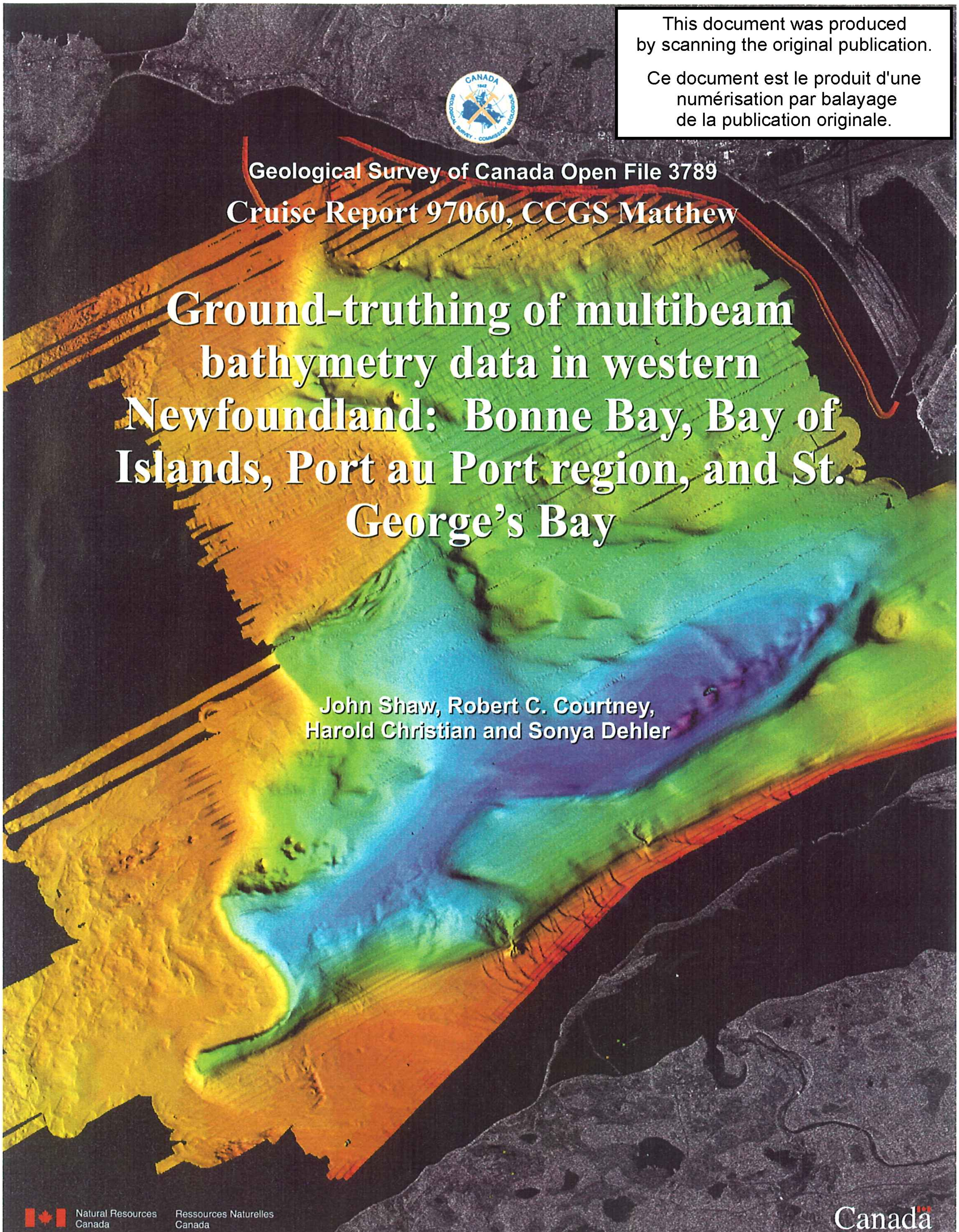

Geological Survey of Canada Open File 3789

Cruise Report 97060, CCGS Matthew

Ground-truthing of multibeam bathymetry data in western Newfoundland: Bonne Bay, Bay of Islands, Port au Port region, and St. George's Bay

John Shaw, Robert C. Courtney,
Harold Christian and Sonya Dehler

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CRUISE REPORT 97060

CCGS *Matthew*

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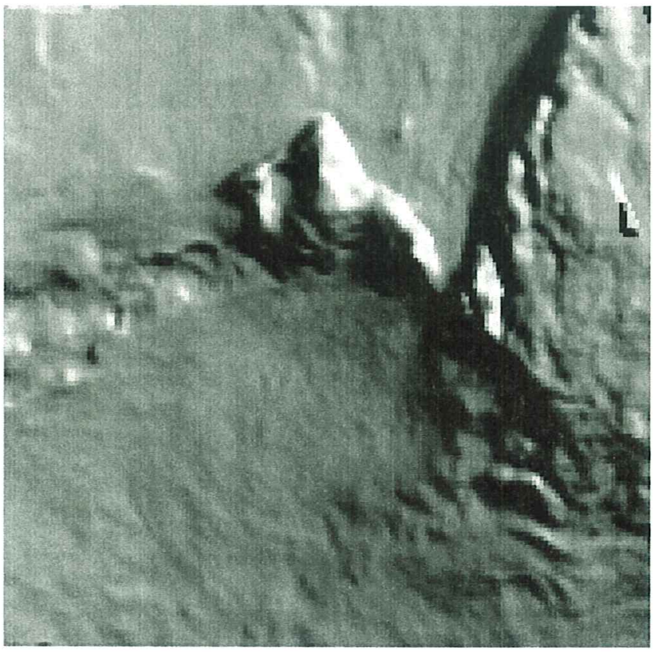


Multibeam image of an area west of Cape St. George showing bedrock platform (right) and a feature of unknown origin (middle).

John Shaw, Robert C. Courtney,
Harold Christian and Sonya Dehler

Geological Survey of Canada Open File 3789

Cover: multibeam image of inner St. George's Bay.

Contents

GENERAL INFORMATION

Vessel CGGS *Matthew*

Dates 15-31 October 1997

Areas of operation Western Newfoundland coastal waters: Cape St. George, Bonne Bay, Bay of Islands, and inner St. George's Bay.

GSC personnel

J. Shaw	*Chief scientist*
H. Christian	*Scientist*
R. Courtney	*Scientist*
S. Dehler	*Scientist*
D. Beaver	*Navigation technician*
R. Murphy	*Sampling technician*
B. Chapman	*Electronics technician*

CRUISE OBJECTIVES

- Collection of seismic data off the Port au Port Peninsula, to assist with interpretation of multibeam imagery previously collected, and thus enable correlation of onshore and offshore bedrock geology.

- Ground-truthing of multibeam imagery collected in 1996 and 1997 in Bonne Bay, Bay of Islands and inner St. George's Bay, in order to further understand Quaternary history, in particular the record of relative sea-level change since deglaciation.

- Collection of magnetometer and gravity data to assist with bedrock geological mapping.

- Collection of data using the geotechnical tool 'Excalibur', in order to provenance shallow gas and to obtain *in situ* test data on geotechnical properties, for geohazard mapping and multibeam ground truthing.

CCGS *MATTHEW*

CCGS *Matthew* is an inshore hydrographic survey vessel with the following particulars:

Length overall	51.25 m
Breadth	10.50 m
Displacement (light)	745 tonnes
Displacement (loaded)	950 tonnes
Speed	12 knots
Range	4000 nautical miles
Crew	12 persons
Scientific staff	8 persons

Normally *Matthew* carries a pair of hydrographic launches. These were removed for this survey, and replaced with deck ballast consisting of railway wheels.

CRUISE NARRATIVE

Note: Times are Atlantic Daylight Saving Time (i.e., Nova Scotia time), which is Z-3 hours. On 26 October clocks were put back 1 hour, so times from the 26 th onwards are Atlantic Standard Time , which is Z-4 hours.

Day 288 Wednesday 15 October

The day is sunny, with light winds. Shaw, Christian, Murphy and Dehler leave BIO at 15:00 and drive to North Sydney, arriving at 20:30. Two persons from Geomatics (Ottawa) also travel this route (John Halpenny and Dan Oleskevitch). The ferry departs just after 11:30. CCGS *Matthew* departs BIO at 16:30.

Day 289 Thursday 16 October

The day begins clear with light easterly winds. Later the sky becomes overcast to broken with light to moderate ENE winds. GSCA personnel arrive in Newfoundland at 06:30 and reach Stephenville at 09:30. In the early afternoon Excalibur is readied at the Canadian Coastguard Station and the magnetometer is set up at Kippens (Station 'Playhouse'). Beaver and Chapman leave BIO to take the 16:00 ferry to Port aux Basques. By evening the magnetometer base station is not functioning correctly. R. Courtney arrives by air at 23:30.

Day 290 Friday 17 October

The morning is overcast with moderate to brisk easterlies and occasional light rain showers. Shaw and Murphy drive to the Stephenville wharf at 07:30. *Matthew* has just arrived. The nose cone of Excalibur has to be re-threaded at a machine shop near the airport. The gravity personnel decide that they cannot join the vessel as the instrument is not functioning. Murphy and Christian work on Excalibur, and Dehler and Courtney drive to Kippens to set up the magnetometer base station. Word is received that Oleskevitch will join the vessel in a few days time at Stephenville. Chapman and Beaver arrive at 11:15. The re-threaded Excalibur part is received after lunch, and mobilisation continues.

Matthew puts to sea at 15:20. Excalibur is deployed at 15:50. The deployment is delayed while shackles are changed. At 16:10 Excalibur is re-deployed and is on the bottom in a depth of 102 m at 16:46 in the large pockmark with the assumed gas plume (see Shaw and Courtney, 1995). This is sample 97060-001. After this, the sparker is deployed (at about 17:30) and a test line is run seaward, crossing the landward edge of the spillover deposits at about 17:55. There is bad noise on the record, but this problem is soon solved and testing ends. *Matthew* anchors just after dark near the Limestone Quarry at Pigeon Head.

Day 291 Saturday 18 October

The morning starts with light easterlies which become NW 15-20 knots during the day, producing a slight to moderate sea. The chop eases as the wind speed decreases in the late afternoon. *Matthew* weighs anchor at 06:15 and gets under way. The sparker is deployed at 07:01, as dawn arrives, and line running commences (Line S1). The sea is calm. The Simrad 992 sidescan sonar system is deployed soon after, and work commences on preparing the magnetometer. It is deployed at 08:40, near the end of Line S2. At 13:25 we start on a line bearing 250 degrees. When L. S11 is finished we run a short transit line and start L. W1. Because the record is becoming faint, the sparker tips are trimmed. The record improves, but degrades quickly. The sparker tips are trimmed again. After an improvement, the record degrades even more quickly. The sparker is recovered and a new sparker is deployed.

At 19:45 we finish L. W4 and start to recover gear, beginning with the sparker and its hydrophone eel. It is impossible to pull in the magnetometer, and it appears to be snagged. The sidescan sonar is pulled in and when it reaches surface it is snagged in a thick rope. The rope is cut away and the sidescan is brought aboard. It is then easy to pull in the magnetometer. (Presumably, it was snagged on the same rope). The kevlar cable appears to be twisted due to tension. After recovery of equipment, the vessel heads for an anchorage behind Cape St. George.

Day 292 Sunday 19 October

The morning is cloudy with very light NW winds and a moderate swell from the west. It becomes sunny by noon, and clouds over again as we enter St. George's Bay. The early part of the night is clear and starlit. There is no wind but a swell is reaching the beaches at Kippens. *Matthew* weighs anchor at 05:30 and gets under way. Gear is deployed at 07:05, on the north grid - a pattern of lines off the Port au Port Peninsula, north of Red Island. AGC DIGS is difficult to start, and has to be re-booted several times before it works. The sparker record looks bad, and in an attempt to improve it, the hydrophone eel is removed from its position on the starboard side to a position on the port side. At about 11:00 the sparker is brought aboard and it is decided that the tips have been rubbing against the sidescan sonar cable. The sparker is deployed again at 12:00 as *Matthew* heads towards the coast, near the end of L. N5. At 12:51 L. N6 is finished and the gear is recovered. The magnetometer is missing a tail fin.

Matthew heads for St. George's Bay. We arrive at the Excalibur deployment site at 16:15 and the recovery procedure begins. With *Matthew* drifting nearby, and ship's sounders turned off, we attempt to communicate but fail, perhaps because the hydrophone is on the far side of the ship. Recovery is difficult because penetration has not been complete and the cable is wrapped around the pipe. When Excalibur is aboard at 17:06 we observe that the probe is bent at an angle of 45 degrees. *Matthew* ties up at Stephenville at 17:45. Shaw and Dehler take Courtney to the Holiday Inn and drive to Kippens to check the magnetometer base station. They discover that the base station has not been logging. Dehler makes repairs by flashlight. They return to the wharf at Stephenville. *Matthew* leaves Stephenville after dark and steams towards Bonne Bay.

Day 293 Monday 20 October
There is moderate swell from the north during the early hours, and by 07:00, as *Matthew* approaches Bonne Bay, there is a 20 knot breeze from the northeast, and it is mostly cloudy. The cloud breaks up by noon and the northerly wind increases to more that 30 knots. We reach the start of lines in Bonne Bay area at 08:00, as scheduled. A decision is made to run along the line, deploying gear. This is a bad decision because, in addition to the time required to deploy, time is spent replacing the fins on the magnetometer towfish. Consequently all the gear is deployed by 08:30, and about 3 kilometres of data are not collected. On L. 4 Seistec is deployed. The sidescan is pulled up just before entering the narrows and comes out of the water, bringing the sparker with it. From here onwards the data is poor: very little sidescan because of deep water, intermittent sparker records due to system failures, and the Seistec system will not run properly.

At 13:16 we lose the Port aux Basques differential signal but lock onto MOT313 (Moisie, Quebec). At the head of the bay we decide not to attempt the cross-lines because of the equipment problems and the very high wind that has arisen. We run up the middle of the bay collecting sparker data. L. 13 is a reciprocal of L. 7 and L. 14 is a reciprocal of L. 6. We finish L. 14 at 15:30 and all gear is aboard at 15:50. At 16:10 we drop anchor at the mouth of Neddy's Harbour. Murphy is collected from Woody Point by Zodiac. There is a fire and boat drill at 18:30.

Day 294 Tuesday 21 October
At 06:50 the Seistec towed body is recovered from the water at the stern (where it was being tested) and at 06:55 the anchor is raised. *Matthew* heads seaward for the start of grid 'west.agc'. It is overcast, with a moderate northerly wind which soon decreases, and the first grid is run with swell only. The fog thickens during the morning. The first line is L. 15. The grid is finished at the end of L. 30 at 11:43. The only incident is when the sidescan cable and magnetometer cable become entangled just after the start of L. 30. The sidescan is brought in so that the cables can be disentangled. Upon completion of L. 30 *Matthew* circles while Seistec is prepared. Data collected during circling is designated L. 31. We are ready to commence the next grid by 12:35. This grid - cross.agc - is a series of lines nearly coast-normal. It is started at 12:54 with L. 32. Seistec is running with 0.250 s sweep. Speed is kept at 4 knots when Seistec is deployed. The external eel is not

available as it has been damaged. We turn off the sparker and print the Seistec data on the sparker recorder. The Seistec data is poor quality: penetration is almost nil, until power is increased a few moments before the end of the last line. Line running is terminated at 15:45, near the end of L. 39. Gear is aboard by 16:00 and the vessel is docked at Woody Point by 16:30.

Day 295 Wednesday 22 October

Matthew departs Woody Point at 07:00. It is overcast with a very light southwest wind. We deploy gear at 08:00 in East Arm. We run a pattern of lines from waypoint 26 to waypoint 34, beginning with L. 41. The vessel is off course at times, but excellent cross-sections are obtained. On L. 44, for example, we pass over the elongate bedrock slab seen on the multibeam image, into the central basin containing glacial marine sediments and acoustically transparent Holocene mud. The Holocene mud is banked against the west side of the bay, indicating that bottom currents are strong at their seaward sides.

The last line extends across the tickle at Norris Point. The gear is recovered at 09:30. We proceed towards sampling sites outside the entrance. van Veen grab samples 97060-002 to 97060-017 are collected. Sampling finishes at 15:32 and *Matthew* heads for Woody Point. At 16:20 near Western Head, Beaver, Murphy, and Chapman are put ashore in the Zodiac. The Zodiac is back by 16:50, and *Matthew* heads for Bay of Islands. The day is overcast with patchy light rain and drizzle and a stiff southwest breeze. Seas are slight to moderate away from the shelter of the headlands. We encounter a steep, moderate swell *en route* to Bay of Islands. The sun breaks through the clouds just before dusk. *Matthew* arrives at 21:00. Beaver, Murphy, and Chapman are met at the wharf, having driven from Woody Point.

Day 296 Thursday 23 October

The morning is partly cloudy with moderate southwest winds and scattered light rain showers. There is a sprinkling of snow on the mountain tops. The vessel departs the wharf at 08:00 and proceeds west to the Excalibur deployment site (sample 97060-018). The target is the centre of a ring of high backscatter on the multibeam data, at a depth of about 100 m, NNE of Petries. We are on site at 08:20, and Excalibur is in the water with ship's sounders off at 09:00. It is on the way down at 09:10, and a float is attached. The vessel is under way at 09:25.

Matthew steams to near the start of lines, just south of Lark Harbour Bank. We stream gear at 10:45 and start lines, beginning with waypoint 1, L. 52, the start of the grid 'cornerbr.agc'. The gear consists of Seistec, sidescan sonar, and magnetometer. There is a moderate chop, with strong gusty winds coming from the mountains to the south. Waves diminish as we proceed into the bay. Surveying ends at 15:44 at waypoint 10 on the grid cornerbr.agc. This is the end of L. 60. The gear is recovered near Corner Brook by 16:07 and *Matthew* is tied up at Corner Brook at 16:35.

Day 297 Friday 24 October

The morning is cold and cloudy. Hilltops have a thicker snow cover than yesterday. As we depart the wharf at 08:00 snow is falling. The day is cloudy and breezy, with snow squalls, heavy at times. Snow continues in the evening. The log of Excalibur operations is as follows:

08:27 Start to establish communication; *Matthew* dead in the water with sounder off.
08:32 Communication established.
08:41 Pulling floats aboard.
08:52 Start recovering.
08:58 Free of bottom, on way up.
09:13 Excalibur at deck level.
09:17 Excalibur on deck. Full penetration, black clayey silt on barrel.

It is discovered that the batteries failed, probably because the instrument had been lying on the deck overnight in cold temperatures. At 10:00 it is decided that Excalibur will be ready for another deployment. We head northwest to a point on line 53. This is sample 97060-019, SDT 2961456. The day continues windy with alternating snow squalls and short sunny spells. The water is rough at the deployment site (near Blow Me Down Mountain). Schedule is as follows:

11:08 On site.
11:38 Ready to descend.
11:38 Lowering.
11:40 On bottom at a depth of 101 m, attach floats.
11:46 Communication established.
11:55 Leave Excalibur site.

We proceed back down Humber Arm. Gear is deployed at 13:00 near the start of lines-waypoint 10 in the grid cornerbr.agc. Navigation is bad but works when AGCNav is rebooted. Seistec does not function , so the gear is brought aboard. Inspection reveals flooding of the preamp. A chip is replaced. When redeployed at 14:27 Seistec works for a few shots and dies. Gear is recovered and *Matthew* is tied by at 15:00. Chapman does repairs on Seistec. Murphy collects spares at Deer lake airport in the evening.

Day 298 Saturday 25 October
Matthew departs the wharf at 08:00 with Seistec on the winch. It is partly cloudy, with a sprinkling of snow on low ground and a thicker cover on the hills. Gear is deployed at 08:33 at way point 10 on the AGCNav grid 'cornerbr.agc'. This is start of L.61. We run lines to the end of L. 75. There we turn to port slightly, and continue the line beyond its planned termination. The sidescan hits the bottom at 10:20, damaging the fin. It is pulled aboard. Line running ends at 12:15 when we start to recover gear. Gear is recovered by 12:37 and *Matthew* proceeds towards the Excalibur site (sample 97060-019).

A strong westerly wind is blowing in the Blow Me Down area, with occasional flurries, and the sea is choppy (as usual). We are on site by 13:00 and Excalibur is aboard by

14:06. We then collect a seabed photo from nearby (97060-020), and a grab sample (97060-021). At 14:40 we are underway for the next site. We are on-site for Excalibur sample 97060-022 at 15:45, leave the deployment site at 16:15, and are tied up at Corner Brook by 16:30.

Day 299 Sunday 26 October
The day starts dull and overcast, with light winds. Chapman leaves the vessel to drive Stephenville. *Matthew* departs the wharf at 08:00. We are soon on station to recover Excalibur. We begin sampling, with the camera and grab sampler alternating as the first deployment at the sites. The sample pairs run from 97060-024 to 97060-046. We finish camera station 97060-046 south of Woods Island at 15:00 and depart for Stephenville. Shaw takes numerous photographs of the coast as we leave the bay, until 16:40 when the sun starts to slip below the horizon. It becomes sunny and calm by 15:00 and the voyage to Stephenville is during a clear night with slight to moderate swell. *Matthew* ties up at 23:00 at Port Harmon.

Day 300 Monday 27 October
Chapman arrives aboard. Dehler checks the magnetometer at Kippens and arrives by 07:30. *Matthew* departs at 08:00 to deploy Excalibur -sample 47. We start to deploy seismic gear at 09:05 and start L. 76 at 09:40. This is waypoint 1 on the AGCNav grid 'stephen.agc'. The sea is calm and glassy, except for a swell from the west; it is cold, and overcast with light winds. As line running progresses we hear storm warnings for the next day, so a decision is made to work late in order to finish the lines. In order to expedite the survey, we move from waypoint 12 to waypoint 18, skipping the intervening points. The day is without incident, and line running continues after dark until the last line (L. 104) is finished at 17:27, just at the mouth of Port Harmon. It is dark, and the easterly breeze is stiffening. *Matthew* is tied up at Port Harmon by 20:00.

Day 301 Tuesday 28 October
Matthew departs Port Harmon in rain and 30 knot easterly winds at 07:00. By 07:30 the vessel is on station at the Excalibur sampling site. It is very choppy and the vessel is heeled over in the increasing wind. The ship's master judges that the wind is too strong to attempt a recovery of Excalibur, and *Matthew* returns to Stephenville, docking at 08:10. Winds increase to storm force easterly at times, with heavy rain, then decrease in the evening. Chapman, Murphy, and Beaver leave in the early afternoon and drive to Port aux Basques. *Matthew* leaves at 11:00 for an attempt to recover Excalibur.

Day 302 Wednesday 29 October
Matthew proceeds to the Excalibur site (sample 97060-047) and starts recovery in a strong northeast wind, heavy chop, and rain. Excalibur is free of the bottom at 00:07. *Matthew* is secured at Port Harmon by 00:55. The wind increases to northwesterly gales by early morning, accompanied by rain. Shaw, Dehler, and Christian leave the vessel in the late afternoon, and check in at Hotel Stephenville.

Day 303 Thursday 30 October

Shaw, Dehler, and Christian leave Stephenville at 05:45 (later than intended, forgetting that they are on Nova Scotia time!) and drive to Port aux Basques, arriving at 07:30 (i.e., 08:00 local time). There are rain and snow showers *en route*. *Matthew* leaves at 06:00. GSCA staff leave on the ferry *Caribou* at 08:30 (09:00 local) and after reaching North Sydney drive to Halifax/Dartmouth, arriving at approximately 20:30.

Day 304 Friday 31 October
Matthew arrives at Dartmouth in mid-morning.

TECHNICAL SUMMARY

Equipment included the following:

(1) Simrad MS992 dual frequency side-scan sonar (120kHz, 330kHz fish)
(2) Nova Scotia Research Foundation (NSRF) multi-tip sparker array
(3) NSRF tapered hydrophone array
(4) IKB Seistec cone array and boomer
(5) GEM Magnetometer
(6) Lab receiving and control equipment

Simrad MS992 sidescan sonar system
The MS992 sidescan sonar is a dual frequency system. The dual-beam frequencies provide a means to map the ocean floor in a reconnaissance fashion using the low frequency channels, and in more detail (but with less swath width) using the high frequency channels. The fish is towed behind the ship at about 2/3 water depth, i.e., 1/3 way off the sea floor. Under shallow-water conditions, while close to shore, over shallows, or in tight traffic areas, the MS992 can also perform well close to the bottom or surface.

Deployment and recovery of the towed fish was controlled by an electro-hydraulic winch on the well deck, on the starboard side of the ship. The winch was operated via a remote controlled system in the main laboratory spaces of the vessel. This allowed rapid deployment and recovery of the fish as bottom conditions changed. Ship's power provided operating voltages to run the winch motor. No “down time” was experienced with the sidescan system during the cruise.

The receiver for the MS992 was in the main laboratory of *Matthew*. The receiver consisted of the MS992 deck unit, an Aldin 9" thermal graphic recorder, and an EPC Labs 9200 thermal recorder. The Aldin and the EPC were used to generate hard copy paper records of the bottom topography. At various times both or either of the two channels were displayed on the recorders.

IKB Seistec sub-bottom profiling system
Throughout the second phase of the cruise, the IKB Seistec towed body was employed to

collect high resolution reflection data. The Seistec towed vehicle consisted of three principal parts, the boomer, an external hydrophone and a line cone array.

The boomer is an acoustic source device producing sound waves in the water column. The boomer plate design is such that the pulses generated by the boomer are consistently repetitive. This provides a "clean" sound source when collecting high resolution seismic data. The boomer is powered from a high voltage pulse source generated on board the vessel. The pulse is delivered to the boomer over a heavy electrical cable which forms part of the Seistec vehicle tow bundle or cable. The external hydrophone, used to collect the returned acoustic signal, is towed behind the Seistec vehicle. The external 'phone' is useful for collecting lower frequency signals but has a drawback in that it is subject to higher sea noise levels than the cone array.

The cone array is a series of hydrophone mounted in a conical housing attached to the centre of the Seistec vehicle. The positioning of the array, and the shape of the cone allow for excellent signal to noise ratio, and is ideal for the clean reception of the reflected acoustic seismic signal. Both the external eel and the cone array signals are amplified within a pre amplifier build on board the towed vehicle. The two signals are then passed to the deck receiver through shielded cables which form part of the vehicle towing system.

The record was displayed on an EPC recorder., mostly at 1/4 s sweep, with a delay. On the final leg - off Stephenville - the record was displayed side by side with the sparker record on the EPC recorder. In this instance the Seistec record was 0.125 s sweep with 0.016 s delay, and the sparker data was at 0.250 s sweep and 0.016 s delay.

NSRF Sparker sub-bottom profiling system

The NSRF sparker is a small portable sparker array, approximately 2 m in length, consisting of approximately 20 tips of electrical wire protruding through a PVC pipe. Power for the sparker was delivered through the tow cable from the ship. The NSRF LT21" eel is a 20 foot "tapered" hydrophone array. The eel was towed about midships, close to the sparker. It was used to collect the sparker return signal. The sparker return signal was amplified within the eel and passed to a termination deck unit via a shielded cable. The amplified signal was then delivered to the lab through coaxial cable for further signal processing.

Deck System Firing Control

The sequential firing of the boomer and sparker was controlled from the vessel using the MITS, Master Interval Timing System computer. The MITS allows different acoustic sources to be used during a survey, and by controlling the interval and the sequence of the firing, aids in the reduction of acoustical interference in the water column. This is accomplished by masking out one or all of the devices form generating a sound in the water at any one time.

Seismic High Voltage Sources

The high voltages required to "fire" the boomer plate on the Seistec vehicle and the sparker were generated by two ORE Geopulse Power Supplies, Model 170's. The power supplies were located in the after load centre of the vessel, port side, aft. Both used 220VAC, 20 Amp from the ship's generators.

Analog Signal Processing

The acoustic signals from the Seistec fish and the sparker were further processed in the main laboratory on the ship. Both further amplification and filtering were added to enhance the signals. Ore Geopulse receivers and Khron-Hite filters were employed. The processed Seistec and the NSRF sparker signals were displayed on an EPC 9800 dual channel graphic recorder. Annotation of the date/time was done through the graphic recorder and originated from a lap top PC connected to the EPC recorder's control port. The recorder was used throughout the entire cruise and displayed either or both of the seismic signals. No problems were experienced with this equipment.

Data Logging

A digital recorder, AGC_DIG was used to log side scan data to exabyte tapes throughout the cruise. The recorder logged both channels and the trigger signals from the MS992. This digital data was checked periodically during the cruise to truth the data quality. The AGC_DIG logger was found to have become intermittent. The exabyte tape recorder within the logger was replaced because of tape data drop out. It has since been proven to have been an overheat problem, and corrective action has been taken to ensure non repeat of this condition. A second tape logger, a Sony DAT recorder (8 channel) was employed to provide a level of redundancy for the side-scan logger. This too was checked periodically for data logging quality.

Summary of sub-bottom profile and sidescan systems

Throughout the entire cruise MEG equipment worked satisfactorily with minimal down time. Problems with the GEM magnetometer have since been addressed and corrected. No data loss due to the AGC_DIG problems occurred as the Sony DAT provide the required redundancy. Data quality was judged to be good overall. Additional AC supply outlets have been suggested for the after load center of the ship to make connections of the Geopulse power supplies easier. Future additions of a number of coaxial cable runs from the after load center area to the main laboratory, and from the main laboratory to the navigation center are also suggested.

Computer systems

The DI04 work station was set up in the laboratory. It was linked to four disk drives, some of which contained grass projects, as follows: devco (Stephenville area multibeam data) on dsk6, Bonne_Bay (Bonne Bay multibeam) and Corner Brook (Bay of Islands multibeam data) on dsk 4. Shaw's laptop was set up in the Chief Scientist's cabin. It was linked to DI04 over the LAN. ReflectionX software was used to run GRASS and transfer of files by FTP between the two computers. R. Courtney also used this program to display GRASS data on his laptop computer in the laboratory.

The Excalibur system

Excalibur is a remotely operated seabed pore fluid sampling system, capable of collecting a 75 cc water/gas sample from depths up to 6.6 m below the mud line. The operational water depth range is 0-1000 m (up to 400 m on a mooring). The device has a telescoping sampling probe which is rigidly connected to the electronics and mechanics subsystem, where the fluid sample chamber is mounted. An onboard Tattletale 8 computer controls system operation while on the bottom, allowing fluid to enter the hydraulic lines according to a preset sequence. Data on pressures, tilts, acceleration and temperature are stored on a 2 megabyte non-volatile memory Persistor card, for downloading and interpretation after recovery from the sea floor.

An underwater acoustic modem was used to monitor system status after deployment and prior to recovery, as well as permitting remote over-riding of system presets. The sample chamber was flushed and charged with nitrous oxide and left at atmospheric pressure prior to deployment. The hydraulic lines between the filter stone on the tip and the sample chamber were filled with salt water (collected off the wharf at Stephenville) to facilitate pressure measurements before sampling and to prevent ice forming inside the system. A Datasonics sounder was mounted on the baseplate and was used to observe penetration depth. Data was recorded at a rate of 5 sec/sample. Typically, the system was directed to monitor pressures at the probe tip and above the mud line in the water column, for several hours prior to fluid sampling, which lasted up to 14 hours. Internal battery packs required replacement after two deployments.

Gravity surveys

Arrangements were made with the Gravity Section of Geomatics Canada in Ottawa to collect gravity data during the cruise to test the feasibility of using the gravity meter for high resolution data collection at sea. J. Halpenny, R. Cooper and D. Oleskevitch arrived at BIO on 14 October 1997 with the Lacoste & Romberg Straight Line (SL-1) Gravity Meter. A replacement part was delayed in arrival, and MATTHEW sailed on 15 October before the gravity meter could be placed aboard. Halpenny and Oleskevitch travelled to Stephenville with the gravity meter and acquired base station readings at the Coast Guard wharf and at the airport. However, serious technical difficulties with the meter could not be satisfactorily resolved and, after several days of troubleshooting and repairs, the gravity component of the cruise was cancelled and Halpenny and Oleskevitch left Stephenville on 19 October to return to Ottawa.

Magnetometer surveys

Total field magnetic data were acquired in conjunction with the seismic and sidescan components of the survey. A base station was established near Stephenville, to measure diurnal variation in the magnetic field. The base station was located near the shoreline at the home of Abe and Judy Gallant on Bayview Road in Kippens. The station consisted of a GSM-90 Overhauser Magnetometer connected to a 12 V DC power supply with a battery backup, running off household current via a 100 m extension cord. The sensor unit was placed in the horizontal position, oriented approximately east-west, on a loose limestone rock at a distance of 80 m from the main house, and 10 m from the "playhouse" which provided weather protection for the electronics. Signal quality was excellent throughout the survey. Data were logged at 10s increments using the program "Maglog". However, data were not logged for the first leg of the survey (17-19 October) due to an I/O error in the software. Data were successfully logged for all other days by redirecting screen output to a disk file.

Two tow magnetometer systems were used aboard *Matthew*. The GSC system consisted of a GSM-19MD Overhauser Marine Magnetometer with a 24 V DC power source. The sensor was located in a 2.35 m towfish towed 100 m behind the ship. (Note that there is a 40 m offset between the stern of the ship and the GPS positioning antenna.) This towing distance provided a clear, quiet signal while permitting reasonably short radius turns at the ends of lines. The towfish depth sensor reported depths of 25 to 30 m, but appeared to be uncalibrated and the towfish depth was believed to be 5 to 6 m. The logging interval was set to 0.2 s, although usually only 3 readings per second were actually logged, using GEMLINK v4.1. Data quality on all days is excellent, with good signal to noise ratio.

A second towfish system was deployed (briefly) to acquire horizontal gradient information by comparing data collected on two sensors towed approximately 8 m apart. Such information could be used to guide interpolation between lines, which are spaced hundreds of metres apart compared to the few metre sampling interval along lines, thereby allowing more short wavelength information to be included in data grids. The system, provided by DND, was similar to the GSC system, except for data logging which was at 0.25 s increments using GEMLINK v5. Signal quality was erratic with this system, with numerous spikes or bad bits recorded, and only 90 minutes of data were acquired (18 October) before signal was lost altogether. The fish was pulled in and testing revealed a fault in the cable. The fish was not redeployed and testing with a cable tester several days later (23 October) showed a break within the sealed connector to the towfish that could not be repaired aboard ship.

SUMMARY OF SCIENTIFIC RESULTS

Bonne Bay Moraine

The shaded-relief multibeam bathymetry image shown in Figure 1 (data collected 19 - 23 June 1998) shows part of an arcuate shoal (A) that reaches the coast north and south of Bonne Bay. This shoal was interpreted by Grant (1989) as an end moraine. West of the moraine (B), the seabed shallows gently from -90 m in the west to -70 m in the east, and has been intensely furrowed by icebergs. On multibeam imagery the furrows are subdued, and average 0.5 m deep, with the deepest at 1.5 m. They are linear and curvilinear, and typically trend at 040° T. The furrows are not distinct on the sidescan record, probably because the largest furrows were on the first part of the line, the part that was not surveyed with sidescan sonar (see cruise narrative).

The principal part of the moraine is a broad ridge composed of acoustically incoherent ice-contact sediment that attains a maximum thickness of 30 m. The ridge extends from a depth of 70 m in the west, and has a steep western face, with a crest at -46 m. A narrower, superimposed ridge is at a depth of 33 m. The east face of the moraine slopes gently to a depth of 46 m. Sidescan sonar records show that the seabed on the ridge is gravelly, with scattered boulders. It has a smooth appearance on the multibeam imagery, although there are some faint lineations on the crest and steep slope (in the same direction as the iceberg furrows).

Seabed east of the Bonne Bay Moraine

The area of unusual texture (C) east of the moraine is Quaternary sediment. The bouldery surface is suggestive of ice-contact sediment rather than glacial marine mud, i.e., Scotian Shelf Drift rather than Emerald Silt, using the terminology of King and Fader (1986). Grab sample 97060-017 shows that the bottom is covered with bouldery gravel. The low-relief rectilinear pattern observed on the multibeam data is of unknown origin.

East of this patterned area the seabed is relatively smooth (D). On the multibeam backscatter image, the area of fine sediment here is more reflective in the west than in the east. The boundary between the two reflectivity domains corresponds with a change in tone and pattern on the sidescan sonar records collected during the cruise. In the west, the seabed has elongate dark patches averaging 2 m wide, caused by a thin sand sheet with bedforms; the underlying gravel lag appears in bedform troughs. Farther east, the sand is thicker, and no high-reflectivity gravel lags are present.

East Bay (Bonne Bay)

East Bay (Fig. 2) contains a Quaternary sediment package that is up to 100 m thick. Most of the package is probably glaciomarine mud (strong acoustic stratification), which is overlain by postglacial mud (acoustically transparent). The survey lines repeatedly traverse the fiord, from the steep fiord sidewalls (where sediments are thin), across the floor of the bay, (where sediments are thickest), to the opposite sidewalls. It is not clear (on the sparker record) whether the Tickle - the narrow arm extending west near the top of Figure 2 - is underlain by till or bedrock.

Littoral platform at the entrance to Bonne Bay

The survey lines ran parallel to the coast and also transverse to the shallow platform that extends from southwest to northeast, offshore from the cliffs at the entrance to Bonne Bay (Fig. 3). The sidescan sonar data show that the surface of this littoral platform is mostly rippled gravel, with patches of medium sand. The positions of sand and gravel areas coincide with their positions on the multibeam backscatter image collected earlier in the year (19-23 June). Bedrock crops out in several places on the littoral platform. The Seistec system had poor penetration of platform sediments but the sparker records show faint progradational structure, with clinoforms extending into the deep water.

The submarine fans (see Fig. 3) that fringe the platform consist of medium-fine sand, with small amounts of silt. A few pebbles were found in sample 97060-013, collected on the platform slope at a depth of 87 m (see Fig. 4 for sample locations on the platform). Seismic records show clearly the channels and levees on the fans. The sidescan sonar record delineates the steep channels southeast of Eastern Head (not clearly seen on Figure 3 because of the illumination direction) as areas of high reflectivity. They are regularly spaced, several metres deep, and coincide with areas of high reflectivity on the multibeam backscatter data.

St. George's Bay

Multibeam data collected in 1995 St. George's Bay were published as a GSC Open File report (Shaw et al., 1996a,b), and further analysed in two subsequent papers (Shaw and Courtney, 1997; Shaw et al., 1997a). Additional data collected in 1997 and 1998 have been added to the original data to produce the image shown in Figure 5. The grid of survey lines (Fig. 5) begins southwest of Indian Head, extends along the front of Flat Island, crosses onto the sill, and ends at the entrance to Port Harmon. The lines begin with L. 76, which is located in the central basin - the St. George valley (Shaw and Forbes, 1990). Gas masking occurs at a depth of 3 m depth, becoming 11 m on the lip of a large pockmark, decreasing to 1 m within the pock mark. The line crosses a knoll on which a drape of glacial marine sediment has been partly eroded, perhaps during an early postglacial sea-level lowering (Forbes et al., 1993; Shaw and Forbes, 1995). The postglacial mud around the knoll and the gravel on top are marked by 'fresh' anchor drag marks. The bedrock core of the knoll is covered by about 5 m of ice-contact sediment.

The end of L. 76 is in a basin with up to 5 m of postglacial mud over well-draped glacial marine sediments (Emerald Silt facies equivalent). Similar stratigraphy occurs on L. 77. L. 78 crosses a bedrock ridge that rises to within 10 m of the seabed. The shoal on the multibeam imagery has exposed glacial marine sediments, including a slide deposit 3 m thick near the top of the sequence. After 14:20 on the record, reflections within the unit are truncated at the seabed. L. 79 is a loop west of the planned line, and shows gas masking of postglacial sediments. L. 80 crosses just south of the shoal, and shows a series of bedrock or till ridges with the glacial marine unit draped over them. This suggests that notched face of the large shoal here may be due to the irregular terrain below the draped unit, and not to some other process (slumping, fluvial action during a sea-level lowstand).

L. 81 crosses the slide deposits at the distal end of Sandy Point Spit (Shaw and Forbes, 1992). The postglacial sand is a 2 m veneer unconformably overlying glacial marine mud. The acoustically transparent slide deposits are up to 5 m thick. On L. 82 the vessel was off course - too far landward. The record shows the unconformity at varying depths below barrier-platform sediments. Gas masking occurs in the pro-platform sediments in places. On L. 84 the seismic record shows about 5 m of acoustically unstratified sediment in the easternmost of two prominent submarine fans (Christian Fan). The leveed channel is about 2 m deep. The second lobe of fan sediments (Shaw Fan) is also about 5 m thick. The ship's track (L. 85) curves up onto the top of the barrier platform where sand waves 2 m high are crossed.

Gas masking occurs at the start of L. 86. At the end, lobes of slumped sediment about 5 m thick are stacked en echelon. This is the Flat Bay Slide Complex (FBSC). A narrow zone of alternating black and white bands on the sidescan sonar - the 'zebra effect' - is interpreted as sand waves with wavelengths of 20 - 30 m on a gravel substrate. This is probably the meandering channel observed in the FBSC. Gravel ripples occur on top of the barrier platform. Stacked slide lobes occur on L. 89, and gas masking occurs in the basin. Much of L. 90 crosses a high-backscatter zone in which irregular mounds - bedrock or till - are mostly mantled by glacial marine sediment. Another band of sand waves over gravel occurs on L. 91, possibility indicating a wide channel in which sand waves are migrating into deeper water. Inactive lenticular debris lobes on L. 92 occur below 1-2 m of postglacial mud. Gas masking is present in Holocene mud on the second part of L. 92.

L. 93 is important, as it crosses a zone of concentric ridges that project from the base of a large lobe of the prograding spillover structure. These lobes constitute a compressional slump buried by a thin veneer of postglacial mud. The constituent material is possibly glacial marine mud, and the head of the slump is now buried by spillover deposits. The end of L. 93 and start of L. 94 cross the spillover terrace; the sidescan sonar shows large sand waves on top of gravel. The small debris fan that is intersected by L. 94 (Tiny Tim Fan) shows faintly on the Seistec record. The remainder of L. 94 crosses a basin with gas-masking at 8 m depth in postglacial muds that overlie glacial marine muds. From the latter part of L. 94 to the end of L. 95 the gas is patchy, and partly strata-bound: in places it occurs at a horizon 10 m below the seabed, sometimes at 8 m.

It is unclear if the protrusion on the ridge crossed by lines 96 and 97 is bedrock or till. Glacial marine mud occurs on the ridge flanks, with reflections that extend below the prograded spillover deposits. L. 98 crosses a small gas pocket, then continues over glacial marine sediments with a postglacial mud veneer, and up the progradational wedge of the spillover deposit. Where L. 100 crosses the edge of the spillover at an oblique angle it intersects a mounds of debris flow sand that originated on the spillover terrace. It is 7 m thick and overlies older debris-flow lenses.

L. 100 continues across a basin with gas masking and reaches a ridge on which glacial marine sediments are exposed at the seabed. L. 101 cross glacial marine sediments with reflections truncated at the seabed. At the turning point at the end of L. 101, bedrock ridges or pinnacles are mantled by till, but crop out at the seabed in one place. Till occurs at the seabed at the end of L. 102 (boulders present on the sidescan sonar record) and another bedrock pinnacle reaches the surface at the end of L. 103. Thin sand organised into ripples occurs on top of the gravel along lines 101-104.

Bay of Islands

Bay of Islands is a fiord containing deposits of glaciomarine and postglacial mud ponded between steep bedrock sidewalls (Shaw et al., 1995). On the first day of surveys (day 296) Seistec data were collected on a line running into the bay from near Lark Harbour Bank (Figure 6). The latter part of this line was a repeat of sparker lines surveyed in 1996 (see the cruise report: Shaw et al., 1997b).

Just after the start of the survey (L. 52) the ship's track crosses the sedimentary furrow (A) present on multibeam imagery. It is about 4 m deep and appears to truncate internal reflections. It lies in the middle of a muddy area in which stratigraphy is obscured by gas. At the edge of the masked area, where the mud is thinner, a patch of reflections extends from the sea bed into the water column. This is also present on the ship's sounder record. A second, more faint patch is present on the Seistec and sounder records a short distance farther. This is believed to be evidence of gas release from the margins of an area of gas masking.

Southeast of Woods Island stratified sediments are more than 100 m thick. The top 60 m of sediment shows strong acoustic stratification. The survey line crosses a recent slide deposit visible on the multibeam record (B). It emanates from shallow water at the southeast tip of Woods Island. The survey line crosses an area of strong banking of mud on the north side of the bay (C). South of here lenses of sediment with chaotic internal reflections are present on the Seistec record. These are interpreted as slide deposits. They occur approximately at the interface between lateglacial and postglacial sediments. These lenses may be correlable with the numerous slide failures visible on multibeam imagery of the fiord side walls.

On L. 58 the acoustically transparent postglacial mud thickens to >15 m, and stratigraphy is masked by shallow gas (D). Postglacial mud thins to zero thickness on the ridge at Meadows (E), and then increases again towards the southeast. The track crosses furrows in Holocene mud that do not appear to have any acoustic expression in the underlying glacial sediments.

The lines begun at Corner Brook on day 298 provide useful ground-truthing information in an area with many intriguing features on the sea floor. The sidescan record shows the shipwreck off the mouth of the Humber River, faintly visible as a small area of positive relief on the multibeam image (Fig. 7, A). In this area the uppermost Quaternary sediments contain slide deposits, indicative of slope failure on the delta front. Small lenses of recently slumped material occur on the modern seabed at the delta front. Returning seaward (L. 63), the line crosses the toe of submarine slide deposits (B) off Seal Head. The slide deposits are 2-5 m above the surrounding sea floor. The slope failure occurred in recent years, possibly as a result of fill being dumped during an operation to improve the wharfs.

The survey line intersects an oval trench 3 metres deep and measuring 320 x 210 m, in a water depth of 95 m (C). Gas masking is observed on the east side of the trench'. For a short distance west of the trench, the stratigraphy is partly masked by gas in the wood-chip deposits that cover the seabed. These deposits have high backscatter on the multibeam backscatter imagery, although the sea floor is smooth on the multibeam relief imagery. Sidescan sonar shows that the seabed is highly disturbed by human impact off Corner Brook: anchor drags and dredge spoils are common. The survey line intersects the slide deposit (D) just west of the paper plant. In this instance, road fill slipped down a steep slope into deep (95 m) water. The vessel intersected a series of elongate and oval trenches (E) developed in postglacial mud, perhaps as a result of fluid escape.

Port au Port area

A bedrock platform surrounding the Port au Peninsula is the dominant geomorphic feature on the multibeam data in that area (see Appendix 2). The platform is between 1.0 and 1.5 km wide off the south coast and about 0.3 km wide or absent on the west coast. It extends to a water depth of 30 m on average. The outer part of the south-coast platform is gently sloping or flat, but the middle part rises more steeply towards the coast. There is a prominent break in slope at -18 m, however, and above this depth the platform slopes gently towards the modern coast, which consists of continuous cliffs developed in sedimentary rocks. The platform is generally devoid of thick Quaternary sediments, except off the south coast, near the east end of the multibeam image, where sediments infill an elongate depression on its surface.

MAGNETOMETER DATA OVERVIEW

Bonne Bay

The Bonne Bay area is in the vicinity of a major ophiolite complex and, as expected, there are several extremely large anomalies associated with the edges of the complex. Lines heading to and from the cliffs at the southwest entrance to the bay show a variation of up to 800 nT, with highest values farther offshore and several +400 - 1000 nT short wavelength features along the coast. A prominent positive anomaly, up to 700 nT, trends southerly through the northern part of East Arm and Deer Arm. Smaller anomalies, on the order of 50 to 100 nT, tie with seabed ridges visible on multibeam records for the area and shallow basement is inferred. Other ridge-like features do not have a significant magnetic anomaly associated with them and may not involve basement.

Bay of Islands

Like Bonne Bay, Bay of Islands also lies within the ophiolite complex, but the magnetic anomalies are much more subdued, the largest less than 250 nT adjacent to Blow Me Down Mountain at the entrance to Humber Arm. Many small anomalies (5 to 40 nT) within Humber Arm correlate well with seabed features observed on multibeam and seismic, implying shallow basement structure.

Cape St. George and Port au Port Peninsula

Magnetic data were recorded along all seismic lines except the first few (S1-S3). South of Cape St. George, field variation is on the order of 300 nT, with a pronounced low extending southwest from the tip of the peninsula. Variability does not exceed 150 nT along the western and northern flanks of Cape St. George, with lowest values landward and the field strength increasing steadily offshore. At least two features indicative of faults or contacts are visible on all lines.

St. George's Bay

Several prominent magnetic anomalies, 200 to 400 nT in magnitude and 10-20 km width, were recorded on survey lines in the southern part of the bay. The regional trend indicates higher average values in the northern part of the bay, but this will have to be verified after correcting for diurnal variations. There is considerable small scale variation in the magnetic field (5-20 nT) and this may correlate with basement topography visible in parts of the seismic record.

SEISMIC SURVEY OFF THE SOUTH AND WEST COASTS OF THE PORT AU PORT PENINSULA

Onshore geologic mapping in the Port au Port Peninsula has suggested the presence of a thin skinned tectonic wedge that forms the westernmost limit of the Appalachian Front. This wedge comprises allochthonous materials that had been transported westward during a series of orogenies spanning the late Ordovician through the late Devonian times. The intersection of this tectonic wedge with the seabed lies principally offshore Newfoundland except where it crosses the Port au Port Peninsula.

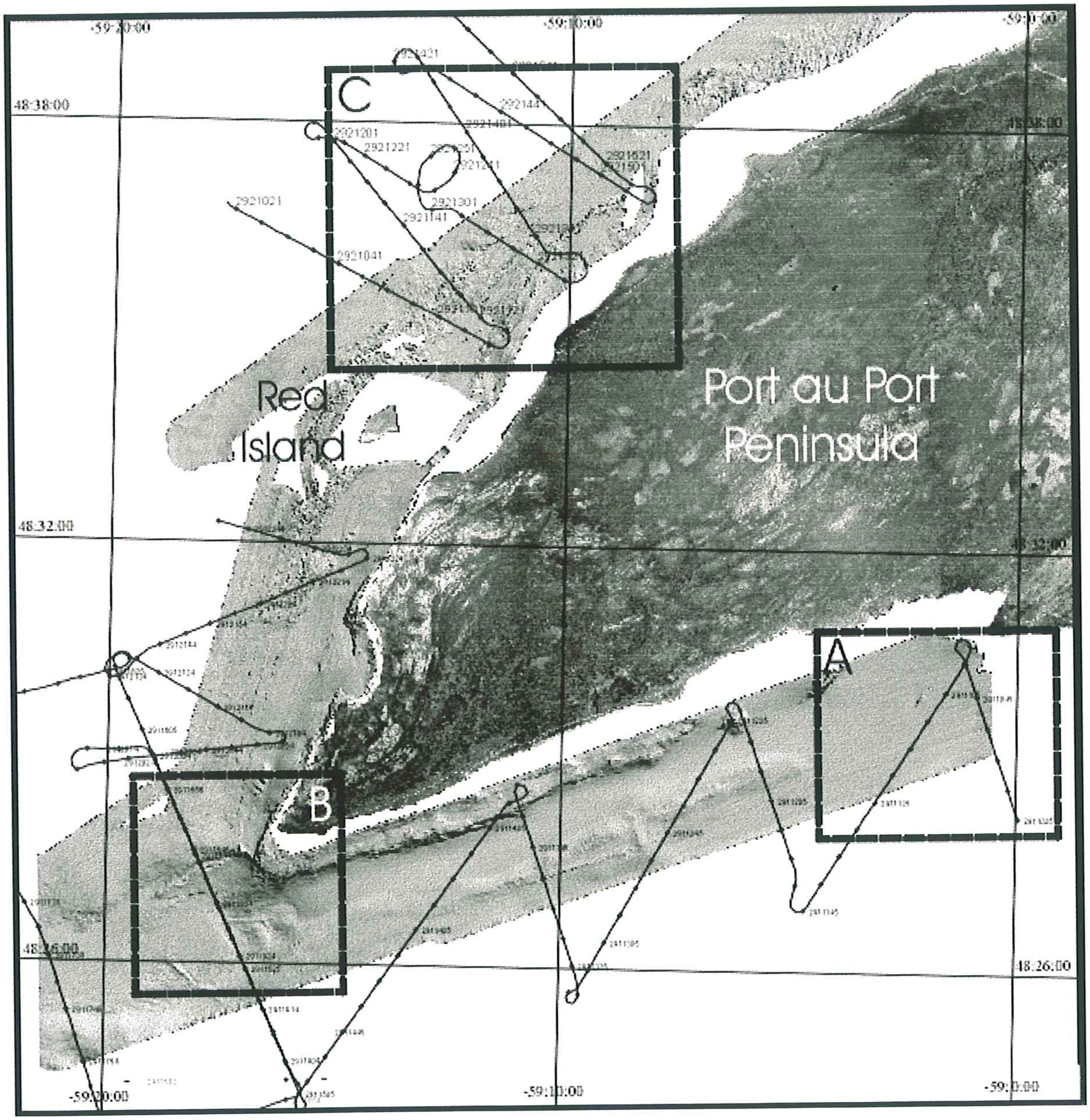
Multibeam bathymetric and magnetic mapping of the south and west coasts of the Port au Port Peninsula in 1996 and 1997 has revealed features on the seabed that are likely related to the outcropping of the deformation front on the seabed. A detailed knowledge of the deformation of sediments above the wedge is critical to the understanding of the kinematics of wedge configuration, emplacement and transport.

The Cambro-Ordovician platform sequences and the subsequent foreland basin units of Silurian though Devonian origin of the Port au Port area were presumably overlain with Carboniferous sediments that now mapped as far as Nova Scotia and PEI. Post-Carboniferous uplift has resulted in the erosion and removal of most of the Carboniferous overburden locally on land, but thick sequences of Carboniferous sediments have been mapped in St. Georges Bay which bounds the peninsula to the south. It has been postulated that differential uplift occurred across a normal fault bounding the south coast but the exact position and nature of this fault is unknown. The nature of this fault as it trends out into the Gulf of St. Lawrence and intersects with the seabed outcrop of the triangle zone is also unknown.

A series of sparker seismic lines were planned to assess the nature of faulting along the southern coast of the Port au Port and, also, to measure deformation of the sediments overlying apparent outcrop of the tectonic wedge north of Red Island. The surveys were performed on two days: activities on JD 291 focused on the southern and southwest end of the Island while the area north of Red Island was surveyed on JD 292. An NSRF multitip sparker and eel combination was used to generate seismic data in this area. Shots were taken every half second and the subsequent trace was recorded to 300 msec. A sidescan was also deployed simultaneously, but due to equipment limitations, it was not recorded digitally.

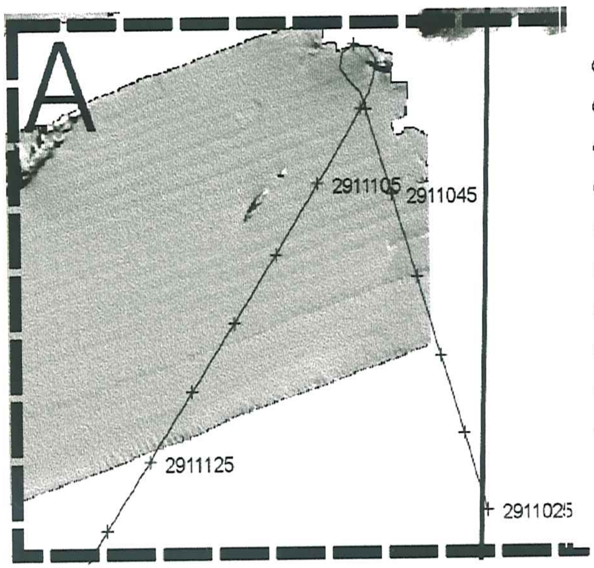
The seismic data were digitized on an AGCDIG digital recording system in SEGY format. A cursory examination of the trace headers revealed that the year and day was incorrectly recorded on the field tape, although the hour, minutes and second fields appeared reasonable. It is likely that the DOS function, *time*, was used to set the recording system clock but the *date* function was not used to set the year/month/day. By default, the system date is reset to sometime in 1986 if the DOS clock battery has failed; this is consistent with the dates observed on the recorded data. No navigation was stored on the digital recording system, so no directly referenced timing information is available. The timing was checked by locating a distinct, short wavelength, ridge-like feature observed on both the seismic data and on preexisting multibeam data. It was found the recorded time appears correct to within a timing error of 1 minute (equivalent to 100 m at 4 nts).

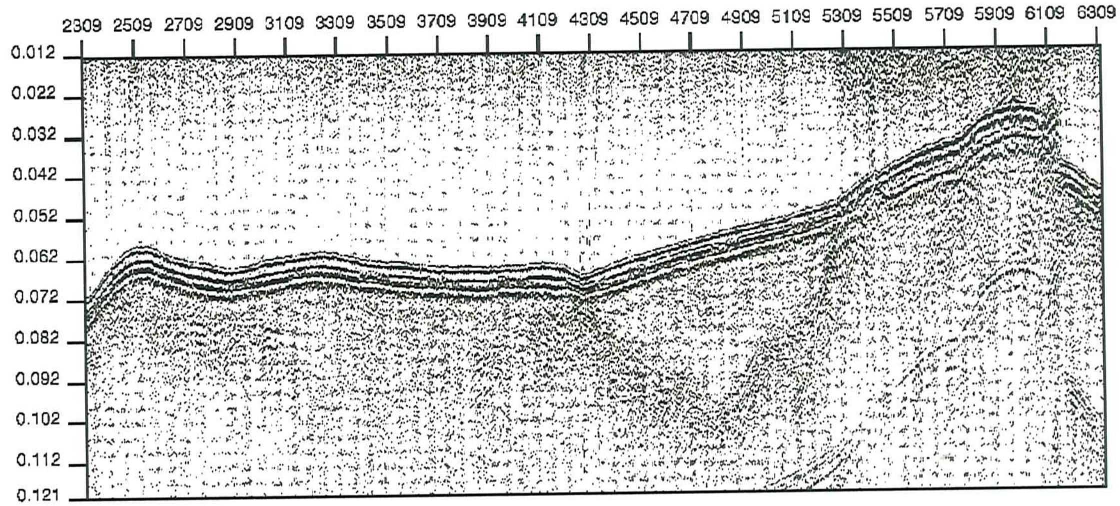
Field Operations



The tracks lines from JD291 and 292 span three distinct areas : region A covering the proposed south coast normal fault, region B covering the intersection between the Carboniferous sediments found to the south and the foreland basin sequences uplifted to the north and region C over the seabed outcrop of the tectonic wedge . Representative seismic sections for the areas denote on the above figure are given to both assess the quality and potential value of the data.

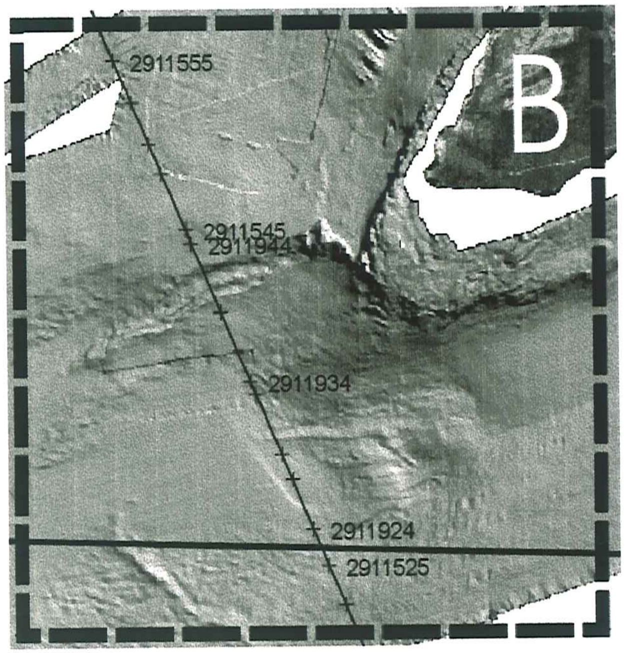
Region A -

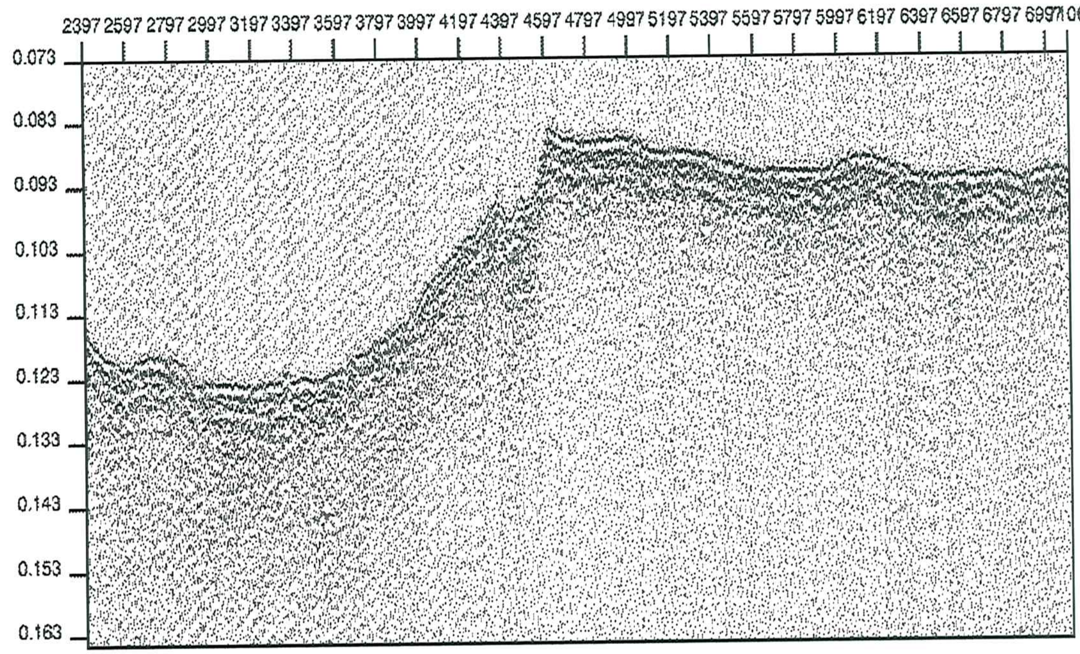




The seismic lines collected over region A crisscross a moat-like structure that parallels the south coast of the Port au Port Peninsula. The seismic data quality is generally good with significant penetration down to 140 msec two way time; the seismic line pictured above comes from the northward leg of the track lines shown in the area cutout (shots between JD 291 10:25Z to JD291 10:55). These data reveal a deeper moat filled with fine unconsolidated sediment (potentially glaciomarine silty to sandy sediments). The basement found before the moat and to the south of the moat allows good penetration with tightly banded, seaward dipping reflectors similar to those observed over the outcropping Carboniferous meta-sediment off Cape Breton. A steep detachment, or fault like structure, appears along the northern edge of the moat. There is little good quality seismic data collected north of the moat as the ship needed to turn back away from the coast in this area so little can be said of the acoustic facies on the northern side. These data likely confirm the position of the normal fault that separates the Carboniferous sediments in St. Georges Bay with the older, uplifted sediments to the north, although the presence of Carboniferous sediments close to the coast cannot be refuted.

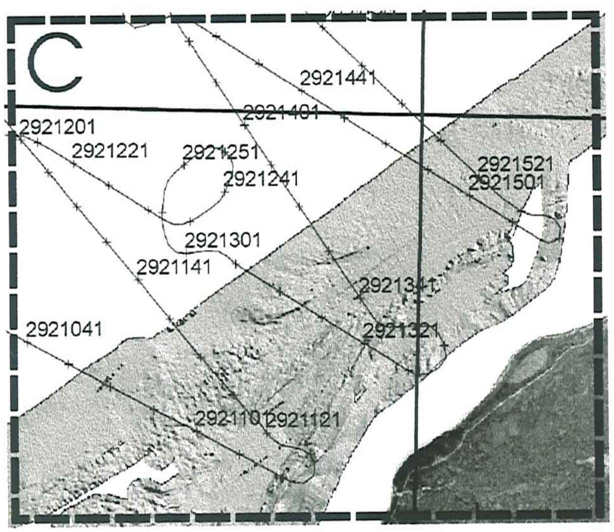
Region B

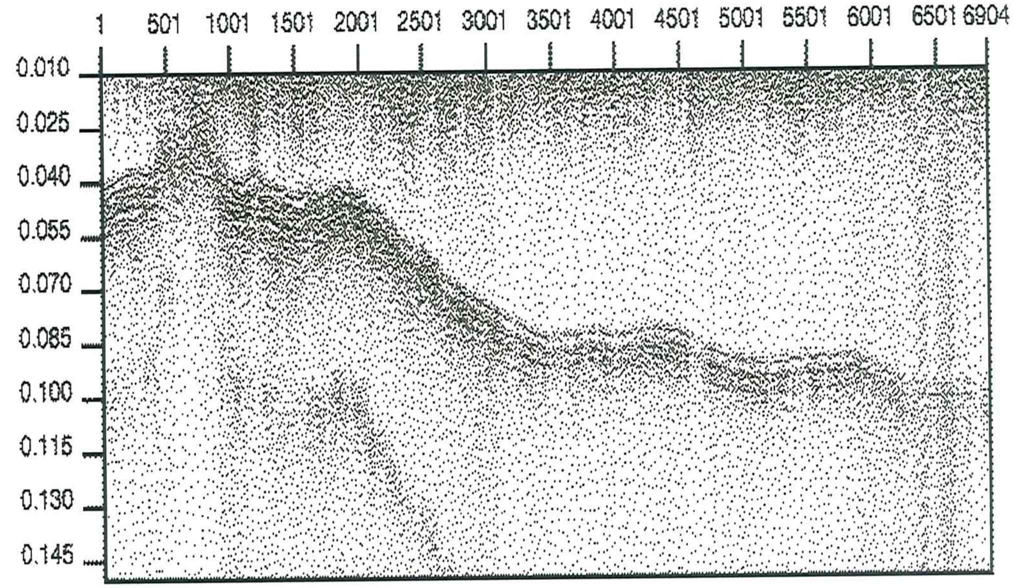




The seismic data in region B were collected to investigate the intersection of the Carboniferous sediments found to the south and the deformed, upturned Silurian-Devonian foreland basin sequences to the north. The multibeam shaded relief imagery shows the moat-like structure that bounds the south coast at the right edge of the shaded relief image and a grooved structure to the immediate west of the southwest tip of land. The seismic section shown above was derived from shots taken between JD 291 15:25 and JD 291 15:55, running from south to north; the track plot can be confusing as the ship ran over the same way points in the opposite direction latter on in the day. The seismic data are starting to degrade as a result of increased sea state, but the data show a change in seismic character across the grooved structure with relatively more penetration through the sediment found to the south and much less penetration through the seabed on the northern side. A closer examination of the field records shows dipping reflectors in the southern section similar to those seen in region A. The change in seismic character across the groove is accompanied by a step up in bathymetry. The grooved structure likely marks the boundary between Carboniferous sediments found to the south and the coarser grained, older sediments from in the foreland sequence to the north. The position of this

Region C





Weather conditions had degraded by JD292, severely limiting utility of the surface towed sparker system. Little, if any, sub-seabed penetration can be recognized in the seismic data. The sidescan data from this area did show the outcropping ridges observed on the multibeam image; but without digital recording the sidescan data was not more than qualitatively useful. The only general conclusion that can be drawn from this data is that the seabed here is relatively hard when compared to the Carboniferous sediments found to the south of the peninsula. This observation is consistent with the identification of Silurian//Devonian clastic facies found nearby onshore. Unfortunately no useful dip information over this area was obtained. Lower frequency seismic sources would be preferable in a future expedition to delineate subseabed structure.

Seismic Data Listing

The seismic data field tapes generated on JD291 and 292 were transcribed onto GSCA's Massive Data Archive System for long term storage. The following listing was created during this process. The data was recorded onto archive tape #00000002. Again, note that although the hour/minute/second fields are correct, but the year should be 1997. The day JD 356 should be JD291 and JD357 should be JD292. The column, FN, is the file number of the transcribed data on the archive tape.

FN	Cruise	Data Type		Start Time (GMT)	End Time(GMT)	
25	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 10:06:51	End : 1986 356 10:59:22	C
26	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 10:59:28	End : 1986 356 11:51:56	C
27	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 11:52:00	End : 1986 356 12:22:18	C
28	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 12:22:23	End : 1986 356 13:21:17	C
29	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 13:21:22	End : 1986 356 13:58:18	C
30	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 13:58:24	End : 1986 356 15:04:24	C
31	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 15:04:28	End : 1986 356 16:23:25	C
32	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 16:23:30	End : 1986 356 16:58:52	C
33	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 16:58:57	End : 1986 356 18:20:33	C
34	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 18:20:37	End : 1986 356 18:57:29	C
35	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 18:57:35	End : 1986 356 20:05:42	C
36	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 20:05:48	End : 1986 356 20:21:36	C
37	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 20:21:40	End : 1986 356 21:01:07	C
38	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 21:01:12	End : 1986 356 21:38:03	C
39	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 21:38:09	End : 1986 356 22:26:06	C
40	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 356 22:26:11	End : 1986 356 22:54:54	C
41	matthew 97060	Seismic -sparker	UNKNOWN	START (user) = 203	END (user) = 205	
42	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 11:01:43	End : 1986 357 11:04:51	C
43	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 11:06:09	End : 1986 357 12:11:27	C
44	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 12:11:35	End : 1986 357 13:34:54	C
45	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 13:35:00	End : 1986 357 14:23:55	C
46	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 14:24:00	End : 1986 357 15:11:25	C
47	matthew 97060	Seismic -sparker	SEGY DATA	rt : 1986 357 15:11:30	End : 1986 357 15:59:38	C
48	matthew 97060	Sidescan	UNKNOWN	START (user) = 293	END (user) = 300	

ACKNOWLEDGEMENTS

We wish to thank the master, officers and crew of the *Matthew* who ensured that the cruise was a success.

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FIGURES

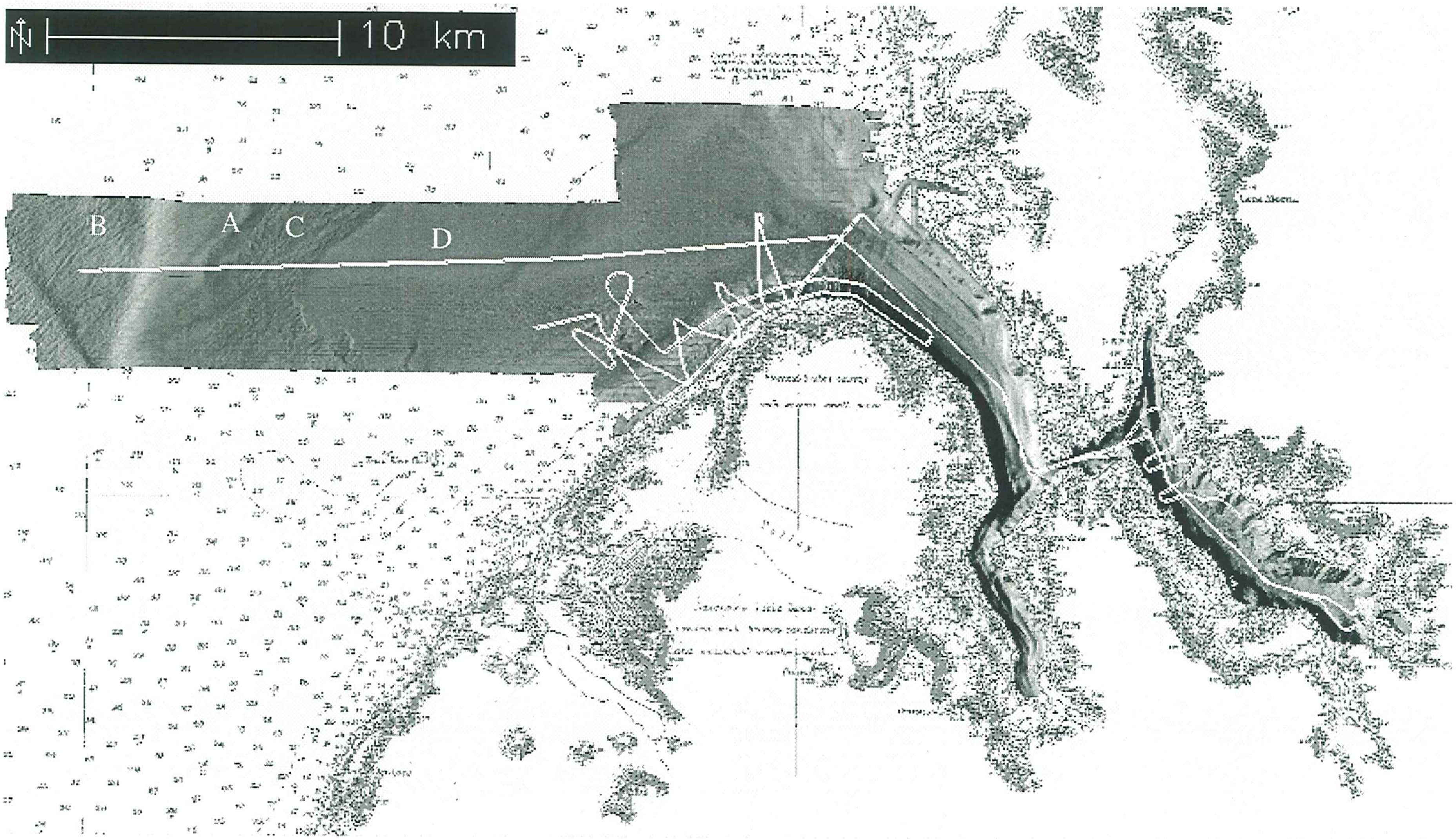


Figure 1

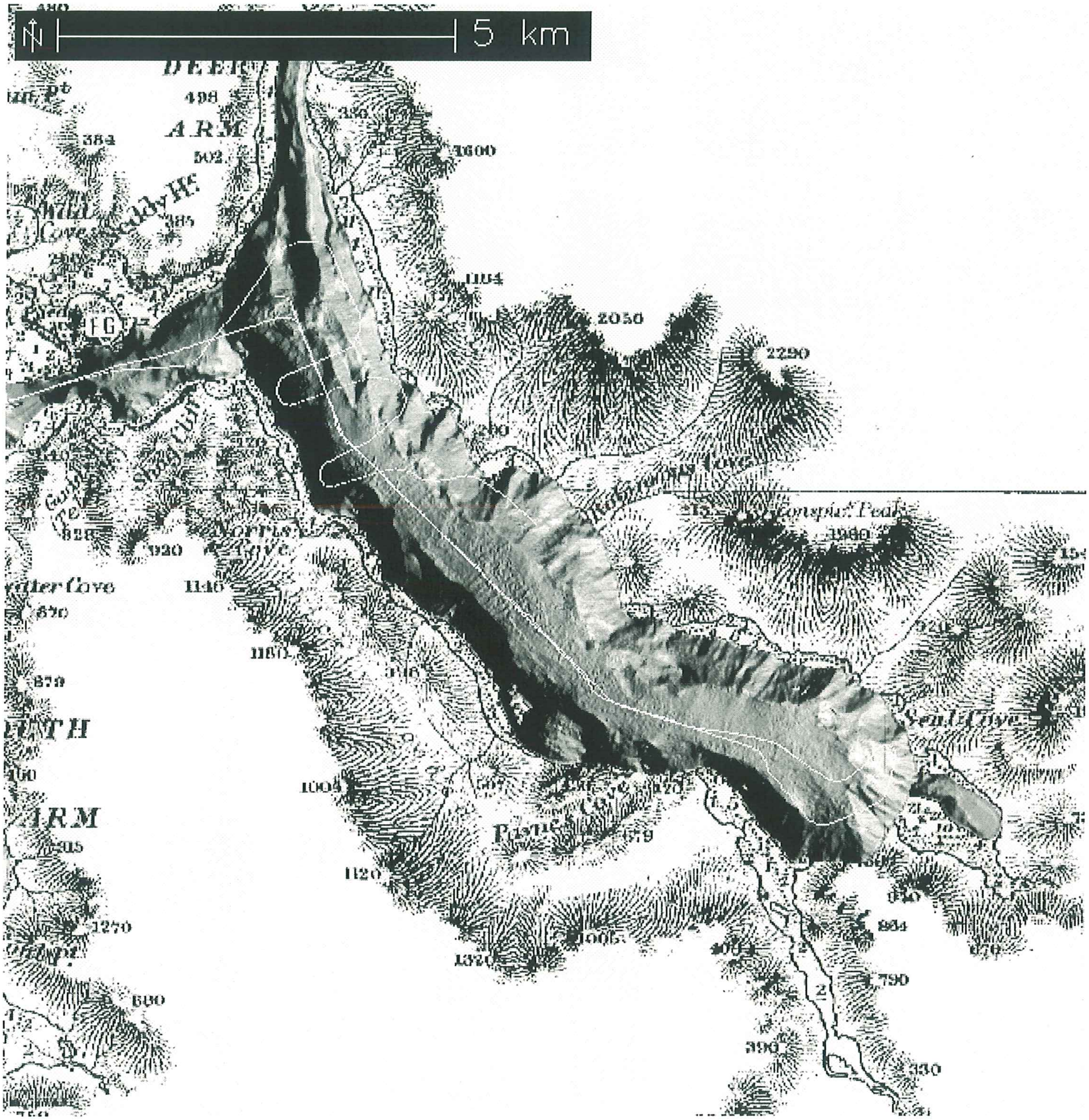


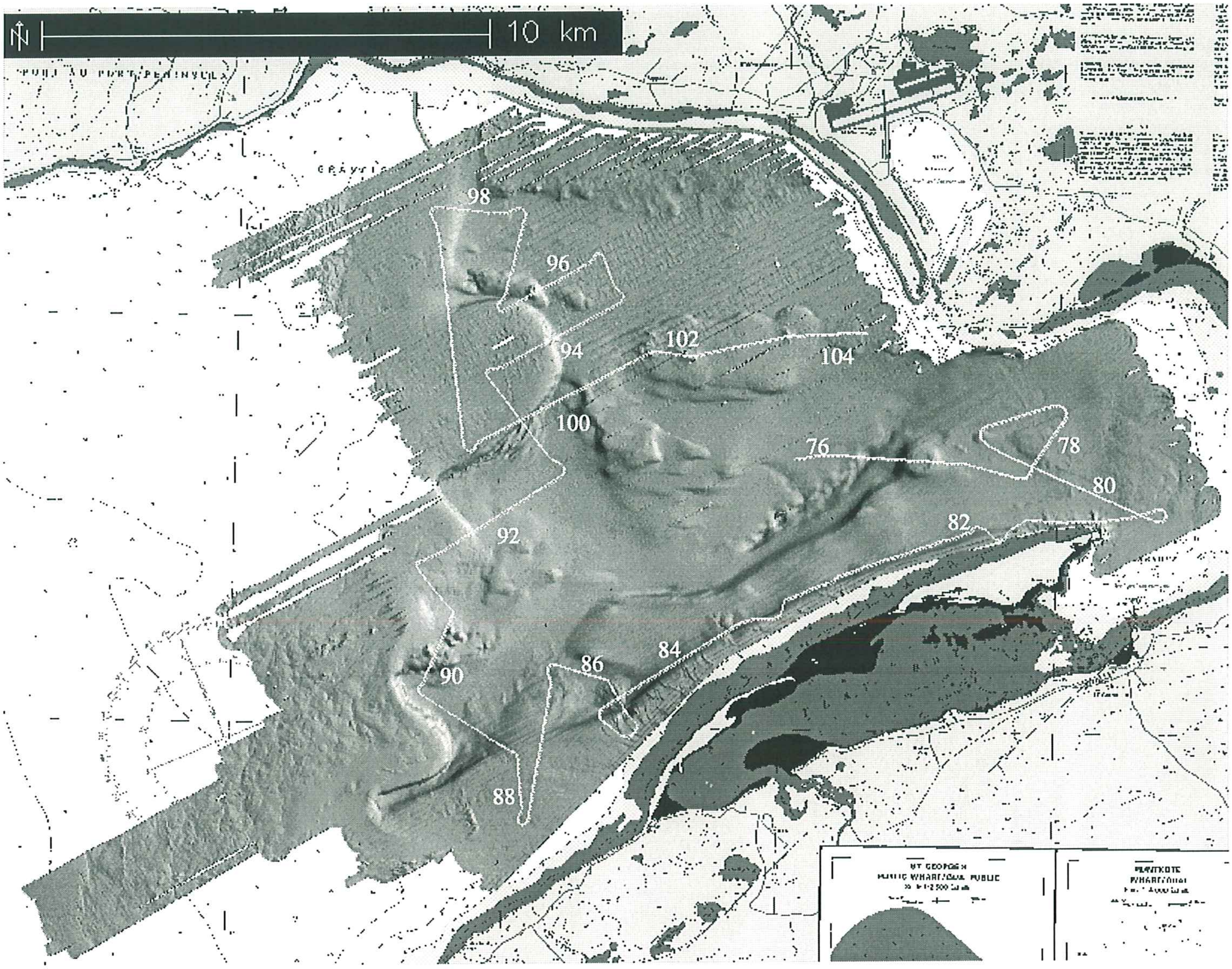
Figure 2


5 km
Elevated broken country
with several small ponds
1005
905
720
774

Figure 3


5 km
N
11
8
7
6
12
5
9
13
3
14
4
10
2
1005
Eastern
Elevated broken country
with several small ponds
Crag
720

Figure 4



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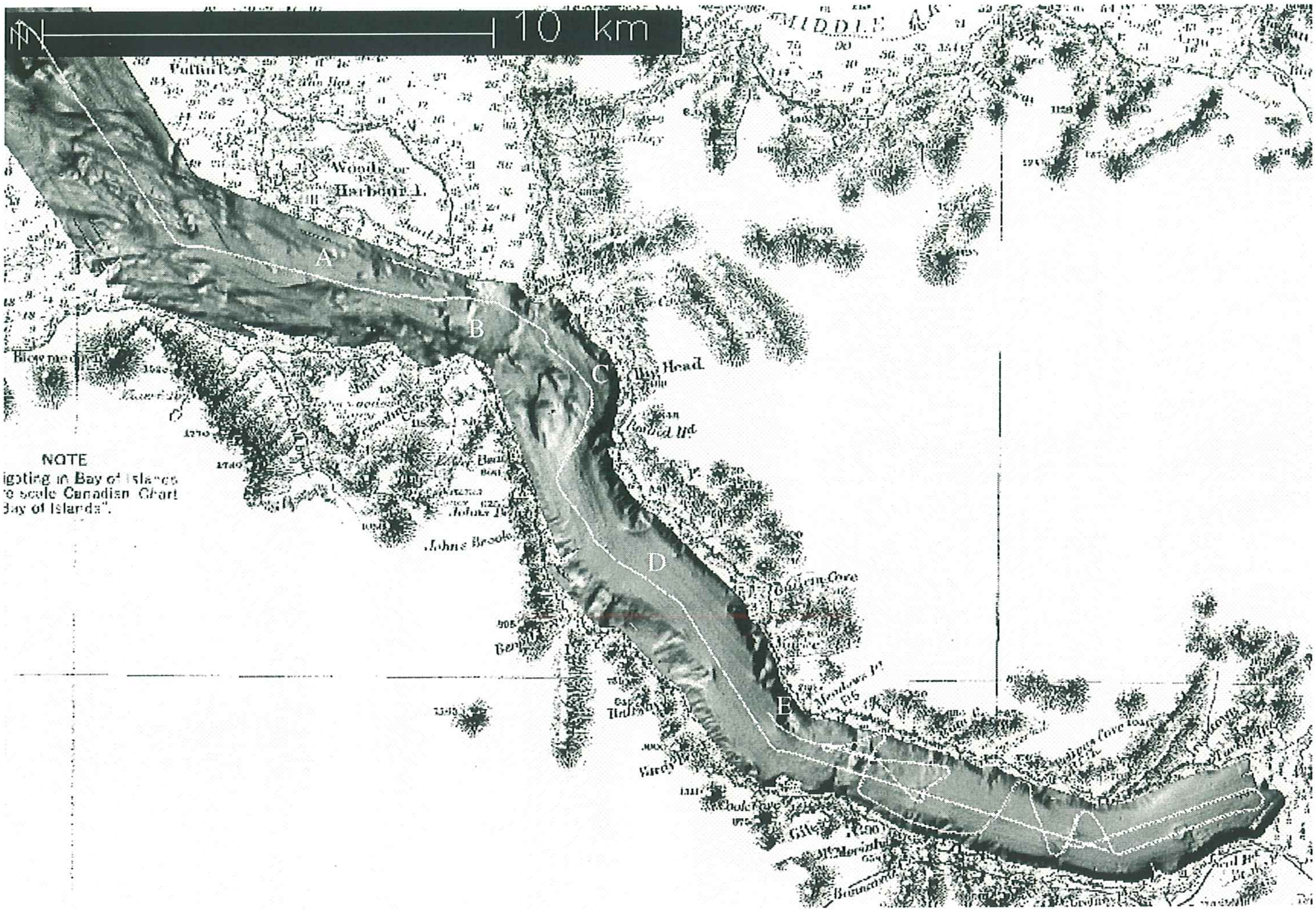
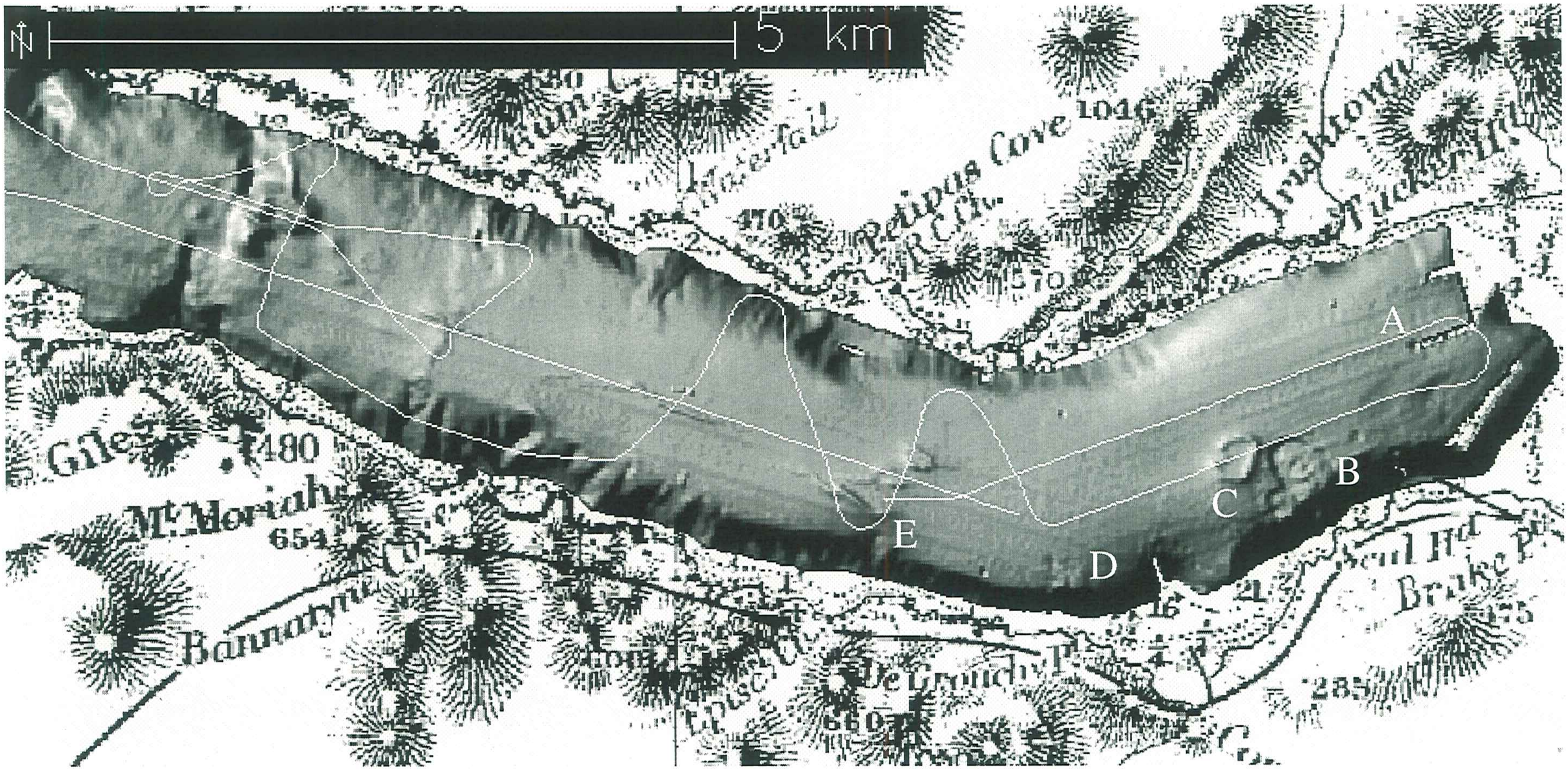


Figure 6



N
5 km
A
B
C
D
E
Giles
480
Mt. Moriah
654
Waterfall
Petipus Cove
1046
470
570
Irishtown
Tucker Hd
Brake Pt
De Grouchy Pt
660
285

Figure 7


5 km
19
20
21
45,46
43,44
41,42
39,40
37,38
36
35
31,32
31,32
27,28
29,30
25,26
23,24
18,22
Big Head
Round Hd
Johns Brook
Johns Beach
Guilem Cove
Meadows Pt
Halfway
Yardy Brook
Cook Cove
Giles
Mt Moriah
Shoal Pt
Frenchman Cove

Figure 8

TABLES

ATLANTIC GEOSCIENCE CENTRE

TABLE 1

DATA SECTION
-SHIP- REPORTING PACKAGE

CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

TOTAL SAMPLE INVENTORY

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
001	EXCALIBUR	2901946		48 27.6631	58 35.0135	99.0	ST. GEORGES BAY
002	GRAB	2951340	2941214	49 32.4071	58 03.1151	27.0	BONNE BAY
003	GRAB	2951359	2941237	49 33.5443	58 01.2024	26.0	BONNE BAY
004	GRAB	2951410	2941404	49 33.5880	58 02.0244	92.0	BONNE BAY
005	GRAB	2951425	2941822	49 33.8896	58 00.4093	85.0	BONNE BAY
006	GRAB	2951437	2941825	49 34.0344	58 00.2008	106.0	BONNE BAY
007	GRAB	2951450	2941830	49 34.2799	57 59.9122	132.0	BONNE BAY
008	GRAB	2951538	2941835	49 34.5121	57 59.6671	135.0	BONNE BAY
009	GRAB	2951555	2941346	49 33.9797	57 59.6726	109.0	BONNE BAY
010	GRAB	2951612	2941300	49 33.6105	57 58.4279	70.0	BONNE BAY
011	GRAB	2951633	2941745	49 34.8723	58 01.6762	111.0	BONNE BAY
012	GRAB	2951650	2941731	49 33.9170	58 01.6192	121.0	BONNE BAY
013	GRAB	2951703	2941727	49 33.6888	58 01.5226	87.0	BONNE BAY
014	GRAB	2951711	2941725	49 33.5763	58 01.4452	36.0	BONNE BAY
015	GRAB	2951741		49 32.6708	58 06.8789	78.0	BONNE BAY
016	GRAB	2951811		49 33.5134	58 13.3740	65.0	BONNE BAY
017	GRAB	2951824		49 33.1867	58 14.0484	62.0	BONNE BAY
018	EXCALIBUR	2961210		48 58.0845	57 59.8667	105.0	HUMBER ARM
019	EXCALIBUR	2971441	2961456	49 04.9984	58 14.1167	98.0	HUMBER ARM
020	CAMERA	2981717		49 05.0178	58 13.8202	97.0	HUMBER ARM
021	GRAB	2981735		49 04.9860	58 13.9130	97.0	HUMBER ARM
022	EXCALIBUR	2981900		48 58.0825	57 59.8341	105.0	HUMBER ARM
023	CAMERA	2991328	2981437	48 58.8863	58 01.3026	80.0	HUMBER ARM
024	GRAB	2991336	2981437	48 58.8716	58 01.3146	79.0	HUMBER ARM
025	GRAB	2991353	2981424	48 59.0315	58 02.7683	90.0	HUMBER ARM

ATLANTIC GEOSCIENCE CENTRE

TABLE 1

DATA SECTION
-SHIP- REPORTING PACKAGE

TOTAL SAMPLE INVENTORY

CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

SAMPLE NUMBER	SAMPLE TYPE	SAMPLE DAY/TIME	SEISMIC DAY/TIME	LATITUDE	LONGITUDE	DEPTH (M)	GEOGRAPHIC LOCATION
026	CAMERA	2991406	2981424	48 59.0403	58 02.7786	91.0	HUMBER ARM
027	CAMERA	2991431	2961715	49 00.5541	58 05.6298	116.0	HUMBER ARM
028	GRAB	2991441	2961715	49 00.5493	58 05.6637	114.0	HUMBER ARM
029	GRAB	2991454		49 00.4406	58 06.3130	51.0	HUMBER ARM
030	CAMERA	2991506		49 00.4338	58 06.3358	47.0	HUMBER ARM
031	CAMERA	2991516		49 00.6002	58 06.8254	38.0	HUMBER ARM
032	GRAB	2991524		49 00.5845	58 06.7872	39.0	HUMBER ARM
033	GRAB	2991538	2961705	49 00.9334	58 06.2496	115.0	HUMBER ARM
034	CAMERA	2991548	2961705	49 00.9478	58 06.2597	115.0	HUMBER ARM
035	CAMERA	2991640	2961650	49 01.2832	58 07.2675	110.0	HUMBER ARM
036	GRAB	2991650	2961650	49 01.4015	58 07.2290	111.0	HUMBER ARM
037	GRAB	2991704	2961635	49 02.2503	58 08.1997	102.0	HUMBER ARM
038	CAMERA	2991715	2961635	49 02.2536	58 08.2198	110.0	HUMBER ARM
039	CAMERA	2991739	2961630	49 02.6356	58 08.0849	112.0	HUMBER ARM
040	GRAB	2991748	2961630	49 02.6452	58 08.1056	111.0	HUMBER ARM
041	GRAB	2991758	2961627	49 03.0441	58 07.8998	109.0	HUMBER ARM
042	CAMERA	2991809	2961627	49 03.0490	58 07.9094	108.0	HUMBER ARM
043	CAMERA	2991822	2961616	49 03.2602	58 07.6538	108.0	HUMBER ARM
044	GRAB	2991832	2961616	49 03.2646	58 07.6624	109.0	HUMBER ARM
045	GRAB	2991847	2961542	49 04.5326	58 09.7405	56.0	BAY OF ISLANDS
046	CAMERA	2991858	2961542	49 04.5273	58 09.7570	57.0	BAY OF ISLANDS
047	EXCALIBUR	3001254		48 27.6044	58 35.3384	92.0	ST. GEORGES BAY

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 2

GRAB SAMPLES

CRUISE NUMBER = 97060
CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO.OF TRIES	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
002	VAN VEEN	2951340	49 32.4071 58 03.1151	27.0	2	2	BONNE BAY	1ST ATTEMPT JAMMED BY ROCK. 2ND ATTEMPT: 1344 49 32.4086N 58 03.0944W, DARK BROWNISH GREY MEDIUM SAND, WELL SORTED, 2 SAND DOLLARS, FINE SHELL. 1 VIAL, 1 BAG SAMPLE.
003	VAN VEEN	2951359	49 33.5443 58 01.2024	26.0	1	1	BONNE BAY	POORLY SORTED FINE GRAVEL. 1 BAG SAMPLE.
004	VAN VEEN	2951410	49 33.5880 58 02.0244	92.0	1	2	BONNE BAY	DARK GREY FINE-MEDIUM SAND, SCATTERED PEBBLES AND WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
005	VAN VEEN	2951425	49 33.8896 58 00.4093	85.0	1	2	BONNE BAY	DARK BROWNISH GREY MEDIUM-FINE SAND, SOME SILT, WORM TUBES. 1 SAND DOLLAR. 1 VIAL, 1 BAG SAMPLE.
006	VAN VEEN	2951437	49 34.0344 58 00.2008	106.0	1	2	BONNE BAY	DARK BROWNISH GREY MEDIUM-FINE SAND, WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
007	VAN VEEN	2951450	49 34.2799 57 59.9122	132.0	1		BONNE BAY	DARK GREY MUDDY MEDIUM SAND, WORM TUBES.
008	VAN VEEN	2951538	49 34.5121 57 59.6671	135.0	1	2	BONNE BAY	DARK BROWNISH GRAY SILTY FINE SAND, MANY WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
009	VAN VEEN	2951555	49 33.9797 57 59.6726	109.0	1	2	BONNE BAY	DARK GREYISH BROWN MEDIUM-FINE SAND, WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
010	VAN VEEN	2951612	49 33.6105 57 58.4279	70.0	1	2	BONNE BAY	DARK GREY MEDIUM-FINE SAND WITH WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
011	VAN VEEN	2951633	49 34.8723 58 01.6762	111.0	1	2	BONNE BAY	DARK OLIVE GREY FINE SAND, MANY WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
012	VAN VEEN	2951650	49 33.9170 58 01.6192	121.0	1	2	BONNE BAY	DARK OLIVE GREY MEDIUM-FINE SAND, SOME WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
013	VAN VEEN	2951703	49 33.6888 58 01.5226	87.0	1	3	BONNE BAY	DARK OLIVE GREY MEDIUM-FINE SAND, A FEW ROUNDED PEBBLES, 1 LARGE COBBLE-GRANITE-SUB-ROUNDED. 1 VIAL, 2 BAG SAMPLES.
014	VAN VEEN	2951711	49 33.5763 58 01.4452	36.0	2	1	BONNE BAY	2ND ATTEMPT: 1714 49 33.5811N 58 1.4452W POORLY SORTED MIXTURE OF COARSE SAND AND FINE GRAVEL. 1 BAG SAMPLE.
015	VAN VEEN	2951741	49 32.6708 58 06.8789	78.0	1	2	BONNE BAY	MEDIUM-FINE SAND, OLIVE. SCATTERED PEBBLES, SOME SHELL, 1 SAND DOLLAR. 1 VIAL, 1 BAG SAMPLE.

TABLE 2

GRAB SAMPLES

CRUISE NUMBER = 97060
CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO.OF TRIES	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
016	VAN VEEN	2951811	49 33.5134 58 13.3740	65.0	1	2	BONNE BAY	WELL-SORTED OLIVE BROWN MEDIUM SAND. 1 SAND DOLLAR. 1 VIAL, 1 BAG SAMPLE.
017	VAN VEEN	2951824	49 33.1867 58 14.0484	62.0	3		BONNE BAY	1ST ATTEMPT:1 COBBLE, A FEW PEBBLES. 2ND ATTEMPT:1827 49 33.172N 58 15.0672W, ANGULAR COBBLES, TRACE OF COARSE SAND. 3RD ATTEMPT:1830 49 33.1948N 58 15.048W, EMPTY.
021	VAN VEEN	2981735	49 04.9860 58 13.9130	97.0	1	2	HUMBER ARM	VERY DARK OLIVE GREY CLAYEY SILT. SCATTERED ANGULAR PEBBLES, 1 COBBLE, A FEW WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
024	VAN VEEN	2991336	48 58.8716 58 01.3146	79.0	1	2	HUMBER ARM	SOFT BLACK MUD, A FEW ANGULAR PEBBLES. 1 VIAL, 1 BAG SAMPLE.
025	VAN VEEN	2991353	48 59.0315 58 02.7683	90.0	1	2	HUMBER ARM	SOFT BLACK MUD, BROWN MOTTLES, ANGULAR PEBBLES. 1 LARGE COBBLE, SUB-ROUNDED, ENCRUSTED WITH ANEMONES. 1 BAG (MUD+ GRAVEL), 1 BAG (COBBLE).
028	VAN VEEN	2991441	49 00.5493 58 05.6637	114.0	1	2	HUMBER ARM	BLACK MUD, WOOD CHIPS AND A PIECE OF WOOD ON SURFACE. 1 VIAL, 1 BAG SAMPLE.
029	VAN VEEN	2991454	49 00.4406 58 06.3130	51.0	1	1	HUMBER ARM	BLACK SILTY MUD, ANGULAR GRAVEL. PROBABLY ON SURFACE. 1 ANGULAR SMALL COBBLE WITH AN ANEMONE AND WHITE CORAL. 1 BAG SAMPLE.
032	VAN VEEN	2991524	49 00.5845 58 06.7872	39.0	1	1	HUMBER ARM	DARK OLIVE GREY SILTY MUD, LOTS OF ANGULAR GRAVEL. 1 BAG SAMPLE.
033	VAN VEEN	2991538	49 00.9334 58 06.2496	115.0	1	2	HUMBER ARM	SOFT BLACK SILTY CLAY MUD. 1 VIAL, 1 BAG SAMPLE.
036	VAN VEEN	2991650	49 01.4015 58 07.2290	111.0	1	2	HUMBER ARM	BLACK CLAY/SILT MUD, BROWN MOTTLES, A FEW WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
037	VAN VEEN	2991704	49 02.2503 58 08.1997	102.0	1	2	HUMBER ARM	BLACK CLAY/SILT MUD. 1 LARGE SUB-ROUNDED COBBLE. 1 VIAL, 1 BAG SAMPLE.
040	VAN VEEN	2991748	49 02.6452 58 08.1056	111.0	1	2	HUMBER ARM	BLACK SILTY-CLAY MUD. 1 GASTROPOD, 1 ANGULAR PEBBLE. 1 VIAL, 1 BAG SAMPLE.
041	VAN VEEN	2991758	49 03.0441 58 07.8998	109.0	1	1	HUMBER ARM	BLACK CLAYEY SILTY MUD WITH MUCH ANGULAR PEBBLY GRAVEL-PERHAPS ON SURFACE. 1 BAG SAMPLE.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 2

GRAB SAMPLES

CRUISE NUMBER = 97060
CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

SAMPLE NUMBER	TYPE OF SAMPLER	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (M)	NO.OF TRIES	NO. OF SUBSAMPLES	GEOGRAPHIC LOCATION	GRAB SAMPLE NOTES
044	VAN VEEN	2991832	49 03.2646 58 07.6624	109.0	1	2	HUMBER ARM	DARK OLIVE GREY/BLACK CLAY/SILT WITH SCATTERED FINE/MEDIUM GRAVEL, WORM TUBES. 1 VIAL, 1 BAG SAMPLE.
045	VAN VEEN	2991847	49 04.5326 58 09.7405	56.0	1	1	BAY OF ISLANDS	DARK OLIVE SANDY MUD, COBBLES WITH ANENOMES AND SOME FINER GRAVEL. 1 BAG SAMPLE.

ATLANTIC GEOSCIENCE CENTRE
DATA SECTION
-SHIP- REPORTING PACKAGE

TABLE 3

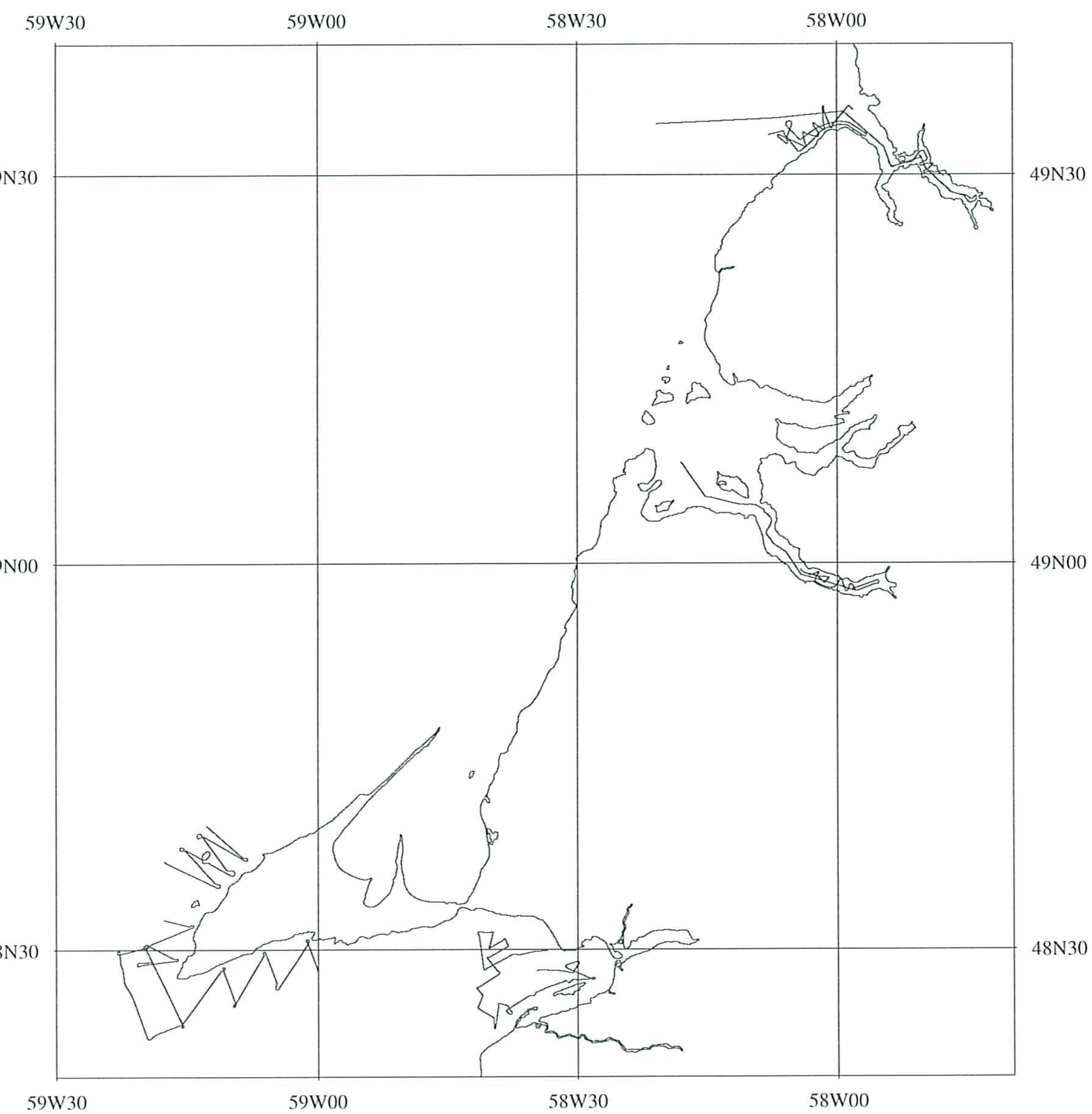
CAMERA STATIONS

CRUISE NUMBER = 97060
CHIEF SCIENTIST = J. SHAW
PROJECT NUMBER = 900031

SAMPLE NUMBER	TYPE OF CAMERA	DAY/TIME (GMT)	LATITUDE LONGITUDE	DEPTH (MTRS)	FRAMES SHOT	DIST OFF. BOTT	STEREO	COLOR1 COLOR2	ASA1 ASA2	FSTOP1 FSTOP2	FOCUS1 FOCUS2	FILM1 FILM2	GEOGRAPHIC LOCATION
020	ICE HOLE	2981717	49 05.0178 58 13.8202	97.0	6	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
023	ICE HOLE	2991328	48 58.8863 58 01.3026	80.0	4	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
026	ICE HOLE	2991406	48 59.0403 58 02.7786	91.0	4	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
027	ICE HOLE	2991431	49 00.5541 58 05.6298	116.0	4	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
030	ICE HOLE	2991506	49 00.4338 58 06.3358	47.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
031	ICE HOLE	2991516	49 00.6002 58 06.8254	38.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
034	ICE HOLE	2991548	49 00.9478 58 06.2597	115.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
035	ICE HOLE	2991640	49 01.2832 58 07.2675	110.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
038	ICE HOLE	2991715	49 02.2536 58 08.2198	110.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
039	ICE HOLE	2991739	49 02.6356 58 08.0849	112.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM
042	ICE HOLE	2991809	49 03.0490 58 07.9094	108.0	5	150	N	COLOR	400	5.6	150	EKTACHROME	HUMBER ARM

APPENDIX 1

SHIP'S TRACKS AND SAMPLE LOCATIONS



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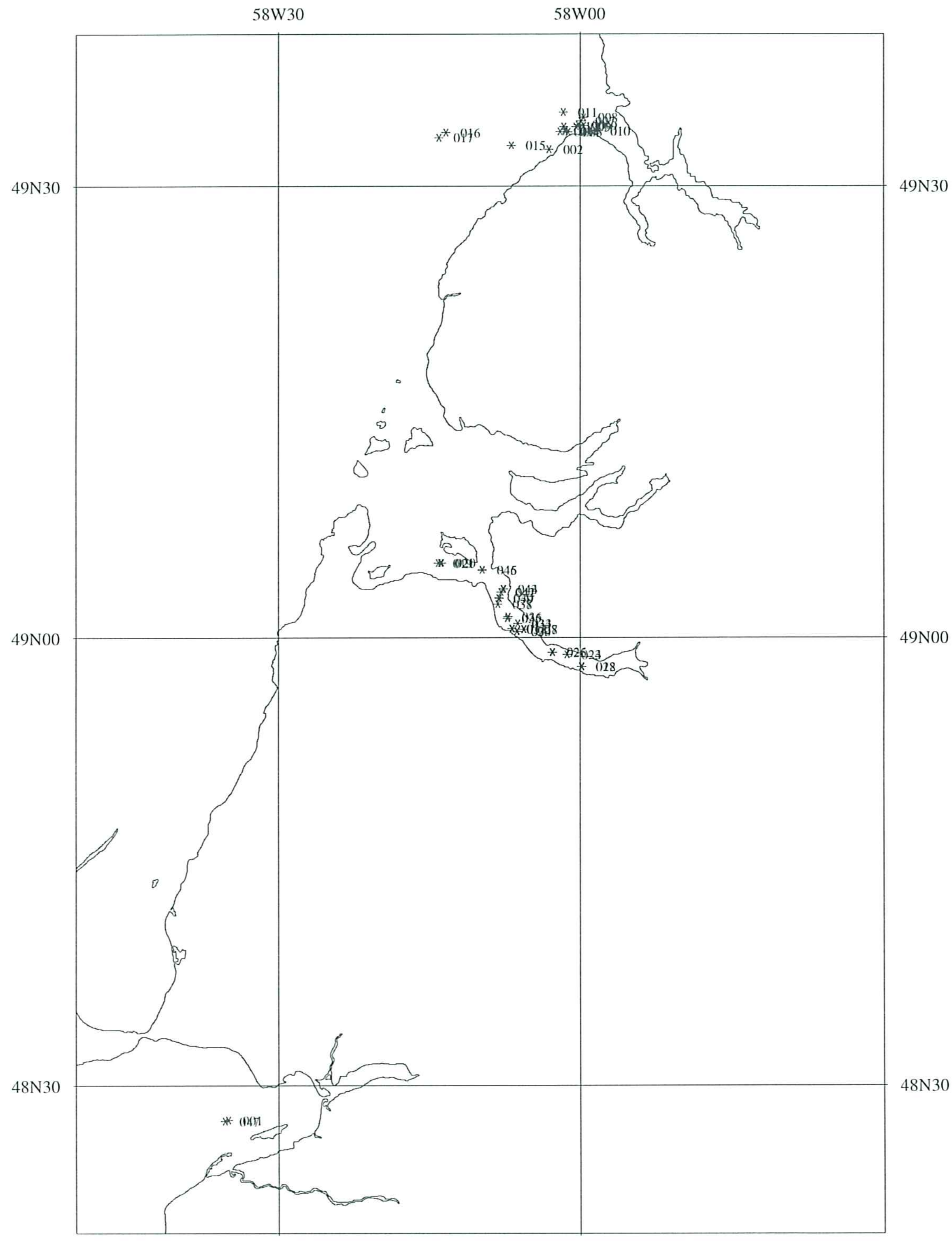

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APPENDIX 2

BOTTOM PHOTOGRAPHS

Sample 97060-20. Frame 1. Bay of Islands. Same location as grab sample 97060-21, depth 97 m. The sea floor is soft, with burrows and animal tracks. The grab contained clayey silt with pebbles and worm tubes.

Sample 97060-20. Frame 2. Same location as grab sample 97060-21, depth 97 m. Bay of Islands. The sea floor is soft and heavily marked by animal burrows and tracks.

Sample 97060-020, frame 3. Bay of Islands, depth 97 m. Same location as grab sample 97060-021. A soft, muddy bottom with animal burrows and tracks.

Sample 97060-023. Frame 1. Bay of Islands, depth 80 m. Same location as grab sample -024 (soft black mud with a few angular pebbles). Soft muddy bottom, burrows, anemone, brittlestar, wood fragment?, worm tubes.

Sample 97060-23, frame 2. Bay of Islands, depth 80 m.   Soft muddy bottom, brittlestar, animal tracks, burrows.

Sample 97060-23, frame 3. Bay of Islands, depth 80 m.   Soft muddy bottom, several brittlestars, burrows, animal tracks.

Sample 97060-023, frame 4. Bay of Islands, depth 80 m. Soft muddy bottom, brittlestar, animal tracks, burrows, anemones.

Sample 97060-026, frame 1. Humber Arm, depth 91 m. Same location as grab sample -025 (soft silty mud, angular pebbles, cobble with anenomes attached). Soft muddy bottom, several brittlestars, burrows, animal tracks, anemones.

Sample 97060-026, frame 2. Humber Arm, depth 91 m. Soft muddy bottom, brittlestars, animal tracks, anenomes.

Sample 97060-026, frame 3. Humber Arm, depth 91 m. Soft muddy bottom, brittlestar, animal tracks, anemones. Unidentified bright object, left of centre.

Sample 97060-026, frame 4. Humber Arm, depth 91 m. Soft muddy bottom, brittlestar, animal tracks, burrows, anenomes.

Sample 97060-027, frame 1. Humber Arm, depth 116 m. Same location as grab sample -028 (black mud, some wood fragments on surface). Soft muddy bottom, brittlestar, burrows, animal tracks.

Sample 97060-027, frame 2. Humber Arm, depth 116 m. Soft muddy bottom, brittlestar, animal tracks, burrows.

Sample 97060-27, frame 3. Humber Arm, depth 116 m. Soft muddy bottom, brittlestars, animal tracks, burrows.

Sample 97060-27, frame 4, Bonne Bay, depth 116 m. Soft muddy bottom with animal tracks and burrows.

Sample 97060-30, frame 1, Bonne Bay, depth 47 m. Soft muddy bottom, numerous anemones, animal tracks, bright objects that may be encrustations of branching coral.

Sample 97060-30, frame 2, Bonne Bay, depth 47 m. Soft muddy bottom, numerous anenomes, animal tracks, shell fragments, scattered sub-rounded gravel with a mud veneer. One of the anenomes clearly attached to gravel.

Sample 97060-30, frame 3, Bonne Bay, depth 47 m. Soft muddy bottom, animal tracks, anemones, shell fragments.

Sample 97060-30, frame 4, Bonne Bay, depth 47 m. Soft muddy bottom, numerous anenomes, animal tracks, shell fragments, scattered sub-rounded gravel with a mud veneer, several gastropods.

Sample 97060-30, frame 5, Bonne Bay, depth 47 m. Soft muddy bottom, numerous anenomes, animal tracks, shell fragments, scattered sub-rounded gravel with a mud veneer, several gastropods.

Sample 97060-31, frame 1, Bonne Bay, depth 38 m. Soft muddy bottom, several partly buried sub-angular to sub-rounded cobbles with red coral coating. Shell fragments, dead bivalve, dead gastropod. A sincle palm-shaped bryozoan, probably attached to hard substrate.

Sample 97060-31, frame 2, Bonne Bay, depth 38 m. Scattered gravel on a muddy substrate with animal tracks, a few anenomes, shell fragments. One clast is coral-encrusted.

Sample 97060-31, frame 3, Bonne Bay, depth 38 m. Angular gravel, partly buried, strewn across a soft muddy bottom with animal tracks, a few anenomes, partly buried dead bivalves.

Sample 97060-31, frame 4, Bonne Bay, depth 38 m. Angular-rounded gravel on a mud bottom. A few anenomes, animal tracks.

Sample 97060-31, frame 5, Bonne Bay, depth 38 m. High concentration of angular gravel on a muddy bottom. Partly buried scallop valves, some anenomes, animal tracks.

Sample 97060-34, frame 1, Bonne Bay, depth 38 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-34, frame 2, Bonne Bay, depth 115 m. Soft muddy bottom, animal tracks, worm tubes.

Sample 97060-34, frame 3, Bonne Bay, depth 115 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-34, frame 4, Bonne Bay, depth 115 m. Soft muddy bottom, animal tracks.

Sample 97060-34, frame 5, Bonne Bay, depth 115 m. Soft muddy bottom.

Sample 97060-35, frame 1, Humber Arm, depth 111 m. Soft muddy bottom, very murky, brittlestars. Same location as grab sample -036.

Sample 97060-35, frame 2, Humber Arm, depth 111 m. Soft muddy bottom, very murky, animal tracks.

Sample 97060-35, frame 3, Humber Arm, depth 111 m. Soft muddy bottom, very murky.

Sample 97060-35, frame 4, Humber Arm, depth 111 m. Soft muddy bottom, very murky, brittlestars.

Sample 97060-35, frame 5, Humber Arm, depth 111 m. Soft muddy bottom, very murky, brittlestars.

Sample 97060-38, frame 1, Humber Arm, depth 110 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-38, frame 2, Humber Arm, depth 110 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-39, frame 1, Humber Arm, depth 112 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-39, frame 2, Humber Arm, depth 112 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-39, frame 3, Humber Arm, depth 112 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-39, frame 4, Humber Arm, depth 112 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-39, frame 5, Humber Arm, depth 112 m. Soft muddy bottom, animal tracks, brittlestars.

Sample 97060-042, frame 1, Humber Arm, depth 108 m. Soft muddy bottom, animal tracks, rough texture. Partly buried crab.

Sample 97060-042, frame 2, Humber Arm, depth 108 m. Soft muddy bottom, animal tracks (including diagonal shrimp track), rough texture, burrows, branched coral

Sample 97060-042, frame 3, Humber Arm, depth 108 m. Soft muddy bottom, animal tracks, shrimp, anenomes, burrows, flatfish (upper right).

Sample 97060-042, frame 4, Humber Arm, depth 108 m. Soft muddy bottom, animal tracks, burrows, one piece of branched coral.

Sample 97060-042, frame 5, Humber Arm, depth 108 m. Soft muddy bottom, anenomes, animal tracks.

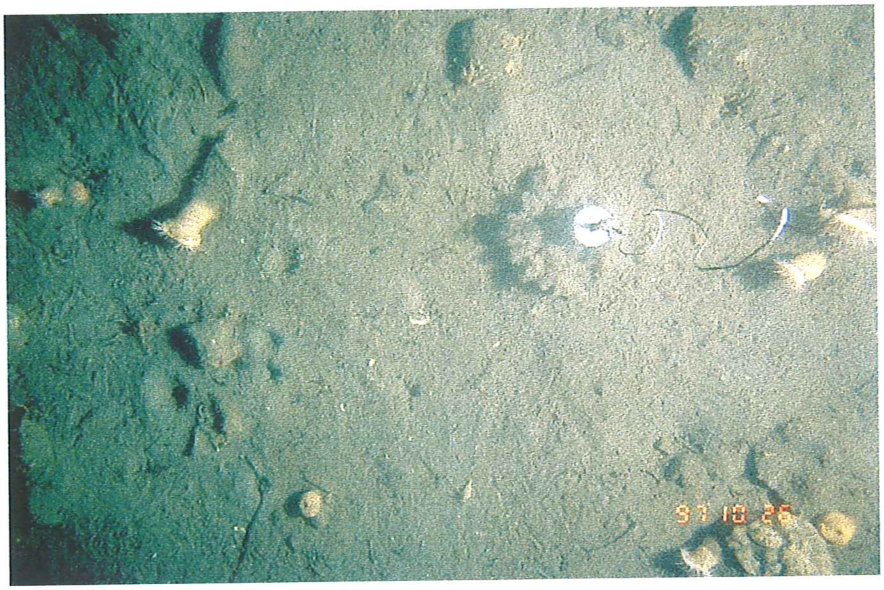
Sample 97060-043, frame 1, Humber Arm, depth 108 m. Soft muddy bottom, burrows, animal tracks.

Sample 97060-043, frame 2, Humber Arm, depth 108 m. Soft muddy bottom, burrows, animal tracks.

Sample 97060-043, frame 3, Humber Arm, depth 108 m. Soft muddy bottom, murky due to sediment suspended by impact of camera weight.

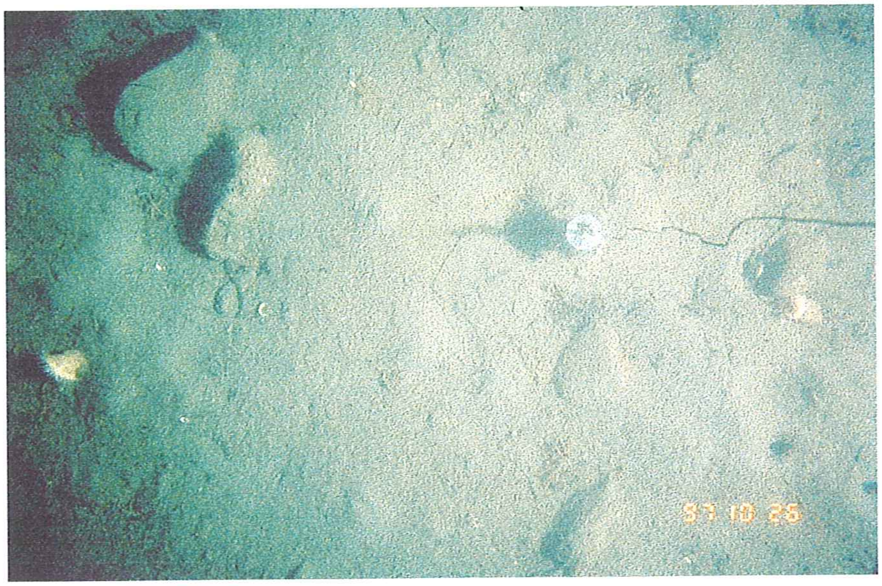
Sample 97060-043, frame 4, Humber Arm, depth 108 m. Soft muddy bottom, burrows, animal tracks.

Sample 97060-043, frame 5, Humber Arm, depth 108 m. Soft muddy bottom, burrows, animal tracks.

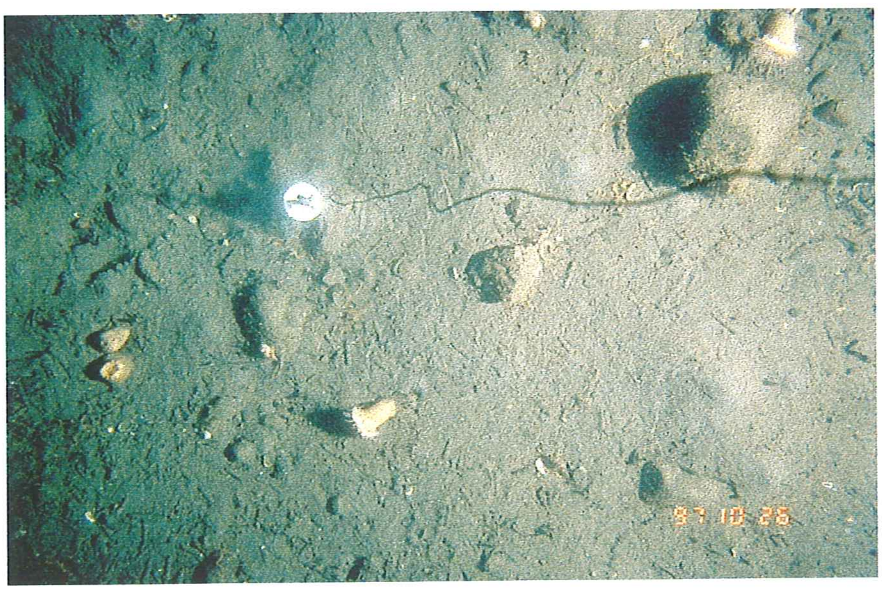


Sample 97060-046, frame 1, Humber Arm, depth 57 m.
Scattered gravel on a muddy substrate, anenomes attached to pebbles, tracks, shell fragments. Same location as sample -045.

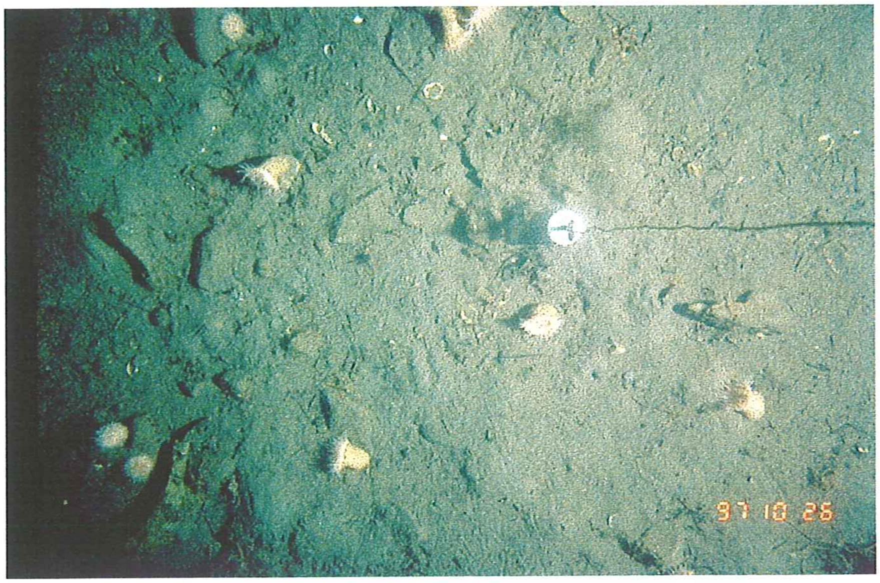
Sample 97060-046, frame 2, Humber Arm, depth 57 m.
Scattered gravel on a muddy substrate, anenomes attached to pebbles, tracks, shell fragments, small brittlestars.



Sample 97060-046, frame 3, bay of Islands. Soft muddy bottom, cobbles, pebbles, sub-angular to sub-rounded, anenomes, small brittlestars. Depth 57 m.



Sample 97060-046, frame 4, bay of Islands. Soft muddy bottom, cobbles and pebbles (some buried in mud), sub-angular to sub-rounded; anenomes, small brittlestars, shell fragments. Depth 57 m.



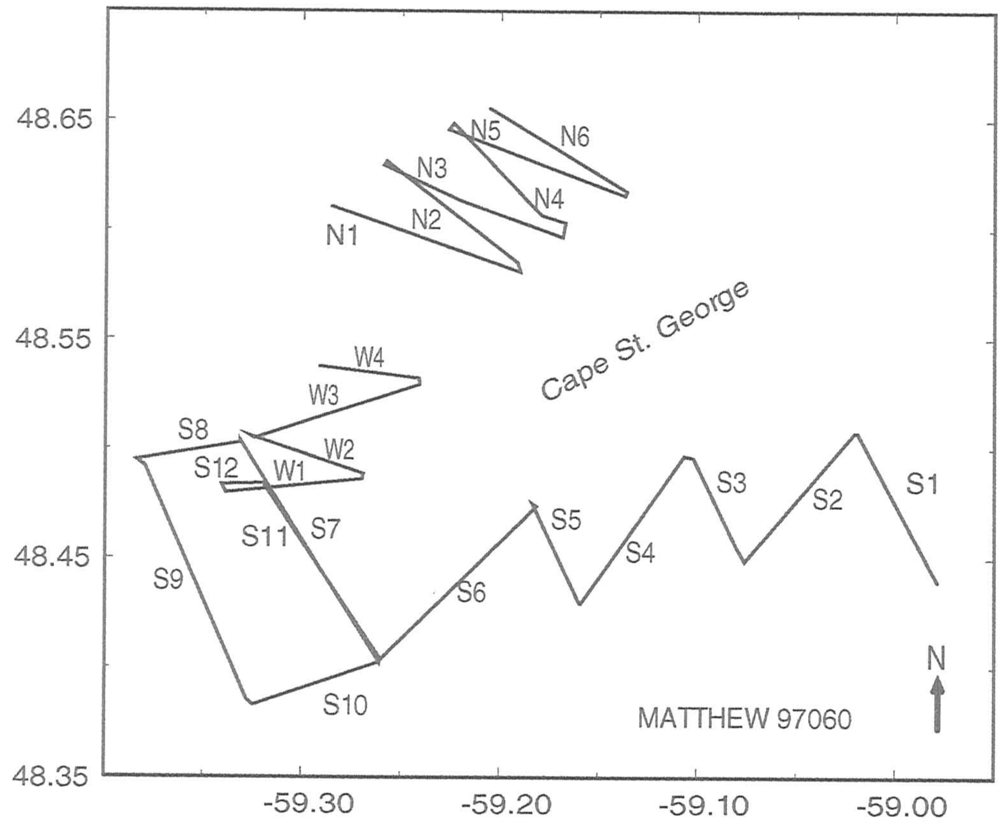
Sample 97060-046, frame 5, bay of Islands. Soft muddy bottom, cobbles and pebbles (some buried in mud), sub-angular to sub-rounded; anenomes, small brittlestars, shell fragments. Depth 57 m.

APPENDIX 3

MAGNETOMETER DATA

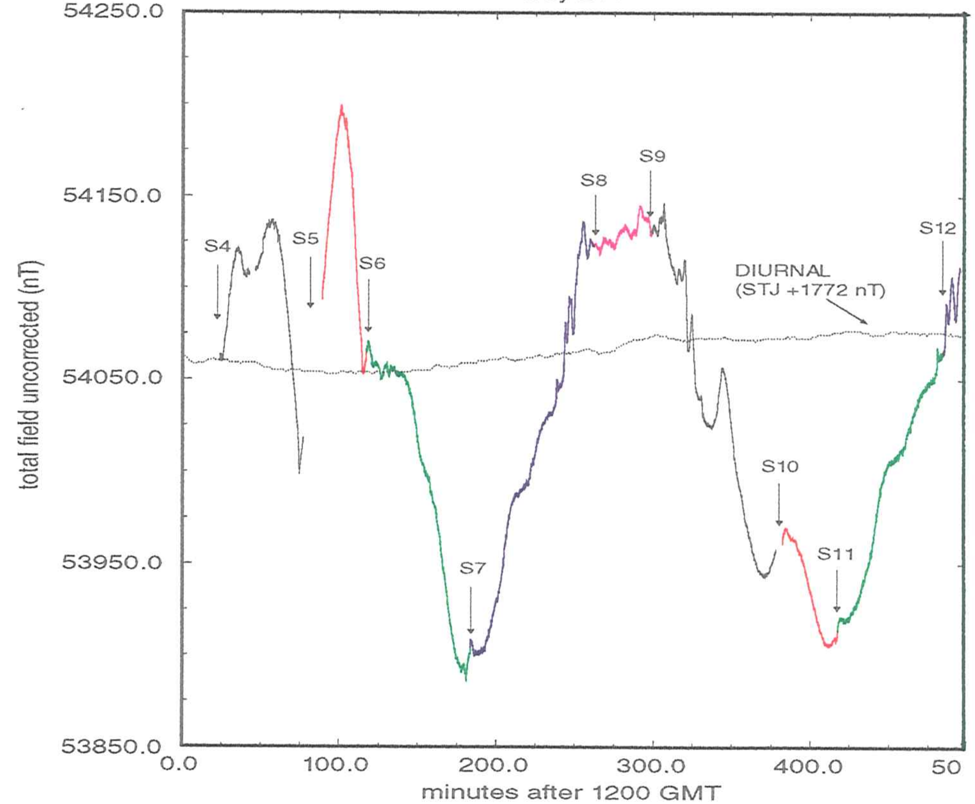
PORT AU PORT PENINSULA

Day 291 - 292 Navigation



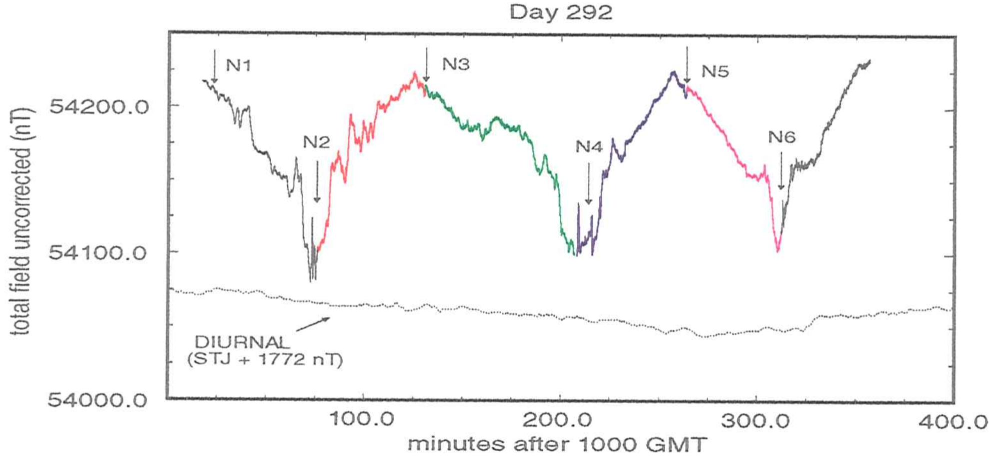
PORT AU PORT Cape St. George

Day 291



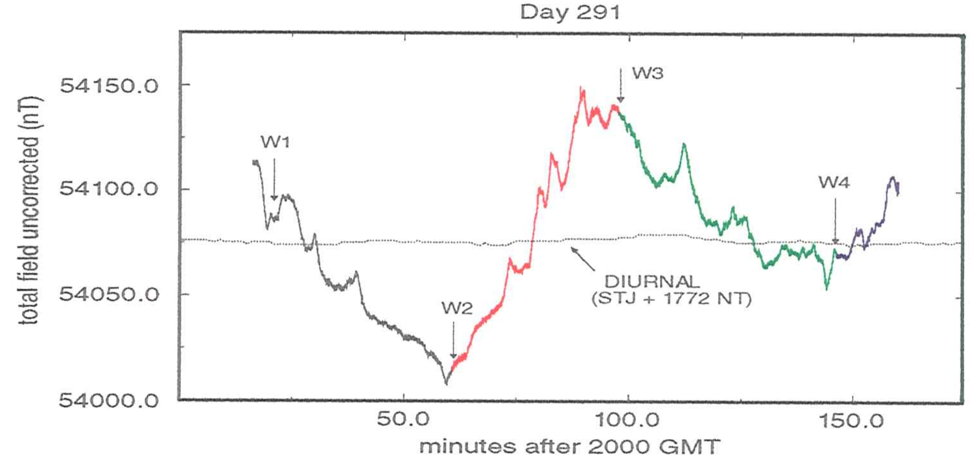
PORT AU PORT Cape St. George

Day 292



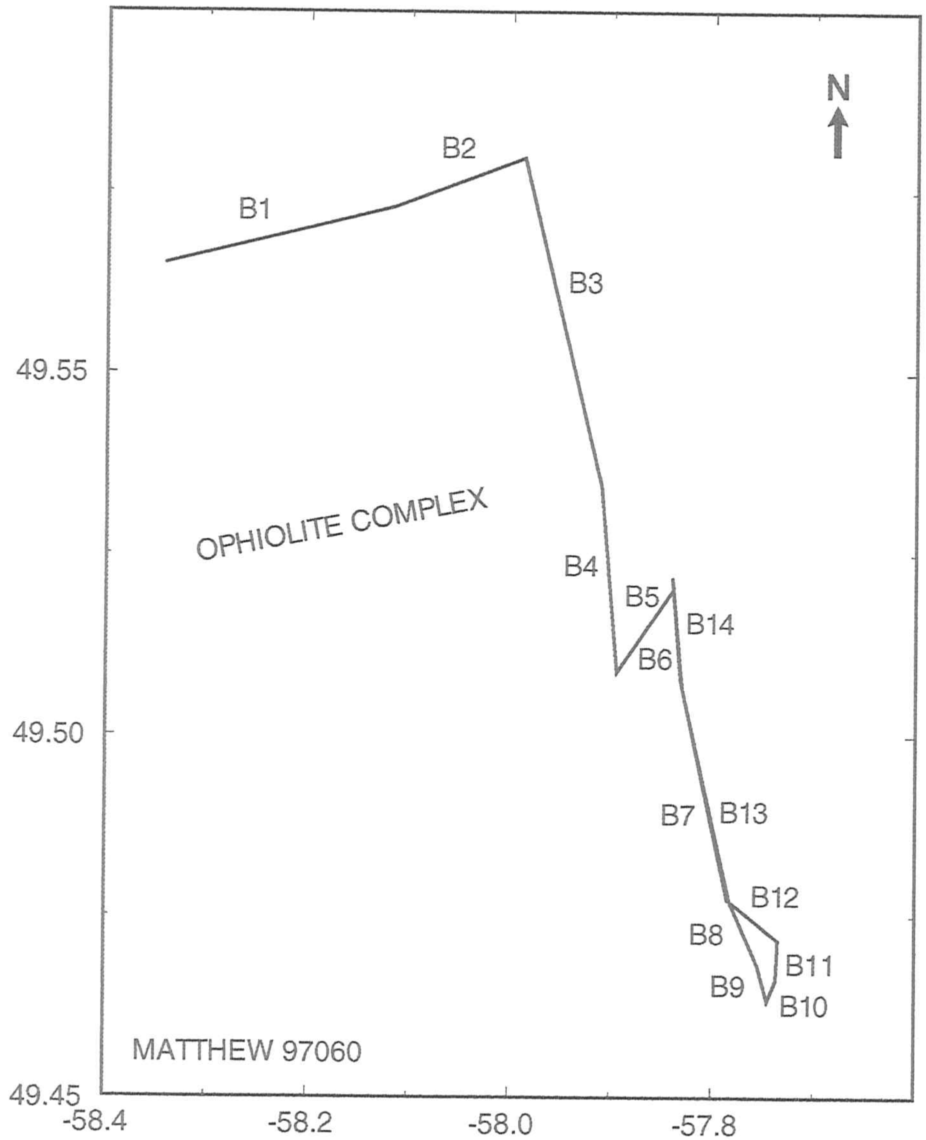
PORT AU PORT Cape St. George

Day 291



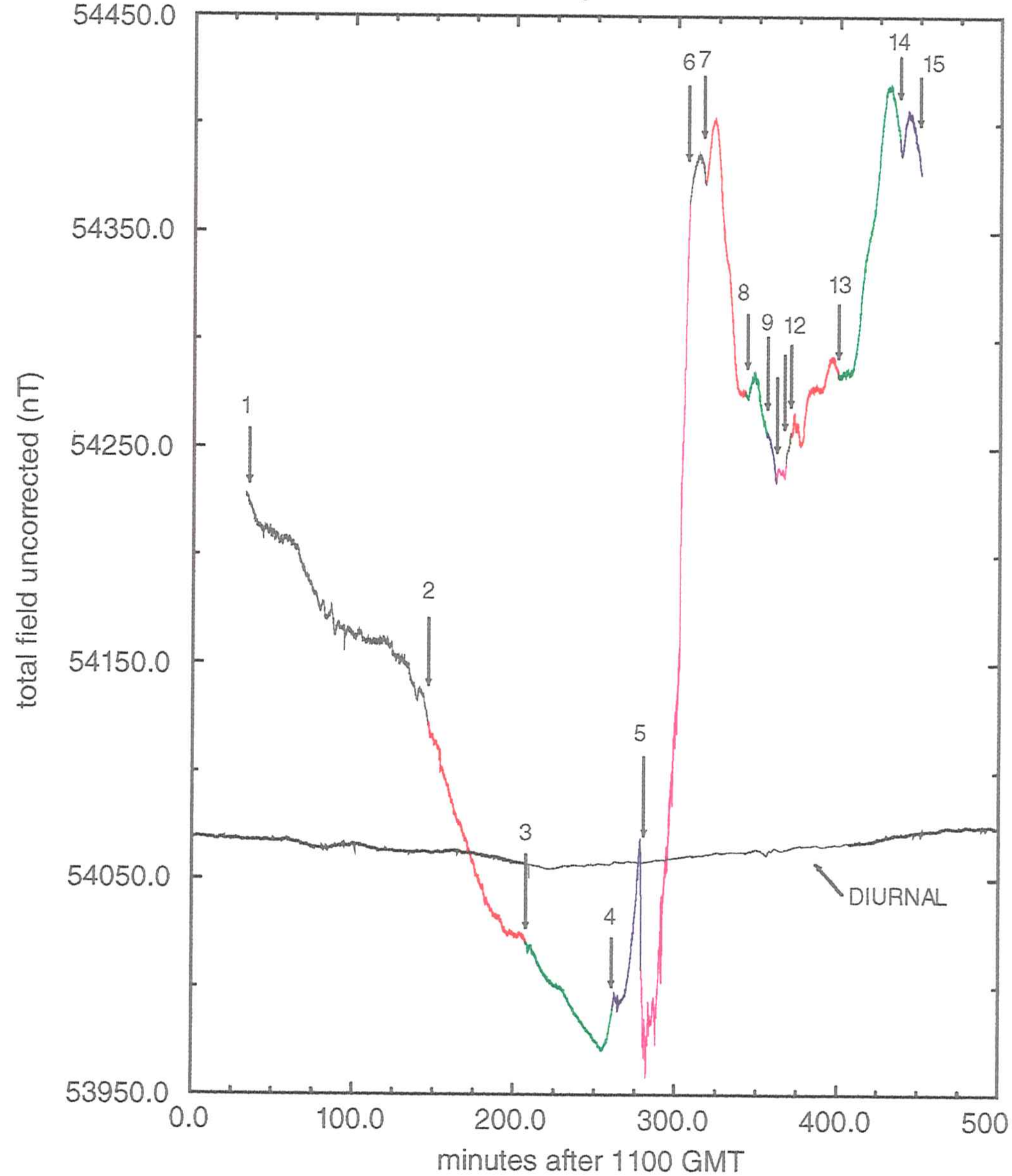
BONNE BAY

Day 293 Navigation



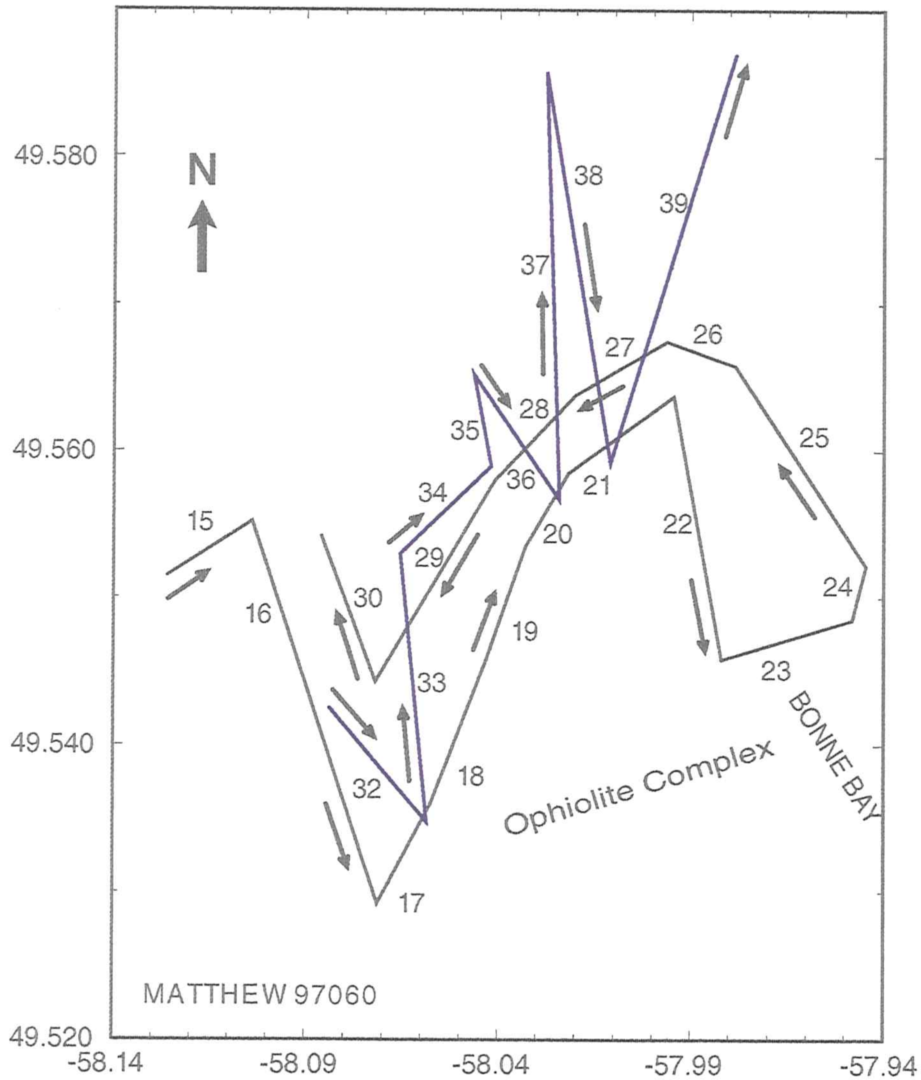
BONNE BAY Approach and East Arm

Day 293



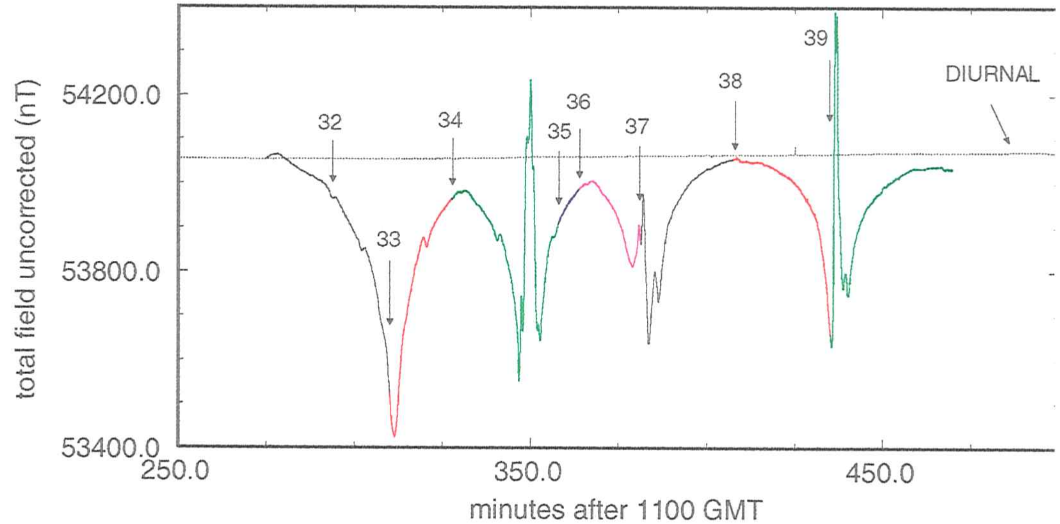
BONNE BAY Approach

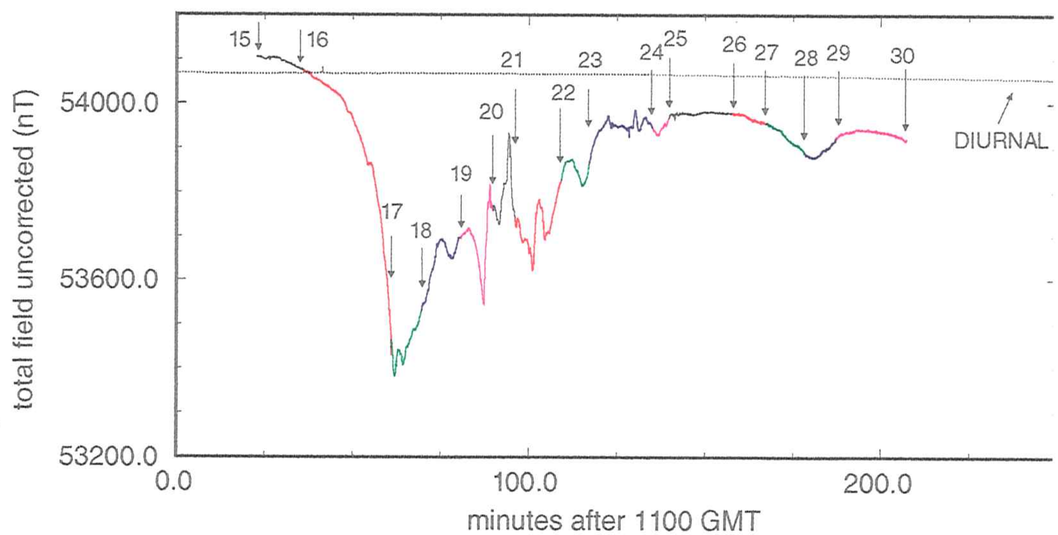
Day 294 Navigation



BONNE BAY Approach

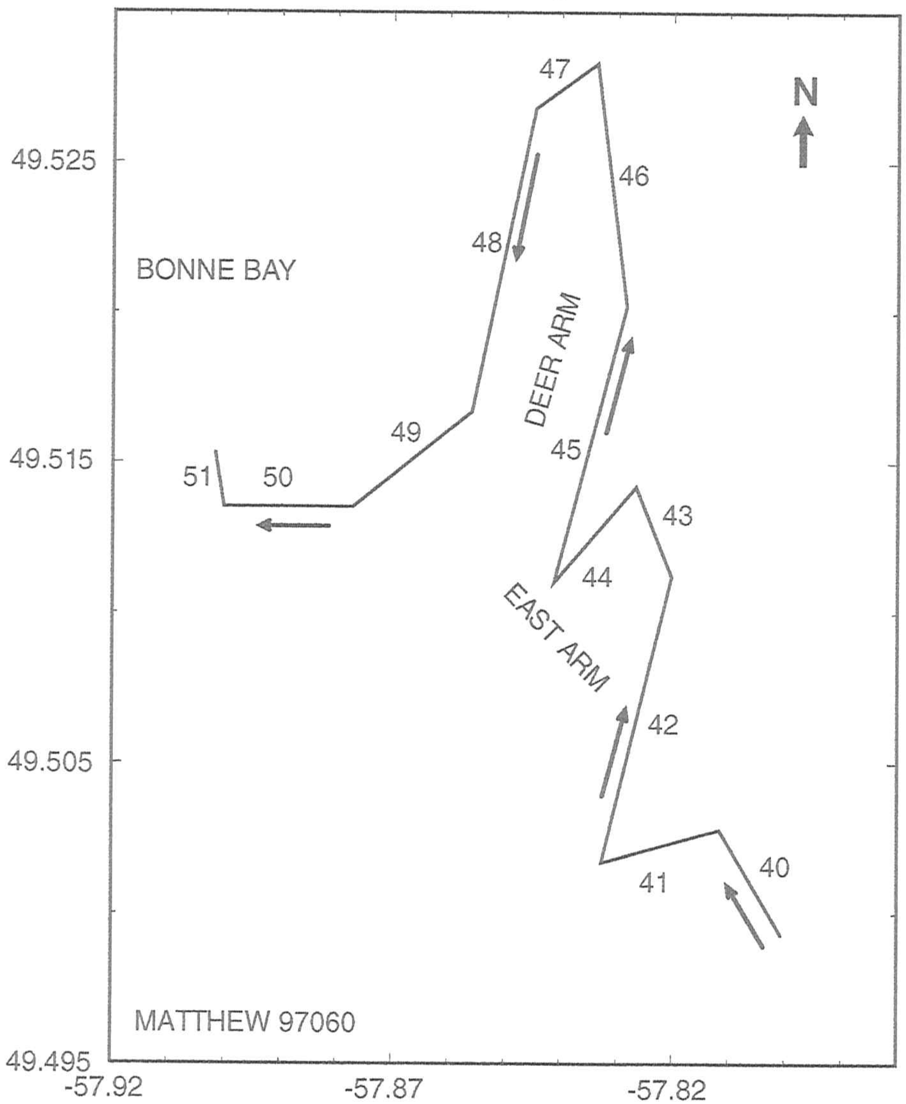
Day 294





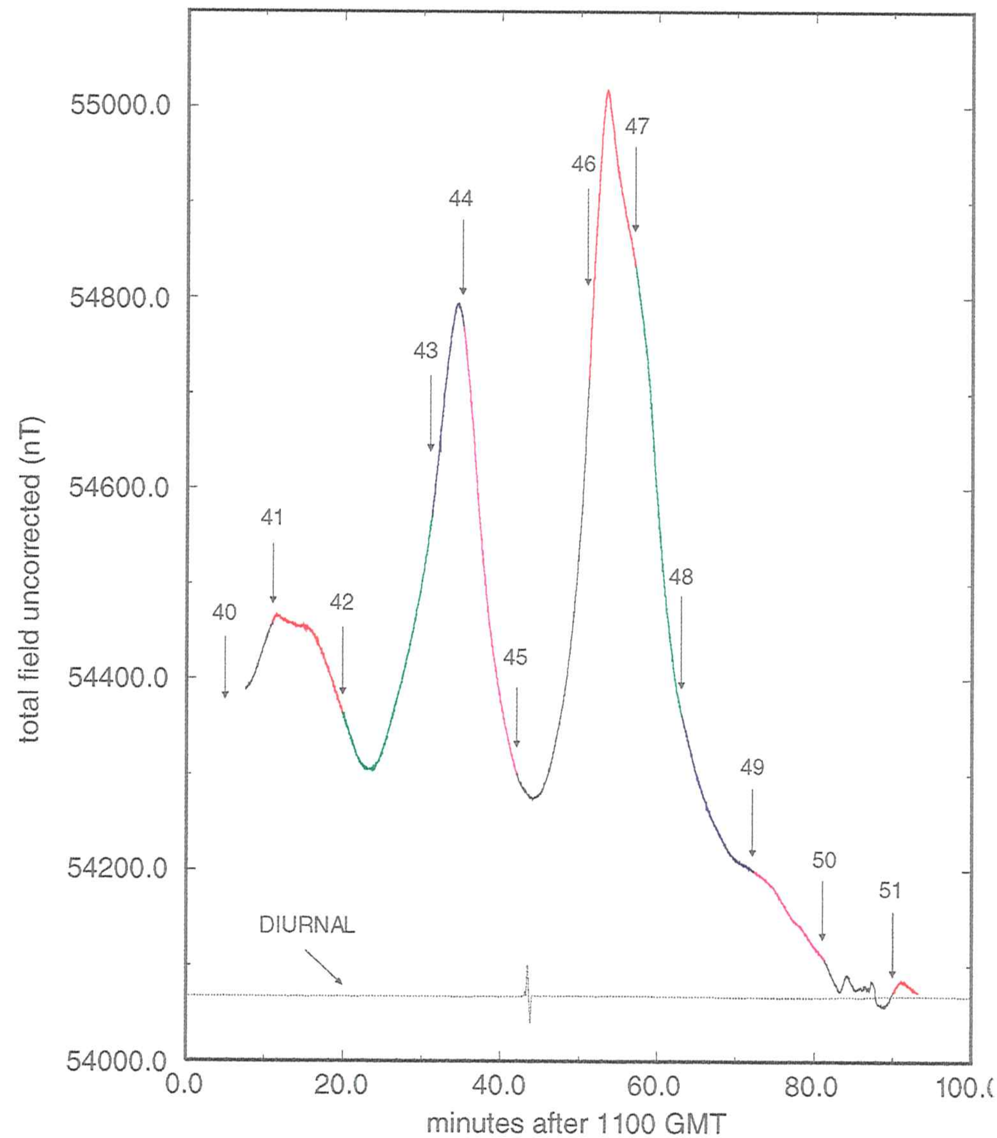
BONNE BAY EAST ARM

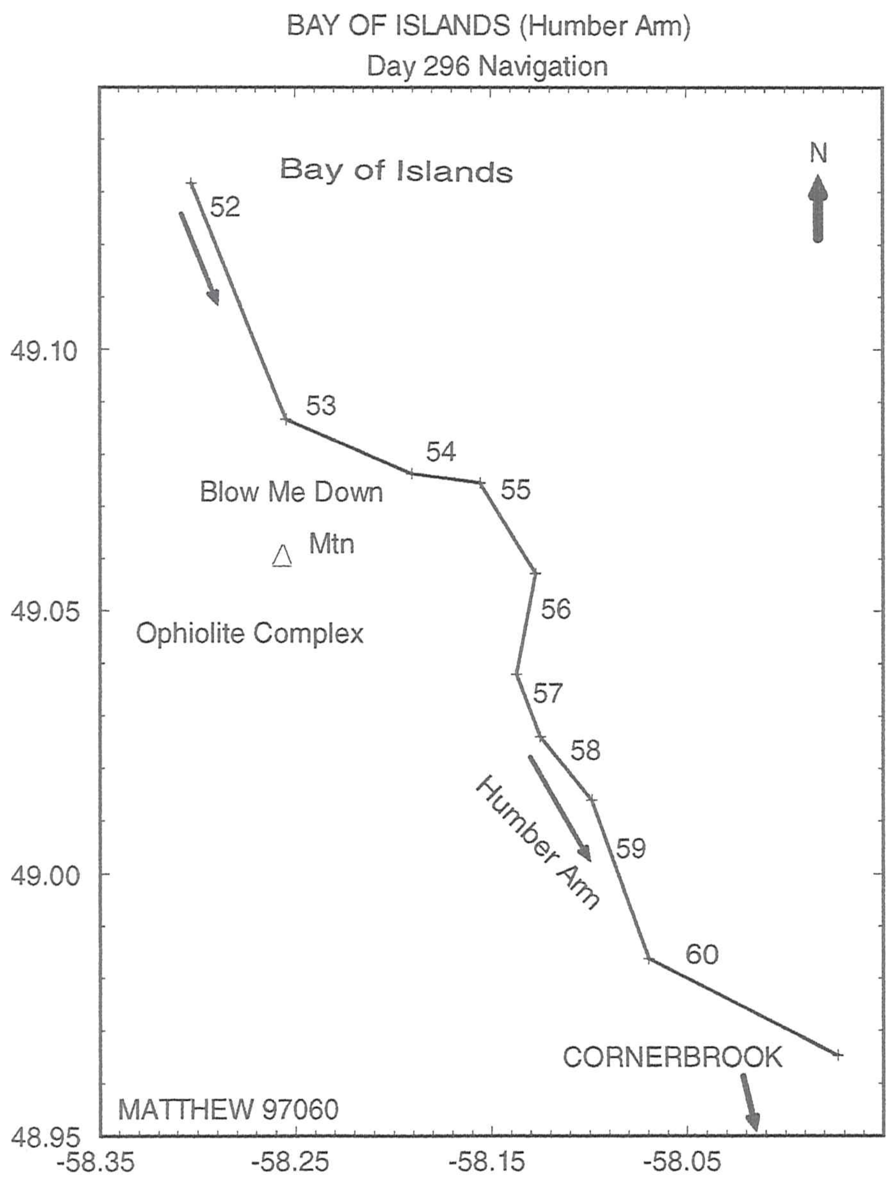
Day 295 Navigation



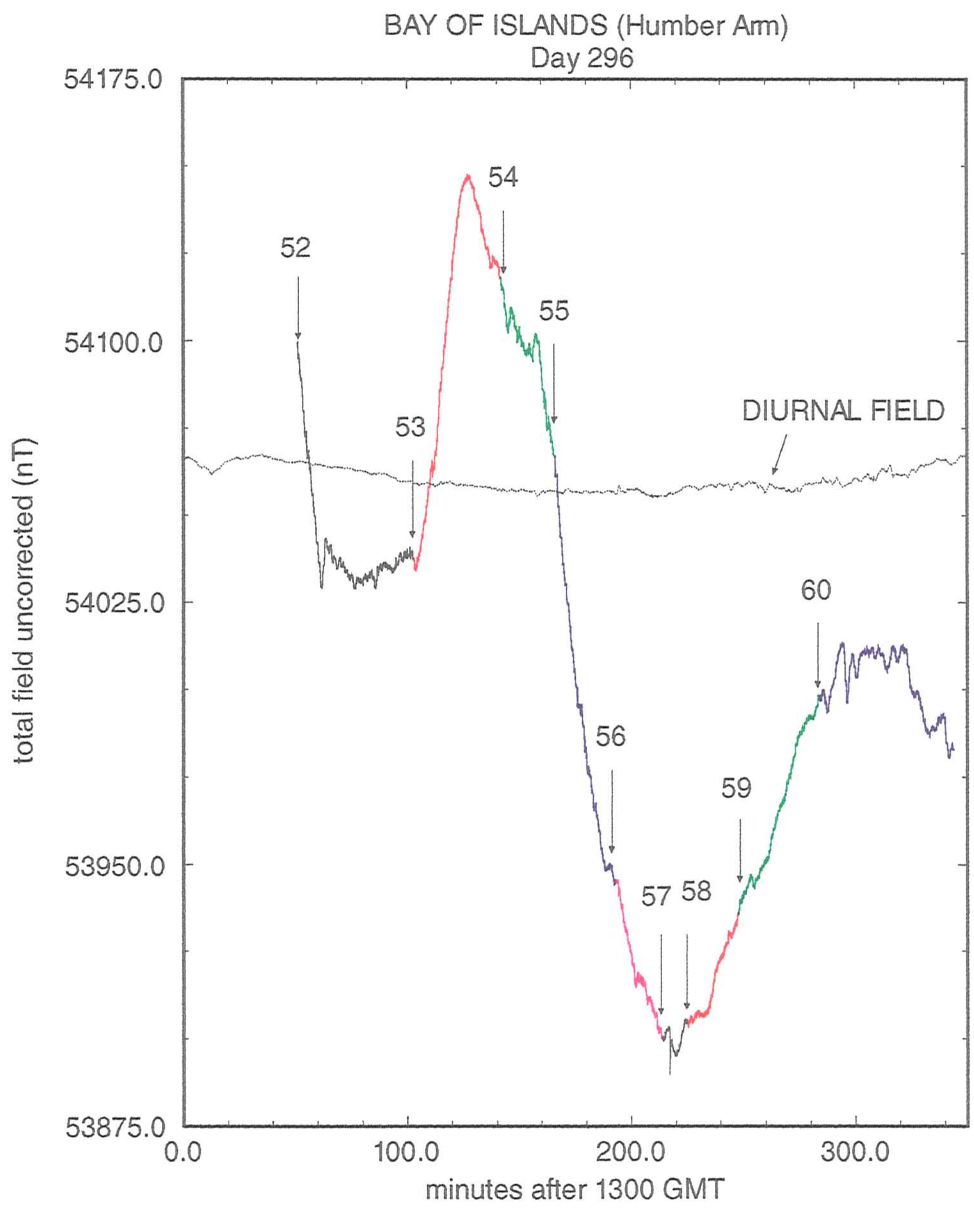
BONNE BAY East Arm

Day 295



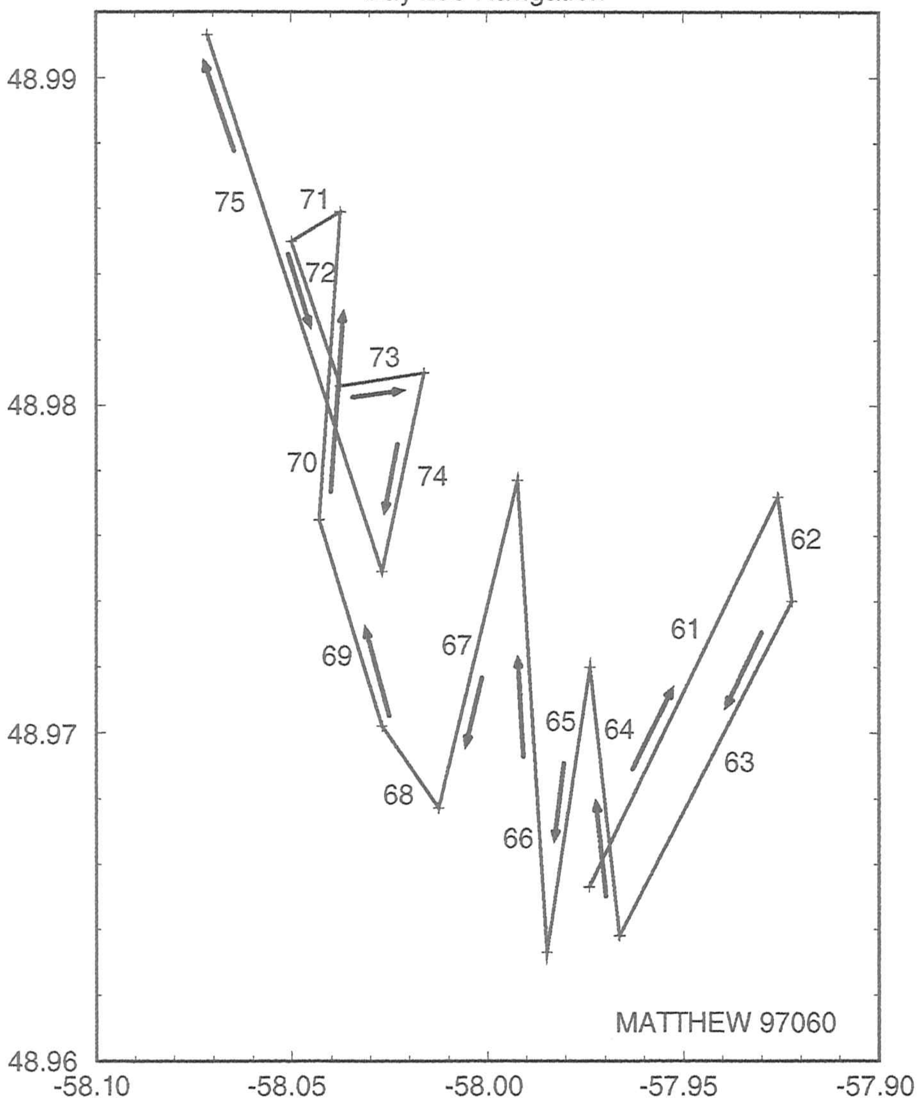


BAY OF ISLANDS (Humber Arm)
Day 296 Navigation
Bay of Islands
N
52
53
54
55
56
57
58
59
60
Blow Me Down
Mtn
Ophiolite Complex
Humber Arm
CORNERBROOK
MATTHEW 97060
49.10
49.05
49.00
48.95
-58.35
-58.25
-58.15
-58.05

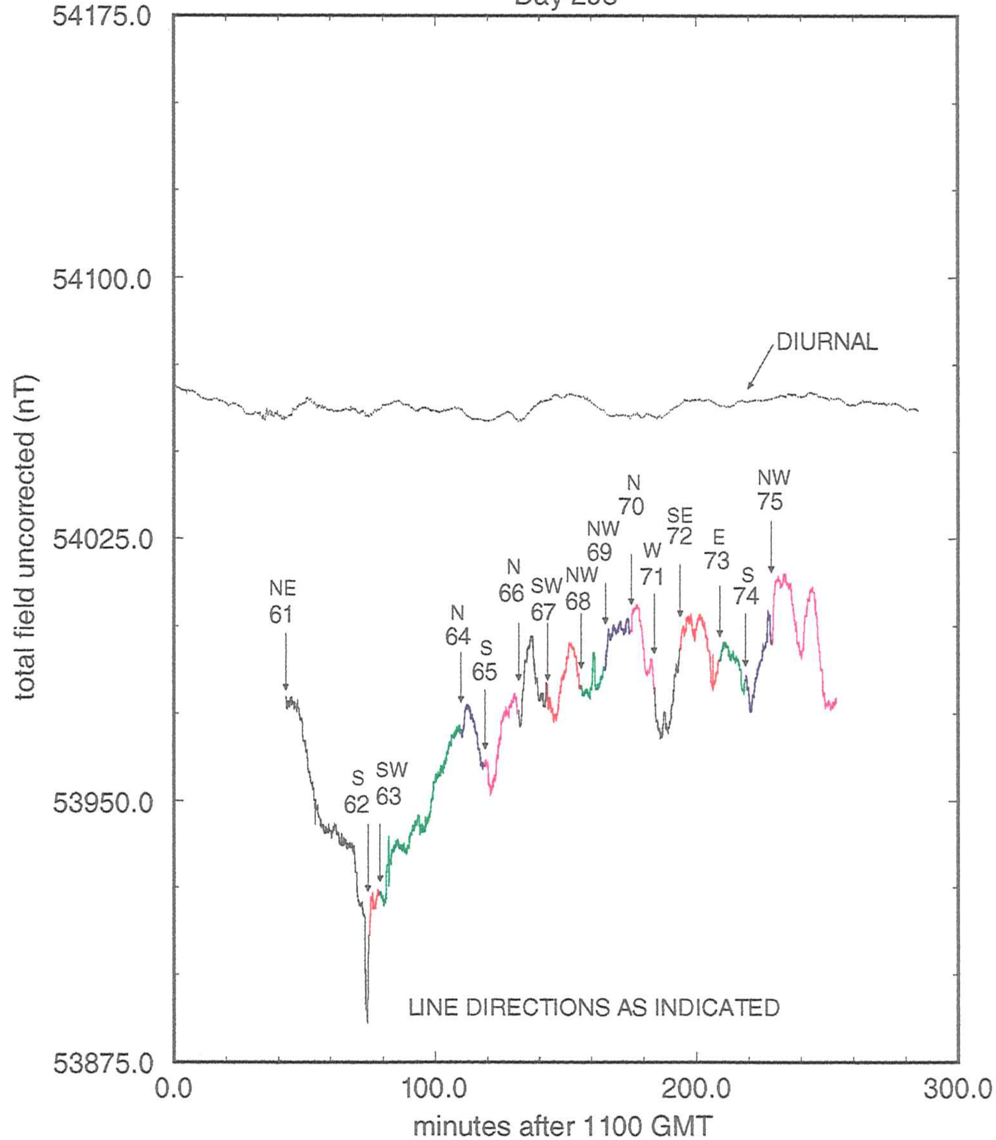


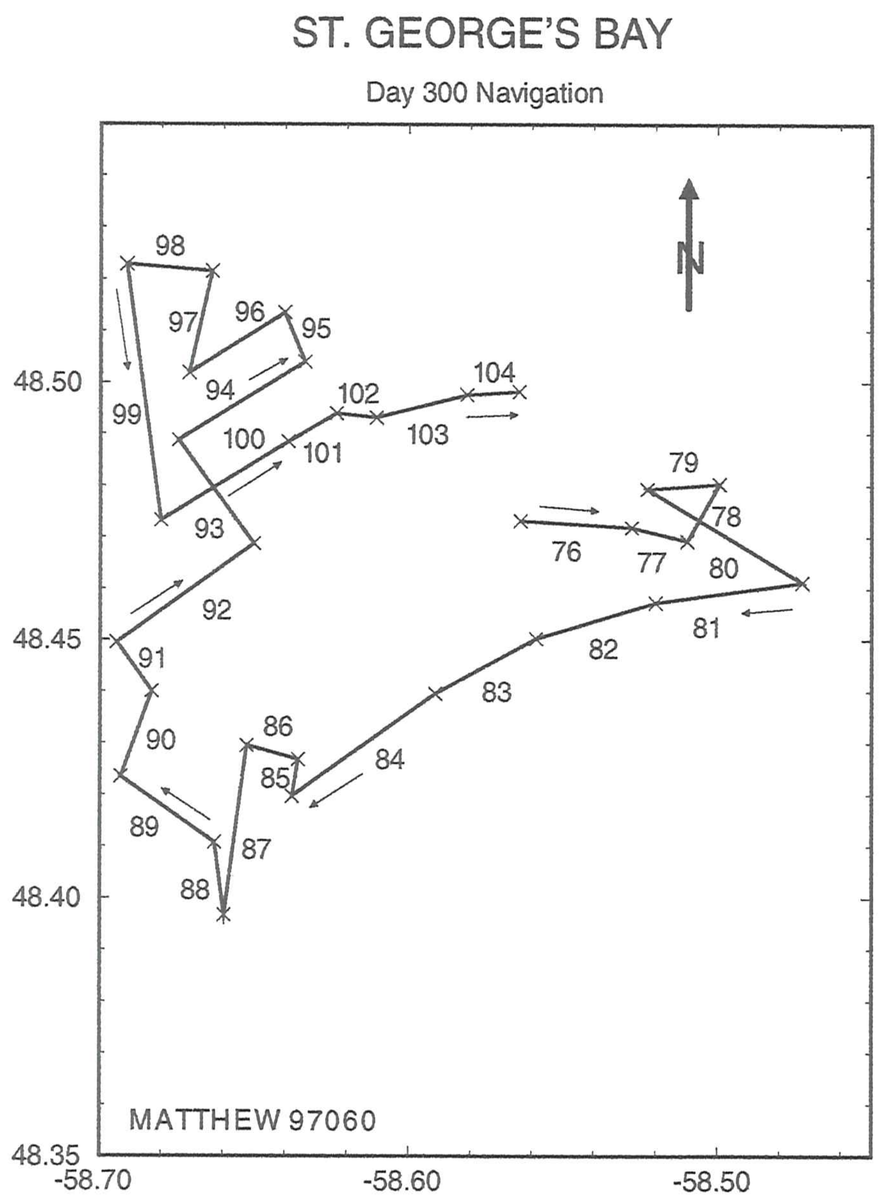
BAY OF ISLANDS (Humber Arm)
Day 296
total field uncorrected (nT)
54175.0
54100.0
54025.0
53950.0
53875.0
0.0
100.0
200.0
300.0
minutes after 1300 GMT
52
53
54
55
56
57 58
59
60
DIURNAL FIELD

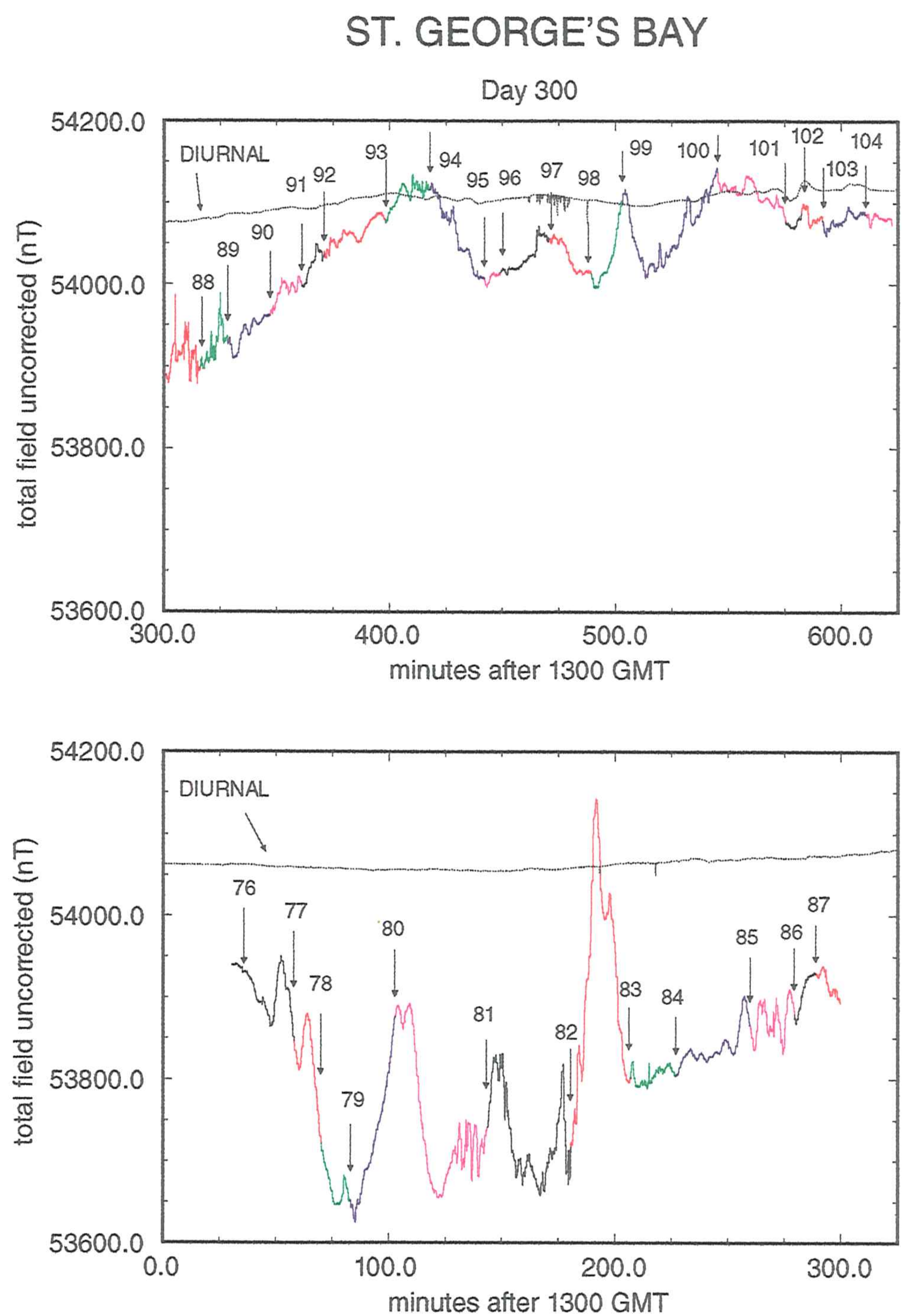
BAY OF ISLANDS (Humber Arm)
Day 298 Navigation



BAY OF ISLANDS (Humber Arm)
Day 298




ST. GEORGE'S BAY
Day 300 Navigation
N
MATTHEW 97060
48.50
48.45
48.40
48.35
-58.70
-58.60
-58.50
76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104


ST. GEORGE'S BAY
Day 300
total field uncorrected (nT)
minutes after 1300 GMT
DIURNAL
54200.0
54000.0
53800.0
53600.0
300.0
400.0
500.0
600.0
0.0
100.0
200.0
88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104
76 77 78 79 80 81 82 83 84 85 86 87