REPORT ON CRUISE 2005-051
CCGS *MATTHEW*

Surveys in Placentia Bay, Newfoundland

Geological Survey of Canada
Open File Report 5347

John Shaw, Brent Ward, Trevor Bell, Denise Brushett,
Angus Robertson, Anthony Atkinson, and Graham Standen

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GENERAL INFORMATION

Vessel	CGGS *Matthew*	
Dates	21 October - 5 November 2005	
Areas of operation	Placentia Bay	
Personnel	J. Shaw	*Chief scientist*
	R. Murphy	*Sampling technician*
	T. Atkinson	*Electronics specialist*
	A. Robertson	*Navigation and network specialist*
	D. Beaver	*Multibeam surveys*
	C. Reid	*Multibeam launch coxswain*
	G. Standen	*Geoforce (Huntec system specialist*
	D. Brushett	*Memorial University*
	B. Ward	*Simon Frazer University*
	T. Bell	*Memorial University*

CCGS *MATTHEW*

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

As an inshore hydrographic survey vessel, *Matthew* normally carries a pair of hydrographic launches. The portside launch was deployed for multibeam mapping near the coast.

INTRODUCTION

Placentia Bay has been the object of scientific investigation at various times in the recent past. A small part of the outer bay is depicted on map 4015-G (Fader et al., 1982), which shows that the Burin Moraine extends from offshore along the southeast part of the Burin Peninsula. Previous workers (e.g., Fader and Miller, 1986; Fader, 1991) have discussed the so-called 'megaflutes' on the east side of Placentia Bay. These erosional pits occur in a 4 km wide band that is over 100 km long. Fader and Miller (1986; 1988) proposed that they formed during the 1929 Grand Banks tsunami by scouring of pock marks.

Shaw et al. (1989) conducted surveys in coastal areas of the bay – Argentia, the Arnolds Cove region, Mortier Bay and Lawrencetown. Among other things this work revealed that the deep trough along Long Island (Eastern Channel) contains up to 100 m of Quaternary sediments, whereas shallower adjacent areas have a very thin and discontinuous cover. In the Argentia area the work showed the presence of gas-charged muddy basins separated by shoals. Submerged deltas were identified in Long Harbour, Swift Current, and Mortier Bay. In 1995 extensive multibeam surveys and other work revealed the complex nature of the natural seafloor in the Argentia area, and the degree to which it has been modified by dredging and other activities. Some understanding of this new multibeam data was gained through knowledge gained from the 1989 survey, but the mass of new information necessitated another ground-truthing survey that was undertaken in 1999 (Shaw et al., 2000).

As a result of the identification of Placentia Bay as a study area in the new Geological Survey of Canada (GSC) project system, more multibeam mapping was undertaken in 2004 and 2005, with the goal of mapping the entire bay and publishing maps of bathymetry, backscatter, and surficial geology. The publication of these maps, particularly the surficial geology map, requires an understanding of the marine geology of the bay. After examination of the new multibeam data, it became clear that the megaflutes extended farther up the bay than was previously thought, and in addition to drumlins and other streamline bedforms already mapped off Argentia, a much larger field of drumlins existed on the west side of the bay. The scientific questions that emerged concerned 1) the origin of the megaflutes; and 2) the style of glaciation and deglaciation indicated by the distribution, orientation and nature of the streamline features. To achieve the goals of creating the map series, and to deal with these questions, the cruise had specific objectives that are outlined in the following section.

OBJECTIVES

- Groundtruth the Argentia multibeam imagery by collecting Huntec DTS (Deep Towed Seismic) sub-bottom profiler data, and sidescan-sonar data, together with bottom photographs, grab samples, and gravity cores.
- Examine features that provide evidence of the pattern of glaciation and deglaciation, and that can be correlated with onshore features of a similar nature. These features include drumlins and de Geer moraines.
- Understand the nature of megaflutes that occur in southeastern of Placentia Bay, and determine their age and relationship with gas-escape structures such as pockmarks and elongated pockmarks.
- Deploy the survey launch CSL *Plover* to survey a nearshore area between Placentia Roads and the Argentia Peninsula.

SUMMARY OF ACCOMPLISHMENTS

Several regions of the bay were mapped using the Huntec DTS and sidescan-sonar systems. Due to bad weather, planned surveys in the southern, more-exposed parts of the bay were not undertaken. In spite of the bad weather, the multibeam launch surveyed an area around the Argentia Peninsula, adjacent to an area (Placentia Roads) surveyed earlier in the year; during bad weather, part of Northeast Arm was mapped. Samples were collected at 47 sites, comprising 20 camera stations and 27 grab stations, but the coring system was not used. Details of samples are given in Appendix 1. Grab sample and bottom camera locations are shown in Appendices 2 and 3. Deck photographs of grab samples are contained in Appendix 8.

CRUISE ORGANIZATION

The CCGS *Matthew* was mobilized at Sydney, Nova Scotia. *Matthew* departed early to take advantage of good weather, and sailed to Argentia, Newfoundland. Some staff traveled aboard the vessel, and some flew to St. John's, Newfoundland, and traveled to Argentia by taxi. The crew of the survey launch drove a vehicle onto the Newfoundland ferry, sailed to Port aux Basques, and drove to Argentia. The survey launch was offloaded at Argentia and used for surveys in that area. The plan was for *Matthew* to sample from 08:00 to 16:00 and survey from 16:00 until midnight. This soon fell apart due to bad weather, and constraints imposed by fishing gear, so that we surveyed on several nights and several days. When the weather was bad we tied up at Argentia, and more commonly anchored at various places, depending on wind direction. On Friday 4 November it was decided to survey a line for much of the day and then to sail to Argentia, load the launch, and make ready for a passage to Nova Scotia.

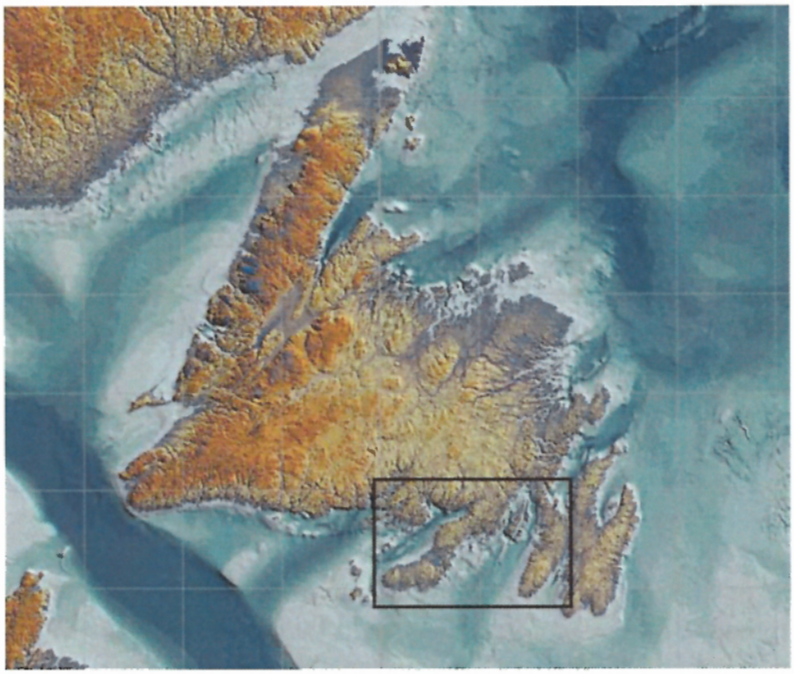

Figure 1: Location of the study area.

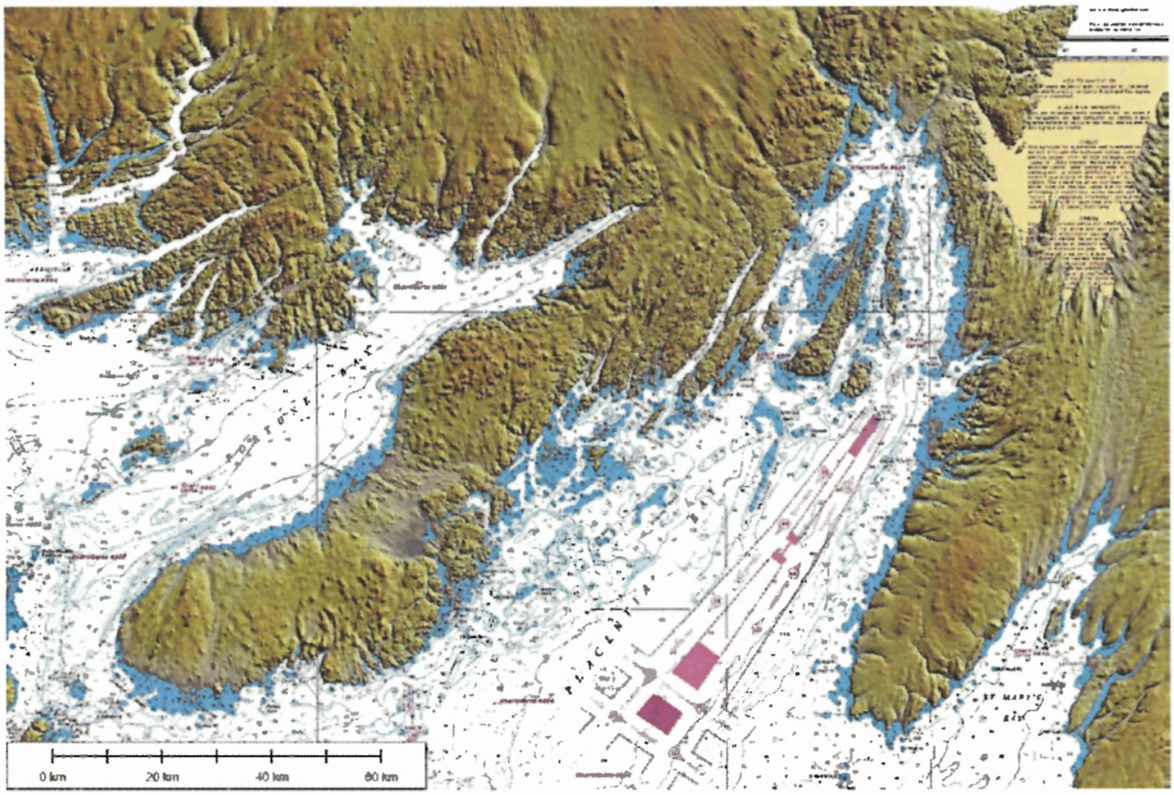

Figure 2: Placentia Bay

CRUISE NARRATIVE

Note: Times are Atlantic Daylight Saving Time (i.e., Nova Scotia time), which is Z-3 hours.

Day 294 Friday 21 October
In the morning GSC staff drive to Sydney, NS. The party comprises Beaver and Reid, Murphy, Atkinson, Wile, Atkinson, Robertson and Standen.

Day 295 Saturday 22 October
It is warm and sunny in Nova Scotia. GSC staff mobilize *Matthew*. The captain decides to make use of a short spell of good weather, and the vessel departs at 19:00.

Day 296 Sunday 23 October
Matthew arrives in Argentia at 18:30 just as strong northeasterlies develop in the bay. These winds are part of a low pressure system that hits Nova Scotia on Sunday, bringing strong winds and heavy rain to Halifax.

Day 297 Monday 24 October
Shaw and Ward leave Halifax on the 11:45 flight, arriving in St. John's at about 14:00. They take a taxi to Argentia, arriving at about 16:00. At Argentia it is partly cloudy with a stiff northerly breeze. Brushett arrives in the evening.

Day 298 Tuesday 25 October
The morning is overcast with a north wind of 10 to 15 knots. *Matthew* deploys the launch CSL *Plover* and is underway from the harbour at 07:45. Sidescan sonar and Huntec are deployed at 09:15. Sea conditions are slight. We run lines 1 to 6. Line running ends at 15:30, and at 15:40 all gear is aboard and *Matthew* heads for Argentia. The equipment runs well from the start, although a paper print of the sidescan sonar data only becomes available part way through the line running. *Matthew* ties up at the former Fleet Dock, Argentia, in darkness at 18:30.

Day 299 Wednesday 26 October
The morning is overcast with occasional rain and strengthening winds from the northeast at 15-20 knots; by evening the wind is gusting over 40 knots. Shaw, Ward and Robertson are driven to Placentia by Reid, and use the internet. They return before lunch. In the late afternoon a welder arrives and Murphy and Standen assist him to re-position the frame for the Huntec DTS system. A seaman is sent home for family reasons. Rain and wind continue overnight.

Day 300 Thursday 27 October
The day begins overcast, with light northeasterly winds. Beaver calls aboard at 07:45 to discuss plans, and the launch is deployed at 08:15 approximately. *Matthew* stays docked as a seaman is expected to arrive in the mid-morning. Shaw, Murphy and Standen drive to Placentia to pick up another seaman. Beaver and Reid return to the inner harbour at Placentia after attempting lines outside, off the Argentia Peninsula. *Matthew* casts off from Argentia at 13:00. The sea is rough, with steep, short-period waves generated by a

strong northwesterly breeze, but the trip north in *Matthew* is pleasant. *Matthew* anchors off Arnolds Cove at 16:50.

Day 301 Friday 28 October

At 06:00 *Matthew* is still at anchor in Arnolds Cove. It is overcast with a 10 to 15 knot north wind. The rib boat is sent ashore at 06:30 to collect a passenger and the anchor is weighed at 06:40. *Matthew* is underway at 06:45 as dawn is breaking. Sampling begins at 08:00 just southeast of Woody Island. We run south, collecting grab samples 1 to 8. After a stop for lunch we start back along the line, collecting photos at the grab sample sites. We finish at 16:00. The day has been sunny with scattered stratocumulus, and a moderate westerly breeze. *Matthew* heads for Arnolds Cove to drop off the passenger. Line running begins at 18:00 near Woody Island. We run lines 7 to 17, finishing at 11:50. Sea conditions are slight at the start of the lines but wind speed increases to westerly 30 knots at times, giving a short-period sea. The sea (and swell) are worst near the end of the lines, at the south end of Merasheen Island. The sidescan and Huntec cables become entangled at 19:30; otherwise the night is uneventful. The sidescan sonar is switched off at about 22:00, because of the great water depth (>400 m).

Day 302 Saturday 29 October

Wind and swell result in a 'bumpy' ride overnight, as *Matthew* loiters in Western Channel, making water. At dawn the wind has died, but short-period swell remains. It is sunny, with scattered stratocumulus. Sample sites are picked based on seismic day times. We commence sampling at 08:00 (Sample 017). During sampling we are 'buzzed' by a fisheries patrol aircraft. Grab sampling finishes just after 11:00 and we prepare the camera and break for lunch. After lunch there are problems with the camera operations at planned site 022, so we stop, change the block, and prepare for survey lines. The vessel sails south, and at 14:20 we begin deploying Huntec and sidescan sonar near the south end of Western Channel, starting with line 18. There is heavy swell and a moderate sea running, but conditions improve as we leave the channel, running south. Line running ends at 22:15 with line 23. Gear is recovered and *Matthew* anchors overnight on Big Shoal, in a very slight swell.

Day 303 Sunday 30 October

Grab sampling begins east of Mortier Bay at 08:00 (sample 2005-051-022). The camera fails here (023). When we move to the next location it fails also, so we do not record the attempt but collect grab sample 024. We move north for grab 025, and, after another camera failure move off to grab sample 026. At the site of grab 026 we do a camera station and it works (camera 027). We have a lunch break and proceed to try more camera work by 12:15. It is overcast with light winds, slight swell and sea. Sampling continues in ideal conditions – glassy sea, warm, partly sunny. Sampling is finished at 15:30 and we proceed south to the survey area for the evening. Gear is deployed at 16:30 and we start a pattern of lines, beginning on line 24. A beautiful sunset is observed. On line 26 the course is altered to the northeast of the planned line, due to tanker traffic. Line running ends at 23:47 in Eastern Channel and *Matthew* anchors for the night due west of Placentia Roads.

Day 304 Monday 31 October
Morning brings overcast cold, conditions and a slight sea running from the north. We begin sampling at 08:00, starting with grab sample 036. The morning brightens, with partly cloudy conditions and a brisk northerly breeze (up to 20 knots). Sampling proceeds normally except that we encounter fishing gear at the final two stations, close to the north end of the Argentia Peninsula. We choose sites that are relatively close. At the final station – grab sample 044, camera 045 – the bottom is too hard and no grab sample is collected. We finish at 11:40 and proceed to Argentia. The ship ties up at 12:50.

Day 305 Tuesday1 November
Matthew departs Argentia at 06:00. It is overcast with a slight sea and swell running from the south. Rain begins by mid morning and it becomes misty, with low stratus on hilltops. Line running begins at 08:00 southwest of Argentia on Line 29 – a continuation of lines previously run. Debris standing several meters above the bottom is observed on the sidescan sonar record (13:40 UTC). At 09:23 the sidescan stops communicating. At 09:40 both systems are brought aboard so the sidescan can be repaired. At 09:48 we are turning and deploying Huntec to continue line running (line 30). It is discovered that the sidescan cable is broken, and that a rope has been wrapped around it. Line running continues uneventfully, although the sidescan sonar system is not repaired in time to be re-deployed. Line running ends at 16:00 and *Matthew* anchors shortly afterwards in Long Cove, on the east side of Long Island, in foggy conditions with calm sea.

Day 305 Wednesday 2 November
Matthew raises anchor at 07:45. It is overcast with south wind at 20 knots. We sail across the bay to start a series of grab samples, but decide it is too windy. We sail to Argentia and start sampling. However, after a grab and camera (grab 046 and camera 047) it is decided to stop sampling and anchor. The captain then decides that it is too risky to anchor, and the docks are full, so *Matthew* sails out of Argentia Harbour at 11:30 in 30 knot southerlies. We anchor at Wild Cove, on the north side of Red Island at 13:00 in strong winds. It becomes overcast and winds gust over 50 knots. The anchor drags about 7 m on one occasion. It becomes very squally, with water spouts on the water surface. We observe lightning at 15:45, and at 16:00 a severe rain squall. As night falls the situation becomes very ugly. The winds pick up, blowing a steady 40 knots at times and giving gusts up to 58 knots. *Matthew* drags her anchor. However, it is forecast that winds will drop to westerly 20 -25 knots at 23:00. This actually happens earlier than predicted. At 21:00 the wind is southwest to south 25 knots gusting to 45; by 21:15 it has dropped to 10 to 15 knots from the west. The vessels swings round at the anchorage, and the captain carefully monitors the situation overnight.

Day 306 Thursday 3 November
Matthew gets under way at 04:45 and drops anchor in Cooper Cove, in Central Channel, at 05:30. It is cold and breezy, with broken cumulus fractus. The wind picks up and is soon gusting at >40 knots. Periodically, violent water spouts race across the surface of the ocean. At 14:30 the anchor is dragging so the Captain decides to move the vessel. *Matthew* sails north then passes between Long Island and Jerseyman Rock. By 16:00 we are anchored just north of Haystack Island, off the east coast of Long Island.

Day 307 Friday 4 November
The vessel weighs anchor at 07:45 and heads towards the start of lines in Central Channel. The wind has decreased to about 10 knots from the northwest. It is sunny, with scattered cumulus fractus and some altocumulus. It has been decided to return to Argentia after today's work and load the launch so as to make passage for Nova Scotia. Line running begins at 08:45 at the start of line 39. At 09:00 the sidescan sonar malfunctions and is brought aboard. A cable is broken- perhaps damaged on a previous cruise. Arrangements are made for transportation of staff to St. John's and accommodation for the night. At the south end of the planned lines, the heavy westerly to southwesterly swell makes conditions difficult for line running and the Huntec is hauled aboard at the end of line 44, at 12:30. The vessel heads for Argentia with a strong roll due to the following sea. The ship is tied up at 14:30. We arrange for a van to takes GSC staff to St. John's; it arrives late due to a mix-up, and we leave at about 17:30 Newfoundland time. We reach St. John's at 19:00 Newfoundland time. T. Bell goes home while Shaw, Standen, Ward, Atkinson, Reid and Robertson check into the Quality Inn, Hill O'Chips.

Day 308 Saturday 5 November
Shaw, Standen, Ward, Atkinson, Reid and Robertson leave for Halifax, most of them on the 16:15 flight from London, UK (AC-861). They arrive in Halifax airport at approximately 17:15.

TECHNICAL SUMMARY

Huntec deep-towed seismic reflection system
The system used was AGC #2. This uses the small Huntec fish with an internal hydrophone and an external streamer. The towed fish contained a boomer plate as sound source. The fish rested on a cradle at the stern of the vessel, and was raised and deployed using the 'A' frame and a winch. The winch did not have remote controls, so to deploy, recover, raise, or lower the fish, the operator had to leave his post beside the receiving equipment in the laboratory, walk across the well deck, and climb the steps to the raised quarterdeck. Data were displayed in two ways, either with the external channel at ¼ second sweep and appropriate delay, or with both internal and external channels, at ⅛ second sweep and appropriate delay. Details of the Huntec system are contained in Appendix 3 and the operator's log is in Appendix 6.

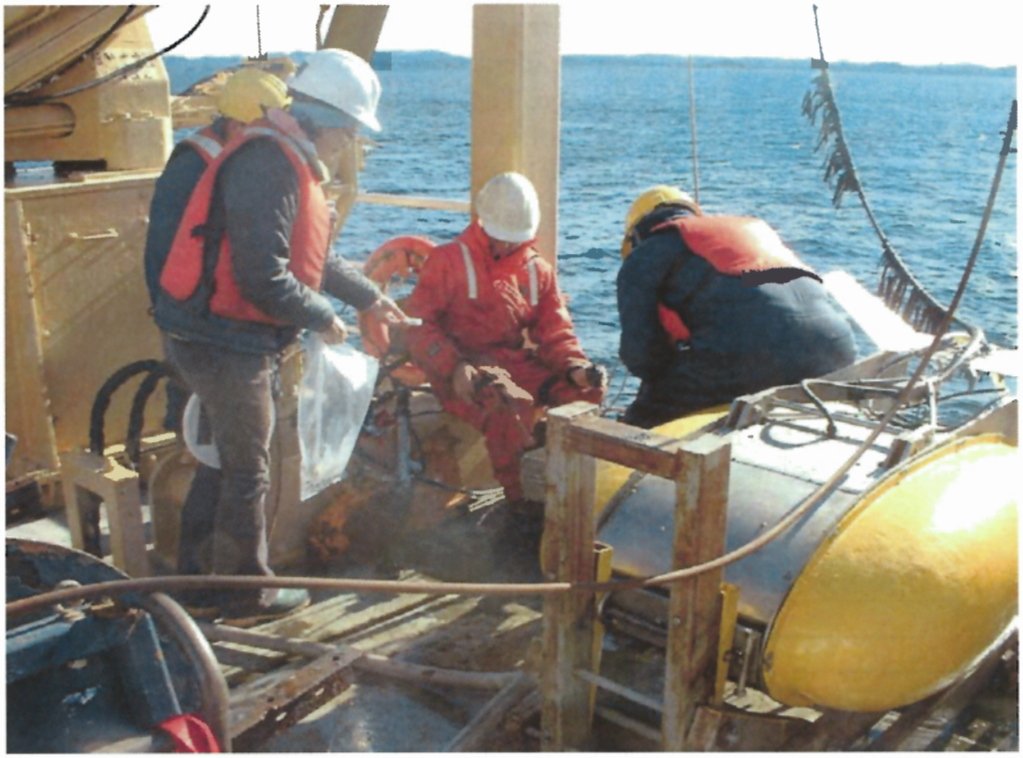

Figure 3: Huntec DTS in its cradle.

Figure 4: A-frame showing the Huntec block (right).

Simrad MS992 neutral tow sidescan sonar system

This system consisted of the neutral tow side-scan system with an AGC DIG data logger that stored digital data on an ExaByte tape. The stated objective of the use of this system on the survey was to help identify areas of boulders on the seabed. Data were collected using a 200 metre range except on day 301-302 when a 100 metre range was used. The 100 metre data is on tape 2.

Communication was lost with the sonar head on day 305 at 1329 UTC. The tow fish and depressor were recovered and it was discovered that we had hit a submerged object with the side scan termination breaking the bulkhead connector and parting the electrical cable leading to the tow fish. Fibrous stands of what appeared to be manila rope were found lodged in the termination. At the time of impact the water depth was 210 metres and the fish was 50 metres from the seabed. Repairs were made from spare parts that were aboard.

Tape Number	Start	End	Range
1	298/1245	298/1825	200
2	301/1224	302/0205	100
3	302/1839	303/0113	200
4	303/2113	304/0345	200
5	305/1215	305/1329	200
6	308/1238	308/1244	200

Table 1: Sidescan-sonar tapes

It appears that the effective depth of the system under ordinary conditions is about 200 metres. It was fairly easy to fly the fish up to this depth, but after 200 metres much more cable had to be put out to maintain a height of 30 to 50 metres off bottom. Undulations of the seabed by 20 metres, variations of vessel speed through the water, and the need to keep the ship traveling at more than 4 knots to maintain steerage made it prudent to fly the fish farther off the seabed rather than closer to it. After the side-scan connectors had been replaced, the fish was deployed on day 308. Noise was noted on the record when the fish was being let out. A small amount of this noise had occurred before the damage. After a few minutes of towing, communication with the fish failed, and it had to be recovered. It was discovered that the armored cable had a break near the termination. This damage is believed to have initially started on *Hudson* when the Bongo weight hit the seabed. The damage was made worse when the termination and Bongo weight hit the submerged object on this cruise.

Digital Benthic Camera System

This was the second outing for GSCA's replacement for the Ice Hole Camera system. The DBC uses a Canon 6 Mega pixel Digital Rebel Camera to take digital still photos about 52 inches from the seabed. Each picture required about 2 Megabytes of storage. This was not a problem since a 1 gigabyte storage card was used in the camera. We have now reached the stage where photos can be downloaded from the system between stations without removing the camera from the rig. Photos of the seabed were taken on

20 stations with adjustments being made to optimize the camera settings and improve the photos. The quality of the photographs is judged to be insufficient for scientific use: they are out of focus.

Day	Station Numbers
301	9,10,11,12,13,14,15,16
303	23,27,28,31,32,35,37
304	38,41,42,45
306	47

Table 2: Camera stations.

Knudsen 320 BR Sub Bottom Profiler

This cruise was the first use of GSCA's 2 Kilowatt, 3.5 Kilohertz, and sub bottom profiling system. The transceiver and transducers are mounted in *Matthew's* ASDIC compartment and remotely controlled from the lab using Knudsen's network version of the Echo Control software. The system performed well and could image sub bottom profiles when the bottom was not too hard to penetrate. Power levels of only 2 were needed to do this. The Client computer frequently lost contact with the sounder's server after a few minutes of operation. This will have to remedied before the system is used again.

Expedition database EDATSEA

We used this to record sample information. In the report on Cruise 99020 (Shaw et al., 1999) we noted that the list of available regions in EDATSEA was incomplete. Although we were working in Placentia Bay, we had to enter Grand Banks as the region. If memory serves right, this list was compiled during an informal staff meeting in the AGC boardroom, and little thought was subsequently given to it.

Coring and sampling equipment

The corer was a 3-m gravity corer that could be deployed over the stern from the 'A' frame using a winch on the afterdeck. The corer was not used. Grab samples were taken with a van Veen grab sampler using the same winch.

Winches

Three winches were used: a sidescan sonar winch on the well deck, starboard side, and a sampling winch and Huntec winch on the quarterdeck, side by side, with the sampling winch to starboard and the Huntec winch amidships.

Figure 5: Winches for grab sampling and bottom photography (left) and the Huntec system (right). The blocks that are barely visible are for the Sidescan sonar and Huntec systems. When setting up for grab sampling and photography the block at left was changed.

Figure 6: Winch for the sidescan sonar system, mounted on the well deck near the unused multibeam sonar launch. The cable extends across the well deck and up to the block on the A-frame (see previous photograph).

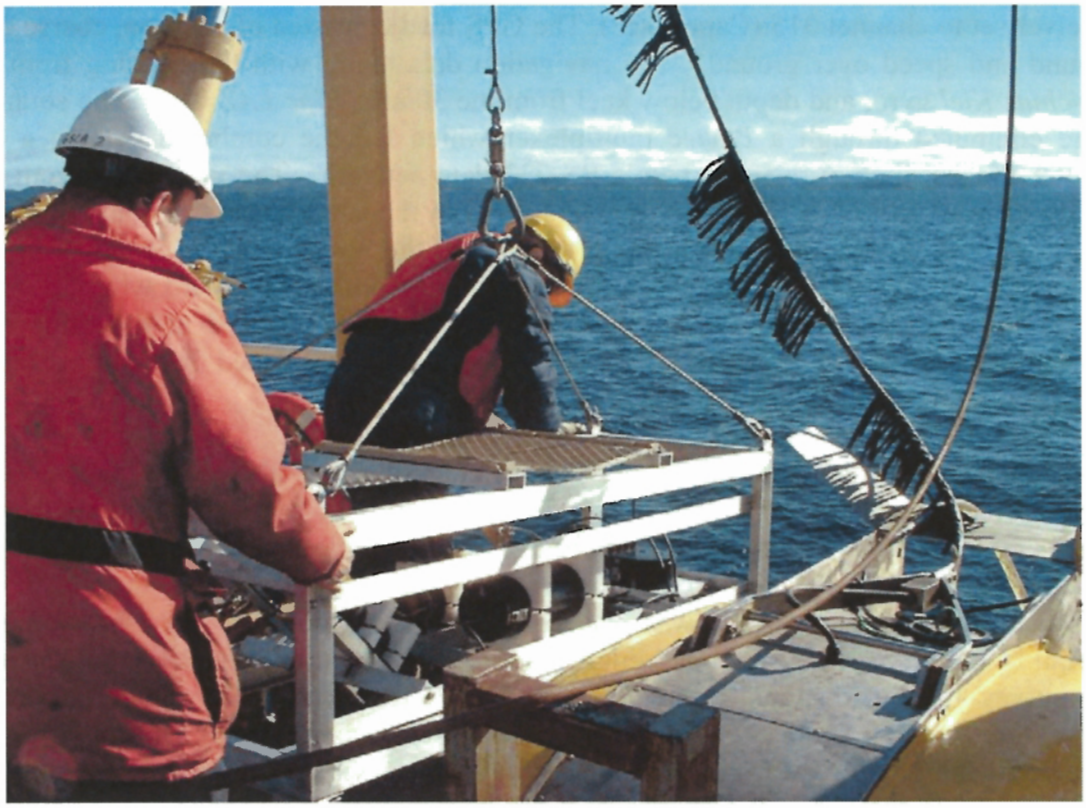

Figure 7: Digital camera system being readied for lowering on day 301.

GIS system

The chief scientist's laptop computer was set up in the laboratory running Global Mapper with a navigation feed. The display showed a Geotiff of the multibeam data, with backscatter superimposed. Backscatter could be made to be semi-transparent. The display was useful for getting a warning of upcoming shoals.

Global Mapper was used to display ship's tracks, to display cleaned navigation supplied by the navigation specialist, to select and display sample sites, and to display sample and track information from previous cruises (shape files). This inexpensive program once again proved it tremendous effectiveness. Its simplicity and capability make it superior – in the chief scientist's opinion- to other far more expensive and cumbersome GIS programs (that shall not be named!). When importing the navigation files, the routine was to select "Open Generic ASCII Text File(s)", then select point only features, northing first, skip one column, include attributes from lines, and use auto detect.

Navigation:

Navigation tasks were undertaken by Angus Robertson. Positioning aboard the vessel was done with navigation software *Regulus II* build 27001 (2004.4.8). The required computers were set up on the vessel prior to the mission departure from Sydney, NS. The primary computer was placed in the survey control room on the bridge deck and received differential GPS signals from the bridge receiver (*Magnavox*). Shore corrections were received via a *CSi MBX-3* 2 channel automatic differential beacon

receiver set to channel 315 (Cape Race). The GPS feed consisted of position, coarse over ground and speed over ground. The navigation data along with the heading from the *Anschutz Kiel* gyro, and depth below keel from the 30 kHz *Elac LAZ 4400* echo sounder, were combined through a *Baytec* multiplexer which fed the combined data to a line splitter for distribution over the ship's RS-232 data network. The video feed from this computer was split by a *VideoView* signal splitter in the survey control room and fed to the bridge. The bridge crew were able to monitor the navigation for geophysical line running from the central telegraph on the bridge and from the starboard wing telegraph for sampling stations. The two bridge monitors could be viewed at the same time through feed from an additional *VideoView* signal splitter placed behind the bridge ceiling monitor.

It should be noted that the primary navigation computer was also configured to allow position feed from the *TSS POS/MV* system but due to poor heading lock while station keeping this feed was abandoned and the bridge positioning as described above was used.

A second navigation computer was placed in the survey control room. Waypoints or sampling station markers could be initially set up on this computer whilst underway with the survey without distracting the bridge crew. A third computer was placed in the survey lab on the main deck. Again, this computer was connected to a line splitter that received positioning data from the line splitter in the navigation room. Data from this splitter were forwarded to the *Huntec* AGCDIGS computer, the *Simrad MS992* sidescan AGCDIGS computer, the sidescan, and the record annotator. This *Regulus* computer allowed a visual positioning display of the vessel over charts and multibeam.

The *Huntec* and *Simrad MS992* data rolls and DIGS tapes were annotated following traditional GSCA procedures as listed in the GSCA Expedition Manual for Operations at Sea. The raw navigation data were cleaned and processed using standard GSCA DOS programs.

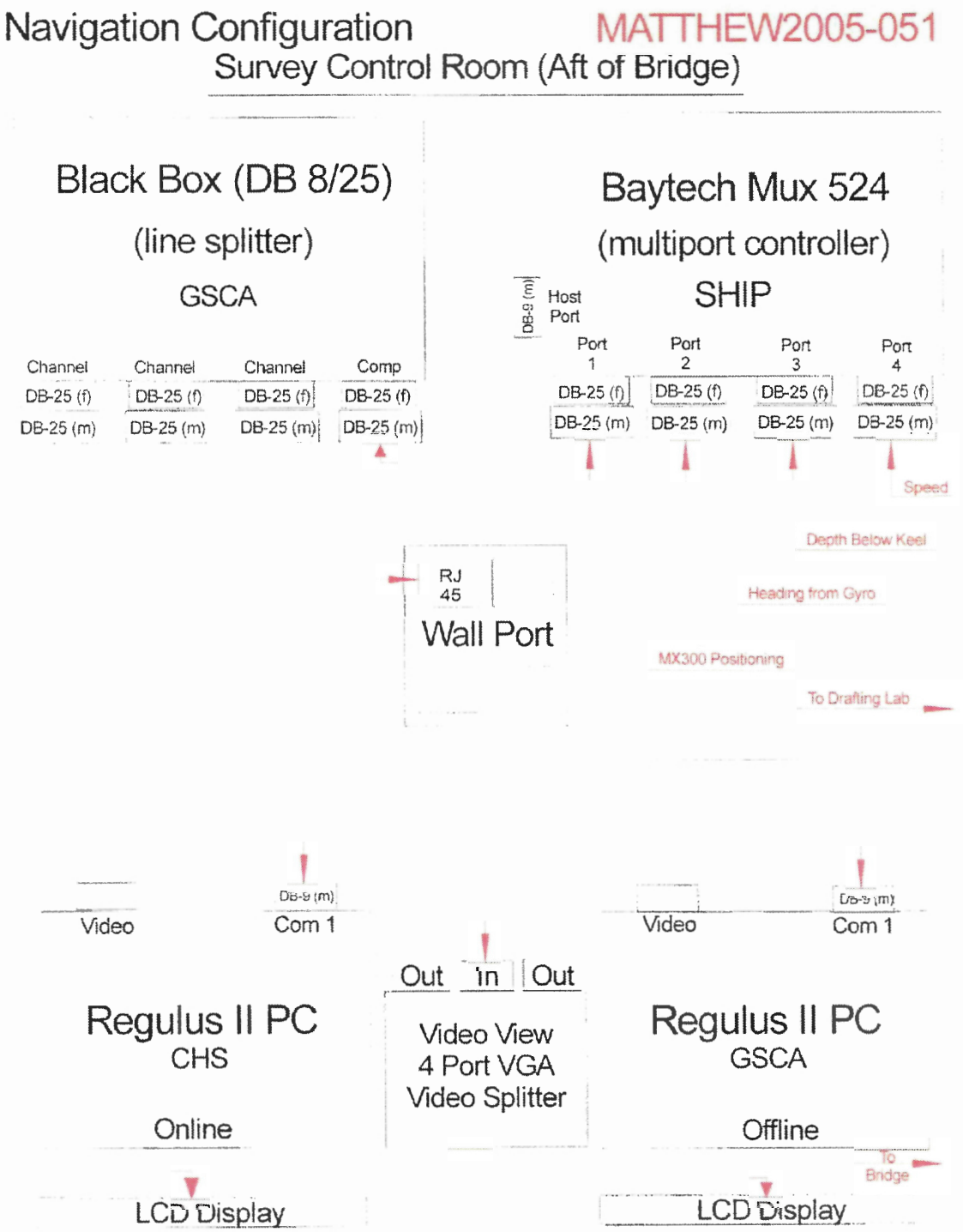

Figure 8: Navigation configuration - survey room.

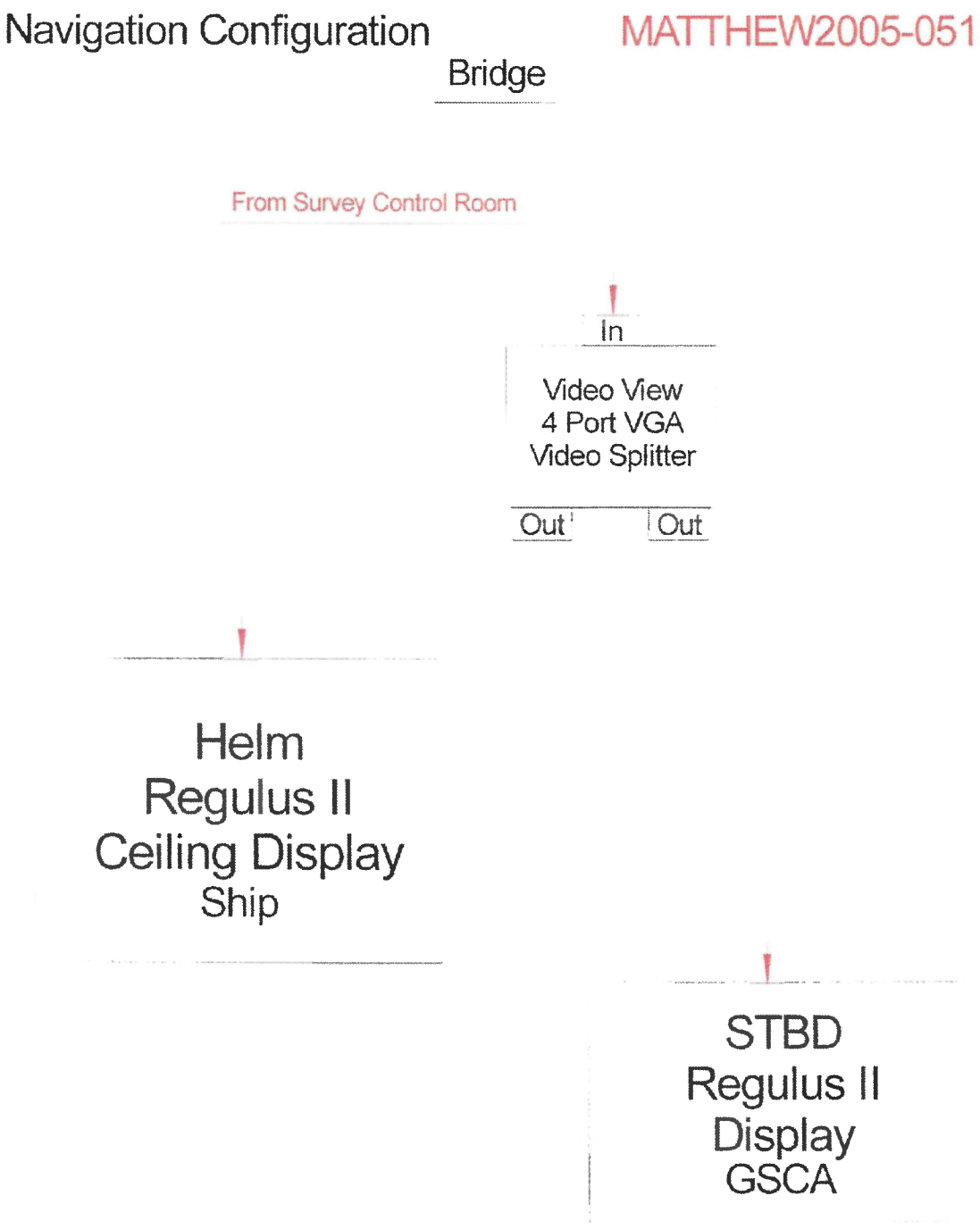

Figure 9: Navigation configuration - bridge.

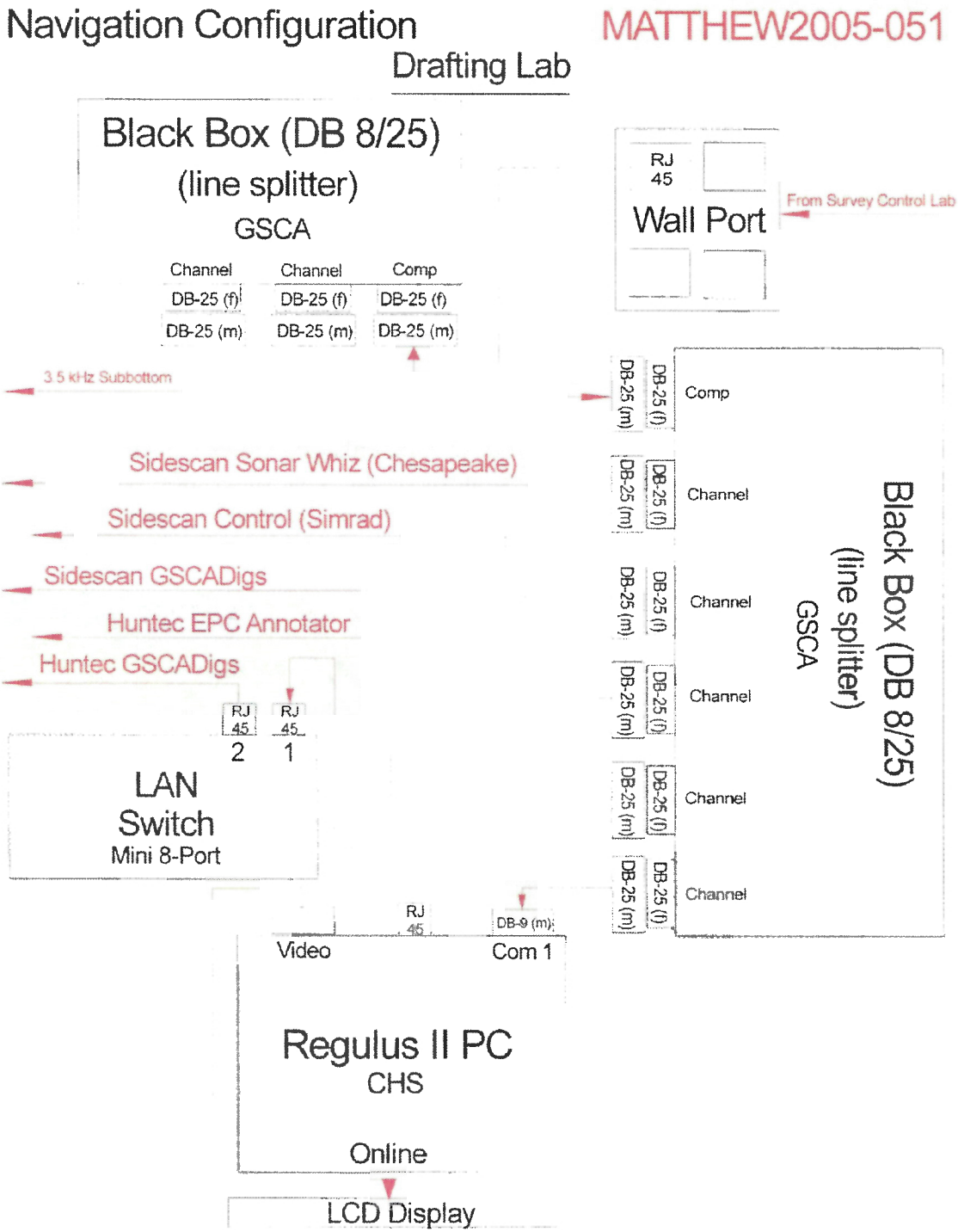

Figure 10: Navigation configuration - laboratory.

Multibeam mapping CSL Plover

While the *Matthew* was being used for seismic surveying and sampling, the launch *Plover* surveyed in shallow water near the coast in the Argentia/Placentia area. During bad weather the launch surveyed Northeast Arm, a body of water connected to the ocean by the Gut at Placentia. The Gut experiences strong tidal currents, as can be seen in the multibeam image that shows a flood delta in the arm, just northeast of a scoured area. The scoured area has transverse ridges that might be de Geer moraines, and near the south coast a rectangular mound may be a wreck. The flood delta is covered with sand waves in a very complex pattern. Farther northeast the sea floor is smooth except for mounds that possibly consist of dredge spoil. Several small mounds on the sea floor may be sunken vessels. There is a deep hole at the south side that does not appear on the CHS chart (4841). On the other hand, a deep hole near the north coast is shown on the chart (Fig. 12) but is perfectly flat on the image.

Another feature – not seen on Figure 11 but seen on enlarged views – is an arcuate ridge extending half way across the arm at the southwest end. One suggestion was that it may have been formed by action of the former cable ferry at Jerseyside. However, another narrow, curvilinear feature intersects the first, and these may be a pair of water pipes.

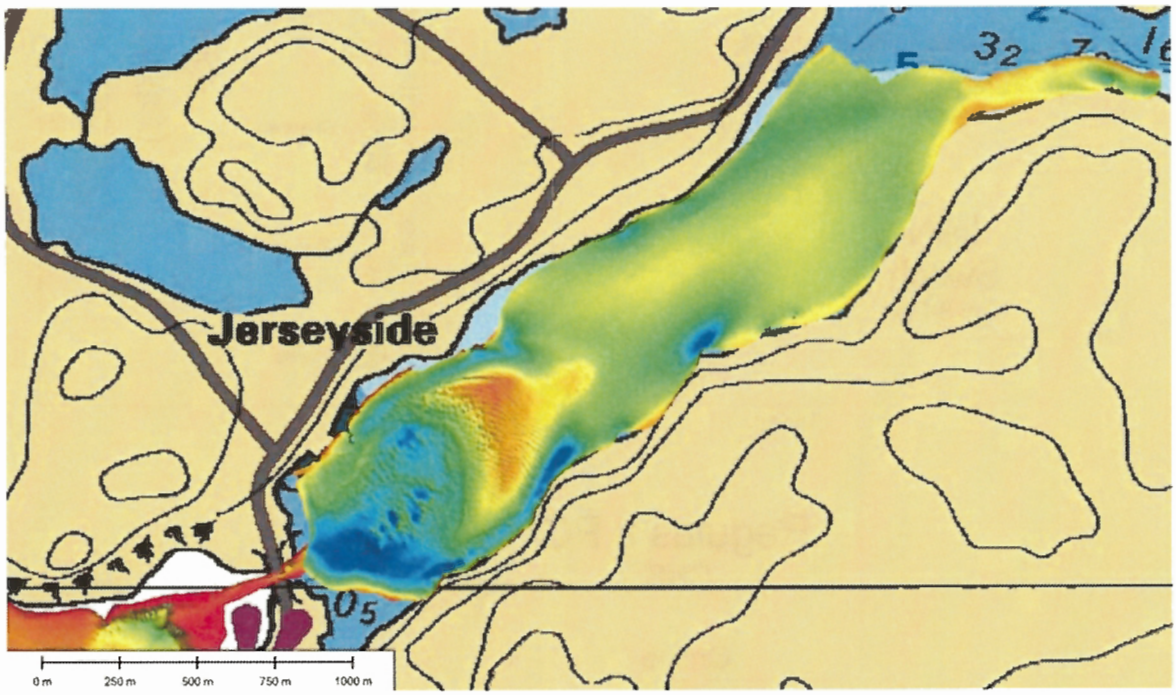

Figure 11: Multibeam sonar image of part of Northeast Arm, Placentia. Note the deep, scoured area at Jerseyside, the shallow tidal delta to the northeast, and the smooth seabed beyond. The deep hole at the south coast, centre of the image, is not on the hydrographic chart (Fig. 12), which shows a deep hole near the north coast.

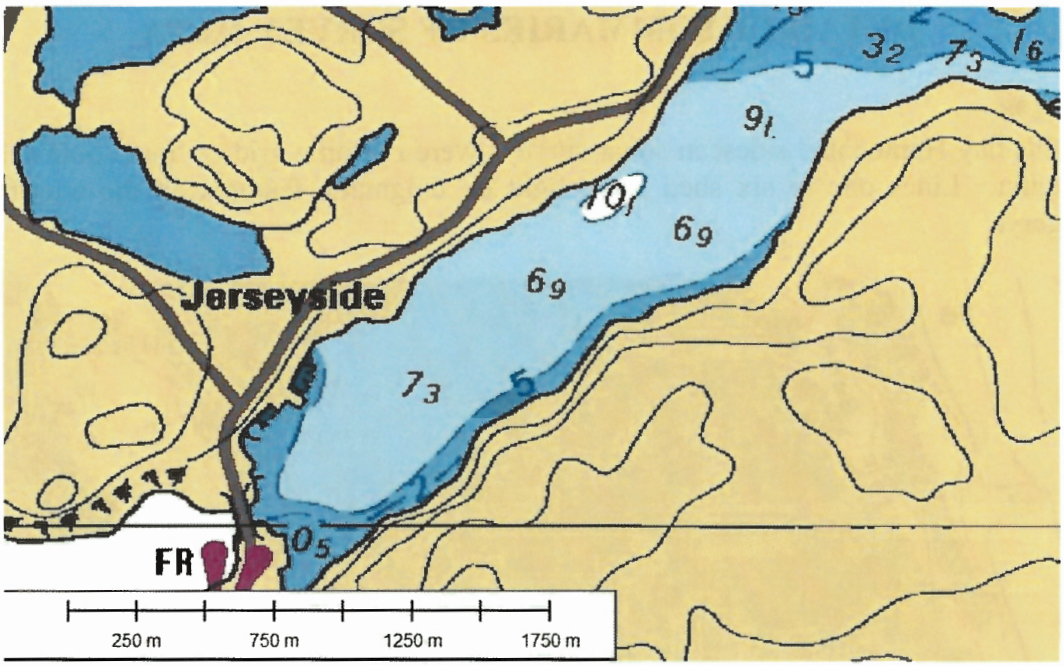

Figure 12: Northeast Arm, as on CHS Chart 4841. Note the deep hole near the north coast which is not present on the multibeam image.

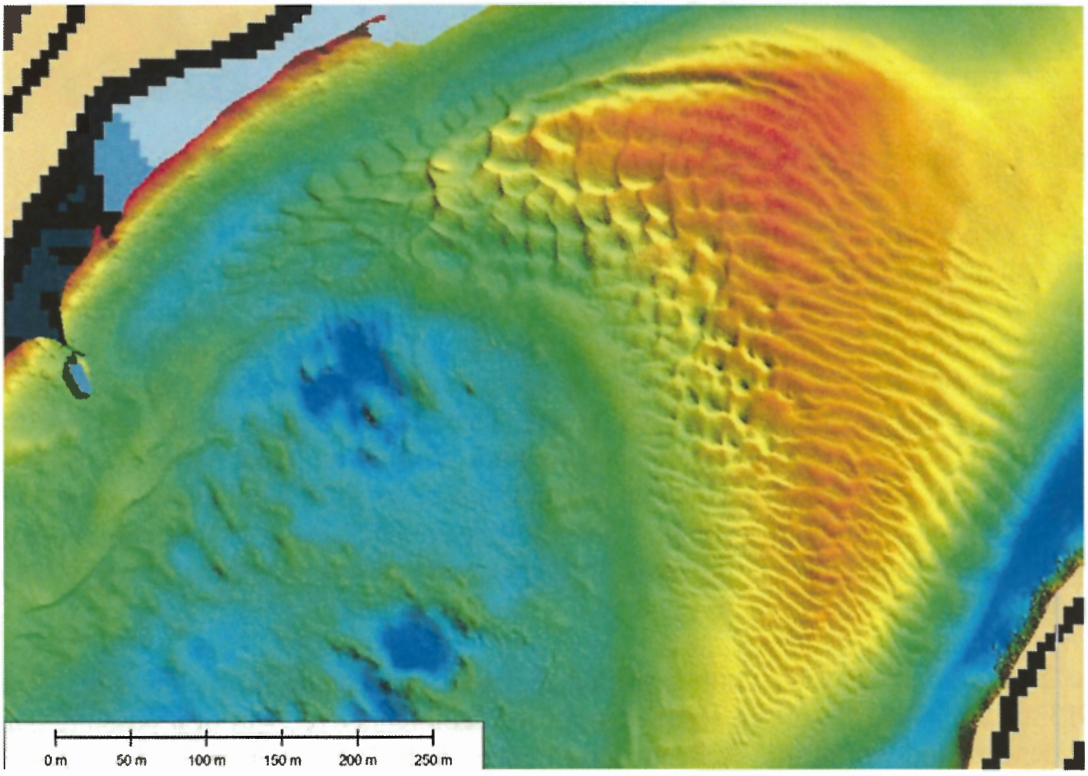

Figure13: Enlarged view of sand waves on the 'flood delta' in Northeast Arm.

DETAILED SUMMARIES OF SURVEY DATA

Day 298

On this day Huntec and sidescan sonar surveys were run on a grid of lines southwest of Argentia. Lines one to six shed some light on enigmatic features on the multibeam imagery.

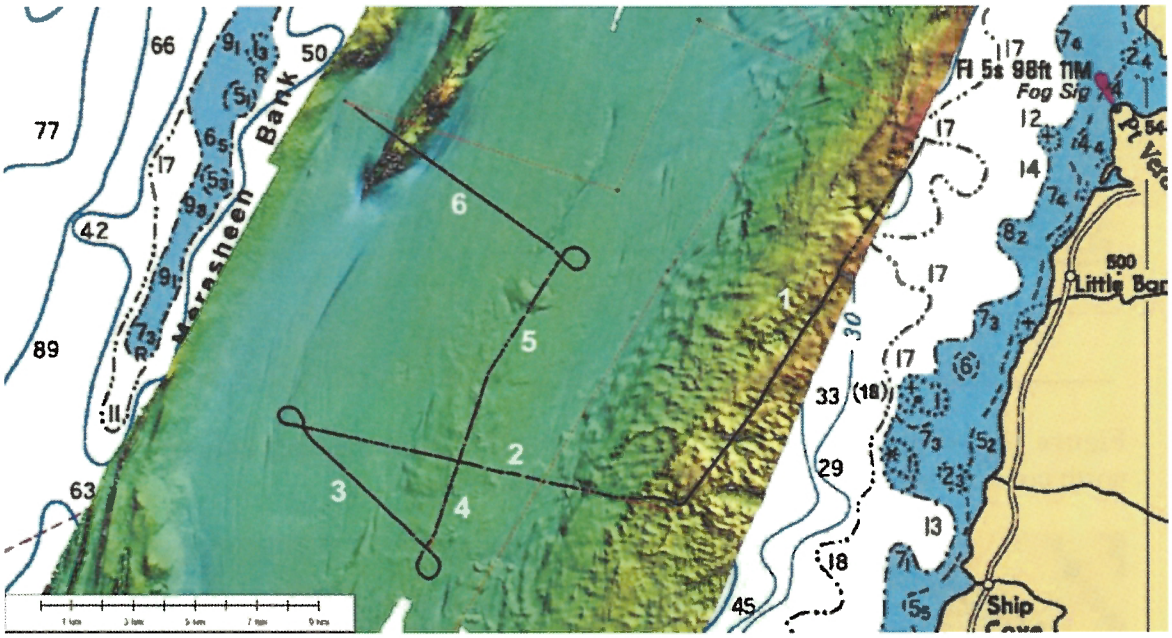

Figure 14: Survey lines on JD 298.

Line 1 ran south along the shallow area close to the coast. The sea floor has a 'corrugated' appearance, perhaps indicative of glacial deposits in the form of shore transverse ridges. The Huntec data revealed ridges of acoustically incoherent sediment (till?) commonly 10-15 m thick overlying bedrock. The ridges mostly have a drape of acoustically stratified sediment, perhaps glaciomarine mud, commonly about 6 m, but thicker in basins and thinner on ridge crests. The till may appear at the surface from 2981305 to 2981312. The sidescan sonar was not printing on paper on this early part of the survey, but imagery on the screen did not appear to show boulders on most of the line, supporting this interpretation. The multibeam backscatter is quite high, but is actually higher from 2981324 onwards, in deeper water on the next line. Why this should be is unknown.

Line 2 ran into deep water, with stratified sediments increasing in thickness to 13 m at 2981330. At 2981341 we see 15 m of stratified sediments over 4 m of a possible debris flow deposit, and 9 m of till. Acoustic stratification in bedrock is observed from 2981330 onwards. This is probably Carboniferous bedrock, based on Fader et al. (1982). Slightly lower backscatter from 2981336 onwards coincides with thickening of the stratified sediments, with the upper part being most likely postglacial in age.

At 2981354 we cross an irregular shoal area that has a pitted appearance. Backscatter increases over the shoal, coincident with thinning of the uppermost (postglacial) part of the stratified sediments. The dimpling is in the lower part of the stratigraphy, in what may be glaciomarine mud. The glaciomarine sediment is draped over underlying till ridges up to 14 m thick over bedrock. The sediment thickens in the deeper water, and well-stratified bedrock can be seen at the base. The combined thickness of glaciomarine and postglacial mud reaches 34 m in places. The sediments thin on the ridge half way along the line. The ridge is underlain by a ridge of ice-contact sediment 15 m thick, capped by glaciomarine mud about 8 m thick. The underlying bedrock may be Carboniferous in age. The origin of the pits is unresolved.

At 2981412 we cross onto low backscatter, coincident with the reappearance of the upper part of the stratified sediment package. The upper unit forms an escarpment 4 m high. This strongly suggests erosion of postglacial sediments. Perhaps 9 m of the postglacial unit has been stripped off. By 2981448 the combined stratified package has increased to about 45 m over Carboniferous bedrock; patches of till up to 6 m thick occur.

Line 3 runs to the southeast. By 2981506 we observe thinning (removal) of the upper part of the postglacial unit. Towards the southeast end of the line, a considerable part of the stratigraphy has been removed, giving cuesta-like features at 2981521 and 1981526 – also observed on the multibeam image. This eroded area coincides with streaks of higher backscatter. The remaining sediment is only 25 m thick in one area, and overlies Carboniferous bedrock.

Line 4 runs north, crossing the 'dimpled' ridge once more. On this ridge stratified sediments – probably glaciomarine mud - thin to 9 m, and overlie 11 m of till, that in turn overlies Carboniferous bedrock. The sidescan sonar of the dimpled area shows numerous shallow circular pits filled with mud. These may be iceberg pits. Buried pits may be present at 2981602 (covered by 8 m of sediment) and 2981620. After 2981636 a decrease in backscatter is coincident with reappearance of the upper (postglacial) part of the stratified sediments.

Line 5 continues north, with 17 m of stratified sediments over bedrock. At 2981700 the postglacial unit again thins and we cross a ridge of high backscatter on which the glaciomarine unit is exposed, with a thickness of 14 m over 5 m of till. The glaciomarine unit is draped over a 15 m-high bedrock ridge (stratified Carboniferous bedrock).

Sediment thickens north of the ridge to 38 m. On Line 6 we recross the shoal. The sediment package thins in the moat immediately east of the shoal to about 9 m, and is 11 m thick on top if the shoal. The shoal is underlain by a bedrock ridge 27 m high. Continuing west the package thickens again to a maximum of 34 - 38 m combined glaciomarine and postglacial mud, before thinning again to only 12 m in the moat at 2981810. On the bedrock ridge outcrops could be observed on the sidescan sonar record from 2981816 to 29818282. Beyond the ridge, the thick sediment package (>50 m) contained gas masking.

Days 301/302

On the evening of day 301 and the beginning of 302 *Matthew* runs a line down Western Channel from north to south. Line 7 has 8 m of sediment cover overlying up to 14 m of till. The line crosses bedrock with thin sediment cover. Line 8 extends onto what was previously interpreted as a field of drumlins. However, while there appear to be some boulders on the surface, and samples consisted of coarse material, the Huntec does not appear to penetrate the 'drumlins' to the underlying bedrock. Are they drumlins? The weight of evidence would suggest they are not. On sidescan boulders appear as linear clusters, suggestive of bedrock outcrop. This region may be an area of relatively soft bedrock that has been sculpted by ice.

However, where we observe the de Geer moraines there is penetration through what may be till. The supposed de Geer moraines are 1.5 - 2.0 m high, superimposed on till ridges up to 12 m thick. We cross very small muddy basins from 3012304 onwards.

Line 10 extends into deeper water, and shows a considerable thickness of Quaternary sediments. Above bedrock the combined thickness of glaciomarine and postglacial mud is up to 34 m. Gas masking occurs in patches. Line 11 reveals extensive gas masking and stratified sediments up to 53 m thick. There may be some small sedimentary furrows developed in the mud. They are seen on sidescan at 3010005 to 3010010. Line 12 starts on a bedrock knoll and runs across stratified sediments up to 19 m thick. Bedrock is encountered again from 3010035 to 3010048. The line then re-enters the basin. Line 13 runs onto bedrock ridges (3020055). The record shows sediment packages again after 3020155. At the end of the lines (line 17 - 3020250) we observe a thick sediment package comprising 56 m combined glaciomarine and postglacial, overlying >20 m of a possible debris flow.

Day 302/303

On Saturday evening and Sunday morning we run a line down Western Channel and then to the southwest, off the west coast of Placentia Bay. The line begins in Western Channel (Line 18) and shows a thick sediment package comprising about 60 m of postglacial and glaciomarine sediments overlying >15 m of debris-flow deposits.

As the line shallows – from 3021822 to 3021833 - we cross several small basins of postglacial mud, between bedrock ridges with a glaciomarine drape. By 3021848 we observe the start of an extensive field of de Geer moraines. These continue until approximately 3021924, where they merge with a field of streamlined forms. The mean crest spacing of de Geer moraines is about 215 m, and the moraines have mean heights between 2 and 6 m. After 3201848 we cross into well developed streamline bedforms, which may be developed in bedrock – we cannot see the base on Huntec. On the other hand we don't observe bedrock on the sidescan sonar – only a reflective background with scattered boulders. From 3022005 to the end of the field at 3202041 the ridges are composed of till that ranges from 8 to 15 m in thickness. Beyond 3022005 the ridges are increasingly mantled by stratified sediments. In the succeeding basin bedrock ridges are thickly covered by stratified sediments, with the postglacial thick in basins and almost

absent on some protruding ridges. Maximum sediment thickness is 21 m, and till is absent.

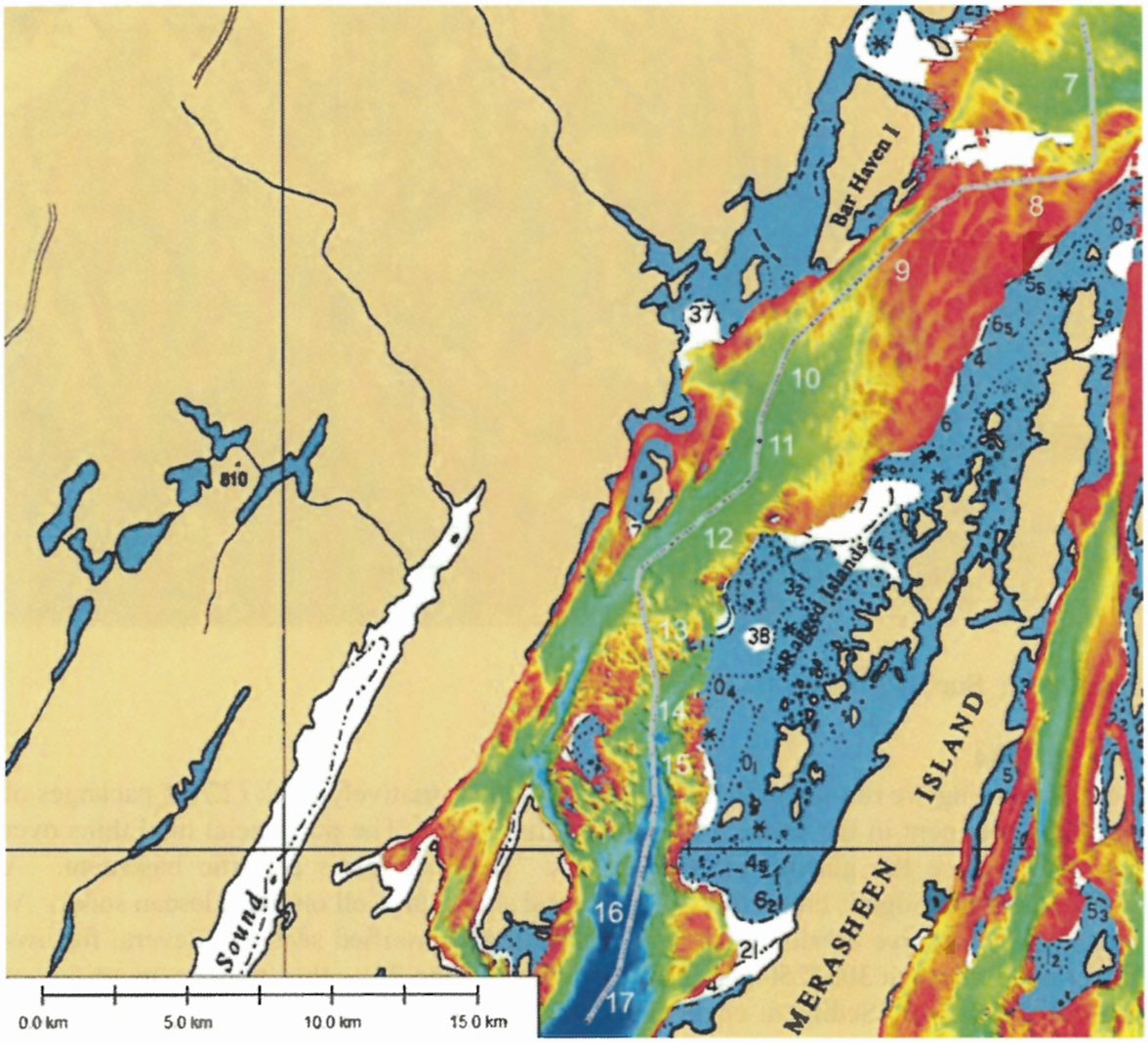

Figure 15: Survey lines on JD 301/302.

By 3022121 the postglacial sediment pinches out and we cross glaciomarine mud with a reflective surface on sidescan (lag gravel). By 3022209 we cross onto till ridges over bedrock. The ridges are commonly 20 m thick and range up to 27 m. By 3022315, bedrock protrudes through thin till in places. On the final line (Line 23), which passes into deeper water, the streamline forms are mantled with sediment or the sediment occurs in inter-ridge basins. Maximum thickness is 8 m. A large anchor drag is at 3020102 to 3020108 on the sidescan sonar record.

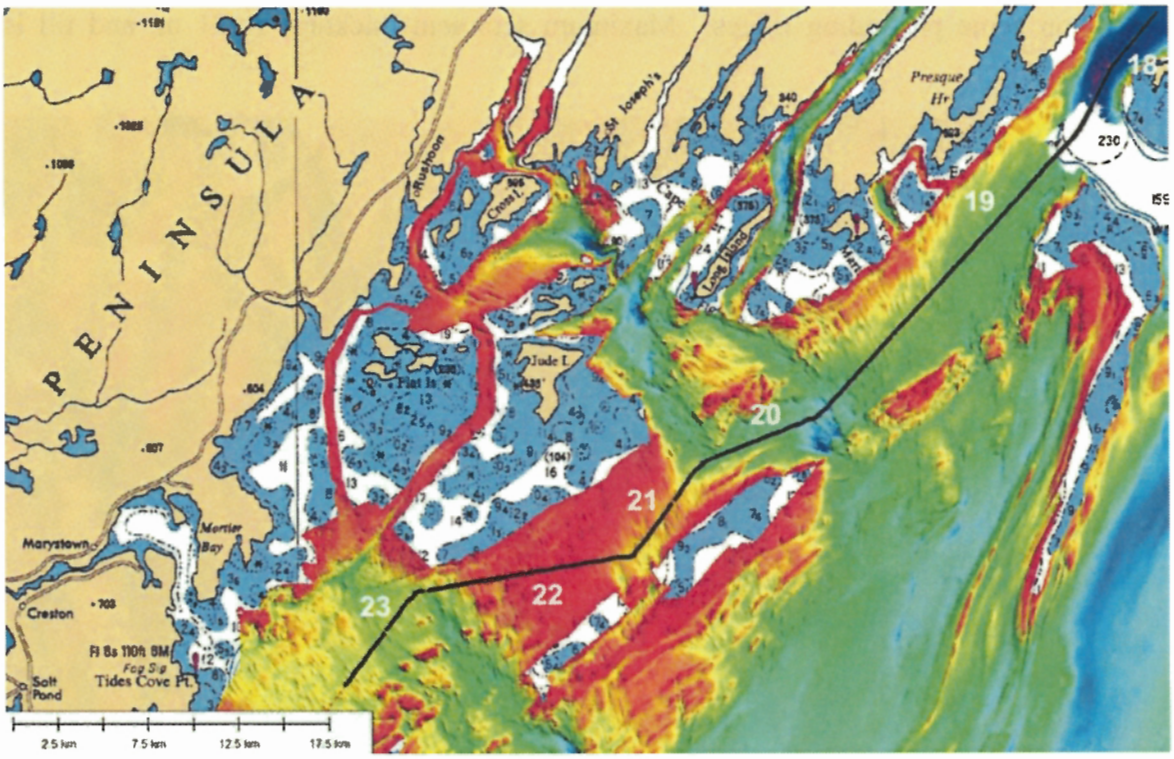

Figure 16: Survey lines on JD 302/303.

Day 303/304

On this evening we run lines 24 to 29. We encounter relatively thick (22 m) packages of stratified sediment in the basin at the start of the lines. The postglacial mud thins over highs to expose the glaciomarine sediments. Bedrock forms acoustic basement. A peaked bedrock ridge is crossed at 3032212, and shows up well on the sidescan sonar. At 3022235 we observe erosion of the upper part of the stratified section. Several furrows are crossed between 3032250 and 3032255 (start of Line 26) – they may be an artifact of the turn, however. Sediment cover thins by 3032300 as we traverse a basement ridge. By 2303310 the line encounters stratified bedrock dipping east (Carboniferous?) below the glaciomarine mud. At 23:35 the apparent dip is to the west, suggesting a syncline. Basement rock is encountered again by 23:40. We cross a series of bedrock ridges with thin (<4 m) Quaternary cover. Bedrock is well seen on the sidescan sonar record. The ridge crest is crossed at 3040105. Beyond 3030135 the depth increases and there is a thickening package of stratified Quaternary sediments.

The postglacial unit thickens beyond 3030203. We probably encounter Carboniferous bedrock by 3040210 and definitely by 3030245, with apparent dip approximately northeast. There is gas masking from 3030222 to 3030241, to the west of a major sedimentary furrow. Sediment thickness is 60 m at 3032240. The upper part of the stratigraphy pinches out at 3030303. There is 18 m of stratified deposits over 12 m of till over east-dipping bedrock.

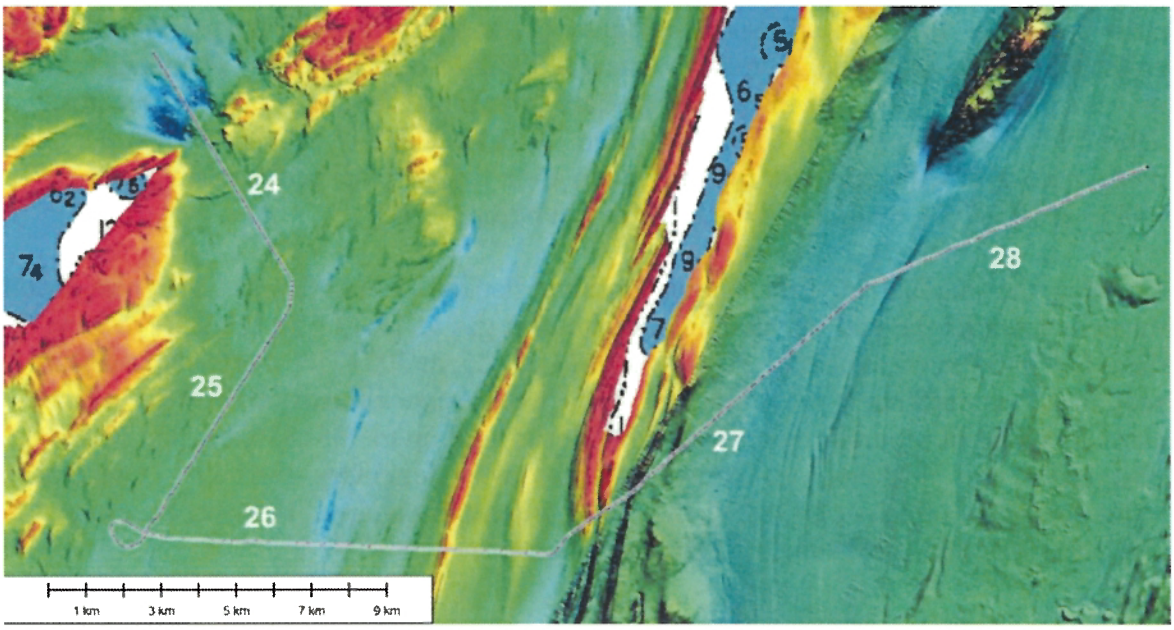

Figure 17: Survey lines on JD 303-304.

Day 305

This survey was conducted during the day for logistical reasons. The line commenced south of Red Island on line 29, with 30 m of stratified sediments and 4 m of ice-contact sediment over Carboniferous bedrock. On a ridge at 3051230 the postglacial sediments appear to be absent, exposing 20 m of glaciomarine sediment. Just beyond the ridge – at 3051235 – the postglacial thickens so that of a 30 m sediment package at 3051240, 15 m is postglacial mud. Ice contact sediment is absent here. At 3051255 the total Quaternary thickness is about 53 m. Some slight gas masking is seen from 3051300 to 3051305.

Line 30 crosses the main channel in a northwesterly direction, intersecting ridges of glaciomarine sediment draped over ice-contact sediment. The relief on the ridges is about 8 m. At 3051435 the postglacial unit pinches out, resulting in a subtle change in backscatter. Here there is 19 m of glaciomarine sediment over less that 5 m of ice-contact over bedrock. On line 31 we cross a slide scar that is 450 m wide between 3051441 and 3051446. About 8 m of layered glaciomarine sediment has been removed. The scar is infilled with 3 - 5 m of postglacial mud that shows up clearly as an area of low backscatter.

Between 3051450 and 3051501 varying amounts of glaciomarine sediment have been removed by mass wasting, with complete loss at one spot only. Beyond 3051500 the postglacial section thickens, to a total of 41 m at 3051509, with faint gas signs. From 3051515 to 3051530 there are possible debris flows in the glaciomarine unit. Total Quaternary thickness is only 12 m at start of Line 32.

Line 32 traverses a series of slide scars from 3051535 onwards. They are not particularly clear on Figure 10 but are distinct on Figure 11, an image created from EM-1000 data collected in 1995. Erosional remnants occur at 3051545 and 3051551. The glaciomarine unit is commonly 12-15 m thick and in scars is missing about 9-12 m. Three stacked debris flows are observed at 16:40. On Line 33, from 3051647 to 3051709 we see thick postglacial mud with gas masking, more than 45 m thick. Total sediment thickness is 40 - 45 m at 3051707. Sediment thins to <8 m just before 17:00.

Crossing the channel on Line 34 we observe stacked debris flows. The postglacial thickens towards the end of this line and contains gas at 17:13. At the start of Line 35 there is >34-38 m of sediment. At the start of Line 36, at 3051756, there is up to 38 m of sediment. Gas masking is present at 3051800. We traverse a furrow at 3051802. Line 37 starts in a current scoured region – the sea floor is hard up to 3051836, beyond which the postglacial unit thickens. It contains numerous sedimentary furrows. Quaternary sediment is 53 m thick at 3051850, and gas is present in patches. Furrows are crossed at 3051845, 3051855, 3051905, 3051910, and 3051937.

Day 308

This was the final Huntec and sidescan sonar survey of the cruise. A series of lines (L. 39 to L. 44) was run down the axis of Central Channel, from a start point just a south of the north end of Merasheen Island to an end point a short distance southwest of Red Island. The tracks are shown on Figure 17. Sidescan sonar data are available only for part of L. 39 due to an equipment malfunction.

On L. 39 bedrock is common, with shallow sedimentary basins in places. There may be a veneer of glaciomarine sediment or ice-contact sediment over the bedrock in places. At the start of L. 40 the picture is similar, except the sediment in basins is increasingly thick, especially after 13:16. At 13:20 under a shallow postglacial sediment cover the combined glaciomarine/ice-contact thickness is 6 m. On a bedrock knoll at 13:35 there is a 3 m sediment cover, compared with 20 m in a depression nearby.

On L. 40 bedrock is exposed on some bedrock highs on the basin flank. The largest bedrock ridge is at 13:45; after this the line drops into the basin again. By 13:52 the postglacial unit is 10-13 m thick and is masked by shallow gas. Gas masking is sporadic up to 14:10, with up to 34 m of total Quaternary sediment in places. The basin-fill ends at 14:15 as the line runs onto the sidewall. By 14:25, on Line 42, bedrock occurs at the sea floor. By 14:39 the line is back in a small basin, with up to 18 m of sediment. At 14:58, on Line 43, we note 18 m of sediment in the basin, with two packages of debris flows. From 14:57 to 15:03 we cross a rounded bedrock knob. From 15:03 to 15:13 we note low-relief bedrock with up to 5 m of Quaternary sediment, including some postglacial sediment. From 15:13 to 15:20 bedrock highs alternate with small basins. From 15:20 to 15:32 is a bedrock high with little sediment and a steep drop-off at the end. At 15:52 we see the start of the de Geer Moraine field. At 15:54 they have a relief of several metres, have a drape of 5 m of glaciomarine mud with a further 8 m of postglacial mud on top. The total till thickness here may as much as 22 m. By 16:10 the de Geer moraines are exposed at the surface. Till thickness is about 15 m but may be as

much as 37 m, with multiple tills present. From 16:15 to 16:20 the relief on the de Geer moraines is averages 2-3 m and the till is at least 13 m thick, but may be > 37 m thick, with multiple tills present.

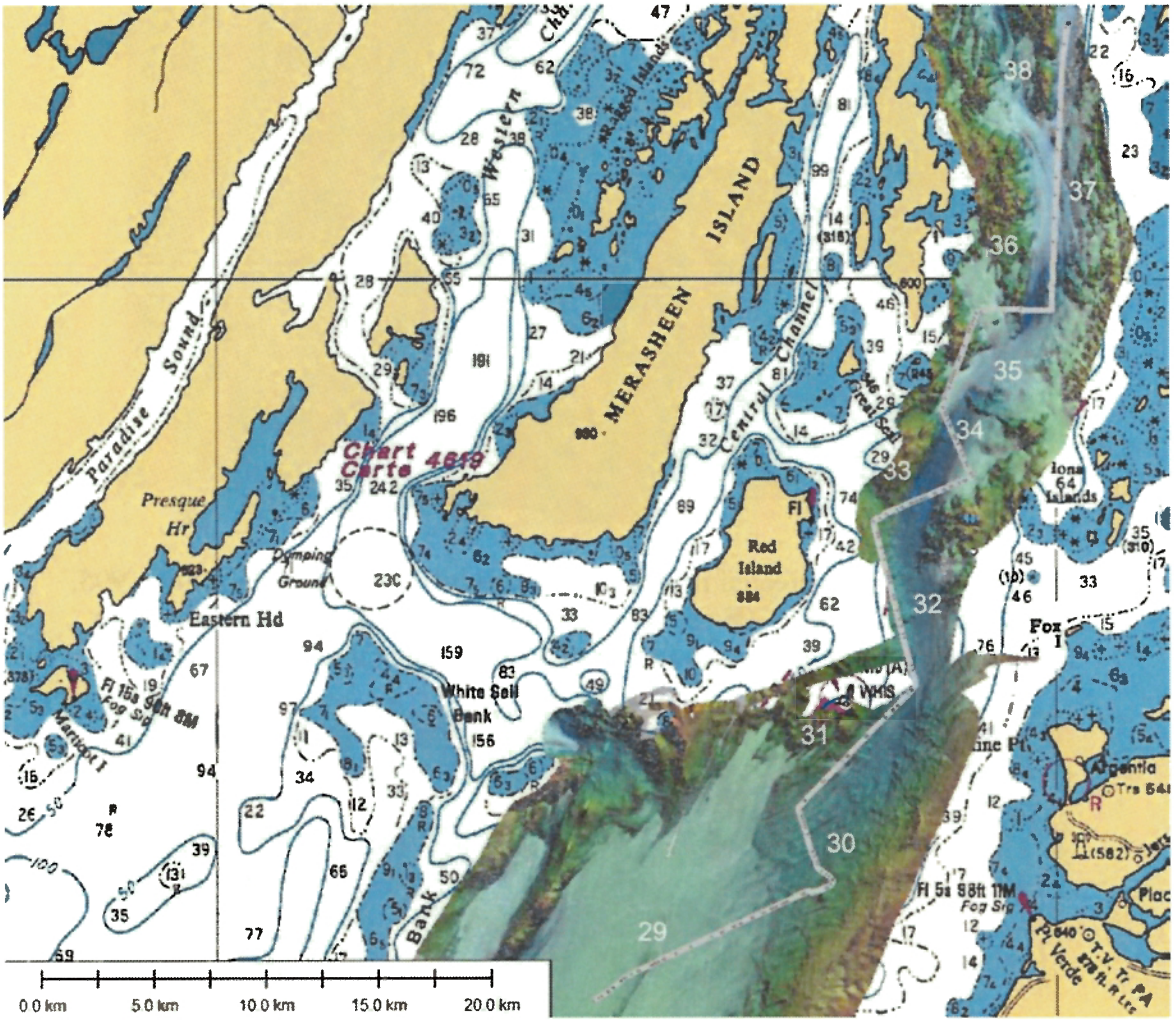

Figure 18: Survey lines on JD 305.

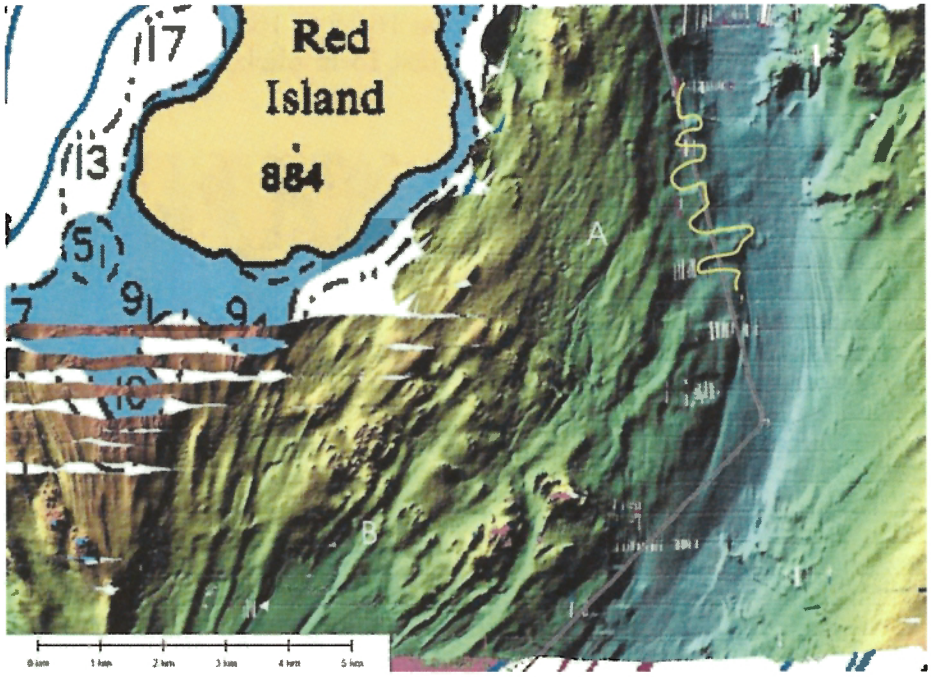

Figure 19 : Image created from EM-1000 multibeam data collected in 1995, showing tracks on day 305 as they cross a series of slide scars (yellow line). Note also the iceberg pits and furrows (A) and crag and tail features (B).

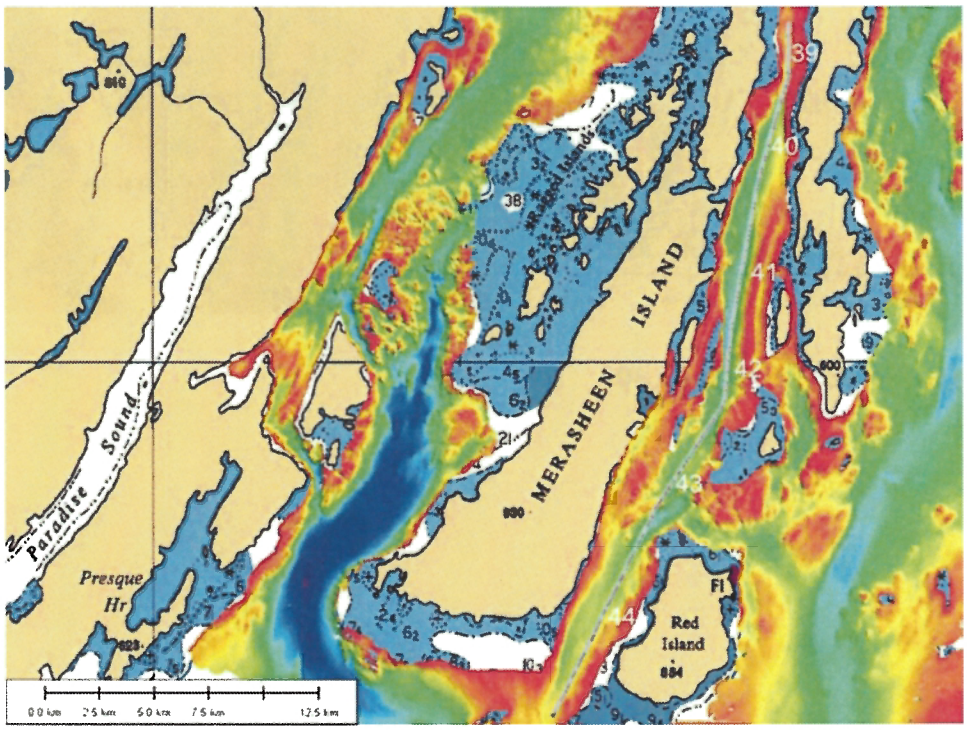

Figure 20: Tracks on day 308.

PRELIMINARY SCIENTIFIC RESULTS

This survey builds upon previous surveys in the region conducted by the GSC. These include a survey in 1989 (Shaw et al., 1990), and one in 1999 (Shaw et al., 2000). More recent surveys carried out in connection with the present project include Shaw et al. (2006a, b). Information summarizing work carried out in the mid-1990s in connection with closure of the US Naval facility Argentia is located on the GSC Atlantic website at:

http://www.gsca.nrcan.gc.ca/oceanmapping/argentia.

1) On the east side of the bay the ridges in shallow water (offshore from the Avalon Peninsula, south of Placentia) probably comprise ice-contact sediment (till). However, at this stage of the interpretation the genesis of these features and their relationship with known features underwater (e.g., de Geer moraines, drumlins) and on land (Rogen moraines) is unknown.

2) On the west side of the bay, a large field of linear features is considered to be drumlins and mega-scale lineations. They consist of acoustically incoherent sediment (ice-contact/till). They appear to be developed in what has been mapped as the Burin Moraine (Fader et al., 1982).

3) The orientation of the extensive drumlin fields, and of drumlins and crag-and-tail features on both sides of the bay, suggest a convergent and accelerating ice flow, perhaps into an ice stream.

4) Analyses of Huntec records from the streamlined features at the north end of the Western Channel has cast doubt on the working hypothesis that these were drumlins; shallow bedrock in places suggests greater bedrock control of seabed morphology than originally thought.

5) The external data from the Huntec system reveals the extensive occurrence of stratified bedrock, probably Carboniferous in age. A ridge on the east side of the bay is underlain by a cuesta of stratified bedrock, probably Carboniferous in age.

6) The upper part of the postglacial sediments on the east side of the bay has been removed in many areas, leaving a lag surface with high backscatter.

7) Thick deposits of Quaternary sediments occur in the Eastern and Western channels. However, whereas in Western Channel postglacial mud overlies glaciomarine gravelly mud in the deepest areas, in Eastern Channel postglacial mud is banked on the valley sides, so that glaciomarine gravelly mud is found on the valley floors. This is suggestive of very strong currents. Part of the source of postglacial sediment may be the erosion farther south (see point 6 above).

8) Submarine slope failures characterize the south end of Eastern Channel. Several slides are probably relatively old, as the scars are infilled with postglacial mud; others are of uncertain age, as they display high backscatter everywhere. However, it is likely that these slides are old, and the high backscatter reflects lack of depositions due to currents.

9) Gas masking occurs in Eastern and Western Channel, in parts of the bay south of Red Island, and to a limited extent in Central Channel.

10) De Geer moraines are apparent on the multibeam data from the bay. Huntec surveys in several areas show that the moraines comprise acoustically incoherent material - probably ice-contact sediment (till). The areas examined were at the south end of Central Channel, and in the west of the bay - southeast of Presque Harbour.

ACKNOWLEDGEMENTS

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Report on Cruise Matthew 2005-020: Multibeam surveys in Placentia Bay, Newfoundland, 19-29 July 2005. Geological Survey of Canada Open File Report 5024.

APPENDIX 1: SAMPLES

Sample	Type	Depth	Latitude	Longitude	Description
001	Grab	96.2	47 45.1023	54 10.5845	Dark gray gravelly sandy mud – possible gravel veneer; clasts up to 8 cm. Ridge on multibeam
002	Grab	122.5	47 45.1741	54 09.8054	Dark olive gray soft silty mud. Basin on multibeam.
003	Grab	137.4	47 44.3512	54 07.3412	Dark gray gravelly sandy mud; worm tubes; fine angular gravel throughout; a few pebbles and one rounded cobble.
004	Grab	36.2	47 42.5462	54 09.8945	First attempt failed – some fine red seaweed. Second attempt failed – some fine red seaweed. Third attempt: several gravel clasts, up to 7 cm, rounded, and thickly coated with Lithothamnion sp. On the top side only. Red seaweed attached to clasts. Small sea urchin, four brittlestars.
005	Grab	50.8	47 42.1396	54 11.6110	Gravelly sand: surface pavement of closely-packed gravel clasts, rounded, up to 15 cm, coated on top with red Lithothamnion, overlying brown gravelly sand with numerous shell fragments. Numerous brittlestars and red seaweed attached to gravel.
006	Grab	99.3	47 41.3872	54 12.8545	Gravelly sandy mud: sub-rounded to sub-angular gravel up to 15 cm, a few worm tubes, and no coral. Possible surficial gravel lag. Area of de Geer moraines.
007	Grab	105.4	47 40.0350	54 14.9378	Gravelly sandy mud. Dark brownish gray; surficial veneer of gravel, with no coralline algae. Clasts up to 14 cm, sub-rounded to sub-angular. Subdued de Geer moraine topography.
008	Grab	200.5	47 38.9460	54 16.0512	Black mud: silty clay; brown surface veneer, worm tubes.
009	Camera	201.4	47 38.9475	54 16.028	Same site as grab 008. 15:50:52
		200.5	47 38.9493	54.16.033	15:51:49
		200.0	47 38.9443	54 16.0484	15:52:43
		200.6	47 38.9491	54 16.0656	15:54:01
		201.1	47 38.9537	54 16.0708	15:55:09
		200.9	47 38.9618	54 16.0689	15:56:24
010	Camera	100.5	47 39.9976	54 14.8990	Same site as grab 007. 16:17:34
		100.5	47 39.9869	54 14.9312	16:19:06
		100.5	47 39.9895	54 14.9409	16:20:09
		100.5	47 40.0020	54 14 9347	16:21:24
		100.5	47 40.0142	54 14.9177	16:22:31
		100.5	47 40.0205	54 14.9069	16:24:02
011	Camera	94.5	47 41.4016	54 12.8753	Same site as grab 006. 16:46:40
		94.5	47 41.4022	54 12.8667	16:48:11
		94.5	47 41.3959	54 12.8467	16:49:31

		94.5	47 31.3795	54 12.8438	16:50:40
		94.5	47 41.3712	54 12.8620	16:51:41
		94.5	47 41.3792	54 12.8762	16:52:47
012	Camera	52.5	47 42.1385	54 11.5988	Same site as grab 005.17:07:41
			47 42.1400	54 11.6029	17:08:51
			47 42.1422	54 11.5977	17:10:03
			47 42.1502	54 11.5807	17:11:18
			47 42.1534	54 11.5736	17:12:13
		42.5	47 42.1520	54 11.5698	17:13:20
013	Camera	36.5	47 42.5565	54 09.9138	Same site as grab 004. 17:27:49
			47 42.5513	54 09.9015	17:29:03
			47 42.5429	54 09.8839	17:30:22
			47 42.5340	54 09.8783	17:31:59
			47 42.5252	54 09.8846	17:32:55
		31.5	47 42.5023	54 09.9067	17:34:11
014	Camera	99.5	47 45.1131	54 10.5371	Same site as grab 001. 18:05:26
			47 45.1291	54 10.5359	18:07:04
			47 45.1315	54 10.5379	18:08:14
			47 45.1306	54 10.5379	18:09:08
			47 45.1302	54 10.5361	18:10:12
			47 45.1082	54 10.5411	18:11:21
		99.5	47 45.0819	54 10.5614	
015	Camera	121.5	47 45.1924	54 09.7754	Same site as grab 002. 18:13:09
			47 45.1927	54 09.7726	
			45 45.1883	54 09.7744	
			47 45.1972	54 09.7642	
			47 45.1976	54 09.7623	
		121.5	47 45.1879	54 09.7700	
016	Camera	139.5	47 44.3286	54 07.3647	Same site as grab 03. 18:53:22
			47 44.3216	54 07.3600	18:54:23
			47 44.3201	54 07.3514	18:55:27
			47 44.3353	54 07.3354	18:56:38
			47 44.3466	54 07.3196	18:57:36
		146.5	47 44.3619	54 07.3001	18:59:02
017	Grab	398.3	47 26.9373	54 21.2045	SDT 3020245. Very dark olive gray clayey mud with a brown surface veneer.
018	Grab	379.5	47 28.6241	54 20.1678	SDT 3020220. Very dark olive gray clayey mud with a brown surface veneer. Small (1 cm) half bivalve; small (2 cm) angular gravel clast.
019	Grab	194.5	47 32.9276	54 19.3882	SDT 3020120 Very dark olive gray silty mud with worm tubes, and numerous angular clasts commonly 2-3 cm long.
020	Grab	126.0	47 33.7769	54 19.6310	SDT 3020110 Three attempts: 1st a small pebble; 2nd empty; 3rd two gravel clasts: one sub-rounded pebble (bare) and one cobble 25 x 15 x15 cm, with sponge encrustations and other unidentified encrustations. Lower part of clast is bare, suggesting it is part of an immobile pavement.
021	Grab	232.5	47 36.5935	54 17.5215	Very dark olive gray silty mud with worm tubes, and a few small shell

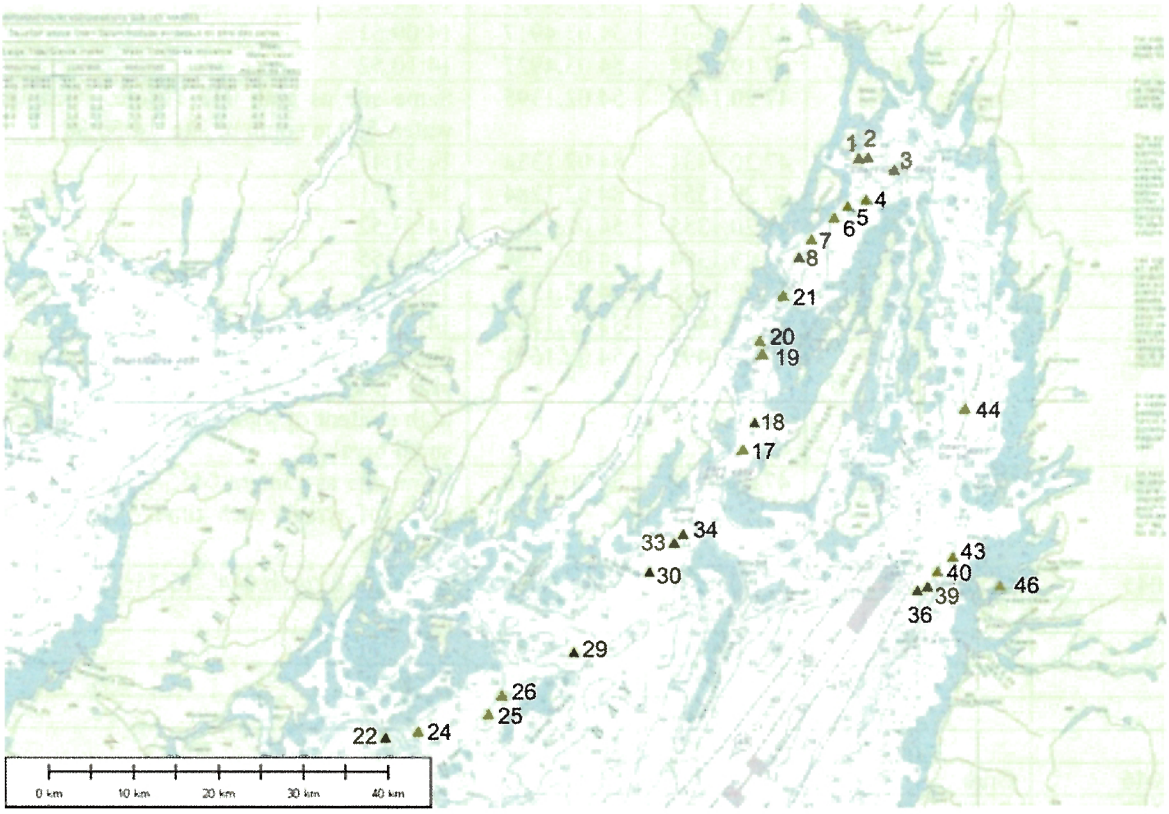
					fragments.
022	Grab	137.5	47 08.8671	54 53.9531	SDT 3030020. Vary dark to black gravelly sandy mud. Surface veneer of scattered sub-rounded red pebbles, light brown on surface; worm tubes.
023	Camera	146.1	47 08.8480	54 53.9946	Same site as sample 022. 12:43:30
			47 08.8371	54 54.0092	12:44:43
			47 08.8281	54 54.0332	12:45:59
			47 08.8217	54 54.0477	12:46:57
			47 08.8131	54 54.0632	12:48:03
			47 08.8039	54 54.0848	12:49:30
					The camera failed - no photographs taken.
024	Grab	87.4	47 09.2220	54 50.9458	SDT 3022348. Two attempts. The first (was bagged as 024 in a single bag, the second – main sample- as 24b, with the complete sequence of bags). The first was dark olive gray sandy gravelly mud, with several red sub-rounded clasts up to 10 cm. The main sample was dark brown gravelly sand with shell fragments, including red gravel clasts up to 10 cm.
025	Grab	109.3	47 10.3096	54 44.4875	SDT 3022240. Muddy sandy gravel. Dark olive brown poorly sorted – perhaps with a concentration of gravel at surface. Shell fragments, worm tubes, clasts up to 10-15 cm, reddish, no Lithothamnion, a few small bio-encrustations.
026	Grab	105.4	47 11.5168	54 43.2298	SDT 302220 Gravel, sub-angular, clean, commonly 5-10 cm, shell fragments, sea urchin.
027	Camera	105.4	47 11.5128	54 43.2448	Same site as 026. SDT 3022220. 15:06:15
		105.4	47 11.5109	54 43.2342	15:07:27
		105.4	47 11.5091	54 43.2294	15:08:43
		105.4	47 11.5046	54 43.2292	15:09:46
		105.4	47 11.5041	54 43.2286	15:10:55
		107.3	47 11.5054	54 43.2267	15:11:59
028	Camera	238.3	47 14.2371	54 36.6472	Same site as grab 029. SDT 3022103 16:24:41
		238.3	47 14.2440	54 36.6427	
		237.4	47 14.2434	54 36.6404	
		237.4	47 14.2442	54 36.6379	
		238.3	47 14.2454	54 36.6353	
		237.4	47 14.2477	54 36.6338	
029	Grab	238.0	47 14.2524	54 36.7354	Same site as camera 028. SDT 3022103. Note: depth approximate. Very dark olive gray mud, slightly pungent.
030	Grab	170.3	47 19.2700	54 29.8158	Same site as camera 031. SDT 3021931. A large (20-30 cm) sub-angular boulder 50% embedded in olive gray gravelly sandy mud – the fine gravel is angular.
031	Camera	170.3	47 19.3428	54 29.7362	Same site as grab 030. SDT 3021931. 17:52:04

		171.2	47 19.3434	54 29.7248	17:53:11
		172.4	47 19.3393	54 29.7143	17:54:14
		172.4	47 19.3372	54 29.7019	17:55:30
		173.3	47 19.3367	54 29.6924	17:56:36
		175.5	47 19.3345	54 29.6807	17:57:52
032	Camera	182.5	47 21.0216	54 27.5464	Same site as grab 033. SDT 3021901 18:25:01
		183.4	47 21.0138	54 27.5568	18:26:21
		183.4	47 21.0075	54 27.5625	18:27:22
		183.4	47 21.0004	54 27.5636	18:28:24
		183.4	47 20.9924	54 27.5718	18:29:41
		182.5	47 20.9874	54 27.5759	18:30:45
033	Grab	182.5	47 21.0424	54 27.5194	Same site as camera 032. SDT 3021901 Coarse angular gravel, forms a veneer over gravelly sandy mud. Bare clasts except for some sponge patches.
034	Grab	169.4	47 21.6423	54 26.7321	Same site as camera 035. SDT 3021850
035	Camera	170.3	47 21.6449	54 26.7199	Same site as grab 034. SDT 3021850 19:22:13
		171.2	47 21.6521	54 26.7198	19:23:15
		171.2	47 21.6579	54 26.7195	19:24:25
		172.4	47 21.6640	54 26.7186	19:25:37
		173.4	47 21.6719	54 26.7190	19:26:39
		173.4	47 21.6802	54 26.7233	19:27:51
036	Grab	250.5	47 18.0614	54 05.3632	Same site as camera 037. 1st attempt: a sub-rounded clast (20 cm) with organic encrustation on the top only, and some gravelly sandy mud. There is a gravel pavement! 2nd attempt: sandy muddy gravel. Angular to sub-rounded gravel in a matrix of dark olive gray sandy mud; a few worm tubes.
037	Camera	250.5	47 18.0550	54 05.3553	Same site as grab 036. 12:40:23
		250.5	47 18.0501	54 05.3565	12:41:37
		250.5	47 18.0444	54 05.3541	12:42:41
		250.5	47 18.0401	54 05.3604	12:43:42
		251.4	47 18.0421	54 05.3631	12:44:39
		250.5	47 18.0530	54 05.3708	12:45:50
038	Camera	218.5	47 18.3188	54 04.6442	Same site as grab 039. 13:04:55
		217.3.	47 18.3260	54 04.6276	13:05:54
		216.3.	47 18.3300	54 04.6076	13:07:06
		215.4.	47 18.3322	54 04.5912	13:08:11
		214.5.	47 18.3330	54 04.5804	13:09:09
		213.3	47 18.3371	54 04.5708	13:10:11
		212.4	47 18.3322	54 04.5592	13:11:16
039	Grab	201.4	47 18.3062	54 04.4432	Same location as camera 038. Dark olive gray sandy silty mud, stiff, worm tubes, several sub-rounded pebbles.
040	Grab	173.4	47 19.2833	54 03.4926	Same location as camera 041. Olive gray silty sand, perhaps up to 40% mud, worm tubes, small bivalves,
041	Camera	174.3	47 19.2860	54 03.5153	Same location as grab 040. 14:05:45

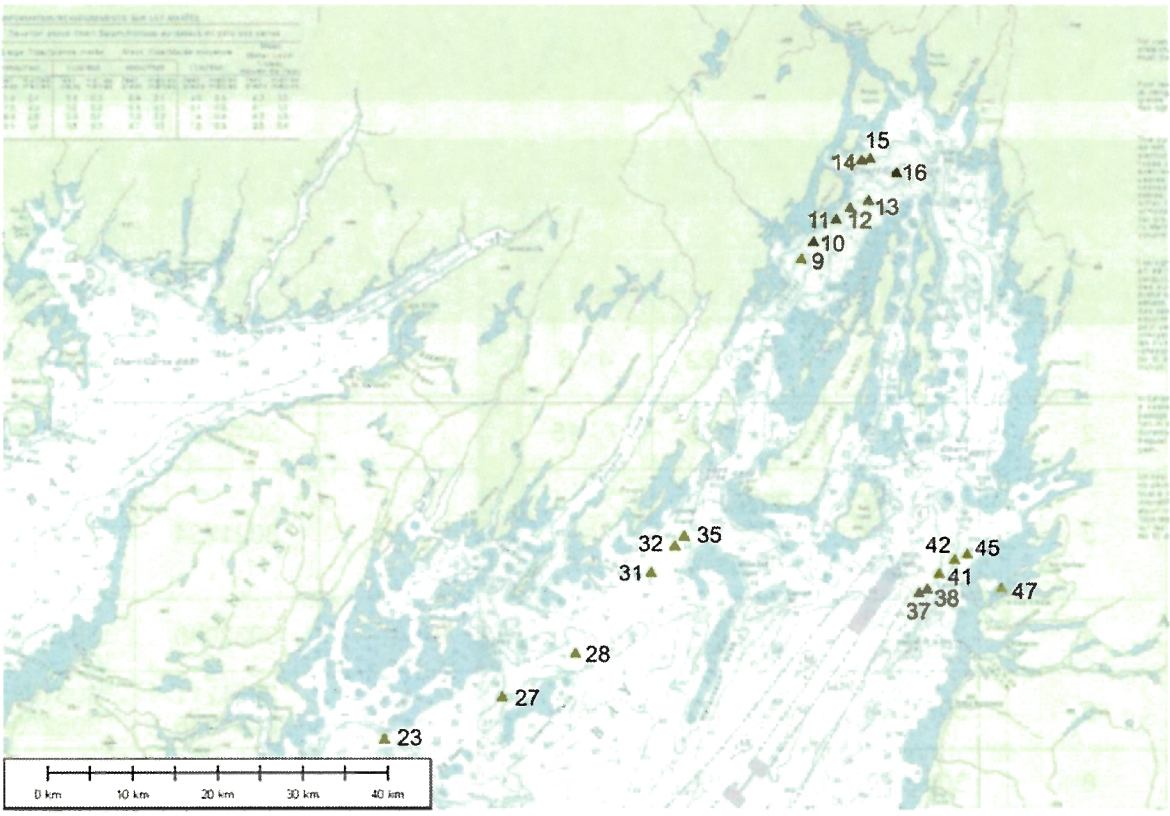
		174.3	47 19.2829	54 03.5150	14:06:52
		174.3	47 19.2833	54 03.5022	14:07:57
		174.3	47 19.2860	54 03.4953	14:08:52
		173.4	47 19.2901	54 03.4917	14:09:51
		174.3	47 19.2934	54 03.4927	14:10:52
042	Camera	89.2	47 20.1481	54 02.1395	Same site as grab 043. Note: Gear in water, 500 m south of site. 14:50:38
		88.3	47 20.1431	54 02.1334	14:51:47
		88.3	47 20.1351	54 02.1284	14:52 51
		88.3	47 20.1355	54 02.1242	14:53:52
		88.3	47 20.1394	54 02.1254	14:54:55
		89.2	47 20.1428	54 02.1379	14:56:01
		90.5	47 20.1492	54 02.1534	14:57:08
043	Grab	90.5	47 20.1491	54 02.1611	Same site as camera 044. Light brownish gray poorly sorted medium sand with high content of shell fragments and a few small bivalves.
044	Grab	27.8	47 29.4612	54 00.9678	Same site as camera 045. 2 attempts – a piece of wrack each time. No sample retained.
045	Camera	27.2	47 20.4851	54 00.9520	Same site as grab 044. 15:35:10
		27.1	47 20.4893	54 00.9519	15:36:13
		27.2	47 20.4901	54 00.9537	15:37:11
		26.9	47 20.4912	54 00.9519	15:38:10
		26.1	47 20.4964	54 00.9440	15:39:20
		25.6	47 20.4965	54 00.9369	15:40:25
046	Grab	49.3	47 18.3755	53 57.7847	Coordinates of 99020-122.
047	Camera	49.8	47 18.3807	53 57.7874	144229
		49.0	47 18.3881	53 57.7849	144338
		48.9	47 18.4118	53 57.8115	144602
		48.9	47 18.4121	53 57.8302	144656
		48.1	47 18.4123	53 57.8456	144745
		48.0	47 18.4124	53 57.8599	144837

Table 1: Sample stations. Note: the depth shown here was calculated by adding 4.5 m to the depth under keel.

APPENDIX 2: GRAB SAMPLE LOCATIONS



APPENDIX 3: BOTTOM CAMERA LOCATIONS



APPENDIX 4: DATA

MATTHEW 2005-051

Records

Sidescan

Record #	Start Time	End Time	Line #
1	2981605	2981822	4 - 6
2	3012110	3020139	7 - 15
3	3021756 3022108 3022123	3022102 3022110 3030114	18 - 23
4	3032102 3040238	3040218 3040346	24 - 28
5	3051208	3051321	29
6	3081237	3081258	39

Huntec

Record #	Start Time	End Time	Line #
1	2981233	2981828	1 - 6
2	3012120	3020250	7 - 17
3	3021734	3030114	18 - 23
4	3032046	3040346	24 - 28
5	3051211 3051345	3051331 3052000	29 - 38
6	3081244	3081628	39 - 44

DIGS Tapes

Sidescan (Sony DAT)

Tape #	Start Time	End Time	Line #
1	2981235	2981615	1 - 4
2	2981617	2981825	4 - 6
3	* Note	* Note	* Note
4	* Note	* Note	* Note
5	* Note	* Note	* Note
6	* Note	* Note	* Note
	* See Tony Atkinson		

Sidescan (ExaByte)

Tape #	Start Time	End Time	Line #
1	2981245	2981825	1 - 6
2	3012124	3020205	7 - 16
3	3021839	3030113	19 - 23
4	3032113	3040345	24 - 28
5	3051215	3051329	29
6	* Note	* Note	* Note
	* See Tony Atkinson		

Huntec

DVD #	Start Time	End Time	Line #
1	2981248	2981825	1 - 6
2	3011228	3020250	7 - 17

3	3021734	3020114	18 - 23
4	3032047	3050345	24 - 28
5	3051215	3052000	29 - 38
6	3081244	3081631	39 - 44

APPENDIX 5: LINES

MATTHEW 2005-051

Line No.	Start	End	Sidescan			Huntec	
			Rec. #	Tape # ExaByte	Tape # DAT	Rec. #	DVD #
1	2981248	2981313	1	1	1	1	1
2	2981323	2981435	1	1	1	1	1
3	2981501	2981541	1	1	1	1	1
4	2981555	2981642	1	1	1,2	1	1
5	2981642	2981719	1	1	2	1	1
6	2981733	2981825	1	1	2	1	1
7	3011228	3012159	2	2	3	2	2
8	3012200	3012241	2	2	3	2	2
9	3012240	3012335	2	2	3	2	2
10	3012337	3012353	2	2	3	2	2
11	3012353	3020005	2	2	3	2	2
12	3020006	3020049	2	2	3	2	2
13	3020049	3020116	2	2	* Note	2	2
14	3020116	3020131	2	2	* Note	2	2
15	3020131	3020149	2	2	* Note	2	2
16	3020149	3020232	2	2	* Note	2	2
17	3020232	3020250				2	2
18	3021734	3021826	3	3	* Note	3	3
19	3021827	3022100	3	3	* Note	3	3
20	3022101	3022156	3	3	* Note	3	3
21	3022156	3022247	3	3	* Note	3	3
22	3022248	3030025	3	3	* Note	3	3
23	3030025	3030114	3	3	* Note	3	3
24	3032047	3032140	4	4	* Note	4	4
25	3032140	3032235	4	4	* Note	4	4

26	3032254	3040050	4	4	* Note	4	4
27	3040050	3040232	4	4	* Note	4	4
28	3040232	3040345	4	4	* Note	4	4
29	3051215	3051331	5	5	* Note	5	5
30	3051345	3051425				5	5
31	3051427	3051520				5	5
32	3051522	3051619				5	5
33	3051620	3051656				5	5
34	3051657	3051721				5	5
35	3051722	3051755				5	5
36	3051757	3051817				5	5
37	3051820	3051945				5	5
38	3051945	3052000				5	5
39	3081244	3081301	6	6	* Note	6	6
40	3081302	3081335				6	6
41	3081335	3081424				6	6
42	3081424	3081447				6	6
43	3081447	3081527				6	6
44	3081527	3081631		* See Tony Atkinson		6	6

APPENDIX 6: HUNTEC REPORT

Re-formatted version of Geoforce Consultants Ltd. report

TECHNICAL REPORT
DEEP TOW OPERATIONS
Argentia Bay NL
C.C.G.S. Matthew #2005-051
Oct 21st -Nov 8th 2005

Submitted by:
Geoforce Consultants Ltd.
P.O. Box 696
Dartmouth, Nova Scotia
B2Y 3Y9

Prepared for:

Natural Resources Canada - Atlantic Region
Bedford Institute of Oceanography
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Distribution: J. Shaw GSCA
B. Wile GSCA (Curation copy)
Project File #C195-1006 Dated: November 16, 2005

TABLE OF CONTENTS

1.0 INTRODUCTION

This is a technical review of the Deep Tow Seismic (DTS) operations onboard the Canadian Coast Guard Ship Matthew, during Natural Resources Canada mission # Matthew 2005-051. This marine geophysical and geological sampling survey was located off Argentia Bay off the coast of The Avalon Peninsula of Newfoundland and Labrador from the 21st of Oct until the 5th Nov 2005. The scientific objective of DTS operations was to provide high resolution sub-bottom information to assist in the ongoing regional geological investigation and mapping of the study area. The field program was directed by Senior Scientist, Dr. John Shaw of the Geological Survey of Canada - Atlantic Region, Bedford Institute of Oceanography.

The DTS was part of the geophysical survey program, which consisted of the following equipment systems.

* Huntec Deep Tow Boomer/Sparker profiling system
* Simrad MS992 Dual frequency side scan sonar system
* GSC DIG Digital Loggers (Simrad, Seismic and Deep Tow)

Overall, DTS operations went well with no problems to report. There was no system downtime and the DTS sub-bottom data quality was good. For full details see Equipment Performance in section 2.2.

Geoforce Consultants Limited provided technician, Graham Standen under the standing offer contract #23420-05S004/001/HAL to supervise the installation, operation and maintenance of the DTS system during the field program.

1.1 DAILY SUMMARY

A digital copy of the Deep Tow Watchkeeper's daily log is included in Appendix A (Microsoft Excel file format).

2.0 DESCRIPTION OF EQUIPMENT

a) Deep Tow Seismic System

Geoforce Consultants Limited of Dartmouth, Nova Scotia is contracted under Standing Offer contract #23420-05S004/001/HAL to supervise the operation, maintenance and ongoing engineering development of the NRCan's DeepTow Seismic (DTS) systems. The DTS system, originally manufactured by Huntec (70) Limited, is a high resolution, sub-bottom profiler with the acoustic source, energy supply, motion sensor, and two receiving hydrophones housed in an underwater tow fish.

The AGC #2 DTS system was used on this mission. The maximum power output of this system is 540 joules (30 mfd storage capacitance) with an ED10F/C Boomer and a multi tip sparker source. For this mission, the internal single element LC10 hydrophone

was configured as Seismic #1. The externally towed Geoforce GF24/24P2i streamer hydrophone was connected as Seismic #2 (overall streamer length 24 feet, two inter-spliced channels with a combined fourteen foot active section, total of twenty-four AQ1 elements with an effective spacing of 12 inches).

The ED10 boomer source is depth compensated and outputs a highly repeatable broadband pulse, capable of resolving 10 centimetres. Peak output intensity is 118 db relative to 1 micro bar at 1 metre, with a pulse duration of 110 microseconds. The sparker source has twenty, #18 awg, solid core tips. Sparker peak amplitude and pulse width are depth dependant.

The deck equipment consists of a Huntec Model 1000 Oceanographic winch, which includes a multi-way slip ring and a 305 metre, fourteen conductor, armoured tow cable. The winch is powered by a 440 VAC, 15 HP hydraulic pump unit. The tow cable is handled by a 36 inch diameter roller cluster rigged on the centre position of the aft A frame.

The lab instrumentation consists of the Huntec Systems Console and DC high voltage power supply (PCU). The Systems Console houses the Bottom Motion Compensator circuits, the +24 volt fish supply, and modules for signal processing and tape outputs. The Huntec Mk III PCU provides DC power to the boomer in switchable ranges from 2 to 6 kilovolts.

b) Graphic Display, Signal Processing and System Key

The two DTS seismic channels were displayed on a single EPC 9802 dual channel recorder (s/n 220). Seismic #1 (internal LC10 hydrophone) was processed by the Systems Console's Adaptive Signal Processor (ASP) module then displayed on Channel A of the EPC recorder. Seismic #2 (external GF24/24P2i streamer) was band passed thru a Krohnhite 3700R filter with nominal settings of 500 to 5000 hertz. An EPC graphic annotator provided time marks on the hard copy records.

The PC based MITS system triggered the DTS and seismic systems. The MITS system allows several systems to be run using a common time base. The MITS masking feature significantly reduces acoustic interference by inhibiting the coincidental triggering of interfering system(s). Each source has two independent, adjustable delayed trigger outputs.

c) Data Recording

The two DTS signal channels were recorded on the PC based GSC DIG (# 3) digital four channel logger with hard drive storage and DVD disk writer. The data directory on the hard drive is: C:/gscdigdata/Mattthew005051/day_xxx-xxx

AGC DIG Inputs	**Description**
Ch. #1	Seismic #1 - Internal LC10 hydrophone

Ch. #2	Seismic #2 - External GF24/24P2i streamer
DIO3	+ 5 volt DTS fire point trigger
Trigger	+5 volt MITS master trigger

d) Equipment List

Unit Description	**Serial Number**
Tow Fish Body	AGC #2
ED10F/C Boomer Source	2023
MK5-2 Attitude Sensor Unit	5005
S500-4 Energy Storage Unit	1019
Internal LC10 Hydrophone	---
External GF24/24P2i Streamer	103
Huntec 1000 Oceanographic Winch and Power Pack	---
Roller Cluster 36" Dia.	---
Systems Console	109
EPC 9802 Graphic Recorder	220
MK 3 Power Control Unit	105
Krohnhite 3700R Filter	1760
GSC DIG Data Logger	#7

2.1 EQUIPMENT SETTINGS

The following equipment settings were used for the majority of DTS survey lines.

Parameter,	Setting
Fire rate	0.5 second (unless otherwise noted on the logs)
PCU power setting	4 kv or 240 joules
ESU power setting	30 microfarad (540 joules max.)
BMC (motion compensation)	Pressure Mode
Display Gain	Seismic #1- Fixed +20 Db (unless otherwise noted)
	Seismic #2- Fixed +20 Db.
Filter Setting - Internal	Seismic #1 - 500 - 5000 hertz
- External	Seismic #2 - 800 - 5000 hertz
Processor Gain (System Console)	4 KV (both channels)
DTS source	Boomer
GSC DIG trigger	master MITS trigger
GSC DIG sample rate	50 microsecond
GSC DIG samples per channel/range	5000 / 250 microseconds
EPC 9802 sweep speed	125 msec. channels A and B
	250 msec. channel A only
EPC print polarity	positive

2.2 EQUIPMENT PERFORMANCE

Overview

In general, the DTS system performance was good, with no system downtime to report. There were no equipment related problems to report on this mission.

Data Quality

Overall, the quality of the boomer data was very good.

Status of Equipment

The Tow cable will have to be reterminated for the next field season and the winch and power pack requires some maintenance and painting.

Parts Consumed

No parts were consumed during this mission

3.0 RECOMMENDATIONS

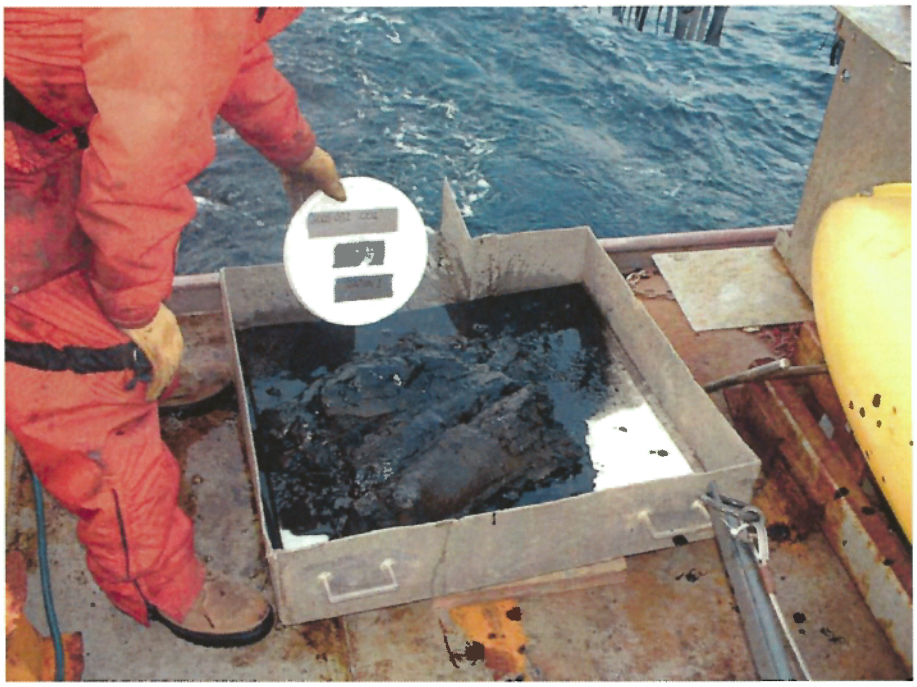
1) This is a recommendation from previous cruise reports. The lifting points on several units of both Deep Tow systems need to be upgraded in-line with Coast Guard safety regulations. The pieces in question are the tow fish/cradle, winch and hydraulic pump. These units should have heavy lifting eyes welded to their frames along with dedicated steel wire lifting straps. A problem arose at the start of the mission because the certificates for the block and shackles were not available for the ships first officer who would not permit the equipment to be set up until the proper paperwork or certified shackles could be obtained.

APPENDIX 7: WATCHKEEPER'S LOG

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	AA	AB	AC
1	WATCHKEEPER'S LOG - GEOFORCE DEEP TOW PROFILER																											
2	DATE:					PROJECT: Matthew 2005		VESSEL: CCGS Mattew				CLIENT: AGC SHAW						LOCATION:										
3	Day / Time		Data Annotation					Environmental				DTS Profiler Settings						Graphic Recorder					Comments					
4	Julian	Time	Data	Line #	Tape #	Tape	WD	Hdg.	Log	Fish	Sea	Source		Fire	PCU	Proc.	ASP	Sweep	SIGNAL			Print						
5	Day	GMT	Log			Pt. / File			Spd.	Depth	State	BM	SP	Rate	KV	Gain	Mode	Speed	CH A	CH B	Print	Delay						
6	298	12:25		1					5.2			X		0.5	4	4	preset	250	INT	EXT			SOL # 1					
7	298	12:49	1	1	1		89	214	5.2	31	2	X		0.5	4	4							EOL # 1					
8		13:13		1				214	5.4	30	2	X		0.5	4	4							SOL # 1					
9		13:23		2			153	271	5.4	31	2	X		0.5	4	4							SOL # 2					
10	298	13:55		2			150	287	4.3	35	2	X		0.5	4	4												
11		1435		2			210	283	5.2	42	2	X		0.5	4	4							EOL #2					
12		14:55		3			208	136	4	54	2	x		0.5	4	4							SOL # 3					
13		15: 19		3							2												Adjusment made on WD					
14		15:42		3			185	146	4	55	2	X		0.5	4	4							EOL # 3					
15		15:54		4			187	033	5.5	48	2	X		0.5	4	4							SOL # 4					
16		16:42		4			186	031	4	81	2	X											EOL # 4					
17		16:43		5			186	032	4	81	2	X		0.5	4	4							SOL # 5					
18		17:19		5			196	058	4.2	73	2	X		0.5	4	4			INT	EXT		240	EOL # 5					
19		17:33		6			196	319	4.3	74	2	X		0.5	4	4							SOL # 6					
20		18:28		6			218																EOL # 6 Equipment recovered					
21																												
22	301	21:00		7																			Equipment deployed					
23		21:28		7			211	177	4	49	2	X		0.5	4	4							SOL # 7					
24		21:59		7			107	177	4.2	31	2	X											EOL # 7					
25		22:00		8																			SOL # 8					
26		22:30		8																			Side scan and huntec cables crossed. Al					
27		22:40		8																			Back on line					
28		22:41		8																			EOL # 8					
29		22:42		9			215		5.5	6		X		0.5	4	4	Preset		INT	EXT			SOL # 9					
30		23:35		9			218		4.7		2	X											EOL # 9					
31		23:37		10			205		5	50	2	X											SOL # 10					
32		23:52		10																			EOL # 10					
33		23:54	37	11			232	202	5.1	65	2	X		0.5	4	4	Preset						SOL # 11					
34	302	00:05		11																			EOL # 11					
35		00:06		12			243	224	4	82	2	X		0.5	4	4							SOL # 12					
36		0049		12			262	242	4	86	2	X											EOL # 12					
37		00:50		12.5			211	261	4.4	89		X		0.5	4	4							SOL # 12.5					
38	302	01:16		12.5				172	4.4	69	3	X		0.5	4	4							EOL # 12.5					
39	0	01:19		14			176	185	4.4	70		X											SOL # 14					
40		01:31																					Eeol # 14					
41		01:31		15																			sol # 15					
42		01:49		15																			eol # 15					
43		01:49		16																			sol # 16					
44		02:32		16																			eol # 16					
45		02:32		17																			sol # 17					
46		02:50		17																			eol # 17					
47																			INT									
48	302	17:20																					EQUIPMENT DEPLOYED					
49		17:34		18			378	225	4.6	87	3			0.6	4	4	Preset						SOL # 18					
50		17:40																					ext displayed only					
51		18:25												0.5					INT	EXT								
52		18:26		18/19			306	212	4.1	87	3			0.5	4	4							EOL # 18					
53		18:27		19																			SOL # 19					
54	302	2100		19			242	239	4.6	77	3	X		0.5									EOL # 19					
55		21:01		20																			SOL # 20					
56		21:57		20			168	227	4.2	82	3	X		0.5	4	4	Preset						EOL # 20					
57		21:58		21			150	227	4.3	82		X											SOL # 21					
58		22:47		21																			EOL # 21					
59		22:48		22			104	263	4.3	53	3	X		0.5	4	4	Preset						SOL # 22					
60	303	00:26		22			132	238	3.8	48													EOL # 22					
61		00:27		23																			SOL # 23					
62		01:14		23					3.8			X		0.5	4	4			INT	EXT			EOL # 23 EQUIPMENT COMING ON BO					
63																												
64																												
65																												
66		20:30																					equipment deployed					
67																												
68		20:47		24			224	145	5.1	44	2	X		0.5	4	4	20DB		INT	EXT			SOL # 24					
69		21:40		24			193		5	51	2			0.5	4	4	20DB						EOL # 24					
70		21:42		25			193	185	5	52	2	X		0.5	4	4	20DB						SOL # 25					
71		22:35		25			207	208	4.6	60	2	X		0.5	4	4	20DB						EOL # 25					
72		22:54		26			206	106	3.1	54	2	x		0.5	4	4	20DB						SOL # 26					
73	304	00:50		26			222	72	3.4	70	2	X					20DB						EOL # 26					
74		00:52		27			224	048	3.6	71	2	X		0.5	4	4	20DB						SOL # 27					
75		02:32		27			230	047	3.6	70	2	X					20DB						EOL # 27					
76		02:36		28			230	061	3.7	70	2	X		0.5	4		20DB						SOL # 28					
77	304	03:45		28			200		3.6	69	2	x					20DB						EOL # 28					
78																							EQUIPMENT RECOVERED					
79	304																											
80																												
81	305	12:11																					Equipment deployed					
82		12:18		29			200	050	3.9	60	2	X		0.5	4	4	20db						SOL # 29					
83		12:48		29			211	075	3.7	54	2	X		0.5	4	4	preset											
84		13:29		29																			Equipment recovered ,sidescan prolem					
85		13:40		30																			Equipment re deployed Huntec only					
86		14:25		30			215		4.5	55	2	X							INT	EXT			EOL # 30					
87		14:27		31			215	042	4.8	55	2	X											SOL # 31					
88		15:20		31			270																EOL # 31					
89		15:22		32			270	a/c	4.2	59	2	X											SOL # 32					
90		16:19		32			171	A/C	3.6														EOL # 32					
91		16:20		33			172		3.7	63	2	X		0.5	4	4	Preset						SOL # 33					

92		16:56		33				A/C														EOL # 33
93		16:57		34			214		3.9	64	2	X		0.5	4	4						SOL # 34
94		17:21		34			224	A/C	3.9	65	2											EOL # 34
95	305	17:22		35			226	021	4	62	2	X		0.5	4	4						SOL # 35
96		17:55		35			208	A/C	3.7	60	2	X							INT	EXT		EOL # 35
97		17:57		36			208	089	3.6	64	2						20db					SOL # 36
98		18:17		36			239	A/C														EOL # 36
99		18:20		37			256	001	4.3	57	2	X		0.5	4	4						SOL # 37
100		19:45		37			317	006	4	63	2	X										EOL # 37
101		19:45		38																		SOL # 38
102		20:00		38																		eol # 38
103		20:04																				Equipment recovered
104																						
105																						
106																						
107																						
108	308	12:35		39																		Equipment deployed
109		12:44		39			93	192	4.5	30	2	x		0.5	4	4						SOL # 39
110		13:01		39																		eol # 39
111		13:02		40			119	203	4.3	29	2											SOL # 40
112		13:35		40			219															EOL # 40
113		13:35		41			219	199	5	47	2	X										SOL # 41
114		14:24		41			285		4.8	61	2	X										EOL # 41
115		14:24		42			285	184	4.8	61	2	X										SOL # 42
116		14:47		42																		EOL # 42
117		14:47		43			212	217	4.6	63	2	X										SOL # 43
118		15:27		43			108	A/C	5	61												EOL # 43
119		15:27		44			144	210	5	61	2											sol # 44
120		16:31		44																		EOL # 44
121																						Equipment recovered. Heading to Argenti

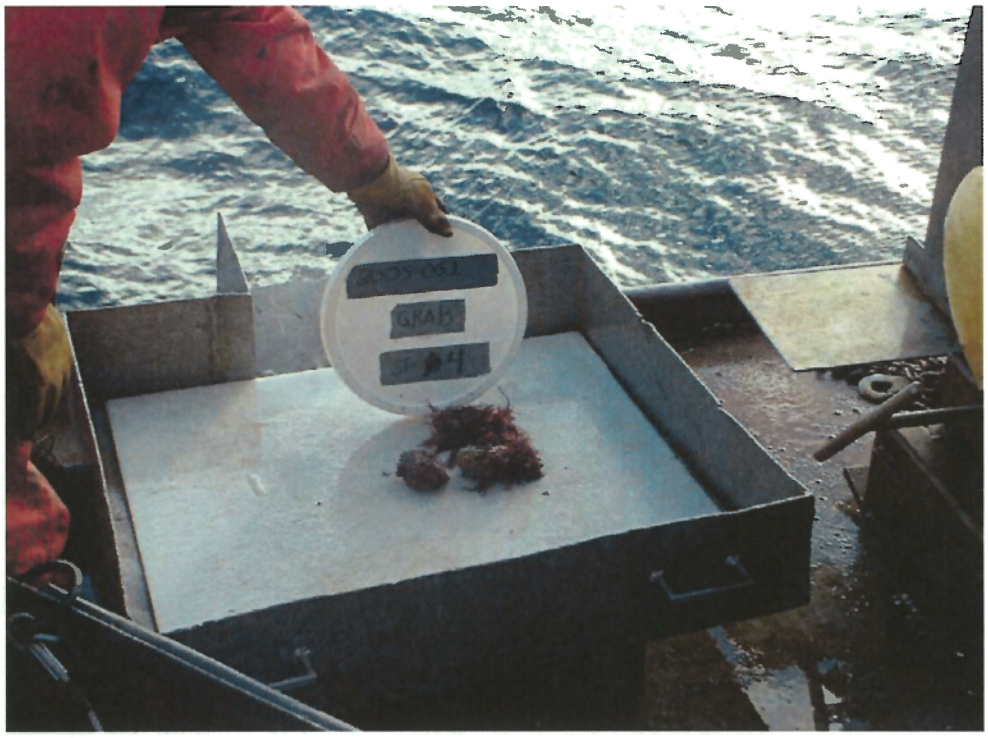
APPENDIX 8: DECK PHOTOS OF GRAB SAMPLES



Grab sample 2005-051-001

Grab sample 2005-051-002

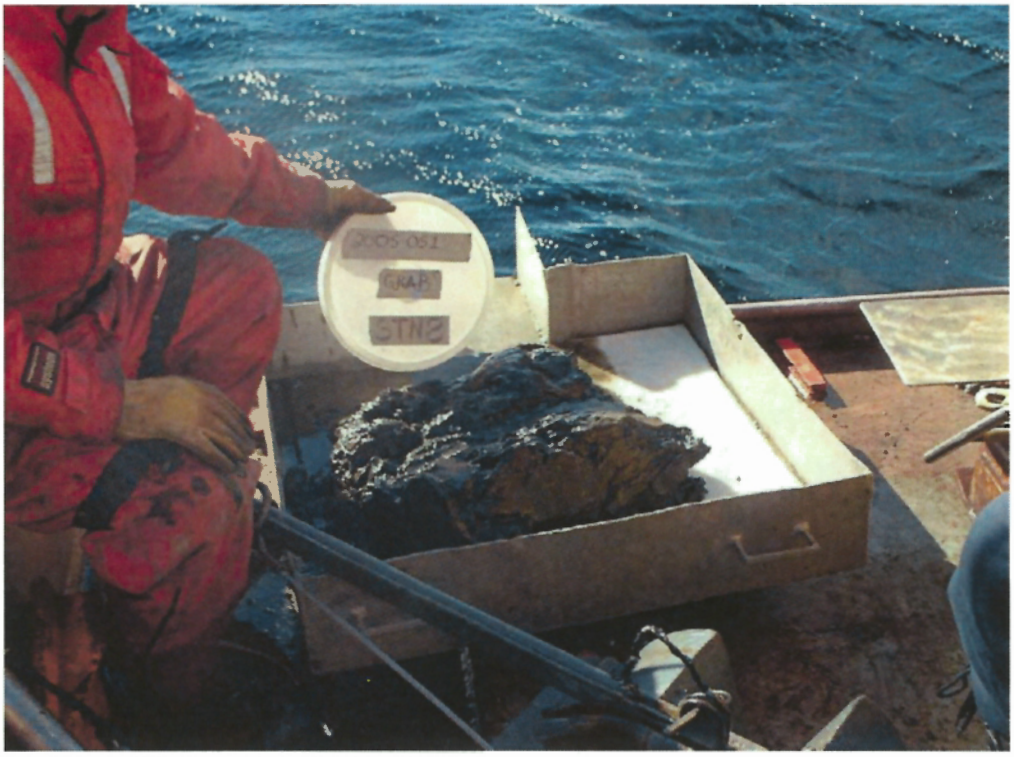
Grab sample 2005-051-003



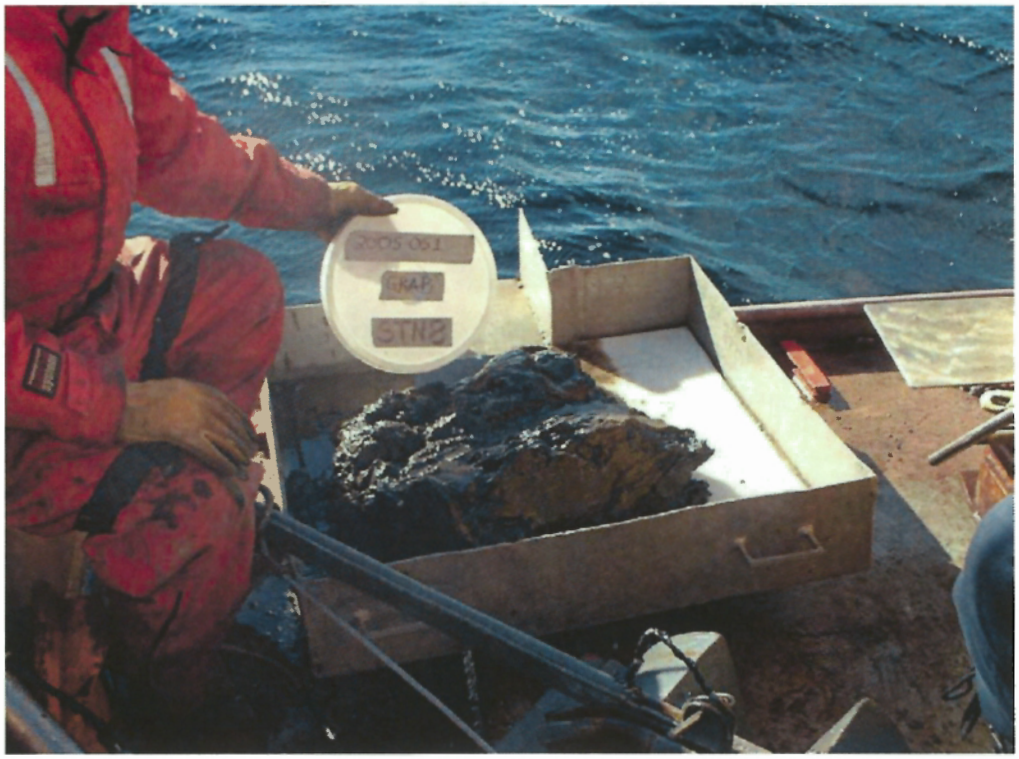
Grab sample 2005-051-004

Grab sample 2005-051-005

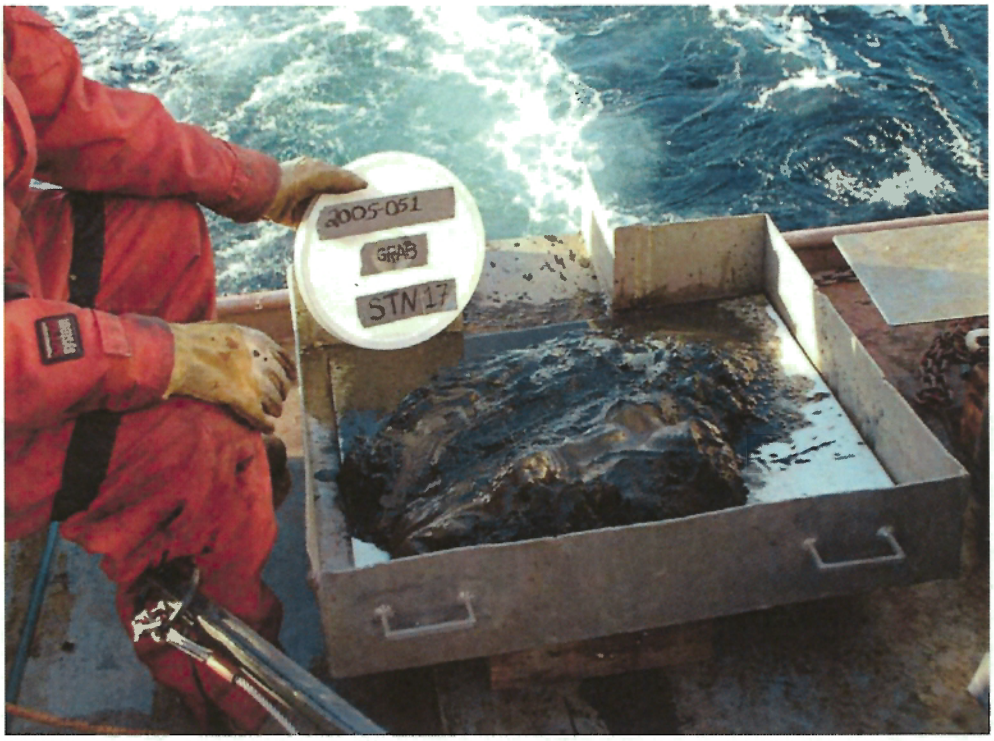
Grab sample 2005-051-006



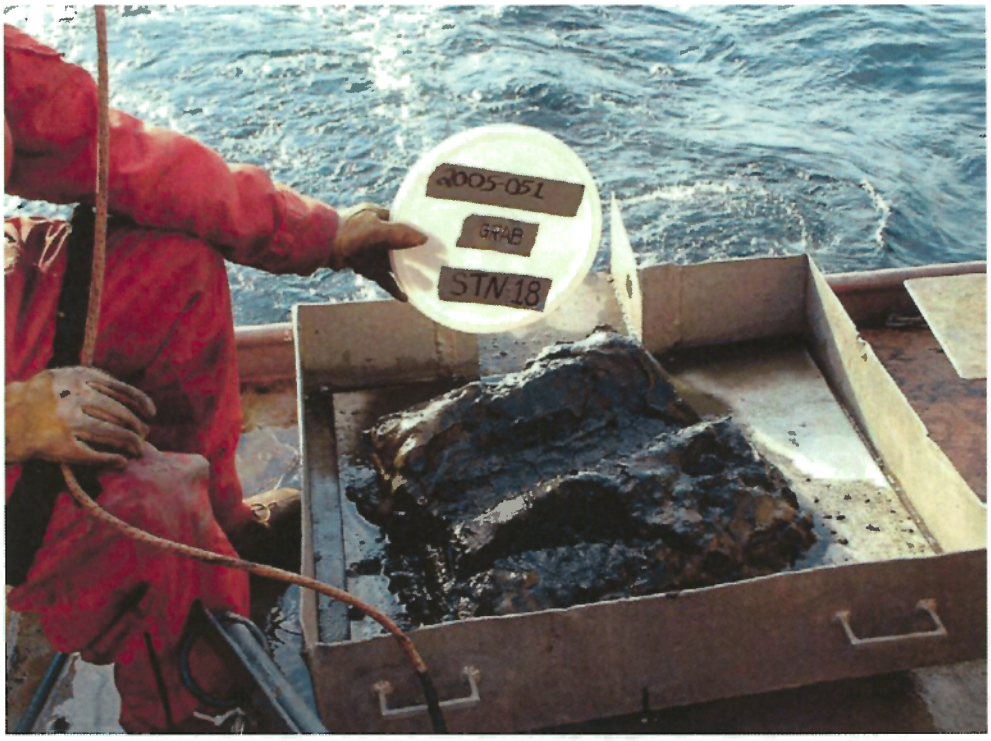
Grab sample 2005-051-007



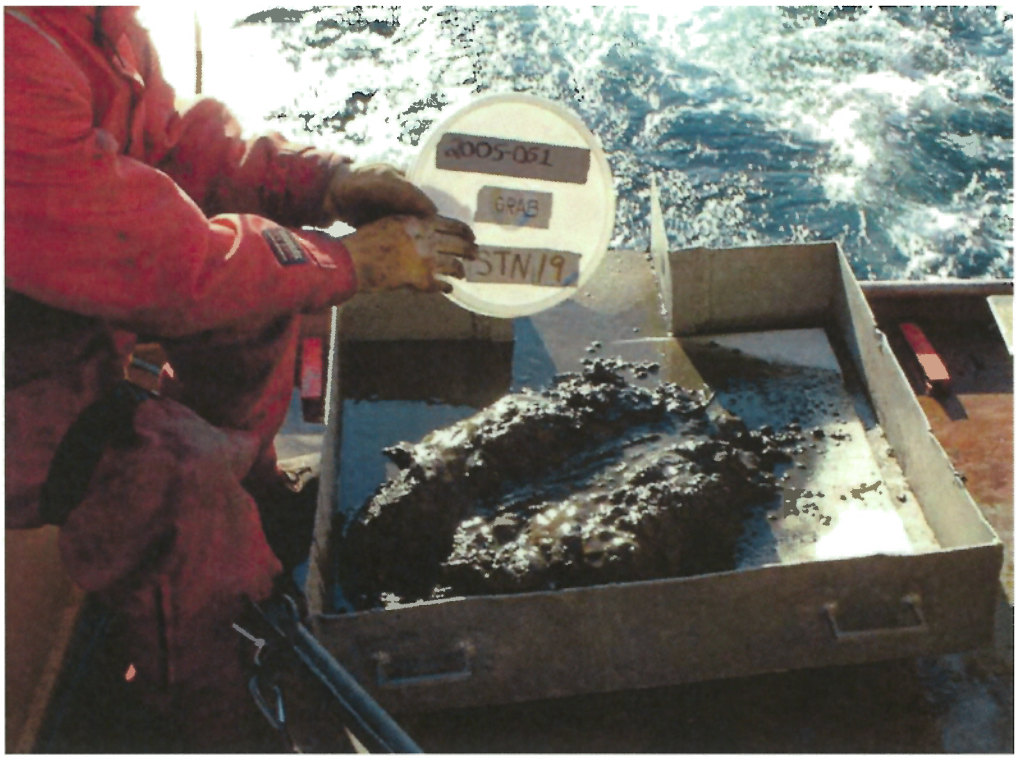
Grab sample 2005-051-008



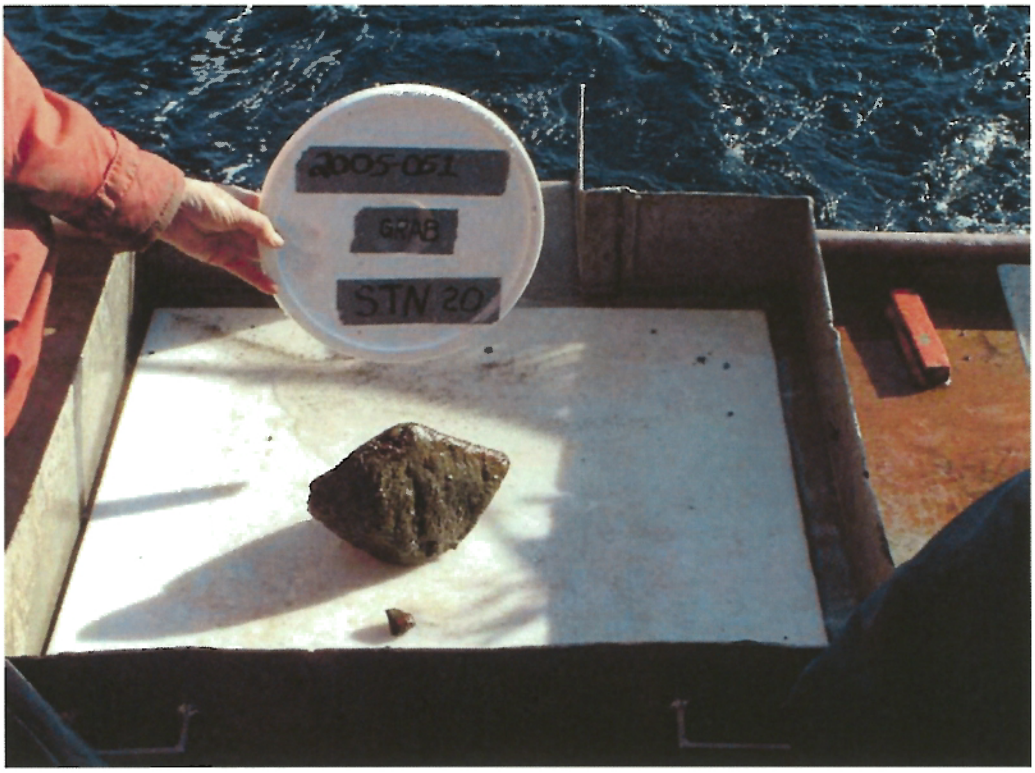
Grab sample 2005-051-017



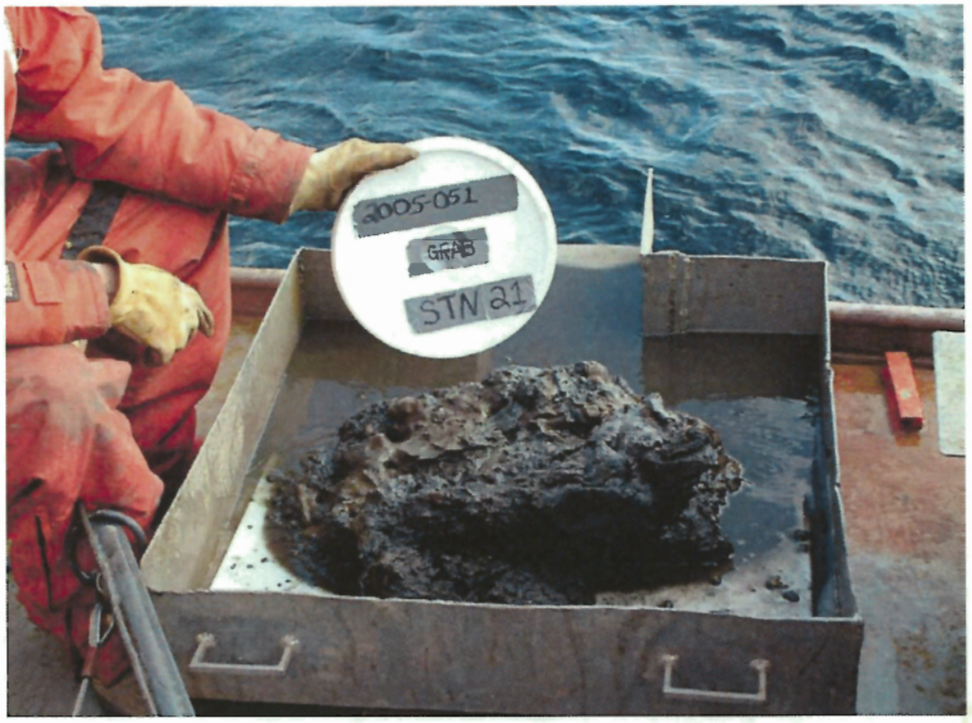
Grab sample 2005-051-018



Grab sample 2005-051-019



Grab sample 2005-051-020



Grab sample 2005-051-021