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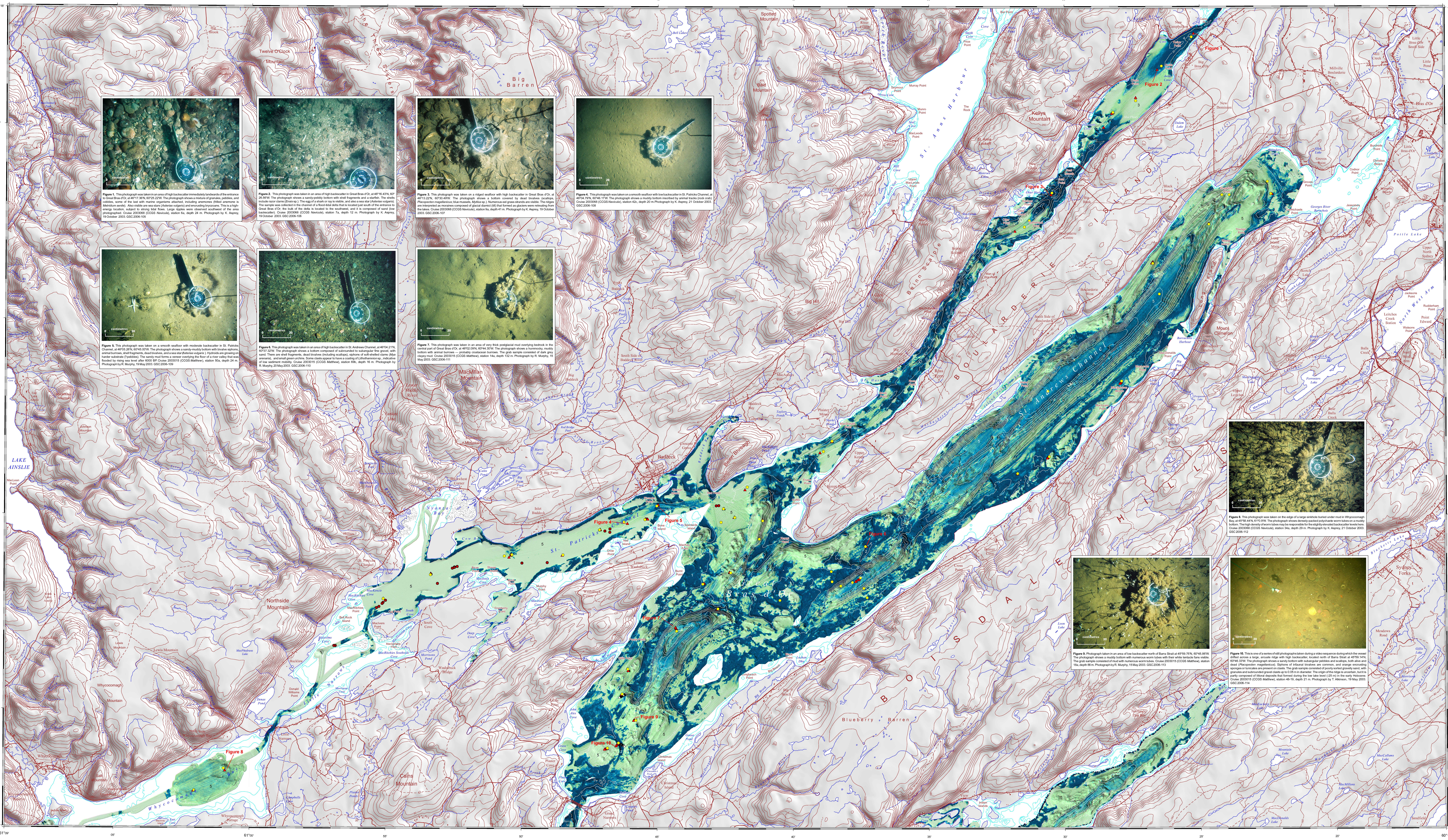


Figure 1. This photograph was taken in an area of high backscatter immediately landwards of the entrance to Great Bras d'Or, at 46°17.36'N, 60°25.22'W. The photograph shows a mixture of granules, pebbles, and cobbles, some of the last with marine organisms attached, including anemones (frilled anemone is *Metridium senile*). Also visible are sea stars (*Asterias vulgaris*) and encrusting bryozoans. This is a high-energy location, subject to strong tidal flows. Large ripples were observed southwest of the area photographed. Cruise 2003068 (CCGS *Navicula*), station 6a, depth 24 m. Photograph by K. Asprey, 19 October 2003. GSC 2006-105

Figure 2. This photograph was taken in an area of high backscatter in Great Bras d'Or, at 46°16.43'N, 60°26.56'W. The photograph shows a sandy-pebbly bottom with shell fragments and a starfish. The shells include razor clams (*Ensis* sp.). The egg of a shark or ray is visible, and also a sea star (*Asterias vulgaris*). The sample was collected in the channel of a flood-tidal delta that is located just south of the entrance to Great Bras d'Or; the bulk of the delta is located to the southwest, and it is composed of sand (low backscatter). Cruise 2003068 (CCGS *Navicula*), station 7a, depth 12 m. Photograph by K. Asprey, 19 October 2003. GSC 2006-106

Figure 3. This photograph was taken on a ridged seafloor with high backscatter in Great Bras d'Or, at 46°13.22'N, 60°30.49'W. The photograph shows a bottom covered by dead bivalves (scallops, *Placopecten magellanicus*; blue mussels, *Mytilus* sp.). Numerous eel grass strands are visible. The ridges are interpreted as moraines composed of glacial diamict (till) that formed as glaciers were retreating from the lakes. Cruise 2003068 (CCGS *Navicula*), station 9a, depth 41 m. Photograph by K. Asprey, 19 October 2003. GSC 2006-107

Figure 4. This photograph was taken on a smooth seafloor with low backscatter in St. Patricks Channel, at 46°04.79'N, 60°46.11'W. The photograph shows a muddy bottom inscribed by animal tracks (rock crab). Cruise 2003068 (CCGS *Navicula*), station 42c, depth 20 m. Photograph by K. Asprey, 21 October 2003. GSC 2006-108

Figure 5. This photograph was taken on a smooth seafloor with moderate backscatter in St. Patricks Channel, at 46°05.26'N, 60°45.00'W. The photograph shows a sandy-muddy bottom with bivalve siphons, animal burrows, shell fragments, dead bivalves, and a sea star (*Asterias vulgaris*). Hydroids are growing on harder substrate (?pebbles). The sandy mud forms a veneer overlying the floor of a river valley that was flooded by rising sea level after 6000 BP. Cruise 2003015 (CCGS *Matthew*), station 50a, depth 24 m. Photograph by R. Murphy, 19 May 2003. GSC 2006-109

Figure 6. This photograph was taken in an area of high backscatter in St. Andrews Channel, at 46°04.21'N, 60°37.32'W. The photograph shows a bottom composed of subrounded to subangular fine gravel, with sand. There are shell fragments, dead bivalves (including scallops), siphons of soft-shelled clams (*Mya arenaria*), and small green urchins. Some clasts appear to have a coating of *Lithothamnion* sp., indicative of low sediment mobility. Cruise 2003015 (CCGS *Matthew*), station 69b, depth 16 m. Photograph by R. Murphy, 20 May 2003. GSC 2006-110

Figure 7. This photograph was taken in an area of very thick postglacial mud overlying bedrock in the central part of Great Bras d'Or, at 46°02.09'N, 60°44.30'W. The photograph shows a hummocky, muddy bottom with animal burrows — probably crustacean burrows. The grab sample consisted of dark grey clayey mud. Cruise 2003015 (CCGS *Matthew*), station 14a, depth 132 m. Photograph by R. Murphy, 15 May 2003. GSC 2006-111

Figure 8. This photograph was taken on the edge of a large sinkhole buried under mud in Whycocomagh Bay, at 45°58.44'N, 61°0.9'W. The photograph shows densely-packed polychaete worm tubes on a muddy bottom. The high density of worm tubes may be responsible for the slightly elevated backscatter levels here. Cruise 2003068 (CCGS *Navicula*), station 34a, depth 29 m. Photograph by K. Asprey, 21 October 2003. GSC 2006-112

Figure 9. Photograph taken in an area of low backscatter north of Barra Strait at 45°59.75'N, 60°45.86'W. The photograph shows a muddy bottom with numerous worm tubes with their white tentacle fans visible. The grab sample consisted of mud with numerous worm tubes. Cruise 2003015 (CCGS *Matthew*), station 18a, depth 56 m. Photograph by R. Murphy, 15 May 2003. GSC 2006-113

Figure 10. This is one of a series of still photographs taken during a video sequence during which the vessel drifted across a large, arcuate ridge with high backscatter, located north of Barra Strait at 45°59.14'N, 60°46.33'W. The photograph shows a sandy bottom with subangular pebbles and scallops, both alive and dead (*Placopecten magellanicus*). Siphons of infaunal bivalves are common, and orange encrusting sponges or tunicates are present on clasts. The grab sample consisted of poorly sorted gravelly sand, with granules and subrounded gravel clasts up to 0.05 m in diameter. The origin of the ridge is uncertain, but it is partly composed of littoral deposits that formed during the low lake level (-25 m) in the early Holocene. Cruise 2003015 (CCGS *Matthew*), station 48-19, depth 21 m. Photograph by T. Atkinson, 19 May 2003. GSC 2006-114

DESCRIPTIVE NOTES

INTRODUCTION

Multibeam bathymetric systems record mean energy and a time series of amplitudes returned in each beam. The mean energy is commonly called the backscatter amplitude. While it is tempting to use this as a direct proxy for surficial sediment type, consideration of the physics of the problem presents a more convoluted picture (Courtney and Shaw, 2000), and there exists no direct relationship between backscatter amplitude and surficial sediment type. For angles of incidence greater than roughly 20° there is a general correspondence between backscatter amplitudes and surficial sediment roughness that can be used for cursory mapping and sediment identification. Coarse gravel and cobble units tend to be locally rough and return high-amplitude, wide-angle backscatter signals, whereas sand and fine-grained materials can be locally smooth with a much lower backscatter.

METHODOLOGY

Data were collected using Canadian Coast Guard vessels. The majority of surveys were performed by the Canadian Hydrographic Service (CHS), but some were conducted by the Geological Survey of Canada (GSC). The *Frederick G. Creed* is a SWATH vessel equipped with a Simrad EM1000 multibeam-bathymetric survey system, with the transducer mounted in the starboard pontoon. The hydrographic launch *Plover* deployed a hull-mounted Simrad EM3000 multibeam-sonar system. The hydrographic launch *Penguin* deployed a Submetrix™ interferometric sidescan-sonar system. A differential Global Positioning System was used for navigation, providing positional accuracy of about 3 m. Survey speeds averaged 10 knots. Data were adjusted for tidal variation using output from a tide gauge installed at Iona Narrows.

Backscatter is depicted using a colour scale ranging from almost white (low backscatter) to indigo (high backscatter). The coloured backscatter is draped over a grey digital elevation model of the bathymetry. The distribution of backscatter values in the map area is strongly bimodal, with a primary peak at 38 dB (low backscatter) and secondary peak at 25 dB (high backscatter). The floor of the lake is extremely patchy, with juxtaposed areas of high and low backscatter. The areas of lowest backscatter include St. Patricks Channel, where postglacial mud has accumulated in low-energy settings. The deep areas of St. Andrews Channel and Great Bras d' Or contain mud, but backscatter values are darker than other muddy areas, for reasons that are unclear at present. Backscatter distributions for the adjoining area to the south are shown on GSC Map 2100A (Shaw and Potter, 2007).

INTERPRETATION OF BACKSCATTER DATA

The interpretations of backscatter are based on GSC marine seismic and sampling surveys: Dawson 85-036; Hart 96-165; Matthew 2002-066, Matthew 2003-015, and the unpublished results of coring in 1996 by Kathy Ellis of the Department of Fisheries and Oceans.

Some high-backscatter areas comprise gravel (1) that forms a surficial lag over subcropping glacial diamict. Boulders visible on sidescan sonograms in some areas are diagnostic of this material. Seabed photographs show a muddy substrate (Fig. 3). The outcrops of gravel are commonly circular to elliptical in the southern lakes, i.e. south of Grand Narrows, and mark portions of drumlins that have been trimmed by wave erosion during the period of lowered lake level.

Other areas of high backscatter (2) consist of subangular to subrounded gravel. This material occurs in linear ridges that resemble modern coastal spits, tombolos, and barrier beaches in their proportions and morphology (Fig. 6, 10). This material is interpreted as beach gravel, reworked from glacial deposits during the period of lowered lake level. Again, most exposures of this unit are in the southern lakes, where extensive fields of drumlins provide a supply of sediment.

Areas of well sorted sand (3) with low backscatter and gravel with high backscatter (Fig. 2) occur near the entrance to the lakes and are interpreted as flood-tidal delta deposits. Close to the entrance the coarse shelly sand is replaced by well sorted, rounded, coarse gravel (4) (Fig. 1) organized into bedforms several metres high. This subunit has high backscatter. The sand and gravel in the inlet region result from reworking of coastal bluffs immediately outside the entrance. The reworked material is entrained by longshore and tidal currents and has been deposited just inside the entrance, where currents attenuate, to form an elongated flood-tidal delta. The sand grades into muddy sand and then mud in a southwest direction.

The predominant sediment in the lakes (5) is mud that ranges from clayey silt in the deep basins (e.g. St. Andrews Channel) to sandy silty clay in much of the lake, and to sandy silt or silty sand in shallows. This unit has low backscatter, and appears almost white in tone across much of the lakes (Fig. 4, 5, 7, 8, 9). Areas of dredge spoil (6) occurring south of Baddeck and perhaps also in the Baddeck region, are distinguished by high backscatter.

Undifferentiated gravel (7) has high backscatter, and may have several origins, including winnowing of glaciolacustrine muds, or low rates of deposition of postglacial mud over topographic highs, such as bedrock ridges. While there are many areas of the lakes where bedrock ridges can be seen on the multibeam imagery, bare rock is seldom exposed at the seafloor. Areas mapped as bedrock on GSC Map 2116A (Shaw and Potter, in press) actually have a veneer of undifferentiated gravel.

ACKNOWLEDGMENTS

The Master and crew of the CCGS *Frederick G. Creed* were instrumental in the multibeam bathymetric surveys carried out by GSC. The Canadian Hydrographic Service (CHS) organized most of the surveys and provided tidal stations. Cartographic support was provided by G. Grant with assistance from Phil O'Regan, Scott Hayward, and Sheila Hynes, Natural Resources Canada. The map was reviewed by R.C. Courtney and R.B. Taylor. The work was part of GSC project X-29 (J. Shaw, leader) in the Geoscience for Ocean Management Program.

REFERENCES

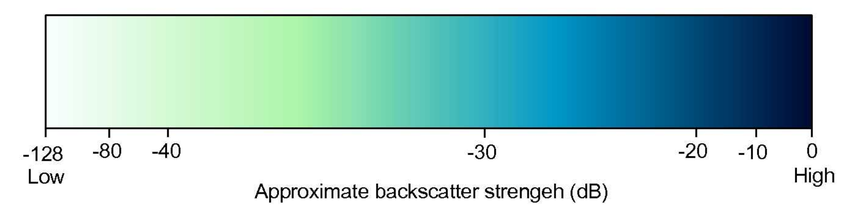
Courtney, R.C. and Shaw, J.
2000: Multibeam bathymetry and acoustic reflectance imaging of the shelf seabed; Geoscience Canada, v. 27, p. 31–42.

Shaw, J. and Potter, D.P.
2007: Backscatter strength and sun-illuminated seafloor topography, Bras d'Or Lake, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2100A, scale 1:50 000.
in press: Surficial geology and sun-illuminated seafloor topography, Great Bras d'Or, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2116A, scale 1:50 000.

SYMBOLS

Grab sample . . . . (yellow circle)
Gravity core . . . . (red circle)
Seafloor photograph . . . . (red triangle)
Video station . . . . (open triangle)

SEABED TEXTURE (INTERPRETED)
Bouldery gravel (glacial diamict) 1
Littoral gravel (submerged beach deposits) 2
Flood-tidal delta sand 3
Flood-tidal delta gravel 4
Mud: clayey silt to sandy silty clay 5
Dredge spoil 6
Undifferentiated gravel 7



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Copies of this map may be obtained
from the Geological Survey of Canada:
601 Booth Street, Ottawa, Ontario K1A 0E8
3303-33rd Street, N.W., Calgary, Alberta T2L 2A7
625 Robson Street, Vancouver, B.C. V6B 5J3
490, rue de la Couronne, Québec, Quebec G1K 9A9
1 Challenger Drive, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2

LOCATION MAP

MAP 2099A

BACKSCATTER STRENGTH AND SUN-ILLUMINATED SEAFLOOR TOPOGRAPHY

GREAT BRAS D'OR

CAPE BRETON ISLAND, NOVA SCOTIA

Scale 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 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

Authors: J. Shaw, and D.P. Potter

Backscatter data compiled by D.P. Potter, 2005

Digital cartography by G. Grant and S. Hayward, GSC (Atlantic)

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

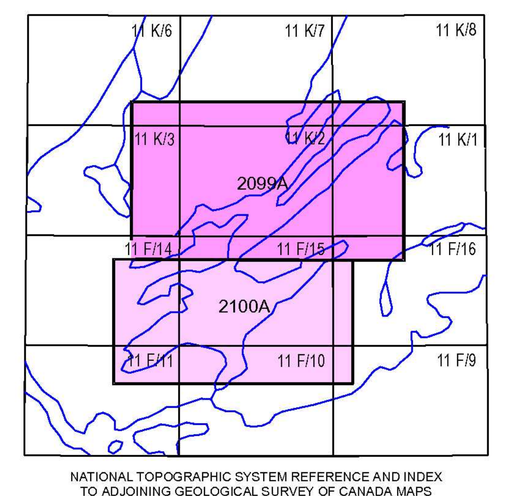
Digital base map (land area) from data compiled by Geomatics Canada, modified by GSC (Atlantic)

Some geographical names subject to revision

Magnetic declination 2007, 19°50'W, decreasing 9.8' annually

Elevations in metres above mean sea level

Depth in metres below sea level



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE AND INDEX TO ADJOINING GEOLOGICAL SURVEY OF CANADA MAPS

Recommended citation:
Shaw, J. and Potter, D.P.
2007: Backscatter strength and sun-illuminated seafloor topography, Great Bras d'Or, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2099A, scale 1:50 000.

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