Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Standard level
Paper 1 – resource booklet

Friday 8 November 2019 (afternoon)

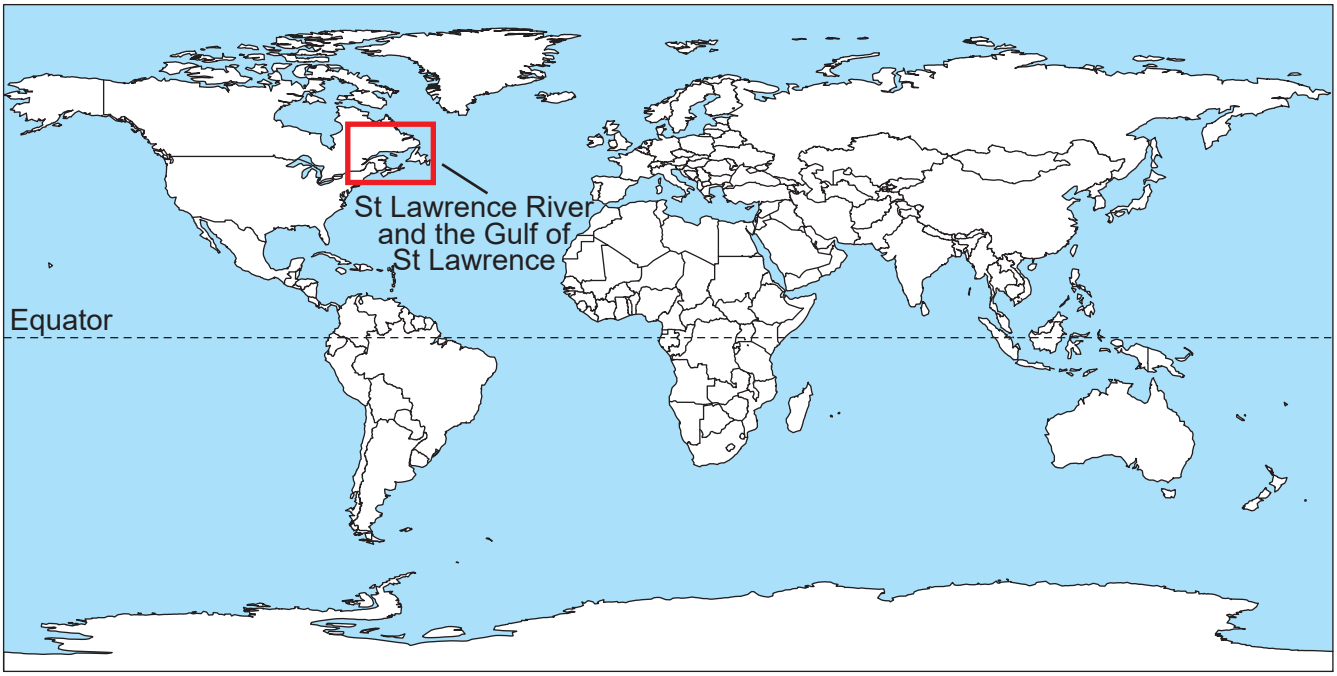
1 hour

Instructions to candidates

- Do not open this booklet until instructed to do so.
- This booklet contains all the resources to answer paper 1.

8819 – 6302

Figure 1(a): World map showing the location of the St Lawrence River and the Gulf of St Lawrence in North America



[Source: adapted from TUBS/Wikimedia.
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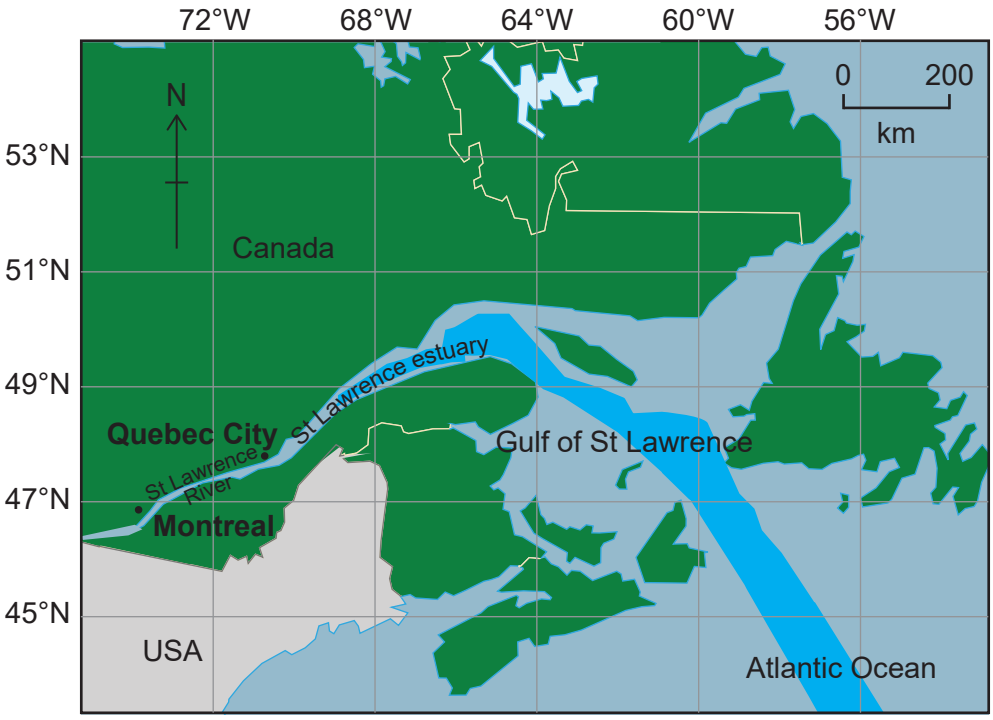
Figure 1(b): Map showing the location of the St Lawrence River from Montreal to the Gulf of St Lawrence



[Source: Fisheries and Oceans Canada. Reproduced with the permission of
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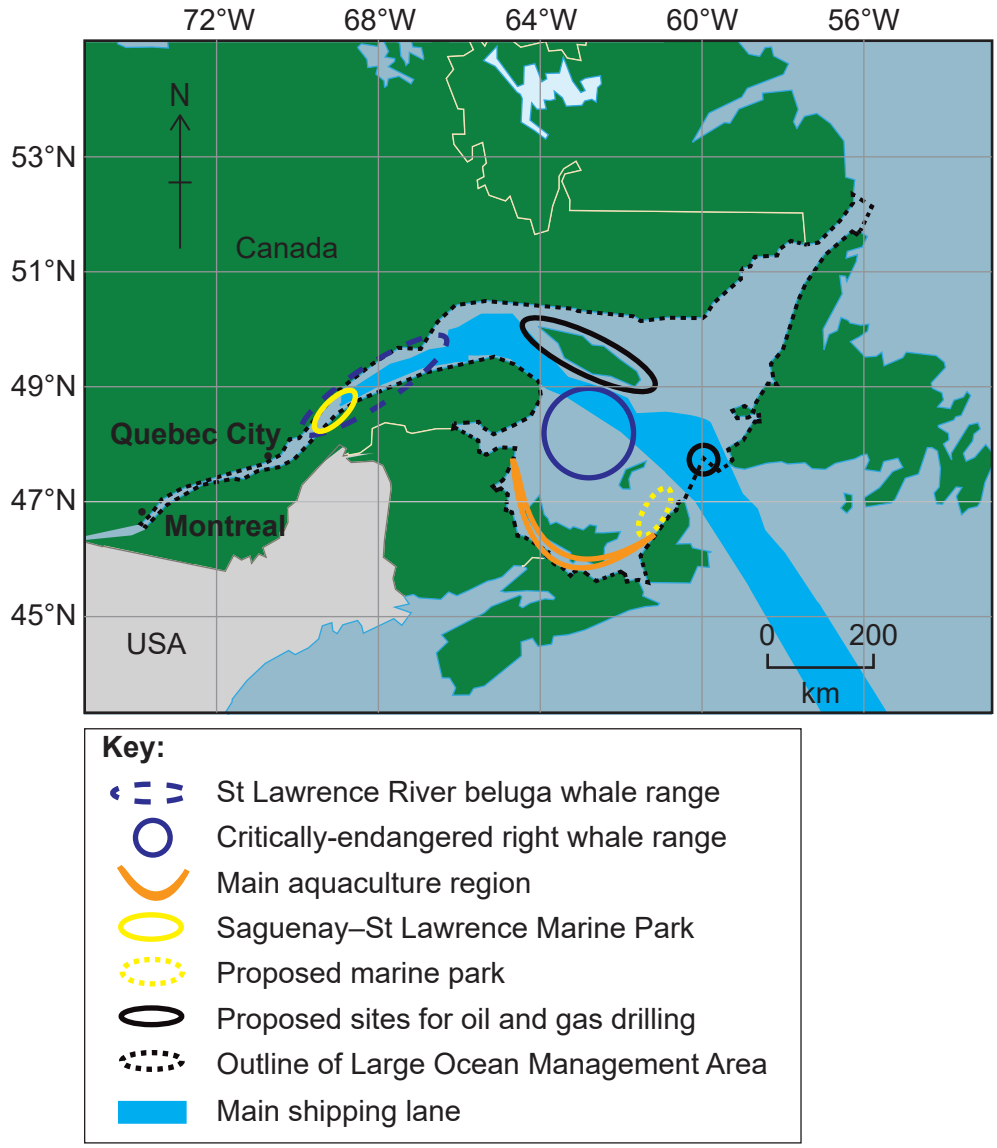
Figure 2(a): Fact file on the St Lawrence River estuary and the Gulf of St Lawrence

The St Lawrence River estuary and the Gulf of St Lawrence are recognized as a Large Ocean Management Area by the Canadian government (Figure 2(b)).

- It is an important shipping route from the Atlantic Ocean to eastern Canada.
- The area is highly productive (Figure 4(a)).
- It provides habitat for wildlife, including resident and migratory birds, whales and crabs.
- It provides nursery grounds for commercial fish species (cod, halibut).
- Management of the area is challenging because the interests of different stakeholders may be in conflict or environmentally damaging.

[Source: adapted from https://www.dfo-mpo.gc.ca]

Figure 2(b): Map showing the Large Ocean Management Area



[Source: Fisheries and Oceans Canada. Reproduced with the permission of
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Figure 3(a): Economic uses of the St Lawrence River estuary and the Gulf of St Lawrence

Commercial snow crab fishing

Removed for copyright reasons

Aquaculture

[Source: FishFarmingExpert]

Oil and gas exploration

Sport fishing

[Source: Dale Scullion]

Tourism such as bird watching and whale watching

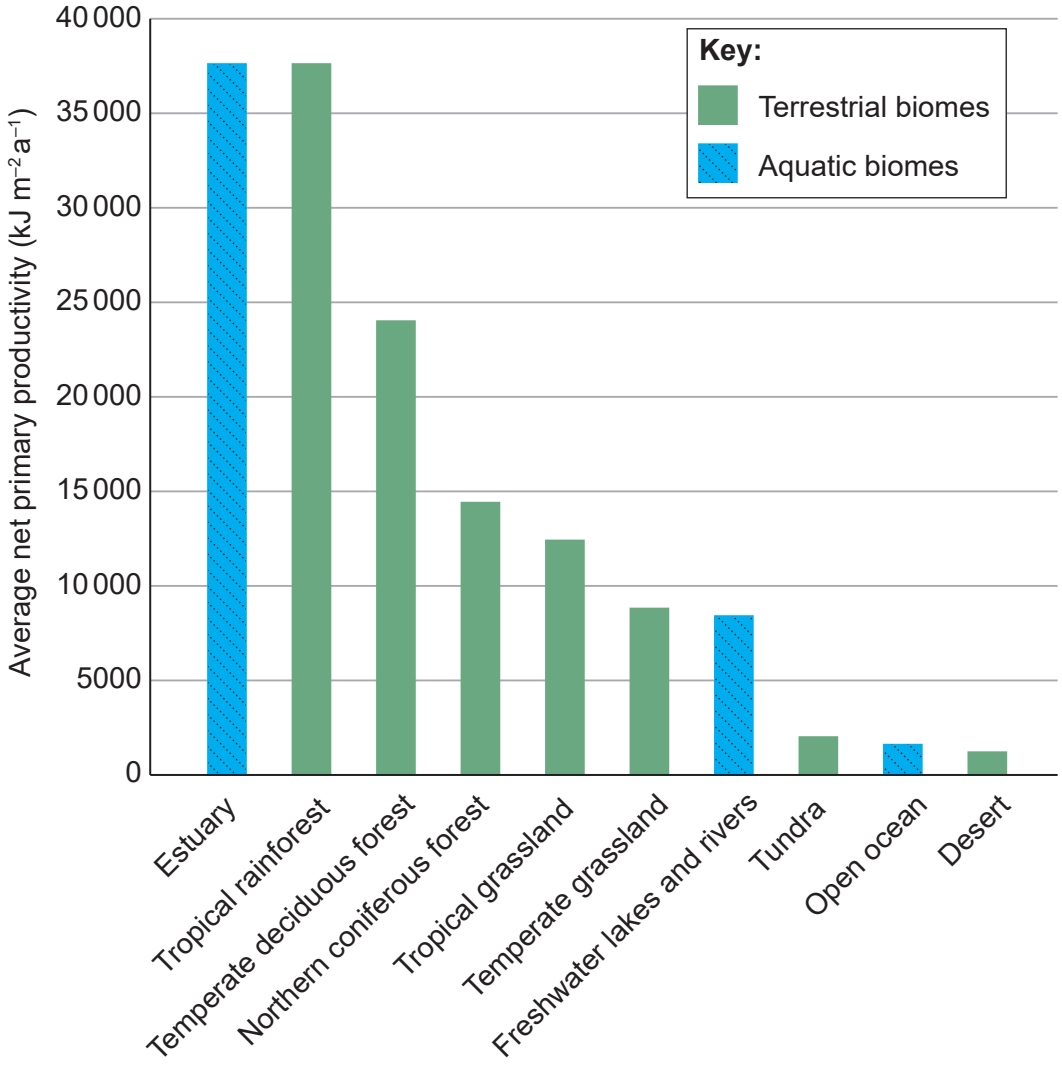
[Source: Jean Iron. Greater Snow Geese in Ontario (2011). Used with permission]

Figure 3(b): Typical annual income (millions of Canadian dollars) from economic activities in the Large Ocean Management Area

Economic activity	Annual income (millions of Canadian dollars)
Oil and gas (estimated)	45 000
Commercial fishing	533
Aquaculture	39
Whale watching	20

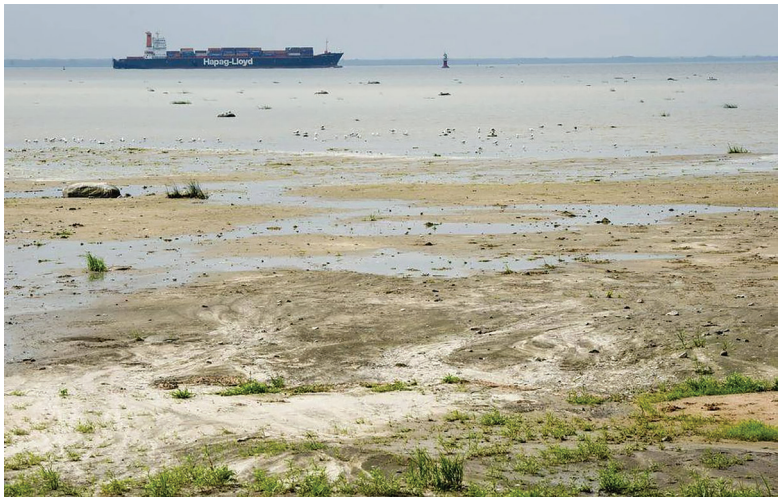
[Source: www.dfo-mpo.gc.ca]

Figure 4(a): Average net primary productivity (kJ m^{-2} a^{-1}) of selected world biomes



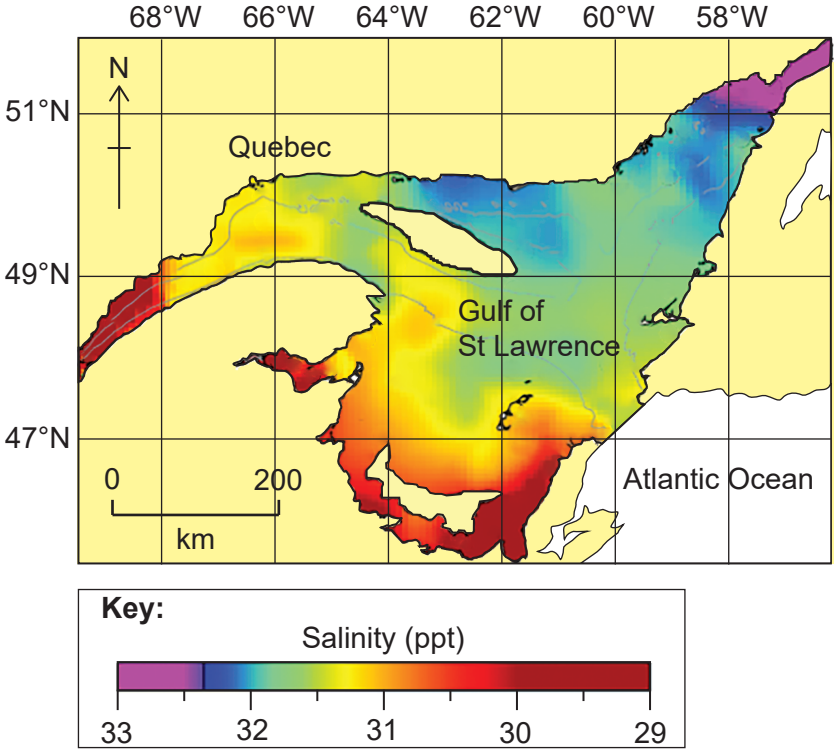
[Source: graphic used with the permission of Integrated Access STEM Sites, LLC]

Figure 4(b): Mudflats along the St Lawrence River estuary at low tide



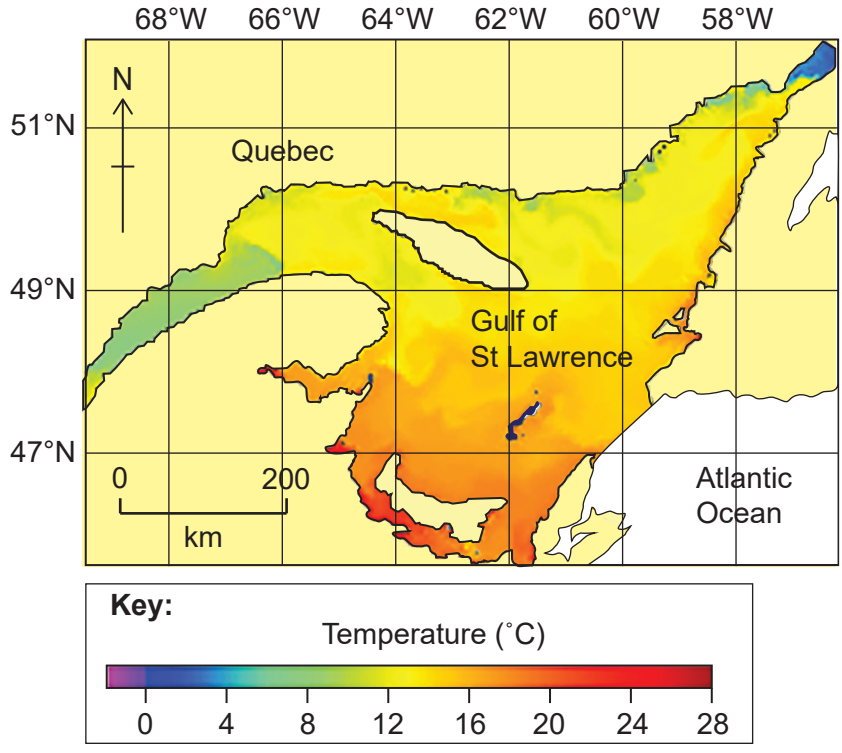
[Source: THE CANADIAN PRESS/Paul Chiasson]

Figure 5(a): Salinity variations in the Large Ocean Management Area



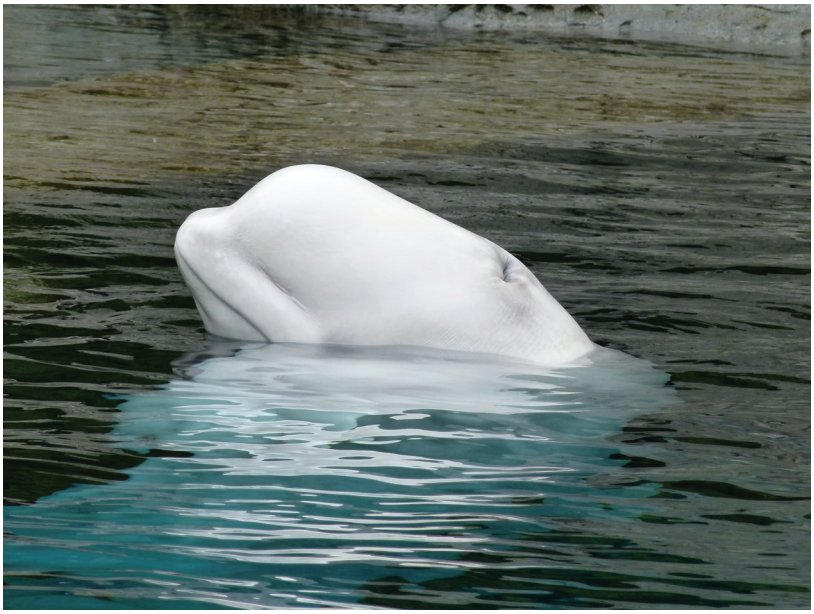
[Source: Fisheries and Oceans Canada. Reproduced with the permission of © Her Majesty the Queen in Right of Canada, 2019]

Figure 5(b): Water-surface temperature variation across the Large Ocean Management Area



[Source: Fisheries and Oceans Canada. Reproduced with the permission of © Her Majesty the Queen in Right of Canada, 2019]

Figure 6(a): Beluga whale (*Delphinapterus leucas*)

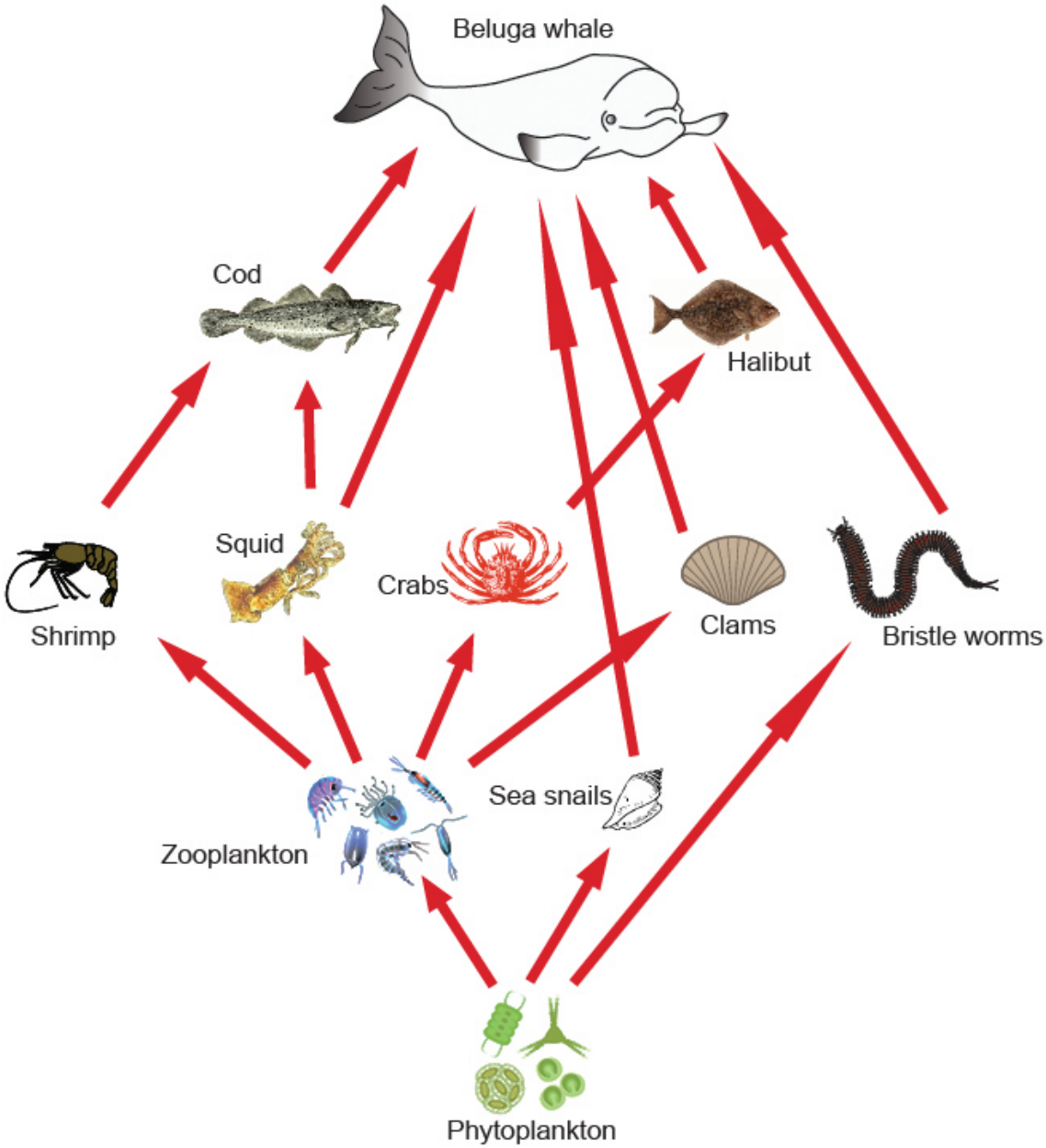


[Source: https://pixabay.com/]

Figure 6(b): Fact file on the beluga whale (*Delphinapterus leucas*)

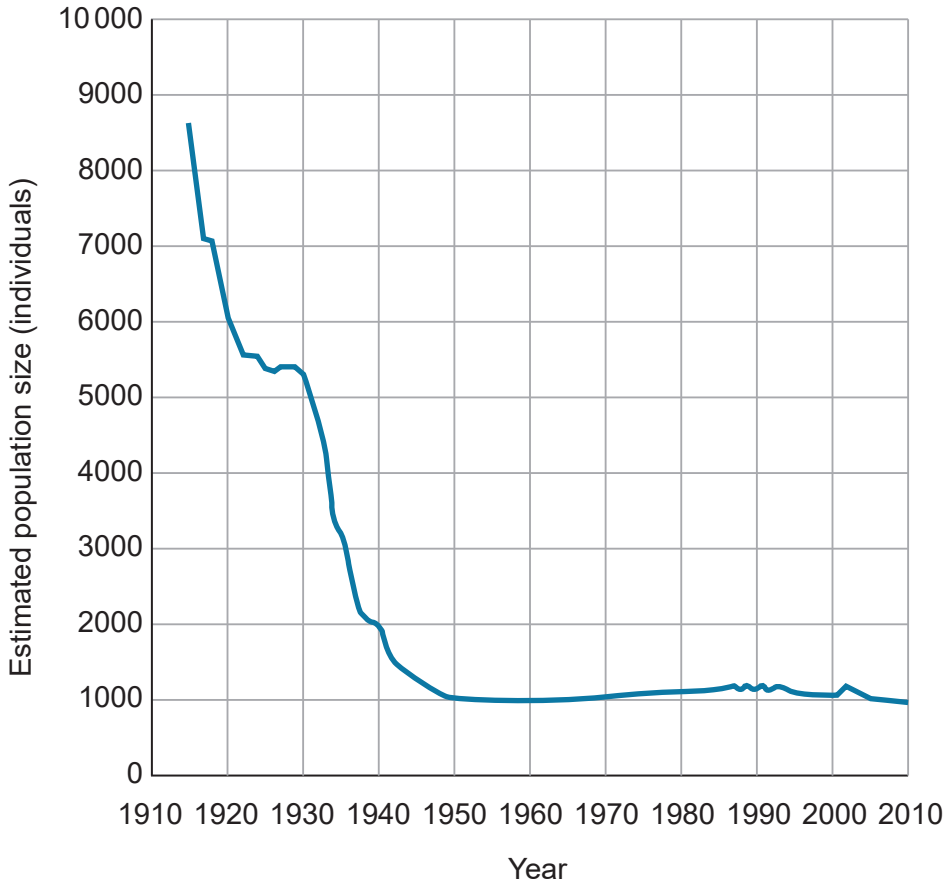
- Opportunistic feeders, change their food sources with the seasons.
- Can live for up to 70 years.
- 40–50 % of the beluga whale's body weight is made up of fat.
- Reaches sexual maturity between 5 and 9 years of age.
- The worldwide population of beluga whales is estimated at 150 000.
- The St Lawrence River estuary population (900 individuals)
    - is isolated from other beluga whales
    - is listed as endangered by the Canadian government
    - has been protected by law since 1983.

Figure 6(c): A simplified food web for the St Lawrence River beluga whale



[Source: Halibut image: FishWatch.gov
Phytoplankton: GreenVector/VectorStock
Zooplankton: macrovector/VectorStock]

Figure 7: Estimated population of the St Lawrence River beluga whales



[Source: An age-structured Bayesian population model for St. Lawrence Estuary beluga (Delphinapterus leucas), Canadian Science Advisory Secretariat (CSAS) Research Document 2013/127, Quebec Region. Fisheries and Oceans Canada. Reproduced with the permission of © Her Majesty the Queen in Right of Canada, 2019]

Figure 8: Threats to the St Lawrence River beluga whale

Shipping and whale watching:

- Noise from ships disturbs feeding behaviour.
- Ships may separate young whales from their mothers.

Hunting:

- Until the 1980s, beluga whales were hunted because they competed with the commercial fishing industry.

Pollution:

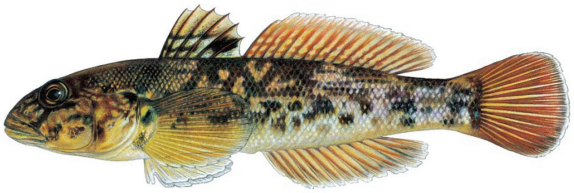
- Heavy metals, such as lead (Pb), mercury (Hg) and cadmium (Cd) from industrial effluent.
- Persistent organic pollutants (POPs), such as DDT and PCBs, from agriculture and industry.
- Treated and untreated sewage from cities along the river.
- Microplastic beads from domestic and industrial waste.
- Pollutants accumulate in the mud at the bottom of the river.

Figure 9(a): Fact file on the round goby (*Neogobius melanostomus*)

- An invasive species from Asia.
- First discovered in the St Lawrence River in 1990.
- Females lay eggs three times a year; up to 5000 eggs at a time.
- Young fish mature quickly.
- Can eat up to 4000 eggs of other fish in 15 minutes.
- Aggressively defend the best egg-laying sites, out-competing the native mottled sculpin (*Cottus bairdii*).
- Eat invasive zebra mussels.
- Eaten by native fish, such as lake trout and yellow perch.

Figure 9(b): Pictures of the round goby and mottled sculpin

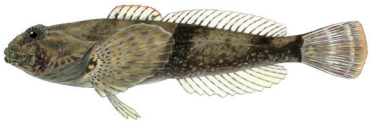
Round goby (*Neogobius melanostomus*)



maximum size 24 cm in length

[Source: © Joseph R. Tomelleri]

Mottled sculpin (*Cottus bairdii*)



maximum size 15 cm in length

[Source: illustration © Emily S. Damstra]

Figure 10: Untreated sewage release into the St Lawrence River

Montreal:
In November 2015, the City of Montreal discharged between 5 and 8 billion litres of untreated sewage into the St Lawrence River.

- It was called “FlushGate” in the Canadian news.
- Citizens were warned to avoid contact with the water.
- River pollution levels returned to normal within 4 to 10 days.
- The Mayor of Montreal described it as the “most environmentally-friendly solution”.

Quebec:
In November 2016, the City of Quebec discharged 110 million litres of untreated sewage into the St Lawrence River.

Nationally:

- 25 % of Canadians do not have access to sewage or wastewater treatment centres.
- 205 billion litres of untreated sewage are released into Canadian rivers and oceans each year.

[Source: adapted from www.cbc.ca/news]

Figure 11(a) and (b): Coliform bacteria concentrations (in units/100 mL) in the St Lawrence River near Montreal

Figure 11(a): Before the release of untreated sewage

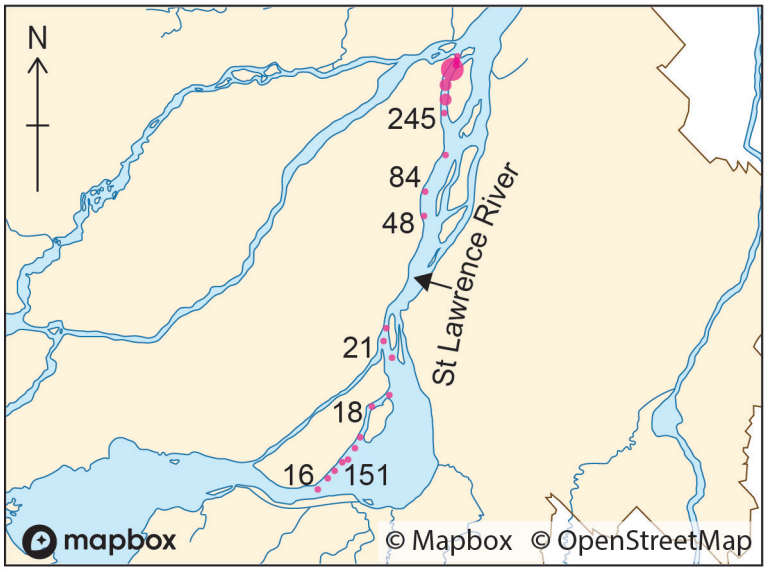
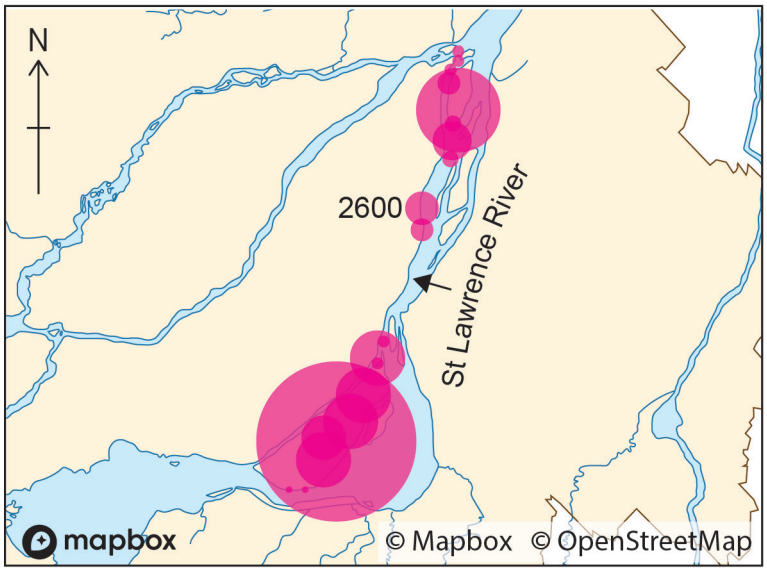
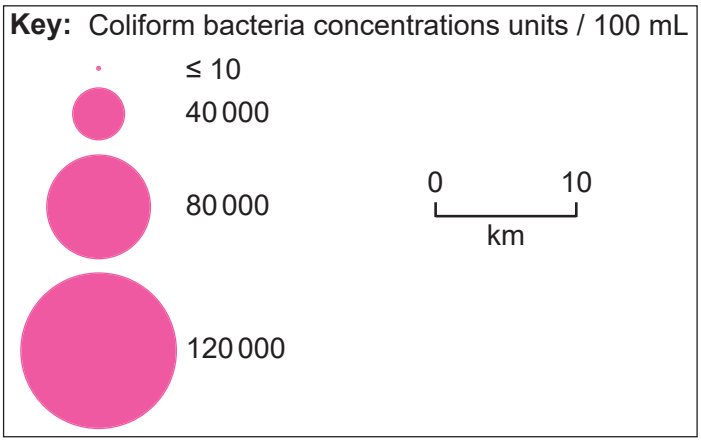


Figure 11(b): One day after the release of untreated sewage





[Source: adapted from CBC news, © OpenStreetMap contributors www.openstreetmap.org/copyright and © Mapbox. Data adapted from Ville de Montréal the open data portal http://donnees.ville.montreal.qc.ca/dataset?q=intercepteur and licensed under CC BY 4.0 https://creativecommons.org/licenses/by/4.0/legalcode]

Turn over

Figure 12: News headlines about the St Lawrence River and the Gulf of St Lawrence areas