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**INNER-SHELF SURFICIAL GEOLOGY - FLINT ISLAND TO CAPE SMOKY,
CAPE BRETON ISLAND, NOVA SCOTIA**

by

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INTRODUCTION

A Bedford Institute of Oceanography cruise Navicula 87-047 (Miller, 1989) was undertaken to assess the potential for aggregates and heavy mineral resources on the inner continental shelf between Flint Island and Cape Smoky, Nova Scotia. A data set comprising 100 kHz Klein sidescan sonograms, 3.5 kHz O.R.E. profiles and 30 kHz ELAC ship's sounder bathymetry was collected. Thirty Van Veen grab samples were also collected to groundtruth the acoustic data (Fig. 1).

The data and interpretation is presented in three maps: 1) ship's tracks and sample locations; 2) along-track bedforms, bedrock outcrop and other seabed features; and 3) surficial geology. Some samples were analyzed for sediment size as well as heavy mineral content (Table 1). This work was done by Dr. Francis Hein (unpublished data report, 1987) under a separate contract for the Atlantic Geoscience Centre (Contract number OSC87-00157-(014)). Previous workers in the area include King and MacLean (1976) who studied and mapped the offshore bedrock geology. The shelf in the present study area is underlain by coal-bearing Carboniferous sediments of the Sydney Basin with non-differentiated Acoustic Basement between St. Ann's Bay and Cape Smoky. Fader *et al.* (1982) studied the distribution of surficial geological sediments and found the area was dominated by gravel facies of the Sable Island Sand and Gravel Formation with areas of outcropping bedrock and bedforms.

However, these studies were broad regional mapping programs that provided little detail in the study area.

SEABED FEATURES

Seabed features were mapped within the study area using bedform nomenclature from Amos and King (1984). Most of the interpretations of the features were based on the interpretation of high resolution sidescan sonograms.

Sand Ribbons:

Sand ribbons range from 5 m to 150 m in width (Fig. 2). Their only occurrence within the map area is along the northwest side of the entrance to St. Ann's Bay (Fig. 3). The sand ribbons overlie large areas of gravel with gravel ripples of 1.5 m wave length. These wave-formed gravel ripples are formed at right angles to the sand ribbons indicating that they are indeed flow transverse bedforms. In some areas, the sand ribbons have 2-D and 3-D megaripples superimposed on them.

Gravel Ripples:

Gravel ripples are widespread throughout the map-area (Fig. 4) but are most abundant near the shoreline between St. Ann's Bay and Cape Smoky. Their wavelengths average between 1.5 m to 4 m and they extend offshore to the 60 metre isobath. Samples from the gravel ripple areas consisted of moderately well-rounded to well-rounded gravel-sized clasts often with a coating of the calcareous pink alga *Lithothamnion* sp. This coating suggests that the clasts in these bedforms are stable and are not frequently moved.

Gravel ripples are also abundant in the areas to the west of the Bird Islands and east of Sydney Harbour (Fig. 3). Samples collected from the area east of Sydney Harbour were also coated with *Lithothamnion* but the individual gravel clasts were angular to sub-angular in contrast to those collected in the area between St. Ann's Bay and Cape Smoky.

Megaripples:

Megaripples (Fig. 3 and Fig. 5) occur locally throughout the study area in sandy sediments but are low in abundance. There are 2-D and 3-D types and they extend offshore to the 60-metre isobath (Fig. 3).

Bedrock Outcrop:

Bedrock at the seabed occurs as: (1) isolated outcrops where structure is not evident and (2) zones of outcropping bedrock where individual beds appear as linear ridges with significant relief (Fig. 6).

Throughout the map-area, bedrock is generally covered with a thin veneer of surficial sediment and is often associated with boulders where it outcrops.

Isolated outcrops appeared as patches of irregular high-intensity acoustic reflections on the sidescan sonograms (Fig. 3). During the survey it was noted that each occurrence of isolated outcrop was accompanied by the presence of lobster traps.

The large zones of outcropping bedrock were confined predominantly to the coastal area between New Waterford and Glace Bay (Fig. 3). Bedrock outcrop in this zone appeared as long linear, parallel ridges (Fig. 6). The orientation of these ridges was mapped, indicating the apparent, strike. The bedrock in this area is most likely an offshore extension of Pennsylvanian rocks which occur on the adjacent land (King and MacLean, 1976). Sandstone cobbles were collected in some of the grab samples overlying the bedrock.

Boulders:

Boulders were most abundant in areas of bedrock outcrop. The resolution of the sidescan sonar system allowed the recognition of boulders greater than 0.5 metres in diameter. However, the boulders occur in large patches, so that individual boulders are not mapped. The largest population of boulders occurs between St. Ann's Bay and Cape Smoky. They are also numerous in the area between New Waterford and Glace Bay. Their occurrence was minimal throughout the rest of the map area and was always in association with bedrock outcrops (Fig. 3).

Channels:

The only channels at the seabed found in the map-area cut the zone of bedrock outcrop between New Waterford and Glace Bay (Fig. 3 and Fig. 6). These channels, which bifurcate, are up to 250 metres wide and are infilled with sand. They appear to be an old paleo-drainage system which may have been formed by either fluvial or glacial processes.

Trawl Marks:

Trawl marks are sporadic in occurrence and they appear to be restricted to areas of sand. They may not represent the total number of accumulated trawl marks because the sand is mobile. They may be more widespread as detection (in some places) may have been beyond the resolution of the sidescan sonar system. Trawl marks are most abundant along the 80-metre isobath between the Bird Islands and Sydney Harbour (Fig. 3).

Cables:

Two crossings of a marine cable were interpreted north of New Waterford. There may be either one or two cables represented by the data.

Isolated Zones of Gravelly Sand:

These zones are interpreted as areas with an equal distribution of sand and gravel. Individual patches were too small to map. They occurred in most areas across the entire map-area (Fig. 3).

SURFICIAL GEOLOGY

Two surficial geological Formations were recognized and have been mapped (Fig. 7) based on the reflectivity characteristics of the sidescan sonograms and 3.5 kHz acoustic profiles and subsequent comparison with the grab samples. They are Sable Island Sand and Gravel and LaHave Clay Formations (King, 1970; Fader *et al.*, 1982). These formations were systematically sampled using a Van Veen grab sampler to ground-truth the acoustic signatures. Maps of the surficial geology, seabed features and track and sample locations for Navicula cruise 87-047 are included with this report at a scale of 1:75,185.

Sable Island Sand and Gravel Formation:

Gravel facies

In general, the gravel facies extends from the nearshore limits of the survey (less than 20-metre water depth) to approximately the 50-metre isobath. It probably underlies the sand facies.

Preliminary provenance studies of the gravels collected with the Van Veen grab sampler suggest a strong local control for the source material. Samples off New Waterford contained a high percentage of sandstone and conglomerate, probably derived from Carboniferous rocks of the Sydney Basin (King and MacLean, 1976). The gravel between St. Ann's Bay and Cape Smoky contained high percentages of granites similar to granites found on land.

The gravel off New Waterford between Sydney Harbour and Glace Bay appears to be a thin veneer overlying bedrock. A similar relationship occurs in the area extending from Sydney Harbour to the Bird Islands but the gravel may be thicker.

At the mouth of St. Ann's Bay, a lack of bedrock outcrop suggests that the gravel in this area may be much thicker and may extend continuously as far seaward as the 50-metre isobath. From St. Ann's Bay to Cape Smoky, the seafloor is dominated by large boulder fields and frequent areas of gravel ripples, a potential good source of aggregate.

Sand Facies

The deposits of the sand facies occur predominantly in three areas:

- (1) North of the Bird Islands in a large deposit which extends from approximately the 40-metre isobath seaward. At the eastern edge of the thin deposit, the sand occurs as alternating bands with gravel trending from the northwest to the southeast;
- (2) North of Sydney Harbour in a large patch which extends from approximately the 30-metre isobath seaward. Off Sydney Harbour the sand is probably a surface veneer covering an infilled channel. An arm of this sand body extends to the east, north of New Waterford;
- (3) Approximately 2 km north of New Waterford in a large isolated patch which is surrounded by outcropping bedrock.

The sand facies often occurs in the form of megaripples. The most notable locations occur approximately 5 km north of Glace Bay, on a gravel patch north of Point Aconi near the Bird Islands and overlying the gravel in small areas in the zone between St. Ann's Bay and Cape Smoky. A zone of megaripples has been mapped in the area east of Ingonish Island. South Bay Ingonish and outer North Bay Ingonish contain the sand facies. Grab samples in these areas obtained very well-sorted white sand. This occurs in small infilled channels cut into bedrock off Indian Bay and in the entrances to Sydney Harbour, Great Bras D'Or and St. Ann's Harbour.

LaHave Clay Formation:

The only surficial deposit of LaHave Clay mapped within the study area occurs in the deepest southeastern area of St. Ann's Bay.

ACKNOWLEDGMENTS

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FIGURE CAPTIONS

- Figure 1: Track plot and sample locations for Navicula cruise 87-047. Also included as map in pouch at scale of 1:75,185.
- Figure 2: Sidescan sonogram of St. Ann's Bay showing field of sand ribbons (light tone) overlying gravel with gravel ripples. The gravel ripples (flow transverse bedforms) are normal to the orientation of the sand ribbons (flow parallel bedforms). Note the occurrence of 2-D and 3-D megaripples superimposed on the sand ribbons near the centre of the photograph.
- Figure 3: Map showing the along-track distribution of seabed features. Also included as map in pouch at scale of 1:75,185.
- Figure 4: Field of megaripples and gravel ripples off South Bay, Ingonish, Cape Breton Island. The gravel ripples often preferentially occur surrounding bedrock outcrops seen on the left hand side of the sonogram.
- Figure 5: Field of megaripples in sand overlying gravel from the coastal area between St. Ann's Bay and Cape Smoky.
- Figure 6: Bedrock outcrop with infilled channel north of Indian Bay. The bedrock in this area consists of parallel ridges of sandstone overlain by gravel and boulders. The channel was possibly formed as either a fluvial or glacial drainage system across the inner shelf.
- Figure 7: Map of the surficial geology of the Flint Island to Cape Smoky study area. Also included as map in pouch at scale of 1:75,185.
- Table 1: Textural properties and petrographic analyses of selected samples collected during the cruise. Analyses by F. Hine.

TABLE 1

TEXTURAL PROPERTIES

AREA	SAMPLE #	LAB #	% GRAVEL	% SAND	% MUD	MEAN (PHI)	ST. DEV. (pH)	KURTOSIS	SKEWNESS
Great Bras D'Or	NV 87047-001	4782	0.16	99.31	0.53	1.87	0.57	79.71	5.66
Sydney	NV 87047-005	4783	2.77	95.67	1.56	2.17	1.15	18.65	-1.01
St. Ann's Harbour	NV 87047-009	4784	0.10	95.07	4.83	2.82	1.14	17.66	3.57
Ingonish	NV 87047-017	4785	0.12	89.63	10.25	3.44	1.24	11.54	2.57
New Waterford	NV 87047-024	4786	0.52	99.29	0.19	1.84	0.57	52.47	-0.75

PETROGRAPHY

AREA	SAMPLE #	# GRAINS	% GARNET	% PYROXENE	% HORNBLLENDE	% OPAQUES	% FELDSPAR	% QUARTZ	% ACCESSORIES & OTHER GRAINS
Great Bras D'Or	4782 #1	160	-	1.3	-	3.1	4.4 Badly Weathered	5.0	Sed. Rock Frags. - 31.3% Igneous Rock Frags. - 9.4% Hypersthene - 0.6%
	4782 #1	194	0.5	-	1.0	1.0	6.7 Badly Weathered	57.7	Sed. Rock Frags. - 27.3% Igneous Rock Frags. - 5.2% Hypersthene - 0.5%
Sydney	4783 #5	195	-	-	1.5	3.6	6.2	51.3	Sed. Rock Frags. - 36.9% Igneous Rock Frags. - 0.5%
	4783 #5	174	0.6	-	1.7	2.9	6.9	39.1	Sed. Rock Frags. - 41.4% Igneous Rock Frags. - 1.7% Weathered? - 10%
St. Ann's Harbour	4784 #9	305	-	-	1.0	2.3	10.5	42.0	Sed. Rock Frags. - 39.3%
	4784 #9	278	-	0.7	2.2	3.6	7.2	38.8	Sed. Rock Frags. - 47.5%
Ingonish	4785 #17	247	-	2.0	2.8	6.1	13.0	40.5	Sed. Rock Frags. - 35.6% ?Amorphous Material - 10%
	4785 #17	271	-	1.1	3.0	4.4	9.2	36.2	Sed. Rock Frags. - 36.9% ?Amorphous Material - 10%
New Waterford	4786 #24	210	-	-	-	0.5	1.0	72.4	Sed. Rock Frags. - 17.1% Igneous Rock Frags. - 10%
	4786 #24	178	-	-	1.7	-	2.8	74.1	Sed. Rock Frags. - 20.2% Igneous Rock Frags. - 1.1%

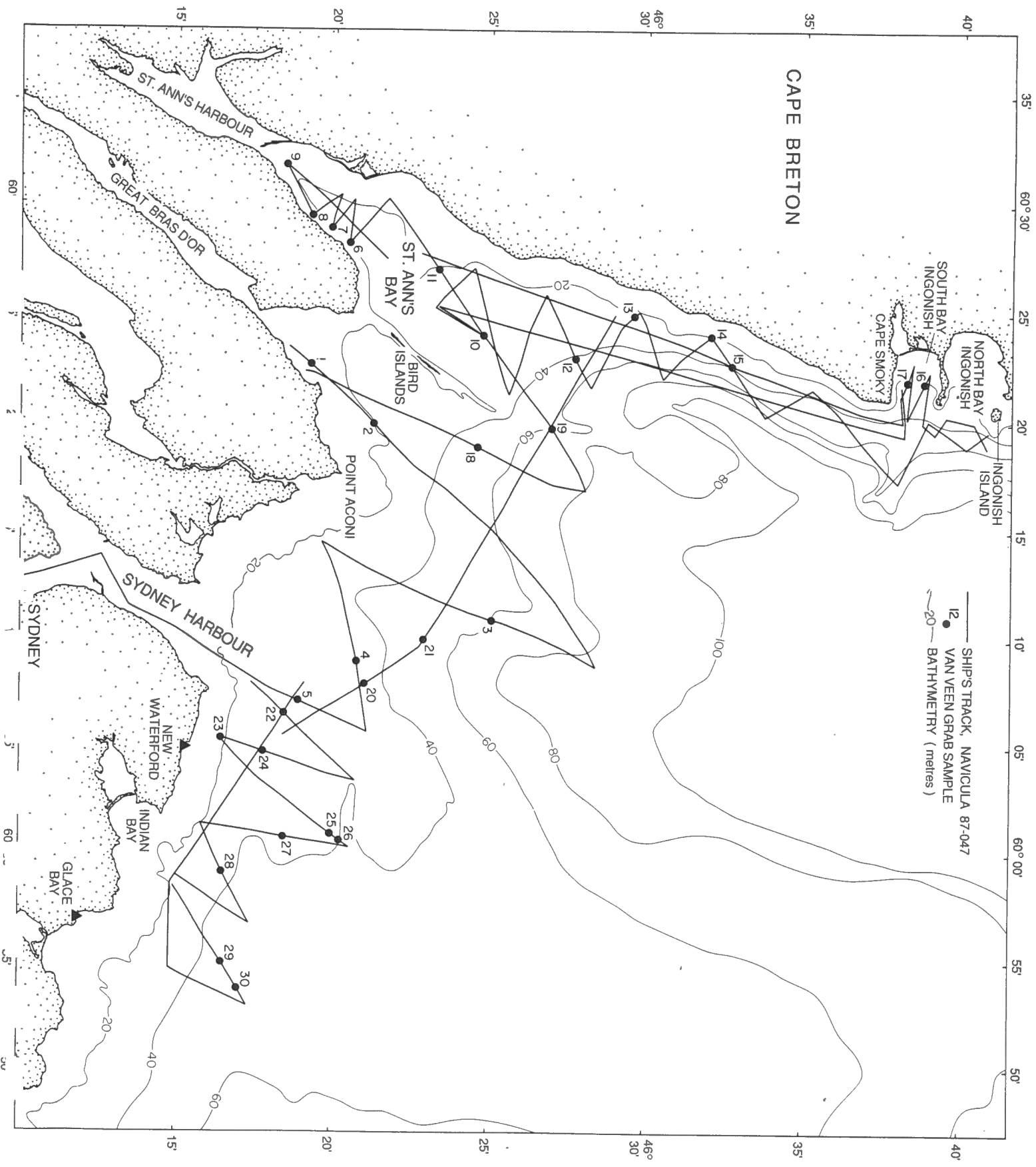


FIGURE 1

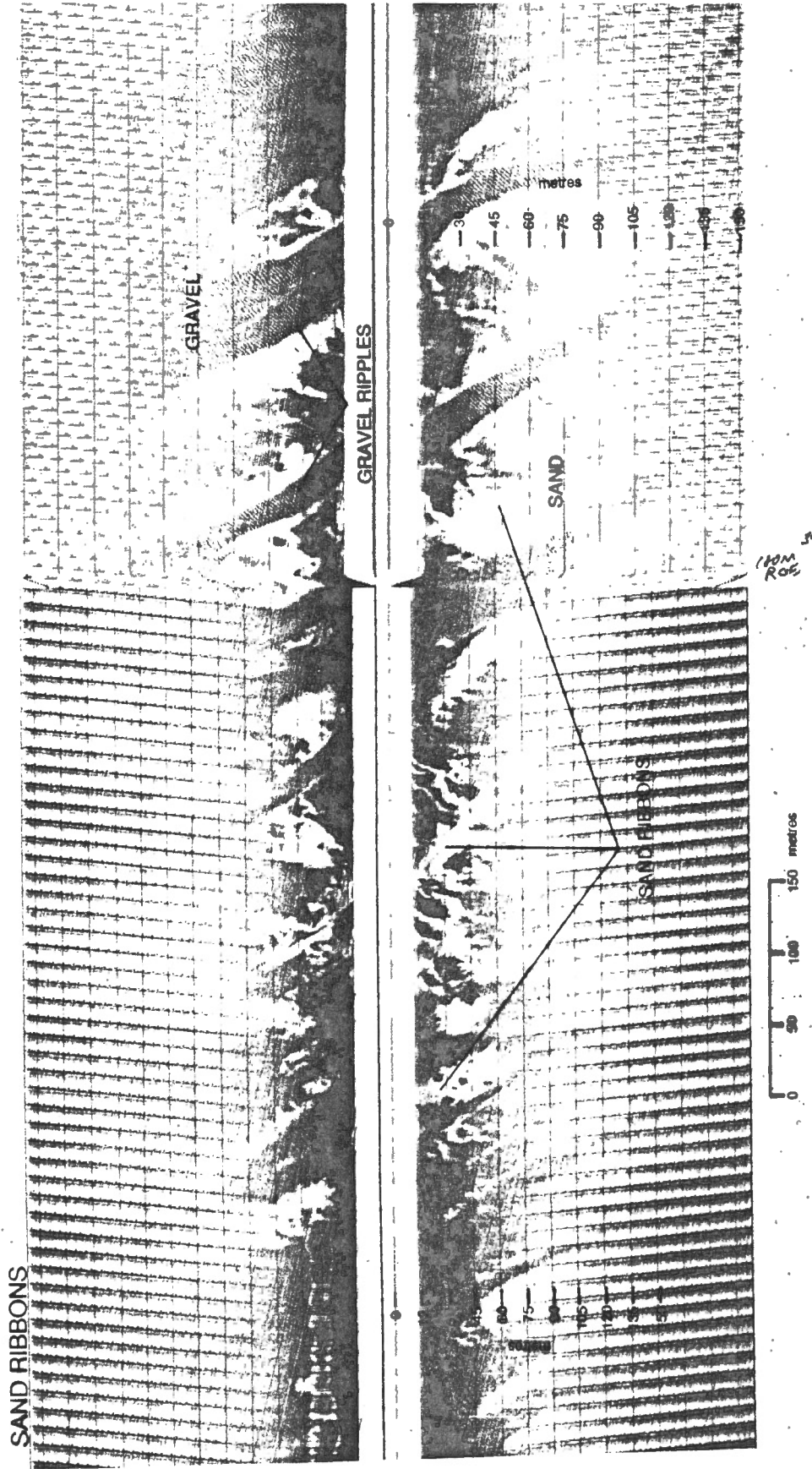


FIGURE 2

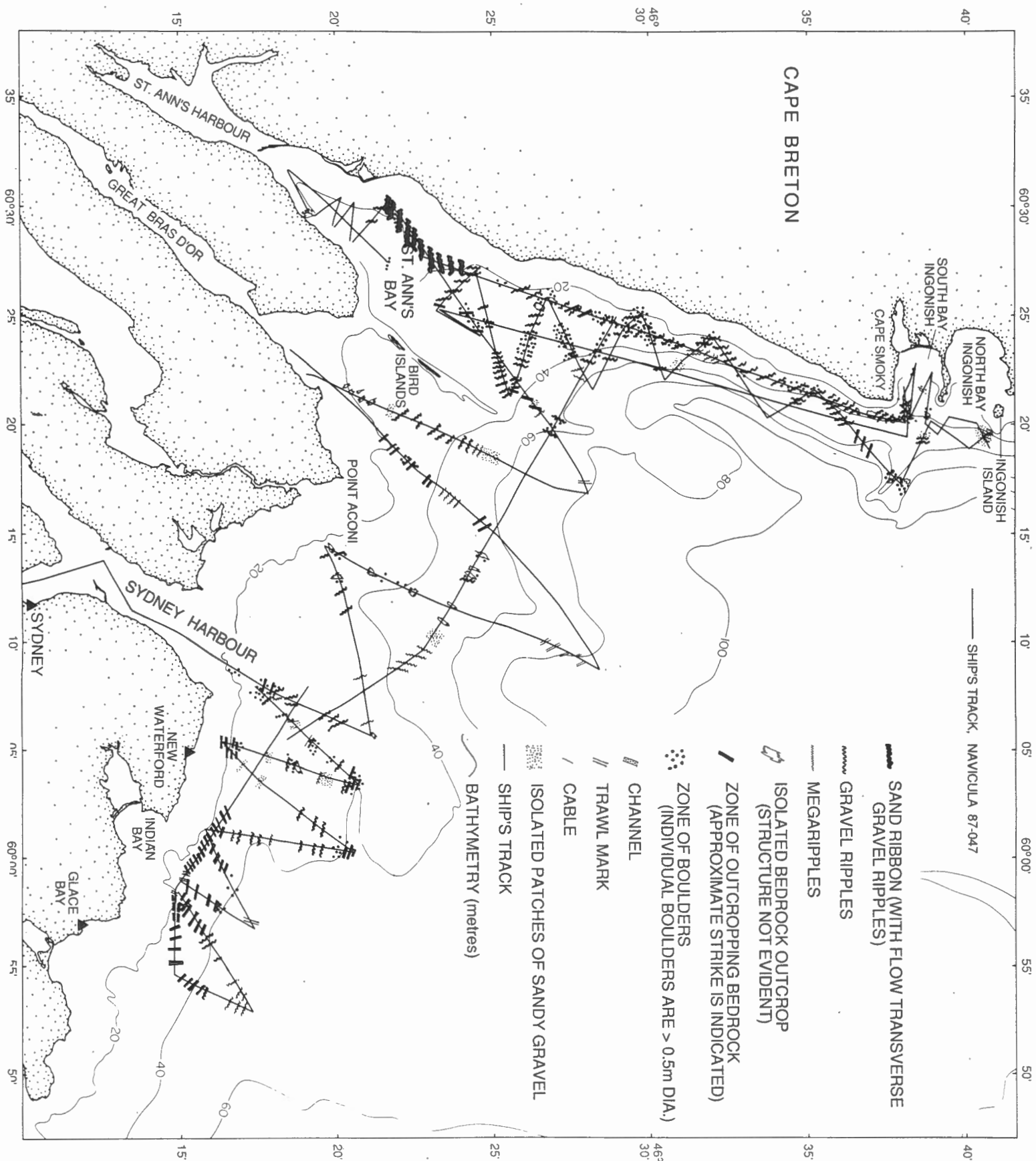
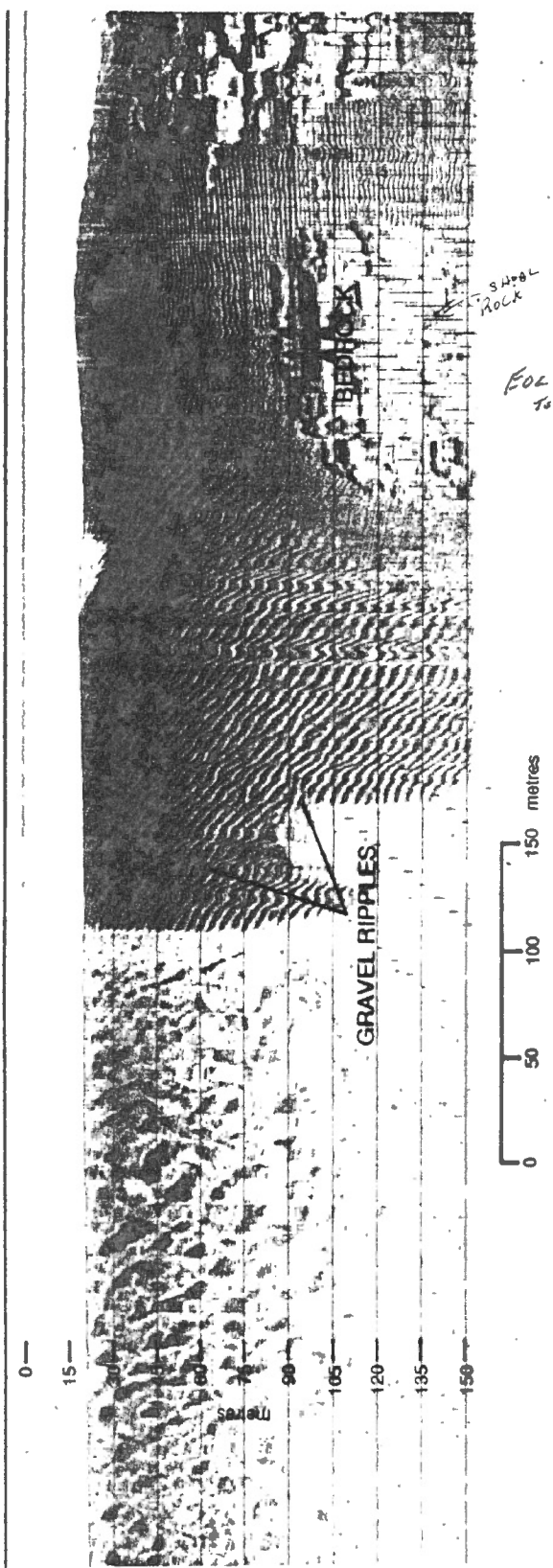
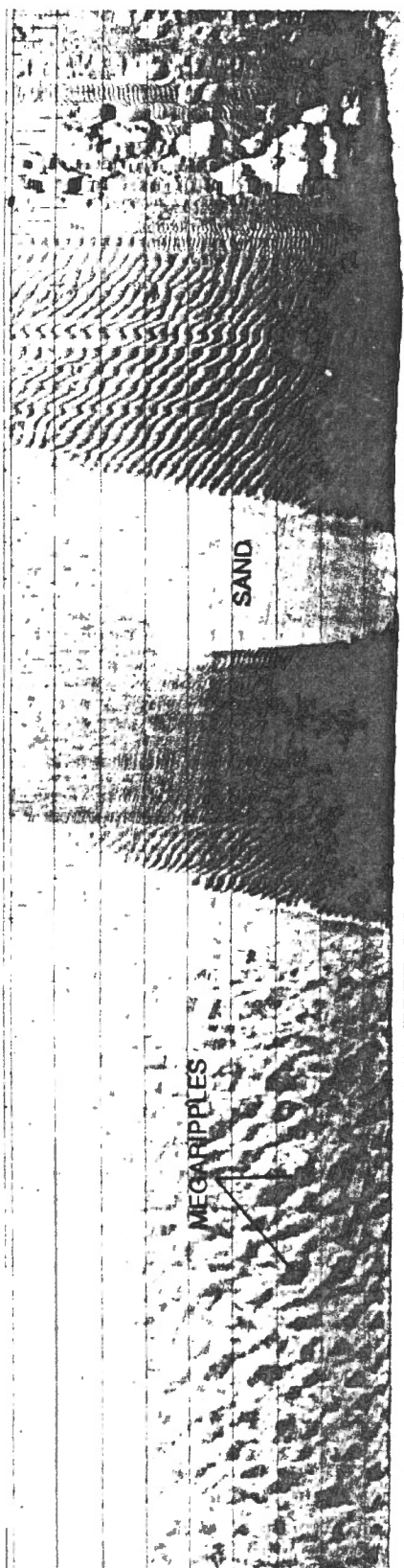
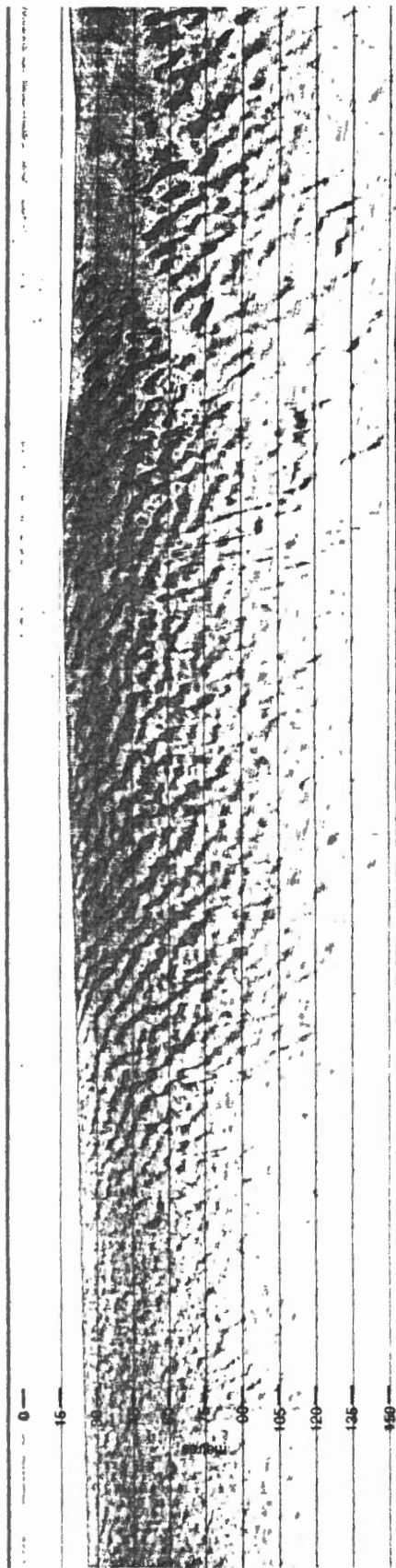
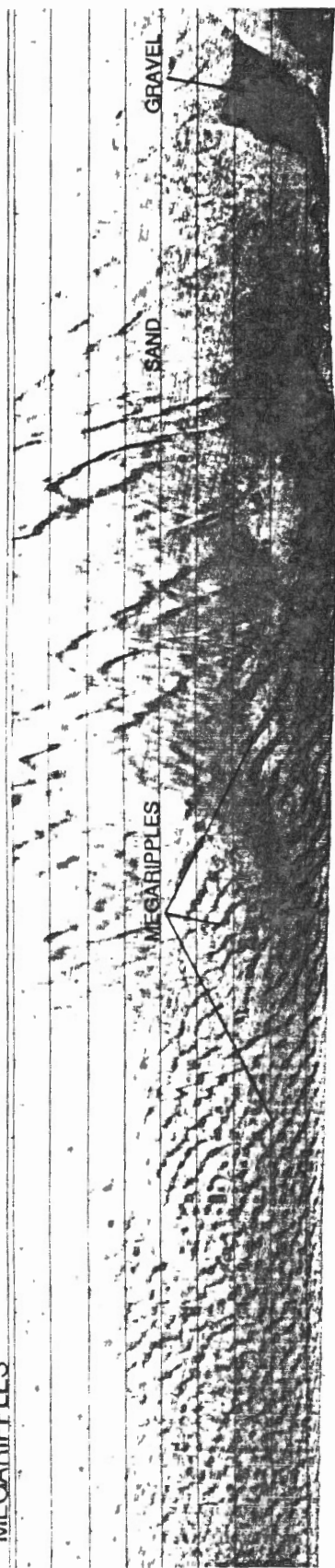


FIGURE 3

GRAVEL RIPPLES AND MEGARIPPLES



MEGARIPPLES



0 50 100 150 metres

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FIGURE 5

BEDROCK AND CHANNEL

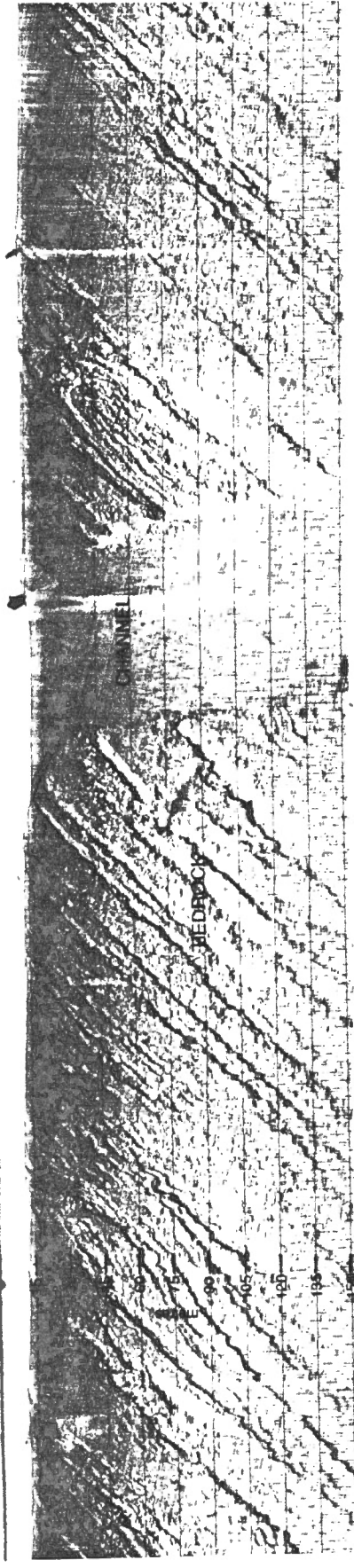


FIGURE 6

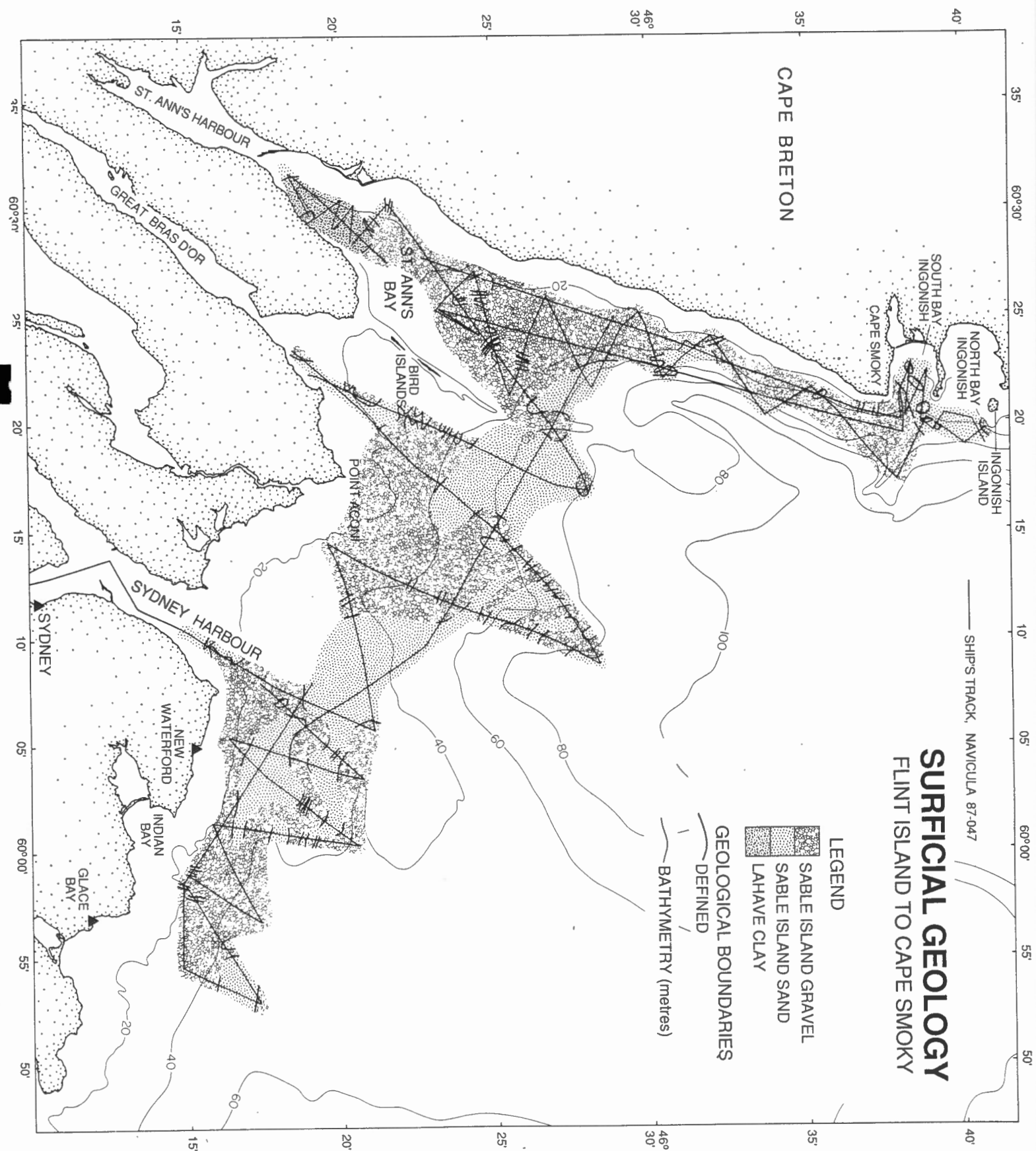


FIGURE 7