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GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA

DESCRIPTIVE NOTES

INTRODUCTION

The traditional product of seabed mapping on Canadian continental shelves was the surficial geology map depicting Quaternary sediment formations (e.g., Fader et al., 1982). With the advent of multibeam sonar, three principal types of 1:50,000 scale maps are now produced, viz. 1) shaded seafloor relief; 2) backscatter strength; and 3) surficial geology. Five maps of shaded seafloor relief and five maps of backscatter in Placentia Bay have been published (see references).

Geologists have long been aware of the links between surficial geology and benthic communities (Maritime Testing, 1985), and the recent increasing awareness by biologists (Todd et al., 1986) has led to multiple approaches to visualizing the links on maps. This 'seascape' map, therefore, is merely one approach among many. It is based on systematic multibeam sonar mapping by the Geological Survey of Canada (GSC) and Canadian Hydrographic Service (CHS), supported by seismic data, sidescan sonograms, bottom photographs, video, submersible observations, and grab samples. Knowledge of time-varying processes is based on radiocarbon and microfauna data from piston cores.

SEASCAPES

Our definition of a 'seascape' is based on the Australian Land-System approach, developed to manage agricultural land. To adequately understand the land and its use and management it was thought necessary to understand the relationships between soils and the soil parent materials, climate, and topography. Land-systems are "areas, or groups of areas, throughout which there is a recurring pattern of topography, soils, and vegetation" (Christian and Stewart, 1953). A good example of the land system approach is the mapping of Bougainville and Buka Islands, Territory of Papua and New Guinea, by Scott et al. (1967). Our definition is as follows: *Seascapes are underwater landscapes characterized by unique combinations of geomorphology, texture, and biota*.

GEOMORPHOLOGY

In northern Placentia Bay three glacially-overdeepened troughs (Fig. 1) are separated by islands; in the south a single basin extends from the Burin Peninsula to the Avalon Peninsula. Bedrock outcrops are common, but much of the bay is floored by landforms formed by glacial ice advance and retreat, and modified by subsequent relative sea-level changes (Shaw and Forbes, 1995). In the southwest, ice-contact sediments (till) occur in streamlined ridges parallel to former flow directions. Glaciomarine sediments–deposited by meltwater plumes as the ice retreated–are draped over glacial sediments and bedrock throughout the bay. Mud liberated by reworking of postglacial sediments has accumulated on the floors of basins, in troughs, and coastal basins, e.g., Mortier Bay. A unique feature of the geomorphology of Placentia Bay is the northeast-trending zone of megaflutes, defined as erosional pits developed in postglacial mud. Immediately east of this zone, all postglacial mud has been removed.

TEXTURE

Figure 2 shows the distribution of backscatter strength, a proxy for sediment texture. It is not a perfect proxy for sediment texture, however, as it has a strong bimodal distribution, whereas seafloor texture is multi-modal. Bedrock areas have high backscatter. Till at the seabed is bouldery gravel (high backscatter). Exposed glaciomarine sediments have a winnowed veneer of angular fine gravel (high backscatter). Muddy basins contain silty clay or clayey silt (low backscatter). In the outer bay, there are extensive areas characterized by high rates of mud deposition early in the postglacial period, but no deposition later; these areas commonly show silty mud or muddy fine sand at the seafloor (low backscatter). In shallow waters, sheets of sand (low backscatter) extend upwards into the intertidal zone in some areas (e.g., off Placentia). In Eastern Channel, strong current stress at the seafloor results in deepwater sand with intermediate backscatter values.

BIOTA

Seabed photographs show that the textural and geomorphic units are characterized by distinct associations. Bedrock areas have attached plant life, although the boulders and cobbles of till areas also provide attachment points. Depth is a control on the biota, so that, for example, light dependent *Lithothamnion* sp., attached to rock and non-mobile gravel, is found only above ~-80 m. Mobile sediments (wave base is about 70 m depth) contain infauna. Muddy basins contain infauna.

CLASSIFICATION

We assume that at this non-shelf scale, physical controls such salinity, mean temperature, currents, dissolved oxygen, etc. are reasonably homogenous. However, the Labrador Current runs strongly north along the east side of the bay, and exits with lesser velocity in the west (Figure 3). This current creates current stress at the seafloor in Eastern Channel, leaving muddy sand lags at the seafloor, and creates banks of mud either side of the channel father north. The extensive band of erosional megaflutes (Fig. 4) and the seafloor stripped of postglacial sediment immediately of the flutes zone coincide with the location of this strong current, although the link between the two is uncertain at present. We define two broad classes of seascapes. Sub-littoral seascapes are generally shallow, are subject to wave disturbance, and lie within the photic zone. Deep-water seascapes are aphotic, and while generally below wave base are subject to strong currents in some areas.

Finally, a map at this scale is a gross simplification. As a rule, as the scale decreases the complexity increases. This is illustrated by Figure 5, a depiction of backscatter strength in Long Harbour, on the coast of the Avalon Peninsula.

ACKNOWLEDGMENTS

We acknowledge the masters and crews of the Canadian Coastguard vessels Matthew, Hudson, and Shamook, used to conduct multibeam sonar and groundtruthing surveys in Placentia Bay from 2004 onwards. We also acknowledge the work of those who conducted multibeam launch surveys, notably D. Beaver, formerly of the Geological Survey of Canada (GSC). Various hydrographers of the Canadian Hydrographic Service supervised multibeam data collection and processing, notably M. Lamplugh, A. Roy, G. Roger, M. Nickerson, D. Sinnott, and D. Street. GSC staff involved in these surveys included S. Hayward and A. Robertson. Geographic Information System work and data processing was provided by S. Hynes, S. Hayward, and P. Fraser. R. Courtney developed algorithms that facilitated backscatter extraction. Cartographic support was provided by P. O'Regan. S. Rumbolt analysed seafloor photographs under contract. This map was reviewed by E.L. King.

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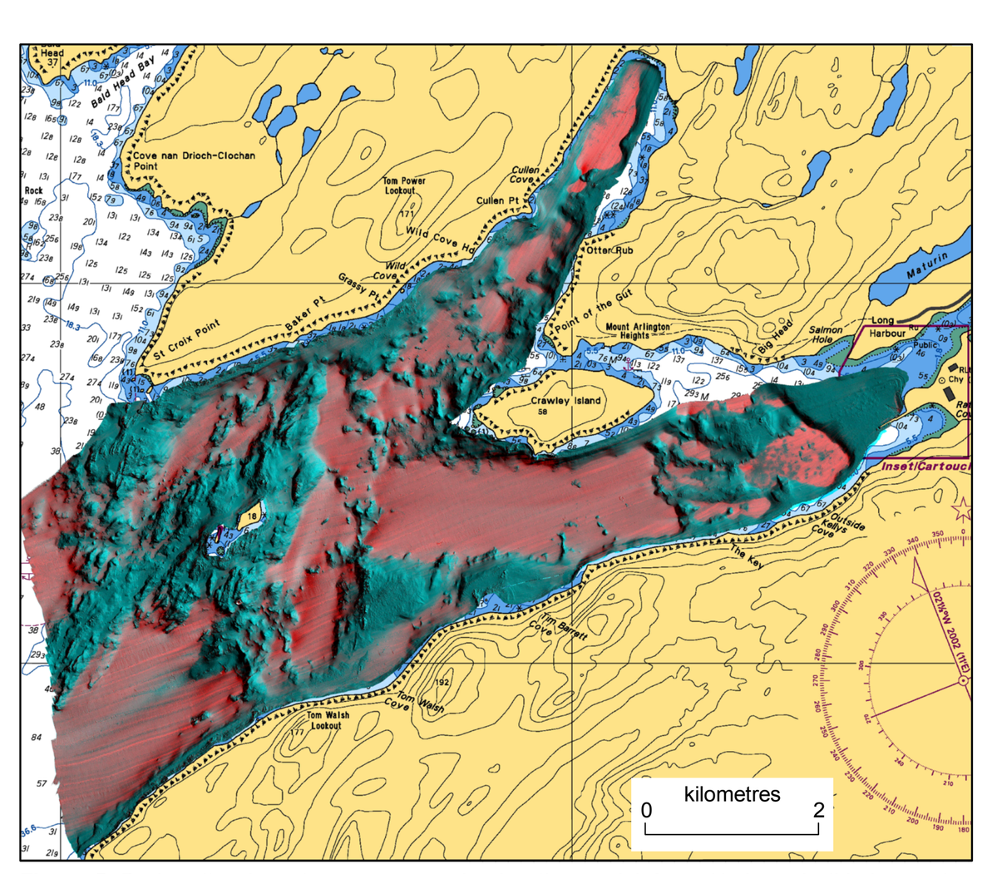
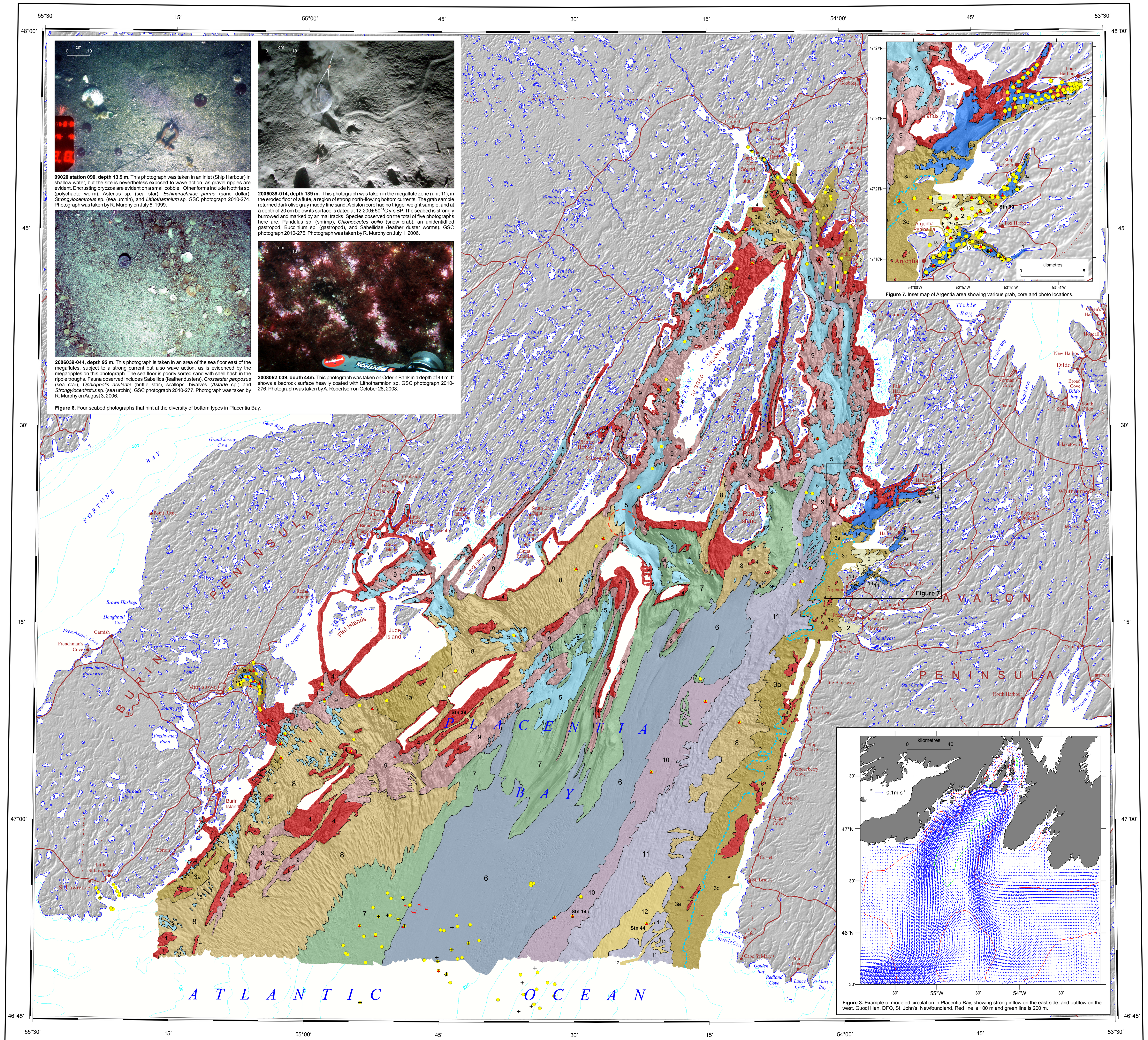


Figure 5. Backscatter draped over a grayscale elevation model, Long Harbour. In this image, low backscatter is pink, and high backscatter is grey. This illustrates the complexity of the sea floor, and the degree to which the main map is a simplification. The low-backscatter mud is confined to basins while high backscatter is typical of the rugged terrain elsewhere. The shallow, smooth platform at the extreme right of the image is a delta formed when sea level was lower (about 8000 years ago). Dredge spoil is strewn on this platform, but has similar high backscatter. However, dredge spoil in the adjacent basin shows up as dark specks against a pink background.



99020 station 090, **depth 13.9 m**. This photograph was taken in an inlet (Ship Harbour) in shallow water, but the site is nevertheless exposed to wave action, as gravel ripples are evident. Encrusting bryozoa are evident on a small cobble. Other forms include Nothria sp. (polychaete worm), Asterias sp. (sea star), *Echinarachnius parma* (sand dollar), *Strongylocentrotus* sp. (sea urchin), and *Lithothamnium* sp. GSC photograph 2010-274. Photograph was taken by R. Murphy on July 5, 1999.

2006039-014, depth 189 m. This photograph was taken in the megaflute zone (unit 11), in the eroded floor of a flute, a region of strong north-flowing bottom currents. The grab sample returned dark olive gray muddy fine sand. A piston core had no trigger weight sample, and at a depth of 20 cm below its surface is dated at 12,200± 50 ^{14}C yrs BP. The seabed is strongly burrowed and marked by animal tracks. Species observed on the total of five photographs here are: Pandulus sp. (shrimp), *Chionoecetes opilio* (snow crab), an unidentdfied gastropod, Buccinium sp. (gastropod), and Sabellidae (feather duster worms). GSC photograph 2010-275. Photograph was taken by R. Murphy on July 1, 2006.

2006039-044, depth 92 m. This photograph is taken in an area of the sea floor east of the megaflutes, subject to a strong current but also wave action, as is evidenced by the megaripples on this photograph. The sea floor is poorly sorted sand with shell hash in the ripple troughs. Fauna observed includes Sabellids (feather dusters), *Crossaster papposus* (sea star), *Ophiopholis aculeate* (brittle star), scallops, bivalves (*Astarte* sp.) and *Strongylocentrotus* sp. (sea urchin). GSC photograph 2010-277. Photograph was taken by R. Murphy on August 3, 2006.

2008052-039, depth 44m. This photograph was taken on Oderin Bank in a depth of 44 m. It shows a bedrock surface heavily coated with Lithothamnion sp. GSC photograph 2010-276. Photograph was taken by A. Robertson on October 28, 2008.

Figure 6. Four seabed photographs that hint at the diversity of bottom types in Placentia Bay.

Figure 7. Inset map of Argentia area showing various grab, core and photo locations.

Figure 3. Example of modeled circulation in Placentia Bay, showing strong inflow on the east side, and outflow on the west. Guoqi Han, DFO, St. John's, Newfoundland. Red line is 100 m and green line is 200 m.

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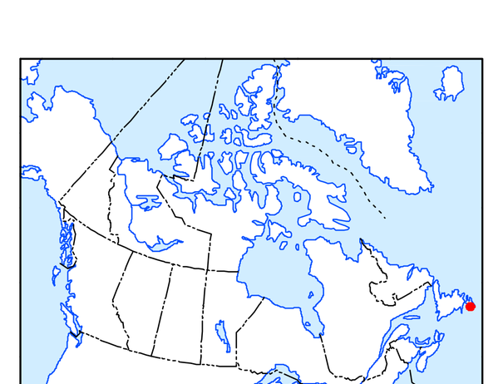


LOCATION MAP

Authors: J. Shaw, D.P. Potter, and V.E. Kostylev

This map was produced by Natural Resources Canada in co-operation with Fisheries and Oceans Canada

Geology by J. Shaw, Geological Survey of Canada, 2010

Geologic compilation by J. Shaw, Geological Survey of Canada, 2010

Digital cartography by P. O'Regan, Data Dissemination Division (DDD)

OPEN FILE 6683

SEASCAPES

PLACENTIA BAY

NEWFOUNDLAND AND LABRADOR

Scale 1:1 250 000/Échelle 1/1 250 000

kilometres 40 0 40 80 120 kilomètres

Universal Transverse Mercator Projection
North American Datum 1983

This map is not to be used for navigational purposes

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983

Cette carte ne doit pas être utilisée aux fins de navigation

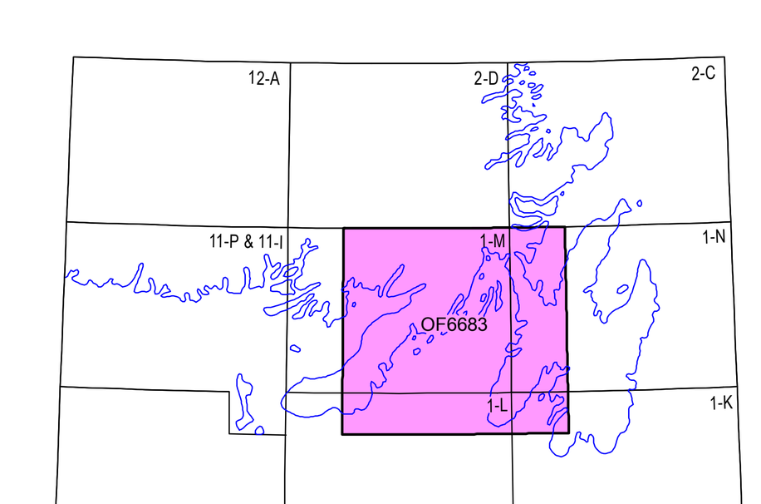
Any revisions or additional information known to the user would be welcomed by the Geological Survey of Canada

Digital base map (land area) from data compiled by Geomatics Canada, modified by GSC (Atlantic)

Digital bathymetric contours in metres supplied by the Canadian Hydrographic Service and GSC (Atlantic)

Mean magnetic declination 2011, 19°32.5′W, decreasing 11.55′ annually. Readings vary from 19°13′W in the SE corner to 19°52′W in the NW corner of the map

Depth in metres below mean sea level



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE

LEGEND

Sublittoral Seascapes

Sub-littoral seascapes encompass: 1) protected inlets with mostly immobile sediments, and: 2) exposed environments in which bottom materials may be mobile or immobile depending on grainsize. Located above wave base and mostly within the photic zone, which is ~80 m depth offshore but shallower in inlets.

1 — Sub-littoral muddy seascapes
Morphology: Low or flat relief.
Texture: Mud, silty mud, sandy mud, low backscatter.
Biota: Polychaete (*Myxicola infundibulum);* sea stars (Asterias sp.); sea urchins (Strongylocentrotus sp.); Lithothamnium sp. Bottom photographs show tube/burrow openings, tracks/trails, and seaweed debris
Deposited in postglacial time by reworking of glacial sediments; stratigraphy masked by gas in parts of Ship Harbour, Argentia Harbour, Mortier Bay. More anthropogenic debris on the seafloor than elsewhere; seafloor in harbours heavily marked by anchor drags. Many metres in thickness.

2 — Sub-littoral mobile sediment seascapes
Morphology: Low relief bodies of sediment, with ripples and other bedforms; includes tidal deltas at Placentia, spillover at Argentia.
Texture: Sand and muddy sand (low backscatter); poorly-sorted sandy gravel (high backscatter).
Biota: Hydrozoa, shrimps (Pandalus sp.); sea stars (Asterias sp.); sea urchins (Strongylocentrotus sp.); sand dollars (*Echinarachnius parma).* Photographs show flatfish (Pleuronectidae), tube/burrow openings, tracks/trails, seaweed debris
Derived from re-worked glacial materials; mobilized by waves, currents, and tidal currents (Placentia Gut).

3 — Sub-littoral glacial/paraglacial seascapes
Morphology: High relief, irregular ridges, mounds of glacial material (3a) submerged paraglacial deltas (3b); low relief platform off Avalon Peninsula (3c).
Texture: Boulder gravel veneer over glacial sediments, interspersed with patches of rippled, poorly-sorted sandy gravel (3a); muddy gravel on old deltas (3b); boulder gravel and patches of coarse sand and poorly-sorted gravel (3c); high backscatter.
Biota: Relatively high diversity of fauna. Encrusting sponges; Hydrozoa; encrusting bryozoa; horse mussels (*Modiolus modiolus*); Spirorbis sp.; sea stars (Asterias sp.); sea urchins (Strongylocentrotus sp.); Lithothamnium sp.; seaweed. Photographs show unidentified fish.
Glacial materials deposited during the last glacial maximum and formed into a range of landforms with strong relief (3a), but includes areas reworked during sea-level lowering 9000 years ago to form submerged deltas (3b), and a low-relief platform off the Avalon Peninsula (3c). Note: the term paraglacial refers to landforms created by reworking of glacial deposits in the early postglacial period, as sea-level dropped to a lowstand.

4 — Sub-littoral bedrock seascapes
Morphology: High-relief ridges, ledges, and pinnacles.
Texture: Rock (high backscatter) and gravel (high backscatter).
Biota: Attached fauna - Lithothamnion sp., seaweeds etc.
Outcrops are rare, and bedrock commonly has a veneer of sand and gravel, with thicker sediments in pockets.

Postglacial lowstand limit
Represents approximate limit of postglacial emergence off the coast of the Avalon Peninsula ca. 8 000 years ago. Glacial terrain above this limit has been planated, so that landforms absent.

Deep-water seascapes

Aphotic and below wave base, but may be stressed by currents. Current erosion has formed megaflutes in some areas. Glaciomarine muds and ice-contact sediments are immobile, with veneers of gravel and boulder cobble gravel respectively.

5 — Deep-water muddy seascapes
Morphology: Little or no relief, except on banks shaped by currents in Eastern Channel.
Texture: Mud, silty mud, sandy mud; low backscatter.
Biota: Infauna of annelids and bivalves; gastropods; snow crab *(Chionoecetes opilio)* and shrimps (Pandalus sp.).
Formed by reworking of glacial sediments; gas masking of sediments in eastern Channel, Argentia, Long Harbour; sedimentary furrows where currents are strong. May be tens of metres thick in places.

6 — Deep-water winnowed muddy seascapes
Morphology: Very low relief except in pockmarks.
Texture: Mud, sandy mud, muddy sand; low backscatter.
Biota: Photographs show snow crabs *(Chionoecetes opilio);* shrimps (Pandalus sp.); brittlestars (*Ophiura sarsi);* tube/burrow openings, tracks/trails.
In early postglacial times, mud derived from erosion of glacial materials accumulated in the outer bay, but with strengthening currents - perhaps the branch of the Labrador Current (Fig. 3) that enters the bay - accumulation ceased, and the upper 0.3 m is a veneer of sandy mud. Imprinted with fields of pockmarks and sedimentary furrows.

7 — Deep-water glaciomarine seascapes
Morphology: Generally smooth, low-relief seafloor
Texture: Angular fine gravel, sandy gravel, and muddy gravel as a veneer overlying glaciomarine mud; high backscatter.
Biota: Attached fauna. Anemones, sea urchins (Strongylocentrotus sp.), frequent tube/burrow openings in sediment.
Sheets of glaciomarine mud derived from melting glaciers about 14 000 years ago, draped over underlying terrains. Winnowed by currents, with no subsequent deposition of postglacial mud or sand. Imprinted by iceberg furrows and pits. Represents a preserved 14 000 year-old surface. Thickness varies from 5 m in outer bay to tends of metres in deep basins.

8 — Deep-water glacial seascapes
Morphology: High and irregular relief.
Texture: Veneer of bouldery sandy gravel over glacial landforms; high backscatter.
Biota: Bottom photographs in this terrain reveal a relatively high diversity of benthos. Encrusting sponges; tunicates (Molgula sp.); anemones *(Bolocera tuediae, Hormathia nodosa);* soft corals *(Eunephthya rubiformis);* polychaetes (Nothria sp.); snow crabs (*Chionoecetes opilio*); shrimps (Pandalus sp.); Echinoderms (Asterias sp., Strongylocentrotus sp., Ophura sp., *Ophiura sarsi,* Gorgonocephalus sp.).
An immobile sediment veneer overlies a range of glacial landforms composed of till or gravel, namely glacial flutes, drumlins, crag and tails, De Geer morianes, and eskers.

9 — Deep-water bedrock seascapes
Morphology: High-relief ridges, ledges, pinnacles; relief more subdued than that of bedrock in shallow water; high backscatter
Texture: Rock, muddy gravel, gravelly mud.
Biota: Relatively barren - anemones *(Hormathia nodosa);* tube/burrow openings in sediment.
Outcrops are very rare, and bedrock commonly has a veneer of glaciomarine muddy sand gravel, with thicker deposits of mud in pockets; in places the terrain classification probably overlaps with terrain 7.

10 — Deep-water fluted seascapes
Morphology: Generally low relief except in vicinity of flutes; seafloor moulded into individual flutes, or coalesced flutes; flute sidewalls up to 5 m high.
Texture: Mud and sandy mud, with low backscatter.
Biota: Bottom photographs reveal a relatively high diversity of benthos. Sabellid piolychaetes and shrimp (Pandalus sp.) are relatively common; sponges *(Vazella pourtalesi);* burrowing anemone; whelks (Buccinum sp.); snowcrabs (*Chionoecetes opilio);* mud stars (*Ctenodiscus crispatus);* sand dollars (*Echinarachnius parma*). Photographs show flounders (Pleuronectidae) and other unidentified fish, tube/burrow openings.
Formed by erosion of postglacial muds by strong currents on the east side of Placentia Bay, at a depth of ~100 m; probably still active; described by G.B. Fader as 'megaflutes'.

11 — Deep-water 'current-stressed' seascapes
Morphology: Gently undulating seabed (outer bay, 11a), flat seabed (Eastern Channel, 11b).
Texture: Muddy gravel, muddy sand.
Biota: Anemones *(Bolocera tuediae);* soft corals (*Eunephthya rubiformis*); gastropods; snow crabs (*Chionoecetes opilio*); shrimps (Pandalus sp.); sea urchins (Strongylocentrotus sp.). Photographs also show flat fish and seaweed debris.
Formed by complete removal of the uppermost postglacial muds by strong currents on the east side of the outer bay, revealing underlying glaciomarine sediment draped over glacial sediments (11a). In Eastern Channel strong currents have precluded sediment accumulation in the channel thalweg, so that underlying glaciomarine muds are close to the seabed (11b).

12 — Deep-water sandy seascapes
Morphology: Flat seabed, with ripples.
Texture: Sandy with shell hash.
Biota: Scallop shell hash fairly common. Fauna observed includes sponges *(Vazella pourtalesi);* anemones; encrusting bryozoa; sea scallops (*Placopecten magellanicus*); brittlestars (*Ophiopholis aculeata);* sea urchins; sea stars; sabellid polychaetes. Moderate species diversity.
The sand is an infilling on terrain on which the glaciomarine sediment had been removed by winnowing. Evidence of mobility (ripples).

Anthropogenic seascapes

Dredging occurred at Argentia in Ww2; spoil was commonly dumped nearby in deeper water. Dredging has also taken place at Marystown (Mortier Bay) and in Long Harbour. A former deepwater dump site received debris from the US naval Facility, Argentia. Harbour floors at Mortier Bay and Argentia are heavily marked by anchor drags.

13 — Dredged areas
Morphology: Seafloor marked by parallel grooves up to several m high.
Texture: Commonly gravel (high backscatter)..
Biota: Attached fauna, especially on boulders. Horse mussels (*Modiolus modiolus);* sea urchins Strongylocentrotus sp.; sea cucumbers (*Cucumaria frondosa);* Lithothamnium sp., seaweed.
Formed by dredging, mostly in WW 2 at Argentia, and later at Mortier Bay. Glacial landforms have been planated.

14 — Debris
Morphology: Mounds, blocks.
Texture: Gravel, concrete, high backscatter.
Biota: Attached fauna.
Includes mounds of dredge spoil, submarine net moorings, seaplane mooring systems (chains, blocks).

Geological contact (map unit boundaries are interpreted from multibeam sonar bathymetry and geophysical seismic profile data and are inferred contacts that may be gradational or conceptual in nature)

Sunken vessel; fishing vessels scuttled in deep water in the 1990s; positive relief up to 8 m; high backscatter

Former deepwater dump; area in which debris from the former US Naval Facility, Argentia, was dumped

Grab samples

Cores

Photos — Stn 14

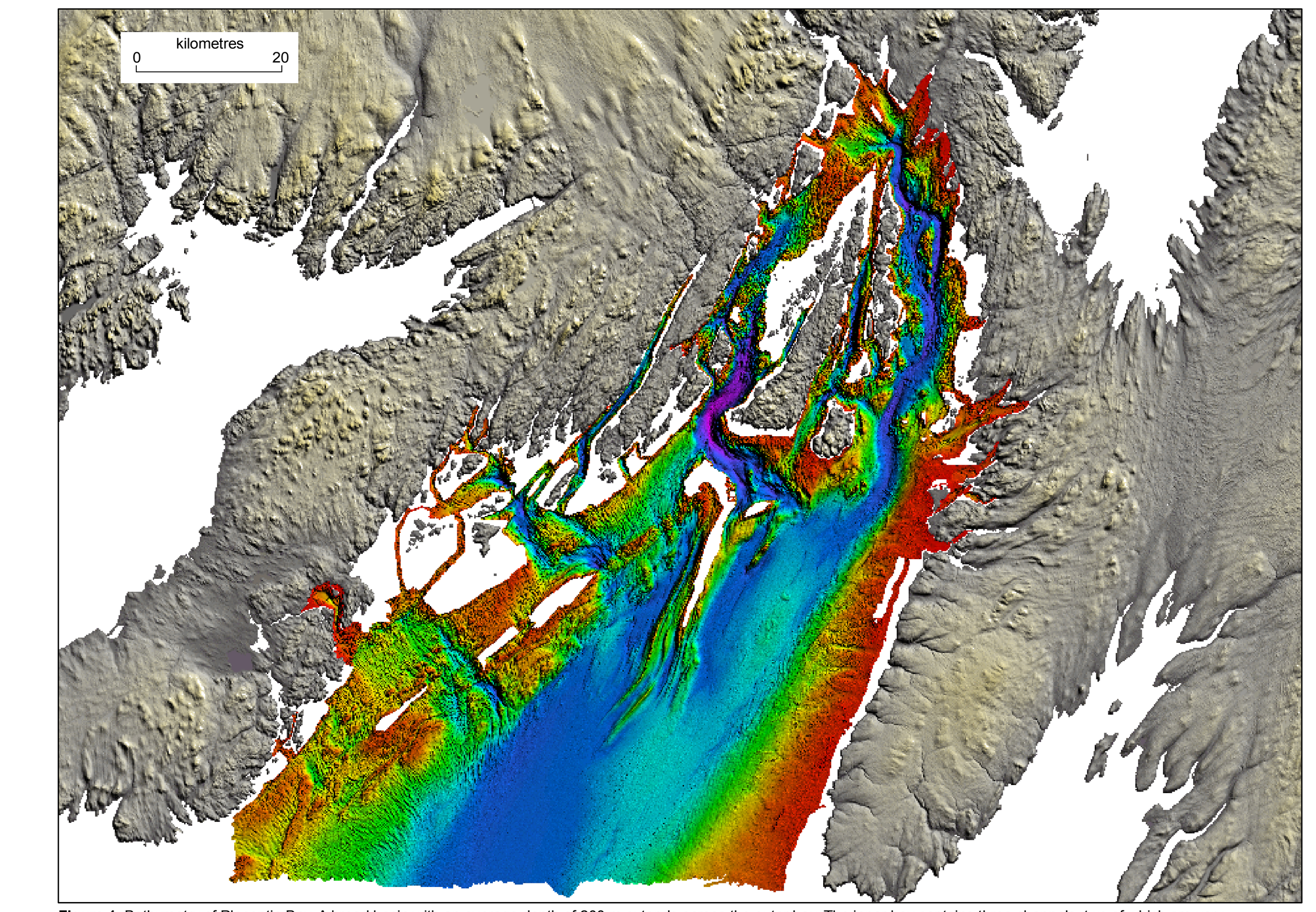


Figure 1. Bathymetry of Placentia Bay. A broad basin with an average depth of 200 m extends across the outer bay. The inner bay contains three channels, two of which are very deep (450 m), and a series of large islands.

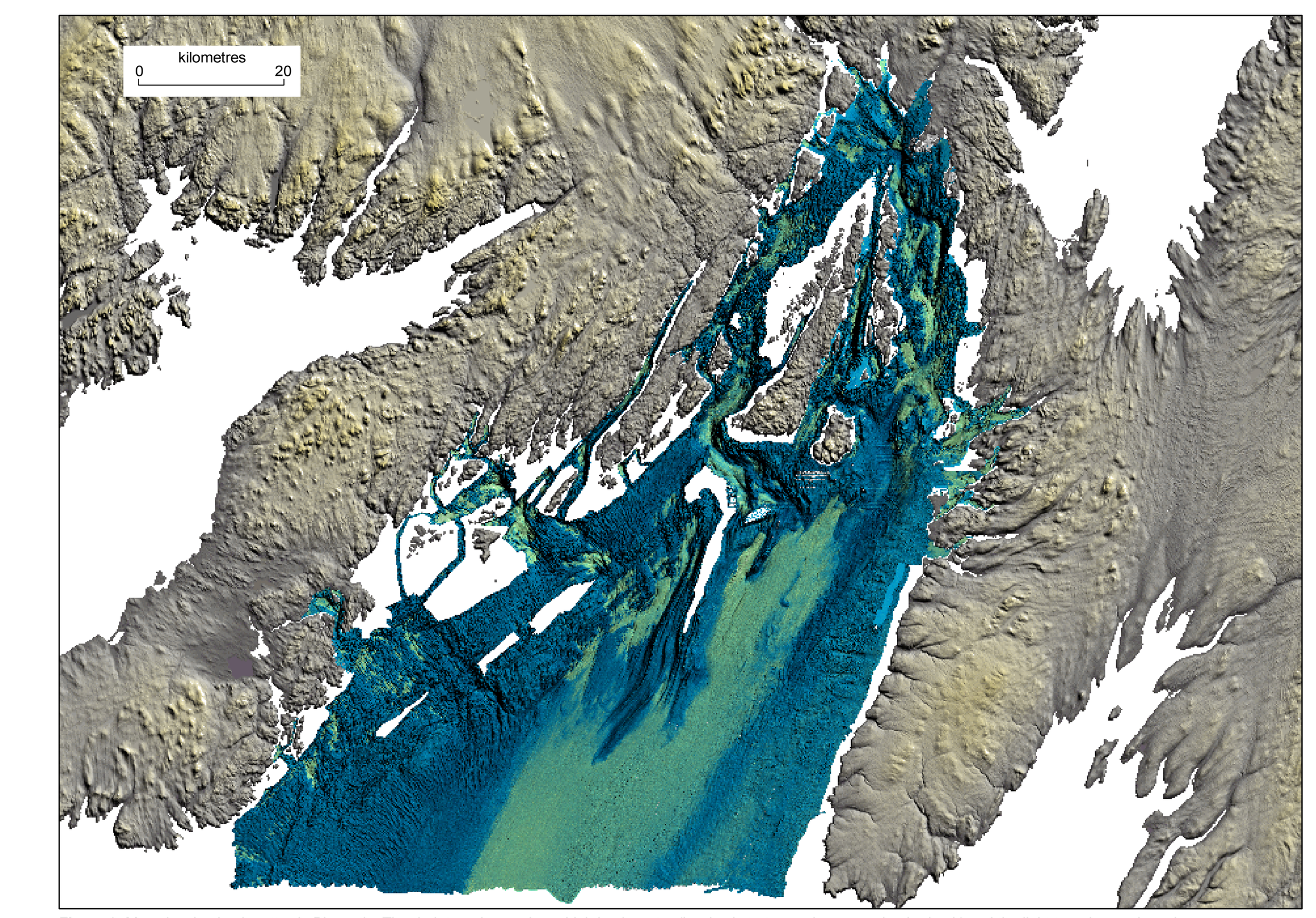


Figure 2. Map showing backscatter in Placentia. The dark-toned areas have high backscatter (hard substrates such as gravel or bedrock) and the light-toned areas have low backscatter (mud and sand).

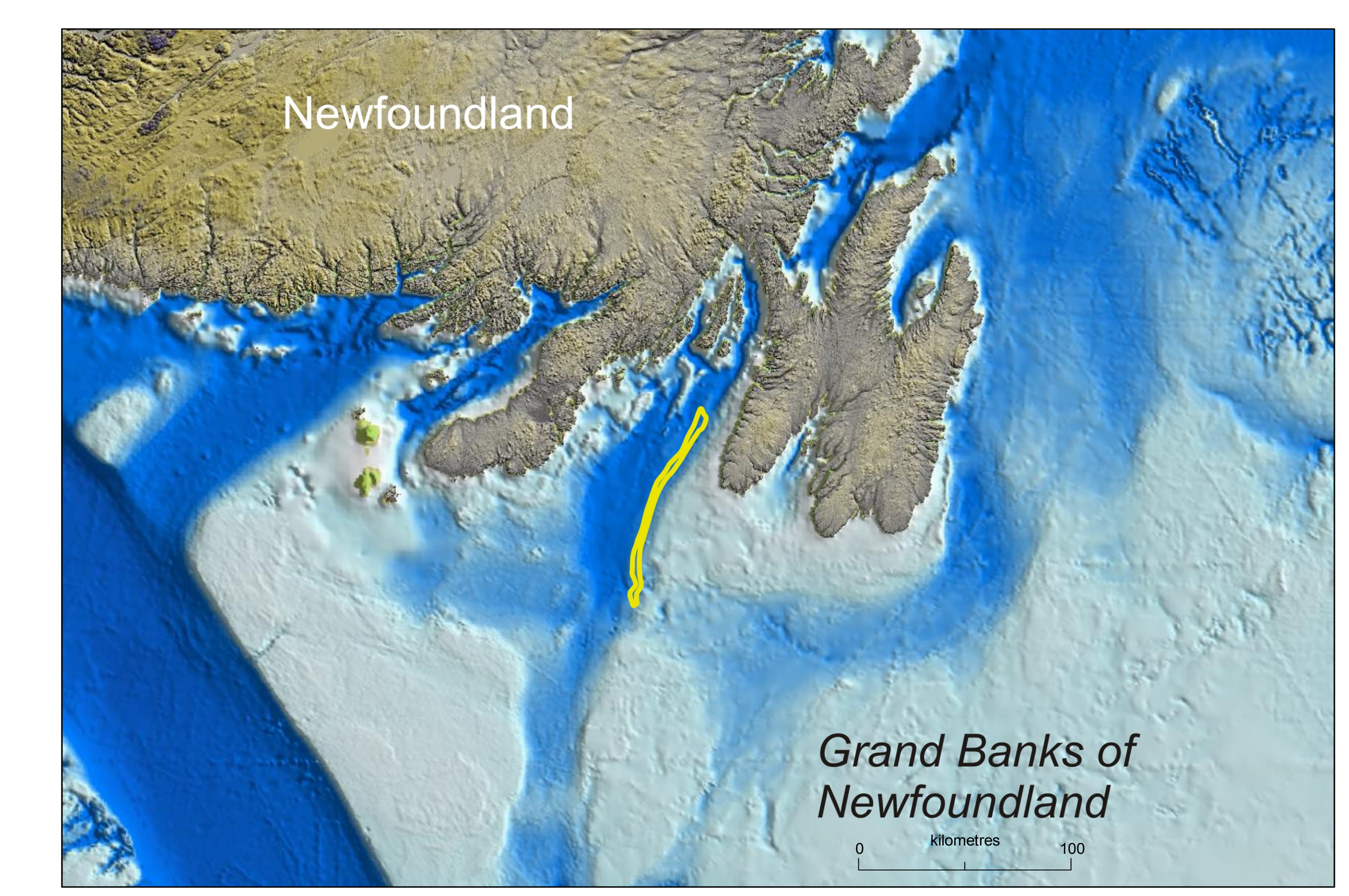


Figure 4. Map showing the approximate locate of the megaflute zone - an area in which current stress continues to remove sediment from the sea floor. From the circulation model (Fig. 3) we infer that the eroded mud may be carried northward, and deposited in the deep-water mud banks of Eastern Channel.

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COMMISSION GÉOLOGIQUE DU CANADA
2011

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