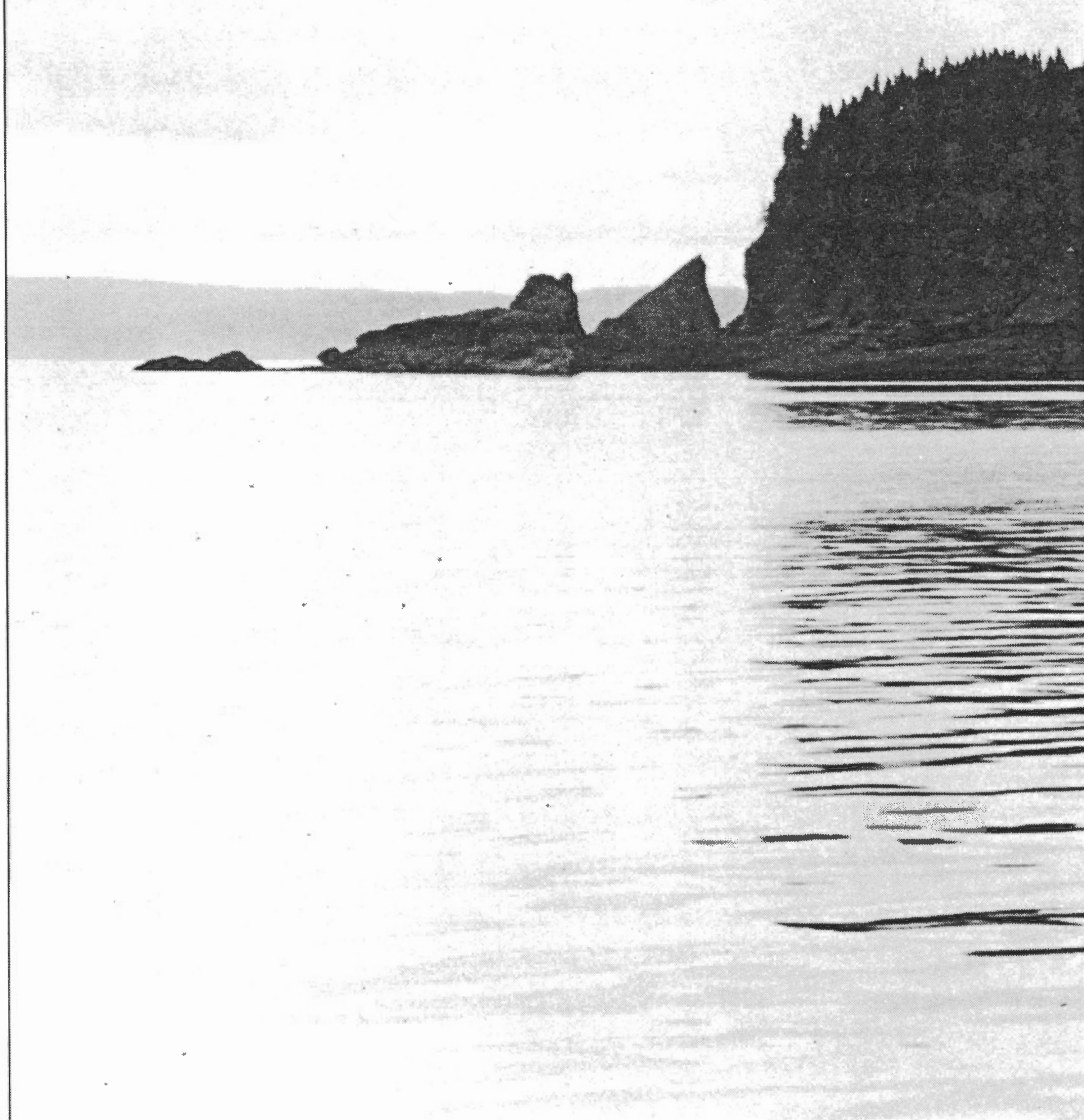
CRUISE REPORT 89-009
PHASE C - SAND WAVE FIELD-SCOTS BAY
F.R.V. NAVICULA



Robert O. Miller, Gordon B.J. Fader

Atlantic Geoscience Centre - Geological Survey Of Canada
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth, N.S., B2Y 4A2

Cruise Summary Sheet

Cruise No.:	89-009 (Phase C - Scots Bay)
Vessel:	F.R.V. Navicula
Cruise Dates:	June 22 - June 25, 1989
Responsible Agency:	Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, N.S., B2Y 4A2
Area:	Scots Bay, Nova Scotia
Ship's Master:	Captain Joe Bray
Senior Scientist:	Robert O. Miller
Scientific Personnel:	Anthony S. Atkinson - Technician, AGC
	Darrell Beaver - Technician, AGC
	Ami Häkkinen - Scientist, Geological Survey of Finland

*Cover: View, to the north, of Cape Split from approximate area of sand wave field in Scots Bay, Bay of Fundy.

NAVICULA CRUISE
89-009 (Phase C - Scots Bay)

ITINERARY

DATE (1989)	TIME (GMT)	OPERATION
June 22 Day 173		Navicula steams to Digby for rendezvous with scientific field party. Field party establishes contact with Navicula and proceeds to Halls Harbour to arrange for fisherman to ferry field party from Halls Harbour to Navicula.
June 23 Day 174	0900	Navicula departs Digby en route to Halls Harbour.
	1700	Scientific field party is ferried from Halls Harbour aboard the Rhonda Ann captained by local fisherman Harold Mosher.
	1750	Deploy geophysical equipment in Scots Bay to survey area of sand waves.
	2000	Recover equipment.
	2030	Rendezvous with Rhonda Ann for transportion of scientific field party to Halls Harbour. Navicula proceeds to anchor inside Spencers Island north of Cape Spencer.
	2100	Scientific field party arrives at Halls Harbour.
June 24 Day 175	0845	Scientific field party is ferried aboard the Rhonda Ann from Halls Harbour to Navicula.
	0920	Field party boards Navicula.
	0955	Deploy geophysical equipment in Scots Bay.
	2013	Recover equipment.
	2030	Rendezvous with Rhonda Ann.
	2100	Scientific field party arrives at Halls Harbour.
June 25 Day 176	0920	Scientific field party is ferried aboard the Rhonda Ann from Halls Harbour to Navicula.
	0940	Field party boards Navicula.
	1013	Deploy geophysical equipment in Scots Bay.
	1353	End geophysical survey in Scots Bay, recover equipment and proceed to sample with medium van Veen during slack tide.
	1915	Sampling completed, head for rendezvous with Rhonda Ann.
	2015	Rendezvous with Rhonda Ann.
	2030	Scientific field party arrives at Halls Harbour, and begins drive back to Halifax.

Introduction

This cruise was an extension of Navicula cruise 89-009 (A). During this cruise an area of Scots Bay, Bay of Fundy, Nova Scotia (Fig. 1), known to have an extensive field of sand waves (Swift *et al.*, 1966), was surveyed using a new high-resolution seismic reflection system and a sidescan sonar. The purpose of the study was to determine: 1) the extent, location and volume of the sand wave field; 2) the changes in bedform distribution and sediment transport which may have occurred since the 1966 survey of Swift *et al.*; 3) the quality of sand for possible use in the aggregate industry; 4) the Quaternary geological history of the sand bodies through the collection of geological and geophysical data in support of a nearshore, regional, geological mapping program; and 5) the nature of seafloor biological habitat.

The cruise extended from June 22 to June 25, 1989. The main activity was the collection of 100 kHz Klein sidescan sonograms set at 100 m range, while simultaneously collecting subsurface geological data using a Datasonics Bubble Pulser, an I.K.B. Seistec-boomer system and an Elac 30 kHz echosounder. The sidescan sonar data were interpreted to identify and map surface attributes of the study area. Data collected with the Datasonics Bubble Pulser were used to delineate the subseabed bedrock surface. These data, together with high-resolution seismic reflection profiles collected with the I.K.B. Seistec-boomer system were used to define the subsurface Quaternary stratigraphy.

A medium sized van Veen grab sampler was used to collect seabed samples in order to ground truth the acoustic data. The location of these samples is shown in Figure 2. A bulk sample from the sand wave field was consolidated by repeated grab sampling. This bulk sample will be processed later to assess the aggregate potential of the sand bodies. Navigation was provided by Loran C using the 5930 chain. Survey transects were run north and south, along Loran C lines, for ease in navigation. Time differences (T.D.'s) were plotted and then compared to computed Loran C latitudes and longitudes. This offset was then applied to all computed fixes.

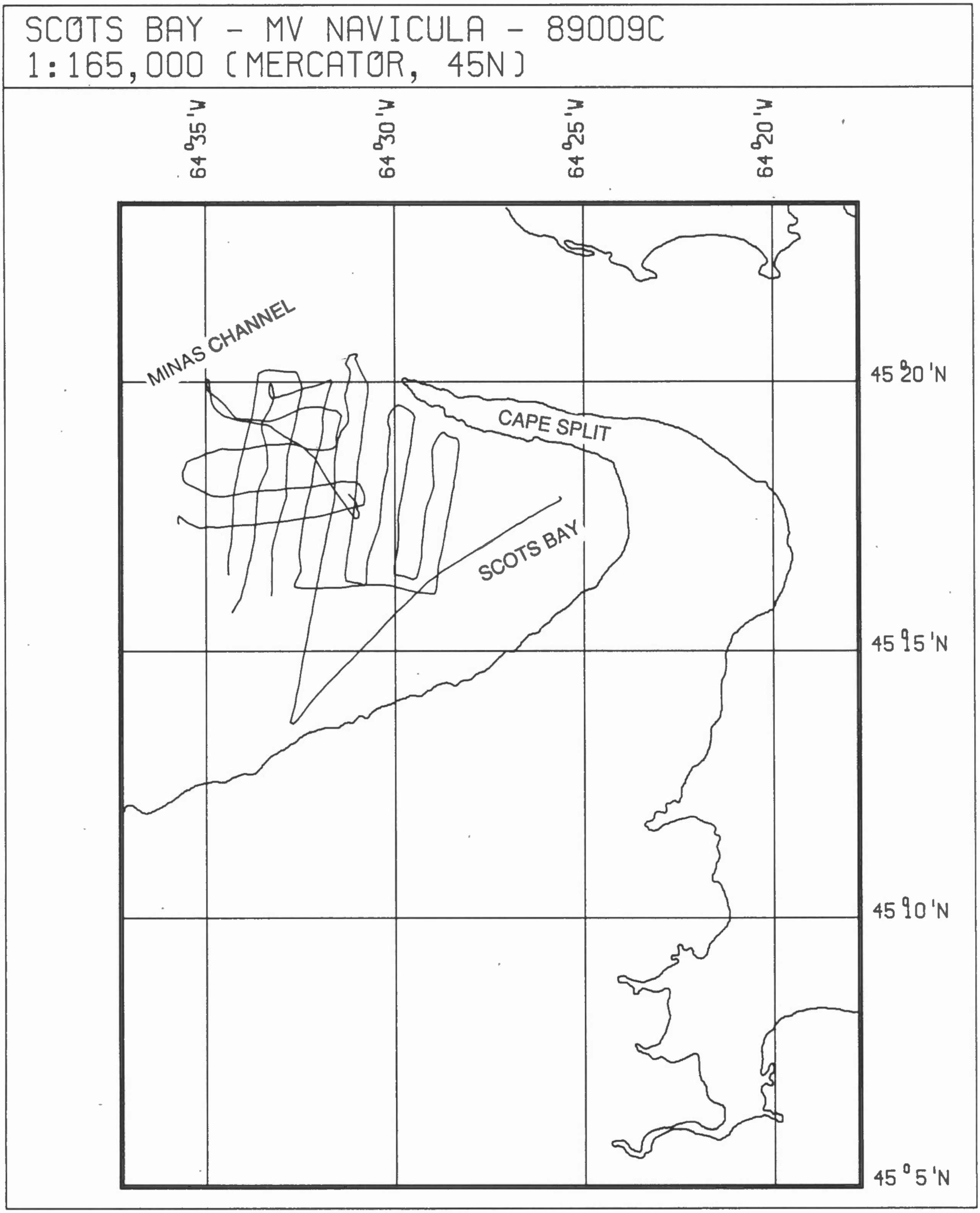


Figure 1. Index map with cruise tracks from Scots Bay.

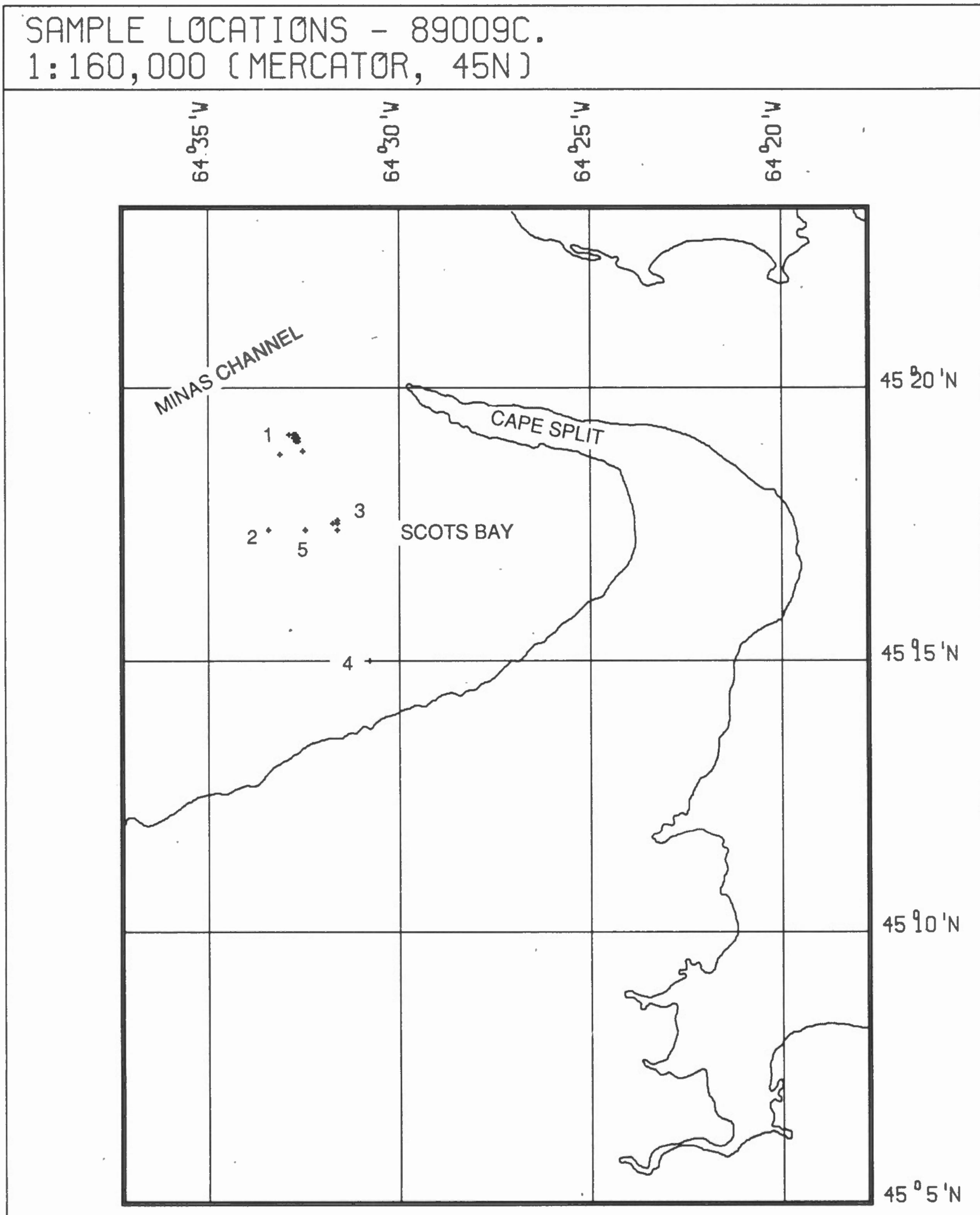


Figure 2. Index map of sample station locations in Scots Bay. Multiple samples were collected at some stations.

Equipment Description and Performance

Sidescan Sonar System

The sidescan sonar deployed during the cruise was a Klein 100 kHz, model 421T, with a "K" wing and a remote controlled Markey hydraulic winch. Sidescan signals were logged on seven inch reels of magnetic analog recording tape at a speed of three and three quarters inches per second. The eighteen hundred foot reels of Ampex type 641 tape provided one and a half hours of recording time per reel. The four channels of the Racal Store 4D tape recorder were used in the following manner: Channel one - FM port sidescan signal, Channel two - FM starboard sidescan signal, Channel three - DR sidescan reference signal, and Channel four - DR Seistec signal and voice fixes. Seismic reflection data collection was synchronized to the sidescan system providing an opportunity to record the Seistec signal on channel four and recover synchronization during playback. A sidescan recorder is necessary for playback of this signal on a digital EPC recorder because it recovers the synchronizing signal for triggering the T.V.G. and graphic recorder from the tape. Voice fixes were kept to a minimum so as not to interrupt the recording process on channel four. Record annotator signals were recorded along with the sidescan signals on channel two. The sidescan was set at a one hundred metre range and sixty lines per inch paper speed. This provided a resolution of approximately 0.5 m across track. Attempts to tow the sidescan fish at a constant height above the seabed were hampered by strong tidal currents which reached 10 knots. The data are generally of high quality.

Datasonics "Bubble Pulser"

A Datasonics "Bubble Pulser" 500 Hz sound source and hydrophone streamer were used to define subsurface stratigraphy and delineate the bedrock surface. Its output was displayed on an EPC 1600 graphic recorder using a paper rate of 150 lines per inch and a sweep speed of 100 milliseconds with a firing rate of 400 milliseconds. The seismic profiles from this system have a resolution of approximately 3-5 m.

IKB Seistec Line in Cone Array - Boomer seismic reflection system

High-resolution seismic reflection data were gathered using an ORE Geopulse power supply, firing a Huntec Model 4425 boomer at 105 Joules, an ORE 5210 A seismic receiver and an IKB Seistec surface towed, line-in-cone array. The Seistec data were displayed on an EPC 1600 graphic recorder using a 60 millisecond sweep speed and a paper rate of 150 lines per inch, with a firing rate of 400 milliseconds. Water column time delays were included as required and noted on the graphic records. The vertical resolution of this system was approximately 0.5 m.

Few equipment problems were experienced. A trigger pulse was sourced from the sidescan recorder and was used to control the Seistec and Datasonics systems. Synchronizing the systems removed a boomer transient pulse from the sidescan records. Using 100 metre range on the Klein sidescan, a trigger pulse was produced every 130 milliseconds. It was necessary to divide this time by three to produce a seismic trigger every 400 milliseconds. Since the low cut frequency of the Seistec was 100 Hz and the Bubble Pulser system had a centre frequency of 500 Hz, there was little overlapping between the two systems and they could be triggered simultaneously.

Discussion and Comments

Sonogram Interpretation

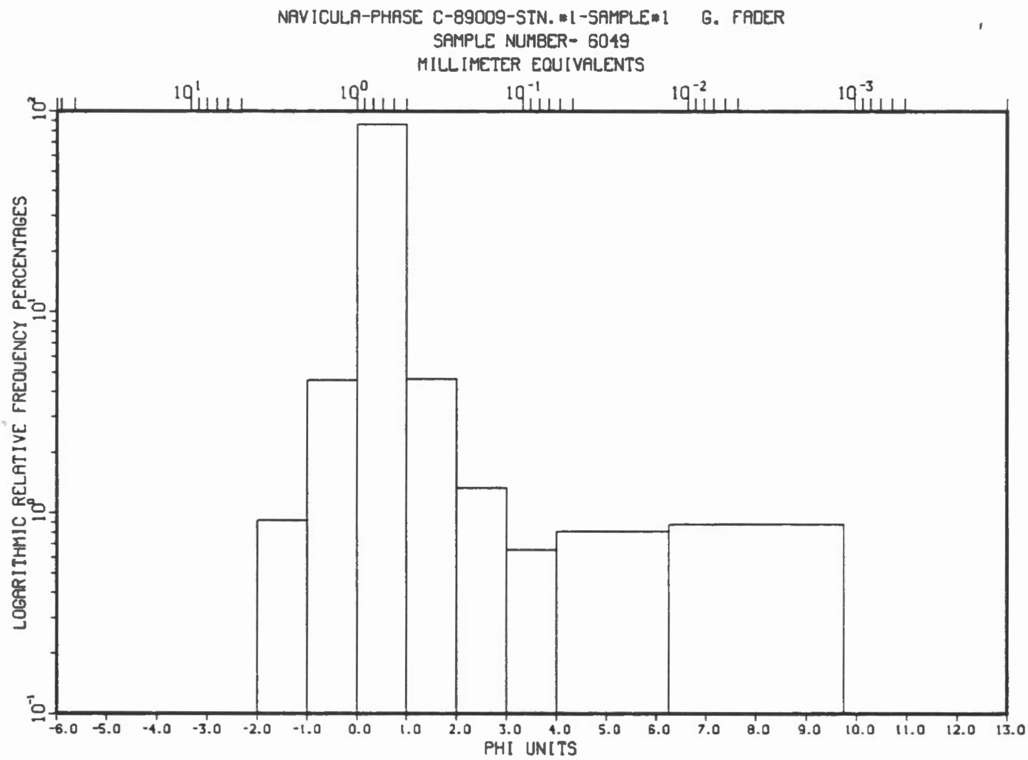
The original intent of the survey was to collect sufficient sidescan sonar data to mosaic the Scots Bay sand wave field, but due to time constraints and the size of the area, the survey was designed to map the extent of the sand wave field so that 100% sidescan sonar coverage was not achieved. Classification of all bedforms in this study is after Amos and King (1984). The sand wave field occurs at the mouth of Scots Bay, southwest of Cape Split in water depths ranging from 22 to 37 m. At the base of the sand wave field is a hard lag surface which consists of a muddy, sandy gravel which crops out to the east and south of the sand wave field. An abrupt drop-off in bathymetry is found to the west and north toward the deep water of Minas Channel where bedrock outcrops. It appears that some spill-over of the sand occurs toward the deep channel . Van Veen grab samples collected from the sand wave field revealed that the sediment is composed of well-sorted, coarse sand with minor amounts of granules and traces of silt (Fig. 3).

The sand wave field is a complex set of large sand waves with wave lengths ranging from 50 m to over 150 m (Fig. 4). The sand waves are sharp-crested with megaripples on their flanks (Fig. 5). The megaripples appear to have wavelengths which range from 1 m to 3 m. In general the sand waves increase in height from 1 m in the south to their maximum of 15 m in the north where the sand waves coalesce.

The smaller sand waves often bottom out on a hard, lag surface. This surface appears to be void of any features on sidescan imagery (Fig. 4).

To the south of the sand wave field, sidescan sonograms reveal a seafloor which is highly reflective with little relief. A grab sample collected in this zone yielded a poorly sorted, sandy gravel with a trace amount of silt (Fig. 6). Sand ribbons are numerous and parallel to the direction of strong current flow. The sand ribbons are linear features which show little relief. Their widths range up to approximately 50 m and can be followed for over 0.5 km in length. Comet marks (obstacle induced current scour features) are also numerous and indicate that the bottom currents move from the southwest to the northeast similar to the directions indicated by the sand ribbons (Fig. 7). This zone is also characterized by the intermittent presence of isolated sand waves with heights of 1-2 m and a small boulder population (Fig. 8). A grab sample collected (from a sand patch) in this zone yielded a moderately sorted sand with a trace amount of silt and minor gravel component (Fig. 9).

Directly adjacent to, and extending farther south of the sand wave field, is a broad patch of sand with a few sand waves , the highest is 3.5 m and exhibits superimposed megaripples. Sand ribbons are numerous, and cuspate, 2-dimensional megaripples superimposed on the sand ribbons, confirm that



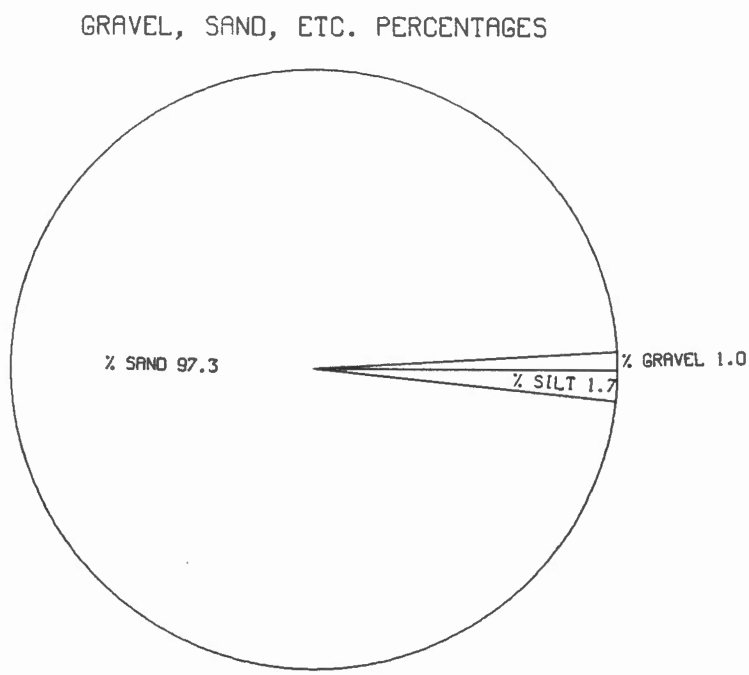


Figure 3. Histogram of particle size distribution and pie diagram of textural components from van Veen grab sample collected at Station 1 in the Scots Bay sand wave field. The sediment consists of a well-sorted coarse-grained sand with minor silt and gravel.

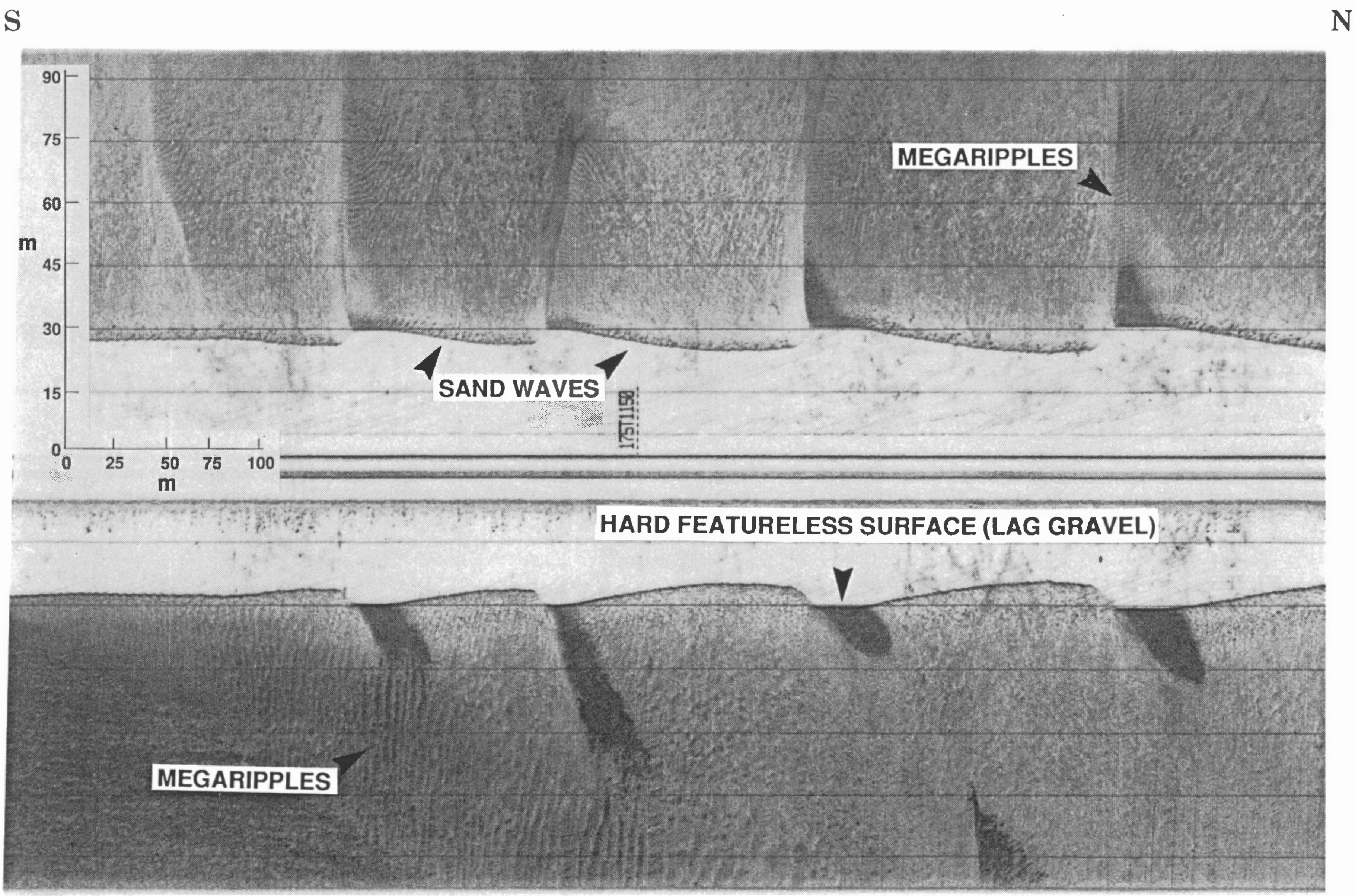


Figure 4. Sidescan sonogram from the Scots Bay sand wave field. Note the presence of megaripples on the flanks of the sand waves. The sand waves are often not fully developed with a flat, featureless trough of probable gravel.

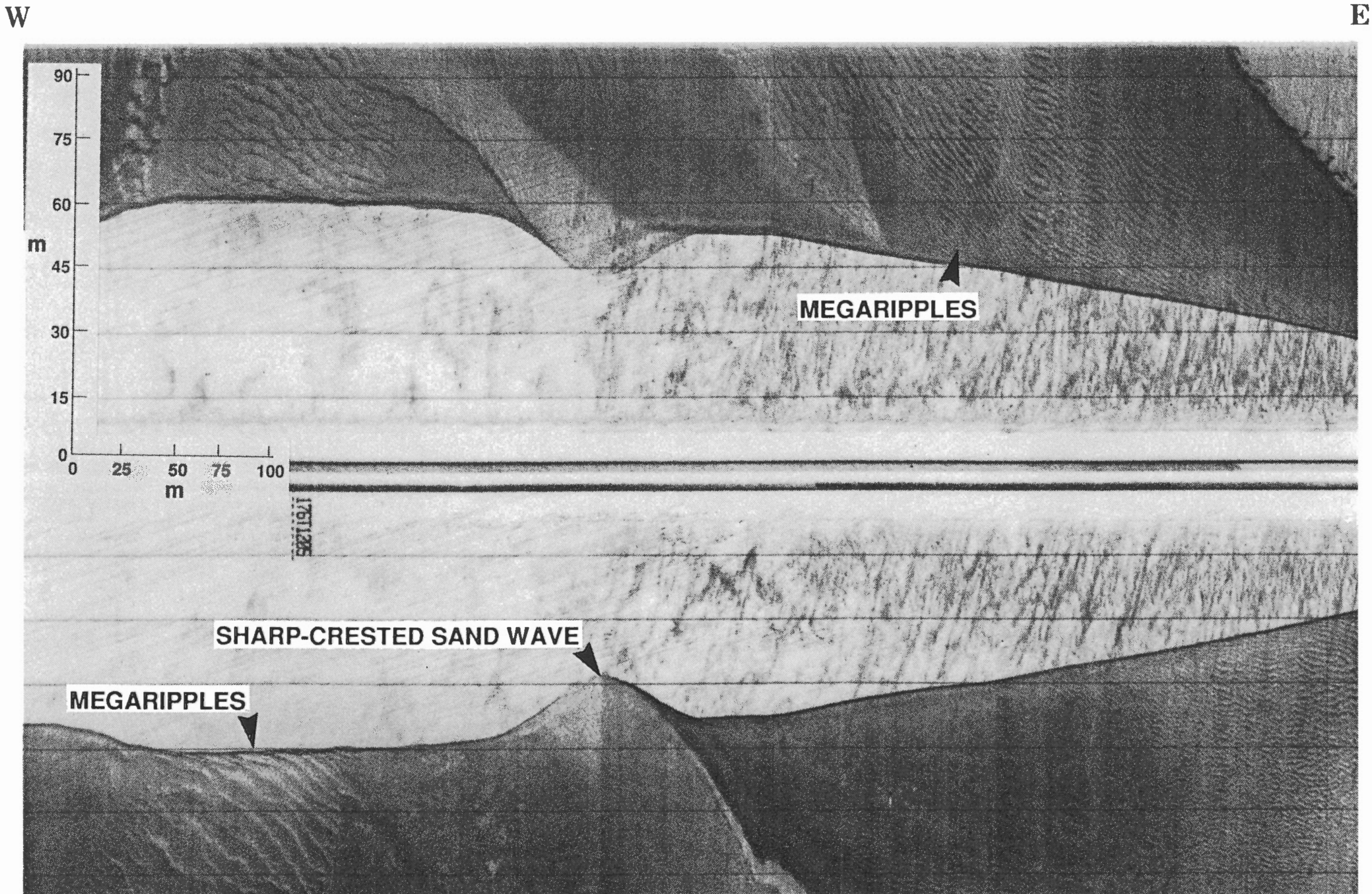
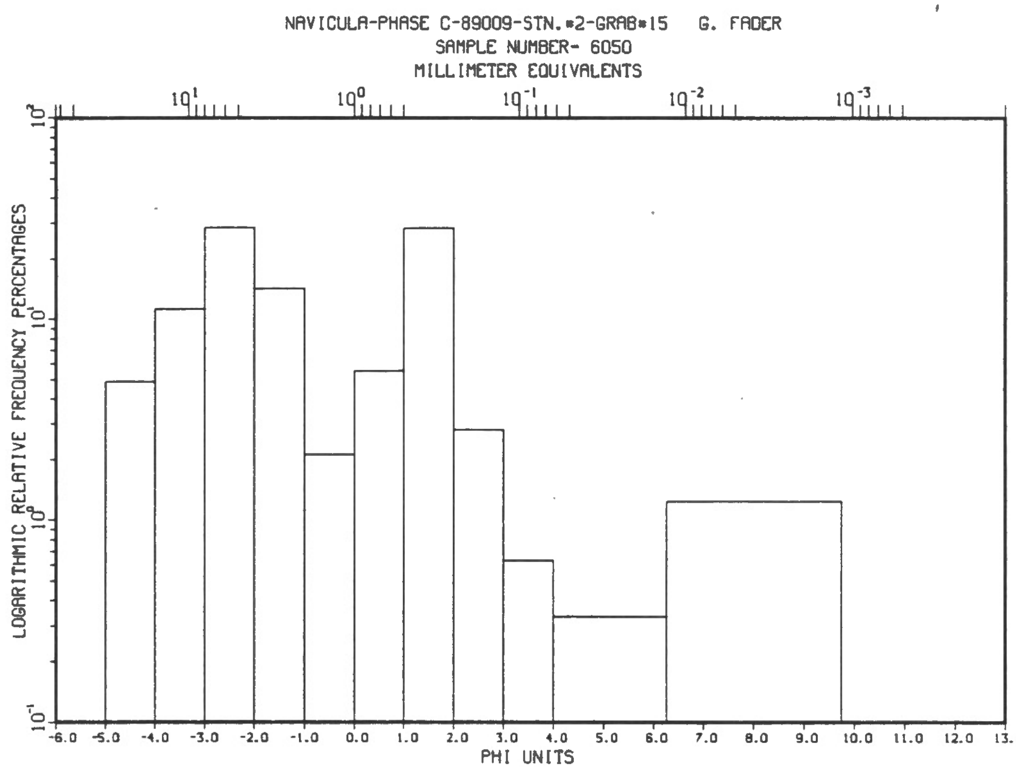


Figure 5. Sidescan sonogram from the Scots Bay sand wave field. Note the sharp- crested sand wave at centre of the sonogram and the presence of megaripples on both flanks. This sand wave is approximately 10 m in height.



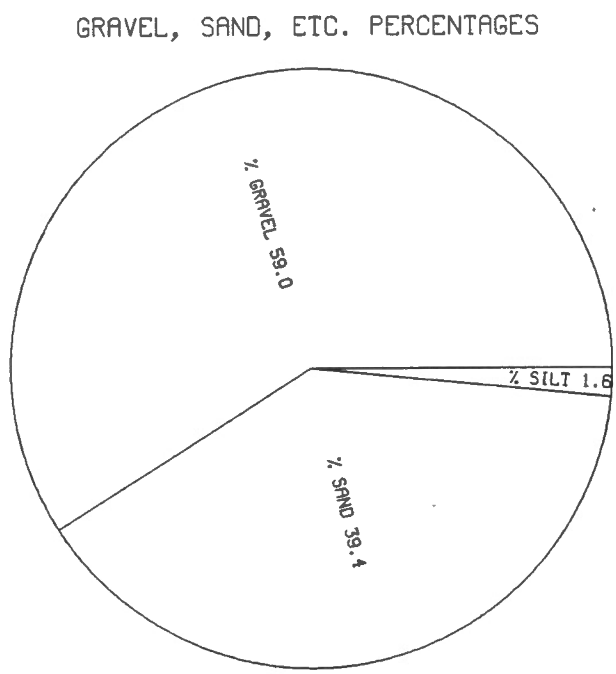


Figure 6. Histogram of particle size distribution and pie diagram of textural components from van Veen grab sample collected at Station 2 south of the Scots Bay sand wave field on a lag gravel surface. It is a poorly-sorted sandy gravel with minor amounts of silt.

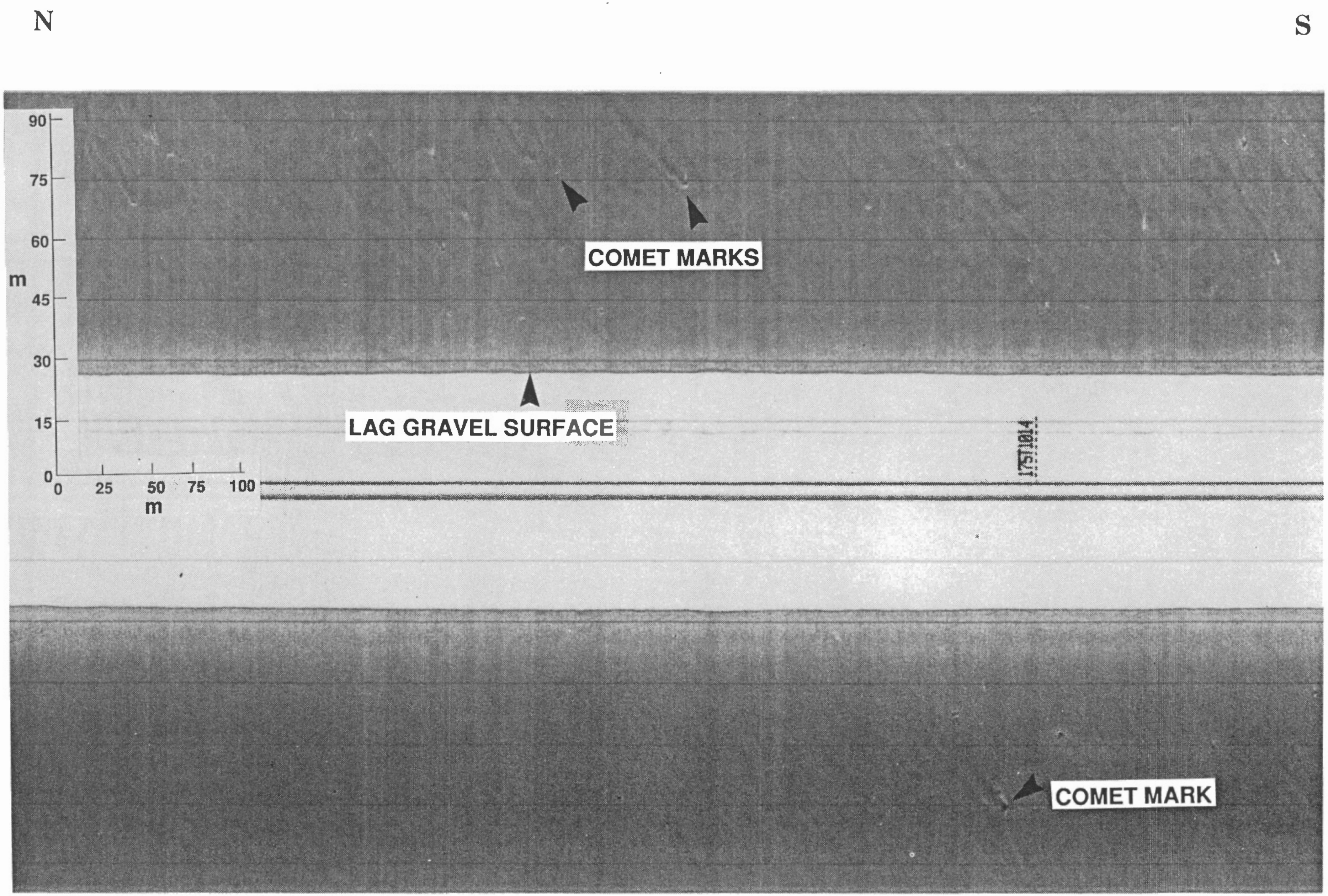


Figure 7. Sidescan sonogram collected over the lag gravel surface south of the Scots Bay sand wave field. Note the comet marks (obstacle induced current scour features) particularly well-developed on the upper sonogram.

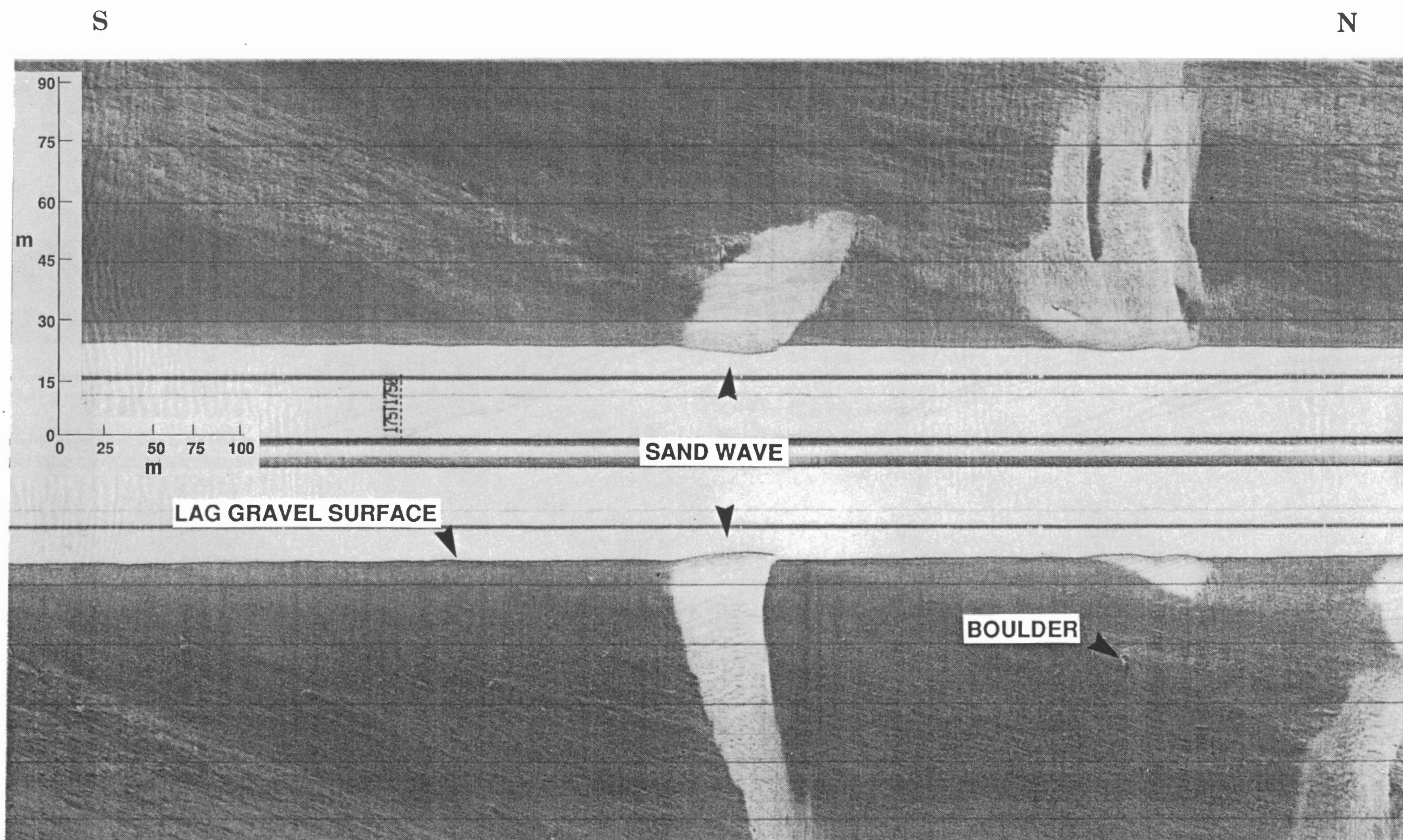
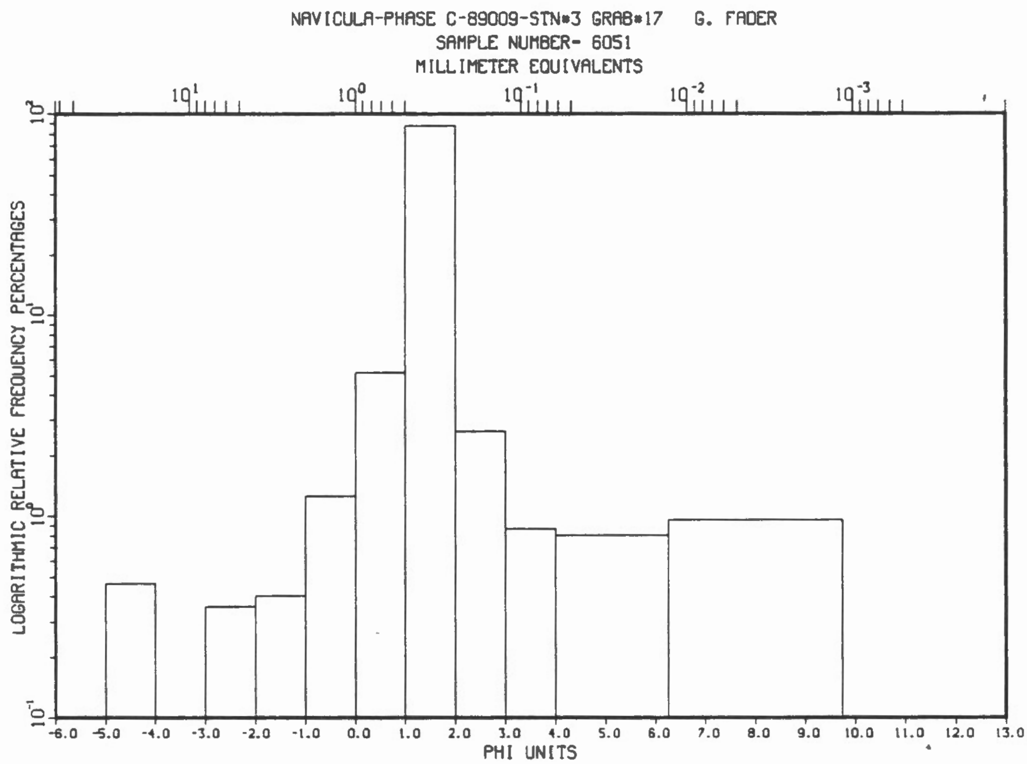


Figure 8. Sidescan sonogram collected over the lag gravel surface south of the Scots Bay sand wave field. Note the isolated sand waves and a few boulders. The flat gravel surface has a lineated appearance arising from the presence of thin stringers of sand (starved sand ribbon). Note that the sand waves are flow-transverse bedforms and the sand ribbons are flow-parallel features.



GRAVEL, SAND, ETC. PERCENTAGES

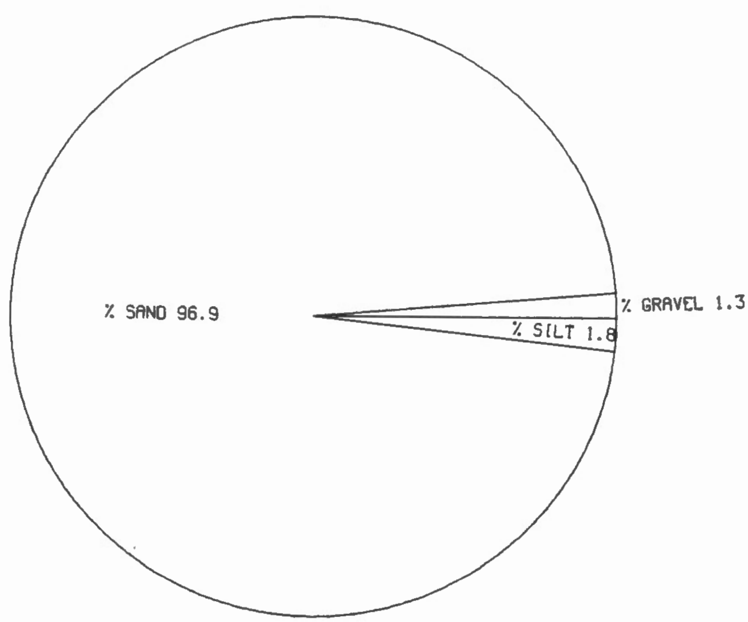


Figure 9. Histogram of particle size distribution and pie diagram of textural components from van Veen grab sample collected at Station 3 south of the Scots Bay sand wave field in a sand patch. Here the sediment is a moderately-well sorted sand with minor silt and gravel.

the sand ribbons have been formed by bottom currents moving from the southwest to the northeast (Fig. 10). This pattern of sediment transport agrees with the regional current pattern in which outgoing tides that move from the northeast would have less of an effect on this local area. The promontory of Cape Split would tend to direct outgoing tidal currents away from this area of sand waves. A small boulder population has also been mapped within this broad patch of sand.

The eastern half of the map-area consists of a highly reflective surface on the sidescan sonograms. It is interspersed with boulders, starved and/or eroded megaripples, sand ribbons and comet marks. The sand ribbons and comet marks indicate that the currents which impinge on the seafloor move through Scots Bay in a counter-clockwise fashion. Trawl marks on the seafloor reveal that the eastern extremity of the map area is extensively fished (Fig. 11). Several generations of trawl marks have been noted on the sidescan sonograms. Recent trawl marks appear as white parallel lines while older generations appear dark and subdued. This, presumably would result from sediment infilling of the trawl marks. Bedrock outcrops in a small area to the south of Cape Split. Lineations of unknown origin have also been mapped and their orientation parallels the local current direction. These lineations may be the result of current scour eroding through the lag gravel surface. A paleoshoreline, occurring as a ridge of coarse material, has been mapped near the eastern limit of the map area. Within this area is a zone of highly reflective non-linear acoustic returns (Fig. 11). The origin is uncertain but may represent biological features such as kelp beds or localized shell deposits on the seabed. A grab sample collected here yielded a very poorly sorted sandy gravel (Fig. 12).

A map of the interpretation of the sidescan sonar imagery is included in Enclosure 1.

Seismic Reflection Data

Interpretation of the seismic reflection data reveals that the sand wave field rests unconformably on an acoustically hard, lag surface. The highest sand wave in the field is approximately 15 m in amplitude, and they range down to approximately 1 m (Enclosure 2). If measured from the base of the

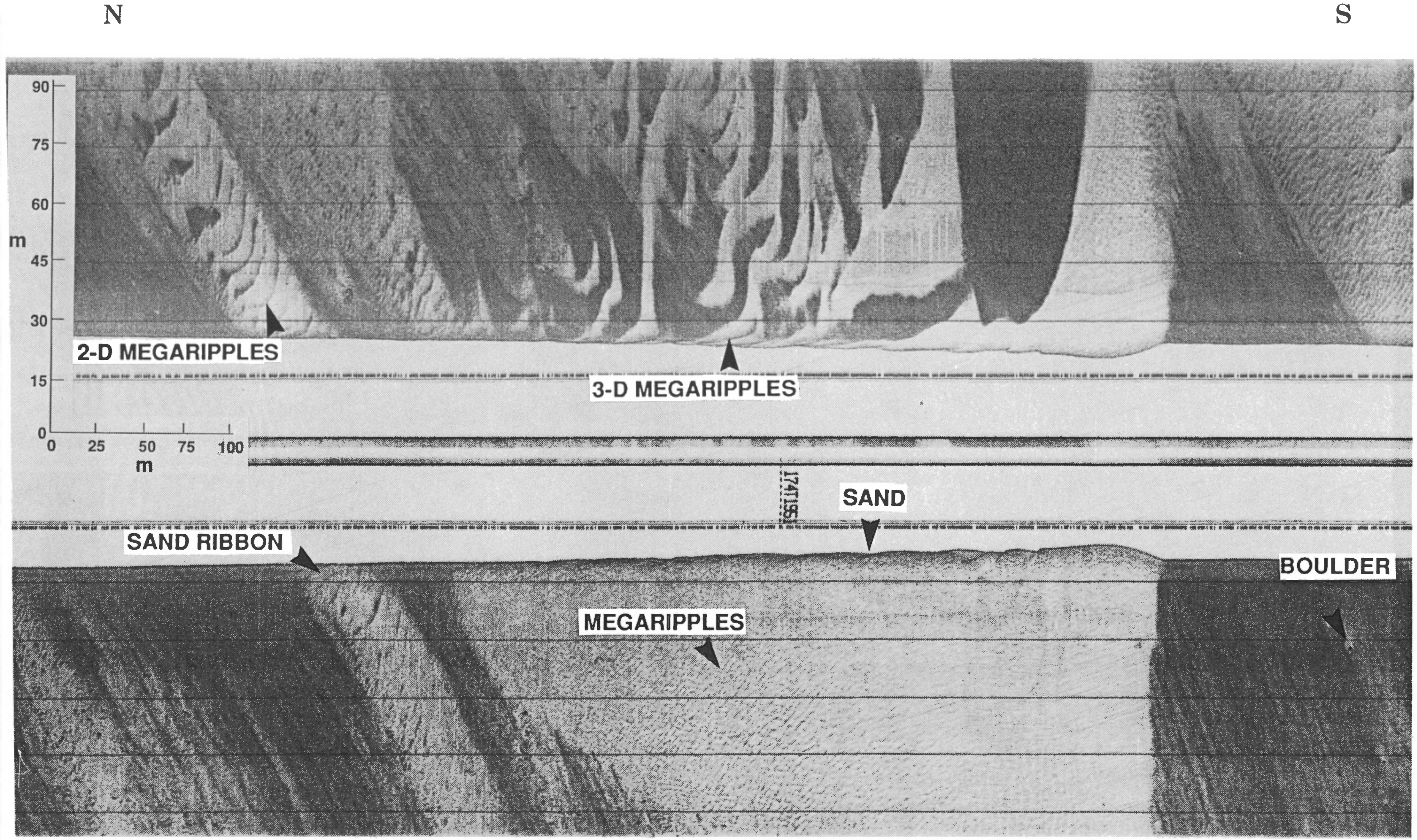


Figure 10. Sidescan sonogram collected from the area south of the Scots Bay sand wave field. Sand ribbons at left, with cuspate 2-D megaripples clearly indicate current direction from southwest to northeast. Also, note 3-D megaripples, sand wave and boulders.

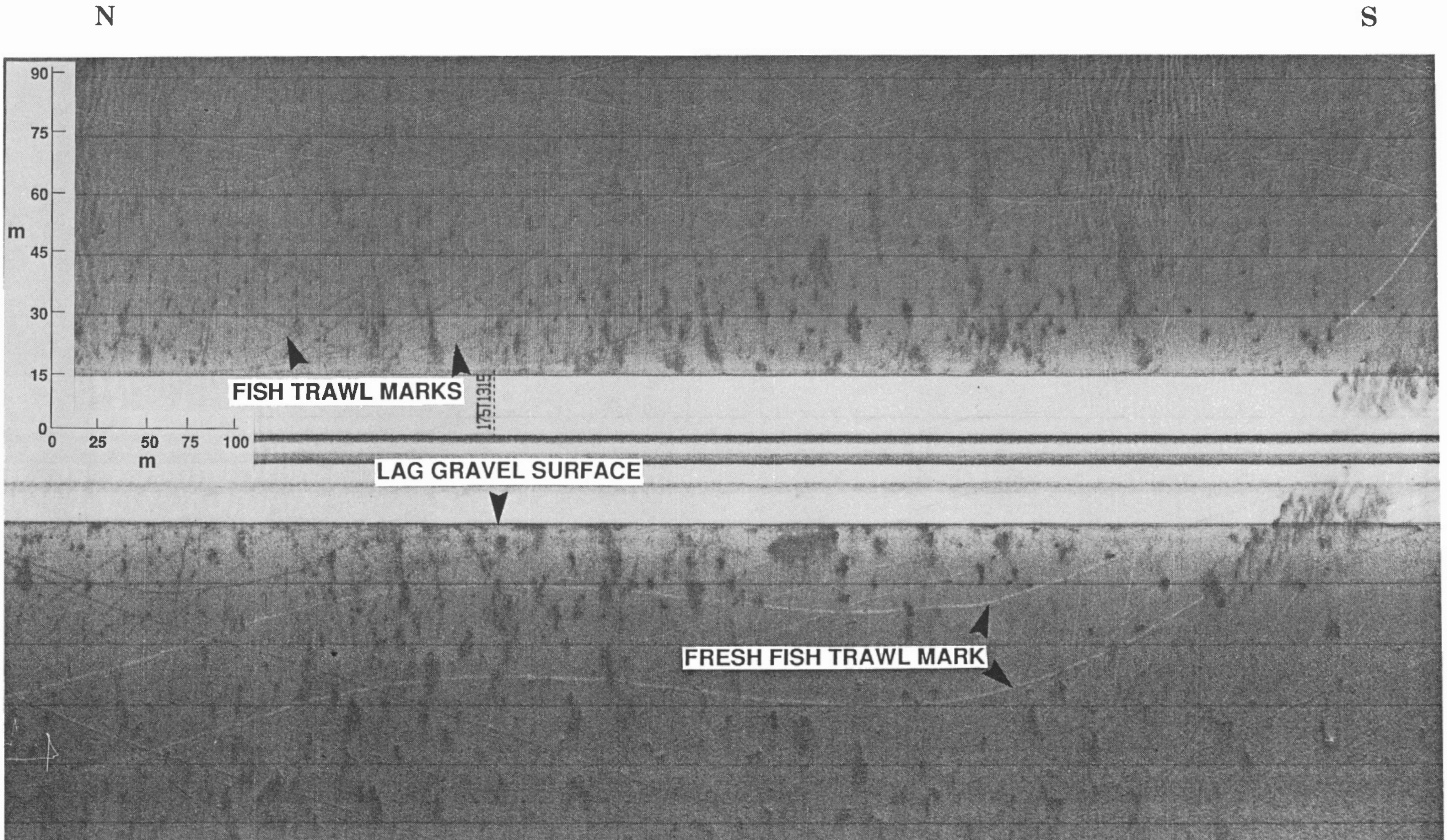
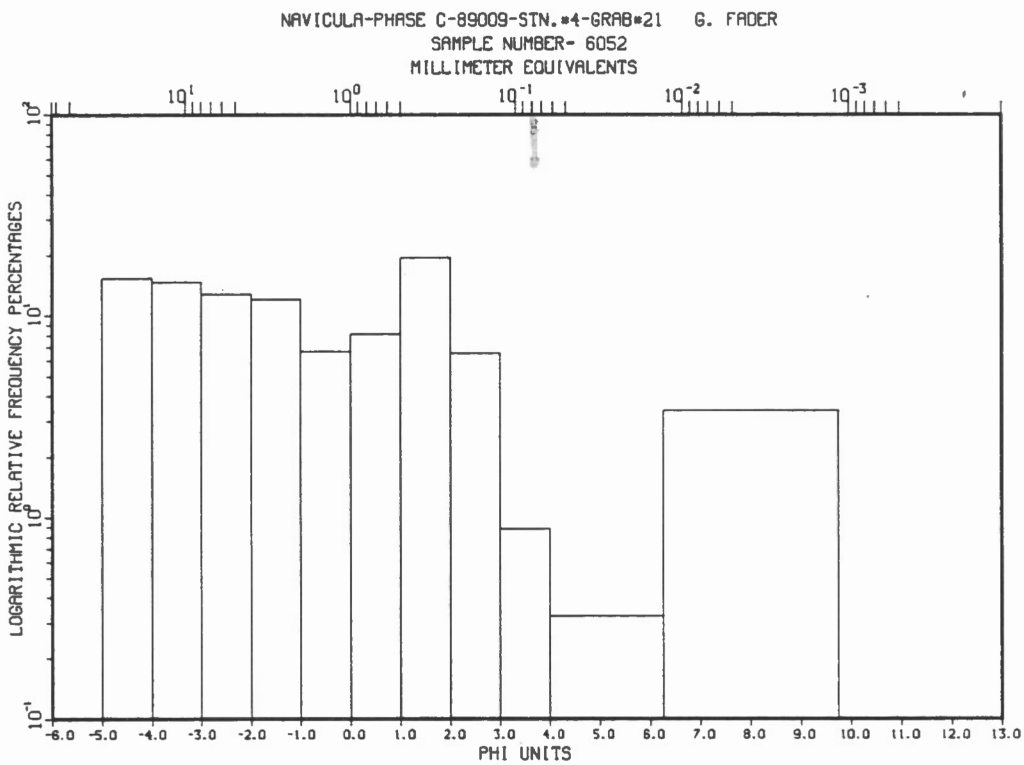


Figure 11. Sidescan sonogram collected in zone to the east of the Scots Bay sand wave field. The seafloor in this zone comprises a muddy lag gravel with several highly reflective, non-linear acoustic returns. These may represent biological communities. Note trawl marks of several generations including a fresh one which was made just prior to survey.



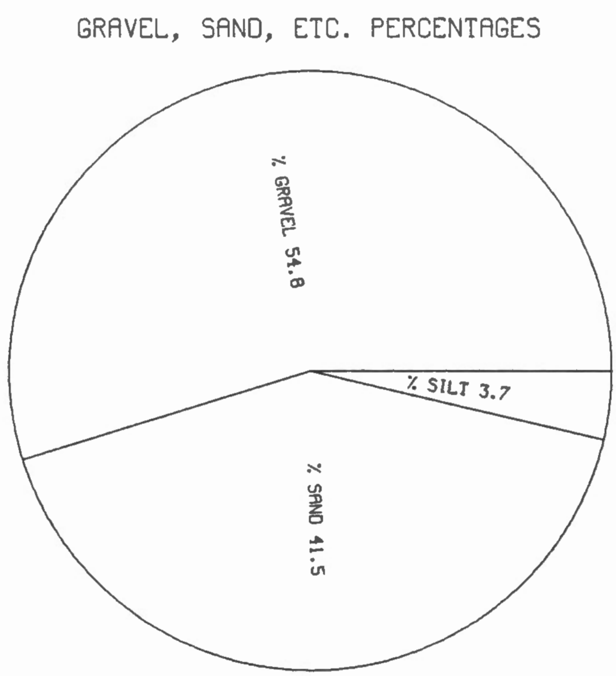


Figure 12. Histogram of particle size distribution and pie diagram of textural components from van Veen grab sample collected at Station 4 in the area of lag gravel to the southeast of the Scots Bay sand wave field. It is a poorly sorted, silty, sandy gravel.

sand wave field (regional lag surface), the height of the highest sand wave is 25 m. The smaller sizes of the individual bedforms in the field reflect the complex effect of coalesced compound sand waves. The sand waves form a line of convergence which runs from the southwest to the northeast through the field (Bob Dalrymple, personal communication, June 1990). This line of convergence provides evidence that the sand wave field is in equilibrium.

A preliminary attempt to determine the volume of sand in the Scots Bay sand wave field was made by assuming an average sand thickness of 5 m and a total area of approximately 7,000,000 m^2. This results in an approximate volume of 35,000,000 m^3.

The sand in this area contains approximately 5% biolithic fragments and is dominated by quartz fragments, many of which are sub-rounded to well-rounded in shape. Some of the quartz grains are iron stained. The remainder of the sand-sized fractions consists of reddish sandstone fragments, feldspar and a suite of metamorphic lithologies.

Internal structure, evident on the seismic reflection profiles within the individual sand waves is interpreted as buried earlier generation of sand waves. This indicates that the field has grown with time. When the present data is compared to that of Swift *et al.*, collected in 1966, it appears that the sand wave field may have migrated in the order of hundreds of metres to the northwest. This may have resulted from the effects of the counterclockwise current gyre in Scots Bay. It is also possible that navigational errors may account for the apparent offset.

The lag, sandy gravel surface overlies a sequence of acoustically stratified sediments, interpreted as glaciomarine/estuarine sediments which varies in thickness to a maximum of 30 m to the south of the sand wave field. Cores are essential to determine the nature and origin of these stratified systems. They overlie an acoustic unit interpreted as glacial till up to 7 m thick.This unit is characterized by a lack of coherent reflections on the seismic profiles.

The bedrock surface could easily be defined and traced in most places within the map area. It is either Triassic sandstone of the Scots Bay Formation (King and MacLean, 1976) or Triassic volcanics. The bedrock surface appears to be undulating and unconformable. A buried channel extends seaward through Scots Bay (Fig. 13) and may connect to present drainage systems on land. The sediments in the channel appear to be gas-charged in places with the amplitude of seismic reflections increased by the presence of gas.

An interpreted cross-section collected on a south to north pass over the Scots Bay sand wave field is included as Enclosure 2.

Acknowledgments

We wish to thank Captain Joseph Bray and his excellent crew, Enrique de Arcos and Hugh Marryatt for their support during the cruise. The work area was approximately 7 hours away from the nearest dock which did not go dry (essential for the F.R.V. Navicula) during the famous Fundy tides so Captain Bray and his crew maintained the F.R.V. Navicula at anchor each night and then worked long hours while we surveyed each day. Anthony Atkinson and Darrell Beaver of Program Support Subdivision receive thanks for their technical support. Discussions and comments of Ami Häkkinen, Geological Survey of Finland during the cruise were very useful. This manuscript was typed and all tables prepared by Lisa O'Neill and the authors thank her very much. The authors also thank Donald Clattenburg for all grain size analyses. This manuscript was reviewed by C. L. Amos and J. Shaw.

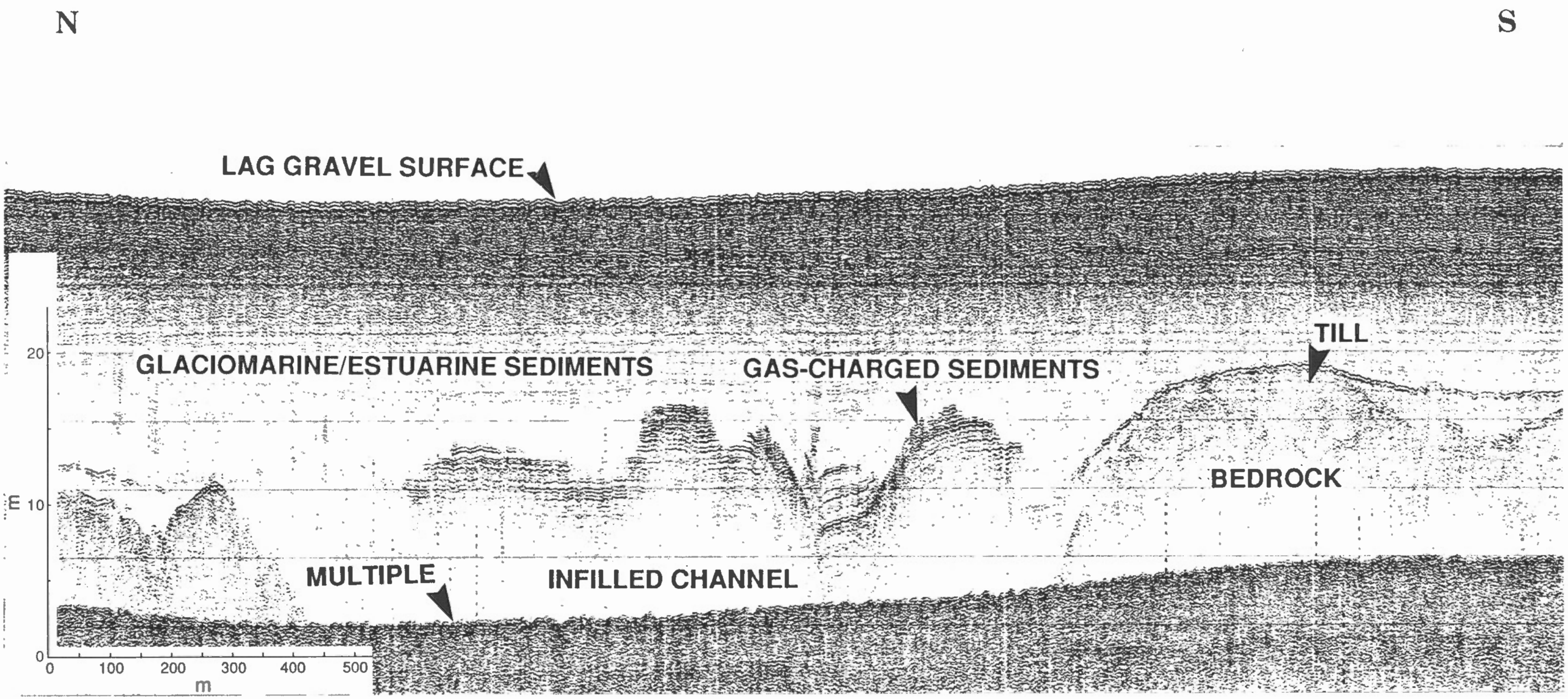


Figure 13. A high resolution IKB Seistec-boomer profile from Scots Bay showing a sequence of glaciomarine/estuarine sediments unconformably overlying and infilling a fluvial channel. Note the presence of gas-charged sediments within the channel. A thin layer of till blankets the bedrock. Dipping beds can be seen in bedrock to the right of the channel.

References

Amos, C. L. and King, E. L.

1984: Bedforms of the Canadian eastern seaboard: A comparison with global occurrences; Marine Geology 57, p. 167-208.

King, L. H. and MacLean, B.

1976: Geology of Scotien Shelf and adjacent areas; Marine Science Paper 7, 31 p. (Also Geollogical Survey of Canada Paper 74-31).

Swift, D. J. P., Cok, A. E. and Lyall, A. K.

1966: A sub-tidal sand body in the Minas Channel, eastern Bay of Fundy; Maritime Sediments, v. 2., p. 175-180.

Table 1: Grab Samples 89-009 Phase C

Samp. #	Sample Type	Jul. Day/ Time	Latitude	Longitude	Depth (m)	# of Attempts	# of Sub-samples	Seismic Time	Geographic Location	Notes
001	van Veen	1761416	45°19.16 N	64°32.88 W	24.0	2	3	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
002	van Veen	1761431	45°19.08 N	64°32.78 W	23.0	3	2	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
003	van Veen	1761437	45°19.06 N	64°32.73 W	23.0	1	1	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
004	van Veen	1761443	45°19.09 N	64°32.64 W	12.0	2	1	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
005	van Veen	1761447	45°19.12 N	64°32.75 W	20.0	1	1	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
006	van Veen	1761454	45°19.06 N	64°32.68 W	14.0	1	3	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
007	van Veen	1761500	45°19.07 N	64°32.72 W	13.0	1	2	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
008	van Veen	1761506	45°19.16 N	64°32.76 W	22.0	3	3	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
009	van Veen	1761517	45°19.02 N	64°32.71 W	16.0	3	3	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
010	van Veen	1761522	45°19.14 N	64°32.72 W	13.0	2	2	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
011	van Veen	1761632	45°19.14 N	64°32.72 W	19.0	2	4	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
012	van Veen	1761641	45°19.06 N	64°32.68 W	17.0	1	1	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
013	van Veen	1761700	45°18.88 N	64°32.52 W	30.0	4	1	1741915	Scots Bay	Small sample-sand, few rounded cobbles, few shells. Stn. No. 1 (sand wave field).
014	van Veen	1761715	45°18.80 N	64°33.12 W	21.0	2	1	1741915	Scots Bay	Coarse sand, minor shell debris, Stn. No. 1 (sand wave field)
015	van Veen	1761746	45°17.44 N	64°33.46 W	38.0	3	2	1761036	Scots Bay	1st attempt: jaws partially open, few pebbles, some sand. 2nd attempt: jaws closed, filled with water. 3rd attempt: good sample, fine sand, coarse sand, pebbles, mostly mafics. Stn No. 2
016	van Veen	1761757	45°17.58 N	64°31.65 W	32.0	1	1	1751745	Scots Bay	Pebbles, sand, few shells. Stn No. 3
017	van Veen	1761806	45°17.53 N	64°31.76 W	32.0	2	4	1751745	Scots Bay	1st attempt: jaws open with a cobble-subrounded basalt. 2nd attempt: good sample of medium sand with 10% shell hash. Stn. No. 3
018	van Veen	1761814	45°17.44 N	64°31.66 W	32.0	1	1	1751745	Scots Bay	Medium sand with 10% shell hash. Stn. No. 3
019	van Veen	1761820	45°17.53 N	64°31.64 W	31.0	1	3	1751745	Scots Bay	Medium sand with 10% shell hash. Stn. No. 3
020	van Veen	1761844	45°15.04 N	64°30.80 W	33.0	3	2	1751900	Scots Bay	Jaws partially open on recovery. Fine sand, pebbles, few bivalves, silt washing out on recovery. Stn. No. 4
021	van Veen	1761844	45°15.04 N	64°30.80 W	33.0	1	2	1751900	Scots Bay	Jaws closed. Fine sand, pebbles, few bivalves. Stn. No. 4
022	van Veen	1761917	45°17.40 N	64°32.47 W	37.0	2	1	1761045	Scots Bay	Well sorted medium sand, one slate cobble, few bivalves; 5% shell hash. Stn. No. 5

Table 2: Sidescan Records 89-009 Phase C

Roll #	Start Day/ Time	Stop Day/ Time	Geographic Location	Recorder	Sidescan System
024	1741755	1742000	Scots Bay	Klein 401	100-kHz Klein
025	1751001	1751600	Scots Bay	Klein 401	100-kHz Klein
026	1751605	1752005	Scots Bay	Klein 401	100-kHz Klein
027	1761014	1761405	Scots Bay	Klein 401	100-kHz Klein

Table 3: Sidescan Tapes 89-009 Phase C

Tape #	Start Day/ Time	Stop Day/ Time	Geographic Location	Channel Information	Sidescan System
058	1741800	1741950	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
059	1741950	1751130	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
060	1751130	1751307	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
061	1751307	1751443	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
062	1751443	1751620	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
063	1751620	1751757	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
064	1751757	1751945	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
065	1751945	1761133	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
066	1761133	1761313	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein
067	1761313	1761353	Scots Bay	Port-FM Stbd.-FM Ref.-FM Voice-DR	100 kHz Klein

Table 4: Seismic Records 89-009 Phase C

Roll #	Start Day/ Time	Stop Day/ Time	Hydrophone	Geographic Location	Recorder	System/Sound Source
015	1741800	1742000	External Eel	Scots Bay	EPC 1600	Bubble Pulser
016	1751001	1751605	External Eel	Scots Bay	EPC 1600	Bubble Pulser
017	1751610	1752005	External Eel	Scots Bay	EPC 1600	Bubble Pulser
018	1760959	1761400	External Eel	Scots Bay	EPC 1600	Bubble Pulser
009	1741800	1742000	Internal	Scots Bay	EPC 1600	Seistec Boomer
010	1751001	1751600	Internal	Scots Bay	EPC 1600	Seistec Boomer
011	1751610	1752005	Internal	Scots Bay	EPC 1600	Seistec Boomer
012	1761019	1761405	Internal	Scots Bay	EPC 1600	Seistec Boomer

Table 5: Bathymetric Records 89-009 Phase C

Roll #	Start Day/ Time	Stop Day/ Time	Geographic Location	Frequency	Recorder
005	1712020	1751320	Pubnico, Scots Bay	30 kHz	ELAC
006	1751340	1761917	Scots Bay	30 kHz	ELAC