CRUISE REPORT 88-018 (D)

PHASE 6/7

M V NAVICULA

Northumberland Strait

JULY 8-23, 1988

by

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Cruise No.: 88-018 (D), Phase 6 and 7

Vessel: M V Navicula

Dates: July 8-23, 1988

Responsible Agency: Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, N.S., Canada

Area: Northumberland Strait, Gulf of St. Lawrence off West Point-southwest P.E.I., and between Borden, P.E.I. and Tormentine, N.B. adjacent and along the proposed Fixed Link Crossing between New Brunswick and Prince Edward Island.

Ship's Captain: Captain Niel Langille

Senior Scientist: Gordon B.J. Fader

Personnel:

R. Currie	Computer Scientist, AGC
G. Fader	Scientist, AGC
D. Locke	Technician, AGC
R. Sparkes	Technician, AGC

Cruise Purpose:

The purpose of the cruise was to collect geological and geophysical data in support of a program of nearshore geological studies recently initiated by the Atlantic Geoscience Centre. The cruise was one of 13 undertaken during the 1988 field season in the nearshore of the Atlantic Provinces using the vessel M.V. Navicula. A particular emphasis of the program was the collection of data in support of studies related to the distribution and occurrence of offshore aggregates and minerals. A portion of the survey centered at the Fixed Link (FLINK) area of Northumberland Strait, was designed to obtain a grid of geophysical and geological data to allow study of conditions at and below the seabed related to the construction of the proposed fixed link crossing of Northumberland Strait. Specific objectives of the cruise were:

1. Western Northumberland Strait - To map the distribution of surficial sediments and bedforms (sand waves, megaripples) previously noted by Kranck, 1971. To determine the direction of sediment transport from interpretation of sidescan sonar data. To determine the thickness of the surficial formations including the areas of bedforms and to delineate the bedrock surface and subsurface structure.

2. FLINK Area Northumberland Strait - To map the distribution of surficial sediments, bedforms (sand waves, megaripples, sand

ribbons), boulders, and other seabed features. To obtain a grid of seismic and sidescan sonar data from which the direction of sediment transport can be determined. To map the distribution of subsurface features. To determine the depth to bedrock and to clearly delineate the bedrock surface.

3. To study the sand bodies delineated by Kranck, 1971, termed Egmont Sand and to determine if these sand bodies have moved since the earlier mapping prior to 1971. To classify and map bedform distributions and thicknesses within the areas of Egmont Sand.

4. To collect seabed sediment samples to provide ground truth for interpretation of the sidescan sonar and seismic data.

5. To assess the construction aggregate potential of both areas and the suitability of gravel and sand as construction materials.

Equipment Description and Performance

Sidescan Sonar System

The Klein 100 kHz sonar performed well during the cruise and provided high quality sonograms of the seabed. The sidescan data was tape recorded. At times, during calm sea conditions and in

shallow water, thermocline interference limited range and degraded the sonograms. At selected sites, the sidescan sonar was operated at 50 m range (100 m swath) and this provided much increased resolution, showing many features and details of the seabed not resolved with the sonar on reconnaissance surveys where range settings of 100 m and greater are normally used. Strong tidal currents also degraded the data by crabbing the towfish and skewing the data making interpretation difficult. During the cruise, an attempt was made to fly the fish at a constant height above the seabed for consistency in interpretation and data presentation.

Huntec Sea Lion Boomer Shallow Tow

This system consisted of a Huntec boomer mounted in a towfish designed for operation ~ 5 m below the sea surface. 1988 was the first year this new system was used. Best results (suppressed bubble pulse and sea surface reflections) were obtained during calm weather conditions when the tow body was positioned as close to the sea surface as possible. The system was fired at 0.75 second intervals. During the cruise, the fish at times became unstable and dove beneath the ship for no apparent reason. During one such dive, the external hydrophone was cut off and lost. A Nova Scotia Research Foundation hydrophone, Model LT06, was substituted and towed from the stern of the vessel. The resolution of the system was ~ 1 m.

Sparker Seismic System

A 280 joule, 20 tipped surface towed sparker was deployed for a short test during the cruise and was found to have resolution of 5-10 m, much less than the Huntec Sea Lion. As only one power unit existed on the vessel, only the sparker or Sea Lion could be deployed at any one time. Because of its higher resolution, the Sea Lion was used extensively for the remainder of the cruise.

Datasonics Bubble Pulser

The Datasonics Bubble Pulser is a 20 joule, vertically mounted, surf board surface towed boomer, and was deployed during the entire cruise. The system proved to be very reliable and provided continuous information with penetration to the bedrock surface. The wide bubble pulse of this system (resolution $\sim$ 10 m) made it difficult to define the bedrock surface when bedrock occurred less than 10 m below the seabed.

Seabed Ground Truth

Seabed samples were collected with a Van Veen grab. A deployment technique which involved a free fall to the seabed provided a rapid sample retrieval rate. The sample sites were largely chosen on the

basis of onboard interpretation of the sidescan sonar data. Large targets were chosen to ensure accurate sampling despite drifting of the vessel under strong currents.

Nature and Quantity of Data Collected

See appendix attached and Fig. 1 and 2 (seismic and sample control).

Discussion, Comments and Preliminary Interpretation

Originally, the cruise was planned to survey each of the two study areas (Southwest P.E.I. and FLINK areas) separately, but as a result of weather constraints and shore-based logistics, the areas were integrated.

FLINK Crossing Area (Borden-Tormentine)

A regional grid pattern was employed as the approach for mapping and understanding the seabed and subsurface geology. Because of strong industry and government interest in the actual proposed FLINK crossing location, and a need for high quality data, during survey periods when optimal survey windows developed additional crossings of the FLINK area were run to obtain the best possible data with the highest resolution. This resulted in 4.5 crossings of the FLINK area. Areas where data were lost due to equipment

failure or navigation problems within the grid were re-run as the survey progressed.

A preliminary interpretation of the data indicates new and previously unknown geological conditions in the area of Northumberland Strait. Fig. 3 shows the distribution of bedrock, gravel, sand, and sand ribbons at the seabed. Large areas of dynamic bedforms cover many areas of the seabed. Sand ribbons and sand streaks occur over large areas of seabed over gravel in the southern survey area adjacent to the N.B. coast (fig. 3). Approximately one-third of the southern part of the FLINK crossing consists of gravel with overlying sand ribbons. Smaller zones also occur to the west and southeast of Borden and some are found in the deepest central part of the Strait west of the proposed crossing. The sand ribbons range from less than 1 m in width to over 400 m. Some have megaripples developed on them, and in one case, sand waves. These indicate active sediment transport.

Associated with the sand ribbons are areas of comet marks: obstacle-induced, long, erosional strips, occurring on current-swept sea bottoms. The flow obstacles, in this case, are interpreted as boulders. Comet marks are good indicators of the direction of sediment transport and, together with the sand ribbon data, indicate a regional sediment transport direction from west to east throughout the study area.

Bedrock outcrops at the seabed in a large area to the northwest of Jourimain Island and in the area adjacent to Borden. The bedrock appears as ledges, ridges, and rough topography and is often covered or flanked with many boulders.

Boulders cover large areas of the strait and some are up to 3 m in diameter. They often are found in clusters or groups and suggest that some may be dredge spoils. The interpretation of boulders at the seabed is difficult, and the sonar fish must be positioned close to the seabed for recognition.

The large sand bank off Jourimain Shoal, the sand reef east of Jourimain Island, and Tryon Shoals along the south coast of P.E.I., east of Borden, were investigated to assess sediment transport directions and to determine the amount of sand for possible use as marine aggregate for construction purposes. In general, the sand banks are located where Kranck (1971) earlier mapped them but the distribution of sand waves and megaripples is complex. The sand banks are composed of extensive fields of sand waves with heights of up to 5 m and megaripples. An additional area of sand bedforms was found west of Borden, and several isolated sand zones occur throughout the western half of the study area in the deeper central area of the Strait.

Ice Scour Features

Ice scour features (long, linear depressions with flanking berms) were found to occur in the shallow water particularly along the nearshore of Prince Edward Island to the west of Borden. They occur in water depths of up to 11 m and exhibit similar criss-crossing relationships to iceberg furrows found on the offshore bank areas of the Grand Banks of Newfoundland and areas northward. Most appear to be parallel or sub-parallel to the bathymetry and are very shallow. The depth of the furrows could not be determined.

Areas of subdued megaripples and/or gravel waves, which have no measureable relief, occur close to Jourimain Island. They appear degraded.

Drag marks at the seabed, made by scallop fishing gear, are common across the Strait and display a unique sonar image of closely spaced lines that make them easily interpreted. At the FLINK crossing site, they are largely confined to the northern section of a centre crossing line. It also appears that very few boulders occur where the scallop fishing takes place. This may be the result of removal of boulders and manicuring of the seabed by the repetitive scallop raking.

At the FLINK crossing, the seismic data clearly shows the bedrock at the seabed and in the subsurface overlain by an acoustic unit consisting of incoherent reflections and commonly interpreted as till. Other areas of the Strait show several units overlying the bedrock surface and some of these may represent glacial sediments or estuarine muds preserved during the Holocene transgression.

In summary, a preliminary interpretation of the data indicates that conditions at the seabed of Northumberland Strait are more dynamic than previously reported. The high quality and resolution of the data, together with the gridded survey pattern, will allow for detailed mapping and a comprehensive understanding of conditions in the Strait of importance to construction of the FLINK. The distribution and significance of ice-formed features at the seabed is also important to an understanding of sediment transport and to an assessment of possible effects of dredging associated with the FLINK construction. The data base indicates large areas of sand that possibly could be used for construction purposes. Most samples of gravel were unsuitable for concrete construction purposes because of the dominance of weak sandstone clasts.

Acknowledgment

I wish to thank Captain Niel Langille and his excellent crew for support during the cruise. During small ship studies like this, the long hours and difficult conditions require high quality technical support. I thank the Program Support Technicians for their dogged efforts. The interpretation and maps of seabed features were supported by Shawn Pecore whom I thank for his efforts. The report was reviewed by B. MacLean and R. Parrott.

Fig. 3 Preliminary interpretation of the surficial geology of Central Northumberland Strait. The areas of bedrock are often covered with discontinuous patches of sand and numerous boulders. The areas of sand are covered with complex distributions of sand waves and megaripples. Sand ribbons are widespread and overlie gravel. The direction of sediment transport is inferred in the sand ribbon symbol.

Kranck, K. 1971. Surficial Geology of Northumberland Strait, Marine Science Paper 5. Geological Survey of Canada, Paper 71-53.

88-018(D) PHASE 6/7 GRABS

SAMPLE NUMBER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
001	FAA	VAN VEEN 1921845	46 11.03	63 36.40	9.0	3	2	TRYON SHOAL PEI	SAND DOLLARS, SAND GRAVEL , 60 % GRAVEL 40 SAND , ON EDGE OF SAND FIELD POSSIBLY IN TROUGH. FEW ROUNDED TRIANGULAR ROCKS 1 LIMESTONE FRAGMENT
002	FAA	VAN VEEN 1921853	46 11.09	63 36.43	9.0			TRYON SHOAL PEI	SANDY GRAVEL , SAME AS #1. FEW YOUNG AND OLD SCALLOP SHELLS AND SAND DOLLARS. GRAVEL ROUNDED , MUST BE IN SAND TROUGH
003	FAA	VAN VEEN 1921858	46 11.20	63 36.53	9.0			TRYON SHOAL PEI	BROWN SAND AND GRAVEL. LOTS OF SAND DOLLARS AND MUD. STILL IN TROUGH OF SAND WAVES
004	FAA	VAN VEEN 1921903	46 11.26	63 36.57	9.0			TRYON SHOAL PEI	MEDIUM BROWN SAND / ROCK MANY SAND DOLLARS. ON SAND WAVE ?
005	FAA	VAN VEEN 1921908	46 11.32	63 36.62	9.0	1	1	TRYON SHOAL PEI	FINE BROWN SAND FEW SAND DOLLARS, NO GRAVEL OVER SAND RIDGES SEE ECHOGRAM
006	FAA	VAN VEEN 1921912	46 11.38	63 36.66	9.0	1	2	TRYON SHOAL PEI	CLEAN BROWN SAND SAND DOLLAR, SHELL FRAGMENTS NO GRAVEL
007	FAA	VAN VEEN 1921919	46 11.44	63 36.68	8.5	1	1	TRYON SHOAL PEI	CLEAN BROWN SAND LARGE SAMPLE, FEW BROKEN SHELLS SAND DOLLARS, NO GRAVEL
008	FAA	VAN VEEN 1921925	46 11.48	63 36.76	7.0	1	2	TRYON SHOAL PEI	BROWN SAND MANY SHELL FRAGMENTS SAND DOLLARS NO GRAVEL

TABLE 1

88-018(D) PHASE 6/7 GRABS

SAMPLE NUMBER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
009FAA	VAN VEEN	1921932	46 11.45	63 36.82	9.0	1	2	TRYON SHOAL PEI	BROWN SAND SOME SURFACE MUD SAND DOLLARS, BROKEN SHELL FRAGMENTS
010FAA	VAN VEEN	1921936	46 11.42	63 36.91	11.0	2	2	TRYON SHOAL PEI	SAND GRAVEL SHELLS OLD BURROWED QUAHOG SHELL, SAND DOLLARS OUT OF SAND WAVE FIELD OR IN TROUGH
011FAA	VAN VEEN	1921942	46 11.39	63 36.97	11.0	1	2	TRYON SHOAL PEI	BROWN SAND, SAND DOLLARS
012FAA	VAN VEEN	1921950	46 11.60	63 35.86	7.5	2	2	TRYON SHOAL PEI	BROWN SAND FEW PEBBLES SAND DOLLAR
013FAA	VAN VEEN	1922000	46 11.33	63 37.19	12.5	1	2	TRYON SHOAL PEI	BROWN SAND SAND DOLLARS FEW BROKEN SHELLS
014FAA	VAN VEEN	1961304	46 38.09	64 28.53	23	1	2	WESTERN PEI	BROWN SANDY GRAVEL SMALL AMOUNT OF SILT CLAY. FEW BROKEN SHELLS, ONE COBBLE. BACKGROUND SAND FLAT AND FEATURELESS ON SIDESCAN
015FAA	VAN VEEN	1961333	46 41.60	64 30.07	22	1	2	WESTERN PEI	CLEAN MEDIUM SAND , CLAM, RAZOR CLAM, SAND DOLLAR, FEW SMALL PEBBLES IN 3M SAND WAVE FIELD. SEE SIDESCAN
016FAA	VAN VEEN	1961349	46 42.80	64 30.06	27	1	2	WESTERN PEI	GOOD CLEAN MEDIUM BROWN SAND, FEW SAND DOLLARS

88-018(D) PHASE 6/7 GRABS

AMPLE BER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
017	FAA	VAN VEEN 1961412	46 41.83	64 26.67	16	3	2	WESTERN PEI	SAND AND SHELLS, GRAVEL BROKEN SHELLS, BROWN COLOR HARD BOTTOM SAND RIBBONS
8	FAA	VAN VEEN 1961430	46 41.69	64 27.75	15	1	2	WESTERN PEI	BROWN SAND AND SAND DOLLARS FINE MEDIUM SAND
9	FAA	VAN VEEN 1961500	46 41.08	64 33.66	18	1	2	WESTERN PEI	BROWN SAND SHELLS
0	FAA	VAN VEEN 1961544	46 38.62	64 35.19	25	1	2	WESTERN PEI	GRAVEL SAND, SHELLS HARD BOTTOM
21	FAA	VAN VEEN 1961630	46 38.90	64 30.73	25	1	2	WESTERN PEI	SAND AND GRAVEL SMALL SAMPLE HARD BOTTOM
122	FAA	VAN VEEN 1961502	46 37.39	64 26.79	14	1	2	WESTERN PEI	SMALL SAMPLES GRAVEL AND SAND
23	FAA	VAN VEEN 1961339	46 42.09	64 30.24	32	1	2	WESTERN PEI	SAND , MEDIUM TO COARSE, BROKEN SHELLS, SHELL HASH, CARBONATE 20 % OF SAMPLE . FEW SAND DOLLARS, RAZOR CLAMS AND CLAMS
	FAA	VAN VEEN 1961612	46 39.59	64 30.32	28	1	2	WESTERN PEI	SAND AND SOME SHELLS

88-018(D) PHASE 6/7 GRABS

SAMPLE MBER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
025FAA	VAN VEEN	2001735	46 11.78	63 51.29	11	2	2	NORTHUMBERL STRAIT	1 LARGE COBBLE, SAND, FEW PEBBLES, MOSTLY SAND, BROWN, MEDIUM, WELL SORTED, IN AREA OF SAND RIBBONS. GOOD SAMPLE. SEE SIDESCAN SONAR PROFILE.
026FAA	VAN VEEN	2001748	46 11.92	63 52.98	11	2	2	NORTHUMBERL STRAIT	SAND , BROWN, FEW SAND DOLLARS, NO GRAVEL MEDIUM CLEAN SAND, SEE ECHOGRAM. IN SAND WAVE OR MEGARIPPLE AREA, POSSIBLY NOT OVER SAND "MEGARIPPLE" RIBBONS AS ORIGINALLY INTENDED.
027FAA	VAN VEEN	2001757	46 12.37	63 54.16	11	3	2	NORTHUMBERL STRAIT	LARGE SAMPLE OF MEDIUM TO COARSE SAND , BROWN, NO GRAVEL , HERMIT CRAB IN GASTRO-POD, FEW ALIVE AND DEAD BRITTLE STARS GOOD SAMPLE OVER SAND WAVE
028FAA	VAN VEEN	2011812	46 13.26	63 52.99	17	2	2	NORTHUMBERL STRAIT	MUDDY GRAVELLY SAND , 5 % MUD, 70 % SAND 25 % GRAVEL. DARK BROWN , FEW BROKEN SHELLS IN AREA OF FINE SAND RIBBONS
029FAA	VAN VEEN	2011835	46 14.83	63 50.82	18	1	2	NORTHUMBERL STRAIT	29A MEDIUM SAND 5% FINE SHELL HASH ALONG SAND RIBBON. TAKEN IN SAND WAVES MID CHANNEL SEE SIDESCAN SONAR PROFILE
029FAA	VAN VEEN	2011835	46 14.83	63 50.82	18	1	2	NORTHUMBERL STRAIT	29B WELL ROUNDED PEBBLES OF SANDSTONE WITH SHELLS AND SAND WELL ROUNDED PEBBLES INDICATE MUCH EROSION HIGH ENERGY, MOVING BACK AND FORTH
029FAA	VAN VEEN	2011835	46 14.83	63 50.82	18	1	2	NORTHUMBERL STRAIT	29C MEDIUM SAND TAKEN IN SAND WAVES ON SAND RIBBON MID-CHANNEL. SEE SIDESCAN SONAR PROFILE
9FAA	VAN VEEN	2011835	46 14.83	63 50.82	18	1	2	NORTHUMBERL STRAIT	29D MEDIUM SAND WITH FEW LARGE SHELLS TAKEN IN SAND WAVES MID-CHANNEL SEE SIDESCAN

88-018(D) PHASE 6/7 GRABS

SAMPLE NUMBER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
030	FAA	VAN VEEN 2011914	46 17.02	63 45.47	12	2	2	NORTHUMBERL STRAIT	SLIGHTLY MUDDY BROWN SAND. SAND DOLLARS MUD THIN VENEER ON SAND SURFACE. NON-REFLECTIVE . SEE SIDESCAN
031	FAA	VAN VEEN 2011940	46 14.64	63 42.91	12	4	2	NORTHUMBERL STRAIT	FLINK (FIXED LINK) CROSSING PEBBLES, COBBLES , SAND, SHELLS, SMALL VERY HARD BOTTOM. POSSIBLY BEDROCK OUTCROPPING
032	FAA	VAN VEEN 2011953	46 14.21	63 43.42	13	3	2	NORTHUMBERL STRAIT	FLINK CROSSING SAND MOSTLY WASHED OUT, FEW COBBLES MOSTLY DEAD HORSE MUSSELS DO NOT DETERMINE GRAIN SIZE. JAWS OPEN HARD BOTTOM, POOR SAMPLE.
033	FAA	VAN VEEN 2012005	46 13.47	63 44.34	19	4	2	NORTHUMBERL STRAIT	FLINK CROSSING FINE GRAVEL, SAND, SOME MUD SOME BORKEN SHELLS, SCALLOP SHELL AND FRAG, 5 % MUD SEE SIDESCAN
034	FAA	VAN VEEN 2012021	46 12.47	63 45.54	18	4	2	NORTHUMBERL STRAIT	FLINK CROSSING SAND GRAVEL SHELLS , SOME MUD SCALLOP (LIVE) , HORSE MUSSELS ETC FLAT COBBLE , DISK SHAPED.
035	FAA	VAN VEEN 2021310	46 11.73	63 46.39	16	2	2	NORTHUMBERL STRAIT	FLINK CROSSING GRAVEL SAND , BROKEN SHELLS FEW COBBLES MUD ?? TRACE 5% , HARD BOTTOM FLAT FEATURELESS HARD BOTTOM ON SIDESCAN
036	FAA	VAN VEEN 2021320	46 11.13	63 47.14	13	2	2	NORTHUMBERL STRAIT	FLINK CROSSING SAND RIBBON AREA FINE GRAVEL AND SAND < 2% MUD AND FEW BROKEN SHELLS
037	FAA	VAN VEEN 2021331	46 10.58	63 47.83	8	3	2	NORTHUMBERL STRAIT	FLINK CROSSING AREA OF SUBDUED MEGARIPPLES OVER GRAVEL SEE SIDESCAN ; GRAVEL SAND , KELP ,SAND DOLLARS BROKEN. WATER RUNS CLEAR 2% MUD FEW COBBLES. JOURIMAIN ISLAND

TABLE 1

88-018(D) PHASE 6/7 GRABS

SAMPLE NUMBER	SAMPLE TYPE	JULIAN DAY/TIME	LATITUDE	LONGITUDE	DEPTH (MTRS)	NO OF ATTEMPTS	NO OF SUBSAMPLES	GEOGRAPHIC LOCATION	NOTES
038FAA	VAN VEEN	2021350	46 09.18	63 45.36	8	3	2	NORTHUMBERL STRAIT	FLINK CROSSING A TROUGH OF MEGARIPPLES- MUD BALL, SAND AND SHELLS B MOSTLY SHELLS
039FAA	VAN VEEN	2021356	46 08.98	63 45.07	8	3	2	NORTHUMBERL STRAIT	FLINK CROSSING MEGA RIPPLES - SEE ECHOGRAM CLEAN BROWN SAND - NO GRAVEL , BROKEN SHELLS - NO LIVE SHELLS, 2M AMPLITUDE ON MEGARIPPLES

TABLE 2

MAGNETIC RECORDS 88-018 (Phase D)

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBER	GEOGRAPHIC LOCATION	
001	1911622	1912250	1	WESTERN PEI	NORTHUMBERLAND ST.
001	1921310	1921815	2	WESTERN PEI	NORTHUMBERLAND ST.
001	1941320	1942000	3	WESTERN PEI	NORTHUMBERLAND ST.
001	1951310	1952010	4	WESTERN PEI	NORTHUMBERLAND ST.
001	1971440	1971724	5	WESTERN PEI	NORTHUMBERLAND ST.
001	1981240	1981605	6	WESTERN PEI	NORTHUMBERLAND ST.
002	1981743	1982055	6	WESTERN PEI	NORTHUMBERLAND ST.
002	1991240	1992124	7	WESTERN PEI	NORTHUMBERLAND ST.
002	2001320	2001900	8	WESTERN PEI	NORTHUMBERLAND ST.
002	2011530	2011713	9	WESTERN PEI	NORTHUMBERLAND ST.
002	2021450	2022016	10	WESTERN PEI	NORTHUMBERLAND ST.
002	2031230	2031910	11	WESTERN PEI	NORTHUMBERLAND ST.

TABLE 3

SEISMIC PROFILES 88018

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	HYDROPHONE	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
001	1911610	1912050	EXTERNAL	1	WESTERN PEI	EPC 1600	BUBBLE PULSER
002	1921252	1921818	EXTERNAL	2	WESTERN PEI	EPC 1600	BUBBLE PULSER
003	1941315	1942006	EXTERNAL	3	WESTERN PEI	EPC 1600	BUBBLE PULSER
004	1951300	1952010	EXTERNAL	4	WESTERN PEI	EPC 1600	BUBBLE PULSER
005	1971436	1971724	EXTERNAL	5	WESTERN PEI	EPC 1600	BUBBLE PULSER
006	1981232	1981552	EXTERNAL	6	WESTERN PEI	EPC 1600	BUBBLE PULSER
007	1981556	1982056	EXTERNAL	6	WESTERN PEI	EPC 1600	BUBBLE PULSER
008	1991234	1992120	EXTERNAL	7	WESTERN PEI	EPC 1600	BUBBLE PULSER
009	2001320	2001916	EXTERNAL	8	WESTERN PEI	EPC 1600	BUBBLE PULSER
10	2011450	2011714	EXTERNAL	9	WESTERN PEI	EPC 1600	BUBBLE PULSER
011	2021432	2021910	EXTERNAL	10	WESTERN PEI	EPC 1600	BUBBLE PULSER
12	2021914	2022016	EXTERNAL	10	WESTERN PEI	EPC 1600	BUBBLE PULSER
013	2031230	2031980	EXTERNAL	11	WESTERN PEI	EPC 1600	BUBBLE PULSER
001	1911626	1911731	NSRF	1	WESTERN PEI	EPC 4100	GEOPULSE SPARKER
1	1911742	1912052	EXTERNAL	1	WESTERN PEI	EPC 4100	HUNTEC SEA LION
002	1921250	1921820	EXTERNAL	2	WESTERN PEI	EPC 4100	HUNTEC SEA LION
3	1941316	1942004	EXTERNAL	3	WESTERN PEI	EPC 4100	HUNTEC SEA LION
4	1951392	1952010	EXTERNAL	4	WESTERN PEI	EPC 4100	HUNTEC SEA LION
005	1971436	1971724	EXTERNAL	5	WESTERN PEI	EPC 4100	HUNTEC SEA LION
6	1981234	1982058	EXTERNAL	6	WESTERN PEI	EPC 4100	HUNTEC SEA LION

TABLE 3

SEISMIC PROFILES 88018

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	HYDROPHONE	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
007	1991244	1991626	EXTERNAL	7	WESTERN PEI	EPC 4100	HUNTEC SEA LION
008	1991630	1992104	EXTERNAL	7	WESTERN PEI	EPC 4100	HUNTEC SEA LION
009	2001328	2001916	EXTERNAL	8	WESTERN PEI	EPC 4100	HUNTEC SEA LION
010	2011452	2011714	EXTERNAL	9	WESTERN PEI	EPC 4100	HUNTEC SEA LION
011	2021430	2022018	EXTERNAL	10	WESTERN PEI	EPC 4100	HUNTEC SEA LION
012	2031230	2031908	EXTERNAL	11	WESTERN PEI	EPC 4100	HUNTEC SEA LION

TABLE 4

SIDESCAN TAPES 88018-06 (PHASE D)

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	CHANNEL INFO	SIDESCAN SYSTEM
001	1911600	1912012	1	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
002	1912016	1912155	1	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
002	1921240	1921510	2	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
003	1921520	1921820	2	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
004	1941313	1941636	3	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
005	1941639	1941950	3	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
006	1941956	1942005	3	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
006	1951244	1951549	4	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
007	1951549	1951900	4	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
008	1951904	1952010	4	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS

TABLE 4

SIDESCAN TAPES 88018-06 (PHASE D)

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	CHANNEL INFO	SIDESCAN SYSTEM
008	1971433	1971628	5	WESTERN PEI	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
010	1981438	1981800	6	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
011	1981802	1982056	6	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
012	1991235	1991530	7	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
013	1991535	1991900	7	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
014	1991904	1992124	7	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
014	2001315	2001400	8	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
15	2001400	2001712	8	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
016	2001716	2001918	8	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
16	2011447	2011545	9	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS

TABLE 4

SIDESCAN TAPES 88018-06 (PHASE D)

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	CHANNEL INFO	SIDESCAN SYSTEM
017	2011445	2011713	9	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
017	2021439	2021613	10	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
018	2021639	2021707	10	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
018	2021707	2021948	10	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
019	2021950	2022024	10	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
019	2031245	2033650	11	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
020	2031507	2031830	11	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS
021	2031840	2031910	11	NORTHUMBERLAND STRAT	PORT-FM STBD-FM REF-DR SPEED-DR	KLEIN 100KHZ SSS

TABLE 5

SIDESCAN PROFILES 88018-06 (PHASE D)

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	SIDESCAN SYSTEM
001	1911300	1912058	1	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
002	1921240	1921826	2	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
003	1941306	1941636	3	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
004	1941638	1942006	3	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
005	1951254	1951716	4	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
006	1951718	1951924	4	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
007	1951930	1952018	4	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
008	1971412	1971720	5	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
009	1981222	1981417	6	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
010	1981421	1981920	6	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
011	1981924	1982100	6	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
012	1991220	1991624	7	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
13	1991626	1991842	7	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
14	1991848	1992126	7	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
15	2001314	2001656	8	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
16	2001822	2001916	8	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
17	2011444	2011720	9	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS

TABLE 5

SIDESCAN PROFILES 88018-06 (PHASE D)

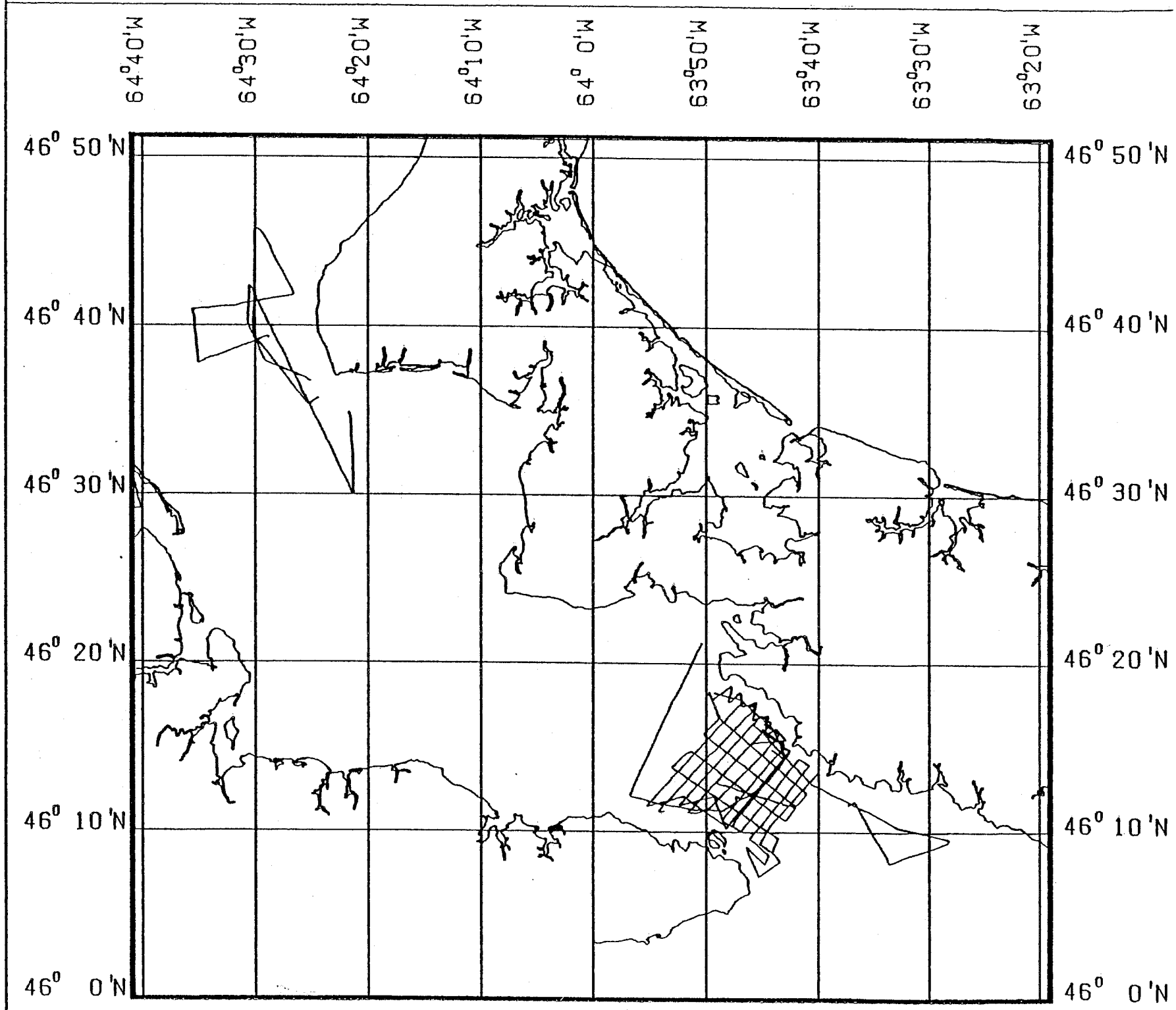
ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	SIDESCAN SYSTEM
018	2021420	2021816	10	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
019	2021818	2021956	10	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
020	2021958	2022022	10	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
021	2031224	2031644	11	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
022	2031646	2031708	11	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS
023	2031710	2031916	11	WESTERN PEI NORTHUMBERLAND ST.	KLEIN	100 KHZ KLEIN SSS

TABLE 6

BATHYMETRY RECORDS 88018-06 PHASE D

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	FREQUENCY	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	NOTES
001	1911615	1912045	30 KHZ	1	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
001	1921235	1921245	30 KHZ	2	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
002	1921240	1921817	30 KHZ	2	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
002	1941320	1942000	30 KHZ	3	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
002	1951245	1951425	30 KHZ	4	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
003	1951426	1952010	30 KHZ	4	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
003	1971430	1971726	30 KHZ	5	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
004	1981205	1981830	30 KHZ	6	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
004	1991240	1992054	30 KHZ	7	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
005	1991845	1992121	30 KHZ	7	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
005	2001310	2001917	30 KHZ	8	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
005	2011458	2011630	30 KHZ	9	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
006	2011635	2012021	30 KHZ	9	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
006	2021310	2021715	30 KHZ	10	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
006	2021745	2022015	30 KHZ	10	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	
006	2031244	2031908	30 KHZ	11	WESTERN PEI NORTHUMBERLAND STRAT	ELAC	

FRV NAVICULA SHIPS TRACKS NAV 88-018(D), PHASE 677 FIG. 1

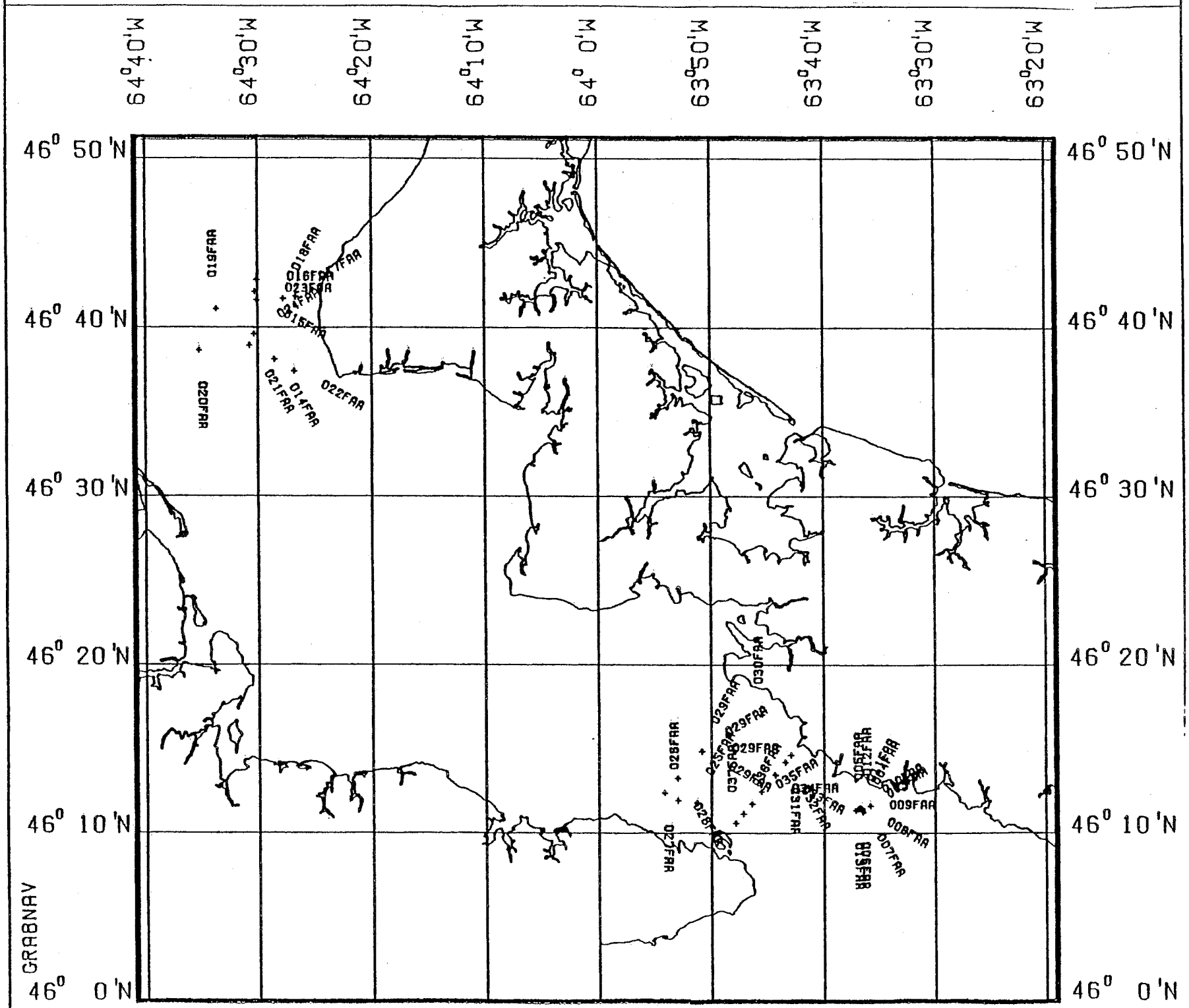


FRV NAVICULA

SEABED SAMPLE LOCATIONS

NAV 88-018(D), PHASE 6/7

FIG. 2



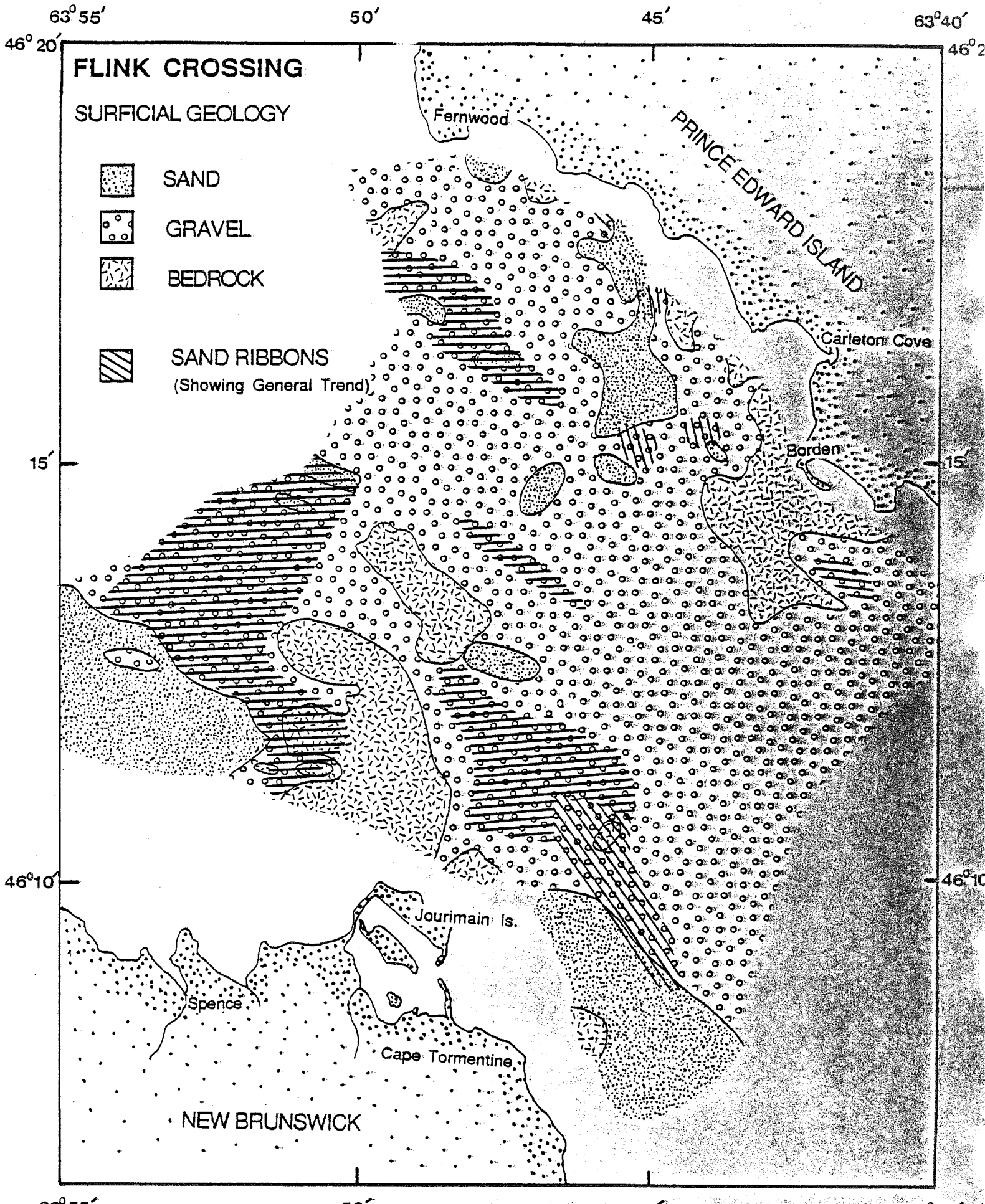

63°55′
50′
45′
63°40′
46° 20′
FLINK CROSSING
SURFICIAL GEOLOGY
SAND
GRAVEL
BEDROCK
SAND RIBBONS
(Showing General Trend)
Fernwood
PRINCE EDWARD ISLAND
Carleton Cove
Borden
15′
46°10′
Jourimain Is.
Spence
Cape Tormentine
NEW BRUNSWICK

FIGURE 3