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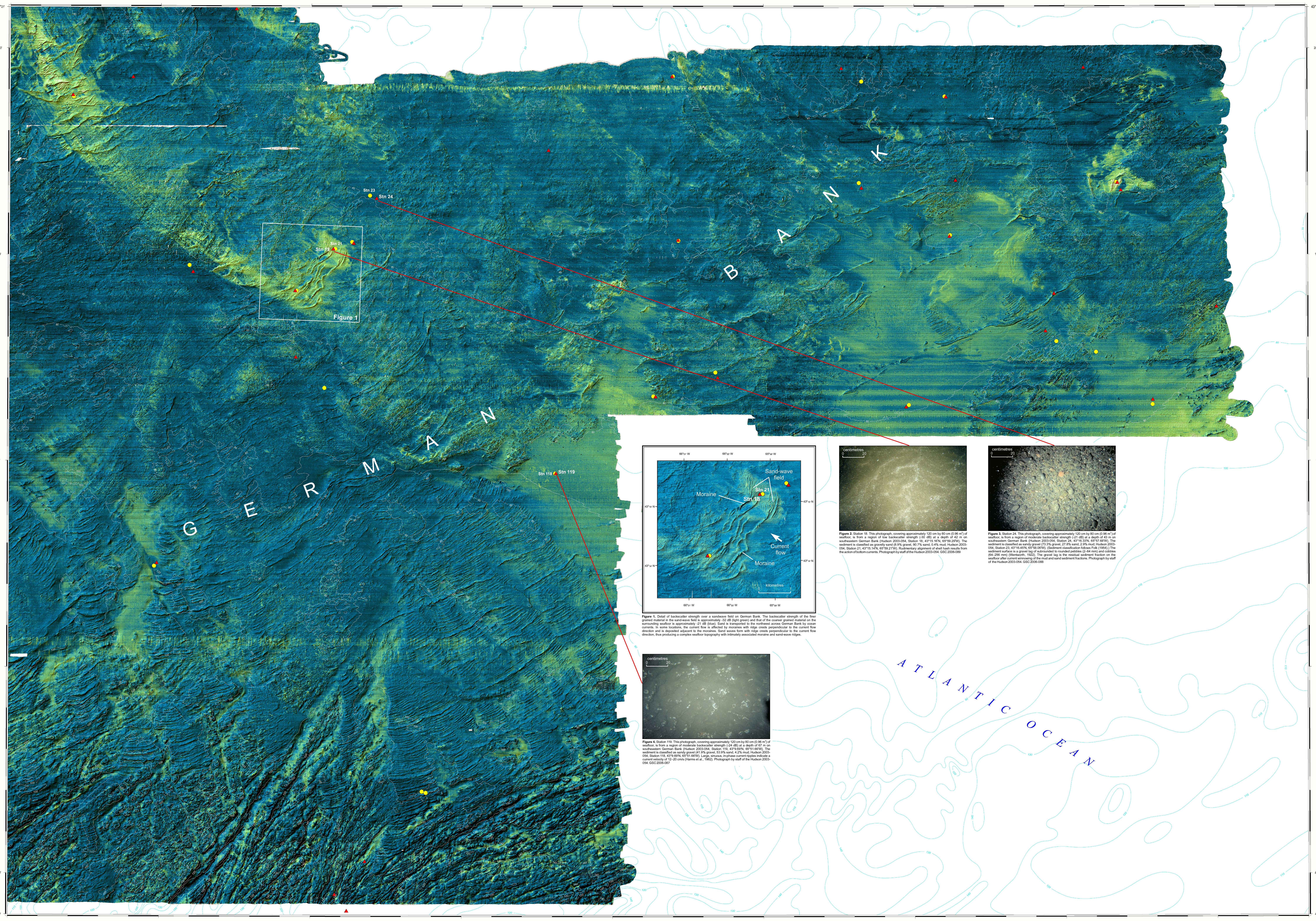

Figure 1. Detail of backscatter strength over a sandwave field on German Bank. The backscatter strength of the finer grained material in the sand-wave field is approximately -32 dB (light green) and that of the coarser grained material on the surrounding seafloor is approximately -21 dB (blue). Sand is transported to the northwest across German Bank by ocean currents. In some locations, the current flow is affected by moraines with ridge crests perpendicular to the current flow direction and is deposited adjacent to the moraines. Sand waves form with ridge crests perpendicular to the current flow direction, thus producing a complex seafloor topography with intimately associated moraine and sand-wave ridges.

Figure 2. Station 18. This photograph, covering approximately 120 cm by 80 cm (0.96 m^2) of seafloor, is from a region of low backscatter strength (-30 dB) at a depth of 42 m on southeastern German Bank (Hudson 2003-054, Station 18, 43°15.16'N, 65°59.29'W). The sediment is classified as gravelly sand (8.9% gravel, 90.7% sand, 0.4% mud; Hudson 2003-054, Station 21, 43°15.14'N, 65°59.21'W). Rudimentary alignment of shell hash results from the action of bottom currents. Photograph by staff of the Hudson 2003-054. GSC 2006-089

Figure 3. Station 24. This photograph, covering approximately 120 cm by 80 cm (0.96 m^2) of seafloor, is from a region of moderate backscatter strength (-21 dB) at a depth of 43 m on southeastern German Bank (Hudson 2003-054, Station 24, 43°16.33'N, 65°57.68'W). The sediment is classified as sandy gravel (73.3% gravel, 27.8% sand, 2.9% mud; Hudson 2003-054, Station 23, 43°16.45'N, 65°58.06'W). (Sediment classification follows Folk (1954).) The sediment surface is a gravel lag of subrounded to rounded pebbles (2–64 mm) and cobbles (64–256 mm) (Wentworth, 1922). The gravel lag is the residual sediment fraction on the seafloor after current winnowing of the mud and sand sediment fractions. Photograph by staff of the Hudson 2003-054. GSC 2006-088

Figure 4. Station 119. This photograph, covering approximately 120 cm by 80 cm (0.96 m^2) of seafloor, is from a region of moderate backscatter strength (-24 dB) at a depth of 67 m on southeastern German Bank (Hudson 2003-054, Station 119, 43°9.69'N, 65°51.66'W). The sediment is classified as sandy gravel (41.9% gravel, 53.9% sand, 4.2% mud; Hudson 2003-054, Station 118, 43°9.69'N, 65°51.66'W). Large, sinuous, in-phase current ripples indicate a current velocity of 12–20 cm/s (Harms et al., 1982). Photograph by staff of the Hudson 2003-054. GSC 2006-087

DESCRIPTIVE NOTES

INTRODUCTION

This map is part of a four-map series of German Bank, located on the Scotian Shelf off southern Nova Scotia. This map is the product of a 1997–2003 survey that used a multibeam sonar system to map 1521 km^2 of the seafloor. Other surveys collected geological and biological data for scientific interpretation. This map shows the seafloor topography of German Bank (southeast area) in shaded-relief view and backscatter strength (coded by colour) at a scale of 1:50 000.

Low backscatter values are white to light green and high backscatter values are blue. Topographic contours generated from the multibeam data are shown (in white) on the colour-coded backscatter strength at a depth interval of 20 m. Bathymetric contours (in blue) outside the multibeam survey area, presented at a depth interval of 10 m, are from the Natural Resource Map series (Canadian Hydrographic Service, 1967, 1971a, b, 1972). Map 2107A (Todd, 2007) shows colour-coded seafloor topography in shaded-relief view. Map 2108A (Todd, in press) shows seafloor topography in shaded-relief view with colour-coded surficial geological units. Map 2109A (Todd and Kostylev, in press) shows seafloor topography in shaded-relief view with colour-coded benthic habitat zonation.

The map includes two adjoining map areas at a scale of 1:50 000: sheet 1 and sheet 2. The three map areas comprise 5321 km^2 of seafloor surveyed with a multibeam sonar system. In total, twelve maps constitute the German Bank map suite (three map sheets on four themes: topography, backscatter strength, surficial geology, and benthic habitat).

BACKSCATTER STRENGTH

Multibeam bathymetric data were collected by the Canadian Hydrographic Service using the Canadian Coast Guard Ship *Frederick G. Creed*, a SWATH (small waterplane area twin hull) vessel. The ship was equipped with a Simrad Subsea EM1000 multibeam bathymetric survey system (95 kHz) with the transducer mounted in the starboard pontoon. This system produces 60 beams arrayed over an arc of 150° and operates by ensonifying a narrow strip of seafloor across track and detecting the seafloor echo. The width of seafloor imaged on each survey line was five to six times the water depth. Line spacing was about three to four times water depth to provide ensonification overlap between adjacent lines. The Differential Global Positioning System was used for navigation, providing positional accuracy of ±3 m. Survey speeds averaged 14 knots, resulting in an average data collection rate of about 5.0 km^2/h in water depths of 35–70 m. The sound velocity in the ocean was measured during multibeam data collection and used to correct the effect of sonar beam refraction. During the survey, water-depth values were inspected and erroneous values were removed. The data were adjusted for tidal variation using tidal predictions from the Canadian Hydrographic Service.

Backscatter strengths ranging from 0 to -128 dB were logged by the Simrad Subsea EM1000 system simultaneously with the bathymetric data. To reduce the dynamic range of the recorded data, the system applied a partial correction 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 seafloor. 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 artifacts 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 near 43°12´N, 65°40´W. Because these artifacts 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 seafloor 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 downgoing 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, coarse-grained material (gravel). Subsurface coarse-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 Clark, 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 seafloor materials, and seafloor photographs. This groundtruth surveying and accompanying interpretation is an essential component in the production of German Bank surficial geology and benthic habitat maps (Todd, in press; Todd and Kostylev, in press).

BACKSCATTER DISTRIBUTION

The distribution of backscatter strength on German Bank provides insight into ocean circulation and related modern seafloor sediment transport processes not apparent in the bathymetric image (Todd, 2007). Ocean circulation in the region of German Bank has been studied using moored current meters, drifting buoys, and finite-element modelling (Smith, 1983; Page and Smith, 1989; Lynch and Naimie, 1993; Hannah et al., 2000). Seasonal circulation is tidally dominated with a persistent westward and northwestward flow toward the Gulf of Maine. The winnowing and transport of fine-grained sediment under the influence of currents results in remnant coarse-grained deposits with moderate backscatter strength as illustrated in seafloor photograph Station 24 (Fig. 3). Sand is deposited in bedforms in sand-wave fields characterized by low backscatter strength (Fig. 1, Station 18, Fig. 2). Mixed sediment, e.g. sandy gravel at Station 119 (Fig. 4), has a backscatter value between sand and gravel lag.

ACKNOWLEDGMENTS

G. Costello of the Canadian Hydrographic Service (CHS) organized the multibeam bathymetric survey of German Bank and oversaw data processing. Canadian Hydrographic Service provided the data to the Geological Survey of Canada (GSC) for further processing and interpretation. K. DesRoches processed the backscatter strength using software developed by R.C. Courtney (GSC). The authors thank the master and crew of the CCGS *Frederick G. Creed* for their efforts at sea. R.A. Pickrill (GSC), G. Costello, and M. Lamplugh (CHS) supported the development of the German Bank maps. Geographical Information Systems and cartographic support was provided by S. Hayward, W.A. Rainey, S. Hynes, and P. O'Regan. The authors thank V. Barrie and A. Bolduc for scientific review of the map.

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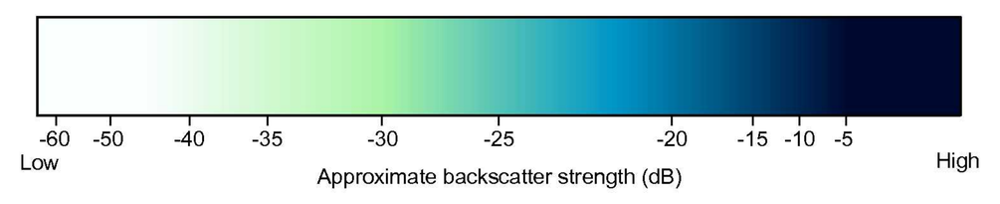
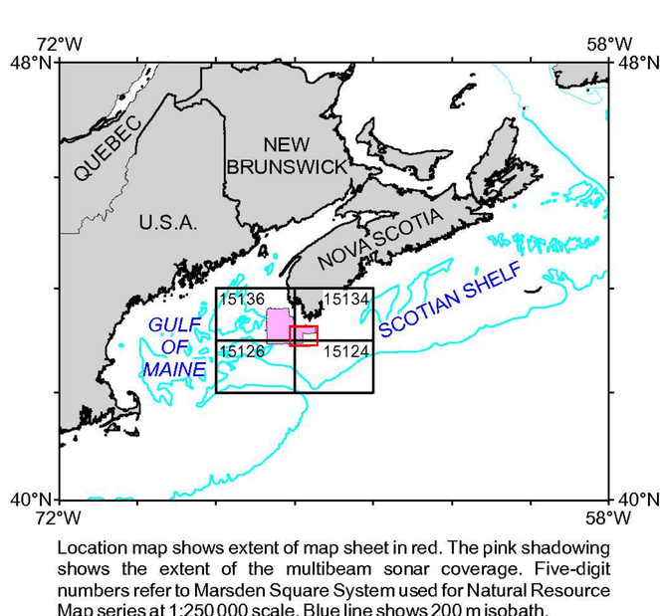
SYMBOLS

Grab sample . . . . Stn 23
Seafloor photograph . . . . Stn 24





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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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 2106A

BACKSCATTER STRENGTH AND SUN-ILLUMINATED SEAFLOOR TOPOGRAPHY

GERMAN BANK

SCOTIAN SHELF
OFFSHORE NOVA SCOTIA

Scale 1:50 000/Échelle 1/50 000

kilometres 1 0 1 2 3 4 kilometrès

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

Author: B.J. Todd

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

Multibeam backscatter data compiled by Geological Survey of Canada, 2004

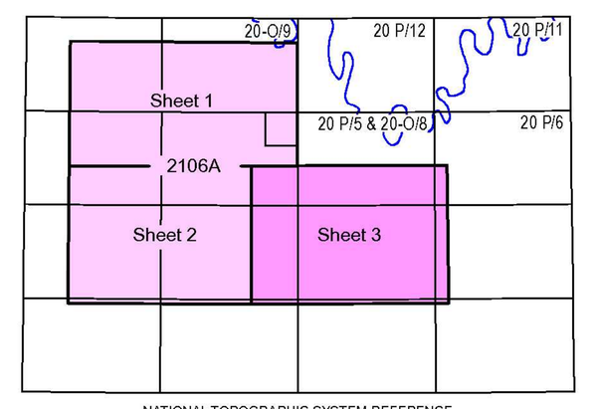
Digital cartography by P. O'Regan, Data Dissemination Division (DDD) and S. Hayward, GSC (Atlantic)

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

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

Magnetic declination 2007, 17°40W, decreasing 6.2 'annually

Depth in metres below mean sea level



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE

Sheet 3 of 3, backscatter strength and sun-illuminated seafloor topography (southeast area)

Recommended citation:
Todd, B.J.
2007: Backscatter strength and sun-illuminated seafloor topography, German Bank, Scotian Shelf, offshore Nova Scotia; Geological Survey of Canada, Map 2106A, scale1:50 000.

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