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Distribution des invertébrés benthiques dans l'estuaire et le golfe du Saint-Laurent

Distribution of benthic invertebrates in the Estuary and Gulf of St. Lawrence

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Résumé

La présente étude avait deux objectifs. Le premier était de rassembler les données de relevés scientifiques disponibles à l'Institut Maurice-Lamontagne (IML) et au Centre des Pêches du Golfe (CPG) qui permettraient de déterminer les patrons de distribution et d'abondance relative des invertébrés benthiques de l'estuaire maritime et du golfe Saint-Laurent (EMGSL). Le second objectif était de proposer, à partir des données de distribution et d'abondance relative, des Zones d'Importance Écologique et Biologique (ZIEB) potentielles pour les invertébrés benthiques de l'EMGSL.

La plupart des relevés de l'IML sont réalisés dans l'Estuaire et le nord du Golfe (nGSL), quoique certains relevés plus côtiers couvrent aussi la Gaspésie (incluant la baie des Chaleurs) et les Îles-de-la-Madeleine. Les relevés du CPG couvrent l'ensemble du sud du Golfe (sGSL), excluant les Îles-de-la-Madeleine. Le gros des données présentées dans cette étude provient de relevés annuels réalisés par les deux régions. Pour l'IML, il s'agit du relevé multidisciplinaire et du relevé des Pêches Sentinelles par engins mobiles. Le CPG a trois relevés annuels, le relevé d'automne, de crabe des neiges, et du détroit de Northumberland. Plusieurs autres relevés étaient disponibles à l'IML, certains réalisés sur plusieurs années mais à couverture géographique moins importante (relevé de crabe des neiges, de pétoncle, de mactre), d'autres réalisés moins régulièrement et à faible couverture géographique (relevés de mye, du buccin). Finalement des contenus stomacaux de morue et de flétan du Groenland ont aussi été utilisés comme échantillonneurs d'invertébrés benthiques. Malgré ce grand nombre de relevés, la zone côtière (moins de 50 m de profondeur dans l'Estuaire et le nGSL, moins de 30 m dans le sGSL) est très mal échantillonnée, exception faite du détroit de Northumberland.

Les distributions de 44 taxons d'invertébrés benthiques sont présentées dans la partie principale du rapport et ont été utilisées pour définir des ZIEB : 4 grands regroupements (coraux mous, anémones, éponges, ascidies), 5 échinodermes, 6 mollusques, 1 mysidacé, 22 crevettes et 6 crabes. Les zones d'abondance maximale de chaque taxon, avec pondération inversement proportionnelle à l'étendue de leur distribution, ont servi à calculer un indice de concentration d'invertébrés benthiques pour chaque parcelle de 10 x 10 km pour laquelle il y avait des données. Cet indice a été le principal outil pour l'identification des ZIEB potentielles. Un total de 17 ZIEB pour les invertébrés benthiques sont proposées. Il faut cependant noter que ces ZIEB sont basées sur une très petite sélection (environ 0,02%) des espèces d'invertébrés benthiques répertoriées dans la zone d'étude. L'absence de données adéquates pour la zone côtière constitue une lacune sérieuse. Nous présentons en annexe les quelques données disponibles pour 6 espèces côtières.

Abstract

This study had two objectives. The first was to gather all the available data from scientific surveys both at the Maurice-Lamontagne Institute (MLI) and the Gulf Fisheries Centre (GFC) in order to establish distribution patterns and relative abundance of benthic invertebrates in the lower estuary and the gulf of St. Lawrence (LEGSL). The second objective was to propose Ecologically and Biologically Significant Areas (EBSAs) for benthic invertebrates of the LEGSL, according to these distribution and relative abundance data.

Surveys from the MLI are mainly conducted in the lower estuary and in the northern gulf of St. Lawrence (nGSL) but some cover Gaspesie, including Chaleurs bay, and the Magdalen Islands. The southern gulf of St. Lawrence (sGSL) is covered by the GFC surveys. The bulk of the information presented here comes from annual scientific surveys carried out by the two regions: the multi-species survey and the mobile gear Sentinel survey by the MLI and the fall survey, snow crab survey, and Northumberland survey by the GFC. Several other surveys by MLI provided useful data, some even with a long time series but with limited geographical coverage (surveys for snow crab, scallop and surf clam), while others were conducted less frequently and at a small geographic scale (surveys for clam and whelk). Cod and Greenland halibut stomach contents have also been used as a sampling device for the distribution on some benthic invertebrates. Despite the large number of surveys considered here, the coastal zone (less than 50 m deep in the Estuary and the nGSL and less than 30 m deep in the sGSL) was not adequately sampled, except for the Northumberland Strait.

In the main section of this document, distributions of 44 taxa are presented and have guided the identification of EBSAs: 4 general groups (soft corals, anemones, sponges, ascidians), 5 echinoderms, 6 molluscs, 1 mysid, 22 shrimps, and 6 crabs. Zones of maximum relative abundance of each taxa, weighted inversely to their surface area of high abundance, were used to calculate an index of benthic invertebrate concentration for each 10 x 10 km square sampled in the study area. This index was the primary tool in the identification of potential EBSAs. As a result, 17 EBSAs for benthic invertebrates are proposed. However, it is important to keep in mind that only a small proportion (approximately 0.02%) of the benthic invertebrate species known to be present in the study area was considered in the process. In particular, the lack of data for the coastal zone is a major gap. We present in appendix to this report the data on 6 coastal species that we were able to obtain.

1 Introduction

In November 2004, a group of experts from the Department of Fisheries and Oceans Canada (DFO) worked towards establishing criteria to identify "Ecologically and Biologically Significant Areas (EBSAs) in Canadian waters (MPO, 2004). This document is part of a series of reports resulting from this initiative. They describe the physical, oceanographic and biological characteristics of the Lower Estuary and Gulf of St. Lawrence (LEGSL) by gathering the scientific information available to the DFO and in the literature in order to identify specific areas of importance for each component studied. A more in depth assessment is expected by combining the potential EBSAs for all components in order to identify EBSAs for the LEGSL.

This report focuses on one of the components studied for identifying EBSAs. It aims at determining the distribution and relative abundance of benthic invertebrates in the LEGSL by identifying available data sources and selecting relevant data that could be used to adequately describe the distribution of species or taxonomic groups of benthic invertebrates. EBSAs are then proposed based on the evaluation of this information according to MPO (2004) criteria. The Quebec and Gulf Regions of DFO are involved in several sampling programs covering the study area. Among these programs, there are sampling campaigns at sea to gather information on several fish species and marine invertebrates, many of which are commercially exploited. The objective has been to include as many species or taxonomic groups as possible in order to get a complete picture of the study area in terms of distribution and relative abundance of benthic invertebrates. This resulted in the use of data from a large number of sampling campaigns (research surveys), each with a different methodology and spatial and temporal coverage.

Each survey was examined to determine which species were sufficiently well represented to be included in this study. The criteria used to do this included catchability by fishing gear used, the reliability of the taxonomic identification during the survey and spatial coverage of the survey in relation to knowledge of the species distribution. Most of the time, the data from a single survey per region were selected for a given species, although there are some exceptions to this rule. On some occasions, we had to regroup the captured invertebrate into larger taxonomic groups than the species (e.g. genus or family) because the identification made on board the vessel did not allow the distinction between related species. We also had to exclude several broad taxa from the study because they would not have allowed distinction between the different areas of the LEGSL: overly large groupings (e.g. polychaetes and amphipods, each containing hundreds of species) would have likely resulted in a uniform abundance of taxa in the entire study area.

But we must be very careful when several surveys are combined to increase the geographic coverage for a given species or taxon. In fact, survey sampling gear and techniques may be very different which makes it difficult to compare catches between areas covered by different surveys. As the Estuary and northern Gulf (nGSL) and the southern Gulf (sGSL) were sampled by different surveys, the study of the distribution and relative abundance of taxa in the LEGSL necessitated combining data from different surveys. We have therefore adopted a data standardizing method (see Materials and Methods below) that allows comparison of relative abundances, but it should not be used to interpret absolute abundance.

Surveys with extensive spatial coverage often exclude coastal areas. Based on the heterogeneous nature of coastal areas, few sampling methods are effective on a large scale or for a large number of taxa, thus limiting the study of often highly complex habitats, possibly species-rich and often with significant biological functions for some offshore species. The lack of coverage of coastal areas in our surveys has resulted, for example, in the partial or complete exclusion of Chaleurs Bay, Miramichi Bay and St. Georges Bay. The coastal areas (less than 50 m) of the Estuary, the middle and Lower North Shore and western Newfoundland also have very little coverage. Furthermore, some surveys targeting infralittoral species such as clams, rock crab and lobster were found to cover too little of their distribution range so that in practice we could not use these data to determine an EBSA. In addition, hard bottom habitats are particularly poorly represented because the fishing gear used (mostly trawls) are not suitable. Therefore, a significant part of the area from the Lower North Shore to the Esquiman Channel is not adequately sampled.

However, we believe that the data presented in the following pages will help determine the distribution of taxa that we have selected, in compliance with the intended purposes, which are the identification of potential EBSAs for benthic invertebrates. We recognize, however, that better knowledge of many species could alter how EBSAs are determined. Research limitations are further developed in the discussion.

2 Materials and Methods

2.1 Study Area

The limits of the study area for determining the EBSAs for the LEGSL were set at 71° and 55° west longitude and 45° and 52.5° north latitude. For designing the distribution maps it was better to work with equidistant scales on both axes. The degree positions have been converted to km based on UTM projection (Area 20) with PBS Mapping (Schnute *et al.*, 2004) and the R software (R Development Core Team, 2006). In UTM coordinates, the limits of the study area correspond to the polygon formed by the four following points†: (-130.6, 5014.2), (1130.5, 5014.2), (-42,6, 5846.8) and (1042.6, 5846.8). However, the data available to study the distribution of benthic invertebrates in the LEGSL cover an area slightly smaller than the EBSA study area (Figure 1). The approximate area of the LEGSL is 226773 km^2.

† Updated: October 2010

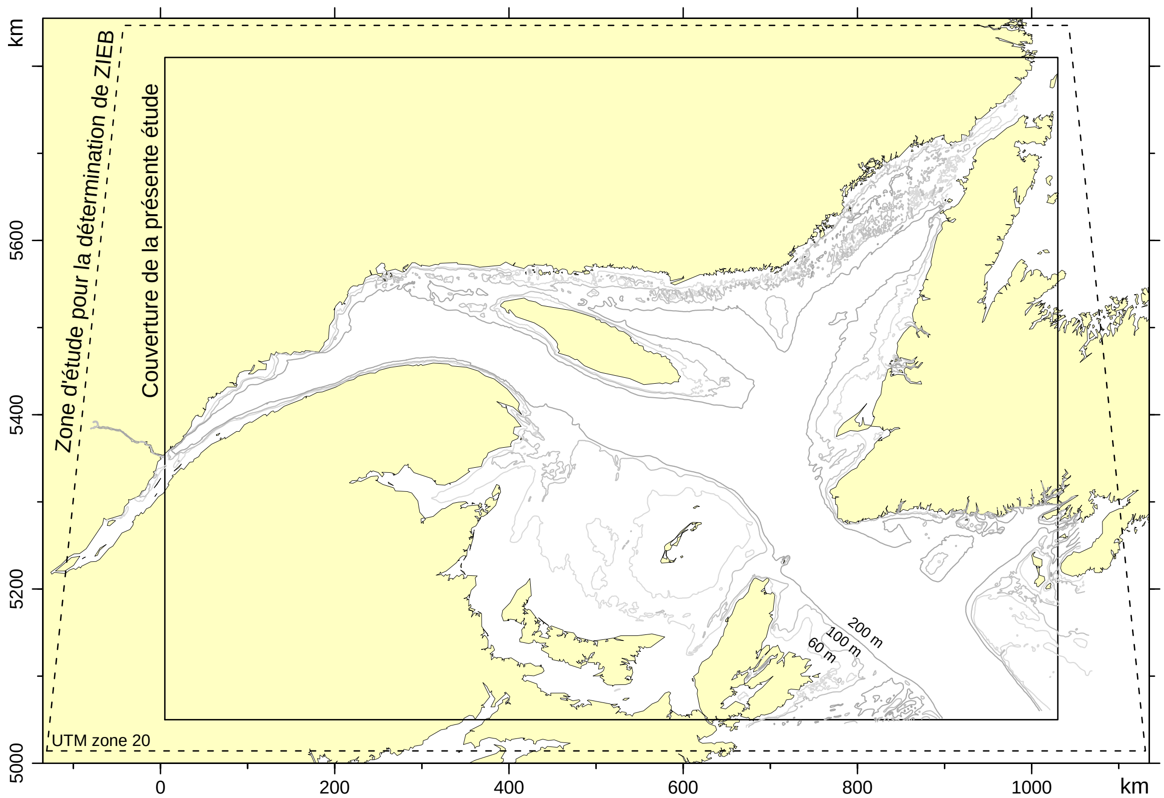


Figure 1 – Limits of the study area for determining the ESBAs in the lower Estuary and Gulf of St. Lawrence (71 and 55° west longitude and 45 and 52.5° north latitude) after converting to UTM coordinates (dashed lines). The smaller area covered by this study is indicated by the solid lines.

2.2 Sampling Methods

We have included the largest number of benthic invertebrate taxa as possible by using data already available at the Maurice-Lamontagne Institute (MLI, Quebec Region) and the Gulf Fisheries Centre (GFC, Gulf Region). Table 1 lists the benthic invertebrate taxa in this study and surveys used to describe their distributions. The surveys are then described in detail in the text following Table 1.

It should be noted that certain surveys covered an overly small proportion of the distribution area of the target species and their results could not be used in determining EBSAs. We chose to present the methodology and results of these surveys in appendix so that this report constitutes a comprehensive source of information on the distribution of benthic invertebrates based on all available data. The species targeted by these surveys were species occupying the infralittoral or circalittoral areas, which were not sampled by the main surveys.

Table 1 – List of benthic invertebrate taxa whose spatial distribution has been evaluated and data sources have been used.

	Estuary and Northern Gulf			Southern Gulf		
Species or Taxon	Survey	Year(s)	Units	Survey	Year(s)	Units
Taxa used for determining the EBSAs						
Soft coral (Alcyoniidae)	Needler et Teleost	2000-2006	kg/km^2			
Anemones (Anthozoa)	Teleost	2006	kg/km^2	Fall	1988-2005	kg/km^2
Sponges (Porifera)	Teleost	2006	kg/km^2	Fall	1988-2005	kg/km^2
Ascidians	Teleost	2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Molluscs						
Shortfin squid (*Illex illecebrosus*)	Teleost	2004-2006	kg/km^2	Fall	1971-2005	kg/km^2
Spoonarm octopus (*Bathypolypus bairdii*)	Teleost	2004-2006	kg/km^2	Fall	1988-2005	kg/km^2
Lesser bobtail squid (*Semirossia tenera*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Whelk (*Buccinum* sp. & *Neptunea* sp. and others)	Whelk	2005	Nb/km^2	Snow crab	1988-2005	Nb/km^2
Iceland scallop (*Chlamys islandica*)	Scallop	variable	Nb/km^2	Snow crab	1988-2005	Nb/km^2
Sea scallop (*Placopecten magellanicus*)	Scallop	variable	Nb/km^2	Fall	1988-2005	kg/km^2
Echinoderms						
Starfish (Asteroidea)	Teleost	2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Basket stars (Gorgonacea)	Teleost	2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Brittle stars (Ophiuridae)	Teleost	2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Round and asymmetric sea urchins	Teleost	2005-2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Sea cucumbers (Holothuroidea)	Teleost	2006	kg/km^2	Snow crab	1988-2005	Nb/km^2
Crustaceans						
Mysids						
Boreomysis arctica	Turbot stomachs	1993-2003	Fullness			
Shrimp						
Acanthephyra pelagica	Teleost	2004-2006	kg/km^2			
Arctic argid (*Argis dentata*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Atlantopandalus propinquus	Teleost	2004-2006	kg/km^2	Fall	2005	kg/km^2
Arctic eualid (*Eualus fabricii*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Circumpolar eualid (*E. gaimardi*)				Fall	2003-2005	kg/km^2
E. gaimardi belcheri	Teleost	2004-2006	kg/km^2			
E. gaimardi gaimardi	Teleost	2004-2006	kg/km^2			
Greenland shrimp (*E. macilentus*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Doll eualid (*E. pusiolus*)				Fall	2003-2005	kg/km^2
Spiny lebbeid (*Lebbeus groenlandicus*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
L. microceros	Teleost	2004-2006	kg/km^2	Fall	2004-2005	kg/km^2
Polar lebbeid (*L. polaris*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Northern shrimp (*Pandalus borealis*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Striped pink shrimp (*P. montagui*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Pink glass shrimp (*Pasiphaea multidentata*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Crimson pasiphaeid (*Pasiphaea tarda*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2

Table 1 – List of benthic invertebrate taxa (cont.).

	Estuary and Northern Gulf			Southern Gulf		
Species or Taxon	Survey	Year(s)	Units	Survey	Year(s)	Units
Norwegian shrimp (*Pontophilus norvegicus*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Sars shrimp (*Sabinea sarsi*)	Teleost	2004-2006	kg/km^2			
Sevenline shrimp (*S. septemcarinata*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Sculptured shrimp (*Sclerocrangon boreas*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Sergestes arcticus	Teleost	2004-2006	kg/km^2			
Friendly blade shrimp (*Spirontocaris lilljeborgii*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Punctate blade shrimp (*S. phippsii*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Parrot shrimp (*S. spinus*)	Teleost	2004-2006	kg/km^2	Fall	2003-2005	kg/km^2
Crabs						
Snow crab (*Chionoecetes opilio*)	Snow crab	1992-2005	Nb/km^2	Snow crab	1988-2005	Nb/km^2
Snow crab (*C. opilio*)	Teleost	2004-2006	kg/km^2			
Snow crab (*C. opilio*)	Sentinel fisheries	1995-2005	kg/km^2			
Immature snow crab (*C. opilio*)	Cod stomachs	1993-2005	Fullnesss	Cod stomachs	1987-2004	Fullness
Toad crab (*Hyas araneus*)	Snow crab	1992-2005	Nb/km^2			
Toad crab (*H. araneus*)	Teleost	2004-2006	kg/km^2			
Arctic lyre crab (*H. coarctatus*)/	Snow crab	1992-2005	Nb/km^2			
Arctic lyre crab (*H. coarctatus*)	Teleost	2004-2006	kg/km^2			
Toad crabs *Hyas sp.*				Snow crab	1988-2005	Nb/km^2
Lady crab (*Ovalipes ocelatus*)				Northumberland	2000-2005	Nb/km^2
Hermit crab (*Pagurus* sp.)	Teleost	2004-2006	kg/km^2	Snow crab	1999-2005	Nb/km^2
Spiny crab (*Lithodes maja*)	Snow crab	1992-2005	Nb/km^2	Snow crab	1988-2005	Nb/km^2
Taxa not used for determining EBSAs						
Molluscs						
Arctic surfclam (*Mactromeris polynyma*)	Surfclam	variable	Nb/km^2			
Atlantic surfclam (*Spisula solidissima*)	Surfclam	variable	Nb/km^2			
Common softshell clam (*Mya arenaria*)	Clam	2001-2005	Nb/km^2			
Crustaceans						
Sand shrimp (*Crangon septemspinosa*)				Fall	2003-2006	kg/km^2
Atlantic rock crab (*C. irroratus*)				Fall	1981-2005	kg/km^2
Atlantic rock crab (*C. irroratus*)				Northumberland	2000-2005	Nb/km^2
American lobster (*Homarus americanus*)	Commercial catches	1999-2005	tons	Fall	1971-2005	kg/km^2
American lobster (*H. americanus*)				Northumberland	2000-2005	kg/km^2

2.2.1 Multidisciplinary† Survey of Groundfish and Shrimp in the nGSL

The majority of the data presented for the nGSL is from the multidisciplinary survey. This survey was conducted from 1990 to 2005 on the CCGS Alfred Needler and from 2004 to 2006 on the CCGS Teleost. The survey followed a stratified random sampling plan according to predetermined depth strata. It was conducted in August and primarily targeted groundfish (cod, *Gadus morhua*, redfish, *Sebastes* sp. and Greenland halibut, *Reinhardtius hippoglossoides*) and northern *Pandalus borealis*. The gear used on the Needler was a 81'/114' "URI (GOV)" 44-mm stretched mesh bottom shrimp trawl equipped with a 19-mm codend lining (Bourdages *et al.*, 2003), while the Teleost was equipped with a four-panel shrimp trawl, the "Campelen 1800" with a 44-mm stretched mesh and with a 12.7-mm lining (Bourdages *et al.*, 2004). The duration of a standard tow conducted at a speed of 3 knots was 24 minutes on the Needler and 15 minutes on the Teleost. The corrections made for differences in catchability between the Needler and the Teleost are described in Bourdages *et al.* (2007).

In general, the Teleost trawl captured smaller organisms (thus more benthic invertebrates) than the Needler trawl. Therefore, the data analyzed for the nGSL are primarily from this survey. In 2004, due to a major ship breakdown, only 121 valid tows were made, but 171 and 190 tows were made in 2005 and 2006, respectively (Figure 2). However, soft corals were of particular interest on the Needler beginning in 2000 and we also used these data (2000-2005, 175-217 tows per year except in 2004 when only 10 tows were successful) (Figure 2). It should be noted that benthic invertebrates other than crab and shrimp typically received little attention in the nGSL survey. However, beginning in 2006, all individuals caught (fish and invertebrates) were carefully identified, most often to the species.

† Updated: October 2010

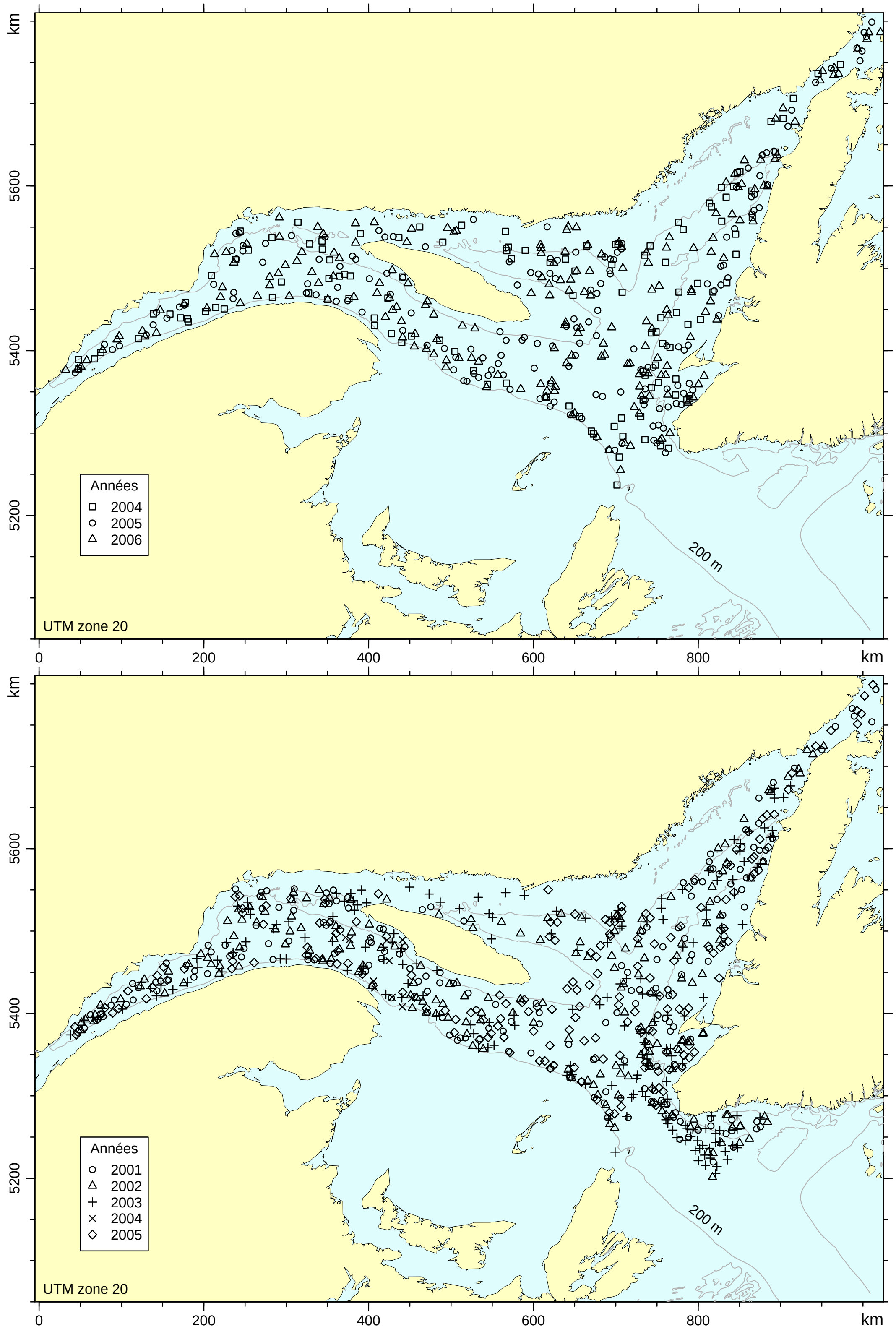


Figure 2 – Distribution of sampled stations during the multidisciplinary survey in the nGSL by the Teleost between 2004 and 2006 (above) and the Needler between 2000 and 2005 (below).

2.2.2 Fall Survey in the sGSL

Each September since 1971, a stratified-random bottom trawl survey has been conducted in the sGSL. This survey provides an information time series for more than 70 species of marine and diadromous fish as well as for forty groups of marine invertebrates. Over the past decade, approximately 200 tows have been made annually during this survey (Figure 3). A total of five ships and two different types of trawls ("Yankee-36"and "Western IIA", with 6 and 19 mm codend mesh, respectively, Carrothers, 1988) were used for data collection, thereby affecting the catchability of individuals. Corrections and adjustments made based on different vessels and fishing gear are described by Benoît & Swain (2003*b*), Benoît (2006)† , and Hurlbut & Clay (1990). A typical fishing tow lasted 30 minutes at a speed of 3.5 knots. From 1971 to 1984, all fishing activity took place in daylight but beginning in 1985, ships ran on a 24 hour basis. The difference in catchability of certain species based on the time of day was assessed by Benoît & Swain (2003*a*).

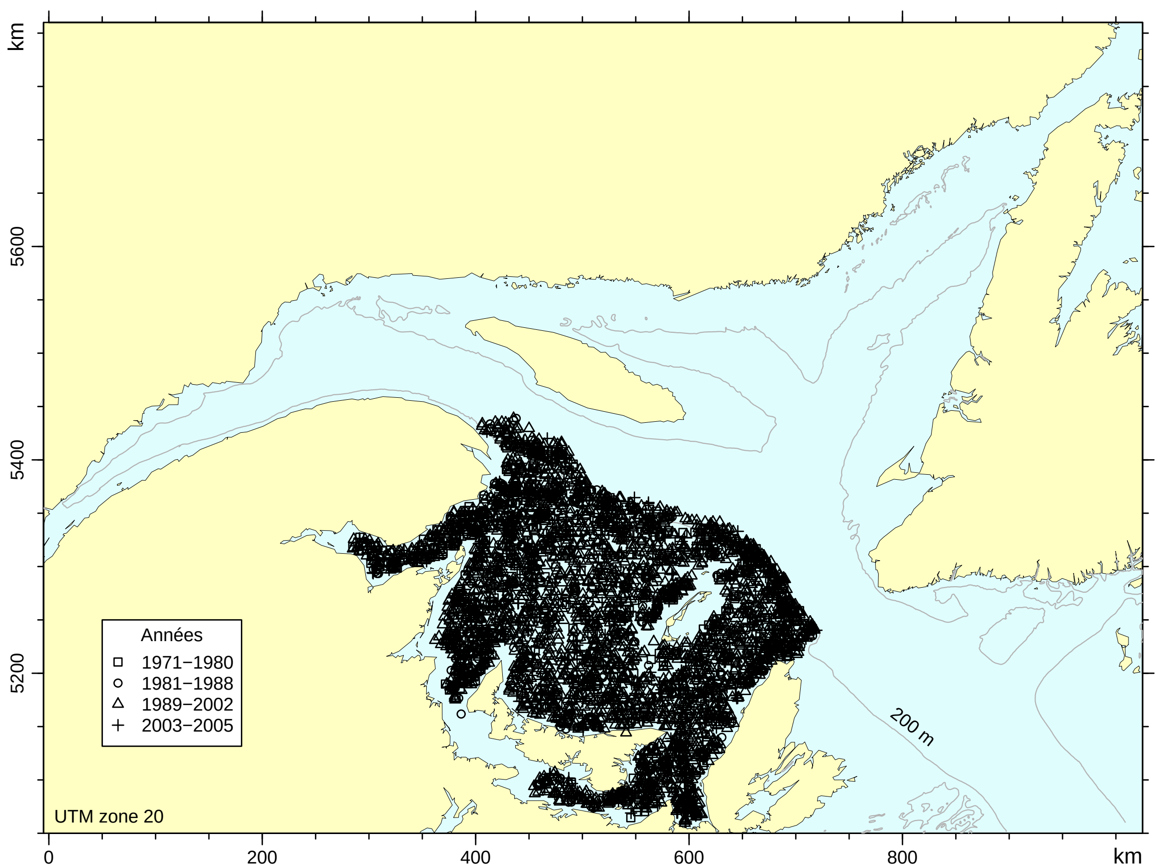


Figure 3 – Distribution of sampled stations during the fall survey in the sGSL from 1971 to 2005.

† Updated: October 2010

2.2.3 Snow Crab Survey in the nGSL

Data for snow crab, spiny crab and *Hyas* crab from the nGSL are taken from a beam trawl survey conducted since 1992 in the Estuary and the north-east GSL (Figure 4). Initially, this survey followed a random sampling plan (1992-1996, 1998) and then followed a systematic method to facilitate the kriging of data (1997, 1999-2005). The trawl had a fixed aperture width of about 3 m and a mesh size of 20 mm in the codend; each tow was carried out at a speed of 2.5 knots for a period ranging from 5–20 minutes depending on areas and the type of bottom to be sampled. The survey was conducted in July-August on board a DFO vessel and typically consisted of 30-80 tows annually (Figure 4).

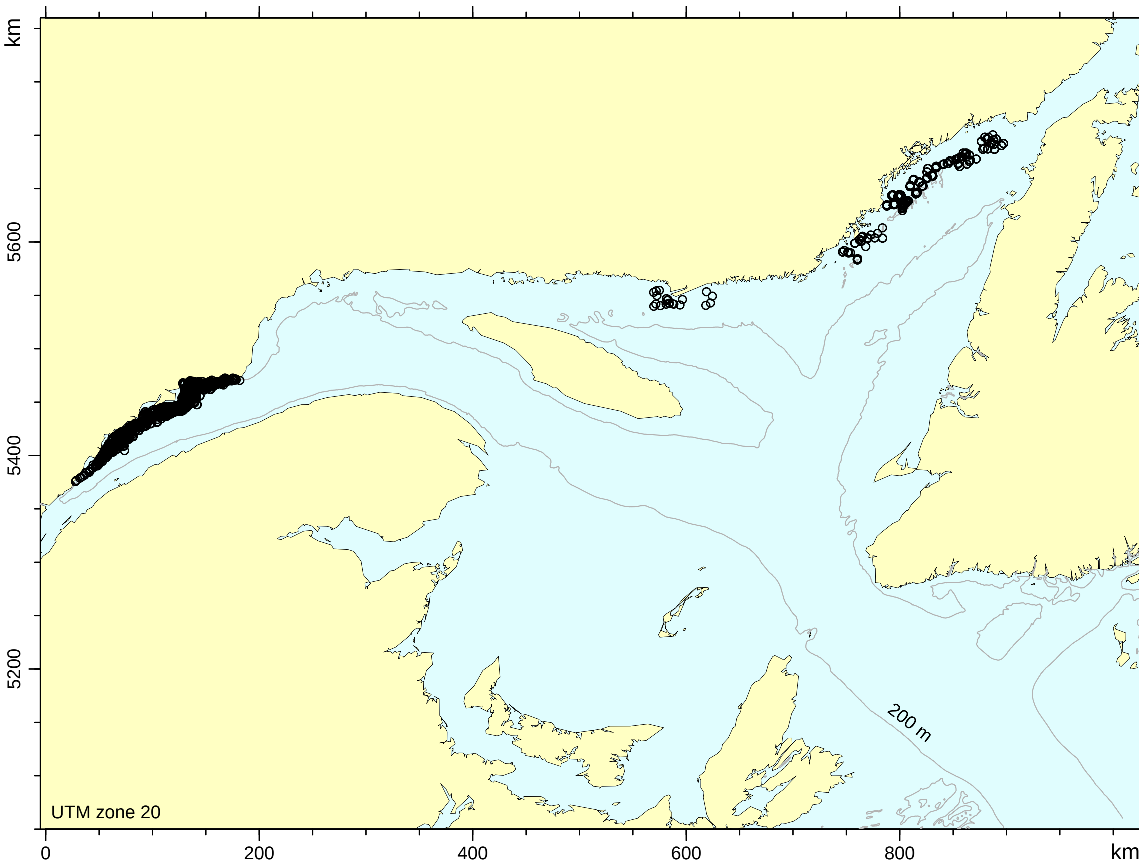


Figure 4 – Distribution of sampled stations during the snow crab survey in the nGSL from 1992 to 2005.

2.2.4 Snow Crab Survey in the sGSL

Since 1988, an annual trawl survey has been conducted in the snow crab fishery Area 12. This survey has been conducted after the commercial crab harvesting season, around August and September, from chartered commercial fishing vessels. The gear used was a "Bigouden" nephrops trawl with 80 mm mesh in the panels and 50 mm in the codend (Moriyasu *et al.*, 1998). It was a daytime survey based on a 10x10 minute grid and its stations, once determined by a random stratified plan in the first year, remained unchanged each year. Sampling activities were generally limited to waters deeper than 40 m and bottoms not conducive to trawling were avoided. With the exception of 1996, when the survey could not be conducted, between 173 and 326 tows have been made annually at a speed of 2 knots over a five minute period (Figure 5). A more detailed description of this survey can be found in Hébert *et al.* (2005).

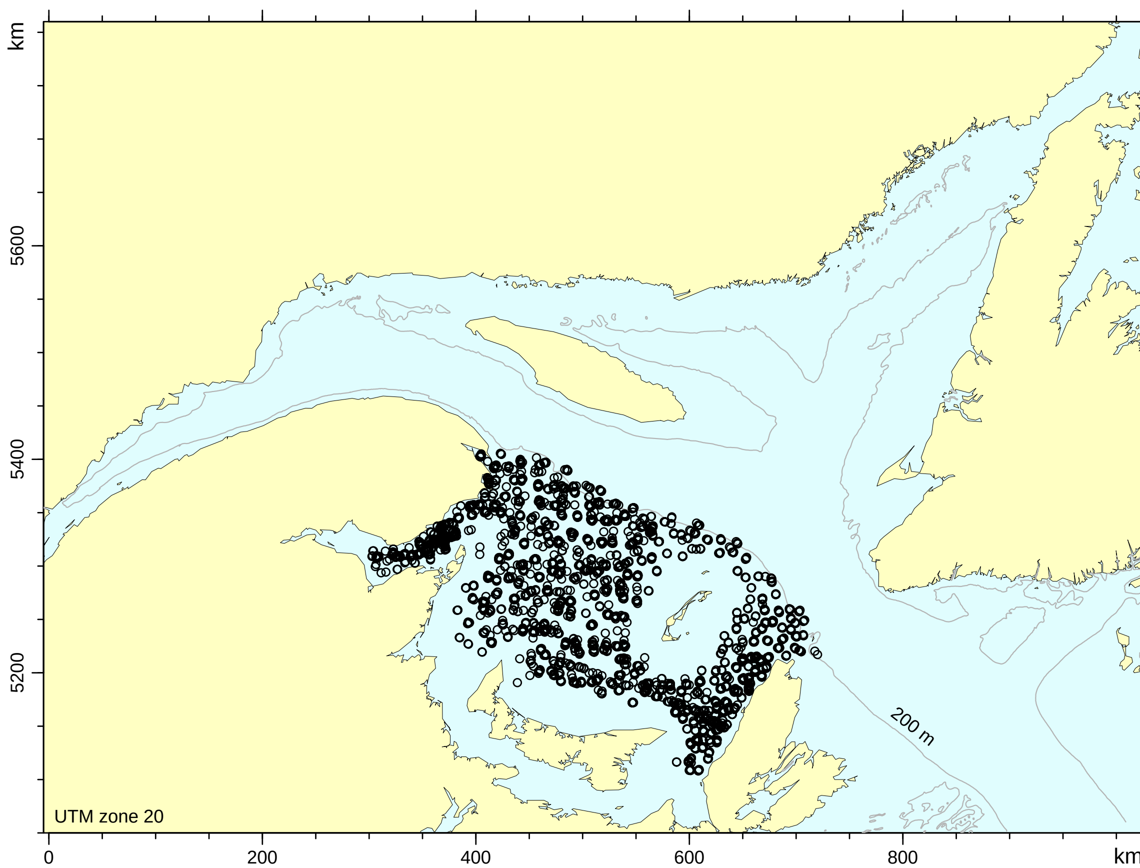


Figure 5 – Distribution of sampled stations during the snow crab survey in the sGSL from 1998 to 2005.

2.2.5 Multispecies Survey in Northumberland Strait

Since 2000, a multispecies survey based on a random blocks sampling plan has been conducted in Northumberland Strait. This survey includes between 143 and 253 tows per year (Figure 6) and was made with a "Rock-Hopper 286" bottom trawl, with a mesh size of 140 mm and 19 mm lining in the codend, towed for 15 minutes at a speed of 2.5 knots (Hanson, 2001). Only one research vessel was used for this survey. Trawling was restricted to waters deeper than 4 m and tows were completed during daylight hours (Comeau *et al.*, 2004).

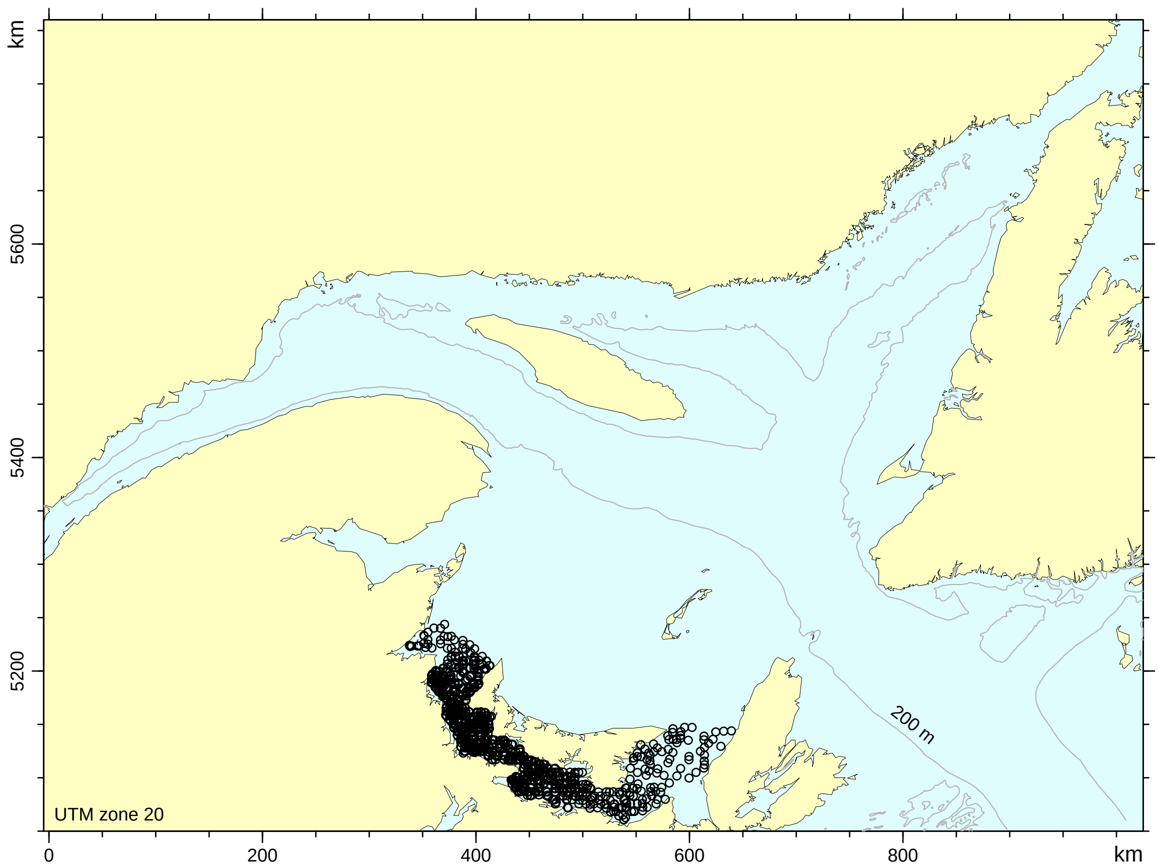


Figure 6 – Distribution of sampled stations during the multispecies survey in Northumberland Strait from 2000 to 2005.

2.2.6 Mobile Gear Sentinel Fisheries

The mobile gear Sentinel Fisheries have been conducted since 1995, sometimes twice a year, and they are equivalent to the multidisciplinary research mission in the nGSL, except that nine commercial fishing vessels have been used rather than one DFO vessel. Therefore, these were random surveys stratified by depth (the same strata as the multidisciplinary survey). Each of these surveys covered almost the entire nGSL area with about 300 stations per year (Figure 7). The data used for this report are from the 1995-2005 period.

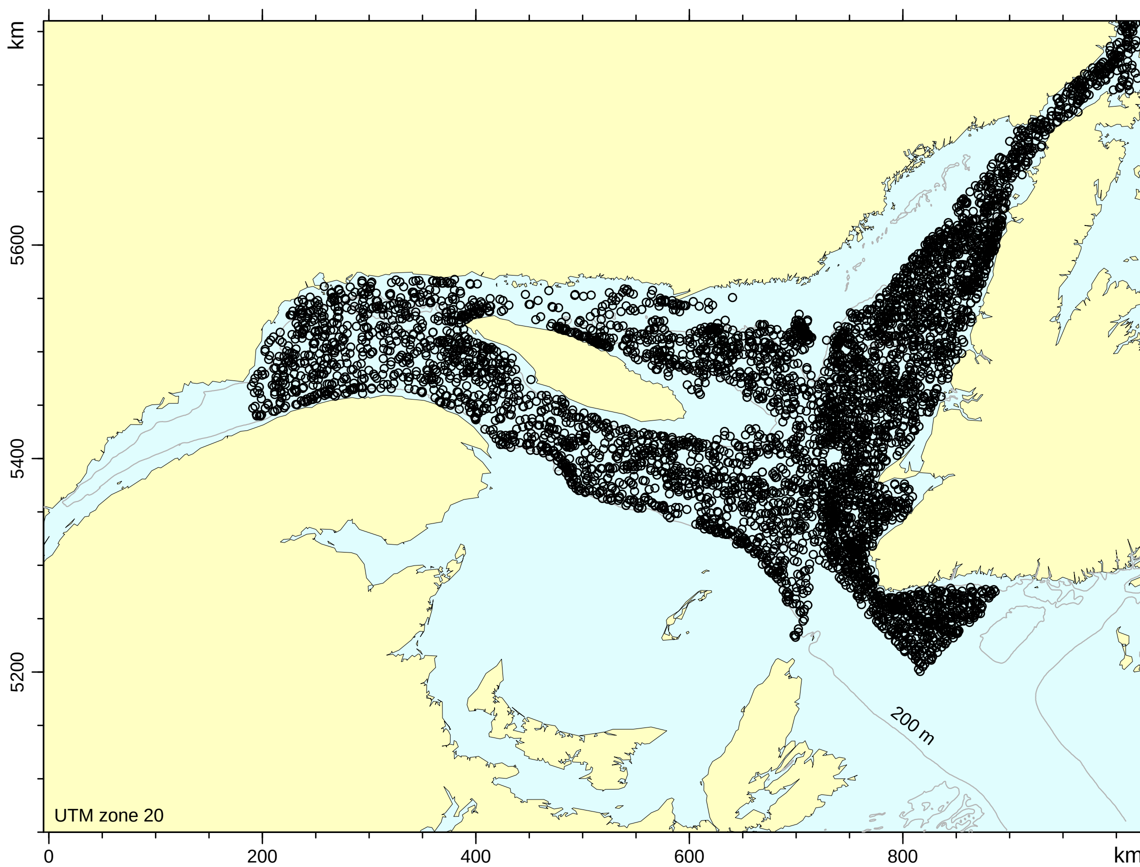


Figure 7 – Distribution of sampled stations during the mobile gear Sentinel Fisheries survey in the nGSL for the 1995-2005 period.

Nine trawlers, five from Newfoundland and four from Quebec, shared the survey stations. A station consists of a 30-min trawl at a speed of 2.5 knots. The trawl used was a "Star Balloon 300" mounted on a "Rock Hopper" bicycle, with a 145 mm mesh size and a 40 mm lining (Fréchet *et al.*, 2005). The data were standardized to compensate for variations in duration or speed. Because this trawl does not capture many benthic invertebrates, only snow crab (*Chionoecetes opilio*) data were considered sufficiently representative to be included in this analysis.

2.2.7 Scallop Surveys by the MLI

Several research surveys have been conducted to study the distribution and abundance of two scallop species, sea scallop *Placopecten magellanicus* and Iceland scallop *Chlamys islandica*. However, vessels, gear and protocols have varied between years and regions.

Estuary: For the Estuary region, an exploratory survey was conducted in 2000 on a commercial fishing vessel (BelMer I) with a "Digby" dredge (Hartog *et al.*, 2001). In 2002 and 2003, research surveys were conducted on the Calanus II with an offshore dredge lined with a 19 mm mesh net.(Hartog *et al.*, 2001).

Anticosti Island For the Anticosti Island region, an exploratory survey was conducted in 1994 on a commercial fishing vessel with two "Digby" dredges (Guay, 1994). The 2003 exploratory fishery was conducted with a commercial fishing vessel with a non-lined offshore dredge.

North Shore For the Greater North Shore region (Lower, Middle and Upper), surveys were conducted aboard a commercial fishing vessel in 1985 and 1986, and on the Calanus II in 1991-1993, 1996, 1998, 2000, 2001, 2004 and 2005, always with a "Digby" dredge. Data from three exploratory fisheries were also available for this region. In 1994, the fishery was carried out aboard a commercial fishing vessel (Rémy-Martin) with a "Digby" dredge. In 1999, several commercial fishing vessels with a "Digby" dredge were used. Finally, several commercial fishing vessels were involved in the 2003 exploratory fishery survey. A "Labrador Rake" dredge (a variant of the offshore dredge) was used. See Giguère *et al.* (2000) for additional information on the scallop surveys on the North Shore.

Gaspé Peninsula: For the Gaspé Peninsula region, two research surveys (2002 and 2006) were conducted on board the Calanus II with a "Digby" dredge.

Magdalen Islands: For the Magdalen Islands region, all the research surveys used (1991–1999, 2004, 2005) were conducted on the Calanus II with a "Digby" dredge.

Because of the widely variable coverage and fishing methods, data interpretation must be done with caution. But overall, these data (Figure 8) have helped identify the main scallop beds in their coverage area (Estuary and nGSL north shore, Chaleurs Bay, Magdalen Islands). The commercial catches indicate that only minor beds exist outside the areas covered by all of these surveys.

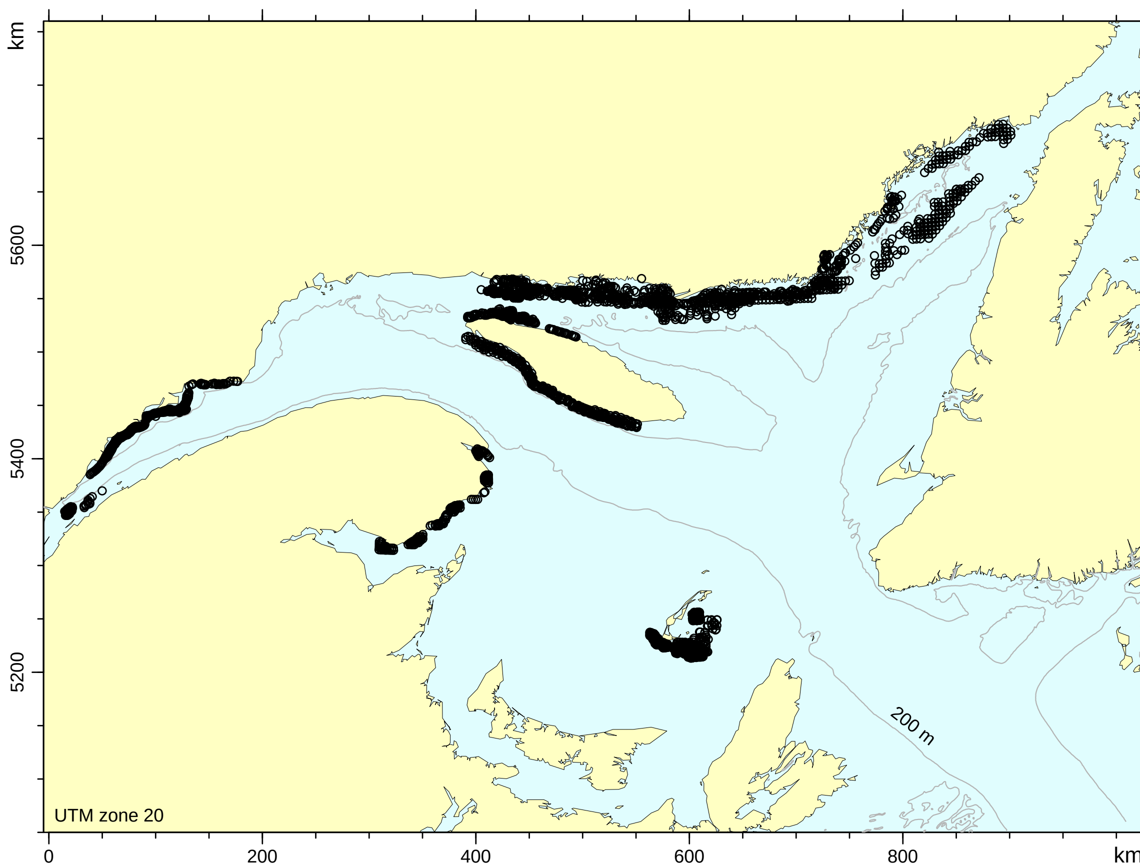


Figure 8 – Distribution of sampled stations during the scallop survey in the nGSL for the 1985-2006 period (18 years included).

2.2.8 Whelk Survey by the MLI

A whelk research mission was conducted in 2005 aboard the research vessel Calanus II in the St. Lawrence Estuary (Figure 9). Most stations were sampled with a "Digby" dredge. Tows had a targeted duration of 5–6 minutes. There were a few stations sampled with a beam trawl with mesh lining of 18 mm. Tows lasted approximately 10 minutes. In addition, a "Rock Hopper" trawl was used at 2 stations with a mesh lining of 18 mm over of approximately 10 minutes. In all cases, the number of *Buccinum undatum* was recorded.

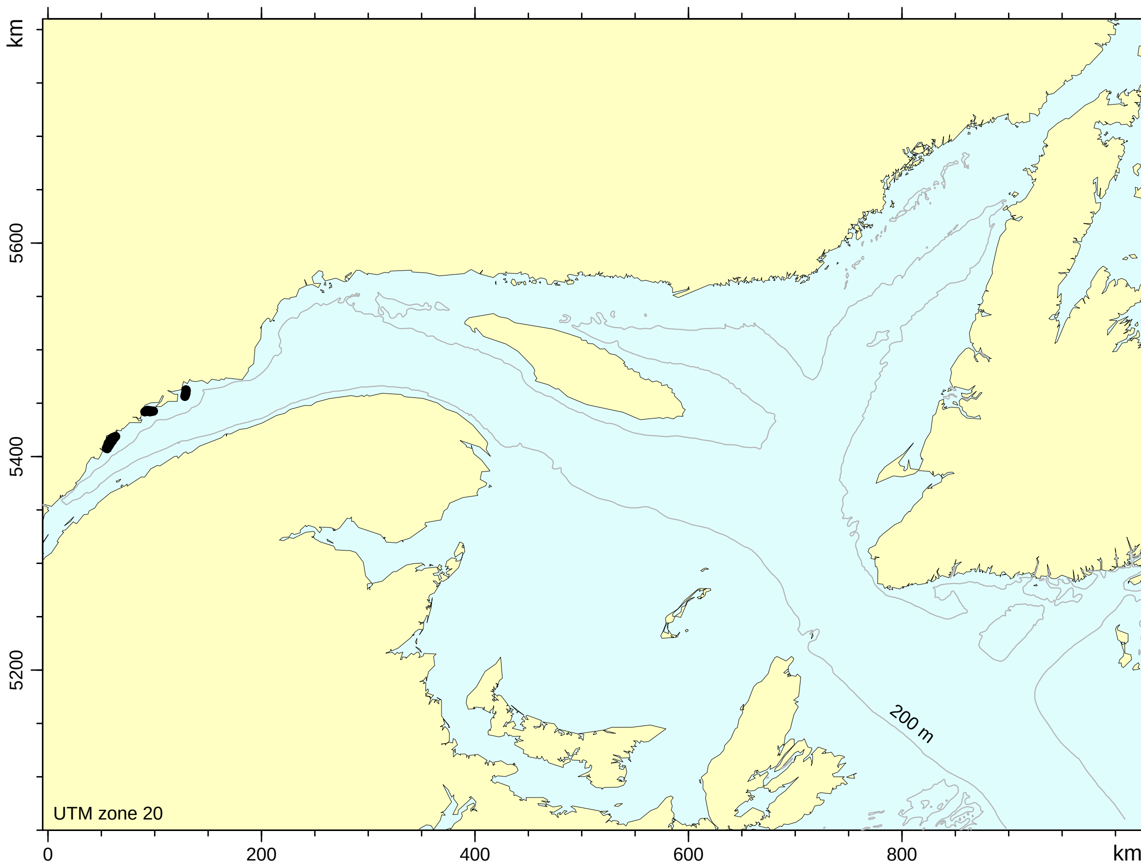


Figure 9 – Distribution of sampled stations during the whelk survey in the nGSL in 2005.

2.2.9 Stomach Contents of Cod and Greenland Halibut

The stomachs of cod and Greenland halibut are routinely collected during scientific surveys capturing groundfish. These stomachs can be used to estimate the relative abundance of different prey on the bottom (Gotshall, 1968; Parsons *et al.*, 1986; Livingston, 1989; Hanson & Chouinard, 2002; Link, 2004; Briand, 2004). Such data are characterized by significant variability, each stomach generally only containing a small number of prey species among a larger number of possible prey species. To reduce this variability and improve the representativity of the sampling method, we selected for each predator only the stations with at least three stomachs containing food and we calculated the average stomach contents for each of these stations. The empty stomachs were excluded because they revealed nothing about the availability of prey. Only stations whose precise location was known were selected.

For the nGSL, 18,881 cod stomachs were selected from 1,482 stations (Figure 10). The majority of these stomachs were collected during the multidisciplinary survey, from 1993 to 2005. Several cod stomachs were also collected during the mobile gear Sentinel Fisheries from 1994 to 1999 and in 2002, and during the fixed gear Sentinel Fisheries (longline and gillnet) from 1995 to 1998. For more information on these stomach content sources, see Chabot *et al.* (2008)†. In addition to the stomachs mentioned in this study, a small number of cod stomachs were collected opportunistically during other surveys with limited geographic coverage in 1994, 1995 and 1997.

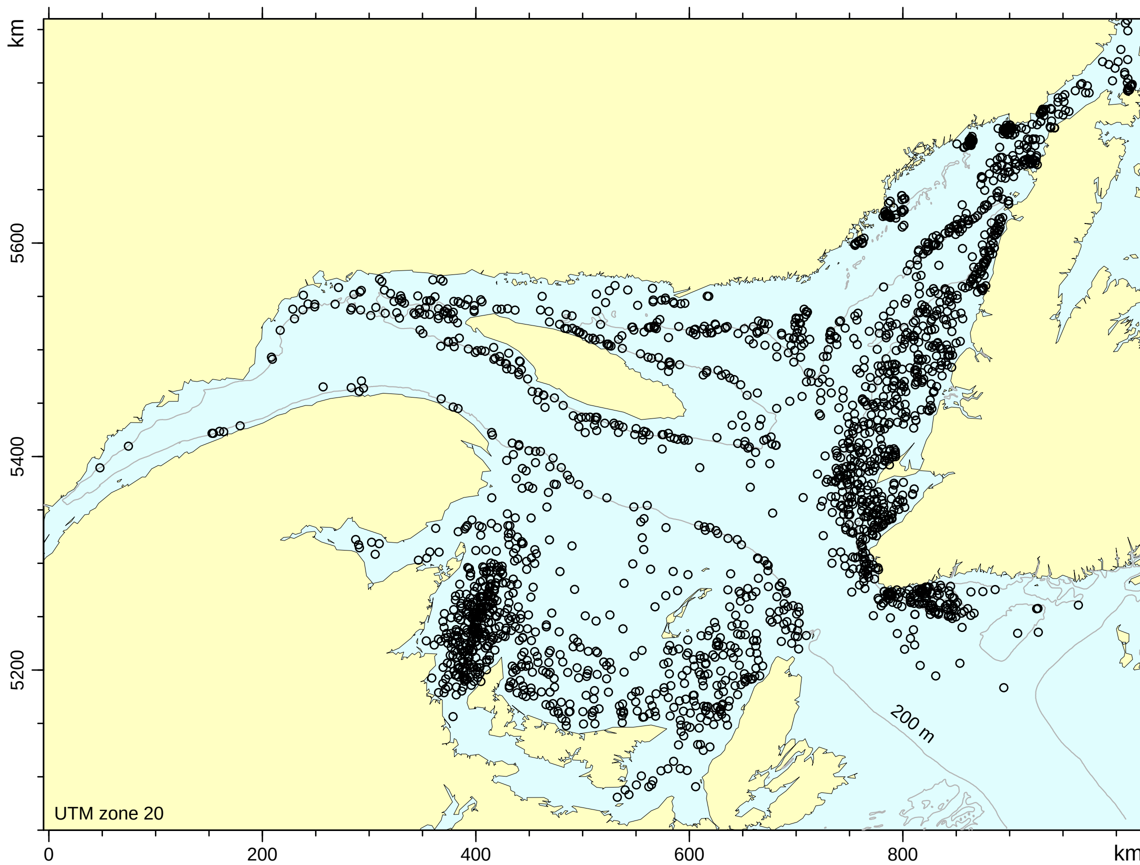


Figure 10 – Station positions with at least three cod stomachs containing food (1993-2005 for the nGSL, 1987-2004, with a few interruptions, for the sGSL).

For the sGSL, 11,285 cod stomachs were used from 647 tows (Figure 10). The majority of stomachs were collected during the fall mission (1987, 1990-1995, 1999-2004). Several stomachs were collected by the mobile gear Sentinel Fisheries (1994, 1999-2003) and in juvenile cod surveys from 1990 to 1995. Other surveys contributed to the harvest of stomachs in 1990, 1992 and 2001-2003. Hanson (1996), Hanson & Chouinard (2002) and Chabot *et al.* (2008)† provide more details on these surveys and stomach sampled.

† Updated: October 2010
† Updated: October 2010

We used 7,053 Greenland halibut stomachs from 743 stations located in the Estuary and nGSL (Figure 11). The majority of these stomachs were collected during the MLI multidisciplinary survey, 1993-2004, with an interruption in 2000. The fixed gear and mobile gear Sentinel Fisheries contributed a few hundred stomachs in 2002 and 2003. A small number of stomachs were collected opportunistically in surveys with limited spatial coverage in 1994, 1995, 1997, 2002 and 2004.

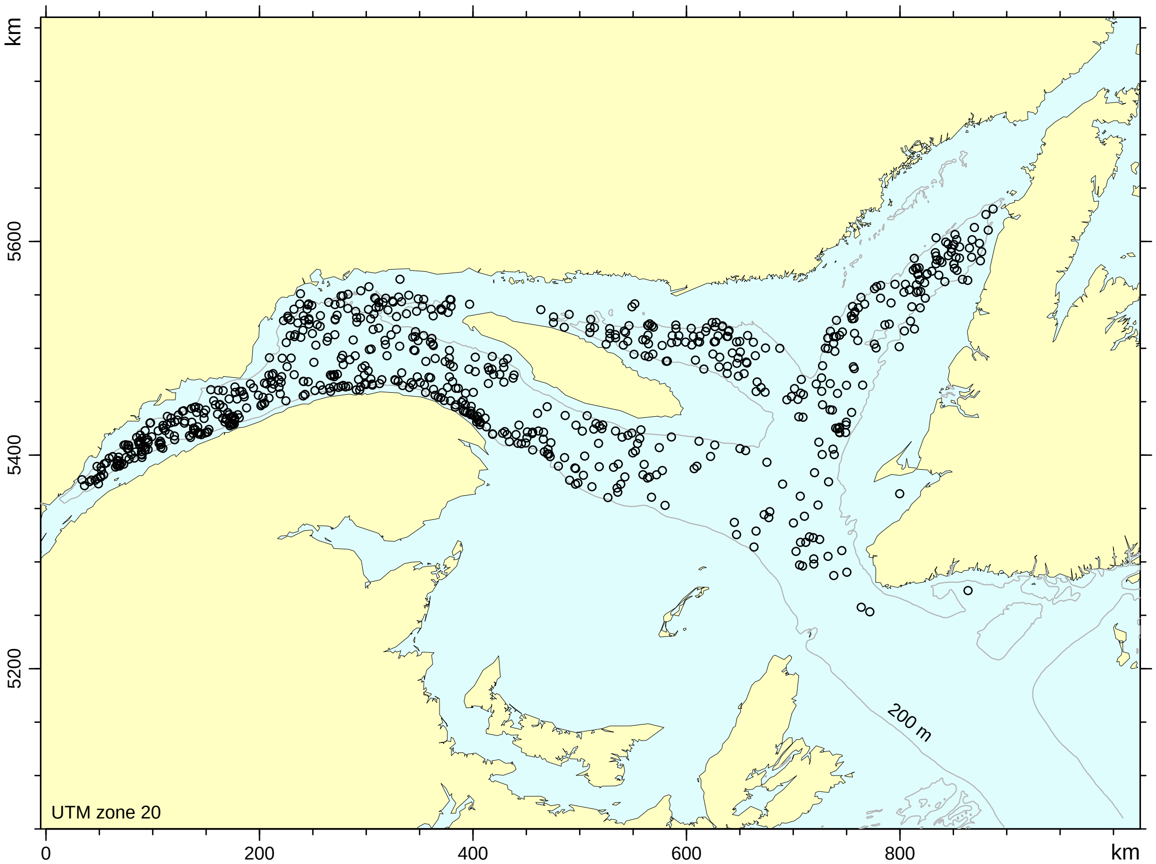


Figure 11 – Station positions with at least three Greenland halibut stomachs containing food (1993-2004, with an interruption in 2000).

The stomachs were collected to cover the entire size range of cod and Greenland halibut captured and to attribute the effort to all the tows where one or the other of these two species was caught. The length and mass of each fish were recorded, as well as tow details (latitude, longitude and depth). In all cases, the stomachs were excised soon after capture and frozen until analysis of stomach contents. In the laboratory, each stomach was thawed, the contents sorted, weighed and identified to species when the digestion level permitted. Some groups that contributed very little to the stomach contents, such as gammarian amphipods, were identified to higher taxonomic levels. The abundance of each prey in a stomach was expressed in terms of partial fullness index (Lilly, 1991):

$$\text{Fullness} = \frac{\text{Prey mass}}{\text{Fish length}^3} \times 10^4$$

This calculation removes the effect of fish size on the amount of food consumed, as stomach volume is proportional to fish length raised to the 3rd power. It is more effective than expressing prey abundance as a percentage of the mass of ingested food because with the latter, the abundance of a given prey is influenced by the abundance of other prey. With two exceptions, the prey found in a sufficient number of stomachs to be useful in determining EBSAs, were prey that had already been successfully sampled in the surveys (shrimp, crab). We have therefore only selected this type of sampling for the two exceptions: immature snow crab (cod stomachs) and *Boreomysis arctica* (Greenland halibut stomachs).

2.3 Data Processing

2.3.1 Data standardization†

Catches from different surveys are recorded with different units (number or mass per surface unit, stomach content rate) (see Table 1 for details). In addition, different surveys used different gear, hence catchability of a given species varied in different surveys. Therefore, the data presented in this report do not correspond to the absolute abundance of species per sampling site, but rather represent relative abundances or densities that have been transformed to make different surveys more comparable.

The stations visited by the surveys were assigned to 10×10 km parcels. For each type of survey (nGSL multidisciplinary survey, snow crab survey, scallop survey, etc) and each taxa, an average relative abundance was first calculated for each parcel. To facilitate the identification of significant areas from various surveys and gear, the average catch data for each parcel have been converted into quartiles. This was done separately for each survey providing data for a given taxon. Parcels with fishing effort but no catch were excluded from calculations, but are represented on the maps. Parcels where catches took place were allocated to four categories, each representing 25% of the observations. These results are shown on maps using different colors for the 4 quartiles.

If more than one survey contributed data for a species, sometimes data from more than one survey were available for the same parcel. In this case, abundance was the mean of the quartile values observed in each survey.

As we rarely had enough data to make comparisons between seasons, years or even groups of years, this procedure was applied over the entire data set for a taxon in a survey.

Unfortunately, this method does not provide a direct comparison of taxa abundance between different types of surveys as the maximum catch from each survey corresponds to the highest quantile, but not the same absolute abundance. This warning is especially important because the surveys may cover different regions (e.g. northern and southern Gulf). The use of quartiles calculated separately for the two regions conceals the real differences in abundance between regions. To emphasize this, when stations from different surveys were used to determine the distribution of a taxon, we used different symbols on the distribution maps to show which survey or survey combination was used in each parcel. We did not notice any survey-related major difference in the relative abundance of taxa in areas covered by more than one survey. Therefore, this presentation of relative abundances appears to be

† Updated: October 2010, this section was rewritten.

appropriate for identifying areas of abundance for benthic invertebrate taxa covered by this study.

2.3.2 Integrative Indices

In addition to assessing the distribution of different taxa in order to identify significant areas for each, we also calculated integrative indices to assess the concentration of invertebrates and species diversity for each parcel of the study area. The primary index is the "concentration" index of all taxa in each parcel of the study area. It takes into account both the abundance of the taxon and how widely distributed it is. A parcel containing a few taxa that have a high relative abundance, but a very restricted distribution, may have a higher concentration index than a parcel containing a high relative abundance for a greater number of taxa, if they are widely distributed throughout the study area.

Thus, in calculating concentration, the relative abundance of each taxon was weighted according to the inverse of the surface area of high abundance for the taxon. Hence, taxa distributed over large areas were weighted down more than taxa distributed over a smaller area. Ultimately, a taxon for which all important catches would have been located in a single parcel would have a weight of 1. The concentration index is calculated as follows:

- For each taxon, retain the parcels with the highest quartile, i.e. those corresponding to a normalised catch ranging among the highest 25%. Selecting only the highest quartile is arbitrary, but it is obvious that these catches represent significant concentrations for determining EBSAs.
- For each taxon and each parcel, divide the quartile by the total number of selected parcels.
- Combine the taxa by combining (i.e. taking the sum) this concentration value for all taxa present in the parcel.
- Convert this value in quartiles once again by distributing the parcel indices into four classes each containing 25% of the data. Show these quartiles on a map.

This method allowed us to combine data from the fall, snow crab and Northumberland Strait surveys in the sGSL, and for the snow crab, scallop and multidisciplinary surveys in the nGSL. This index also reflected the abundance of immature snow crab in cod stomachs and of *Boreomysis arctica* in Greenland halibut stomachs. Exclusively coastal surveys were not used because an overly high proportion of the coasts were not covered. This index did not take into account the abundance of snow crab found in the multispecies survey (Teleost) or in the Sentinel Fisheries in the nGSL because the gear used did not have† a sufficiently high catchability for snow crab and the results could not be compared with the results from the snow crab surveys.

However, parcels covered by several surveys had a higher likelihood of obtaining high concentration indices than those covered by a single survey. This was because a parcel covered by multiple surveys often contained a greater number of species, especially when

† Updated: October 2010

several years were considered or when different fishing gear were used. The alternative of only considering the areas visited by all the surveys would have eliminated this bias, but was not accepted because it would have excluded an overly large proportion of the study area. Despite this bias, some of the parcels assessed by a single survey obtained high values of the concentration index in this analysis and the method was very useful for identifying areas with high concentrations of organisms.

We also calculated other integrative indices: total biomass, species richness (number of species) and diversity (Shannon index). However, these indices are not presented in this report because they were overly influenced by the number of surveys associated to each parcel.

2.3.3 Identification and Description of Potential EBSAs

Potential EBSAs were determined by identifying areas where the parcels with the highest concentration indices were most dense. We also took into account the topography and oceanographic characteristics in defining the geographic limits of the EBSAs. Once these potential EBSAs were identified, each was examined in order to assign scores to the five established criteria to qualify EBSAs (MPO, 2004), each criterion was rated on a scale of 3:

Uniqueness Species with a high relative abundance in an area were examined and their distribution assessed. A low score was assigned when only widely distributed species were abundant, while a high score was given if species with limited distributions were abundant. Some areas received an average score because there was a high concentration of one or more taxa with an average distribution range. Unique physical characteristics could also receive a high score.

Aggregation A low score was assigned if an area was characterized by a large proportion of parcels from the second quartile and the presence of parcels from the two lower quartiles. An average score was given if the two upper quartiles were present in similar proportion and there were little or no parcels with lower quartiles. Finally, a maximum score was given if the majority of parcels were in the upper quartile. This was a visual assessment. In retrospect, it would have been easy to make an exact calculation and values in some areas may have changed. However, calculated values were not available at the December 2006 workshop for defining EBSAs in the LEGSL, only the visual assessment. We decided to use these values in this document also instead of calculating them more rigorously.

Fitness Consequences A high value for this criterion indicates that an EBSA is likely essential for the fitness value of one or more species. A spawning ground or a nursery, for example, could provide a high score for an EBSA. However, little data were available in order to identify life cycle details of the considered taxa associated with a limited geographic area. In addition, most taxa considered have a pelagic larval phase with the potential to disperse widely. The few species for which we have better knowledge are discussed in the Results section. We gave the same minimum score to all potential EBSAs, with the exception of an area where a species' entire population was found.

Resilience Resilience refers to the sensitivity of habitats or species themselves to perturbation or their ability to recover from disturbance. High sensitivity or great difficulty recovering from a disturbance results in a high score for this criterion. Considering the lack of information on the subject and the lack of an operational definition, we awarded the minimum score to all EBSAs, except for EBSAs where scallop beds were found: these highly localized structures can be damaged or overexploited, and for these reasons a score of 2 was given. The maximum score was not given.

Naturalness Most areas are relatively unaffected by pollution or other disturbances, apart from fishing and maritime traffic, and are still quite “natural”. Therefore, most areas have been given an average score. Only one area received the maximum score because of rugged bottoms that significantly reduced fishing activities. Some areas were given the minimum score if fishing activities and/or maritime traffic were particularly intense, or if pollution or a high anthropogenic influence on the quality of water was observed.

3 Results

The distribution data for benthic invertebrate species were examined and the relative abundance of each taxon per parcel was calculated in order to produce the concentration index. This index was represented on a map to identify potential EBSAs. The relevance of these EBSAs should be examined for each taxon. For this reason, we first present the concentration index results and potential EBSAs for benthic invertebrates of the LEGSL. Subsequently, the distributions of different taxa are presented on a map showing the limits of the proposed EBSA to assess the relevance of the latter for each taxon.

3.1 Concentration Index of Benthic Invertebrates

The distribution of 50 benthic invertebrate taxa (subspecies, species, genus, families and classes combined) has been examined throughout the LEGSL from 13 types of surveys using sampling methods as different as predator stomachs, dredges and trawls (Table 1). The best represented groups are crustaceans (23 shrimp species [one with two subspecies], six crab species and one genus [two species are combined in the sGSL], lobster and one mysid species), molluscs (eight species and one family) and echinoderms (one species, one genus, four families). Soft corals, anemones, sponges and ascidians were unfortunately not identified with the same precision as crustaceans, molluscs and echinoderms.

Six coastal species (two surfclam, softshell clam, sand shrimp, lobster and rock crab) were excluded from the determination of EBSAs because their distribution was poorly covered by the available surveys. The remaining taxa were included in the concentration index calculation, an integrative index for identifying sites with high relative abundance according to data from eight surveys (see p. 19 how concentration was calculated). The values for this index for the sampled parcels are presented in Figure 12.

The surveys used to calculate concentration provided a coverage of 87% of the LEGSL (1,981 parcels of 2,268 possible parcels). Most of the non-sampled parcels are located in the nGSL. The majority of the nGSL area has only been sampled by the multispecies survey and we only selected the data collected since 2004 on board the Teleost. Morover, several taxa had usable data only for 2006. We also considered the data collected on board the Needler since 2000 for soft corals, and predator stomachs for two more taxa, but station density still remains low. In contrast, two surveys covering several years, even going back to 1971 in the case of the fall survey, are used in the sGSL, which increases the probability of visiting all the available parcels in the study area (compare Figures 2 and 3). The larger proportion of non-sampled parcels in the nGSL, particularly in the deep channels, represented a negative bias for identifying EBSAs in the nGSL.

The sampled parcels that did not include maximum relative abundance (first quartile) for at least one species have a zero value in terms of concentration index and are represented by small crosses in Figure 12. Again, a greater proportion of parcels with a concentration index of zero come from the nGSL. Besides cod and Greenland halibut stomachs, which only measured the abundance of a single taxon per predator, most of the nGSL parcels were only sampled by the Teleost multispecies survey and only for 3 years. In addition, most taxa selected for the nGSL were not identified until 2006 (see Table 1). The nGSL is characterized by only a small number of stations per parcel, a single sampling gear (except for stomachs) and a small number of recognized species per station. Therefore, this reduced the possibilities of obtaining catches from the upper quartile for one or more species. The situation is completely different in the sGSL, which is well covered by two types of trawls along with predator stomachs, with a very high density of stations in each parcel. Using two types of trawls with different selectivity and catchability increases the probability of capturing different species in significant amounts. Considering these large differences in sampling techniques and the cumulative sampling effort, it is important not to conclude that there exists a lower biodiversity or biomass in the nGSL than in the sGSL. This represents a second negative bias to this part of the LEGSL for identifying EBSAs.

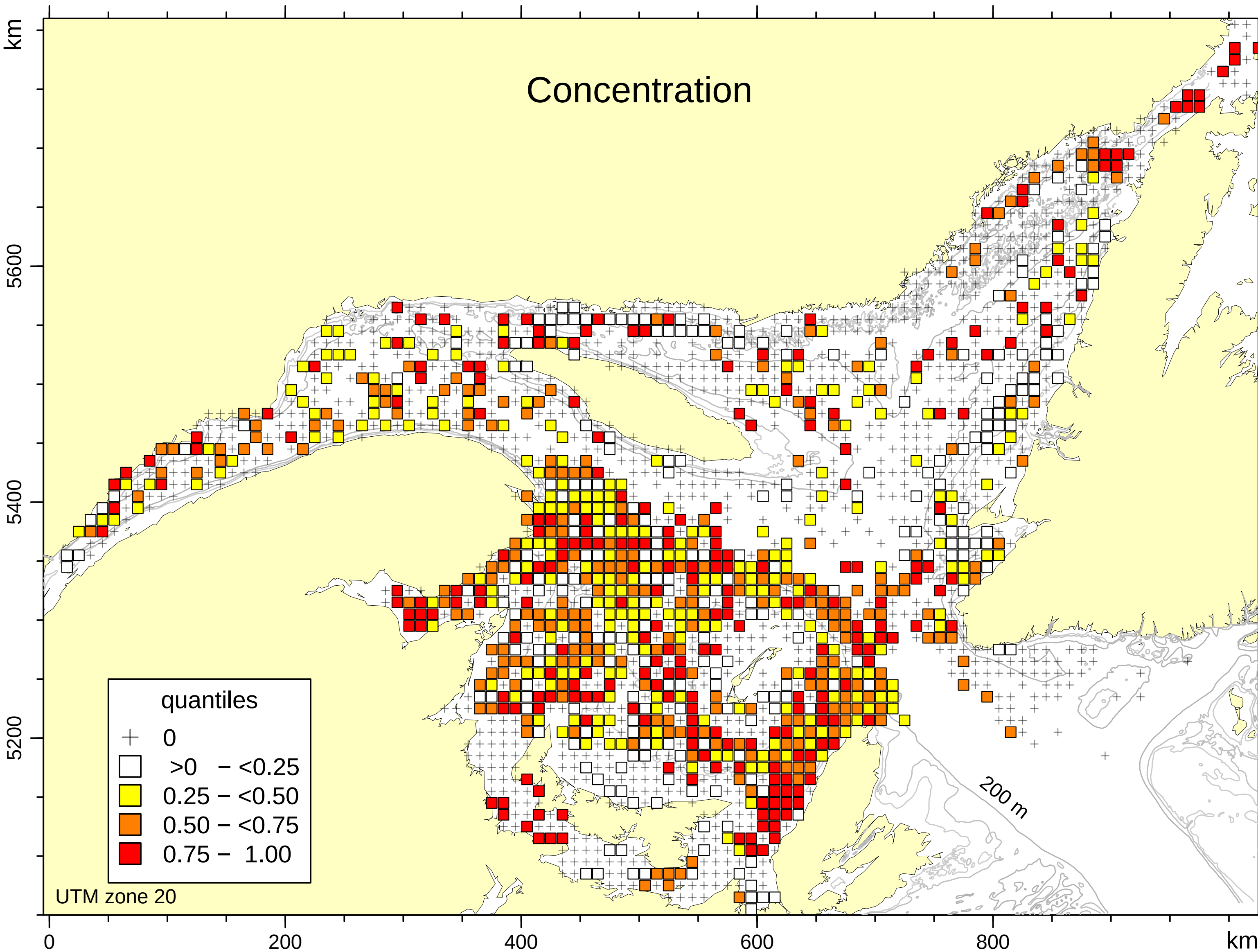


Figure 12 – Concentration index of benthic invertebrates in the LEGSL combining the highest abundances of all species, weighted by the distribution range of each species.

That being said, some areas are characterized by the dominance of parcels with the two highest values of the concentration index. Such aggregations show the importance of these areas for the ecology and biology of benthic invertebrates in the LEGSL. Areas with a high index may correspond to aggregations of some species with very limited distribution or to a very large concentration of several species whose distribution is widespread.

3.2 Description of Potential EBSAs

Potential EBSAs have been identified when there were high densities of parcels with high concentration values, taking into account the bathymetry and circulation patterns of the bodies of water (Figure 13). Seventeen areas have been defined. They include more than 90% of parcels with a concentration index equal to the two upper quartiles, while covering only about 41% of the study area.

The potential EBSAs are identified in Figuree 14. Table 2 describes each of the 17 EBSAs and gives their scores for the five criteria developed by MPO (2004). Each criterion is rated on a scale of 1 to 3.

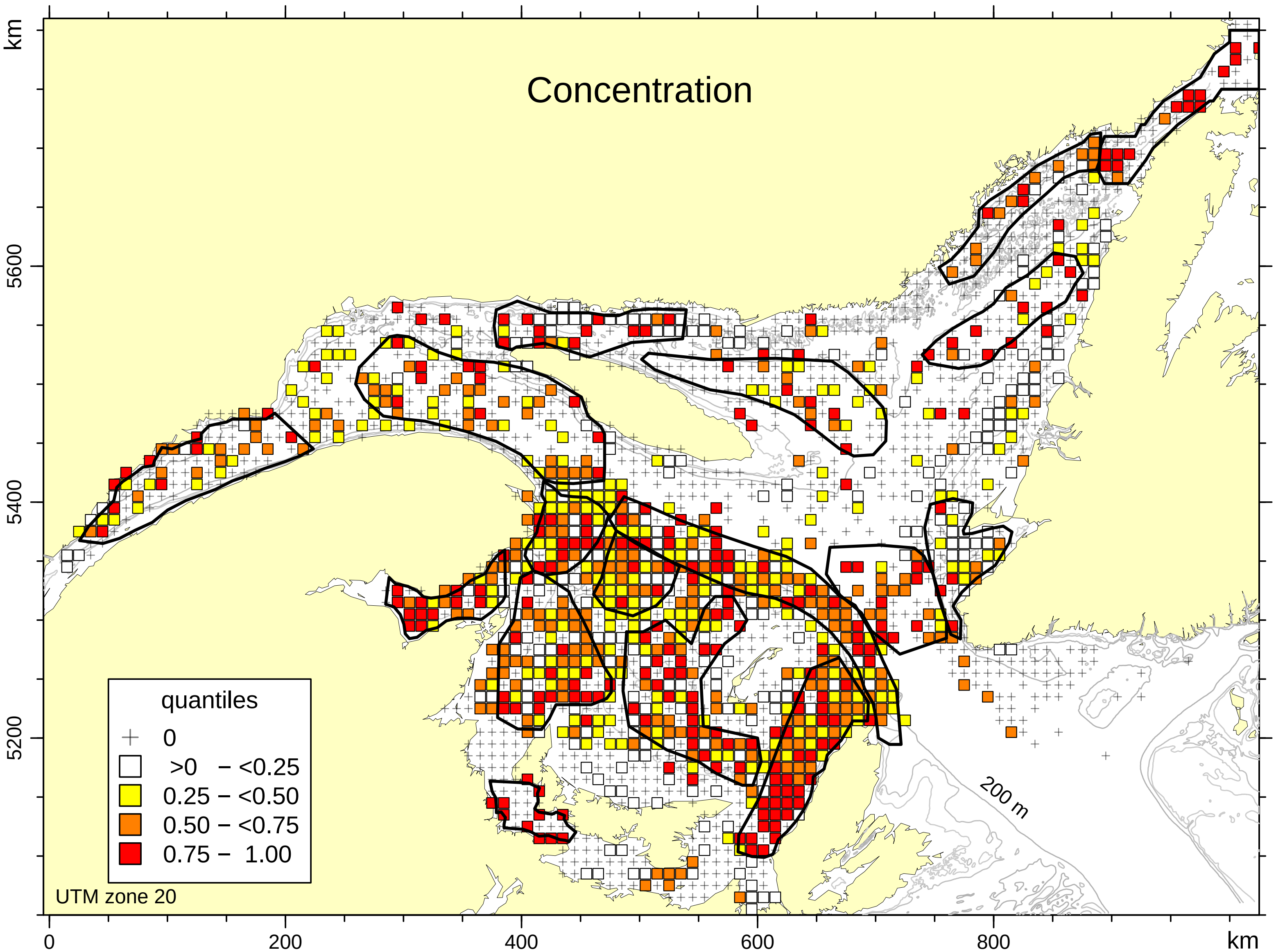


Figure 13 – Potential EBSAs: areas in the LEGSL with a high concentration index of benthic invertebrates.

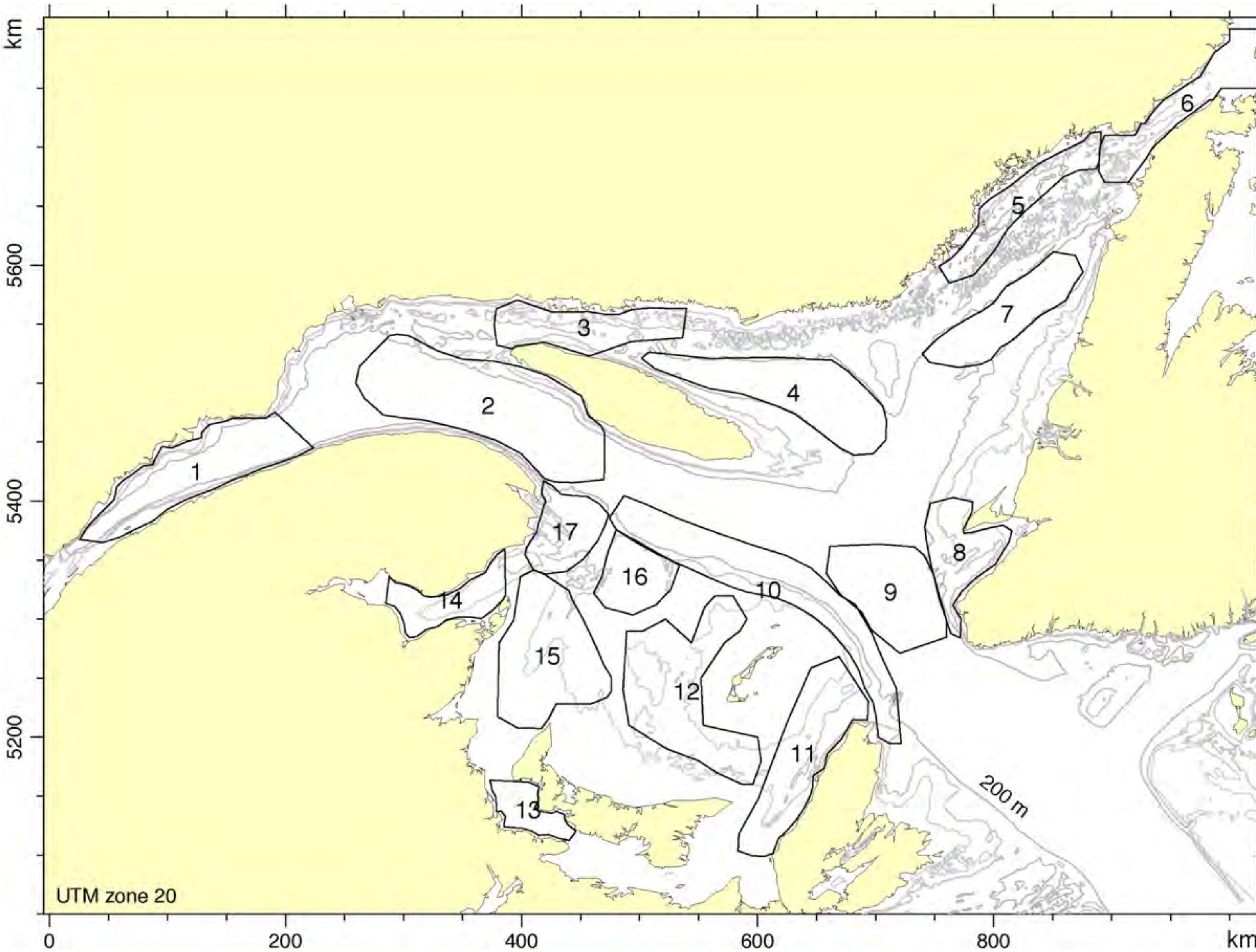


Figure 14 – The 17 potential ecologically and biologically significant areas (EBSAs) for benthic invertebrates in the LEGSL.

Table 2 – Description of the 17 proposed ecologically and biologically significant areas (EBSAs) for benthic invertebrates in the lower Estuary and Gulf of St. Lawrence (LEGSL). R = criterion rating; T = total score.

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
1. Estuaire maritime											
1. Lower Estuary											
End of the Laurentian Channel. • Shallower part with beds of Iceland scallop, including the furthest known upstream bed in an estuary. • Includes cold waters at its western limits (deepwater upwellings). • Marginally sampled infralittoral.	One of the 3 areas where *B. arctica* is abundant.	2	Low concentration index. • For the deep part, significant concentrations of species or widespread aggregations (B. arctica) and very widespread distribution (e.g. anemones, spoonarm octopus, basket stars, brittle stars, sea urchins). • The shallower part is significant for snow crab (widespread species) and includes beds of Iceland scallop.	1	Shallower part is important for snow crab recruitment, but immature crab seek temperatures between -0.5 to 3 °C, common elsewhere in the GSL where the bottom is in contact with the CIL.	1	Scallop beds in the shallower area.	2	Deep waters are naturally hypoxic, but human activities have made the situation worse over the last 75 years.	1	7
2. Honguedo Strait and north-west GSL											
Laurentian Channel in Honguedo Strait and in the north-west part of the GSL. • Strong influence from the Anticosti Gyre in the western half of the area. • A small portion of the area is less than 200 m from Anticosti Island.	One of two significant areas for soft corals and *B. arctica*.	2	Average concentration index. • Significant area for two taxa of limited distribution (see Uniqueness). • Area where the abundance of northern shrimp is highest in the Gulf and where the commercial fishery is most significant. • Significant area for other widespread taxa (anemones, sponges, stars, sea urchins, *Pasiphaea multidentata, Lebbeus polaris* [deep part], *Pandalus montagui* [around 200 m]) or not widespread but dispersed (spoonarm octopus, squid). • Iceland scallop beds near Anticosti Island.	2	Has very high concentrations of all northern shrimp life stages. Berried females migrate and concentrate southwest of Anticosti Island in spring to release larvae.	1	No information. [In retrospect, the presence of scallop beds should have resulted in a score of 2, but these beds represent a very small part of the area.]	1	Little influence from human activities, other than fishing.	2	8

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
3. Jacques-Cartier Strait and north-west sector of Anticosti Island											
Area with depths of less than 200 m characterized by deep water upwellings.	Significant for two species (*Lebbeus groelandicus, L. microceros*) and one subspecies (*Eualus gaimardii belcheri*) not widespread. • Significant Iceland scallop beds	2	Very high concentration index over the entire area. • Significant for species not widespread (see Uniqueness). • Significant Iceland scallop beds [supports the most significant commercial scallop fishery (both species combined)]. • Significant for ascidians and lesser bobtail squid, moderately widespread. • Significant for a few widespread species (*Pandalus montagui, Argis dentata, Eualus fabricii, E. macilentus, Spirontocaris spinus, Lebbeus polaris*, sea urchins, cucumbers). • Somewhat significant for other widespread species (sponges, *Sclerocrangon boreas*, starfish, basket stars, brittle stars, hermit crab)	3	Nothing of specific importance for the listed benthic invertebrates or lack of information	1	Scallop beds.	2	Little influence from human activities, other than fishing.	2	10
4. Anticosti Channel											
Branch of the Laurentian Channel skirting the north of Anticosti Island. • Decreasing depth towards the head of channel to the west. • Circulation patterns resulting in the retention of certain species at the head of the channel.	There are two other channels and channel heads in the LEGSL .	1	Average to low concentration index. • Significant for one species moderately widespread (*Pontophilus norvegicus*, spoonarm octopus). • Significant for widespread species (*Pasiphaea multidentata, Pandalus borealis*). • Somewhat significant for widespread species (starfish, anemones)	1	Supports considerable concentrations of all *P. borealis* life stages: adults in the deeper part, juveniles in shallower waters.	1	No information.	1	Natural hypoxia, little influence from human activities.	2	6

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
5. Mecatina Trench											
Trench surrounded by regions of less than 200 m with very prominent relief, not trawlable by the multispecies survey and thus only marginally exploited by trawlers.	Steep relief, typical of the Lower North Shore.	1	Average concentration index. • Significant for widespread species or aggregations (basket stars, snow crab [overexploited, fishing has been prohibited since 2003], Arctic lyre crab and toad crab).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	Iceland scallop beds.	2	Relatively undisturbed habitat, a considerable portion of the area is untrawlable.	3	9
6. Strait of Belle Isle											
Exchange area between the Labrador current and our region, very cold conditions. • Cold and shallow waters.	Unique physical characteristics: exchange of water masses and organisms between the Labrador current and the study area. • Area supporting an assemblage of shrimp species associated with arctic conditions (*Eualus gaimardii gaimardii, E. g. belcheri, Lebbeus groenlandicus, L. microceros, Spirontocaris phippsii*), some very rare or absent from the rest of the study area.	3	High relative abundance for species that are rare or with limited distribution (see Uniqueness). • Significant for ascidians and lesser bobtail squid, average distribution elsewhere. • Significant area for widespread species or aggregations (sponges, starfish, basket stars, *Sclerocrangon boreas, Eualus fabricii, E. macilentus, Spirontocaris spinus, Lebbeus polaris, Pandalus montagui, Sabinea septemcarinata, Argis dentata*).	3	Appears significant for three not widespread species (emphS. boreas, A. dentata et L. groenlandicus), with high catches and diverse size range from juveniles to very large adult individuals. • There are likely one of several scallop beds not covered by our surveys.	1	No information.	1	Undisturbed habitat, other than fishing.	2	10

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
7. Head of the Esquiman Channel											
Branch of the Laurentian Channel skirting the west coast of Newfoundland. • Decreasing depth towards the head of the channel to the north (which is excluded from the area).	No unique factors, channel similar to the two others in the LEGSL	1	Of average significance according to the concentration index. • Significant for widespread species in deep waters (*Pasiphaea multidentata, Pandalus borealis, Pontophilus norvegicus*). • Somewhat significant for other deep water species (shortfin squid, lesser bobtail squid, starfish).	2	Supports considerable concentrations of all life stages of *P. borealis*: adults in the deeper part, juveniles in shallower water .	1	No information.	2	Natural hypoxia, little influence from human activities.	2	7
8. St. George's Bay											
Shallow area (< 200 m) where the bottom is in contact with the CIL.	Because of its depth profile and its opening on the channel, the area supports both deep water species and very coastal cold water species. • Only Gulf area where the shrimp species *Sabinea sarsi* is found.	1	High concentration index over almost half of the area, low for the rest. • Significant for widespread species in shallow waters, in contact with the CIL (*Eualus macilentus, Sabinea septemcarinata, S. sarsi*, sponges, shortfin squid). • Somewhat significant for other widespread species on bottoms that are in contact with the CIL (*Lebbeus polaris, Pandalus borealis, Argis dentata*, brittle stars, sea cucumbers, starfish, basket stars).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	No information.	1	Little influence from human activities, other than fishing.	2	7

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
9. Laurentian Channel – Cabot Strait											
Influx of deep and warm waters from the Atlantic into the Gulf. • Outflow of surface waters from the Gulf. • The least hypoxic deep waters in the LEGSL.	Exchanges with the exterior of the GSL via Cabot Strait. • One of the rare significant areas for soft corals. • Only area where certain rare deep water shrimp species are found (*Pasiphaea tarda, Sergestes arcticus, Atlantopandalus propinqvus, Acanthephyra pelagica*), however, these species are at the limit of their distribution and are of less significance in terms of Uniqueness.	2	Concentration index varies from low to high. • Occurrence of rare species (see Uniqueness). • Significant area for widespread species (spoonarm octopus, shortfin squid, *Pasiphaea multidentata, Lithodes maja*) and moderately widespread species (lesser bobtail squid).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	No information.	2	Maritime traffic	2	8
10. Southern slope of the Laurentian Channel											
Extended area centered on the 200 m isobath. • Influenced to the west by the Gaspé current and to the east by Cabot Strait. • Junction between the southern Gulf system, characterized by waters of less than 200 m, and by the northern Gulf, characterized by the deep waters of the Laurentian Channel.	Supports an assemblage made of abundant species in shallow and deep waters. • One of the rare significant areas for soft corals.	2	Concentration index varies from moderate to high. • Soft corals (see Uniqueness). • Iceland scallop beds. • One of the significant areas for other moderately widespread or widespread species in the LEGSL: anemones, *Pasiphaea multidentata, Spirontocaris lillgeborgi*, shortfin squid, sponges, spoonarm octopus and spiny crab (in the eastern part).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	Iceland scallop beds.	2	Little influence from human activities, other than fishing.	2	9

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
11. Cape Breton Trough											
Trench not as deep as the large channels in the nGSL, cutting across the north-eastern part of the sGSL, influenced both by the Laurentian Channel to the north and by the Magdalen Shallows area to the south.	Very prized area for one or several species and aggregations, but other areas are also conducive to these taxa, likely on account of similar physical conditions.	1	High concentration index throughout almost the entire area. • Very significant concentrations of species or aggregations that are widespread (brittle stars) and very widespread (e.g. starfish, basket stars, hermit crab). • Significant concentrations (but less extensive in the area) of very widespread species (anemones, sponges, shortfin squid, lesser bobtail squid, North Atlantic octopus, sea urchins, *P. montagui, Argis dentata*, snow crab) or widespread species (*Sabinea septemcarinata, Eualus macilentus*, Iceland scallop, sand-dollar, ascidians).	3	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	Beware of the few remaining sea scallop beds (Margaree).	2	Little influence from human activities, other than fishing.	2	9
12. Bradelle Bank, Eastern Bradelle Valley and surroundings											
Bottoms ranging between 50–70 m, including the western slope of the Magdalen Shallows. • Deep water species almost non-existent	Very favorable area for several species and aggregations, but other areas are also conducive to these taxa, likely on account of similar physical conditions. • Includes concentrations of relatively rare shrimp species such as *Spirontocaris phippsi* and *Eualus pusiolus*	1	High concentration index throughout almost the entire area. • Significant for widespread species or aggregations (*Sclerocrangon boreas*) or very widespread (basket stars, anemones, sponges, sea urchins, *Spirontocaris spinus*). Moderate abundance of Arctic lyre crab and snow crab, *Eualus fabricii, E. macilentus, Spirontocaris spinus, S. phippsi, Lebbeus polaris, Pandalus montagui, Sabinea septemcarinata, Argis dentata*, starfish, sea cucumbers, sand-dollar).	3	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	No information.	1	Little influence from human activities, other than fishing.	2	8

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
13. Western Northumberland Strait											
Very shallow area, warm in summer, very cold in winter.	Occurrence of an endemic species (subspecies), lady crab, which is not found elsewhere in the LEGSL.	3	Significant concentration of lady crab (see Uniqueness).	3	Lady crab spends its entire life cycle in the area.	3	Possible sea scallop beds (anectodal evidence).	2	Area with a lot of human activity which was and still is heavily disturbed.	1	12
14. Chaleurs Bay											
Moderately deep bay with a considerable escarpment. • Area influenced both by the north-western Gulf and the Magdalen Shallows.	Very favorable area for several species and aggregations, but other areas are also conducive to these taxa.	1	Variable concentration index but with high values in parts of the area. • High abundance of *Eualus macilentus, Spirontocaris spinus, Pandalus montagui, Argis dentata*, starfish, brittle stars, sea urchins, *Hyas* crab. • Average abundance of less widespread taxa (*Lebbeus groenlandicus, Sclerocrangon boreas*) or widespread (sea scallop, Iceland scallop, anemones, sponges, sea cucumbers, scallops, shortfin squid, *E. fabricii, P. borealis, Sabinea septemcarinata*, snow crab, hermit crab).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	Sea scallop beds.	2	Little influence from human activities, other than fishing.	2	8

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
15. Shediac Valley and Miscou Bank											
Shallow plateaus and flanks of a trench that is shallower than the large channels.	Very favorable area for several species and aggregations, but other areas are also conducive to these taxa. • Includes concentrations of rather rare shrimp species such as *Spirontocaris phippsi* and *Lebbeus microceros*.	1	Concentration index varying from low to average to high. • High abundance (snow crab, starfish, sea scallop, sea urchins) to average abundance (sponges, cucumbers, shortfin squid, anemones, Iceland scallop, *Eaulus macilentus, Spironto-caris spinus, Lebbeus polaris, Pandalus montagui, Sabinea septemcarinata, Argis dentata, Hyas* sp., hermit crab, whelk) of several widespread species or taxonomic groups. • Average significance for less widespread species (*L. groenlandicus, Sp. phippsi, Sp. Lillje-borgi, L. microceros*).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	No information.	1	Little influence from human activities, other than fishing.	2	7
16. Orphelin Bank and Western Bradelle Valley											
Shallow area influenced by the Shediac Valley, Laurentian Channel and Gaspé current.	Very prized area for several species and aggregations, but other areas are also conducive to these taxa. • Overflow area for the distribution of species occurring in the Laurentian Channel (shortfin squid, spoon-arm octopus, northern shrimp).	1	Low to high concentration index. • Average abundance for snow crab, sea urchins, sponges and a few widespread shrimp species (*Eualus macilentus, Sabinea septemcarinata*).	2	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	No information.	1	Little influence from human activities, other than fishing.	2	7

Table 2 – The 17 proposed EBSAs for benthic invertebrates in the LEGSL (continued).

Potential	Uniqueness		Aggregation		Fitness consequences		Resilience		Naturalness		T
EBSA	Description	R	Description	R	Description	R	Description	R	Description	R	
17. American Bank and Gaspé Gyre											
Area highly influenced by the Gaspé current, conducive to the retention of organisms.	Very prized area for several species and aggregations, but other areas are also conducive to these taxa. • Overflow area for the distribution of species occurring in the Laurentian Channel (shortfin squid, spoonarm octopus, northern shrimp). • Occurrence of a rare shrimp species, *Eualus pusiolus*.	1	High concentration index almost throughout the area, average in some parts. • High (starfish, basket stars, *Eualus macilentus, Pandalus borealis, P. montagui*) to average (ascidians, sponges, snow crab, anemones, sea urchins, whelk, sea scallops and Iceland scallops, shortfin squid, spoonarm octopus, *E. macilentus, E. fabricii, Spirontocaris spinus, Lebbeus polaris, Sabinea septemcarinata, Argis dentata*, Arctic lyre crab) abundance of many widespread species.	3	Nothing of specific importance for the listed benthic invertebrates or lack of information.	1	Sea scallop and Iceland scallop beds.	2	Little influence from human activities, other than fishing.	2	9

Uniqueness Only once was the bulk of a species' distribution present in a single EBSA. This was the case for lady crab in Area 13, which thereby received full marks for uniqueness. This score was also given to Area 5 because a majority of large concentrations of several shrimp species with limited distribution was present and the physical characteristics of the area were unique. Some EBSAs (1–3, 9–10) were rated average because a fairly large proportion of large catches of species with average widespread distribution was present. The other EBSAs received the minimum score for this criterion. Admittedly, the uniqueness concept loses much of its significance when only a small proportion of the total number of benthic invertebrate species occurring in the LEGSL is considered, as in the present study.

Aggregation Several areas are made up primarily of parcels whose concentration index is in the upper quartile and therefore received the maximum score (Areas 3, 6, 11–13, 17). Some areas had a relatively high proportion of parcels in the third or fourth quantiles and received the minimum score (Areas 1 and 4). Other areas are of intermediate concentration. A precise quantification of the proportion of parcels from the different quantiles would likely result in a slightly lower score for Areas 8 and 17, but the values used in establishing the final EBSAs during the December 2006 workshop were retained.

Fitness Consequences As stated on p. 20, all areas received the minimum score for this criterion because the pelagic larval stage of most taxa considered here has a widespread distribution and we possess little information linking the juvenile or adult stages to specific geographic locations. However, two crustacean species, northern shrimp and snow crab were evaluated under this criterion because knowledge of their distribution and life cycle is more detailed. The conclusion remains the same: no area has a great impact on the adaptive value of these two species, which find conditions conducive to their life cycle in several areas of the LEGSL. The only exception to this criterion is EBSA 13, where lady crab are endemic, justifying the maximum score.

Resilience Due to a lack of operational definition (p. 21), all areas received a minimum score for this criterion, unless they contained scallop beds (Areas 1, 3, 5, 10, 11, 13, 14 and 17), geographically circumscribed entities that may be damaged or overexploited, in which case they received a score of 2.

Naturalness We attributed an intermediate score to most EBSAs (p. 21) because they have a fairly large surface area and cover circalittoral or bathyal areas that do not appear, overall, particularly disturbed. However, two EBSAs are considered more disturbed, the Estuary and the northwest of Northumberland Strait (EBSAs 1 and 13, respectively). Maritime traffic is intense, and intakes of nutrients and pollutants are more marked than for other areas. In contrast, a high score was given to Area 5, Mecatina Trench, because bottoms are not trawlable and therefore have not been disturbed by mobile fishing gear.

Total The total is the sum of the scores assigned to each of the five criteria assessed (maximum total = 15). A high total for an area indicates that it is very important to benthic invertebrates that are listed. Table 3 shows the distribution of areas by total score. The minimum total observed was 6 while the maximum was 12. The average score per area was 8.3. Only three potential EBSAs received a total above ten which corresponds to a score of at least 2 for each criterion. The Northumberland Strait Area (EBSA 13) obtained the highest total (12) because of the unique presence of lady crab. The Strait of Belle Isle (EBSA 6) and Jacques-Cartier Strait (EBSA 3) achieved a total of 10 because they contain an unusual assemblage of species associated with relatively shallow depths combined with very cold water from the Labrador current in the case of the Strait of Belle Isle, or strongly influenced by upwellings in the case of Jacques-Cartier Strait.

Table 3 – Distribution of the total score frequencies for the 17 proposed EBSAs.

Total score	6	7	8	9	10	11	12
Number of EBSAs	1	5	4	4	2	0	1

3.3 Benthic Invertebrate Distribution Data for the LEGSL

3.3.1 Soft Corals

We only have data on soft corals (Alcyoniidae Family) for the Estuary and nGSL (Figure 15). Soft corals are sessile and must be torn from their substrate (often dead shells or rocks) to be sampled. It is therefore difficult to assess their catchability during trawl surveys. Moreover, the most common species in the LEGSL, *Gersemia rubiformis* or sea strawberry, is normally found in the infra and circalittoral and its distribution is only partially covered by our surveys. Available data suggests that soft corals are found mainly in relatively deep waters in the Laurentian Channel, from the Estuary to the west to Cabot Strait to the east, as well as at the head of Esquiman Channel and in the Strait of Belle Isle.

Soft corals can reproduce both sexually (release of male and female gametes in the water) or asexually (by budding or stolon). Frequently, the same species alternates between these two methods of reproduction. Asexual reproduction greatly limits the distribution of individuals (Sumich, 1992). Soft corals are suspension feeders and have few predators except for some nudibranch species.

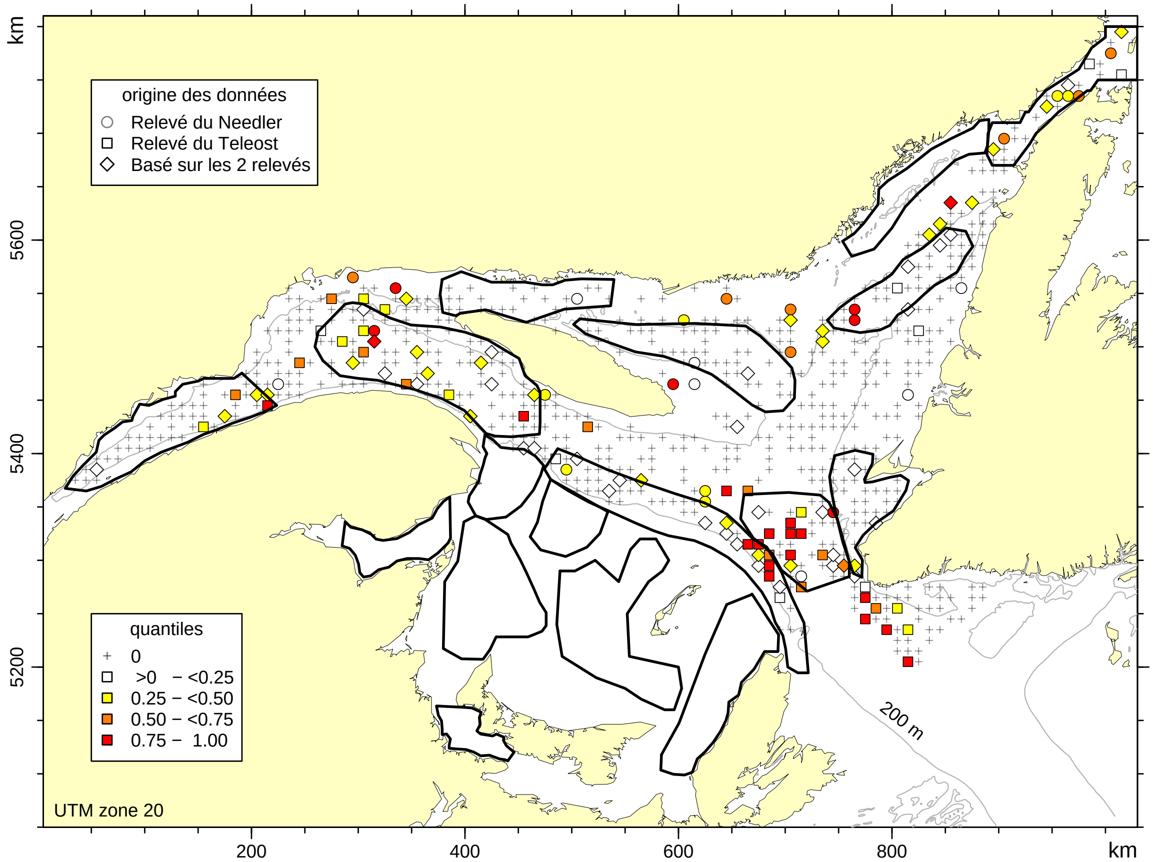


Figure 15 – Soft coral (Alcyoniidae) distribution based on the multidisciplinary survey in the nGSL, 2000-2006.

3.3.2 Anemones

There are about fifteen anemone species (Class Anthozoa) in the circalittoral and bathyal areas of the LEGSL (Brunel *et al.*, 1998). Two species that are relatively widespread are rather coastal: the frilled anemone (*Metridium senile*) and dahlia anemone (*Urticina felina*, synonym *Tealia felina*). Several others are scattered geographically and also bathymetrically. They are therefore more likely to be captured during our surveys: swimming anemone (*Stomphia coccinea*), rugose sea anemone (*Hormathia nodosa*), *Actinauge cristata, Bolocera tuediae* and *U. crassicornis* (Brunel *et al.*, 1998). Anemones are generally attached to a hard substrate or may be burrowing and are therefore potentially under-sampled by trawl surveys, which also exclude the infralittoral zone where anemones abound. They are particularly abundant in the Estuary and along the south side of the Laurentian Channel (Figure 16). Unfortunately, anemones were not identified as to species in our surveys. It should be noted that sampling intensity is low for the Estuary and nGSL (one single year).

Anemone reproduction can be sexual or asexual as soft corals belonging to the same Class. Some anemone species are suspension feeders, while others are carnivorous, feeding on small fish, crustaceans and molluscs. They are sometimes preyed upon by nudibranches and some starfish.

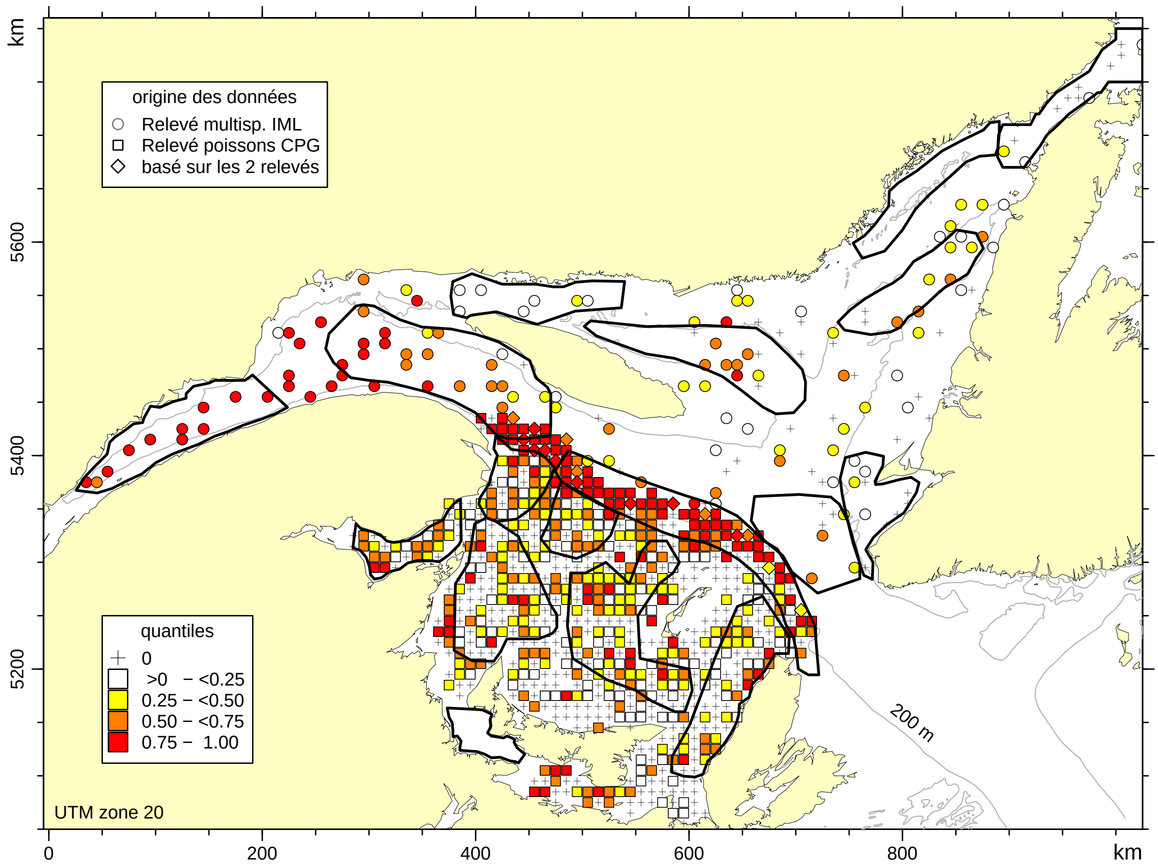


Figure 16 – Anemone (Anthozoa) distribution based on the 2006 multidisciplinary survey in the nGSL and the fall surveys in the sGSL, 1988-2005.

3.3.3 Sponges

Sponges (Phylum Porifera) can be found almost all over the LEGSL, reflecting the fact that a mix of coastal and bathyal species have been listed (Brunel *et al.*, 1998). It should be noted that sampling intensity is low for the Estuary and nGSL (one single year).

Sponges are suspension feeders, attached to a solid substrate and their catchability by our gear is unknown. The shape and color of sponges vary from one individual to another; therefore, they can only be identified by microscopic examination of their spicules. Sponges have a structural role in the ecosystem, serving as a shelter or substrate to other associated species, sometimes even commensal or symbiotic (Jensen, 2004; Saito *et al.*, 2006).

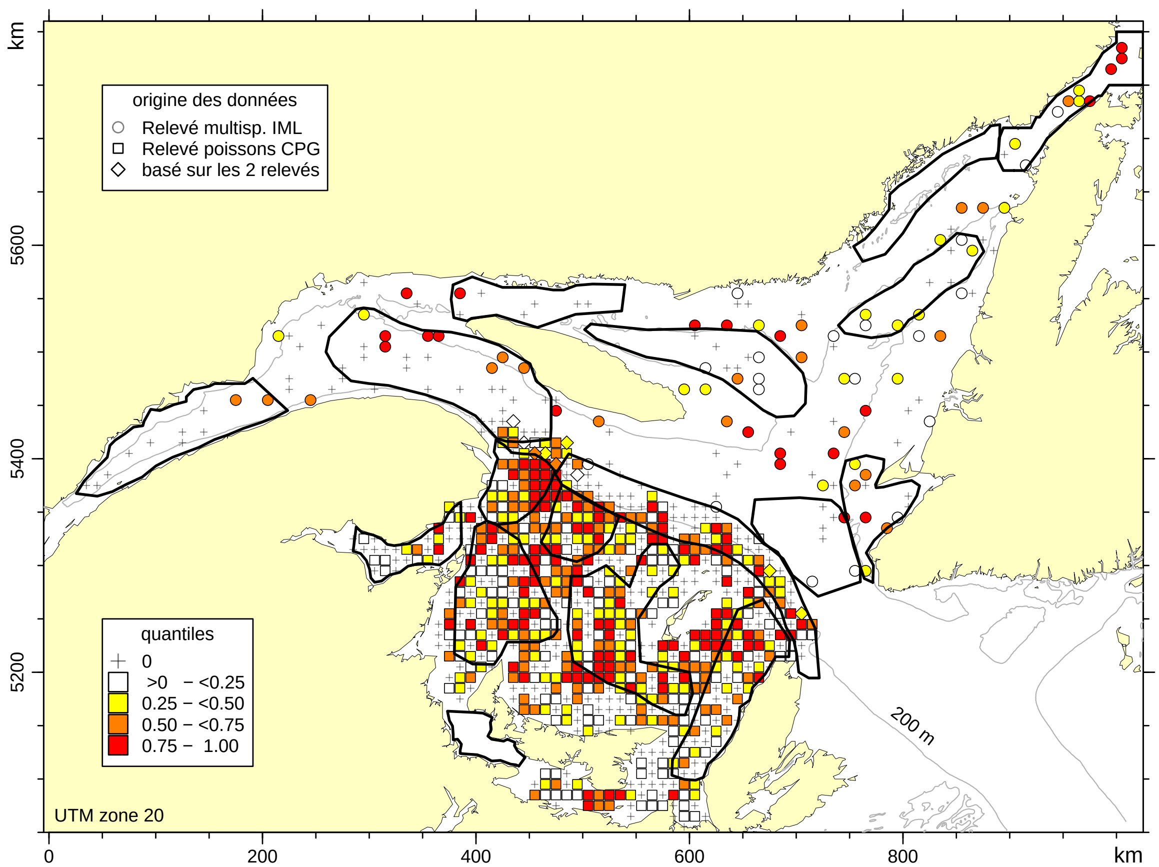


Figure 17 – Sponge (Porifera) distribution based on the 2006 multidisciplinary survey in the nGSL and the fall surveys in the sGSL, 1988-2005.

3.3.4 Ascidians

In the Gulf, two ascidian species (Class Ascidiacea) are of a size that makes them likely to be caught by trawls: the sea potato (emphBoltenia ovifera), that lives from the infralittoral zone up to the characteristic depths of the Laurentian Channel, and the sea peach (*Halocynthia pyriformis*), that lives at depths of less than 200 m. These species probably have a low catchability due to their sessile lifestyle. Trawl surveys show almost zero catches in the Estuary and Laurentian Channel (Figure 18). They are most abundant at lower depths, in the Strait of Belle Isle and Jacques-Cartier Strait for the nGSL. They are also abundant in the northern sector of sGSL, such as the American Bank, Orphelin Bank and in the Cape Breton Trough. It should be noted that the sampling intensity is low for the Estuary and nGSL (one single year).

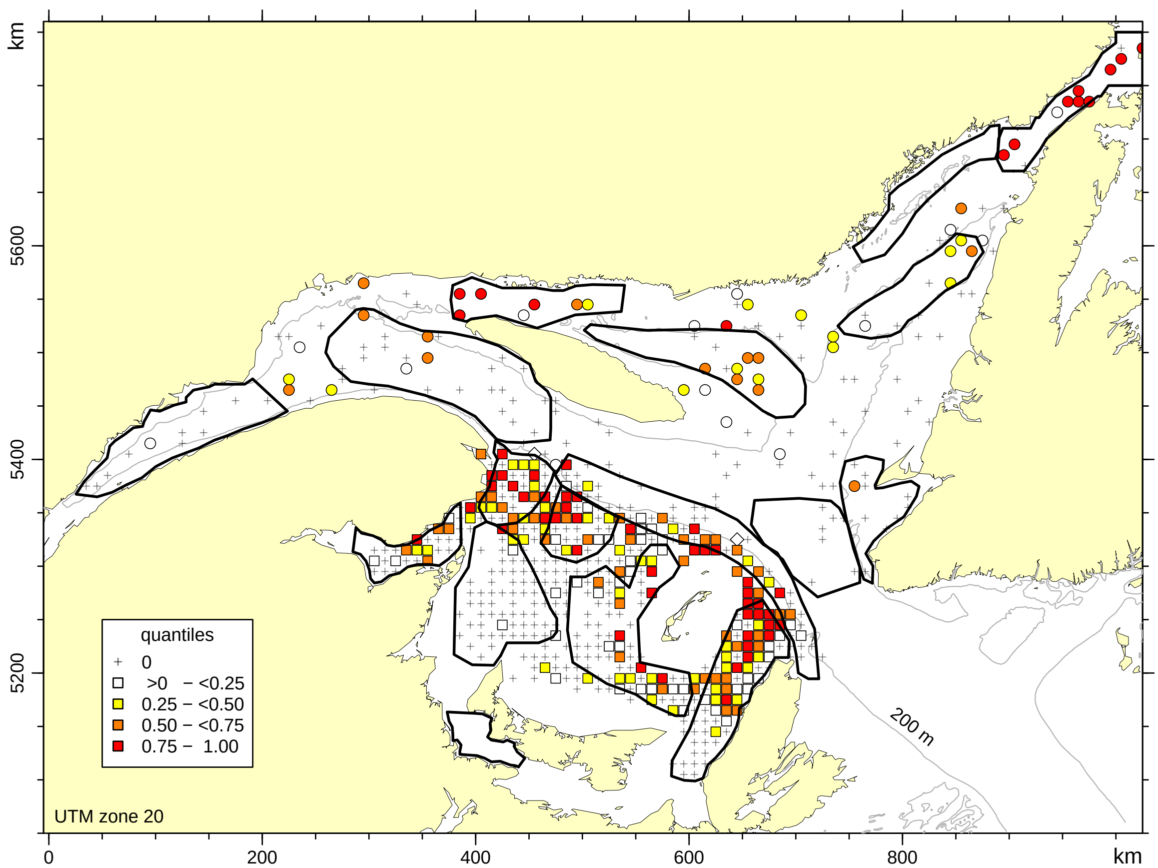


Figure 18 – Ascidian distribution based on the 2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005.

These ascidian species resemble bags with two orifices, one for pumping water into the animal's pharynx, the other for expelling it. These animals are hermaphroditic and the fertilization of the gametes, which is external, produces swimming pelagic larvae in the form of tadpoles. At the adult stage, the tunic of these animals is rather tough, thus protecting them from predators. However, young ascidians newly attached may be eaten by some animals, but our knowledge on this subject is limited. Sea potato and sea peaches are attached to hard substrates, sometimes in dense fields and have a structuring role in the ecosystem (Marchenkov & Boxshall, 2003; Ooishi, 2006; Sepulveda *et al.*, 2003). It is important to mention that several exotic ascidian species have recently appeared in coastal waters and are considered invasive. Their presence is causing serious problems in terms of mussel farm yields. The species most frequently encountered is *Styela clava* (Locke *et al.*, 2007)[†]. Other *Styela* species (*S. rustica, S. coriacea*) are present in the study area, but are not invasive. They are found mainly in coastal areas, although *S. rustica* can be bathyal (Brunel *et al.*, 1998).

3.3.5 Echinoderms

Starfish Class Asteroidea (starfish) in the LEGSL is represented by several infra or circalittoral species, such as *Asteria rubens*, *Leptasterias polaris* and *Solaster endeca*, as well as species whose distribution extends to the bathyal zone such as *Ctenodiscus crispatus*, *Ceramaster granularis*, *Crossaster papposus* et *Hippasteria phrygiana*. Starfish are widespread and abundant throughout the study area, both in the deep waters of the Estuary and shallow waters of the Gulf (Jacques-Cartier Strait, Strait of Belle-Isle, American Bank, Cape Breton Trough, Chaleurs Bay) (Figure 19). It should be noted that the sampling intensity is low for the Estuary and nGSL (one single year).

Starfish were not identified as to species in these missions, which partly explains the diversity of habitat they were found in our surveys, as different species may prefer different habitats. This reduces our ability to identify important areas in addition to skew results in favour of the dominant species.

Starfish prefer rocky and/or gravel substrate, from the low tide line to about 300 m deep, except for *Henricia sanguinolenta* which can be found at depths of up to 1,000 m and feeds on sponges. All the above mentioned species have a wide distribution in the Atlantic and some also extend into the Pacific. These are animals with low mobility, so populations are usually resident. The larval stages of most Asteroidea species are pelagic (bipinnaria and branchiolaria), which leads to the spreading or a wider distribution of individuals. Different species may differ in their environmental preferences, their spawning season and diet. In fact, some starfish are suspension feeders, others are predators and scavengers, while others ingest sediment, especially mud (Howell *et al.*, 2003). Some species, like emphCtenodiscus crispatus, play a bioturbation role in the deep soft sediments. Starfish have few predators.

† Updated: October 2010

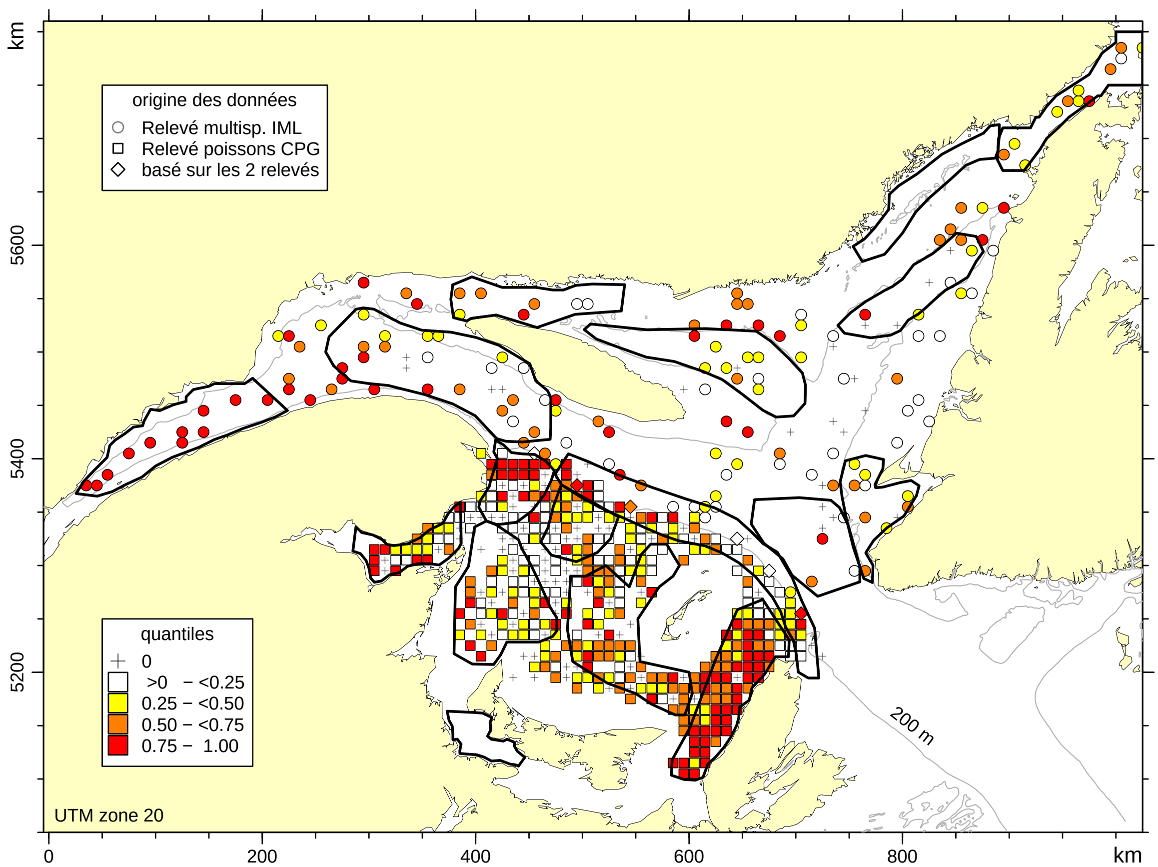


Figure 19 – Starfish (Asteroidea) distribution in the 2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005.

Basket Stars The basket star species most common in the study area is *Gorgonocephalus arcticus*, but *G. eucnemus* has also been reported (Packard, Jr., 1863), although the taxonomic status of these samples is considered uncertain (Brunel *et al.*, 1998). Basket stars are widespread in the LEGSL in waters less than 200 m deep (Strait of Belle Isle, Cape Breton Trough, American Bank and Orphelin Bank) (Figure 20). They are also abundant in the Estuary's bathyal zone.

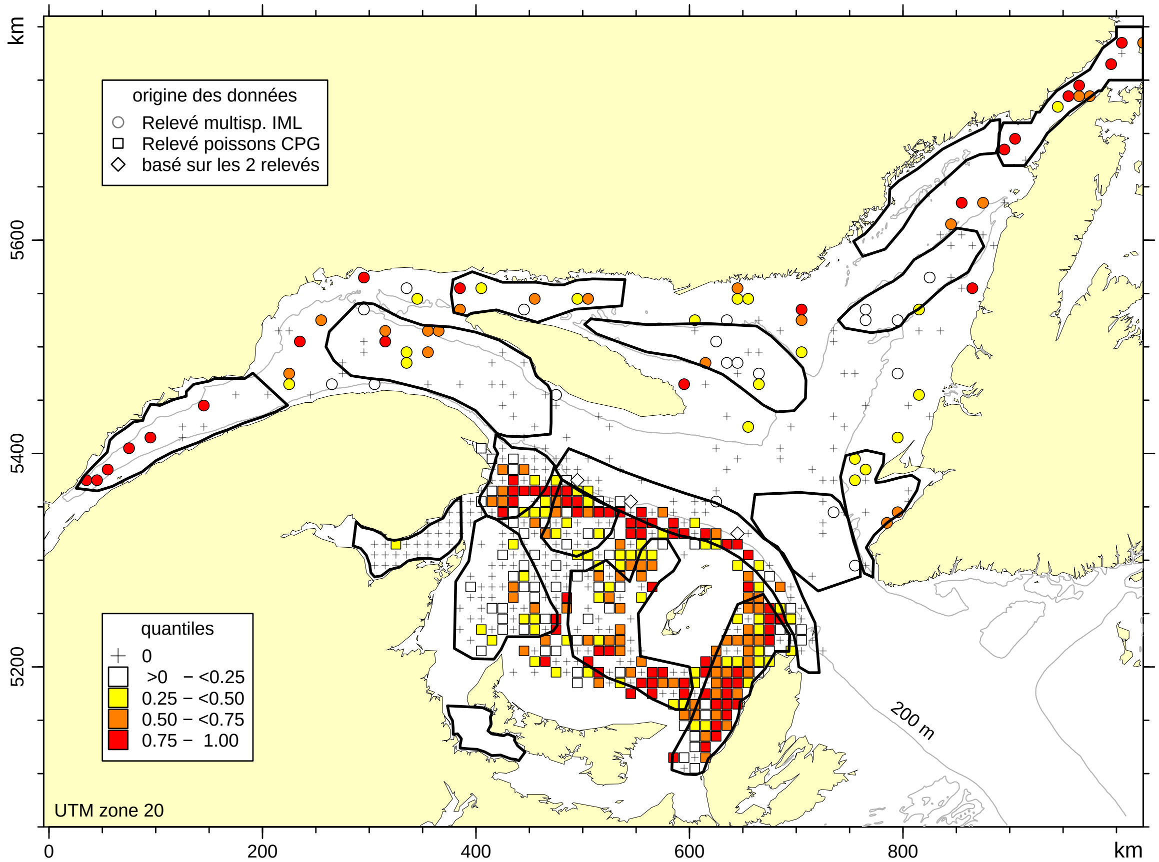


Figure 20 – Basket star (Gorgonocephalidae) distribution in the 2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005.

Outside the St. Lawrence, *G. arcticus* ranges from the Arctic to Cape Cod, usually on rocky bottoms, in waters a few meters to over 1,000 m deep. Its main prey in a neighbouring region, the Bay of Fundy, is the euphausiid *Meganyctiphanes norvegica* (Emson *et al.*, 1991). Basket stars have low mobility but like most echinoderms, the pelagic larval stages allow a wide distribution of individuals.

Brittle Stars Our surveys likely capture more than one species, because at least three species are very abundant from the infralittoral to the bathyal zones, the daisy brittle star, *Ophiopholis aculeata* on hard substrates, and *Ophiura sarsi* and *Ophiacantha bidentata* on soft or heterogeneous bottoms. There are also *Amphiura filiformis* (P. Archambault, unpublished data), and others such as *Stegophiurra nodosa*, commonly found in Sainte-Marguerite Bay and elsewhere (B. Sainte-Marie, unpublished data). According to the surveys, brittle stars are common in the Estuary and shallow waters of the nGSL, and are concentrated in Chaleurs Bay and the Cape Breton Trough in sGSL (Figure 21). This disparity between the two parts of the study area is likely due to a low sampling effort in the Estuary and nGSL (one year of data), because 40-150 brittle stars per m^2 were reported at depths exceeding 15 m near Cacouna in the Estuary (TransCanada Pipelines Limited 2005). Densities of more than 110 *Ophiura sarsi* per m^2 were also observed in the Laurentian Channel (307 m) in the area of Les Escoumins in the Estuary, during the Hypoxia project (P. Archambault, pers. obs.).

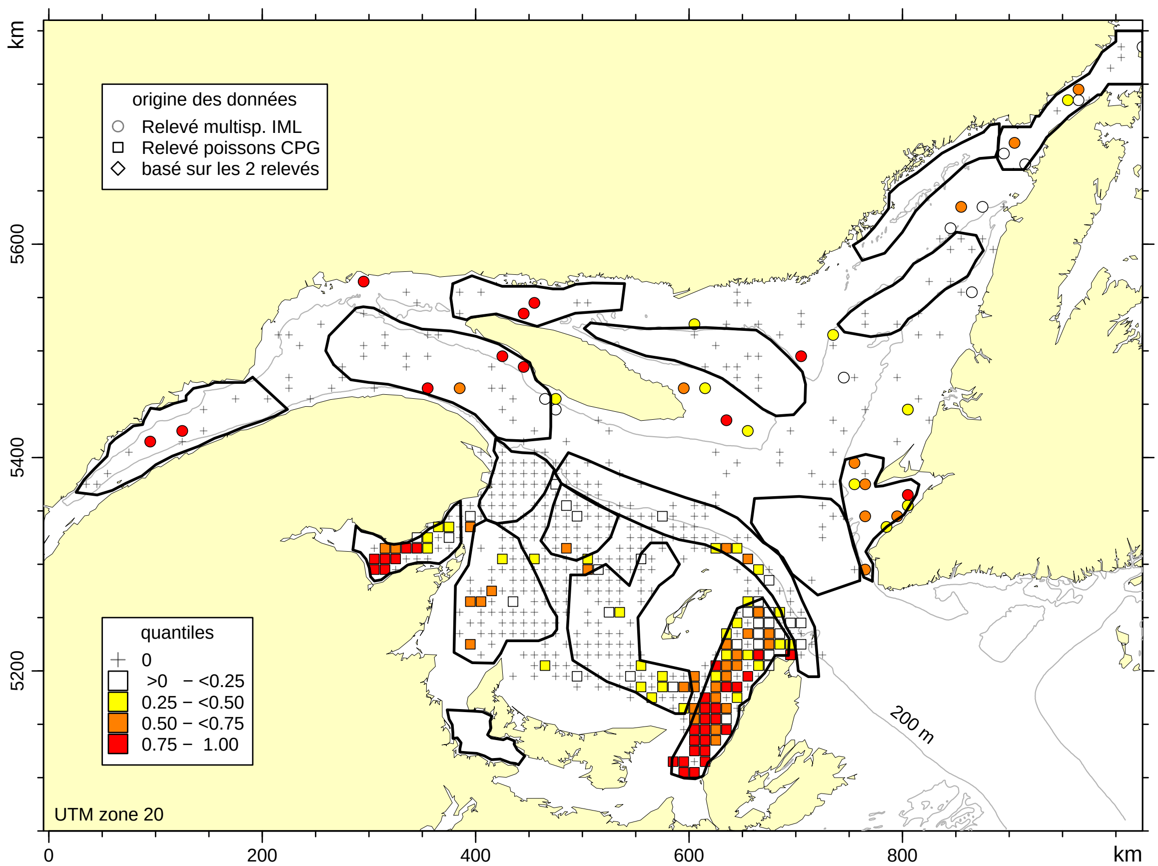


Figure 21 – Brittle star (Ophiuridae) distribution in the 2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005.

Brittle stars a widely distributed in the Atlantic and the Pacific, from the low tide line to great depths. Like most echinoderms, brittle stars do not travel great distances and the wide distribution of adults is probably due to the transport of the pelagic larval stages and a wide range of habitats conducive to their establishment. *Ophiopholis aculeata* are suspension feeders, while *Ophiura sarsi* are surface deposit feeders and are a good indicator of the sedimentation rate of an area. Despite their low calorie content, brittle stars are prey for many fish and crustaceans and may even be an important prey for fish such as American plaice *Hippoglossoides platessoides* (Klemetsen, 1993; Packer *et al.*, 1994).

Round and Asymmetric Sea Urchins Among the invertebrates identified as "sea urchins", the green sea urchin (*Strongylocentrotus droebachiensis*) is probably the species most caught in the surveys at shallower stations, and *Brisaster fragilis* at stations in the channels. However, *Strongylocentrotus pallidus* is also important between 40 and 200 m (Gagnon & Gilkinson, 1994; Brunel *et al.*, 1998). These sea urchins are found from the Arctic to New Jersey, at varying depths on rocky bottoms and in kelp beds which they can strip rather quickly. The sea urchins *Strongylocentrotus* are also found at great depths, including the bathyal zone, but in very specific areas on sandy bottoms (e.g. Les Escoumins, 320 m, P. Archambault, pers. obs.). Our data indicates that sea urchins are found throughout the LEGSL except in the eastern portion of the Laurentian Channel and in the Esquiman Channel (Figure 22).

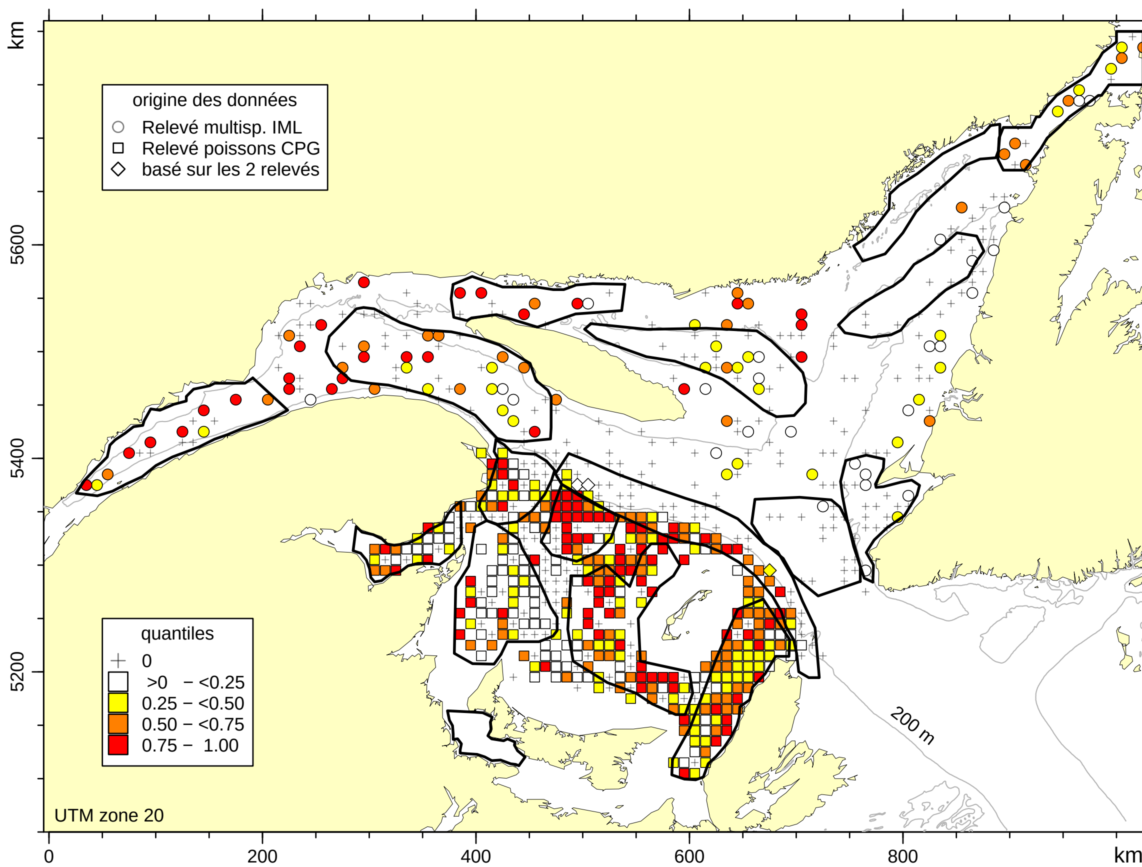


Figure 22 – Round and Asymmetric Sea Urchin distribution in the 2005-2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005.

Green sea urchins are primarily herbivorous, but sometimes feed on carrion or young mussels found on the bottom and probably on organic matter. Sexual reproduction based on external fertilization and pelagic larval stages assures the distribution of this species. Green sea urchins are a prey of choice for three wolffish species in the LEGSL, two of which are considered "threatened" and another of "special concern" by the COSEWIC (Committee on the Status of Endangered Wildlife in Canada). There is a green sea urchin commercial fishery in the LEGSL using traps or by diving.

Sand-Dollar Sand Dollar (*Echinarachnius parma*) is the only species of the order Clypeasteroida present in the LEGSL. Its distribution extends from Labrador to Cape Cod. This species was not recorded in the nGSL surveys, although it is known that it occurs at shallow depths on the north shore of the Estuary and Gulf (for example, in Sainte-Marguerite Bay, unpublished data from B. Sainte-Marie). The ease with which it could have been identified suggests that the minimum sampled depth did not allow for its capture in the nGSL and it is best to consider that information is missing. In the sGSL, sand-dollars are particularly abundant in the periphery of the Magdalen Shallows and in the Shediac Valley (Figure 23).

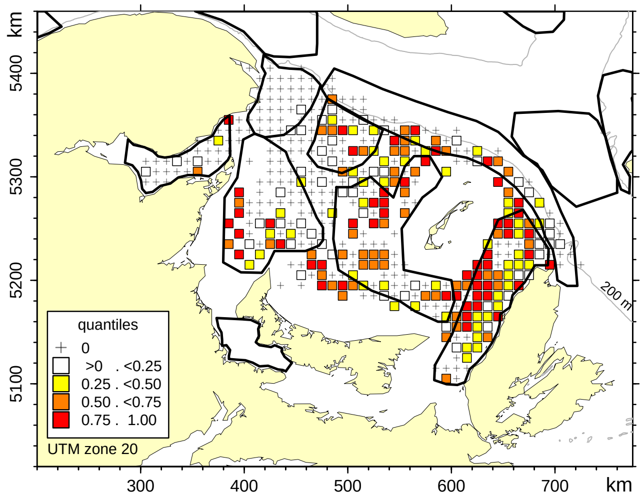


Figure 23 – Sand-Dollar (*Echinarachnius parma*) distribution in the snow crab survey in the sGSL, 1988-2005.

This animal is a deposit feeder and is found on sandy bottoms where it can burrow partially, from the intertidal zone to over 1,000 m deep. Sand-dollars are able to move and sometimes are prey to certain species of fish feeding on the bottom such as flounder, cod and ocean pout (*Zoarces americanus*). During breeding, male and female gametes are released into the water and, after external fertilization, pelagic larvae are found in the water column for several weeks before they metamorphisize and deposit on the bottom.

Sea Cucumbers Some species of cucumbers (Class Holothuroidea) are found in the study area, the most common are sea cucumber (*Cucumaria frondosa*) and scarlet psolus (*Psolus fabricii*), two species that can be found from the low tide line to 200 m depth (Brunel *et al.*, 1998). Our data shows a very sparse distribution in the nGSL where sampling effort is low (only one year of data) and where the coastal zone is not sampled. In this region, the few parcels where sea cucumbers were captured are located in water shallower than 200 m, especially in Jacques-Cartier Strait (Figure 24). Their presence in shallow water (10 m) is known on the northern coast of the Gaspé Peninsula (P. Archambault, pers. obs.). In the sGSL, sea cucumbers are more abundant in the south-west (Chaleurs Bay and Shediac Valley) and south-east (south of the Magdalen Islands and Cape Breton Trough). Outside the study area, sea cucumbers are found from the Arctic to Cape Cod.

Cucumbers and psolus occur between rocks and in crevices or are attached to solid surfaces, making them difficult to sample by trawling. However, there are species living in

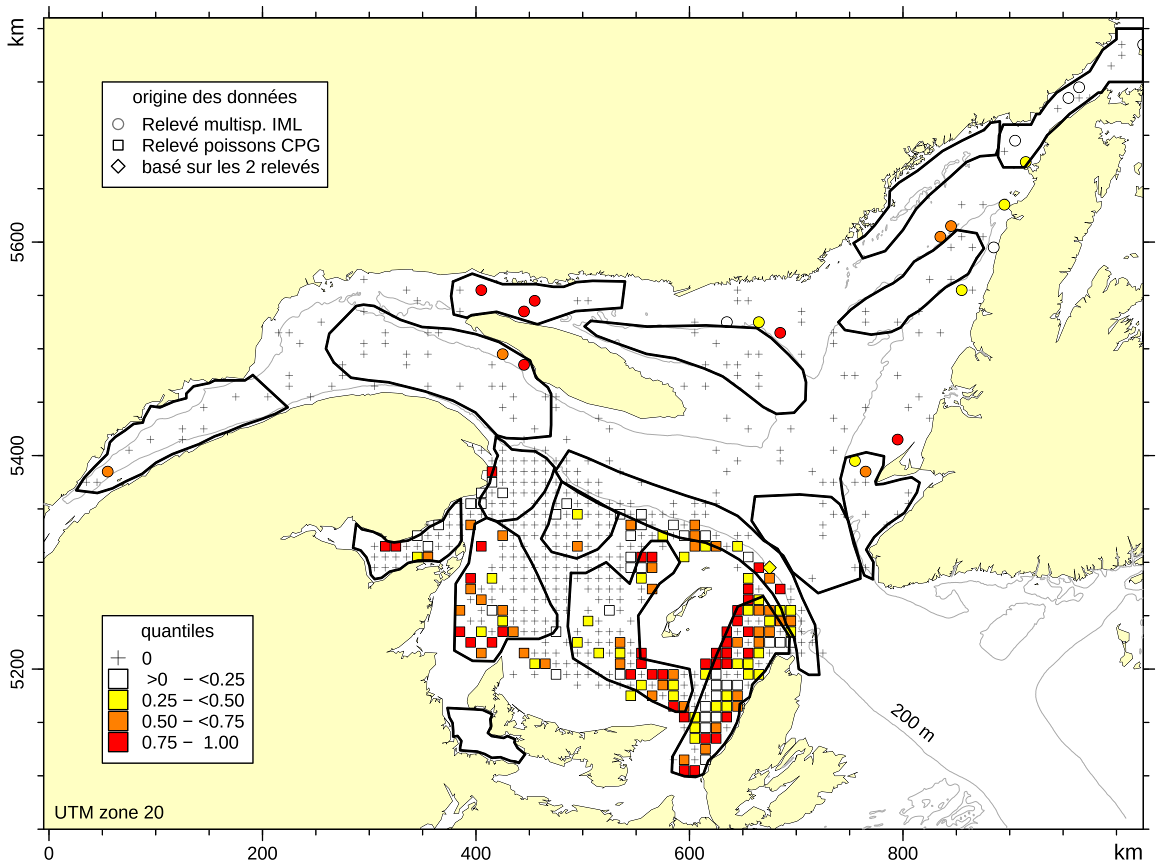


Figure 24 – Sea cucumber (Class Holothuridea) distribution in the 2006 multidisciplinary survey in the nGSL and the snow crab survey in the sGSL, 1988-2005. Note: in the sGSL, data concern only sea cucumbers (*Cucumaria frondosa*).

soft sediments at greater depths, such as *Molpadia oolitica*. Their absence in our data from deep channels may be due to the fact that we only had one year of data. The distribution of *C. frondosa* in the coastal zone between Matane and Cap-Gaspé in the Estuary is described in Campagna *et al.* (2005). Like other echinoderms, sea cucumbers reproduce sexually with a release of male and female gametes in the water, an external fertilization and pelagic larval stages. These are passive filter feeders, so they are dependent on currents for their food.

3.3.6 Molluscs

Whelk Whelk are not listed in the multidisciplinary survey in the nGSL because they are almost never caught. Whelk data in the Estuary are from a survey exclusively dedicated to the species *Buccinum undatum*, but with very small geographic coverage (Figure 25). This taxon has not contributed to determining EBSAs in the nGSL, as this survey was not used for calculating the concentration index. Whelk are captured in the snow crab survey in the sGSL, but were not identified as to species. In addition to *B. undatum*, *Neptunea decemcostata* and possibly other *Buccinum* and *Colus* species are probably included in these data. In the sGSL, the main whelk concentrations are found in the Cape Breton Trough, Chaleurs Bay, Shediac Valley and on the Orphelin Bank.

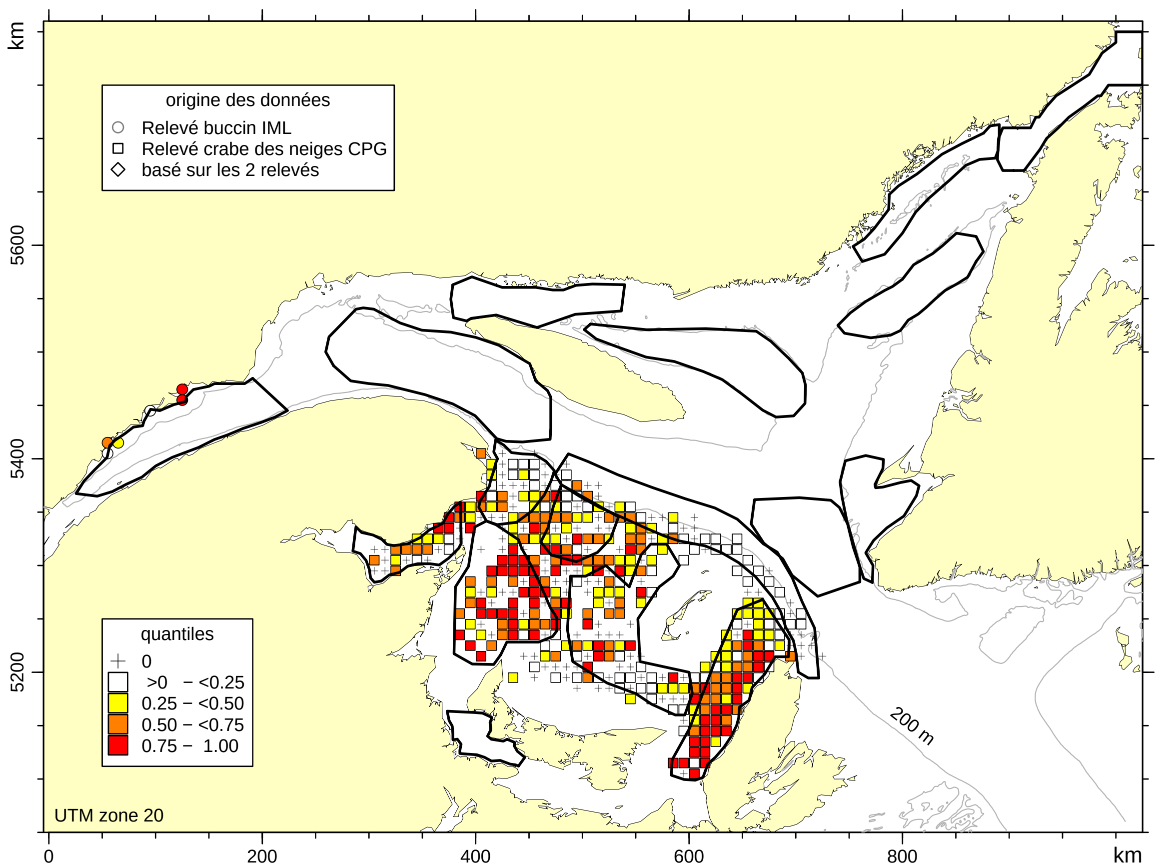


Figure 25 – Whelk distribution in the whelk surveys and snow crab survey in the sGSL. Whelk were only identified as to species (*Buccinum undatum*) for the whelk survey in the nGSL.

Whelk sexual reproduction with internal fertilization and the lack of a pelagic larval stage (young whelk emerge directly from deposited eggs in capsules on the bottom) severely limits the dispersal of this species. Whelk are active predators of bivalves, but are also scavengers. Their strong shell at adulthood protects them from most predators, except for rock crab and *Hyas* crab (B. Sainte-Marie, unpublished obs.). There is a commercial trap fishery for whelk in the nGSL and Magdalen Islands.

Sea Scallops Sea scallops (*Placopecten magellanicus*) are at the northern limit of their distribution in the LEGSL. This species lives in beds that are exploited commercially using scallop dredges. In the sGSL, the beds are located around the tip of the Gaspé Peninsula into Chaleurs Bay, in Shediac Valley, north of Prince Edward Island, south and east of the Magdalen Islands and in the eastern part of Northumberland Strait (Figure 26). However, sea scallop beds exist in the north-west portion of Northumberland Strait, where we have no data for this species. Sea scallops are almost absent from the North Shore, but they occur in some relatively warm bays. Scallop surveys have only revealed its presence in Jacques-Cartier Strait and the Lower North Shore near Aylmer Sound.

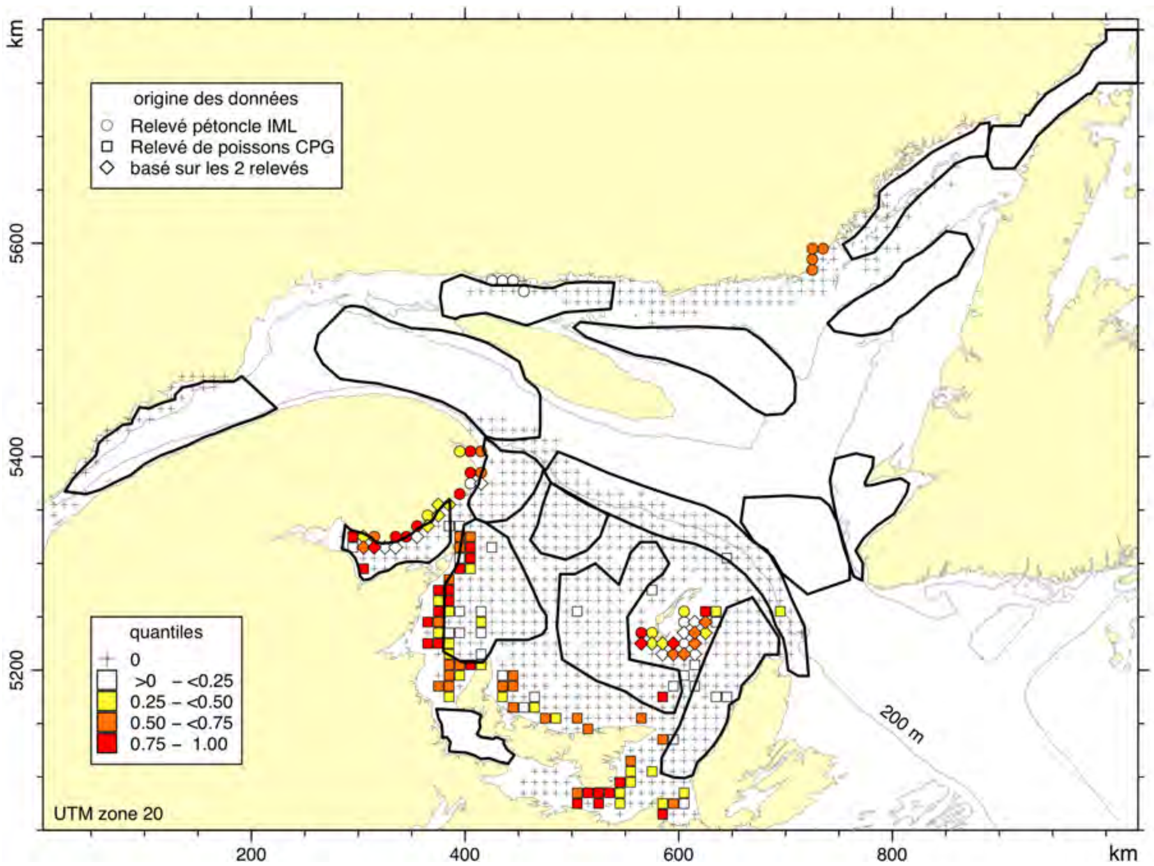


Figure 26 – Sea scallop (*Placopecten magellanicus*) distribution in the scallop reseach survey in the nGSL (1985-2006, but spatial coverage was limited each year) and in the fall survey in the sGSL (1988-2005).

Sea scallops are sedentary once deposited on the bottom and there is no or very little movement between beds, even if the larvae are pelagic. This scallop species occurs in warmer water that Iceland scallops, which often results in a distribution in shallower water in the study area, between 5 and 50 m deep. The two scallop species seek the same types of substrates, sand and gravel. There is high fishing pressure on the known beds.

Iceland Scallops Iceland scallops (*Chlamys islandica*) are found in cooler and usually deeper waters than sea scallops and are more widespread than the latter. The main areas of abundance for this species are the Jacques-Cartier Strait, along the North Shore of Quebec and along the south coast of Anticosti Island (Figure 27). In the sGSL, Iceland scallops are abundant on the southern slope of the Laurentian Channel, in the Cape Breton Trough and on Orphelin Bank.

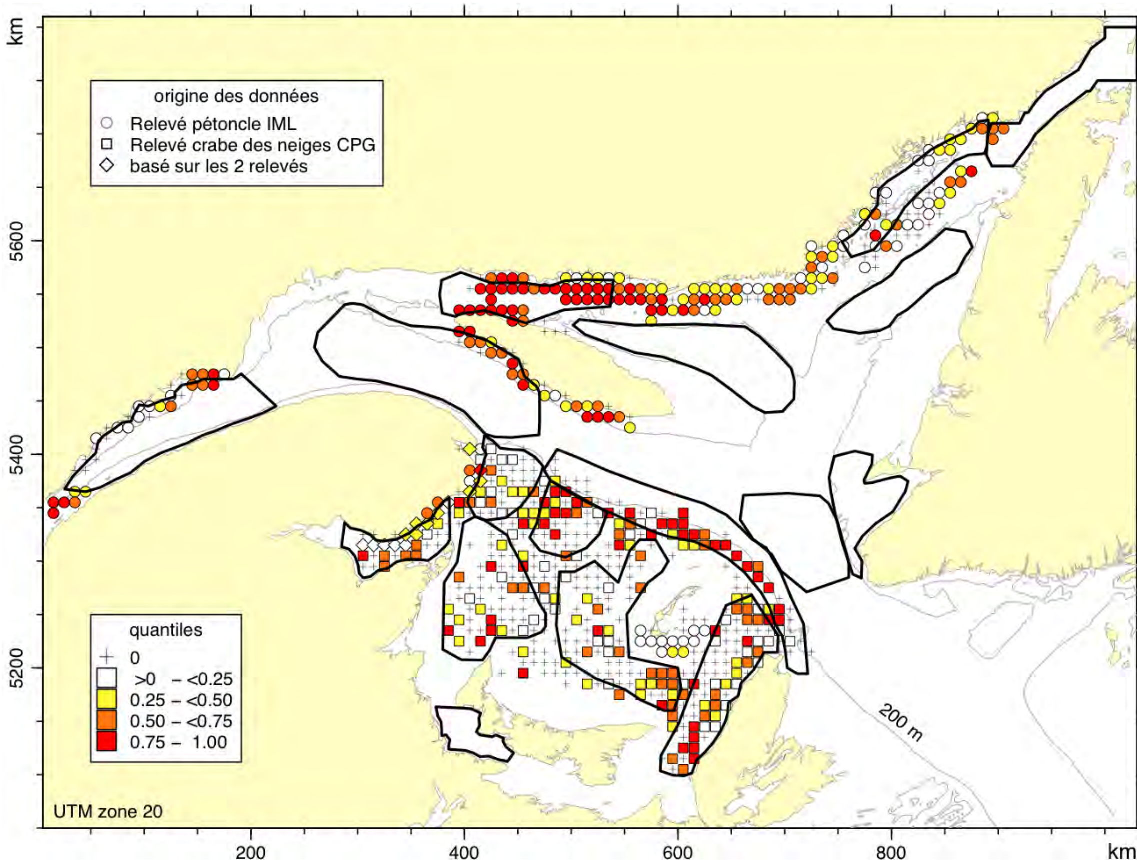


Figure 27 – Iceland scallop (*Chlamys islandica*) distribution in the scallop reseach survey in the nGSL (1985-2006, but spatial coverage was limited each year) and in the snow crab in the sGSL (1988-2005).

Commercial catches indicate that there are a few beds outside the areas sampled by the research surveys. One of them is known as the most upstream known bed in an Estuary and is found within the Saguenay St. Lawrence Marine Park around Grandes Bergeronnes, downstream from Ile Rouge (Hartog *et al.*, 2001). This bed is exploited and very fragile and we do not know its degree of isolation because it is confined to a small area between the Laurentian Channel and South Channel.

Like sea scallops, Iceland scallops are sedentary and the larval stages (trochophore and veliger) are pelagic. This species is less intensely targeted commercially as the sea scallop in the sGSL, but is the main target species along the North Shore. It is prey to some invertebrates and fish such as Atlantic wolfish (*Anarhichas lupus*). The Iceland scallop is usually found on substrates of sand or gravel between 20 and 100 m deep (in the Estuary and nGSL) and up to 200 m in the sGSL, especially on the southern slop of the Laurentian Channel.

Shortfin Squid Distributed from Greenland to North Carolina, from the water surface to 100 m, the shortfin squid (*Illex illecebrosus*) is more of a pelagic invertebrate that benthic, but appears to be sufficiently present in our surveys to be considered in this document. However, its presence in high concentrations at some sites has likely more to do with circulation patterns (some years, it enters the GSL via Cabot Strait) and the presence of pelagic prey rather than bottom characteristics. This squid species appears to be less present in the nGSL than in the sGSL (Figure 28), but it is likely due to the difference in terms of effort and gear between the two regions (2004-2006 in the north and 1971-2005 in the south). In the nGSL, shortfin squid are present near Cabot Strait and its abundance decreases towards the west and north as the distance from Cabot Strait increases. In the sGSL, this species is concentrated on the southern slope of the Laurentian Channel and in the Cape Breton Trough, but significant catches have been made everywhere.

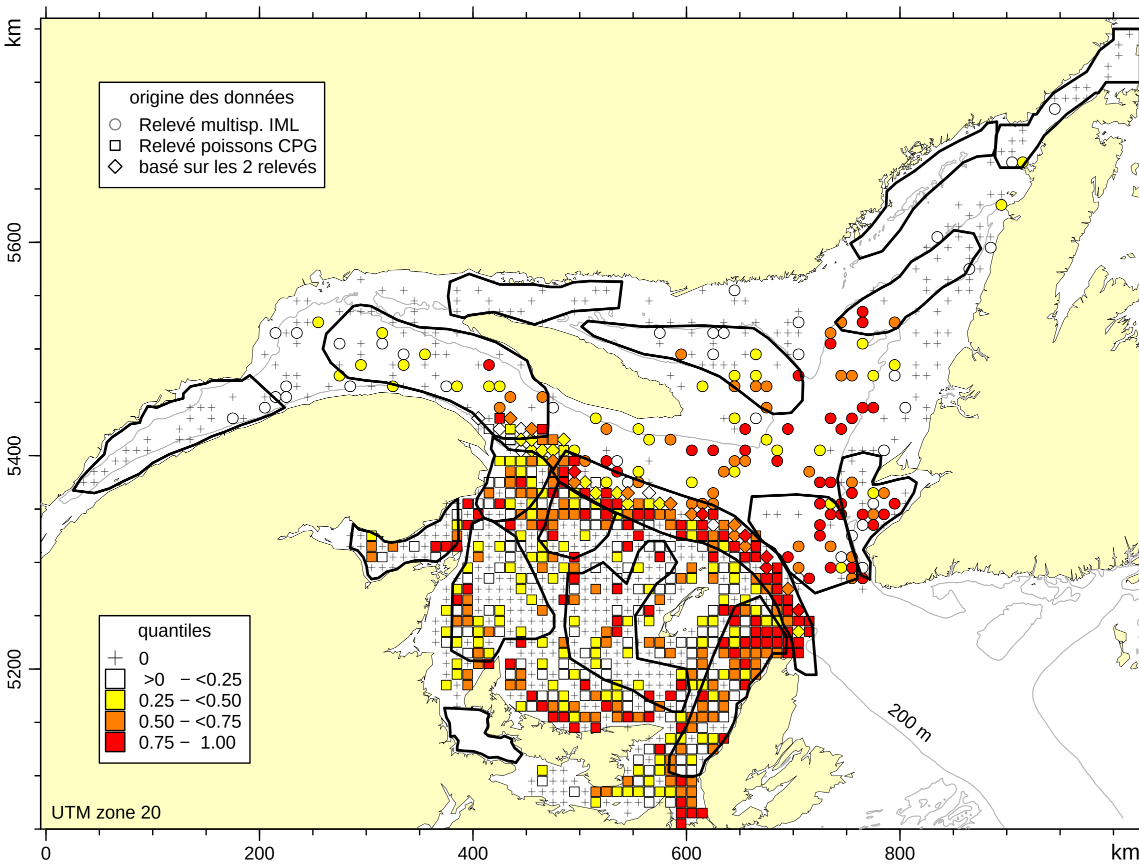


Figure 28 – Shortfin squid (*Illex illecebrosus*) distribution based on the multidisciplinary and fall surveys.

In the western Atlantic, shortfin squid make extensive daily (bottom-surface) and seasonal migrations based on environmental conditions, for feeding and reproduction. Squid become sexually mature at about 18 months and undergo a high mortality rate after their reproduction. Adults feed mainly on capelin, herring and young mackerel and are in turn eaten by cod, adult mackerel, pilot whales and dolphins.

Lesser Bobtail Squid The Lesser bobtail squid (*Semirossia tenera*) has a wide distribution in the north-western Atlantic, but it is considered more abundant from Maine to the Caribbean, on soft substrates at more than 30 m deep. In the LEGSL, the lesser bobtail squid is encountered sporadically, mainly in the channels (Figure 29). This small mimetic cephalopod occurs mainly near the bottom or buried, swimming in open water only to capture its prey, usually shrimp. The lesser bobtail squid are prey to certain marine mammals.

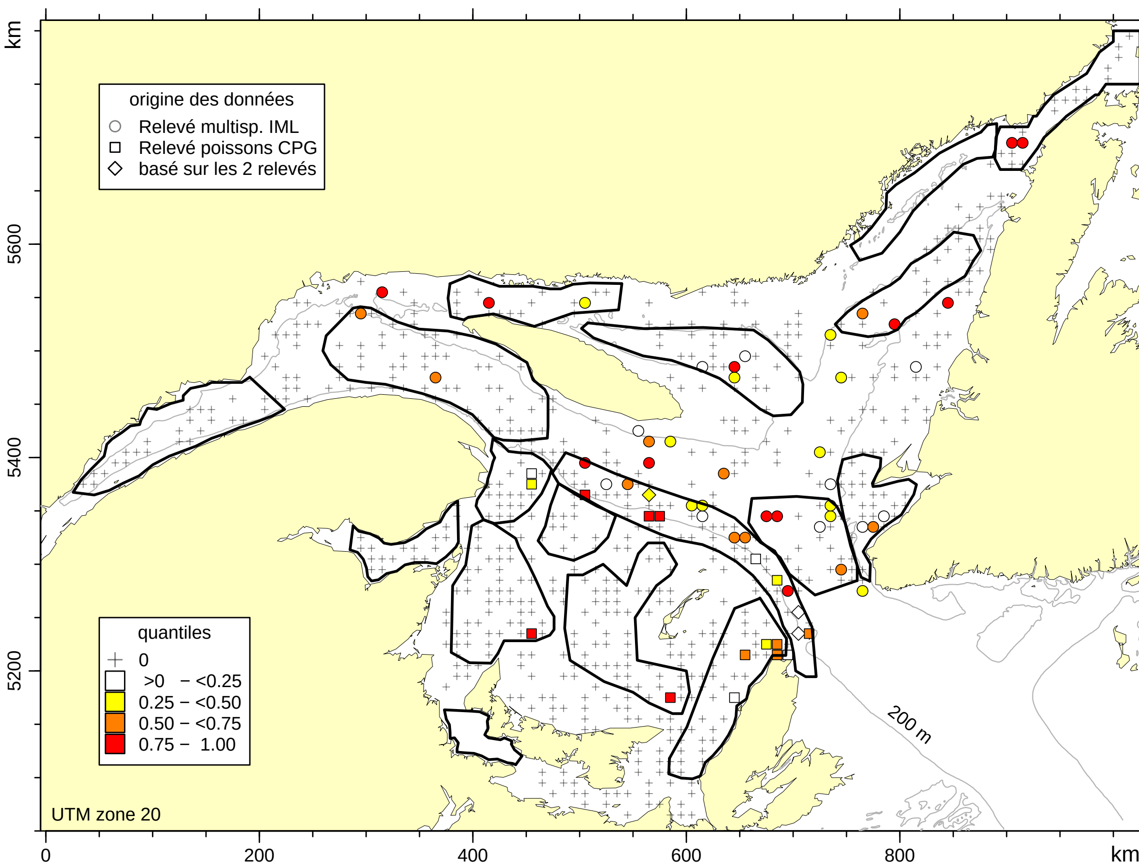


Figure 29 – Lesser bobtail squid (*Semirossia tenera*) distribution based on the multidisciplinary (2004-2006) and fall surveys (2003-2005).

Spoonarm Octopus The spoonarm octopus (*Bathypolypus bairdii*) is an octopus occurring generally in the deeper waters from Newfoundland to Cape Hatteras. Therefore, this octopus is abundant in the deep channels of the study area. The highest concentrations observed are near Cabot Strait in the Laurentian Channel and in particular on the southern side of the channel (Figure 30). Significant concentrations are also present in the Estuary, Honguedo Strait and the Anticosti Channel.

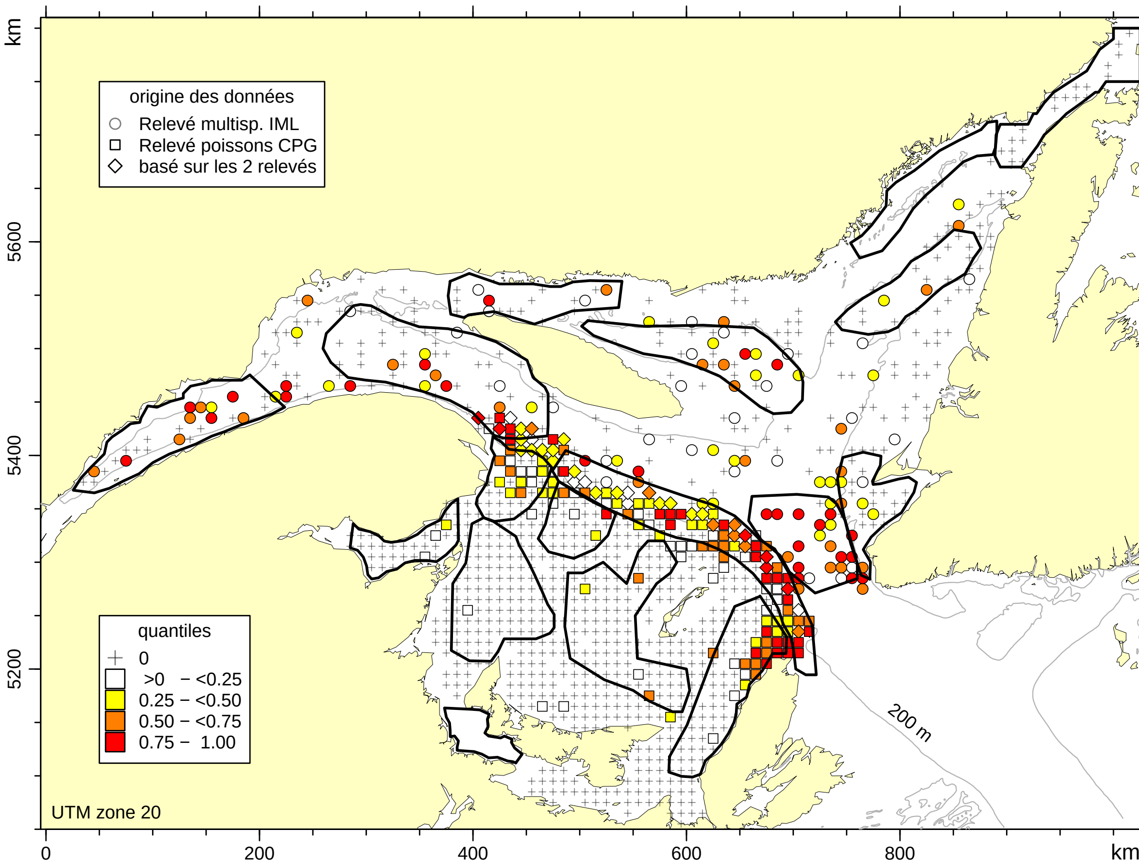


Figure 30 – Northern Atlantic octopus (*Bathypolypus bairdii*) distribution based on the multidisciplinary (2004-2006) and fall surveys (2003-2005).

Octopus are specialized predators that can move very quickly in the water column and on the bottom to catch their prey (crustaceans, molluscs, fish) or escape predators (cod, halibut, marine mammals). Octopus reproduce sexually and fertilization is internal. Eggs are deposited on the bottom and kept by the female until they hatch, and tiny replicas of the parents emerge.

3.3.7 Mysids

Boreomysis arctica The mysid *Boreomysis arctica* is a suprabenthic bathyal species (Brunel *et al.*, 1998), which can, however, perform vertical migrations. It is also frequently captured during the campaigns targeting the zooplankton (MPO, 2002). Nevertheless, it is mainly associated with the few meters above the bottom, but considering its small size (around 2 cm), it is not well captured by bottom trawls. However, it is one of the main prey of Greenland halibut and we have a large number of halibut stomachs from all the deep channels in LEGSL. *B. arctica* is only abundant in the stomachs of Greenland halibut from the Estuary and north-western Gulf (Figure 31).

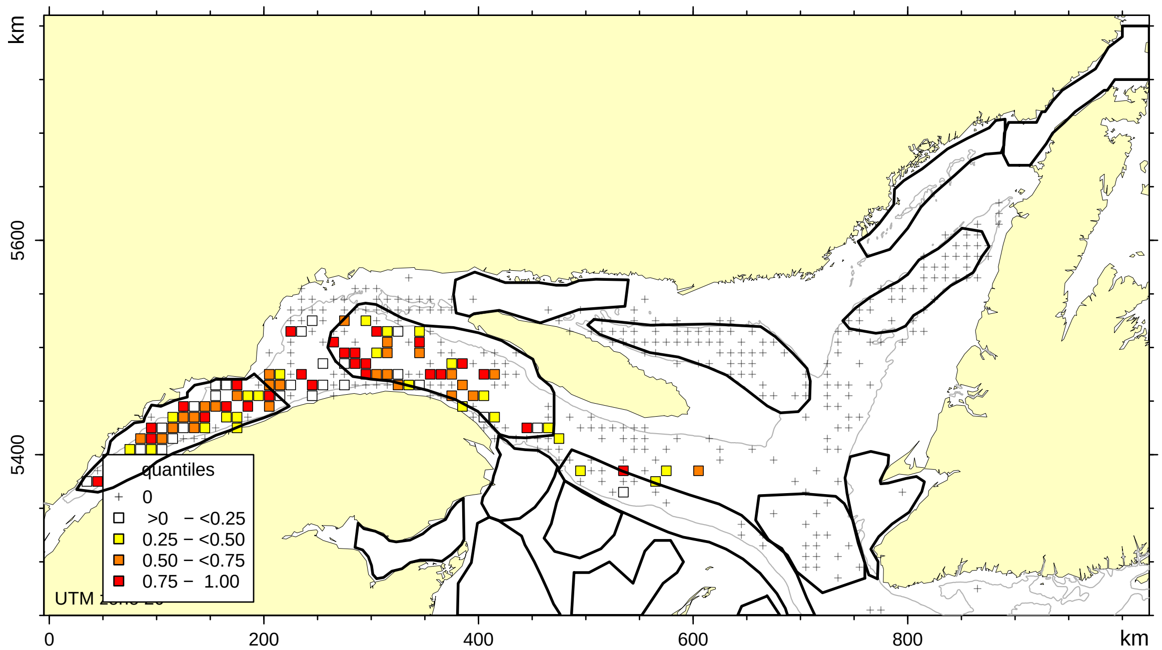


Figure 31 – Mysid *Boreomysis arctica* distribution according to turbot stomachs.

This mysid species could play an important role in energy transfer to higher trophic levels. Its diet has not been studied in the LEGSL, but off the French coast, *B. arctica* consumes a lot of crustaceans, including several planktonic species as well as phyto-detritus (Cartes & Sorbe, 1998).

3.3.8 Shrimp

The shrimp sampled in this study can be divided into three groups according to whether they are mesopelagic or associated with bottoms located in deep water below the cold intermediate layer (CIL) or bottoms located in or above the CIL (coastal areas). Each group is characterized by the dominance of a species whose abundance is far superior to other species of the assemblage. Northern shrimp (*Pandalus borealis*) are by far the most abundant of all shrimp species and are associated with warmer waters of the deep water masses. Striped pink shrimp (*Pandalus montagui*) dominate the shrimp assemblage associated with the cold water of the intermediate cold layer, while pink glass shrimp (*Pasiphaea multidentata*) dominate the catches of the mesopelagic shrimp group.

Mesopelagic Shrimp Pelagic species are present in the nGSL where water depth exceeds 200 m. They are therefore absent from the sGSL. Pink glass shrimp (*Pasiphaea multidentata*) are the most common mesopelagic shrimp (Brunel *et al.*, 1998; Koukouras *et al.*, 2000) and are especially abundant in the Laurentian Channel and in the Anticosti Channel and at the head of Esquiman Channel (Figure 32). This species is abundant outside the LEGSL. Its distribution extends from Greenland to New England in the western Atlantic, but it is also found in the eastern Atlantic and even the Mediterranean (Squires, 1990). Pink glass shrimp feed on euphausids and copepods (Squires, 1990); it represents a relatively important prey for cod in the nGSL (D. Chabot, unpublished data).

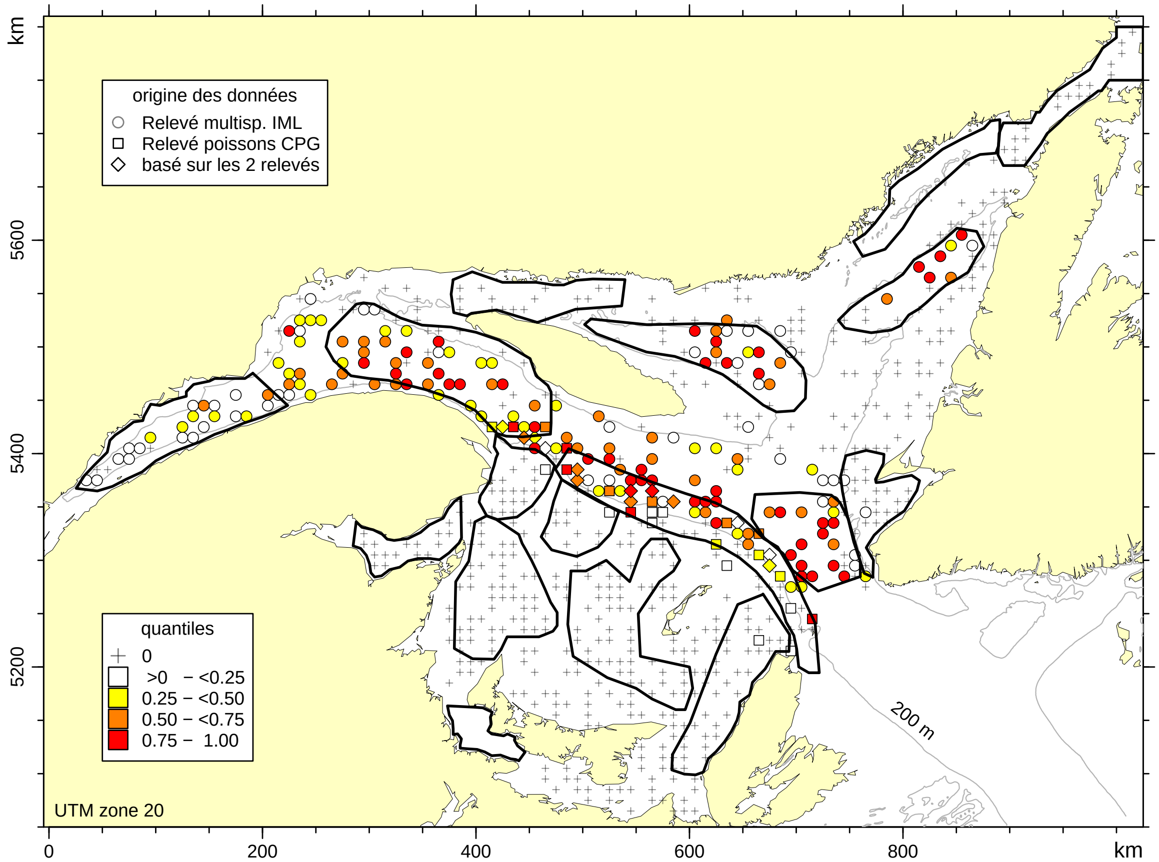


Figure 32 – Pink glass shrimp (*Pasiphaea multidentata*) distribution based on scientific trawl surveys in the GSL.

Three other species of this assemblage are present in the study area. However, they are rare, because they are at the limit of their distribution, as evidenced by the fact they are caught mainly at the entrance to the Gulf, near Cabot Strait. The species are *Pasiphaea tarda* (Figure 33), *Sergestes arcticus* (Figure 34) and *Acanthephyra pelagica* (Figure 35). All have a distribution covering much of the western Atlantic, including the east and sometimes the South Atlantic (Squires, 1990). Their prey is mesopelagic/nektonic (euphausids, chaetognaths, copepods, other shrimp, fish, Squires, 1990).

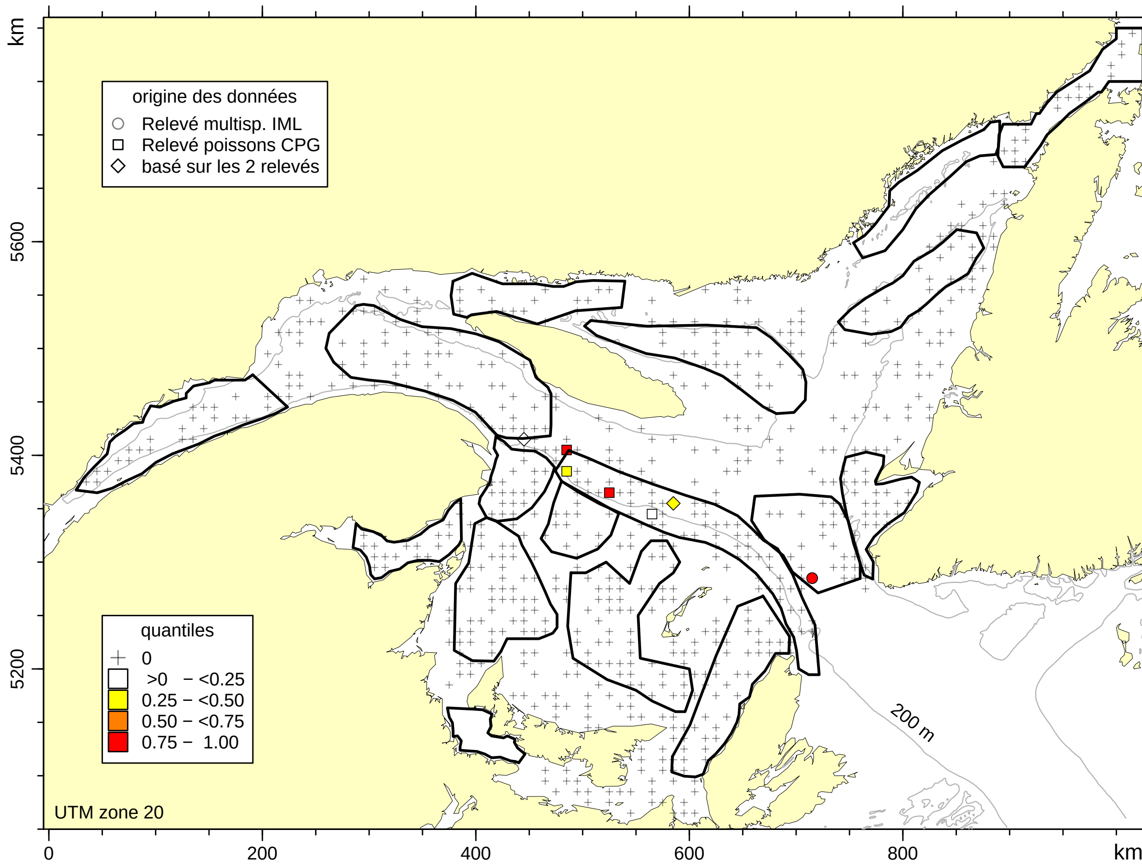


Figure 33 – *Pasiphaea tarda* shrimp distribution based on scientific trawl surveys in the GSL.

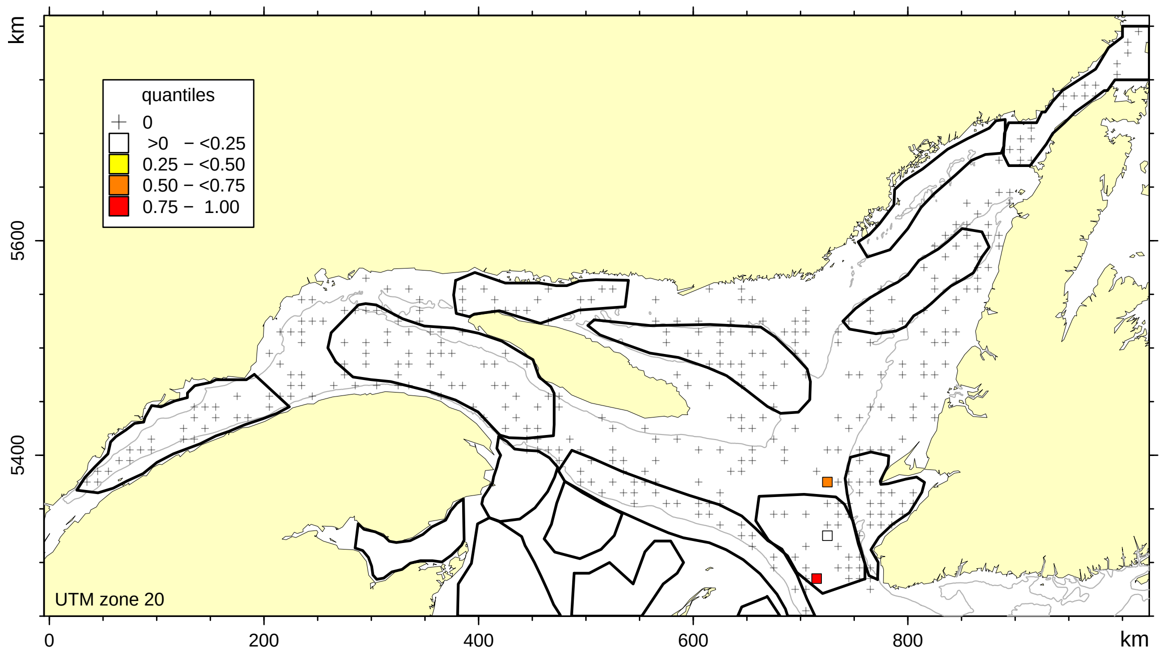


Figure 34 – *Sergestes arcticus* shrimp distribution based on scientific trawl surveys in the GSL.

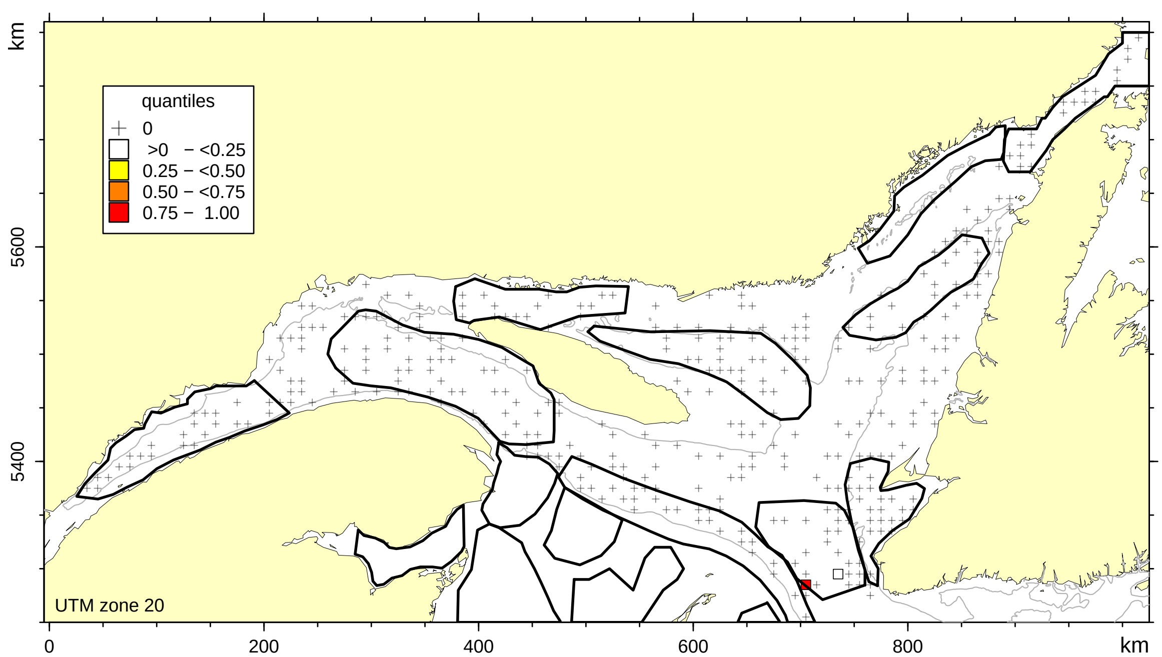


Figure 35 – *Acanthephyra pelagica* shrimp distribution based on scientific trawl surveys in the GSL.

Deep Water Shrimp (Below the CIL) Several shrimp species are caught mostly in the deep channels of nGSL and are essentially absent from the sGSL. The most abundant species by far and the most widespread is the northern shrimp, which is bathyal and suprabenthic (Brunel *et al.*, 1998). It is the species that is targeted by commercial fisheries. Northern shrimp are particularly abundant in the north-western Gulf including Honguedo Strait and the area between the American Bank and Orphelin Bank, and in the Anticosti Channel and Esquiman Channel (Figure 36). The abundance of *P. borealis* decreases rapidly between the western limits of the Gulf and the Estuary. The general distribution of northern shrimp is vast. In the north-west Atlantic, it extends from Greenland to New England. It also occurs in the eastern Atlantic, in the Bering Sea and the Pacific (Squires, 1990).

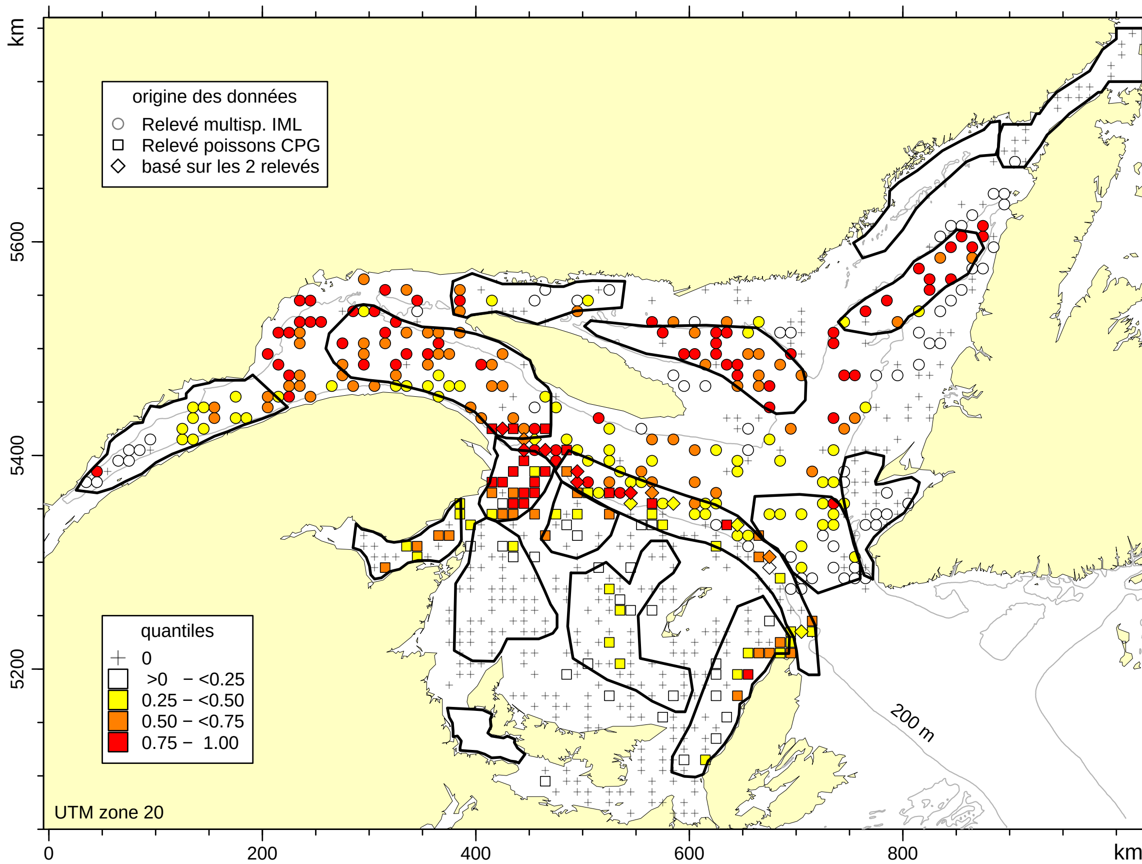


Figure 36 – Northern shrimp (*Pandalus borealis*) distribution based on scientific trawl surveys in the GSL.

Eggs are incubated throughout the winter under the abdomen of females. The larvae are pelagic and the juveniles are benthic. The species is protandrous hermaphrodite, juveniles becoming males first and then females. Adults are usually found at greater depths than juveniles who are mainly present at the head of channels (Simard & Savard, 1990). Northern shrimp migrate vertically and feed in the water column (euphausids, amphipods, copepods) and on the bottom (polychaetes, foraminifers). Northern shrimp are an important prey for cod and Greenland halibut (Squires, 1990).

The other widespread deepwater shrimp species in the LEGSL is *Pontophilus norvegicus*.

This species is rare west of Anticosti Island. It is present in the Laurentian Channel, in the Anticosti Channel and Esquiman Channel (Figure 37). Its diet (hytobenthos, polychaetes, foraminifers, crustaceans, Squires, 1990) suggests that it is suprabenthic. Its distribution outside the study area extends from Greenland to Maryland in the western Atlantic. It is also found in the north-east Atlantic (Squires, 1990).

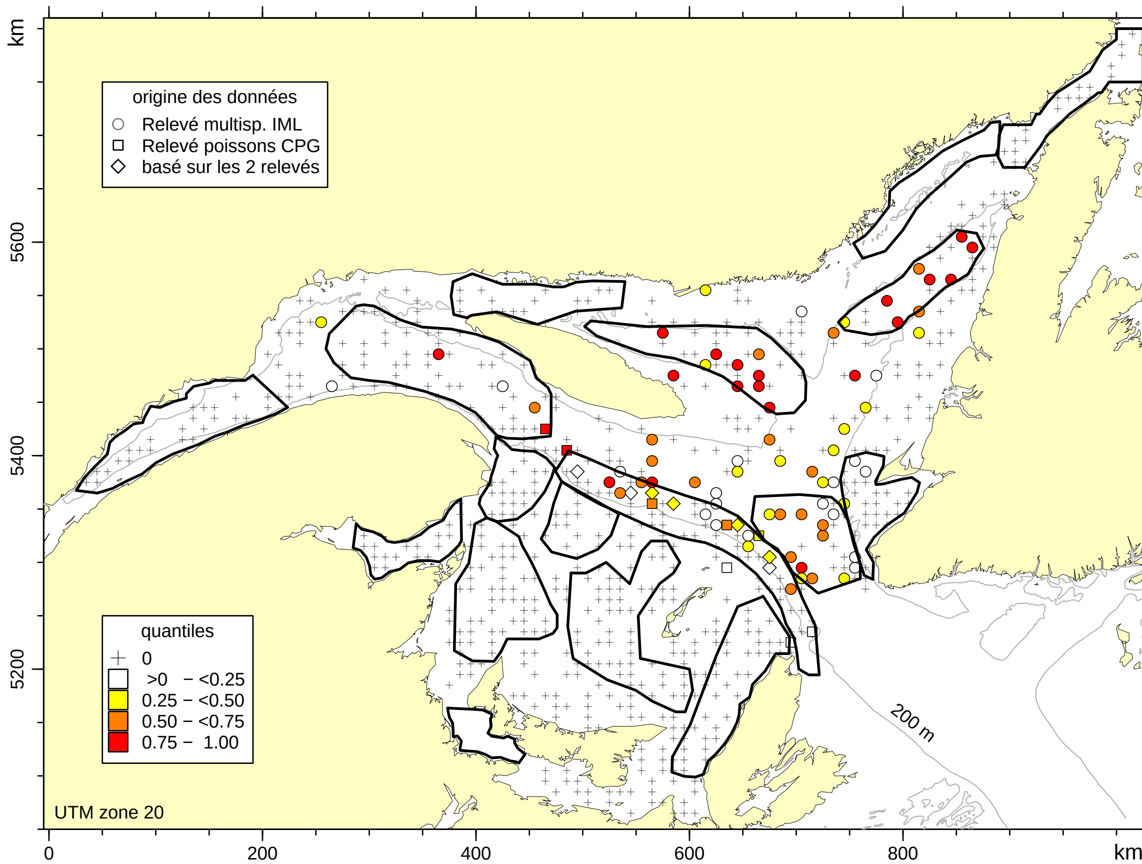


Figure 37 – *Pontophilus norvegicus* shrimp distribution based on scientific trawl surveys in the GSL.

Another species is present in very low abundance in the Laurentian Channel near the entrance to the Gulf which indicates that it probably comes from outside the Gulf. *Atlantopandalus propinqvus* (previously *Pandalus propinqvus*) (Figure 38) is suprabenthic, as demonstrated by examining its prey (phytobenthos, isopods, polychaetes, bivalves, euphausids, Squires, 1990). Although rare in the LEGSL, *A. propinqvus* has a fairly general distribution in the North Atlantic. On the west side, it can be found from Davis Strait in the north to Delaware Bay in the south (Squires, 1990). Off Nova Scotia, it is associated with octocorallia (Gorgonacea), which it seems to use to protect itself from predators (Buhl-Mortensen & Mortensen, 2004). On the coasts of Sweden, *A. propinqvus* is associated with the bathyal anemone *Bolocera tuediae* (Jonsson *et al.*, 2001), which is also present in the LEGSL (Brunel *et al.*, 1998). Such associations with species living directly on the bottom probably reduce the catchability of this species by trawls used in our surveys.

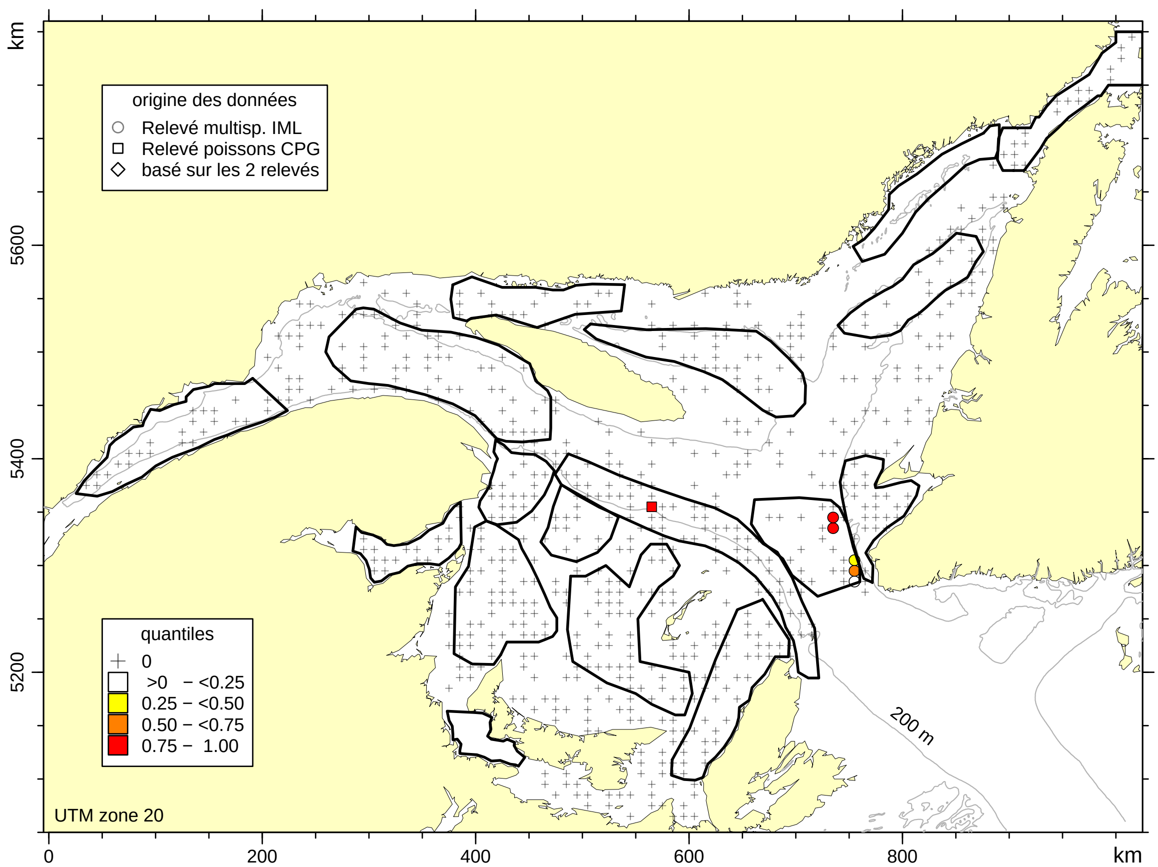


Figure 38 – *Atlantopandalus propinqvus* shrimp distribution based on scientific trawl surveys in the GSL.

Friendly blade shrimp (*Spirontocaris lilljeborgii*) are intermediate between shrimp living in the CIL and those living in the below the CIL. This species is considered circalittoral and bathyal by Squires (1990) and Brunel *et al.* (1998) and appears to be associated with the 200 m isobath according to our surveys (Figure 39). There are also a few large concentrations on the outskirts of the Magdalen Shallows. As it may be associated with anemones (Jonsson *et al.*, 2001), its catchability with our trawls could be low.

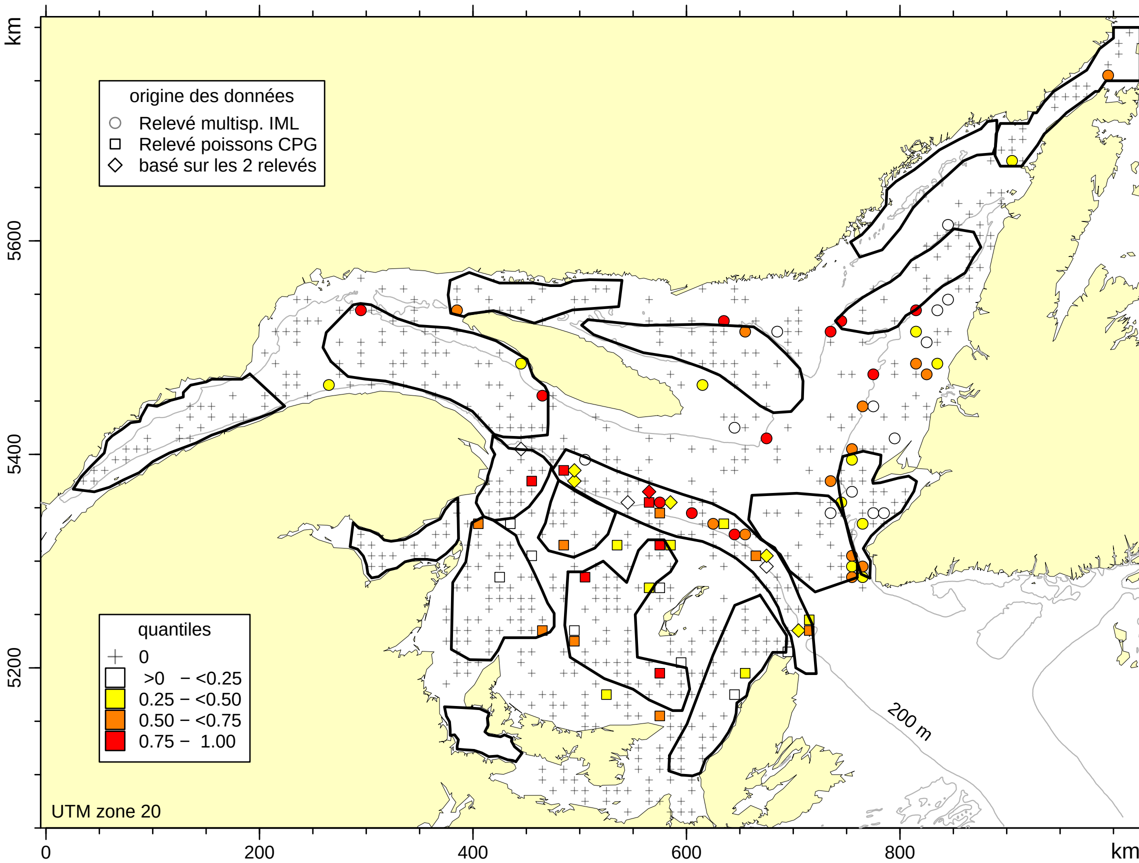


Figure 39 – Friendly blade shrimp (*Spirontocaris lilljeborgii*) distribution based on the multidisciplinary and fall surveys.

Shrimp Living In and Above the CIL A large number of shrimp species inhabit the circalittoral and are generally caught at the lower survey depths (50 m in the nGSL and 30-40 m in the sGSL) up to 150-200 m, the depths where the CIL is in contact with the bottom. We have listed 15 species in LEGSL. They all have a wide distribution outside the study area, particularly in the western Atlantic, where they can be found from Greenland to the north, at least to southern Nova Scotia (Squires, 1990). However, the nGSL survey doesn't cover much of the coastal area west of the Gulf and in particular, in the Estuary. The abundance of these coastal species is underestimated in these sectors, as evidenced by the presence in the ecosystemic survey in Sainte-Marguerite Bay or the northern shrimp recruitment survey, two surveys conducted by the MLI, of several species from this group (see below).

Much of the prey consumed by these cold-water shrimp are associated with sediments (phytobenthos, polychaetes, gammian amphipods, ostracods, isopods, cumaceans, copepods, small bivalves, brittle stars, foraminifers, sponge spicules, Squires, 1990), revealing† a suprabenthic lifestyle. These shrimp, in particular the striped pink shrimp, are prey to fish such as cod (D. Chabot and M. Hanson, unpublished data) and sculpins (Squires, 1990). Outside the study area, it was shown that these shrimp are consumed by seabirds, several species of seals and even beluga whales (*Delphinapterus leucas*) (Squires, 1990).

The most widespread species of this group is the striped pink shrimp (*Pandalus montagui*). Its distribution is widespread on all bottoms up to 270 m deep. The highest concentrations were found along the west coast of Newfoundland up to the Strait of Belle Isle, along the north shore of Beaugé Bank up to Jacques-Cartier Strait and the southwest side of Anticosti Island in the nGSL (Figure 40).

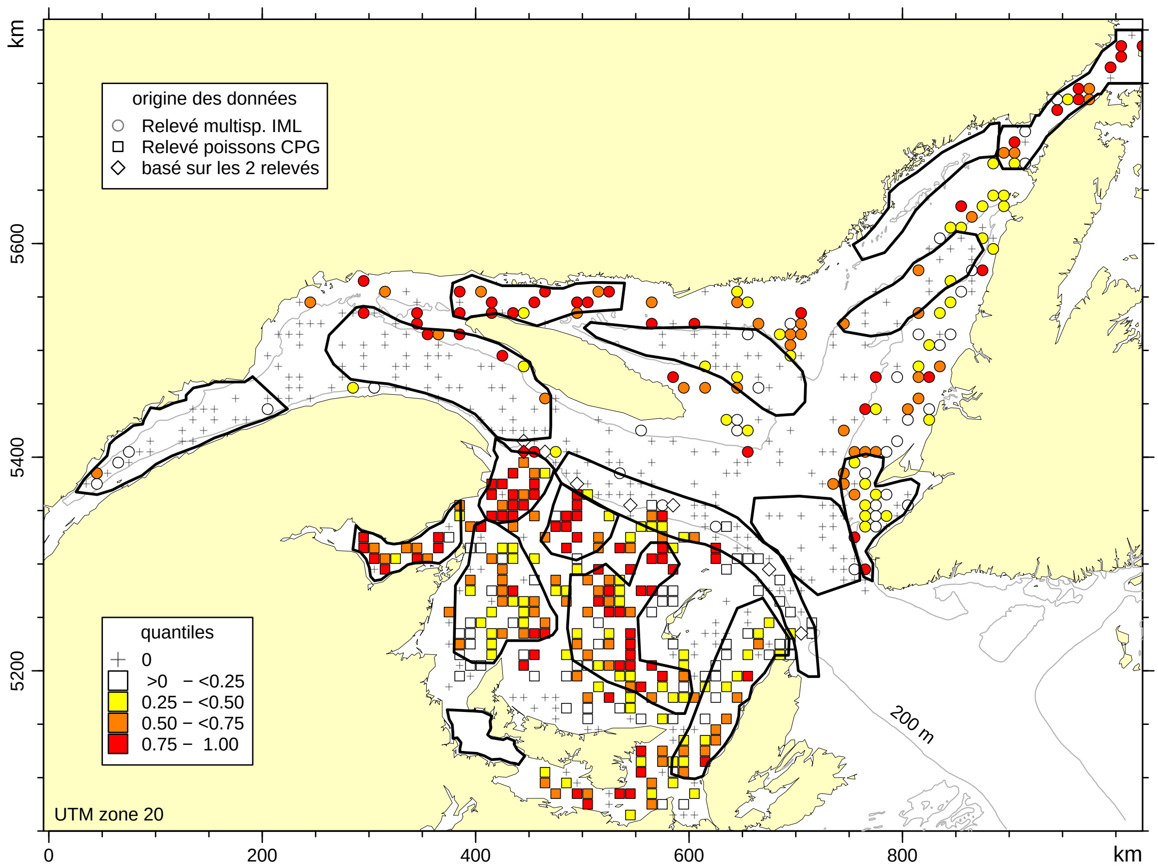


Figure 40 – Striped pink shrimp (*Pandalus montagui*) distribution based on the multidisciplinary and fall surveys.

Striped pink shrimp occur throughout the sGSL, but is particularly abundant in Chaleurs Bay, on the American Bank and Orphelin Bank (Figure 40). Like northern shrimp, striped pink shrimp are protandrous hermaphrodite (Squires, 1990).

Like striped pink shrimp, polar lebbeid (*Lebbeus polaris*) shrimp are found in circalittoral zones and the bathyal zone (Figure 41). Polar lebbeid are most abundant along the west

† Mise à jour: Octobre 2010

coast of Newfoundland to the Strait of Belle Isle, along the north shore of the Beaugé Bank up to Jacques-Cartier Strait and the southwest side of Anticosti Island in the nGSL. The main concentrations of this species in the sGSL are observed around the American Bank, east of Shediac Valley. Unlike the striped pink shrimp, polar lebbeid shrimp are rare in Chaleurs Bay and the Cape Breton Trough. It also occurs in the Estuary and western nGSL (B. Sainte-Marie, unpublished data). It likely seldom ventures in the water column, as it is associated with the anemone *Bolocera tuediae* (Jonsson *et al.*, 2001). Such an association could make it less vulnerable to the trawls used in our surveys.

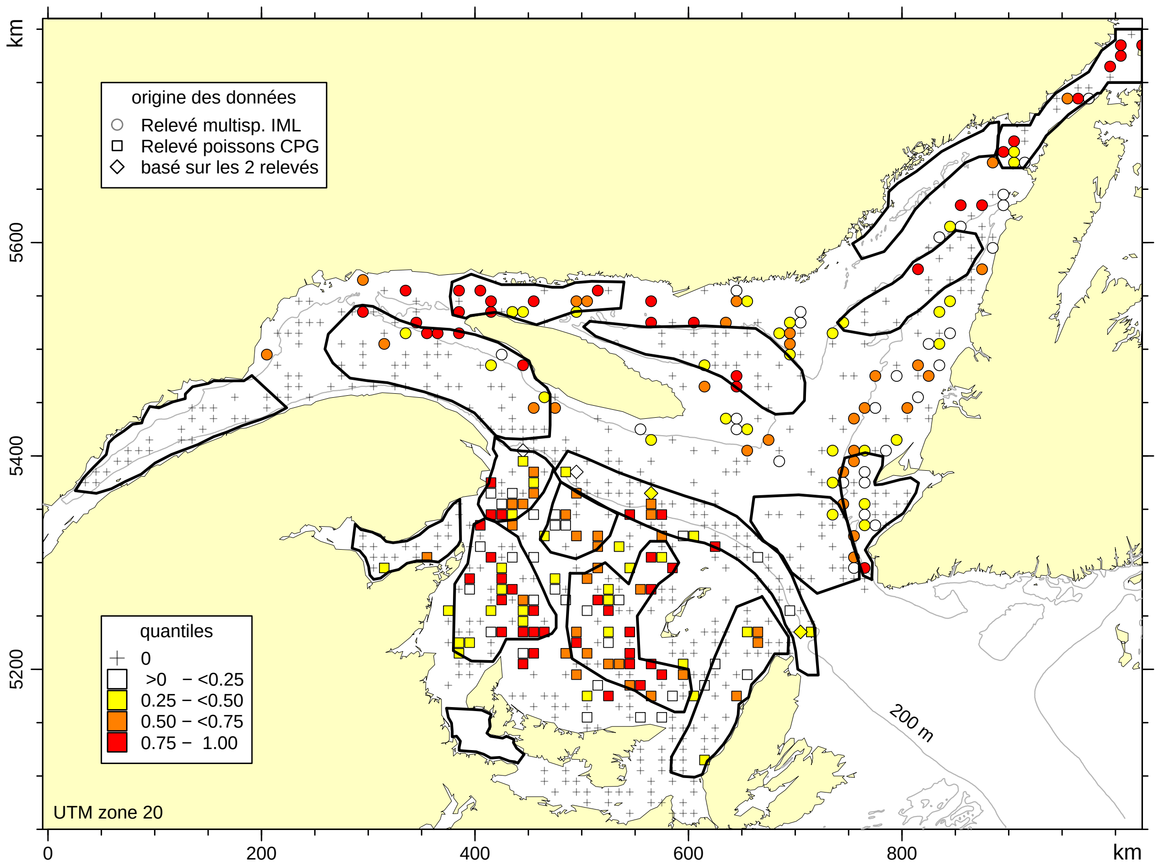


Figure 41 – Polar lebbeid (*Lebbeus polaris*) distribution based on the multidisciplinary and fall surveys.

The other shrimp species from this group are virtually absent from bottoms at depths exceeding 170 m. Because the coastal zone of the Estuary and western Gulf is generally not as well covered by the nGSL survey, these species appear to be virtually absent from areas located west of Anticosti Island. The most abundant species is the arctic argid shrimp (*Argis dentata*) which is found in coastal areas in the northern and eastern part of the Gulf and throughout the sGSL, in particular in Chaleurs Bay and the Cape Breton Trough, but also in Shediac Valley and the plateau immediately east of it, and on the Bradelle Bank (Figure 42). In the nGSL, this species is also frequently observed in beam trawl surveys in Sainte-Marguerite Bay and the Estuary (B. Sainte-Marie, unpublished data), and at Sainte-Luce during shrimp recruitment surveys (L. Savard, unpublished data) at depths of less than 50 or 100 m.

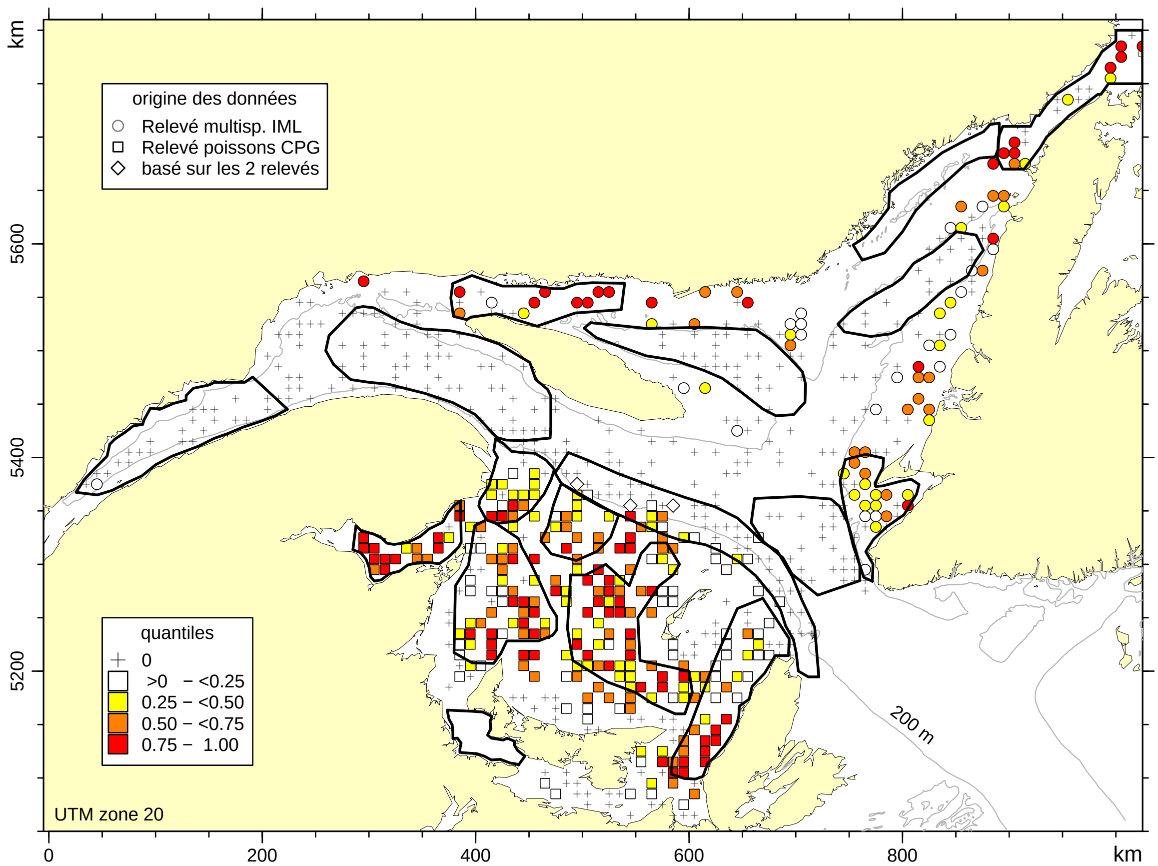


Figure 42 – Arctic argid(*Argis dentata*) distribution based on the multidisciplinary and fall surveys.

The largest concentrations of Greenland shrimp (*Eualus macilentus*) were found in the same sectors of the nGSL and sGSL as the Arctic argid (Figure 43). This species could also use the bathyal zone according to Brunel *et al.* (1998), but it was not captured in our surveys. Squires (1990) considers it primarily as a species of shallow water, although the depth where it occurs outside the study area seems to depend on the presence of cold water. It is also found in the Estuary and the north-western Gulf (Squires, 1990, L. Savard et B. Sainte-Marie, unpublished data), although our surveys do not show any catches in this region.

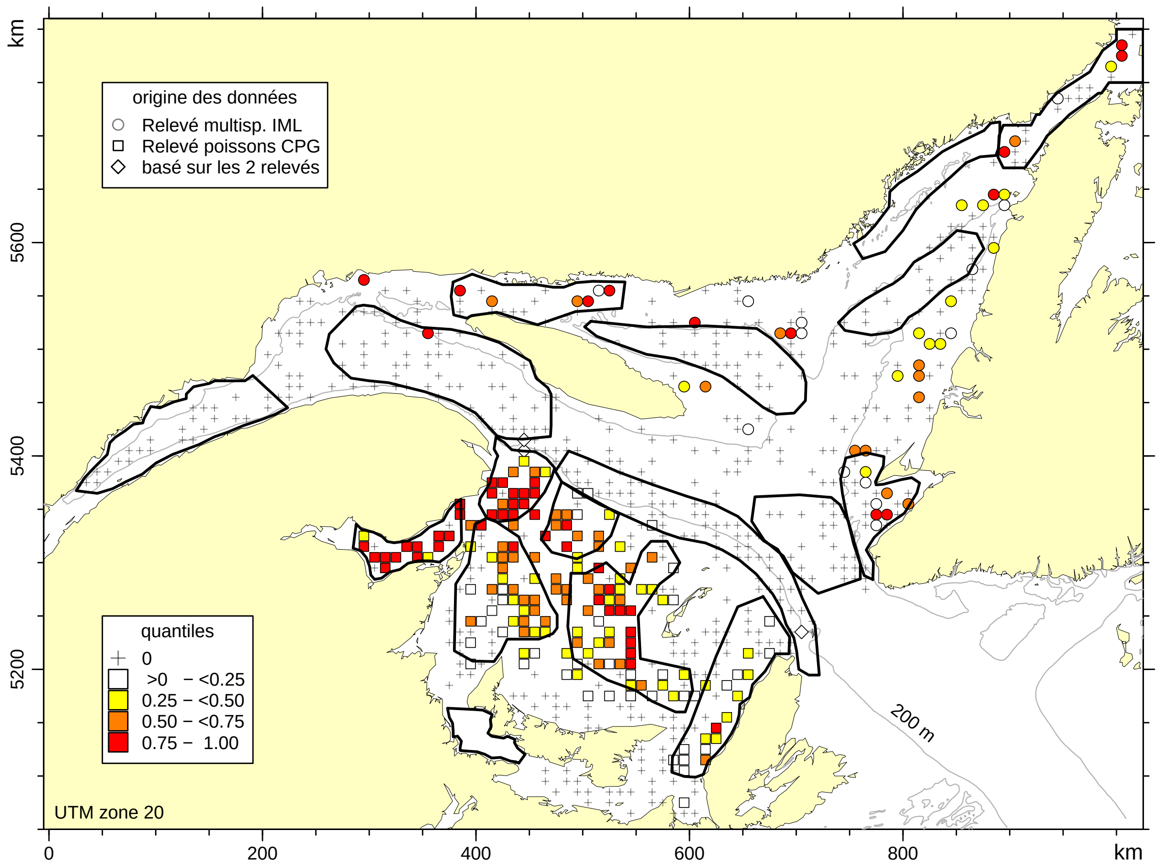


Figure 43 – Greenland shrimp (*Eualus macilentus*) distribution based on the multidisciplinary and fall surveys.

Sevenline shrimp (*Sabinea septemcarinata* occur only in the eastern part of the nGSL, especially along the west coast of Newfoundland to the Strait of Belle Isle (Figure 44). However, it has been captured in the Sainte-Marguerite Bay (L. Savard, unpublished data). In the sGSL, it occurs from the American Bank and Shediac Valley in the west, to the Magdalen Islands in the east.

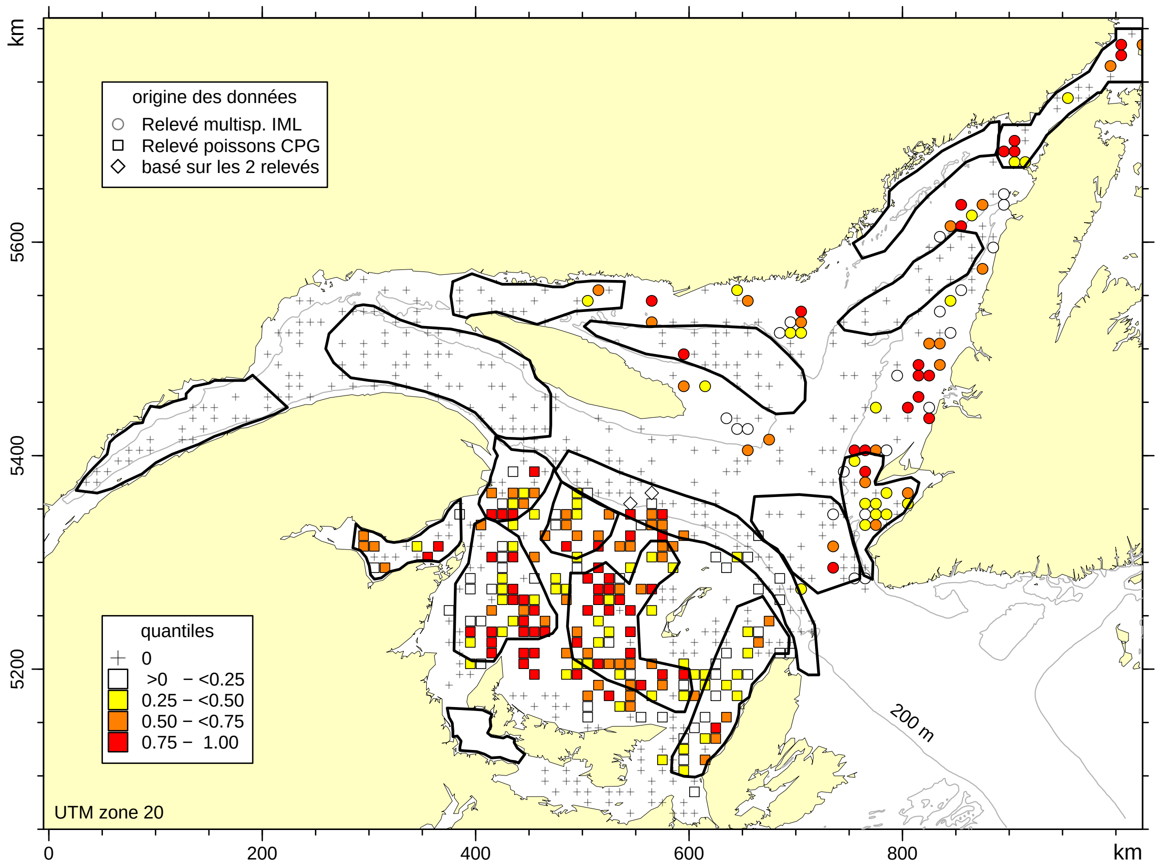


Figure 44 – Sevenline shrimp *Sabinea septemcarinata* distribution based on the multidisciplinary and fall surveys.

Parrot shrimp (*Spirontocaris spinus*) are more abundant in Jacques-Cartier Strait, Strait of Belle Isle, Chaleurs Bay, in the eastern part of Shediac Valley, on Bradelle Bank and south-east of this bank (Figure 45). This species can be found from the intertidal zone to the circalittoral zone (Brunel *et al.*, 1998), therefore, a good portion of its distribution range has not been sampled by our surveys. Its presence in the Estuary is confirmed by Squires (1990). It has also been caught during the ecosystemic survey in Sainte-Marguerite Bay (B. Sainte-Marie and L. Savard, unpublished data).

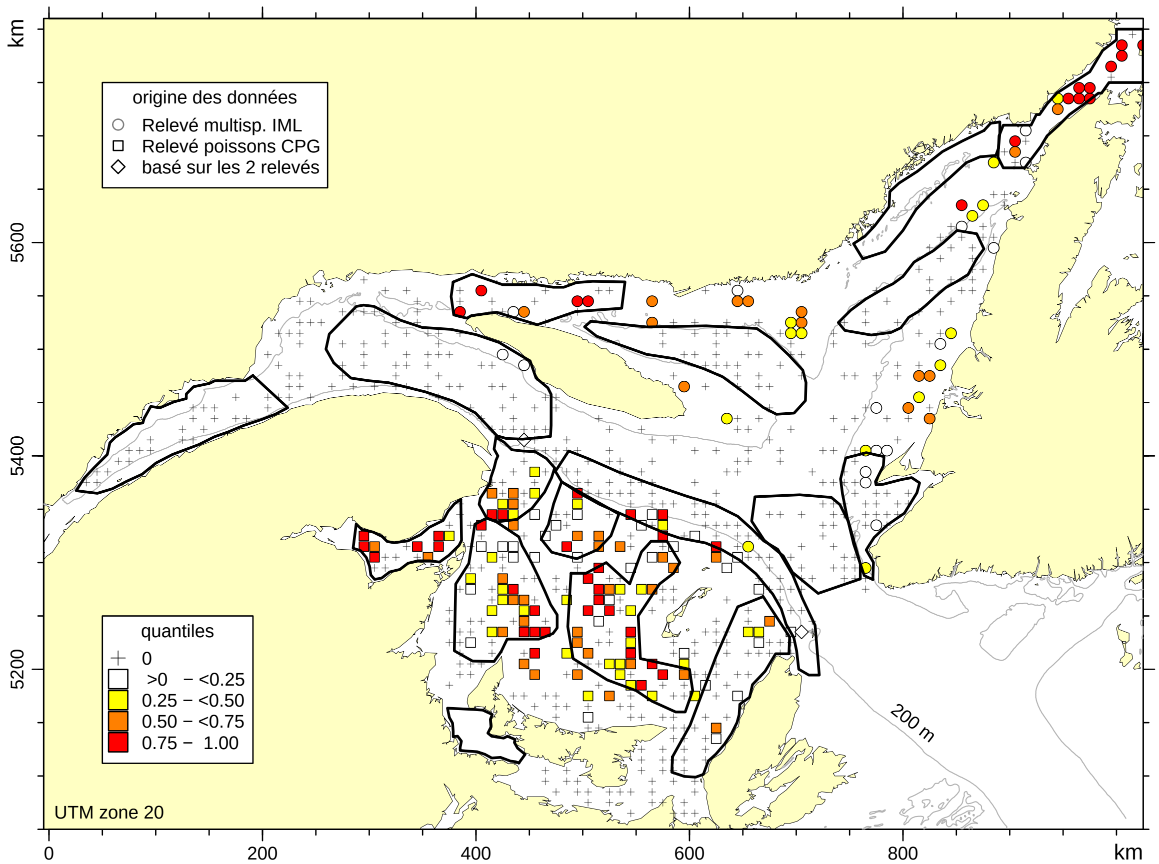


Figure 45 – Parrot shrimp (*Spirontocaris spinus*) distribution based on the multidisciplinary and fall surveys.

Three species, arctic eualid, *Eualus fabricii* (Figure 46), sculptured shrimp, *Sclerocrangon boreas* (Figure 47) and punctate blade shrimp, *Spirontocaris phippsii* (Figure 48) have a similar distribution in the study area. These species occur in the Strait of Belle Isle in the nGSL, and in Shediac Valley and south and west of the Magdalen Islands in the sGSL. Furthermore, *E. fabricii* and *S. boreas* are found in Jacques-Cartier Strait and Chaleurs Bay. These species are widespread in infralittoral and circalittoral zones (Brunel *et al.*, 1998) where they are not regularly sampled by our surveys, especially in the nGSL. They are present up to the Estuary and the north-west of the GSL (Squires, 1990; Brunel *et al.*, 1998; Sainte-Marie *et al.*, 2006), although our surveys do not reflect it.

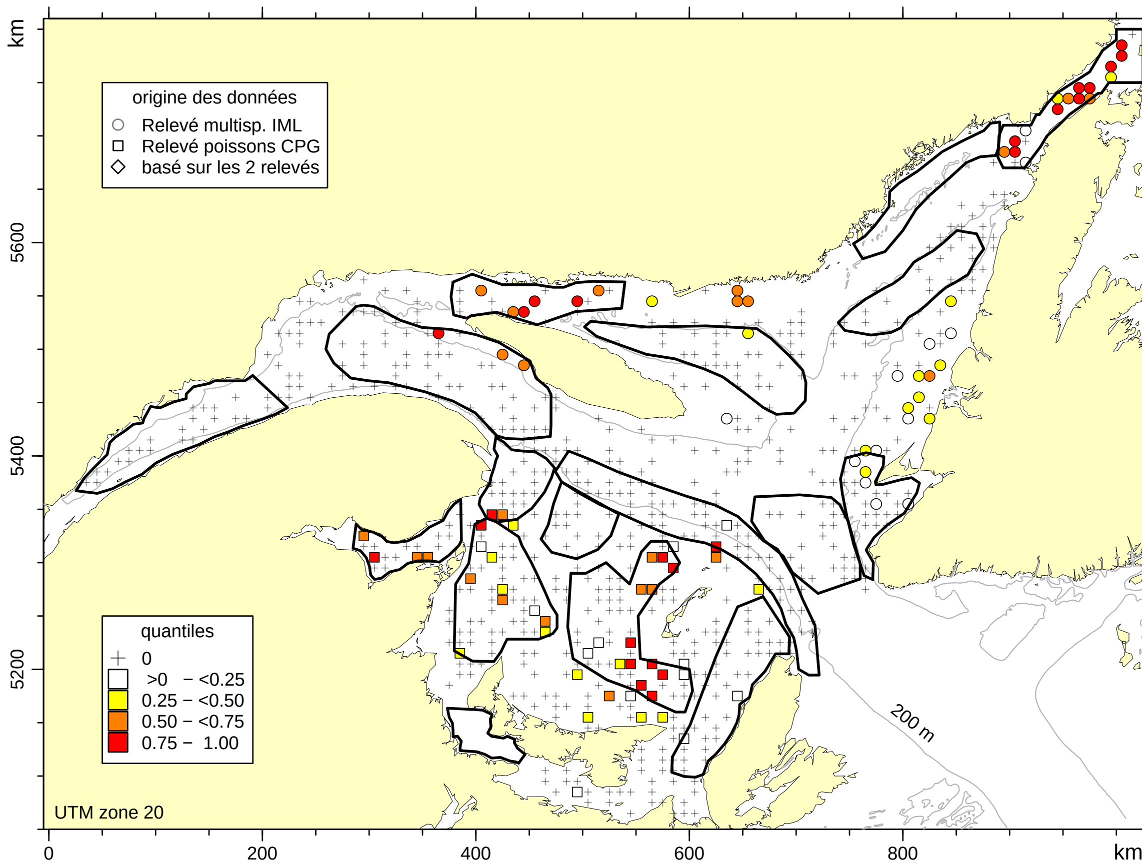


Figure 46 – Arctic eualid (*Eualus fabricii*) distribution based on the multidisciplinary and fall surveys.

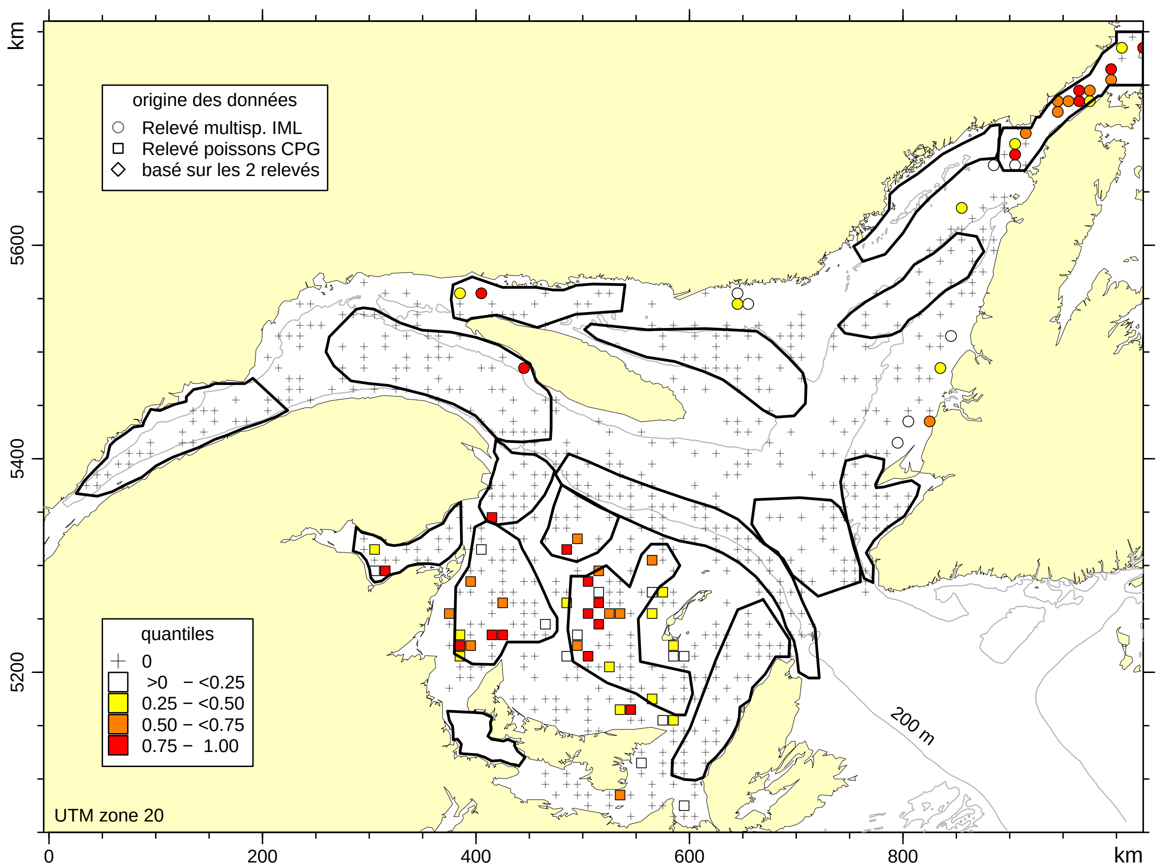


Figure 47 – Sculptured shrimp (*Sclerocrangon boreas*) distribution based on the multidisciplinary and fall surveys.

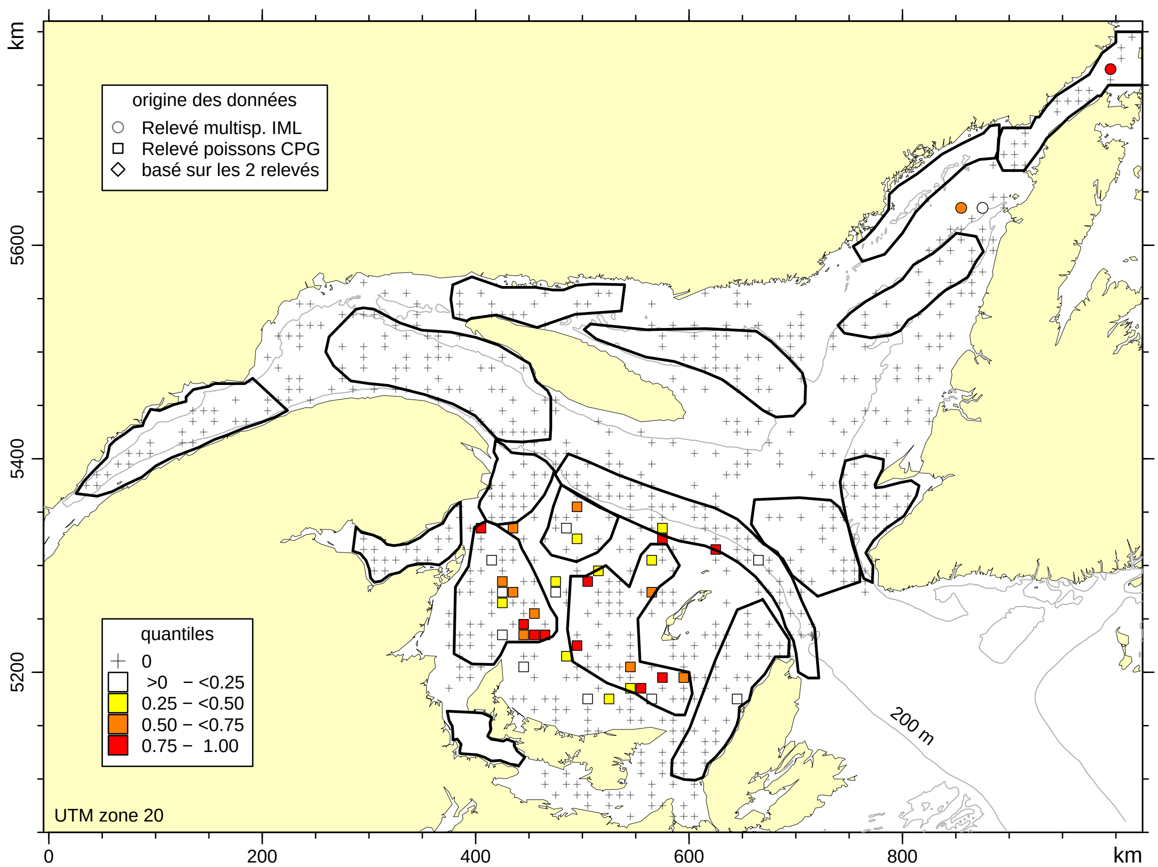


Figure 48 – Punctate blade shrimp (*Spirontocaris phippsii*) distribution based on the multidisciplinary and fall surveys.

Two species of the genus *Lebbeus*, *L. groenlandicus* and *L. microceros*Lebbeus, have similar distributions as the previous three, but more scattered: catches occur in the Strait of Belle Isle and Jacques-Cartier Strait, in Shediac Valley and other locations in the sGSL (Figures 49 and 50). These species are found mainly in the circalittoral (Brunel *et al.*, 1998; Squires, 1990) and are therefore poorly sampled by our surveys, especially in the nGSL.

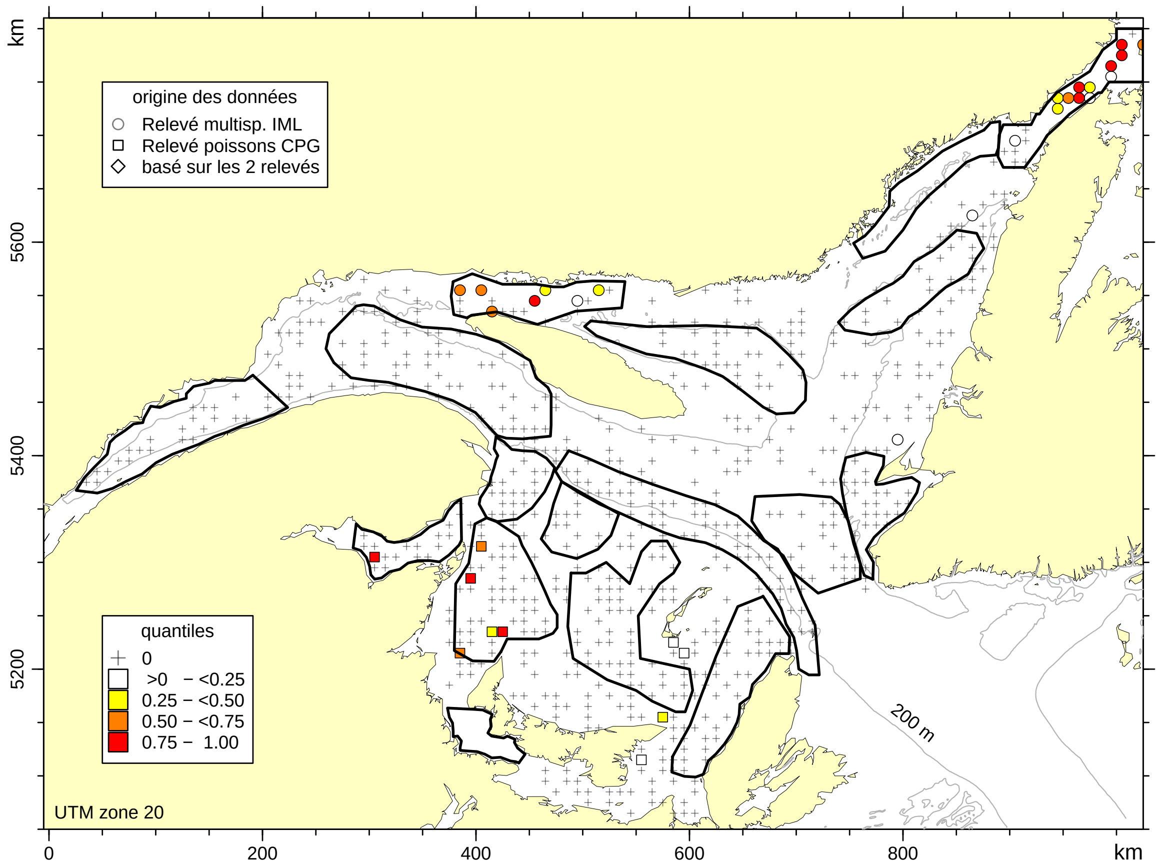


Figure 49 – Greenland lebbeid (*Lebbeus groenlandicus*) distribution based on the multidisciplinary and fall surveys.

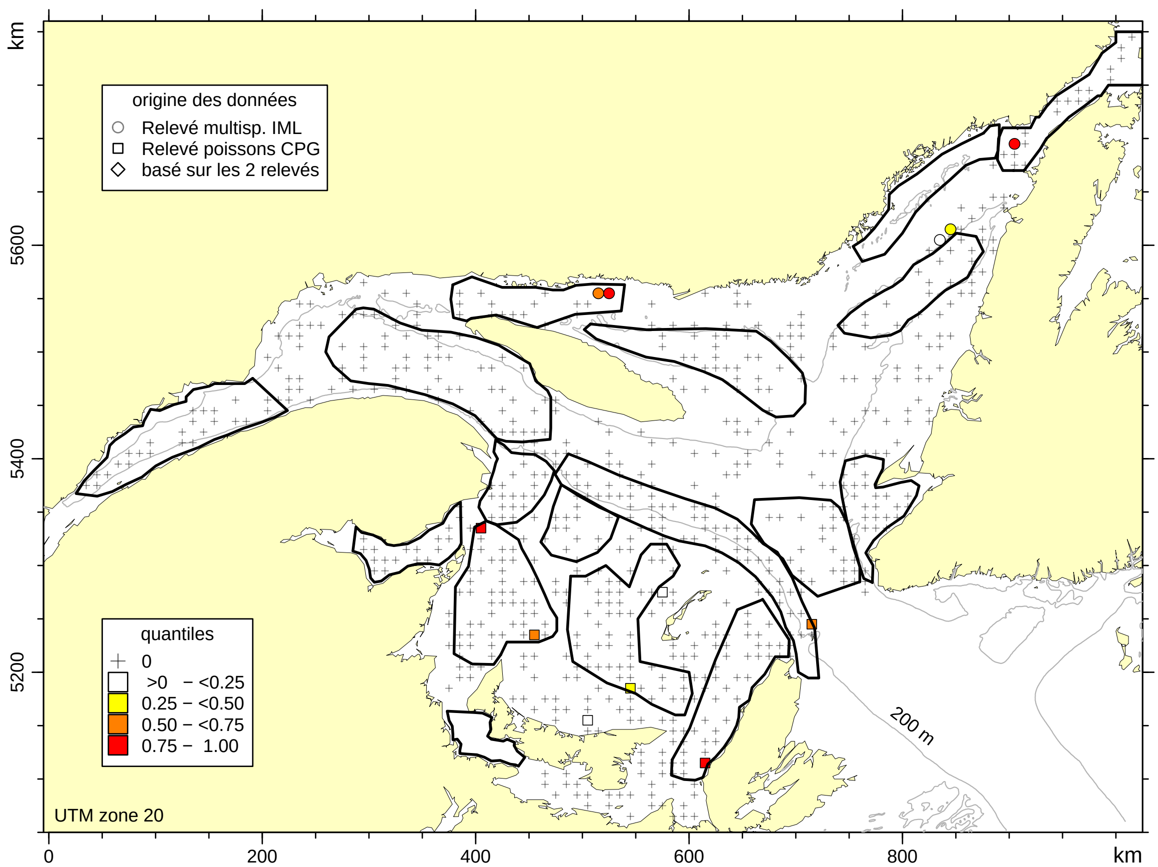


Figure 50 – *Lebbeus microceros* shrimp distribution based on the multidisciplinary and fall surveys.

There are two subspecies of circumpolar eualid shrimp (*Eualus gaimardii*), but this distinction has not been made in the sGSL. Circumpolar eualid shrimp are more abundant in Chaleurs Bay, on the American Bank and Bradelle Bank, south of the Magdalen Islands and east of Shediac Valley (Figure 51). *E. g. gaimardii* and *E. g. belcheri* were separated in the nGSL, and they are mostly found in the Strait of Belle Isle (Figure 52). The two subspecies are present in the Estuary (Brunel *et al.*, 1998; Squires, 1990), even if they are not present in our surveys, likely due to the low coverage of shallow water areas in the multidisciplinary survey, but also because of the few years sampled (2004-2006). Unlike most other LEGSL shrimp living in the CIL, *E. gaimardii* feeds mostly in the water column (pelagic prey) (Birkely & Gulliksen, 2003).

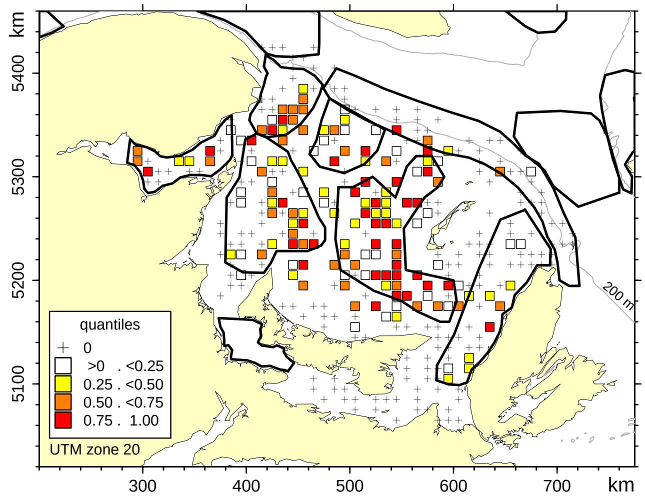
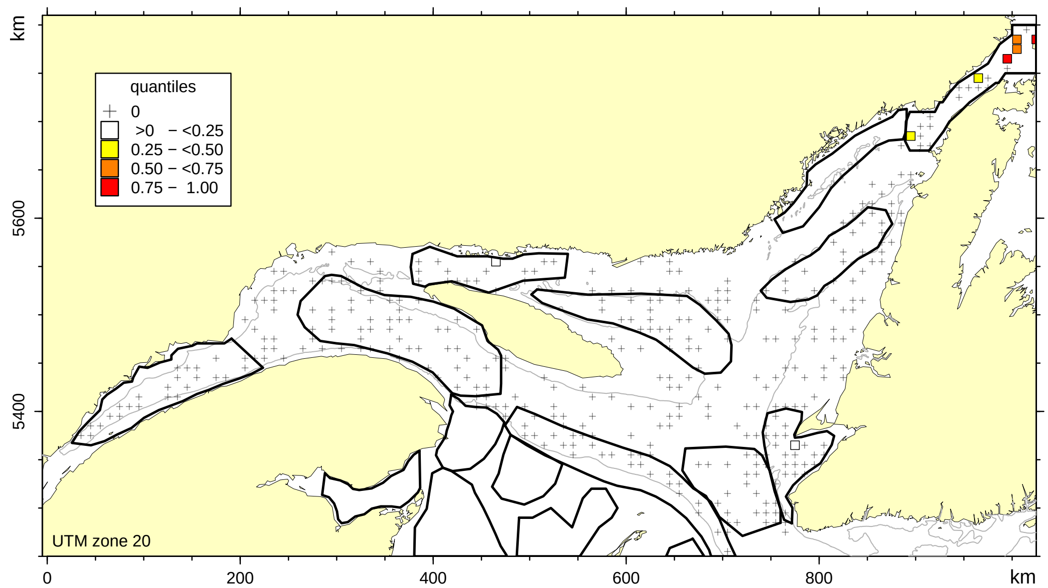


Figure 51 – Circumpolar eualid shrimp (*Eualus gaimardii*) distribution in the sGSL, without any subspecies distinction based on the fall surveys in the sGSL.



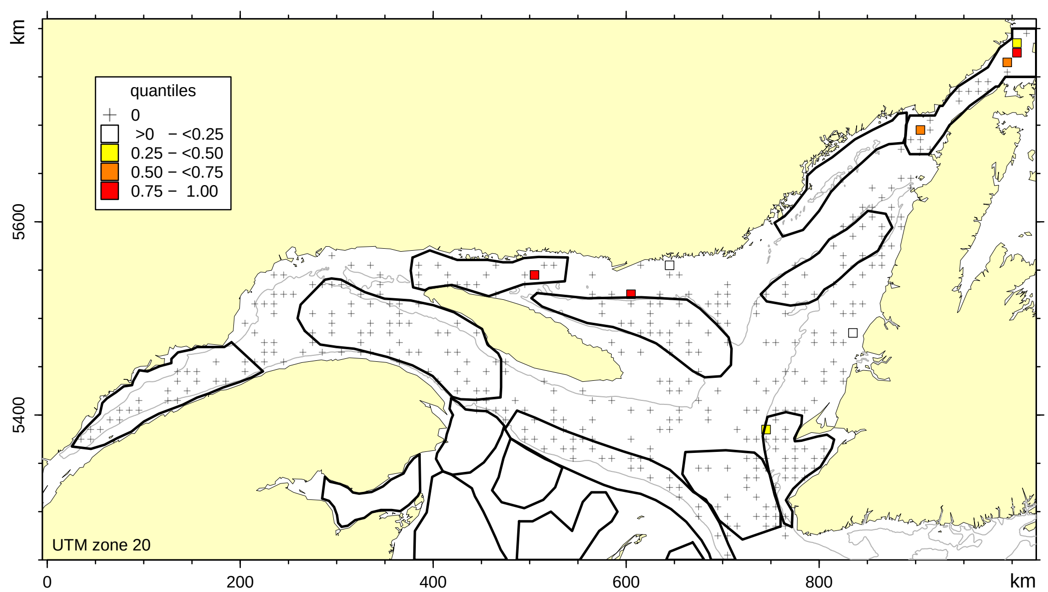


Figure 52 – Distribution of two shrimp subspecies, *Eualus gaimardii gaimardii* (above) and *E. g. belcheri* (below) based on the multidisciplinary surveys in the nGSL.

Finally, two shrimp species associated with the CIL have a very sparse distribution in the study area according to our surveys, which Squires (1990) and Brunel *et al.* (1998) corroborate. The species are the doll eualid (Eualus pusiolus) (Figure 53), for which we only have data in the sGSL, and Sars shrimp (*Sabinea sarsi*) (Figure 54), which, on the other hand, we only have data in the nGSL.

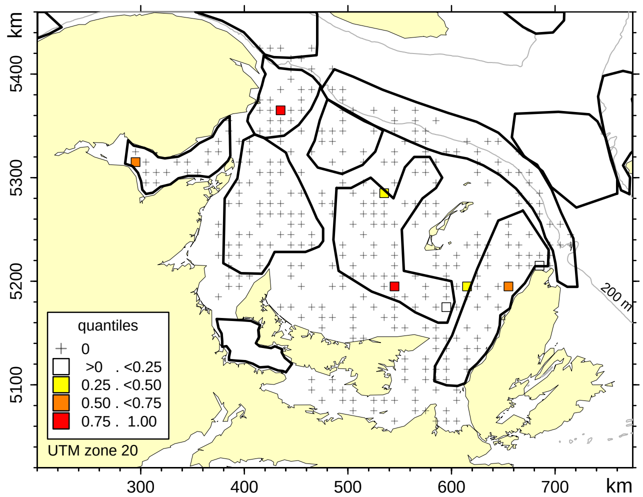


Figure 53 – Doll shrimp (*Eualus pusiolus*) distribution based on the fall surveys in the sGSL.

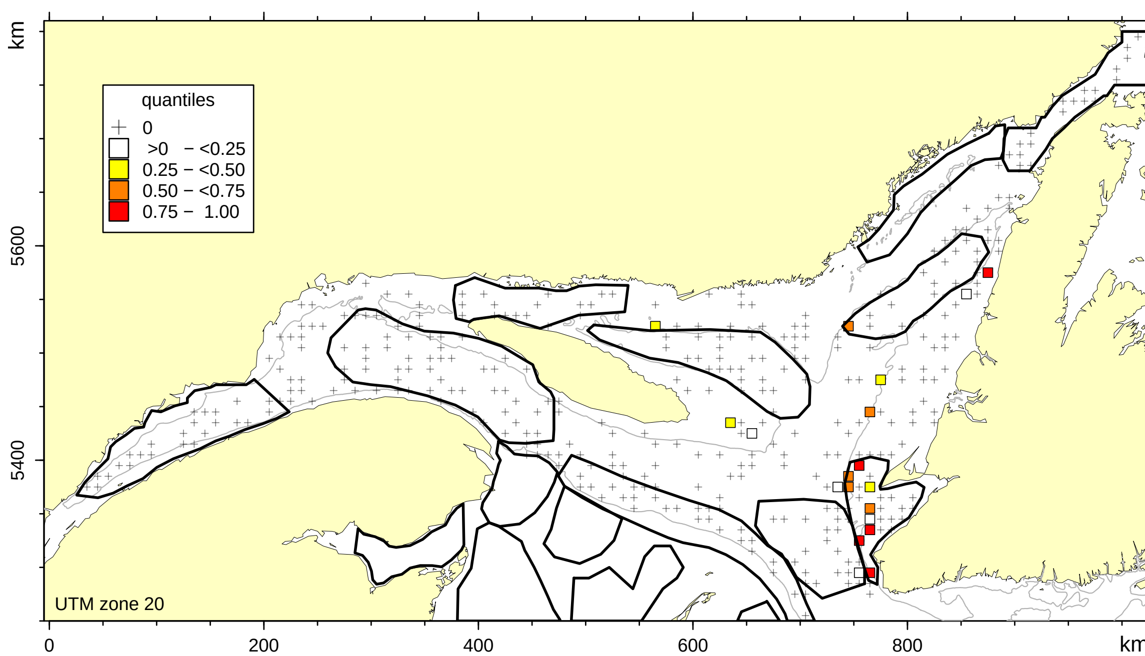


Figure 54 – Sars shrimp (*Sabinea sarsi*) distribution based on the multidisciplinary surveys in the nGSL.

3.3.9 Crab

Snow Crab We examined the distribution of immature snow crab, sampled using the stomach contents of cod, and that of all crabs caught in the surveys, irrespective of maturity or sex.

Cod are snow crab predators and most crabs consumed are <50 mm carapace width (Chabot *et al.*, 2008)†. Based on cod stomach contents, the main snow crab nurseries are on the west coast of Newfoundland, the American Bank, Shediac Valley and the Cape Breton Trough (Figure 55).

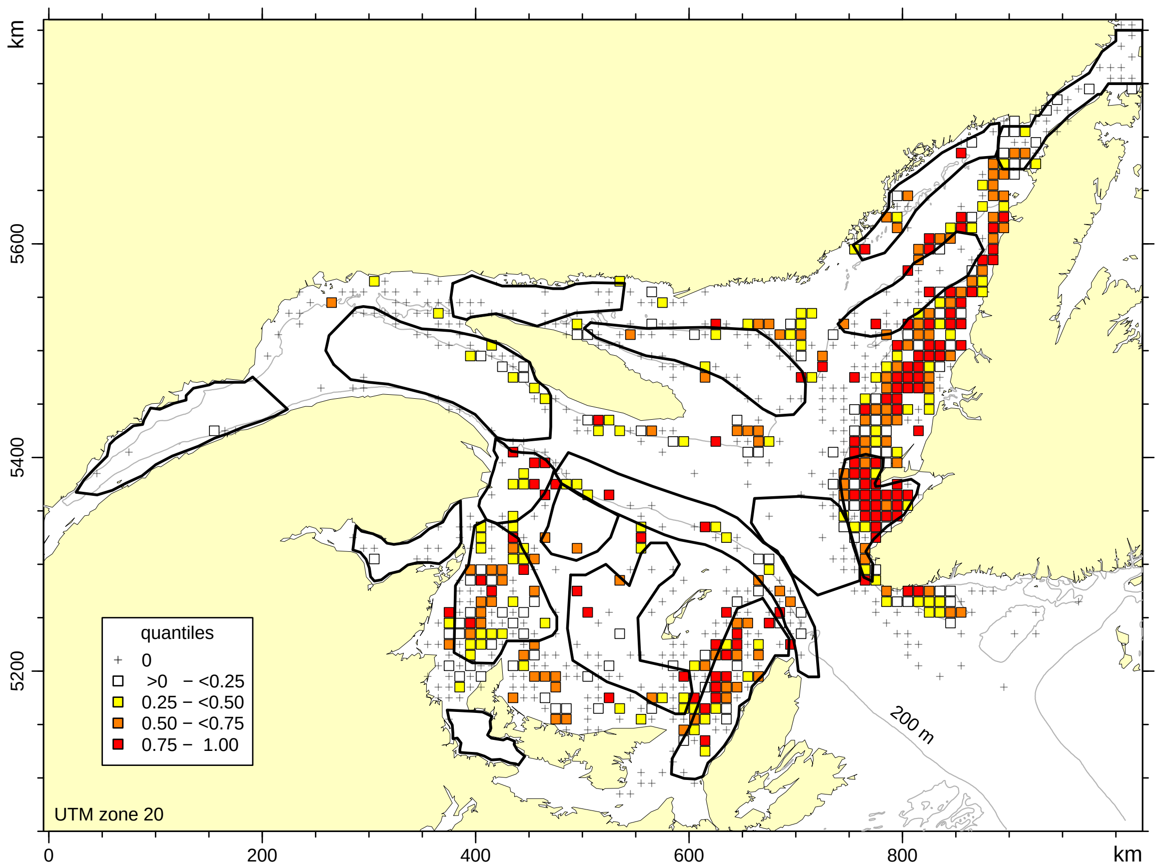


Figure 55 – Immature snow crab (*Chionoecetes opilio*) distribution based on cod stomachs.

The work carried out by Briand (2004) shows that the nurseries are associated with depths of about 65-165 m in the nGSL and 40-80 and 130-170 m in the sGSL, and temperatures ranging from -0.5 to 3 °C . Dionne et al. (2003) demonstrated a dichotomous structure of the nursery in the nGSL. Immature crabs abound on both ends of the CIL, but are less abundant in the center of it. The shallow part of the nursery is the most important, at least in Sainte-Marguerite Bay, but very few stomachs were collected from this area along the North Shore. The use of stomach contents as a sampling device requires a large number of stomach contents to be representative, which could explain the apparent rarity of immature snow crabs in the Estuary and along the North Shore, where commercial catches of adult

† Updated: October 2010

males suggest the presence of significant concentrations of immature crabs. In fact, Lovrich *et al.* (1995) and Dionne *et al.* (2003) confirm the presence of immature snow crab in large numbers in Sainte-Marguerite Bay.

The snow crab survey in the nGSL shows large concentrations of snow crab in the Estuary and along the North Shore, except at depths exceeding 200 m, but coverage is not complete (Figure 56). In the sGSL, where the survey coverage is very good, snow crab are especially abundant in Shediac Valley and on the American, Orphelin and Bradelle Banks (Figure 56).

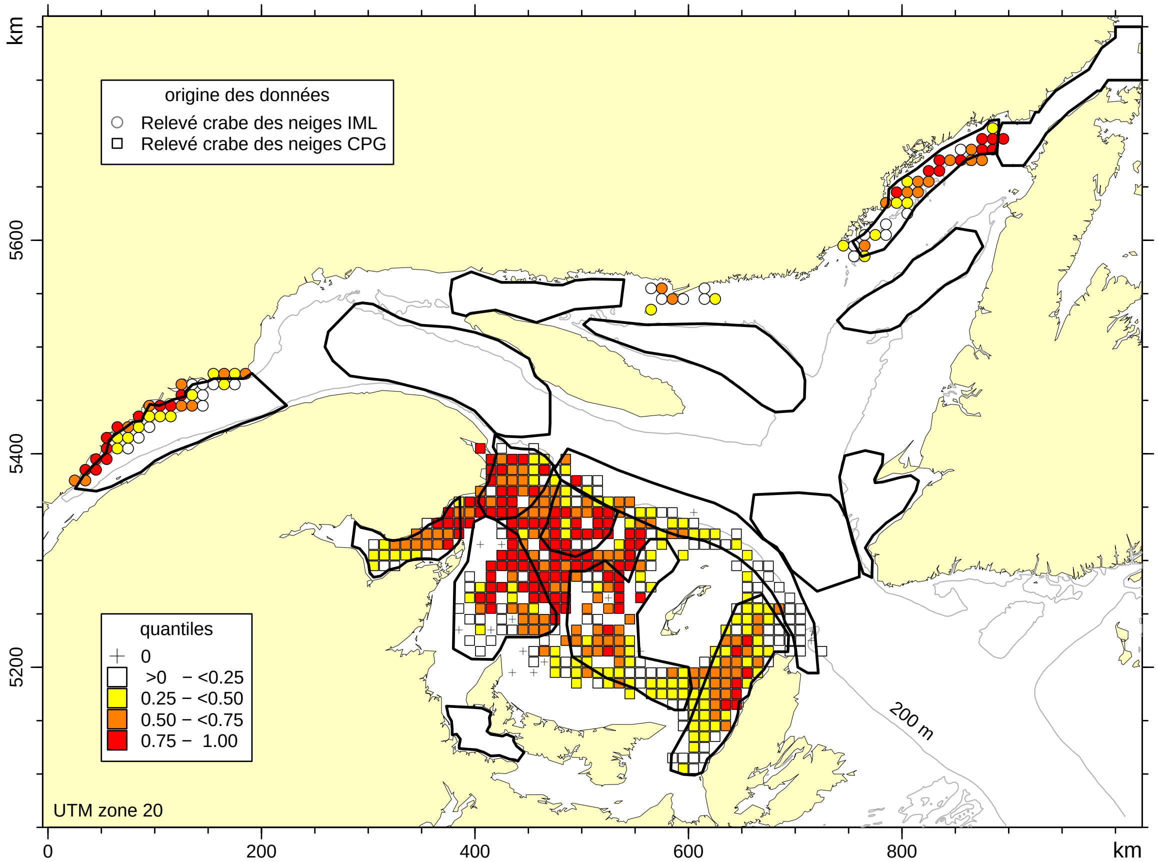


Figure 56 – Snow crab (*Chionoecetes opilio*) distribution in the snow crab surveys in the nGSL (1992-2005) and sGSL (1998-2005).

Snow crab by-catches in the multidisciplinary survey in the nGSL and those from the mobile gear Sentinel Fisheries show that snow crab also venture into the channels (Figure 57). These individuals are almost exclusively large adult males (Sainte-Marie *et al.*, 2005).

Snow crab feed on several benthic or suprabenthic organisms. Examination of stomach contents revealed the presence of phytobenthos, foraminifers, shrimp, crabs (including snow crab), amphipods, copepods, isopods, cumaceans, ostracods, bivalves, brittle stars, polychaetes, gastropods, chitons, jellyfish and fish (Lovrich & Sainte-Marie, 1997; Squires, 1990). It should be noted there is a gradual shift towards larger prey with ontogeny, especially males (Lovrich & Sainte-Marie, 1997).

Immature snow crab are consumed by cod (Waiwood & Elner, 1982; Robichaud *et al.*,

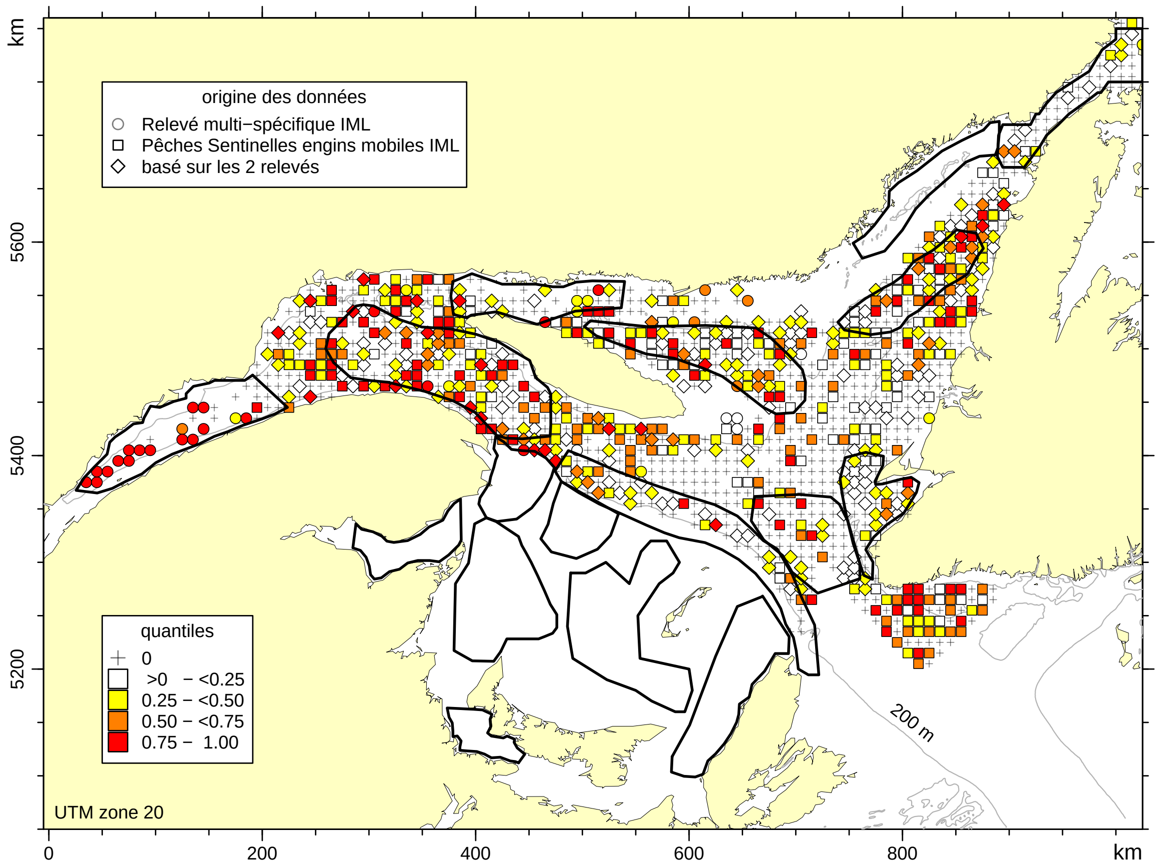


Figure 57 – Snow crab (*Chionoecetes opilio*, mostly adult males), distribution in the nGSL, based on the multidisciplinary (2004-2006) and Sentinel Fisheries (1995-2005) surveys.

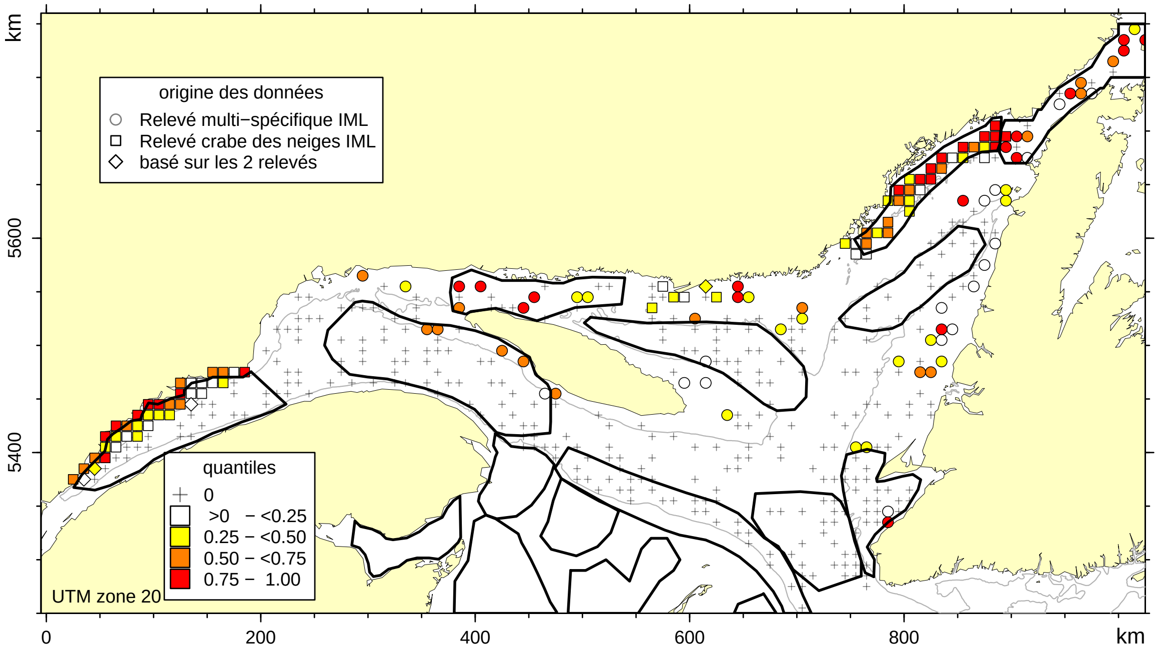
1991; Chabot *et al.*, 2008)† and thorny skate (Robichaud *et al.*, 1991). Male adolescents and adults, however, are invulnerable to predation by these fish, except for a short period after moulting (Robichaud *et al.*, 1991; Chabot *et al.*, 2008)†.

Toad Crab (*Hyas* sp.) Both species of *Hyas* crab (Arctic lyre crab *H. coarctatus*, and toad crab, *H. araneus*) have been observed in the nGSL. It seems that the distribution of the first includes the second (Figure 58). They are coastal type species (infralittoral and circalittoral, Brunel *et al.*, 1998) better sampled by the snow crab survey, which shows concentrations in the Estuary and the Lower North Shore. Because this survey's coverage is poor, it is difficult to establish the relative abundance of these species along the other coasts. The multidisciplinary survey indicates that they are absent in the deep channels and relatively abundant in the Jacques-Cartier Strait and Strait of Belle Isle. However, this could be the result of low catchability, since Squires (1990) observed that *H. araneus* was present in the channels, as it was caught with northern shrimp in relatively warm water beneath the CIL.

Both species are considered together in the sGSL (*Hyas* sp.). Although the spatial coverage is better than in the nGSL, the snow crab survey does not fully cover the distribution

† Updated: October 2010

† Updated: October 2010



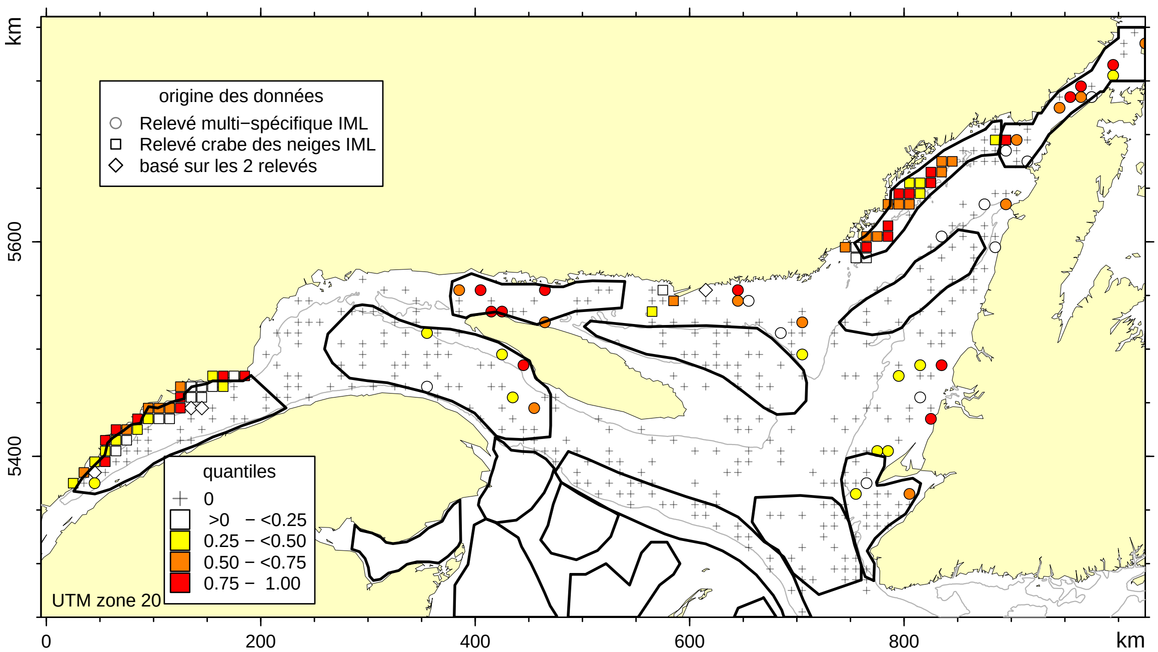


Figure 58 – Distribution of Arctic lyre crab (*Hyas coarctatus*), above, and toad crab (*H. araneus*), below, in the snow crab surveys in the nGSL (1992-2005).

of these crab species. Most of the *Hyas* crab commercial fishing activities take place outside the area covered by the survey, which suggests that large concentrations of toad crab and/or sections of its preferred habitat were not sampled. Within the area covered by the survey, toad crab is most abundant in Chaleurs Bay, Shediac Valley and the area east, and the Cape Breton Trough (Figure 59).

In the sGSL, Sabean (2007) mentioned that *H. coarctatus* is much more abundant than *H.*

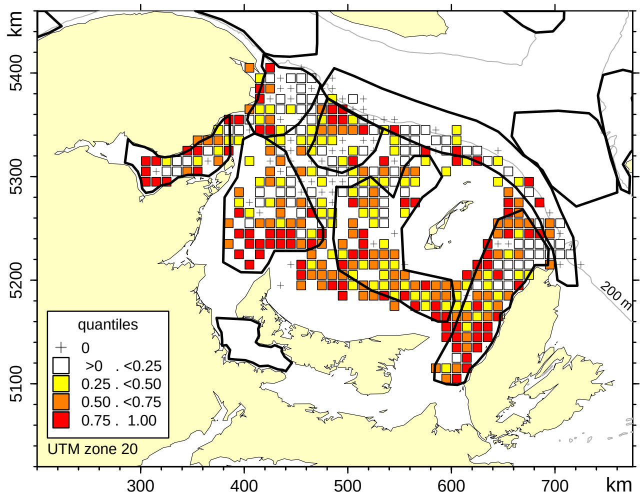


Figure 59 – Toad crab (*Hyas* sp.) distribution in the snow crab surveys in the sGSL (1988-2005).

araneus and has a more contagious distribution. In recent years, it seems that the presence of female *H. araneus* is concentrated mainly in a specific area between Cape Breton Island and Prince Edward Island, in deep waters.

Juvenile *Hyas* crabs generally occupy the same bottoms as adults, i.e. gravelly or rocky bottoms, from the intertidal zone to about 60 m deep. In summer, the distribution of the genus *Hyas* is usually surrounded by that of rock crab and lobsters in shallow waters and by snow crab in deep waters. *Hyas* crab feed on phytobenthos, crab, hermit crab, shrimp, gammarian amphipods, euphausids, copepods, foraminifers, bivalves, brittle stars, sea urchins, jellyfish, polychaetes, chitons, sponges, etc., and even fish occasionally (Squires, 1990). Cod (D. Chabot and M. Hanson, unpublished data) and thorny skate (*Raja radiata*) (Robichaud *et al.*, 1991)consume immature *Hyas* crab.

Lady Crab Lady crab (*Ovalipes ocellatus*) are normally found further south than the study area and are very widespread from Maine to South Carolina. However, a population exists in the western portion of Northumberland Strait (Figure 60). Moreover, these crabs are morphologically different from other lady crab populations; they are larger and their color pattern is different, being significantly darker. The lady crab population in Northumberland Strait is currently part of a morphological and genetic study to demonstrate its difference compared to other populations outside the GSL and thereby recognize it as a new species or subspecies endemic to the GSL (Voutier & Hanson, 2007).

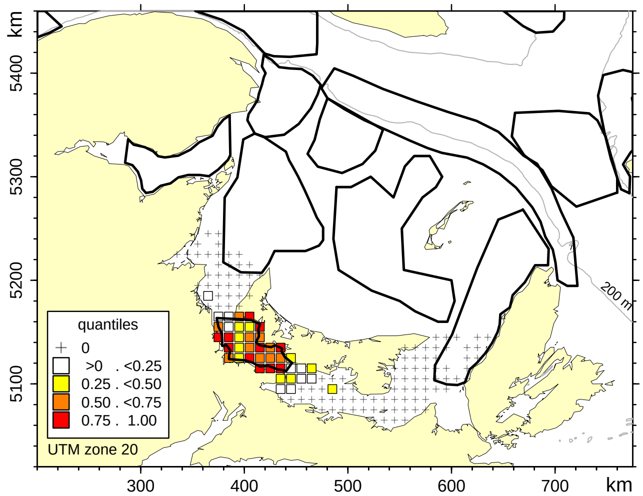


Figure 60 – Lady crab (*Ovalipes ocellatus*) distribution in the Northumberland Strait surveys (2000-2005) in the sGSL.

Lady crab are usually found from the low tide line to about 40 m deep (deeper in winter), on soft bottoms where it can bury itself completely. This kind of swimming crab is very aggressive and has sharp claws, making it a formidable predator and rarely a prey. This species• pelagic larval stages do not appear sufficient to increase its distribution outside of Northumberland Strait, the only place that seems to combine the physical and environmental conditions necessary for its survival.

Hermit Crab Hermit crabs (*Pagurus* sp.) are anomuran crabs. The most likely to be encountered in the study area is the Acadian hermit crab (*Pagurus acadianus*), the hairy hermit crab (*Pagurus arcuatus*) and *Pagurus pubescens* in infralittoral and circalittoral zones, although *P. pubescens* can also be found in the bathyal zone (Brunel *et al.*, 1998). Our surveys thus cover only part of the hermit crab distribution area. These crabs are abundant in Chaleurs Bay, Shediac Valley (including the plateau at about 60 m east) and the Cape Breton Trough (Figure 61). Our surveys show no hermit crab in the Estuary, but the occurrence of *P. pubescens* in this region has been documented (Squires, 1990). Outside the Gulf, hermit crabs are found from the Arctic to the Chesapeake Bay at depths ranging from 0 to 400 m.

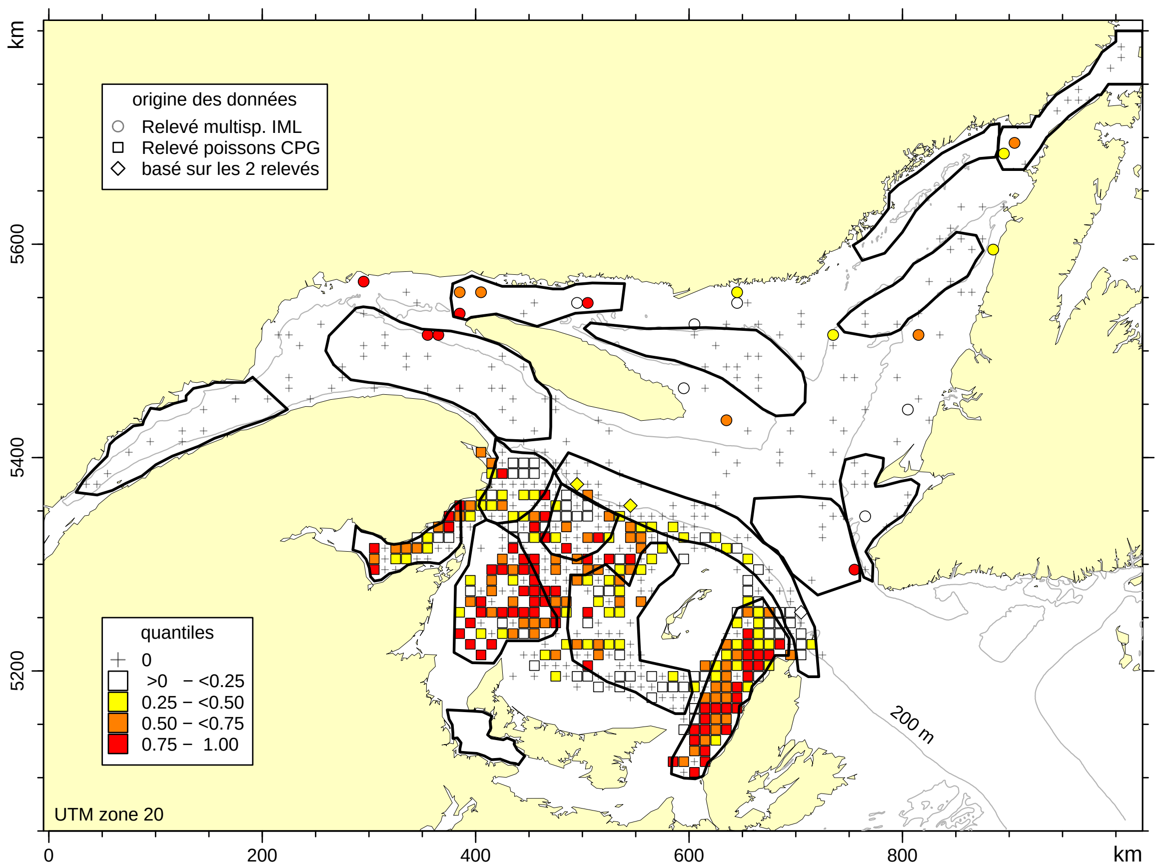


Figure 61 – Hermit crab (*Pagurus* sp.) distribution based on the multidisciplinary survey in the nGSL (2004-2006) and the snow crab survey in the sGSL (1999-2005).

Hermit crabs use the empty shells of gastropods, primarily of periwinkles and whelk to protect their abdomen uncovered by an exoskeleton (Squires, 1990). These animals are omnivorous and reproduce sexually like other decapods presented here, with pelagic larval stages. Hermit crabs are scavengers (at least *P. acadianus*), but they also eat phytobenthos and hunt small bivalves, foraminifers, gastropods, polychaetes, amphipods, brittle stars and Hydrozoa (Squires, 1990). Hermit crabs are a minor prey for cod (D. Chabot and M. Hanson, unpublished data).

Spiny Crab Spiny crab (*Lithodes maja*) is a large anomuran crab covered with spines, as its name indicates. It is common in the western Atlantic from the Arctic to New Jersey, and also in the eastern Atlantic, from the British Isles to the Netherlands, at depths ranging from 65 to nearly 800 m. Spiny crab are particularly fond of sandy bottoms and mud that line the large channels (Laurentian, Anticosti and Esquiman) as shown by our data (Figure 62). Concentration is higher near Cabot Strait.

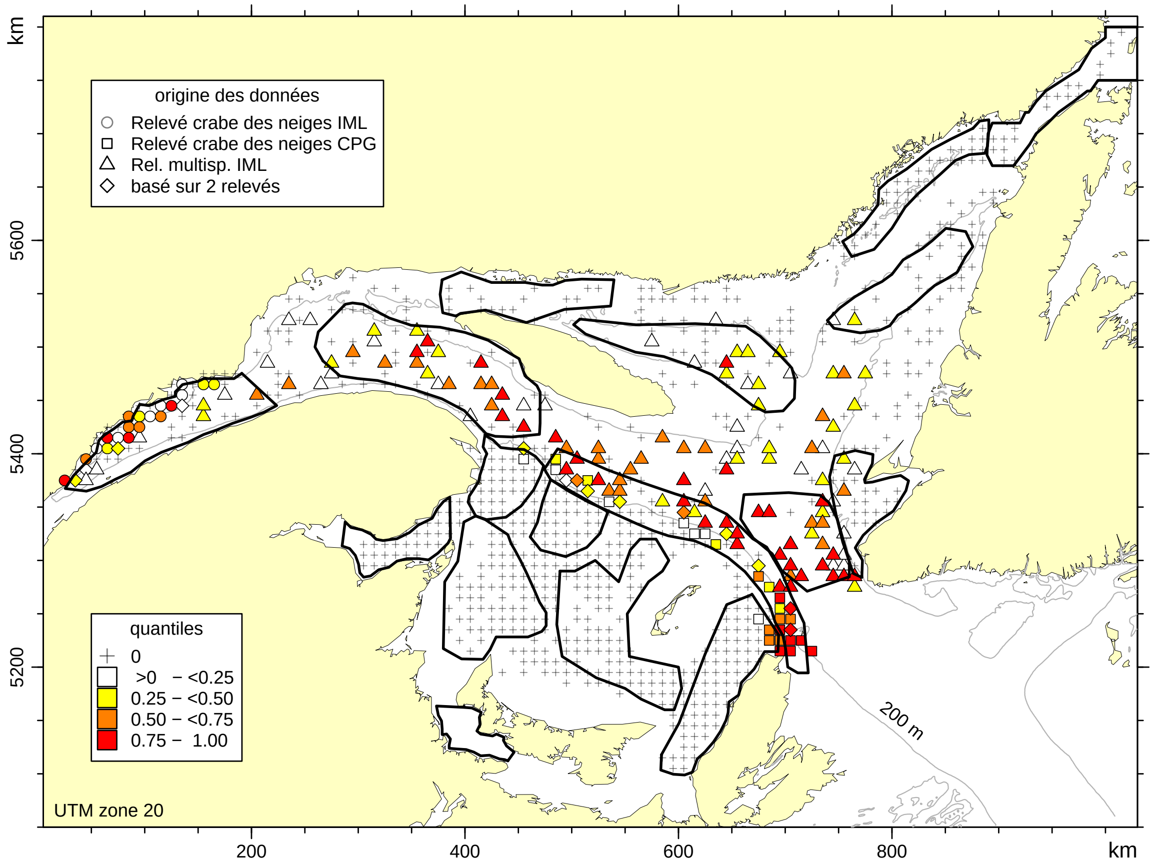


Figure 62 – Spiny crab (*Lithodes maja*) distribution based on the snow crab survey in the nGSL (1992-2005) and in the sGSL (1988-2005) and based on the multidisciplinary survey in the nGSL (2004-2006).

This species is closely related to Alaska king crab (Genus *Paralithodes*) harvested in Alaska. On the Canadian east coast, spiny crab are frequently caught in small quantities in the snow crab, northern shrimp, redfish and groundfish fisheries. The species is not very fertile (females carry few eggs, which are larger in diameter) and larvae are lecithotrophic (i.e. survive on their yolk reserves without feeding) (Anger, 1996). Although the vertical distribution of these larvae is unknown, it is doubtful they are found in surface waters such as brachyuran crab larvae, given the higher predation risk in this layer.

4 Discussion

4.1 Potential EBSAs

The proposed EBSAs in this study are primarily characterized by concentrations of a high number of very widespread benthic invertebrate species, but in some cases, by significant concentrations of a number of species with a more limited distribution. The bathymetry and circulation patterns of water masses have been used primarily to determine the boundaries of the EBSAs. Given the number of taxa examined, we decided not to attempt to identify important areas for each taxon. The concentration index that we calculated provided a more equitable way of establishing potential EBSAs from abundance data of all taxa simultaneously. To mitigate the impact of not having described significant areas species by species, the EBSAs are superimposed on distribution maps of all species and species groups considered in the Results section, to assess the extent to which areas with higher concentration of a given species or group are covered by one or more of the proposed EBSAs.

The proposed EBSAs were assessed according to five criteria (Table 2) applied to the taxa present or to physical characteristics of the EBSAs. Although in the case of most species and areas examined, knowledge was lacking to be able to accurately assess each criterion. It appears that three sectors stand out which have a high value for each criterion and influence many EBSAs. These areas are influenced by different oceanographic systems so they support varied and unique assemblages of species. The first area is located in the eastern Gulf, along the north shore, and is most likely influenced by the cold waters from the Labrador current entering the Gulf through the Strait of Belle Isle, and by the cold water upwelling in Jacques-Cartier Strait. A second area is located near Cabot Strait and is influenced by the warm water entering from the Atlantic. A third area is located around the Gaspé Peninsula and is influenced by the circulation from the Gaspé current.

In the north-eastern GSL, EBSA 3 (Jacques-Cartier Strait) and 6 (Strait of Belle Isle) are characterized (total score of the five criteria = 10) by the fact that they support a particular assemblage of coastal shrimp species (12 species were listed in the Strait of Belle Isle and 11 in Jacques-Cartier Strait) associated with very cold water. Most are arctic species whose distribution extends into the Hudson Strait and Foxe Basin, and may even exceed 70 °N latitude in some cases. Three of these species have a very restricted distribution in the LEGSL (*Eualus fabricii*, *Sclerocrangon boreas* and *Lebbeus groenlandicus*) while two are rather rare (*L. microceros* et *Spirontocaris phippsi*). EBSA 15 (Mécatina Trench) is unique (total score = 9) because it represents a habitat awash with very cold water which has been little disturbed by human activities.

The Cabot Strait sector includes EBSA 10 and 11 which have a total score of 9 along with EBSA 9 which has a total score of 8. These EBSAs are characterized by the presence of species associated with warmer waters from the deep water masses from the Atlantic. Some shrimp species found there are rare in the LEGSL (*Pasiphaea tarda*, *Acantephyra pelagica*, *Sergestes arcticus*, *Atlantopandalus propinqvus*).

The third area composed of EBSAs with relatively high scores is located on the periphery of the Gaspé Peninsula (EBSA 2, 17 and 14) and is strongly influenced by the Gaspé current. For example, it is interesting to note how the distribution of *Pandalus borealis*, which is very abundant in the western GSL, continues into Chaleurs Bay.

Finally, EBSA 13 in the west of Northumberland Strait is characterized (sum of the scores from the five criteria = 12) by the fact that it contains a unique population of lady crab.

The concentration index has helped highlight the significant areas for the benthic invertebrates sampled in our surveys. No other area of the LEGSL has a high density of parcels with values among the two upper quartiles for this index. In fact, over 90% of the parcels with a high concentration index are included in the proposed EBSAs, despite the fact that they cover only 41% of the surface area of the LEGSL.

However, this index was calculated after excluding the very coastal species for which we have some data (see Appendix A), because the surveys covered an overly small part of their distribution. The whelk species *Buccinum undatum* was excluded from the index for the Estuary and nGSL for the same reason: the MLI whelk survey had a poor geographic coverage of the coast. Whelk (several species) were sampled on a larger scale in the sGSL and are included in the index calculation for this region. Snow crab catches by the Teleost (multidisciplinary survey of the nGSL) and by the Sentinel Fisheries in the nGSL were also excluded from the concentration index due to the low catchability of this species by the trawls used in these surveys compared to the high catchability of the trawl used in the snow crab surveys.

The concentration index performs well even when different surveys have contributed to the results. However, the areas sampled more intensely had a favourable bias. First, parcels containing several stations are more representative, i.e. the odds are better of identifying whether they are significant for a species when it is actually the case. On the other hand, a significant portion of a parcel containing only one station was thereby not sampled at all, and it is possible that a species was perhaps not caught in great abundance, even if it is normally present in large numbers in this parcel. In addition, the number of species examined in a parcel depended on the gear used and was usually higher when several types of surveys covered the parcel. The probability that the concentration index was high for a parcel was greater if more species were examined, i.e. the number of superimposed layers was greater. In general, the index was somewhat biased in favor of the sGSL compared with the Estuary and nGSL, regions where a greater proportion of parcels were not sampled at all, where several parcels contained a small number of stations and where a small portion of the total area was covered by more than one type of survey. Nevertheless, regions covered by a single survey that only measured a single species still produced high concentration values if they included a taxon with limited distribution. This applies to EBSA 13, whose concentration index was high, even if based solely on one species, lady crab, from a single survey.

4.2 Research Limitations

We must first recognize the limitations of the data. The large-scale DFO surveys do not cover the infralittoral and the resulting distributions are truncated for several species described in this study. An important portion of the benthic invertebrates in the LEGSL occur exclusively in coastal waters, from the intertidal zone up to 30 m deep. These species are not considered at all because this area is only marginally sampled.

Moreover, even at depths covered by the surveys, we have no data on the species forming the endobenthos. Species living in marine sediments are undoubtedly an important link in the LEGSL food webs and also in the recycling process of nutrients and carbon mineralization, but no large-scale research survey exists for these species and fishing gear used in conventional surveys are not appropriate for sampling the endobenthos. The main endobenthos components include polychaetes and gammarian amphipods, which are important food sources for many shrimp and crab species, as well as several bivalve species that make up a significant fraction of all biomass contained in the endobenthos.

No correction for catchability was made in this study. Catchability obviously varies from one species to another and from one gear to another. It is difficult to determine whether the low abundance of a species in the study area reflects an actual scarcity, or poor catchability. However, the use of relative abundances can locate areas of maximum abundance even for a low catchability species, as long as the catchability is stable from year to year. A project such as establishing EBSAs would benefit if the data were corrected, when species-specific catchability data become available.

The identification of invertebrates has been neglected on large scale multispecies surveys. In addition, a multitude of small organisms are under-represented in the catches from these surveys, either on account of the gear meshing that is inappropriate for small organisms or gear type which does not penetrate sufficiently into the marine sediment to sample burrowing organisms. Several species described in this study live in association with structuring species (anemones, octocorals, sponges). This association may reduce their catchability if these animals remain entangled in these structures during the passage of the trawl. Thus, even in areas covered by our surveys, only a small proportion of the species present were sampled. Table 4 demonstrates this by summarizing the number of invertebrates recorded at two sites in the Estuary that were the subject of a comprehensive wildlife survey (Figure 63). By comparison, our surveys only list a few dozen taxa for the Estuary.

The implications of the combined effect of low taxonomic coverage in the areas covered by our surveys and the almost non-existent coverage of the infralittoral zone are enormous:

Table 4 – Number of crustacean, polychaete or mollusc species found at two stations in the St. Lawrence Estuary.

Location	Crustacea	Polychaeta	Mollusca	Sources
Estuary, sta. 408: 22 m; 48°28'45"N, 68°37'41"W	58	nd	40	Hessler-Sanders gear, sample no. 111S: Huberdeau & Brunel (1982).
Estuary, sta. 487: 90 m; 48°45'24"N, 68°49'36"W	81[a]	39[b]	9[c]	[a]gamarian amphipods only : Besner (1976); [b]Massad & Brunel (1979); [c]Robert (1974).

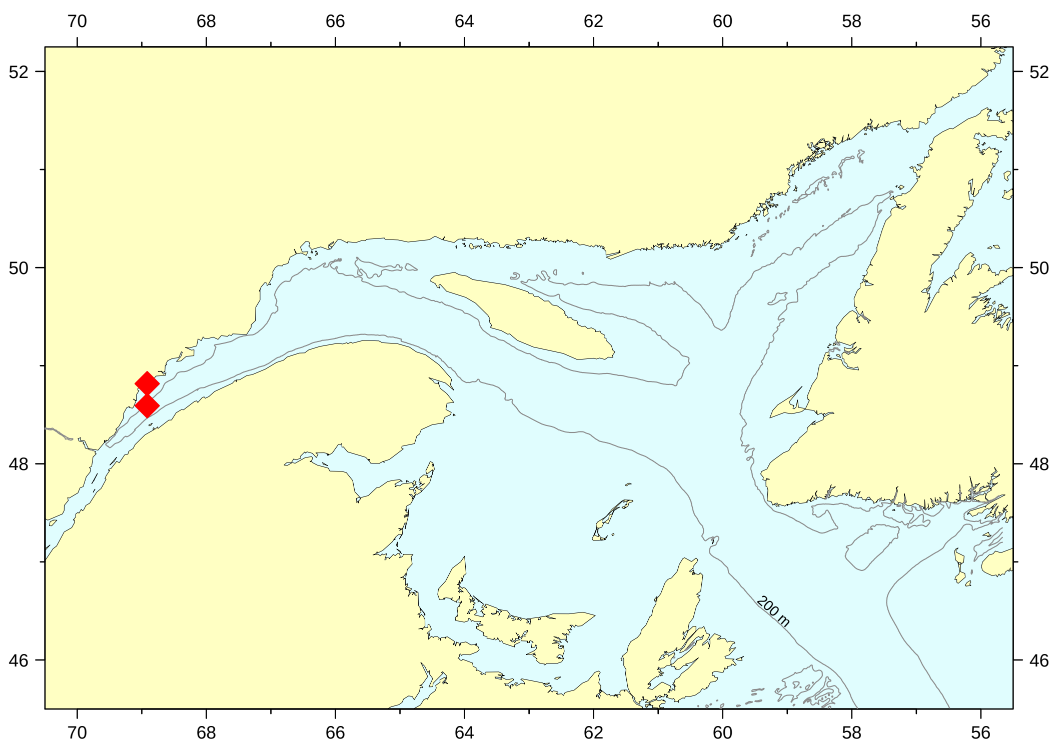


Figure 63 – Position of two stations in the Estuary that were part of a comprehensive wildlife survey.

This study, and therefore the identification of potential EBSAs, is based only on a small proportion, around 0.02%, of known benthic invertebrate species in the LEGSL (Tableau 5).

Moreover, species inventoried adequately tend to be decapod crustaceans whose size or link with species of commercial interest provides greater visibility in the catches. Thus, approximately 31 of the 50 species identified in this study are decapod crustaceans (23 shrimp species, 7 crab taxa and lobster) belonging to the Malacostracan class. This class is largely dominated by gammarian amphipods, which are not represented in this study.

Table 5 – Comparison between the number of recorded invertebrate taxa in the Estuary and Gulf of St. Lawrence by Brunel et al. (1998) and by this study. C: primarily coastal; Pl: primarily planktonic; Pr: significant prey for young stages of demersal fish and large crustaceans; S: structuring, forming complex biogenic structures on soft substrate bottoms or that contribute towards making them stable.

	Number of species			
Taxon	Brunel et al. (1998)	Current study	Ratio	Notes
PARAZOA AND RADIATA				
Porifera	43	1	0,02	S
Cnidaria				
Hydrozoa	126		0,00	
Scyphozoa	10		0,00	
Anthozoa				
Octocorallia	8	1	0,13	S
Hexacorallia	18	1	0,06	S
Ceriantipatharia	1		0,00	
Ctenophora	4			Pl
Platyhelminthes	107		0,00	
Nemertea	14		0,00	
Aschelminthes (certain parasites)	147		0,00	
Entoprocta	2		0,00	
Lophophorata				
Phoronida	1		0,00	
Bryozoa	168		0,00	S
Brachiopoda	4		0,00	
Sipuncula	5		0,00	
Mollusca				
Aplacaphora	1		0,00	
Polyplacaphora	6		0,00	
Gastropoda	178	1	0,01	
Bivalvia	114	5	0,04	Pr; S
Cephalopoda	9	3	0,33	
Scaphapoda	3		0,00	
Annelida				
Polychaeta	304		0,00	Pr; S
Oligochaeta	8		0,00	
Hirudinea	7		0,00	
Echiura	3		0,00	
Crustacea				
Cladocera	10		0,00	
Ostracoda	55		0,00	
Copepoda	(217)			
Harpacticoida	165		0,00	Pr
Branchiura	3		0,00	
Cirripedia	14		0,00	C; S
Malacrostraca	477	31	0,06	
Chelicerata	18		0,00	
Uniramia (Insects et Tardigrada)	26		0,00	C

Table 5 – Comparison between the number of taxa in Brunel et al. (1998) and this study (continued).

Taxon	Number of species Brunel et al. 1998	 Current study	Ratio	Notes
DEUTEROSTOMES				
Chaetognatha	5		0,00	Pl
Hemichordata	2		0,00	Pl
Echinodermata				
Crinoidea	1		0,00	S
Holothuroidea	14	1	0,07	
Asteroidea	21	2	0,10	
Echinoidea	4	1	0,25	S
Ophiuroidea	18	2	0,11	S
Urochordata				
Larvacea	4		0,00	
Ascidiacea	36	1	0,03	S
Thaliacea	1		0,00	
TOTAL benthic species	**2161**	**50**	**0,02**	
Major taxa represented	**43**	**13**	**0,31**	
“Structuring” Taxa represented	**11**	**7**	**0,64**	

Therefore, for lack of data, we could not account for the vast majority of non-commercial species in deciding which areas of the LEGSL should be considered as biologically and ecologically significant for benthic invertebrates. These non-commercial species play important roles in terms of biodiversity, trophic flux, recycling of nutrients (e.g. the importance of bioturbation, Meysman *et al.*, 2006) and even physical support for other organisms (see for example Scharf *et al.*, 2006).

4.3 Recommandations

The DFO surveys are a valuable and unique source of abundance and distribution data for marine species throughout the LEGSL. It is therefore recommended to make some changes to the protocol of these surveys to improve the gathering of information which is essential to any biodiversity study.

Thus, it is recommended to prioritize the identification and sorting of all marine organisms (invertebrates as well as fish) that are captured in these surveys. Moreover, this identification should be at the lowest possible taxonomic level, knowing that species of the same genus may have different migration patterns or environmental requirements. This recommendation has already been successfully applied to two surveys in the nGSL in 2006 (Teleost survey and crab survey in Sainte-Marguerite Bay) and it appears that this approach is feasible with minimal additional costs in relation to the total survey costs. It would also be useful to estimate the catchability of benthic invertebrates to the fishing gear used in a given survey.

It is also important to increase our knowledge of the coastal infralittoral zone, in order to then evaluate whether or not to establish EBSAs specifically for this zone, which has been neglected by the current process. It is recommended to increase the coverage in coastal areas by DFO surveys that are conducted across the LEGSL. Stations should be added in depth strata that are not currently sampled, particularly in the Estuary. Even though many of these areas are considered untrawlable, it would surely be possible to add fixed stations on sites which can be sampled safely by fishing gear.

There are already some surveys targeting particular species and specific geographical areas. It would be appropriate to expand the spatial coverage of these specialized surveys, such as the whelk survey in the nGSL, as described in this study but excluded in establishing EBSAs because of its limited spatial coverage. Other examples (surfclam and softclam surveys in the nGSL and Northumberland Strait survey in the sGSL) allowed us to document in part the distribution of some additional species in Appendix A.

Furthermore, the people in charge of these surveys have quantified the abundance of other benthic invertebrate and small demersal fish species. However, these additional data were not available in electronic form or were not in a format that would enable us to integrate them in this study within the established deadlines. Thus, there are several data sources that could be used at low cost to begin addressing our weaknesses in terms of coastal zones.

In addition to the surveys mentioned above, additional data sources on coastal benthic invertebrates are available with a minimal investment. For instance, there is a clam survey covering all bays of the North Shore in the 1980s, data provided by Edwin Bourget, but not in electronic format yet. Another program sampled invertebrates colonizing buoys from the St. Lawrence over a period of nearly 10 years (1975-1985) and now two more years, i.e. 2004 and 2005 (P. Archambault, unpublished data). It is a great source of information for several coastal zone species. Again, these data are not yet in electronic format. Hydraulic trawl surveys have been conducted by the MLI, but the data must be processed before being used.

We therefore recommend the establishment of a corporate database for the many historical surveys already available at the DFO, in particular for bivalve surveys. It is uncommon to be able to sample in the past, and the importance of historical data should not be ignored, it will likely provide for interesting comparisons with contemporary data.

Finally, it would be interesting to explore the use of other integrating indices in additions to the single concentration index in order to develop other aspects from the different sectors of the LEGSL (productivity, diversity). The tight deadlines did not permit us to explore all possibilities. For example, a recently developed index, taxonomic distinctness (Clarke & Warwick, 1999), could be used with the kind of data we currently have, where different sectors of the study area are covered by a variable number of surveys, each focussing on different species.

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Appendix A Coastal Species

A.1 Arctic and Atlantic Surfclam

A.1.1 Methods

The methodology of these surveys has varied over time, especially in terms of gear and the units used to express the results. The most common fishing gear for the Arctic surfclam *Mactromeris polynyma* was the hydraulic dredge. The dredge's basket was sometimes doubled to capture juvenile specimens. In some cases, Arctic surfclams were by-catches in surveys using other fishing gear (Cyr, 1994; Brulotte, 1995; Lambert & Goudreau, 1997).

Commercial fishermen conducted the exploratory fisheries made in 2000-2001, with their commercial hydraulic dredge. These data were expressed in kg per fishing hour with a 1-meter-wide dredge. The results were expressed in relation to time since many fishermen tended to use non-linear patterns during the fishing activities and the distances between start and end positions were not representative of the actual distance fished.

Data for the Atlantic surfclam (*Spisula solidissima*) were collected in 1978, 1984 and 1985 exclusively around the Magdalen Islands (Bio Conseils Inc., 1986; Bernier & Poirier, 1979). Different boats were used during these three years. The specimens were sampled by hydraulic dredge (dredge dimensions varied from one year to another). In addition, Patrice Goudreau (DFAS, MLI) participated in all Arctic surfclam surveys in the Estuary and Quebec North Shore and has confirmed that the Atlantic surfclam has never been present in these samples. We have added these positions, with zero abundance for Atlantic surfclam, to produce our distribution map.

A.1.2 Results

The Arctic surfclam (Figure 65, above) is more northerly and lives in deeper and colder waters than the Atlantic surfclam (Figure 65, below). The Arctic surfclam is found along the north shore of the Estuary and Gulf and particularly in the western part of this area. It also occurs off the Magdalen Islands. The Atlantic surfclam is absent from the samples from the North Shore. It occurs at the Magdalen Islands, near the coast (infralittoral) on sandy bottoms (Giguère *et al.*, 2005). It is also occurs along the coasts of the sGSL, but we do not have quantitative data.

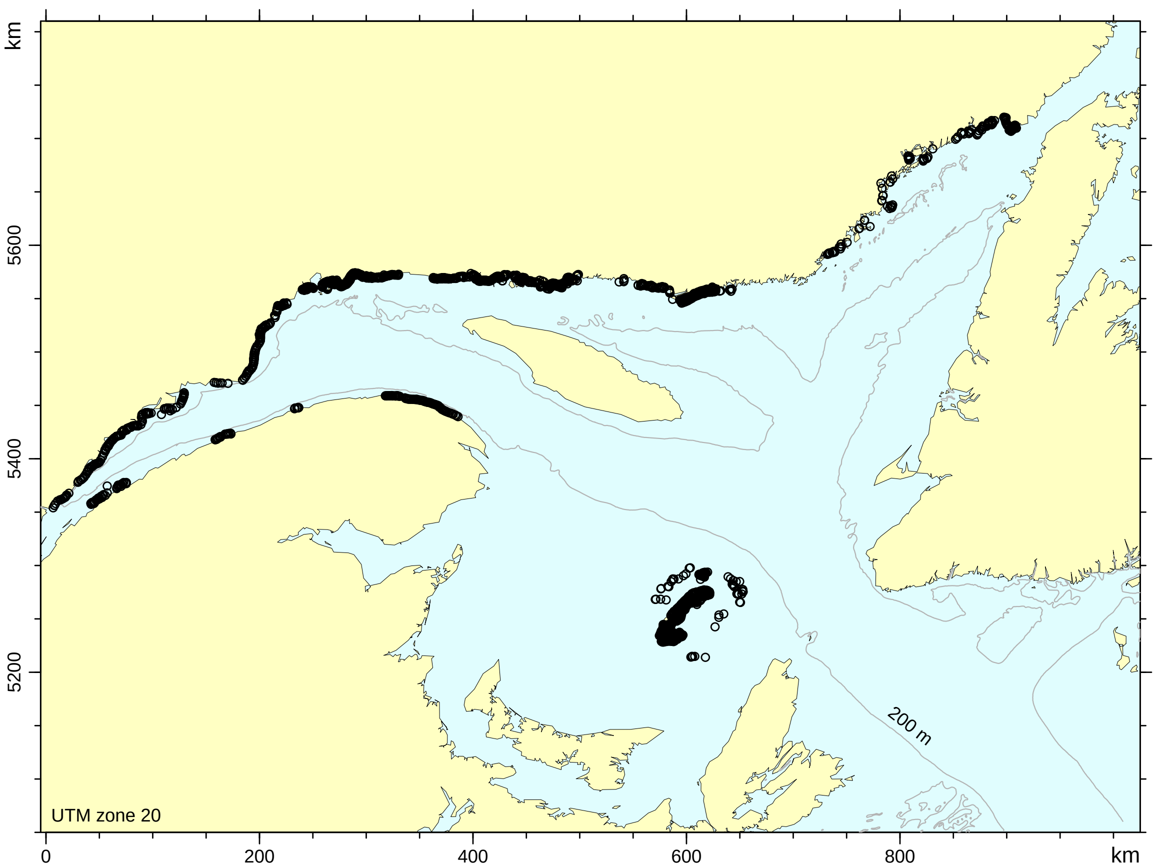

Figure 64 – Distribution of sampled stations during the Atlantic surfclam survey in the nGSL, 1978-2001 (11 years).

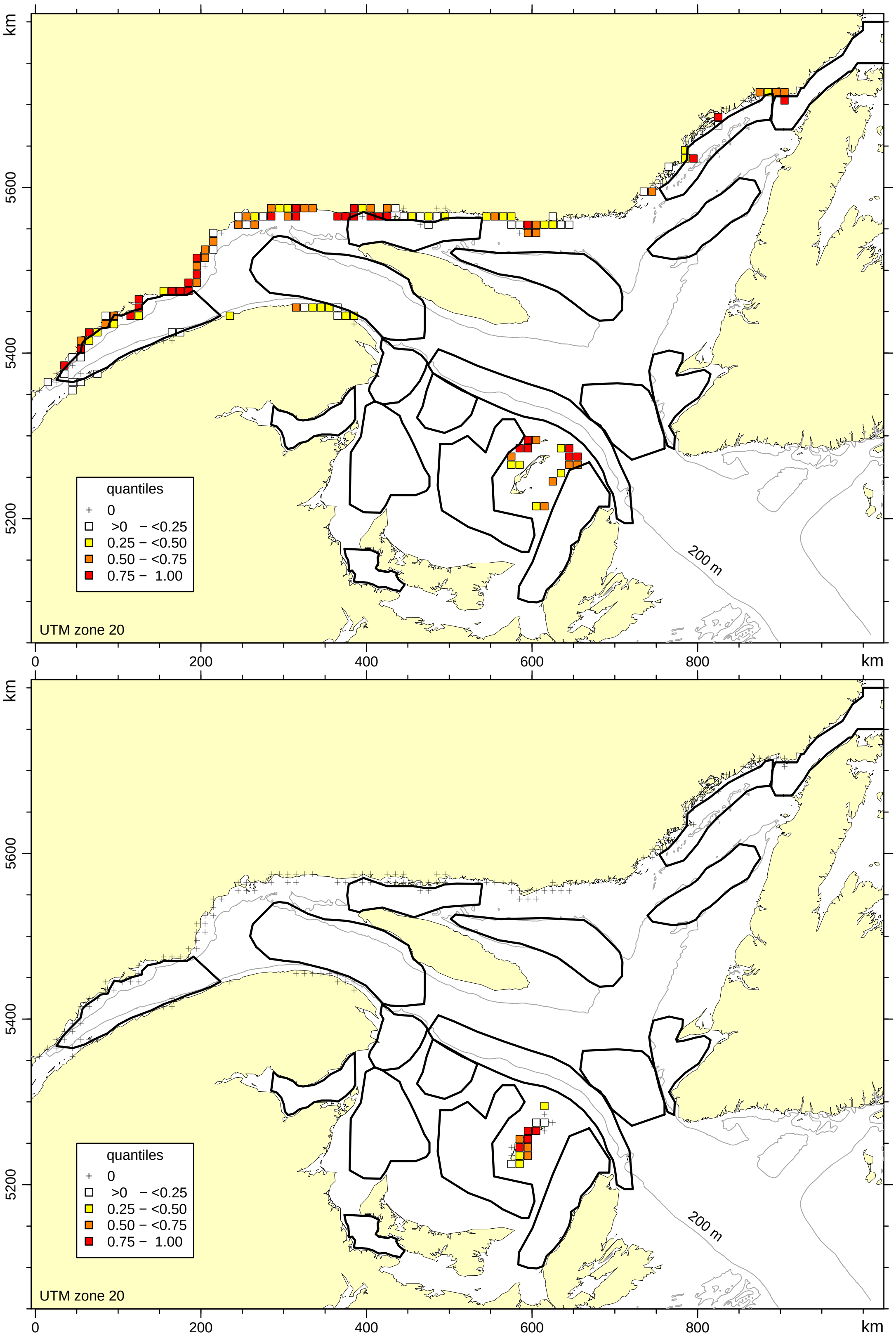

Figure 65 – Arctic surfclam (*Mactromeris polynyma*) (above) and Atlantic surfclam (*Spisula solidissima*) (below) distribution in the surfclam research surveys.

A.2 Softshell Clam

A.2.1 Methods

The softshell clam *Mya arenaria* were sampled with a shovel or venturi on the littoral on both sides of the Estuary, in the southern part of the Gaspé Peninsula including Chaleurs Bay, the Magdalen Islands and Jacques-Cartier Strait, during the period 2001-2005 (3,155 samples) (Figure 66, above) (Brulotte *et al.*, 2006).

A.2.2 Results

The geographical coverage of this survey is reduced compared to the entire LEGSL, but the largest concentrations are on the north shore of the Estuary, at the tip of the Gaspé Peninsula and in the Magdalen Islands (Figure 66, below).

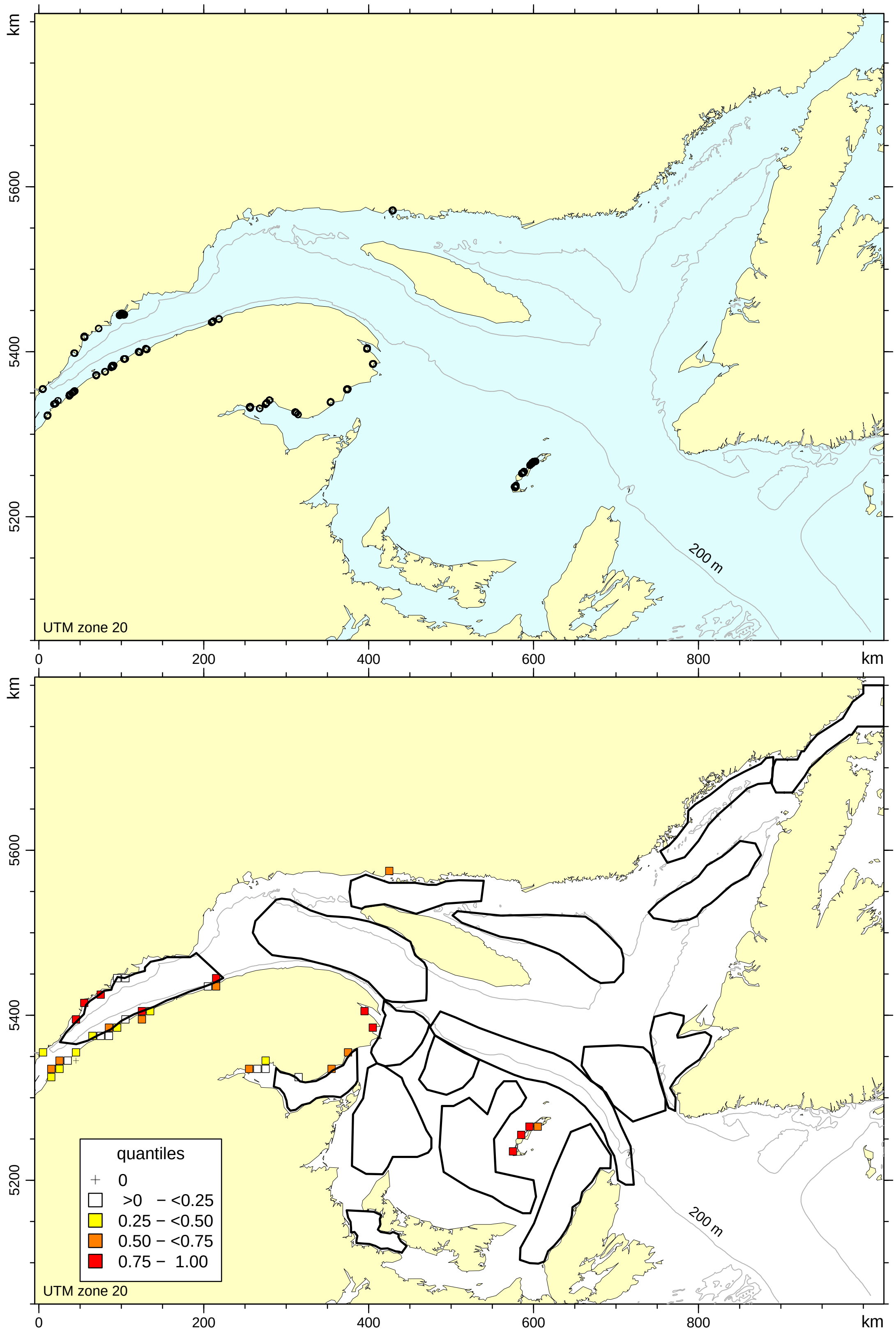

Figure 66 – Distribution of sampled stations (above) and of softshell clam (*Mya arenaria*) in the softshell clam research surveys for the period 2001-2005.

A.3 Sand Shrimp

A.3.1 Methods

This shrimp species was sampled during the fall surveys and the Northumberland Strait surveys in the sGSL. It would have been recognized had it been captured during the multispecies survey in the nGSL, these data were used as evidence of its absence.

A.3.2 Results

Grey sand shrimp are very coastal and are only present in the catches from the fall survey in Shediac Valley and Northumberland Strait (Figure 67). Much of its distribution is simply not covered by the survey. Its catchability by trawl in the fall and multispecies surveys may also be low, though the biggest reason for low or zero catches is no doubt that these surveys were not sufficiently near the infralittoral zone.

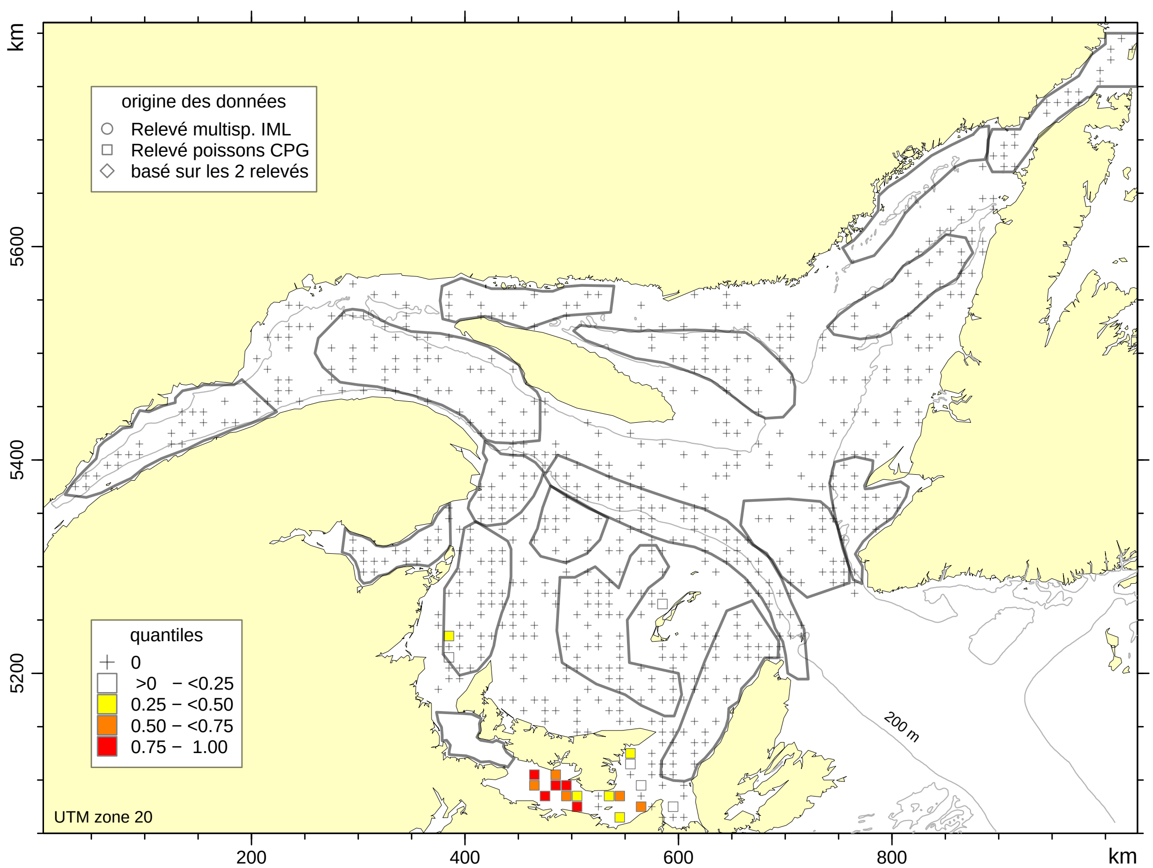

Figure 67 – Sand shrimp (*Crangon septemspinosa*) distribution based on the fall surveys in the sGSL.

A.4 Lobster

A.4.1 Methods

In the sGSL, lobster was measured on the Northumberland Strait survey (p. 11). However, no scientific survey targets lobster in the Quebec region (nGSL + Gasp• Peninsula + Magdalen Islands), other than one with limited spatial coverage at the Magdalan Islands, which is dedicated to the study of the non-commercial age class. Rather than dismissing this species, we have resolved to present the total commercial catches between 1999 and 2005 for each fishing sub-area. The approximate center of each sub-area was used to locate these catches on a map (Figure 68).

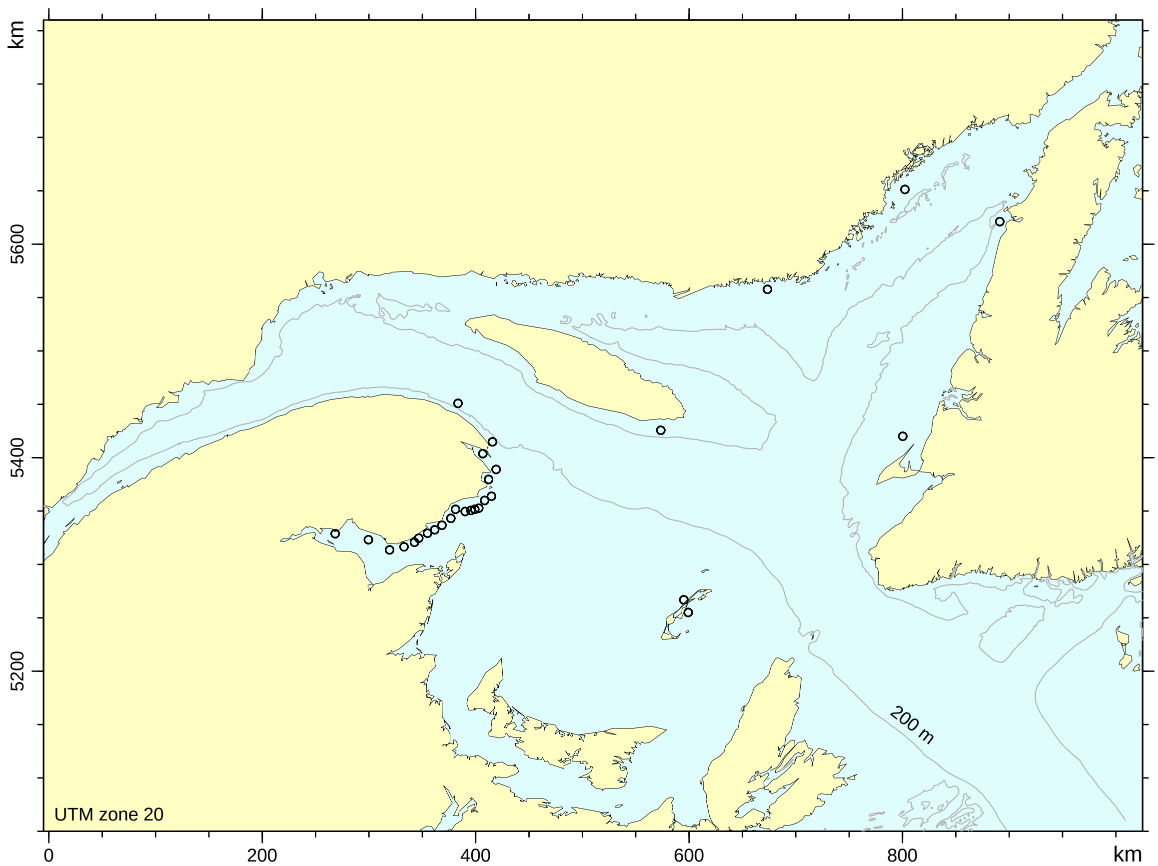

Figure 68 – Positions given to commercial lobster fishing sub-areas in the nGSL.

A.4.2 Results

Lobster is a coastal species very poorly represented in the surveys used: lobsters live at depths ranging from a few meters of water to about thirty meters, poorly covered by the surveys, except for the Northumberland Strait survey. Lobster distribution is very widespread and its abundance is relatively high almost everywhere in the sGSL, except perhaps in the center of Northumberland Strait. Its distribution in the nGSL is poorly known except by the landings. Available data suggests that Northumberland Strait is the area of peak abundance in the sGSL (Figure 69), which the fishing landings contradict. This is an artifact of the poor coverage of the infralittoral zone in our study. Lobster was much more abundant in the sGSL in the past, but is now reduced. This area does not receive any larval input from other areas and thus recruitment is limited to local spawning populations which have been declining.

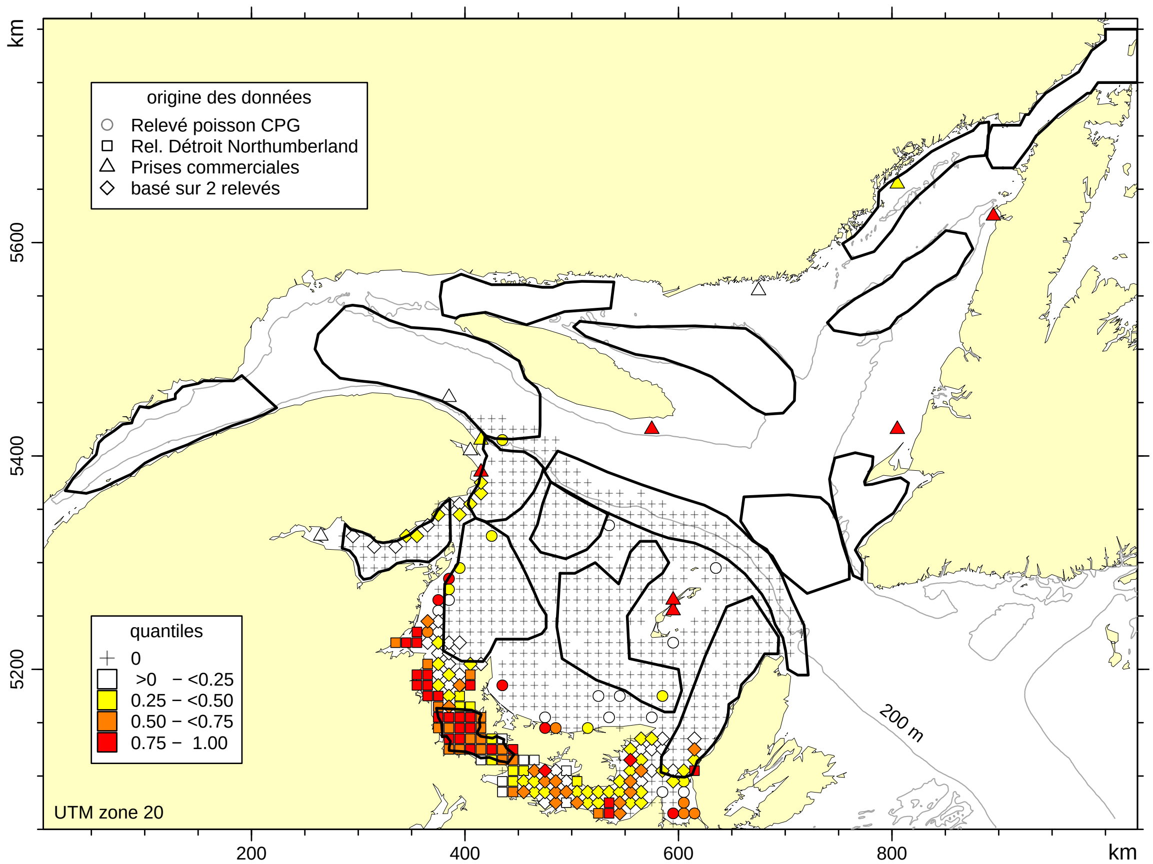

Figure 69 – American lobster (*Homarus americanus*) distribution based on the demersal fish surveys in the sGSL and the Northumberland Strait surveys. The relative abundance of commercial catches, with approximate positions, is also indicated for the Gaspé Peninsula, Magdalen Islands, Anticosti east, the west coast of Newfoundland and the North Shore.

A.5 Atlantic Rock Crab

A.5.1 Methods

See sections describing the fall and Northumberland Strait surveys in the sGSL, p. 8 and 11, respectively.

A.5.2 Results

Atlantic rock crab (*Cancer irroratus*) is very widespread very close to the coasts of Chaleurs Bay and Northumberland Strait (Figure 70). It is also present in Shediac Valley and the north shore of Prince Edward Island and around the Magdalen Islands. Its distribution is poorly known in the Estuary and nGSL because the surveys do not cover depths of less than 50 m.

Rock crab are a significant prey for lobster (Gendron *et al.*, 2001; Sainte-Marie & Chabot, 2002) and is part of a commercial fishery.

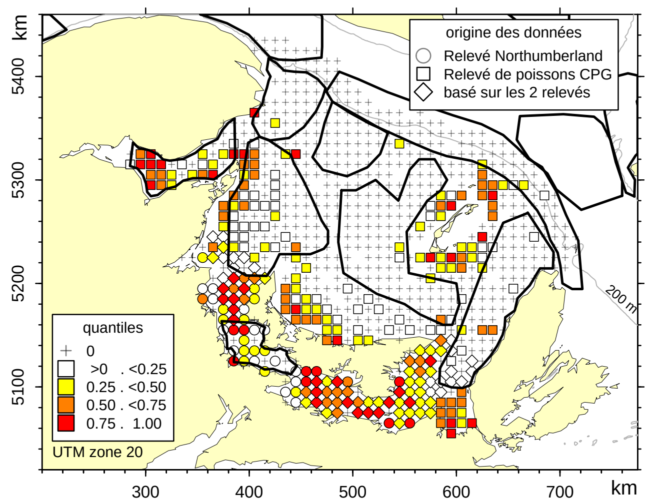

Figure 70 – Atlantic rock crab (*Cancer irroratus*) distribution based on the fall surveys in the sGSL and the Northumberland Strait surveys.