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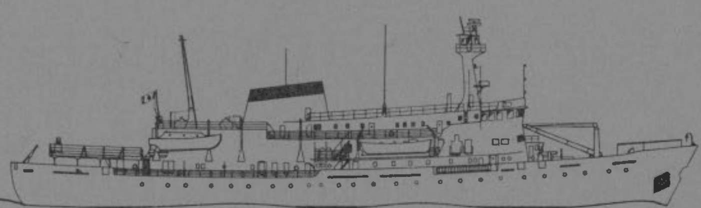

Canada

CRUISE REPORT 88-018 (A) PHASE I,

F.R.V. NAVICULA

HALIFAX - SAMBRO

MAY 26th - JUNE 2nd, 1988

by

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B2Y 4A2

CRUISE SUMMARY SHEET

Cruise No.:	88-018 (A) Phase I	
Vessel:	F.R.V. Navicula	
Cruise Dates:	May 26 - June 2, 1988	
Responsible Agency:	Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, N.S., B2Y 4A2	
Area:	Bedford Basin, Halifax Harbour and approaches, Northwest Arm, Sambro (see Index Map, Figure 1)	
Ship's Master:	Captain Niel Langille	
Senior Scientist:	Robert O. Miller	
Scientific Personnel:	Darrell Beaver	Technician, AGC
	Austin Boyce	Technician, AGC
	Randy Currie	Scientist, AGC
	Gordon B.J. Fader	Scientist, AGC
	Mike Kennah	Engineer, Teleglobe Canada Ltd.
	Don Locke	Technician, AGC
	Ann Miller	Scientist, George Washington University
	Robert O. Miller	Technician, AGC
	Charles Schafer	Scientist, AGC

NAVICULA CRUISE
88-018 (A) PHASE I
BEDFORD BASIN, HALIFAX HARBOUR AND APPROACHES, NORTHWEST ARM AND SAMBRO

ITINERARY:

DATE (1988)	TIME (GMT)	OPERATION
May 26, 27		Load equipment at BIO.
May 28	1030	Begin shakedown of equipment in Bedford Basin. Test equipment along F.C.G. Smith track (Seg. 1) to evaluate performance of each sensor over different bottom types. Run line up to Pemex dry dock in Halifax Harbour.
	2100	Return to BIO.
May 29	1030	Leave BIO and run line out to Georges Island; in and out of Northwest Arm.
	1500	Return to BIO to pick up C. Schafer and 2 Chinese guests.
	1530	Leave BIO and run line out to the approaches of Halifax Harbour.
	2130	Return to BIO.
May 30		Navicula tied up at BIO to load equipment; to Sambro.
May 31	1000	Leave Sambro and run long line to tie into previous cruise data.
	2200	Return to Sambro.
June 1	1000	Leave Sambro and run small grid in Pennant Bay.
	2000	Return to Sambro.
June 2	1000	Leave Sambro and collect 10 grab samples. Run tie line across outer Pennant Bay using Huntec Sea Lion.
	2100	Return to Sambro. End of cruise.

PURPOSE

This cruise was the first of a new series of geological-geophysical nearshore studies of the Atlantic Maritimes region. The purpose of this cruise was to evaluate several seismic reflection systems and to determine their effectiveness over a variety of bottom types for use on further cruises of the nearshore program. A survey was then to be run in the Sambro area. The data and interpretations will form part of a program to map the surficial sediments, shallow bedrock geology, and subsurface stratigraphy of the nearshore, throughout the nearshore marine areas around the Maritimes, and to understand the processes that have affected the distribution and character of the sediments. Specific objectives of the cruise were:

1) To carry out tests of the various seismic systems along a previous survey line (Segment 1), run by F.C.G. Smith in Bedford Basin as ground truth support for TIBS (through the ice bathymetry) project. A core was recovered along this line during Hudson cruise 88-010 (Piper [ed], 1988; Fitzgerald *et al.*, 1989). Sidescan was operated at various ranges at various firing rates in order to determine optimum settings.

2) To survey selected portions of Halifax Harbour and approaches as well as the Northwest Arm to evaluate the effectiveness of the various seismic systems over varying geology.

3) To survey an area off Sambro Harbour and Pennant Bay with sidescan sonar and seismic reflection systems and collect grab samples to groundtruth the acoustic information. These data will be used to assess the nature of the sediments and the potential for aggregate mining in the area. To map the distribution of surficial sediments, bedforms, other seabed and subsurface features, and to determine bedrock characteristics.

4) To set up a system to automatically log magnetic and Loran-C navigational data.

5) To devise a method of recovering magnetic data, without acoustic and electrical interference from the sparker seismic system.

EQUIPMENT PERFORMANCE

Sidescan Sonar

A Klein tow fish containing a 100 kHz, 3/4° side-looking beam and a 200 kHz down-looking, wide-angle beam was used as a sound source to produce wet paper sidescan sonograms on a 421T, two channel tranceiver-recorder, and altimeter profiles on an EPC 1600 graphic recorder. Sidescan sonar data were recorded on a Racal Store 4D, reel to reel tape recorder using normal FM bias (channel one - port signal, TVG; channel two - starboard signal, TVG; channel three - 421T reference recorder pulses; and channel four - voice fix). The width of the sonar swath was set from 50 m to 200 m depending upon water depth, towing speed and seabed roughness.

The Klein system performed well and yielded high-quality sonograms of the sea floor. Data quality decreased in shallow water (<20 metres) when the fish was towed in the ship's wake or when sea conditions were rough. The wakes of pleasure craft degraded the data in the Northwest Arm.

Seismic Reflection Systems:

1) O.R.E. Geopulse Seismic System (Sparker)

A 15 tip Nova Scotia Research Foundation (NSRF) sparker was powered by an O.R.E. Geopulse system amplifier and high voltage power unit with a source of 350 joules. A 25 foot NSRF surface streamer was used to receive the returning seismic signals. The seismic data were printed on an EPC 4100-19 inch graphic recorder set at 0.25 second sweep rate and fired at 0.75 second intervals.

2) Datasonics 20 joule Bubble Pulser

The Datasonics 20 joule Bubble Pulser is a surface towed (surf board) seismic source and power unit. Reception of the incoming seismic signals was on a 25 foot NSRF surface streamer and Geopulse amplifier system, or a Datasonics Benthos surface streamer and portable amplifier unit with a Krohn-Hite (20 db) bandpass filter. These data were displayed on an EPC 4100-19 inch graphic recorder set at 0.25 second sweep rate and fired at 0.75 second intervals.

3) Huntec Sea Lion Shallow Tow Boomer

The Huntec Sea Lion is a shallow-towed seismic boomer system powered by an O.R.E. Geopulse system amplifier and high voltage power unit. The Huntec Sea Lion has a self-contained 4425/1000 joule mini-boomer which was operated at 350 joules. Reception of the return seismic signals was with a 25 foot NSRF surface streamer, an internal LC-32 hydrophone or a 15/10P Benthos streamer. Huntec data was displayed on an EPC 4100-19 inch graphic recorder set at 0.25 second sweep rate and a firing rate of 0.75 seconds.

The shallow-towed Huntec seismic system was used during the cruise for the first time. It provided higher resolution ($\approx$ 1 m) than the Datasonics Bubble Pulser and the Sparker. Handling procedures limited the use of the system especially in areas where rapid retrieval was necessary.

The Benthos external streamer was severed by the propeller of the Navicula during retrieval at the end of the survey in Sambro Harbour.

<u>Bathymetry</u>

Bathymetry was recorded using Navicula's 30 kHz Elac type LAZ72 boat sounder.

Magnetics

Total magnetic field data were collected with the Barringer Model M-123 portable sea magnetometer. The system has a sensitivity of one gamma at a 10 second cycle. The toroidal, non-directional, noise cancelling GM-122 sensor was towed on a 100 foot cable. Readings in gammas were logged on computer at six readings per minute as well as on an integrated Hewlett Packard 7155 strip chart paper recorder. During this cruise (SAMBRO), the chart range was set at 100 gammas.

An attempt at resolving a magnetic interference problem was partially resolved by the addition of an inhibit key pulse box, so that the seismic systems could not be fired during the polarization/sense cycle. This system appeared to work but requires further modifications for future use.

Seabed Ground Truth

A medium size van Veen grab sampler was used on a 3/8 inch Sampson braid rope with a swivel. The Navicula boom was used as a high shive point and the deck capstan was used for hauling during recovery. This system seemed to be adequate for ground truthing.

System Configuration

A normal survey set-up consisted of the sidescan deployed off the starboard sidearm using a Markey DEWS-8 slip ring winch with added hydraulic remote control in the lab. This configuration proved to be absolutely indispensable. The Klein 422S-101AF tow fish with added K-wing depressor was deployed to a maximum 60 metre depth at Navicula's minimum boat speed of four knots using a three channel, 300 metre armored tow cable. The sparker, or bubble pulser, was deployed from one half of the centre stern with the NSRF on the other half. The magnetometer sensor was also deployed from the stern and the Huntec Sea Lion shallow-tow was deployed off the port side arm, using the Navicula boom winch and a fixed length of tow wire. During towing the boom wire was slack in this configuration. The sidescan was operated from 50 to 150 metre range settings, producing in general short range data due to minimal water depths. The 30 kHz boat sounder produced interference on the data due to interference ticks on the record and long sparker pickup lines caused by tow fish auto firing part way through the sidescan sweep. After many attempts to ground out this interference, it was concluded that the 30 kHz sounder had an inherent acoustic component that could not be removed. The sparker influence arose from the isolation of the tow cable armor, which was required due to the lack of a spare slip ring, and the floating winch fastened on the wooden deck of the survey vessel.

The sparker and bubble pulser both produced severe noise on the magnetic data in a range up to ± 40 gammas. The seismic data from sparker or Bubble Pulser with NSRF streamer was of high quality with low filtering to 300 - 500 hertz. The high end of the band pass has no effect on data quality or noise reduction.

The Huntec Sea Lion vehicle was cumbersome to deploy as it is attached with three tow lines. A slip ring winch would be a better solution. In addition, a fixed tow wire is recommended since the rubber jacket on the Kevlar power umbilical will not stand up to strumming and chaffing. Since a winch is not part of the system, towing over extreme bathymetry changes in shallow water requires that the shallow-tow must be set close to the sea surface where Navicula's engine noise is a problem. Low band pass filtre settings higher than 700 hertz are required to overcome this noise. This limits seismic penetration using the Benthos 15 foot, ten-hydrophone array towed by the Huntec shallow-tow. Since the signal to noise ratio is so high, the Geopulse amplifier bottom tracking TVG cannot be used, so constant TVG delay adjustment must be performed as well as TVG slope adjust. Signal to noise ratio may improve as the shallow-tow is set to its maximum 15 m tow depth when the survey occurs in deeper water. Reception of the Sea Lion Boomer data on the surface towed NSRF streamer was better, but weaker than the independent hydrophone, but the source/sensor separation produced double reflectors. The internal LC-32 hydrophone had severe noise pick-up and could not be used.

The Bubble Pulser was deployed centre stern, using the NSRF and Geopulse system for reception. Its resolution was less than the sparker, with less high frequency data and less penetration. However, it was easily handled, reliable, and towed near the sea surface. It did not interfere with sidescan, and only affected the magnetic data to ± 20 gammas.

NATURE AND QUANTITY OF DATA COLLECTED

See appendix attached and Figures 1 and 2 (cruise track and sample plot)

DISCUSSION AND COMMENTS

Bedford Basin

As was learned on many of the other cruises of the 1988 Navicula nearshore geological program, the choice of a seismic reflection system depended on the nature of the geology of the area, sea conditions, towing characteristics and the desired results. This was the first test cruise of the program and was largely designed to prepare for the upcoming 13 cruises in the series. However, many new geological observations were made on seabed conditions.

The floor of Bedford Basin is a post-glacial muddy sediment ranging in thickness to over 20 m. In most places, it is completely covered with a criss-crossing pattern of linear depressions interpreted as anchor drag marks (Fig. 3). They are up to several metres in depth and resemble sea ice keel or iceberg furrow marks from the Beaufort Sea or the Grand Banks of Newfoundland. These marks dominate the surface of the muddy sediments and suggest that the upper few metres has been highly disturbed and the stratigraphy mixed. A number of circular, highly-reflective patches especially near the mouth of the Basin where it joins the Harbour are probably dredge spoils. Several sunken ships such as a large rectangular barge and an apparent schooner-shaped hull were found off the Bedford Institute facility. At the junction of the Harbour and Basin, the seabed is gravelly and appears to consist of boulders and outcropping bedrock. Apparent shallow gas charging of sediments is widespread throughout the Basin. This acoustic blanking does not allow penetration of the high frequency energy of the seismic systems. The sparker data did not clearly define the bedrock surface in the deepest part of the basin. A large sill of linear bedrock ridges, strewn with gravel containing boulders, separates Bedford Bay from the Basin proper. Fewer anchor marks occur in Bedford Bay compared to the dense pattern in the Basin proper, suggesting that sedimentation in the Basin from material transported by the Sackville River is minimal, most of the material being deposited immediately after discharge into Bedford Bay. A pattern of circular mottles on the sidescan data south of the bedrock sill between Bedford Bay and the Basin suggests they may arise from venting gas, or from distributions of benthic organisms.

<u>Halifax Harbour</u>

Areas of Halifax Harbour are similar to the Basin. Bedrock, till and boulders dominate the seabed from the A. Murray McKay bridge to the Pemex Dock at the northern end of the harbour. Several of the bedrock/boulder ridges protrude from the seabed and may be navigational hazards to large container vessels. A part of the survey concentrated in the area where the 1917 Halifax explosion occurred, but failed to locate any large crater or depression at the seabed as had been postulated in descriptions of the explosion. The seabed of both Bedford Basin and the Harbour is covered with anchor marks and drag marks of all sizes and shapes. Debris is common. Adjacent to areas of known sewage outfall, the pattern of anchor marks is somewhat obscured, suggesting that the sewage deposits are actively filling in the scour marks close to the outfall.

Northwest Arm

The survey of the Northwest Arm revealed a central depression with steep bedrock flanks suggesting a drowned river origin for the inlet. In the area adjacent to the Flemming Park Tower, the seabed changed from the muddy substrate characteristic of the remainder of the Arm, to a highly reflective gravel or bedrock bottom. Anchor pull marks were common and a few sunken small vessels were seen.

Outer Harbour and Approaches

In the outer harbour, the muddy sediments of the inner area gave way to coarser sediments, bedrock exposures and bedforms. Many of the bedrock outcrops were surrounded by areas of gravel ripples (Fig. 4) possibly suitable for aggregate use. Megaripples of sand overlie muddy sediments in the outer Harbour.

Sambro

The survey off Sambro Bay and Pennant Bay was intended to investigate the aggregate and mineral potential of the area and to assess the seabed for a possible telecommunication cable route. The area is dominated by outcropping bedrock, probably Devonian granite characterized by a lack of beds, commonly seen in areas of outcropping Halifax Slate. Sand patches are localized east of inner Sambro Island, south of Sambro Island, in Terrance Bay, west of Pennant Point, and further offshore, to distances of approximately 4 nautical miles south of Pennant Point. Flat areas of gravel are also present with the largest patch southwest of Pennant Point. Many areas of gravel consist of gravel ripples with wave lengths of several metres and heights of less than 1 metre. Samples of these areas show they consist of granule to pebble sized fragments of angular granite (Fig. 5).

Included in this cruise report (pocket) is an interpreted track line map of the surficial geology and seabed features for the area offshore Pennant Bay, Pennant Point and Sambro. Prepared at a scale of 1:36,480, it can be used as an overlay for hydrographic chart No. 4385.

ACKNOWLEDGMENTS

We wish to thank the Captain and crew of the Navicula for their excellent support and enthusiasm for the program. Many AGC Program Support group technicians assisted in the shakedown of the equipment for the cruise which resulted in many last minute design changes. We thank them for their support. Mike Kennah of Teleglobe Canada is also thanked for his support to the project and his participation was welcomed. The manuscript was reviewed and improved by I. Hardy and D. Buckley.

REFERENCES

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1989: Geochemical data from analysis of sediments and pore water obtained from piston core and box cores taken from Bedford Basin, LaHave Basin, Emerald Basin and the slope of the southern Scotian Shelf, Hudson Cruise 88-010; Geological Survey of Canada Open File 1984, 47 p.

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1988: Cruise Report Hudson 88-010; Unpublished report; Bedford Institute of Oceanography, Box 1006, Dartmouth, N.S., Canada, B2Y 4A2, 100 p.

APPENDIX

Table 1: 88-018(A) Phase 1 Grabs

Samp. #	Sample Type	Jul. Day/ Time	Latitude	Longitude	Depth (m)	# of Attempts	# of Sub-samples	Geographic Location	Notes
001	van Veen	1541148	44°20.60'N	63°36.44'W	103	2	0	Sambro	First attempt, cobbles caught in jaws, 3 cobbles. Second attempt, jaws partially open fines washing out on recovery. Probably glacial till, 10% silt, 70% sand, 20% cobbles (angular), minor shells.
002	van Veen	1541223	44°22.80'N	63°38.18'W	86	1	0	Sambro	Good sample, stored in bag. 70% olive-green fine sand, 30% silt. Some macrofauna.
003	van Veen	1541243	44°23.82'N	63°40.78'W	70	1	0	Sambro	All sample in one bag. 90% olive-green silty sand. 10% silt. Minor macrofauna. Trace of dark minerals.
004	van Veen	1541306	44°25.38'N	63°40.15'W	52	3	0	Sambro	First attempt, gravel, coarse sand, jaws partially open. Second attempt, jaws open, no recovery. Third attempt, gravel to 2 inches diameter with *Lithothamnia*, granite, well-rounded and coarse sand, minor macrofauna.
005	van Veen	1541318	44°25.57'N	63°40.40'W	52	3	0	Sambro	Three attempts made, each time grab jaws partially opened, recovered two clasts per attempt. Granite cobbles, some with *Lithothamnia* and sand (quartz) attached. Angular to sub-rounded.
006	van Veen	1541329	44°25.82'N	63°40.58'W	47	1	0	Sambro	Good sample of rounded to well-rounded gravel (granitic), grading to coarse sand. Good aggregate material.
007	van Veen	1541335	44°26.08'N	63°48.78'W	44	3	0	Sambro	Three attempts made, jaws open each time, few granitic cobbles, angular with *Lithothamnia*.
008	van Veen	1541349	44°26.70'N	63°40.59'W	42	2	0	Sambro	First attempt, couple of granitic clasts held jaws open, subrounded. Second attempt, good sample, very coarse sand to fine gravel, granitic, well-rounded.
009	van Veen	1541359	44°27.06'N	63°41.00'W	41	1	0	Sambro	Good gravel, 10% sand, 5% silty sand. Clasts up to 1/2 inch in diameter, granitic, rounded to well-rounded.
010	van Veen	1541414	44°27.99'N	63°42.31'W	25	1	0	Sambro	Clean fine sand, grey-green, some dark minerals, good sample.

Table 2: Sidescan Records 88-018(A) Phase 1

Roll #	Start Day/ Time	Stop Day/ Time	Line #	Geographic Location	Recorder	Sidescan System
001	1491429	1491953	Test Lines	Bedford Basin	Klein	100 kHz Klein SSS
002	1501145	1501718	Test Lines	Halifax Harbour	Klein	100 kHz Klein SSS
003	1501719	1501834	Test Lines	Halifax Harbour	Klein	100 kHz Klein SSS
004	1501839	1501956	Test Lines	Halifax Harbour	Klein	100 kHz Klein SSS
005	1501958	1502050	Test Lines	Halifax Harbour	Klein	100 kHz Klein SSS
006	1521128	1521704	1-2	Sambro	Klein	100 kHz Klein SSS
007	1521705	1521902	2	Sambro	Klein	100 kHz Klein SSS
008	1521907	1522054	2	Sambro	Klein	100 kHz Klein SSS
009	1531058	1531431	3	Sambro	Klein	100 kHz Klein SSS
010	1531433	1531910	3-4	Sambro	Klein	100 kHz Klein SSS
011	1541557	1541832	5	Sambro	Klein	100 kHz Klein SSS
001	1491408	1491852	Test Lines	Bedford Basin	EPC1600	100 kHz SSS Altitude
002	1491854	1501702	Test Lines	Bedford Basin	EPC1600	100 kHz SSS Altitude
003	1501705	1502050	Test Lines	Halifax Harbour	EPC1600	100 kHz SSS Altitude
004	1521127	1521353	1	Sambro	EPC1600	100 kHz SSS Altitude
005	1521354	1522010	1-2	Sambro	EPC1600	100 kHz SSS Altitude
006	1522010	1531532	2-3	Sambro	EPC1600	100 kHz SSS Altitude
007	1531534	1531911	3-4	Sambro	EPC1600	100 kHz SSS Altitude
008	1541559	1541832	5	Sambro	EPC1600	100 kHz SSS Altitude

Table 3: Sidescan Tapes 88-018(A) Phase 1

Tape #	Start Day/ Time	Stop Day/ Time	Line #	Geographic Location	Channel Information	Sidescan System
001	1491500	1501408	Test Lines	Bedford Basin	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
002	1501410	1501820	Test Lines	Halifax Harbour	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
003	1501828	1502100	Test Lines	Halifax Harbour	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
004	1521130	1521500	1	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
005	1521503	1521816	1-2	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
006	1521818	1522057	2	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
007	1531114	1531430	3	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
008	1531430	1531750	3-4	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
009	1531755	1541800	4-5	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz
010	1541804	1541850	5	Sambro	Port-FM Stbd.-FM Ref.-DR Speen-DR	Klein 100 kHz

Table 4: Seismic Records 88-018(A) Phase 1

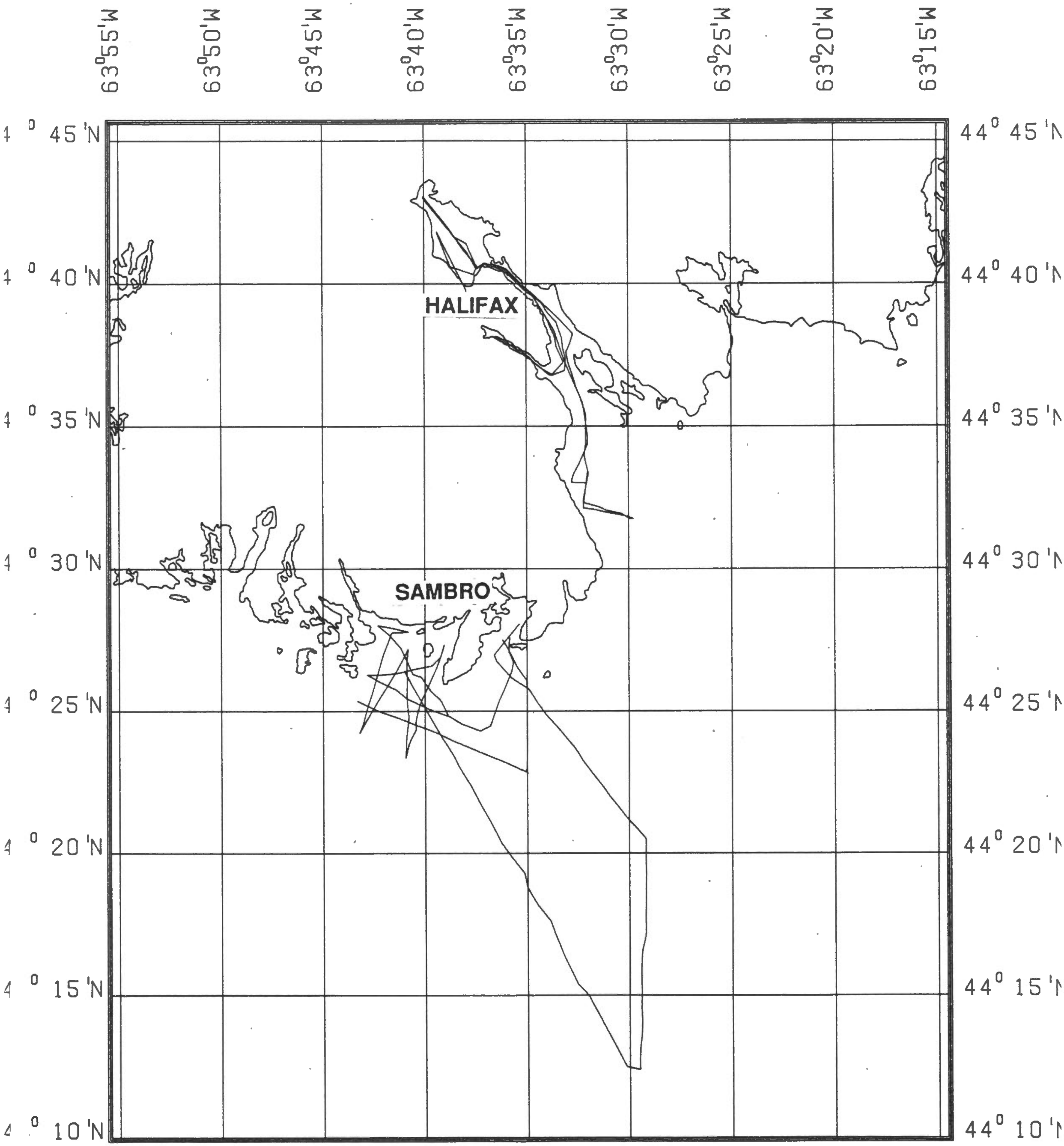
Tape #	Start Day/ Time	Stop Day/ Time	Hydrophone	Line #	Geographic Location	Recorder	System/Sound Source
001	1491530	1491638	External	Test Lines	Bedford Basin	EPC4100	Huntec Sea Lion
002	1491650	1491947	NSRF	Test Lines	Bedford Basin	EPC4100	Various
003	1501232	1502006	NSRF	Test Lines	Halifax Harbour	EPC4100	Various
004	1521138	1521652	NSRF	1-2	Sambro	EPC4100	Bubble Pulser
005	1521659	1531636	NSRF	2-3	Sambro	EPC4100	Geopulse Sparker
006	1531711	1531908	NSRF	4	Sambro	EPC4100	Bubble Pulser
007	1541614	1541832	External	5	Sambro	EPC4100	Huntec Sea Lion

Table 5: Bathymetry Records 88-018(A) Phase 1

Roll #	Start Day/ Time	Stop Day/ Time	Line #	Geographic Location	Frequency	Recorder
001	1491425	1491947	Test Lines	Bedford Basin	30 kHz	Elac
002	1501134	1502050	Test Lines	Halifax Harbour	30 kHz	Elac
003	1521120	1521915	1-2	Sambro	30 kHz	Elac
004	1521920	1531750	2-3	Sambro	30 kHz	Elac
005	1531536	1541830	3-4-5	Sambro	30 kHz	Elac

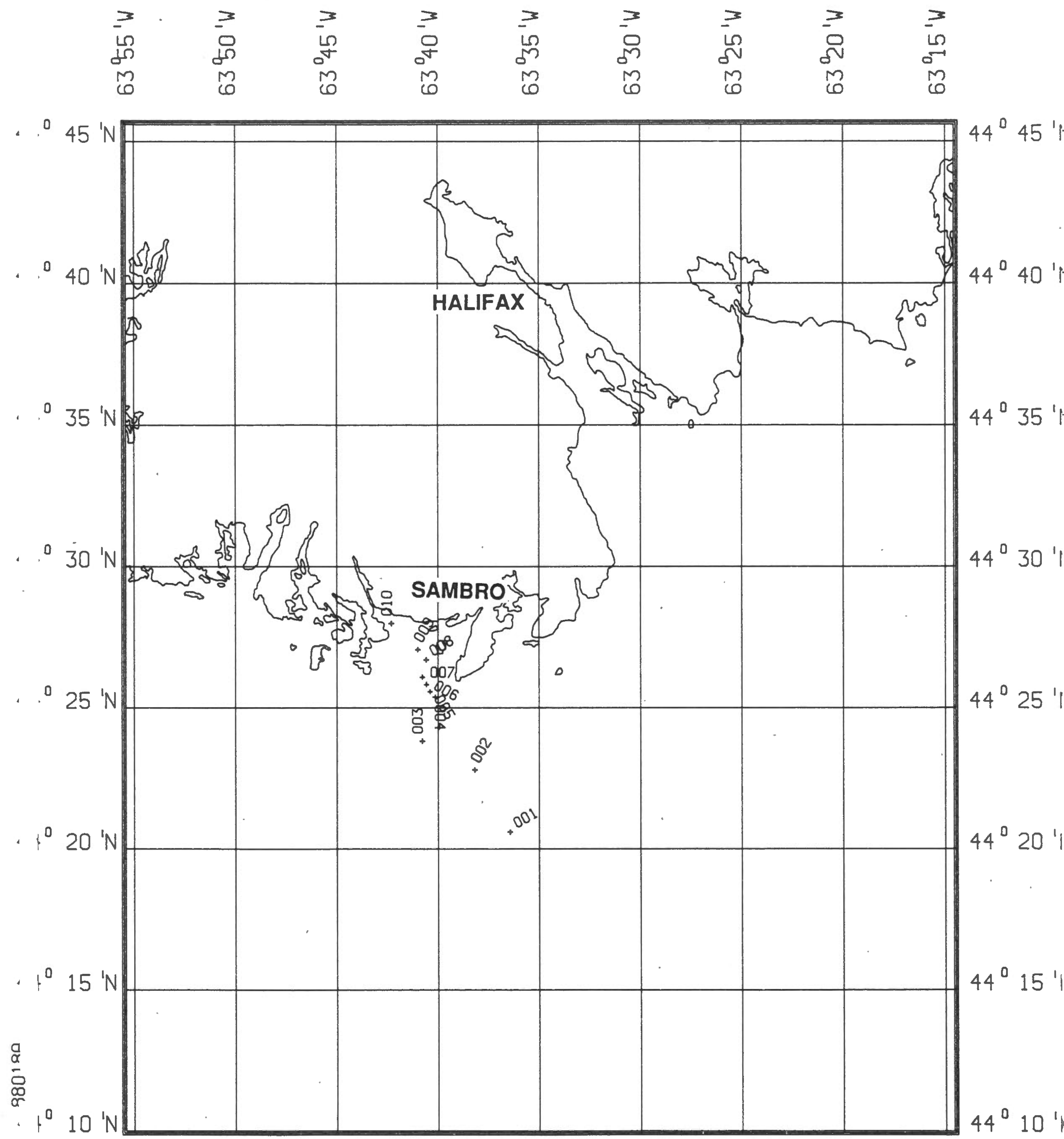
Table 6: Magnetics Records 88-018(A) Phase 1

Roll #	Start Day/ Time	Stop Day/ Time	Line #	Geographic Location	Recorder
001	1501805	1501830	Test Lines	Halifax Harbour	HP7155
002	1521140	1541820	1-2-3-4-5	Sambro	HP7155



63°55'W
63°50'W
63°45'W
63°40'W
63°35'W
63°30'W
63°25'W
63°20'W
63°15'W
44° 45'N
44° 40'N
44° 35'N
44° 30'N
44° 25'N
44° 20'N
44° 15'N
44° 10'N
HALIFAX
SAMBRO

FIGURE 1



63°55'W
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63°15'W
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44° 45'
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FIGURE 2

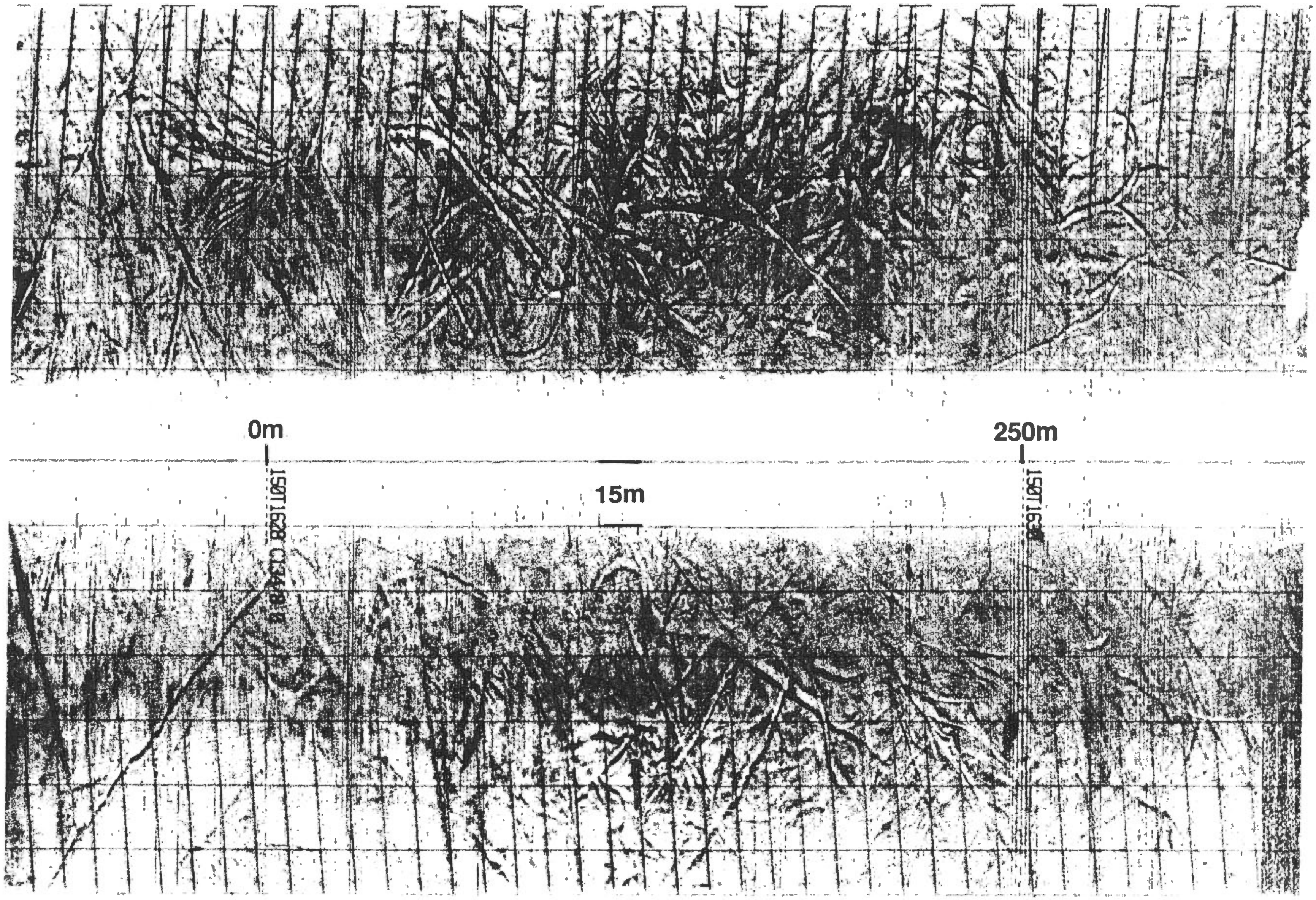

FIG 3) 100KHZ SIDESCAN SONOGRAM FROM BEDFORD BASIN. THE HOLOCENE MUDDY SEABED IS CRISS-CROSSED WITH LINEAR-CURVILINEAR DEPRESSIONS INTERPRETED AS ANCHOR DRAG MARKS. THE DENSE PATTERN SUGGESTS THAT THE MAJORITY OF THE FEATURES MAY HAVE RESULTED FROM THE MILITARY CONVOYS ANCHORED IN THE BASIN DURING THE SECOND WORLD WAR.

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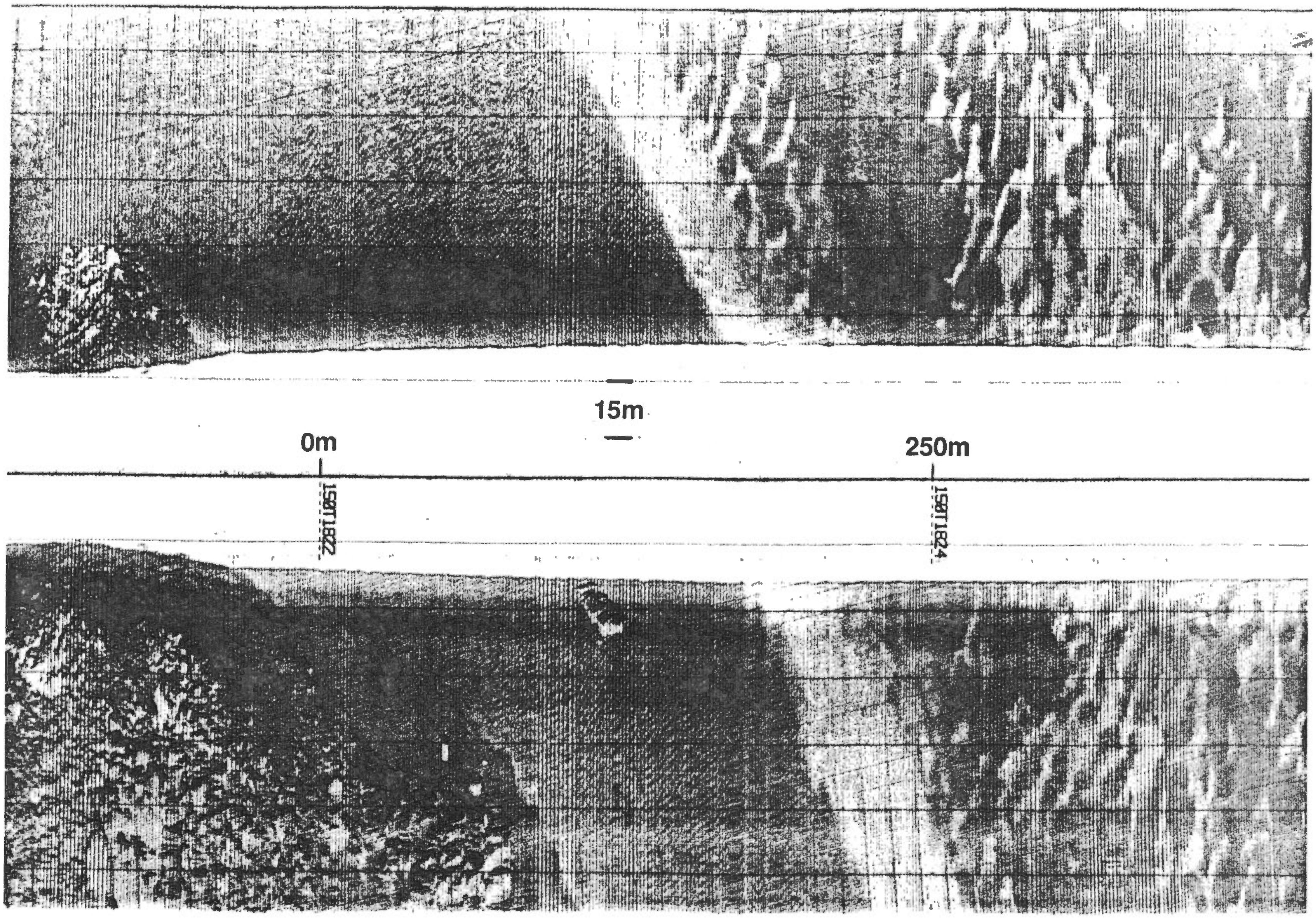

FIG 4) SIDESCAN SONOGRAM FROM THE OUTER HALIFAX HARBOUR SHOWING A SEABED OF BEDROCK WITH BOULDERS, GRAVEL RIPPLES AND MEGARIPPLES. THE GRAVEL RIPPLES MAY BE A SOURCE OF AGGREGATE AT THE SEABED.

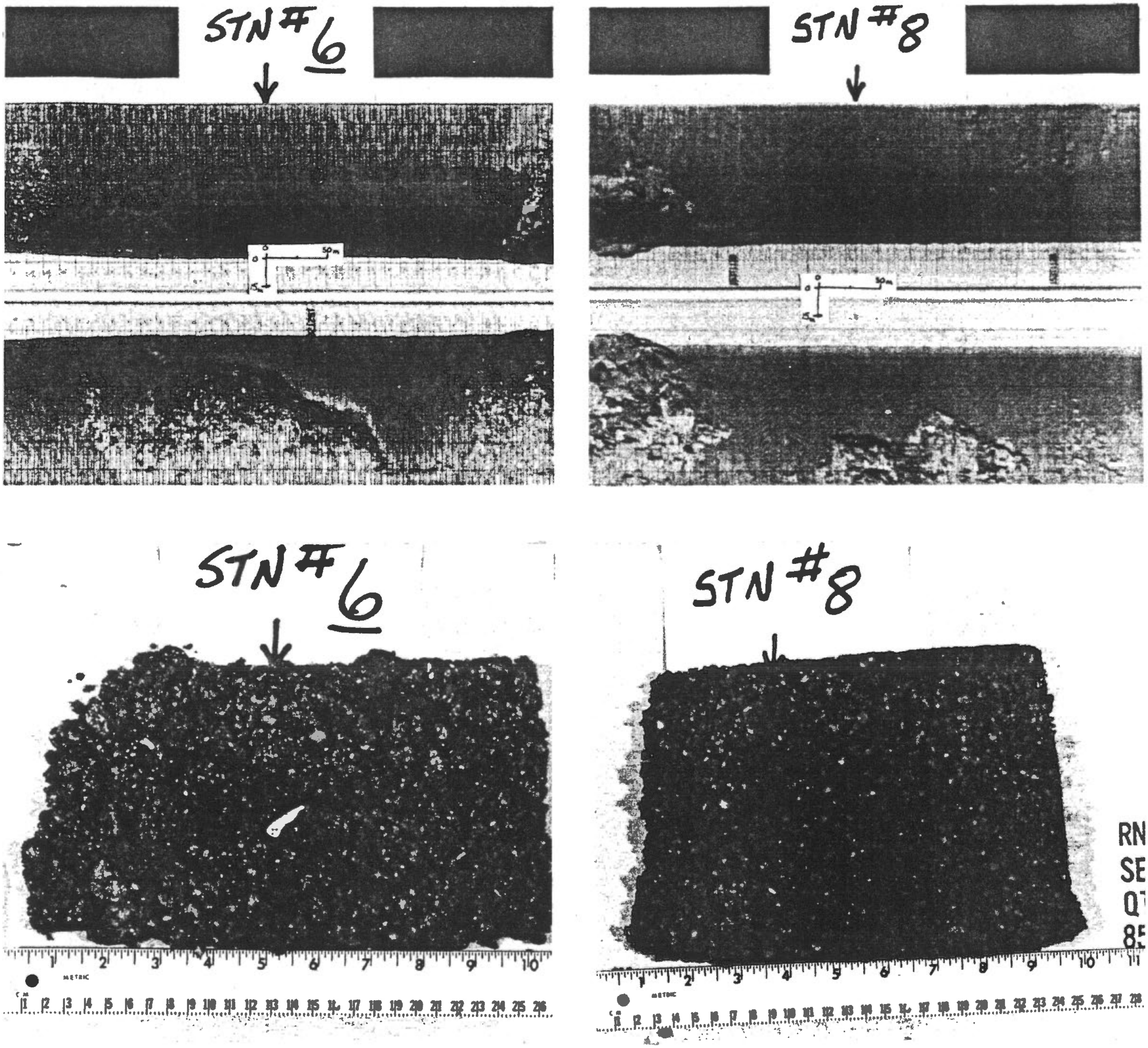

FIG 5) SIDESCAN SONOGRAMS AND PHOTOGRAPHS OF GRAB SAMPLES COLLECTED AT STATIONS 6 AND 8 OFF SAMBRO. THE BEDROCK IS DEVONIAN GRANITE AND THIS IS REFLECTED IN THE LITHOLOGY OF THE GRAVEL IN THE SAMPLES WHICH CONSISTED OF GRANULE-PEBBLE SIZED CLASTS. THIS IS A POTENTIAL SOURCE OF OFFSHORE AGGREGATE AS THE GRAVEL RIPPLES OCCUR OVER LARGE AREAS OF THE SEABED.