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GEOLOGICAL SURVEY OF CANADA
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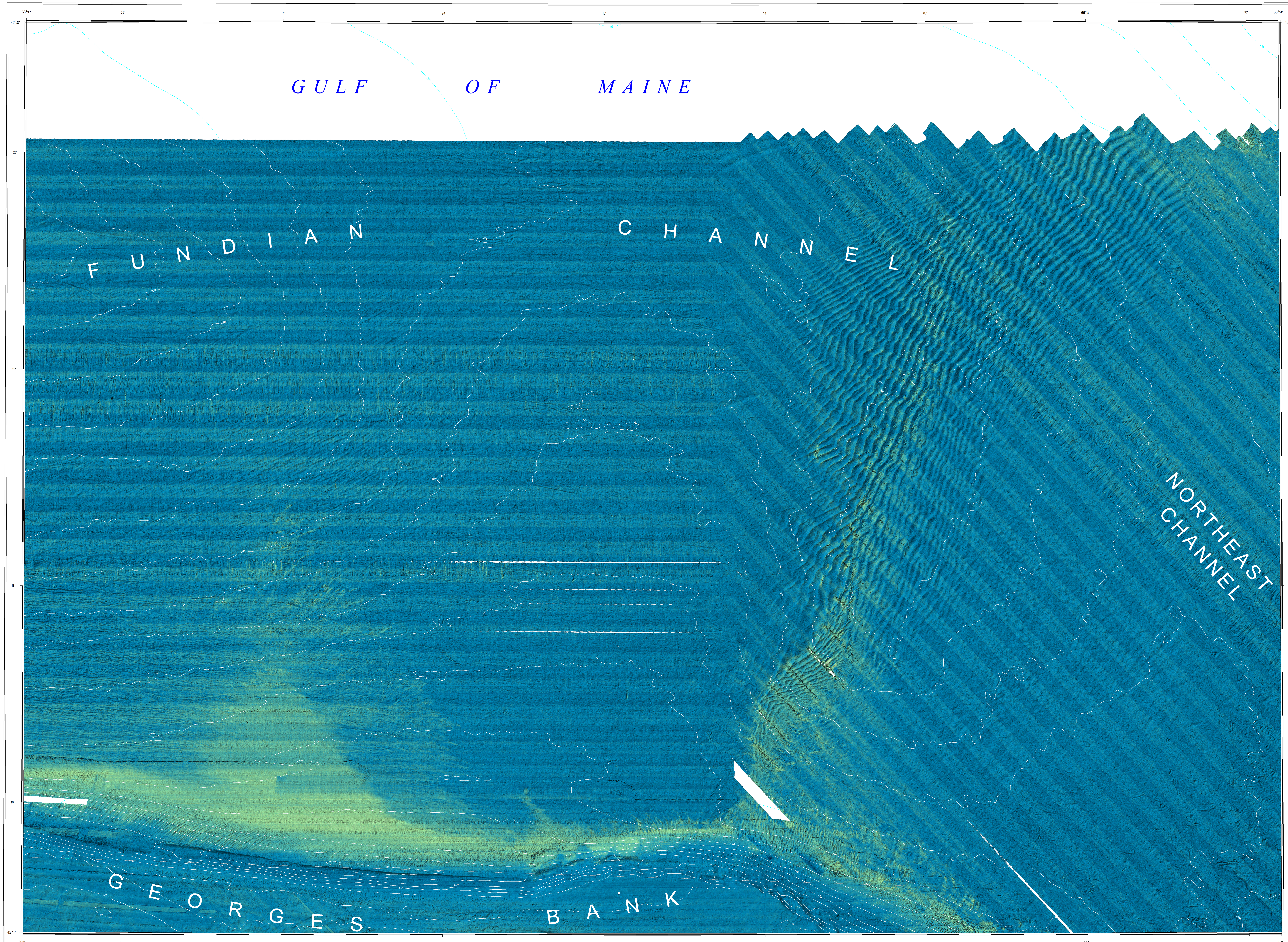

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LOCATION MAP

Canada

Authors: B.J. Todd, R.C. Courtney

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

Multibeam bathymetric data collected by Canadian Hydrographic Service, 1997, 1998, 2000, 2002, 2003

Multibeam backscatter data compiled by Geological Survey of Canada, 2004

Cartography by P. O' Regan, Data Dissemination Divison (DDD) and Scott Hayward GSC (Atlantic)

OPEN FILE 7250

BACKSCATTER STRENGTH AND SHADED SEAFLOOR RELIEF

GEORGES BANK, FUNDIAN CHANNEL, AND NORTHEAST CHANNEL; SHEET 2

GULF OF MAINE

Scale 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 kilomètres

Universal Transverse Mercator Projection	Projection transverse universelle de Mercator
North American Datum 1983	Système de référence géodésique nord-américain, 1983
© Her Majesty the Queen in Right of Canada 2014	© Sa Majesté la Reine du chef du Canada 2014
This map is not to be used for navigational purposes	Cette carte c'est nes pas utiliser pour les functiones navigationelle

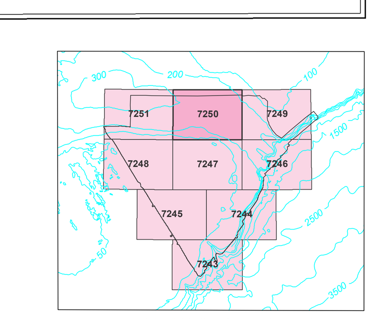
Any revisions or additional bathymetric information known to the user would be welcomed by the Geological Survey of Canada

Digital bathymetric contours in metres supplied by Geological Survey of Canada

Magnetic declination 2014, 16°34'W, decreasing 5.8' annually

Some geographical names subject to revision

Depth in metres below mean sea level



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DESCRIPTIVE NOTES

INTRODUCTION

Georges Bank is a large submarine bank in the Gulf of Maine near the edge of the continental shelf south of Nova Scotia and east of Cape Cod (Fig. 1). The bank is approximately 280 km long and 150 km wide. The international boundary between Canada and the United States transects the bank with the northeastern third of the bank being Canadian territory.

This map is part of a nine-map series of Georges Bank, Fundian Channel and Northeast Channel (Todd and Courtney, 2014a, b, c, d, e, f, g, h). The nine maps are the products of a 1999–2000 bathymetric survey that used multibeam sonar systems to map 11,965 km^2 of the sea floor. Other oceanographic expeditions to the area collected geological and biological data for scientific interpretation. This map sheet shows the sea floor topography of Georges Bank in shaded-relief view and backscatter strength (coded by colour) at a scale of 1:50 000. Topographic contours generated from the multibeam data are shown (in white) on the colour-coded backscatter strength with an interval of 10 m. Bathymetric contours (in blue) outside the multibeam survey are from the Natural Resource Map series (Canadian Hydrographic Service, 1966, 1967, 1971, 1972). Map 2192A (Todd et al., 2013) shows colour-coded seafloor topography in shaded-relief view.

BACKSCATTER STRENGTH

Details of the multibeam sonar data collection are given by Todd et al. (2013). Backscatter strengths ranging from 0 to -128 decibels (dB) were logged simultaneously with the bathymetric data. To reduce the dynamic range of the recorded data, a partial correction was applied to the backscatter strength values for the varying angle of incidence by using Lambert's law for the variation with angle and assuming a flat sea floor. Backscatter strengths were computed using calibration values for the electronics and transducers at the time of instrument manufacture.

Some features in the backscatter data are artefacts of data collection, environmental conditions during the survey periods and data processing. The orientation of the survey track lines can, in some instances, be identified by faint parallel stripes in the image. These stripes are particularly evident on areas of sea floor having low backscatter strength (light green). Because these artefacts are usually regular and geometric in appearance on the map, the human eye can disregard them and distinguish real patterns of backscatter strength distribution.

Courtney and Shaw (2000) summarized the relationship of backscatter strength to sea floor sediment. Multibeam systems record the mean backscattered signal strength, or mean amplitude, in each returned beam. The amount of acoustic energy returned in each beam depends upon the interaction of the incident energy in the down-going ray with the physical characteristics of the seabed and the shallow subsurface, and is strongly dependent on the angle of incidence of the beam to the seabed. Multibeam sonar systems project sound from an angle of 0° for beams pointing directly down from the survey vessel to angles as high as 75° for the outermost beams. For angles of incidence less than approximately 20°, the signal returned from the seabed is within the specular zone where a reflection from the seabed is recorded from objects larger than the acoustic wavelength (~ 1.6 cm). The amount of energy returned from a specular reflection increases with the acoustic impedance contrast across the water-seabed boundary (acoustic impedance is the product of density and acoustic velocity). At wide beam angles, the signal returned from the seabed arises from constructive interference with roughness on the seabed and this scattered energy increases with increasing surface roughness. At these angles, there can also be an added contribution to the backscatter energy from volume heterogeneity within the subsurface material. For example, acoustic energy penetrates deeper below the seabed into soft, fine-grained material (silt and sand) than it does into hard, course-grained material (gravel). Subsurface course-grained material will contribute to backscattered energy.

No simple relationship exists between backscatter strength and surficial sediment type. However, for incidence angles beyond the specular range, there is a correspondence between backscatter strength and surficial sediment roughness. This correspondence can be utilized for preliminary sediment identification and rudimentary mapping (Mitchell and Hughes Clarke, 1994; Shaw *et al*., 1997; Todd *et al*., 1999). Cobbles and boulders (> 64 mm) constitute a locally rough seabed, return high-amplitude backscatter signals (typically -10 to -30 dB), and are shown as blue on this map. Silt and sand (< 2 mm) constitute a locally smooth seabed, return low-amplitude backscatter signals (typically -30 to -60 dB), and are shown as light green to white on this map. Because backscatter is a function of a suite of acoustical variables, it is prudent to interpret backscatter images in conjunction with other geophysical data (seismic reflection profiles and sidescan sonar sonograms), geological samples of sea floor materials and sea floor photographs. This ground truth surveying and accompanying interpretation is an essential component in understanding the surficial geology and sediment transport processes on Georges Bank (Todd and Valentine, 2012).

BACKSCATTER DISTRIBUTION

The distribution of backscatter strength on Georges Bank provides insight into ocean circulation and related modern sea floor sediment transport processes suggested in the bathymetric image (Todd et al. (2013). The mean clockwise ocean circulation around Georges Bank is defined by a strong, jetlike northeastward flow on the northern edge of the bank and a weaker, broader, southwestward flow along the southern flank; on the Canadian section of Georges Bank, flow is eastward, southeastward and southward (Butman et al., 1982; Butman, 1987; Butman and Beardsley, 1987). The M_2 semidiurnal tidal currents are the strongest currents on Georges Bank; these currents flow into and out of the Gulf of Maine twice a day as the tide rises and falls. The major axis of the semidiurnal tidal current ellipse is oriented northwest–southeast, across the general topographic trend of Georges Bank. The amplitude of the major axis of the semidiurnal tidal current increases from less than 10 cm s^{-1} along the southern flank of Georges Bank to more than 100 cm s^{-1} along the northern edge of the bank. These strong tidal currents over the top of Georges Bank cause sediment reworking, resuspension, and transport. As discussed in Todd and Valentine (2012), the winnowing and transport of fine-grained sediment under the influence of strong tidal currents results in remnant coarse-grained gravel lag deposits with high backscatter strength. Transported sand is deposited in bed forms in sand wave fields characterized by low backscatter strength. In some areas, epi fauna on the seafloor influence the backscatter strength.

ACKNOWLEDGMENTS

K. Paul of the Canadian Hydrographic Service (CHS) organized the multibeam bathymetric survey of the mouth of Fundian Channel (Northeast Channel). M. Lamplugh and G. Costello (CHS) organized the multibeam bathymetric survey of Georges Bank in cooperation with the Canadian Offshore Scallop Association Industry Mapping Group. D. Beaver of the Geological Survey of Canada (GSC) participated in the Fundian Channel survey undertaken by Clearwater Fine Foods Inc. The Georges Bank and Fundian Channel maps are based on multibeam sonar data used in agreement with the Canadian Offshore Scallop Association Industry Mapping Group and Clearwater Fine Foods Inc. Multibeam sonar data were processed by CHS and GSC. Processing of the backscatter strength was undertaken with software developed by R.C. Courtney (GSC). We thank the master and crew of the CCGS *Frederick G. Creed* and of the MV *Anne S. Pierce* for their efforts at sea. Geographical Information Systems and cartographic support was provided by P. O'Regan, E. Patton, W.A. Rainey, S. Hayward and S. Hynes. John Shaw undertook scientific review of the map.

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2014b: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 3; Geological Survey of Canada, Open File 7249, scale 1:50 000.
2014c: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 4; Geological Survey of Canada, Open File 7248, scale 1:50 000.
2014d: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 5; Geological Survey of Canada, Open File 7247, scale 1:50 000.
2014e: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 6; Geological Survey of Canada, Open File 7246, scale 1:50 000.
2014f: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 7; Geological Survey of Canada, Open File 7245, scale 1:50 000.
2014g: Backscatter strength and sun-illuminated sea floor topography of Georges Bank and Fundian Channel, Gulf of Maine, Sheet 8; Geological Survey of Canada, Open File 7244, scale 1:50 000.
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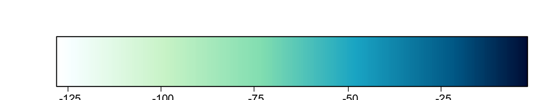

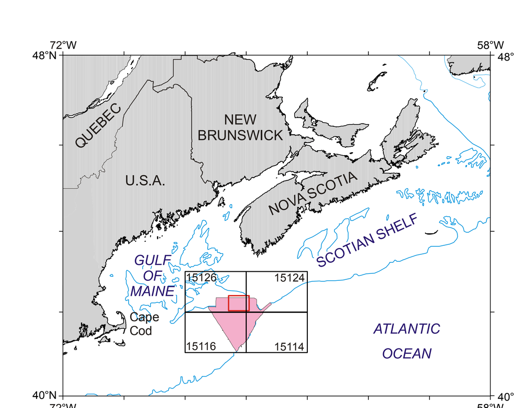

Figure 1. Location map shows extent of map sheet in red. The pink shadowing shows the extent of the multibeam sonar coverage. Five-digit numbers refer to Marsden Square System used for Natural Resource Map series at 1:250 000 scale. Blue line shows 200 m isobath.

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