,500	605	1,634	1,800	1,952	2,305
2017	2,054	1,052	-	1,501	1,202	1,800	301	2,214	1,952	1,650	1,667

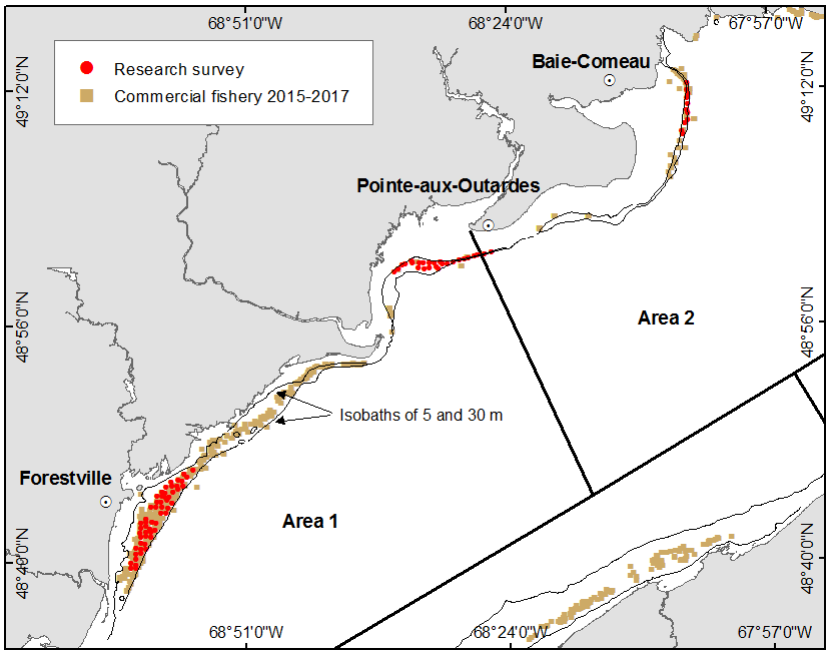
Appendix 5. Identification of the various whelk measurements. (Photos : N. Paille DFO 2008).



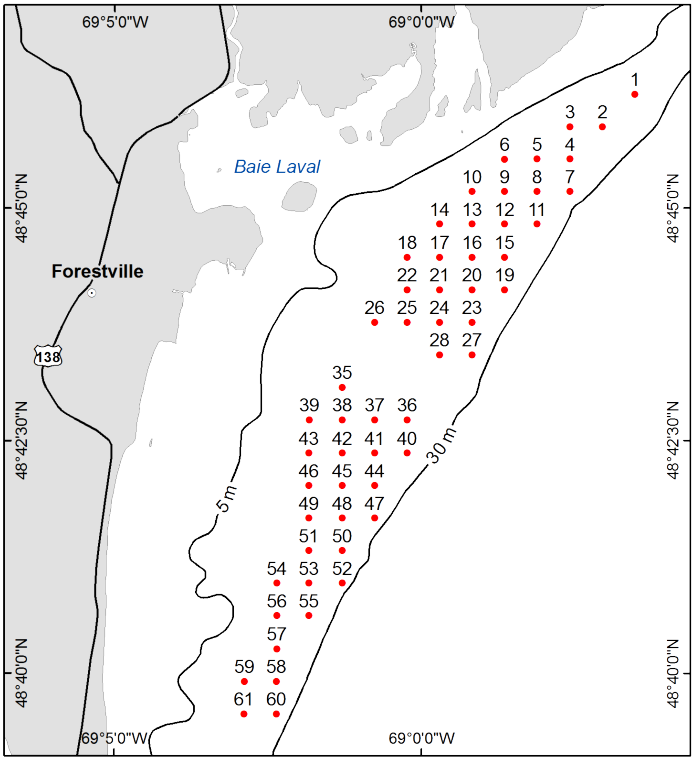
Minimum width (mm)

Appendix 6. Location A) of the whelk research survey sampling sites and commercial whelk fishery from 2015 to 2017 and sampling stations in B) Forestville, C) Pointe-aux-Outardes and D) Baie-Comeau.

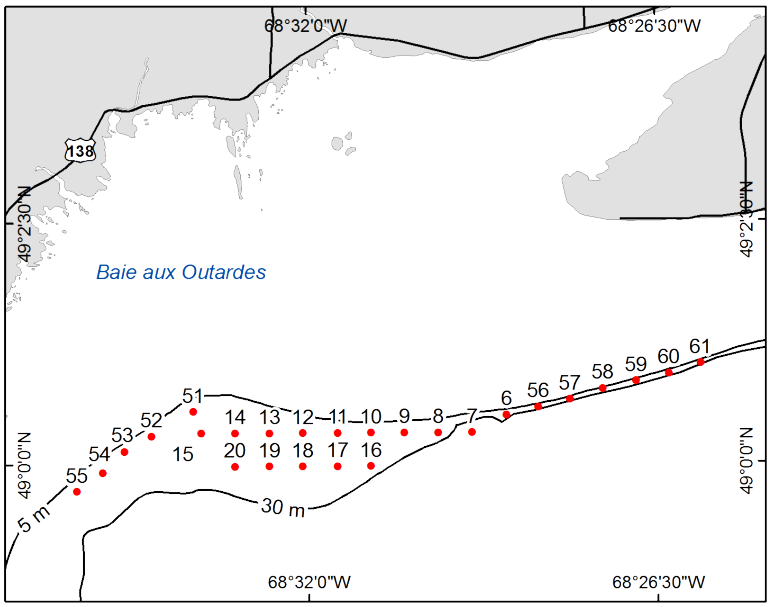
A)



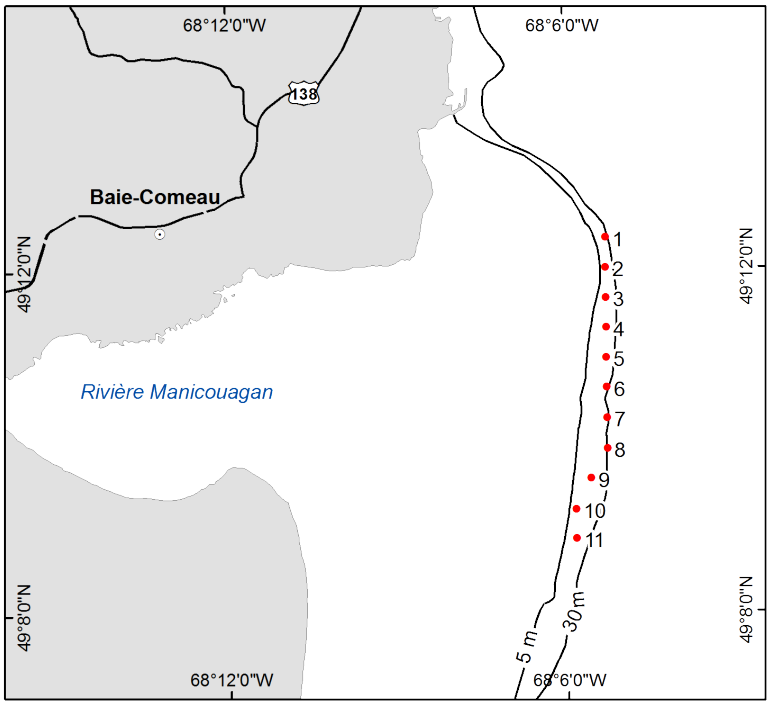
B)



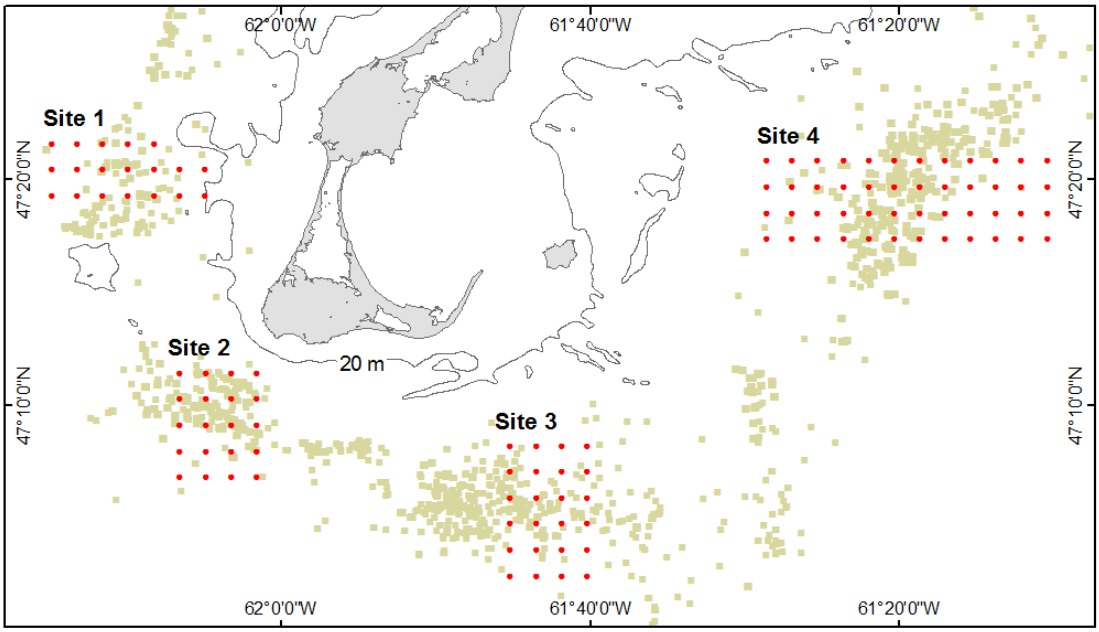
C)


68°32'0"W
68°26'30"W
138
49°2'30"N
Baie aux Outardes
51
52
53
54
55
14
13
12
11
10
9
8
7
6
56
57
58
59
60
61
15
20
19
18
17
16
49°0'0"N
5 m
30 m
68°32'0"W
68°26'30"W

D)


68°12'0"W
68°6'0"W
138
Baie-Comeau
49°12'0"N
Rivière Manicouagan
1
2
3
4
5
6
7
8
9
10
11
49°8'0"N
5 m
30 m
68°12'0"W
68°6'0"W

Appendix 7. Sampling plan and location of sites and stations (red circles) during the research survey carried out in the Îles-de-la-Madeleine in 2016. The shaded symbols in the background show the distribution of the fishery from 2003 to 2017.



Appendix 8. Parameters of linear relationships between total live weight in g (y) and height in mm (x) of Buccinum undatum *and estimated weight of an 80 mm whelk from research surveys conducted in Forestville, Pointe-aux-Outardes and Baie-Comeau since 2005.*

Site	Year	Equation	R^2	*n*	Weight (g) for an 80 mm whelk
Forestville	2005	ln(y) = 2.897 ln(x) – 8.566	0.974	303	62
	2007	ln(y) = 2.875 ln(x) – 8.566	0.992	176	56
	2009	ln(y) = 2.904 ln(x) – 8.594	0.991	324	62
	2011	ln(y) = 2.930 ln(x) – 8.708	0.993	269	62
	2013	ln(y) = 2.914 ln(x) – 8.663	0.992	238	61
	2015	ln(y) = 2.888 ln(x) – 8.578	0.994	238	59
	2017	ln(y) = 2.875 ln(x) – 8.489	0.992	371	61
Pointe-aux-Outardes	2005	ln(y) = 2.861 ln(x) – 8.447	0.963	133	60
	2007	ln(y) = 2.805 ln(x) – 8.244	0.987	155	57
	2009	ln(y) = 2.927 ln(x) – 8.696	0.992	261	62
	2011	ln(y) = 2.881 ln(x) – 8.556	0.995	196	58
	2013	ln(y) = 2.894 ln(x) – 8.609	0.995	191	59
	2015	ln(y) = 2.921 ln(x) – 8.734	0.995	275	58
	2017	ln(y) = 2.871 ln(x) – 8.489	0.992	276	60
Baie-Comeau	2005	ln(y) = 2.823 ln(x) – 8.297	0.972	209	59
	2007	ln(y) = 2.797 ln(x) – 8.244	0.984	137	55
	2009	ln(y) = 2.975 ln(x) – 8.909	0.995	250	62
	2011	ln(y) = 2.924 ln(x) – 8.750	0.993	171	58
	2013	ln(y) = 2.820 ln(x) – 8.258	0.988	123	60
	2015	ln(y) = 2.898 ln(x) – 8.661	0.996	256	57
	2017	ln(y) = 2.906 ln(x) – 8.669	0.995	108	58

Appendix 9. Implementation year of various management measures and changes for commercial whelk fisheries.

Management measures	Year	Details
Fishing season	2000	Areas 1 to 7 and 9 to 15: 6 months, except in Area 8 (12 months).
	2004	Area 8: Reduced to 8 months
	2005	Area 8: Reduced to 7 months
	2007	Area 8: Reduced to about 6 months
Number of traps	1999	Areas 1 to 7 and 11 to 13: Fishermen who made landings in 1996 and 1997 are entitled to use 150 traps (volume ≤ 0.15 m^3). Other fishermen are entitled to use 100 traps (volume ≤ 0.3 m^3). Areas 8, 9 and 15: 100 traps ≤ 0.3 m^3.
	2007	Areas 1 to 14: The number of traps allocated to fishermen who did not report any landings from 2000 to 2005 was reduced to 50.
	2011	North Shore and Gaspé–Lower St. Lawrence: Licence buy-back (reduces potential effort) with the option of increasing the number of traps. Area 15: Option to use 150 traps if the fisherman chooses to shorten his fishing season from August to October.
Minimum legal size	2000	Areas 1 to 15: 65 mm
	2001	Areas 1 to 15: 66 mm
	2002	Areas 1 to 9 and 15: 67 mm Areas 11 to 14: 70 mm
	2003	Areas 1 to 9: 68 mm Area 15 = 70 mm
	2004	Areas 1 to 9: 69 mm
	2005	All Areas: 70 mm
TAC	2001	Area 1 : 491 t Area 2 : 109 t
	2003	Area 15A (southern portion of Area 15): 400 t
	2006	Area 15 (grouping of subareas 15 and 15A): 450 t
	2010	Area 11 : 32 t Area 12 : 128 t Area 13 (east of Bic): 100 t Area 13B (west of Bic): 50 t
	2011	Area 13 (east of Bic): 73 t Area 13 (west of Bic): no TAC
	2012	Area 12 : 135 t Zone 13 : 82 t (no division) Area 15 : 376 t
	2015	Area 11 : 11 t Area 12 : 46 t
Buddy-up	-	Maximum of two captains (licences) per boat with the addition of traps
	2012	Area 8
	2014	Areas 4 andt 7
	2017	Areas 4, 5, 6, 7, 8 (allows 225 traps instead of 200) and 15

Appendix 10. Management measures for the 2017 commercial whelk fishery.

Area	Number of Active/Issued Licences	Number of Active/Authorized Traps	TAC	Season	Number of Authorized Traps per Licence
1	5 / 11	650 / 1,300 (50%)[1]	491	30/03 to 21/09	50 and 150
2	2 / 6	200 / 550 (36%)	109	30/03 to 07/09	50 and 150
3	3 / 7	350 / 850 (41%)	-	13/04 to 09/11	100 and 150
4	12 / 28	1,250 / 2,559 (49%)	-	20/04 to 21/10	50 and 450
5	5 / 17	650 / 1,750 (37%)	-	07/04 to 06/10	50 and 350
6	11 / 15	1,200 / 1,450 (83%)	-	24/04 to 23/10	50 and 600
7	2 / 6	300 / 600 (50%)	-	24/04 to 23/10	50 and 150
8	17 / 64	1,700 / 6,400 (27%)	-	29/05 to 30/11	100
9	0 / 1[2]	-	-	26/04 to 05/10	100
10	0	-	-	-	-
11	2 / 16	200 / 1,200 (17%)	11	01/04 to 30/09	50 and 100
12	9 / 34	1,000 / 2,875 (35%)	46	01/04 to 30/09	50 and 175
13	4 / 11	425 / 1,050 (40%)	82	01/04 to 30/09	50 and 175
14	0 / 13	0 / 800 (0%)		01/04 to 30/09	50 and 100
15	9 / 11	900 / 1,100 (82%)	376[3]	01/05 to 30/11	100 or 150[4]
Total	**81 / 240**	-	-	-	-

[1] Percentage of active traps

[2] Fishermen in Areas 5, 6 and 7 also have access to Area 9.

[3] The TAC is divided equally among the 11 licence holders, who are entitled to 37.54 t each (for a total of 413 t). If the TAC is exceeded, fishermen who landed more than 34.18 t will have their quota reduced the following year by the excess amount caught.

[4] Fishermen who shorten their fishing season from August to November have the option of using 150 traps.

Appendix 11. Commercial whelk fishery landings (t) from 1995 to 2017 by region and Fishing Area and for Québec as a whole.

Year	North Shore									Gaspé–Lower St. Lawrence					Îles-de-la-Madeleine	Québec
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1995	80	40	4	56	186	119	7	81	0	0	34	14	4	0	0	624
1996	179	57	8	176	275	178	2	82	0	0	51	17	5	< 1	0	1,032
1997	196	42	12	68	286	109	181	8	0	0	54	21	20	0	0	999
1998	207	11	4	29	346	107	29	1	0	0	47	26	17	< 1	0	825
1999	457	120	42	65	493	130	64	5	0	0	36	20	21	0	0	1,453
2000	550	207	18	108	401	184	14	37	0	0	28	15	8	0	0	1,571
2001	589	157	52	162	359	201	0	0	0	0	18	12	24	0	0	1,573
2002	594	132	25	143	310	243	93	6	0	0	29	32	23	1	20	1,649
2003	408	119	33	149	385	282	60	90	0	0	25	34	27	< 1	388	2,000
2004	204	71	39	161	322	279	89	7	0	0	24	39	22	cd	369	1,628
2005	202	72	30	114	272	193	62	63	22	0	44	84	24	0	442	1,623
2006	247	cd[1]	28	107	221	196	90	47	cd	0	35	150	34	0	392	1,587
2007	151	cd	14	83	168	152	42	21	0	0	cd	127	77	0	382	1,269
2008	118	cd	16	48	146	216	19	24	0	0	cd	117	67	0	352	1,147
2009	300	cd	6	51	274	330	67	11	0	0	cd	110	57	0	23	1,255
2010	204	cd	10	60	363	358	34	38	0	0	cd	129	91	0	150	1,484
2011	132	cd	14	42	312	314	22	21	0	0	cd	95	78	0	265	1,368
2012	114	cd	12	64	409	296	49	27	0	0	cd	75	81	0	239	1,432
2013	241	cd	6	82	250	280	45	36	cd	0	cd	70	66	cd	327	1,445
2014	290	cd	6	41	115	270	22	23	cd	0	cd	46	cd	cd	15	952
2015	225	cd	1	60	148	308	24	31	cd	0	cd	48	50	0	11	937
2016	428	cd	3	47	160	366	76	30	0	0	cd	47	89	0	111	1,418
2017	378	cd	3	57	142	307	50	30	cd	0	cd	46	59	0	204	1,329
Average[2]	278	66	18	88	263	268	50	30	2	0	12	76	55	< 1	248	1,423
Variation[3]	36%		- 82%	- 35%	- 46%	15%	1%	1%				- 40%	8%		- 17%	- 7%

[1] cd = confidential data (four fishermen or fewer).

[2] 2001–2016 reference average, except for Area 15, where the 2003–2016 average was used.

[3] Variation between the 2017 value and the reference average.

Appendix 12. 2002 to 2017 commercial whelk fishing effort (number of trap hauls x 10^2) by region and Fishing Area and for Québec as a whole.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine	Québec
	1	2	3	4	5	6	7	8	12	13	15	
2002	50,700	14,700	3,300	47,200	88,500	47,900	9,000	1,500	11,700	5,300	1,700	293,700
2003	43,300	11,100	5,500	54,700	109,700	71,100	13,000	26,200	12,500	8,000	15,500	385,800
2004	29,700	8,100	6,800	53,300	106,200	89,100	13,900	2,000	13,100	5,800	18,500	356,300
2005	27,700	10,500	6,100	41,400	85,400	75,800	8,800	14,300	26,600	5,500	19,200	340,900
2006	31,900	cd[1]	4,900	35,400	65,800	64,600	11,000	15,000	36,900	6,400	17,200	305,200
2007	22,300	cd	3,000	24,600	53,800	47,200	6,100	5,300	32,400	12,400	17,800	231,700
2008	15,300	cd	3,300	16,400	40,900	56,900	4,200	7,500	30,300	10,900	16,400	206,200
2009	33,100	cd	1,600	14,900	62,200	64,300	9,300	2,300	27,200	8,500	1,000	229,100
2010	28,800	cd	1,800	20,700	75,800	64,300	6,100	13,100	27,900	10,100	6,500	261,900
2011	19,500	cd	2,900	10,600	54,700	63,400	4,500	6,700	21,500	8,800	13,600	214,700
2012	13,600	cd	2,600	15,700	79,900	67,500	7,600	7,900	19,900	11,000	11,900	244,900
2013	21,700	cd	1,700	19,000	62,500	61,000	7,300	8,700	18,000	9,000	17,200	230,600
2014	27,600	cd	1,500	10,500	29,400	55,300	4,100	6,900	18,800	9,200	2,700	173,200
2015	19,000	cd	200	13,100	33,100	62,200	3,800	8,800	14,400	8,300	1,100	167,200
2016	27,100	cd	1,300	12,100	47,000	78,000	9,300	10,400	14,700	12,700	8,700	227,000
2017	25,000	cd	1,000	17,400	46,400	70,500	6,300	10,200	11,900	10,100	9,300	212,400
Average[2]	27,400	6500	3,100	26,000	66,300	64,600	7,900	9,100	21,700	8,800	11,900	257,900
Variation[3]	- 9%	-	- 67%	- 33%	- 30%	9%	- 19%	12%	- 45%	15%	- 23%	- 18%

[1] cd = confidential data (four fishermen or fewer).

[2] 2002–2016 reference average, except for Area 15, where the 2003–2016 average was used.

[3] Variation between the 2017 value and the baseline level.

Appendix 13. Annual average of standardized catch per unit effort (kg/trap) in the 2001 to 2017 commercial whelk fishery by region and Fishing Area. The values in red and bold in square brackets are the lowest in the series by fishing area.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine
	1	2	3	4	5	6	7	8	12	13	15
2001	12.8	12.3	6.5	4.6	4.4	5.1	-	-	3.1	4.4	-
2002	11.0	8.3	5.4	3.1	4.4	5.9	11.1	4.8	2.9	4.0	-
2003	9.0	11.2	5.6	**[2.9]**	4.3	4.6	**[3.5]**	3.6	**[2.5]**	**[3.4]**	20.3
2004	**[6.5]**	8.9	5.7	3.1	3.7	3.8	7.0	3.8	3.0	3.8	19.0
2005	7.2	7.7	4.9	3.0	3.8	**[3.3]**	7.2	4.6	3.6	4.2	20.9
2006	7.6	**[7.1]**	5.6	3.1	4.1	3.7	8.7	**[3.4]**	4.2	5.0	20.1
2007	6.8	13.2	4.6	3.6	3.5	3.9	7.6	4.8	4.6	5.9	19.2
2008	7.2	10.6	4.4	**[2.9]**	4.0	4.4	5.5	3.8	3.9	5.8	18.2
2009	8.7	9.6	2.7	3.6	5.3	6.0	7.5	5.4	4.3	6.2	21.1
2010	7.1	10.9	5.2	**[2.9]**	5.9	5.7	5.2	**[3.4]**	4.7	8.3	20.9
2011	6.7	12.5	3.5	3.8	6.7	5.4	5.0	3.7	4.6	8.6	17.5
2012	8.2	10.3	4.3	4.1	6.2	4.8	5.9	4.1	4.2	7.1	17.1
2013	10.4	11.1	3.7	4.8	4.7	4.9	6.1	5.0	4.4	6.8	16.6
2014	10.4	10.3	3.2	4.0	4.3	5.0	5.2	4.1	**[2.5]**	7.2	**[4.7]**
2015	11.3	7.8	-	4.5	4.4	5.3	6.1	3.9	3.4	5.4	-
2016	15.2	10.3	3.1	3.9	3.7	5.2	8.5	**[3.4]**	3.7	5.8	9.6
2017	15.4	13.8	**[1.9]**	3.2	**[3.3]**	4.7	8.1	**[3.4]**	4.4	6.7	17.3
Average[1]	9.1	10.1	4.6	3.6	4.6	4.8	6.7	4.1	3.7	5.7	19.2
Variation[2]	69%	36%	- 57%	- 11%	- 28%	- 3%	22%	- 19%	17%	16%	- 10%

[1] 2001–2016 reference average, except for Area 15, where the 2003–2016 average was used.

[2] Variation between the 2017 value and the reference average.

Appendix 14. Average size (mm) of whelk landed by region and Fishing Area during the commercial whelk fishery from 1995 to 2017.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine
	1	2	3	4	5	6	7	8	12	13	15
2005	74	74	-	87	80	83	81	77	88	77	82
2006	77	71	-	83	80	87	84	76	85	80	83
2007	79	74	-	89	85	85	83	76	85	87	81
2008	78	72	-	89	85	83	87	71	88	83	88
2009	78	79	-	89	86	84	87	74	87	83	88
2010	79	82	-	90	89	88	87	75	88	87	85
2011	81	75	-	91	88	88	90	73	87	85	87
2012	80	78	92	95	90	89	90	74	89	85	83
2013	79	78	-	94	91	88	90	73	89	85	85
2014	78	82	-	95	88	88	86	75	90	84	93
2015	79	78	95	96	91	88	88	80	93	86	81
2016	80	80	97	96	92	86	86	78	91	87	86
2017	78	79	-	97	94	88	91	80	91	89	84
Average[1]	78	77	94	91	87	86	86	75	88	84	85
Variation[2]	0%	3%	-	6%	8%	2%	5%	6%	3%	6%	- 1%

[1] 2005–2016 reference average.

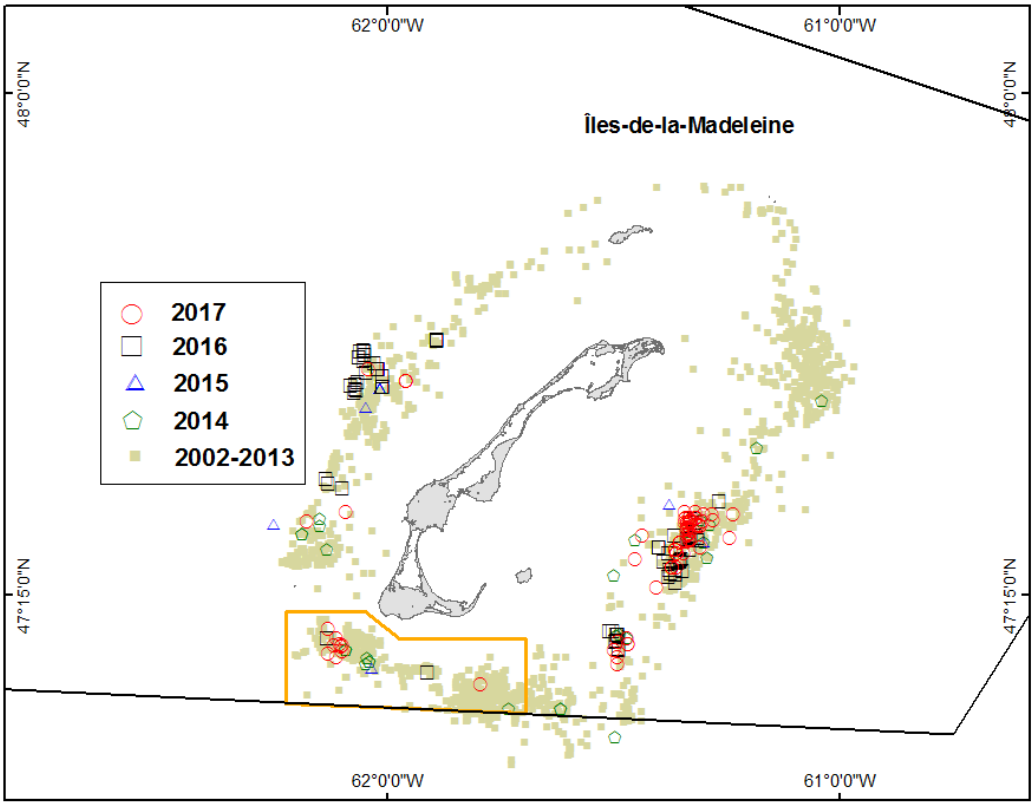
[2] Variation between the 2017 value and the reference average.

Appendix 15. Percentage (%) of sub-legal size whelk in commercial whelk fishery landings from 2005 to 2017 by region and Fishing Area.

Year	North Shore								Gaspé–Lower St. Lawrence		Îles-de-la-Madeleine
	1	2	3	4	5	6	7	8	12	13	15
2005	29	30		4	11	10	9	27	3	16	8
2006	19	41		14	15	3	4	26	4	9	4
2007	8	27		3	6	4	10	27	3	1	7
2008	15	43		3	4	6	5	40	2	6	2
2009	14	12		3	2	6	4	32	2	6	1
2010	12	6		2	2	2	7	27	3	2	2
2011	5	21		2	1	2	2	32	3	< 1	1
2012	7	10	< 1	< 1	1	2	1	32	3	1	3
2013	8	12		< 1	1	2	2	32	2	< 1	7
2014	10	2		< 1	4	2	3	19	2	< 1	1
2015	8	8	< 1	< 1	1	3	5	8	< 1	< 1	2
2016	4	4	0	< 1	1	6	3	9	1	< 1	1
2017	12	6		< 1	1	3	3	7	1	< 1	3
Average[1]	12	18	< 1	3	4	4	4	26	2	4	3

[1] Reference average 2005-2016.

Appendix 16. Delineation of the southern sector (bordered by a yellowish line) in the Îles-de-la-Madeleine used to monitor catches by unit of effort.



Appendix 17. Central position of tow (latitude and longitude WGS84), density (number/100 m^2) and yield (g/100 m^2) of whelk by size class, site and station during the 2015 research survey in Haute-Côte-Nord.

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
Forestville							
1	48° 46.175'	68° 56.609'	315	5.37	25.33	279.2	500.3
2	48° 45.866'	68° 57.049'	299	4.19	21.04	227.8	336.5
3	48° 45.823'	68° 57.667'	305	3.99	12.85	237.3	192.2
4	48° 45.525'	68° 57.577'	302	3.14	33.26	183.7	539.2
5	48° 45.560'	68° 58.040'	327	5.58	12.29	320.1	193.6
6	48° 45.533'	68° 58.605'	314	4.52	8.60	262.0	130.4
7	48° 45.148'	68° 57.591'	323	2.3	3.04	141.9	60.3
8	48° 45.151'	68° 58.144'	335	7.46	29.86	441.0	378.2
9	48° 45.206'	68° 58.627'	321	3.79	14.05	199.2	216.9
10	48° 45.163'	68° 59.212'	285	4.5	10.06	244.7	187.5
11	48° 44.778'	68° 58.153'	327	3.31	3.10	200.9	47.9
12	48° 44.771'	68° 58.661'	318	7.44	19.55	407.4	284.2
13	48° 44.843'	68° 59.115'	274	8.39	16.54	488.7	214.9
14	48° 44.849'	68° 59.755'	303	6.58	4.13	347.8	86.0
15	48° 44.450'	68° 58.650'	312	15.47	20.23	874.2	412.7
16	48° 44.435'	68° 59.195'	318	7.86	27.20	475.5	360.2
17	48° 44.440'	68° 59.757'	331	3.98	8.98	209.9	97.2
18	48° 44.449'	69° 00.280'	326	5.7	4.66	293.1	79.1
19	48° 44.065'	68° 58.670'	315	10.85	10.85	623.7	285.7
20	48° 44.095'	68° 59.197'	323	4.6	5.33	274.5	96.8
21	48° 44.108'	68° 59.723'	287	5.06	36.82	289.2	486.4
22	48° 44.105'	69° 00.350'	334	3.75	6.99	201.3	119.3
23	48° 43.763'	68° 59.188'	318	7.22	8.29	403.8	200.5
24	48° 43.746'	68° 59.722'	352	6.43	23.90	364.4	355.8
25	48° 43.744'	69° 00.244'	322	8.51	28.15	442.3	415.0
26	48° 43.777'	69° 00.873'	312	3.79	3.68	201.5	36.2
27	48° 43.404'	68° 59.166'	340	7.15	5.46	408.9	142.4
28	48° 43.465'	68° 59.631'	323	8.67	14.31	498.3	276.1
35	48° 43.007'	69° 01.397'	366	3.14	3.05	179.4	76.7
36	48° 42.679'	69° 00.268'	319	2.97	3.60	175.6	79.8
37	48° 42.714'	69° 00.748'	336	1.48	2.69	88.2	39.3
38	48° 42.683'	69° 01.291'	306	1.66	0.88	86.4	16.4
39	48° 42.659'	69° 01.880'	326	2.59	1.35	135.7	41.4
40	48° 42.347'	69° 00.238'	308	2.19	1.65	130.4	45.5
41	48° 42.367'	69° 00.740'	336	4.02	15.97	223.6	249.9
42	48° 42.397'	69° 01.285'	363	3.35	13.01	174.7	231.1
43	48° 42.280'	69° 01.855'	309	3.17	5.91	157.2	127.9
44	48° 42.029'	69° 00.753'	334	5.97	14.97	336.9	262.1

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
45	48° 41.982'	69° 01.315'	316	3.1	5.99	161.1	137.4
46	48° 41.945'	69° 01.840'	316	1.28	2.99	75.3	72.5
47	48° 41.687'	69° 00.730'	297	2.96	31.61	161.1	385.1
48	48° 41.668'	69° 01.266'	283	6.92	10.97	394.7	198.2
49	48° 41.605'	69° 01.860'	304	1.56	2.56	80.5	67.8
50	48° 41.318'	69° 01.285'	321	6.94	21.04	384.2	435.0
51	48° 41.310'	69° 01.834'	334	3.34	2.73	182.2	69.1
52	48° 40.950'	69° 01.282'	341	4.86	24.30	288.0	354.4
53	48° 41.029'	69° 01.795'	315	4.72	15.35	265.1	218.3
54	48° 40.949'	69° 02.363'	310	0.87	0.98	52.4	20.9
55	48° 40.604'	69° 01.829'	333	2.53	5.27	127.5	139.7
56	48° 40.639'	69° 02.349'	320	2.21	2.11	110.4	54.1
57	48° 40.349'	69° 02.317'	365	1.85	2.59	99.1	64.3
58	48° 39.919'	69° 02.340'	292	2.54	4.04	134.1	109.9
59	48° 39.949'	69° 02.860'	308	0.44	1.75	19.9	48.2
60	48° 39.600'	69° 02.425'	284	4.41	11.91	215.6	293.2
61	48° 39.525'	69° 02.865'	317	0.85	10.37	40.1	256.4
Pointe-aux-Outardes							
6	49° 00.502'	68° 28.868'	321	9.17	1.90	494.1	61.8
7	49° 00.331'	68° 29.418'	298	0.23	0.00	14.2	0.0
8	49° 00.322'	68° 29.939'	305	7.43	1.77	440.0	48.9
9	49° 00.326'	68° 30.475'	303	8.35	6.57	487.8	171.7
10	49° 00.307'	68° 31.028'	250	4.86	10.81	272.3	202.3
11	49° 00.305'	68° 31.553'	253	7.62	2.41	437.8	74.0
12	49° 00.302'	68° 32.071'	248	5.6	1.91	335.3	53.2
13	49° 00.310'	68° 32.555'	299	4.41	1.58	262.2	41.5
14	49° 00.313'	68° 33.085'	321	2.84	1.16	172.6	31.2
15	49° 00.311'	68° 33.680'	330	2.46	0.92	147.2	14.1
16	48° 59.971'	68° 31.017'	334	6.99	1.01	463.3	22.6
17	48° 59.970'	68° 31.584'	275	4.18	4.92	254.8	106.3
18	48° 59.970'	68° 32.087'	236	5.01	11.73	270.1	192.4
19	48° 59.972'	68° 32.692'	250	5.95	18.52	359.0	249.7
20	48° 59.951'	68° 33.127'	343	9.65	2.56	615.3	59.2
51	49° 00.544'	68° 33.781'	316	11.99	6.64	768.5	125.3
52	49° 00.295'	68° 34.424'	321	4.62	1.26	302.4	24.3
53	49° 00.088'	68° 34.986'	334	6.78	1.42	450.9	27.7
54	48° 59.922'	68° 35.190'	313	5.61	1.73	391.2	46.9
55	48° 59.710'	68° 35.674'	322	5.66	2.10	373.5	48.4
56	49° 00.585'	68° 28.367'	320	11.49	2.21	619.8	67.4
57	49° 00.649'	68° 27.860'	306	7.5	0.44	431.6	14.7
58	49° 00.769'	68° 27.346'	320	4.75	5.06	252.5	95.4

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
59	49° 00.843'	68° 26.822'	306	7.29	2.76	411.8	87.6
60	49° 00.922'	68° 26.290'	299	3.5	0.23	201.3	7.8
61	49° 01.023'	68° 25.804'	309	2.08	0.44	124.4	14.2
Baie-Comeau							
1	49° 12.336'	68° 05.245'	299	5.32	1.92	295.8	44.2
2	49° 12.002'	68° 05.250'	271	7.37	35.58	399.5	462.6
3	49° 11.662'	68° 05.262'	262	17.18	8.53	889.4	268.4
4	49° 11.321'	68° 05.264'	269	8.67	4.40	473.1	106.6
5	49° 10.971'	68° 05.260'	264	10.36	2.69	538.0	83.0
6	49° 10.622'	68° 05.265'	284	8.44	4.64	431.1	149.6
7	49° 10.261'	68° 05.264'	265	4.97	4.33	263.4	103.4
8	49° 09.912'	68° 05.262'	273	5.82	2.73	323.3	72.0
9	49° 09.559'	68° 05.555'	277	18.93	9.40	957.0	294.1
10	49° 09.207'	68° 05.827'	265	3.83	7.66	186.0	221.6
11	49° 08.864'	68° 05.826'	268	5.81	5.43	320.2	162.0

Appendix 18. Density (number/100 m^2), yield (g/100 m^2) and average weight (g) of Buccinum undatum *egg masses (when present) by site and station in the 2015 research survey in Haute-Côte-Nord.*

Site	Station	Density	Yield	Average weight
Forestville	4	0.22	12.8	57
	7	0.21	33.2	159
	8	0.30	113.2	374
	11	0.10	1.5	14
	13	0.12	57.7	467
	16	0.32	48.8	153
	20	0.11	0.5	5
	35	0.09	8.1	88
	37	0.13	5.2	39
	39	0.10	29.9	289
	43	0.33	24.0	73
	46	0.11	14.9	139
	53	0.11	7.5	70
Pointe-aux-Outardes	6	0.84	33.4	40
	9	1.34	120.4	90
	10	1.22	94.5	78
	11	3.21	437.1	136
	12	0.82	95.1	116
	13	0.90	14.2	16
	14	0.53	33.5	64
	15	0.41	96.2	235
	16	0.81	47.8	59
	17	0.62	20.0	33
	18	1.14	150.1	131
	19	1.62	221.6	137
	51	2.25	179.1	80
	52	0.42	26.1	62
	53	0.10	2.1	21
	54	0.11	8.1	75
	56	1.37	73.4	54
	57	1.10	54.6	50
	58	1.27	89.7	71
	59	5.30	274.7	52
	60	0.11	0.9	8
	61	0.55	74.1	136
Baie-Comeau	2	0.13	4.2	34
	3	1.03	51.8	50
	4	2.77	519.5	188
	5	8.18	1023.6	125
	6	1.43	105.2	74
	7	0.26	30.9	121
	8	1.49	267.3	180
	9	2.44	125.6	51
	11	6.82	593.1	87

Appendix 19. Central position of tow (latitude and longitude WGS84), density (number/100 m^2) and yield (g/100 m^2) of whelk by size class, site and station during the 2017 research survey in Haute-Côte-Nord.

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
Forestville							
1	48° 46.230'	68° 56.506'	301	8.99	3.71	548.3	104.5
2	48° 45.872'	68° 57.046'	303	11.03	6.35	666.3	141.0
3	48° 45.882'	68° 57.572'	302	7.62	4.15	434.7	126.2
4	48° 45.516'	68° 57.597'	300	6.98	5.63	431.0	139.2
5	48° 45.528'	68° 58.117'	301	12.56	5.72	736.9	153.4
6	48° 45.518'	68° 58.654'	302	5.14	1.45	293.3	34.7
7	48° 45.176'	68° 57.590'	301	6.05	1.79	394.2	48.8
8	48° 45.190'	68° 58.099'	307	8.7	7.82	500.2	177.0
9	48° 45.190'	68° 58.630'	302	10.74	4.48	633.9	108.0
10	48° 45.178'	68° 59.182'	301	7.06	1.68	415.7	56.8
11	48° 44.806'	68° 58.146'	300	13.83	6.19	832.5	168.1
12	48° 44.837'	68° 58.637'	303	15.49	9.92	895.4	220.0
13	48° 44.799'	68° 59.204'	299	13.91	5.32	823.5	164.8
14	48° 44.822'	68° 59.708'	157	10.12	3.01	604.3	95.2
15	48° 44.460'	68° 58.656'	301	12.56	6.95	752.2	171.6
16	48° 44.452'	68° 59.198'	300	16.08	4.39	965.7	109.0
17	48° 44.474'	68° 59.686'	383	9.52	1.76	558.8	50.9
18	48° 44.458'	69° 00.262'	301	11.11	2.02	663.9	41.4
19	48° 44.090'	68° 58.672'	302	11.19	2.69	686.4	85.4
20	48° 44.113'	68° 59.312'	314	14.3	2.9	886.7	68.0
21	48° 44.113'	68° 59.697'	251	19.42	5.12	1,180.0	132.9
22	48° 44.143'	69° 00.201'	300	11.25	1.91	667.7	59.0
23	48° 43.766'	68° 59.171'	301	21.89	11.23	1,282.1	298.9
24	48° 43.775'	68° 59.692'	377	11.92	5.65	719.8	125.1
25	48° 43.750'	69° 00.220'	302	19.45	9.72	1,141.2	190.4
26	48° 43.739'	69° 00.771'	300	13.07	1.46	778.3	49.8
27	48° 43.429'	68° 59.146'	366	9.51	1.85	593.2	53.8
28	48° 43.397'	68° 59.717'	326	14.52	11.72	846.3	268.1
35	48° 43.065'	69° 01.272'	341	10.41	1.49	581.2	45.7
36	48° 42.686'	69° 00.232'	355	16.37	14.76	925.0	356.7
37	48° 42.715'	69° 00.746'	300	7.31	2.36	401.7	70.3
38	48° 42.798'	69° 01.248'	301	8.29	1.91	455.8	57.8
39	48° 42.696'	69° 01.826'	302	8.28	1.46	448.4	52.9
40	48° 42.368'	69° 00.225'	322	7.98	3.47	467.2	91.7
41	48° 42.371'	69° 00.757'	311	8.15	3.91	466.1	105.9
42	48° 42.372'	69° 01.287'	312	8.87	2.49	477.8	77.5
43	48° 42.378'	69° 01.815'	306	10.83	3.54	581.1	123.2
44	48° 42.015'	69° 00.744'	314	11.93	7.85	708.7	173.6
45	48° 42.029'	69° 01.276'	294	11.02	2.07	618.7	64.1
46	48° 42.024'	69° 01.804'	310	9.7	1.42	519.5	52.0

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
47	48° 41.677'	69° 00.781'	105	8.97	12.82	522.9	317.6
48	48° 41.670'	69° 01.278'	306	8.18	2.99	462.2	75.6
49	48° 41.664'	69° 01.817'	308	6.59	1.87	348.0	59.7
50	48° 41.365'	69° 01.294'	292	5.79	4.28	315.3	107.8
51	48° 41.286'	69° 01.823'	313	6.38	1.4	346.3	49.0
52	48° 40.974'	69° 01.277'	305	5.88	6.55	340.0	161.5
53	48° 40.968'	69° 01.831'	334	10.81	6.57	586.5	200.7
54	48° 40.964'	69° 02.343'	306	3.42	2.1	174.1	73.0
55	48° 40.621'	69° 01.822'	305	12.4	7.97	661.5	253.8
56	48° 40.616'	69° 02.347'	304	8.55	4	436.6	131.8
57	48° 40.264'	69° 02.326'	305	9.76	7.21	501.0	234.6
58	48° 39.914'	69° 02.344'	317	6.49	3.41	345.9	116.9
59	48° 39.911'	69° 02.868'	306	3.54	6.19	171.0	210.9
60	48° 39.553'	69° 02.348'	302	5.37	6.04	294.1	184.2
61	48° 39.559'	69° 02.870'	303	5.13	6.92	261.3	227.1
Pointe-aux-Outardes							
6	49° 00.499'	68° 28.862'	299	2.03	0.79	128.5	26.1
7	49° 00.313'	68° 29.427'	316	0.14	0	9.1	0.0
8	49° 00.310'	68° 29.977'	301	4.2	0.3	252.3	11.4
9	49° 00.316'	68° 30.492'	202	10.03	1.34	613.6	49.8
10	49° 00.317'	68° 30.995'	201	24.36	4.37	1,469.3	137.9
11	49° 00.316'	68° 31.541'	201	2.69	0.84	147.1	26.3
12	49° 00.311'	68° 32.142'	203	2.33	0.5	129.7	18.1
13	49° 00.331'	68° 32.606'	301	2.13	0.11	123.6	4.3
14	49° 00.334'	68° 33.155'	300	5.85	1.13	342.9	37.6
15	49° 00.327'	68° 33.676'	301	1.35	0.34	92.3	8.8
16	48° 59.965'	68° 31.030'	301	21.07	0.67	1,366.1	21.2
17	48° 59.975'	68° 31.516'	201	16.1	6.71	967.0	171.4
18	48° 59.970'	68° 32.115'	209	6.8	9.56	360.9	226.7
19	48° 59.970'	68° 32.589'	201	15.27	6.38	907.7	87.6
20	48° 59.968'	68° 33.158'	300	16.42	1.57	1,067.8	54.0
51	49° 00.557'	68° 33.749'	301	12.45	3.25	802.6	66.2
52	49° 00.268'	68° 34.492'	307	3.08	0.11	217.8	3.0
53	49° 00.137'	68° 34.882'	306	3.21	0.44	212.4	3.6
54	48° 59.905'	68° 35.259'	308	2.41	0.66	159.7	12.9
55	48° 59.732'	68° 35.639'	301	5.49	0.45	360.4	13.5
56	49° 00.581'	68° 28.350'	312	5.42	1.73	334.0	58.3
57	49° 00.659'	68° 27.851'	304	5.22	1.22	307.1	41.5
58	49° 00.764'	68° 27.330'	305	6.75	2.54	414.8	72.0
59	49° 00.843'	68° 26.792'	287	6.48	2.47	374.6	77.2
60	49° 00.919'	68° 26.290'	301	1.57	0.34	92.8	12.9
61	49° 01.025'	68° 25.794'	302	0.45	0	25.2	0.0
Baie-Comeau							

Site and station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
				20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
1	49° 12.358'	68° 05.249'	311	7.61	0.87	467.1	28.0
2	49° 12.022'	68° 05.258'	312	13.55	6.18	799.5	135.9
3	49° 11.661'	68° 05.256'	301	7.62	1.79	404.9	58.1
4	49° 11.311'	68° 05.271'	310	39.18	12.11	2,101.9	397.2
5	49° 10.966'	68° 05.264'	308	120.77	28.08	6,469.9	951.9
6	49° 10.611'	68° 05.264'	314	25.68	9.13	1,386.1	290.2
7	49° 10.248'	68° 05.274'	300	14.63	6.08	819.9	204.0
8	49° 09.905'	68° 05.261'	295	13.18	1.95	764.2	65.3
9	49° 09.564'	68° 05.552'	276	151.4	67.18	8,154.9	2,190.5
10	49° 09.207'	68° 05.822'	283	13.48	17.65	691.5	543.2
11	49° 08.859'	68° 05.824'	287	54.3	38.16	2,908.9	1,185.8

Appendix 20. Density (number/100 m^2), yield (g/100 m^2) and average weight (g) of Buccinum undatum *egg masses (when present) by site and station in the 2017 research survey in Haute-Côte-Nord.*

Site	Station	Density	Yield	Average weight
Forestville	10	0.11	8.0	71
	12	0.33	24.2	72
	15	0.34	106.8	318
	16	0.11	9.3	82
	20	0.54	166.9	310
	37	0.11	2.8	25
	45	0.12	36.7	320
	53	0.10	1.1	11
Pointe-aux-Outardes	6	0.23	4.6	20
	9	2.84	230.5	81
	10	11.09	1,025.6	92
	14	0.34	12.4	37
	16	2.58	215.7	84
	17	1.34	162.5	121
	18	0.49	34.7	71
	19	3.19	218.1	68
	20	0.56	55.3	98
	51	7.18	500.2	70
	56	0.98	94.3	97
	57	0.56	34.8	63
	58	0.22	12.2	55
	59	1.30	58.4	45
Baie-Comeau	3	0.22	15.6	70
	4	1.96	318.9	162
	5	4.83	500.6	104
	7	0.23	7.4	33
	9	8.09	732.3	91
	10	0.36	11.2	31
	11	2.95	136.5	46

Appendix 21. Central position of tow (latitude and longitude WGS84), density (number/100 m^2) and yield (g/100 m^2) of whelk by size class, site and station during the 2016 research survey in Îles-de-la-Madeleine.

Site	Station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
					20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
1	102	47° 21.536'	62° 13.234'	540	0	0	0	0
	103	47° 21.540'	62° 11.606'	523	0.19	0	10.4	0
	104	47° 21.511'	62° 09.965'	463	0.29	0.22	15.6	5.6
	105	47° 21.536'	62° 08.286'	497	0.07	0.54	2.9	12.3
	107	47° 20.367'	62° 13.196'	540	0.13	0	6.0	0
	108	47° 20.377'	62° 11.583'	497	0.07	0.07	4.2	0.9
	109	47° 20.360'	62° 09.898'	491	0.28	0.28	14.4	4.7
	110	47° 20.379'	62° 08.255'	513	0.20	0.26	10.8	6.42
	111	47° 20.390'	62° 06.605'	431	0	0	0	0
	112	47° 20.411'	62° 04.941'	475	0.28	0.36	14.1	8.8
2	202	47° 11.417'	62° 04.907'	359	0.19	0.47	13.8	8.5
	203	47° 11.469'	62° 03.279'	356	1.52	5.22	90.4	69.4
	206	47° 10.292'	62° 05.210'	353	1.43	0.38	119.3	7.9
	207	47° 10.313'	62° 03.332'	129	0	0	0	0
	208	47° 10.272'	62° 01.712'	513	0.92	1.32	59.6	24.7
	210	47° 08.869'	62° 04.850'	498	0.75	1.76	54.2	29.4
	211	47° 09.110'	62° 03.260'	364	0.65	0.19	51.4	5.9
	212	47° 09.129'	62° 01.640'	511	0.07	0	3.3	0
	215	47° 07.987'	62° 03.306'	512	0.26	0.13	19.8	2.5
	216	47° 07.926'	62° 01.593'	470	0.50	0.07	32.6	2.4
	218	47° 06.803'	62° 04.902'	488	0.21	0.35	15.2	4.2
	219	47° 06.812'	62° 03.285'	508	0.13	0	7.3	0
	220	47° 06.808'	62° 01.633'	517	0.13	0.07	8.0	0.9
3	303	47° 08.214'	61° 41.851'	292	0	0	0	0
	304	47° 08.220'	61° 40.211'	513	0	0	0	0
	307	47° 07.069'	61° 41.868'	269	0	0	0	0
	308	47° 07.066'	61° 40.243'	479	0.63	0.49	50.0	2.9
	311	47° 05.921'	61° 41.872'	311	0.33	0.54	19.6	7.4
	312	47° 05.904'	61° 40.242'	509	0.27	0.33	22.1	5.7
	314	47° 04.772'	61° 43.530'	305	0.44	0.55	36.6	9.1
	315	47° 04.778'	61° 41.882'	275	0.74	0.61	47.1	11.7
	316	47° 04.781'	61° 40.246'	513	1.32	1.65	84.6	18.6
	318	47° 03.690'	61° 43.669'	242	0	0	0	0
	319	47° 03.624'	61° 41.879'	303	0.45	0.22	28.3	3.8
	320	47° 03.666'	61° 40.669'	357	0.66	2.17	49.4	29.2
	322	47° 02.429'	61° 43.355'	282	0.36	0	22.3	0
	323	47° 02.439'	61° 41.869'	293	0.46	0	33.2	0
	324	47° 02.427'	61° 39.903'	347	3.31	1.27	248.9	20.9
4	402	47° 20.766'	61° 26.900'	512	0	0	0	0
	403	47° 20.758'	61° 25.214'	524	0	0	0	0
	404	47° 20.764'	61° 23.575'	518	0.46	0.13	35.1	0.9
	405	47° 20.767'	61° 21.951'	514	0.39	0.13	25.8	3.6
	406	47° 20.762'	61° 20.294'	511	0.99	0.66	64.5	14.1
	407	47° 20.773'	61° 18.647'	511	1.06	0.46	62.8	10.0
	408	47° 20.765'	61° 17.016'	518	0.72	0.33	45.3	11.1
	409	47° 20.778'	61° 15.272'	509	0.93	0	70.7	0

Site	Station	Latitude (W)	Longitude (N)	Distance (m)	Density		Yield	
					20-69 mm	≥ 70 mm	20-69 mm	≥ 70 mm
4	410	47° 20.748'	61° 13.663'	513	0.20	0.20	9.7	3.5
	411	47° 20.758'	61° 11.984'	513	0.07	0.39	4.6	7.8
	413	47° 19.624'	61° 28.651'	514	0	0	0	0
	414	47° 19.640'	61° 27.003'	510	0.13	0.20	9.4	2.5
	415	47° 19.627'	61° 25.453'	512	0	0.07	0	0.9
	416	47° 19.640'	61° 23.648'	518	0.26	0.07	21.1	1.8
	417	47° 19.638'	61° 22.029'	523	1.23	0.13	77.4	3.7
	418	47° 19.635'	61° 20.329'	513	0.86	0.07	61.3	1.8
	419	47° 19.630'	61° 18.646'	512	0.53	0.26	29.1	5.8
	420	47° 19.627'	61° 17.123'	515	1.38	0.46	92.4	12.5
	421	47° 19.619'	61° 15.421'	525	0.19	0.19	10.5	4.1
	422	47° 19.624'	61° 13.798'	516	0	0.33	0	6.5
	423	47° 19.620'	61° 12.093'	518	0	0.72	0	11.0
	424	47° 19.625'	61° 10.379'	513	0	0.66	0	12.4
	425	47° 18.431'	61° 28.430'	368	0	0.09	0	0.2
	427	47° 18.429'	61° 25.409'	517	0	0	0	0
	428	47° 18.460'	61° 23.588'	518	0.52	0.13	39.4	2.6
	429	47° 18.477'	61° 21.972'	517	1.24	0.26	72.9	5.8
	430	47° 18.444'	61° 20.260'	520	0.59	0.07	38.4	2.2
	431	47° 18.490'	61° 18.615'	524	0.13	0.26	5.2	5.3
	432	47° 18.471'	61° 17.090'	542	0	0.12	0	2.8
	433	47° 18.437'	61° 15.518'	517	0	0.96	0	13.5
	434	47° 18.495'	61° 13.946'	524	0.09	0.86	3.0	16.9
	435	47° 18.515'	61° 12.221'	518	0.07	0.46	2.0	7.2
	436	47° 18.394'	61° 10.459'	521	0.06	0.06	3.6	1.2
	437	47° 17.313'	61° 28.402'	510	0	0	0	0
	438	47° 17.319'	61° 26.883'	545	0.50	0.56	47.9	4.2
	439	47° 17.307'	61° 25.173'	518	1.24	0.20	119.7	1.9
	440	47° 17.319'	61° 23.519'	513	0.72	0.20	60.0	2.1
	441	47° 17.315'	61° 21.994'	515	4.40	0	368.6	0
	442	47° 17.308'	61° 20.230'	514	0.53	0	36.9	0
	443	47° 17.332'	61° 18.722'	510	0.46	0.27	36.6	5.7
	444	47° 17.320'	61° 17.118'	512	0	0.20	0	3.3
	445	47° 17.343'	61° 15.512'	530	0	0.64	0	9.6
	446	47° 17.331'	61° 13.860'	512	0.07	0.53	2.6	10.3
	447	47° 17.275'	61° 12.176'	513	0	0.66	0	14.4

Appendix 22. Density (number/100 m^2), yield (g/100 m^2) and average weight (g) of whelk egg masses (when present) by site and station in the 2016 research survey in Îles-de-la-Madeleine.

Site	Station	Density	Yield	Average weight	Species
1	105	0.07	1.7	25	*B. undatum*
	108	0.07	2.9	42.1	*B. undatum*
	109	0.07	43.8	635.8	*B. undatum*
2	207	0.26	109.5	419	*B. undatum*
	215	0.07	0.2	3.4	*Buccinum* sp.[1]
	216	0.07	1.6	21.9	*B. undatum*
	219	0.07	4.4	65.9	*B. undatum*
3	308	0.21	9.4	44.27	*B. undatum*
	315	0.12	3.9	31.9	*B. undatum*
	316	0.07	3.1	47.3	*B. undatum*
	318	0.19	31.4	168.7	*B. undatum*
	319	0.11	3.6	31.9	*B. undatum*
	320	0.10	3.5	36.6	*B. undatum*
	324	0.78	99.9	128.05	*B. undatum*
4	405	0.33	67.9	206.44	*B. undatum*
	406	0.20	32.0	161.5	*B. undatum*
	407	0.13	8.5	64.15	*B. undatum*
	408	0.26	24.3	92.93	*B. undatum*
	409	0.13	91.9	692.3	*B. undatum*
	416	0.07	3.1	47.9	*B. undatum*
	417	0.39	61.5	158.75	*B. undatum*
	418	0.40	87.1	220.18	*B. undatum*
	420	0.20	57.0	289.9	*B. undatum*
	421	0.06	8.7	134.4	*B. undatum*
	422	0.06	1.5	23.3	*Buccinum* sp.
	423	0.07	0.8	12.3	*Buccinum* sp.
	424	0.07	0.8	12.9	*Buccinum* sp.
	425	0.09	4.0	43.1	*B. undatum*
	428	0.07	1.1	17	*B. undatum*
	429	0.20	22.3	113.6	*B. undatum*
	431	0.06	16.8	260	*B. undatum*
	432	0.62	10.0	16.11	*B. undatum*
	432	0.19	4.8	25.4	*Buccinum* sp.
	434	0.09	3.7	43.6	*Buccinum* sp.
	436	0.06	3.8	58.8	*Buccinum* sp.
	438	0.06	1.7	28.1	*B. undatum*
	439	0.07	3.0	46	*B. undatum*
	440	0.13	10.6	80.75	*B. undatum*
	441	0.85	195.3	228.88	*B. undatum*
	441	0.07	0.2	2.6	*Buccinum* sp.
	442	0.20	48.4	245.27	*B. undatum*
	443	0.13	89.4	674.25	*B. undatum*
	444	0.07	2.4	35.7	*Buccinum* sp.
	445	0.13	2.4	18.55	*Buccinum* sp.
	446	0.07	1.4	21.6	*Buccinum* sp.

[1] *Buccinum* other than *B. undatum*.