MINISTÈRE DE L'ENVIRONNEMENT
ET DE LA LUTTE CONTRE
LES CHANGEMENTS CLIMATIQUES

REPRESENTATIVENESS FOR BIODIVERSITY CONSERVATION IN SECTORS OF ECOLOGICAL INTEREST IN THE ESTUARY AND GULF OF ST. LAWRENCE

Votre gouvernement

Québec

Coordination and editing
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Information

Telephone: 418-521-3830
1-800-561-1616 (toll free)

Fax: 418-646-5974
Form: www.environnement.gouv.qc.ca/formulaires/renseignements.asp
Internet: www.environnement.gouv.qc.ca

To obtain a copy of the document
Direction générale de la conservation de la biodiversité,
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675, boulevard René-Lévesque Est
4e étage, boîte 21
Québec (Québec) G1R 5V7

Telephone: 418-521-3907

or

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PRODUCTION TEAM

Writing:	Frédéric Poisson[1] Virginie Galindo[2]
Cartography:	Tingxian Li[1] Frédéric Poisson[1] Denis Bellavance[1]
Classification and Analyses:	Frédéric Poisson[1]
Revision:	Francis Bouchard Marie-Josée Côté[1] Alexandre Iracà[1] Jean-Pierre Laniel[3] Sylvie Létourneau[3]
Traduction:	Terrance Hugues[4]

1 – Direction de la connaissance écologique

2 – Direction des aires protégées

3 - Direction générale de la conservation de la biodiversité

4 – Traductions Terrance Hugues inc.

FOREWORD

In March 2018, the Government of Canada and the Québec government signed the *Canada-Québec collaboration agreement to establish a network of marine protected areas in Québec*. This administrative agreement provides a collaborative framework to jointly identify, plan and establish marine protected areas, as well as ensure their monitoring. This collaboration has consolidated efforts to meet Canada's commitment to protect by the end of 2020 10% of marine and coastal zones, and Québec's commitment to protect by the end of 2020 10% of the Estuary and the Québec portion of the Gulf of St. Lawrence. The Bilateral Group on Marine Protected Areas (BGMPA) is responsible for implementing the *Canada-Québec collaboration agreement to establish a network of marine protected areas in Québec*. The BGMPA comprises representatives of federal and Québec government departments.

The two projects under study in the Estuary and the northern Gulf of St. Lawrence, presented during information sessions in June 2019, represent the outcome of a rigorous analysis of existing ecological and biological data in the member government departments of the BGMPA. They meet the conservation priorities of the government departments responsible for creating marine protected areas. The project in the Estuary seeks to protect vulnerable marine mammals, i.e., belugas, blue whales, and fin whales, and their prey species, vulnerable fish species, and their habitats. The proposed marine protected area in the northern Gulf of St. Lawrence seeks to strengthen the protection of cold-water corals and sponges and the ecosystems that provide a habitat for them.

Accordingly, the authors of this report are simply the recipients of the representativeness analysis conducted in all the sectors of ecological interest under discussion at the BGMPA. It is incumbent upon the Ministère de l'Environnement et de la Lutte contre les changements climatiques to ensure the preservation of the representative sample of biodiversity as stipulated in the *Natural Heritage Conservation Act*. This method has been used since 2002 throughout Québec in both terrestrial and aquatic environments and allows for monitoring the advancement and effectiveness of Québec's network of protected areas. The scientific representativeness analysis is, therefore, an independent analysis of the decision-making processes that have led to the proposal for the sectors of ecological interest. In particular, we would like to thank Rodolph Balej, whose involvement and hard work with his colleagues from the BGMPA made it possible to stay on course to attain the conservation objectives set, in a spirit of respect for the mandates specific to each government department.

1. BACKGROUND

The *Natural Heritage Conservation Act* stipulates that Québec's network of protected areas seeks to preserve a representative sample of the territory's biodiversity[1] (R.S.Q., chapter C -61.01). The recognition of the representativeness of biodiversity consists in establishing a network of properly ecologically and geographically distributed sites to constitute a sample of the existing ecosystems and species in the territory overall.

Conservation based on the distribution of species represents the most fine grid of the analytical filter of biodiversity. To take stock of representativeness, it is essential to ascertain the spatial distribution of all species in the Estuary and the Gulf of St. Lawrence in Québec. This level of knowledge cannot be achieved and reliance on a coarser grid of the analytical filter was preferred. To protect living organisms, it is essential to protect their habitat. The physical environment is the genetic factor of the organization of ecosystems and the attendant species. In a given bioclimatic context, the diversity of the physical environment considered directly affects biological diversity and, consequently, the representativeness of species. This approach through reliance on the coarse filter, defined by the physical environment, is thus distinct from the approach centred on the fine filter, defined by species (Ducruc *et al*., 2019).

For this analysis, the Québec Ecological Reference Framework is used as an analysis grid with a coarse filter. Québec's Ecological Reference Framework is based on a cartographic approach to the territory that distinguishes differences in the spatial organization of the physical and geological parameters of the marine environment. It relies on the organization of sea bottom topography and the distribution of surface sediments on the seabed. The territory is thus divided into units with increasingly small areas that fit inside each other like Russian dolls (Ducruc *et al.*, 2019). Ecological districts (the fourth level of Québec's Ecological Reference Framework) with an average area of 700 km^2 are the units adopted to establish Québec's network of protected areas. They are described by the proportion of occupancy of different types of biotopes. In the ecological districts, the type of biotope is defined by the combination of sea bottom topography and of a surface sediment on the seabed (see Appendix 1).

[1] Biodiversity: the diversity of living organisms.

2. PHYSICAL-SEDIMENTOLOGICAL PORTRAIT OF THE ESTUARY AND THE GULF OF ST. LAWRENCE

2.1. Depth of the water column and ocean circulation

The Laurentian Channel, a deep submarine valley more than 1 200 km long, crosses the Gulf of St. Lawrence. It stretches from the confluence of the St. Lawrence River and the Saguenay River to the edge of the continental shelf off Newfoundland. The Anticosti Channel and the Esquiman Channel in the northeastern gulf are also two deep submarine valleys. The channels can reach a depth of more than 500 m. The plateaus bordering the Côte-Nord region around the Anticosti Island and the Magdalen Islands do not exceed 100 m in depth.

The Gulf of St. Lawrence receives cold water from the Labrador Shelf, which penetrate through the Strait of Belle Isle to the north, and water from the Atlantic that penetrates through the Cabot Strait to the east (Figure 1. DFO, 2005). The gulf also receives a significant amount of freshwater from an extensive drainage basin. The layer of surface water, which is fresher and less dense, mixes with the underlying saltier and denser ocean layer, fed by the Laurentian Channel. This process causes the formation of the two main surface currents that travel in the waters of the Estuary and the Gulf of St. Lawrence: the Labrador Current, near the shores of the Côte-Nord region, and the Gaspé Current, which runs alongside the north shore of the Gaspé Peninsula and then disperses on the Magdalen Shelf. The complexity of the marine currents creates gyres, such as the counterclockwise gyre situated at the western tip of Anticosti Island.

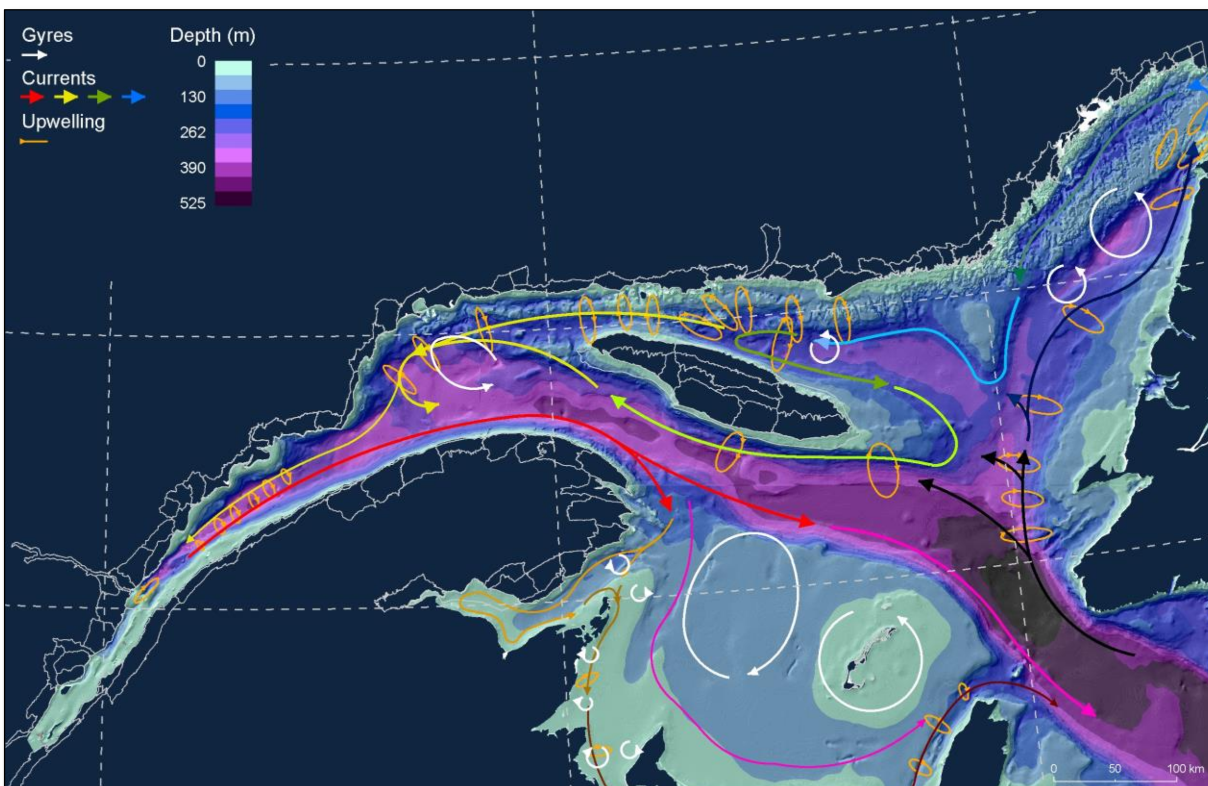

Figure 1: Depth of the water column and ocean circulation in the Estuary and Gulf of St. Lawrence

2.2. Distribution of surface sediments on the seabed

The seabed in the Estuary and the Gulf of St. Lawrence displays two main categories of deposits of marine or terrestrial origin. In the channels, fine deposits (pelite and sandy pelite) of marine or glaciomarine origin are observed (Figure 2). In shallower regions, coarse deposits of sand and gravel of deltaic, littoral, or alluvial origin can be observed.

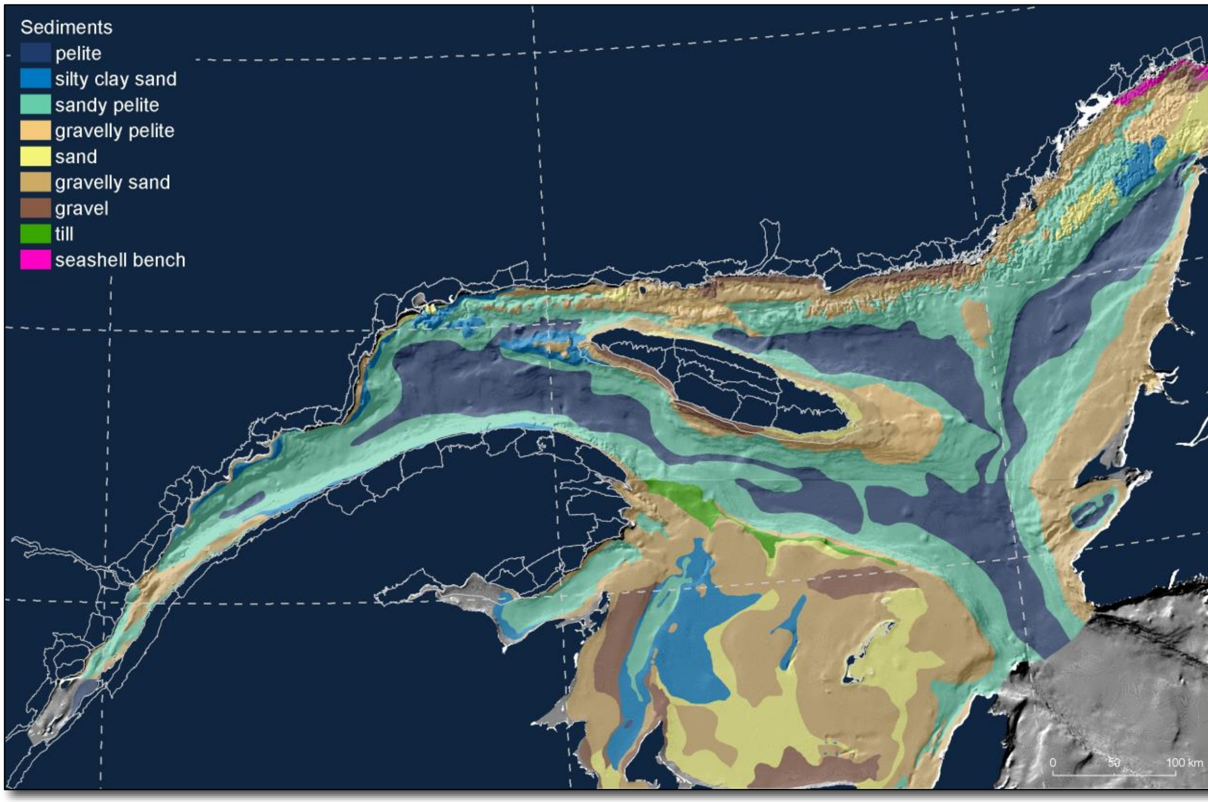

Figure 2: Distribution of surface sediments on the seabed in the Estuary and Gulf of St. Lawrence

2.3. Québec's Ecological Reference Framework

The spatial organization of the physical and geological parameters of the marine environment (depth, currents, and surface sediment on the seabed) (Figures 1 and 2) facilitates the mapping delimitation of the Estuary and the Gulf of St. Lawrence with the method of Québec's Ecological Reference Framework (Ducruc *et al*., 2019) and thus makes it possible to obtain the polygons of the fourth level of perception (ecological districts).

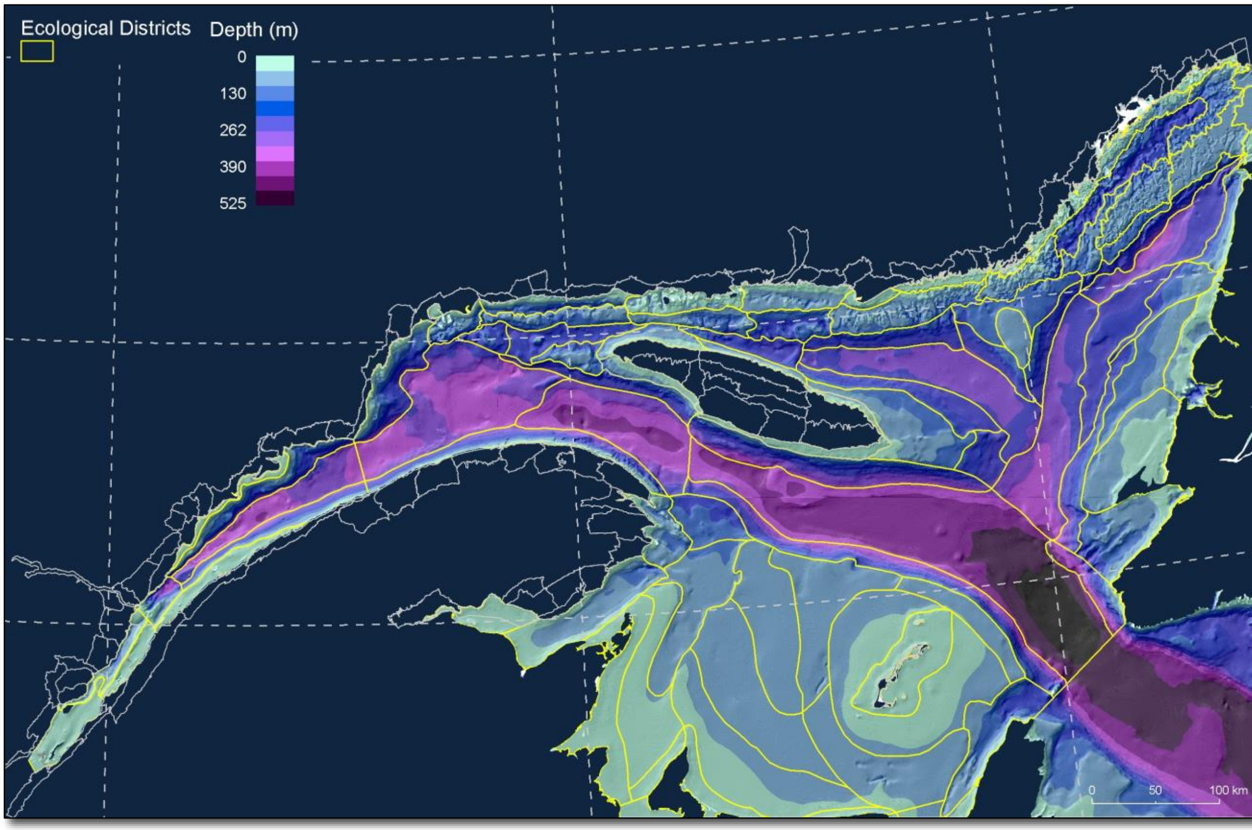

Figure 3: The delimitation of the ecological districts of the Estuary and Gulf of St. Lawrence according to the depth of the water column

2.4. Classification

Based on the ecological districts and by drawing inspiration from the methodology developed in the *Atlas de la biodiversité du Québec nordique* (Poisson *et al*., 2016), a classification was made that determined 10 territorial zones in the Estuary and the Québec portion of the Gulf of St. Lawrence (Figure 4). The ecological districts in each territorial zone possess certain common characteristics that reveal regional ecological contexts (Poisson *et al.*, 2016), essentially morphology such as berms and shelves, and the different depths of the topography of the sea floor that make it possible to distinguish the territorial zones. They are linked to salinities, currents, or oceanographic phenomena such gyres that are specific to them. Accordingly, each territorial zone represents a reference territory whose diversity must be represented.

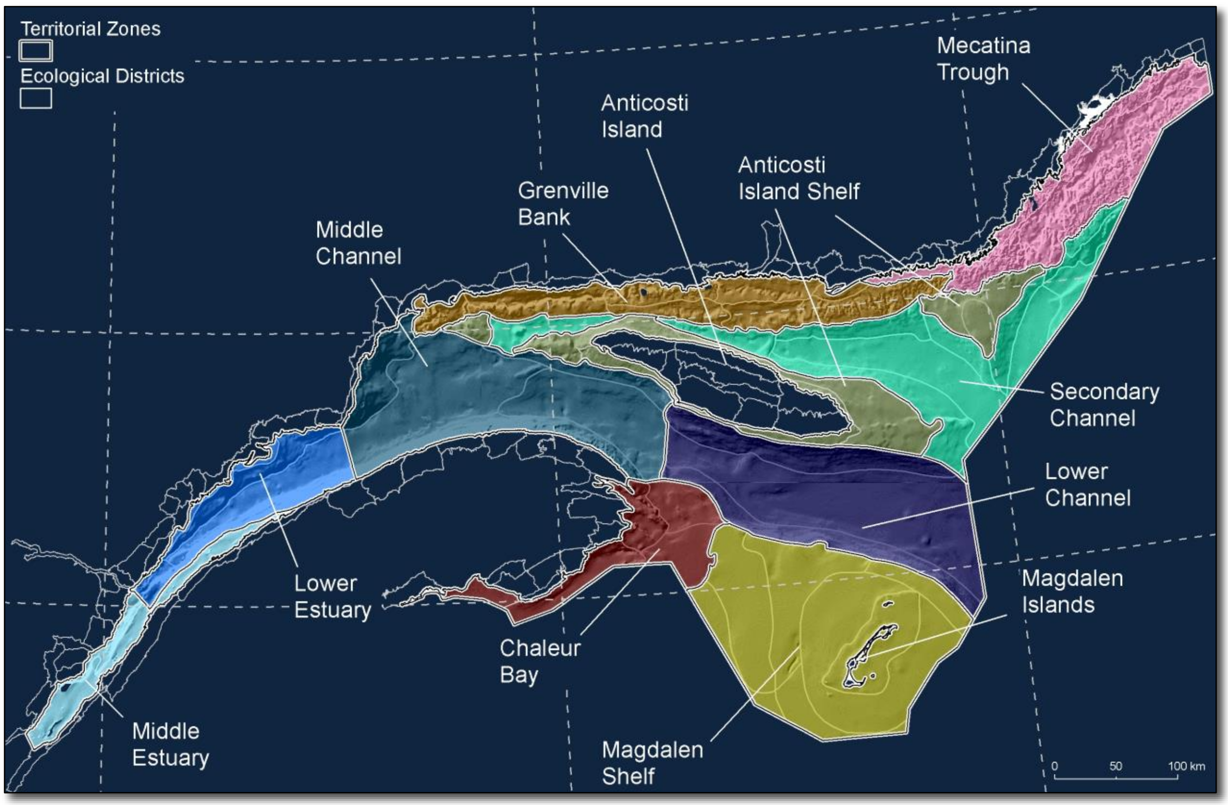

Figure 4: Classification of the territorial zones in the Estuary and the Québec portion of the Gulf of St. Lawrence

2.5. Sectors of ecological interest

Marine protected areas with legal status in Québec (hereinafter marine protected areas) and the sectors of ecological interest under discussion with the federal government are distributed in different territorial zones (Figure 5). The three marine protected areas, i.e., the Saguenay-St. Lawrence Marine Park, the proposed Manicouagan aquatic reserve, and the Bonaventure River Estuary marine reserve, are situated in the territorial zones of the upper estuary, the maritime estuary, and the Chaleur Bay, respectively. The Banc-des-Américains joint marine protected area is situated in the territorial zone of the Chaleur Bay, while the sectors of ecological interest in the northern gulf are situated, by and large, in three territorial zones, i.e., those of the lower channel, the middle channel, and the Anticosti Island Shelf. The sectors correspond to the federal government's coral and sponge conservation zones, called marine refuges.

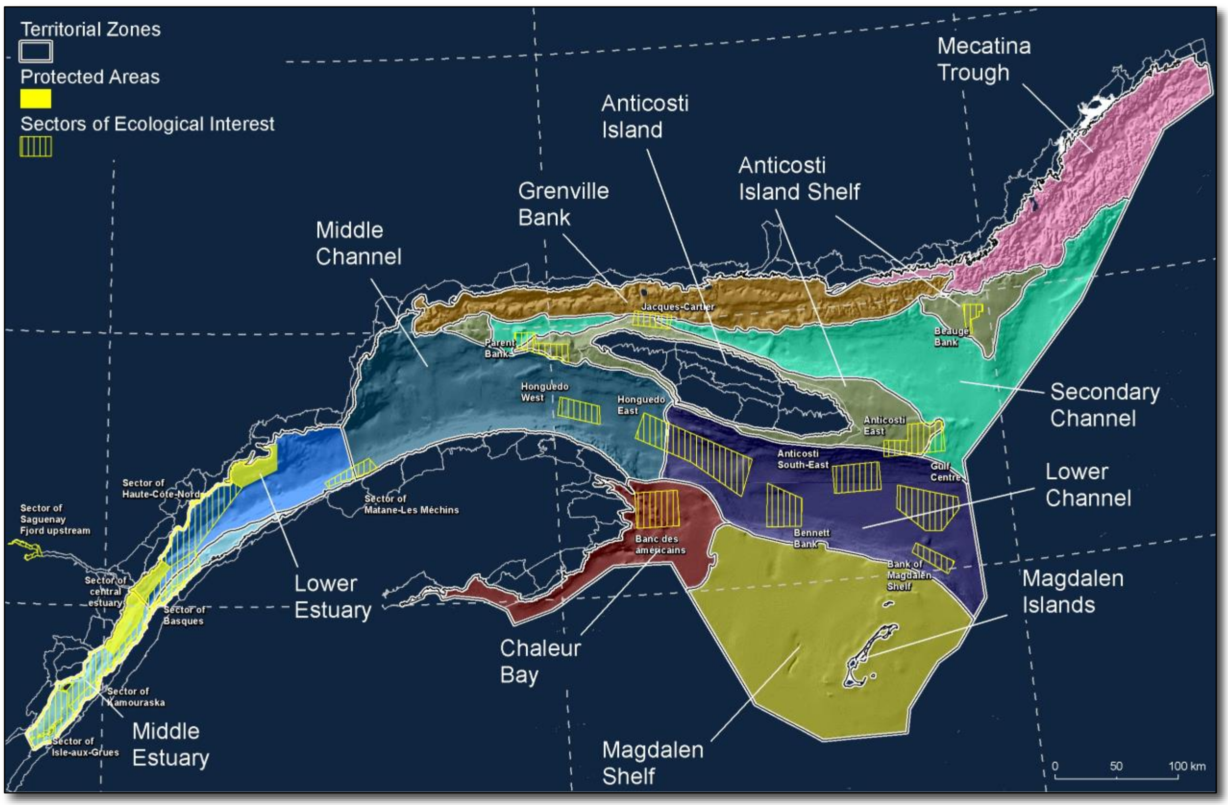

Figure 5: Distribution of marine protected areas and sectors of ecological interest in the territorial zones of the Estuary and the Québec portion of the Gulf of St. Lawrence

3. METHODOLOGY

An analysis of the contribution to the attainment of the conservation objectives of the network of protected areas relies on the biotope. For this analysis in the marine environment, the biotope is defined by the combination of a sea bottom topography and the type of seabed sediment associated with it. For the network of marine protected areas to be representative of biodiversity, the network must be able to represent on an equal basis the entire array of types of biotopes encountered in each of the territorial zones defined.

If the total area of each type of biotope is known (area Tb) in each territorial zone (reference territory), the individual contribution (contri.) of the marine protected areas (MPAs) can be calculated. To calculate the contribution of the sectors of ecological interest being proposed to become new MPAs, the areas of the types of biotopes of the marine protected area are reduced to the initial objectives. It is also possible to calculate the contribution of the entire array of units (MPAs and sectors of ecological interest) for each territorial zone. Table 1 presents an example of fictitious results, including the equations, to explain the methodology in detail.

Table 1. Example of fictitious results obtained by means of the equations mentioned in the methodology

	Territorial zone			Unit (MPA and/or sectors of ecological interest)			
	Area Tb.	**%**	**Obj. 10%**	**Area of unit**	**Contri.**	**Contri. 100**	**Weighted contri.**
Type 1	175	70	17.5	10	57	57	40
Type 2	50	20	5	0	0	0	0
Type 3	25	10	2.5	5	200	100	10
	250					**Total contri.**	**50**

Area of Tb. The total areas of the type of biotope of all the ecological districts in a territorial zone.

% Percentage of the area of a type of biotope in relation to all the types of biotopes in each territorial zone.
% = area Tb. × 100 / Σ area Tb.

Obj. 10% Objective of 10% of the area of the type of biotope in the territorial zone
Obj. 10% = tot. area × 0.1

Area of unit Area of the type of biotope in the marine protected areas and/or the sectors of ecological interest

Contri. Contribution to the attainment of the conservation objectives
Contri. = area of unit × 100 / Obj. 10%

Contri. 100 If the area exeeds the area of the objective, the contribution is reduced to 100
Contri. 100: if contri. ≥ 100 then contri. 100 = 100 otherwise contri. 100 = contri.

Weighted contri. Contribution weighted by the percentage of the type of biotope
Weighted contri. = contri. 100 × % / 100

Total contri. Total of all the weighted contributions
Total contri. = Σ weighted contri.

The contribution analysis and the gap analysis are complementary measurements. Accordingly, a territorial zone that makes a strong contribution displays a narrow gap, while a territorial zone that makes a small contribution displays extensive gaps.

4. RESULTS

4.1. The contribution of the ecological districts

Each ecological district encompasses different types of biotopes and their individual contribution to the representativeness of the types of biotopes varies accordingly (Figure 6). Ecological districts that make a strong contribution represent districts that possess the greatest capacity to attain the conservation objectives within a territorial zone. It should be noted that rare, irreplaceable elements are not identifiable on the map.

Figure 6: The individual contribution of ecological districts to the representativeness of the types of biotopes by territorial zone

4.2. The attainment by marine protected areas of the objectives by territorial zone

In the context of the conservation objective of 10% in marine and coastal environments and bearing in mind the presence of the Bonaventure River Estuary marine reserve, in the proposed Manicouagan aquatic reserve and the Saguenay-St. Lawrence Marine Park, , 56% and 52.1%, respectively, of the biotope representation objectives have already been achieved in the maritime estuary and in the upper estuary (Figure 7).

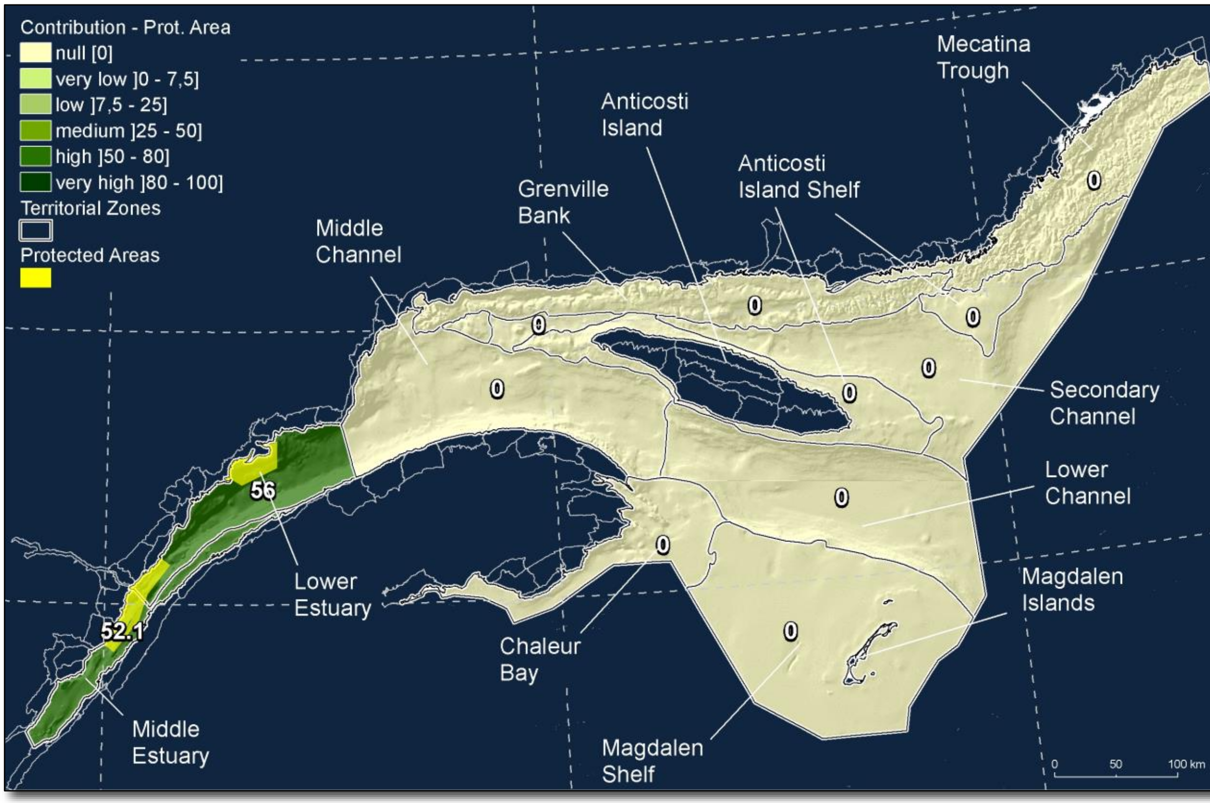

Figure 7: The total contribution of marine protected areas to the representativeness of the types of biotopes by territorial zone

4.3. The contribution of the sectors of ecological interest

The contribution of the sectors of ecological interest proposed to preserve the marine environment is calculated bearing in mind the types of biotopes present in the existing marine protected areas (Figure 8). The contribution to the representativeness of the types of Honguedo-Est biotopes in the lower channel and the Banc-des-Américains in the Chaleur Bay is strong, while it is weaker for all the other sectors of ecological interest in the northern portion of the gulf. In the maritime and upper estuary, certain sectors contribute very strongly to the representativeness of the types of biotopes.

Despite medium to strong representativeness, sectors of ecological interest in the lower channel, the diversity observed in coral and sponge communities differs markedly between the sectors. Indeed, the South-East of Anticosti site displays a heavy concentration of sponges (*Porifera* spp.), while three of the sites in the vicinity display a high abundance of sea pens and the portion of the Honguedo-West site has a high abundance of sea pens and sponges. The microecosystems created by the sponges should be different in the presence of a high abundance of sea pens or in their absence. Accordingly, even if the sectors of ecological interest are situated in the same territorial zone, i.e., the lower channel, and the latter includes the same types of geophysical environments, certain sites are noteworthy for the communities found there. The sectors of ecological interest correspond to the federal government's marine refuges, which take into consideration the areas of concentration of coral and sponge communities, and fishing activities. This is a finer analysis grid, which affords added value to representativeness, but which has induced biases concerning the distribution of the sectors of ecological interest, since the majority are found in the Laurentian Channel.

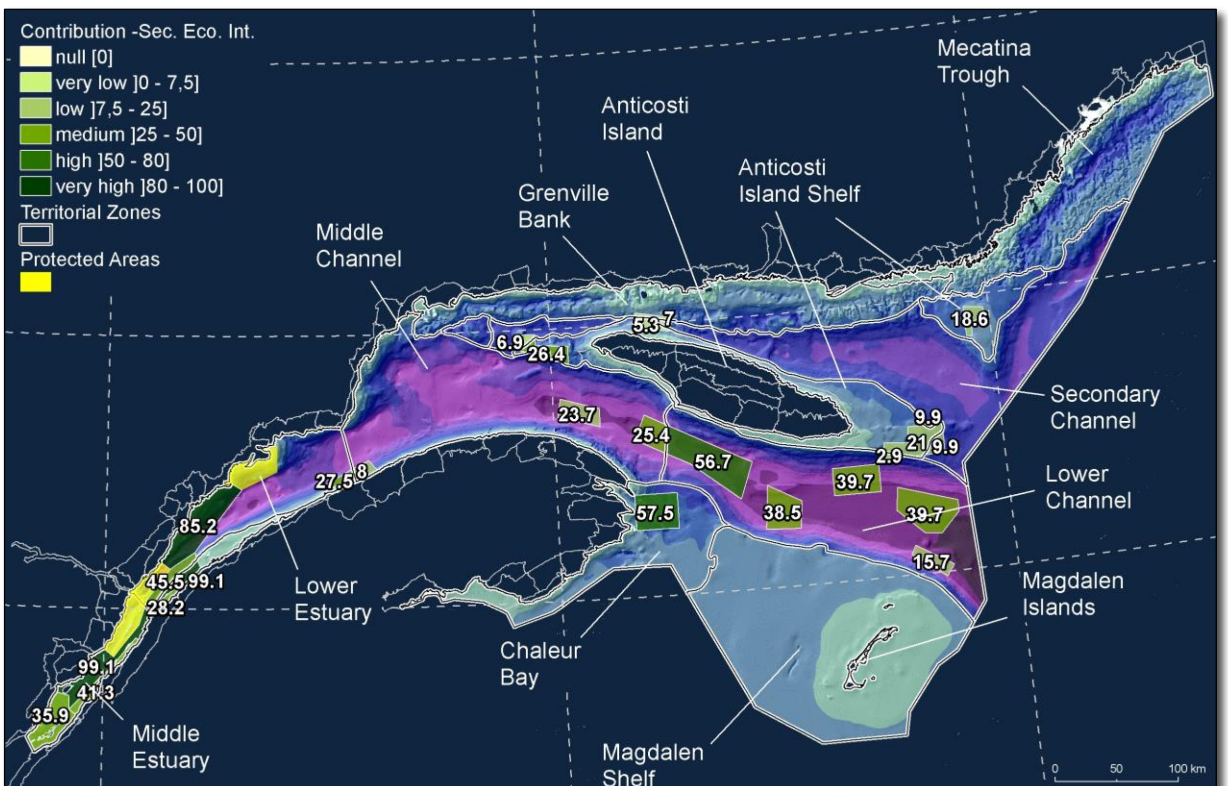

Figure 8: The individual contribution of the sectors of ecological interest to the representativeness of the types of biotopes by territorial zone

4.4. The achievement of objectives by territorial zone by marine protected areas and sectors of ecological interest

In the context of the conservation target of 10% in marine and coastal environments, the contribution to representativeness of biotopes by territorial zone in the sectors of ecological interest added to that of the marine protected areas is very strong (> 81.8%) in the lower channel, the maritime estuary, and the upper estuary, while it is nil for the Mecatina Trough and the Magdalen Shelf (Figure 9). It should be noted that the objective of the project in the northern Gulf of St. Lawrence is to strengthen the protection of corals and sponges, therefore the sectors of ecological interest that correspond exactly to the delimitation of the federal government's marine refuges. The project in Magdalen Islands, in collaboration with Parks Canada, is not considered in the attainment of the target of 10% in marine and coastal environments since it is in the feasibility study phase.

Figure 9: The total contribution of marine protected areas and sectors of ecological interest to the representativeness of the types of biotopes by territorial zone

4.5. The percentage of marine protected areas and sectors of ecological interest by territorial zone

The area of each territorial zone occupied by the marine protected areas and the sectors of ecological interest confirms the heterogeneousness of the distribution of the sectors of ecological interest (Figure 10). Indeed, marine protected areas and sectors of ecological interest occupy more than 20% of three of the 10 territorial zones (the lower channel and the upper and maritime estuary), while they account for less than 6% if three territorial zones (the Grenville Bank, the middle channel, and the secondary channel), and none at all in two of them (the Mecatina Trough and the Magdalen Shelf).

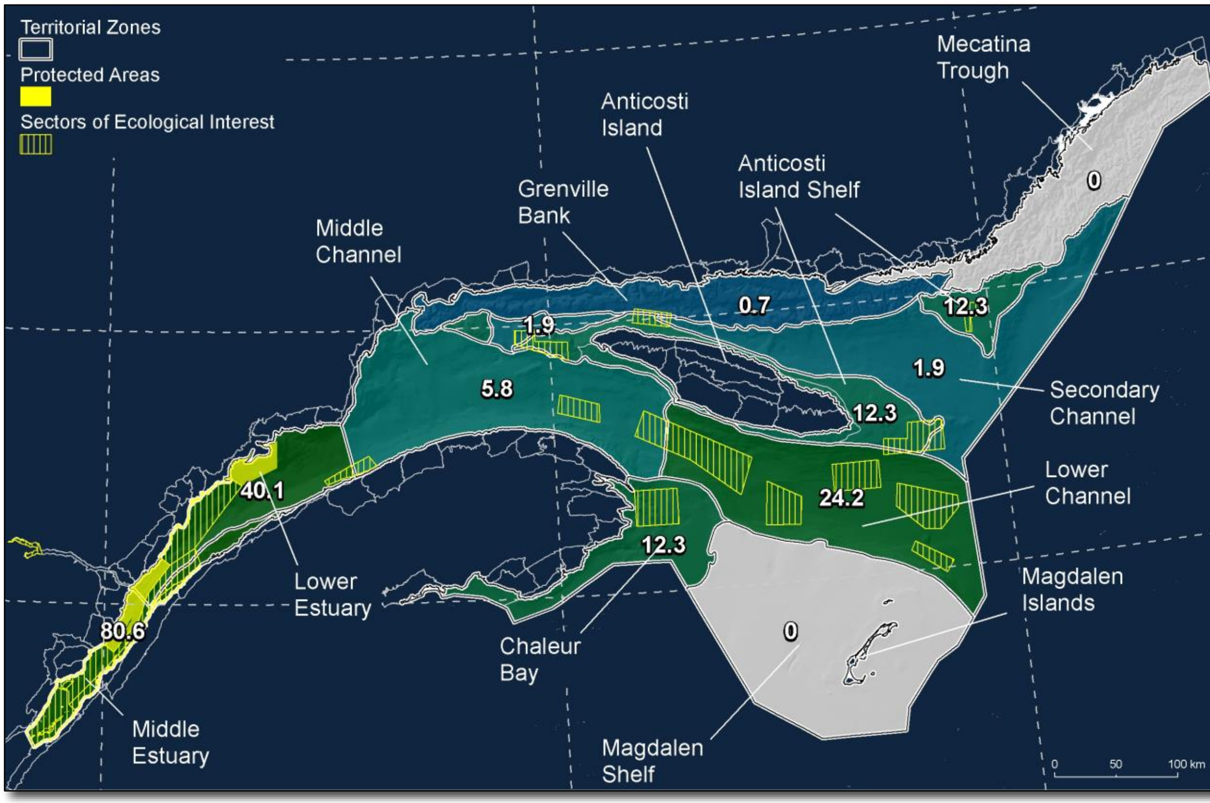

Figure 10: The percentage of the area of each territorial zone occupied by marine protected areas and sectors of ecological interest

4.6. The effectiveness of the network in the attainment of representativeness objectives

Lastly, Figure 11 represents the percentage of types of biotopes not represented in each territorial zone occupied by marine protected areas and sectors of ecological interest. Figures 9, 10 and 11 reveal the over-representation of certain biotopes in certain territorial zones and the gaps that remained to be filled.

Accordingly, to enhance the representativeness of the network of marine protected areas in Québec, efforts should focus on the territorial zones that display a percentage greater than or equivalent to 50% when the new conservation targets will be determined.

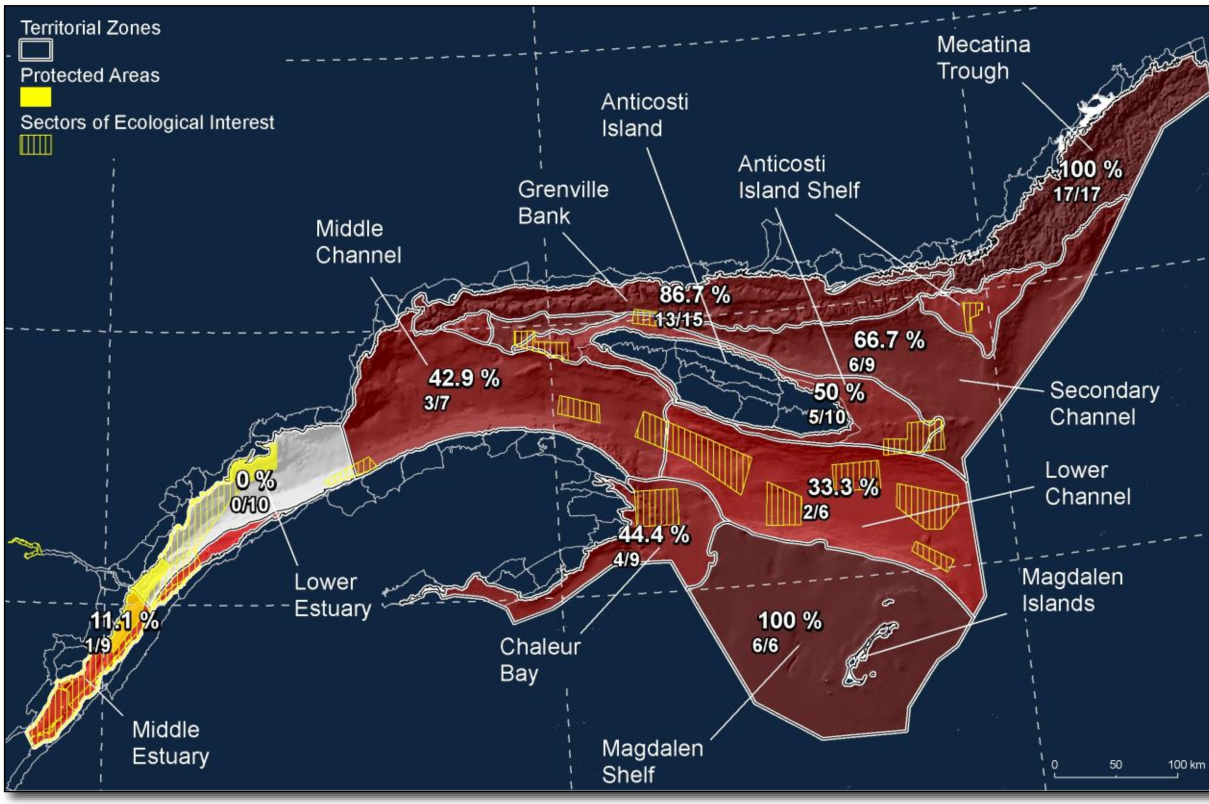

Figure 11: The percentage of biotopes not represented in each territorial zone occupied by marine protected areas and sectors of ecological interest. The fraction indicates the number of biotopes not represented out of the entire array of biotopes present in the territorial zone.

5. CONCLUSION AND OUTLOOK

The Québec government has selected certain sectors of ecological interest in the Estuary and in the Québec portion of the Gulf of St. Lawrence to attain the target of 10% of coastal and marine environments protected in Québec before the end of 2020. The selection of the sectors of ecological interest strengthens the protection of key organisms in the Estuary and the Gulf of St. Lawrence, even if such sectors do not allow for the establishment of a network of ecologically and geographically well distributed sites. The recognition of fine elements of biodiversity has afforded added value to the representativeness of a network of marine protected areas, but it has led to a bias respecting the spatial distribution of the sectors of ecological interest since most of them are situated in the Laurentian Channel.

The use of the coarse filter is well-tried in terrestrial environments. Given the complexity of the marine environment, a greater number of oceanographic variables must be recognized in future analyses to better characterize the ecosystem's physical component. The addition of data on salinity, temperature, oxygenation, light, and the speed and direction of currents in the ocean bottom layer could thus contribute to enhancing the coarse filter analysis. Since the ecosystem's physical features affect the distribution and dynamics of communities of living organisms, the additions will create a more robust link between the habitat and the bottom communities that develop there. While the distribution of specific species such as corals, sponges, belugas, and so on has been emphasized to determine these sectors of ecological interest, it is recommended that a coarse filter analysis be conducted for the forthcoming conservation targets. This approach will overcome the gaps in certain types of biotopes in order to grasp the overall biodiversity of the estuary and the Gulf of St. Lawrence in Québec.

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Québec's Ecological Reference Framework Données Québec – Ecological reference framework: https://www.donneesquebec.ca/recherche/fr/dataset/cadre-ecologique-de-reference

Territorial zones: « Zone_ter » column in Level 4 table in Québec's Ecological Reference Framework. Données Québec – Ecological reference framework: https://www.donneesquebec.ca/recherche/fr/dataset/cadre-ecologique-de-reference.

APPENDIX 1 – TYPES OF BIOTOPES

The description of the ecological districts is based on the evaluation of the proportions that different types of biotopes occupy. The biotope, an environment that displays homogeneous environmental conditions where living organisms develop, is characterized by a sea bottom topography, the surface sediments of the seabed, and the nature of the rock present.

Given the thickness of the sedimentary layer on the Earth's crust or the oceanic crust, the latter has very little impact on the development of biocenosis, or the entire array of living beings coexisting in a given ecological space.

In the Estuary and the Gulf of St. Lawrence, 18 varieties of sea bottom topography have been identified based on the characteristics of the seabed, i.e., the depth of the water column, the slope of the geological structure and/or the magnitude of the topography (Table 1, Figure 1).

Table 1. Varieties of sea bottom topography in the Estuary and Gulf of St. Lawrence

Sea bottom topography	%
ISL : Island	0.5
MN : Mounds - topography of the sea floor with less than 25 m of vertical drop	0.1
HI : Hillocks - topography of the sea floor with between 25 m and 50 m of vertical drop	0.4
HUM : Hummocks - topography of the sea floor with between 50 m and 100 m of vertical drop	0.3
SL1 : Slope	17.9
SL2 : Steep slope	7.6
SU : Sumit	0.5
BE : Bench	0.3
LG : Lagoon - a body of water lying between dry land and an offshore bar	0.2
FO : Foreshore tidal flats - the portion of the shoreline periodically covered by the sea	0.2
SH1 : Shelf (<30 m deep)	6.7
SH2 : Shelf (between 30 m and 100 deep)	21.6
SH3 : Shelf (between 100 m and 200 deep)	4.1
CB1 : Subtidal channel bottom connecting channel	2.1
CB2 : Average channel bottom connecting channel (> 100 m)	5.2
CB3 : Deep channel bottom connecting channel (between 100 m and 300 m deep)	9.6
CB4 : Very deep channel bottom connecting channel (>300 m)	20.9
TR : Trough (bottom >250 m deep with slope)	1.8

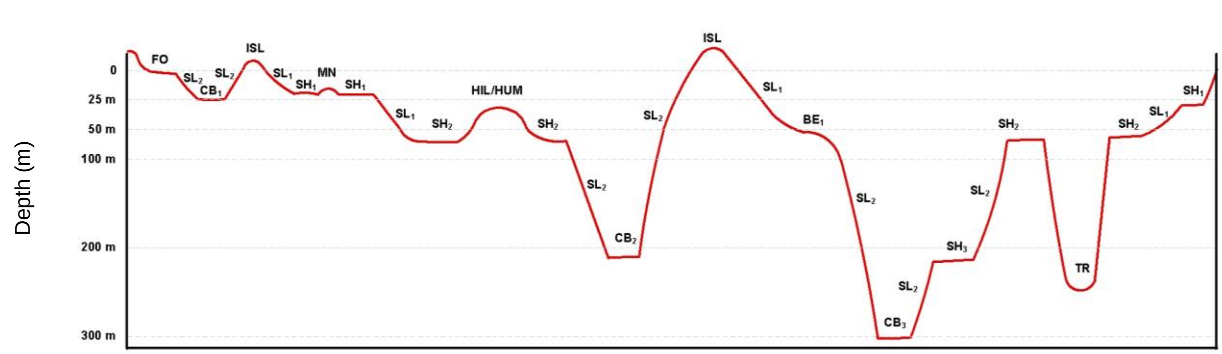

Figure 1. Fictitious profile indicating different varieties of sea bottom topography observable in the Estuary and the Gulf of St. Lawrence

In the Estuary and the Gulf of St. Lawrence, 11 types of sediments have been identified, two of which are strictly terrestrial (Table 2).

Table 2. Origin and size of surface sediment grains on the seabed identified in the Estuary and Gulf of St. Lawrence

Origin and size of surface sediment grains on the seabed	%
Aquatic	
10A: Marine deposits; fine texture	6.1
10AC: Marine deposits; fine texture; carbonate-bearing	13.0
10AS: Marine deposits; fine texture; sandy	37.8
10C: Marine deposits; shellfish beds	0.3
10G: Marine deposits; gravelly texture	4.3
10S: Marine deposits; medium texture	34.3
10SC: Marine deposits; medium texture; carbonate-bearing	2.5
1AE: Glacial deposits; moraine without morphology; thick	1.0
Terrestrial and aquatic	
1A: Glacial deposits; moraine without morphology	0.4
Terrestrial	
0R: Outcrops; with other deposit < 20%	0.2
6DH: Littoral deposits; old glaciomarine deposits; upper beach	0.1

For the description of the ecological districts in the Estuary and the Gulf of St. Lawrence, 51 combinations are used by linking the different varieties of sea bottom topography and the distribution of surface sediments on the seabed (Table 3).

Table 3. Percentage occupancy of different types of biotopes in the 10 territorial zones of the Estuary and the Québec portion of the Gulf of St. Lawrence. Z_X01: upper estuary, Z_X02: lower estuary, Z_X03: middle channel, Z_X04: lower channel, Z_X05: secondary channel, Z_X06: Chaleur Bay, Z_X07: Magdalen Island Shelf, Z_X08: Grenville Bank, Z_X09: Anticosti Island Shelf, Z_X10: Mecatina Trough

Biotopes	Territorial zones in the estuary and Gulf of St. Lawrence;									
	Z_X01	Z_X02	Z_X03	Z_X04	Z_X05	Z_X06	Z_X07	Z_X08	Z_X09	Z_X10
BE_10AS		3	1							
CB1_10AS	6									
CB1_10G	6					1				
CB1_10S	32					13				
CB2_10AS						15				
CB2_10C										0
CB2_10S	12	1				20	14			
CB2_10SC										1
CB2_1AE							2			
CB3_10A					21					
CB3_10AC					20					
CB3_10AS					11	6			2	
CB3_10S						18				
CB3_1AE						13				
CB4_10A			16							
CB4_10AC			31	31						
CB4_10AS		29	20	31						
CB4_10S		11								
FO_10A	4									
FO_10AS	2									
HIL_10AS								3		2
HUM_10AS								2		
HUM_10S						2				
ISL_0R										3
ISL_1A								2		
ISL_6DH	4									
LG_10S							1			
MN_10AC					1					
SH1_10C										3
SH1_10G		3						6		5
SH1_10S	28	7					12	1	4	7
SH1_10SC									12	
SH2_10AS								6	21	13
SH2_10G							17			
SH2_10S							54	28	20	9
SH2_10SC									3	7
SH3_10AC					3					
SH3_10AS					3			8	21	12
SL1_10A					5					
SL1_10AC					5					
SL1_10AS		32	16	20	32			13		
SL1_10S		4	9					10	14	3
SL1_10SC										2
SL2_10AS	6	8	6					5	2	13
SL2_10C										0
SL2_10S		3		15		12		7	2	1
SL2_10SC				2						
SL2_1A				2						
SU_10S								5		
SU_10SC								1		
TR_10AS								3		18

Environnement
et Lutte contre
les changements
climatiques

Québec