REPORT OF 1991 NOGAP COASTAL SURVEYS IN THE BEAUFORT SEA

S.M. Solomon, D.L. Forbes, P.J. Mudie

Geological Survey of Canada
Open File 2579

Atlantic Geoscience Centre
Bedford Institute of Oceanography
Box 1006, Dartmouth, Nova Scotia
B2Y 4A2 Canada

NOGAP D.1 BEAUFORT COAST GEOTECHNICS

A contribution to the Northern Oil and Gas Action Program

1992

CONTENTS

CONTENTS continued

LIST OF FIGURES

LIST OF TABLES

NOTE re Cruise Numbers:

Spring coastal program was assigned cruise number 91600.
Summer coastal program was assigned cruise number 91302.
Paleoecology samples (summer program) were designated ARK-91.
Arktos-ß cruise was assigned cruise number ARKTOS-91.
Nahidik cruise was assigned cruise number NAH-91.

INTRODUCTION

The Northern Oil and Gas Action Program (NOGAP) is charged with acquiring information for use in the planning, regulation, and management of hydrocarbon-related developments in the north. The coastal zone of the Beaufort Sea is a dynamic and complex environment. It is therefore a critical area of concern in planning for future production and pipeline facilities. Rapid coastal erosion, thaw settlement, sediment transport, and other processes along the coastline can have a significant impact on the stability of these facilities. As a result, there is a need for improved understanding of shallow stratigraphy, permafrost and ground-ice distribution, and other geotechnical properties in the coastal zone and of nearshore and estuarine dynamics, including waves and currents, storm-surge effects, sediment transport and deposition. There is also an ongoing need for information on rates and processes of coastal erosion and on factors influencing spatial and temporal variability of erosion rates, including sea-level change, sea-ice distribution, and other climatic effects.

In order to address some of these concerns, a four-part field program was undertaken in 1991 by personnel from the Atlantic Geoscience Centre of the Geological Survey of Canada (AGC/GSC), with participation from Terrain Sciences Division (TSD/GSC), Canadian Coast Guard (CCG), Centre for Cold Ocean Resources Engineering (C-CORE), Watercraft Offshore Limited (WOL), and Hill Geoscience Research (HGR). The field work was funded under NOGAP Project D.1, with logistical support from the Polar Continental Shelf Project (PCSP) in Tuktoyaktuk, the Science Institute of the Northwest Territories (SINT) in Inuvik, and Technical Field Support Services (TFSS) in Hull.

The 1991 activities described in this report include the following sub-programs:

(1) **spring coastal program**: shallow coring and geophysical surveys through the ice;
(2) **summer coastal program**: coastal erosion and sediment transport
(3) *Arktos-ß* cruise: geophysical surveys and sampling using amphibious vehicle;
(4) *Nahidik* cruise: geophysical surveys and coring using shallow-draft vessel;

OBJECTIVES

The objectives of the 1991 field work were:

(1) to collect data on shallow stratigraphy in the coastal zone with particular emphasis on characterizing the offshore to onshore transition, to provide a framework for detailed studies of pipeline routes and coastal stability;
(2) to investigate nearshore wave dynamics, circulation, and sediment transport in the vicinity of North Head in order to understand the present status and future development of the coast in that area;
(3) to maintain the GSC network of coastal erosion monitoring stations in the western Arctic;

(4) to collect materials for palynological analysis in modern coastal environments as an aid to interpretation of shallow stratigraphy and studies of recent changes in sea level.

The spring coastal program in March dealt with objectives 1 and 2. The summer program, in July and August, was concerned with items 2, 3, and 4. The *Arktos-ß* and *Nahidik* cruises, in August and September respectively, were designed primarily to address objective 1 but also supported objective 2.

STUDY AREA AND PREVIOUS WORK

Surficial Geology and Thermal Conditions

The study area is shown in Figure 1. The onshore surficial geology of the North Head area (Rampton, 1988; Kurfurst and Dallimore, 1989) consists of discontinuous till underlain by sands of the Kittigazuit and Kidluit formations. Well within the zone of continuous permafrost, the area contains abundant evidence of active thermal processes. Permafrost reaches thicknesses up to 700 m. Ice bonding or visible ice occurs in most of the sediments and massive ice is present in a variety of lenses and wedges. In some locations, ice may represent up to 13% by volume of the upper 8 m of ground (Wolfe, 1989). Ice wedges can be up to 1 m wide and 5 to 8 m deep.

Degradation of massive ice results in the development of thermokarst topography. On Richards Island and the Tuktoyaktuk Peninsula, the land surface is mottled with thermokarst lakes (Figure 1). The lakes enlarge progressively by melting at their edges, producing distinctive retrogressive-thaw failures in the form of flow-slides with ice-rich headwalls feeding sediment onto mudflow aprons. Deep taliks (unfrozen zones) form beneath the lakes as a result of thawing of the permafrost underneath the accumulated water. The coastline adjacent to thermokarst-dominated areas is convoluted (Ruz et al., 1992), attesting to recent relative sea-level rise and associated breaching of the lake basins (Figure 1).

Paleoecology

Palynological studies of the Holocene vegetation history for Tuktoyaktuk Peninsula show that average summer and annual temperatures were about 3°C higher than present during the last warm interval, from about 7,000 to 5,500 years B.P. (Ritchie, 1984). Peat layers from boreholes in the upper Mackenzie Delta (Johnson and Brown, 1965) and from the Beaufort Sea also show that there was an early (pre-Holocene) retreat of continental ice along the coast from Mackenzie Trough to Cape Dalhousie (Figure 1), with a steady rise in relative sea level (RSL) from about 8,000 to 4,000 years B.P. (Hill et al., 1985). These paleoecological data are important for predicting the changes that might accompany continued global warming and

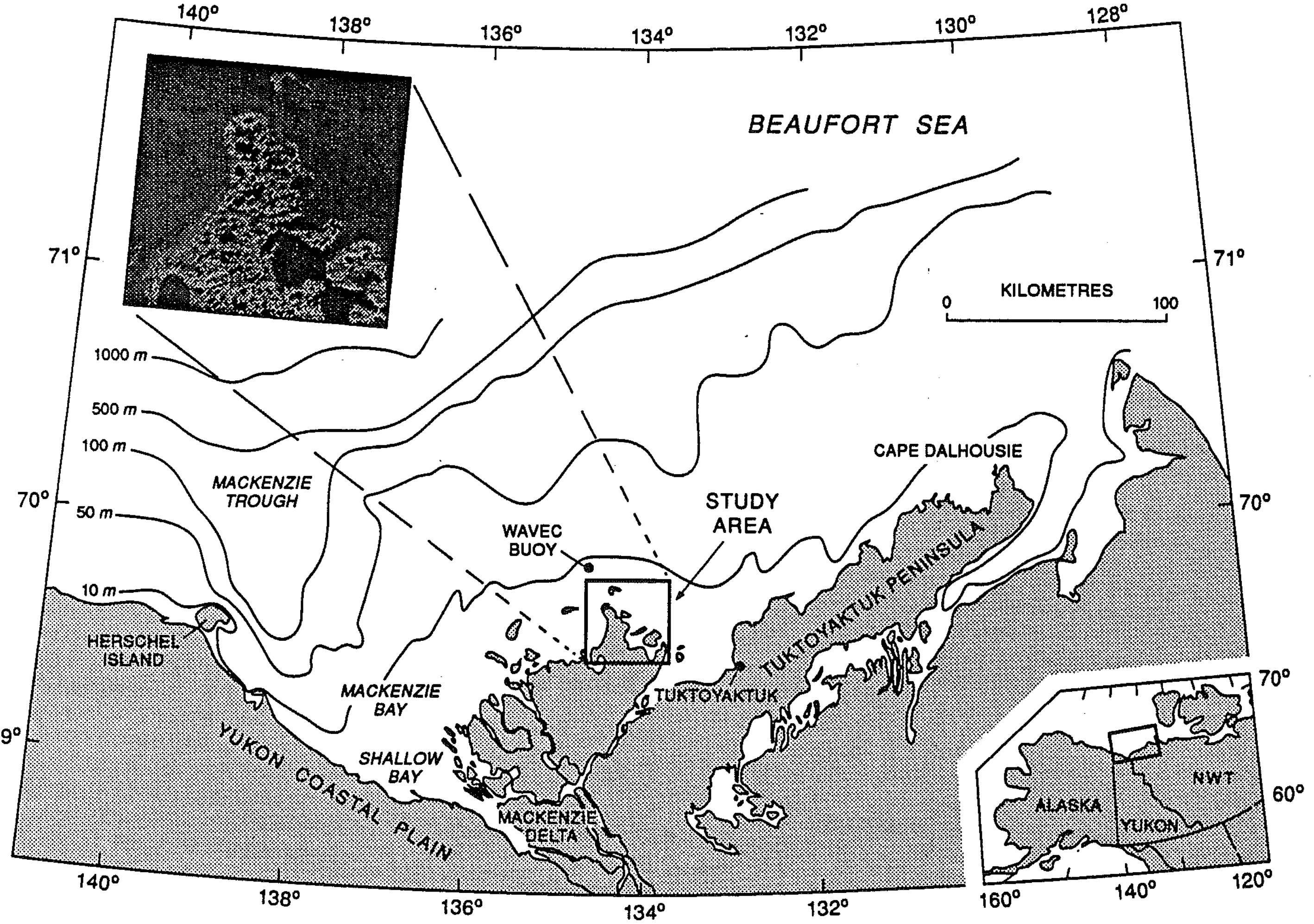


FIGURE 1: Canadian Beaufort Sea showing North Point study area and Wavec position.

RSL rise along the Beaufort Sea coast. However, there have been few previous paleoecological studies of estuarine and nearshore sediments of the outer Mackenzie Delta (Mudie, in press) because of a lack of surface sample controls needed for precise interpretation of fossil records, and a lack of data on the relation between modern plankton species and microenvironments in the Delta (Bujak and Davies,.1987). Quaternary paleoenvironmental studies have also been limited by the sparcity of calcareous fossils (foraminifera and molluscs) in the surface sediments below the freshwater plume of the Mackenzie River (Vilks et al., 1979). A summer field program was therefore organized in 1991 to obtain baseline data on acid-resistant microfossil assemblages, including pollen, dinoflagellates, acritarchs, and algal and fungal spores in various micro-environments along the coast in the Richards Island area. These studies were designed to determine the correlation between microfossil distributions, RSL, water salinity, and marsh vegetation in the vicinity of the outer Mackenzie Delta.

Climatology and Coastal Processes

The dominant storm winds, waves, and sediment transport are from the west and northwest. However, the effectiveness of the wind to generate waves during the 4-month open-water season is limited by the presence of sea ice offshore. In heavy ice years, such as 1991, pack ice can be present within 20 km throughout the summer. The ice-limited fetch results in relatively small waves (deepwater characteristic wave heights H_s< 4 m and peak periods T_p< 8 s). The very gentle slope of the shoreface in the Richards Island area leads to significant wave-energy dissipation over the soft bottom.

In spite of the low-energy wave climate, coastal retreat is rapid, averaging 2 m/a with a maximum rate of up to 20 m/a (Forbes and Frobel, 1985). Rapid coastal erosion results from thermal instability of ice-bonded unconsolidated coastal bluffs. Fine gravel and sand are transported downdrift to accumulate in spits, beaches, bars, and shallow nearshore platforms, with sand forming multiple nearshore bar systems, while finer sand and mud accumulate on the shoreface and in coastal embayments.

Water levels are governed primarily by storm effects (Henry, 1975), with the tides playing a secondary role. The tidal range is less than 0.5 m, whereas maximum storm surge levels of more than 2.5 m above MWL have been interpreted from log debris lines (Forbes and Frobel, 1985; Harper et al., 1988). Typically, northwest winds cause positive surges and easterly winds cause negative surges. A one-metre rise in water level over 12 hours is not unusual.

Offshore Geology

Silty clays are currently being deposited on the inner shelf in water depths greater than 5 m (Vilks et al., 1979; Blasco et al., 1990). The Mackenzie River supplies copious quantities of suspended material to its delta during the summer months. Estimates of sediment discharge

are in the range of about $35x10^6$ to $182x10^6$ tonnes/year (Hirst et al., 1987). Inshore of the 5 m isobath, sediment textures range from muds to medium sands. Recent grab sampling undertaken as part of the 1990 NOGAP field program, within and adjacent to embayments on the northeast coast of Richards Island (Hill and Frobel, 1991), indicated that muddy sand is the dominant sedimentary material present between 1.0 and 2.5 m water depth.

The inundation of permafrost-bearing coastal deposits by the sea results in higher mean annual seabed temperatures and the initiation of gradual thaw where the water depth is greater than about 1.5 m (Taylor, 1991). Under these conditions, the seabed is separated from overlying ice by an insulating layer of water. Two boreholes in the vicinity of a large, recently prograded spit complex extending south east from North Head (informally named Wolfe Spit) encountered ice-bonded sediments to a depth of >20 m (Dyke in Dallimore et al., 1991). A third borehole in deeper water (1.7 m) was ice-bonded to a depth of only 1.5 m.

The extensive distribution of onshore permafrost and ground ice and its impact on the regional geomorphology suggest that thermal conditions within the coastal and nearshore zones may play a significant role in the distribution of sediments and geotechnical properties. To date, investigations within these areas have been limited to borehole studies by the GSC (Kurfurst, 1984, 1986, 1988; Hill et al., 1986) and industry (unpublished). High-resolution geophysical surveys were required to provide a framework for these studies, but they had not been undertaken previous to the 1991 survey because the water depths are too shallow for conventional survey vessels. The recent NOGAP field programs were designed in part to address this problem by using innovative technology.

PERSONNEL

Spring coastal program

Steve Solomon, senior scientist, AGC/GSC
Philip R. Hill, contract geologist, HGR
Alan Judge, geophysicist (radar), TSD/GSC
Jean Pilon, geophysicist (em conductivity), TSD/GSC

Summer coastal program

Donald Forbes, senior scientist, AGC/GSC
Dave Frobel, scientific support technician, AGC/GSC
Elaine Bishop, student assistant, AGC/GSC/ McMaster University
Robert Harmes, scientific support technician, AGC/GSC
Peta Mudie, palynologist, AGC/GSC

Arktos-ß *cruise*

Steve Solomon, senior scientist, AGC/GSC
Lori Henley, pilot, CCG (Northern)
Ian Marr, pilot, CCG (Northern)
Don Locke, electronics technician (acoustics), AGC/GSC
Darrell Beaver, program support technician (navigation), AGC/GSC
Mike Hughes, program support technician, AGC/GSC
Duncan Ferguson, contract engineer, WOL
Bill Scott, contract geophysicist (resistivity), C-CORE

Nahidik *cruise*

Steve Solomon, senior scientist, AGC/GSC
Mike Hughes, program support technician, AGC/GSC
Tony Atkinson, electronics technician (coring), AGC/GSC
Don Locke, electronics technician (acoustics), AGC/GSC
Darrell Beaver, program support technician (navigation), AGC/GSC

ACKNOWLEDGEMENTS

The field activities described in this report were supported by the Polar Continental Shelf Project (PCSP) and by the Science Institute of the Northwest Territories (SINT). We thank Claude Brunet, Barry Hough, Charlie Beatton, Debbie Cloutier, and Eric Osmond (PCSP Tuktoyaktuk) and Les Kutny and Gary White (SINT Inuvik Research Lab) for their assistance. The pilots and engineers of Canadian Helicopters based at PCSP in Tuktoyaktuk provided safe and essential transportation and Twin-Otter crews from Aklak Air in Inuvik assisted in delivery and removal of equipment directly to and from an unprepared strip on Wolfe Spit. We appreciate the efforts of staff at Technical Field Support Services (EMR) in Hull, Québec, without whom much of the necessary field equipment would not have been available. Mark Chin-Yee and Dick Wardle of Bedford Institute of Oceanography are thanked for their efforts in design and fabrication of the current meter stands.

Arktos-β and CCGS *Nahidik* were provided by the Canadian Coast Guard (Department of Transport). Captain E. Lien of *Nahidik* and his crew were enthusiastic and professional in helping us to meet our objectives. The *Arktos-β* pilots, Ian Marr and Lori Henley, contributed not only their excellent driving skills but also their spirited assistance around the camp. Duncan Ferguson of Watercraft Offshore Limited was even more central to the success of the *Arktos-β* program. We are grateful to all of the technical staff whose names are listed in the personnel section above. Their dedication under trying conditions deserves special credit. The Marine Environmental Data Service (MEDS/DFO), Ottawa, collaborated in the deployment of the Wavec buoy off North Head by providing the equipment and covering shipping costs. Jim Murphy, André Bolduc, Don Spear, and Jean Gagnon of MEDS supported the project enthusiastically and contractors Randy Kashino and Lindsay Giles of Seakem in Sidney, B.C., assisted with the instrument deployment and the setup of data-logging equipment at the Hansen Harbour (North Point) camp. OERD provided funds which allowed us to enhance the acoustic survey output.

Appendix E1 was prepared by Dave Frobel. The data inventory tables in Appendices C2 and D2 were prepared by Darrell Beaver. We thank Dave Frobel and Mike Lewis for reviews of the draft report.

SPRING COASTAL PROGRAM

Objectives

The purpose of the program was to collect cores and perform geophysical surveys (shallow electromagnetic and ground-penetrating radar) in shallow embayments on the northeast side of Richards Island (Figure 1). The North Point area has been identified as a potential shore-crossing site for a pipeline from the Amauligak field offshore (this is the source of the informal name 'Pipeline Harbour' for the embayment in which most of the coring was done). Material from the cores was to be dated and a number of chemical and physical properties were to be measured in order to ascertain the rate and type of sediment accumulation. The geophysical surveys were to provide information on sediment properties, ice thickness and shallow stratigraphy.

Methods and logistics

The field program was based at the Polar Continental Shelf Project base camp in Tuktoyaktuk, Northwest Territories. A Bell 206L helicopter was used to fly to the field site at North Point whenever weather permitted. A snowmobile and sled were slung to the site and were used to transport personnel and equipment between coring locations. Weather conditions during the period permitted operations about 70% of the time with ice fog being the main cause of lost time. Daytime temperatures were generally between -30° and -20°C and winds were about 10 to 30 km/h.

Navigation

Drilling sites were located using a Trimble™ Global Positioning System (GPS) receiver onboard the helicopter. Geophyscial survey positions were chained from auger locations along bearings. The GPS positions are believed to be accurate within ±30 m.

Drilling/coring

Note: the first 5 digits (91600) are omitted from all core numbers quoted below.

Drilling was performed using a CRREL ice auger which had been modified to core in sediments. The auger is approximately 0.5 m long and is powered by a two-stroke gasoline engine. The technique for coring is to drill approximately 20 to 30 cm into the material and then extract the core. The auger works very well in ice and well-bonded icy sands. As the auger penetrates, the ice or frozen sediment expands slightly and is held firmly in the core barrel as it is extracted from the hole. The core is then removed through the top of the auger and the hole is re-entered until the desired penetration depth is reached.

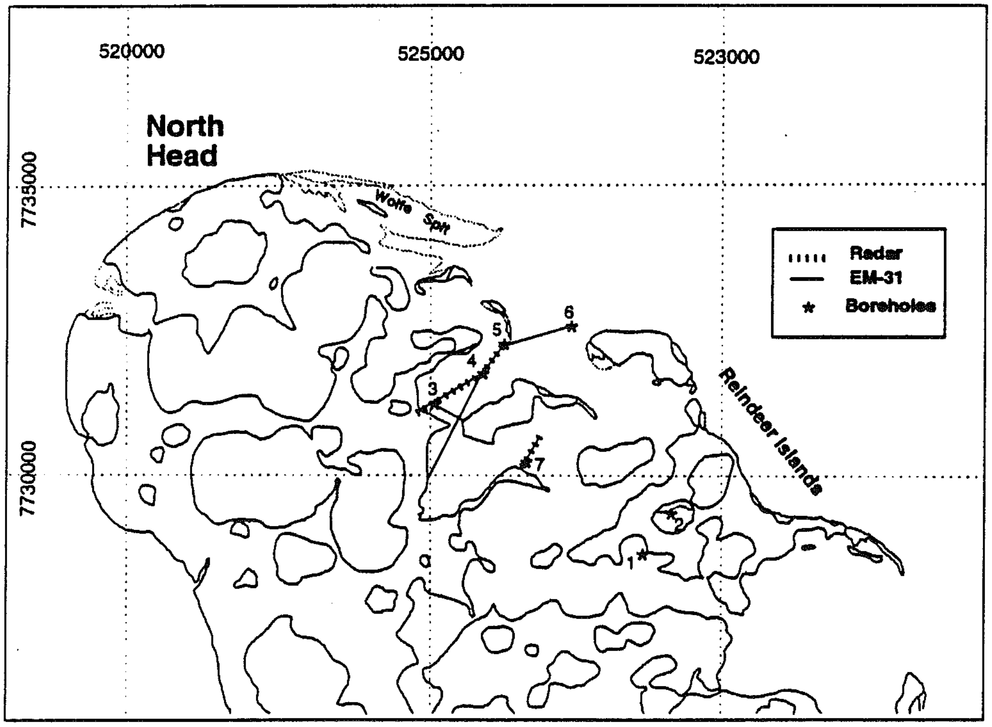


FIGURE 2: Drilling locations and geophysical profile lines, March 1991.

In less well-bonded materials and in more clay-rich sediments the auger does not perform as well. Based on previous experiences in the area (Dyke in Dallimore et al., 1991; Wolfe, 1989), we anticipated that the seabed sediments would be very well-bonded in water depths of less than about 1.5 m (the zone in which the sea ice freezes to the bottom). Although ice and frozen sediments were found in all drilling locations, the coring operations did not proceed entirely smoothly. In most of the holes it did not appear that the material had sufficient strength to withstand the torque induced by the rotating core barrel. At locations 003, 004, 005, and 006 (Figure 2), the sandy sediments were reduced to a disaggregated mixture of mud, sand, and ice. Muddier material was more cohesive and came to the surface as puck-shaped disks or cylinders. The cores retrieved at locations 001 and 007 (Figure 2) were continuous and very well preserved. The former location however, was very difficult to penetrate, probably because of its relatively high clay (and associated water) content. In one location (002), a freshwater lake, unfrozen water was encountered beneath the ice and the core barrel froze in too solidly to be extracted with the available tools. The site was marked with a buoy for retrieval of the core barrel in the summer.

Subsampling

Cores were kept frozen at ambient temperatures and flown to the Inuvik Research Centre. The cores were then split using a hammer and a knife, photographed, thawed, and subsampled for textural analysis, ^{210}Pb dating, and magnetic susceptibility measurements. The textural samples will also be used for water content and salinity measurements. Core from hole 001 was thawed prior to splitting and therefore was difficult to handle and not photographed. Cores from locations other than 001 and 007 consisted of mixtures of core and disaggregated sand and ice. Where possible the core fragments were split and photographed after the vertical orientation was determined. In some cases, it was not possible to obtain an orientation for the fragments with confidence.

Geophysical Surveys

Electrical conductivity measurements were made with a Geonics™ EM-31 electromagnetic conductivity meter. The measurements were made to assess the electrical properties of the materials in the vicinity of the core holes. Lines were chained from each core site to the next with conductivity stations every 10 or 20 m (Figure 2). Several lines were run along bearings from core locations. The instrument was checked every day of use at hole 003 to ensure that drift was negligible. In order to maximize the amount of information obtained, readings were taken with the instrument on the ice surface in both the vertical and horizontal dipole modes. The horizontal mode effectively halves the penetration distance of the unit so that vertical variation in electrical properties can be ascertained.

Ground-penetrating radar (GPR) surveys (Figure 2) were performed using a PulseEKKO™ IV digital GPR system with 100 kHz antennae and and an antenna spacing of 1 m. Lines were

run with soundings at 1 m intervals along several of the EM lines. Returns were recorded on a portable computer. Each sounding location represents an average of 64 soundings.

Operations and Preliminary Results

Drilling locations for this study were chosen based on their proximity to the proposed pipeline route, degree of exposure to the open sea, and relationship to beach profiles surveyed in the summer of 1990 (Hill and Frobel, 1991). Drill site coordinates are provided in Table 1 and geophysical survey lines are shown on Figure 2. Lithostratigraphic logs are presented in Appendix A.

TABLE 1

Coring sites (March 1991)

Hole number	Northing	Easting	Ice Thickness	Total Penetration
001	7728747	528607	0.70 m	1.92 m
002	7729377	528998	1.50 m	1.50 m
003	7731293	524992	0.73 m	2.71 m
004	7731664	525842	0.83 m	1.78 m
005	7732141	526326	0.72 m	2.10 m
006	7732575	527237	1.22 m	1.75 m
007	7730223	526625	0.44 m	2.39 m

Hole 001 (Figure 2) was drilled in a very protected embayment. The material at this site consisted almost entirely of well-bonded clay and mud with visible ice veins throughout. The bottom 28 cm contained pebbles. Hole 002 was drilled in a thermokarst lake and was not successful in recovering any core. The auger penetrated the ice cover, entered the unfrozen water below and froze in place. The hole was attempted within about 15 m of the shore of the lake, illustrating the rather steep slope of the lakebed (about 10%).

Holes 003 to 006 were chosen to investigate sediment properties along the proposed pipeline route. Hole 003 was closest to a proposed landfall. All four holes presented similar drilling difficulties and produced discontinuous recoveries. Hole 003 (Figure 2) consisted of olive grey, fine- to medium-grained sand, overlain by about 20 cm of silty clay. Where intact sections of core were recovered, the sand was massive and uniform in size. Recovery of core from hole 004 (Figure 2) was very poor and the entire core consisted of cuttings of sandy and muddy ice with thin discs of intact core material. Core recovery from hole 005 consisted of

interbedded sandy mud and muddy sand with abundant cuttings and ice. In some intervals, the sands and muds were thinly interlaminated. Core from hole 006 consisted of massive silt and thinly laminated silty clay where intact core was recovered.

Hole 007 (Figure 2) was located in an embayment southeast of the pipeline embayment at the end of a beach profile line (90-4 *[=5043-04]*; Figure 3) surveyed during the summer of 1990 (Hill and Frobel, 1991). Core recovery was excellent. The core consisted of a lower unit of sand and muddy sand with occasional bivalves and pebbles, overlain by silty clay with ice veinlets. The latter graded into an upper unit of very fine grained, massive to thin-bedded sand.

Ground conductivity measurements have been plotted on a UTM grid and are displayed in Figure 2. The most obvious features of the measurements are the areas in which conductivities exceed about 200 milliSiemens/metre (mS/m) and areas which are <5 mS/m. The high conductivities represent locations where unfrozen brines are present beneath the ice (i.e. water depth > ice thickness). The very low conductivities are found in close proximity to the shoreline in very shallow water and may represent permafrost. Intermediate conductivities suggest locations where the sea ice is bottomfast and the bottom sediments are freezing to some depth beneath the ice. Further work is in progress to model the electrical variation with depth and to extract lithological and/or salinity information from the data.

Unprocessed data from the radar surveys indicate that the GPR system can penetrate the sediments in this area to depths of approximately 15 metres and that the sediments are layered. Further processing is required to ascertain the coherence of the layering and the geological properties which are represented. Earlier work in this area (Davis et al., 1976) suggests that it is possible to detect massive ice within the sediments as well as lithological boundaries.

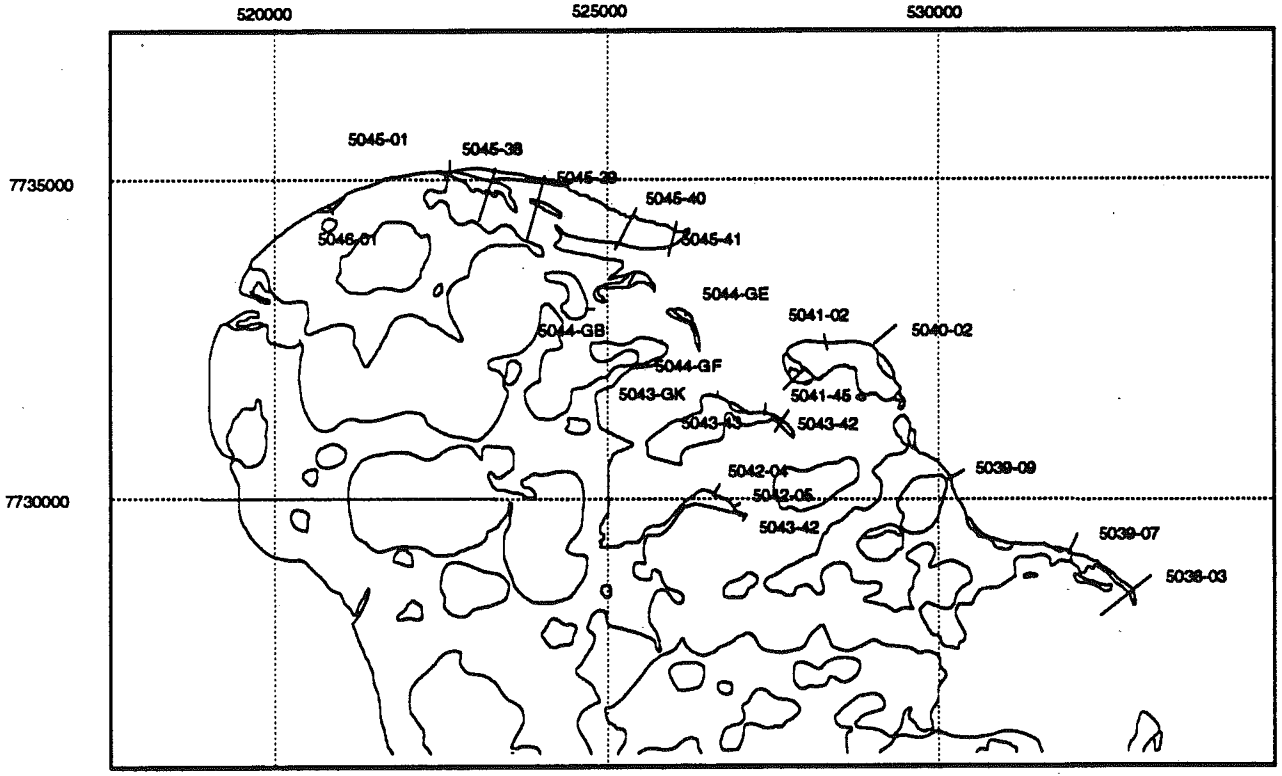


FIGURE 3: Cross-shore profile lines in the North Point area, 1990 and 1991.

SUMMER COASTAL PROGRAM

Objectives

This activity was organized with several distinct objectives. The first was to investigate sediment transport processes in the coastal zone around northern Richards Island, with the following purposes: (1) to provide a framework for interpreting the shallow acoustic and lithostratigraphic data obtained in other phases of the program, as a basis for developing a coastal sediment budget for the northeast Richards Island coast; (2) to assist in determining the stability and future evolution of shore-zone depositional systems in the area; and (3) to provide insight into possible engineering problems associated with trenching for a pipeline. The second objective, related to longer-term needs and the broader aspects of the NOGAP project, was to resurvey a number of sites as part of the ongoing maintenance of the GSC network of coastal monitoring stations in the western Arctic. The third objective was to collect material for palynological analysis in order to provide an improved basis for interpretation of relict coastal deposits in cores and to assist in developing an improved understanding of recent sea-level adjustments in the southern Beaufort Sea.

Methods and logistics

Logistics

Several activities were undertaken simultaneously to achieve the several objectives of this program. A camp ["North Point"] was established at Hansen Harbour on Richards Island (Figure 1) in late July. CCGS *Nahidik* transported equipment from Tuktoyaktuk to a short distance off Hansen Harbour. A Bell 206L helicopter was then used to sling the gear ashore. The camp was later shared with the geophysics program, when additional equipment was brought in from Tuktoyaktuk aboard *Arktos-ß* and by helicopter. Local shore surveys and nearshore oceanographic studies in the northern Richards Island area were carried out from the camp using a 5-m inflatable boat with 8 and 25 hp outboard motors. In general, this proved to be a reasonable form of tranportation inside the embayments, although we had some difficulty with the extensive shallow depths at low water levels. The rubber boat was less satisfactory for work in unprotected areas, in particular for working on the outer beaches in rough weather. Travel times from the camp to field sites between the Reindeer Islands and North Head ranged from roughly 30 to 100 minutes, depending on weather conditions. The physical difficulty of access and extended travel times are estimated to have reduced overall accomplishments to about 65% of the intended program.

Regional surveys were conducted with transportation provided by Bell 206L helicopter flying out of Tuktoyaktuk, refuelling at Shingle Point, Camp Farewell, and the Richards Island camp.

TABLE 2A

Shore profiles surveyed in northern Richards Island area during 1991 (Figure 3): GSC/AGC site, line, and benchmark numbers, line orientation, GPS coordinates for benchmarks, and dates of survey in 1991 and earlier (where applicable).

site	line	BM	orientation (°True)	latitude (°North)	longitude (°West)	date (YY/MM/DD)
5038	03	rod[1]	050	69.664752	134.150327	90/07/29[a]
		279		69.664983	134.150747	91/08/18
5040	02[2]	**308**	046	69.700118	134.249980	91/08/03
						91/08/11
						91/08/19
5041	02	rod[3]	002	69.700403	134.265960	90/07/29[a]
						90/08/04[a]
						90/08/15[a]
						91/08/12
	GL	stake[4]	345	69.700167	134.277452	88/08/10[b]
						90/08/01[a]
		317				91/08/12
5043	GK	stake[4]	000	69.693407	134.312105	88/08/10[b]
						90/08/02[a]
		316		69.693645	134.312085	91/08/17
5044	GE	stake[4]	033	69.704992	134.321200	88/08/07[b]
						90/08/02[a]
		276		69.705130	134.321323	91/08/17
	GF	stake[4]	042	69.701285	134.331680	88/08/07[b]
						90/08/02[a]
		277		69.701193	134.331735	91/08/17
5045	01	**311**	010	69.720763	134.415225	91/08/01
						91/08/10
	39	**318**		69.720067	134.380098	91/08/05
						91/08/10
						91/08/19
5046	01	rod[5]	331	69.720075	134.458623	90/07/30[a]
						90/08/04[a]
						91/08/02

[1] rebar (90-03 BM 1)
[2] also lines 3 and 4
[3] rebar (90-02 BM 1)
[4] wooden stake (rear marker)
[5] rebar (90-01 BM 1 and inst. pin)
[a] Hill and Frobel (1990)
[b] Gillie (1989)

TABLE 2B

Other shore profiles surveyed in the Beaufort Sea during 1991 (Figure 4).

site	line[a]	BM[b]	orientation (°True)	latitude[c] (°North)	longitude[c] (°West)	date (YY/MM/DD)
Yukon/Alaska boundary						
5010	01	monument[1]	000	69.645922	140.997447	12/07/30
						72/07/17
						84/07/28
						91/08/07
	02	**333**	024	69.646207	140.996340	91/08/07
	03	**334**	024			91/08/07
	04	**335**	024			91/08/07
Komakuk Beach						
5011	01	rod[2]		69.595797	140.186300	86/07/18
						91/08/07
	02	**336**	328			91/08/07
Tuktoyaktuk						
5012	01	**288**[3]				84/07/25
						86/07/19
		287	304	69.446998	133.038477	91/08/08
	02					84/07/25
						86/07/19
		289				91/08/08
	03	DLS[4]		69.450732	133.036797	84/07/25
						86/07/19
		290				91/08/08
	04					84/07/25
						91/08/30
Tent Island						
5340	00	G-1[5]				86/07/13
		GSI[6]		68.916370	136.613302	91/08/09
Ellice Island						
5360	00	G-2[7]		69.288922	135.854583	86/07/13
						91/08/09

[1] International Boundary Commission monument

[2] rear marker: rod+ wooden 2x2 (1985)

[3] forward benchmark (1991)

[4] Dominion Land Survey benchmark (1949)

[5] 1986 BM on one of several lines surveyed (see Gillie, 1987)

[6] GSI Syledis 1 (1988)

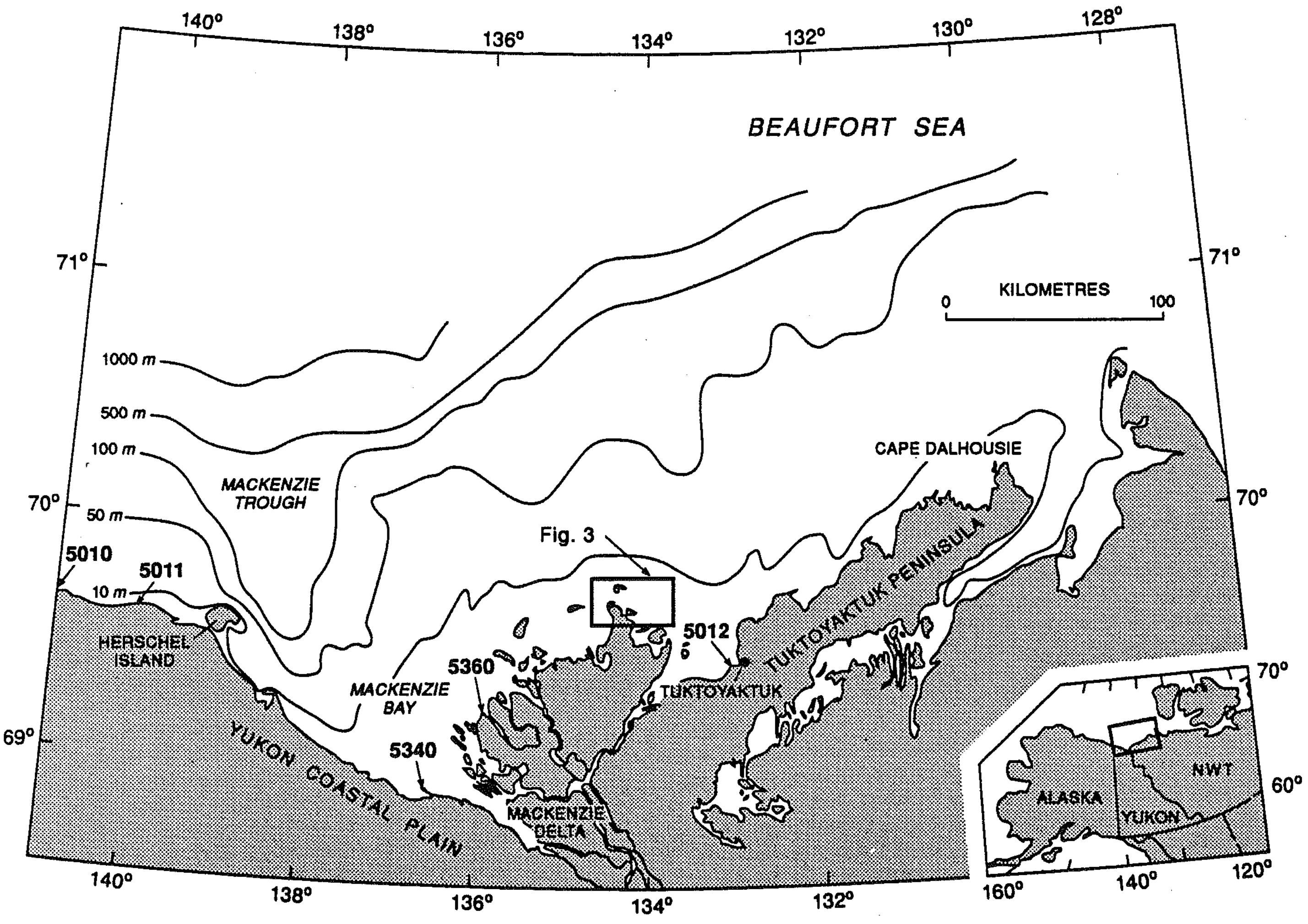


FIGURE 4: Regional monitoring network, 1991 surveys.

Surveys and positioning

Beach and cliff profiles were surveyed at a number of locations, some of which corresponded to earlier surveys in 1985, 1986, and 1988 by Gillie (1987, 1989) and in 1990 by Hill and Frobel (1991). Vertical air photographs were used as the principal method of locating sites in the field. All reoccupied sites were marked by survey pins, wooden posts, steel rods, or rods with aluminum benchmark caps hand scribed with Roman numerals (Gillie, 1987). In 1991, for the first time, we began installing Geological Survey of Canada benchmarks with precast Arabic numerals in a series from 001 to 500. The site numbers, line numbers, dates, benchmark numbers, and coordinates of lines surveyed in the Beaufort Sea area in 1991 are given in Table 2. Survey locations in the northern Richards Island area are plotted in Figure 3; sites surveyed as part of the wider regional program are shown in Figure 4.

Survey measurements (horizontal and vertical angles and slope distance) were obtained using a Geodimeter^{TM} 1404 infrared electronic total-station survey instrument, with observations taken to a prism mounted on a range pole. Data were stored during the day in a portable memory box (Geodat^{TM} 124) attached to the Geodimeter instrument. At the end of the day, the data were transferred to a computer in camp for reduction to horizontal distance, position, and elevation. Unfortunately, the Geodat failed in early August and much of the survey data had to be handwritten in a notebook, reducing the efficiency of the survey operations. The Geodimeter survey system performed very well, even under quite adverse weather conditions and despite some physical abuse under rough water conditions in the rubber boat. Fog occasionally reduced the range of the system. Although measurements over as much as 2 km were obtained under good visibility, most surveys involved distances of less than 500 m. The nominal accuracy of the system is ±(5 mm +5 ppm). Line bearings were determined using a KVH DataScope^{TM}, a gimballed fluxgate compass with a monocular sight. The resolution of this instrument is 0.1° and the nominal accuracy is ±0.5°.

The coordinates of benckmarks, instrument moorings, and other locations of interest were determined using a hand-held Magellan NAV 1000 PRO^{TM} GPS receiver, averaging 32 individual positions. The accuracy of this system is considered to be better than ±30 m. The mean value of the PDOP (Positional Dilution of Precision) was 1.97 ±0.19 with a maximum of less than 10 (Appendix E1).

Positioning of the echo-sounding line at 5045-01 was by Geodimeter from shore. An echo-sounding profile run by *Arktos-ß* at line 5040-02 was positioned using the onboard GPS receiver (see following section on *Arktos-ß* surveys)

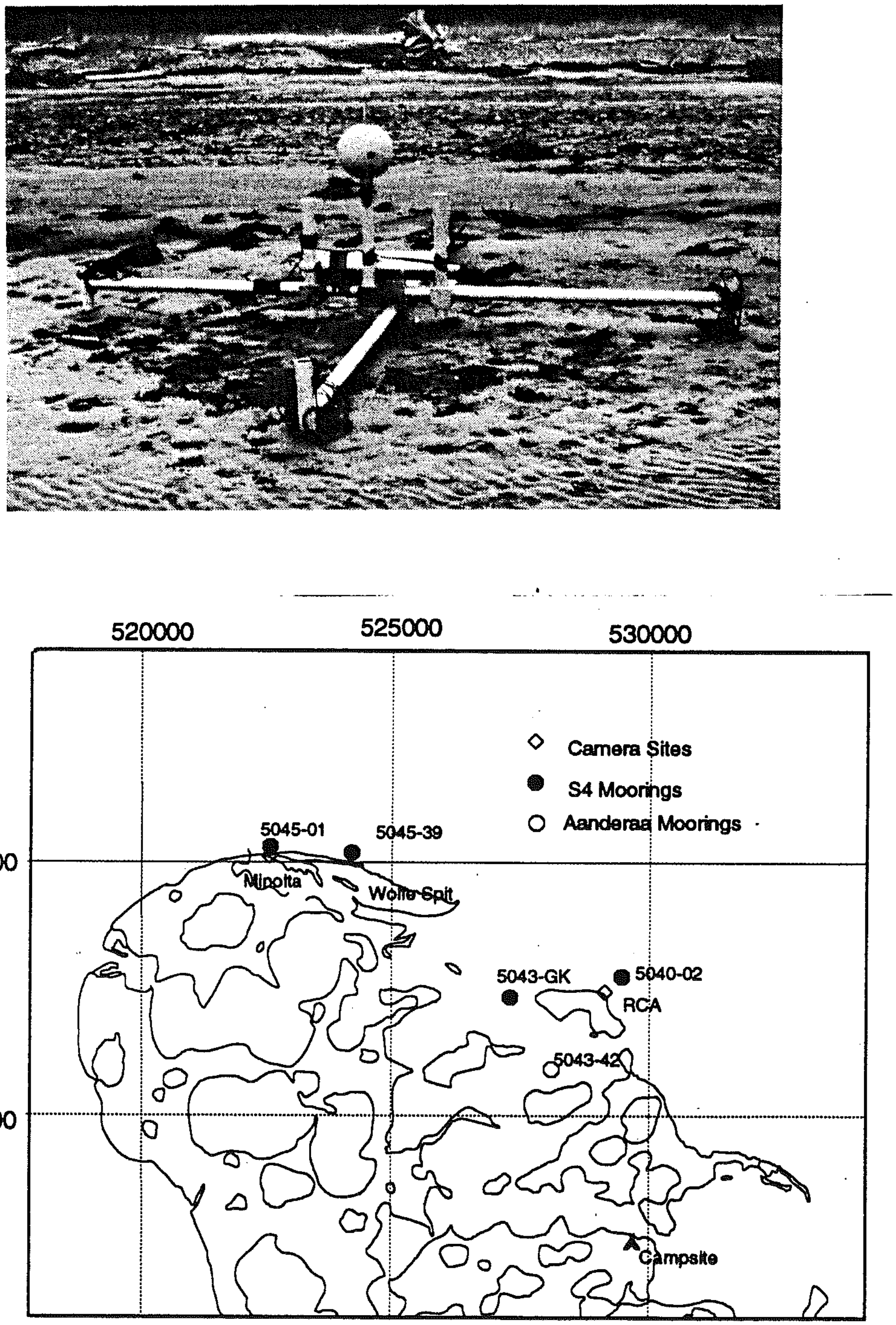


FIGURE 5: Video camera and current meter locations, summer 1991. Above: current meter stand with S4 current meter and optical backscatter (*obs*) instruments.

Oceanographic instrumentation

'Deepwater' directional wave data off North Head were collected in collaboration with the Marine Environmental Data Service (MEDS), who provided a Wavec^{TM} directional wave buoy. This instrument was deployed in 7 m of water west of Pullen Island (Figure 1). The location was chosen so that exposure to northwest storms was maximized while reducing potential interference from pack ice. Unfortunately, during 1991, the pack withdrew only a short distance offshore, returning under northwest wind stress in late August to fill Kugmallit Bay. At that time, the Wavec buoy with its anchor system was carried more than 30 km to the southeast, coming to rest off Crumbling Point. An Argo satellite transmitter allow us to track its whereabouts and eventually to retrieve it using CCGS *Nahidik*. Our original plan called for the deployment of two buoys, one on each side of Pullen Island in 10 m of water, but ice conditions and the lack of a functioning Argo transmitter on the second buoy resulted in the decision to deploy only one. During the functioning lifetime of the western buoy, data on pitch, heave and yaw were collected and archived for 34 minutes every hour over about 4 weeks. Data were telemetered 20 km from the buoy to a receiver setup in a Logan tent at the North Point camp. Because the receiver and logging system required 110V AC power, a diesel generator with gravity-feed fuel supply was set up to operate continuously throughout the period of data collection.

Measurements of nearshore wave conditions were obtained at four locations (Figure 5) using InterOcean^{TM} S4DW electromagnetic current meters with pressure transducers, enabling determination of instantaneous and mean velocities and directional wave spectra. The instruments carried 1 Mb of memory and were programmed to sample at 1 Hz for 540 s every 3 hours. This allowed us to leave them out for about 10-12 days at a time. On one of the instruments (SN# 07581591), the pressure transducer failed and no depth measurements were obtained. This instrument also carried temperature and conductivity sensors, enabling measurements of water temperature and salinity. Two optical-backscatter sensors (*obs*) and data loggers were leased from Coastal Leasing Inc. in Massachusetts. One worked well and the other failed. As a result, good 2 Hz data were obtained 0.2 m off the bed at two locations, but there were no measurements of vertical variation in sediment concentration. The *obs* packages and S4DW current meters were mounted on custom-designed and -fabricated stands (Figure 5 [inset]), providing a stable platform with the current meter at a nominal height of 0.82 m off the bottom. The primary design consideration was that the stands be deployable and recoverable from a single rubber boat and stable under storm conditions.

Observations of breaking-wave characteristics and other beach conditions were made using two time-lapse video systems. These were set up at 5040-02 and 5045-01 (Figures 4 and 5) and operated for about 3 weeks (see Table B3 in Appendix B).

Two paddle-equipped Aanderaa current meters were deployed in a narrow channel in the southern arm of Pipeline Harbour (Figure 5). These instruments were deployed on rope

moorings with steel anchor weights and subsurface floats. Unfortunately, the water depth was barely adequate for this arrangement, the subsurface floats frequently broke the surface, and at one point during the first deployment the mooring came away. As a result, there may be some contamination in the data, although even gross changes in current direction and speed will be valuable indicators of circulation characteristics in the channel system.

Water levels in Hansen Harbour were determined from a graduated staff driven into low-intertidal muds at the North Point camp. The staff, 0.7 m long, was installed on 30 July and observations continued until 23 August. On a number of occasions, water levels overtopped the staff and measurements could not be taken. Tide-gauge data from Tuktoyaktuk have been provided by the Canadian Hydrographic Service for comparison with the Hansen Harbour data. In addition, pressure records from two of the S4DW current meters provide measures of mean water level at the deployment sites on the outer coast.

An attempt was made during the 1991 field program to collect information on longshore sediment transport under storm conditions using streaming traps, as described by Rosati and Kraus (1989). Two trap arrays were deployed at line 5045-39 during a storm on 6 August. The 4-trap array was placed approximately 103 m seaward of benchmark 2 at a water depth of 0.7 m; the 5-trap array was placed 111 m seaward of the benchmark in 0.9 m water depth. The traps consisted of 70-µm polyester filter cloth, 2 m long, with rigid rectangular orifices 140 mm wide by 70 mm high. They were mounted on copper-tube frames at heights of 10, 303, 605, and 900 mm (4-trap array) and 10, 225, 444, 690, and 900 mm (5-trap array), all measurements being to the base of the trap. Suspended sand was successfully sampled in this experiment, but the physical difficulty of access to the beach and deployment of the traps during significant transport events prevented any further use being made of these devices during the 1991 program.

Paleoecology

Field work for paleoecological studies was carried out by sampling surface sediments, vegetation, and water at sites along transects from nearshore marine to freshwater environments on Richards and Reindeer Islands. The transects were located near the coring sites (Figure 2) and the beach profiles (Figure 3). Sediments were sampled with grabs (0-1 cm) and push cores (as long as 30 cm). Water salinity was measured in the field with a Goldberg refractometer. Dominant terrestrial and aquatic plant species were identified in the field using Porsild (1964). Key species were press-dried for detailed lab studies. Sediment samples were stored at 0-5°C in the field and on return to AGC. Unfortunately, samples shipped by air-freight from Tuktoyaktuk took 3 weeks to arrive at AGC, by which time much of the vegetation had decayed.

In the laboratory, subsamples (10-20 cm^3) were processed for palynological studies, using standard methods for marine sediments (Mudie, 1982). The coarse fractions (>125 µm) were

sent to J. Matthews, Terrain Sciences Division, Ottawa, for identification of macrophytes, seeds, and insects. Selected subsamples were sent to Davies Research Limited, Calgary, for taxonomic studies of dinoflagellates and algal spores (Davies and Mudie, in prep.).

Preliminary results

Wind data recorded by the Atmospheric Environment Service (AES) at an unmanned meteorological station on Pelly Island (Figure 6) show several events with northwesterly winds in excess of 10 m/s (10-minute mean) during August 1991. These generated persistent high water levels for a large part of the month and a maximum storm surge of about 1.7 m (1.2 m above MWL) at Tuktoyaktuk on August 24th (Figure 6). In general, water levels at Tuktoyaktuk showed the expected relationship to wind velocity, with lower water levels on August 1-2, 11-15, and 26-31, associated with easterly winds, while water levels were well above average on August 4-5, 6-7, 8-10, and 17-25, with winds out of the north and west. Tide gage data from Tuktoyaktuk shows good correlation with water levels in the North Point area (Hill and Frobel, 1991) and will be used to correct bathymetric data. However, some discrepancies are apparent in the August 1991 data set, in particular during a moderate surge on the 4th (Figure 6) and these will require further investigation and analysis.

The Wavec data are currently being analysed by MEDS personnel in Ottawa and a preliminary report will be issued by that agency. Field data checks revealed maximum wave heights of about 1.5 m on August 4. The maximum 10-minute wind speed that day was about 8.9 m/s or 32 km/h (Figure 6). The largest characteristic wave height measured off the Reindeer Islands (station 5040-02) during the same event was about 0.45 m with a peak period of about 6 s (Figure 7), reflecting energy losses associated with shoaling and refraction over the broad platform south and east of Pullen Island. Although the wind direction and the presumed deepwater wave approach were from the north (Figure 6), the wave approach off Reindeer Islands was almost directly onshore, from the northeast (Figure 7).

Wave-induced oscillatory currents measured by the S4DW current meters occasionally exceeded 1 m/s. Figure 8 shows a typical record from August 4th off North Head, with a mean longshore current of about 0.35 m/s and wave-induced oscillatory currents exceeding 0.5 m/s. Video records suggest that the small wave heights measured reflect the location of the instrument inside the zone of wave breaking during the most severe weather. Optical backscatter detectors recorded time-averaged suspended sediment concentrations up to 5 g/L during storm conditions (Figure 7). Repetitive beach profiles at several sites indicated minor adjustment of the beachface in response to the moderate storm events observed during the field program. Much of Wolfe Spit, the rapidly-growing barrier southeast of North Head (Wolfe, 1989), is low-lying and subject to extensive flooding during moderate storm surges. At the time of the streaming-trap sampling of suspended sediment concentration in longshore drift at line 5045-39 on August 6, the entire barrier was submerged at that location.

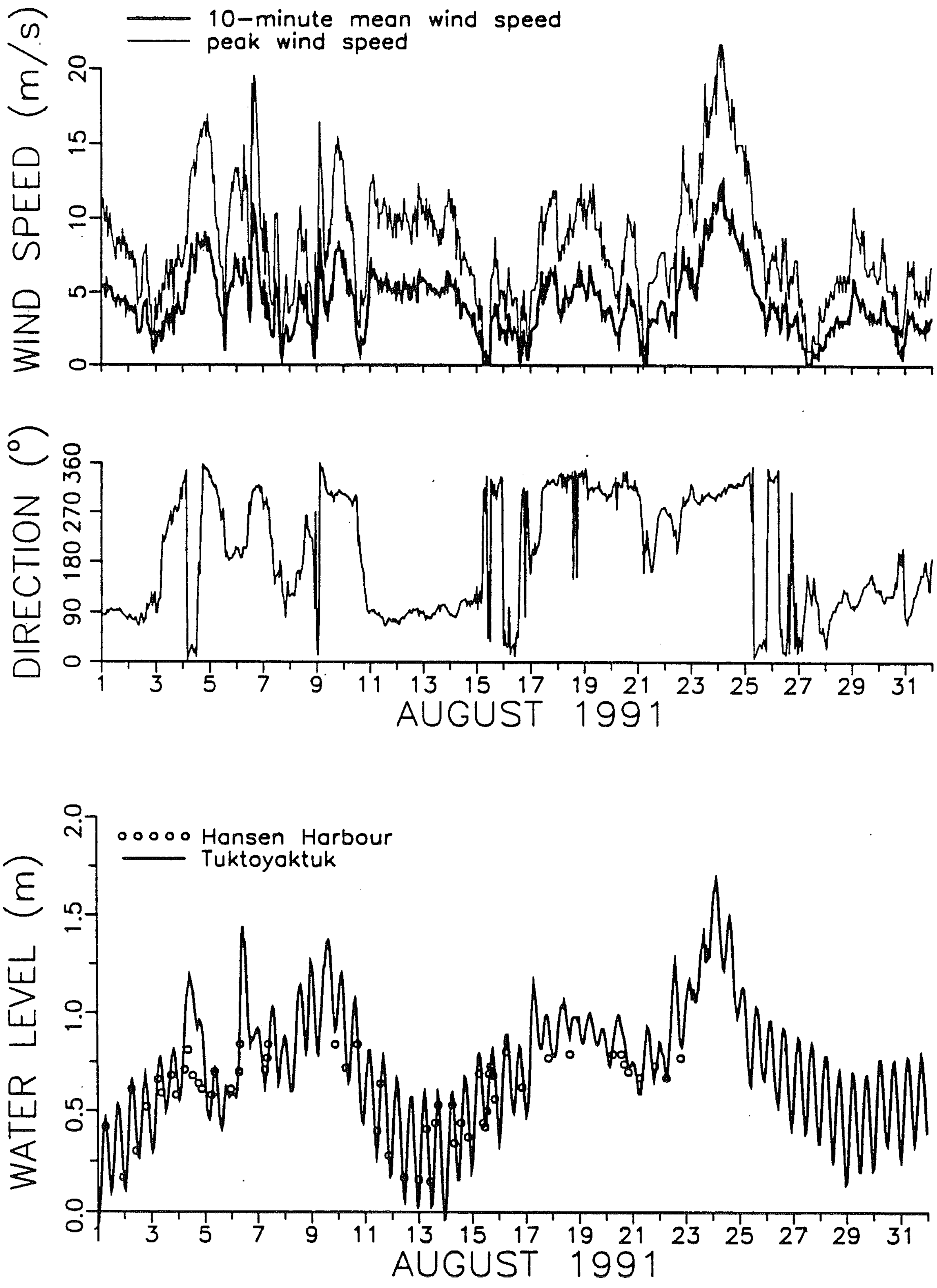


FIGURE 6: Wind and water levels observed during August 1991.

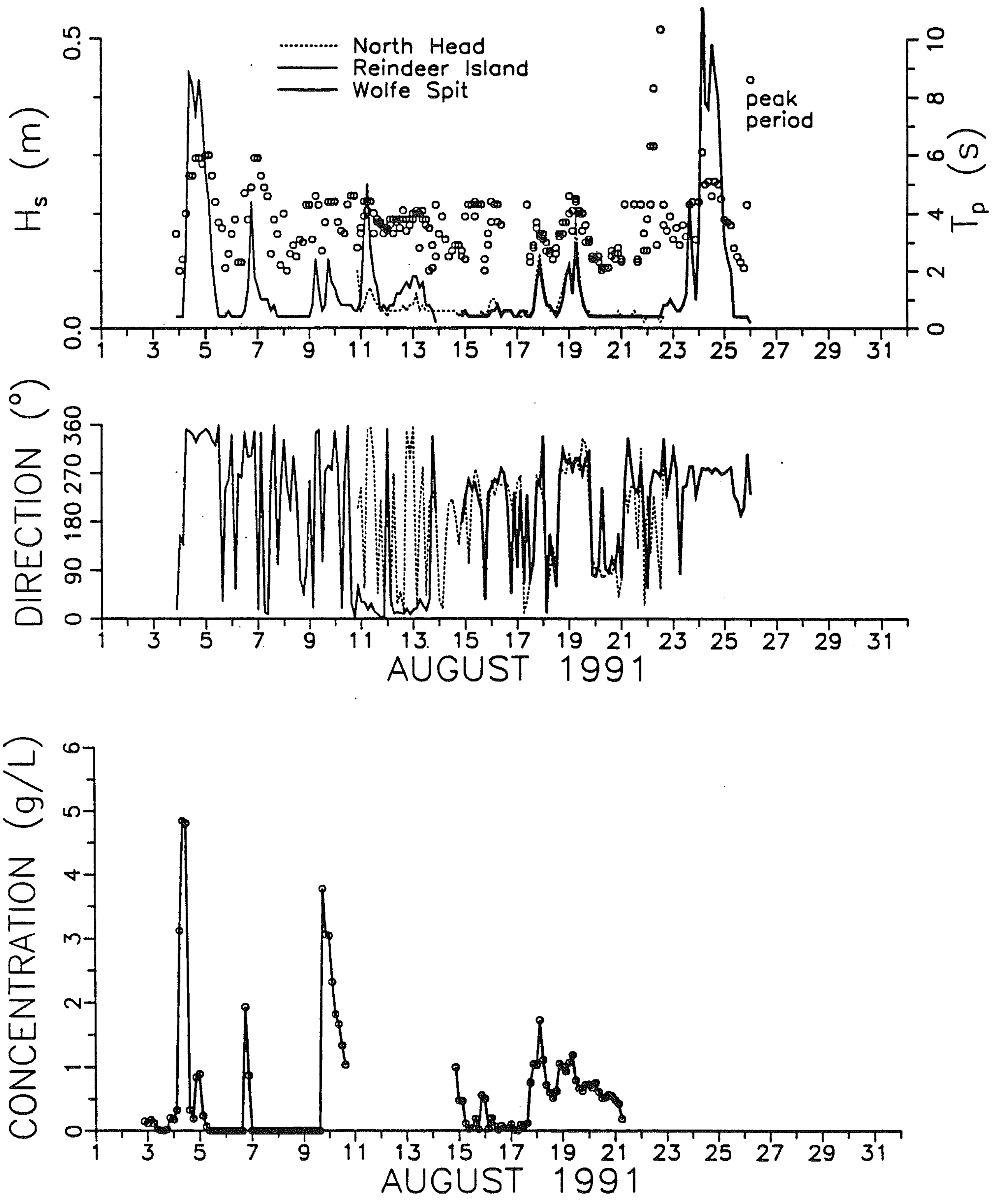


FIGURE 7: Waves and suspended sediment concentrations measured during August 1991. Note that directions are magnetic and should be increased by about 39° to account for declination.

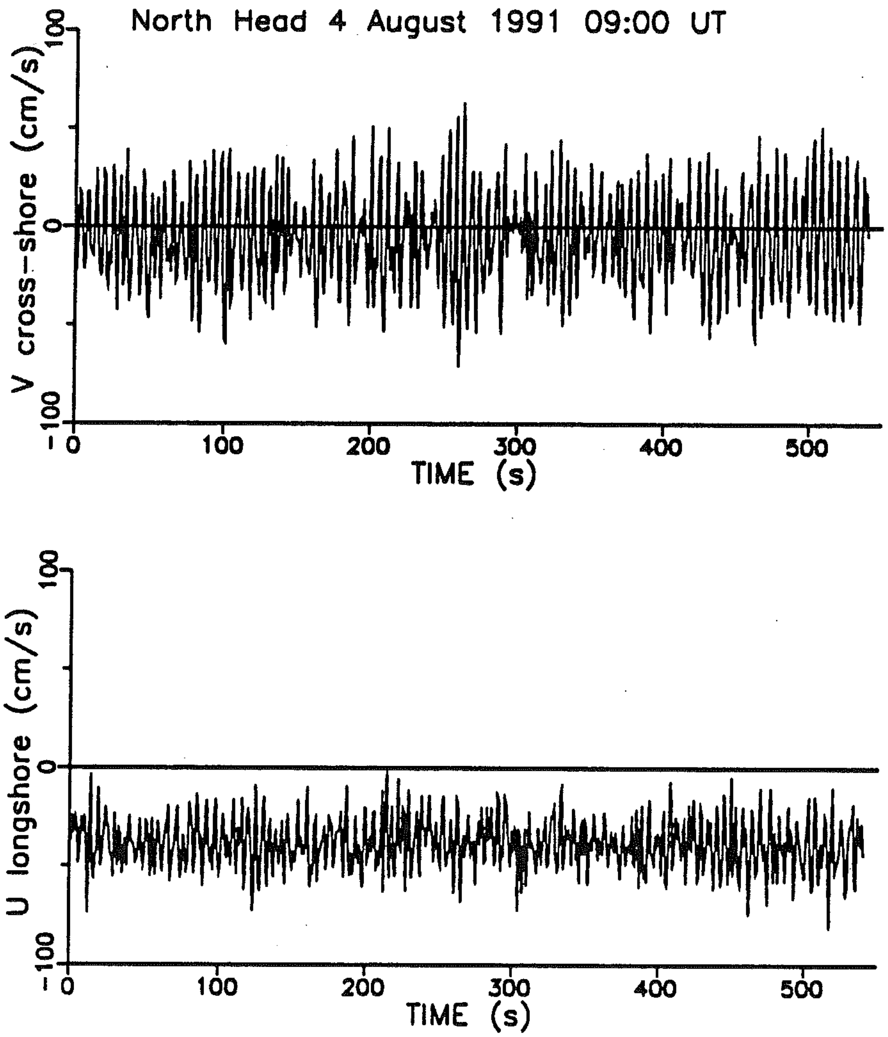


FIGURE 8: Current meter record showing nearshore oscillatory and mean currents at North Head.

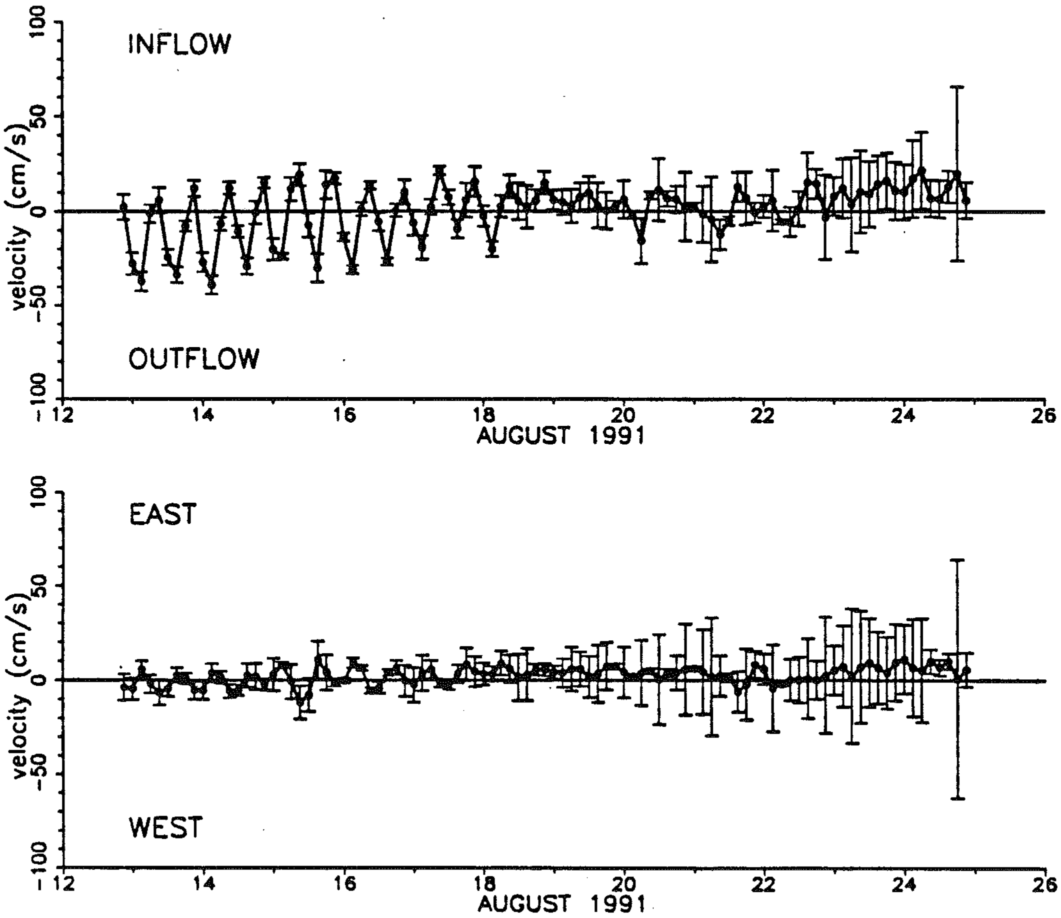


FIGURE 9: Tidal and storm-driven exchange in mouth of Pipeline Harbour during August 1991. Longitudinal and transverse components of velocity showing mean and standard deviation at 3-hour intervals.

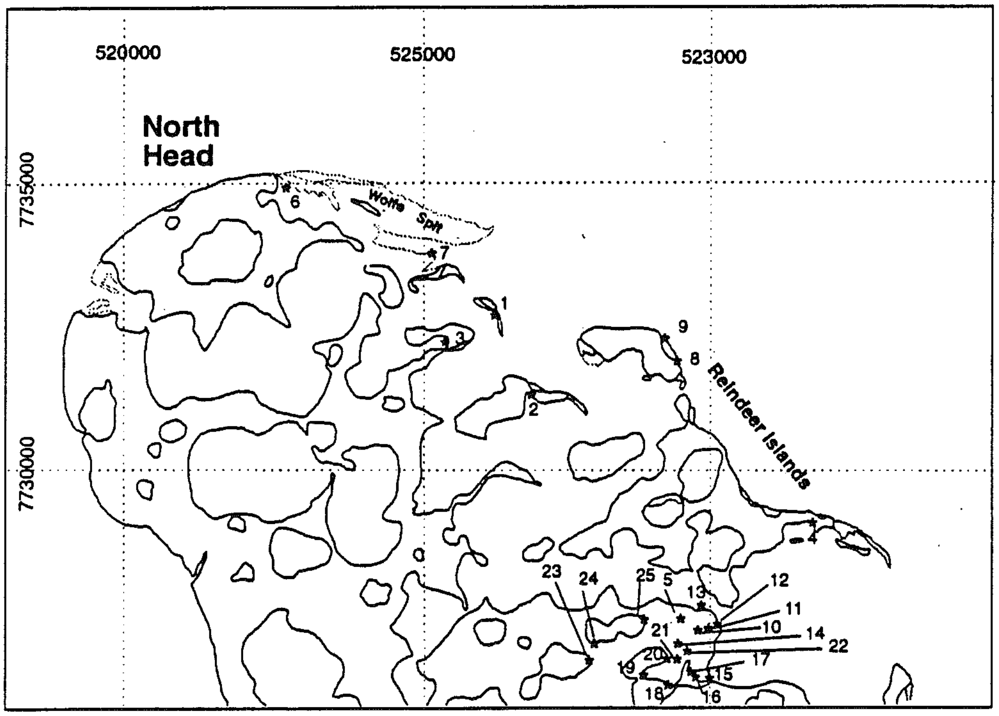


FIGURE 10: Locations of samples collected for palynological analysis.

Current-meter measurements in the entrance to Pipeline Harbour indicated a pattern of tide-driven exchange flow under non-storm conditions, with mean velocities approaching 0.4 m/s at maximum ebb (Figure 9). Storm surges induce large volume changes in the coastal embayments (see Forbes, 1981), resulting in persistent inflow (Figure 9) or outflow lasting more than 48 hours in some cases. These observations lend credence to the view that the channel system identified in the embayment in 1990 (Hill and Frobel, 1991) is a response to present conditions of tidal and storm-driven flow and not a relict lacustrine or fluvial feature.

Regional coastal surveys are part of an ongoing program to monitor coastal recession and beach profile changes in a variety of depositional settings throughout the western Arctic (Taylor et al., 1979; Forbes and Frobel, 1985; Gillie, 1987; Taylor and Forbes, 1987; among others). A number of previously established sites were resurveyed in 1991. It is desirable to reoccupy sites at least once every two years in order to maintain benchmarks and keep pace with the rapid erosion taking place at many sites.

Palynological analysis of surficial materials in modern environments is important for identification and accurate interpretation of paleoecological records in sediment cores. During the field season, baseline surface samples were collected systematically along transects from subtidal marine environments to freshwater lakes and ponds on Richards and Reindeer Islands (Figure 10). Polygons and other freshwater thermokarst basins were also sampled (Appendix B3). These data provide the first information on the assemblages of terrestrial pollen, spores, and marine microfossils and their correlation with surface salinity and RSL in the outer Mackenzie Delta area. This study also appears to be the first survey of modern pollen-spore and microplankton facies in an arctic estuarine environment.

Initial results of the palynological and vegetation studies (Figure 11) show that five different palynofacies characterize the intertidal and freshwater environments in coastal areas adjacent to the Mackenzie Delta. (1) Subtidal channel areas of tidal channels (August 1991 salinity 0-10‰) are dominated by dinoflagellate cysts; most of the cysts are heterotrophic proto-peridinioid species in contrast to the outer shelf and slope, where photosynthetic gonyaulacoids are common (Mudie, in press). (2) Mudflats (extreme low water to mean sea level) are distinguished by a low-diversity flora dominated by spores of blue-green algae (e.g. *Nostoc* Zygnemataceae) similar to those described for Holocene raised bogs near the Wadden Sea (van Geel, 1978) and for Pliocene North Sea bays (Head, in press). The acritarch *Sigmopollis psilatus* is also locally abundant in this mudflat environment. (3) Low salt marsh (mean sea level to mean higher high tide) is characterized by a dominance of fungal mycelia and fruit bodies, similar to species of *Stomiopeltis* described by van Geel (1978). (4) Upper marsh (mean higher high tide to extreme high water) is marked by abundant wood fragments and a diverse pollen-spore flora. This palynofacies is dominated by pollen of sedges, grass, dwarf birch and by spores of *Polytrichum* moss, together with common local herb pollen (Compositae, Ranunculaceae, Caryophyllaceae, Gentianaceae) and rare wind-transported alder and spruce pollen. The lower part of this zone, up to about lower extreme high water (about

0.8 m, see Figure 6), contains a transitional flora and palynofacies dominated by fungal spores and by common pollen of sedge, grass, and dwarf birch. (5) Freshwater ponds above extreme high water all contain assemblages dominated by birch, willow, and cotton-sedge (*Eriophorum*) pollen and by abundant colonial green algae (*Pediastrum*). Brackish (1-2‰) ponds in sandy areas just above extreme high water often contain mare's tail (*Hippuris vulgaris*) and its pollen. Higher, non-saline (<1‰) ponds and ice-wedge thaw troughs frequently contain *Myriophyllum* (water milfoil) and its pollen, or abundant green algae (*Spirogyra* and zygospores of *Mougeotia*, *Lecaniella*, and *Planctonites*).

These distinctive palynofacies can now be used to interpret the paleoenvironments represented by peat deposits previously observed in nearshore sediment cores (Héquette and Hill, 1989; Hill et al., 1985) and organic-rich muds found in the 1991 spring cores. These new data will be used to refine the RSL history of the inner shelf area for the past 2 ka. Also of salient interest is the presence of blue-green algal mats on the estuarine mudflats. These fibrous surface coatings may play an important role in sediment stabilization. The algal mats were observed to expand and contract with the expansion and expulsion of gas during a tidal cycle. This movement appeared to be associated with the formation of polygonal structures on a scale of 0.1-0.2 m.

Richards Island Marsh Profile

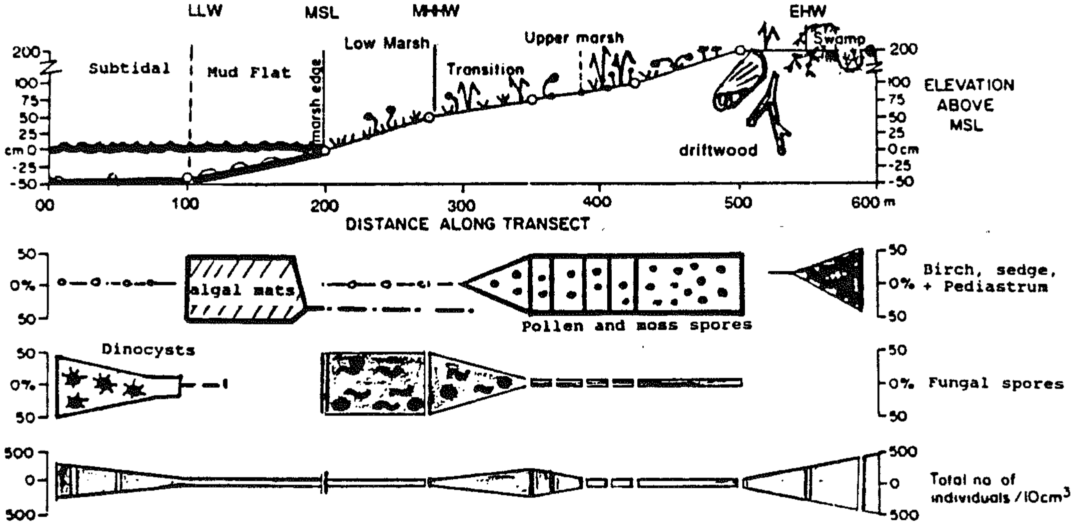


FIGURE 11: Schematic profile of typical estuarine marsh on eastern Richards Island, showing relationship between the five main marsh biozones (subtidal to swamp environments) and the palynofacies found in *Arktos*-91 surface samples. EHW = extreme high water; LLW = extreme low water; MSL = mean sea level; MHHW = mean higher high water at Tuktoyaktuk (see Figure 6).

ARKTOS-ß CRUISE

Objectives

To collect data on shallow stratigraphy in the coastal zone with particular emphasis on characterising the onshore to offshore transition.

Methods and Logistics

Transportation

Arktos-ß (Figure 12) is an amphibious vehicle designed and manufactured as an Arctic escape and rescue craft by Watercraft Offshore Limited of Richmond, B.C. The vehicle is owned and operated by the Canadian Coast Guard. It consists of two linked units and uses a combination of tracks and jets to propel itself through ice-infested waters and over ice, shoals or on land. Its rated speed is 4 knots in the water and 20 knots on land using standard diesel fuel. Preliminary sea trials in August, 1990 established its ability to carry out high resolution acoustic surveys in shallow water (Lewis, 1990). As part of the 1991 field program, refinements identified in those initial trials were implemented in order to improve the safety and efficiency of *Arktos-ß* surveying operations. These included fabrication and mounting of deck units and raising the mounting point of the forward towing boom. The layout and equipment configuration are shown in Figure 13.

When *Arktos-ß* arrived in Tuktoyaktuk in July 1991, it required repairs to the linkage between the two units. This had been damaged during loading onto CCGS *Nahidik* in Hay River. The repairs involved complete removal of the anti-roll unit and reinforcement of the linkage with gussets. In addition, racks for mounting electonic equipment were built within both the forward and rear units. Generators, winches, and sampling handling equipment were mounted on the decks. Following shakedown cruises in Tuktoyaktuk Harbour, *Arktos-ß* was was moved to the camp on Richards Island, already established for the summer coastal program, to commence survey work. A daily log of *Arktos-ß* operations is included in Appendix C1.

Navigation

Raytheon™ global positioning systems were mounted in both the forward and rear units of *Arktos-ß*. The datum used was NAD27. The rear unit was interfaced to a portable computer and navigation fixes were recorded every two seconds. Positions monitored while parked at Tuktoyaktuk indicate that accuracy of the positions should be within ±30 m. In general the unit worked well and provided PDOP (Positional Dilution of Precision) of 5 or less. Occasionally the satellite signals were too weak or obscured and a compass course was held until a position could be established. This rarely took longer than 15 minutes, or about 1 km

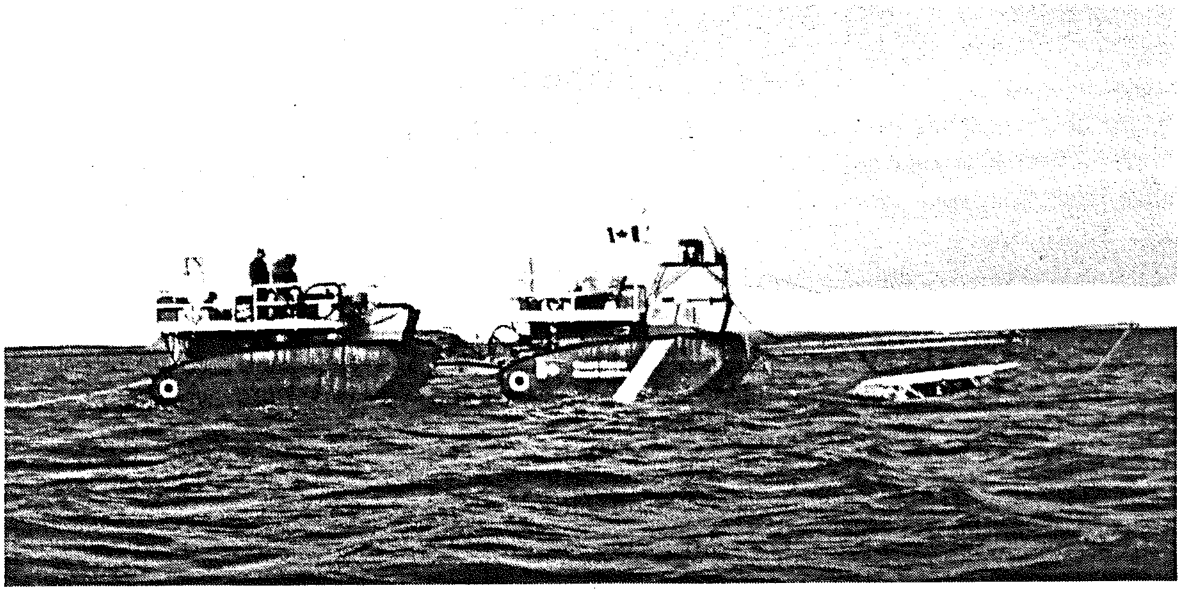


FIGURE 12: *Arktos-β*.

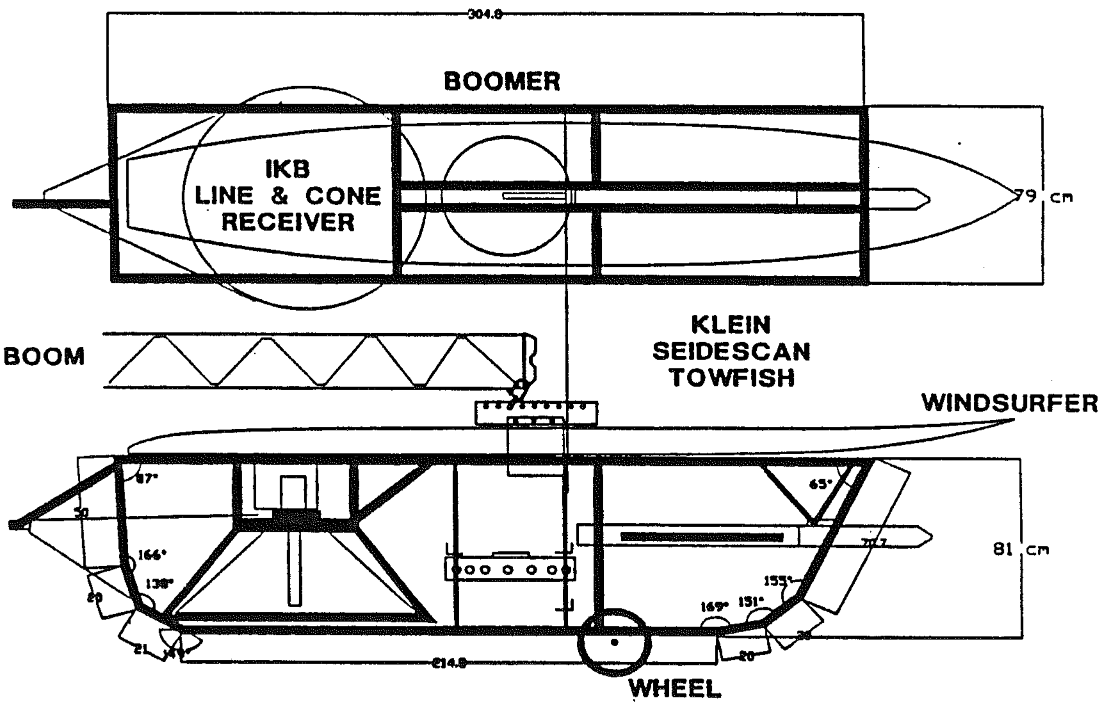


FIGURE 13: Configuration of equipment on *Arktos-ß* boom.

at survey speeds of 2 knots or less.

Acoustics and resistivity

Acoustic sources included an EG&G model 230 Uniboom^{TM} boomer, the C-CORE prototype 120-tip sparker, and a conventional multitip sparker. Acoustic receivers used were an IKB Technologies Seistek^{TM} cone and a Nova Scotia Research Foundation (NSRFC) eel. The sidescan sonar system was a Klein model-531 unit with a 100-kHz fish. In addition, bathymetry was recorded using a Raytheon DE-719 200-kHz system. Electrical resistivity profiles were also collected during the *Arktos-β* cruise, using a MicroWip^{TM} electrical resistivity system, provided and operated under contract by C-CORE.

Coring and Sampling

An extensive sampling program was undertaken from *Arktos-β* using a Van Veen grab sampler deployed from the aft unit. In addition, one core was attempted using the AGC portable vibrocorer developed for shore-based coastal studies.

Operations and preliminary results

The program was successful in achieving its objective with some qualifications. Weather was generally a problem in that winds were persistent and strong (more than 20 km/hr) from the northwest. It became obvious that operations in exposed areas under those conditions were not possible because of our method of gear deployment. It was therefore decided to concentrate on inshore surveying in protected shoal areas, a job that no other vessel/vehicle could accomplish. Problems with the cooling system limited our speed to less than 2 knots (about 4.5 km/h) throughout the survey period thus compromising our ability to work very far from camp.

Our major accomplishment was a detailed geophysical coverage (about 550 line-km) of the environments which comprise the eastern Richards Island embayment complex from North Point to Mason Bay (Figure 14, **Appendix C2**). This area includes the potential Amauligak pipeline landfall. We also took 30 grab samples and 1 vibrocore (Figure 15). The survey area is complex and includes a variety of nearshore, spit, and spit-platform depositional environments (Figure 16). Some of the most interesting acoustic records were taken in breached thermokarst lakes which exhibit various amounts of infilling (Figure 17). The marine resistivity survey provided an excellent complement to the acoustic profiles. In particular it seemed to respond with great sensitivity to frozen versus unfrozen ground. This should help to differentiate between sand/gravel and frozen near-surface materials.

Survey equipment generally worked well with a few exceptions. The power supplies for OERD-supported work never functioned and conditions at camp made it impossible to try to fix them. The sidescan sonar system functioned well but all records were heavily contaminated by noise from the echo sounder and boomer. Our equipment configuration could not be changed and, because there were very few features of interest seen in the records, nothing was done to correct it. On the last day of the survey the Geopulse power supply for the boomer broke down and had to be completely dismantled in Tuktoyaktuk in preparation for the *Nahidik* cruise.

Arktos-ß performed well throughout the survey and only about half a day of lost time could be attributed directly to the vehicle. Had it been able to operate at its rated speed of 4 knots, we would certainly have accomplished more. However, the shallow water depths in which we operated required extremely slow survey speeds so we were hampered only by being limited in running time. Mobilization of *Arktos-ß* took about one week longer than expected. The extra time required to mobilize *Arktos-ß* resulted in the elimination of proposed surveys along the Tuktoyaktuk Peninsula.

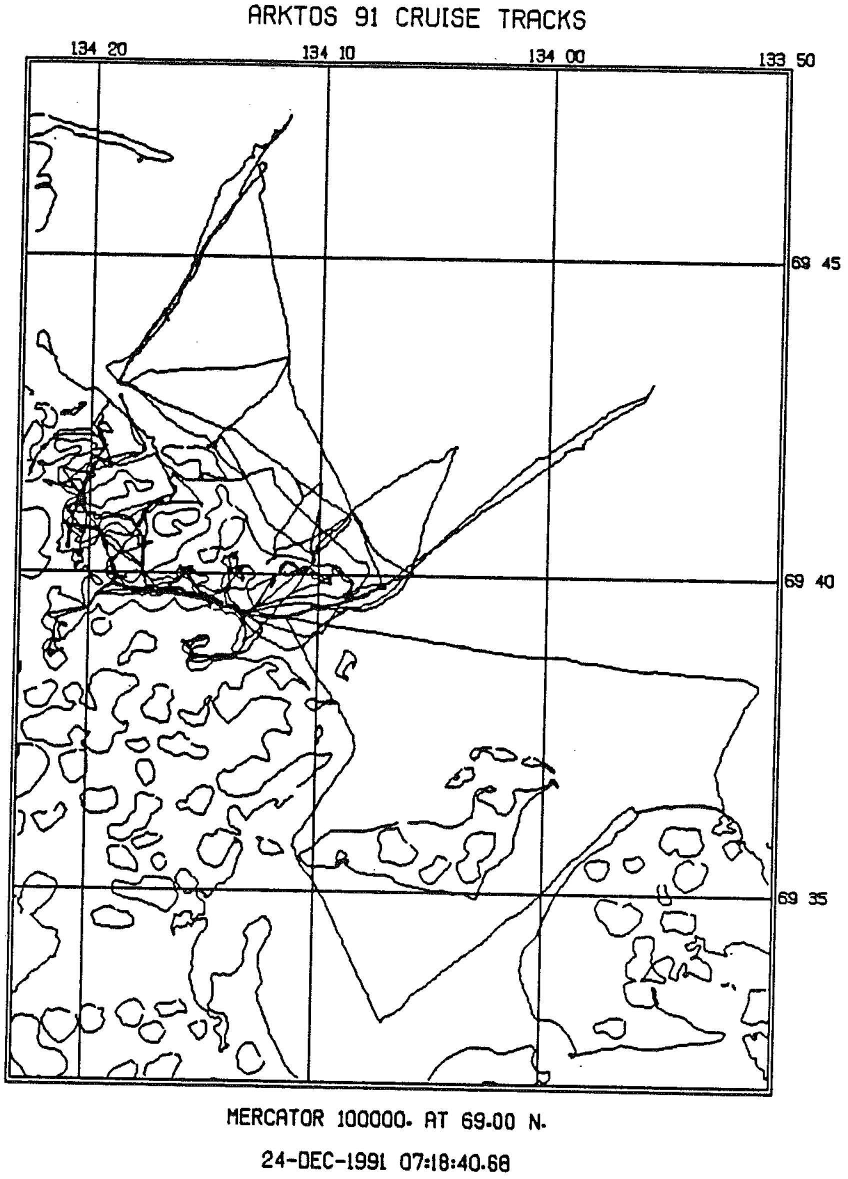


FIGURE 14: *Arktos-ß* trackplot.

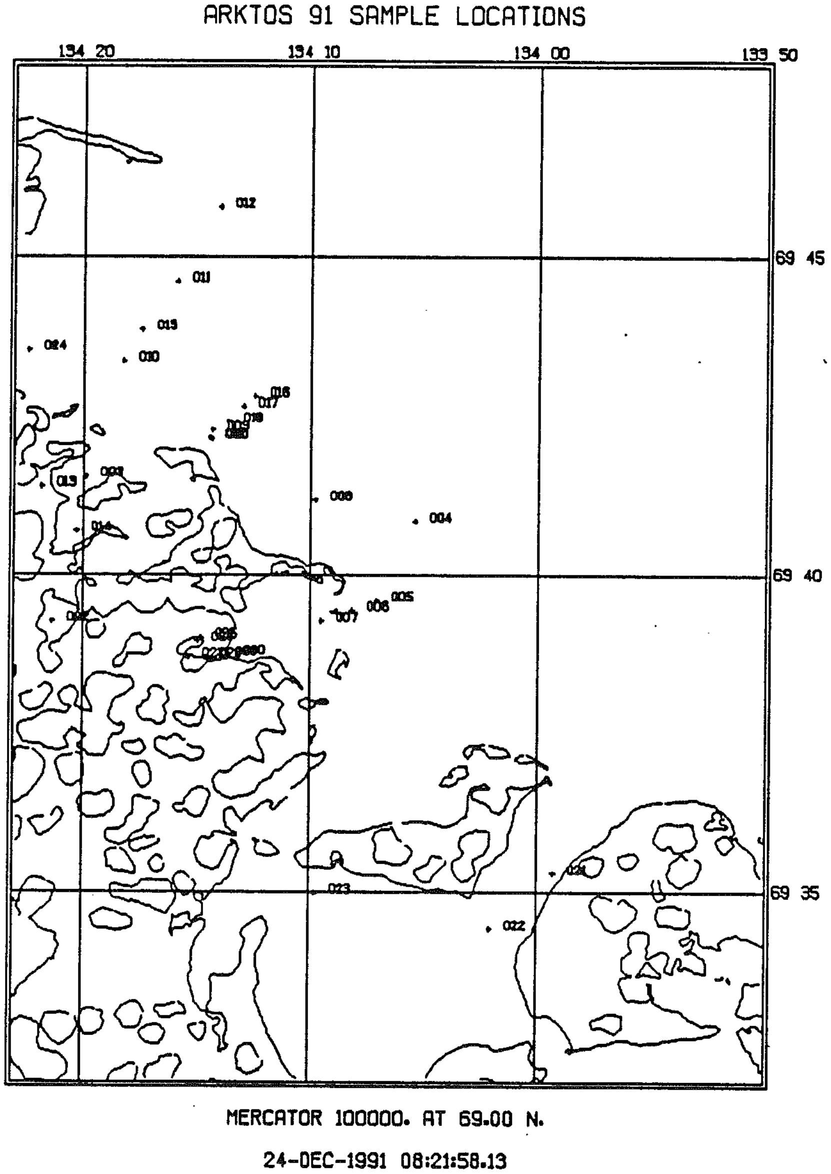


FIGURE 15: *Arktos-ß* sample locations.

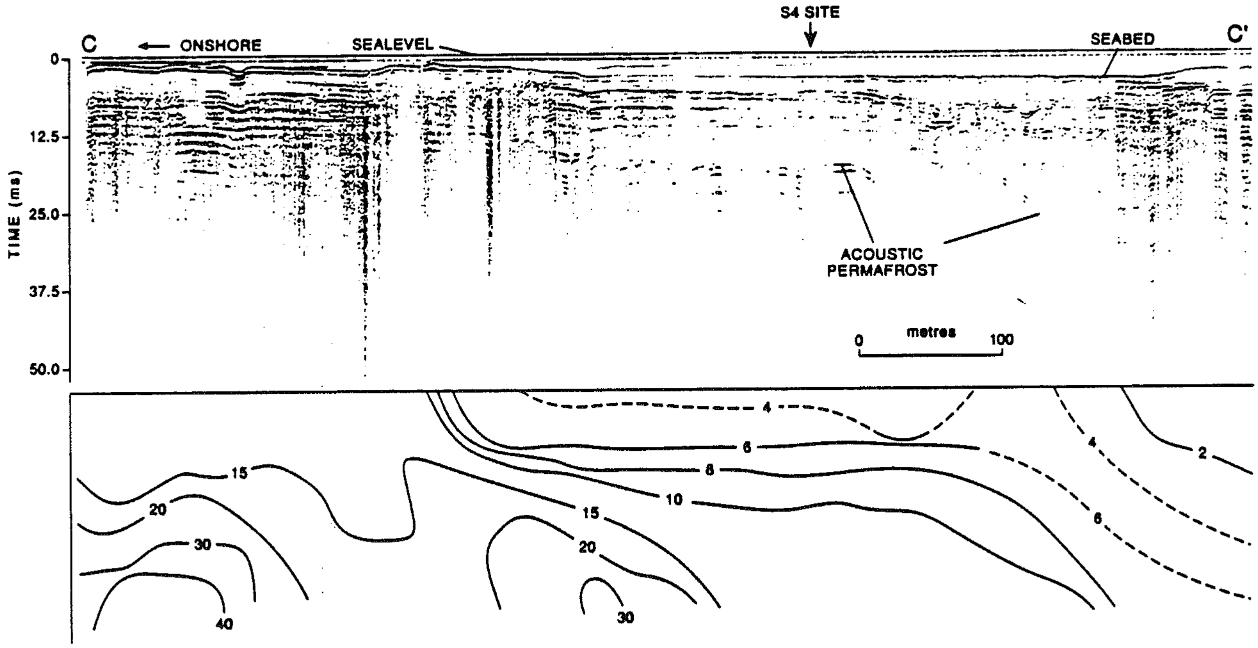


FIGURE 16: Nearshore acoustic and resistivity profile. Acoustic permafrost can be seen rising through the sequence although it is not clear whether it cuts across lithologies. Water depth decreases from about 3.5 m at right to about 1.0 m at left. The lower panel shows resistivity contours in ohm-metres (depths are schematic). Electrical resistivity at the seabed surface rises dramatically shoreward from less the 2 Ωm to about 15 Ωm. Resistivity at depth rises from about 4 Ωm to more than 40 Ωm over the interval in which acoustic permafrost can be seen.

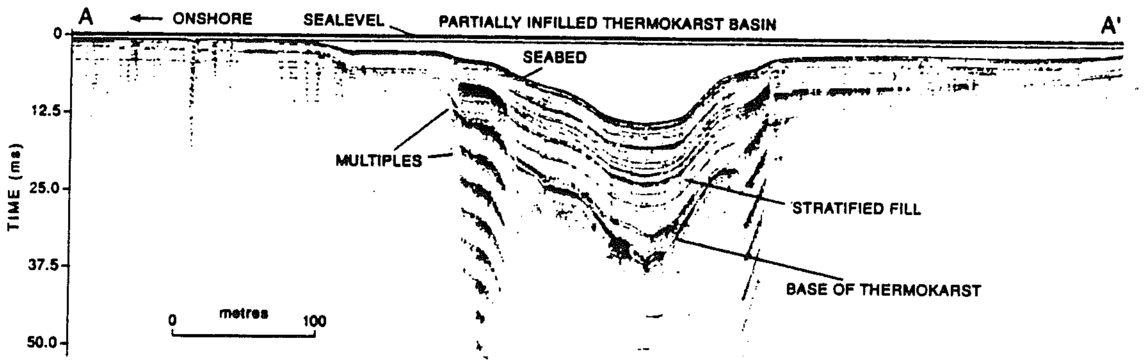


FIGURE 17: Acoustic profile across a 10 m depression partially infilled with stratified sediments draped over a hummocky surface. In shallower water and along the edges of the basin, the seabed is acoustically very hard and produces numerous multiple reflections. The position, size, and shape of the basin suggest that it is a thermokarst feature that has been exposed to marine processes by rising sea level and lake breaching.

CCGS *Nahidik* CRUISE

Objectives

To collect data on nearshore stratigraphy in order to provide a framework for detailed studies of pipeline routes and coastal stability,

Methods

In order to achieve the objective for this activity, high resolution acoustic data was collected in a series of shore-parallel and shore-orthogonal lines from the west side of Pullen Island to Crumbling Point (Figure 18). Vibrocore transects were undertaken along five of the shore-orthogonals in order to ascertain nearshore to offshore changes at sites exposed to varying wind and wave climates (Figure 19).

Navigation

A Northstar™ GPS unit was used for navigation. The antenna was mounted below the radar mast. Positions were calculated using the WGS84 datum and logged every two seconds using a portable computer. The system worked very well and position fixes were continuous and agreed with radar fixes whenever they were available. Position accuracy is assumed to be similar or better than that of the Raytheon™ GPS used onboard the *Arktos-β* (i.e. ±30 m).

Acoustics

As for the *Arktos-β* cruise, acoustic sources included the EG&G model-230 Uniboom™ boomer. An IKB Technologies Seistek™ cone and NSRFC eel were used as receivers. Sidescan sonar records were collected using the Klein model-531 system and 100-kHz towfish. Bathymetry was recorded using a Raytheon DE-719 200-kHz system. A Raytheon RTT-1000 3.5 and 7.0-kHz subbottom profiler was used for part of the cruise, but did not produce useable results. The acoustic equipment was deployed off of the sides of the CCGS *Nahidik* using a combination of booms, mounts and cranes.

Coring

An extensive coring program was carried out using the old AGC Aimers and MacLean vibrocorer with a 3.0 m core barrel. The vibrocorer was deployed in a similar fashion using a 10 tonne crane on the forward deck of the ship. The system worked well and 20 cores were obtained in 3 days, with core recovery ranging from 1.02 to 3.13 m (Appendix D2).

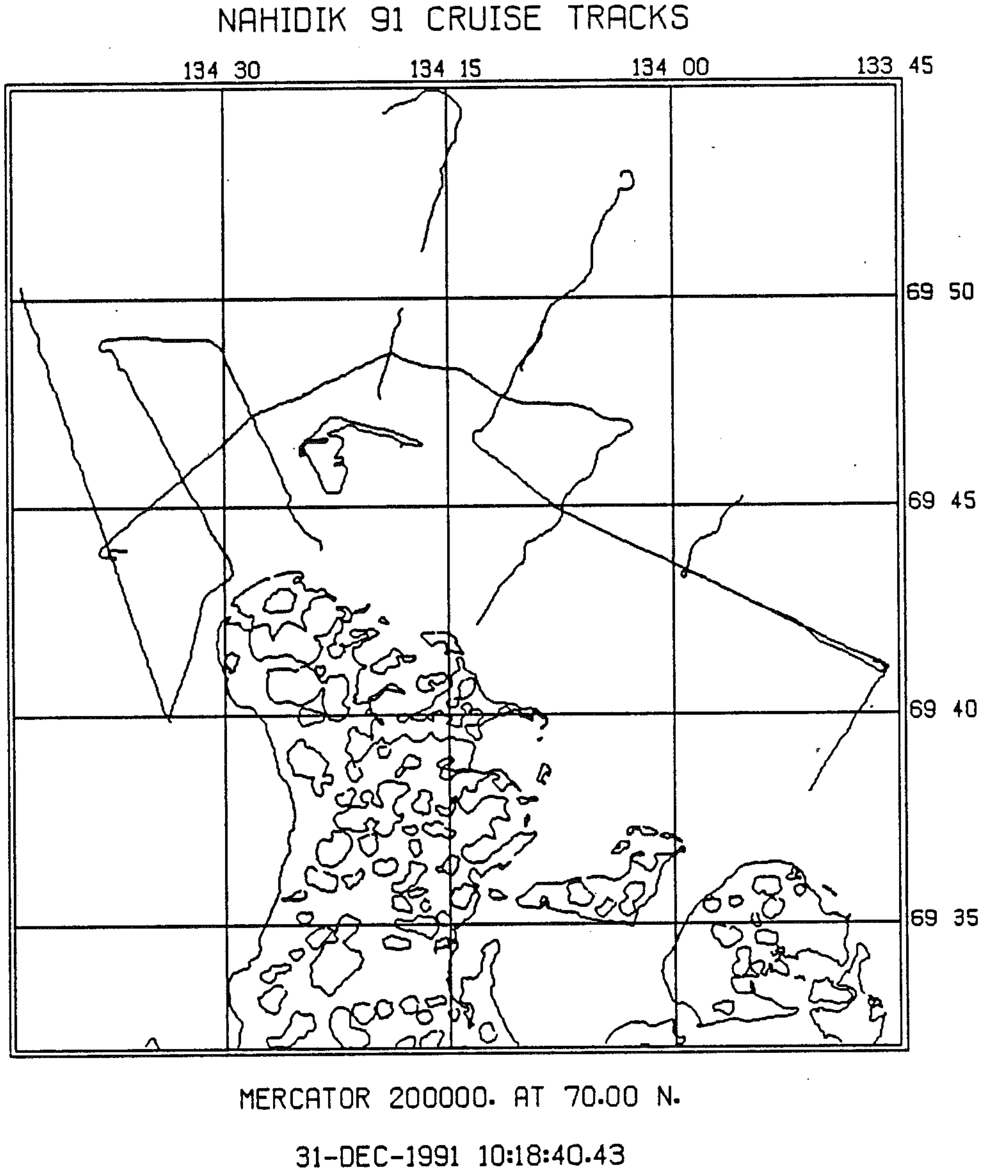


FIGURE 18: CCGS *Nahidik* trackplot.

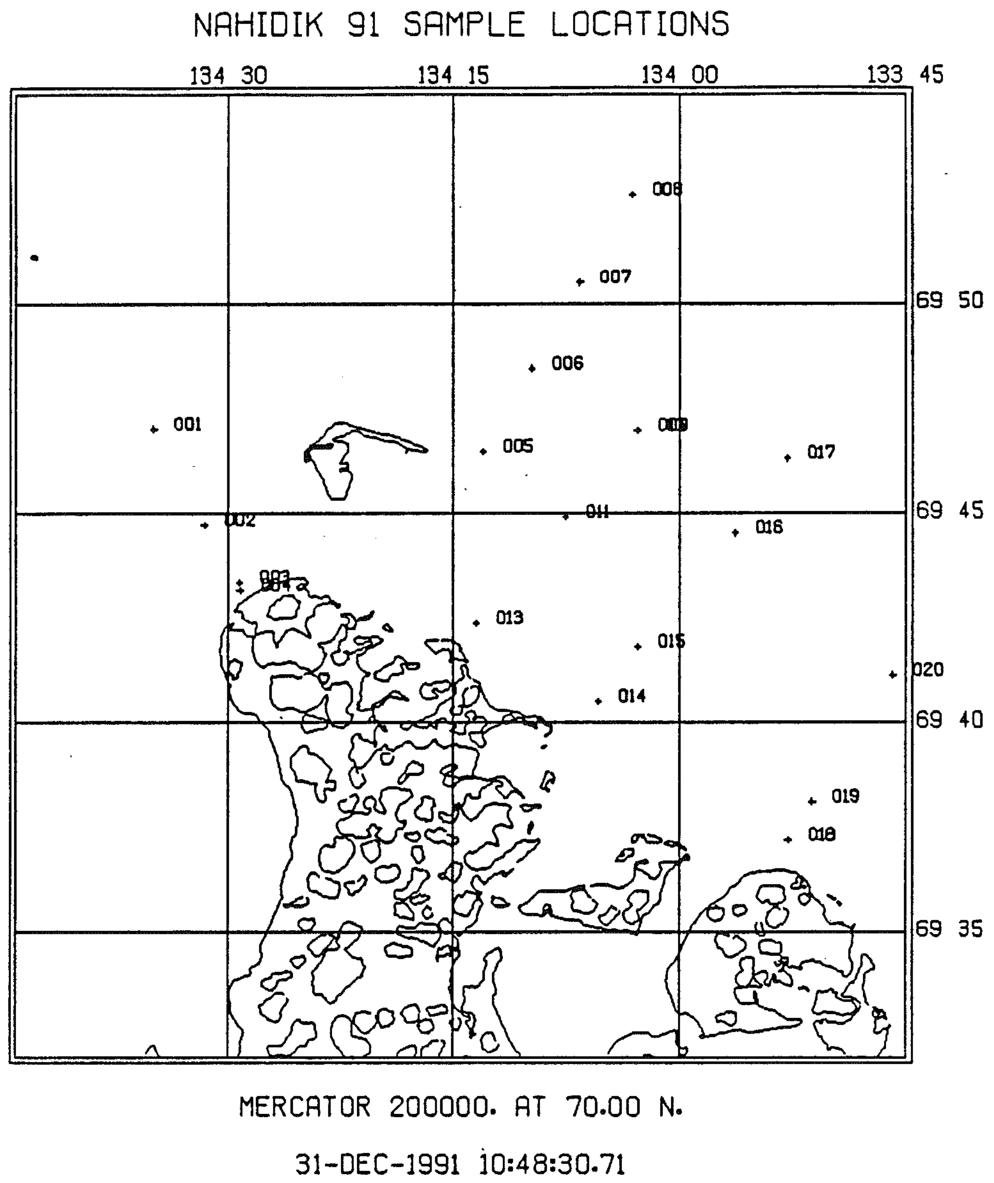


FIGURE 19: CCGS *Nahidik* core locations.

Operations and preliminary results

Planning for the *Nahidik* cruise was delayed for some time at the end of August as a result of severe ice conditions along the Tuktoyaktuk Peninsula. The ship remained in Liverpool Bay for about 2 weeks waiting for ice to clear. At the end of the last week in August the NW winds and ice pressure abated and *Nahidik* was able to proceed to Tuktoyaktuk.

After mounting the accomodation modules on the helicopter flight deck in Tuktoyaktuk, the ship proceeded to Inuvik where the rest of the equipment was mobilized. This operation involved mounting the laboratory container and generator shack on the forward deck and loading and connecting the geophysical and vibrocoring equipment.

Ice conditions were still bad enough in Kugmallit Bay to hamper our operations. We were unable to survey beyond a water depth of 6-7 m and we could not survey at night (between 2200 and 0700 hrs). We were successful in acquiring about 100 km of shallow high resolution acoustics in water depths from about 2.5 m to 7 m. The lines were designed to extend and complement *Arktos-ß* lines and to be run wherever borehole control existed. Thus, lines were run orthogonal to the Richards Island Coast from the 1984 borehole transect (Kurfurst, 1984) to Crumbling Point. Five vibrocore transects were taken along 5 of the 12 acoustic lines (a total of 20 vibrocores). Recovery on all but two cores was more than 2.5 m (using a 3 m barrel). The survey ended when the sidescan hit a chunk of ice. No damage was done, but conditions were sufficiently difficult to call the survey to a halt since we were halfway through the last line.

Much of the area is characterised by highly gas-charged sediments which limit acoustic penetration. However, windows through the gaseous sediment permitted intermittent glimpses into the deeper subbottom. The area is characterised by an upper unit of well stratified sediment overlying material with less well-defined layering. The contact between the units is often highly reflective and may be gas charged.

Sidescan surveys recorded notable scour activity in water depths as shallow as 4 m. Some of the scours were undoubtedly new features formed during the summer since obvious grounded ice pans were ubiquitous throughout the survey area. In several locations gas piping to the surface correlated with features identified to be pock marks on the sidescan records. In general, however, much of the surveyed area was featureless.

Vibrocore transects were designed on the basis of geographical position and bathymetry rather than acoustic character. It is hoped that we will be able to ascertain variation in sediment type and structures with distance from major sediment sources (e.g. Pullen Island). Most core-catcher samples were described as olive grey muds.

REFERENCES

Blasco, S.M., Fortin, G., Hill, P.R., O'Connor, M.J. and Brigham-Grette, J. 1990. The late Neogene and Quaternary stratigraphy of the Canadian Beaufort continental shelf. In: Grantz, A., Johnson, L. and Sweeney, J.F. (editors), The Arctic Ocean region. Geological Society of America, The Geology of North America, v. L, p. 491-502.

Bujak, J.P. and Davies, E. 1987. Micropaleontology and palynology of 15 shallow core samples from Herschel Basin, Arctic Canada. Contract report 87-0024 to Geological Survey of Canada, Calgary, 5 p.

Dallimore, S., Dyke, L., Kurfurst, P., Jenner K. , Gillespie D. , Blasco, S. and Hill, P. 1991. Geological, geotechnical, and geophysical studies along the onshore-offshore transect of the Beaufort Shelf. Geological Survey of Canada, Open File 2408, 264 p.

Davies, E. and Mudie, P.J. in prep. Atlas of Quaternary and Pliocene dinoflagellates and acritarchs, Beaufort Sea and adjacent regions. Geological Survey of Canada, Open File, 35 p.

Davis, J.L., Scott, W.J., Morey, R.M., and Annan, A.P. 1976. Impulse radar experiments on permafrost near Tuktokaktuk, Northwest Territories. Canadian Journal of Earth Sciences v. 13, p. 1584-1590.

Forbes D. F. and Frobel, D. 1985. Coastal erosion and sedimentation in the Canadian Beaufort Sea. Geological Survey of Canada, Paper 85-1B, p. 69-80.

Gillie, R.D. 1987. Beaufort Sea coastal morphology study. Geological Survey of Canada, Open File 1826, vi + 21 p. and 8 appendices.

Gillie, R.D. 1989. Beach and cliff erosion surveys, Beaufort Sea, 1988. Amauligak Development Studies 1988/89. Confidential report to Gulf Canada Resources Limited, Calgary, prepared on behalf of the Joint Venture participants (Gulf Canada Resources Ltd, Husky Oil Operations Ltd, Norcen Energy Resources Ltd, AT&S Exploration Ltd, ATCOR Ltd, and Texaco Canada Enterprises Ltd). Seakem Oceanography Limited, Sidney, B.C., ix + 35 p. and 4 appendices.

Harper, J.D., Henry, R.F. and Stewart, G.G. 1988. Maximum storm surge elevations in the Tuktoyaktuk region of the Canadian Beaufort Sea. Arctic, v. 41, p. 48-52.

Head, M.J. in press. Zygospores of the Zygnemataceae (Division Chlorophyta) and other freshwater algal spores from the uppermost Pliocene St. Erth Beds of Cornwall, southwest England. Micropaleontology, Spring 1992.

Henry, R.F. 1975. Storm surges. Beaufort Sea Project, Technical Report 19, 41 p.

Hill, P.R., Mudie, P.J., Moran, K. and Blasco, S.M. 1985. A sea-level curve for the Canadian Beaufort Sea. Canadian Journal of Earth Sciences, 22, 1383-1393.

Hill, P.R., Moran, K., Kurfurst, P., and Pullen, S. 1986. Geotechnical, geophysical, and sedimentological properties of seabottom sediments near Richards Island, southern Beaufort Sea. Proceedings, 3rd Canadian Marine Geotechnical Workshop, St. John's, Newfoundland, June, 1986, p. 301-327.

Hill, P.R. and Frobel, D. 1991. Documentation of summer NOGAP activities, July 22 to August 25, 1990. Geological Survey of Canada, Open File 2451, 84 p.

Hirst, S.M., Miles, M., Blachut, S.P., Goulet, L.A., and Taylor, R.E. 1987. Quantitative synthesis of the Mackenzie Delta ecosystems. Unpublished contract report prepared for the Inland Waters Directorate, Environment Canada, contract no. 62SS Kn107-5-4370 (UP-B-477).

Johnston, G.H. and Brown, R.J.E. 1965. Stratigraphy of the Mackenzie River Delta, Northwest Territories, Canada. Geological Society of America Bulletin, 76, 103-112.

Kurfurst P.J. 1984. Geotechnical investigations in the southern Beaufort Sea, spring 1984. Geological Survey of Canada, Open File 1078, 87 p.

Kurfurst, P.J. 1986. Geotechnical investigations of the nearshore zone, North Head, Richards Island, N.W.T. Geological Survey of Canda, Open File 1376, 82 p.

Kurfurst, P.J. 1988. Geotechnical investigations off northern Richards Island, NWT, spring 1987. Geological Survey of Canada, Open File 1707, 137 p.

Kurfurst, P.J. and Dallimore, S.R. 1989. Geological and geotechnical conditions of the Beaufort Sea coastal zone, Arctic Canada. Geologie en Mijnbouw, v. 68, p. 121-129.

Lewis, J. 1991. Operations report on *Arktos-ß* amphibious vehicle high resolution geophysical survey test trials, August 1990, Tuktoyaktuk, NWT. Unpublished contract report prepared for the Geological Survey of Canada, contract no. 23420-0-M088/01-OSC, 103 p.

Mudie, P.J. 1982. Pollen distribution in recent marine sediments, eastern Canada. Canadian Journal of Earth Sciences, 19, 729-747.

Mudie, P.J. in press. Circum-Arctic Quaternary and Neogene marine palynofloras:

paleoecology and statistical analysis. American Association of Stratigraphic Palynologists, Contribution Series 23B, 1-25.

Porsild, A.E. 1964. Illustrated flora of the Canadian Arctic Archipelago. National Museum of Canada, Bulletin 146, 218 p.

Rampton, V.N. 1988. Quaternary geology of the Tuktoyaktuk coastlands, Northwest Territiories, Geological Survey of Canada, Memoir 423, 98 p.

Ritchie, J.C. 1984. Past and present vegetation of the far northwest of Canada. University of Toronto Press, 251 p.

Rosati, J.D. and Kraus, N.C. 1989. Development of a portable sand trap for use in the nearshore. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Technical Report CERC-89-11, 109 p. and 5 appendices.

Ruz, M.-H., Héquette, A. and Hill, P.R. 1992. A model of coastal evolution in a transgressed thermokarst topography, Canadian Beaufort Sea. Marine Geology, 106, 251-278.

Taylor, A.E. 1991. Marine transgression, shoreline emergence: evidence in seabed and terrestrial ground temperatures of changing relative sea levels, Arctic Canada. Journal of Geophysical Research, 96, 6893-6909.

van Geel, B. 1978. A paleoecological study of Holocene peat bog sections in Germany and the Netherlands. Review of Paleaobotany and Palynology, 25, 1-120.

Vilks, G., Wagner, F.J.E. and Pelletier, B.R. 1979. The Holocene marine environment of the Beaufort Shelf. Geological Survey of Canada Bulletin, 303, 43 p.

Wolfe, S.A. 1989. Investigations of nearshore conditions across an aggrading coastal shoreline in permafrost, Richards Island, NWT. Unpublished M.Sc. thesis, Queen's University, Kingston, Ontario, 188 p.

APPENDICES

Appendix A1: Daily operations log: spring coastal program

March 15	Arrive at Tuktoyaktuk.
March 16	Open freight. Test CRREL corer off PCSP beach.
March 17	Prepare gear. Mark coring sites.
March 18	Sling gear to site 1.
March 19	Sling more gear. Drill hole 1.
March 20	Low ice fog (-21°C). No flying. Grounded all day.
March 21	Drill holes 2 and 3.
March 22	Ice fog. No flying.
March 23	Drill holes 4 and 5. Run EM line.
March 24	Drill hole 6. Run EM survey from site 3 bearing 250°true. Run EM line 120°true from site 3.
March 25	Run EM survey from site 3 to site 4.
March 26	Drill hole 7. Run EM survey bearing 040°true from site 7. Sling gear back to Tuktoyaktuk.
March 27	Prepare gear for shipment.
March 28	Depart Tuktoyaktuk for Inuvik. Work on cores until approximately midnight.
March 29	Work on cores. Depart Inuvik.
March 30	Arrive Dartmouth.

Appendix A2: Lithostratigraphic logs: March 1991 cores

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 001

Total Length 120 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 40' 01.6"

Longitude 134 15' 44.4"

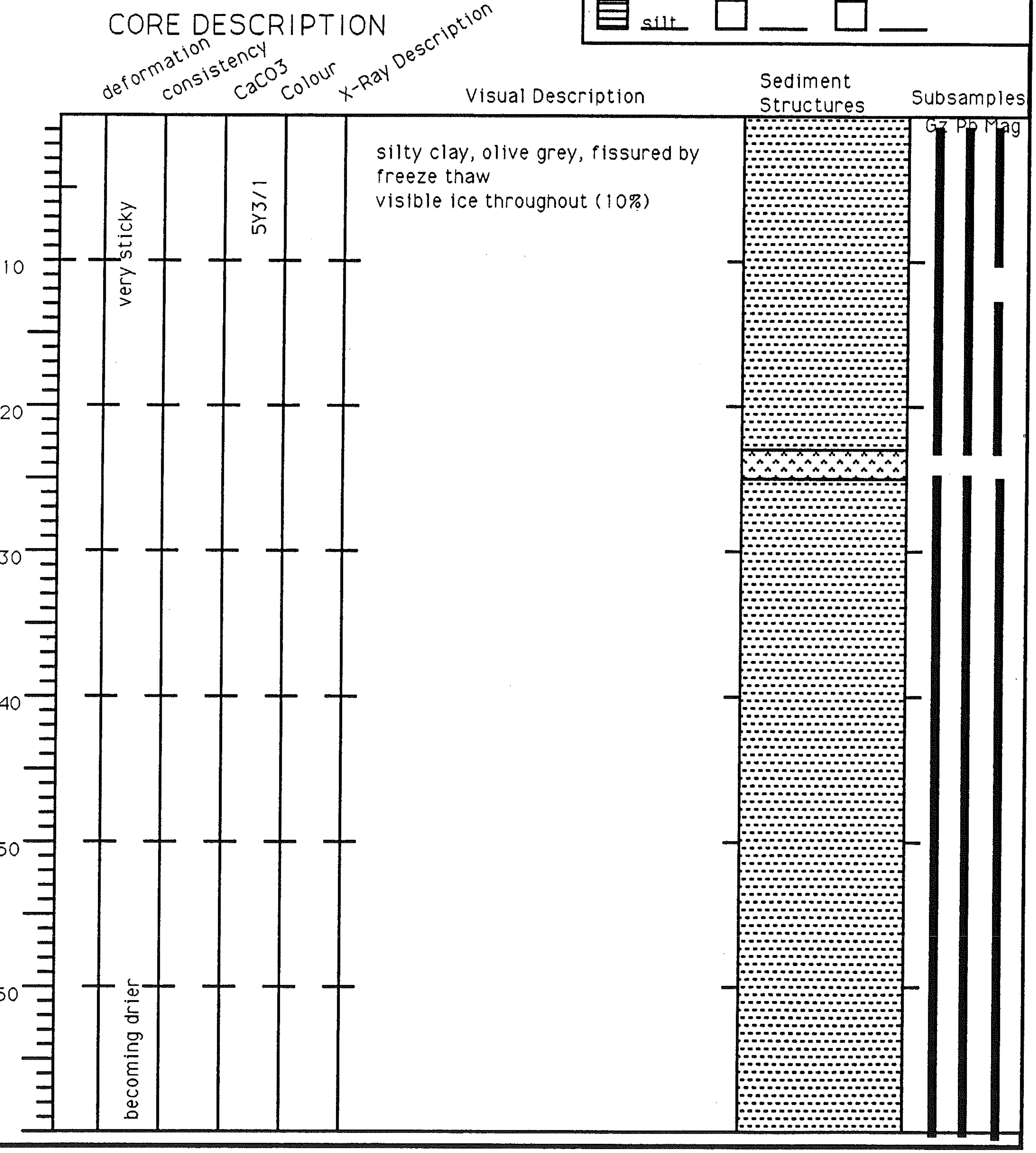
Described by Solomon

Page 1 of

Symbol Legend

- ▤ mud
- ▨ clay
- ☐
- ▩ sand
- ▦ ice
- ☐
- ☰ silt
- ☐
- ☐

CORE DESCRIPTION



silty clay, olive grey, fissured by freeze thaw
visible ice throughout (10%)

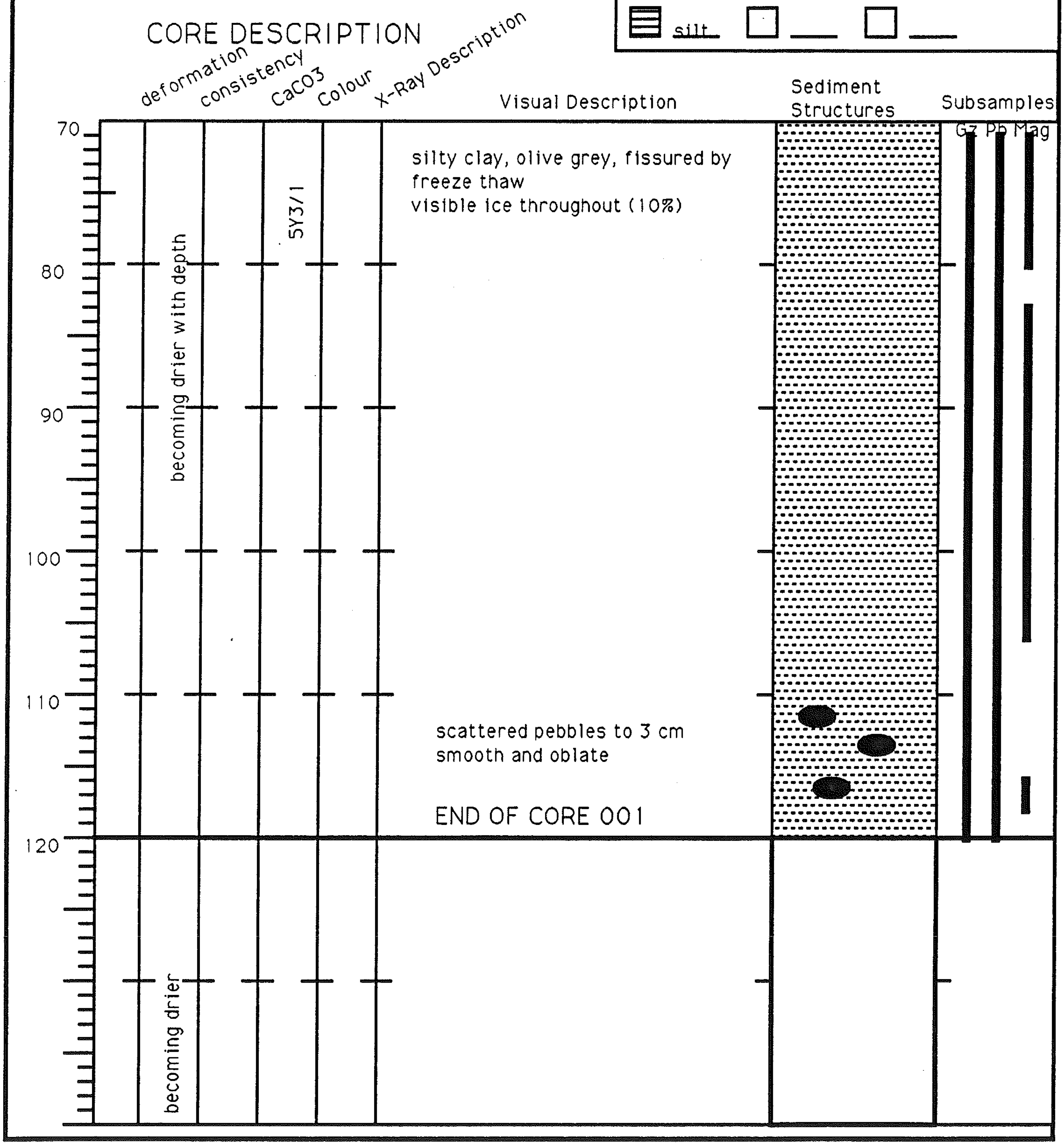
ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 001	Total Length 120 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 40' 01.6"	Longitude 134 15' 44.4"	
Described by Solomon	Page 2 of 2	

Symbol Legend

- ▤ mud
- ▨ clay
- ▩ sand
- ▧ ice
- ☰ silt

CORE DESCRIPTION



ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 003

Total Length 198 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 41' 25.1"

Longitude134 21" 17.5"

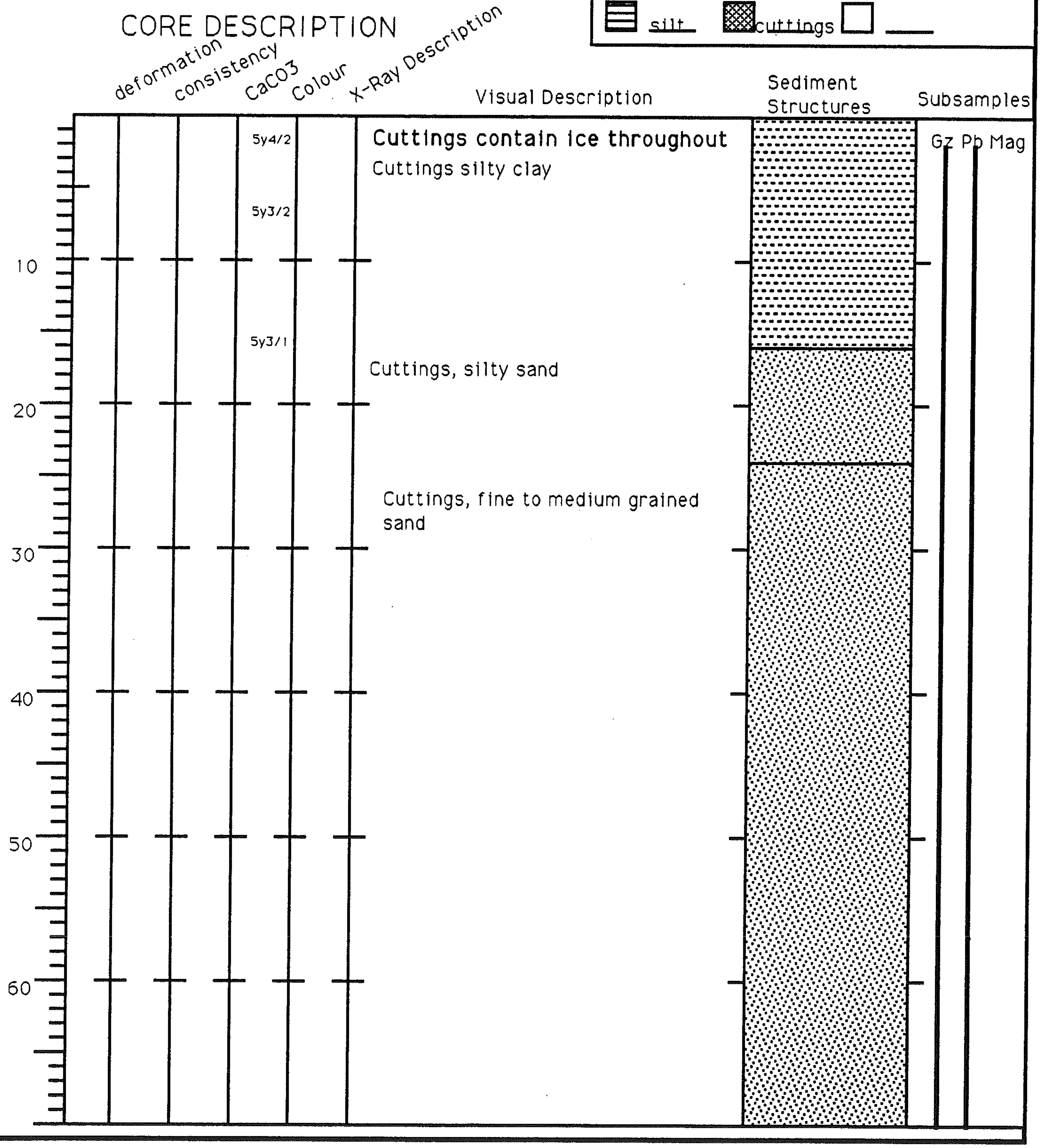
Described by Solomon

Page 1 of 3

Symbol Legend

▤	mud	▨	clay	☐	
▒	sand	▒	ice	☐	
☰	silt	▩	cuttings	☐	

CORE DESCRIPTION



Cuttings contain ice throughout

Cuttings silty clay

Cuttings, silty sand

Cuttings, fine to medium grained sand

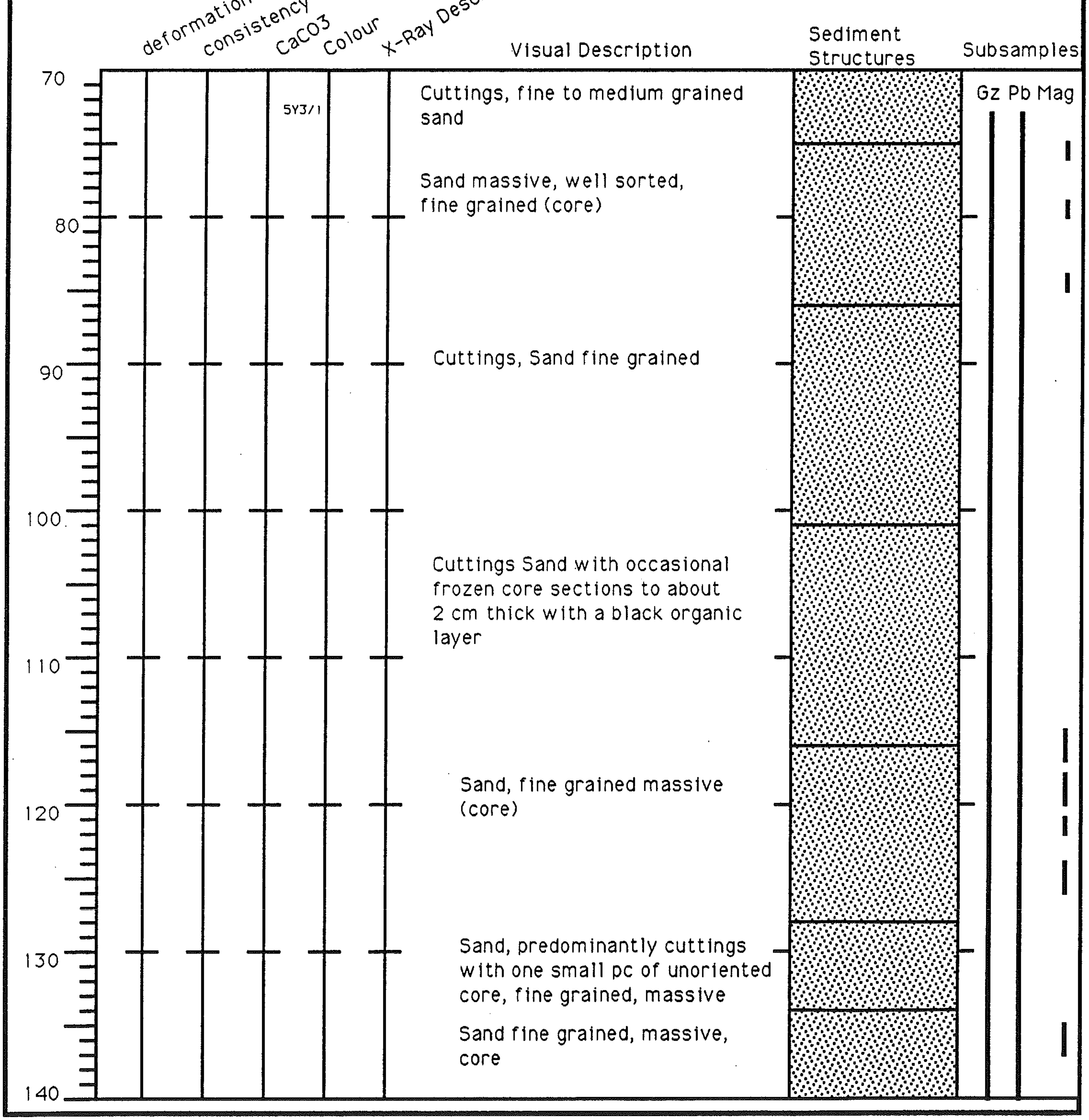
ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 003	Total Length 198 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 41' 25.1"	Longitude134 21" 17.5"	
Described by Solomon	Page 2 of 3	

Symbol Legend

▤ mud	▨ clay	☐ ___
░ sand	☐ ice	☐ ___
☰ silt	▩ cuttings	☐ ___

CORE DESCRIPTION



Cuttings, fine to medium grained sand

Sand massive, well sorted, fine grained (core)

Cuttings, Sand fine grained

Cuttings Sand with occasional frozen core sections to about 2 cm thick with a black organic layer

Sand, fine grained massive (core)

Sand, predominantly cuttings with one small pc of unoriented core, fine grained, massive

Sand fine grained, massive, core

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 003

Total Length 198 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 41' 25.1"

Longitude134 21" 17.5"

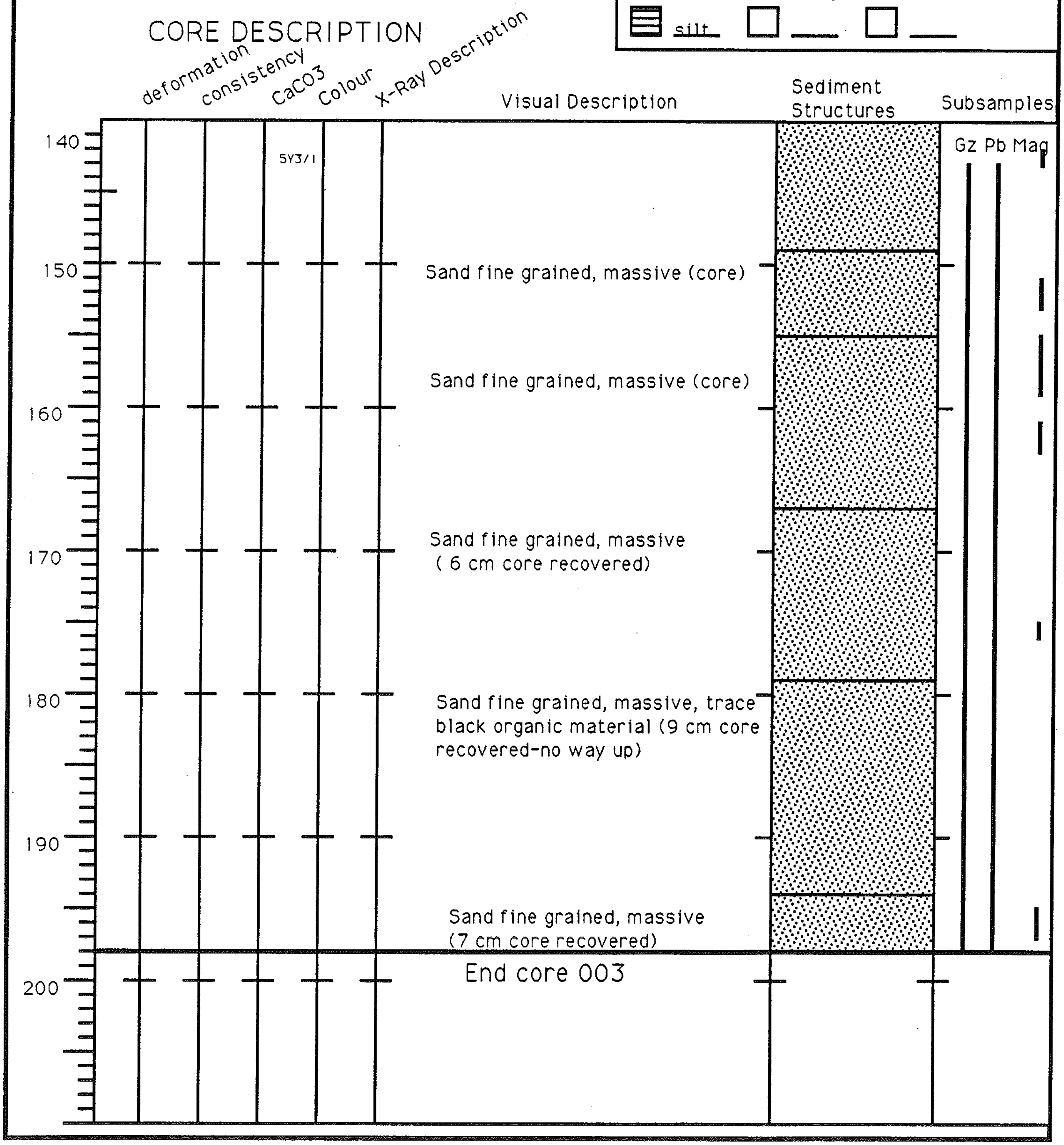
Described by Solomon

Page 3 of 3

Symbol Legend

- ▤ mud
- ▨ clay
- ☐ ___
- ▒ sand
- ▩ ice
- ☐ ___
- ☰ silt
- ☐ ___
- ☐ ___

CORE DESCRIPTION



Sand fine grained, massive (core)

Sand fine grained, massive (core)

Sand fine grained, massive
(6 cm core recovered)

Sand fine grained, massive, trace black organic material (9 cm core recovered-no way up)

Sand fine grained, massive
(7 cm core recovered)

End core 003

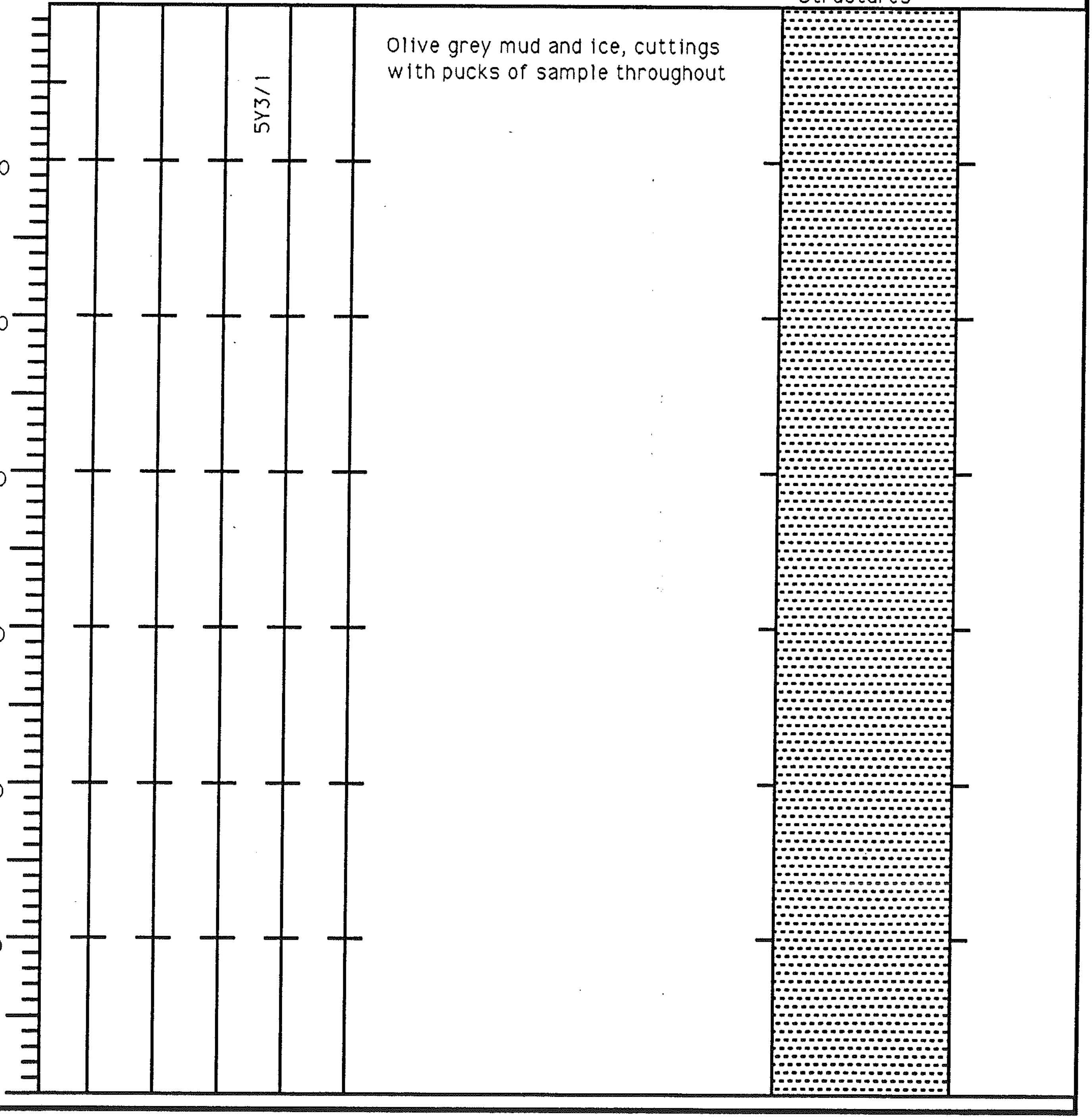
ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 004	Total Length 95 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 41' 36.8"	Longitude 134 19' 51.8"	
Described by Solomon	Page 1 of 2	

Symbol Legend

▤ mud	▨ clay	☐ ___
▦ sand	▦ ice	☐ ___
☰ silt	☐ ___	☐ ___

CORE DESCRIPTION



Olive grey mud and ice, cuttings with pucks of sample throughout

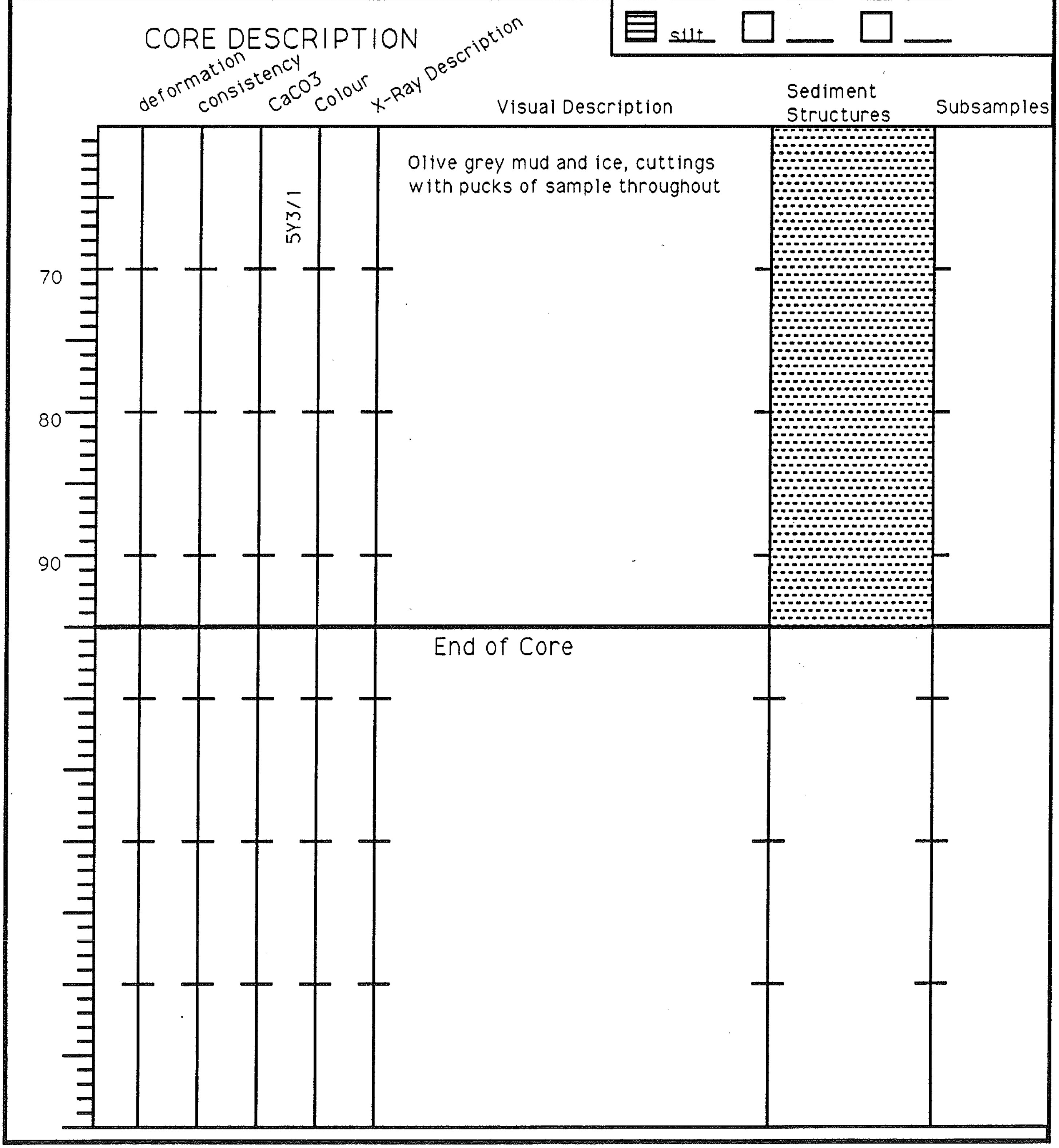
ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 004	Total Length 95 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 41' 36.8"	Longitude 134 19' 51.8"	
Described by Solomon	Page 2 of 2	

Symbol Legend

▨ mud	▨ clay	☐ ___
▨ sand	▨ ice	☐ ___
▤ silt	☐ ___	☐ ___

CORE DESCRIPTION



Olive grey mud and ice, cuttings with pucks of sample throughout

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 005

Total Length 138 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 41' 52.0"

Longitude 134 19' 12.6"

Described by Solomon

Page 1 of 2

Symbol Legend

▤ mud

▨ clay

☐ ___

▩ sand

▧ ice

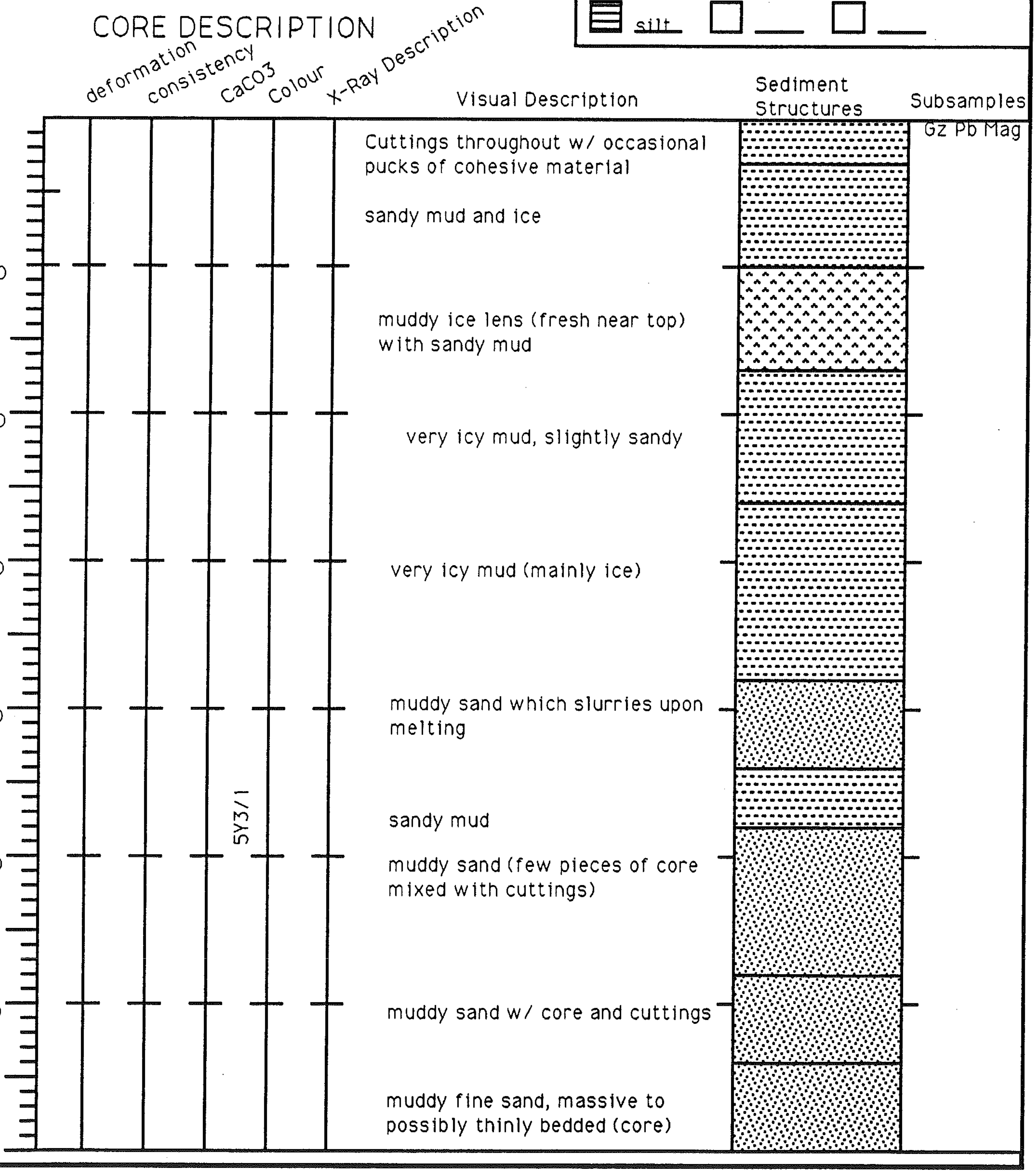
☐ ___

☰ silt

☐ ___

☐ ___

CORE DESCRIPTION



Cuttings throughout w/ occasional pucks of cohesive material

sandy mud and ice

muddy ice lens (fresh near top) with sandy mud

very icy mud, slightly sandy

very icy mud (mainly ice)

muddy sand which slurries upon melting

sandy mud

muddy sand (few pieces of core mixed with cuttings)

muddy sand w/ core and cuttings

muddy fine sand, massive to possibly thinly bedded (core)

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 005

Total Length 138 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 41' 52.0"

Longitude 134 19' 12.6"

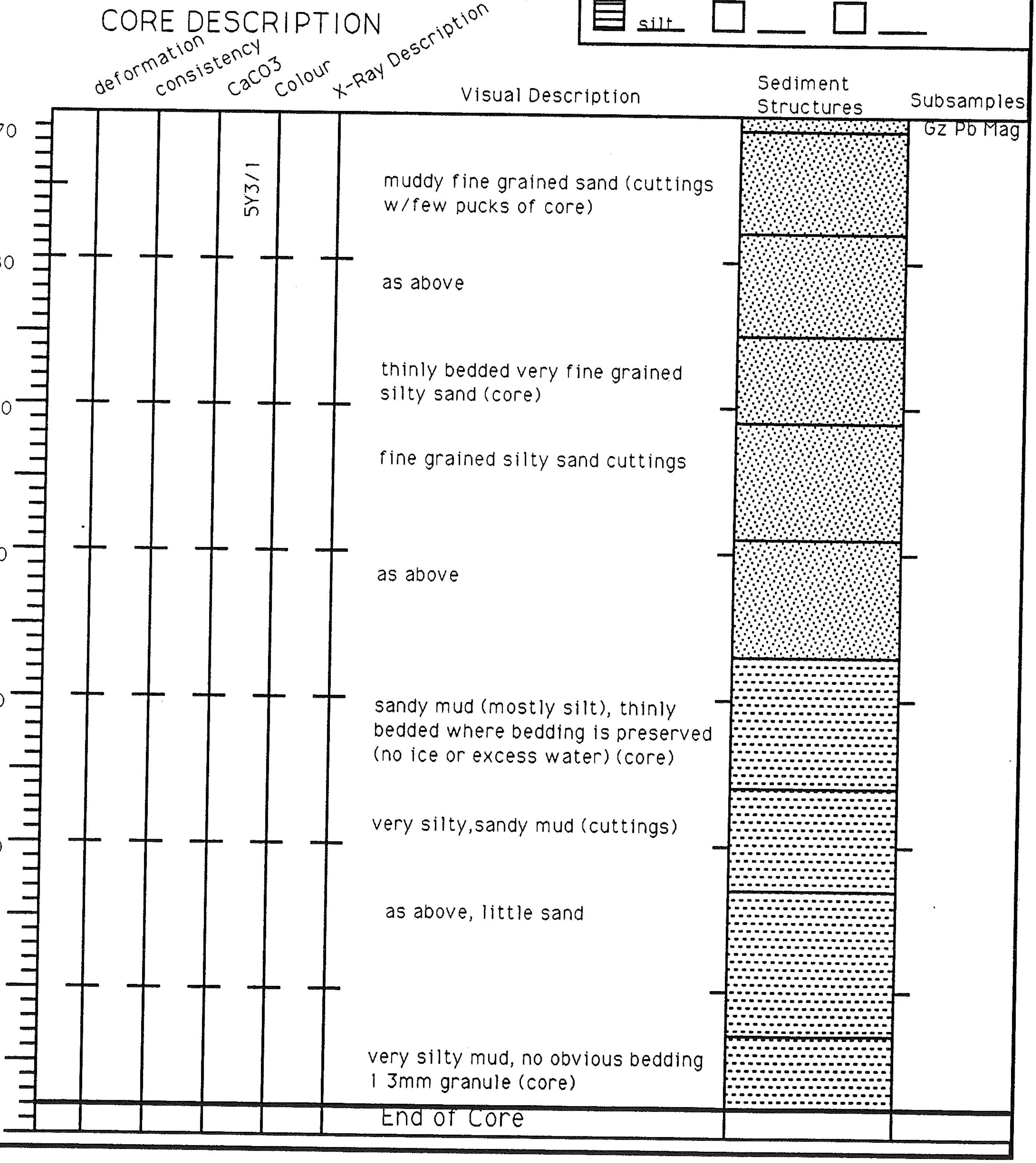
Described by Solomon

Page 2 of 2

Symbol Legend

▦ mud	▨ clay	☐
░ sand	░ ice	☐
▤ silt	☐	☐

CORE DESCRIPTION



muddy fine grained sand (cuttings w/few pucks of core)

as above

thinly bedded very fine grained silty sand (core)

fine grained silty sand cuttings

as above

sandy mud (mostly silt), thinly bedded where bedding is preserved (no ice or excess water) (core)

very silty,sandy mud (cuttings)

as above, little sand

very silty mud, no obvious bedding 1 3mm granule (core)

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 006

Total Length 53 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 42' 05.7"

Longitude 134 17' 47.5"

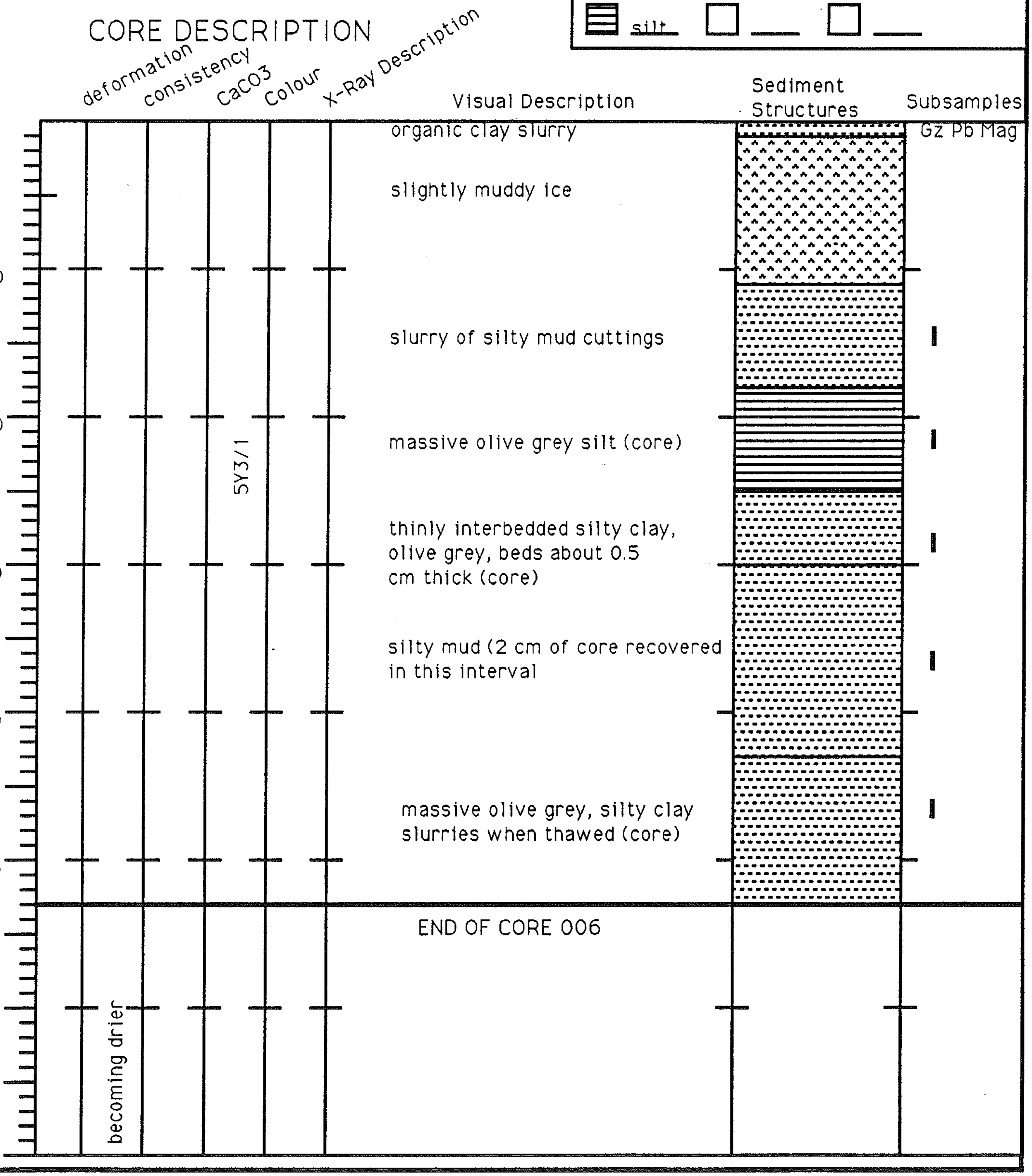
Described by Solomon

Page 1 of 1

Symbol Legend

- ▤ mud
- ▧ clay
- ☐ ___
- ▩ sand
- ▨ ice
- ☐ ___
- ☰ silt
- ☐ ___
- ☐ ___

CORE DESCRIPTION



organic clay slurry

slightly muddy ice

slurry of silty mud cuttings

massive olive grey silt (core)

thinly interbedded silty clay, olive grey, beds about 0.5 cm thick (core)

silty mud (2 cm of core recovered in this interval

massive olive grey, silty clay slurries when thawed (core)

END OF CORE 006

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600

Sample Number 007

Total Length 195 cm

Sample Type CRREL auger

Date March 28, 1991

Project Number 830007

Latitude 69 40' 50.0"

Longitude 134 18' 46.8"

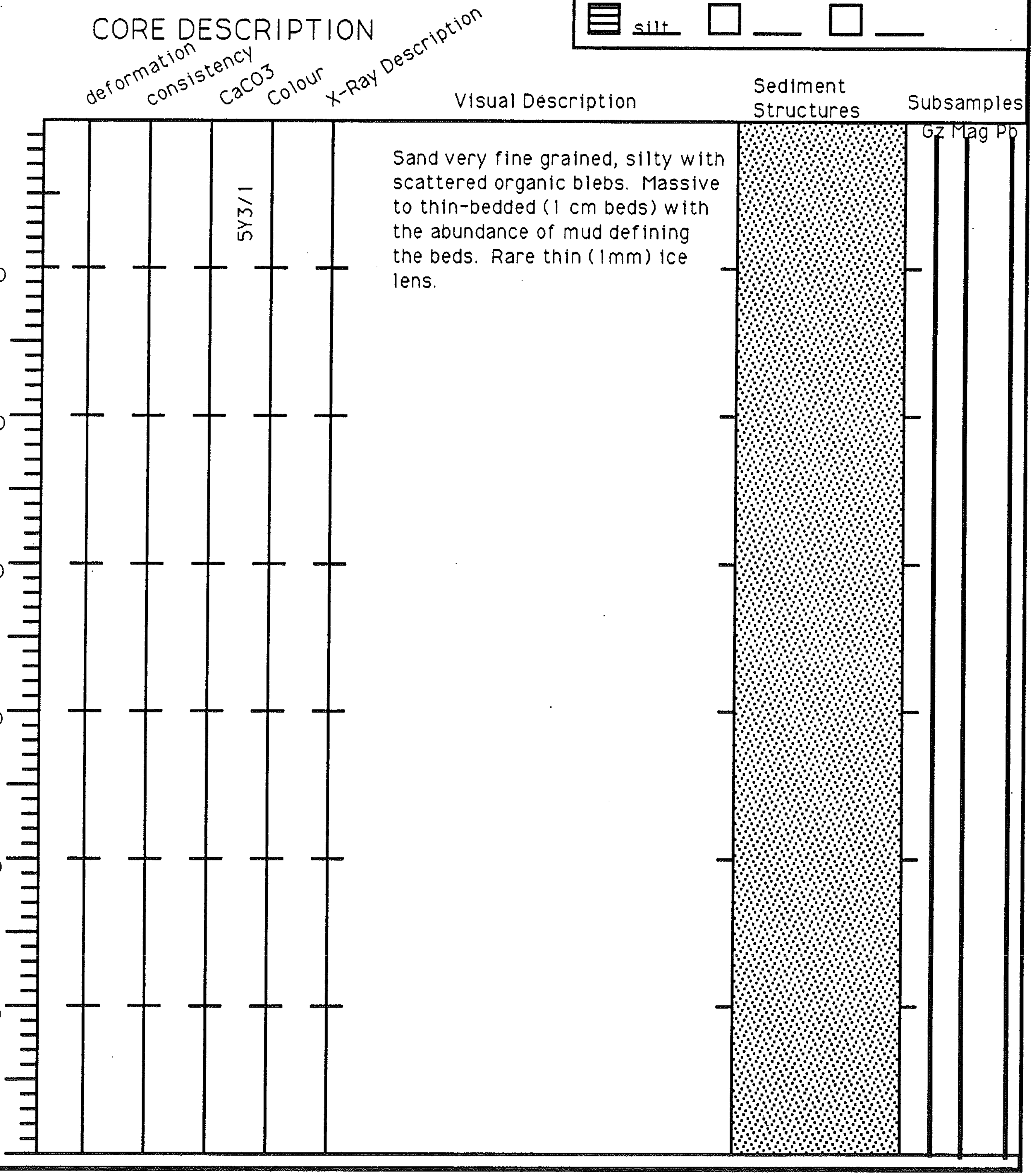
Described by Solomon

Page 1 of 3

Symbol Legend

- ▤ mud
- ▨ clay
- ☐ ___
- ▩ sand
- ▦ ice
- ☐ ___
- ☰ silt
- ☐ ___
- ☐ ___

CORE DESCRIPTION



Sand very fine grained, silty with scattered organic blebs. Massive to thin-bedded (1 cm beds) with the abundance of mud defining the beds. Rare thin (1mm) ice lens.

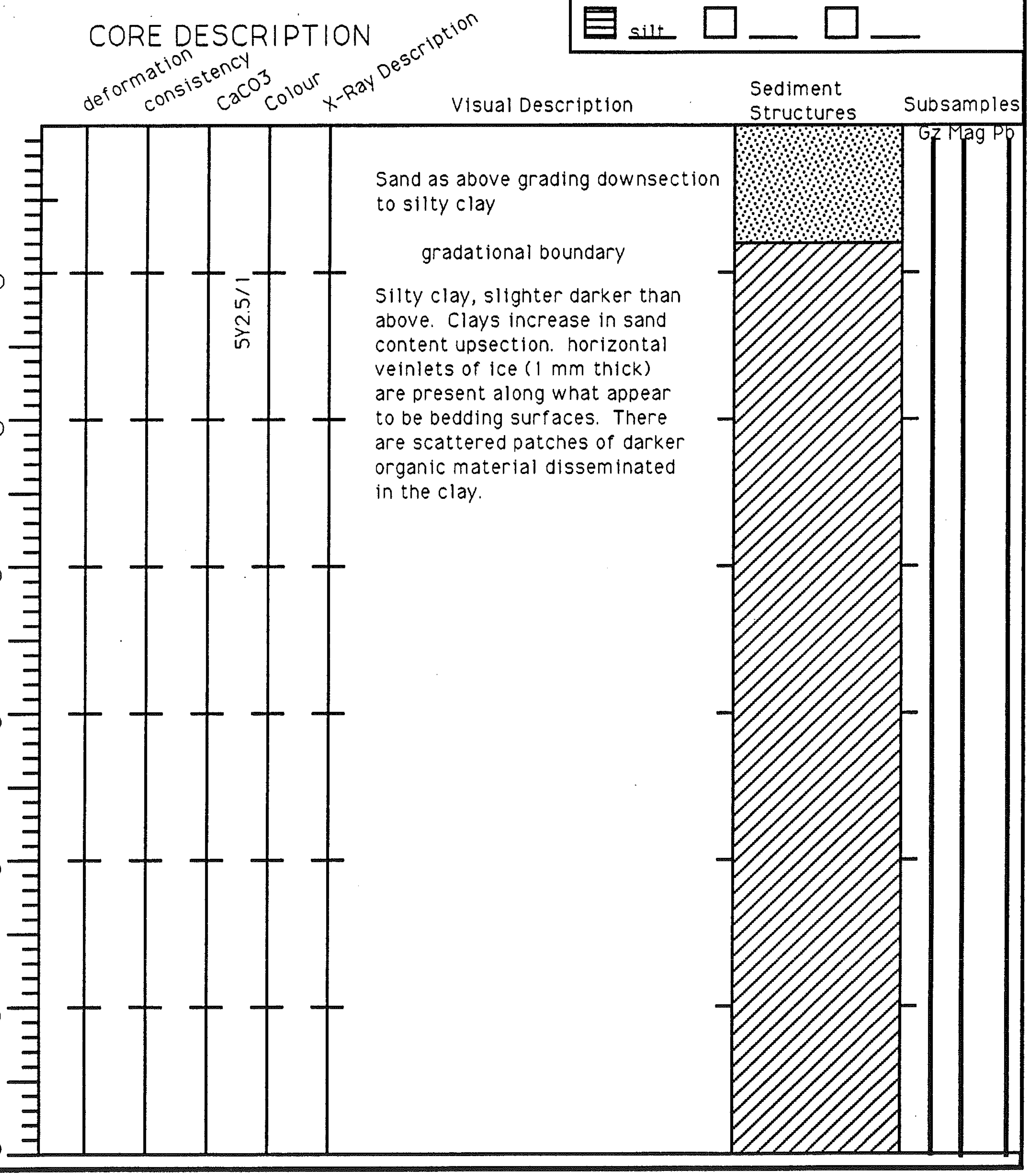
ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 007	Total Length 195 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 40' 50.0"	Longitude 134 18' 46.8"	
Described by Solomon	Page 2 of 3	

Symbol Legend

▤ mud	▨ clay	☐ ___
▩ sand	▦ ice	☐ ___
☰ silt	☐ ___	☐ ___

CORE DESCRIPTION



Sand as above grading downsection to silty clay

gradational boundary

Silty clay, slighter darker than above. Clays increase in sand content upsection. horizontal veinlets of ice (1 mm thick) are present along what appear to be bedding surfaces. There are scattered patches of darker organic material disseminated in the clay.

ATLANTIC GEOSCIENCE CENTRE

Cruise Number 91-600	Sample Number 007	Total Length 195 cm
Sample Type CRREL auger	Date March 28, 1991	Project Number 830007
Latitude 69 40' 50.0"	Longitude 134 18' 46.8"	
Described by Solomon	Page 3 of 3	

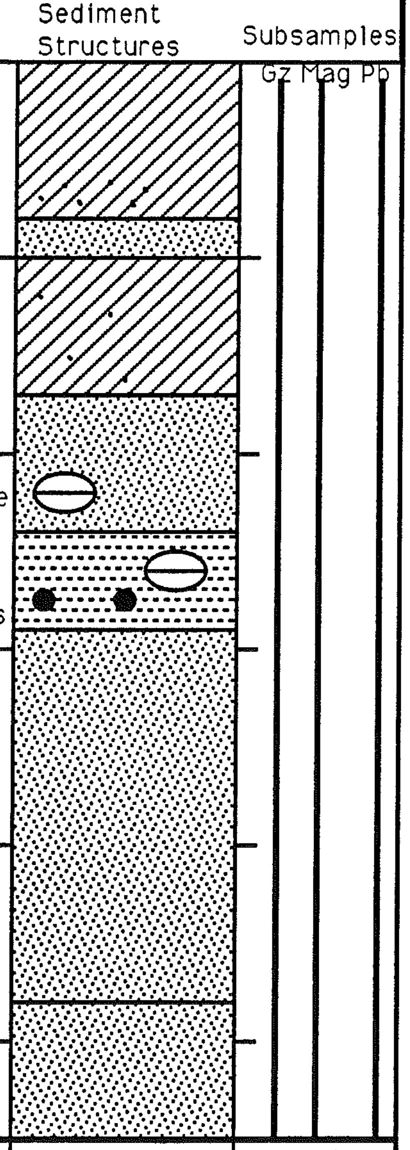
Symbol Legend

▤ mud	▨ clay	☐
▦ sand	▦ ice	☐
☰ silt	☐	☐

CORE DESCRIPTION

deformation	consistency	CaCO3	Colour	X-Ray Description	Visual Description
			5Y2.5/1		Silty clay as above, becoming slighty sand downsection
			5Y5/3		Sand yellow olive fine gr, mass.
			5Y3/1		Slighty sand silty clay, with thin horiz. ice veins every 2-3mm
			5Y5/3		Sand fine gr, sli muddy grades up section to silty clay. Intact bivalve shell
			5Y3/1		Muddy sand with scatterd 2 mm granules and shell frags, sd is mass sli muddy and organic
			5Y4/3		Sand fine grained, well sorted, massive, fines upsection
			5Y3/1		Sand as above, slightly muddy with scat organic matter, fetid odor

END OF 007



Appendix B1: Daily operations log: summer coastal program

July 24	Arrive Tuktoyaktuk and begin organizing gear.
July 25	Organize gear. Forbes to Inuvik.
July 26	Presentation to Inuvik Science Forum.
	Deploy Wavec buoy. Organize gear and supplies.
July 27	Forbes to Tuktoyaktuk. Organize gear and supplies.
July 28	Establish North Point camp on Richards Island.
July 29	Move out to North Point camp. Establish Wavec receiving station.
July 30	Organize camp. Establish tidal staff. Put S4 stands together.
July 31	Set up boat. Check 5041-02. Set up RCA camera at 5040-02 (MR2-south).
August 1	Set up camera at 5045-01 (North Head). Survey profile 5045-01.
August 2	Deploy *S491+obs* at 5045-01 (North Head).
August 3	Deploy *S468* at 5040-02 (MR2-south). Survey profiles 5040-02,-03,-04.
	Wind getting up.
August 4	Storm. Work up data in camp.
August 5	Deploy *Aa8697* in channel. Survey line 5045-39 (Wolfe Spit).
	Change video tapes at North Head and MR2-south.
	Resurvey line 5046-01.
August 6	Storm. Very rough passage to Wolfe Spit.
	Streaming-trap samples at 5045-39.
August 7	Fly to Yukon-Alaska boundary. Survey lines 5010-01,-02,-03,-04.
	Fly to Komakuk Beach. Survey lines 5011-01,-02.
	Refuel at Shingle Point and fly to Tuktoyaktuk.
August 8	Organize supplies in Tuktoyaktuk. Survey lines 5012-01,-02,-03.
August 9	Fly to Tent Island. Survey site 5340.
	Fly to Ellice Island. Survey site 5360.
	Refuel at Camp Farewell and fly to North Point camp.
August 10	Recover *S491+obs* and deploy *S490* at North Head.
	Resurvey lines 5045-01,-39.
August 11	Resurvey lines 5040-02,-03,-04. Change video tapes.
August 12	Deploy *S491* in Pipeline Harbour. Resurvey lines 5041-02,-GL.
	Recover *Aa8697* from channel.
August 13	Recover *S468* and download data.
August 14	Deploy *S468+obs* at 5045-39 (Wolfe Spit).
	Forbes to Tuktoyaktuk.
August 16	Harmes and Mudie to North Point.
	Deploy *Aa0828* in channel.
	Change video tapes at North Head and MR2-south.
	Survey cliff north of 5040 (MR2).

August 17	Resurvey Gillie lines 5043-GK and 5044-GE,-GF.
August 18	Resurvey line 5038-03.
August 19	Resurvey line 5045-39 and lines 5040-02,-03,-04.
August 21	Run echo-sounding line at 5045-01. Recover *S4*90 at North Head. Continue cliff survey north of 5040 (MR2).
August 22	Mudie to Tuktoyaktuk.
August 23	Recover *Aa*-0828 from channel. Shut down and recover video cameras.
August 24	Demobilize camp.
August 25	Recover *S468+obs* from off Wolfe Spit. Recover *S4*91 from Pipeline Harbour. Demobilize camp.
August 26	Sling camp to Wolfe Spit. Move to Tuktoyaktuk.
August 27	Pack gear for shipment south.
August 28	Pack gear for shipment south.

Appendix B2: Data inventory: summer coastal program

TABLE B2-1

Nearshore instrument deployments in northern Richards Island area (1991)

station[a]	depth[b] (m)	distance[c] (m)	instrument[d]	start[e] (MM/DD/hh:mm)	end[e] (MM/DD/hh:mm)
5040-01	2.4	427	*S4*-68	08/03/21:00	08/13/21:09
5043-GK	1.2	baymouth	*S4*-91	08/12/21:00	08/26/00:09
5043-42	2.5	channel	*Aa*-8697	08/05/18:32	08/? *[broke mooring]*
5043-42	2.5	channel	*Aa*-0828	08/16/16:15	08/24/20:22
5045-39	2.5	285	*S4*-68+*obs*	08/14/21:00	08/26/00:09
5045-01	2.3	178	*S4*-91+*obs*	08/02/21:00	08/10/18:09
5045-01	2.3	178	*S4*-90	08/10/21:00	08/25/00:09

[a] Identified by site and line number:
5040-01: 91-02 ('MR2 South')
5043-GK: Gillie-K ('Pipeline Harbour')
5043-42: 90-42 ('Pipeline Harbour')
5045-39: 90-39 ('Wolfe Spit')
5045-01: 91-01 ('Wolfe Spit' proximal end)

[b] Approximate depth to seabed at mean water level (MWL)

[c] Approximate distance seaward from MWL shoreline
(except *S4* in baymouth and *Aa* in channel)

[d] *S4* refers to InterOcean S4DW wave and current meters:
$z = 0.82$ m (*S4*-68: #07801668; *S4*-90: #07581590; *S4*-91: #07581591)
obs refers to addition of optical backscatter sensors:
$z = 50$ mm
Aa refers to paddle-equipped Aanderaa current meters:
$z = 1$ m

[e] Start and end times given as month/day/hour:minute in UT
S4DW wave and current meters:
sampling interval $\Delta t = 1$ s
burst length 540 s
burst interval 3 hours
Aanderaa current meters:
burst length and interval 300 s
direction instantaneous at cycle interval
speed averaged over burst

TABLE B2-2

Current meter station locations in northern Richards Island area (1991)

stn	latitude[a]	longitude[a]	UTM easting[b]	UTM northing[b]
5040-01	69°42.1612'N	134°14.4742'W	529376 m	7732724 m
5043-GK	69°41.9549'N	134°17.7985'W	527235 m	7732315 m
5043-42	69°41.1897'N	134°16.5900'W	528032 m	7730902 m
5045-39	69°43.5188'N	134°22.4627'W	524195 m	7735189 m
5045-01	69°43.5929'N	134°24.8879'W	522631 m	7735311 m

[a] NAD27 coordinates from GPS.
[b] UTM zone 08.

TABLE B2-3

Time-lapse video imagery in northern Richards Island area (1991)

station[a]	camera	tape	start[b] MM/DD/hh:mm	end[b] MM/DD/hh:mm
5040-01	RCA	1	07/31/20:30	08/05/19:55
		2	08/05/20:00	08/11/17:55
		3	08/11/18:00	08/16/15:40
		4	08/16/15:45	08/23/03:00
5045-01	Minolta	1	08/01/12:30	08/05/14:55
		2	08/05/15:00	08/11/16:10
		3	08/11/16:15	08/16/18:05
		4	08/16/18:10	08/24/13:25

[a] Camera at station 5040-01 (also known as MR2-South and profile site 91-02) was located near GSC benchmark 308, on a low mound behind the beach. The camera orientation was 061°true and line 1 crossed the field of view from bottom right to top left.

Camera at station 5045-01 (also known as proximal end of Wolfe Spit and profile site 91-01) was located near GSC benchmark 311, on a low rise overlooking the beach. The camera orientation was 009°true and line 1 crossed the field of view from bottom right to top left. Two buoys marking the position of the S4 current meter deployed on the line can be seen in some of the imagery.

[b] Start and end times are given as month/day/hour:minute, where all times are Mountain Daylight, 6 hours slow on Greenwich (MDT = UT - 6 h). All dates refer to August 1991. Imagery consists of 2.5 minute bursts at 3 hour intervals.

TABLE B2-4

Sample Inventory (summer 1991 coastal program)

Sample numbers cited below omit the cruise number (leading digits 91302).
List excludes palynological samples (see Appendix B3).

sample number	sample type	site	line	setting	material	latitude	longitude
LS1[1]	trap[2]	5045	39	nearshore	muddy sand	69°43.51'N	134°22.46'W
001	anchor	5043	Aa[3]	channel	sandy mud	69°41.20'N	134°16.57'W
002	scoop	5010	03	cliff	icy mud	69°38.77'N	140°59.78'W
003	scoop	5010	03	cliff	mud	69°38.77'N	140°59.78'W
004	scoop	5010	03	beach	gravel	69°38.77'N	140°59.78'W
005	scoop	5011	02	cliff	mud	69°35.75'N	140°11.18'W
006	scoop	5011	02	cliff	mud	69°35.75'N	140°11.18'W
007	scoop	5011	02	beach	sand	69°35.75'N	140°11.18'W
008	scoop	5011	02	beach	gravel	69°35.75'N	140°11.18'W
009	anchor	5045	01	nearshore	silt	69°43.59'N	134°24.89'W
010	scoop	5045	01	beach	sandy mud	69°43.27'N	134°24.90'W
011	scoop	5045	01	beach	sand	69°43.27'N	134°24.90'W
012	scoop	5045	01	beach	sand	69°43.27'N	134°24.90'W
013	scoop	5045	39	beach	sand	69°43.30'N	134°22.70'W
014	scoop	5045	39	washover flat	sand	69°43.20'N	134°22.81'W
015	scoop	5040	02	beach	gravel	69°42.01'N	134°15.96'W
016	scoop	5040	02	beach	gravel	69°42.01'N	134°15.96'W
017	scoop	5040	02	beach	sand	69°42.01'N	134°15.96'W
018	scoop	5040	02	beach	sand	69°42.01'N	134°15.96'W
019	anchor	5045	39	nearshore	muddy sand	69°43.52'N	134°22.46'W
020	anchor	5043	Aa[3]	channel	mud	69°41.19'N	134°16.59'W
021	scoop	5041	02	ramp	sand	69°42.02'N	134°15.96'W
022	scoop	5041	02	beach	sand	69°42.02'N	134°15.96'W
023	scoop	5041	02	lowtide terrace	sand	69°42.02'N	134°15.96'W
024	scoop	5041	02[4]	cliff	gravelly mud	69°42.01'N	134°16.10'W
025	scoop	5041	GL	cliff	sand[5]	69°42.01'N	134°16.65'W

---

[1] Nine subsamples labelled LS1-4A,4B,4C,4D and LS1-5A,5B,5C,5D,5E.
[2] Streaming trap samples collected to determine longshore transport.
[3] Aanderaa current meter station.
[4] Base of slump west of line 02.
[5] Kittigazuit Sand.

Appendix B3

Richards Island palynology sampling program

d: dominant
c: common
a: abundant
r: rare

l: locally
EHW: extreme high water
LLW: lowest low water

Field no. Date	Location	Sample no. and type
ARK 91-1 17/08/91	Gillie-E island, tidal salt marsh, profile in lee of sand spit, with round cobble; *Festuca*, *Elymus* [d], *Achillea* [c], *Artemesia* [c/ld]	1A - High marsh, muddy with *Elymus* just below storm drift. 1AA- EHW, thin algal mat and peat. 1B - Low marsh, muddy sand with *Puccinellia.* 1C - Tidal flat (LLW) with yellowish ?algal mat, especially in hollows and deer tracks. 1D - *Agarica*-type mushroom with dark brown spores.
ARK 91-2 17/08/91	Gillie-K, large island with east-west orientation, steep bluffs with a few thaw flows, south beach with blade clasts, summit with rounded Toker Point gravel. Grass and *Salix repens* [d], lichens and *Salix arctica* [d], *Carex nigra*, *Potentilla*, *Dryas*, *Ranunculus* [c], *Cassiope* [r], *Agarica*-type mushroom [c]. Sampled tidal salt marsh on north side of west beach.	2A - High marsh, winnowed peat, *Puccinellia* [d], *Potentilla* [c], *Juncus* [d], *Elymus* and *Cerastium* [r] 2B - Low marsh, loose herbaceous peat
ARK 91-3 17/08/91	Gillie-F, large low sandy island with little or no ice core and many large stabilized thaw flows and polygon wedges. Blade clasts on east point, elsewhere mostly rounded clasts. Tidal marsh with *Puccinellia* on northwest side of island. Flora like Gillie-K, but with more *Lupinus*, *Dryas*, *Armeria*, *Carex nigra*, and large *Saxifraga* and *Gentiana* spp. [r].	3A - High marsh peat with clumps of *Puccinellia.*

ARK 91-4 18/08/91	South end Reindeer Islands off Hansen Harbour, north end of beach survey line 90-3 (5038-03). Muddy sand with thin rim of *Elymus* marking EHW. East beach with blade clasts grading to shingle, wave-deposited cobbles on ridge top and outer spit.	4B - Push core 30 cm long with 19 cm grey sandy mud overlain by 9 cm black peat (displaced block).
ARK 91-5 18/08/91	Hansen Harbour campsite, small pond in polygon channel.	5A - Peaty anoxic sapropel, with algal mat at surface.
ARK 91-6 18/08/91	Wolfe Spit east of North Head, near proximal end of sand spit, with well-sorted blade clasts on seaward berm, smaller rounded clasts in intertidal area.	6A - High marsh with *Elymus arenarius*, approximately EHW, about 1 m below storm line. 6B - Low marsh with *Puccinellia* and *Festuca*. 6C - Tidal flat with algal mat and caribou tracks.
ARK 91-7 19/08/91	Wolfe Spit, distal end, south of profile line 90-40 (site 5045-40).	7A - High marsh with *Elymus*. 7B - Low marsh. 7C - Core through raised, gas-filled, blue-green algal mat.
ARK 91-8 19/08/91	MR2 Island, south end of beach at RCA camera site (site 5040).	8A - Flora from south end of spit. 8B - *Hippuris* pond above south end of lagoon, behind storm tide line.
ARK 91-9 19/08/91	MR2 Island, north end of beach at RCA camera site (site 5040-02).	9A - Push core through bubble mat in pond at north end of barrier.
ARK 91-10 20/08/91	Valley south of Hansen Harbour camp, freshwater pond above storm tide line, about 3.5 m asl. *Scirpus* and *Eriophorum* [d], thick mass of submerged moss.	10A - Water sample. 10B - Bottom sample. 10C - Moss.
ARK 91-11 20/08/91	Pond at storm tide line, with *Festuca* and *Eriophorum* [d], *Hippurus vulgaris* [c].	11A - Filtered water sample. 11B - Blue-green algae. 11C - Mud.
ARK 91-12 20/08/91	Pond in low marsh with *Elymus arenarius*, *Carex* spp. and *Puccinellia*.	12A - Filtered water. 12B - Algal mat. 12C - Mud.
ARK 91-13 20/08/91	Hansen Harbour channel, east of camp site. High tide with brisk wind from northwest.	13A - Approx. 15 litres of water.

ARK 91-14 20/08/91	South of Hansen Harbour camp, northeast face of first ridge. Open, thin tussock grass cover with scattered erratics.	14A - *Boletus* with dark brown spores (puff ball).
ARK 91-15 21/08/91	South of Hansen Harbour. Sand bar at mouth of breach-lake embayment.	15A - Low marsh on landward side of bar. *Puccinellia* cf. *phryganoides* and *Ranunculus* cf. *Pallasii* below. 15B - High marsh, sandy, with *Elymus* and Compositae.
ARK 91-16 21/08/91	Near shore of breached-lake channel south of Hansen Harbour.	16A - Low marsh, monospecific turf *Puccinellia phyganoides* and unspecified.
ARK 91-17 21/08/91	Brackish central basin of breached-lake embayment south of Hansen Harbour, north shore west of polygons.	17A - Floral gradient from drift line with *Elymus*, *Festuca* and *Puccinellia* to high marsh with tussock grass, *Cerastium* and *Potentilla*.
ARK 91-18 21/08/91	Same as 91-17.	18A - Low marsh with monospecific *P. phryganoides*.
ARK 91-19 21/08/91	Inner part of breached-lake embayment south of Hansen Harbour, southeast shore near channel to brackish central basin.	19A - Low marsh dominated by *Puccinellia*.
ARK 91-20 21/08/91	Inner end of inner lake basin in breached-lake embayment south of Hansen Harbour.	20A - Low marsh dominated by *Puccinellia*, grading landward to *Puccinellia*, *Festuca* and *Eriophorum*.
ARK 91-21 21/08/91	Above inner basin in small freshwater pond about 10 m asl in polygon field.	21A - Shoreline dominated by *Carex* spp.; abundant submerged moss.
ARK 91-22 21/08/91	Saddle between ridges in polygon thaw channel.	22A - Mud and ?*Scirpus* leaves.
ARK 91-23 21/08/91	East end of freshwater lake west of Hansen Harbour camp.	23A - *Scirpus* and *E. angustifolium* [d].
ARK 91-24 21/08/91	West end of freshwater pond at Hansen Harbour camp.	24A - Polygon pond in divide at west of end of lake; *Carex*, *Eriophorum* and *Ranunculus* [d], peat with aquatic moss [c]. 24B - Mud sample from south shore of pond with *Scirpus* and submerged moss [a], *Potentilla* and *Oxytropis*.
ARK 91-25 21/08/91	East end of freshwater pond at Hansen Harbour camp.	

Appendix C1: Daily operations log: *Arktos-β* 1991

July 23	Leave Dartmouth.
July 24	Repair and mobilize *Arktos-β*.
July 25	Repair and mobilize *Arktos-β*.
July 26	Repair and mobilize *Arktos-β*.
July 27	Repair and mobilize *Arktos-β*. Check campsite.
July 28	Repair and mobilize *Arktos-β*. Establish camp on Richards Island.
July 29	Repair and mobilize *Arktos-β*.
July 30	Repair and mobilize *Arktos-β*.
July 31	Repair and mobilize *Arktos-β*.
August 1	Repair and mobilize *Arktos-β*.
August 2	Repair and mobilize *Arktos-β*.
August 3	Repair and mobilize *Arktos-β*.
August 4	Stormy. Prepare *Arktos-β* for trials.
August 5	Still stormy. *Arktos-β* trials in lagoon.
August 6	*Arktos-β* trials in Tuktoyaktuk Harbour.
August 7	Load freight on *Arktos-β* and prepare for move to Richards Island.
August 8	*Arktos-β* and crew move to Richards Island.
August 9	Unload freight from *Arktos-β*. Trial survey. Forward engine quits (dirty fuel).
August 10	Run lines 1-5.
August 11	Run lines 6-7.
August 12	Run lines 8-9 in breached lakes.
August 13	Run line 10. Try C-CORE sparker.
August 14	Run line 11. Marr to North Point. Henley to Tuktoyaktuk.
August 15	Run lines 12-16. Try EG&G box on pipeline route.
August 16	Run lines 17-21 in Hansen Harbour and breached lake.
August 17	Run lines 22-23 in Pipeline Harbour and onshore resistivity.
August 18	Run lines 24-30 in lakes and breached lakes.
August 19	Run lines 31-38 on pipeline route and 5040-02 nearshore profile.
August 20	Run lines 39-43 in Mason Bay.
August 21	Run lines 44-46. Wolfe Spit (too rough). Back outside Reindeer Islands.
August 22	Run line 47 in breached lakes. Bill Scott tears out.
August 23	Demobilize camp and *Arktos-β*.
August 24	Demobilize camp and *Arktos-β*.
August 25	Demobilize camp. *Arktos-β* leaves for Tuktoyaktuk with load of gear.
August 26	Sling camp to Wolfe Spit for removal by Aklak Twin-Otter.
August 27	Pack gear for shipment south.
August 28	Pack gear for shipment south.
August 29	Pack gear for shipment south. Fix Geopulse. Atkinson, Hughes, Beaver to Inuvik.

Appendix C2: Data Inventory: *Arktos-ß* 1991

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 1

TOTAL SAMPLE INVENTORY

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
001	GRAB	2242057		69 38.74N	134 21.55W	1.4	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
002	GRAB	2242134		69 39.26N	134 21.32W	1.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
003	CORE	2252235		69 41.55N	134 19.87W	1.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
004	GRAB	2261852		69 40.84N	134 05.39W	2.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
005	GRAB	2261926		69 39.59N	134 07.07W	1.7	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
006	GRAB	2261940		69 39.44N	134 08.14W	0.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
007	GRAB	2261958		69 39.27N	134 09.50W	0.8	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
008	GRAB	2271727		69 41.18N	134 09.77W	1.6	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
009	GRAB	2271841		69 42.29N	134 14.35W	0.7	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
010	GRAB	2271958		69 43.37N	134 18.24W	2.2	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
011	GRAB	2272103		69 44.62N	134 15.92W	1.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
012	GRAB	2272150		69 45.78N	134 14.02W	2.6	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
013	GRAB	2301924		69 41.39N	134 21.80W	1.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 1

TOTAL SAMPLE INVENTORY

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
014	GRAB	2302057		69 40.68N	134 20.28W	2.6	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
015	GRAB	2312005		69 43.87N	134 17.45W	3.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
016	GRAB	2312141		69 42.81N	134 12.46W	2.6	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
017	GRAB	2312148		69 42.65N	134 12.97W	2.4	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
018	GRAB	2312157		69 42.41N	134 13.63W	2.3	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
019	GRAB	2312207		69 42.16N	134 14.46W	2.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
020	GRAB	2312319		69 42.14N	134 14.39W	2.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
021	GRAB	2322137		69 35.30N	133 59.27W	1.3	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
022	GRAB	2322208		69 34.42N	134 02.03W	2.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
023	GRAB	2322338		69 34.99N	134 09.72W	3.8	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
024	GRAB	2331932		69 43.54N	134 22.39W	2.3	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
025	GRAB	2341820		69 39.01N	134 14.82W	1.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
026	GRAB	2341831		69 38.96N	134 14.96W	5.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 1

TOTAL SAMPLE INVENTORY

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
027	GRAB	2341857		69 38.70N	134 15.38W	23.0	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
028	GRAB	2341909		69 38.70N	134 14.61W	1.8	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
029	GRAB	2341918		69 38.73N	134 13.92W	0.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND
030	GRAB	2341924		69 38.75N	134 13.57W	0.5	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE2

GRAB SAMPLES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO. OF ATTEMPTS	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
001	VAN VEEN	2242057	69 38.74N 134 21.55W	1.4	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	BLACK ORGANIC OOZE.
002	VAN VEEN	2242134	69 39.26N 134 21.32W	1.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	BLACK ORGANIC OOZE.
004	VAN VEEN	2261852	69 40.84N 134 05.39W	2.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE SILTY CLAY.
005	VAN VEEN	2261926	69 39.59N 134 07.07W	1.7	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE SILTY CLAY.
006	VAN VEEN	2261940	69 39.44N 134 08.14W	0.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN FINE SAND.
007	VAN VEEN	2261958	69 39.27N 134 09.50W	0.8	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE SILTY SAND.
008	VAN VEEN	2271727	69 41.18N 134 09.77W	1.6	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE SILTY CLAY.
009	VAN VEEN	2271841	69 42.29N 134 14.35W	0.7	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN FINE SAND.
010	VAN VEEN	2271958	69 43.37N 134 18.24W	2.2	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	SLIGHTLY SILTY OLIVE CLAY.
011	VAN VEEN	2272103	69 44.62N 134 15.92W	1.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	BROWNISH-GREEN MEDIUM SAND WITH SOME MUD-POSSIBLY AS DRAPES.
012	VAN VEEN	2272150	69 45.78N 134 14.02W	2.6	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE SILTY MUD.
013	VAN VEEN	2301924	69 41.39N 134 21.80W	1.0	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK BROWN ORGANIC OOZE WITH GRASS, WORMS.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE2

GRAB SAMPLES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO. OF ATTEMPTS	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
014	VAN VEEN	2302057	69 40.68N 134 20.28W	2.6	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN CLAY WITH A LITTLE SILT.
015	VAN VEEN	2312005	69 43.87N 134 17.45W	3.0	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	GREY-GREEN SAND MUD.
016	VAN VEEN	2312141	69 42.81N 134 12.46W	2.6	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN, SILTY, SANDY MUD.
017	VAN VEEN	2312148	69 42.65N 134 12.97W	2.4	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN, SILTY CLAY.
018	VAN VEEN	2312157	69 42.41N 134 13.63W	2.3	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN, SILTY CLAY.
019	VAN VEEN	2312207	69 42.16N 134 14.46W	2.0	2		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN, MUDDY FINE SAND.
020	VAN VEEN	2312319	69 42.14N 134 14.39W	2.0	10		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	1ST AND 2ND ATTEMPTS DID NOT TRIP. SAMPLE TO BE USED TO CALIBRATE S4'S, ALL ATTEMPTS IN ONE BUCKET.
021	VAN VEEN	2322137	69 35.30N 133 59.27W	1.3	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN MUD.
022	VAN VEEN	2322208	69 34.42N 134 02.03W	2.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN SILTY CLAY.
023	VAN VEEN	2322338	69 34.99N 134 09.72W	3.8	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN SILTY CLAY.
024	VAN VEEN	2331932	69 43.54N 134 22.39W	2.3	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	OLIVE GREEN FINE SAND.
025	VAN VEEN	2341820	69 39.01N 134 14.82W	1.0	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY FINE SAND WITH ABUNDANT ORGANIC MATTER AND A BROWN OXIDIZED SURFACE CRUST 1CM THICK.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE2

GRAB SAMPLES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO. OF ATTEMPTS	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
026	VAN VEEN	2341831	69 38.96N 134 14.96W	5.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY CLAY WITH A BROWN OXIDIZED SURFACE, APPROX. 1/2CM THICK.
027	VAN VEEN	2341857	69 38.70N 134 15.38W	23.0	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY CLAY WITH THIN BROWN OXIDIZED SURFACE.
028	VAN VEEN	2341909	69 38.70N 134 14.61W	1.8	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY ORGANIC OOZE WITH A 1/2CM THICK BROWN OXIDIZED SURFACE.
029	VAN VEEN	2341918	69 38.73N 134 13.92W	0.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY ORGANIC OOZE, ABUNDANT PLANT MATERIAL, BROWN OXIDIZED SURFACE CRUST.
030	VAN VEEN	2341924	69 38.75N 134 13.57W	0.5	1		BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	DARK GREY SANDY CLAY, ORGANIC FRAGMENTS.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 3

CORE SAMPLES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (MTRS)	CORER LENGTH (CM)	APP. PENN (CM)	CORE LENGTH (CM)	NO OF SECT	GEOGRAPHIC LOCATION	NOTES
003	VIBRO	2252235	69 41.55N 134 19.87W	1.0	307	100		1	BEAUFORT SEA, NORTH HEAD, RICHARDS ISLAND	

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 4

SEISMIC RECORDS

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	HYDROPHONE	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
1	2221540	2230213	NSRF 25 FT	1 - 5	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
2	2231720	2252211	NSRF 25 FT	6 - 10	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
3	2252310	2272217	NSRF 25 FT	10 - 14	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
4	2272306	2292115	NSRF 25 FT	15 - 23	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
5	2301629	2302111	NSRF 25 FT	24 - 30	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
6	2311534	2320055	NSRF 25 FT	31 - 38	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
7	2321552	2321657	NSRF 25 FT	39	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
8	2321700	2330147	NSRF 25 FT	39 - 43	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
9	2331934	2332345	NSRF 25 FT	44 - 46	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
10	2341656	2341835	NSRF 25 FT	47	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
11	2341837	2341953	NSRF 25 FT	47	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	BOOMER BOOMER
1	2211920	2221752	INTERNAL	1 - 3	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
2	2221813	2230213	INTERNAL	3 - 5	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
3	2231720	2242047	INTERNAL	6 - 8	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
4	2242111	2262050	INTERNAL	9 - 11	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
5	2262101	2290100	INTERNAL	11 - 21	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
6	2291542	2292115	INTERNAL	22 - 23	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 4

SEISMIC RECORDS

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	HYDROPHONE	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
7	2301628	2302111	INTERNAL	24 - 30	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
8	2311534	2312008	INTERNAL	31 - 35	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
9	2312010	2320055	INTERNAL	35 - 38	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
10	2321552	2330147	INTERNAL	39 - 43	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
11	2331933	2332345	INTERNAL	44 - 46	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
12	2341656	2341953	INTERNAL	47	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	EPC1600	SEISTEC BOOMER

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 5

SIDESCAN RECORDS

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SIDESCAN SYSTEM
1	2221540	2221701	1 - 3	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
2	2221703	2230125	3 - 5	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
3	2231719	2231817	6	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
4	2231822	2232352	6 - 7	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
5	2241726	2242311	8 - 9	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
6	2251704	2252212	10	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
7	2252311	2260039	10	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
8	2261521	2261913	11	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
9	2261921	2262117	11	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
10	2271516	2271822	12 - 13	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
11	2271833	2272351	13 - 15	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
12	2280003	2280025	15	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
13	2282048	2290100	17 - 21	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
14	2291926	2292005	22	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
15	2311613	2312037	31 - 35	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
16	2312040	2312215	36 - 37	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
17	2321552	2321925	39 - 40	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 5

SIDESCAN RECORDS

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SIDESCAN SYSTEM
18	2322057	2330147	41 - 43	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
19	2331934	2332345	44 - 46	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
20	2341656	2341951	47	SINGLE	BEAUFORT SEA, RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 6

BATHYMETRY RECORDS

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	FREQUENCY	LINE NUMBERS	PARAMETER	GEOGRAPHIC LOCATION	RECORDER	NOTES
1	2211605	2230213	200KHZ	1 - 5	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
2	2231717	2242120	200KHZ	6 - 8	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
3	2242134	2252338	200KHZ	9 - 10	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
4	2261522	2261722	200KHZ	11	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
5	2261730	2272214	200KHZ	11 - 14	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
6	2272225	2291905	200KHZ	14 - 22	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
7	2291918	2312027	200KHZ	22 - 35	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
8	2312032	2330035	200KHZ	35 - 43	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	
9	2330050	2341954	200KHZ	43 - 47	OVERSIDE	BEAUFORT SEA, RICHARDS ISLAND	RAYTHEON	

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 7

SIDESCAN TAPES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	SIDESCAN SYSTEM	GEOGRAPHIC LOCATION	NOTES
1	2231917	2232230	6-7	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
2	2232238	2241748	7-8	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
3	2241754	2242053	8-9	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
4	2251826	2252145	10	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
5	2252149	2261645	10-11	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
6	2261648	2262001	11	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
7	2262003	2271716	11-13	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
8	2271718	2272034	13-14	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
9	2272035	2272348	14-15	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
10	2272350	2282116	15-17	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
11	2282118	2290031	17-21	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
12	2290033	2291824	21-22	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
13	2291826	2301646	22-24	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
14	2301649	2302043	24-26	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
15	2302044	2311821	26-34	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
16	2311823	2312136	34-37	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
17	2312138	2321705	37-39	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 7

SIDESCAN TAPES

CRUISE NUMBER = ARKTOS 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	SIDESCAN SYSTEM	GEOGRAPHIC LOCATION	NOTES
18	2321707	2322147	39-41	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
19	2322149	2330104	41-43	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
20	2330105	2332202	43-45	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
21	2332203	2341826	45-47	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	
22	2341827	2341954	47	SEISMIC + SIDESCAN	BEAUFORT SEA, RICHARDS ISLAND	

Appendix D1: Daily operations log: CCGS *Nahidik* 1991

August 30	Prepare gear in Tuktoyaktuk for *Nahidik* survey.
August 31	Load *Nahidik*.
Sept. 1	Depart Tuktoyaktuk onboard *Nahidik*.
Sept. 2	*Nahidik* arrives Inuvik. Prepare gear.
Sept. 3	Load *Nahidik*.
Sept. 4	Mobilize *Nahidik*.
Sept. 5	Depart Inuvik for Tuktoyaktuk.
Sept. 6	Depart Tuktoyaktuk for survey area. Run lines 1-4.
Sept. 7	Cores 1-4. Run lines 5-6.
Sept. 8	Cores 5-17. Run line 7.
Sept. 9	Cores 18-20. Run lines 8-12. Proceed to Tuktoyaktuk.
Sept. 10	Demobilize *Nahidik*.
Sept. 11	Demobilize and pack gear for transport south.
Sept. 12	Depart Tuktoyaktuk.
Sept. 13	Arrive Dartmouth.

Appendix D2: Data inventory: CCGS *Nahidik* 1991

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 1

TOTAL SAMPLE INVENTORY

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
001	CORE	2501445		69 47.02N	134 34.89W	4.8	BEAUFORT SEA, WEST OF PULLEN ISLAND
002	CORE	2501540		69 44.73N	134 31.55W	3.3	BEAUFORT SEA, WEST OF PULLEN ISLAND
003	CORE	2501639		69 43.36N	134 29.26W	1.6	BEAUFORT SEA, WEST OF PULLEN ISLAND
004	CORE	2501722		69 43.17N	134 29.20W	1.6	BEAUFORT SEA, WEST OF PULLEN ISLAND
005	CORE	2511335		69 46.40N	134 13.04W	2.3	BEAUFORT SEA, PIPELINE ROUTE
006	CORE	2511413		69 48.45N	134 09.79W	4.6	BEAUFORT SEA, PIPELINE ROUTE
007	CORE	2511522		69 50.51N	134 06.61W	6.0	BEAUFORT SEA, PIPELINE ROUTE
008	CORE	2511628		69 52.60N	134 03.16W	7.9	BEAUFORT SEA, PIPELINE ROUTE
009	CORE	2511948		69 46.98N	134 02.81W	4.1	BEAUFORT SEA, NORTH OF REINDEER ISLS.
010	CORE	2512012		69 46.98N	134 02.81W	4.1	BEAUFORT SEA, NORTH OF REINDEER ISLS.
011	CORE	2512111		69 44.91N	134 07.54W	2.7	BEAUFORT SEA, NORTH OF REINDEER ISLS.
012	CORE	2512210		69 43.12N	134 11.57W	1.7	BEAUFORT SEA, NORTH OF REINDEER ISLS.
013	CORE	2512249		69 42.38N	134 13.51W	1.1	BEAUFORT SEA, NORTH OF REINDEER ISLS.
014	CORE	2520010		69 40.51N	134 05.39W	1.7	BEAUFORT SEA, N.E. OF HANSEN HARBOUR

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 1

TOTAL SAMPLE INVENTORY

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
015	CORE	2520048		69 41.83N	134 02.78W	2.5	BEAUFORT SEA, N.E. OF HANSEN HARBOUR
016	CORE	2520133		69 44.53N	133 56.30W	3.4	BEAUFORT SEA, N.E. OF HANSEN HARBOUR
017	CORE	2520211		69 46.31N	133 52.88W	4.7	BEAUFORT SEA, N.E. OF HANSEN HARBOUR
018	CORE	2521329		69 37.18N	133 52.81W	1.1	BEAUFORT SEA, CRUMBLING POINT TRANSECT
019	CORE	2521353		69 38.11N	133 51.20W	2.0	BEAUFORT SEA, CRUMBLING POINT TRANSECT
020	CORE	2521434		69 41.15N	133 45.89W	3.6	BEAUFORT SEA, CRUMBLING POINT TRANSECT

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 2

CORE SAMPLES

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (MTRS)	CORER LENGTH (CM)	APP. PENN (CM)	CORE LENGTH (CM)	NO OF SECT	GEOGRAPHIC LOCATION	NOTES
001	VIBRO	2501445	69 47.02N 134 34.89W	4.8	305	200	213	2	BEAUFORT SEA, WEST OF PULLEN ISLAND	14:48 OFF BOTTOM. CATCHER SAMPLE IN A-BOTTOM - 8CM IN BAG. OLIVE GREY F SAND. ADD 1.6M TO ALL SAMPLE WATER DEPTHS FOR SHIPS DRAFT.
002	VIBRO	2501540	69 44.73N 134 31.55W	3.3	305	305	102	1	BEAUFORT SEA, WEST OF PULLEN ISLAND	15:46 OFF BOTTOM. CATCHER SAMPLE IN DARK OLIVE GREY SILT, FIRM, COHESIV
003	VIBRO	2501639	69 43.36N 134 29.26W	1.6	305	230	226	2	BEAUFORT SEA, WEST OF PULLEN ISLAND	16:44 OFF BOTTOM. NO CATCHER SAMPLE BOTTOM OF CORE IS VERY FIRM, DARK G FINE SAND.
004	VIBRO	2501722	69 43.17N 134 29.20W	1.6	305	305	264	2	BEAUFORT SEA, WEST OF PULLEN ISLAND	17:24 OFF BOTTOM. NO CATCHER SAMPLE BOTTOM OF CORE IS VERY FINE GRAINED OLIVE GREY-GREEN SAND. SOME CRACKS THE CORE SUGGESTING GAS RELEASE.
005	VIBRO	2511335	69 46.48N 134 13.04W	2.3	305	250	239	2	BEAUFORT SEA, PIPELINE ROUTE	13:41 OFF BOTTOM. NO CATCHER SAMPLE VERY STIFF OLIVE SILTY CLAY AT BASE
006	VIBRO	2511413	69 48.45N 134 09.79W	4.6	305	200	213	2	BEAUFORT SEA, PIPELINE ROUTE	14:21 OFF BOTTOM. CATCHER SAMPLE IN DARK OLIVE GREY SILTY CLAY, VERY ST CLOSE TO PLASTIC LIMIT.
007	VIBRO	2511522	69 50.51N 134 06.61W	6.0	305	150	188	2	BEAUFORT SEA, PIPELINE ROUTE	15:31 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY STIFF SLIGHTLY SILTY CLA CLOSE TO PLASTIC LIMIT.
008	VIBRO	2511628	69 52.60N 134 03.16W	7.9	305	130	142	1	BEAUFORT SEA, PIPELINE ROUTE	16:44 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREEN FINE GRAINED SAND WITH FRAGMENTS.
009	VIBRO	2511948	69 46.98N 134 02.81W	4.1	305	118	122	1	BEAUFORT SEA, NORTH OF REINDEER ISLS.	19:50 OFF BOTTOM. STATION ABORTED D TO SHIP DRIFTING OVER CORER. CATCHE SAMPLE IN BAG. OLIVE GREEN STIFF SI CLAY.
010	VIBRO	2512012	69 46.98N 134 02.81W	4.1	305	270	313	2	BEAUFORT SEA, NORTH OF REINDEER ISLS.	20:28 OFF BOTTOM. SECTION C-TOP 15C EXTRUDED OUT OF LINER (IN BAG). CAT SAMPLE IN BAG. OLIVE GREEN STIFF SI CLAY.
011	VIBRO	2512111	69 44.91N 134 07.54W	2.7	305	305	298	2	BEAUFORT SEA, NORTH OF REINDEER ISLS.	21:19 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY CLAYEY SILT-FIRM.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 2

CORE SAMPLES

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SAMPLE NUMBER	SAMPLE TYPE	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (MTRS)	CORER LENGTH (CM)	APP. PENN (CM)	CORE LENGTH (CM)	NO OF SECT	GEOGRAPHIC LOCATION	NOTES
012	VIBRO	2512210	69 43.12N 134 11.57W	1.7	305	305	265	2	BEAUFORT SEA, NORTH OF REINDEER ISLS.	22:14 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY SILTY CLAY-SOFT.
013	VIBRO	2512249	69 42.38N 134 13.51W	1.1	305	305	255	2	BEAUFORT SEA, NORTH OF REINDEER ISLS.	22:51 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY SILTY CLAY WITH FRAGMENT DARK GREY PEATY MATERIAL. VERY SOFT RAPID PENETRATION.
014	VIBRO	2520010	69 40.51N 134 05.39W	1.7	305	305	264	2	BEAUFORT SEA, N.E. OF HANSEN HARBOUR	00:12 OFF BOTTOM. NO CATCHER SAMPLE BOTTOM OF CORE IS SLIGHTLY SILTY OL GREY CLAY-STICKY. VERY RAPID PENETRATION.
015	VIBRO	2520040	69 41.83N 134 02.78W	2.5	305	230	293	2	BEAUFORT SEA, N.E. OF HANSEN HARBOUR	00:57 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY STIFF SILTY CLAY. VERY S PENETRATION LAST 0.5M.
016	VIBRO	2520133	69 44.53N 133 56.30W	3.4	305	200	258	2	BEAUFORT SEA, N.E. OF HANSEN HARBOUR	01:41 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY STIFF CLAY.
017	VIBRO	2520211	69 46.31N 133 52.88W	4.7	305	250	235	2	BEAUFORT SEA, N.E. OF HANSEN HARBOUR	02:16 OFF BOTTOM. CATCHER SAMPLE IN VERY SOFT OLIVE GREY SLIGHTLY SILTY CLAY. PIECE OF LINER BROKEN OUT OF BOTTOM - B-TOP WHICH WAS RE-ATTACHE THE GALLANT SAMPLING CREW. ** CARE SHOULD BE TAKEN WHEN SPLITT THIS CORE **
018	VIBRO	2521329	69 37.18N 133 52.01W	1.1	305	250	253	2	BEAUFORT SEA, CRUMBLING POINT TRANSECT	13:32 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY PLASTIC, SOFT, SLIGHTLY CLAY.
019	VIBRO	2521353	69 38.11N 133 51.20W	2.0	305	305	264	2	BEAUFORT SEA, CRUMBLING POINT TRANSECT	13:56 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY SOFT, PLASTIC SLIGHTLY S CLAY.
020	VIBRO	2521434	69 41.15N 133 45.89W	3.6	305	250	245	2	BEAUFORT SEA, CRUMBLING POINT TRANSECT	14:38 OFF BOTTOM. CATCHER SAMPLE IN OLIVE GREY SILTY CLAY, FIRM, PLASTI

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 3

SEISMIC RECORDS

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	HYDROPHONE	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
1	2491543	2500406	NSRF 25 FT	1,2,3,3A,4	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	BOOMER BOOMER
2	2500408	2500433	NSRF 25 FT	4	SINGLE	BEAUFORT SEA OFF RICHARDS ISLAND	EPC1600	BOOMER BOOMER
3	2501820	2510117	NSRF 25 FT	5,6	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	BOOMER BOOMER
4	2511716	2511917	NSRF 25 FT	7	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	BOOMER BOOMER
5	2521517	2530025	NSRF 25 FT	8,9,10,11,12	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	BOOMER BOOMER
1	2491534	2500433	INTERNAL	1,1A,2,3,3A,4	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
2	2501820	2510117	INTERNAL	5,6	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
3	2511716	2511917	INTERNAL	7	SINGLE	BEAUFORT SEA OFF RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
4	2521510	2530025	INTERNAL	8,9,10,11,12	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC1600	SEISTEC BOOMER
1	2501840	2510117	NSRF+INT.	5,6	COMBINED	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC3200	BOOMER + SEISTEC BOOMER
2	2511716	2511917	NSRF+INT.	7	COMBINED	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC3200	BOOMER + SEISTEC BOOMER
3	2521521	2530025	NSRF+INT.	8,9,10,11,12	COMBINED	BEAUFORT SEA, OFF RICHARDS ISLAND	EPC3200	BOOMER + SEISTEC BOOMER

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 4

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

SIDESCAN RECORDS

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	RECORD TYPE	GEOGRAPHIC LOCATION	RECORDER	SIDESCAN SYSTEM
1	2491534	2492054	1,2	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
2	2492115	2500236	2,3,3A,4	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
3	2500239	2500434	4	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
4	2501911	2502216	5	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
5	2502222	2510117	5,6	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
6	2521716	2521917	7	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
7	2521520	2521849	8,9	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)
8	2521852	2530026	9,10,11,12	SINGLE	BEAUFORT SEA, OFF RICHARDS ISLAND	KLEIN 531	KLEIN 531T (100 KHZ)

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 5

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

BATHYMETRY RECORDS

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	FREQUENCY	LINE NUMBERS	PARAMETER	GEOGRAPHIC LOCATION	RECORDER	NOTES
1	2481912	2482030	200KHZ		OVERSIDE	MACKENZIE RIVER	RAYTHEON	
2	2491534	2500052	200KHZ	1,1A,2,3,3A	OVERSIDE	BEAUFORT SEA, OFF RICHARDS ISLAND	RAYTHEON	
3	2500100	2510119	200KHZ	4,5,6	OVERSIDE	BEAUFORT SEA, OFF RICHARDS ISLAND	RAYTHEON	
4	2511716	2530025	200KHZ	7,8,9,10,11,12	OVERSIDE	BEAUFORT SEA, OFF RICHARDS ISLAND	RAYTHEON	

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 6

3.5 KHZ RECORDS

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

ROLL NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	GEOGRAPHIC LOCATION	RECORDER	SYSTEM / SOUND SOURCE
1	2481912	2482023		MACKENZIE RIVER	EPC3200	OVERSIDE TRANSDUCER

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 7

SIDESCAN TAPES

CRUISE NUMBER = NAHIDIK 91
CHIEF SCIENTIST = S. SOLOMON
PROJECT NUMBER = 830007

TAPE NUMBERS	START DAY/TIME	STOP DAY/TIME	LINE NUMBERS	SIDESCAN SYSTEM	GEOGRAPHIC LOCATION	NOTES
1	2491534	2492106	1,1A,2	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
2	2492108	2500021	2,3,3A	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
3	2500023	2500335	3A,4	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
4	2500337	2502119	4,5	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
5	2502121	2510032	5,6	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
6	2510033	2521613	6,7,8	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
7	2521614	2522124	8,9,10	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	
8	2522126	2530025	10,11,12	SEISMIC + SIDESCAN	BEAUFORT SEA, OFF RICHARDS ISLAND	

Appendix E1: GPS positions determined along Beaufort Sea coast during 1991

Table E1-1

LOCATION	LAT	LONG	EAST	NORTH	ZONE
West MEDS *Wavec*	69°48.64'	134°36.21'	515373	7744633	08
East MEDS planned	69°51.09'	134°09.56'	532318	7749360	08
5045 WOLFE SPIT borehole pipe	69°43.2458'	134°23.4422'	523569	7734675	08
5045-01 NORTH HEAD BM311	69°43.4804	134°24.9135'	522617	7735102	08
5041-02 MR2 (90-02) BM1	69°42.0242	134°15.9576'	528422	7732458	08
5041-02 MR2 (90-02) BM3	69°42.0475	134°15.9647'	528417	7732501	08
5041-GL MR2A (Gillie-L) back	69°42.0100	134°16.6471'	527977	7732426	08
5045-01 NORTH HEAD (91-01) BM1	69°43.4622	134°24.9156'	522616	7735068	08
5045-01 NORTH HEAD camera (Minolta)	69°43.4839	134°24.9135'	522616	7735108	08
5040 MR2 (1990)	69°42.0256	134°15.3546'	528811	7732465	08
5040-02 MR2 camera (RCA)	69°42.0027	134°15.0032'	529038	7732425	08
5040-02 MR2 (91-02) BM1= BM308	69°42.0071	134°14.9988'	529041	7732433	08
5046-01 NORTH HEAD IV (90-01) BM2	69°43.2045	134°27.5174'	520943	7734573	08
5046-01 NORTH HEAD (90-01) instrument pin	69°43.2169	134°27.5358'	520931	7734596	08
5045-01 NORTH HEAD *S4*/obs	69°43.5929	134°24.8879'	522631	7735311	08
5040-02 MR2 (91-02) *S4*	69°42.1612	134°14.4742'	529376	7732724	08
5043 PIPELINE HBR channel *Aanderaa*8697	69°41.1959'	134°16.5961'	528028	7730913	08
5012-01 TUKTOYAKTUK BM287	69°26.8199'	133°02.3086'	576846	7705260	08
5010-01 YUKON-ALASKA boundary BM333	69°38.7724'	140°59.7804'	500142	7726243	07
5010 YUKON-ALASKA boundary marker	69°38.7553'	140°59.8468'	500099	7726211	07
5012-03 TUKTOYAKTUK BM:1949 DLS	69°27.0439'	133°02.2078'	576899	7705678	08
5010 Boundary Commission marker1A 1973	69°38.7496'	140°59.8570'	500093	7726201	07
5360 ELLICE ISLAND Gillie-II	69°17.3353'	135°51.2750'	466270	7686636	08
5360 ELLICE ISLAND instrument position	69°17.4595'	135°51.2459'	466292	7686866	08
5010 YUKON-ALASKA boundary instrument pos	69°38.7893'	140°59.7476'	500163	7726274	07
5011 KOMAKUK BEACH Gillie BM rebar/stake	69°35.7478'	140°11.1780'	531661	7720832	07
5011 KOMAKUK BEACH instrument position	69°35.7682'	140°11.2330'	531625	7720870	07
5012 TUKTOYAKTUK inst pos 2 near school	69°26.9960'	133°02.3378'	576817	7705587	08
5340 TENT ISLAND GSI Syledis1 BM TENT 88	68°54.9822'	136°36.7981'	435236	7645708	08
5012 TUKTOYAKTUK inst pos 1 on spit	69°26.8397'	133°02.4065'	576781	7705295	08
5340 TENT ISLAND instrument position	68°55.0480'	136°36.4382'	435480	7645824	08
5045-39 WOLFE SPIT (90-39) BM318	69°43.2040'	134°22.8059'	523980	7734601	08
5045-39 WOLFE SPIT inst pos 91/08/10	69°43.2341'	134°22.6954'	524051	7734658	08
5045-39 WOLFE SPIT Dyke borehole tripod	69°43.2522'	134°22.7654'	524005	7734691	08
5043 PIPELINE HARBOUR entrance *S4*	69°41.9549'	134°17.7985'	527235	7732315	08
5045-39 WOLFE SPIT *S4*/obs	69°43.5188'	134°22.4627'	524195	7735189	08
5038-03 HANSEN HBR spit (90-03) BM1 rebar	69°39.8851'	134°09.0196'	532954	7728540	08
5043 PIPELINE HARBOUR channel *Aanderaa*	69°41.1897'	134°16.5900'	528032	7730902	08
5039 REINDEER ISLANDS MR3 (1990)	69°40.2456'	134°10.3534'	532083	7729198	08
5043-GK (Gillie-K) BM316	69°41.6187'	134°18.7251'	526644	7731683	08
5044-GE (Gillie-E) BM276	69°42.3078'	134°19.2794'	526272	7732960	08
5044-GF (Gillie-F) BM277	69°42.0716'	134°19.9041'	525874	7732516	08
5044-GE (Gillie-E) back stake	69°42.2995'	134°19.2720'	526277	7732945	08
5044-GF (Gillie-F) back stake	69°42.0771'	134°19.9008'	525876	7732527	08
5043-GK (Gillie-K) back stake	69°41.6044'	134°18.7263'	526644	7731657	08
5044 MR4 (1990) approximate	69°42.3245'	134°19.2793'	526272	7732991	08
5038-03 HANSEN HBR spit (90-03) inst pos	69°39.8909'	134°09.0448'	532938	7728551	08

Table E1-2

LOCATION	DATE	SIGMA	DATUM	TIME(UT)	PDOP	SATS	SQ
West MEDS *Wavec*	26-Jul-91		NAD 27				
East MEDS planned	26-Jul-91		NAD 27				
5045 WOLFE SPIT borehole pipe	27-Jul-91	17.3	NAD 27	22:15:34		03;18;20	9;9;9
5045-01 NORTH HEAD BM311	1-Aug-91	11.3	NAD 27	21:18:35	1.6	03;14;14	9;9;9
5041-02 MR2 (90-02) BM1	1-Aug-91	11.4	NAD 27	00:01:06	1.5	16;17;18	9;9;9
5041-02 MR2 (90-02) BM3	1-Aug-91	11.3	NAD 27	00:13:34	1.5	16;17;18	9;9;9
5041-GL MR2A (Gillie-L) back	1-Aug-91	19.6	NAD 27	00:46:07	2.0	16;17:19	9;9;9
5045-01 NORTH HEAD (91-01) BM1	1-Aug-91	12.5	NAD 27	21:30:58	1.5	03;13;14	9;7;9
5045-01 NORTH HEAD camera (Minolta)	1-Aug-91	15.9	NAD 27	21:06:08	1.9	12;13;14	9;9;9
5040 MR2 (1990)	1-Aug-91	30.2	NAD 27	03:01:40	2.8	11;17;23	9;9;9
5040-02 MR2 camera (RCA)	1-Aug-91	17.4	NAD 27	02:39:37	2.2	17;19;23	9;8;9
5040-02 MR2 (91-02) BM1= BM308	3-Aug-91	19.6	NAD 27	20:51:35	2.1	12;13;14	9;6;9
5046-01 NORTH HEAD IV (90-01) BM2	2-Aug-91	8.9	NAD 27	22:40:23	1.4	03;16;18	9;9;9
5046-01 NORTH HEAD (90-01) instrument pin	2-Aug-91	10.2	NAD 27	23:16:18	1.4	16;17;18	9;9;9
5045-01 NORTH HEAD *S4*/obs	2-Aug-91	16.1	NAD 27	20:53:39	2.1	12;13;14	9;9;9
5040-02 MR2 (91-02) *S4*	3-Aug-91	18.4	NAD 27	19:25:33	2.0	12;14;20	9;9;9
5043 PIPELINE HBR channel *Aanderaa*8697	6-Aug-91	19.8	NAD 27	22:21:07	2.1	16;18;20	9;8;9
5012-01 TUKTOYAKTUK BM287	8-Aug-91	12.6	NAD 27	19:34:26	1.7	12;14;20	9;9;9
5010-01 YUKON-ALASKA boundary BM333	8-Aug-91	20.7	NAD 27	00:04:03	9.9	16;17;19	9;9;7
5010 YUKON-ALASKA boundary marker	7-Aug-91	12.7	NAD 27	23:31:07	1.5	16;17;18	9;6;8
5012-03 TUKTOYAKTUK BM:1949 DLS	9-Aug-91	14.9	NAD 27	00:32:33	2.0	16;17;19	9;9;8
5010 Boundary Commission marker1A 1973	7-Aug-91	11.5	NAD 27	23:40:33	1.5	16;17;18	9;9;8
5360 ELLICE ISLAND Gillie-II	9-Aug-91	10.0	NAD 27	20:55:52	1.5	03;13;14	9;8;9
5360 ELLICE ISLAND instrument position	9-Aug-91	18.2	NAD 27	19:54:06	1.9	12;14;20	9;8;9
5010 YUKON-ALASKA boundary instrument pos	8-Aug-91	15.9	NAD 27	00:11:42	2.0	16;17;19	9;9;9
5011 KOMAKUK BEACH Gillie BM rebar/stake	8-Aug-91	11.0	NAD 27	01:35:30	1.4	03;11;16	9;9;9
5011 KOMAKUK BEACH instrument position	8-Aug-91	17.0	NAD 27	01:47:01	2.2	03;19;23	9;6;9
5012 TUKTOYAKTUK inst pos 2 near school	9-Aug-91	24.3	NAD 27	00:58:43	2.9	03;16;23	9;9;9
5340 TENT ISLAND GSI Syledis1 BM TENT 88	9-Aug-91	12.9	NAD 27	17:25:25	1.5	06;12;15	9;9;9
5012 TUKTOYAKTUK inst pos 1 on spit	8-Aug-91	14.3	NAD 27	19:18:34	1.8	12;14;20	9;9;9
5340 TENT ISLAND instrument position	9-Aug-91	18.0	NAD 27	15:47:56	2.0	02;11;23	9;9;9
5045-39 WOLFE SPIT (90-39) BM318	10-Aug-91	10.9	NAD 27	21:02:56	1.5	03;13;14	9;7;9
5045-39 WOLFE SPIT inst pos 91/08/10	10-Aug-91	19.9	NAD 27	20:19:53	2.6	12;14;20	9;6;9
5045-39 WOLFE SPIT Dyke borehole tripod	10-Aug-91	11.7	NAD 27	20:54:48	1.5	03;13;14	9;9;8
5043 PIPELINE HARBOUR entrance *S4*	12-Aug-91	13.9	NAD 27	19:36:36	1.8	12;14;20	9;9;9
5045-39 WOLFE SPIT *S4*/obs	14-Aug-91	15.6	NAD 27	18:18:01	1.6	13;15;20	9;9;9
5038-03 HANSEN HBR spit (90-03) BM1 rebar	17-Aug-91	11.1	NAD 27	02:17:07	1.5	06;17;21	8;9;9
5043 PIPELINE HARBOUR channel *Aanderaa*	16-Aug-91	12.1	NAD 27	16:23:03	1.3	13;15;23	8;9;9
5039 REINDEER ISLANDS MR3 (1990)	17-Aug-91	10.9	NAD 27	01:46:02	1.4	17;19;21	9;9;9
5043-GK (Gillie-K) BM316	17-Aug-91	14.9	NAD 27	18:58:55	1.7	12;14;20	9;9;9
5044-GE (Gillie-E) BM276	17-Aug-91	13.9	NAD 27	21:36:14	1.4	03;16;18	9;9;9
5044-GF (Gillie-F) BM277	17-Aug-91	14.9	NAD 27	22:56:34	1.5	16;17;18	9;9;8
5044-GE (Gillie-E) back stake	17-Aug-91	27.3	NAD 27	20:52:55	2.5	03;18;20	9;9;9
5044-GF (Gillie-F) back stake	17-Aug-91	12.8	NAD 27	22:43:22	1.5	16;17;18	9;9;9
5043-GK (Gillie-K) back stake	17-Aug-91	16.9	NAD 27	19:06:37	1.8	12;14;20	9;9;9
5044 MR4 (1990) approximate	17-Aug-91	12.0	NAD 27	21:46:03	1.5	03;16;18	9;9;9
5038-03 HANSEN HBR spit (90-03) inst pos	18-Aug-91	11.5	NAD 27	18:46:37	1.8	12;14;20	9;9;9