Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

C S A S / **S C C S**

Canadian Science Advisory Secretariat / **Secrétariat canadien de consultation scientifique**

Research Document 2007/015 / **Document de recherche 2007/015**

Not to be cited without permission of the authors *

Ne pas citer sans autorisation des auteurs *

Identification of Ecologically and Biologically Significant Areas for the Estuary and Gulf of St. Lawrence

Identification des zones d'importance écologique et biologique pour l'estuaire et le golfe du Saint-Laurent

Claude Savenkoff[1], Marie-Noëlle Bourassa[1], Daniel Baril[1], and / et Hugues P. Benoît[2]

[1]: Pêches et Océans Canada, Institut Maurice-Lamontagne,
C.P. 1000, 850 Route de la Mer, Mont-Joli, Québec, G5H 3Z4

[2]: Fisheries and Oceans Canada, Gulf Fisheries Centre,
343 Université Ave, Moncton, New Brunswick, E1C 9B6

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

Research documents are produced in the official language in which they are provided to the Secretariat.

This document is available on the Internet at:

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

Ce document est disponible sur l'Internet à:

http://www.dfo-mpo.gc.ca/csas/

ISSN 1499-3848 (Printed / Imprimé)

TABLE OF CONTENTS / TABLE DES MATIÈRES

Page

LIST OF TABLES ii

LIST OF FIGURES iii

ABSTRACT / RÉSUMÉ iv

INTRODUCTION 1

MATERIAL AND METHODS 1

Study area 1

Data used 2

Analyses 2

RESULTS 3

Overlaps of IAs identified for each biological layer with at least one high rank on the dimension *uniqueness* 3

Overlaps of IAs identified for each biological layer with at least one high rank (3) on the dimension *aggregation* 3

Overlaps of IAs identified for each biological layer with at least one high rank (3) on the dimension *fitness consequences* 4

Overlaps of IAs selected for each biological layer with at least one high rank on one of the three criteria (sum of the three main criteria) 4

IA scores summed over all biological layers and all of the 3 main EBSA dimensions 4

Description of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence 5

DISCUSSION 6

Comparisons of the proposed EBSAs and the IAs identified by the “topography and physical processes” layer 6

Comparisons between the proposed EBSAs and the IAs identified by the Delphic approach 7

Regions with little biological information 7

Other sources of uncertainty 7

CONCLUSION 8

ACKNOWLEDGMENTS 8

REFERENCES 9

Tables / Tableaux 10

Figures 32

LIST OF TABLES

Table 1. Three main dimensions used to characterize important areas 10

Table 2. Two additional dimensions used to characterize important areas 11

Table 3. Layering exercise comparing areas of physical and biological importance at three trophic levels 12

Table 4. Characteristics of the important areas (IAs) identified in the "primary production" layer 13

Table 5. Characteristics of the important areas (IAs) identified in the "secondary production" layer 14

Table 6. Characteristics of the important areas (IAs) identified in the "meroplankton" layer 16

Table 7. Characteristics of the important areas (IAs) identified in the "benthic invertebrates" layer 17

Table 8. Characteristics of the important areas (IAs) identified in the "pelagic fishes" layer 19

Table 9. Characteristics of the important areas (IAs) identified in the "demersal fishes" layer 21

Table 10. Characteristics of the important areas (IAs) identified in the "pinnipeds and cetaceans" layer 23

Table 11. Number and surface area of the different important areas identified for each biological layer 25

Table 12. Description of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence 26

Table 13. Description of IAs discarded during the Mont-Joli workshop 28

Table 14. Comparison of overlaps between the EBSAs and the IAs (hydrodynamic features) identified by the "topography and physical processes" layer 30

Table 15. Comparison of overlaps between the EBSAs and the IAs identified by the Delphic process 31

LIST OF FIGURES

Figure 1. Important areas (IAs) highlighted using a modified Delphic process (scientific knowledge advisory approach)....32

Figure 2. Map of the lower Estuary and Gulf of St. Lawrence showing the 200 m isobath 33

Figure 3. Important areas identified in the “topography and physical processes” layer 34

Figure 4. Important areas identified in the “primary production” layer....35

Figure 5. Important areas identified in the “secondary production” layer 36

Figure 6. Important areas identified in the “meroplankton” layer....37

Figure 7. Important areas identified in the “benthic invertebrates” layer 38

Figure 8. Important areas identified in the “pelagic fishes” layer....39

Figure 9. Important areas identified in the “demersal fishes” layer 40

Figure 10. Important areas identified in the “pinnipeds and cetaceans” layer....41

Figure 11. Locations sampled for at least one of the layers....42

Figure 12. Number of biological layers for which a high rank for *uniqueness* was reported for a given area 43

Figure 13. Number of biological layers for which a high rank for *aggregation* was reported for a given area 44

Figure 14. Number of biological layers for which a high rank for *fitness consequences* was reported for a given area 45

Figure 15. Quantile distribution of the criteria scores summed across thematic layers and EBSA dimensions for cases where there was a high rank on at least one of the three dimensions 46

Figure 16. Quantile distribution of the criteria scores summed across thematic layers and EBSA dimensions....47

Figure 17. Number of overlapped biological layers without criteria scores summed across thematic layers and EBSA dimensions....48

Figure 18. Location of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence....49

ABSTRACT

This report describes the analyses presented in a regional workshop held in Mont-Joli (Qc.) in order to synthesize the information across thematic layers based on physical, chemical, and biological data and identify the ecologically and biologically significant areas (EBSAs) for the Gulf of St. Lawrence Integrated Management (GOSLIM) initiative. Across all thematic layers, 96 important areas (IAs) have been identified based on the best scientific information available (geographically referenced data). These IAs are all characterized by specific scores for each of three main dimensions used to define EBSAs: uniqueness, aggregation, and fitness consequences. In synthesizing IAs across thematic layers, two general approaches were used based on: (1) each of the three main dimensions used separately and (2) the sum of their scores. The workshop concluded by identifying ten regions as EBSAs for the Estuary and the Gulf of St. Lawrence, covering 77,184 km^2 (30% of the total area). All ten proposed EBSAs are related, at least in part, to IAs previously identified by a Delphic (expert opinion) approach. Potential sources of uncertainty and recommendations for the definition of EBSAs in other systems or in the present one in the future are discussed.

RÉSUMÉ

Ce rapport décrit les analyses présentées lors d'un atelier de travail régional tenu à Mont-Joli (Qc) afin de synthétiser l'information de couches thématiques basées sur des données physiques, chimiques et biologiques et d'identifier les zones d'importance écologique et biologique (ZIEBs) pour la gestion intégrée du golfe du Saint-Laurent (GIGSL). Pour l'ensemble des couches thématiques, 96 aires importantes (AIs) ont été identifiées à partir de la meilleure information scientifique disponible (données géographiquement référencées). Ces AIs sont toutes caractérisées par des scores spécifiques pour chacune des trois principales dimensions utilisées pour définir les ZIEBs : unicité, concentration et conséquences sur la valeur adaptative. Lors du processus de synthèse des AIs à travers les couches thématiques, deux approches générales ont été utilisées en se basant sur (1) chacune des trois principales dimensions utilisées séparément et (2) la somme de leurs scores. L'atelier a conclu en identifiant 10 régions comme ZIEBs pour l'estuaire et le golfe du Saint-Laurent, couvrant 77,184 km^2 (30 % de la superficie totale). Toutes les 10 ZIEBs proposées sont associées au moins en partie aux AIs identifiées par l'approche Delphique (opinion d'experts). Des sources potentielles d'incertitude et des recommandations pour la définition des ZIEBs dans d'autres systèmes ou celui-ci dans l'avenir sont discutées.

INTRODUCTION

Canada's Oceans Act authorizes Fisheries and Oceans Canada (DFO) to take an Ecosystem Approach to the integrated management of human activities in the sea. This is being pursued in five Large Ocean Management Areas (LOMAs), for which Integrated Management Plans are being developed. One of the four components of setting Ecosystem Objectives for the LOMAs is the identification of ecologically and biologically significant areas (EBSAs). Certain ocean areas can be significant from a biological or ecological point of view because of the functions they fulfill in the ecosystem and/or because of structural properties. Many functional activities, such as fish feeding and spawning, occur throughout the ocean. To operationalize the term "significant", it is first necessary to determine if specific areas and species are particularly significant for each function and then, if they deserve special attention in the context of an integrated management plan. Guidance to this end is provided in DFO (2004).

At a conceptual level, there are three main criteria or dimensions along which specific areas can be evaluated with regard to their ecological and biological significance: uniqueness, aggregation, and fitness consequences (Table 1) (DFO, 2004). Interpretation of specific cases on these three dimensions should take into account two additional dimensions on which specific areas can be evaluated: resilience and naturalness (Table 2). Further detail and clarification on the interpretation and application of each of these dimensions can be found in DFO (2004).

A zonal workshop was held in Moncton (N.B.) from February 21 to 23, 2006 in order to launch the EBSA identification process for the Gulf of St. Lawrence Integrated Management (GOSLIM) initiative (DFO, 2006a). This meeting, based on a scientific knowledge advisory approach (consultative or "Delphic" approach), identified a certain number of potential large important areas (IAs) for this ecosystem (Figure 1 and Table 3). A second approach, of a more analytical nature and based on available information layering, was suggested as the next step for EBSA identification in the Estuary and the Gulf of St. Lawrence (DFO, 2006a). Eight thematic (information) layers were therefore identified:

Topography and physical processes
Primary production
Secondary production
Meroplankton (fish and invertebrate larvae)
Benthic invertebrates (molluscs, crustaceans, anthozoa, etc.)
Pelagic fish
Demersal fish
Pinnipeds and cetaceans

For each thematic layer, different IAs have been identified based on the best scientific information available (geographically referenced data). Except for the "topography and physical processes" layer for which other processes were used for IA identification, experts also provided rankings of each IA they identified according to each of the five EBSA dimensions. A workshop was held in Mont-Joli (Qc.) from December 5 - 7 2006 in order to synthesize the information across thematic layers. This synthesis along with the analyses conducted during the workshop which led to the identification of EBSAs for the Estuary and Gulf of St. Lawrence are presented in this report.

MATERIAL AND METHODS

Study area

The Gulf of St. Lawrence (GSL) is a highly-stratified semi-enclosed sea connected to the North Atlantic Ocean through the Cabot Strait to the southeast and through the Strait of Belle-Isle to the northeast (Koutitonsky and Bugden, 1991) (Figure 2). The Cabot Strait (104 km wide and 500 m deep) is an order of magnitude wider and deeper than the Strait of Belle Isle (16 km wide and 60 m deep) and is the only significant passage for the penetration of deep North Atlantic waters into the Gulf (Koutitonsky and Bugden, 1991).

Two deep channels (Laurentian and Esquiman), with depth exceeding 200 m, cover nearly 50% of the total GSL surface area; most of the remainder is largely occupied by the Magdalen Shallows, a productive shelf area averaging 50 m depth, located in the southern part of the Gulf (Figure 2). The Laurentian Channel, a glacially overdeepened trough system starts at the Atlantic Ocean margin and enters the Gulf through Cabot Strait before branching into the St. Lawrence Estuary to the northwest and the Esquiman Channel to the northeast. A branch of the Esquiman Channel, the Anticosti Channel, separates Anticosti Island from the north shore of the Gulf. At its eastern end, the Anticosti Channel is about 110 km wide with a maximum depth of about 250 m. The bathymetry then converges towards the west to a narrow 30 km passage where depths exceed 100 m only in the mid-channel area (Koutitonsky and Bugden, 1991). The GSL has an estuarine circulation, where runoff from the St. Lawrence drainage system is balanced by a deep inflow of oceanic waters through the Laurentian Channel.

Data used

The different IAs identified by each information layer based on the best scientific information available were used in this synthesis. Each IA was characterized by specific values for each of the three main EBSA dimensions, with some layers also scoring in the 4th and 5th dimensions. In order to have a consensus in the ranking processing among the layers, only the three main dimensions were used. The scores for each dimension and layer ranged from 1 for a low overall rating, to 3 for a high overall rating. The characteristics and the location of the different IAs identified by each information layer are presented in Tables 4 to 10 and Figure 3 to 10 (No table for the "Topography and physical processes" layer). Details of the methods, data and descriptions of the different IAs for each layer are given in the corresponding reports and are not repeated here (Gilbert et al., 2007; Lavoie et al., 2007; Plourde et al., 2007; Ouellet, 2007, McQuinn et al., 2007, Swain and Benoît, 2007, Castonguay and Valois, 2007; Lesage et al., 2007). Overall 96 IAs were identified (Table 11).

Generally speaking, there were differences among layers in the resolution and occasionally the quality of the data. For example, some data were excluded from the respective analyses because of lack of georeferencing or because suitable electronic versions of the data were not available in the time-frame provided for defining IAs. In other cases, large areas of the Gulf were poorly sampled, leaving data gaps. These areas include the shallower coastal regions in general, as well as the upper Estuary, the Middle and Lower North Shore, the waters southeast of Anticosti Island, a portion of the west coast of Newfoundland, and the nearshore waters of the Magdalen Islands (Figure 11). Furthermore, much of the data come from large scale surveys that are not amenable to defining fine scale IAs. All these factors needed to be considered when synthesizing data across layers to ensure that, to the extent possible, significance was judged based on merit and not scientific sampling intensity. Sources of uncertainty, data gaps, and recommendations for future surveys are identified however.

Analyses

The IAs were analyzed based on: (1) each of the three main criteria used separately and (2) the sum of their scores.

The first analysis is justified because an area can be identified as an EBSA if it ranks highly on one or more of the three main dimensions, uniqueness, aggregation and fitness consequences for a single species or habitat feature (DFO, 2004). The three main dimensions were therefore considered independently, overlaying across thematic layers only the IAs in which a high rank was reported. The resulting three synthesis maps therefore indicate the number of layers for which a high score was reported at least once, for a given area. The main potential EBSAs were identified as the regions with the largest number of overlapping high-ranking IAs from the thematic maps.

The second type of analysis considers the cumulative importance of a wide range of attributes (dimensions). By doing so, areas that possess a low or intermediate rank across a large number of EBSA dimensions and thematic layers can also be considered potential EBSAs. Two approaches were taken to look at cumulative importance. In the first, criteria scores were summed over thematic layers and criteria, and then binned into quantiles to produce a new index for mapping. However, because justification for identifying an area as an EBSA is stronger when it ranks highly in at least one feature/dimension (DFO, 2004), a second approach was also taken, in which such a constraint was added. The IAs for each thematic layer with at least one high rank for one of the three dimensions were selected. The scores were then summed over thematic layers and dimensions, and again binned into quantiles for mapping.

RESULTS

Overlaps of IAs identified for each biological layer with at least one high rank on the dimension *uniqueness* (Figure 12)

For high uniqueness ranks, four main potential EBSAs have been identified based on the IA overlaps:

1) Lower Estuary (overlap of three biological layers: primary production [IA#1; see in corresponding table], secondary production [1], and demersal fishes [1]).

2) Northeast Anticosti Island (overlap of three biological layers: primary production [3], secondary production [2], and meroplankton [1]).

3) Western Northumberland Strait (overlap of three biological layers: meroplankton [5], benthic invertebrates [13], and demersal fishes [12]).

4) St. Georges Bay (overlap of three biological layers: meroplankton [5], pelagic fishes [7], and demersal fishes [11]).

Overlaps of IAs identified for each biological layer with at least one high rank (3) on the dimension *aggregation* (Figure 13)

For high aggregation ranks, nine main potential EBSAs have been identified based on the IA overlaps:

1) Lower Estuary (overlap of three biological layers: primary production [1], secondary production [1], and demersal fishes [1]).

2) Tip of Gaspé Peninsula (overlap of four biological layers: secondary production [6], meroplankton [5], benthic invertebrates [17], and pelagic fishes [1]).

3) Baie des Chaleurs (overlap of three biological layers: secondary production [6], meroplankton [5], and pelagic fishes [1]).

4) Western Northumberland Strait (overlap of three biological layers: meroplankton [5], benthic invertebrates [13], and demersal fishes [12]).

5) St. Georges Bay (overlap of three biological layers: meroplankton [5], pelagic fishes [9], and demersal fishes [11]).

6) Inverness/Port Hood, N.S., area (overlap of three biological layers: secondary production [4], meroplankton [5], and benthic invertebrates [11]).

7) Cape Breton Trough (overlap of three biological layers: meroplankton [5], benthic invertebrates [11], and demersal fishes [10]).

8) East slope of the Esquiman Channel (overlap of three biological layers: meroplankton [3], pelagic fishes [4 and 19], and demersal fishes [6]).

9) Strait of Belle Isle (overlap of three biological layers: benthic invertebrates [6], pelagic fishes [2, 6, and 10], and pinnipeds and cetaceans [1]).

Overlaps of IAs identified for each biological layer with at least one high rank (3) on the dimension *fitness consequences* (Figure 14)

For fitness consequence ranks, four main potential EBSAs have been identified based on the IA overlaps:

1) Lower Estuary (overlap of three biological layers: primary production [1], secondary production [1], and demersal fishes [1]).

2) Baie des Chaleurs (overlap of three biological layers: secondary production [4], meroplankton [5], and pelagic fishes [3]).

3) Western Northumberland Strait (overlap of three biological layers: meroplankton [5], benthic invertebrates [13], and demersal fishes [12]).

4) West of Cape Breton (overlap of three biological layers: secondary production [4], meroplankton [5], and demersal fishes [10]).

Overlaps of IAs selected for each biological layer with at least one high rank on one of the three criteria (sum of the three main criteria; Figure 15)

Based on the highest quantile scores and IA overlaps, eight main potential EBSAs have been identified by integrating across EBSA dimensions: (1) Lower Estuary, (2) coast of the Northwest Gulf (North Shore), (3) northeast Anticosti Island, (4) southwest coast of the Magdalen Shallows including the tip of Gaspé Peninsula, Baie des Chaleurs, Shediac Valley, Miscou Bank, and the western Northumberland Strait, (5) southeast of the Bradelle Bank, (6) west of Cape Breton including the eastern Northumberland Strait and the St. Georges Bay, (7) West Newfoundland and Esquiman Channel, and (8) the Strait of Belle Isle. In comparison with the three individual dimension maps considered separately (Figures 12-14), all the main potential EBSAs are characterized by a high score for the cumulative index used.

IA scores summed over all biological layers and all of the 3 main EBSA dimensions (Figure 16)

IA scores were summed across layers and dimensions, irrespective of specific score levels, to produce a cumulative index. This index is mapped using quantiles (Figure 16). Areas identified using this cumulative index include the Baie des Chaleurs-Shediac Valley area, parts of the Magdalen shallows, the waters west of Cape Breton, the southern slope of the Laurentian channel, the eastern slope of the Esquiman channel, the Strait of Belle Isle, north Anticosti Channel, parts of the western Gulf, and the lower Estuary. There is a general congruence between the high scoring areas in Figures 15 and 16. Exceptions include the western portion of the Northumberland Strait which is highlighted in Figure 15 but scored only moderately in Figure 16, and central portions of the Magdalen Shallows, the southern slope of the Laurentian channel, and the northeast Anticosti Island for which the reverse is true.

Finally, the number of overlapping IAs across thematic layers and dimensions was also mapped (Figure 17). The objective was to ensure that low-scoring areas on a high number of thematic layers and dimensions were not overlooked. Areas for which at least half of the IAs identified in the thematic layers, include all those identified in Figure 16, with the addition of Cabot Strait and the Gaspé current.

Description of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence (Figure 18 and Table 12)

All the previous analyses highlight several common potential regions. Ten regions were identified as ecologically and biologically significant areas during the Mont-Joli workshop:

1) Lower Estuary (EBSA # 6) with 9,046 km^2 is an overlap of 5 IAs from 5 biological layers and covers 3.5% of the study area.

2) Northeast Anticosti Island (EBSA # 7) with 3,822 km^2 is an overlap of 11 IAs from all the 7 biological layers and covers 1.5% of the study area.

3) Southwestern Gulf including the tip of Gaspé Peninsula, Baie des Chaleurs, Shediac Valley, and Miscou Bank (EBSA # 5) with 13,506 km^2 is an overlap of 19 IAs from all the 7 biological layers and covers 5.3% of the study area.

4) Western Northumberland Strait (EBSA # 3) with 2,194 km^2 is an overlap of 4 IAs from 4 biological layers and covers 0.9% of the study area.

5) St. Georges Bay (EBSA # 2) with 1,216 km^2 is an overlap of 9 IAs from 6 biological layers and covers 0.5% of the study area.

6) West of Cape Breton (EBSA # 1) with 8,198 km^2 is an overlap of 11 IAs from all 7 biological layers and covers 3.2% of the study area.

7) South slope of the Laurentian Channel (EBSA # 4) with 5,941 km^2 is an overlap of 15 IAs from all 7 biological layers and covers 2.3% of the study area.

8) Northeast of Anticosti Channel and Jacques Cartier Passage (EBSA # 8) with 7,620 km^2 is an overlap of 10 IAs from all 7 biological layers and covers 3.0% of the study area.

9) West Newfoundland and Esquiman Channel (EBSA # 10) with 18,238 km^2 is an overlap of 20 IAs from all 7 biological layers and covers 7.1% of the study area.

10) Strait of Belle Isle and Coast of the Lower North Shore including the Mécatina Deep (EBSA # 9) with 7,403 km^2 is an overlap of 12 IAs from 5 biological layers and covers 2.9% of the study area.

Details about these EBSA, including descriptions of the biological and physical characteristics that contribute to their significance are given in DFO (2007). The estuary and Gulf LOMA covers a total of 255,845 km^2. The 10 areas identified here as EBSAs cover 77,184 km^2 and then represent 30% of the total area. This corresponds with a recommendation from the regional Eastern Scotian Shelf

Integrated Management (ESSIM) workshop on significant areas that ≤ 40% of the total area should be assigned EBSA status (DFO, 2006b).

Several potential IAs, including some with at least one high rank on one of the three dimensions were discarded during the Mont-Joli workshop. For some, the spatial extent of the area was reduced (northwest gulf [Anticosti Gyre and north shore], central Laurentian region, south Northumberland area, Beaugé bank, Cabot Strait and Laurentian Channel, south slope of the Laurentian Channel in the Cabot Strait area), whereas others were completely rejected (Gaspé Current, Bradelle Bank) (Table 13). The Gaspé current IA was rejected because this region is mainly influenced by the hydrodynamic processes and productivity occurring in the lower Estuary. Because its perceived significance was judged to result mainly from upstream processes, the decision was made to attribute that significance accordingly to the upstream area. For its part, the Bradelle Bank was rejected because although it is characterized by an above average level of aggregation and abundance for a number of species, most of these species are generally widely distributed in other areas.

DISCUSSION

Comparisons of the proposed EBSAs and the IAs identified by the “topography and physical processes” layer

The framework and the concepts of ecological and biological significance may work best when applied to defined geographic sites or physical features. An advantage of largely identifying EBSAs based on physical features of the marine environment is greater ease in determining boundaries, as these are well defined and mapped in many cases. Nonetheless the locations of some features, particularly physical and biological oceanographic ones, may vary substantially seasonally and inter-annually, and still be ecologically and biologically significant. Spatial and temporal scales are both important to application of the framework to identify boundaries of areas considered ecologically and biologically significant. In these cases, documenting the range of interannual boundary location change is important.

Overall, nine out of ten proposed EBSAs for the Estuary and the Gulf of St. Lawrence are captured at least in part by the oceanographic IAs (Table 14; Figures 3 and 18). This represents an areal overlap of about 22%. Only, the St. Georges Bay EBSA is not characterized by main distinguishable hydrodynamic features. Several oceanographic IAs are completely overlapped by the EBSAs while others did not score highly as potential EBSAs (Figures 3 and 18), most notably those around Anticosti island and along Québec’s north shore.

Except the St. Georges Bay, all EBSAs were characterized by shear-based retention features dependant on both horizontal and vertical current patterns (Gilbert et al., 2007). The Lower Estuary, the southwest coast of the Magdalen Shallows, and the Strait of Belle Isle also contain areas of upwelling. Specifically, the Lower Estuary is characterized by intense vertical mixing and upwelling near the head of the Laurentian Channel (Koutitonsky and Bugden, 1991). Upwelling generated by wind occurs along the Lower north shore (e.g., in the “Strait of Belle Isle” EBSA), the south shore of Anticosti Island, and the north shore of Baie des Chaleurs (e.g., in the “southwest coast of the Magdalen Shallows” EBSA) (Gilbert et al., 2007). Tidal mixing, in which tidal energy is focused by the funnelling effect associated with shallower water and the narrowing geometry of the coast, can be observed at the head of the Lower Estuary, the head of Baie des Chaleurs (e.g., in the “southwest coast of the Magdalen Shallows” EBSA), the western Northumberland Strait, the northeast tip of Prince Edward Island (e.g., in the “west of Cape Breton” EBSA), and the Strait of Belle Isle. Finally, the western Northumberland Strait is characterized by relatively high summer temperatures and a strong annual temperature cycle, while the Lower Estuary is consistently cooler and undergoes considerably less pronounced seasonal changes (Gilbert et al., 2007).

A large part of the North Shore coast and the south shore of Anticosti Island, where upwellings occur, are not related to EBSAs. Also, the upper St. Lawrence Estuary, an area of high tidal mixing, is not captured by the EBSAs due to the lack of biological data in this region. This represents an important data gap that ideally would be filled prior to future revisions of the EBSAs for the Gulf of St. Lawrence. Finally, some retention regions such as the Anticosti Gyre (northwestern Gulf), the southeast Anticosti Island, and the south Northumberland Strait, did not score highly as potential EBSAs, despite being studied with intensities comparable to other EBSA areas.

Comparisons between the proposed EBSAs and the IAs identified by the Delphic approach

We examined the extent to which the initial biological IAs identified by the Delphic approach (DFO, 2006a) overlap each identified EBSA. The Delphic IAs cover 180,555 km^2 or ~71% of the total area. In contrast, the final EBSAs identified here represent ~30% of the total area. Given the large area covered by IAs defined using the Delphic approach, it is perhaps not surprising that there exists a good congruence between those IAs and the EBSAs proposed here. All ten of the proposed EBSAs are related to the Delphic IAs with a mean overlap of 84% (Table 15). The EBSAs that are only partially overlapped by the Delphic IAs are the northeast Anticosti Island (63%), the southwest coast of the Magdalen Shallows (56%), the south slope of the Laurentian Channel (58%), while the overlap between the other EBSAs and the Delphic IAs is at least 90% (Table 15).

Discrepancies between the two approaches are mainly for the upper Estuary, the Anticosti Gyre (northwestern Gulf), the whole North Shore, the east of the Magdalen Islands (center of the Magdalen Shallows), and the southeast of Anticosti Island. These regions were identified by the Delphic approach, but did not score highly as potential EBSAs. Refinement of areas in light of the data was proposed during the workshop as one of the principal reasons for the smaller scale of the EBSAs proposed here as compared to the Delphic IAs.

Regions with little biological information

The different IAs identified by each information layer were based on the best scientific information available. However, there are several large areas of the Gulf which were poorly sampled in general, leaving data gaps. These areas include the shallower coastal regions in general, the upper Estuary, the Middle and Lower North Shore, the waters southeast of Anticosti Island, a portion of the west coast of Newfoundland, and the nearshore waters of the Magdalen Islands (Figure 11). With the exception of the Estuary, lack of sampling in these areas reflects, among other things, their very rough bottom which prevents sampling by bottom-trawl during the large scale surveys. Filling the data gaps in these areas for many species will be very difficult as a consequence. It is notable that these regions were identified by the Delphic approach (i.e., perceived as significant based on expert opinion), but not captured by our present analyses with the data at hand.

It is also important to note when interpreting Figure 11 that the map represents sampling density across all thematic layers. Consequently, for the most part, the map reflects the distribution of bottom-trawl survey sets. Areas with important data gaps for layers not informed by those surveys (i.e., lower trophic levels and marine mammals) exist and are documented in the respective research documents mentioned previously.

Other sources of uncertainty

Data considerations aside, the process of identifying EBSAs is characterized by a number of sources of uncertainty that may affect the selection of particular areas. While the gathering and standardization of data inputs to the exercise were done with the highest scientific rigour possible in the time frame provided, the synthesis of those data both within and across thematic layers remains a partly philosophical exercise, despite some scientific guidance (DFO, 2004). For example, within thematic layers, some authors took a more inclusive approach (e.g., McQuinn et al., 2007) whereas others strove for exclusivity (e.g., Swain and Benoît, 2006). The scientific process cannot be used to judge the superiority of one approach; the decision remaining one of philosophy and policy (what do we consider significant). Indeed, a simple constraint as to the number and size of areas desired could greatly help to structure the debate, as it does in the planning for marine protected areas, by establishing a threshold for significance. This is almost necessary because while ecological and biological significance can be qualified relatively easily, its quantification is considerably more difficult. Aside from physical structures with very clear boundaries (e.g., seamounts), most processes in the marine environment have continuous spatial distributions that are just not amenable for informing the scale at which EBSAs should be defined.

Subjectivity also exists in the final synthesis of IAs across thematic layers. We have shown here only a few ways in which layers can be superimposed. While there is an encouraging general congruence among layers, it is clear that the open boundaries (i.e., those not constrained by physical features such as land and the sea floor) of EBSAs are not precisely defined. Furthermore, no consideration was given at the workshop as to the weightings attributed to different layers. Should layers composed of a vastly different number of species (e.g., benthic invertebrates vs. marine mammals) be given equal weights? Should there also be weighting for the precision of data inputs in each layer?

These are but a few of the considerations that should meaningfully be addressed prior to future revisions of the EBSAs defined here. In most cases, they will require firm decisions on policy and approach to provide a more consistent determination than was possible here in the current context.

CONCLUSION

EBSAs are just one component in the suite of science advice in support of ecosystem-based management. The framework in which EBSA advice will be presented and used by managers to provide enhanced management has yet to be developed. Analyses conducted during the Mont-Joli workshop and presented here synthesize information across thematic layers, ultimately leading to the identification of ten potential EBSAs for the Estuary and Gulf of St. Lawrence. These were based on the best scientific data available. However, several data sets that do not currently exist in electronic format or for which considerable standardization is required were not included as a result of the time frame provided. In light of these potentially informative data sets, the uncertainties listed in the previous section and the interannual dynamism of ecosystems, it is advisable that the definition of EBSAs for the Estuary and Gulf of St. Lawrence should be revisited in the future. Indeed this is a general recommendation for EBSAs (DFO, 2004).

ACKNOWLEDGEMENTS

We are grateful to all project contributors who made data available for this report. Gratitude is extended to Réjean Dufour and Michel Gilbert for coordinating the project and to the SIGHAP team (David Gauthier) for their expertise.

REFERENCES

Castonguay, M., and Valois, S., 2007. Ecologically and biologically significant areas for demersal fishes in the northern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/014.

Chabot, D., Rondeau, A., Surette, T., Sainte-Marie, B., and Archambault, P., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Benthic invertebrates (molluscs, crustaceans). DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

DFO, 2004. Identification of Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Ecosystem Status Report 2004/006.

DFO, 2006a. Proceedings of the Zonal Workshop on the Identification of Ecologically and Biological Significant Areas (EBSA) within the Gulf of St. Lawrence and Estuary. DFO Can. Sci. Advis. Sec. Proceedings Series. 2006/011.

DFO. 2006b. DFO/FSRS Workshop on Inshore Ecosystems and Significant Areas of the Scotian Shelf, January 16-19, 2006. DFO Can. Sci. Advis. Sec. Proceedings Series. 2006/002.

DFO, 2007. Zones d'importance écologique et biologique (ZIEB) de l'estuaire et du Golfe du Saint-Laurent : Identification et caractérisation. DFO Can. Sci. Advis. Sec. Science Advisory Report, 2007/016

Gilbert, D., Chassé, J., and Larouche, P., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Physical oceanography and topography. DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

Koutitonsky, V.G., and Bugden, G.L., 1991. The physical oceanography of the Gulf of St. Lawrence: a review with emphasis on the synoptic variability of the motion. In The Gulf of St. Lawrence: small ocean or big estuary? Edited by J.-C. Therriault. Canadian Special Publication of Fisheries and Aquatic Sciences 113, pp. 57-90.

Lavoie, D., Starr, M., Zakardjian, B., Larouche, P., and Saucier, F., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Primary production. DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

Lesage, V., Gosselin, J.-F., Lawson, J., and Hammill, M.O., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Pinnipeds and cetaceans. DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

McQuinn, I.H., Grégoire, F., and Leblanc, C., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Pelagic fishes. DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

Ouellet, P., 2007. Contribution to the identification of ecologically and biologically significant areas (EBSA) for the Estuary and the Gulf of St. Lawrence: The fish eggs and larvae and crustacean decapods larvae layer. DFO Can. Sci. Advis. Sec. Res. Doc., 2007/011.

Plourde, S., Harvey, M., McQuinn, I.H., Ouellet, P., and Plourde, J., 2007. Ecologically and biologically significant areas in the Estuary and the Gulf of St. Lawrence: Secondary production. DFO Can. Sci. Advis. Sec. Res. Doc. In prep.

Swain, D.P., and Benoît, F., 2007. Ecologically and biologically significant areas for demersal fishes in the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/012.

Table 1. Three main dimensions used to characterize important areas (DFO, 2004).

Dimension	High rate description	Low rate description
(1) Uniqueness	Areas whose characteristics are unique, rare, distinct, and for which alternatives do not exist.	Areas whose characteristics are widespread with many areas which are similar in most important features.
(2) Aggregation	Areas where (i) most individuals of a species are aggregated for some part the year; or (ii) most individuals use the area for some important function in their life history; or (iii) some structural feature or ecological process.	Areas where: (i) individuals of a species are widespread and even areas of comparatively high density do not contain a substantial portion of the total population; or (ii) individuals may congregate to perform a life-history function, but the area in which they perform the function varies substantially over time; or (iii) structural property or ecological process occurs in many alternative areas.
(3) Fitness Consequences[1]	Areas where the life history activity(ies) undertaken make a major contribution to the fitness of the population or species present.	Areas where the life history activity(ies) undertaken make only marginal contributions to fitness.

[1]: This dimension generally applies to functional properties of areas, and in most cases reflects contributions to reproduction and/or survival of a species. However, “fitness consequences” is considered to be a more inclusive term, to include cases which may influence survival or reproduction indirectly as well as directly.

Table 2. Two additional dimensions used to characterize important areas (DFO, 2004).

Dimension	High rate description	Low rate description
(4) Resilience[1]	Areas where the habitat structures or species are highly sensitive, easily perturbed, and slow to recover (low resilience = high importance).	Areas where the habitat structures or species are robust, resistant to perturbation, or readily return to the pre-perturbation state (high resilience = low importance).
(5) Naturalness	Areas which are pristine and characterized by native species.	Areas which are highly perturbed by anthropogenic activities and/or with high abundances of introduced or cultured species.

[1]: This dimension more readily applies to structural properties of habitats and ecological communities, but can apply to functional properties of species as well.

Table 3. Layering exercise comparing areas of physical importance (one level) and biological importance at three coarsely defined taxonomic levels (taken from DFO, 2006). See Figure 1 for locations.

Physics and bathymetry	Physical and biological oceanography	Fish and macroinvertebrates	Marine Mammals
1) West of Cape Breton	1) West of Cape Breton	1) West and North of Cape Breton	1) Magdalen Shallows and the Northumberland Strait and Cape Breton Trough
2) Western Northumberland Strait	2) Northwest Gulf Coast	2) East of PEI / St. Georges Bay	2) Laurentian Channel including that portion far up the estuary as well as the area surrounding Anticosti Island
3) Tip of Gaspé Peninsula	3) Tip of Gaspé	3) Northumberland Strait plus area North and West	3) Most of west coast of Newfoundland through Strait of Belle Isle
4) Head of Estuary	4) Chaleurs Trough	4) Tip of Gaspé plus area East and South	4) Areas of upwelling
5) West Anticosti Channel	5) Head of Estuary and max turbidity zone	5) Head of Estuary	5) Pack Ice, especially edge
6) Northeast of Anticosti Island	6) Northeast and eastern Anticosti point	6) Waters all around Anticosti Island	6) Large whales – whole Gulf
7) West Coast of Strait of Belle Isle	7) South Anticosti Coast	7) West Coast and coastal areas	
8) East Coast of Strait of Belle Isle	8) Anticosti Gyre	8) East Coast + coastal areas	
	9) West Coast and Lower North Shore	9) Port-au-Port around to Burgeo Bank	
	10) St Georges Bay, NL	10) Deep waters to Cabot Strait	

Table 4. Characteristics of the important areas (IAs) identified in the “primary production” layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Lower Estuary	High productivity, upwelling, and tidal mixing region	3	3	3	9
2) Gaspé Current	High productivity, intense mixing (permanent coastal jet) and horizontal transport (nutrient and phytoplankton)	3	3	3	9
3) Northwest Anticosti Island	High productivity, aggregation and vertical mixing region (quasi-permanent geostrophic cyclonic eddy, upward density dome, and Gaspé Current)	3	2	2	7
4) Magdalen Shallows	Productivity and region influenced by the Gaspé Current	2	2	2	6
5) Strait of Belle Isle and Coast of the Lower North Shore	Important productivity, Labrador Shelf Waters entering the Gulf through the Strait of Belle Isle, tidal mixing, and upwelling	2	1	1	4
6) Coast of the Middle and Lower North Shore	High limited production related to local upwellings	2	2	1	5
7) South Anticosti Island	High limited production related to local upwellings and influenced by the Gaspé Current	2	2	1	5
8) Northeast Gulf	Spring phytoplankton bloom at ice melting	1	2	1	4

Table 5. Characteristics of the important areas (IAs) identified in the “secondary production” layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Lower Estuary	High secondary productivity, biomass retention, upwelling and tidal mixing region	3	3	3	9
2) Northwest Anticosti Island	High productivity, aggregation and vertical mixing region (quasi-permanent geostrophic cyclonic eddy, upward density dome, and Gaspé Current)	3	2	3	8
3) Gaspé Current	High productivity, intense mixing (permanent coastal jet) and horizontal transport	3	2	3	8
4) Baie des Chaleurs and Southwest Gulf Coast	Productivity, high concentration of small mesozooplankton (<1 mm), tidal mixing, and region influenced by the Gaspé Current	2	2	3	7
5) Max turbidity zone and Estuary	High biomass and productivity, tidal mixing and frontal region (fresh water and marine water)	3	2	2	7
6) Coast of Tip of Gaspé Peninsula and Baie des Chaleurs	High zooplankton biomass (aggregation) and region influenced by the Gaspé Current	2	3	1	6
7) Region including Orphelin and Bradelle Banks as well as Shediac Valley	High biomass of large mesozooplankton (> 1mm) and region influenced by the Gaspé Current	2	2	1	5
8) South slope of the Laurentian Channel	High biomass and production spatially and temporally limited and aggregation region	2	2	2	6
9) East slope of the Esquiman Channel	High biomass and production spatially and temporally limited and aggregation region	1	2	2	5

Table 5. Cont.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
10) North slope of the Anticosti Channel	High limited biomass and production and aggregation region	1	2	2	5
11) West of Cape Breton	High limited biomass and production and aggregation region (Current Gaspé outflow)	2	1	1	4
12) Coast of the Middle and Lower North Shore	Limited production related to local upwellings and primary production	1	1	1	3

Table 6. Characteristics of the important areas (IAs) identified in the “meroplankton” layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Anticosti Island	High abundance and diversity of fish and invertebrate eggs and larvae, upwelling, and strong tidal current (Jacques Cartier Strait)	3	3	3	9
2) Beaugé Bank	High abundance and diversity of fish and invertebrate eggs and larvae, region between the Anticosti and the Esquiman Channels	2	2	2	6
3) West coast of Newfoundland (East Slope of Esquiman Channel)	High concentration of cod eggs (main spawning region) and high abundance of capelin and herring larvae	3	3	2	8
4) Central Laurentian region	Main redfish larval zone	3	2	2	7
5) Tip of Gaspé, Baie des Chaleurs and Southwest Gulf Coast (South Magdalen Shallows)	High abundance and diversity of fish and invertebrate eggs and larvae, shallow coastal region influenced by the Gaspé Current	3	3	3	9
6) Magdalen Shallows Centre	High concentration of snow crab larvae and eggs of American plaice, winter flounder, and mackerel	2	2	2	6
7) Estuary and Gaspé Current[a]	High concentration of rainbow smelt and Atlantic tomcod larvae, upwelling and tidal mixing region	2	2	2	6
8) Coast of the Northwest Gulf (North Shore)	High concentration of northern shrimp larvae and upwellings	2	2	2	6

[a]: This IA initially identified based on expertises only has not been included in the analyses (see Ouellet, 2007).

Table 7. Characteristics of the important areas (IAs) identified in the "benthic invertebrates" layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Lower Estuary	High species abundance (boreomysid *Boreomysis arctica*, northern basket star, northern Atlantic octopus)	2	1	1	4
2) Honguedo Strait and Northwest Anticosti Island	High abundance of the boreomysid *Boreomysis arctica* and Alcyonacea soft corals	2	2	1	5
3) Jacques Cartier Strait	High abundance of Greenland lebbeid, Eualid *Eualus gaimardii*, and Icelandic scallop	2	3	1	6
4) Anticosti Channel	High abundance of Norwegian shrimp and northern shrimp	1	1	1	3
5) Mécatina Deep	High abundance of widespread species	1	2	1	4
6) Strait of Belle Isle	High abundance of limited species (Eualid *Eualus gaimardii* and Greenland lebbeid), Labrador Shelf Waters entering the Gulf through the Strait of Belle Isle	3	3	1	7
7) Head of Esquiman Channel	Aggregation of widespread species	1	2	1	4
8) Southwest Newfoundland	Aggregation of widespread species	1	2	1	4
9) Cabot Strait and Laurentian Channel	Deep shrimp region (*Pasiphaea tarda*, *Sergestes arcticus*, *Atlantopandalus propinqvus*, etc), High abundance of widespread species	2	2	1	5
10) South slope of the Laurentian Channel	High abundance of deep widespread species, important region for Icelandic scallop and Alcyonacea soft corals	2	2	1	5

Table 7. Cont.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
11) West of Cape Breton	Aggregation and high abundance of widespread species	1	3	1	5
12) Bradelle Bank	Aggregation and high abundance of widespread species	1	3	1	5
13) West Northumberland Strait	Unique region for the crab Calico	3	3	3	9
14) Baie des Chaleurs	High abundance of widespread species	1	2	1	4
15) Shediac Valley and Miscou Bank	High abundance of widespread species	1	2	1	4
16) Orphelin Bank and West Bradelle Valley	High abundance of widespread species	1	2	1	4
17) Tip of Gaspé Peninsula	Aggregation and high abundance of species	1	3	1	5

Table 8. Characteristics of the important areas (IAs) identified in the “pelagic fishes” layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Baie des Chaleurs - Shediac Valley	Principal feeding area for southern gulf herring	2	3	2	7
2) Strait of Belle Isle	Most northerly spawning area for Gulf herring (edge of distribution) and principal spawning area for autumn spawning population	2	3	2	7
3) Baie des Chaleurs	Principal winter refuge for juveniles of southern spawning herring	2	2	3	7
4) Esquiman Channel	Only known winter refuge for northern Gulf herring	2	3	3	8
5) Head of Esquiman Channel	Only known winter refuge for Gulf capelin	2	2	3	7
6) Strait of Belle Isle	High concentration of capelin	2	3	2	7
7) St. Georges Bay - Northumberland	The only area of feeding for the isolated Butterfish population	3	2	2	7
8) Shediac Valley	High concentration of species (alewife, spiny dogfish, adult and juvenile herring, mackerel, rainbow smelt) for multiple biological function (feeding, refuge, spawning)	3	3	2	8
9) St. Georges Bay - Northumberland	High feeding concentration of species (alewife, spiny dogfish, adult and juvenile herring, mackerel, Butterfish, rainbow smelt and silver hake) as well as spawning for herring	3	3	2	8
10) Strait of Belle Isle	High feeding concentration of species (spiny dogfish, herring, capelin and sand lance) as well as spawning for herring	2	3	2	7

Table 8. Cont.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
11) South slope of the Laurentian Channel (Edge)	Area of importance for multiple biological functions (feeding, migration, refuge) for many species	3	2	2	7
12) Baie des Chaleurs	Co-occurrence of several pelagic species for feeding	1	2	2	5
13) North Prince Edouard Island	Co-occurrence of several pelagic species for feeding	1	2	2	5
14) Gaspé Current	Co-occurrence of several pelagic species for feeding	1	2	2	5
15) Beaugé Bank Slope	Co-occurrence of several pelagic species for feeding	2	3	2	7
16) Laurentian Channel Northern Slope	Co-occurrence of several pelagic species for feeding	1	2	2	5
17) Anticosti Channel	Co-occurrence of several pelagic species for feeding	1	2	2	5
18) Cabot Strait - Mouth of Esquiman Channel	Co-occurrence of several pelagic species for feeding, migration, and refuge	1	2	2	5
19) Head of Esquiman Channel	Co-occurrence of several pelagic species for feeding	2	3	2	7
20) Strait of Belle Isle	Co-occurrence of several pelagic species for feeding	1	2	2	5
21) Cabot Strait - Mouth of Esquiman Channel	Co-occurrence of several pelagic species for feeding	2	3	2	7
22) South slope of the Laurentian Channel (Edge)	Co-occurrence of several pelagic species for multiple functions	2	2	2	6
23) Shediac Valley	Co-occurrence of several pelagic species for feeding	2	2	2	6
24) St. Georges Bay - Northumberland	Co-occurrence of several pelagic species for multiple functions	2	2	2	6

Table 9. Characteristics of the important areas (IAs) identified in the "demersal fishes" layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Lower Estuary	Aggregation of juveniles (Greenland halibut, witch flounder, and thorny skate)	3	3	3	9
2) Northwest Anticosti Island (Anticosti Gyre)	Aggregation of juveniles (Greenland halibut, American plaice, and skate)	1	1	1	3
3) South Coast of Anticosti Island	Aggregation of juveniles (Greenland halibut, Atlantic cod, American plaice, and skate)	2	2	2	6
4) Head of Anticosti Channel	Aggregation of Greenland halibut juveniles	1	1	2	4
5) Coast of the Lower North Shore	Aggregation of cod juveniles	2	2	2	6
6) West Newfoundland and Esquiman Channel	Aggregation of juveniles (cod, redfish, American plaice, skate, and Atlantic wolffish)	3	3	3	9
7) Cabot Strait and Laurentian Channel	Winter refuge for many species	3	3	3	9
8) West Newfoundland and Esquiman Channel	Main migration corridor for many species (cod, redfish, etc.)	3	3	3	9
9) Whole Laurentian Channel[a]	High diversity of species	2	1	2	5
10) Cape Breton Trough	1) Migration corridor for cod and other species, 2) summer grounds for witch flounder and white hake (deepwater stock component), 3) high biodiversity	3	3	3	9

[a]: This IA initially identified only has not been included in the analyses (extremely wide area; see Castonguay and Valois, 2007).

Table 9. Cont.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
11) St. Georges Bay	Spawning, nursery and summer feeding grounds of white hake	3	3	3	9
12) Western Northumberland Strait	Area of concentration of winter skate	3	3	3	9
13) South slope of the Laurentian Channel in the Cabot Strait area	Cod overwintering grounds	3	3	3	9
14) Shediac Valley Region	1) Nursery area, 2) High demersal fish biomass	2	2	2	6
15) Southern slope of the Laurentian Channel, Gaspé to Cape Breton	Species diversity	1	2	1	4
16) Baie des Chaleurs	Species diversity	1	1	1	3

Table 10. Characteristics of the important areas (IAs) identified in the “pinnipeds and cetaceans” layer.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Strait of Belle Isle and Coast of the Lower North Shore	High biomass and aggregation of piscivorous marine mammals and large cetacea (feeding area)	3	3	3	9
2) Lower Estuary	Aggregation of piscivorous and planktivorous marine mammals over the entire year (feeding area)	2	2	2	6
3) Coast of the Northwest Gulf (North Shore)	Aggregation of piscivorous marine mammals (feeding area)	2	3	2	7
4) Northwest Anticosti Island and Jacques Cartier Strait	Aggregation of piscivorous marine mammals (feeding area)	2	2	2	6
5) North slope of the Anticosti Channel and Coast of the Middle and Lower North Shore	Aggregation and high number of small cetacea and seals, presence of the blue whale	1	2	1	4
6) East slope of the Esquiman Channel	Co-occurrence of several marine mammals for feeding	1	1	1	3
7) Central Laurentian region	Co-occurrence of several planktivorous marine mammals for feeding (blue whale, harbour seals in winter, etc.)	2	2	1	5

Table 10. Cont.

IA	Description	Uniqueness	Aggregation	Fitness Consequences	Total
8) Southwest Newfoundland, East Cabot Strait and Laurentian Channel	Co-occurrence of several marine mammals for feeding including deep-divers and blue whale in winter (ice-free area)	2	2	2	6
9) West of Cape Breton	Co-occurrence of several marine mammals for feeding, including deep-divers	2	2	2	6
10) Coast of Gaspé Peninsula and Baie des Chaleurs	Co-occurrence of several planktivorous marine mammals for feeding (blue whale, harbour seals in winter, etc.)	2	2	2	6
11) Shediac Valley Region	Co-occurrence of several marine mammals for feeding, including deep-divers and grey seals	1	1	1	3
12) Magdalen Shallows Centre and St. Georges Bay - Northumberland	Whelping of grey, harp, and hooded seals	2	2	2	6

Table 11. Number and surface area of the different important areas identified for each biological layer. Total area: 255,845 km^2 (see Figure 2).

Layer	Number[a]	Surface (km²)	% of total area
Primary production	8 (3)	198,485	78%
Secondary production	12 (6)	101,463	40%
Meroplankton	7 (4)	127,458	50%
Benthic invertebrates	17 (6)	105,656	41%
Pelagic fishes	24 (14)	77,020	30%
Demersal fishes	16 (8)	95,805	37%
Pinnipeds and Cetaceans	12 (2)	135,918	53%
Total	96 (43)		

[a]: the number in parentheses is the number of IAs for which at least one of the main EBSA dimensions is high.

Table 12. Description of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence.

	IA #								
EBSA	Primary production	Secondary production	Meroplankton	Benthic invertebrates	Pelagic fishes	Demersal fishes	Pinnipeds and cetaceans	Surface (km²)	% of total area
1) Lower Estuary	1[a]	1[a]		1		1[a]	2	9,046	3.2%
2) Northeast Anticosti Island	3[a], 6, 7	2[a]	1[a], 8	2, 3[a]	16	2	4	3,822	1.5%
3) Southwest coast of the Magdalen Shallows	4	4[a], 6[a], 7	5[a]	14, 15, 17[a]	1[a], 3[a], 8[a], 12, 23	12[a], 14, 15, 16	10, 11	13,506	5.3%
4) Western Northumberland Strait			5[a]	13[a]		12[a]	11	2,194	0.9%
5) St. Georges Bay		4[a]	5[a]	11[a]	7[a], 9[a], 24	11[a]	9, 12	1,217	0.5%
6) West of Cape Breton	4	4[a], 11	5[a]	11[a]	9[a], 13, 24	10[a]	9, 12	8,198	3.2%
7) South slope of the Laurentian Channel	4, 8	8	5[a]	10, 16	11[a], 22	7[a], 10[a], 13[a], 15	8, 9, 12	5,941	2.3%
8) Northeast of Anticosti Channel and Jacques Cartier Passage	6, 8	10	1[a]	3[a], 4	17	4	4, 5	7,620	3.0%

Table 12. Cont.

	IA #								
EBSA	Primary production	Secondary production	Meroplankton	Benthic invertebrates	Pelagic fishes	Demersal fishes	Pinnipeds and cetaceans	Surface (km²)	% of total area
9) West Newfoundland and Esquiman Channel	8	9	3[a], 4[a]	7, 8, 9	4[a], 5[a], 15[a], 18, 19[a], 21[a]	6[a], 7[a], 8[a]	1[a], 5, 6, 8	18,238	7.1%
10) Strait of Belle Isle and Mécatina Deep	5, 6, 8			5, 6[a]	2[a], 6[a], 10[a], 20	5	1[a], 5	7,403	2.9%

[a]: IAs with at least one high rank on one of the three main criteria.

Table 13. Description of IAs discarded during the Mont-Joli workshop. The IAs have at least one high rank on one of the three criteria.

IA	Biological layer [IA #]	Description	Uniqueness	Aggregation	Fitness Consequences	Total
1) Gaspé Current	Primary production [2] and secondary production [3]	High productivity	3 (3)[a]	3 (2)[a]	3 (3)[a]	9 (8)[a]
2) Northwest gulf (Anticosti Gyre and north shore)	Primary production [3] secondary production [2], and pinnipeds and cetaceans [3]	High productivity and aggregation	3 (3)[a] {2}[b]	2 (2)[a] {3}[b]	2 (3)[a] {2}[b]	7 (8)[a] {7}[b]
3) Central Laurentian region	Meroplankton [4]	Main redfish larval zone	3	2	2	7
4) Bradelle Bank	Benthic invertebrates [12]	Aggregation and high abundance of widespread species	1	3	1	5
5) South Northumberland area	Pelagic fishes [7]	The only area of feeding for the isolated Butterfish population	3	2	2	7
6) Beaugé bank (east sector)	Pelagic fishes [15]	Co-occurrence of several pelagic species for feeding	2	3	2	7
7) Cabot Strait and Laurentian Channel	Demersal fishes [7]	Winter refuge for many species	3	3	3	9

[a]: In parentheses, there are the characteristics identified by the “secondary production” layer.
[b]: In curly brackets, there are the characteristics identified by the “pinnipeds and cetaceans” layer.

Table 13. Cont.

IA	Biological layer [IA #]	Description	Uniqueness	Aggregation	Fitness Consequences	Total
8) South slope of the Laurentian Channel in the Cabot Strait area	Demersal fishes [13]	Cod overwintering grounds	3	3	3	9

Table 14. Comparison of overlaps between the EBSAs and the IAs (hydrodynamic features) identified by the “topography and physical processes” layer.

EBSA	Hydrodynamic feature	Overlapped surface (km²)	% of EBSAs overlapped by hydro. IAs
1) Lower Estuary	Retention, upwelling, temperature	5,980	66.1%
2) Northeast Anticosti Island	Retention	379	9.9%
3) Southwest coast of the Magdalen Shallows	Retention, upwelling, tidal mixing	1,969	14.6%
4) Western Northumberland Strait	Retention, tidal mixing, temperature	2,178	99.3%
5) St. Georges Bay		0	0.0%
6) West of Cape Breton	Retention, tidal mixing	274	3.3%
7) South slope of the Laurentian Channel	Retention	87	1.5%
8) Northeast of Anticosti Channel and Jacques Cartier Passage	Retention	3,125	41.0%
9) West Newfoundland and Esquiman Channel	Retention	645	3.5%
10) Strait of Belle Isle and Mécatina Deep	Retention, upwelling, tidal mixing	2,359	31.9%
Total		16,997	22.0%

Table 15. Comparison of overlaps between the EBSAs and the IAs identified by the Delphic process.

EBSA	Overlapped surface (km²)	% of EBSAs overlapped by Delphic IAs
1) Lower Estuary	8,181	90%
2) Northeast Anticosti Island	2,416	63%
3) Southwest coast of the Magdalen Shallows	7,601	56%
4) Western Northumberland Strait	2,095	95%
5) St. Georges Bay	1,105	91%
6) West of Cape Breton	8,018	98%
7) South slope of the Laurentian Channel	3,423	58%
8) Northeast of Anticosti Channel and Jacques Cartier Passage	7,523	99%
9) West Newfoundland and Esquiman Channel	17,240	95%
10) Strait of Belle Isle and Mécatina Deep	7,259	98%
Total	64,861	84%

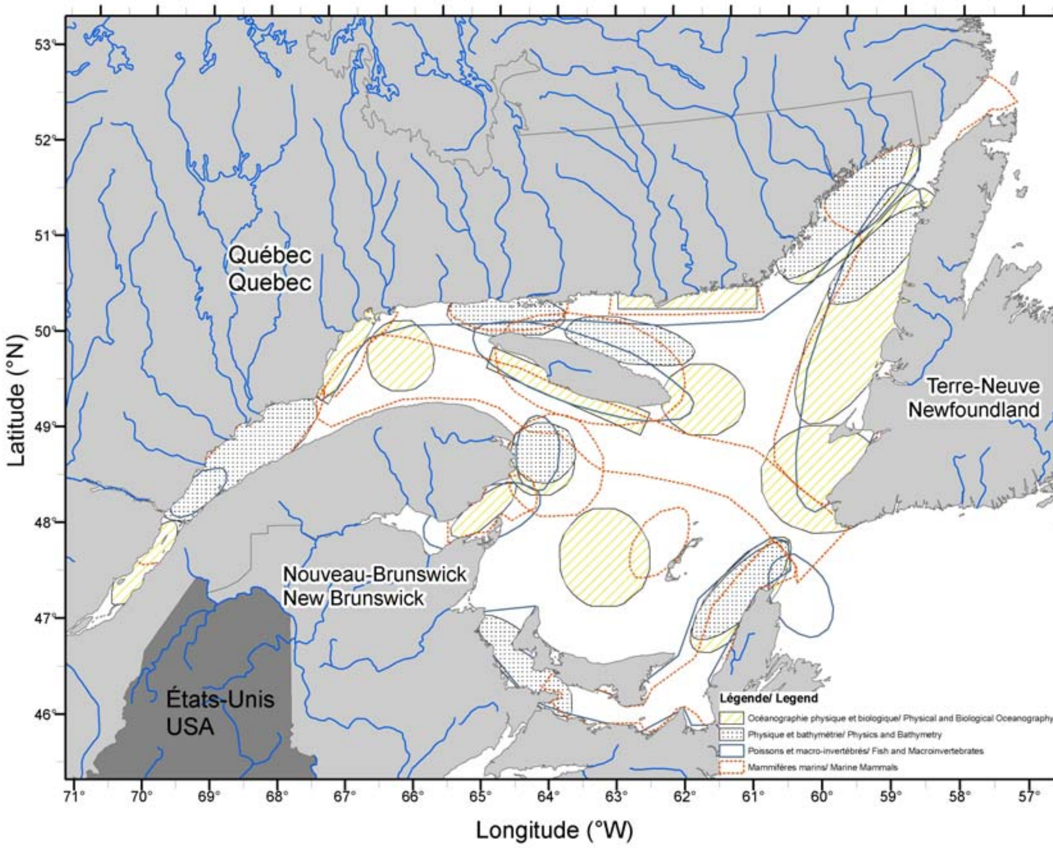

Figure 1. Important areas (IAs) highlighted using a modified Delphic process (scientific knowledge advisory approach) (from DFO 2006a).

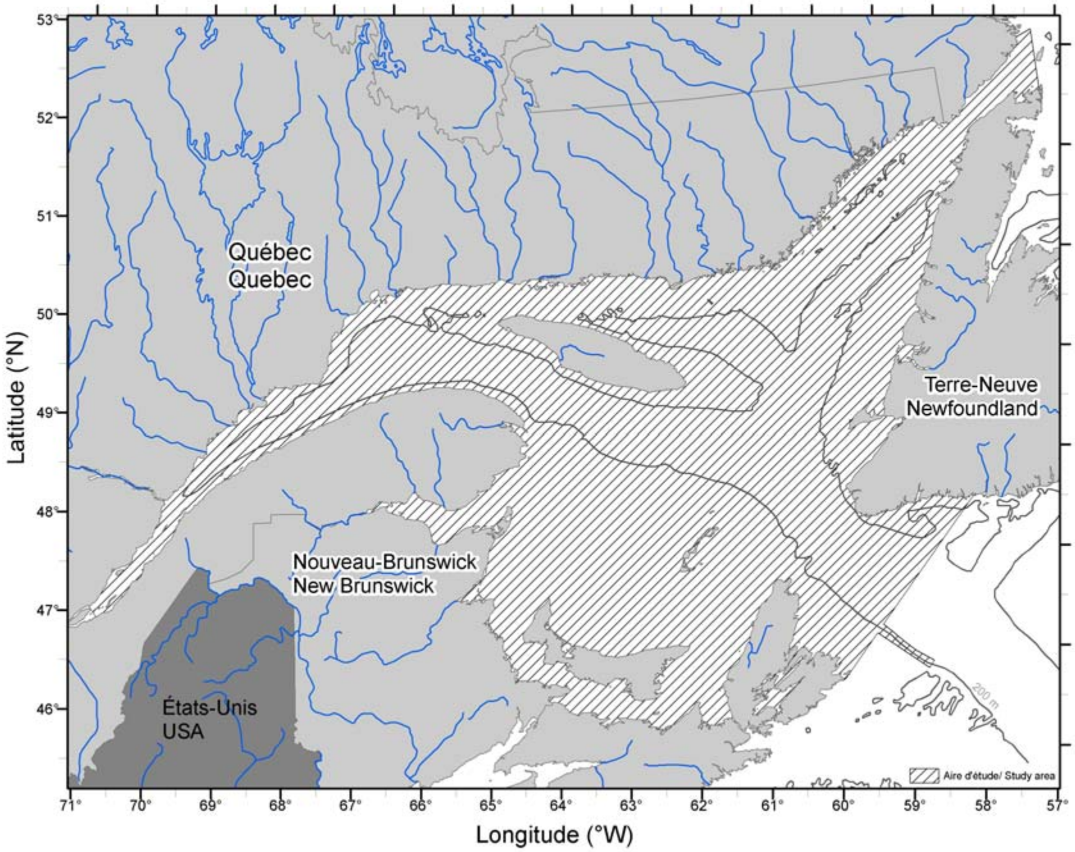

Figure 2. Map of the lower Estuary and Gulf of St. Lawrence showing the 200 m isobath (total area: 255,845 km^2).

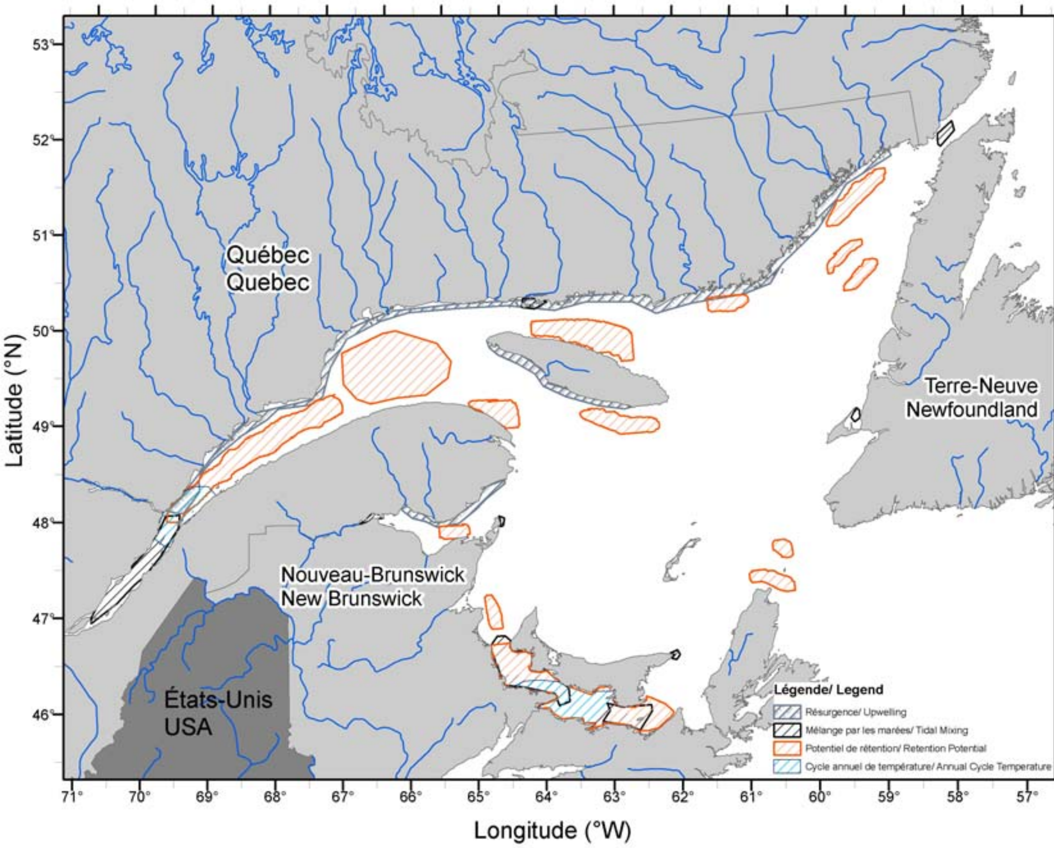

Figure 3. Important areas identified in the “topography and physical processes” layer.

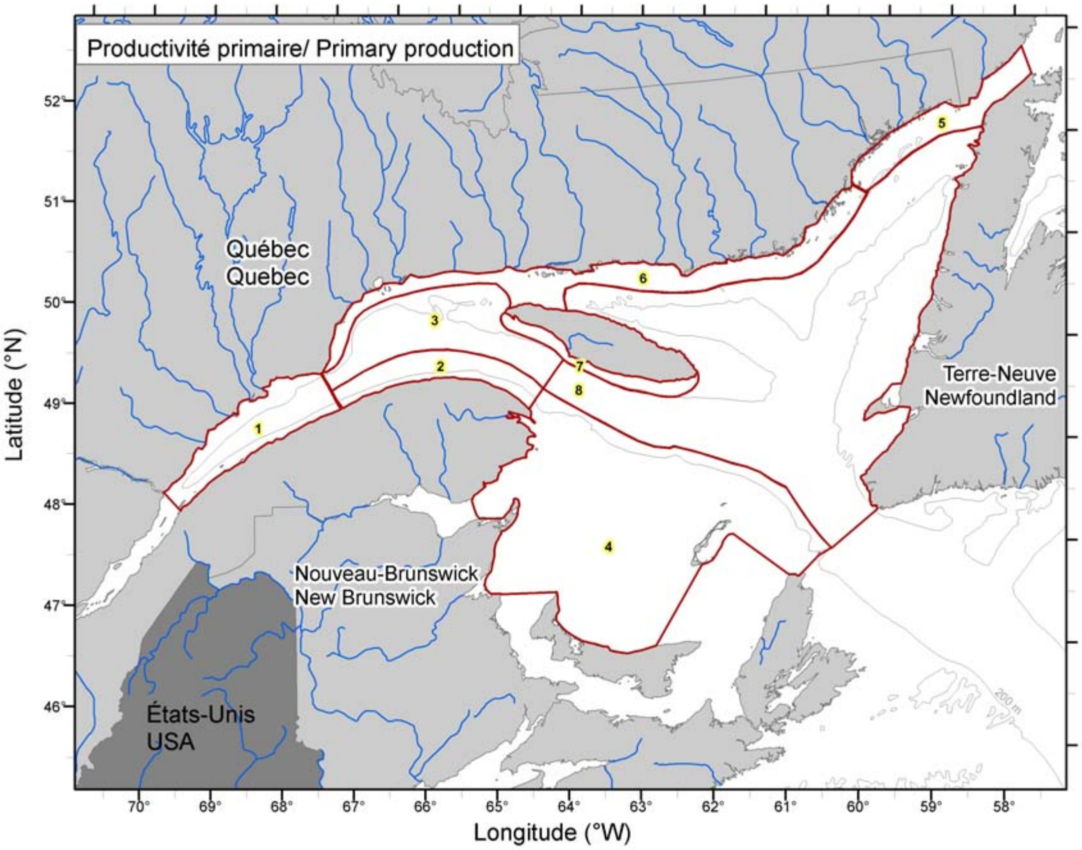

Figure 4. Important areas identified in the “primary production” layer.

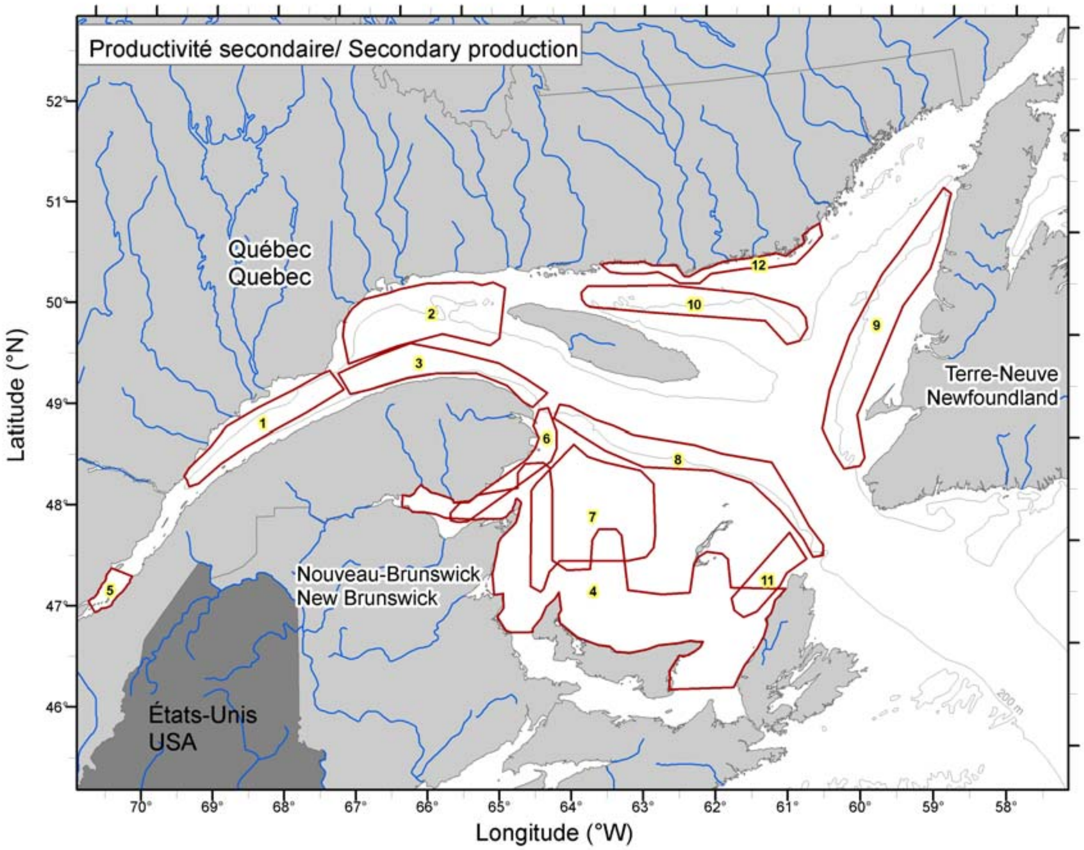

Figure 5. Important areas identified in the “secondary production” layer.

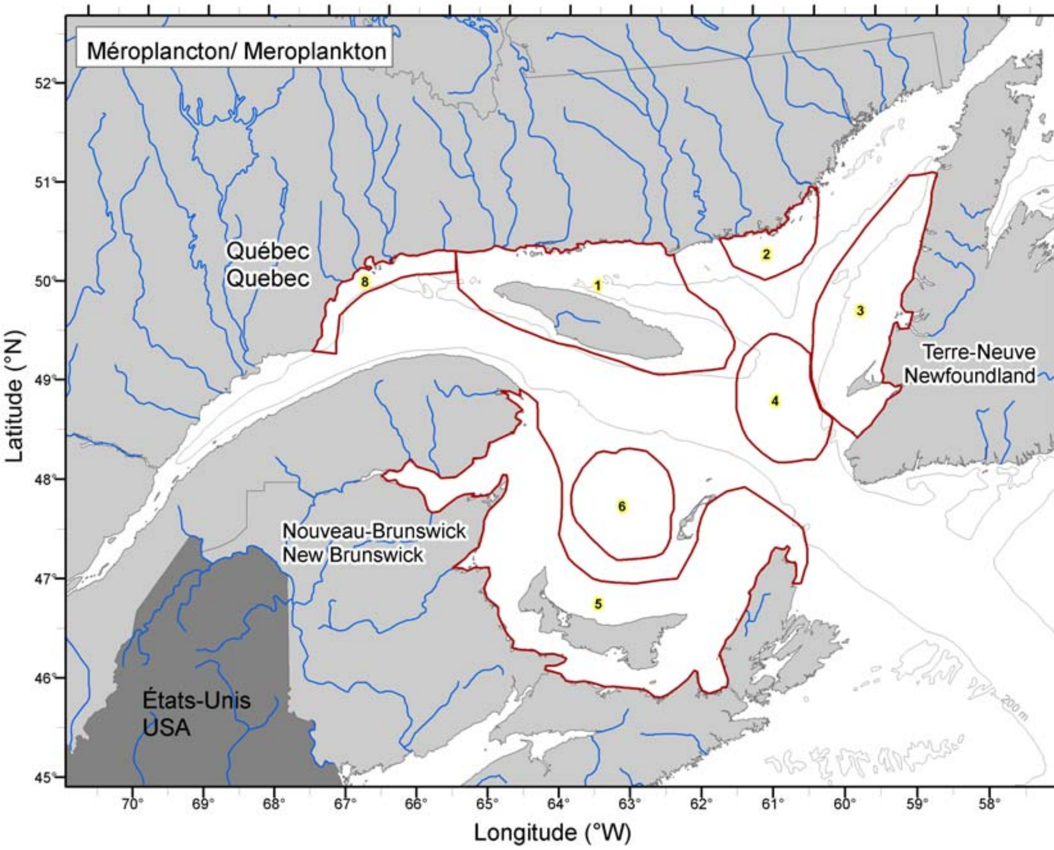

Figure 6. Important areas identified in the "meroplankton" layer. Note that a potential IA initially identified based on expertises only (IA#7 lower Estuary and Gaspé Current) has not been included in the analyses (see Ouellet, 2007).

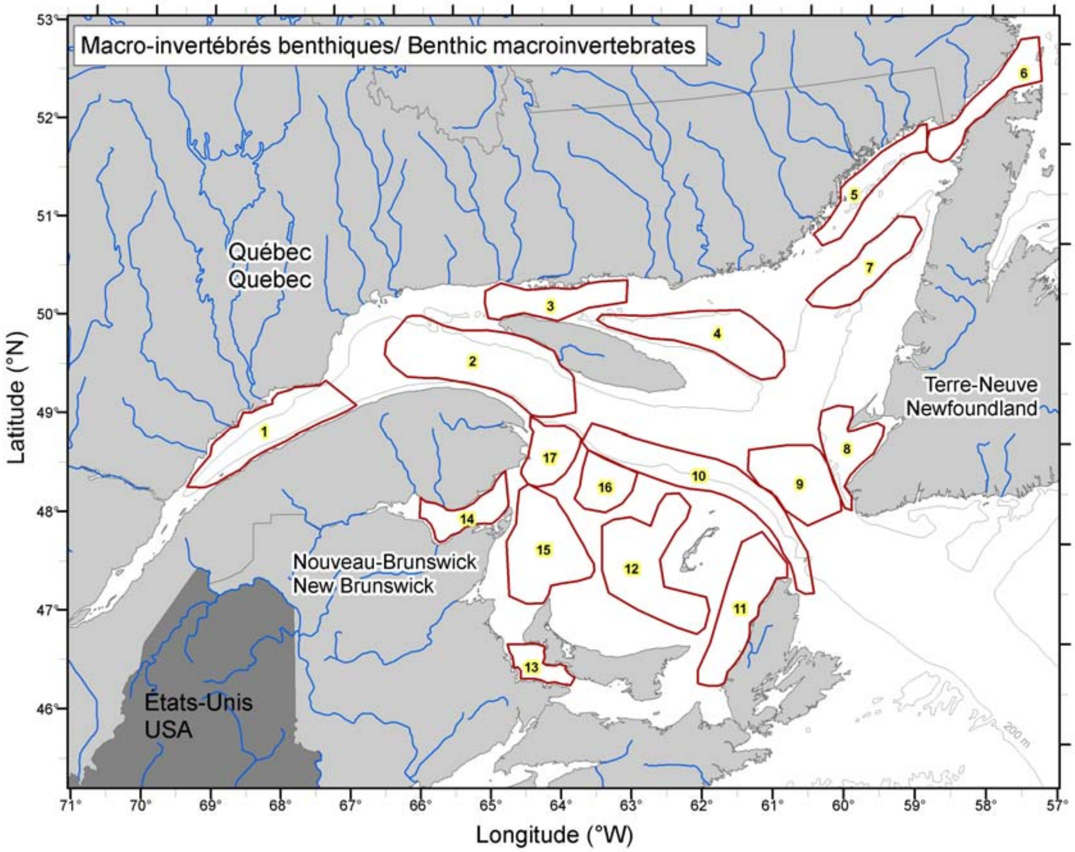

Figure 7. Important areas identified in the “benthic invertebrates” layer.

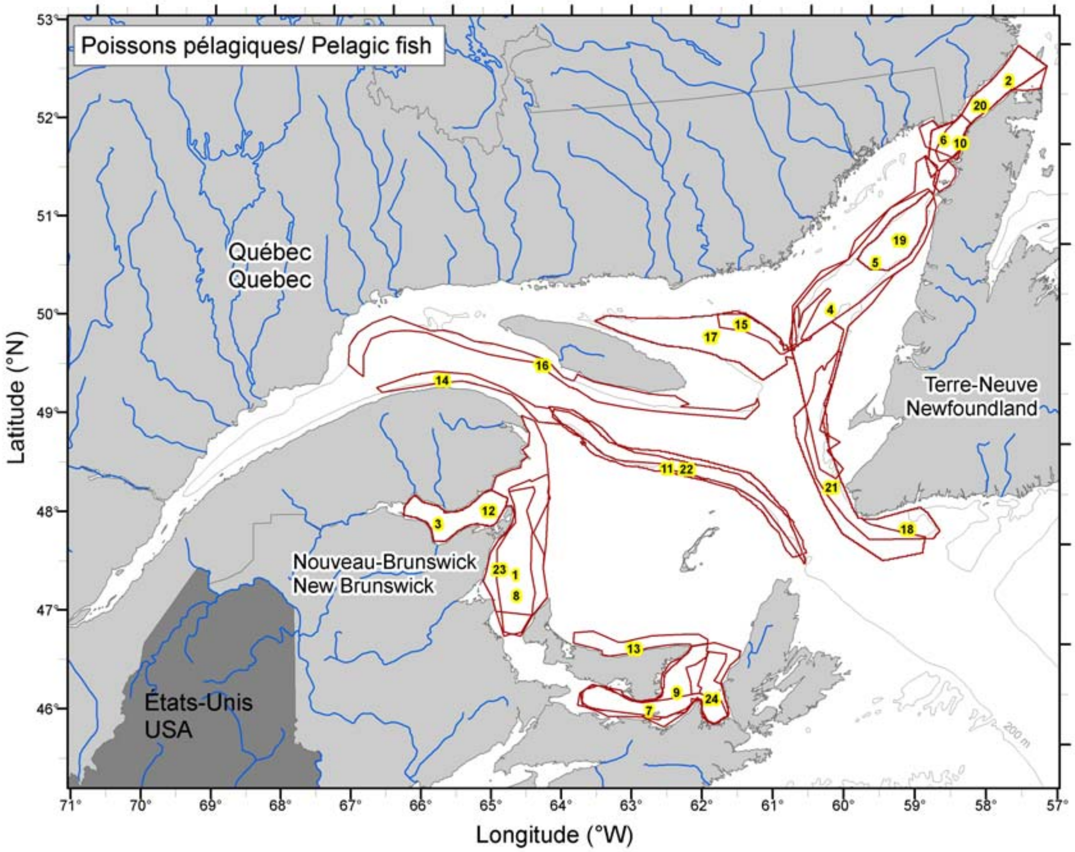

Figure 8. Important areas identified in the “pelagic fishes” layer.

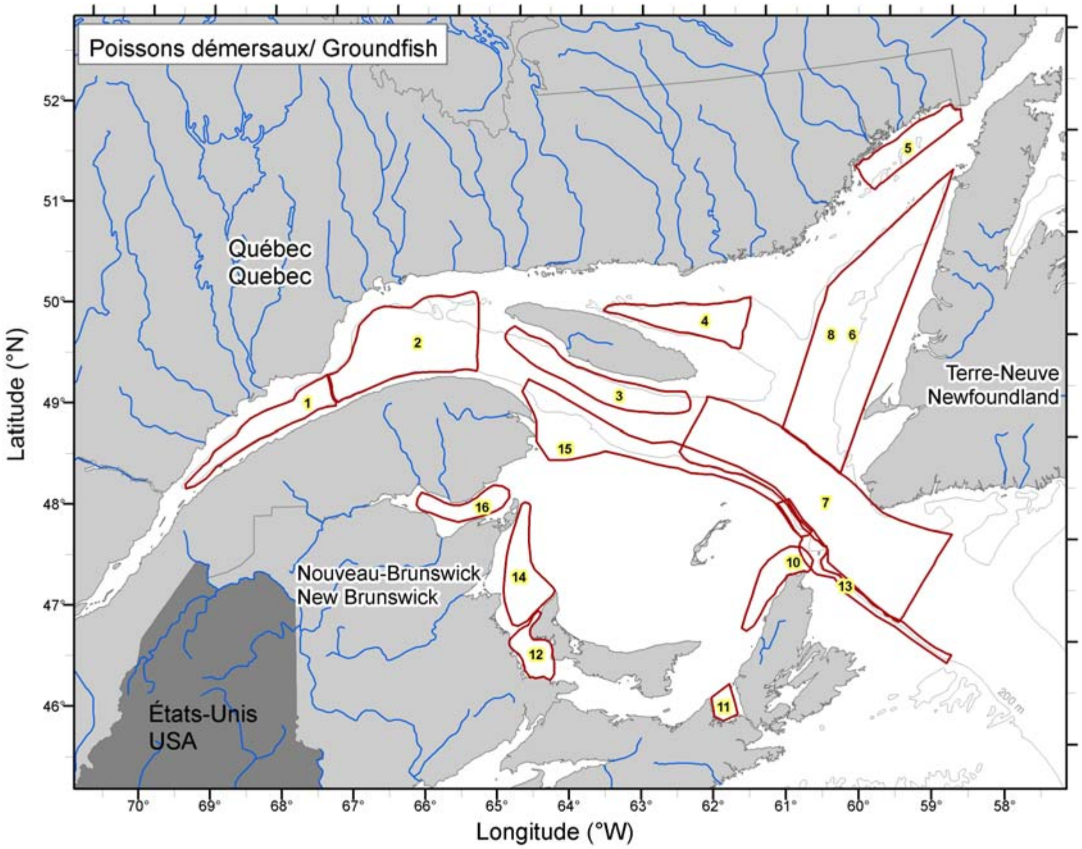

Figure 9. Important areas identified in the "demersal fishes" layer. The IA "whole Laurentian Channel" (#9) which had been initially identified, has not been included here because it was deemed too large (see Castonguay and Valois, 2007).

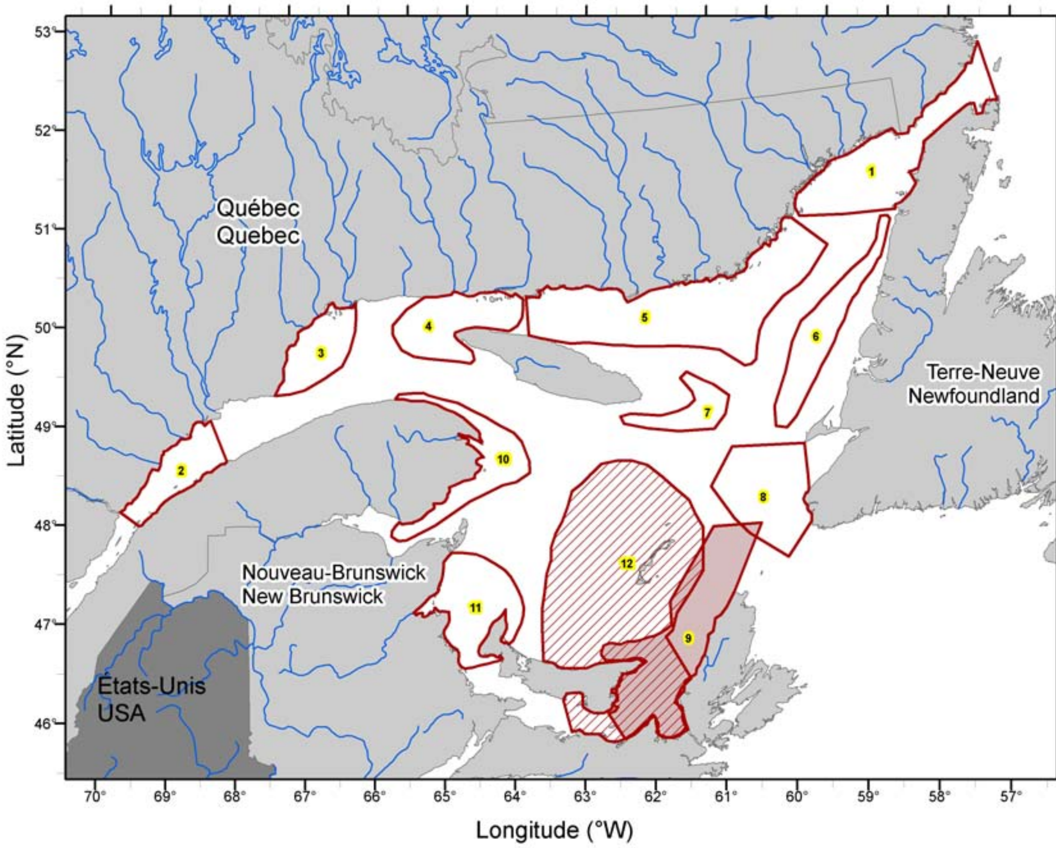

Figure 10. Important areas identified in the “pinnipeds and cetaceans” layer.

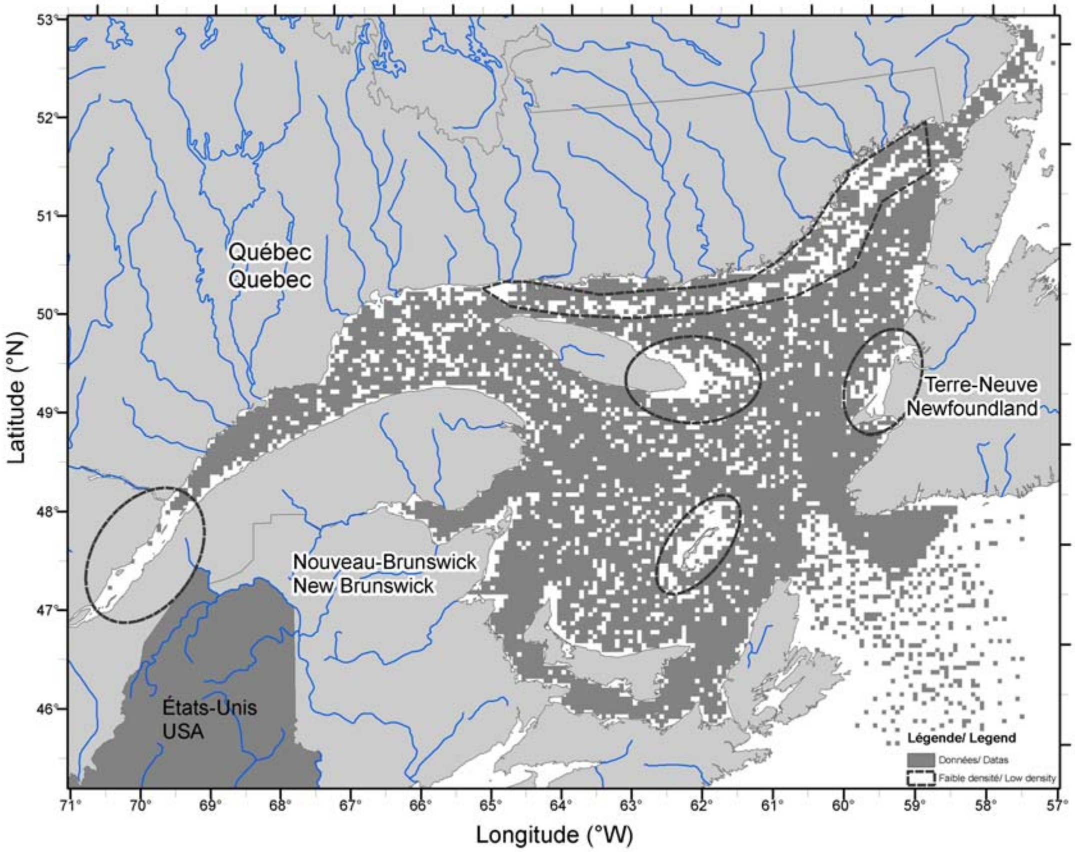

Figure 11. Locations sampled for at least one of the layers. Regions with data gaps are circled. Sampled locations outside the Gulf in the Cabot Strait represent only a subset of locations sampled in surveys conducted mainly by other DFO regions. Consequently, the coverage as presented here is not representative for these areas.

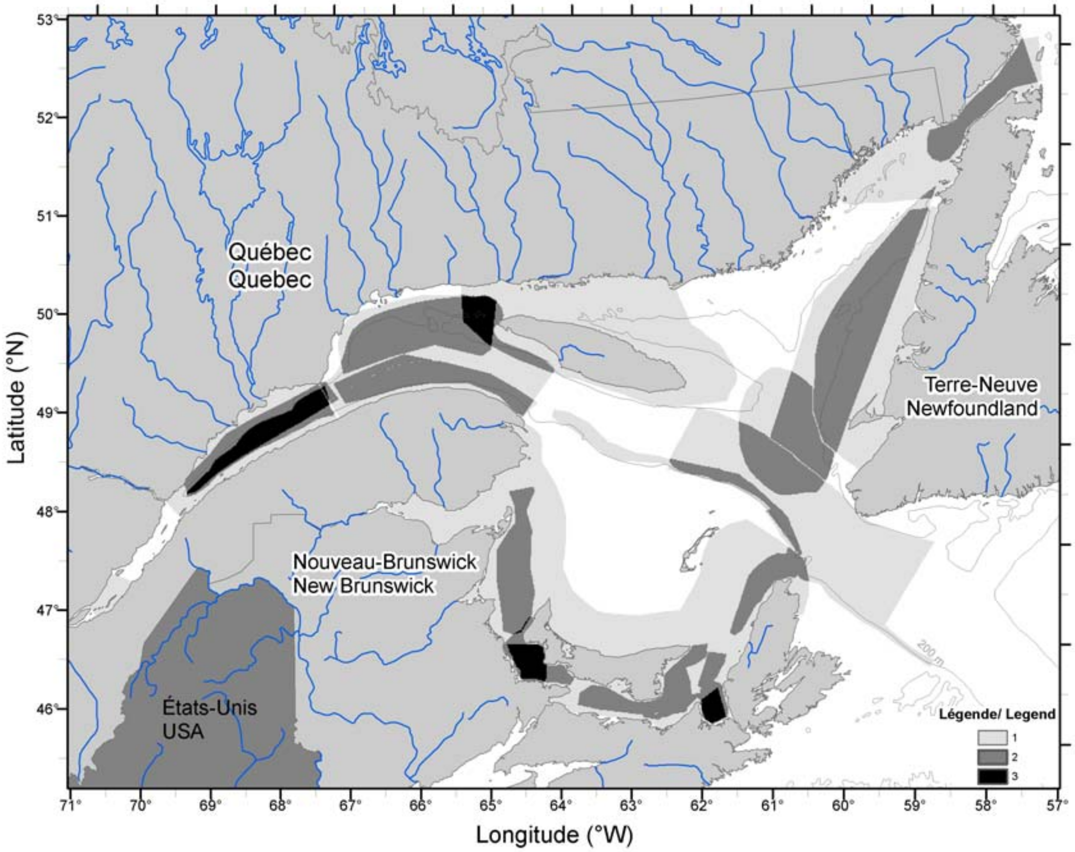

Figure 12. Number of biological layers for which a high rank for *uniqueness* was reported for a given area.

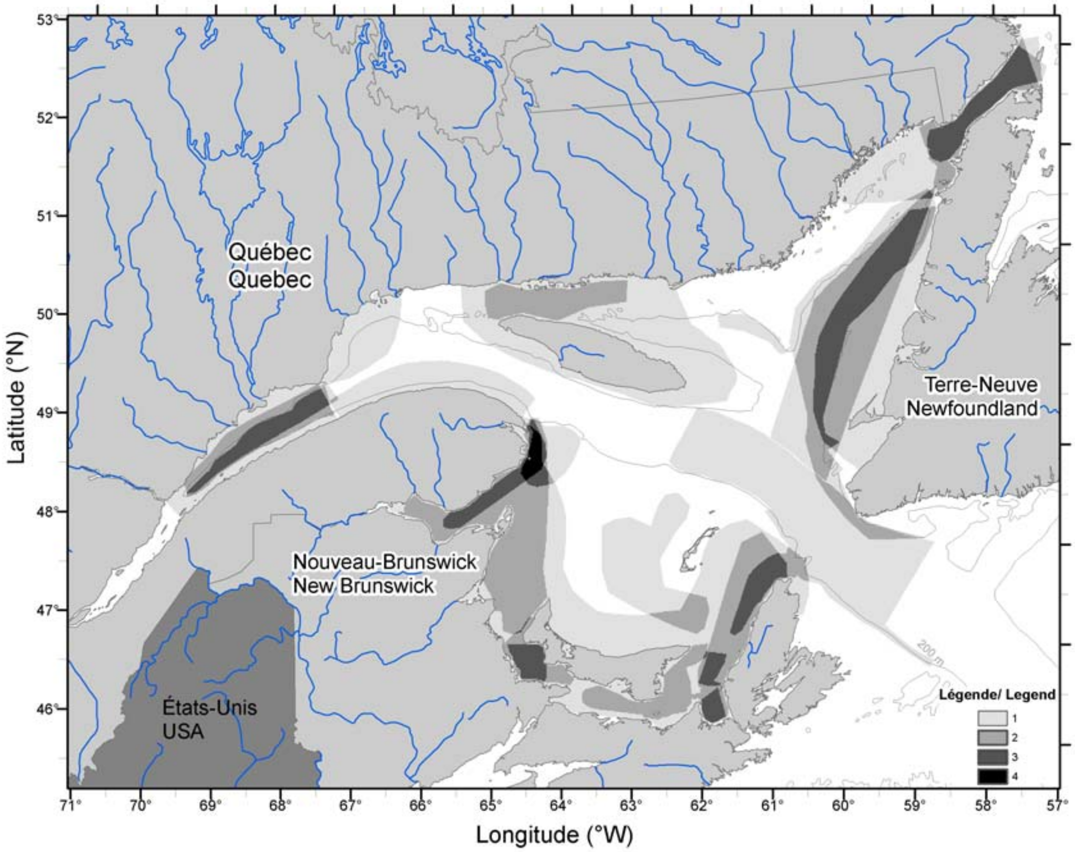

Figure 13. Number of biological layers for which a high rank for *aggregation* was reported for a given area.

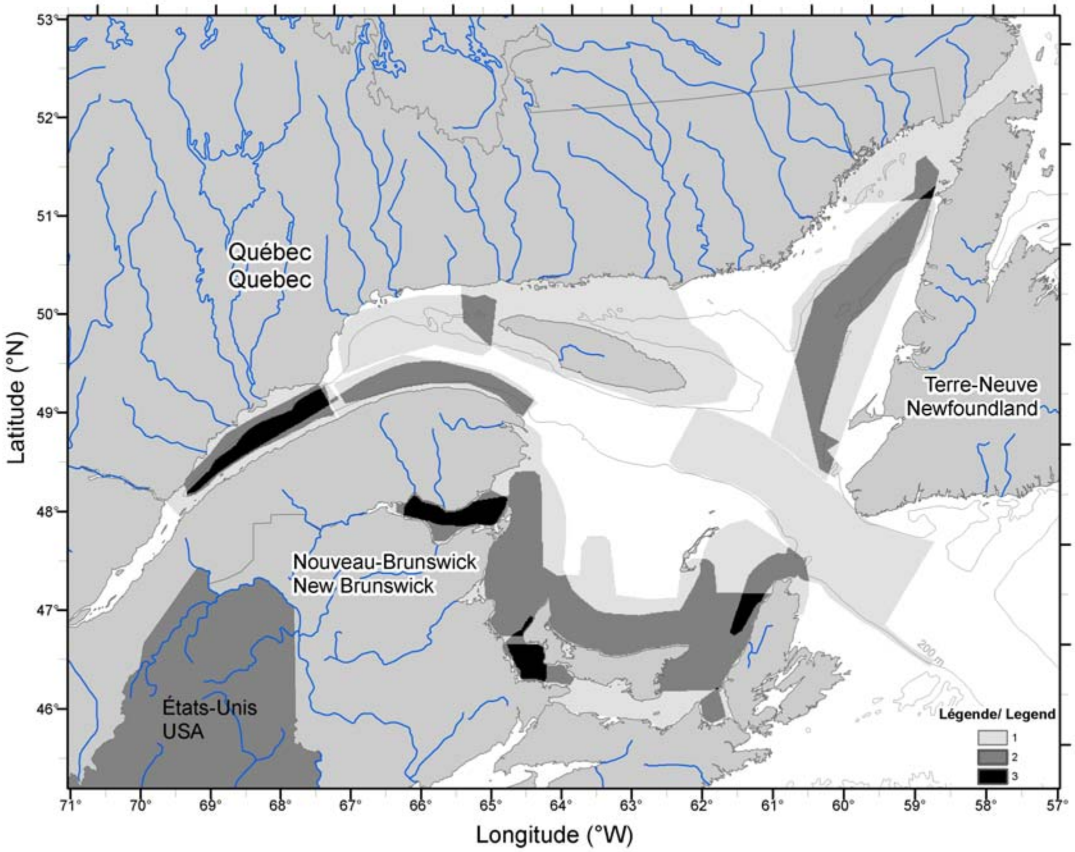

Figure 14. Number of biological layers for which a high rank for *fitness consequences* was reported for a given area.

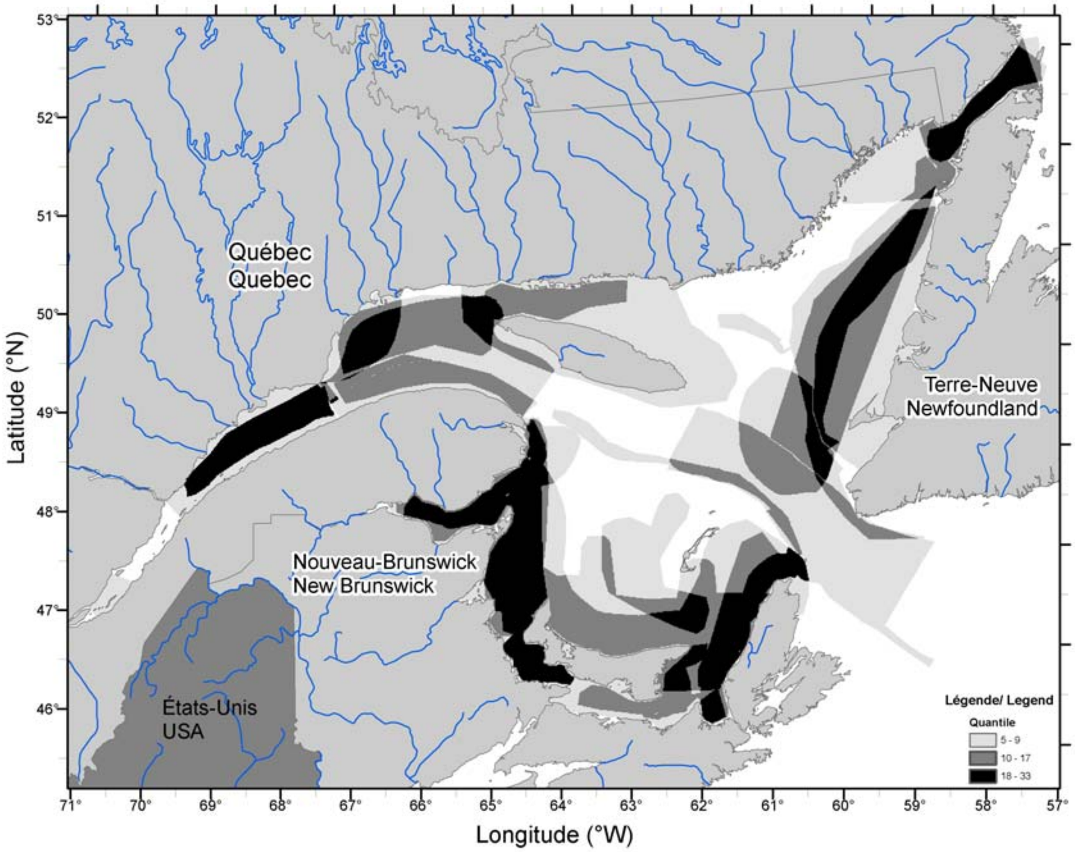

Figure 15. Quantile distribution of the criteria scores summed across thematic layers and EBSA dimensions for cases where there was a high rank on at least one of the three dimensions.

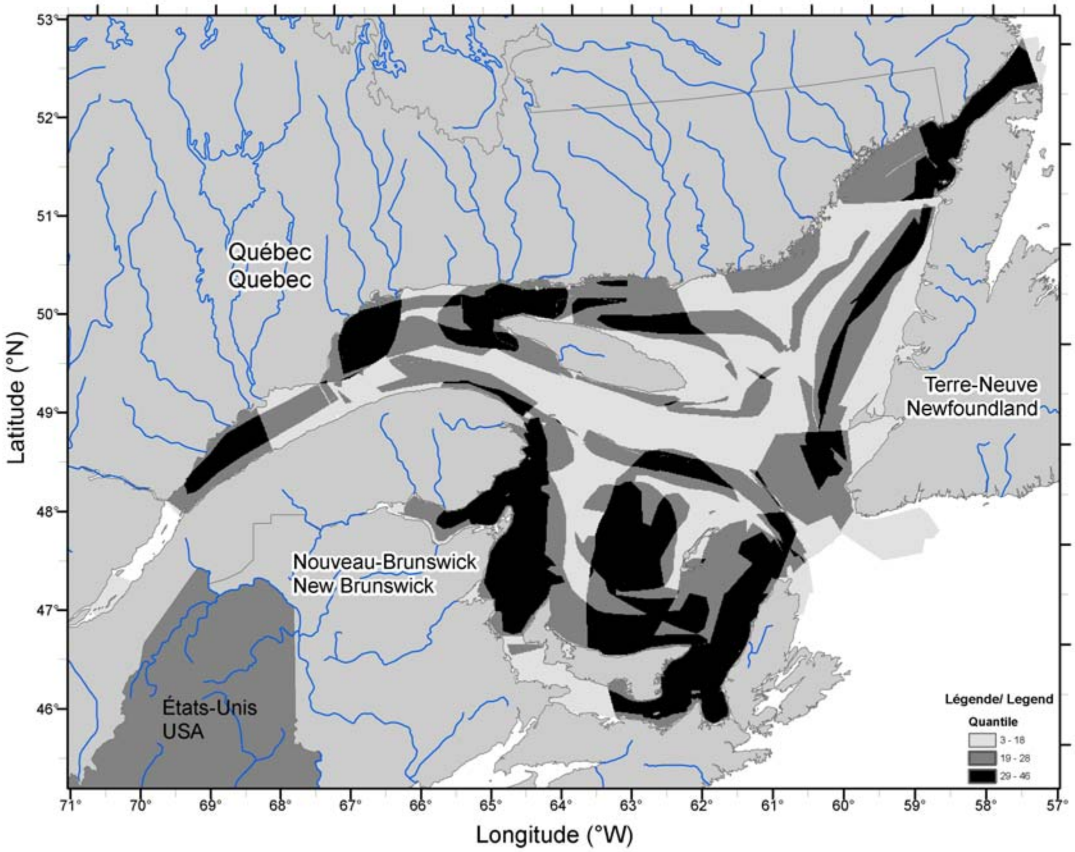

Figure 16. Quantile distribution of the criteria scores summed across thematic layers and EBSA dimensions.

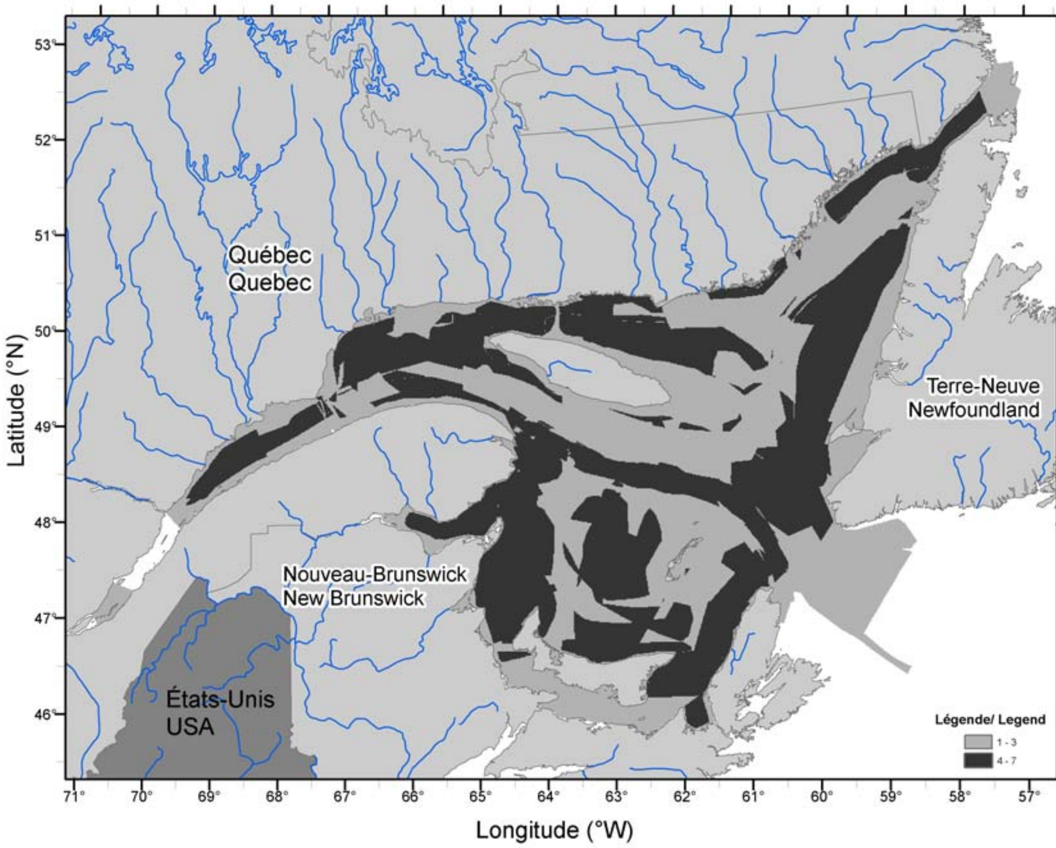

Figure 17. Number of overlapped biological layers without criteria scores summed across thematic layers and EBSA dimensions. Legend: 1-3: from one to three overlapped biological layers, 4-7: from four to seven overlapped biological layers.

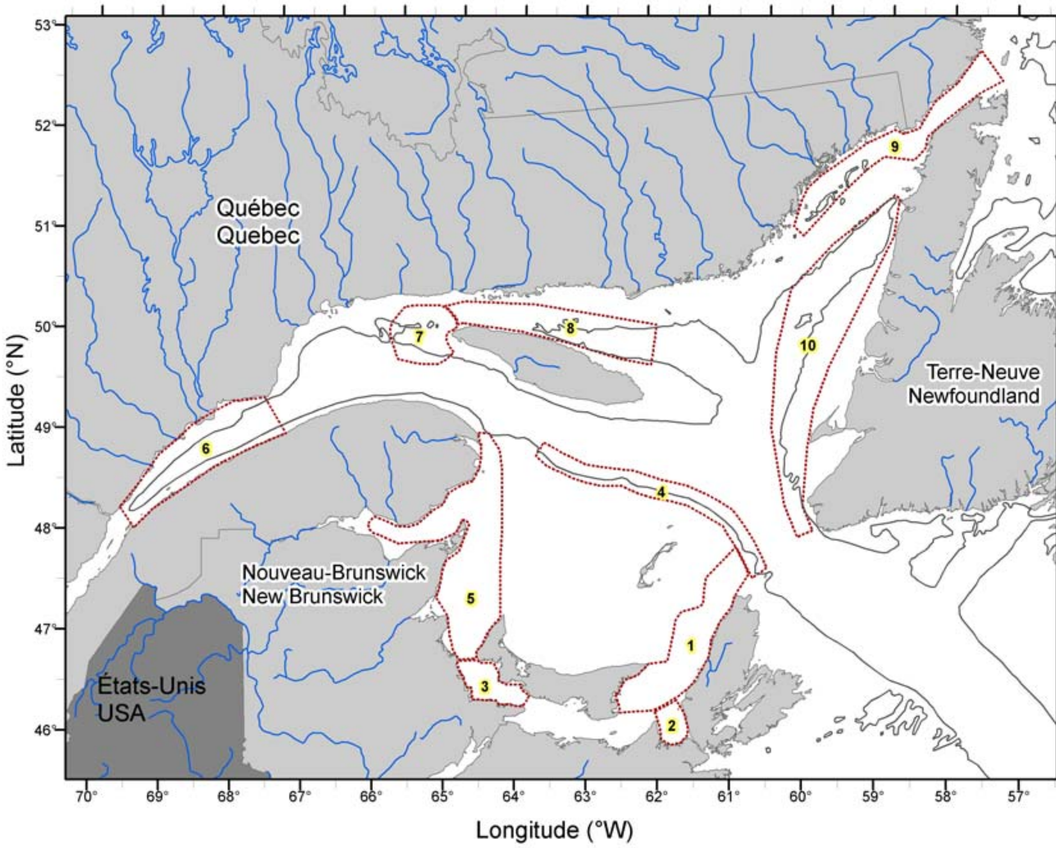

Figure 18. Location of the ecologically and biologically significant areas (EBSAs) in the Estuary and the Gulf of St. Lawrence as selected during the workshop.