



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Ecosystems and
Oceans Science

Sciences des écosystèmes
et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2023/073

Quebec Region

Stock assessment of whelks in Quebec: Results from the commercial fishery (2002 – 2021) and scientific surveys (2005 – 2019)

Bruno L. Gianasi

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

Foreword

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

Published by:

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

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



© His Majesty the King in Right of Canada, as represented by the Minister of the
Department of Fisheries and Oceans, 2023

ISSN 1919-5044

ISBN 978-0-660-68079-8 Cat. No. Fs70-5/2023-073E-PDF

Correct citation for this publication:

Gianasi, B.L. 2023. Stock assessment of whelks in Quebec: Results from the commercial fishery (2002 – 2021) and scientific surveys (2005 – 2019). DFO Can. Sci. Advis. Sec. Res. Doc. 2023/073. ix + 62 p.

Aussi disponible en français :

Gianasi, B.L. 2023. Évaluation des stocks de buccin au Québec : Résultats de la pêche commerciale (2002 – 2021) et du relevé de recherche (2005 – 2019). Secr. can. des avis sci. du MPO. Doc. de rech. 2023/073. ix + 62 p.

TABLE OF CONTENTS

| | |
|--|----|
| ABSTRACT | ix |
| INTRODUCTION | 1 |
| BIOLOGY | 1 |
| MATERIAL AND METHODS | 2 |
| COMMERCIAL FISHERY | 2 |
| Management measures of the commercial fishery | 4 |
| RESEARCH | 4 |
| Upper North Shore Survey | 4 |
| Sexual maturity of Females and re-evaluation of minimum legal size | 5 |
| COMMERCIAL FISHERY RESULTS | 5 |
| NORTH SHORE | 7 |
| Fishing Area 1 | 7 |
| Fishing Area 2 | 9 |
| Fishing Area 3 | 12 |
| Fishing Areas 4 and 5 | 14 |
| Fishing Area 6 | 17 |
| Fishing Area 7 | 19 |
| Fishing Area 8 | 22 |
| GASPÉ–LOWER ST. LAWRENCE | 24 |
| Fishing Area 12 | 24 |
| Fishing Area 13 | 27 |
| ÎLES-DE-LA-MADELEINE | 30 |
| Fishing Area 15 | 30 |
| RESEARCH | 33 |
| SEXUAL MATURITY OF FEMALES AND RE-EVALUATION OF MINIMUM LEGAL SIZE | 33 |
| UPPER NORTH SHORE SURVEY | 34 |
| ACKNOWLEDGEMENTS | 43 |
| REFERENCES CITED | 43 |
| APPENDICES | 45 |

LIST OF TABLES

| | |
|--|----|
| Table 1. Average size at which 50% of female whelks are sexually mature (T_{50}), current minimal legal size (MLS) and suggested MLS during the 2022 peer review for some fishing areas (in grey)..... | 34 |
| Table 2. Average whelk density (number/100 m ² ± standard error) by size class and egg mass by site and year in research surveys in Upper North Shore. | 35 |
| Table 3. 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 Upper North Shore..... | 39 |

LIST OF FIGURES

| | |
|--|----|
| Figure 1. Fishing areas (Areas 1 to 15) and known distribution (red circles) of whelks in Québec (source: logbooks, commercial sampling program, research surveys and exploratory fishing).... | 1 |
| Figure 2. Annual landings by the commercial whelk fishery by region of Quebec..... | 6 |
| Figure 3. Annual landings and effort (number of traps hauled) for the commercial whelk fishery for all of Québec..... | 6 |
| Figure 4. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 1 in 2021..... | 7 |
| Figure 5. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 1..... | 8 |
| Figure 6. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 1..... | 8 |
| Figure 7. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 1..... | 9 |
| Figure 8. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 2 in 2021..... | 9 |
| Figure 9. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 2..... | 10 |
| Figure 10. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 2..... | 11 |
| Figure 11. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 2..... | 11 |
| Figure 12. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 3 in 2021..... | 12 |
| Figure 13. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 3..... | 13 |
| Figure 14. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 3..... | 13 |
| Figure 15. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 3..... | 14 |
| Figure 16. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Areas 4 and 5. Data from both areas have been grouped together to maintain confidentiality..... | 15 |
| Figure 17. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Areas 4 and 5. Data from both areas have been grouped together to maintain confidentiality..... | 15 |
| Figure 18. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 4..... | 16 |
| Figure 19. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 5..... | 16 |

| | |
|--|----|
| Figure 20. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 6 in 2021. | 17 |
| Figure 21. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 6. | 18 |
| Figure 22. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 6. | 18 |
| Figure 23. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 6. | 19 |
| Figure 24. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 7 in 2019. | 20 |
| Figure 25. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 7. | 20 |
| Figure 26. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 7. There is not enough information to calculate standardized CPUE in 2019 and 2020, and there was no fishing in 2021. | 21 |
| Figure 27. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 7. | 21 |
| Figure 28. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 8 in 2021. | 22 |
| Figure 29. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 8. | 23 |
| Figure 30. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 8. | 23 |
| Figure 31. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 8. | 24 |
| Figure 32. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 12 in 2021. | 25 |
| Figure 33. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 12. | 26 |
| Figure 34. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 12. | 26 |
| Figure 35. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 12. | 27 |
| Figure 36. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 13 in 2021. | 28 |
| Figure 37. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 13. | 29 |
| Figure 38. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 13. | 29 |
| Figure 39. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 13. | 30 |

| | |
|--|----|
| Figure 40. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 15 in 2021. | 31 |
| Figure 41. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 15. | 32 |
| Figure 42. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 15. | 32 |
| Figure 43. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 15. | 33 |
| Figure 44. Density (number/100 m ²) of all whelks (\geq 20 mm) and whelks of legal size (\geq 70 mm) per station during research surveys in Forestville. | 36 |
| Figure 45. Density (number/100 m ²) of all whelks (\geq 20 mm) and whelks of legal size (\geq 70 mm) per station during research surveys in Pointe-aux-Outardes. | 37 |
| Figure 46. Density (number/100 m ²) of all whelks (\geq 20 mm) and whelks of legal size (\geq 70 mm) per station during research surveys in Baie-Comeau. | 38 |
| Figure 47. Whelk size structure obtained from Forestville research surveys. The vertical line in the right panel (A) represents the minimum legal size of 70 mm and the red diamond represents the median size. | 40 |
| Figure 48. Whelk size structure obtained from Pointe-aux-Outardes research surveys. The vertical line represents the minimum legal size of 70 mm and red diamond represents the median size. | 41 |
| Figure 49. Whelk size structure obtained from Baie-Comeau research surveys. The vertical line represents the minimum legal size of 70 mm and the red diamond represents the median size. | 42 |

LIST OF 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 proportion of <i>B. undatum</i> (density) of all Buccinum by site and by year in the Upper North Shore and Îles-de-la-Madeleine research surveys..... | 45 |
| Appendix 2. Photographs of the various Buccinum species observed since 2009 in the Upper North Shore and Îles-de-la-Madeleine research surveys, and an example of an unidentified Buccinum (photographers: M. Boudreau DFO 2010 and S. Brulotte DFO 2015). | 45 |
| Appendix 3. Number of whelk specimens collected by region, fishing area and year as part of DFO's landed commercial catch sampling program. | 46 |
| Appendix 4. Number of whelks measured by region, fishing area and year through DFO's landed commercial catch sampling program. | 47 |
| Appendix 5. Identification of the various whelk measurements. (Photos : N. Paille DFO)..... | 48 |
| Appendix 6. Management measures for the 2021 commercial whelk fishery. | 48 |
| Appendix 7. Location A) of the whelk research survey sampling sites and commercial whelk fishery, and sampling stations at B) Forestville, C) Pointe-aux-Outardes and D) Baie-Comeau. | 49 |
| Appendix 8. Parameters of linear relationships between total live weight in g (y) and height in mm (x) of <i>Buccinum undatum</i> from research surveys conducted in Forestville, Pointe-aux-Outardes and Baie-Comeau since 2005..... | 51 |
| Appendix 9. Commercial whelk fishery landings (t) by fishing area and for Québec as a whole. | 52 |
| Appendix 10. Commercial whelk fishing effort (number of trap hauls) by region, fishing area and for Québec as a whole. | 53 |
| Appendix 11. Annual average of standardized catch per unit effort (kg/trap) by region and fishing area, according to commercial whelk logbook..... | 54 |
| Appendix 12. Annual median size (mm) of whelk landed by region and fishing area during the commercial whelk fishery..... | 55 |
| Appendix 13. Percentage (%) of sub-legal size whelk in commercial whelk fishery landings by region and fishing area. See Appendix 6 for legal sizes in the various fishing areas. | 56 |
| Appendix 14. 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 2019 research survey in Upper North Shore..... | 57 |
| Appendix 15. Density (number/100 m ²), yield (g/100 m ²) and average weight (g) of <i>Buccinum undatum</i> egg masses (when present) by site and station in the 2019 research survey in Upper North Shore..... | 60 |

ABSTRACT

The Waved whelk, *Buccinum undatum*, is a gastropod mollusc that is found along the Estuary and Gulf of St. Lawrence. In Quebec, it can reach a shell height of 120–130 mm, but individuals larger than 105 mm are increasingly rare. Its growth rate is fairly slow and its life span is at least 15 years.

There are 15 whelk fishing areas in Québec. The whelk fishery is an inshore fishery that uses traps. It 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 which varies according to the fishing areas. Quotas on landings are in place in six areas. The stock status is determined primarily based of commercial fishery indicators.

In 2021, Quebec landings totalled 910 t, of which 73% were from the North Shore, 18% from the Îles-de-la-Madeleine and 8% from the Gaspé Peninsula–Lower St. Lawrence. Landings had decreased in most fishing areas compared to 2017. For areas managed by a total allowable catch (TAC), landings were below the TAC in Areas 1, 12, 13 and 15; however, landings exceeded the TAC by 4.2 t (3.8% of the current TAC) in Area 2. The percentage of undersized whelk landed was below 4%, except in Area 8 (5.8%). The trend in catch per unit effort (CPUE) over the 2018-2021 period is positive in Area 8, relatively stable in Areas 1 and 2, and declining in Areas 3, 4-5, 6, 12, 13, and 15. More specifically, the stock status in some areas of the Gaspé Peninsula (Areas 12 and 13), the Middle North Shore (Areas 3, 4, 5 and 6) and the Îles-de-la-Madeleine (Area 15) is of concern. These stocks do not seem to be able to sustain the current fishing effort over the long term and are therefore vulnerable to overexploitation and local depletion. According to a recent assessment, the minimum legal size (MLS) should be adjusted to the average size at which 50% of female *Buccinum undatum* are sexually mature (T_{50}). Such an adjustment would represent an increase in MLS for Areas 4, 5, 6, 7, 8, 12 and 13.

The research survey conducted in 2019 in Areas 1 and 2 showed that the density of commercial size whelks (≥ 70 mm) decreased from 2017 at Forestville, Pointe-aux-Outardes and Baie-Comeau sites. In addition, total whelk density (≥ 20 mm) was significantly lower than the highest value observed historically.

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. This fishery expanded to the North Shore in the early 1990s and to the Îles-de-la-Madeleine in 2003. It has been more intensive in the Gaspé Peninsula – Lower St. Lawrence 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. 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, with some exceptions. The most recent review was conducted on April 29, 2022. In support of this review, this document presents the data, techniques, analyses, and findings of this assessment following the 2021 fishing season. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada Science Advisory Schedule](#) as they become available.

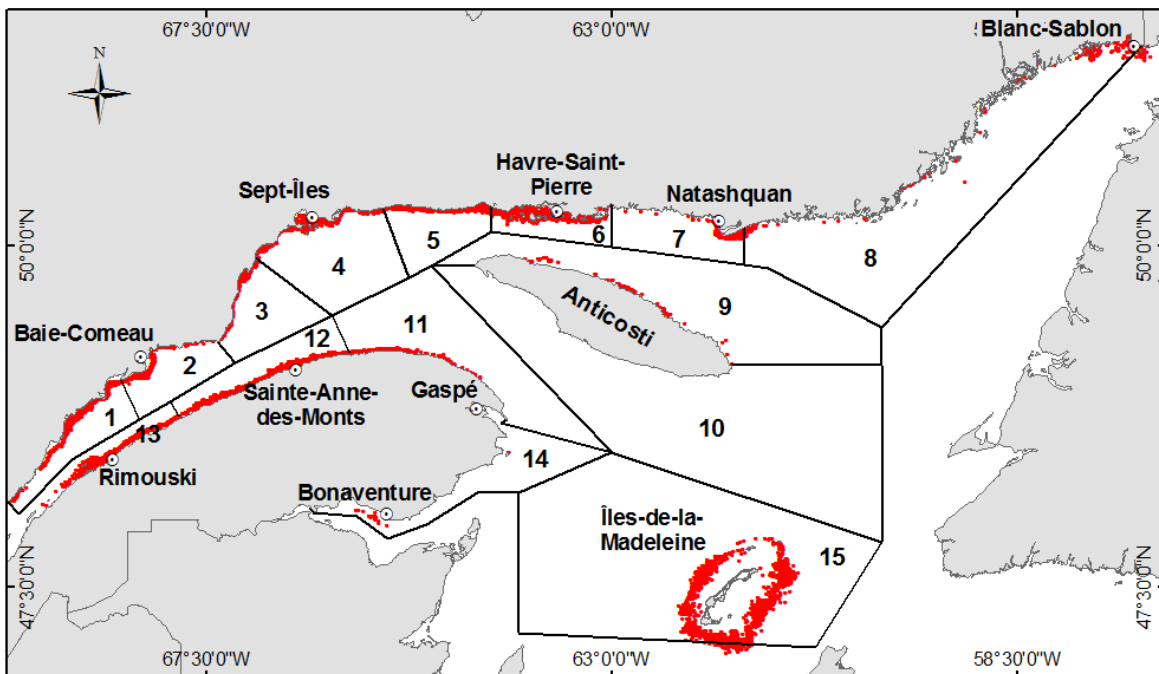


Figure 1. Fishing areas (Areas 1 to 15) and known distribution (red circles) of whelks in Québec (source: logbooks, commercial sampling program, research surveys and exploratory fishing).

BIOLOGY

The Waved whelk, *Buccinum undatum*, is a gastropod mollusc found along the western Atlantic coast from New Jersey to Arctic, 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 predatory carnivore and a scavenger (Himmelman and

Hamel 1993). It feeds mostly on invertebrates, primarily Polychaetes, Molluscs and Echinoderms (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, but individuals larger than 105 mm are increasingly rare. Its life span is at least 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 Peninsula, 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 have 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 Upper North Shore region and in the Îles-de-la-Madeleine, the species *B. glaciale*, *B. totteni*, *B. scalariforme* and *B. undatum* (WoRMS 2021) were found along with some individuals that could not be identified to the species level¹ However, the main species is *B. undatum*, which accounted for more than 90% of the whelks collected during the research surveys (Appendices 1 and 2).

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 do not include estimates for unreported landings. Whelk logbooks, introduced in 2001, are

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.

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 aims to sample organisms at dock 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 size (mm) of landed whelk;
- Percentage (%) of sub-legal size whelk 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. Annual landings are the aggregate of all commercial fishing activities. Fishing effort has been compiled from logbooks since 2002². 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 (area-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 box plot on which the minimum legal size is shown.

The reference median of CPUE and size is calculated for each fishing area over the entire data period, excluding the last three years. In the Îles-de-la-Madeleine, the reference median excludes the years 2014-2016 due to the low temperatures observed during the 2014 season at fishing sites and the high presence of shell-boring polychaetes, which may have affected CPUE during these years.

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

Where there are fewer than five 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. From 2018 to 2021, data on landings, fishing effort and CPUE have been grouped for Areas 4 and 5 in order to respect confidentiality.

Management measures of the commercial fishery

Various management measures have been put in place since 1999. 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 (Appendix 6).

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, to 240 in 2017 and to 229 in 2021. However, there were only 59 active licences in 2021. The number of traps allocated to inactive fishermen was also reduced in 1999 and 2006 in order to decrease potential effort. In 2021, 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 100 to 1,650 traps per fishing area. In 2021, between 0% and 100% of traps were active depending on the fishing area (Appendix 6).

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. They were respectively 491, 109, 32, 75, 82 and 330 t in 2021. The minimum legal size varies from 70 to 80 mm depending of the fishing areas (see sexual maturity results for an update and a new proposal for the minimum legal size in several fishing areas).

RESEARCH

Upper North Shore Survey

A research survey has been conducted every two years, with some exceptions, in the Forestville, Pointe-aux-Outardes and Baie-Comeau sites along the Upper North Shore in the fishing Areas 1 and 2 (Appendix 7). 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.

The survey is generally carried out in July and August 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 7). 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 width (4 x 0.76 m) and distance.

All individuals of the genus *Buccinum* are collected, identified to species, counted, and measured (shell height to the nearest mm). A stratified subsample (at least 4 whelks per mm of height) was preserved by site (Forestville, Pointe-aux-Outardes and Baie-Comeau), 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 weighed at each station.

Different variables are compiled on the individuals collected (sub-sample). A sequential number was assigned to each individual. The height (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 preserved for age determination.

Due to the mesh-size used in the 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 8). Density (number/100 m²) and yield (g/100 m²) 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 (\pm 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, with a significance threshold of 0.05. The Tukey test was used for post hoc comparisons (Ricker 1980). Size structure histograms are presented by year and site.

Sexual maturity of Females and re-evaluation of minimum legal size

The size at sexual maturity is greater in female than in male whelks (Brulotte 2015). Thus, the minimum legal size (MLS) is based on the size of females. Since 2013, *Buccinum undatum* samples have been collected during commercial fishing activities and DFO research surveys to assess the average size (shell height) at which 50% of individuals are sexually mature (T_{50}). However, current MLSs are still below T_{50} in some fishing areas. In 2022, T_{50} was reassessed in some fishing areas with new samples collected in 2013 and between 2018 and 2021. The new samples came from Areas 1 and 2 (2013 and 2019 research surveys), Area 13 (2018; 3 samples), Area 8 (2021; 1 sample) and Area 15 (2021; 10 commercial size samples from the fishery). One sample corresponds to 150 whelks. According to this assessment, an increase in the minimum legal size was proposed in certain fishing areas during the 2022 peer review in order to better adjust to the T_{50} and ensure the sustainability of this resource (see result section on sexual maturity).

COMMERCIAL FISHERY RESULTS

From 1993 to 1998, annual landings ranged from 493 t to 1,032 t and were primarily from the North Shore (Figure 2 and Appendix 9). 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 900 t and 1,484 t. In 2022, they were 910 t, which 73% of it were from the North Shore, 8% from the Gaspé–Lower St. Lawrence and 18% from the Îles-de-la-Madeleine. Landings decreased in many fishing areas relative to 2017. For areas managed by a total allowable catch (TAC), landings were below the TAC in Areas 1, 12, 13 and 15; however, it exceeded the TAC by 4.2 t (3.8% of the current TAC) in Area 2.

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 3 and Appendix 10). 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 151,500 to 261,900 trap hauls per year. In 2021, there were 156,200 trap hauls in Quebec.

Area 10 has not been fished since 1997, 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.

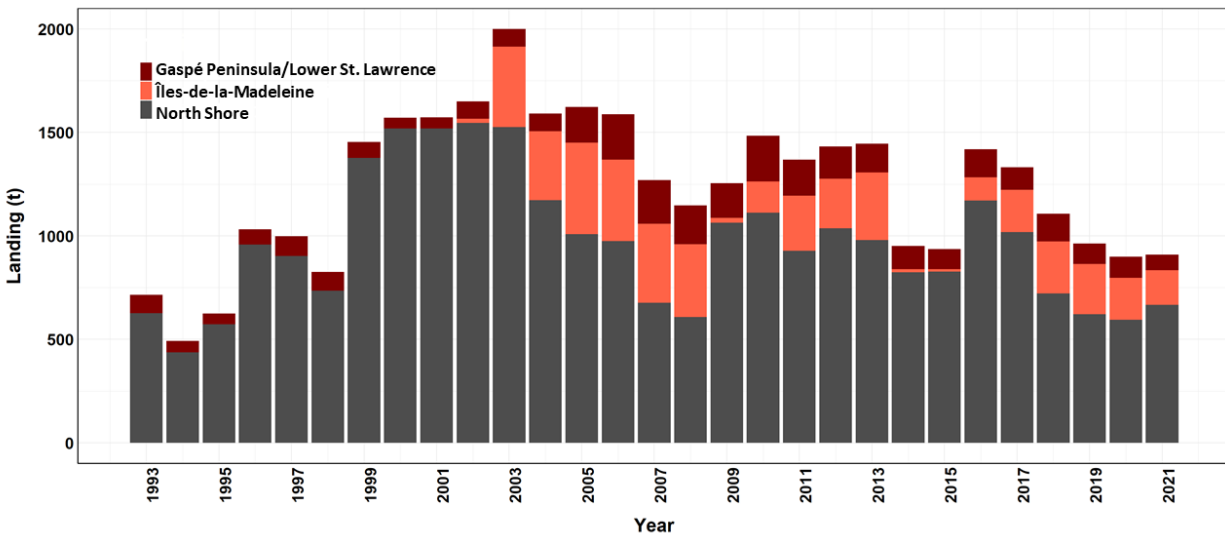


Figure 2. Annual landings by the commercial whelk fishery by Quebec region.

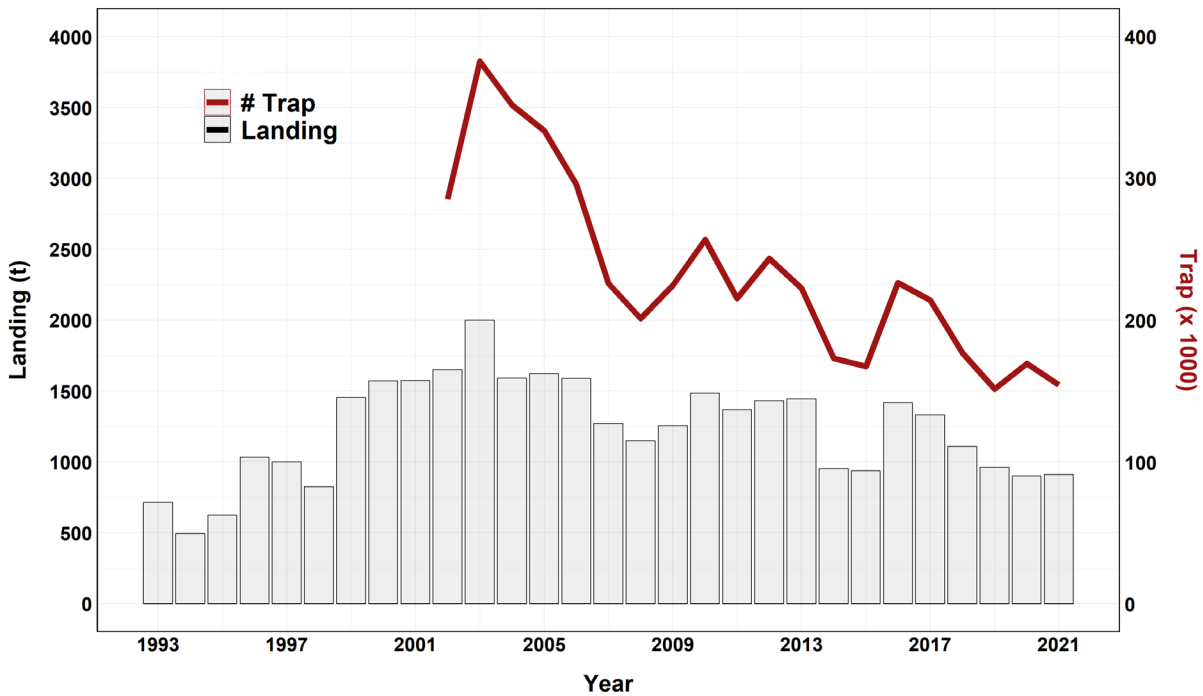


Figure 3. Annual landings and effort (number of traps hauled) for the commercial whelk fishery for all of Québec.

NORTH SHORE

Fishing Area 1

Fishing Area 1 extends from Pointe Rouge (Tadoussac) to Pointe du Bout at Pointe-aux-Outardes. For several years, commercial fishing has been concentrated mainly in the central-eastern portion of the area (Figure 4). In 2021, there were 7 active licences in this area of a total of 8 licences issued (Appendix 6).

Landings greater than 500 t were recorded in 2000, 2001 and 2002 (Figure 5 and Appendix 9). From 2003 to 2020, landings ranged from 114 t to 428 t and in 2021, landings were 260 t, or 28% of Québec landings. A preventive 491 t TAC was introduced in 2003 to limit exploitation in this area, but the TAC has never been reached.

Fishing effort decreased from close to 50,700 trap hauls in 2002 to 13,600 trap hauls in 2012. In 2021, effort was 29,900 trap hauls. Changes in landings are largely attributable to changes in fishing effort (Figure 5 and Appendix 10).

From 2001 to 2004, CPUE declined from 12.8 to 6.6 kg/trap, the lowest value in the series (Figure 6 and Appendix 11). Subsequently, CPUE were fairly stable and ranged from 6.8 to 8.8 kg/trap until 2012. Between 2013 and 2017, CPUE increased to 15 kg/trap. From 2018 onwards, there is a strong downward trend. In 2021, the CPUE was 8.8 kg/trap, close to the reference median.

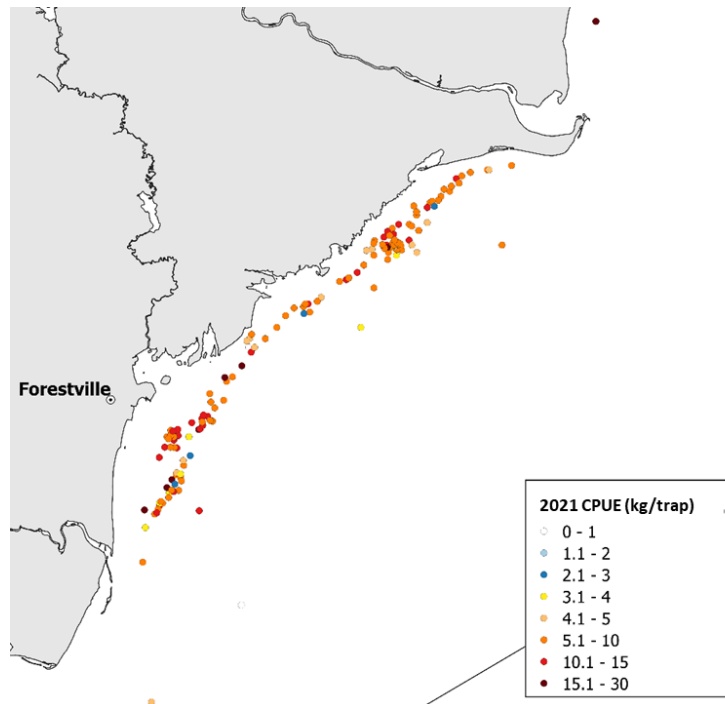


Figure 4. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 1 in 2021.

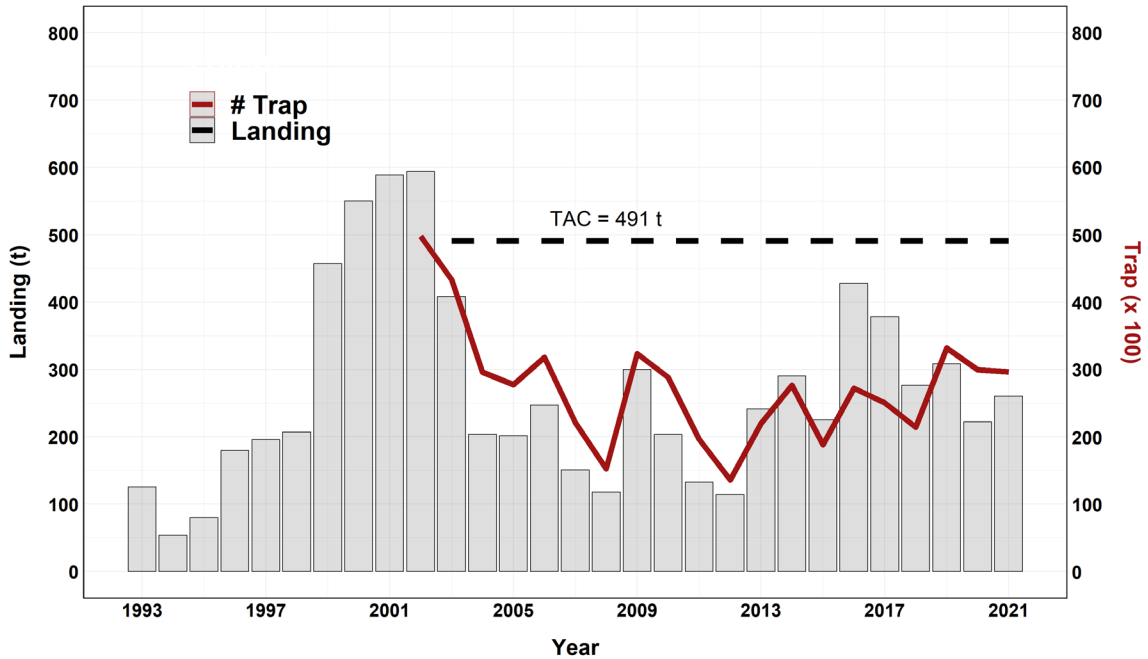


Figure 5. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 1.

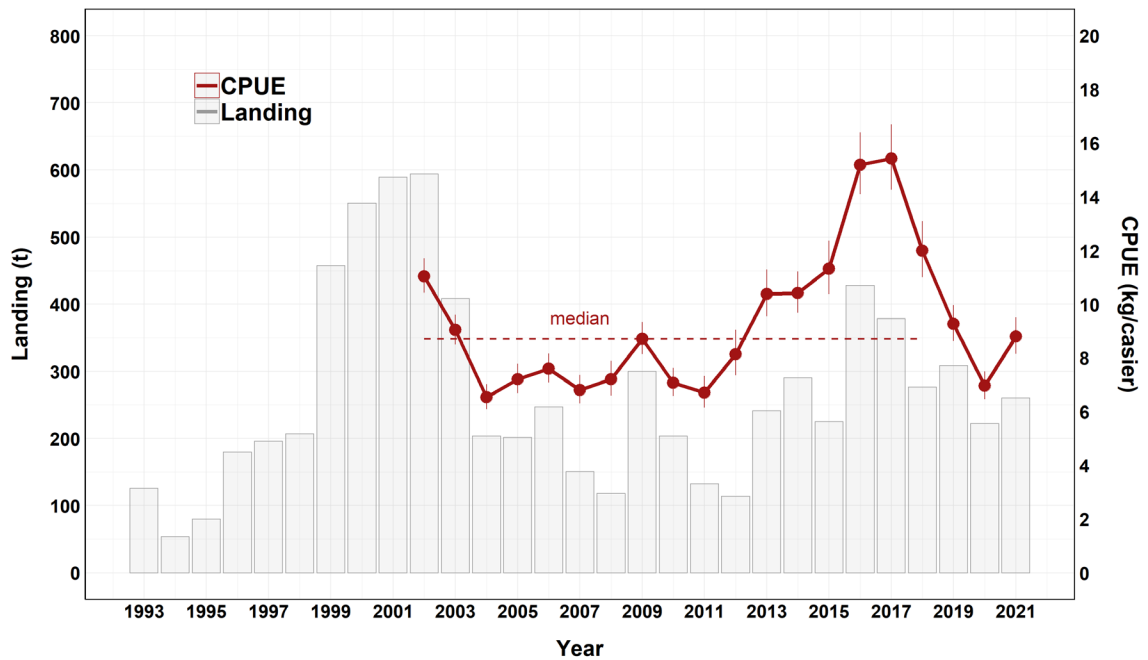


Figure 6. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 1.

Since 2014, the median size of landed whelk has been relatively stable, varying around 80 mm (Figure 7 and Appendix 12). In 2021, the median size was 83 mm, but is comparatively low compared to other fishing areas. Since 2011, the percentage of undersized landed whelks has generally been between 1.6% and 10% (Figure 7 and Appendix 13).

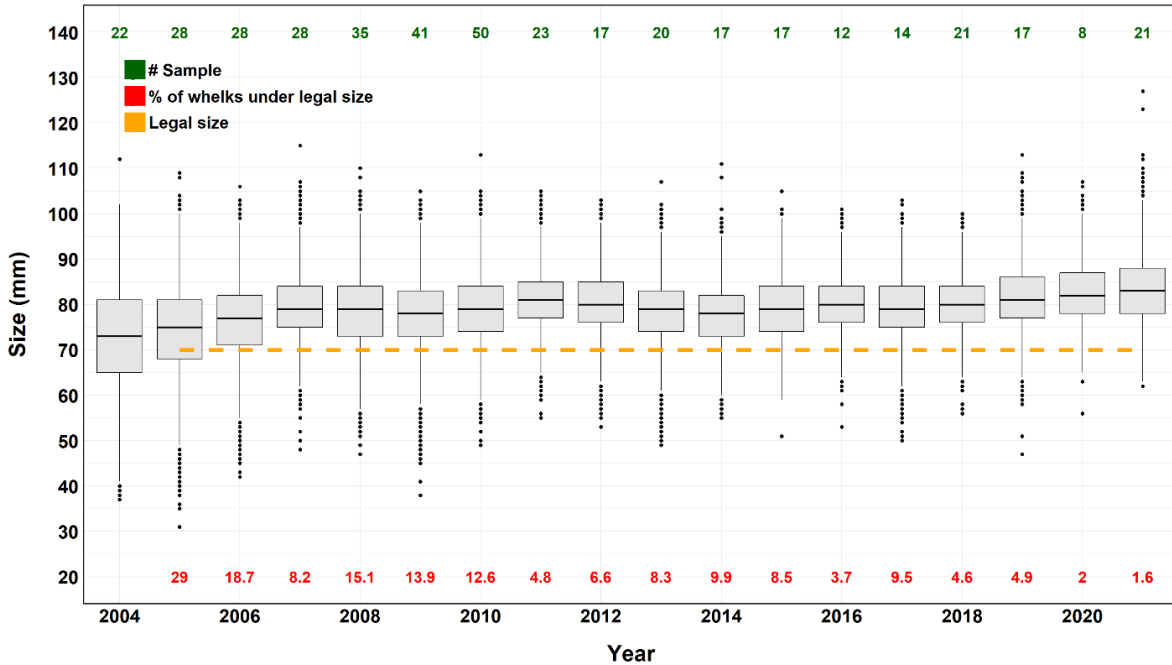


Figure 7. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 1.

Fishing Area 2

Fishing Area 2 extends from the Pointe du Bout at Pointe-aux-Outardes to Pointe-des-Monts. In recent years, fishing has been concentrated in the Baie-Comeau area (Figure 8). Three or four licences have been active since 2007. In 2021, there were four active licences for 480 traps out of a total of 6 licences issued and 550 authorized traps (Appendix 6).

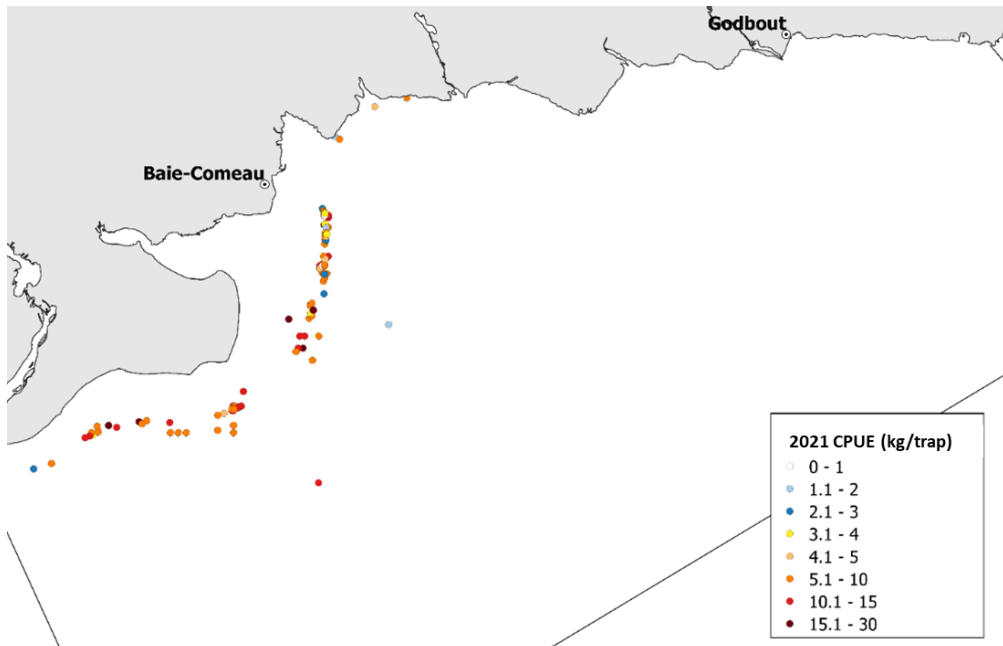


Figure 8. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 2 in 2021.

Landings from this area were quite high from 2000 to 2003 with values ranging from 119 t to 207 t (Figure 9, Appendix 9). Subsequently, landings decreased. Landings and fishing effort from 2006 to 2017 are confidential, given the low number of active fishermen. A preventive 109 t TAC was introduced in 2003 to limit landings. Since 2018, landings have increased rapidly, reaching 113 t in 2021, exceeding the TAC by 4 t (or 3.8% of the current TAC).

Fishing effort fluctuated between 8,100 trap hauls in 2002 to 14,700 trap hauls in 2005. Since 2018, effort has increased, reaching 12,200 traps hauls in 2021 (Figure 9 and Appendix 10). Changes in landings are largely attributable to changes in fishing effort.

CPUE for this area fluctuated between 8 and 15 kg/trap. In 2021, the CPUE was 9.6 kg/trap, slightly below the historical median (Figure 10 and Appendix 11).

Since 2012, size of landed whelks vary slightly from year to year (Figure 11). The median size of landed whelk is similar to Area 1, but lower than other areas (Appendix 12). Since 2014, the proportion of sub-legal size whelk in landings has been between 2% and 8%, a marked improvement over previous years (Appendix 13).

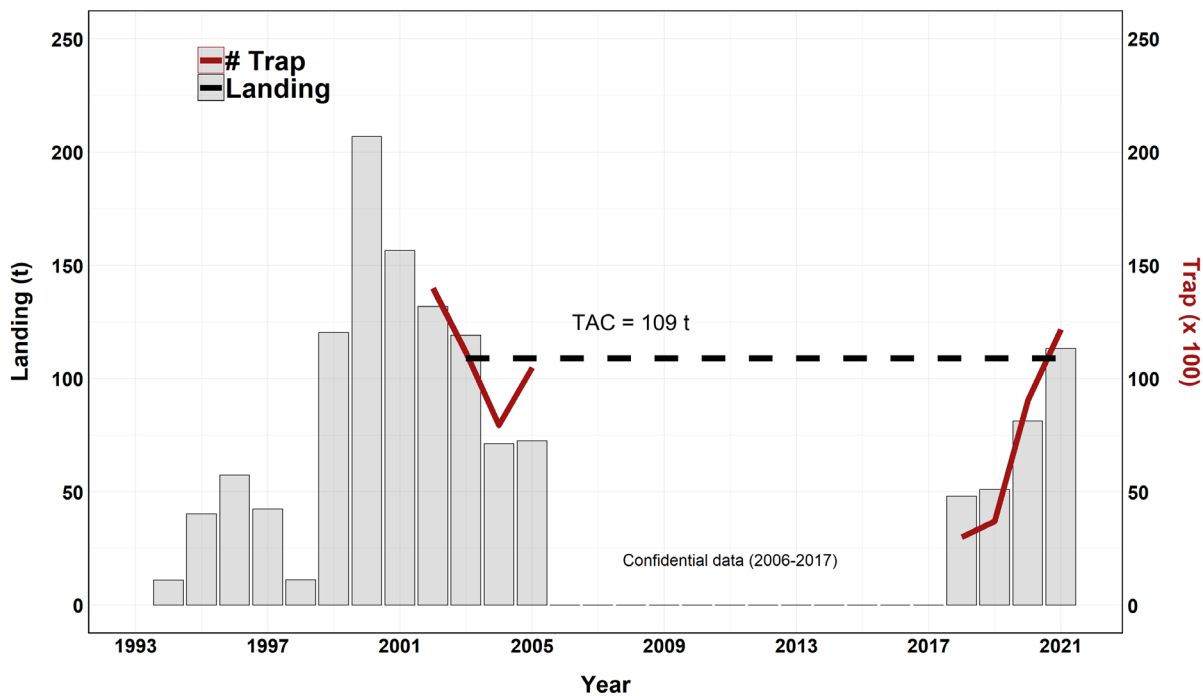


Figure 9. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 2.

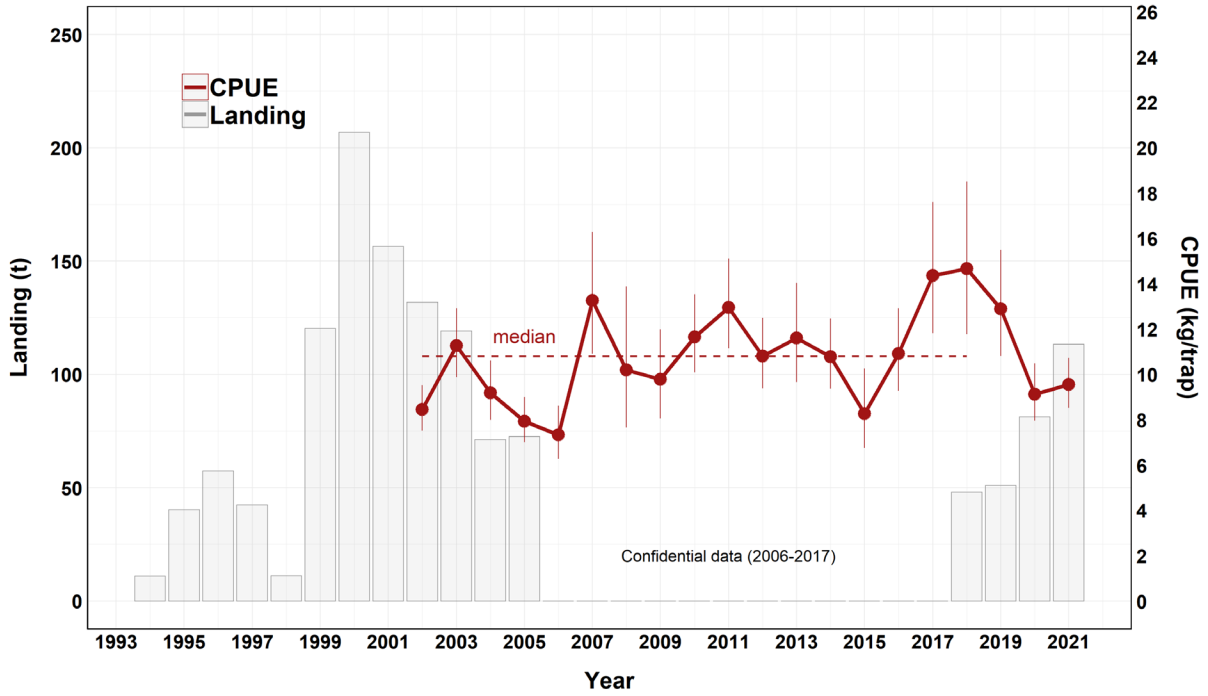


Figure 10. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 2.

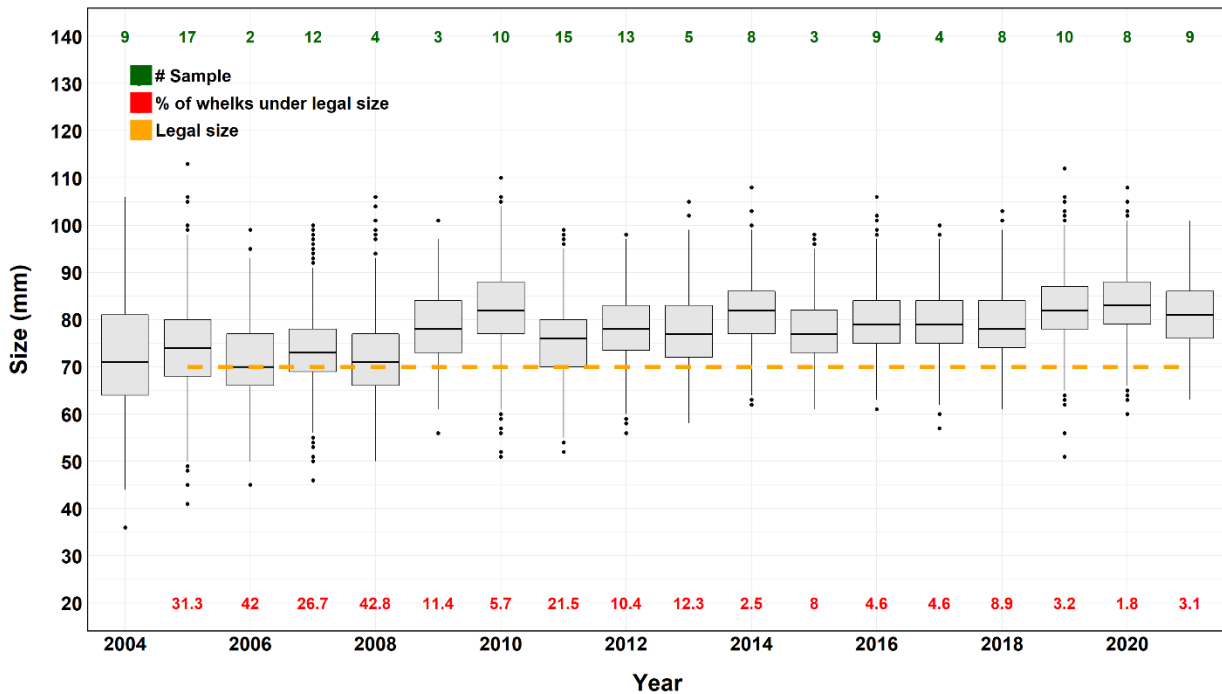


Figure 11. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 2.

Fishing Area 3

The boundaries of Fishing Area 3 extend from Pointe-des-Monts in the west to Pointe Jambon in the east. The areas near Baie-Trinité and east of Rivière-Pentecôte have been the most visited since 2014 (Figure 12). The number of active fishermen is usually low. In 2021, there were one active licence for 100 traps out of a total of seven licences issued and 850 authorized traps (Appendix 6).

Landings peaked at 52 t in 2001 (Figure 13 and Appendix 9). Then, they have decreased to less than 10 t in recent years. The fishing effort has also been low since 2013; it was 1,600 trap hauls in 2021 (Figure 13 and Appendix 10).

Since 2010, the average CPUE values have declined to 1.9 kg/trap in 2020 and 2.7 kg/trap in 2021, the lowest value in the series (Figure 14 and Appendix 11). The 2021 CPUE is 38% lower than the historical median for this area.

In this area, landed whelk sampling is sporadic. According to the most recent sampling campaign in 2016 and 2018, the median size was 97 mm and 93 mm (Appendix 12). The percentage of sub-legal size whelk in landings varied between 0 and 1.3% (Figure 15 and Appendix 13).

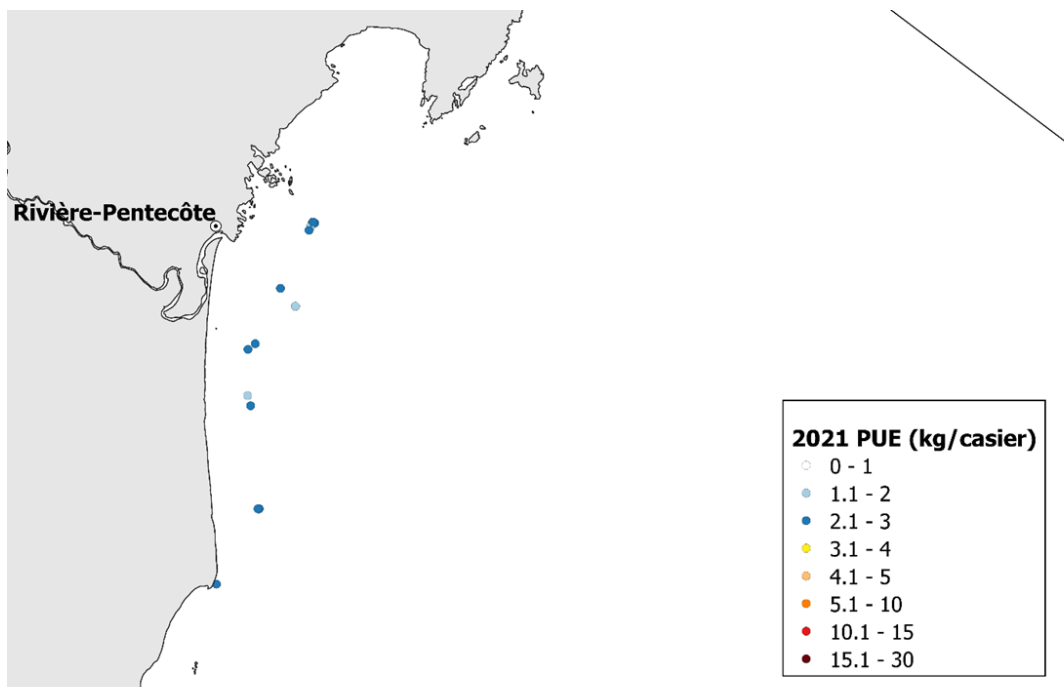


Figure 12. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 3 in 2021.

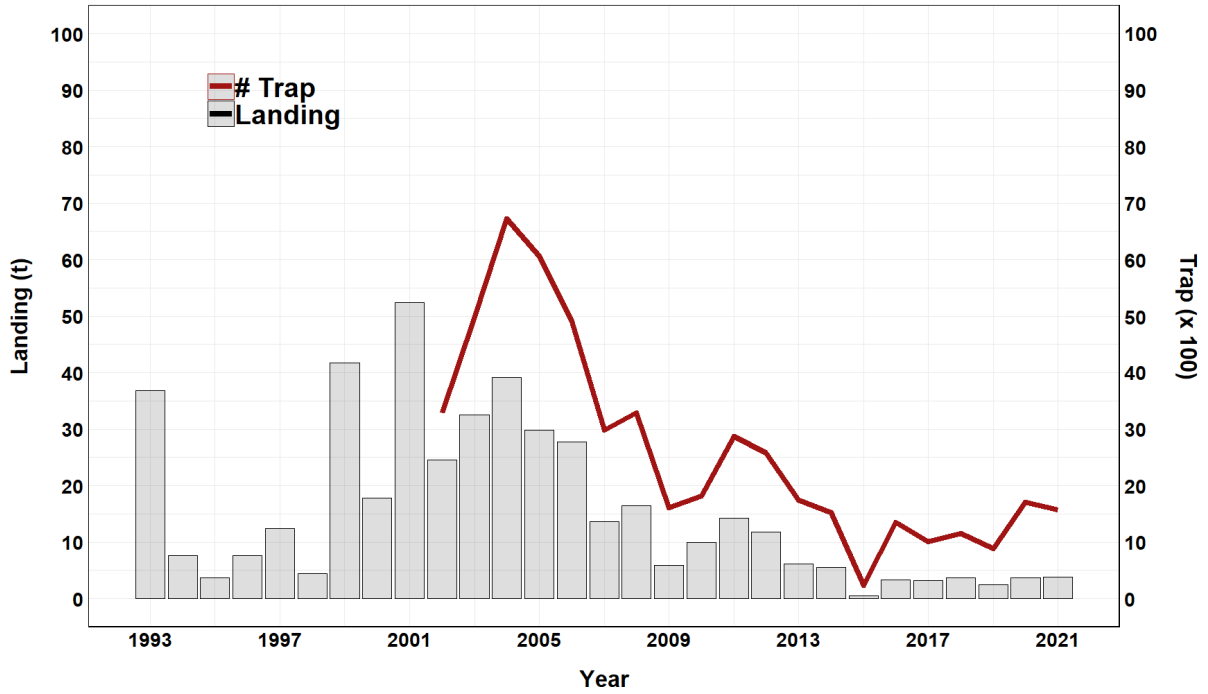


Figure 13. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 3.

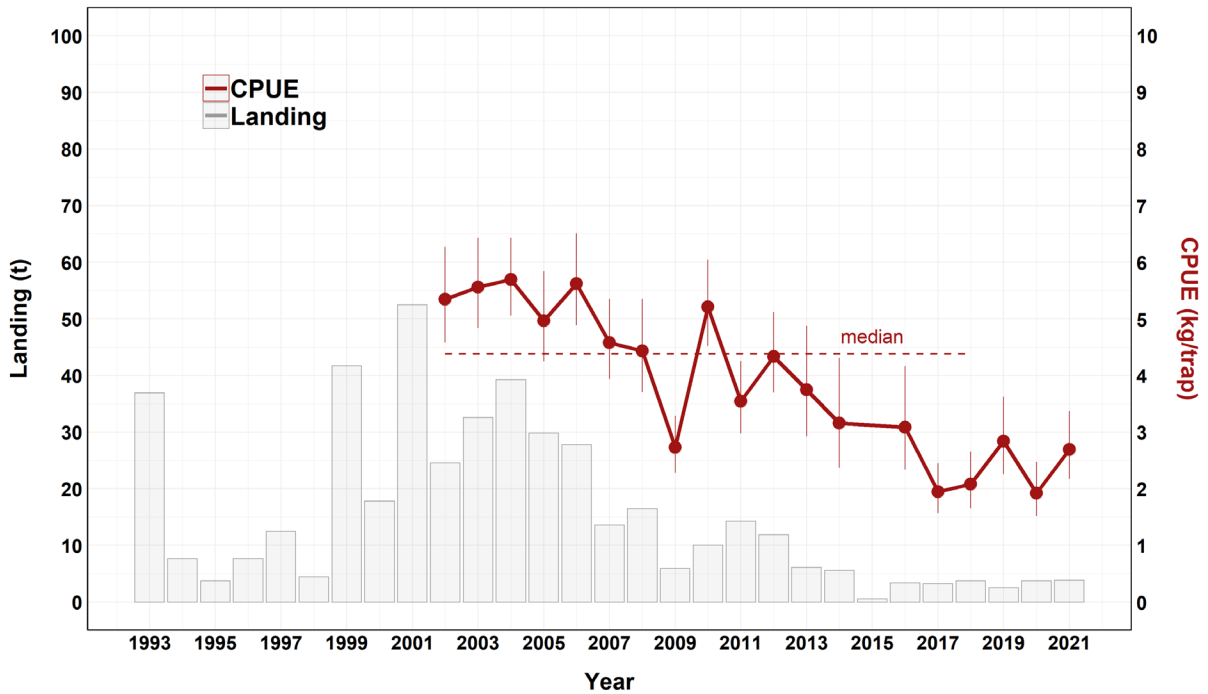


Figure 14. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 3.

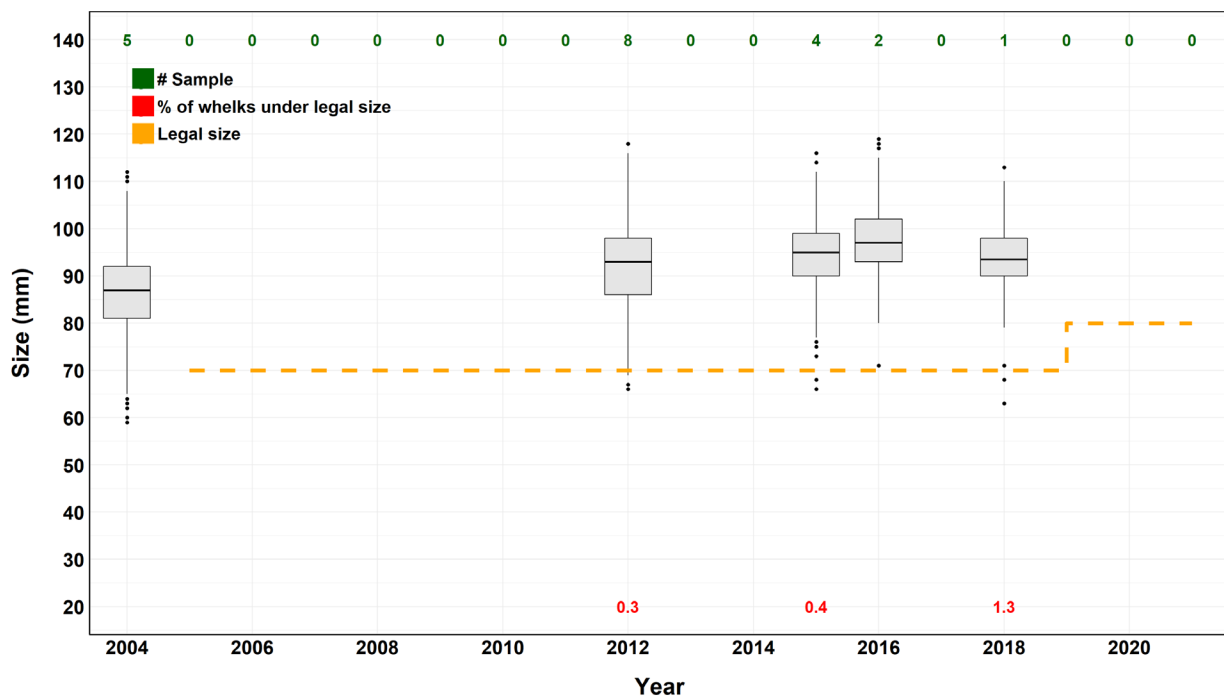


Figure 15. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 3.

Fishing Areas 4 and 5

For this assessment, data from Areas 4 and 5 were grouped to respect data confidentiality given the low number of active licences since 2017.

Fishing Area 4 extends from Pointe Jambon to Cap du Cormoran (Rivière-au-Tonnerre). In recent years, commercial fishery has covered the central portion of the area in the Moisie Bay sector and farther west. In 2021, there were 3 active licences of a total of 27 licences issued (Appendix 6). Fishing Area 5 extends from Cap du Cormoran (Rivière-au-Tonnerre) to Rivière Saint-Jean and 4 of the 17 licences issued were active. In 2021, a total of 835 traps had been used in these two areas, out of a total of 4,109 authorized traps (Appendix 6).

Aggregate landings for Areas 4 and 5 fluctuated between 233 and 560 t from 1993 to 2013. After 2017, annual landings declined. In 2021, they were 49 t (Figure 16 and Appendix 9). Fishing effort peaked in 2003 and 2004, with over 164,300 traps hauls. Thereafter, effort declined considerably. It stood at 24,200 traps hauls in 2021 for both areas (Figure 16 and Appendix 10).

CPUE were fairly stable, but low, from 2002 to 2008 at around 3.5 kg/trap (Figure 17 and Appendix 11). Between 2012 and 2016, CPUE rose to 4-5 kg/trap and were above the historical median. However, CPUE has decreased considerably since 2017, remaining at 2.1 kg/trap until 2021, the lowest values of the historical series.

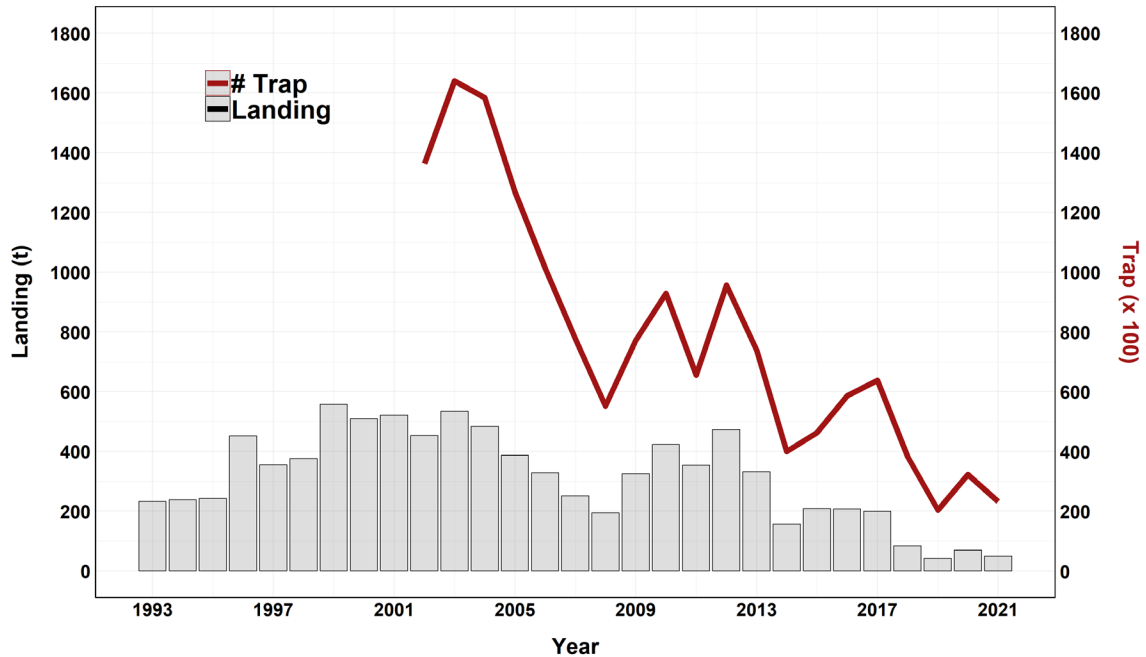


Figure 16. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Areas 4 and 5. Data from both areas have been grouped together to maintain confidentiality.

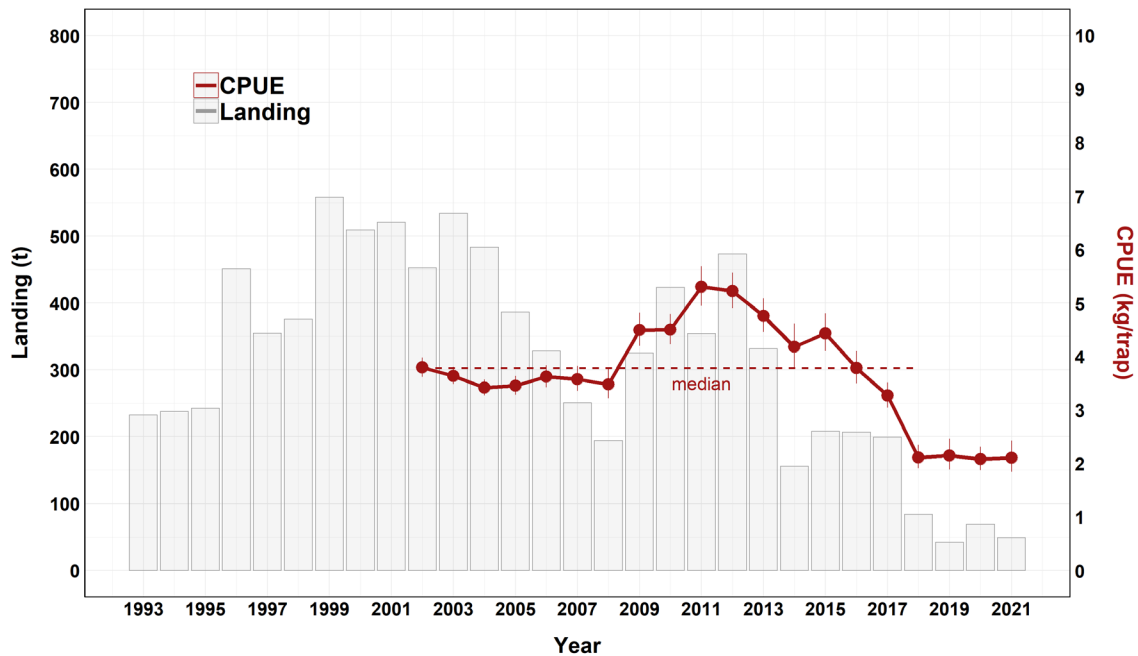


Figure 17. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Areas 4 and 5. Data from both areas have been grouped together to maintain confidentiality.

In 2021, the median size of landed whelks has increased from 94 mm in 2013 to 100 mm in Area 4 (Figure 18 and Appendix 12). Size structures are varied with maximum sizes occasionally reaching 120 mm. In the last three years, sub-legal size whelk accounted for less than 2% of landings (Figure 18 and Appendix 13).

In Area 5, the median size of landed whelk has been gradually increasing since 2014 (Figure 19 and Appendix 12). In 2021, median size of landed whelks reached 97 mm. The percentage of sub-legal size whelk in landings has remained below 5%, except in 2019 with 6.8% (Figure 19 and Appendix 13).

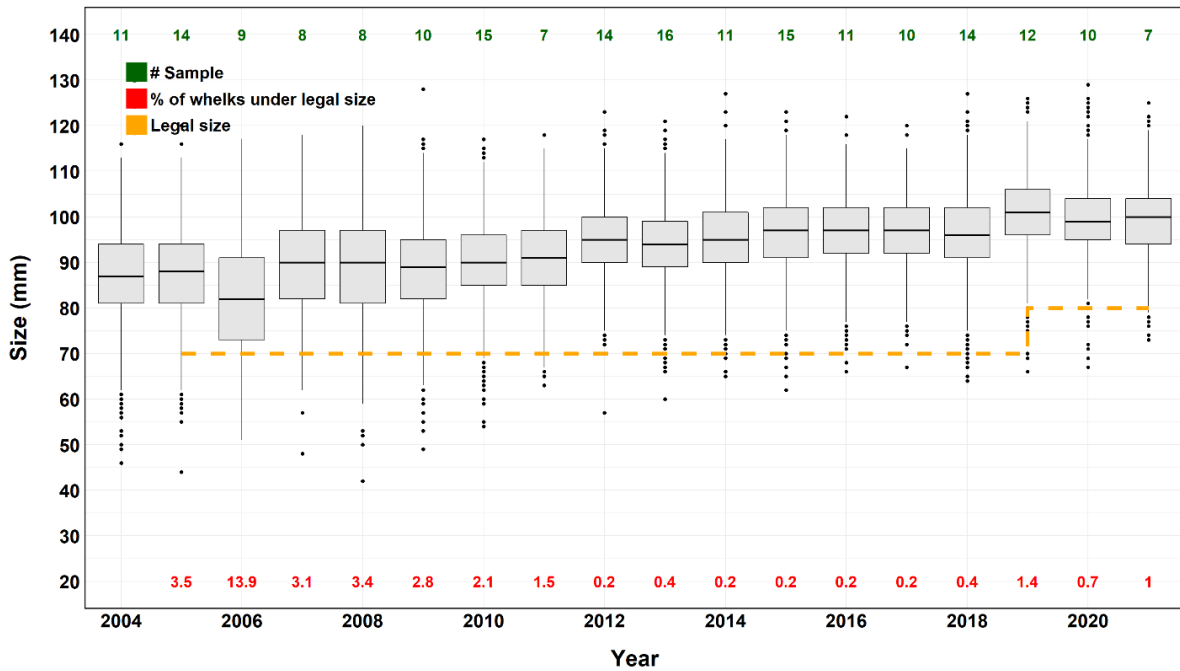


Figure 18. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 4.

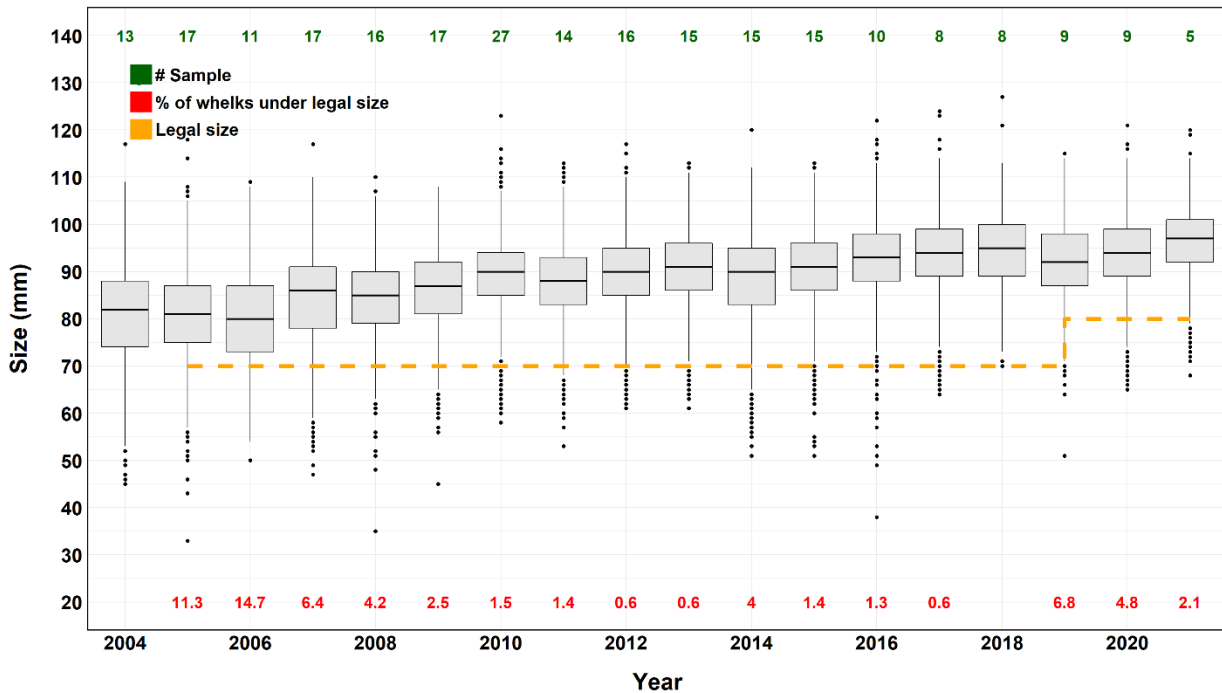


Figure 19. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 5.

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. Commercial fishing covers almost the entire area except the far eastern portion (Figure 20). In 2021, there were 7 active licences for 850 traps out of a total of 15 licences issued and 1,450 authorized traps (Appendix 6).

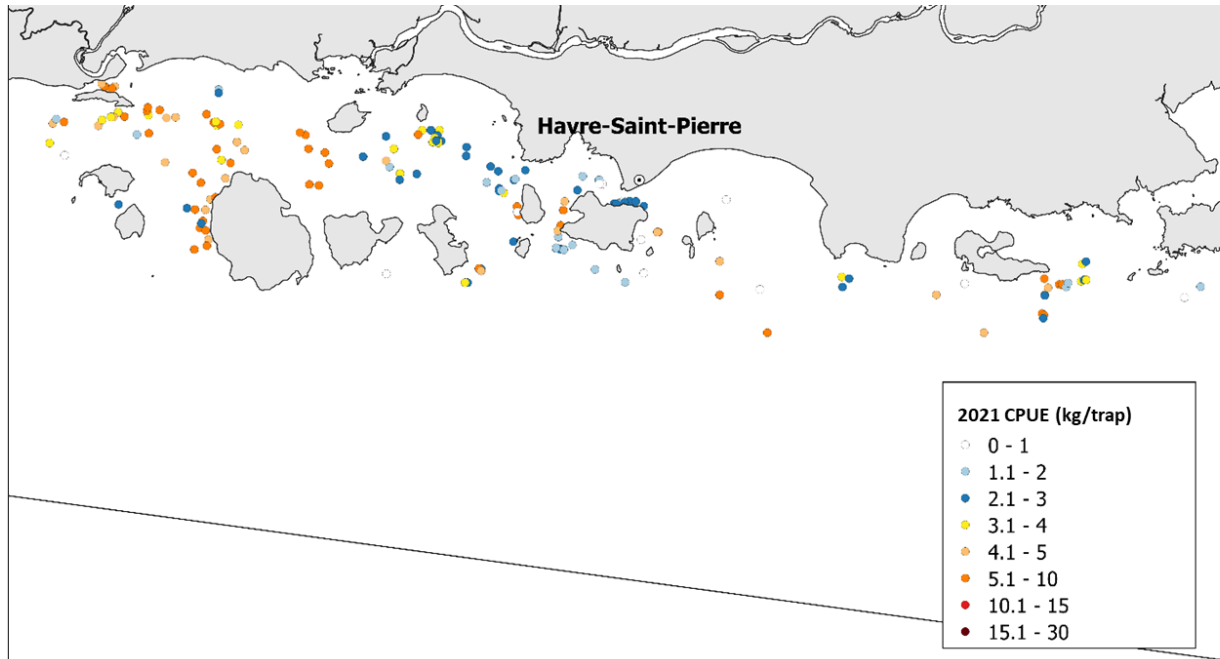


Figure 20. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 6 in 2021.

Between 2001 and 2008, landings ranged from 152 t to 282 t (Figure 21 and Appendix 9). Between 2009 and 2017, landings ranged from 270 t to 366 t. However, they have declined considerably in 2018. In 2021, landings reached 138 t and accounted for 14% of total Québec landings.

The largest fishing effort occurred from 2003 to 2005, with over 89,100 trap hauls in 2004 (Figure 21 and Appendix 10). Subsequently, effort remained stable around 65,000 trap hauls. Since 2018, there has been a sharp drop in the number of traps used. In 2021, the effort was 37,400 traps hauls. In general, changes in landings are largely related to changes in fishing effort.

CPUE has fluctuated considerably over the years (Figure 22 and Appendix 11). They fell between 2003 and 2005 and rose between 2006 and 2009. Thereafter, CPUE remained around 5 kg/trap between 2010 and 2016. However, CPUE has been declining sharply since 2017, reaching 4 kg/trap in 2021.

Between 2010 and 2017, the annual median size of landed whelk was around 88 mm. From 2018, it increased to 93 mm (Figure 23 and Appendix 12). The percentage of sub-legal size whelks in landings has remained below 4% since 2010 except in 2016 and 2019 with 5.7% and 13.1% respectively (Figure 23 and Appendix 13).

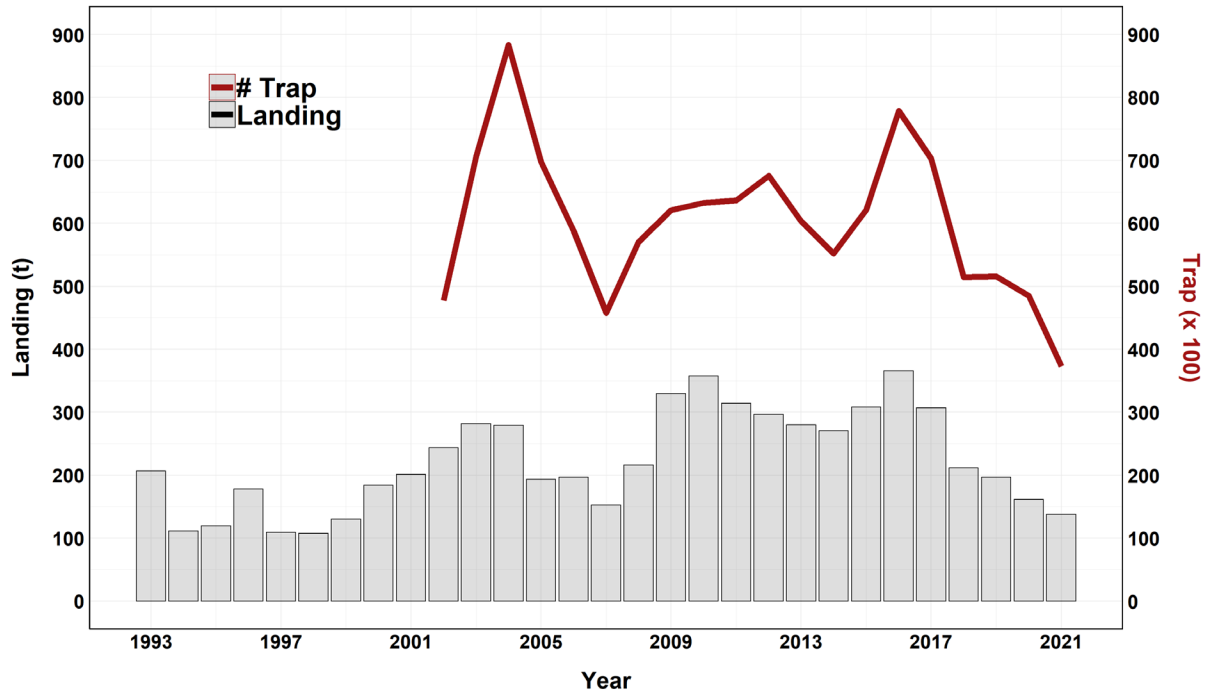


Figure 21. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 6.

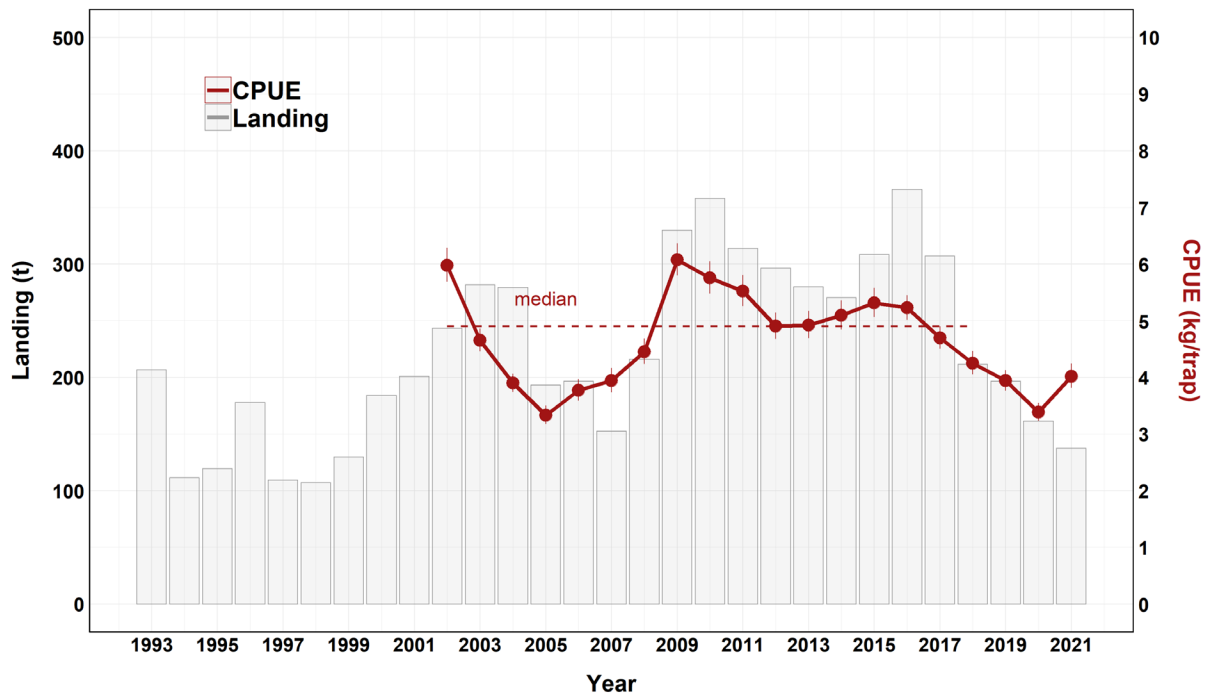


Figure 22. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 6.

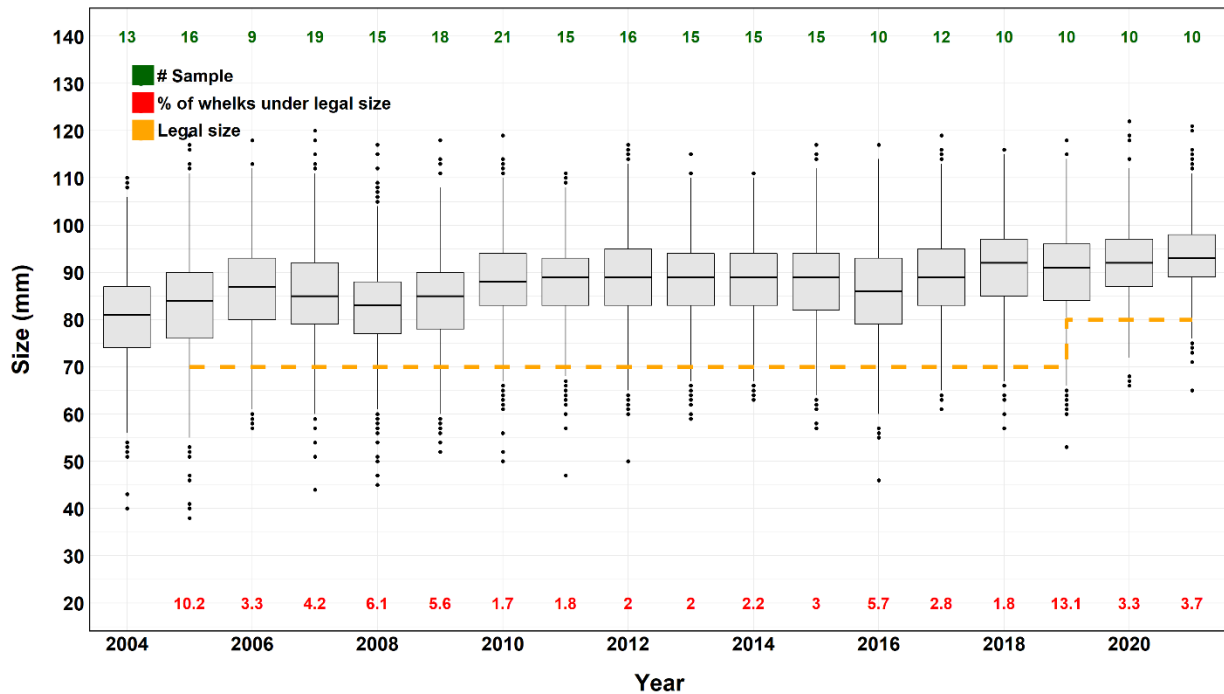


Figure 23. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 6.

Fishing Area 7

Fishing Area 7 extends from baie de la Grande Hermine to Rivière de l'Étang. However, the commercial fishery is conducted only near Natashquan. Since 2008, there have been only two or three active licences. There are a total of 6 licences issued with the right to use 550 traps; however, there was no fishing in 2021 (Appendix 6). Fishing distribution data for Area 7 was last available in 2019 (Figure 24).

Between 2005 and 2018, landings have ranged from 19 to 90 t (Figure 25 and Appendix 9). However, landings dropped considerably in 2019 and 2020 to 8 t and 1 t respectively. Effort oscillated between 4,100 and 11,000 traps hauls between 2005 and 2018, but decreased to 2,200 and 200 traps hauls in 2019 and 2020 (Figure 25 and Appendix 10). In general, changes in landings are largely related to changes in fishing effort.

CPUE vary somewhat from year to year. Over the years, the CPUE ranged from 5 to 8 kg/trap (Figure 26 and Appendix 11).

Between 2008 and 2016, the median size of landed whelks was around 86 and 88 mm (Figure 27 and Appendix 12). From 2017, the median size increased slightly to 90 mm in 2018 and to 95 mm in 2019. Since 2010, the proportion of sub-legal size whelks in landings has been relatively low and below 4%, except in 2015 with 5.0% and in 2019 with 4.6% (Figure 27 and Appendix 13).

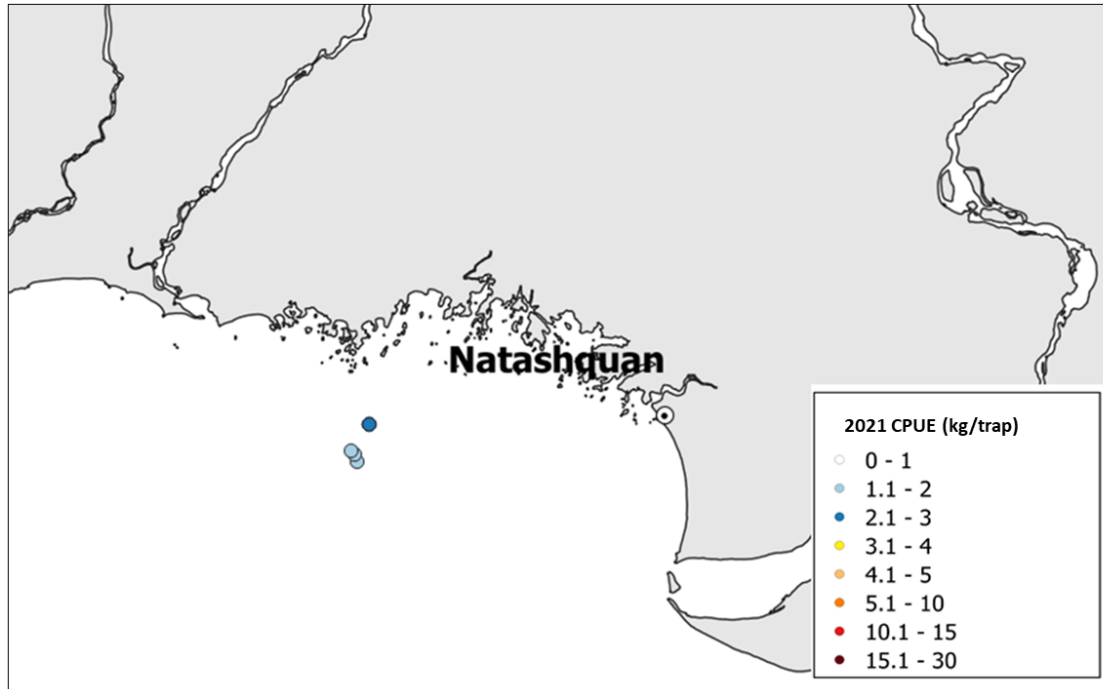


Figure 24. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 7 in 2019.

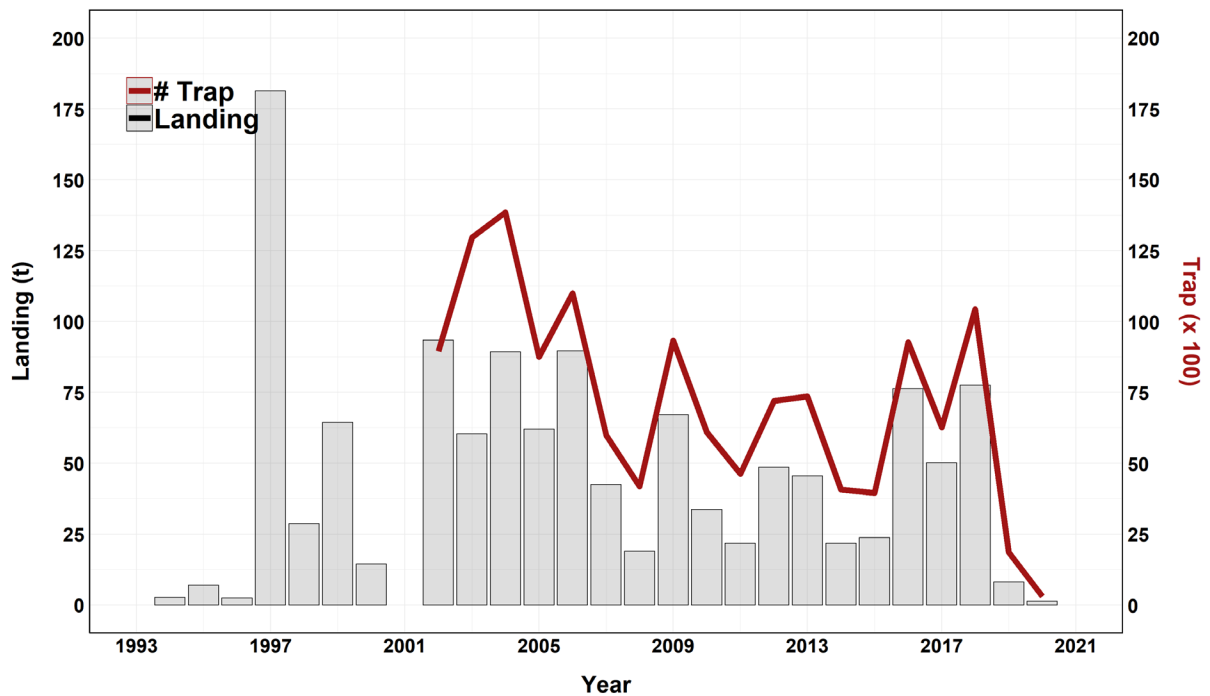


Figure 25. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 7.

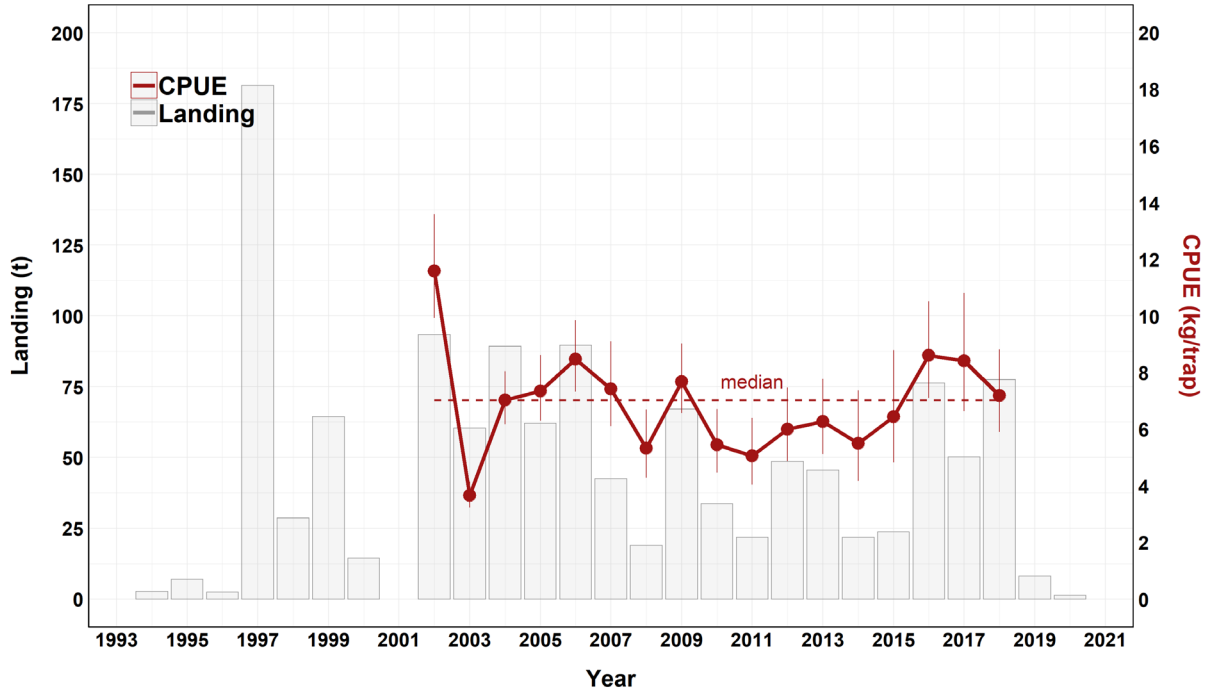


Figure 26. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 7. There is not enough information to calculate standardized CPUE in 2019 and 2020, and there was no fishing in 2021.

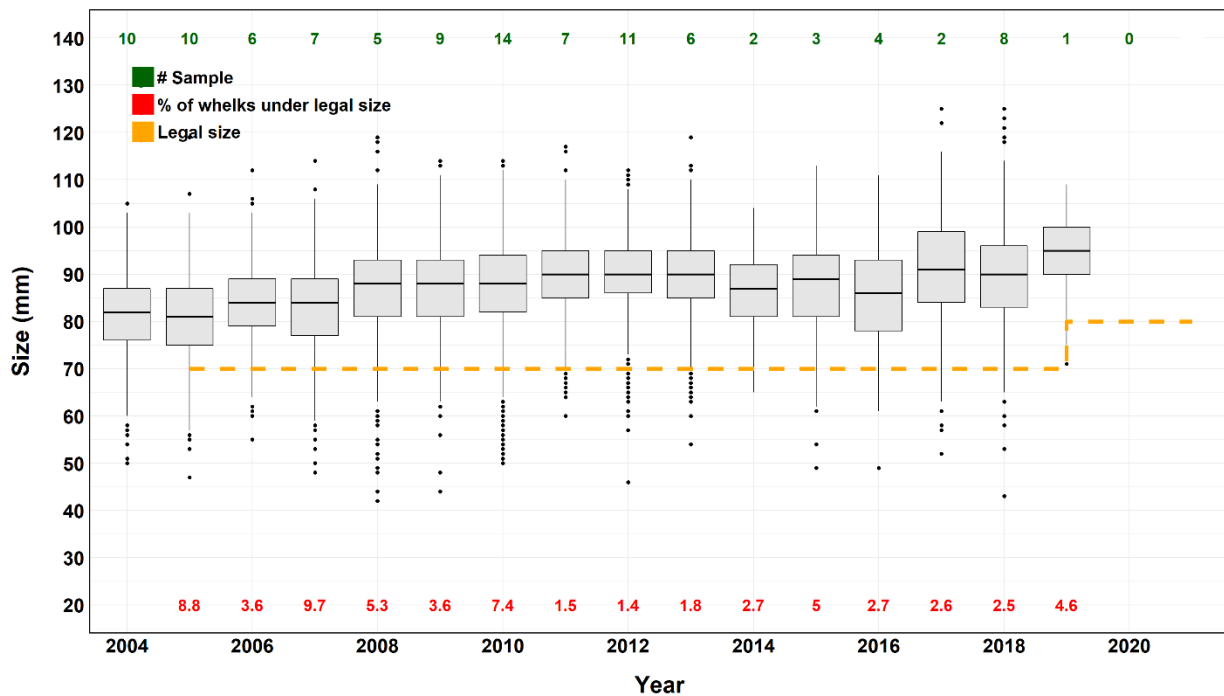


Figure 27. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 7.

Fishing Area 8

Fishing Area 8 is the largest fishing area in Québec, extending from Rivière de l'Étang to Blanc-Sablon. The commercial fishery is primarily concentrated in the Blanc-Sablon area. However, some fishing activities have been occurring West of La Romaine since 2018 (Figure 28). In 2021, there were 8 active licences for 850 traps out of a total of 64 licences issued and 6,400 authorized traps (Appendix 6).

Landings from Area 8 are highly variable from year to year and highly dependent on fishing effort (Figure 29 and Appendices 9 and 10). Landings have varied between 11 and 38 t between 2009 and 2019. However, they increased significantly to 56 and 103 t in 2020 and 2021, respectively (Appendix 9). The 2021 landings represents the highest value of the historical series. The increase in landings in recent years is linked to the beginning of fishery in La Romaine since 2018. Between 2009 and 2020, fishing effort varied between 2,300 and 13,100 traps hauls. However, it reached 16,000 traps hauls in 2021 (Figure 29 and Appendix 10).

CPUE was relatively stable until 2014. From 2015 onwards, CPUE decreased to around 3 kg/trap; a decrease that is exclusively linked to the Blanc-Sablon fishery (Figure 30 and Appendix 11). After 2018, the fishery began in the La Romaine area, causing CPUE to rise. In 2021, the average CPUE in Blanc-Sablon was 3.5 kg/trap, while in La Romaine it was 7.5 kg/trap (Figure 28).

The median size of landed whelk was low in this area due to the high percentage of sub-legal size whelk in landings (Figure 31 and Appendices 12 and 13). From 2007 to 2018, the median size varied between 71 and 79 mm. The median size increased to 91 mm in 2019, but decreased to 83 mm in 2021 (Appendix 12). From 2005 to 2014, the percentage of sub-legal size whelk in landings ranged from 19 to 40% (Figure 31 and Appendix 13). Since 2015, the situation has improved and a percentage of less than 10% has been observed, except in 2018 and 2020 when the percentage reached 10.7% and 11.2% respectively.

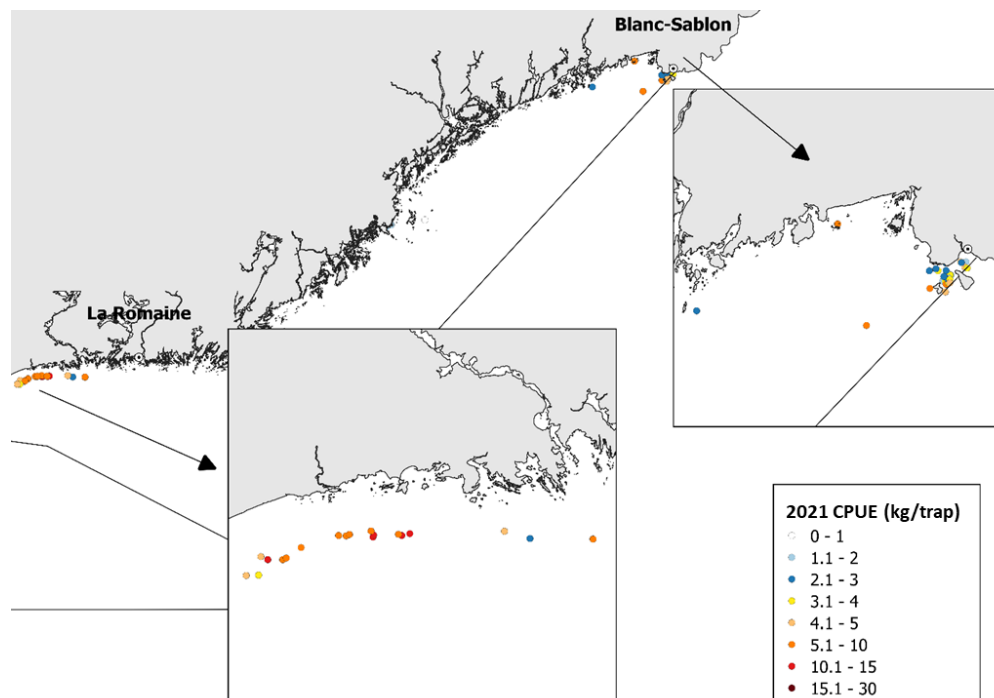


Figure 28. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 8 in 2021.

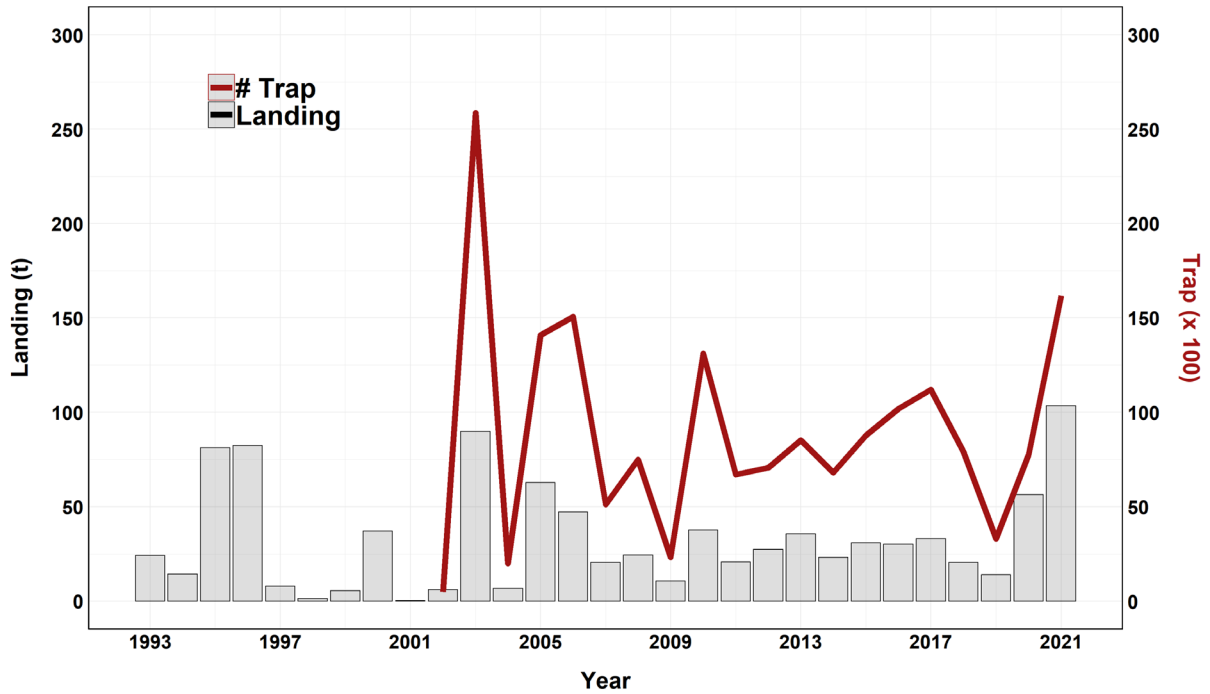


Figure 29. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 8.

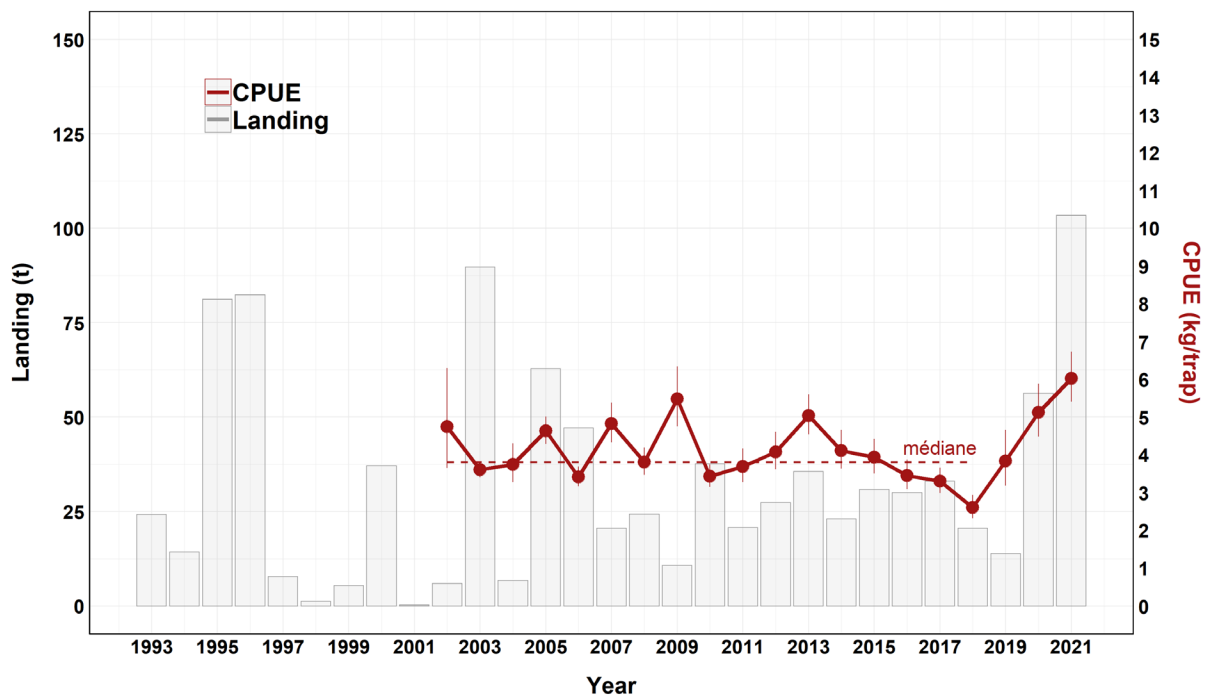


Figure 30. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 8.



Figure 31. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in 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. The commercial fishery covers most of the area, however, it was concentrated further west in 2021. In 2021, there were 7 active licences for 1,150 traps out of a total of 29 licences issued and 2,775 authorized traps (Appendix 6).

From 2005 to 2011, landings remained stable between 84 t and 150 t (Figure 33 and Appendix 9). Thereafter, landings declined considerably, reaching 17 t in 2021. 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. Finally, the TAC was increased to 75 t in 2018 (Figure 33).

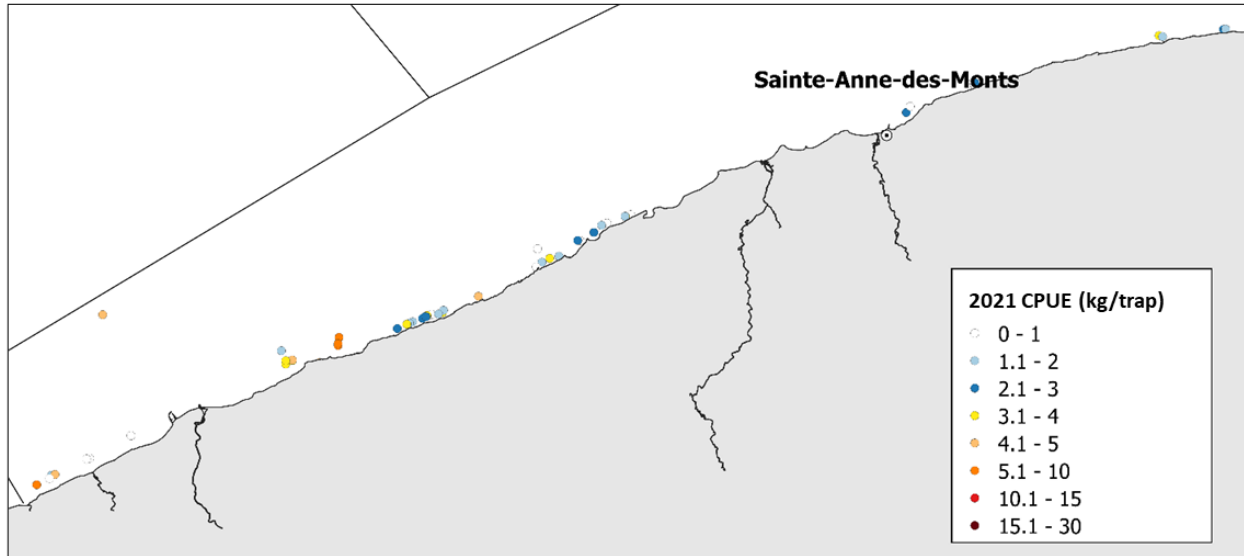


Figure 32. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 12 in 2021.

Fishing effort reached the maximum value of 36,900 trap hauls in 2006 and then decreased until 2014 to 18,800 trap hauls (Figure 33 and Appendix 10). 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. Despite the increase of the TAC in 2018, effort has continued to decline, reaching 6,500 traps hauls in 2021, the lowest value of the historical series (Figure 33 and Appendix 10).

A minimum CPUE of 2.5 kg/trap was observed in 2003 and 2014 (Figure 34 and Appendix 11). From 2015 to 2017, the CPUE increased to 3.4 kg/trap. Thereafter, they have been declining until now, reaching 2.9 kg/trap in 2021.

Since 2014, the median size of landed whelk have been above 90 mm (Figure 35 and Appendix 12). In 2021, the median size was 95 mm. The percentage of sub-legal size whelk has been less than 3% of landings since 2013 (Figure 35 and Appendix 13).

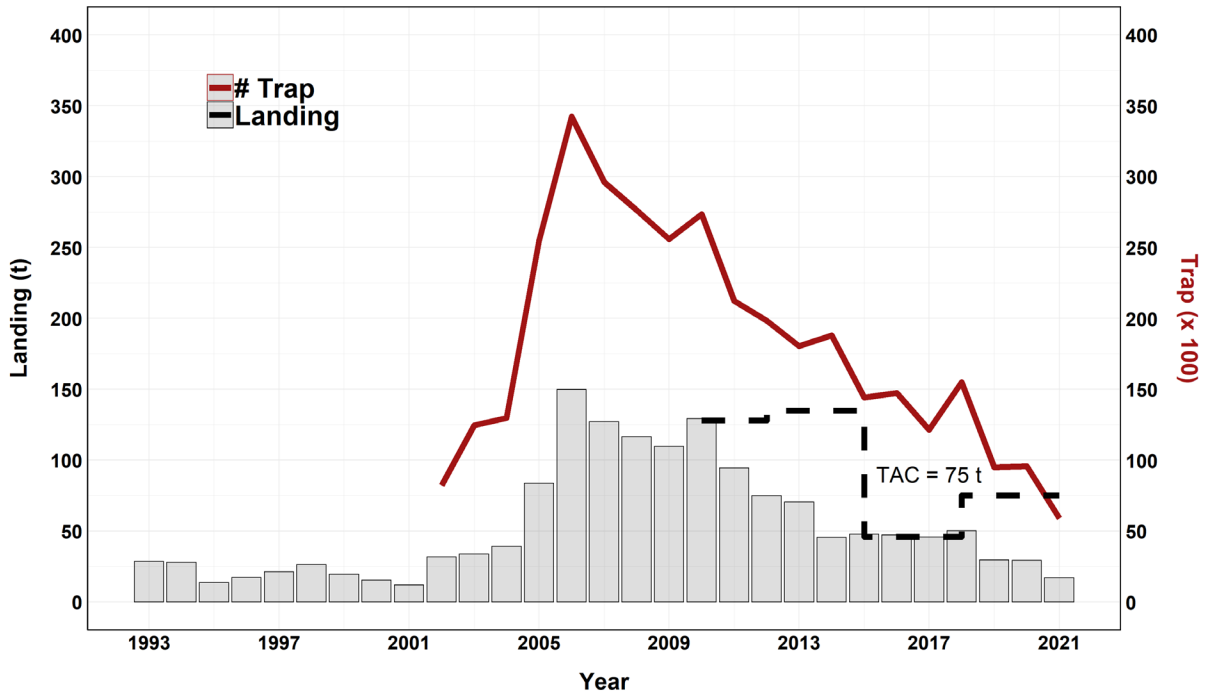


Figure 33. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 12.

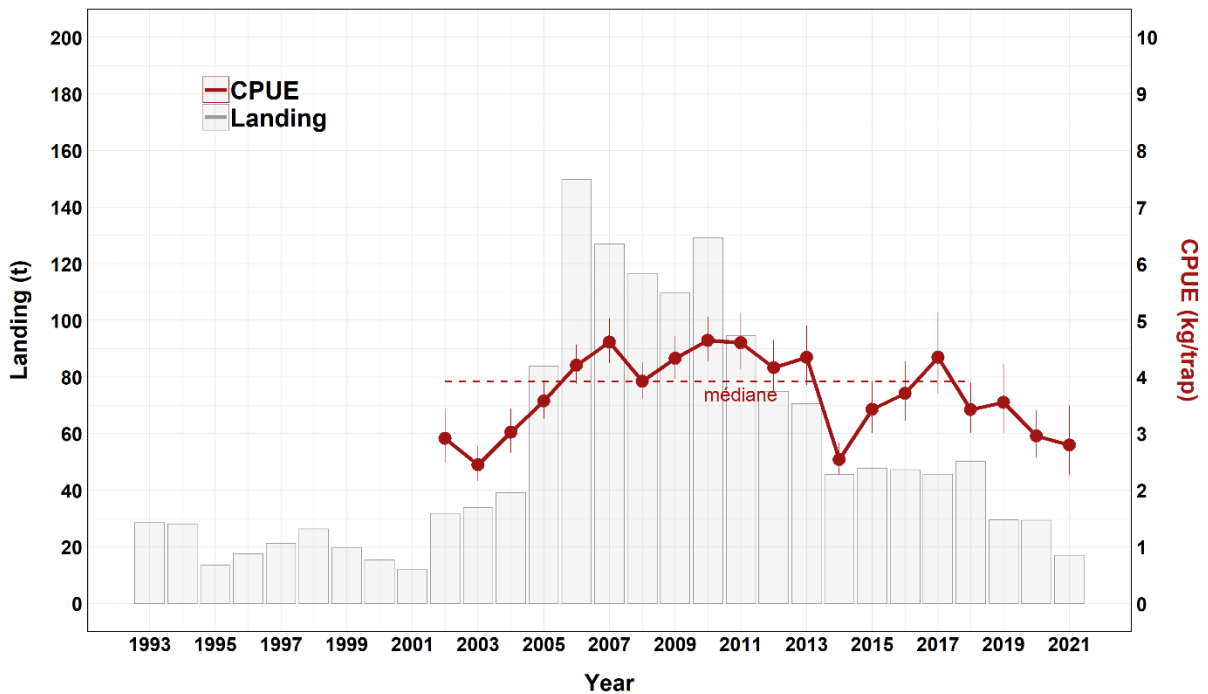


Figure 34. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 12.

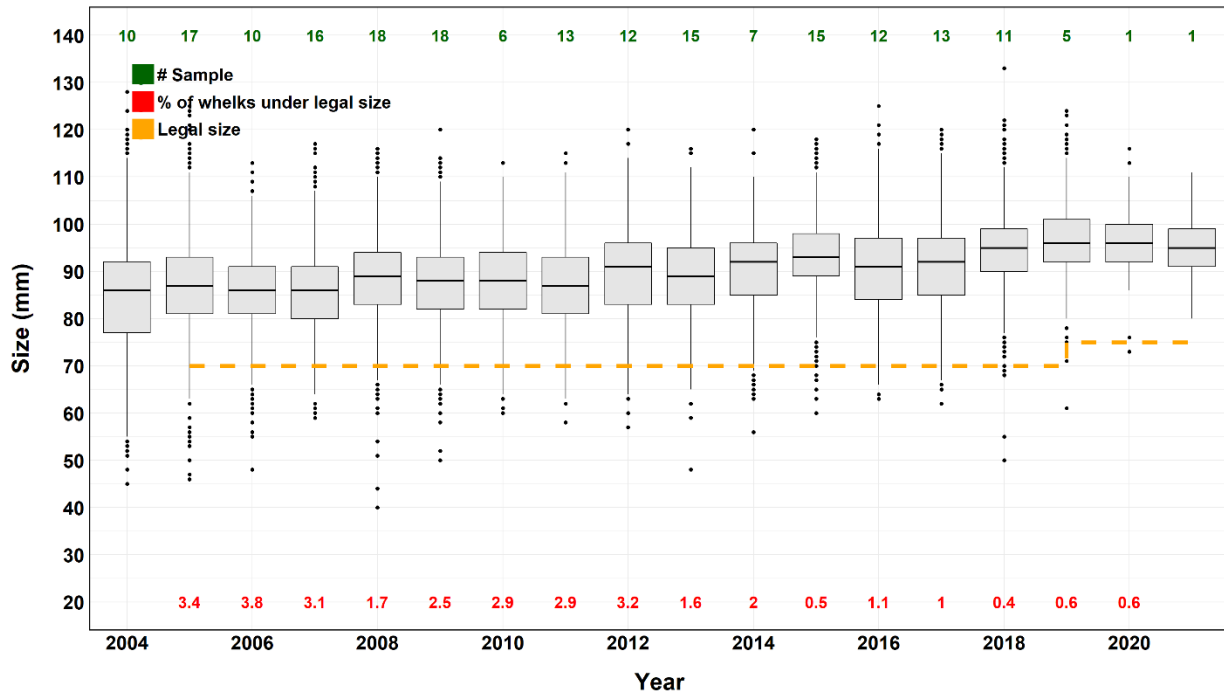


Figure 35. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 12.

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. It then extends from the southern side of the Estuary to Rivière Tartigou (Figure 36). The commercial fishery exclusively covers the eastern portion of the area, starting at the Bic archipelago (near Rimouski). In 2021, there were 7 active licences for 800 traps out of a total of 9 licences issued for 900 authorized traps (Appendix 6).

From 1993 to 2006, landings were less than 35 t (Figure 37 and Appendix 9). 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. In 2010, after the TAC was reached in 13a, some fishermen made trips to subarea 13b, but landings were disappointing, and 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. The TAC was exceeded in 2016 (total landings of 89 t) and in 2018 (total landings of 83 t). In 2021, landing reached 59 t (Figure 37 and Appendix 9).

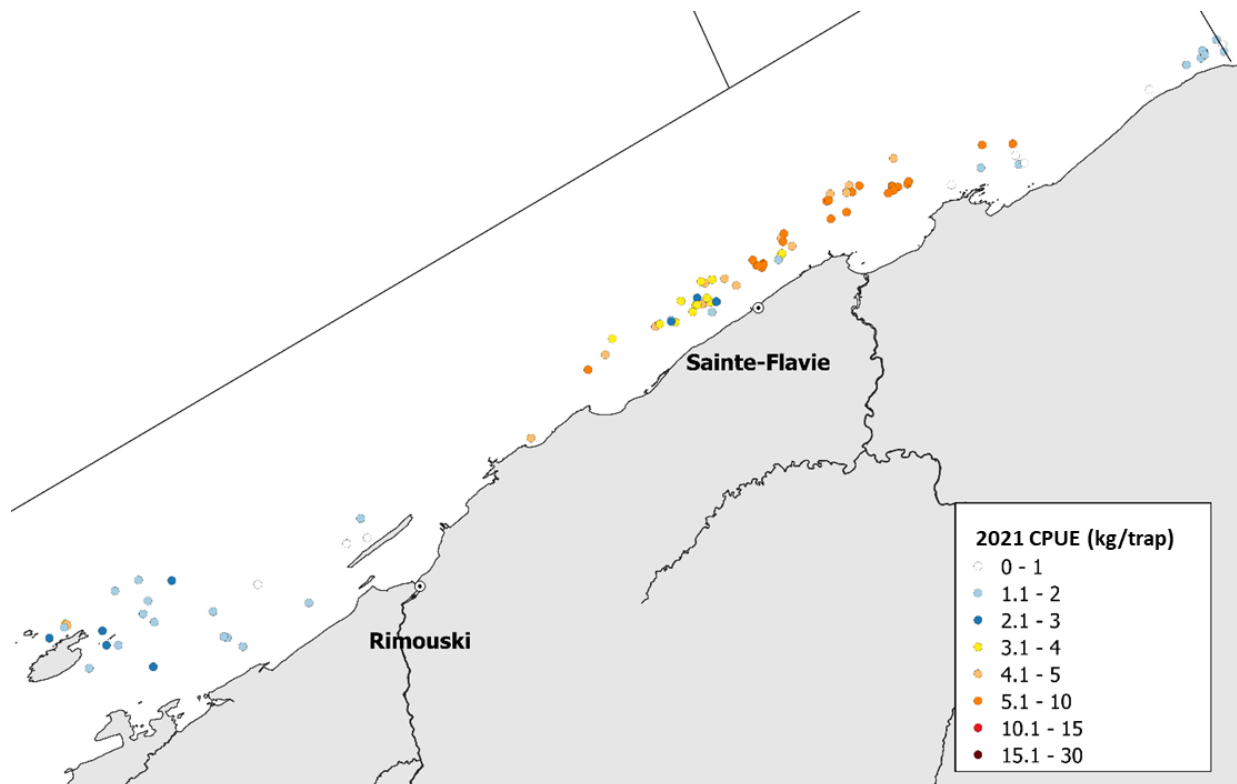


Figure 36. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 13 in 2021.

Since 2014, fishing effort has increased significantly, from 8,300 to 15,500 trap hauls in 2021 (Figure 37 and Appendix 10). This increase in effort has not been followed by an increase in landings. This situation is exerting strong fishing pressure on the whelk stock and may become problematic if there is no effort reduction in this area.

From 2001 to 2005, CPUE values were the lowest in the series, around 4 kg/trap (Figure 38 and Appendix 11). Subsequently, CPUE gradually increased to 8.9 kg/trap in 2011, the highest value of the historical series. Since 2012, the CPUE has decreased sharply. They reached 4.5 and 2.9 kg/trap in 2020 and 2021 respectively, the lowest values since 2012 (Figure 38). In addition, there is a clear separation of CPUE between the eastern and western portions of Area 13 in 2021. In the Rimouski/Bic area, CPUE was relatively low at around 2 kg/trap, while CPUE in the Saint-Flavie area was higher at around 3.6 kg/trap (Figure 36).

The median size of landed whelk increased from 77 mm in 2005 to 87 mm in 2007, possibly as a result of the exploitation of new sites (Figure 39 and Appendix 12). Since then, median size has ranged from 83 mm to 89 mm between 2008 and 2018. In 2019 and 2021, the median size has increased slightly to 92 mm. The percentage of sub-legal size whelk in landings has been below 2% since 2010 (Figure 39 and Appendix 13).

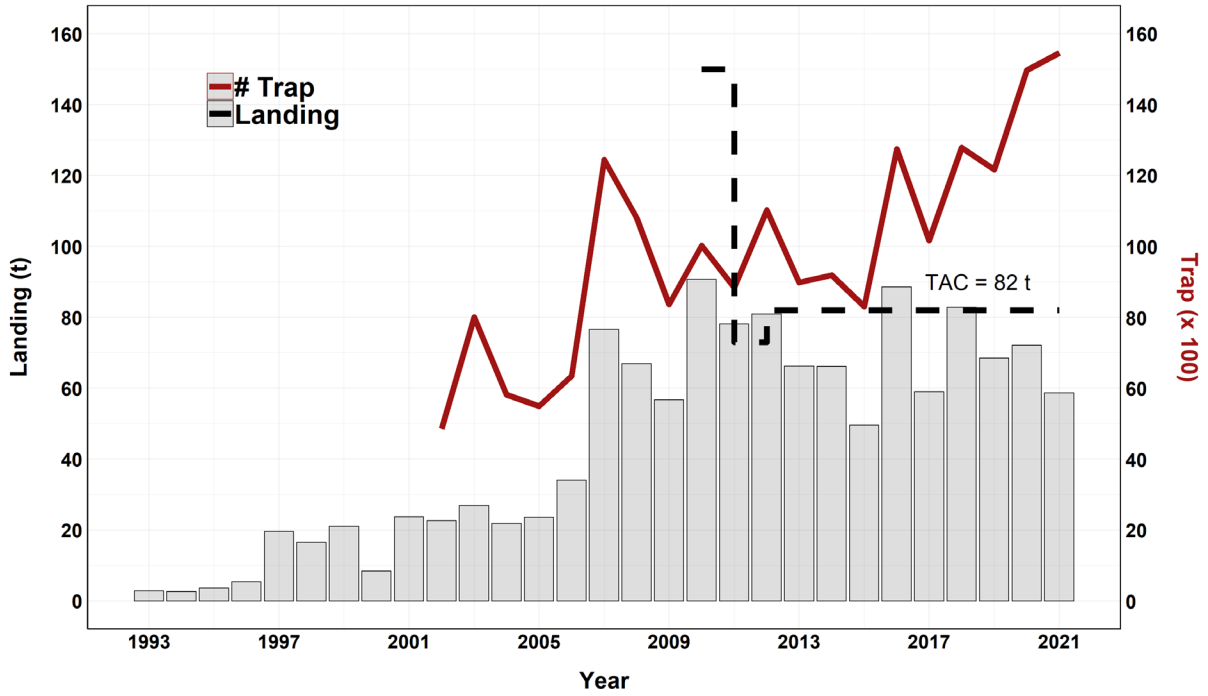


Figure 37. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 13.

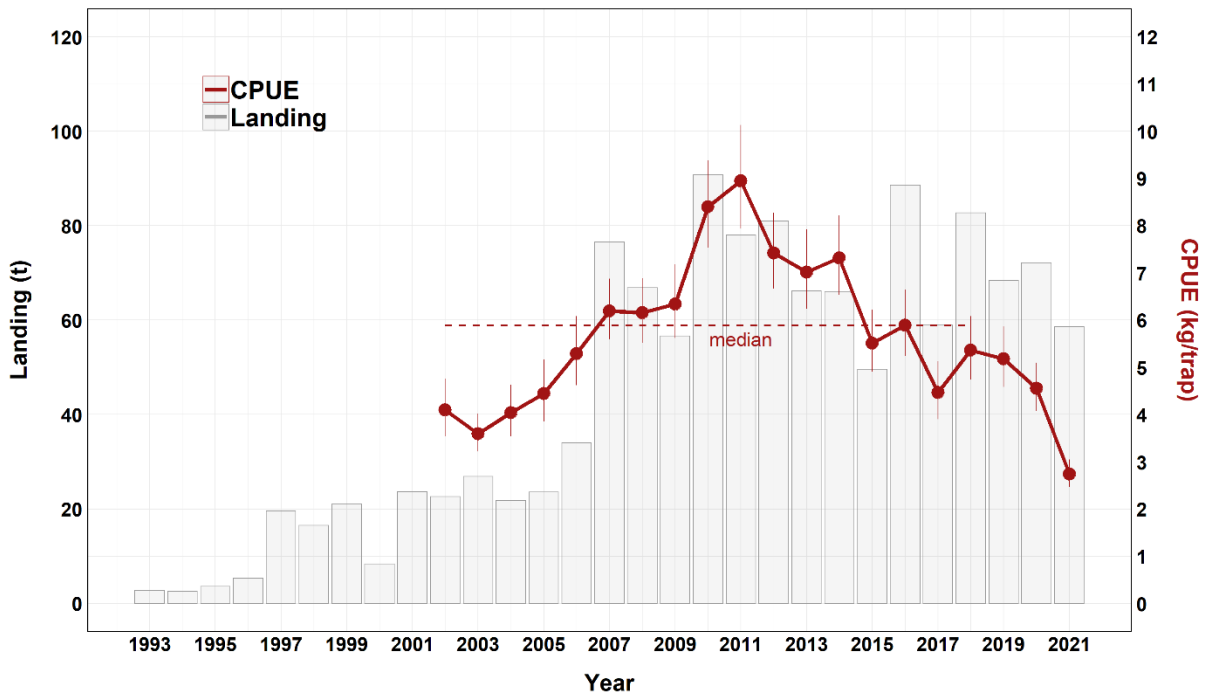


Figure 38. Annual landings and standardized catch per unit effort (CPUE, \pm 95% confidence interval) in the commercial whelk fishery in Area 13.

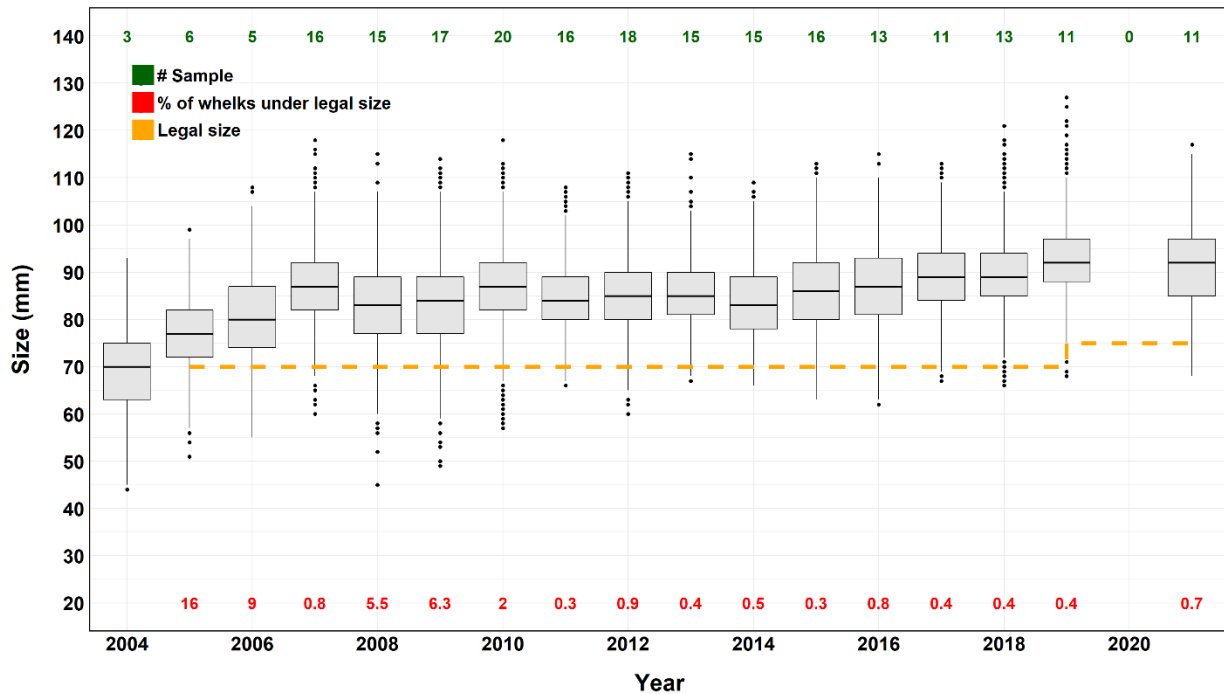


Figure 39. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 13.

ÎLES-DE-LA-MADELEINE

Fishing Area 15

Fishing Area 15 covers the entire coastal area around the Îles-de-la-Madeleine. 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 (Figure 40). In 2021, there were 11 active licences and 1,650 authorized traps. All licences were used in 2021. 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. 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 and to 330 t in 2021. The Area 15 TAC is divided equally among the 11 licence holders, which may explain why the TAC has not been reached since 2006.

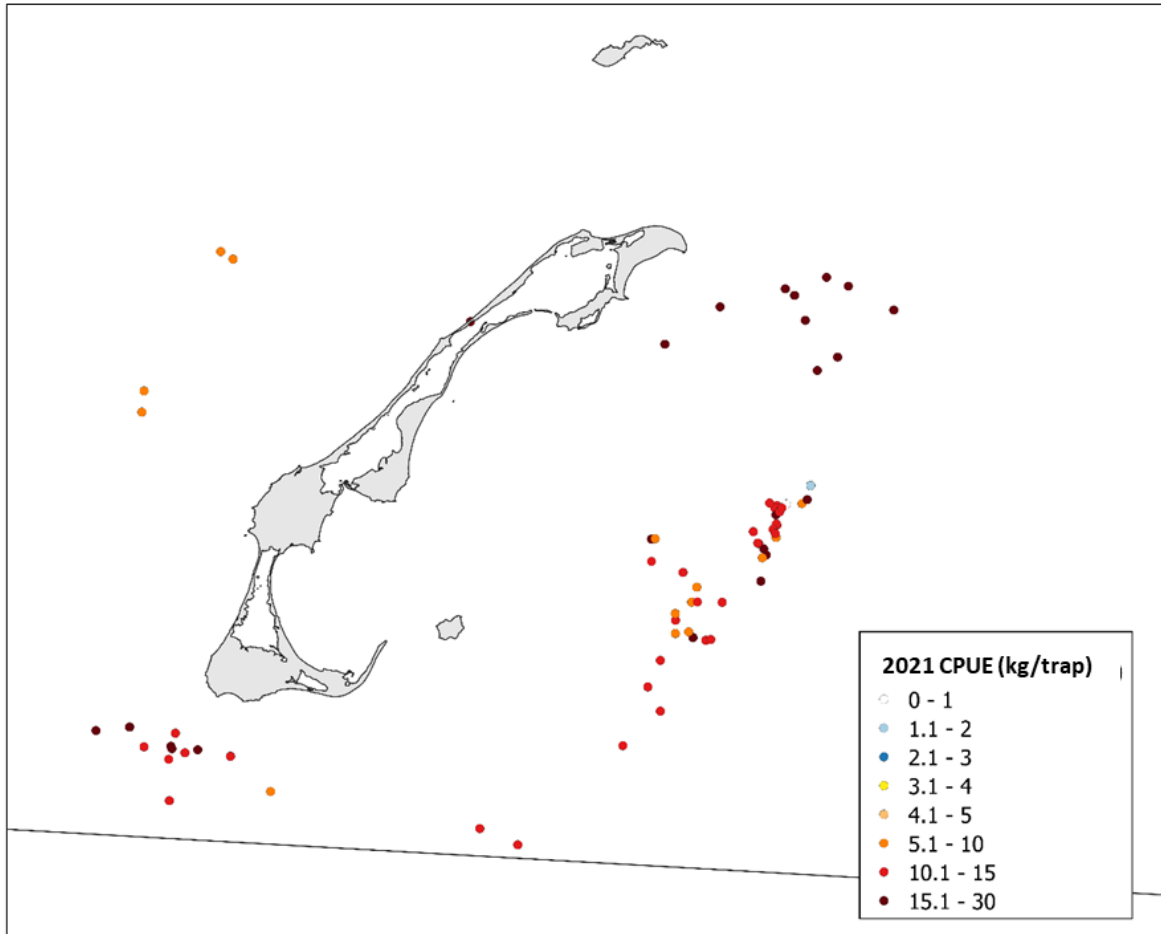


Figure 40. Distribution of commercial whelk fishing sites and non-standardized catch per unit effort (CPUE) in Area 15 in 2021.

From 2003 to 2008, landings ranged from 352 t to 442 t (Figure 41 and Appendix 9). 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 with landings of 111 t. In 2021, landings were 167 t.

From 2003 to 2008, fishing effort changed little from 15,500 to 19,200 trap hauls (Figure 41 and Appendix 10). Since then, the effort has been more variable and is primarily related to the number of active fishermen. In 2021, fishing effort was 12,800 trap hauls.

From 2003 to 2010, CPUE in this area were the highest in Québec. They generally ranged around 20 kg/trap (Figure 42 and Appendix 11). From 2011 to 2013, there was a slight decrease in CPUE with values around 17 kg/trap. 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 17.5 kg/trap, a value similar to those from 2011 to 2013. However, CPUE has been declining in recent years, reaching 11.6 kg/trap in 2021 (Appendix 11).

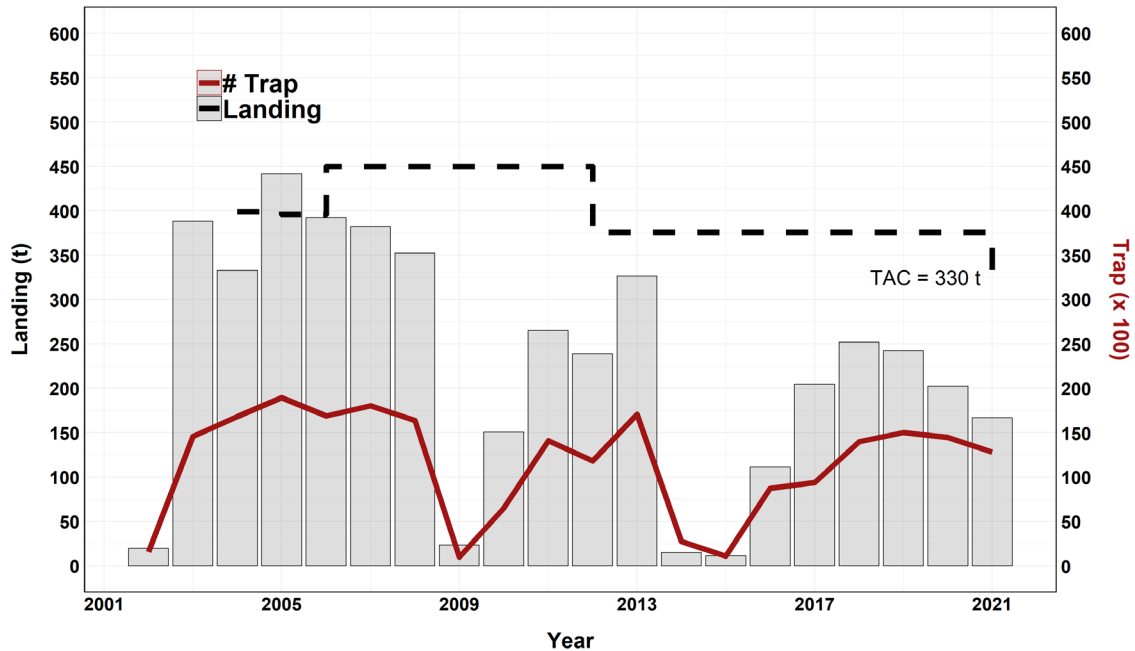


Figure 41. Annual whelk landings, total allowable catch (TAC) and fishing effort (in numbers of traps hauls) in Area 15.

The 2013 CPUE did not foreshadow such a sharp decline in CPUE in 2014 (Figure 42). Environmental conditions in the Îles-de-la-Madeleine during the 2014 season, such as abnormally cold temperatures ($\sim 6^{\circ}\text{C}$) at fishing sites (Galbraith et al. 2021) and the high presence of shell-boring polychaetes 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.

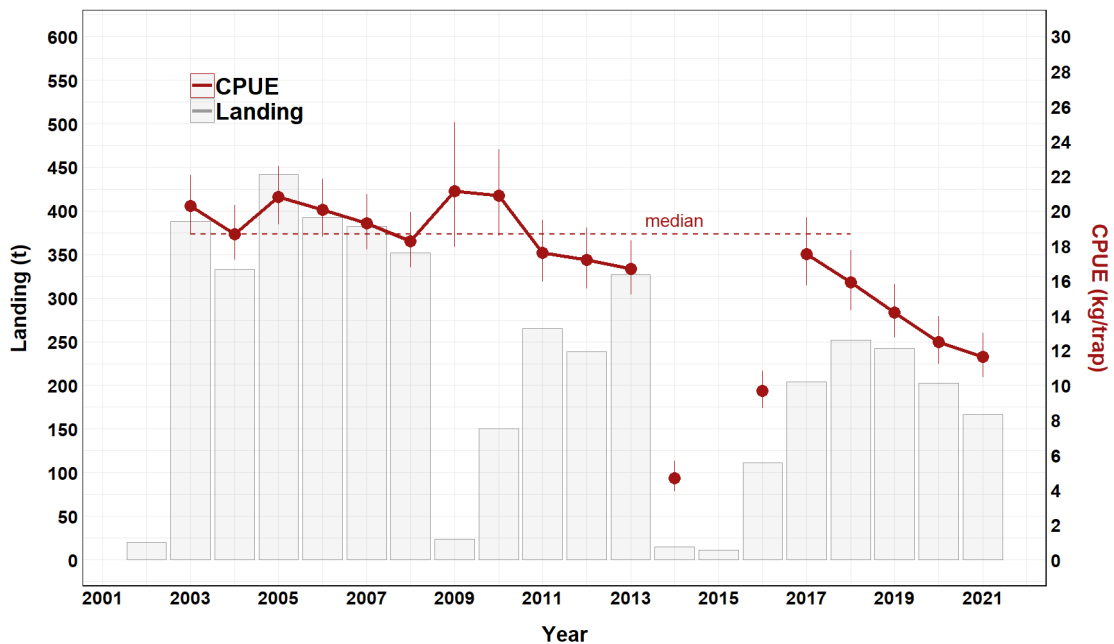


Figure 42. Annual landings and standardized catch per unit effort (CPUE, $\pm 95\%$ confidence interval) in the commercial whelk fishery in Area 15.

The median size of landed whelk is equal to or greater than 81 mm (Figure 43 and Appendix 12). 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 4% since 2008 (Figure 43 and Appendix 13).

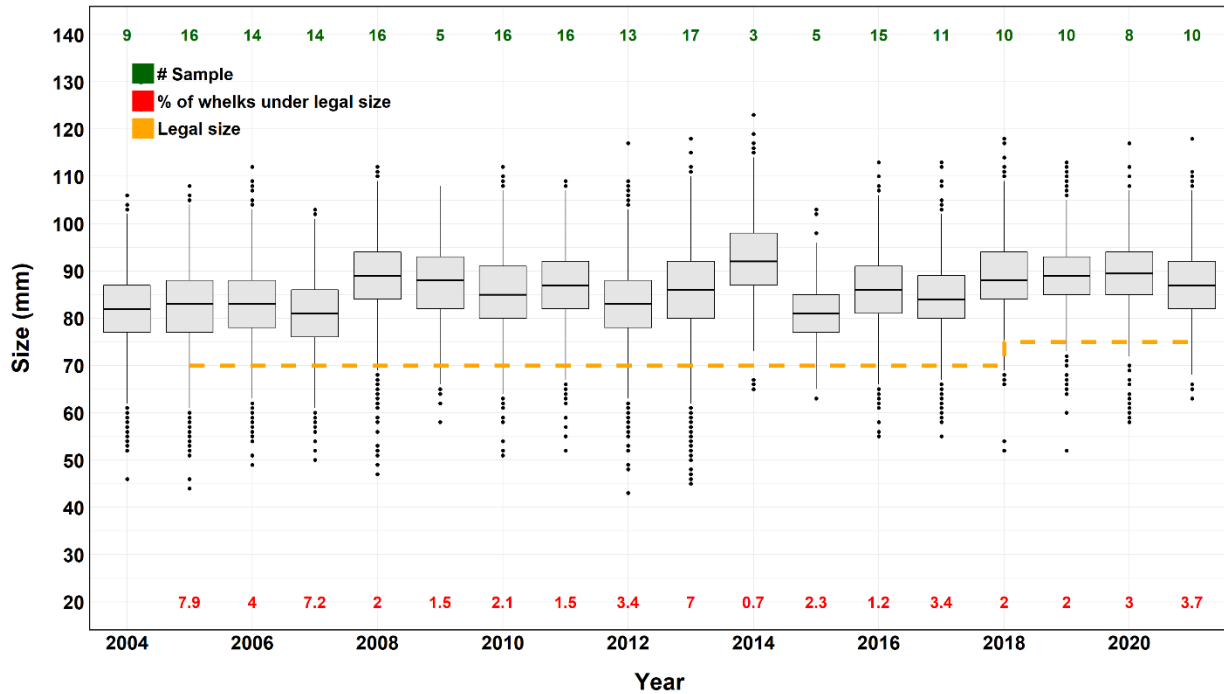


Figure 43. Median sizes, percentages of sub-legal size whelks and number of samples harvested per year of whelks landed during commercial fishery in Area 15.

RESEARCH

SEXUAL MATURITY OF FEMALES AND RE-EVALUATION OF MINIMUM LEGAL SIZE

The size at sexual maturity is greater in female than in male whelks. Thus, the minimum legal size (MLS) is based on the size of females. In 2022, the size at which 50% of females are sexually mature (T_{50}) was re-evaluated in some fishing areas with new samples.

The T_{50} of the females ranged from 62 to 92.8 mm depending on the fishing area. Areas 1 and 2 of the Upper North Shore have the lowest values with 69.9 and 62 mm, while other areas have $T_{50} \geq 74$ mm (Table 1). The T_{50} of females in Areas 3 and 7 could not be determined because of an insufficient number of individuals, but is estimated to be greater than 75 mm. In Area 8, the samples to determine the T_{50} (67 mm) collected in 2021 were from outside of the traditional fishing grounds and, therefore, this value was not retained. Instead, the T_{50} previously established with samples collected in 2016 (80.2 mm) were kept. New samples will have to be collected separately from the usual fishing grounds in the La Romaine and Blanc-Sablou areas to update the T_{50} for Area 8.

To protect the spawning population and ensure the sustainability of this resource, the MLS should be adjusted according to the T_{50} in several fishing areas. Such an adjustment would represent an increase in the MLS in Areas 4, 5, 6, 7, 8, 12 and 13 (Table 1).

Table 1. Average size at which 50% of female whelks are sexually mature (T_{50}), current minimal legal size (MLS) and suggested MLS during the 2022 peer review for some fishing areas (in grey).

| Fishing Area | T_{50} (mm) | Current MLS (mm) | Suggested MLS (mm) |
|--------------|------------------|---------------------|-----------------------|
| 1 | 69.9 | 70 | 70 |
| 2 | 62.0 | 70 | 70 |
| 3 | - | 80 | 80 |
| 4 | 89.7 | 80 | 90 |
| 5 | 92.8 | 80 | 90 |
| 6 | 85.7 | 80 | 85 |
| 7 | - | 80 | 85 |
| 8 | 80.2 | 75 | 80 |
| 12 | 79.5 | 75 | 80 |
| 13 | 76.0 | 75 | 80 |
| 15 | 74.6 | 75 | 75 |

UPPER NORTH SHORE SURVEY

The densities of whelks by size class and the density of egg masses by site and year are presented in Table 2, along with the results of the density comparison test. Densities and yields of whelks and egg masses per station from the 2019 survey are found in Appendices 14 and 15. Maps of whelk densities calculated from 2005 to 2019 are provided in Figure 44 for Forestville, in Figure 45 for Pointe-aux-Outardes, and in Figure 46 for Baie-Comeau.

Overall, whelk densities decreased in all three areas surveyed in 2019 compared with 2017 (Table 2). The most significant decreases were observed in Forestville and Baie-Comeau.

In Forestville, total densities (whelks ≥ 20 mm) differed significantly between years ($\text{Chi}^2 = 145.04$ and $P < 0.0001$); they were higher in 2013, 2015, and 2017, and lower in 2005, 2007, 2009 and 2019 (Table 2). In Pointe-aux-Outardes, total densities also differed between years ($\text{Chi}^2 = 25.56$ and $P = 0.0006$); densities were significantly higher in 2011 than in 2005, 2007, and 2009. However, in Baie-Comeau there was no difference between years ($\text{Chi}^2 = 13.9562$ and $P = 0.0520$) despite the low value observed in 2019. This could be attributed to the high variability of density between stations.

For whelks of legal size (≥ 70 mm), the year of the survey was a significant factor in relation to the densities at Forestville ($\text{Chi}^2 = 200.354$ and $P < 0.0001$), at Pointe-aux-Outardes ($\text{Chi}^2 = 39.523$ and $P < 0.0001$) and at Baie-Comeau ($\text{Chi}^2 = 21.989$ and $P = 0.0026$).

For whelks of sub-legal size (20 to 69 mm), the densities differed significantly between years at Forestville ($\text{Chi}^2 = 136.817$ and $P < 0.0001$), at Pointe-aux-Outardes ($\text{Chi}^2 = 25.456$ and $P = 0.0006$) and at Baie-Comeau ($\text{Chi}^2 = 23.675$ and $P = 0.0013$). At Forestville, the densities were significantly higher in 2011, 2013, and 2015 than in other years (Table 2). At Pointe-aux-

Outardes, the densities obtained in 2011 were significantly higher than those of other years. At Baie-Comeau, the 2019 density was significantly lower than that of 2005-2011 (Table 2).

Table 2. Average whelk density (number/100 m² ± standard error) by size class and egg mass by site and year in research surveys in Upper North Shore.

| 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 | 2.5 ± 0.2 d | 3.0 ± 0.3 b | - |
| 2009 | 6.6 ± 0.6 c | 1.9 ± 0.2 d | 4.7 ± 0.4 b | 0.01 ± 0.01 |
| 2011 | 11.9 ± 1.0 b | 2.9 ± 0.2 d | 9.2 ± 0.9 a | 0.02 ± 0.01 |
| 2013 | 15.7 ± 1.2 ab | 5.8 ± 0.4 b | 10.2 ± 0.9 a | 0.01 ± 0.01 |
| 2015 | 16.1 ± 1.5 a | 4.7 ± 0.4 bc | 11.5 ± 1.3 a | 0.04 ± 0.01 |
| 2017 | 14.9 ± 0.8 ab | 10.4 ± 1.5 a | 4.6 ± 0.4 b | 0.03 ± 0.01 |
| 2019 | 7.0 ± 0.6 c | 4.7 ± 0.4 c | 2.3 ± 0.3 b | 0.26 ± 0.04 |
| Pointe-aux-Outardes | | | | |
| 2005 | 3.3 ± 0.7 b | 2.0 ± 0.6 c | 1.3 ± 0.3 b | 1.0 ± 0.3 |
| 2007 | 4.2 ± 0.8 b | 2.9 ± 0.6 bc | 1.3 ± 0.3 b | |
| 2009 | 4.6 ± 0.7 b | 2.1 ± 0.4 c | 2.7 ± 0.5 b | 1.1 ± 0.4 |
| 2011 | 11.9 ± 2.3 a | 3.5 ± 0.6 bc | 8.5 ± 1.9 a | 1.4 ± 0.6 |
| 2013 | 6.8 ± 1.6 ab | 4.1 ± 1.0 abc | 2.8 ± 0.6 b | 1.5 ± 0.5 |
| 2015 | 9.5 ± 1.1 ab | 6.1 ± 0.6 ab | 3.4 ± 0.8 b | 1.0 ± 0.2 |
| 2017 | 8.9 ± 1.6 ab | 7.1 ± 1.3 a | 1.7 ± 0.5 b | 1.3 ± 0.5 |
| 2019 | 6.9 ± 1.2 ab | 5.2 ± 0.8 abc | 1.7 ± 0.6 b | 1.6 ± 0.5 |
| Baie-Comeau | | | | |
| 2005 | 42.7 ± 12.7 a | 8.2 ± 3.4 b | 34.5 ± 10.1 a | 1.5 ± 1.0 |
| 2007 | 21.7 ± 4.1 a | 6.7 ± 1.3 b | 15.0 ± 3.6 a | |
| 2009 | 24.3 ± 5.6 a | 6.2 ± 1.3 b | 18.1 ± 5.3 a | 0.7 ± 0.2 |
| 2011 | 41.7 ± 8.2 a | 16.8 ± 4.0 ab | 24.9 ± 5.0 a | 4.2 ± 1.9 |
| 2013 | 36.2 ± 12.9 a | 18.7 ± 5.6 ab | 17.5 ± 8.6 ab | 1.6 ± 0.6 |
| 2015 | 16.7 ± 3.3 a | 9.1 ± 1.6 b | 7.6 ± 2.9 ab | 2.2 ± 0.8 |
| 2017 | 59.1 ± 20.4 a | 42.5 ± 14.8 a | 16.6 ± 6.1ab | 1.7 ± 0.8 |
| 2019 | 13.1 ± 2.3 a | 9.6 ± 1.7 b | 3.5 ± 0.8 b | 0.8 ± 0.3 |

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

Average whelk yields according to the size class and egg mass values recorded during the various research surveys are presented in Table 3. As in the case for densities, yields were much higher at Baie-Comeau than in the other two sites, and average yields sometimes exceeded 1,000 g/100 m². At Forestville and Pointe-aux-Outardes, average yields ranged from 200 to 500 g/100 m².

Egg masses were much more abundant in the Pointe-aux-Outardes and Baie-Comeau sites, with average densities ranging from 0.7 to 4.2 masses/100 m², compared to Forestville where average densities ranged from 0.01 to 0.26 mass/100 m² (Table 2). However, the average weight of egg masses is quite variable between years for the same site and between sites, with values between 51 and 222 g/mass (Table 3).

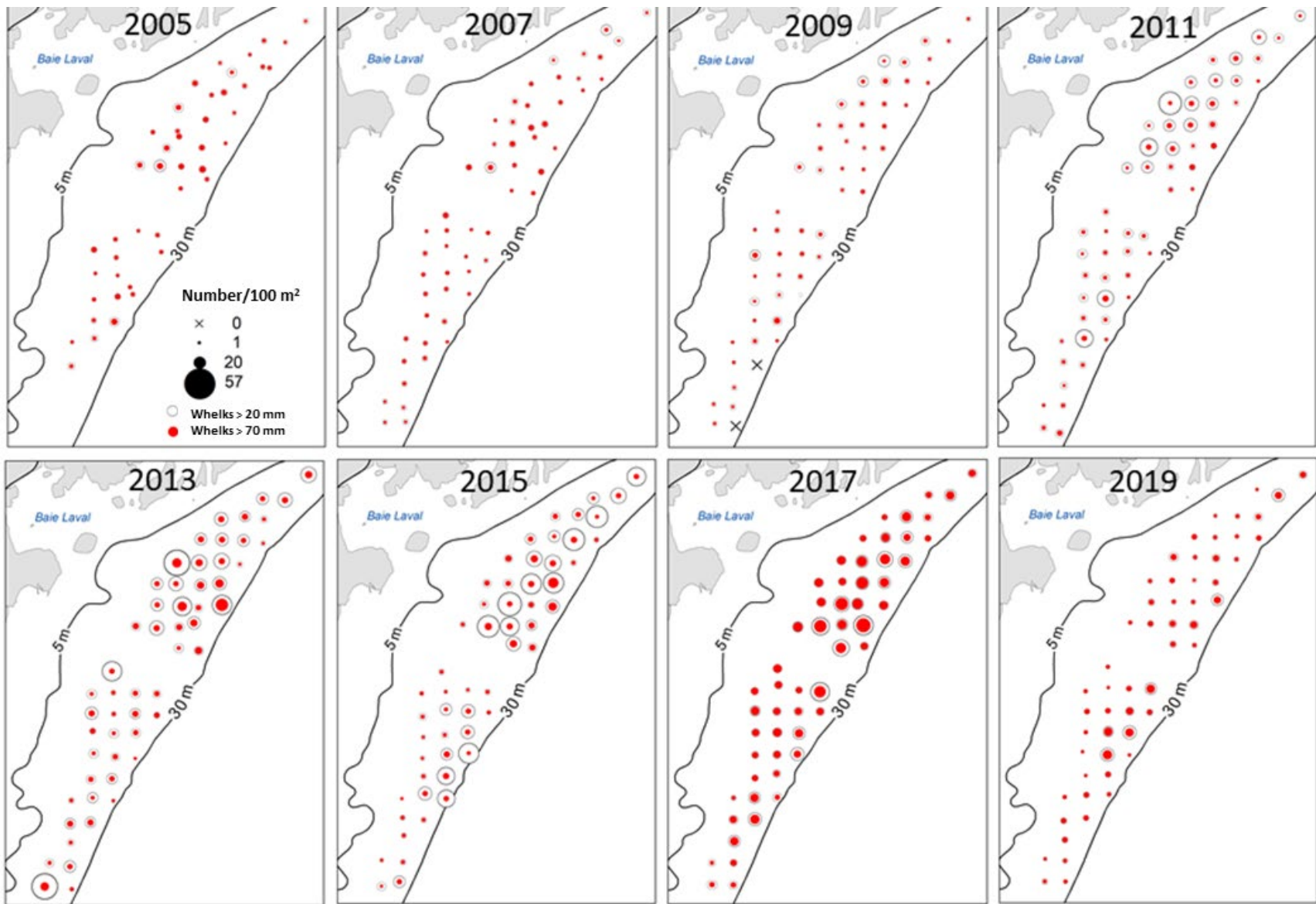


Figure 44. Density (number/100 m²) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Forestville.

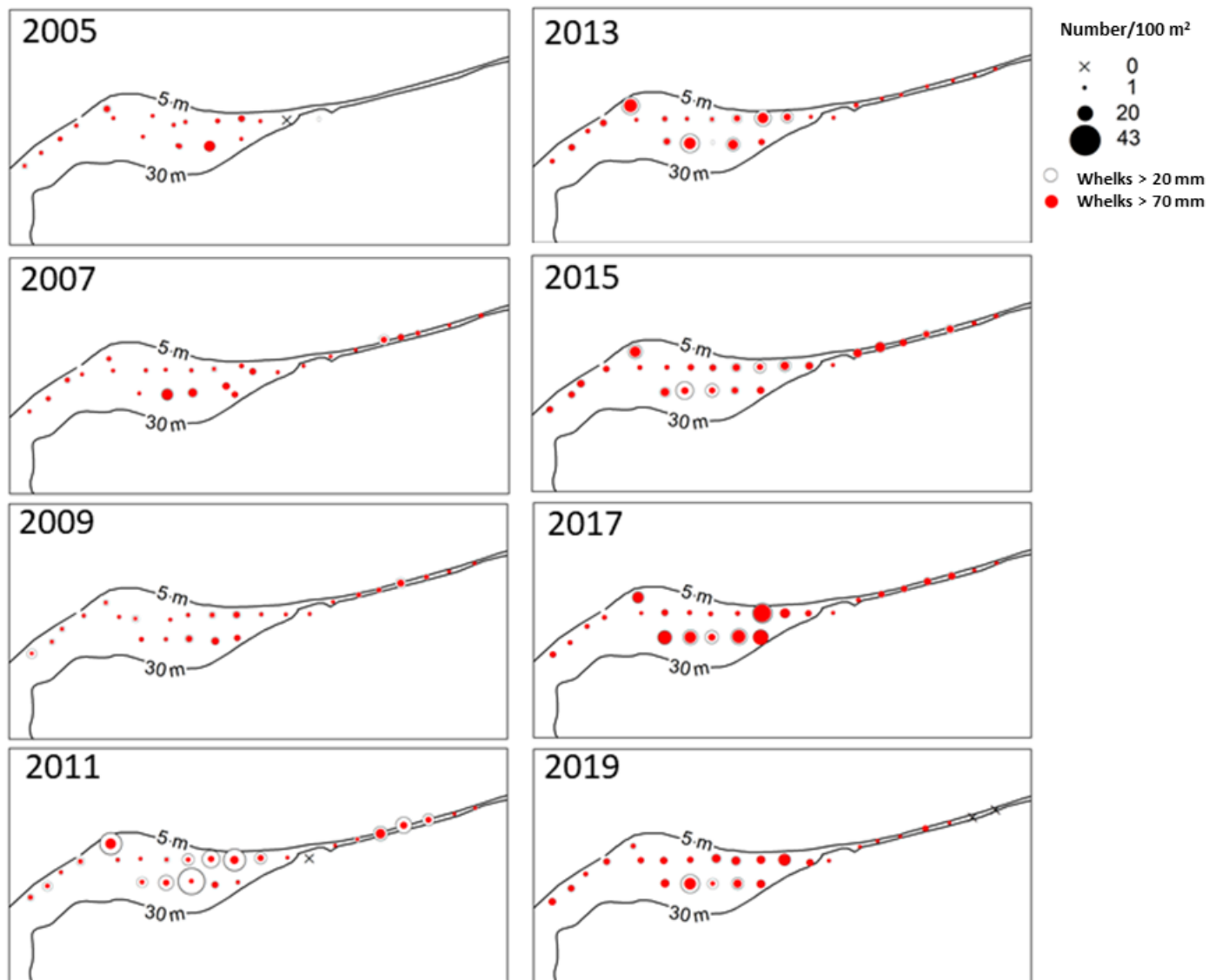


Figure 45. Density (number/100 m²) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Pointe-aux-Outardes.

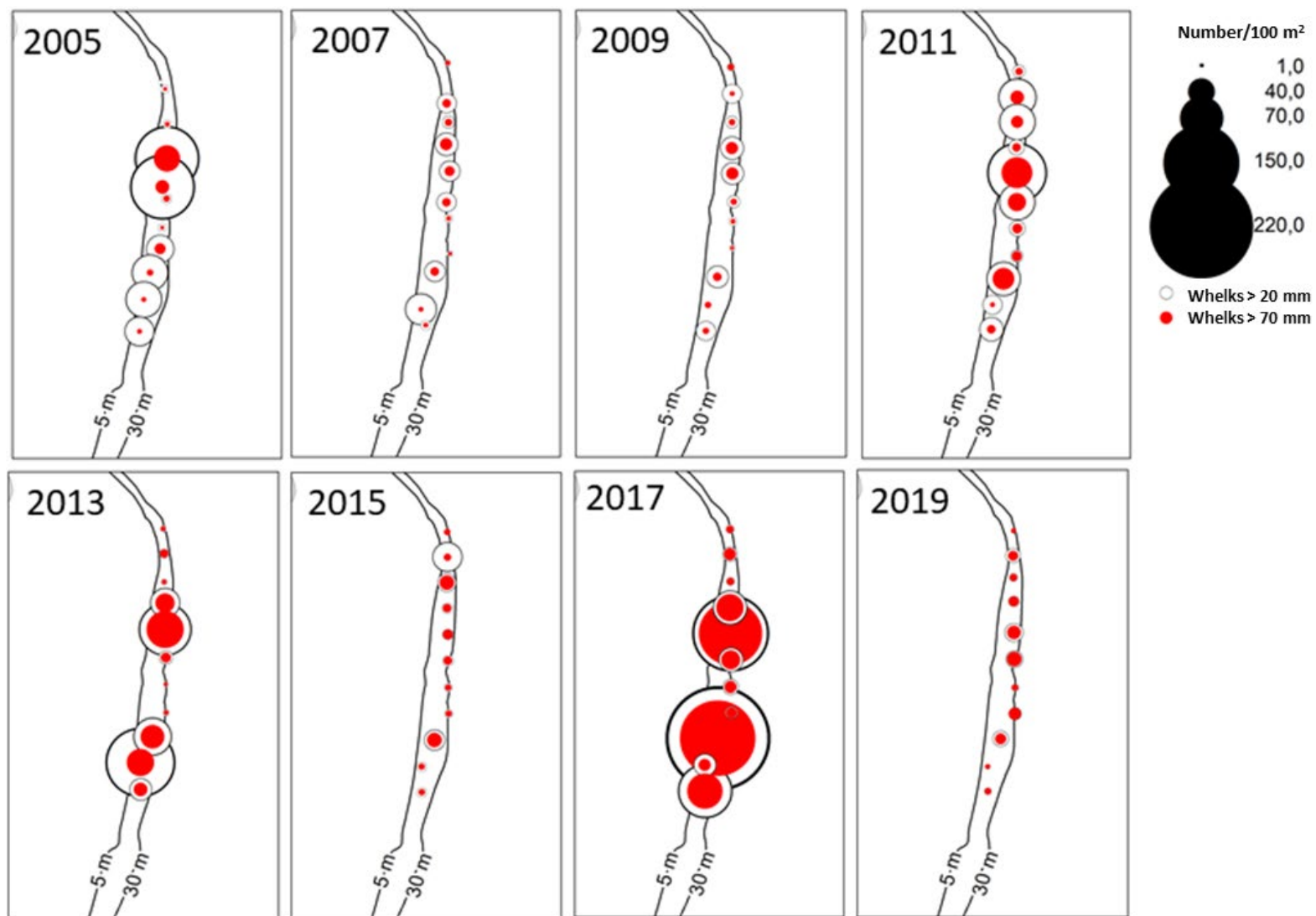


Figure 46. Density (number/100 m²) of all whelks (≥ 20 mm) and whelks of legal size (≥ 70 mm) per station during research surveys in Baie-Comeau.

Table 3. Average whelk yield (g/100 m² ± 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 Upper North Shore.

| 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 | 159 ± 40 |
| 2017 | 718 ± 37 | 588 ± 33 | 129 ± 10 | 6,5 ± 3,6 | 202 ± 49 |
| 2019 | 333 ± 28 | 284 ± 29 | 49 ± 7 | 45 ± 7,0 | 173 ± 41 |
| Pointe-aux-Outardes | | | | | |
| 2005 | 159 ± 49 | 130 ± 47 | 34 ± 6 | - | - |
| 2007 | 197 ± 38 | 165 ± 33 | 37 ± 8 | 90 ± 27 | - |
| 2009 | 175 ± 30 | 129 ± 23 | 49 ± 10 | 73 ± 32 | 69 ± 5 |
| 2011 | 337 ± 59 | 200 ± 36 | 145 ± 30 | 106 ± 54 | 77 ± 4 |
| 2013 | 304 ± 71 | 239 ± 58 | 71 ± 16 | 107 ± 37 | 75 ± 8 |
| 2015 | 432 ± 38 | 365 ± 34 | 73 ± 13 | 83 ± 20 | 80 ± 11 |
| 2017 | 455 ± 82 | 413 ± 77 | 48 ± 11 | 103 ± 43 | 79 ± 7 |
| 2019 | 357 ± 52 | 329 ± 49 | 28 ± 7 | 165 ± 48 | 106 ± 12 |
| Baie-Comeau | | | | | |
| 2005 | 1 226 ± 405 | 417 ± 171 | 826 ± 259 | - | - |
| 2007 | 664 ± 112 | 330 ± 65 | 338 ± 67 | 37 ± 18 | - |
| 2009 | 681 ± 118 | 338 ± 69 | 353 ± 78 | 43 ± 17 | 72 ± 13 |
| 2011 | 1 472 ± 326 | 883 ± 209 | 606 ± 138 | 554 ± 283 | 130 ± 6 |
| 2013 | 1 527 ± 491 | 1008 ± 297 | 552 ± 241 | 269 ± 120 | 166 ± 35 |
| 2015 | 641 ± 95 | 475 ± 79 | 179 ± 37 | 247 ± 100 | 111 ± 19 |
| 2017 | 2 671 ± 925 | 2 164 ± 749 | 550 ± 200 | 157 ± 76 | 93 ± 18 |
| 2019 | 658 ± 116 | 557 ± 106 | 82 ± 1,6 | 91 ± 38 | 111 ± 16 |

At Forestville, the size structure of the legal-size whelk population changed little between years, with a maximum size of around 100 mm (Figure 47). However, the percentage of sub-legal size whelks was much more variable. Whelks measuring 40–69 mm were abundant in 2011, 2013, and 2015 (Table 2). In 2017 and 2019, a good portion of these whelks reached the legal size.

At Pointe-aux-Outardes, the size structures are more variable between years (Figure 48). Young whelks were abundant in 2011 (Table 2), but much less so for the other years. Since 2015, the size structures are relatively similar. Maximum sizes occasionally exceed 105 mm.

At Baie-Comeau, size structures are similar for the last three surveys, with whelks measuring 60–75 mm being the most abundant (Figure 49). Whelks smaller than 60 mm increased in abundance in the surveys between 2005 and 2011. The maximum size rarely exceeds 98 mm.

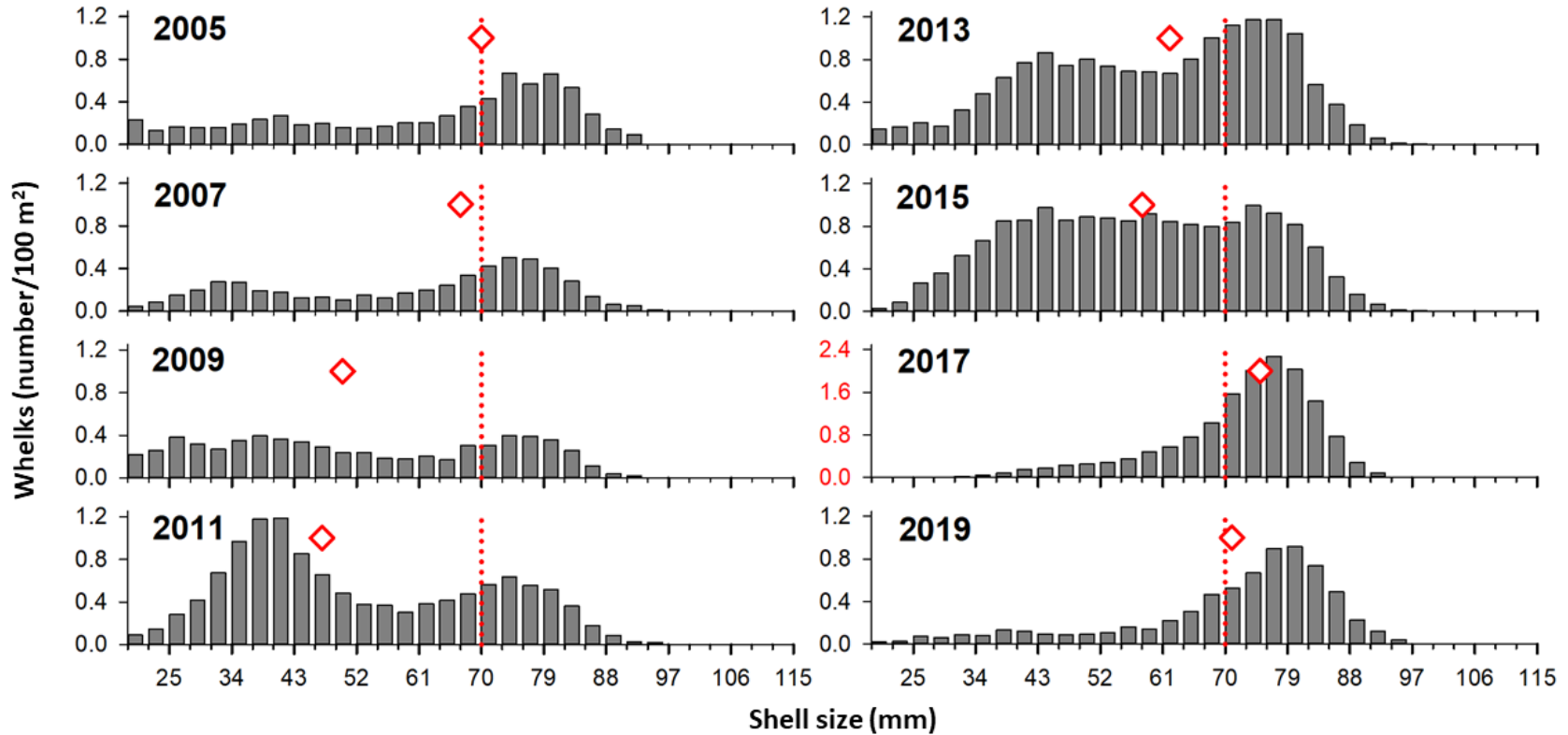


Figure 47. Whelk size structure obtained from Forestville research surveys. The vertical line in the right panel (A) represents the minimum legal size of 70 mm and the red diamond represents the median size.

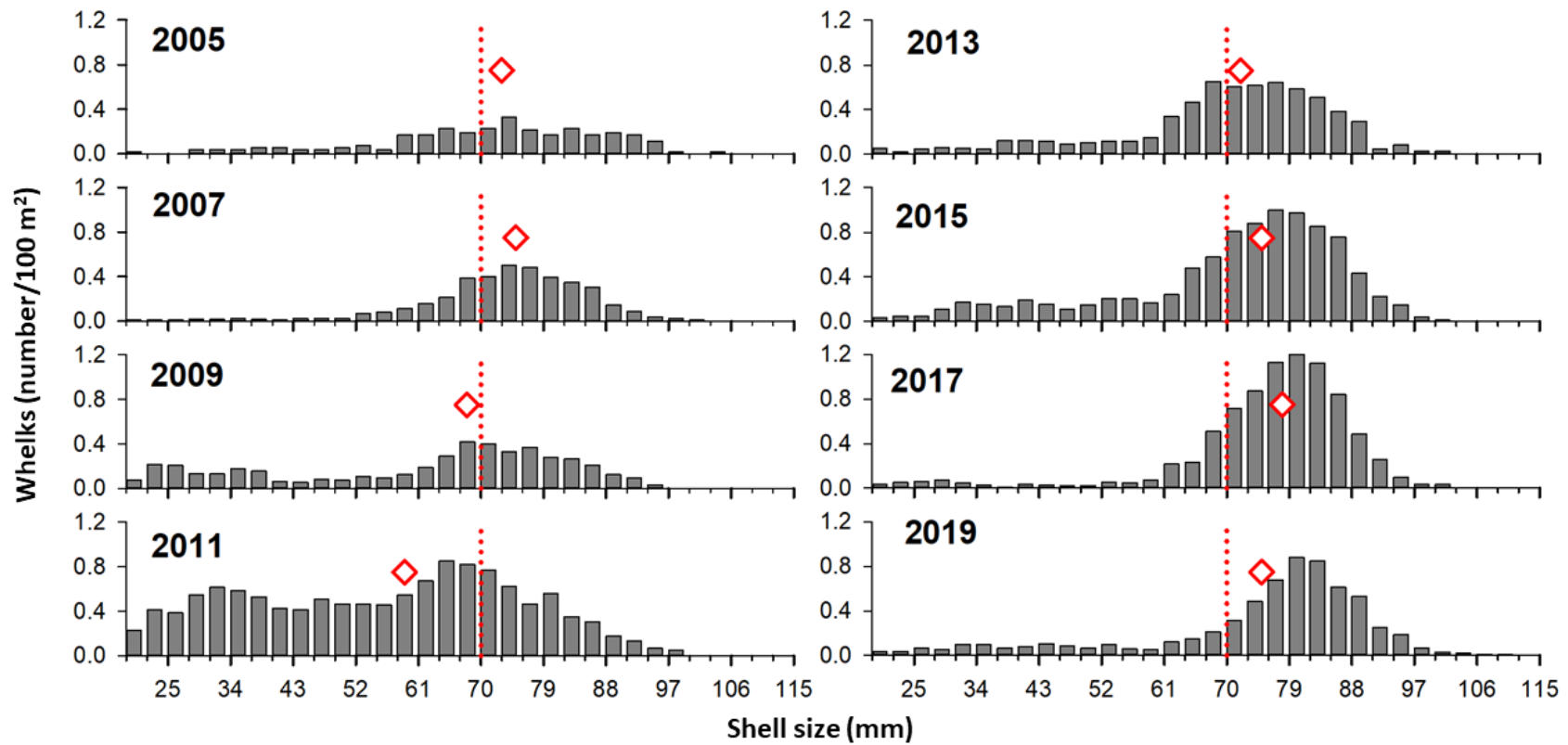


Figure 48. Whelk size structure obtained from Pointe-aux-Outardes research surveys. The vertical line represents the minimum legal size of 70 mm and red diamond represents the median size.

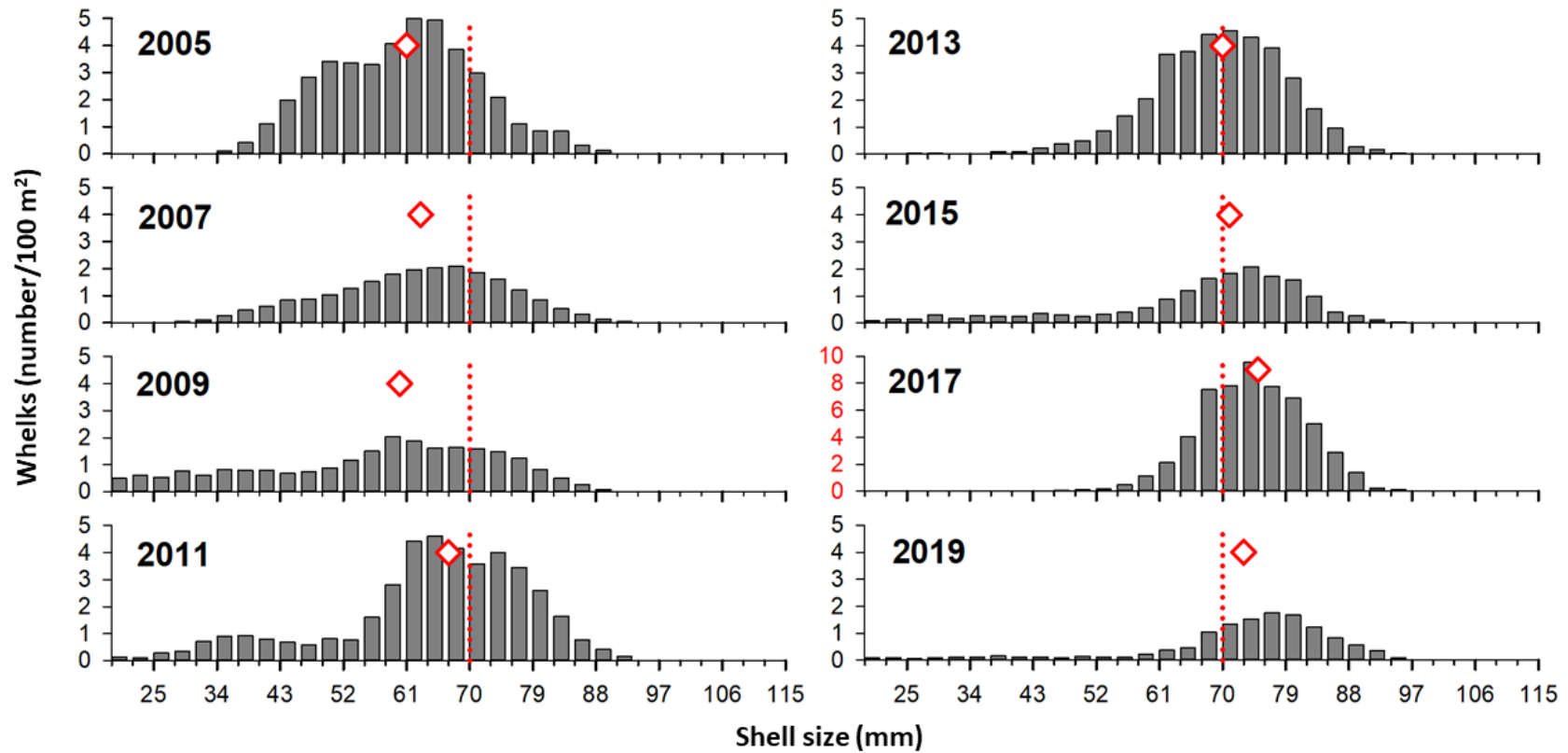


Figure 49. Whelk size structure obtained from Baie-Comeau research surveys. The vertical line represents the minimum legal size of 70 mm and the red diamond represents the median size.

ACKNOWLEDGEMENTS

We would like to thank DFO's entire commercial catch sampling program team, André Chevrier, Yvon Dufresne, Renée Morneau, Mona Rochette, Carole Turbide and Caroline Vanier, as well as Sylvain Hurtubise of Data Management and the staff of the Fisheries and Aquaculture Management Branch – Statistics and Permits in Québec and in the areas. We would also like to acknowledge the survey research team, Sylvie Brulotte, Brigitte Desrosiers, Rénaud Belley, Virginie Roy, Catherine Couillard, Isabelle Lévesque, Nathalie Paille, Hacène Tamdrari, Olivia Lacasse and Denis Bernier for his data management support and the CCGS Leim's crew. The author also wishes to thank all the fishermen involved in the commercial whelk fishery. We would also like to thank Catherine Couillard and Hacène Tamdrari for reviewing the paper.

REFERENCES CITED

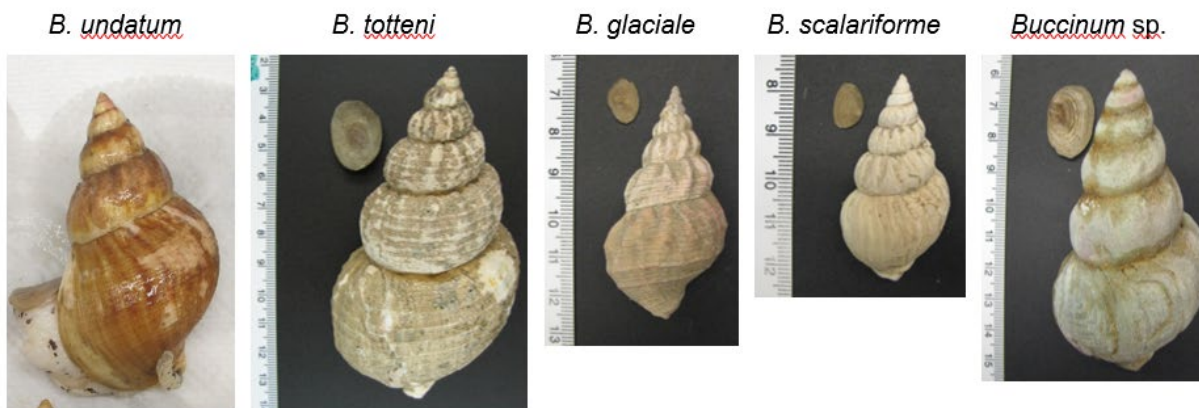
- Boivin, Y., Harvey, C. and Martel, A. 1985. Données écologiques sur le buccin *Buccinum undatum* pour la Gaspésie, Québec. Université du Québec, Chicoutimi. 127 p.
- Bousfield, E.L. 1964. Coquillages des côtes canadiennes de l'Atlantique. Musée national du Canada. 89 p.
- Brulotte, S. 2015. [Whelk Stock Assessment in Québec's Inshore Waters – Methodology and Results](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2015/045. xii + 81 p.
- Caddee, G.C., Boon, J.P., Fischer, C.V., Mensink, B.P. and Ten Hallers-Tjabbes, C.C. 1995. Why the whelk (*Buccinum undatum*) has become extinct in the Dutch Wadden Sea. Netherlands J. Sea Res. 34 (4) : 337-339.
- D'Amours, D., Fortin, J.-L., Himmelman, J., Jalbert, P., Lamoureux, P., Larrivée, D. and Martel, A. 1983. État des connaissances sur le buccin (*Buccinum undatum*) au Québec. MAPAQ, D.R.S.T., Doc. trav. 83/10. 17 p.
- Fahy, E. 2001. Conflict between two inshore fisheries: for whelk (*Buccinum undatum*) and brown crab (*Cancer pagurus*), in the southwest Irish Sea. Hydrobiol. 465 : 73-83.
- Galbraith, P.S., Chassé, J., Shaw, J.-L., Dumas, J., Caverhill, C., Lefavre, D. and Lafleur, C. 2021. [Physical Oceanographic Conditions in the Gulf of St. Lawrence during 2020](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2021/045. iv + 81 p.
- Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. 37 : 2272-2275.
- Gendron, L. 1992. Determination of the size at sexual maturity of the Waved Whelk *Buccinum undatum* Linnaeus, 1758, in the Gulf of St. Lawrence, as a basis for the establishment of a minimum catchable size. J. Shellfish Res. 11(1) : 1-7.
- Giguère, M., Brulotte, S. and Brillon, S. 2007. Essais de 12 modèles de casiers de pêche au buccin commun (*Buccinum undatum*) en milieu naturel et observations comportementales en bassin. Rapp. tech. can. sci. halieut. aquat. 2696 : viii + 36 p.
- Gunnarsson, K. and Einarsson, S. 1995. Observation on whelk populations (*Buccinum undatum* L., Mollusca; Gastropoda) in Breidjifördur, western Iceland. ICES, C.M. 195/K:20. 13 p.
- Hamel, J.-R. 1989. Régime alimentaire et comportements d'alimentation et de reproduction du gastéropode *Buccinum undatum* L. dans le nord du golfe du Saint-Laurent. Thèse (M.Sc.) Université Laval, Québec. 39 p.

-
- Himmelman, J.H. 1988. Movement of whelks (*Buccinum undatum*) towards a baited trap. Mar. Biol. 97 : 521-531.
- Himmelman, J.H. and Hamel, J.-R. 1993. Diet, behaviour and reproduction of the whelk *Buccinum undatum* in the northern Gulf of the St. Lawrence, eastern Canada. Mar. Biol. 116 : 423-430.
- Jalbert, P. 1986. La répartition des populations de *Buccinum undatum* et des autres prédateurs benthiques dans la communauté infralittorale du nord du golfe du Saint-Laurent. Thèse (M.Sc.). Université du Québec, Chicoutimi. 56 p.
- Jalbert, P., Himmelman, J.H., Béland, P. and Thomas, B. 1989. Whelks (*Buccinum undatum*) and other subtidal invertebrate predators in the northern Gulf of St. Lawrence. Nat. Can. 116(1) : 1-15.
- Kenchington, E. and Glass, A. 1998. Local adaptation and sexual dimorphism in the waved whelk (*Buccinum undatum*) in Atlantic Nova Scotia with applications to fisheries management. Can. Tech. Rep. Fish. Aquat. Sci. 2237 : iv + 43 p.
- Lapointe, V. and Sainte-Marie, B. 1992. Currents, predators, and the aggregation of the gastropod *Buccinum undatum* around bait. Mar. Ecol. Prog. Ser. 85 : 245-257.
- Martel, A. 1985. Cycle et comportement de reproduction du néogastropode *Buccinum undatum* L. dans le golfe du Saint-Laurent. Thèse (M.Sc.) Université du Québec, Chicoutimi. 84 p.
- Martel, A., Larrivée, D.H., Klein, K.R. and Himmelman, J.H. 1986a. Reproductive cycle and seasonal feeding activity of the neogastropod *Buccinum undatum*. Mar. Biol. 92 : 211-221.
- Martel, A., Larrivée, D.H. and Himmelman, J.H. 1986b. Behaviour and timing of copulation and egg-laying in the neogastropod *Buccinum undatum* L. J. Exp. Mar. Biol. Eco. 96 : 27-42.
- Morel, G.M. and Bossy, S.F. 2004. Assessment of the whelk (*Buccinum undatum* L.) population around the Island of Jersey, Channel Isles. Fish. Res. 68(1-3) : 283-291.
- Nasution, S. and Roberts, D. 2004. Laboratory trials on the effects of different diets on growth and survival of the common whelk, *Buccinum undatum* L. 1758, as a candidate species for aquaculture. Aquacult. Int. 12(6) : 509-521.
- Ricker, W.E. 1980. Calcul et interprétation des statistiques biologiques des populations de poissons. Bull. Fish. Res. Board Can. 191F : 409 p.
- Sainte-Marie, B. 1991. Whelk (*Buccinum undatum*) movement and its implications for the use of tag-recapture methods for the determination of baited trap fishing parameters. Can. J. Fish. Aquat. Sci. 48 : 751-756.
- World Register of Marine Species (Worms). 2021. [An authoritative classification and catalogue of marine names](#). (consulté en septembre 2021).

APPENDICES

Appendix 1. Average density (number/100 m²) and number of individuals harvested (in parentheses) for the various Buccinum species of ≥ 20 mm and proportion of B. undatum (density) of all Buccinum by site and by year in the Upper North Shore and Îles-de-la-Madeleine research surveys.

| Site and Year | Density and Number | | | | | Proportion (%) |
|-----------------------------|--------------------|-------------------|--------------------|------------------------|---------------------|----------------|
| | <i>B. undatum</i> | <i>B. totteni</i> | <i>B. glaciale</i> | <i>B. scalariforme</i> | <i>Buccinum sp.</i> | |
| 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 % |
| 2019 | 7.000 (2 990) | 0.0024 (1) | 0.0273 (11) | 0 | 0.0081 (4) | 99.5 % |
| 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 % |
| 2019 | 6.930 (1 262) | 0.0042 (1) | 0 | 0 | 0 | 99.9 % |
| 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 % |
| 2019 | 13.126 (1 034) | 0 | 0 | 0 | 0.0121 (1) | 99.9 % |
| Îles-de-la-Madeleine | | | | | | |
| 2016 | 0.982 (823) | 0.065 (63) | 0 | 0.026 (28) | 0.007 (7) | 90.9 % |



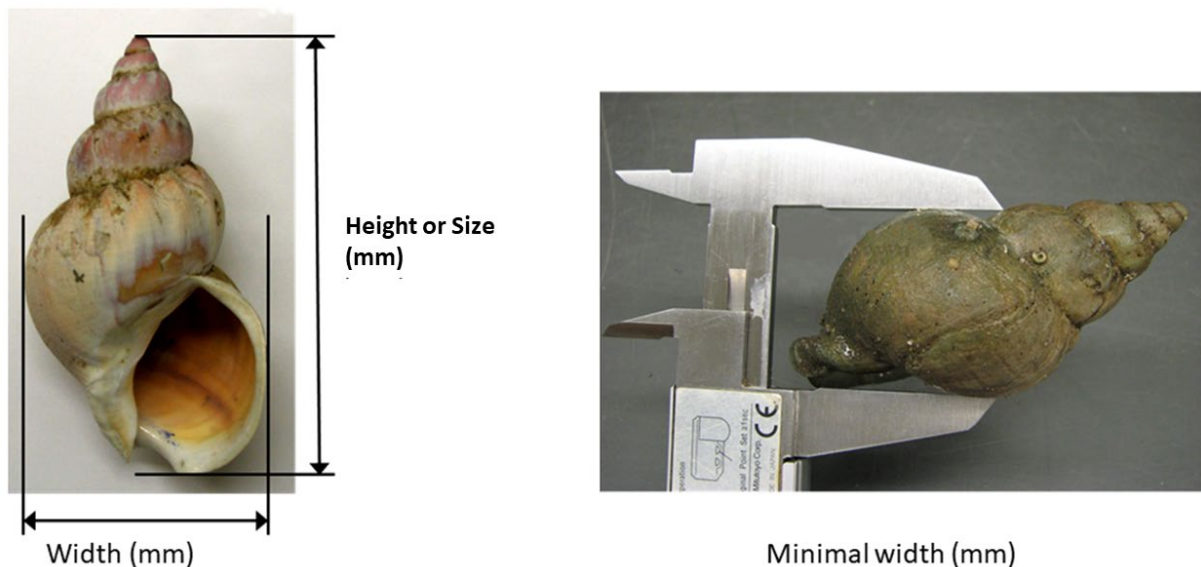
Appendix 2. Photographs of the various Buccinum species observed since 2009 in the Upper North Shore and Îles-de-la-Madeleine research surveys, and an example of an unidentified Buccinum (photographers: M. Boudreau DFO 2010 and S. Brulotte DFO 2015).

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 |
| 2018 | 21 | 8 | 1 | 14 | 8 | 10 | 8 | 9 | 11 | 13 | 10 |
| 2019 | 17 | 10 | 0 | 12 | 9 | 10 | 1 | 5 | 5 | 11 | 10 |
| 2020 | 8 | 8 | 0 | 10 | 9 | 10 | 0 | 8 | 1 | 0 | 8 |
| 2021 | 21 | 9 | 0 | 7 | 5 | 10 | - | 8 | 1 | 11 | 10 |

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 | 0 | 0 | 831 | 628 | 601 | 0 | 1 213 | 0 | 1 000 | - |
| 1996 | 0 | 0 | 0 | 640 | 0 | 507 | 0 | 351 | 0 | 1 646 | - |
| 1997 | 448 | 485 | 0 | 420 | 301 | 381 | 0 | 101 | 1 216 | 0 | - |
| 1998 | 1 051 | 373 | 193 | 640 | 828 | 839 | 315 | 101 | 97 | 301 | - |
| 1999 | 314 | 409 | 310 | 615 | 928 | 920 | 712 | 545 | 0 | 663 | - |
| 2000 | 1 090 | 644 | 226 | 397 | 516 | 669 | 195 | 203 | 307 | 421 | - |
| 2001 | 1 079 | 615 | 497 | 1 043 | 802 | 819 | 0 | 0 | 389 | 515 | - |
| 2002 | 409 | 4 444 | 207 | 1 156 | 2 284 | 3 185 | 203 | 133 | 622 | 906 | 120 |
| 2003 | 219 | 4 380 | 0 | 1 256 | 1 021 | 1 208 | 602 | 536 | 755 | 940 | 940 |
| 2004 | 5 178 | 1 832 | 1 252 | 2 771 | 3 304 | 3 282 | 2 514 | 0 | 1 766 | 725 | 2 341 |
| 2005 | 4 347 | 2 879 | 0 | 2 154 | 2 567 | 2 473 | 1 513 | 876 | 2 600 | 984 | 2 837 |
| 2006 | 4 538 | 385 | 0 | 1 359 | 1 645 | 1 351 | 919 | 489 | 1 724 | 839 | 2 323 |
| 2007 | 4 449 | 2 162 | 0 | 1 213 | 2 580 | 2 936 | 1 055 | 500 | 2 753 | 2 634 | 2 324 |
| 2008 | 5 754 | 621 | 0 | 1 209 | 2 423 | 2 257 | 754 | 519 | 2 808 | 2 439 | 2 699 |
| 2009 | 6 690 | 344 | 0 | 1 543 | 2 553 | 2 698 | 1 364 | 484 | 2 832 | 2 627 | 794 |
| 2010 | 7 837 | 1 537 | 0 | 2 309 | 4 134 | 3 232 | 2 153 | 1 023 | 935 | 3 056 | 2 559 |
| 2011 | 3 631 | 2 337 | 0 | 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 | 0 | 2 431 | 2 269 | 2 263 | 907 | 1 126 | 2 251 | 2 250 | 2 626 |
| 2014 | 2 555 | 1 465 | 0 | 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 | 0 | 1 501 | 1 202 | 1 800 | 301 | 2 214 | 1 952 | 1 650 | 1 667 |
| 2018 | 3 152 | 1 200 | 150 | 2 115 | 1 204 | 1 500 | 1261 | 1 419 | 1 649 | 2 040 | 1 544 |
| 2019 | 2 550 | 1 501 | 0 | 1 801 | 1 350 | 1 501 | 150 | 814 | 750 | 1 649 | 1 511 |
| 2020 | 1 203 | 1 201 | 0 | 1 502 | 1 333 | 1 503 | 0 | 1 329 | 151 | 0 | 1 218 |
| 2021 | 2 626 | 1 351 | 0 | 1 049 | 750 | 1 500 | - | 1 271 | 150 | 1 627 | 1 545 |



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

Appendix 6. Management measures for the 2021 commercial whelk fishery.

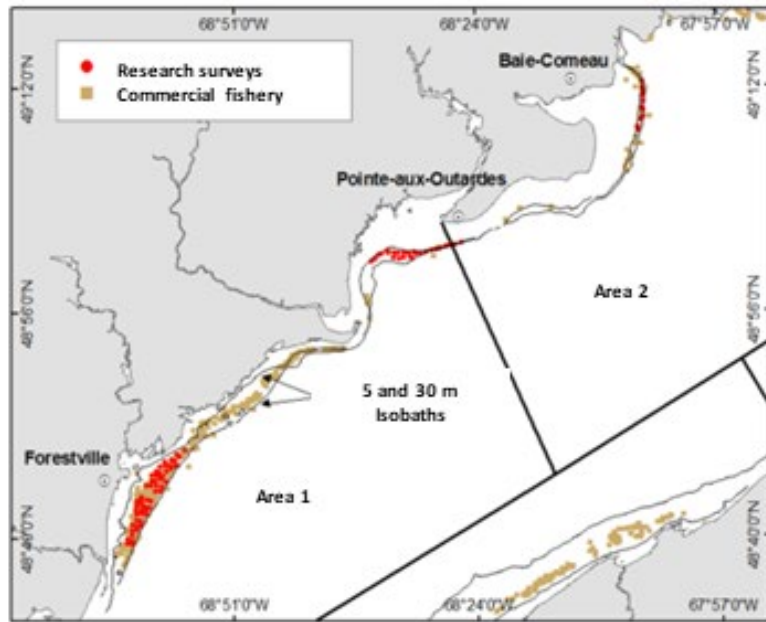
| Area | Number of Active/Issued Licences | Number of Active/Authorized Traps | Proportion of Active Traps (%) | TAC | Minimum Legal Size (mm) ³ | Season |
|--------------|----------------------------------|-----------------------------------|--------------------------------|-----|--------------------------------------|----------------|
| 1 | 7 / 8 | 935 / 1 125 | 83 | 491 | 70 | 03/21 to 09/17 |
| 2 | 4 / 6 | 480 / 550 | 87 | 109 | 70 | 04/01 to 09/30 |
| 3 | 1 / 7 | 100 / 850 | 12 | - | 80 | 04/16 to 11/11 |
| 4 | 3 / 27 | | | - | 80 | 04/23 to 10/21 |
| 5 | 4 / 17 | 835 / 4 109 ² | 20 ² | - | 80 | 04/09 to 10/07 |
| 6 | 7 / 15 | 850 / 1 450 | 59 | - | 80 | 04/24 to 10/23 |
| 7 | 0 / 6 | 0 / 550 | 0 | - | 80 | 04/24 to 10/23 |
| 8 | 8 / 64 | 850 / 6 400 | 13 | - | 75 | 06/01 to 11/30 |
| 9 | 0 / 1 ¹ | - | | - | 80 | 04/09 to 10/23 |
| 10 | 0 | - | | - | - | - |
| 11 | 0 / 16 | 0 / 1 200 | 0 | 32 | 75 | 04/01 to 09/30 |
| 12 | 7 / 29 | 1 150 / 2 725 | 42 | 75 | 75 | 04/01 to 09/30 |
| 13 | 7 / 9 | 800 / 900 | 89 | 82 | 75 | 04/01 to 09/30 |
| 14 | 0 / 13 | 0 / 800 | 0 | - | 75 | 04/01 to 09/30 |
| 15 | 11 / 11 | 1 650 / 1 650 | 100 | 330 | 75 | 08/01 to 11/30 |
| Total | 59 / 229 | | | | | |

¹ Fishermen in Areas 5, 6 and 7 also have access to Area 9.

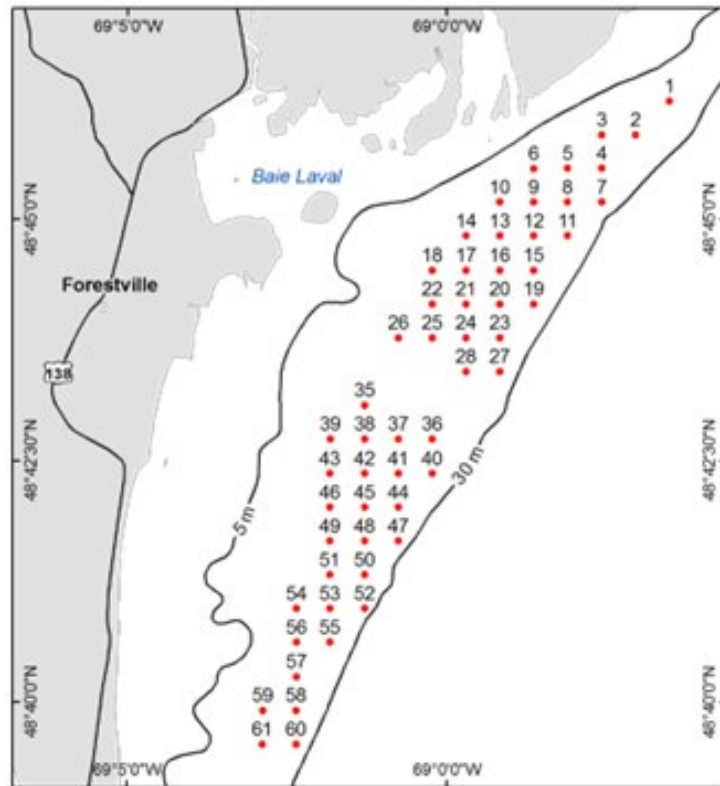
² Data from Areas 4 and 5 combined.

³ See sexual maturity results for a new suggested minimum legal size (Table 1).

A)

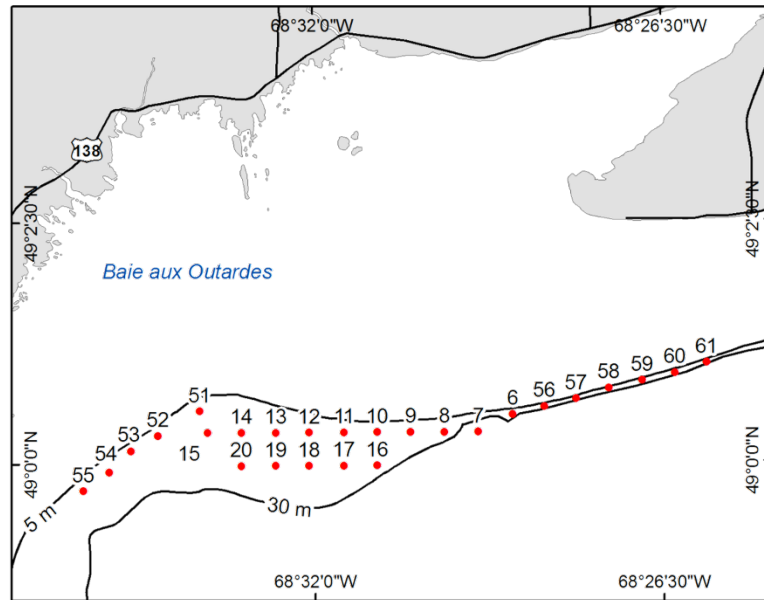


B)

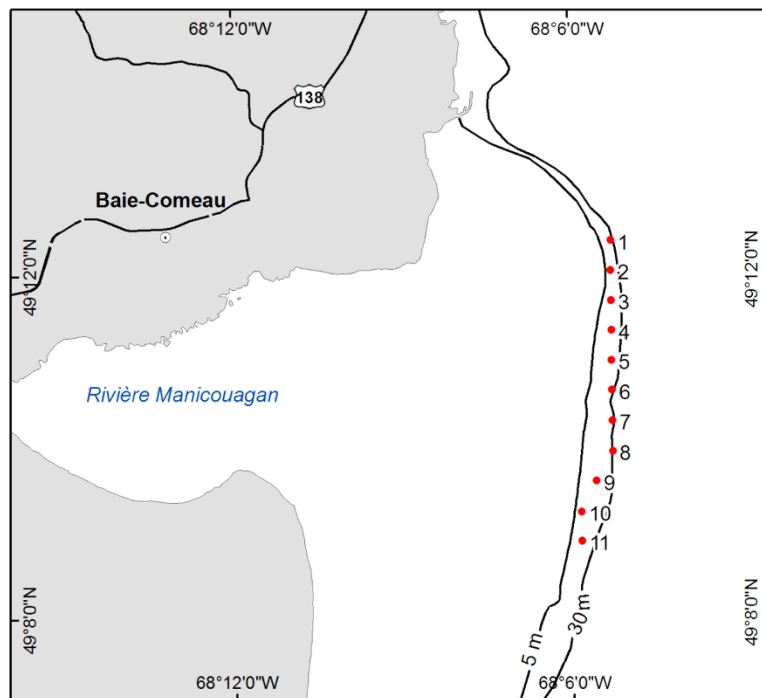


Appendix 7. Location A) of the whelk research survey sampling sites and commercial whelk fishery, and sampling stations at B) Forestville, C) Pointe-aux-Outardes and D) Baie-Comeau.

C)



D)



Appendix 8. Continued.

Appendix 9. Parameters of linear relationships between total live weight in g (y) and height in mm (x) of *Buccinum undatum* from research surveys conducted in Forestville, Pointe-aux-Outardes and Baie-Comeau since 2005

| Site | Year | Equation | R ² | n |
|-------------|---------------------|---------------------------------|---------------------------------|-------|
| Forestville | 2005 | $\ln(y) = 2.897 \ln(x) - 8.566$ | 0.974 | 303 |
| | 2007 | $\ln(y) = 2.875 \ln(x) - 8.566$ | 0.992 | 176 |
| | 2009 | $\ln(y) = 2.904 \ln(x) - 8.594$ | 0.991 | 324 |
| | 2011 | $\ln(y) = 2.930 \ln(x) - 8.708$ | 0.993 | 269 |
| | 2013 | $\ln(y) = 2.914 \ln(x) - 8.663$ | 0.992 | 238 |
| | 2015 | $\ln(y) = 2.888 \ln(x) - 8.578$ | 0.994 | 238 |
| | 2017 | $\ln(y) = 2.875 \ln(x) - 8.489$ | 0.992 | 371 |
| | 2019 | $\ln(y) = 2.967 \ln(x) - 8.897$ | 0.995 | 245 |
| | Pointe-aux-Outardes | 2005 | $\ln(y) = 2.861 \ln(x) - 8.447$ | 0.963 |
| 2007 | | $\ln(y) = 2.805 \ln(x) - 8.244$ | 0.987 | 155 |
| 2009 | | $\ln(y) = 2.927 \ln(x) - 8.696$ | 0.992 | 261 |
| 2011 | | $\ln(y) = 2.881 \ln(x) - 8.556$ | 0.995 | 196 |
| 2013 | | $\ln(y) = 2.894 \ln(x) - 8.609$ | 0.995 | 191 |
| 2015 | | $\ln(y) = 2.921 \ln(x) - 8.734$ | 0.995 | 275 |
| 2017 | | $\ln(y) = 2.871 \ln(x) - 8.489$ | 0.992 | 276 |
| 2019 | | $\ln(y) = 2.949 \ln(x) - 8.879$ | 0.994 | 251 |
| Baie-Comeau | | 2005 | $\ln(y) = 2.823 \ln(x) - 8.297$ | 0.972 |
| | 2007 | $\ln(y) = 2.797 \ln(x) - 8.244$ | 0.984 | 137 |
| | 2009 | $\ln(y) = 2.975 \ln(x) - 8.909$ | 0.995 | 250 |
| | 2011 | $\ln(y) = 2.924 \ln(x) - 8.750$ | 0.993 | 171 |
| | 2013 | $\ln(y) = 2.820 \ln(x) - 8.258$ | 0.988 | 123 |
| | 2015 | $\ln(y) = 2.898 \ln(x) - 8.661$ | 0.996 | 256 |
| | 2017 | $\ln(y) = 2.906 \ln(x) - 8.669$ | 0.995 | 108 |
| | 2019 | $\ln(y) = 2.951 \ln(x) - 8.841$ | 0.996 | 198 |

Appendix 10. Commercial whelk fishery landings (t) by 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 | | |
| 1993 | 125 | 0 | 37 | 53 | 180 | 206 | 0 | 24 | 0 | 0 | 58 | 28 | 3 | 0.1 | 0 | 715 |
| 1994 | 54 | 11 | 8 | 77 | 161 | 111 | 3 | 14 | 0 | 0 | 24 | 28 | 3 | 0 | 0 | 493 |
| 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 | dc | 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 | dc | 14 | 83 | 168 | 152 | 42 | 21 | 0 | 0 | cd | 127 | 77 | 0 | 382 | 1 269 |
| 2008 | 118 | dc | 16 | 48 | 146 | 216 | 19 | 24 | 0 | 0 | cd | 117 | 67 | 0 | 352 | 1 147 |
| 2009 | 300 | dc | 6 | 51 | 274 | 330 | 67 | 11 | 0 | 0 | cd | 110 | 57 | 0 | 23 | 1 255 |
| 2010 | 204 | dc | 10 | 60 | 363 | 358 | 34 | 38 | 0 | 0 | cd | 129 | 91 | 0 | 150 | 1 484 |
| 2011 | 132 | dc | 14 | 42 | 312 | 314 | 22 | 21 | 0 | 0 | cd | 95 | 78 | 0 | 265 | 1 368 |
| 2012 | 114 | dc | 12 | 64 | 409 | 296 | 49 | 27 | 0 | 0 | cd | 75 | 81 | 0 | 239 | 1 432 |
| 2013 | 241 | dc | 6 | 82 | 250 | 280 | 45 | 36 | cd | 0 | cd | 70 | 66 | dc | 327 | 1 445 |
| 2014 | 290 | dc | 6 | 41 | 115 | 270 | 22 | 23 | cd | 0 | cd | 46 | dc | dc | 15 | 952 |
| 2015 | 225 | dc | 1 | 60 | 148 | 308 | 24 | 31 | cd | 0 | cd | 48 | 50 | 0 | 11 | 937 |
| 2016 | 428 | dc | 3 | 47 | 160 | 366 | 76 | 30 | 0 | 0 | cd | 47 | 89 | 0 | 111 | 1 418 |
| 2017 | 378 | dc | 3 | 57 | 142 | 307 | 50 | 30 | cd | 0 | cd | 46 | 59 | 0 | 204 | 1 329 |
| 2018 | 277 | 48 | 4 | 84 ² | 212 | 77 | 21 | 0 | 0 | 0 | 1 | 50 | 83 | 0 | 252 | 1 108 |
| 2019 | 308 | 51 | 2 | 42 ² | 196 | 8 | 14 | 0 | 0 | 0 | 0 | 30 | 68 | 0 | 242 | 962 |
| 2020 | 222 | 81 | 4 | 69 ² | 161 | 1 | 56 | 0 | 0 | < 1 | 29 | 72 | 0 | 0 | 202 | 899 |
| 2021 | 260 | 113 | 4 | 49 ² | 138 | 0 | 103 | 0 | 0 | 0 | 0 | 17 | 59 | 0 | 167 | 910 |

¹ cd = confidential data

² Data combined for Areas 4 and 5.

Appendix 11. Commercial whelk fishing effort (number of trap hauls) by region, 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 |
| 2018 | 21 300 | 3 000 | 1 200 | 37 900 ² | | 51 300 | 10 400 | 8 000 | 15 600 | 12 800 | 14 000 | 176 400 |
| 2019 | 33 000 | 3 700 | 900 | 20 300 ² | | 51 500 | 2 200 | 3 300 | 9 500 | 12 200 | 15 000 | 151 500 |
| 2020 | 30 100 | 9 000 | 1 700 | 32 300 ² | | 48 500 | 200 | 7 900 | 9 600 | 15 000 | 14 500 | 169 500 |
| 2021 | 29 900 | 12 200 | 1 600 | 24 200 ² | | 37 400 | 0 | 16 000 | 6 500 | 15 500 | 12 800 | 156 200 |

¹ cd = confidential data

² Data combined for Areas 4 and 5

Appendix 12. Annual average of standardized catch per unit effort (kg/trap) by region and fishing area, according to commercial whelk logbook.

| Year | North Shore | | | | | | | | Gaspé–Lower St. Lawrence | | Îles-de-la-Madeleine |
|------------------------------|-------------|------|------|-----|-------------------|------|------|-----|--------------------------|------|----------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 12 | 13 | 15 |
| 2001 | 12.9 | 12.8 | 6.5 | 4.6 | 4.4 | 5.2 | - | - | 3.1 | 4.6 | - |
| 2002 | 11.1 | 8.4 | 5.3 | 3.1 | 4.4 | 6.0 | 10.7 | 4.8 | 2.9 | 4.1 | - |
| 2003 | 9.3 | 11.1 | 5.8 | 2.8 | 4.6 | 4.8 | 4.9 | 3.5 | 1.8 | 3.4 | 20.2 |
| 2004 | 6.6 | 9.1 | 5.7 | 3.1 | 4.1 | 3.9 | 6.5 | 4.1 | 3.3 | 3.9 | 18.6 |
| 2005 | 7.3 | 7.8 | 5.2 | 3.0 | 3.9 | 3.3 | 7.0 | 4.6 | 3.7 | 2.8 | 20.8 |
| 2006 | 7.7 | 7.3 | 5.6 | 3.1 | 4.1 | 3.7 | 7.6 | 3.4 | 4.1 | 5.3 | 20.1 |
| 2007 | 6.9 | 13.2 | 4.6 | 3.6 | 3.5 | 3.9 | 7.1 | 4.8 | 4.6 | 6.2 | 19.3 |
| 2008 | 7.3 | 10.3 | 4.4 | 2.7 | 4.0 | 4.4 | 5.0 | 3.8 | 3.9 | 6.2 | 18.3 |
| 2009 | 8.8 | 9.7 | 2.7 | 3.6 | 5.3 | 6.1 | 7.3 | 5.5 | 4.3 | 6.3 | 21.1 |
| 2010 | 7.1 | 11.4 | 5.2 | 3.0 | 5.9 | 5.7 | 5.2 | 3.4 | 4.6 | 8.4 | 20.9 |
| 2011 | 6.8 | 12.8 | 3.5 | 3.8 | 6.7 | 5.5 | 4.9 | 3.7 | 4.6 | 8.9 | 17.6 |
| 2012 | 8.2 | 10.6 | 4.3 | 4.1 | 6.3 | 4.9 | 5.8 | 4.1 | 4.1 | 7.4 | 17.2 |
| 2013 | 10.5 | 11.4 | 3.7 | 4.8 | 4.7 | 4.9 | 6.0 | 5.0 | 4.3 | 7.0 | 16.7 |
| 2014 | 10.5 | 10.6 | 3.1 | 4.0 | 4.3 | 5.1 | 5.3 | 4.1 | 2.5 | 7.3 | 4.7 |
| 2015 | 11.4 | 8.1 | - | 4.5 | 4.4 | 5.3 | 6.1 | 3.9 | 3.4 | 5.5 | - |
| 2016 | 15.3 | 10.7 | 3.1 | 3.9 | 3.7 | 5.2 | 8.0 | 3.4 | 3.7 | 5.9 | 9.7 |
| 2017 | 15.5 | 14.1 | 1.9 | 3.2 | 3.3 | 4.7 | 8.1 | 3.3 | 4.3 | 4.5 | 17.5 |
| 2018 | 12.1 | 14.5 | 2.1 | | 2.1 ³ | 4.2 | 6.9 | 2.6 | 3.4 | 5.3 | 15.8 |
| 2019 | 9.3 | 12.8 | 2.8 | | 2.1 ³ | 3.9 | - | 3.8 | 3.5 | 5.1 | 14.1 |
| 2020 | 7.0 | 8.9 | 1.9 | | 2.1 ³ | 3.4 | - | 5.1 | 2.9 | 4.5 | 12.5 |
| 2021 | 8.8 | 9.6 | 2.7 | | 2.1 ³ | 4.0 | - | 6.0 | 2.9 | 2.9 | 11.6 |
| Median¹ | 8.9 | 10.8 | 4.4 | | 3.9 ³ | 4.9 | 6.5 | 3.8 | 3.8 | 5.8 | 18.2 |
| Variation² | -1% | -12% | -38% | | -43% ³ | -20% | - | 57% | -23% | -49% | -44% |

¹ 2001–2018 reference median, except for Area 15, where the 2003–2018 median was used, excluding 2014–2016, possibly due to environmental conditions and the high abundance of polychaete borer, which may have affected CPUE during these years.

² Variation between the 2021 value and the median.

³ Data combined for Areas 4 and 5.

Appendix 13. Annual median size (mm) of whelk landed by region and fishing area during the commercial whelk fishery

| Year | North Shore | | | | | | | | Gaspé–Lower St Lawrence | | Îles-de-la- Madeleine |
|-------------|-------------|----|----|-----|----|----|----|----|----------------------------|----|--------------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 12 | 13 | 15 |
| 2005 | 75 | 74 | - | 88 | 81 | 84 | 81 | 81 | 87 | 77 | 83 |
| 2006 | 77 | 70 | - | 82 | 80 | 87 | 84 | 77 | 86 | 80 | 83 |
| 2007 | 79 | 73 | - | 90 | 86 | 85 | 84 | 74 | 86 | 87 | 81 |
| 2008 | 79 | 71 | - | 90 | 85 | 83 | 88 | 71 | 89 | 83 | 89 |
| 2009 | 78 | 78 | - | 89 | 87 | 85 | 88 | 73 | 88 | 84 | 88 |
| 2010 | 79 | 82 | - | 90 | 90 | 88 | 88 | 74 | 88 | 87 | 85 |
| 2011 | 81 | 76 | - | 91 | 88 | 89 | 90 | 72 | 87 | 84 | 87 |
| 2012 | 80 | 78 | 93 | 95 | 90 | 89 | 90 | 73 | 91 | 85 | 83 |
| 2013 | 70 | 77 | - | 94 | 91 | 89 | 90 | 72 | 89 | 85 | 86 |
| 2014 | 78 | 82 | - | 95 | 90 | 89 | 87 | 75 | 92 | 83 | 92 |
| 2015 | 79 | 77 | 95 | 97 | 91 | 89 | 89 | 79 | 93 | 86 | 81 |
| 2016 | 80 | 79 | 97 | 97 | 93 | 86 | 86 | 77 | 91 | 87 | 86 |
| 2017 | 79 | 79 | - | 97 | 94 | 89 | 91 | 79 | 92 | 89 | 84 |
| 2018 | 80 | 78 | 93 | 96 | 95 | 92 | 90 | 78 | 95 | 89 | 88 |
| 2019 | 81 | 82 | - | 101 | 92 | 91 | 95 | 91 | 96 | 92 | 89 |
| 2020 | 82 | 83 | - | 99 | 94 | 92 | - | 86 | 96 | - | 89 |
| 2021 | 83 | 81 | - | 100 | 97 | 93 | - | 83 | 95 | 92 | 87 |

Appendix 14. Percentage (%) of sub-legal size whelk in commercial whelk fishery landings by region and fishing area. See Appendix 6 for legal sizes in the various fishing areas.

| Year | North Shore | | | | | | | | Gaspé–Lower St Lawrence | | Îles-de-la-Madeleine |
|-------------|-------------|------|-----|------|------|------|-----|------|-------------------------|------|----------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 12 | 13 | 15 |
| 2005 | 29.0 | 31.3 | - | 3.5 | 11.3 | 10.2 | 8.8 | 25.4 | 3.4 | 16.0 | 7.9 |
| 2006 | 18.7 | 42.0 | - | 13.9 | 14.7 | 3.3 | 3.6 | 26.6 | 3.8 | 9.0 | 4.0 |
| 2007 | 8.2 | 26.7 | - | 3.1 | 6.4 | 4.2 | 9.7 | 26.6 | 3.1 | 0.8 | 7.2 |
| 2008 | 15.1 | 42.8 | - | 3.4 | 4.2 | 6.1 | 5.3 | 39.3 | 1.7 | 5.5 | 2.0 |
| 2009 | 13.9 | 11.4 | - | 2.8 | 2.5 | 5.6 | 3.6 | 32.4 | 2.5 | 6.3 | 1.5 |
| 2010 | 12.6 | 5.7 | - | 2.1 | 1.5 | 1.7 | 7.4 | 26.7 | 2.9 | 2.0 | 2.1 |
| 2011 | 4.8 | 21.5 | - | 1.5 | 1.4 | 1.8 | 1.5 | 31.9 | 2.9 | 0.3 | 1.5 |
| 2012 | 6.6 | 10.4 | 0.3 | 0.2 | 0.6 | 2.0 | 1.4 | 31.5 | 3.2 | 0.9 | 3.4 |
| 2013 | 8.3 | 12.3 | - | 0.4 | 0.6 | 2.0 | 1.8 | 32.0 | 1.6 | 0.4 | 7.0 |
| 2014 | 9.9 | 2.5 | - | 0.2 | 4 | 2.2 | 2.7 | 18.7 | 2.0 | 0.5 | 0.7 |
| 2015 | 8.5 | 8.0 | 0.4 | 0.2 | 1.4 | 3.0 | 5.0 | 7.6 | 0.5 | 0.3 | 2.3 |
| 2016 | 3.7 | 4.6 | 0 | 0.2 | 1.3 | 5.7 | 2.7 | 9.0 | 1.1 | 0.8 | 1.2 |
| 2017 | 9.5 | 4.6 | - | 0.2 | 0.6 | 2.8 | 2.6 | 6.7 | 1.0 | 0.4 | 3.4 |
| 2018 | 4.6 | 8.9 | 1.3 | 0.4 | - | 1.8 | 2.5 | 10.7 | 0.4 | 0.4 | 2.0 |
| 2019 | 4.9 | 3.2 | - | 1.4 | 6.8 | 13.1 | 4.6 | 1.2 | 0.6 | 0.4 | 2.0 |
| 2020 | 2.0 | 1.8 | - | 0.7 | 4.8 | 3.3 | - | 11.2 | 0.6 | - | 3.0 |
| 2021 | 1.6 | 3.1 | - | 1.0 | 2.1 | 3.7 | - | 5.8 | 0 | 0.7 | 3.7 |

Appendix 15. Central position of tow (latitude and longitude WGS84), density (number/100 m²) and yield (g/100 m²) of whelk by size class, site and station during the 2019 research survey in Upper North Shore.

| 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' | 318 | 4.6 | 7.2 | 109.5 | 453.4 | |
| 2 | 48° 45.872' | 68° 57.046' | 301 | 8.9 | 9.2 | 211.1 | 555.9 | |
| 3 | 48° 45.882' | 68° 57.572' | 313 | 0.0 | 1.6 | 0.0 | 102.3 | |
| 4 | 48° 45.516' | 68° 57.597' | 303 | 6.8 | 4.5 | 80.3 | 281.9 | |
| 5 | 48° 45.528' | 68° 58.117' | 307 | 2.9 | 2.4 | 54.8 | 144.4 | |
| 6 | 48° 45.518' | 68° 58.654' | 258 | 0.4 | 1.7 | 14.7 | 105.8 | |
| 7 | 48° 45.176' | 68° 57.590' | 252 | 0.9 | 4.7 | 19.7 | 311.6 | |
| 8 | 48° 45.190' | 68° 58.099' | 257 | 1.1 | 2.4 | 16.8 | 148.5 | |
| 9 | 48° 45.190' | 68° 58.630' | 254 | 1.9 | 3.7 | 48.8 | 229.8 | |
| 10 | 48° 45.178' | 68° 59.182' | 257 | 0.7 | 4.1 | 20.1 | 245.5 | |
| 11 | 48° 44.806' | 68° 58.146' | 254 | 1.9 | 3.6 | 40.0 | 240.0 | |
| 12 | 48° 44.837' | 68° 58.637' | 258 | 3.9 | 6.8 | 35.1 | 411.8 | |
| 13 | 48° 44.799' | 68° 59.204' | 256 | 2.0 | 3.4 | 42.7 | 217.5 | |
| 14 | 48° 44.822' | 68° 59.708' | 161 | 6.1 | 6.3 | 131.3 | 375.4 | |
| 15 | 48° 44.460' | 68° 58.656' | 257 | 2.6 | 4.3 | 36.8 | 271.7 | |
| 16 | 48° 44.452' | 68° 59.198' | 254 | 2.1 | 2.0 | 15.6 | 119.7 | |
| 17 | 48° 44.474' | 68° 59.686' | 259 | 1.3 | 4.2 | 40.3 | 276.7 | |
| 18 | 48° 44.458' | 69° 00.262' | 259 | 1.0 | 3.5 | 36.4 | 222.2 | |
| 19 | 48° 44.090' | 68° 58.672' | 304 | 7.2 | 8.8 | 204.1 | 515.9 | |
| 20 | 48° 44.113' | 68° 59.312' | 253 | 2.0 | 2.9 | 18.7 | 184.5 | |
| 21 | 48° 44.113' | 68° 59.697' | 256 | 1.8 | 2.8 | 21.3 | 192.7 | |
| 22 | 48° 44.143' | 69° 00.201' | 254 | 2.5 | 5.6 | 68.4 | 363.5 | |
| 23 | 48° 43.766' | 68° 59.171' | 249 | 3.1 | 8.9 | 61.7 | 539.4 | |
| 24 | 48° 43.775' | 68° 59.692' | 252 | 4.0 | 6.3 | 23.5 | 408.0 | |
| 25 | 48° 43.750' | 69° 00.220' | 261 | 3.1 | 4.5 | 41.7 | 283.5 | |
| 26 | 48° 43.739' | 69° 00.771' | 265 | 0.3 | 2.9 | 8.2 | 184.1 | |
| 27 | 48° 43.429' | 68° 59.146' | 304 | 0.7 | 3.7 | 16.4 | 236.4 | |
| 28 | 48° 43.397' | 68° 59.717' | 252 | 2.9 | 5.1 | 35.7 | 308.7 | |
| 35 | 48° 43.065' | 69° 01.272' | 256 | 0.0 | 3.3 | 0.0 | 215.2 | |
| 36 | 48° 42.686' | 69° 00.232' | 252 | 5.5 | 11.8 | 112.8 | 723.5 | |
| 37 | 48° 42.715' | 69° 00.746' | 274 | 0.7 | 4.7 | 9.4 | 284.5 | |
| 38 | 48° 42.798' | 69° 01.248' | 259 | 0.0 | 1.6 | 0.0 | 96.3 | |
| 39 | 48° 42.696' | 69° 01.826' | 264 | 0.5 | 2.8 | 14.2 | 168.3 | |
| 40 | 48° 42.368' | 69° 00.225' | 308 | 1.9 | 4.9 | 46.5 | 321.3 | |
| 41 | 48° 42.371' | 69° 00.757' | 255 | 1.3 | 9.7 | 39.2 | 601.4 | |
| 42 | 48° 42.372' | 69° 01.287' | 256 | 0.4 | 4.1 | 9.5 | 245.4 | |
| 43 | 48° 42.378' | 69° 01.815' | 304 | 0.1 | 5.3 | 3.0 | 305.7 | |
| 44 | 48° 42.015' | 69° 00.744' | 253 | 10.8 | 10.0 | 222.0 | 601.4 | |
| 45 | 48° 42.029' | 69° 01.276' | 252 | 2.5 | 11.5 | 67.0 | 691.7 | |
| 46 | 48° 42.024' | 69° 01.804' | 304 | 0.2 | 2.3 | 7.8 | 135.4 | |

| 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' | 206 | 0.7 | 1.1 | 10.4 | 72.6 |
| 48 | 48° 41.670' | 69° 01.278' | 251 | 6.7 | 13.3 | 160.8 | 760.7 |
| 49 | 48° 41.664' | 69° 01.817' | 257 | 0.5 | 1.2 | 16.1 | 71.2 |
| 50 | 48° 41.365' | 69° 01.294' | 257 | 1.4 | 5.0 | 38.7 | 282.9 |
| 51 | 48° 41.286' | 69° 01.823' | 254 | 0.1 | 1.9 | 4.2 | 94.6 |
| 52 | 48° 40.974' | 69° 01.277' | 251 | 1.3 | 3.8 | 29.9 | 223.9 |
| 53 | 48° 40.968' | 69° 01.831' | 252 | 1.1 | 5.0 | 23.8 | 275.8 |
| 54 | 48° 40.964' | 69° 02.343' | 252 | 0.4 | 3.2 | 14.6 | 169.5 |
| 55 | 48° 40.621' | 69° 01.822' | 255 | 1.7 | 4.1 | 47.8 | 239.3 |
| 56 | 48° 40.616' | 69° 02.347' | 257 | 2.2 | 5.0 | 80.1 | 244.4 |
| 57 | 48° 40.264' | 69° 02.326' | 307 | 1.5 | 5.0 | 50.5 | 270.0 |
| 58 | 48° 39.914' | 69° 02.344' | 316 | 1.5 | 3.0 | 48.5 | 167.1 |
| 59 | 48° 39.911' | 69° 02.868' | 251 | 0.9 | 1.3 | 29.9 | 73.5 |
| 60 | 48° 39.553' | 69° 02.348' | 309 | 1.4 | 2.1 | 41.2 | 119.9 |
| 61 | 48° 39.559' | 69° 02.870' | 264 | 4.0 | 3.8 | 132.0 | 201.4 |
| Pointe-aux-Outardes | | | | | | | |
| 6 | 49° 00.499' | 68° 28.862' | 254 | 0.4 | 0.4 | 12.2 | 20.3 |
| 7 | 49° 00.313' | 68° 29.427' | 308 | 0.2 | 0.1 | 6.6 | 4.8 |
| 8 | 49° 00.310' | 68° 29.977' | 302 | 0.2 | 6.3 | 6.5 | 455.4 |
| 9 | 49° 00.316' | 68° 30.492' | 209 | 1.0 | 14.1 | 22.3 | 859.0 |
| 10 | 49° 00.317' | 68° 30.995' | 206 | 1.0 | 8.7 | 13.4 | 513.6 |
| 11 | 49° 00.316' | 68° 31.541' | 204 | 1.3 | 8.8 | 30.9 | 496.0 |
| 12 | 49° 00.311' | 68° 32.142' | 216 | 1.4 | 9.1 | 44.5 | 511.8 |
| 13 | 49° 00.331' | 68° 32.606' | 253 | 0.8 | 4.0 | 19.8 | 230.3 |
| 14 | 49° 00.334' | 68° 33.155' | 303 | 0.6 | 6.4 | 16.7 | 397.5 |
| 15 | 49° 00.327' | 68° 33.676' | 254 | 0.3 | 4.1 | 6.7 | 264.3 |
| 16 | 48° 59.965' | 68° 31.030' | 254 | 0.0 | 9.0 | 0.0 | 583.5 |
| 17 | 48° 59.975' | 68° 31.516' | 207 | 6.0 | 8.7 | 121.1 | 507.3 |
| 18 | 48° 59.970' | 68° 32.115' | 215 | 9.7 | 2.7 | 146.3 | 152.0 |
| 19 | 48° 59.970' | 68° 32.589' | 202 | 12.4 | 14.4 | 109.8 | 873.5 |
| 20 | 48° 59.968' | 68° 33.158' | 307 | 1.3 | 8.1 | 31.8 | 523.7 |
| 51 | 49° 00.557' | 68° 33.749' | 253 | 1.7 | 3.7 | 36.3 | 222.2 |
| 52 | 49° 00.268' | 68° 34.492' | 308 | 1.8 | 5.8 | 29.9 | 423.7 |
| 53 | 49° 00.137' | 68° 34.882' | 322 | 0.2 | 3.6 | 3.8 | 261.4 |
| 54 | 48° 59.905' | 68° 35.259' | 257 | 1.9 | 4.6 | 23.3 | 338.9 |
| 55 | 48° 59.732' | 68° 35.639' | 255 | 0.8 | 6.4 | 11.8 | 422.1 |
| 56 | 49° 00.581' | 68° 28.350' | 254 | 0.1 | 0.5 | 3.8 | 46.0 |
| 57 | 49° 00.659' | 68° 27.851' | 305 | 0.1 | 0.9 | 2.8 | 79.9 |
| 58 | 49° 00.764' | 68° 27.330' | 253 | 1.1 | 4.5 | 31.3 | 296.7 |
| 59 | 49° 00.843' | 68° 26.792' | 253 | 0.0 | 1.1 | 0.0 | 65.4 |
| 60 | 49° 00.919' | 68° 26.290' | 312 | 0.0 | 0.0 | 0.0 | 0.0 |
| 61 | 49° 01.025' | 68° 25.794' | 257 | 0.0 | 0.0 | 0.0 | 0.0 |

| Site and Station | Latitude (W) | Longitude (N) | Distance (m) | Density | | Yield | |
|--------------------|--------------|---------------|--------------|----------|---------|----------|---------|
| | | | | 20-69 mm | ≥ 70 mm | 20-69 mm | ≥ 70 mm |
| Baie-Comeau | | | | | | | |
| 1 | 49° 12.358' | 68° 05.249' | 254 | 0.7 | 2.7 | 21.9 | 170.6 |
| 2 | 49° 12.022' | 68° 05.258' | 257 | 7.6 | 11.0 | 120.4 | 726.5 |
| 3 | 49° 11.661' | 68° 05.256' | 254 | 2.5 | 6.5 | 77.4 | 367.0 |
| 4 | 49° 11.311' | 68° 05.271' | 252 | 1.7 | 10.3 | 46.3 | 572.2 |
| 5 | 49° 10.966' | 68° 05.264' | 256 | 7.8 | 16.5 | 150.8 | 903.2 |
| 6 | 49° 10.611' | 68° 05.264' | 254 | 4.0 | 18.8 | 100.5 | 1194.5 |
| 7 | 49° 10.248' | 68° 05.274' | 256 | 1.7 | 4.9 | 41.4 | 319.6 |
| 8 | 49° 09.905' | 68° 05.261' | 256 | 1.3 | 14.3 | 40.4 | 918.3 |
| 9 | 49° 09.564' | 68° 05.552' | 261 | 7.0 | 13.9 | 198.4 | 765.4 |
| 10 | 49° 09.207' | 68° 05.822' | 260 | 1.3 | 2.1 | 41.6 | 121.9 |
| 11 | 49° 08.859' | 68° 05.824' | 249 | 2.6 | 5.3 | 61.0 | 288.6 |

Appendix 16. Density (number/100 m²), yield (g/100 m²) and average weight (g) of *Buccinum undatum* egg masses (when present) by site and station in the 2019 research survey in Upper North Shore.

| Site | Station | Density | Yield | Average weight |
|-------------|---------|---------|-------|----------------|
| | 1 | 0.6 | 129.8 | 203.6 |
| | 2 | 0.1 | 6.3 | 56.0 |
| | 3 | 0.2 | 64.1 | 297.0 |
| | 4 | 0.2 | 114.3 | 512.5 |
| | 5 | 0.2 | 15.2 | 69.0 |
| | 6 | 0 | 0 | 0 |
| | 7 | 0.9 | 118.9 | 126.7 |
| | 8 | 0.4 | 151.7 | 384.6 |
| | 9 | 0.5 | 67.6 | 127.0 |
| | 10 | 0 | 0 | 0 |
| | 11 | 1.2 | 111.2 | 92.8 |
| | 12 | 0.3 | 32.2 | 123.0 |
| | 13 | 0 | 0 | 0 |
| | 14 | 0 | 0 | 0 |
| | 15 | 0.4 | 104.4 | 264.6 |
| | 16 | 0 | 0 | 0 |
| | 17 | 0.1 | 44.4 | 340.0 |
| | 18 | 0 | 0 | 0 |
| | 19 | 0.3 | 5.8 | 17.3 |
| | 20 | 0.7 | 80.5 | 120.6 |
| | 21 | 0.1 | 15.6 | 118.0 |
| Forestville | 22 | 0 | 0 | 0 |
| | 23 | 1.1 | 152.3 | 140.3 |
| | 24 | 0.1 | 13.1 | 98.0 |
| | 25 | 0.1 | 3.5 | 27.0 |
| | 26 | 0 | 0 | 0 |
| | 27 | 0.1 | 60.9 | 548.0 |
| | 28 | 0.3 | 68.9 | 257.0 |
| | 35 | 0.3 | 11.6 | 44.0 |
| | 36 | 0.7 | 134.5 | 200.6 |
| | 37 | 0.2 | 22.9 | 93.0 |
| | 38 | 0.1 | 19.8 | 152.0 |
| | 39 | 0.5 | 152.3 | 297.5 |
| | 40 | 0.1 | 37.1 | 338.0 |
| | 41 | 0.1 | 18.6 | 140.0 |
| | 42 | 0 | 0 | 0 |
| | 43 | 0.4 | 70.9 | 159.5 |
| | 44 | 0 | 0 | 0 |
| | 45 | 0 | 0 | 0 |
| | 46 | 0.1 | 34 | 306.0 |
| | 47 | 0.2 | 30.3 | 185.0 |
| | 48 | 0 | 0 | 0 |
| | 49 | 0 | 0 | 0 |
| | 50 | 0.5 | 123.3 | 234.5 |

| Site | Station | Density | Yield | Average weight |
|----------------------------|----------------|----------------|--------------|-----------------------|
| | 51 | 0.4 | 128.4 | 321.6 |
| | 52 | 0.7 | 41.2 | 61.2 |
| | 53 | 0.3 | 74 | 276.0 |
| | 54 | 0.4 | 31.8 | 79.0 |
| | 55 | 0 | 0 | 0 |
| | 56 | 0.8 | 80.7 | 102.3 |
| | 57 | 0.3 | 84.8 | 257.0 |
| | 58 | 0 | 0 | 0 |
| | 59 | 0 | 0 | 0 |
| | 60 | 0.1 | 3.2 | 29.0 |
| | 61 | 0 | 0 | 0 |
| <hr/> | | | | |
| | 6 | 0.8 | 101.4 | 127.0 |
| | 7 | 0 | 0 | 0 |
| | 8 | 0.1 | 2.2 | 20.0 |
| | 9 | 6.1 | 591.6 | 96.6 |
| | 10 | 4.3 | 341.1 | 80.0 |
| | 11 | 3.8 | 267 | 70.7 |
| | 12 | 0 | 0 | 0 |
| | 13 | 0 | 0 | 0 |
| | 14 | 0.8 | 45.9 | 58.8 |
| | 15 | 0 | 0 | 0 |
| | 16 | 4.3 | 353.3 | 83.0 |
| | 17 | 0.7 | 82.6 | 126.5 |
| Pointe-aux-Outardes | 18 | 3 | 315.8 | 105.7 |
| | 19 | 0.8 | 63.6 | 76.0 |
| | 20 | 0 | 0 | 0 |
| | 51 | 9.5 | 87 | 114.6 |
| | 52 | 0.1 | 21.8 | 199.0 |
| | 53 | 0 | 0 | 0 |
| | 54 | 0.4 | 8.4 | 24.0 |
| | 55 | 0 | 0 | 0 |
| | 56 | 1.2 | 286.1 | 239.0 |
| | 57 | 0.7 | 120.2 | 180.8 |
| | 58 | 1.5 | 197.2 | 134.2 |
| | 59 | 2 | 268 | 133.8 |
| | 60 | 0.5 | 29 | 53.6 |
| | 61 | 0.5 | 107.8 | 205.0 |
| <hr/> | | | | |
| | 1 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 |
| | 3 | 0 | 0 | 0 |
| | 4 | 0.7 | 125.1 | 186.6 |
| Baie-Comeau | 5 | 3.2 | 391.7 | 123.6 |
| | 6 | 0.4 | 23.7 | 59.3 |
| | 7 | 0.9 | 86 | 93.1 |
| | 8 | 1.8 | 262.4 | 142.0 |
| | 9 | 1.2 | 67.8 | 58.2 |

| Site | Station | Density | Yield | Average weight |
|-------------|----------------|----------------|--------------|-----------------------|
| | 10 | 0 | 0 | 0 |
| | 11 | 0.5 | 44.2 | 81.5 |
