DESCRIPTIVE NOTES

This map is part of a four-map series of Browns Bank, located at the southwestern end of the Scotian Shelf at the entrance to the Gulf of Maine on the Atlantic continental shelf off Nova Scotia. The maps are the products of a 1996–1997 survey that used a multibeam sonar system to map 3056 km² of the seafloor. Previous and subsequent surveys collected geological and biological data for scientific interpretation. This map shows the seafloor topography of Browns Bank in shaded-relief view and backscatter strength (coded by colour) at a scale of 1:100 000. Low backscatter values are light green to white and high backscatter values are blue. Topographic contours generated from the multibeam data are shown (in white) on the colour-coded multibeam topography at a depth interval of 10 m. Bathymetric contours (in blue) outside the multibeam survey area, also presented at a depth interval of 10 m, are from the Natural Resource Map series (Canadian Hydrographic Service, 1972a, b). Map 2086A shows seafloor topography in shaded-relief view with colour-coded seafloor depth (Fig. 2, 3 on this sheet correspond to Fig. 1, 2 on Map 2086A (Todd and Shaw, 2006)). Map 2093A (Todd et al., in press a) shows seafloor topography in shaded-relief view with colour-coded surficial geological units. Map 2092A (Todd et al., in

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 km²/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

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 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 on areas of seafloor having high backscatter strength (blue), for example near 42°39' N, 66°12' 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 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

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). To illustrate the relationship of backscatter and sediment type, seafloor photographs of selected stations are shown on the map. Classification of the sediment at these stations (e.g. sandy gravel) follows the scheme of Folk (1954). Discussion of grain size at these stations follows the scale devised by Wentworth (1922) in which the grain size of mud is less than 63 µm, sand ranges from 63 µm to 2 mm, and gravel is more than 2 mm. The gravel fraction is further subdivided into granules (2–4 mm), pebbles (4–64 mm), cobbles (64–256 mm), and boulders (>256 mm). Cobbles and boulders constitute a locally rough seabed, return high-amplitude backscatter signals (typically -10 to -30 dB), and are shown as blue on this map (Fig. 1). Silt and sand constitute a locally smooth seabed, return low-amplitude backscatter signals (typically -30 dB 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 surficial geology and benthic habitat maps

BACKSCATTER DISTRIBUTION

The distribution of backscatter strength on Browns Bank provides insight into ocean circulation and related modern seafloor sediment transport processes not apparent in the bathymetric image (Todd and Shaw, 2006). Ocean circulation in the region of Browns Bank has been studied using moored curr meters, drifting buoys, and finite element modelling (Smith, 1983; Page and Smith, 1989; Lynch and Naimie, 1993; Hannah et al., 2000). A permanent clockwise gyre exists on Browns Bank with current strengths up to 20 cm/s. Along the northern edge of the bank, adjacent to Browns Channel, circulation is aligned from west to east. Along the southern edge of Browns Bank, adjacent to Northeast Channel, currents are aligned from southeast to northwest, parallel to the bank flank. On both of these bank edges, lag deposits with moderate to high backscatter strength as illustrated in seafloor photograph Figure 4. On the bank, the dominant current direction varies within the gyre and can be inferred from bedform Striking examples of the current-bedform relationship occur on western Browns Bank (west of 66°W).

Figure 3 highlights a 95 km² sand-wave field formed by a southeast current. On the opposite side of the current gyre, Figure 2 highlights barchan dunes and associated obstacle marks formed by a northwest current. The sandy gravel imaged in seafloor photograph Figure 7 is an example of intermediate backscatter strength situated near the centre of the current gyre between Figures 2 and 3. The distribution of backscatter strength on eastern Browns Bank (east of 66°W) is characterized by distinct regions of low backscatter strength composed of low-amplitude sand bedforms as imaged in seafloor photograph Figure 5. The majority of eastern Browns Bank exhibits moderate to high backscatter strength and is composed of gravel as imaged in seafloor photograph Figure 6.

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Seafloor photograph

Approximate backscatter strength (dB)

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