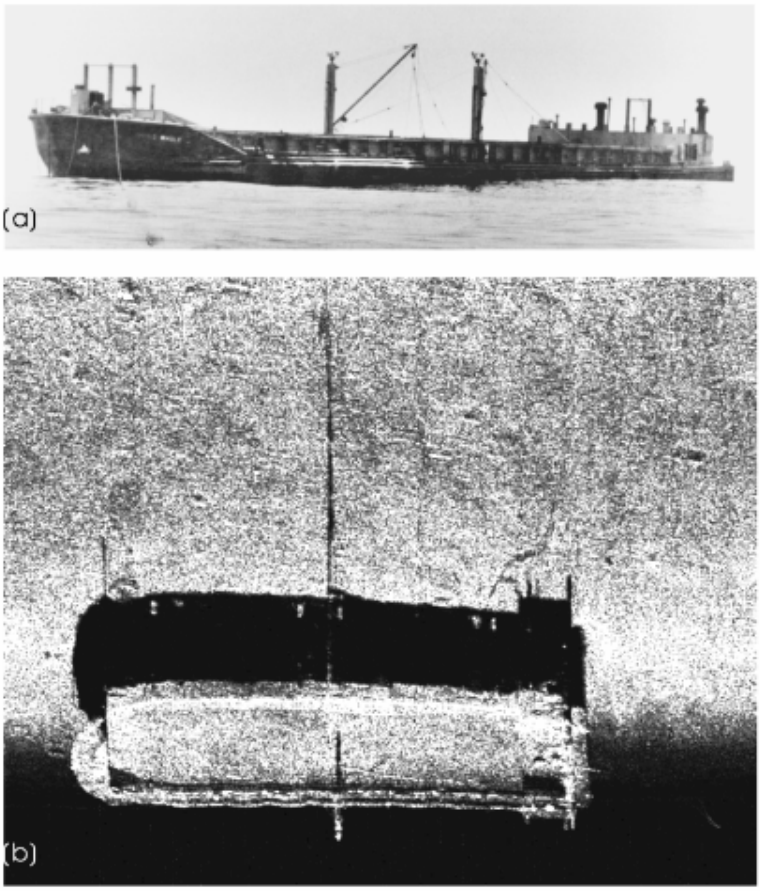
GEOLOGICAL SURVEY OF CANADA
OPEN FILE 4989

Irving Whale Sidescan Sonar and Sediment Sampling Program 20-26 May 1996



D.R. Parrott

2010

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Canada

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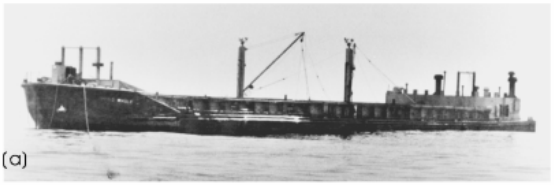
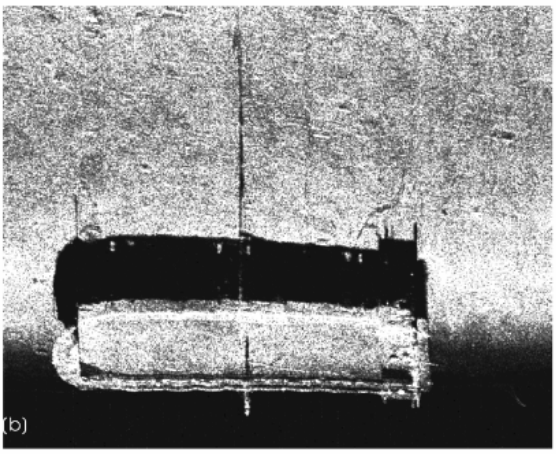
Irving Whale Sidescan Sonar and Sediment Sampling Program 20-26 May 1996





D.R. Parrott

2010

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Parrott, D.R. 2010. Irving Whale Sidescan Sonar and Sediment Sampling Program, 20-26 May 1996; Geological Survey of Canada, Open File 4989, 18 p.

Introduction


Figure 1. The barge IRVING WHALE

The barge IRVING WHALE was built in 1966 by the Saint John Shipbuilding and Dry Dock Company. It measured 82 metres long, 18.5 metres wide, and 5 metres deep (Fig. 1). On 7 September, 1970, the IRVING WHALE was under tow by the tug IRVING MAPLE from Halifax, NS to Bathurst, NB. The barge sank, during a storm, in about 67 metres of water on the Magdalen Shelf, Gulf of St. Lawrence (Fig. 2). At the time of sinking the barge contained about 4200 tonnes of heated No. 6 fuel oil (Bunker C). The barge settled slowly by the stern, which allowed a substantial quantity of oil to escape through the tank vents. Recent studies have shown that the heating system used on the barge to heat the fuel in the cargo tanks contained approximately 6800 litres of Therminol FR-1 which is composed of 80% polychlorobiphenyls (PCBs) (Aroclor 1242), and 20% chlorinated benzene (DFO/EC, 1996). Some contamination of seafloor sediments near the barge has occurred. Attempts to raise the barge during 1995 were halted in August, as a result of a legal injunction filed by le Societe pour Vaincre la Pollution Inc (SVP).

Since the barge sank in 1970, a number of studies have been undertaken to determine its condition and possible effects on the environment. One aspect of these studies has been to assess the surficial geology and seafloor conditions in the area of the barge. From 20-26 May 1996, the second of two sidescan sonar surveys of the area was undertaken in conjunction with a sediment sampling program in the vicinity of the IRVING WHALE. (The results of the sediment sampling program will be reported under a separate cover.) This survey was part of an on-going joint project between Environment Canada, Transport Canada, Department of Fisheries and Oceans (Coast Guard Canada) and the Geological Survey of Canada of Natural Resources Canada.

Background

A sidescan sonar survey of the seafloor near the barge IRVING WHALE, conducted by the Geological Survey of Canada in 1994 (Parrott, 1994), enabled the interpretation of sediment distribution, and provided preliminary information on the presence of boulders. Observations made during manned submersible dives provided information on the condition of the barge and confirmed the presence of the boulders. Observations of the surficial geology were also made during a salvage program in the summer of 1995 when divers used a water jet to excavate a trench under the barge. The bathymetry near the barge was mapped in 1994 using multibeam bathymetry techniques and showed that the barge is situated at the top of a 10 metre high rise on the seafloor. The sidescan sonar surveys were performed to map the seafloor sediments, and to identify boulders and other material (such as moorings, ropes, wire, etc. which may have been lost during previous operations) in the area. The results of the May 1996 sidescan sonar survey will also be used as a baseline to monitor any spills or equipment left on the seafloor. Grab samples were taken near the location of the sunken barge to assist with the interpretation of the sidescan data, and to determine the extent of sediment contamination near the barge.

The IRVING WHALE site

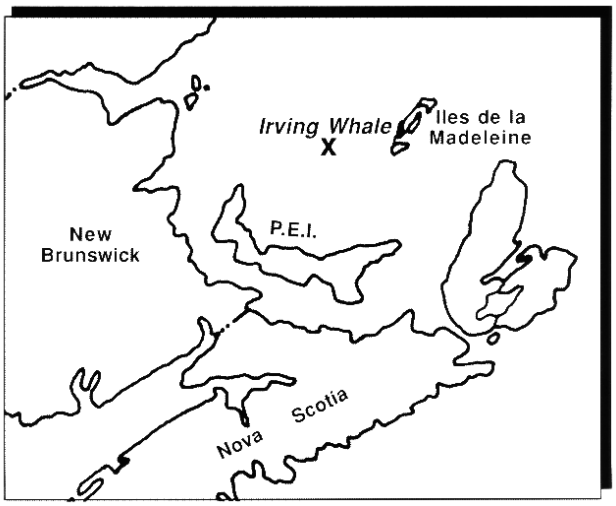


Figure 2 Gulf of St. Lawrence showing the location of the sunken barge IRVING WHALE.

The IRVING WHALE sank on a portion of the Magdalen Shelf, (Fig. 2) which is interpreted to have been glaciated several times in the past. Glaciation resulted in the deposition of glacial till, (ice-contact sediments), and glaciomarine (ice-proximal) sediments (Loring and Nota, 1973). During the most recent of these glaciations, at about 10-12 ka (10,000-12,000 years before present), sea level was lowered to about 60 to 90 metres below the present level, exposing much of the shelf (Piper et al., 1990, Syvitski, 1992).

The surficial sediments in the area consist of a veneer of sands and gravels, partially derived by reworking of pre-existing glacial sediments during a sea level transgression to its present level from the lowered levels during the last glaciation (Josenhans et al., 1990). The sediments have been modified during these changes in sea level, which subjected the marine areas to beach-zone reworking of the glacial sediments. During the low stand of sea level, beach-zone reworking removed fine material from the deposits and produced sandy and gravely deposits (basal transgressive lag). The rise in sea level left littoral (sub-marine beach related) sandy, shelly and gravelly deposits. Modern wave and tidally generated currents continue to winnow and transport sediments in this area. The boulders were probably part of the original sediments and have been exposed by winnowing of these sediments. This concentration of boulders would have been supplemented by ice rafted boulders.

The presence of the gravel deposit and boulders has been confirmed by observations from the Department of National Defense manned submersibles SDL-1 and PISCES, deployed from the CFAV CORMORANT (W. Vickery, 1994, pers. comm.). Recent observations, using manned submersibles and divers, indicate that, in the immediate vicinity of the barge, the surficial sediments occur as a veneer of sands, gravels and boulders up to 10 cm thick. These sediments overlay deposits of sandstone interbedded with fine sediment. In 1995 divers began to excavate a trench under the barge using a water jet, and were able to dislodge the fine sediments interbedded with the sandstone. The sandstone was brittle and pieces were dislodged by the water jet. The presence of sandstone layers near the surface has caused problems sampling the seafloor sediments with a vanVeen grab sampler in 1994 and with a Shipeck sampler in 1995 and 1996. In all cases, only small amounts of sand/gravel sediment were obtained. During the sampling program it was noted that samples taken on the south side of the barge generally produced a smaller volume of sediments than those in other areas, indicating that there may be less sediment present in this area.

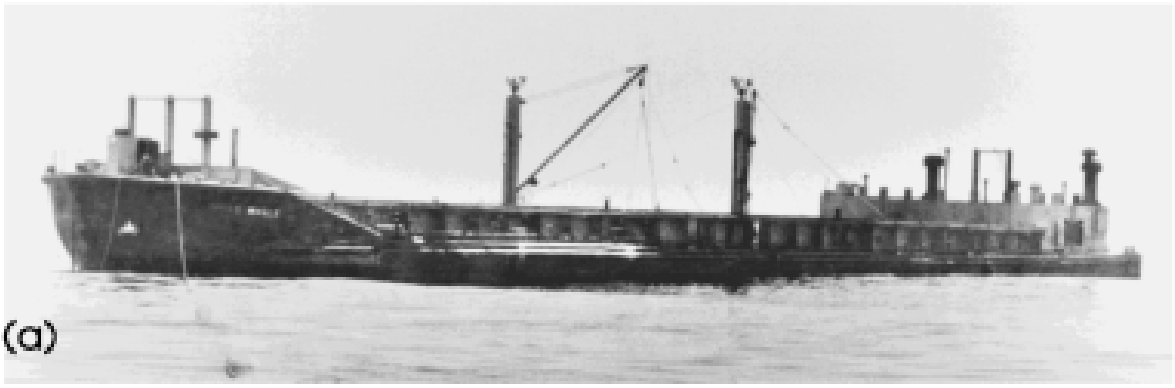
Sediment transport in the area has resulted in the accumulation of 10-20 cm of sand on the seafloor around the perimeter of the barge. This material has been sampled and analyzed for contamination by PCBs. The results of the analysis are reported under a separate cover (DFO 1996).

Sidescan Sonar Survey

The sidescan sonar survey was performed by the Geological Survey of Canada using a Simrad MS992 dual frequency (120 and 330 kHz) sidescan sonar system and recorded on a 4-channel digital data acquisition and display system. Data were displayed as both slant-range corrected and uncorrected data on Alden thermal recorders. The hardcopy records were annotated with time and location for later use in target identification, and calculation of boulder distribution. The sidescan sonar data were recovered from digital tape, imported into a Geographic Information System (GIS), slant-range corrected, integrated with navigation and combined to produce a mosaic of the survey area. Selected records were also replayed from digital tapes for inclusion in this report and to provide a hardcopy record of seafloor conditions at the IRVING WHALE site.

Positions were determined with a Global Position System with real time Differential corrections (D-GPS) and displayed using AGCNav, a navigation display and logging program specifically developed for marine geoscientific surveying. AGCNav accepts input from a range of navigation devices, most notably a GPS or Differential GPS receiver and produces a display of the ship and towed bodies in real time.

The photographs in Figures 1 and 3(a) show different views of the barge. Note the general layout of the barge with its large open deck. The various parts of the superstructure such as the navigation masts, derricks, cargo booms, and vents are quite evident. Figure 3 compares a photograph of the IRVING WHALE with a sidescan sonar image. The sidescan sonar image shows overall structure of the barge with its open cargo deck, cargo bin side bulwarks, high forepeak and stern deckhouse. The image also shows the cargo boom on the deck of the barge and various parts of the superstructure. The acoustic shadow (shown as the large dark patch behind the barge) shows the outlines of various derricks, bollards, and pipes on the barge which can be seen in the photo. Access openings through the cargo bin bulwarks can be seen as the bright spots in the shadow. Also evident on the seafloor in the sidescan sonar image in Figure 3(b) are isolated bright (light coloured) areas with small shadows (dark areas) immediately behind. These features indicate the presence of boulders on the seafloor.



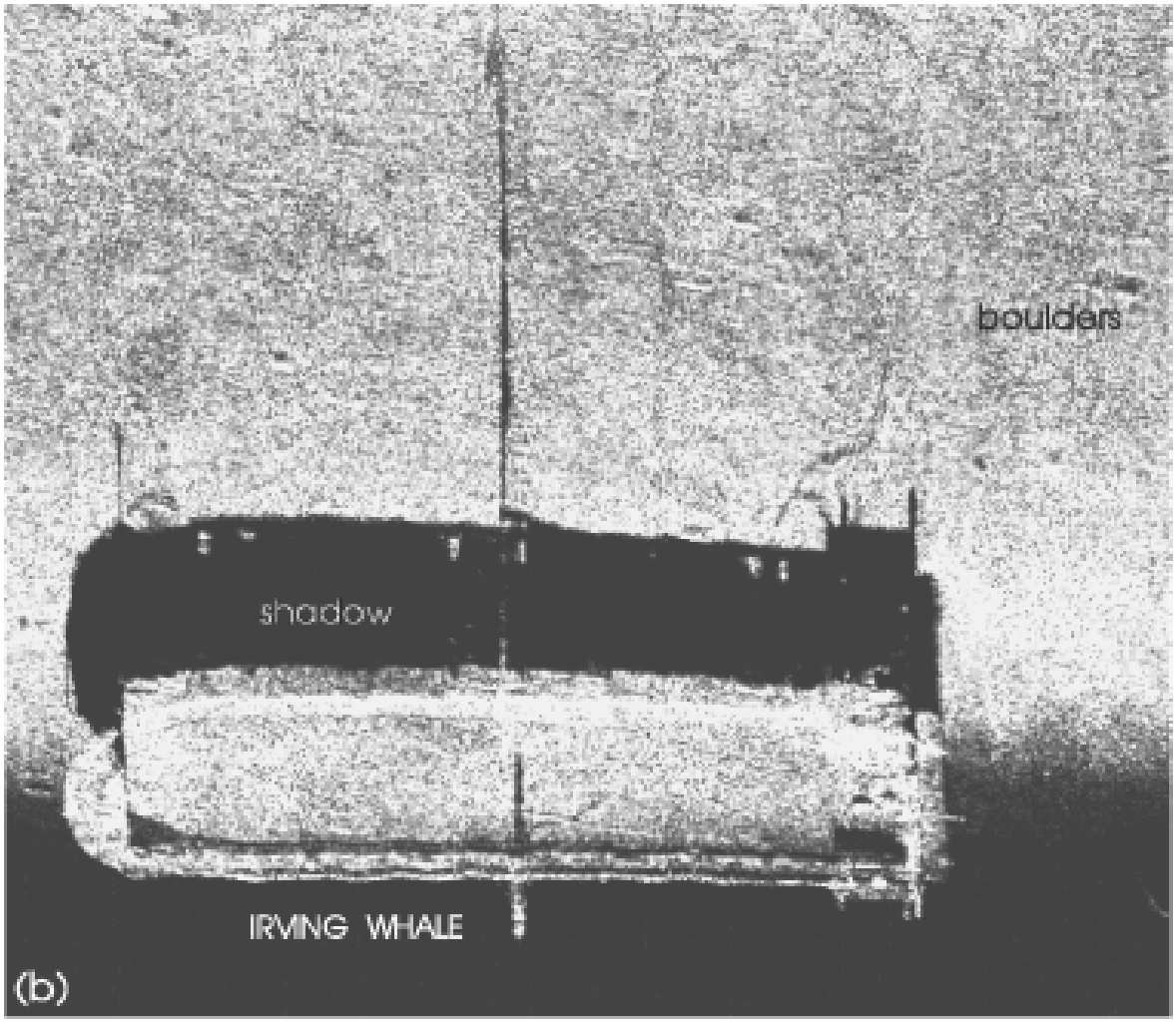


Figure 3 Comparison of a photograph (a) of the IRVING WHALE with a sidescan sonar image (b) from the 1996 survey of the barge.

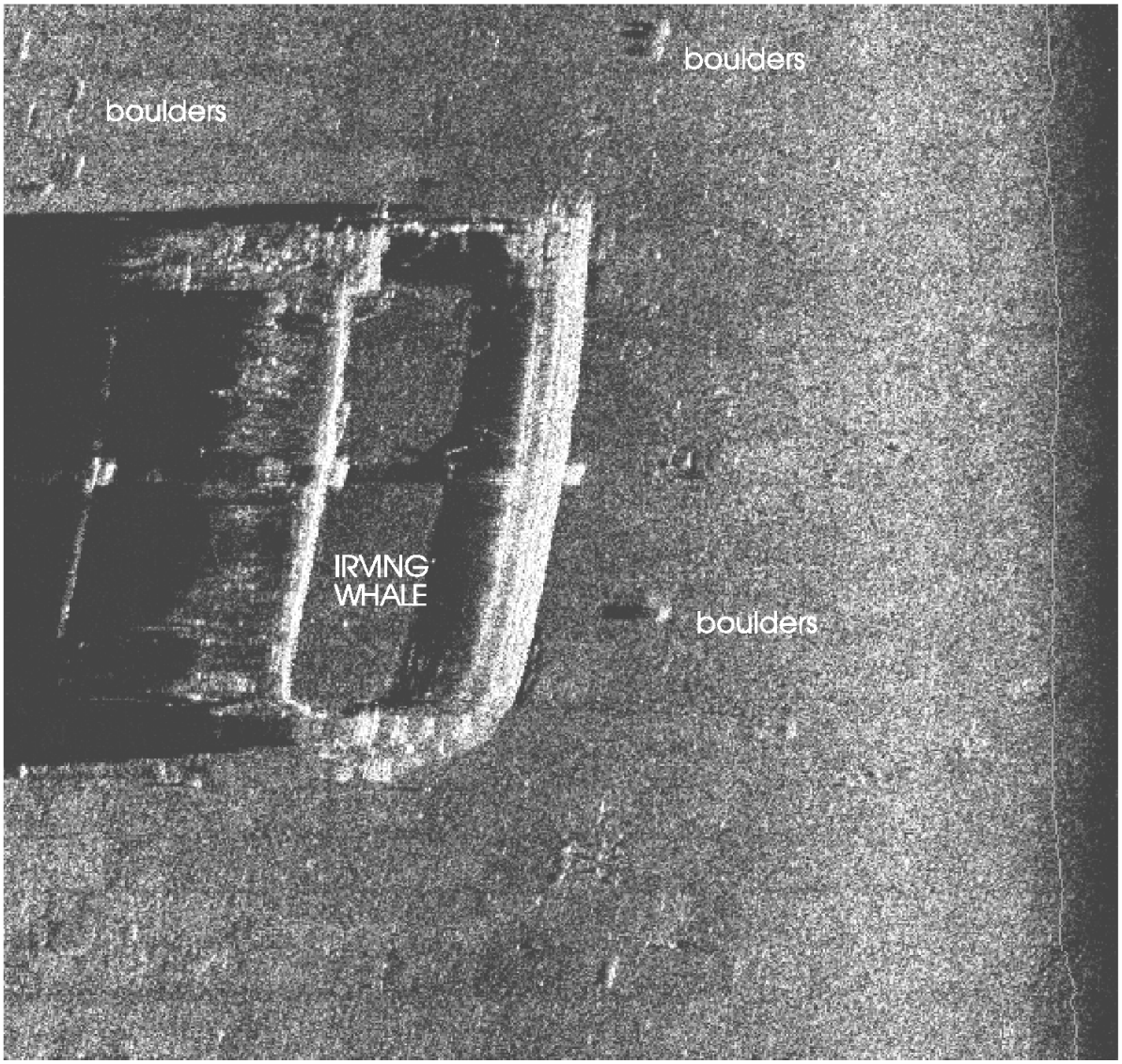


Figure 4. Sidescan sonar image of the IRVING WHALE showing the seafloor conditions immediately east of the barge.

The sidescan sonar image of the IRVING WHALE shown in Figure 4, produced from a survey line east of the barge, shows the general layout of the barge. Isolated bright (light coloured) areas on the seafloor with small shadows (dark areas) indicate the presence of boulders. In particular notice the targets (labelled boulders) on the port (east) side of the barge near the bow and off the stern. The targets (labelled boulders), near the stern on the starboard (west) side of the barge, are also present in the sidescan sonar image shown in Figure 5.

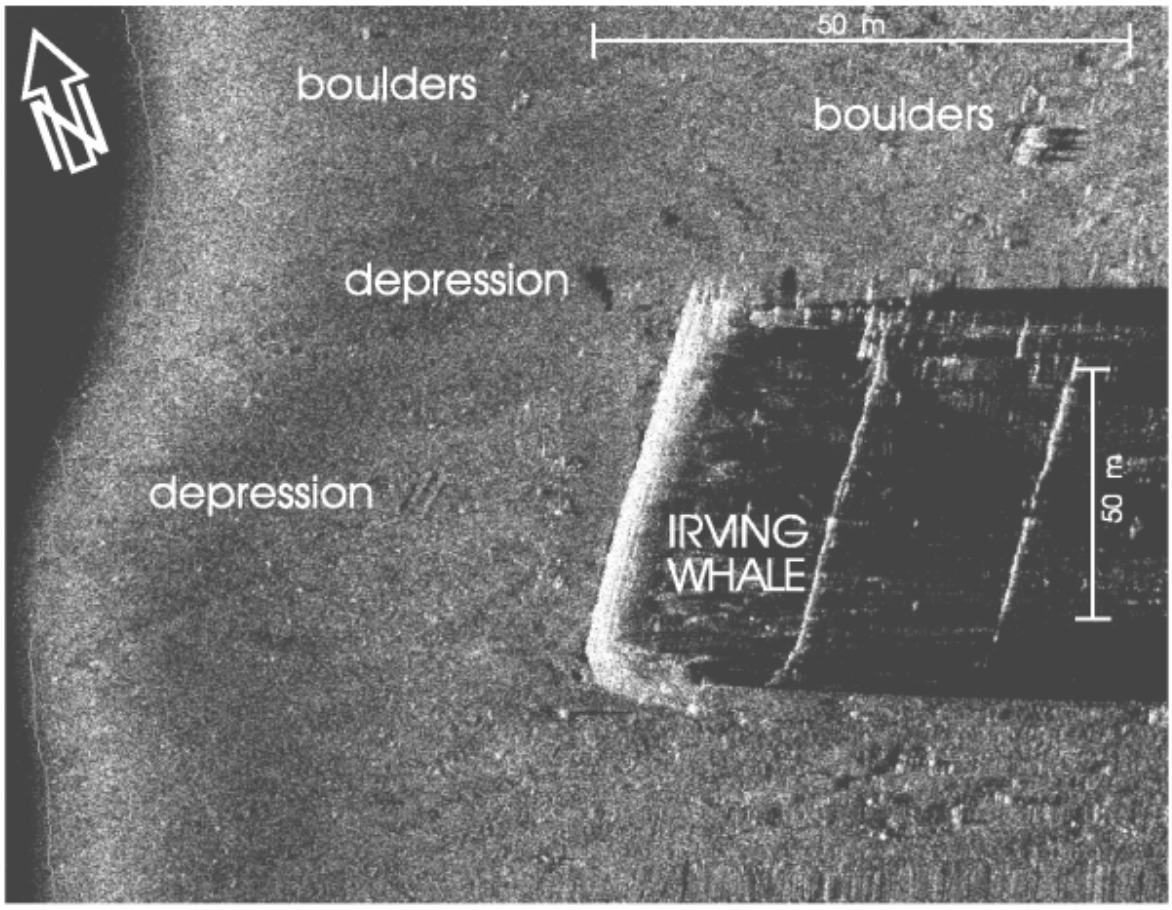


Figure 5. Sidescan sonar image of the IRVING WHALE showing the seafloor conditions immediately west of the barge.

The sidescan sonar image of the IRVING WHALE in Figure 5 is from a survey line west of the barge. Boulders are indicated by isolated bright (light coloured) areas with small shadows (dark areas). The target north of the barge (labelled boulders) is also visible in Figure 4. Several depressions in the seafloor are visible: one near the mid-point on the barge and others near the stern.

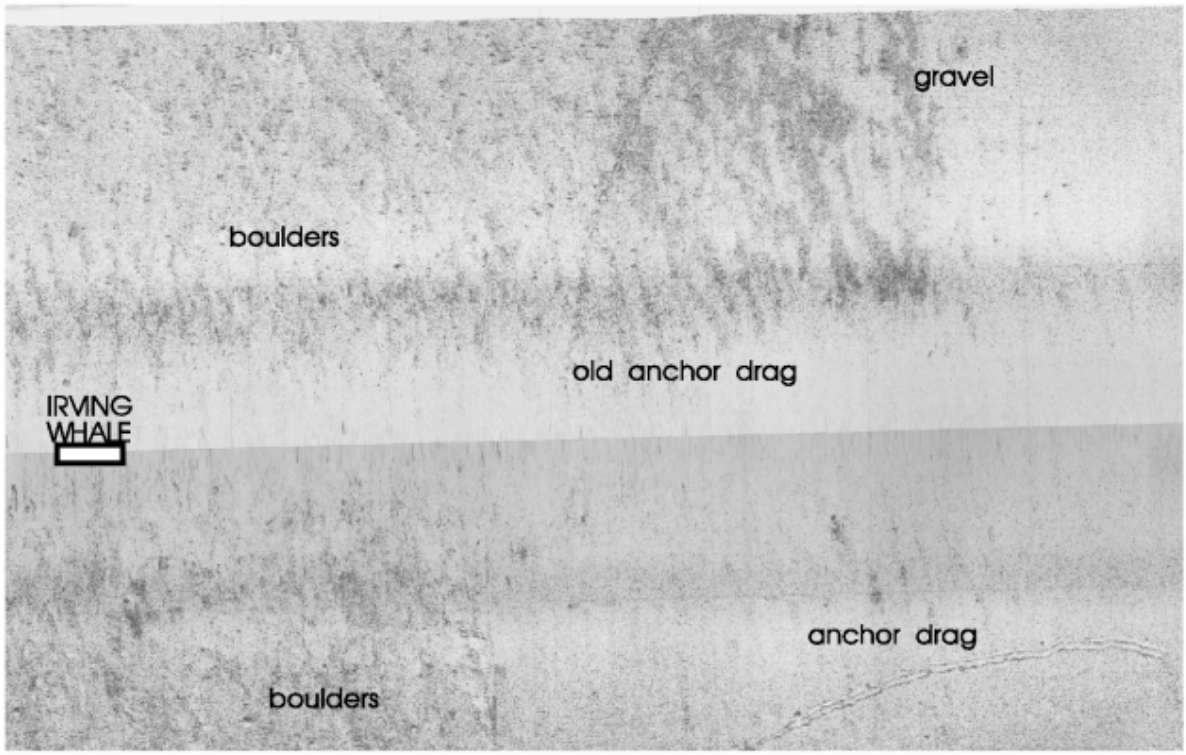


Figure 6. Sidescan sonar record taken directly over the position of the barge. Note in order to optimize the display of the data in this area, the data in Figures 6 and 7 are shown with reversed polarity when compared to other images in this report. The approximate position of the barge in shown. Several anchor drag marks are present. The seafloor surrounding the barge can be seen to contain numerous boulders

The sidescan sonar record shown in Figure 6 was taken directly over the position of the barge. The geometry of the sidescan sonar towfish with respect to the barge on this survey line allowed the sidescan sonar backscatter from the barge to be removed in the slant range correction processing. The position of the barge is indicated on the left side of the diagram. A 150-200 metre long furrow in the seafloor southeast of the barge, is interpreted as having been caused by dragging an anchor or mooring over the seafloor. The scour is characterized by distinct berms on each side forming a sharp boundary between the disturbed and undisturbed seafloor, indicating a recent scour. The furrow comes within 150 metres of the barge. Another scour, east of the barge, has less distinct boundaries and shows signs of degradation as a result of infilling by sediment transport. It is interpreted to be older than the other scour. The areas of high reflectivity on the record (dark areas) indicate the presence of gravel and boulders on the seafloor.

Figure 7 shows an enlargement of the upper portion of the sidescan sonar record shown in Figure 6. The isolated, highly reflective (dark) objects which show a shadow zone (light) have been interpreted as boulders 0.5 metre or larger. Numerous other targets can be seen and have been interpreted as smaller boulders and gravel.

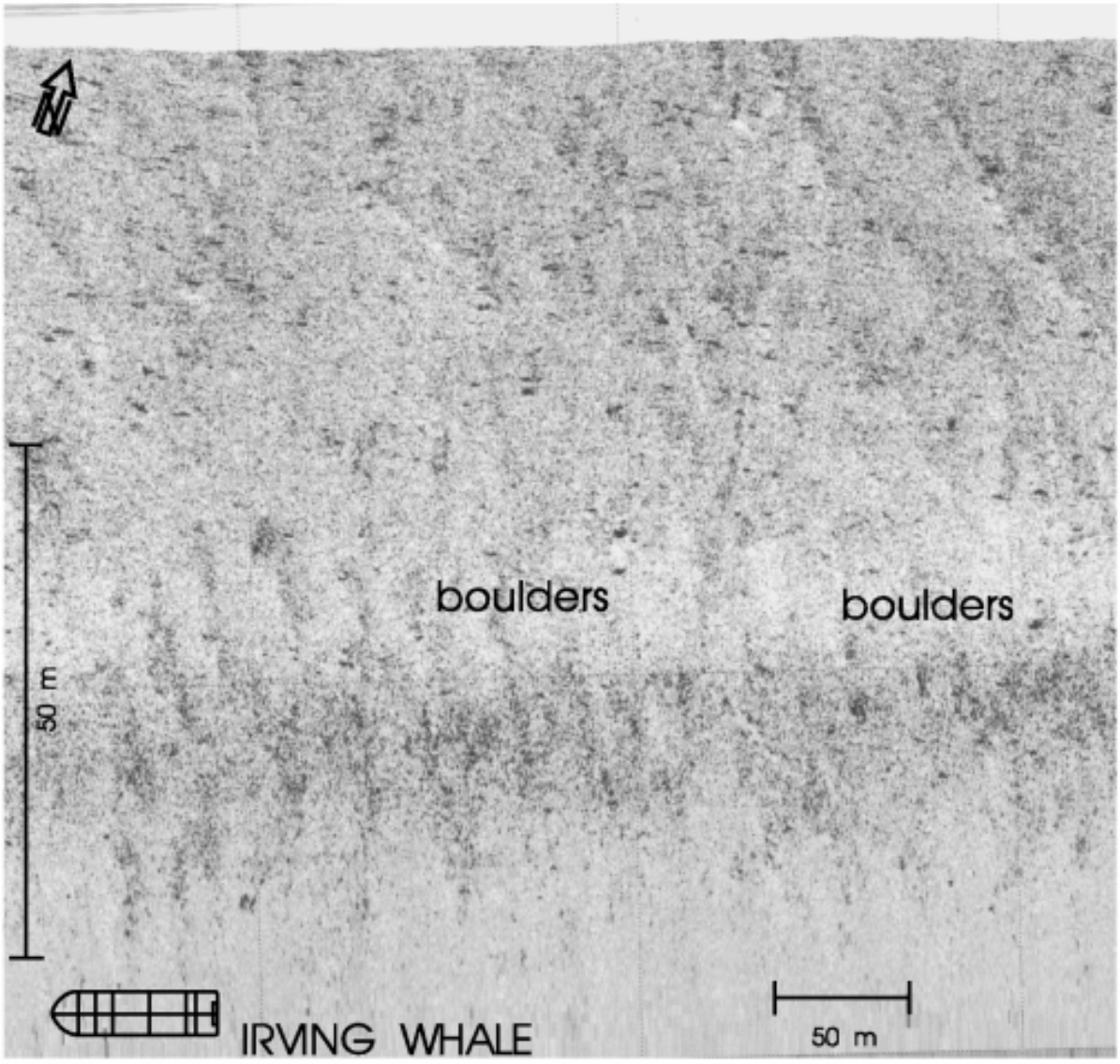


Figure 7. Enlargement of the sidescan sonar record shown in Figure 6 of the seafloor immediately adjacent to the IRVING WHALE. Note in order to optimize the display, the data in Figures 6 and 7 are shown with reversed polarity when compared to other images in this report. The dark reflections on the record indicate the presence of gravel and boulders.

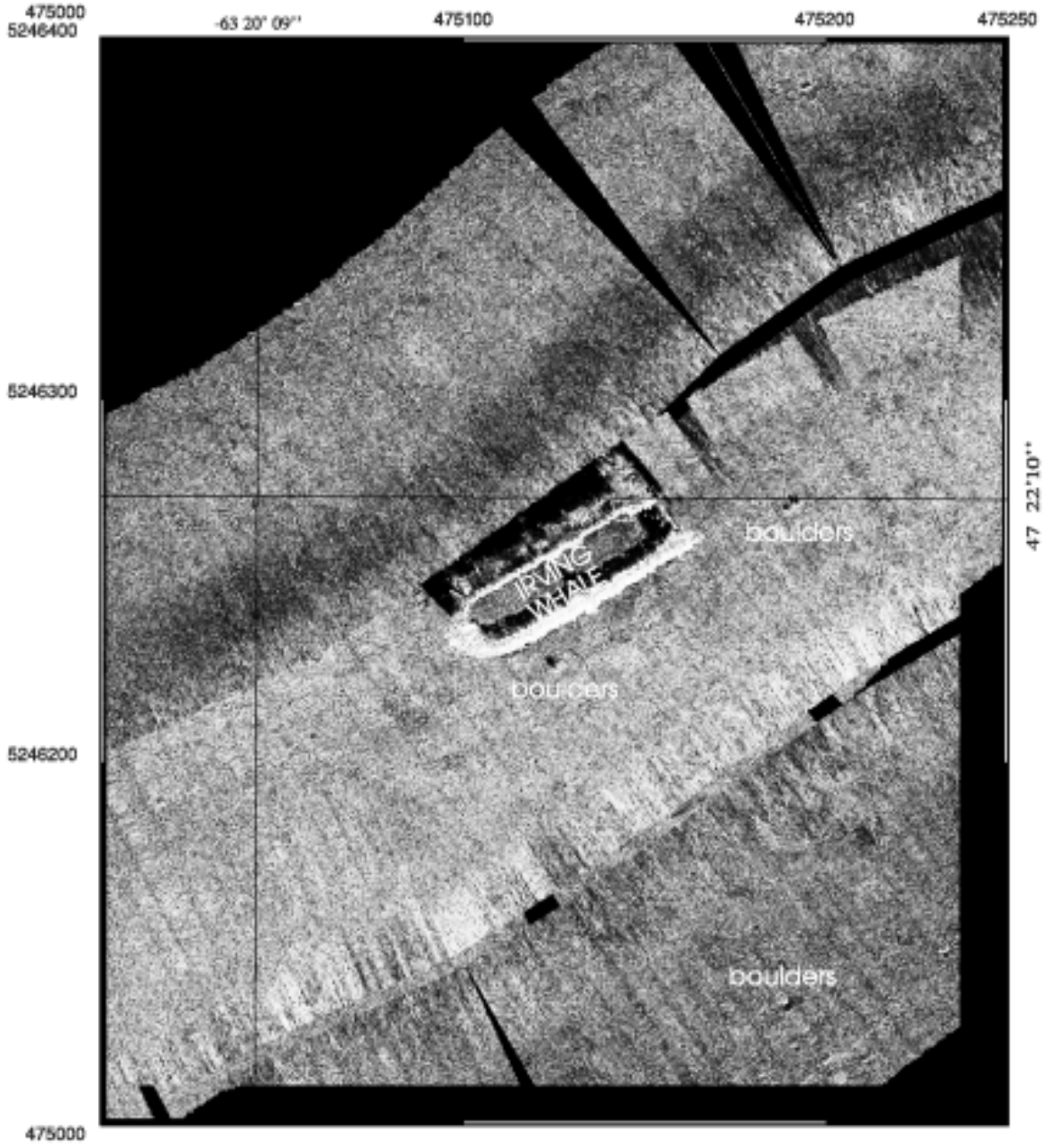


Figure 8. Sidescan sonar mosaic of the IRVING WHALE site

Mosaics of the sidescan sonar data from the IRVING WHALE site show the position of the barge, the distribution of sediments and features (such as those labelled boulders) on the seafloor.

Sampling Program

Grab samples were taken near the location of the sunken barge to assist with the interpretation of the sidescan data, and to provide information on the potential for sediment contamination in the area. In 1994 and 1995 sediment samples were taken in a grid, 100 m, 500 m, and 1000 m from the barge. From 20-26 May and 10-12 June 1996, a sediment sampling program was undertaken near the IRVING WHALE to complement these earlier sampling programs. Sediment samples were taken with a Shipek grab sampler. Many of the sampling attempts produced small amounts of fine-grained sand. Duplicate samples were taken at these location to obtain a sufficient quantity of sediment for chemical analysis.

Additional details of the 1994 and 1995 sampling programs are avialable in Parrott (1994, 1995) and results of the analysis for PCB concentrations are available under a separate cover (DFO 1996).

The locations of the samples relative to the barge from the 1996 sampling program, are shown in Figure 9 and reported in Table 1.

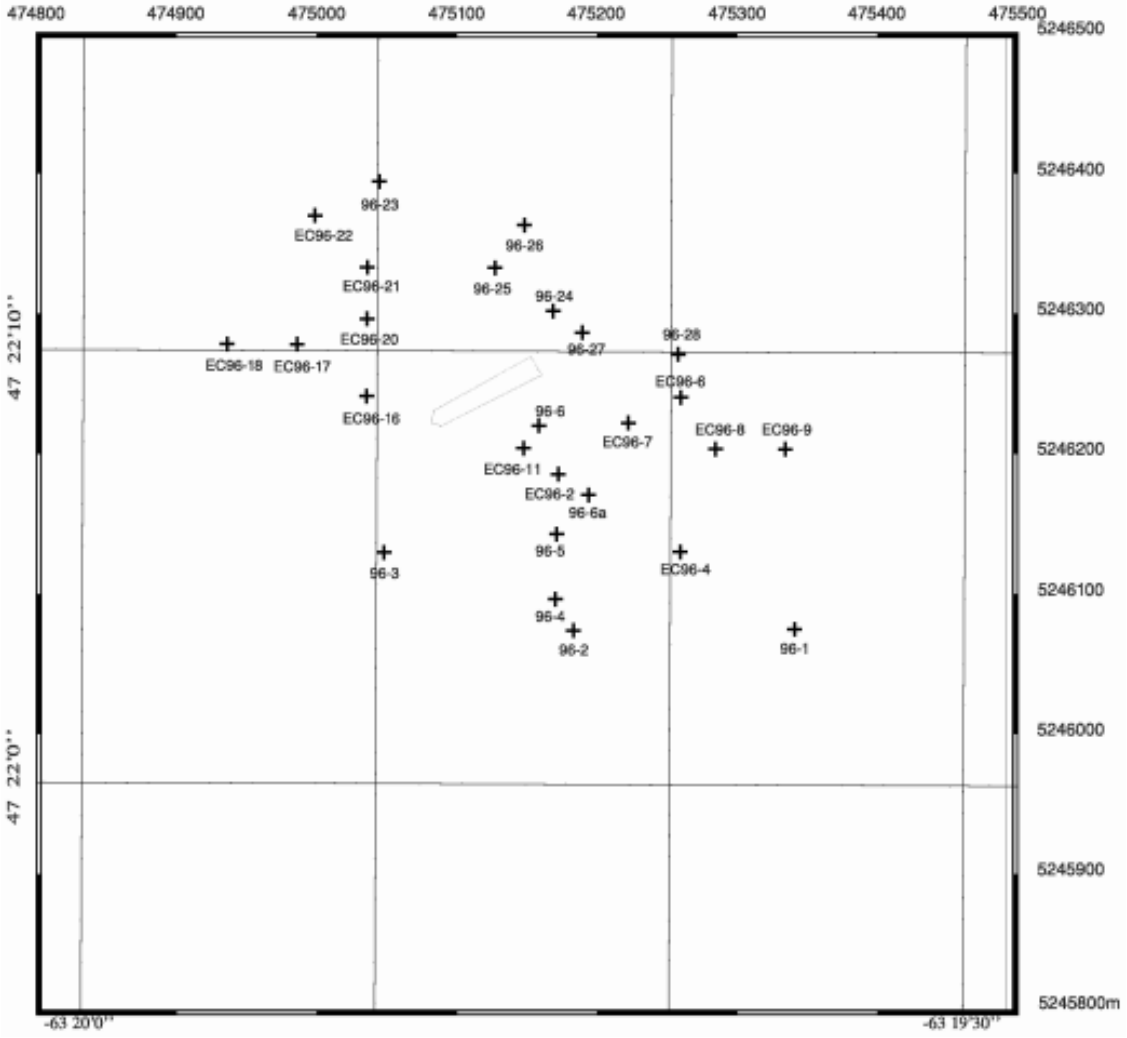


Figure 9. Location of sediment samples taken in 1996near the barge IRVING WHALE. Samples labelled 96-1 to 96-50 were taken from the CCGS Earl Grey during May 1996. Samples labelled EC96-1 to EC96-22 were taken by Environment Canada during June 1996.

Sample	Lattitude	Longitude	Relative position
96-1	47.36767	-63.32657	250 m SE of barge
96-2	47.36766	-63.32868	200 m S of barge
96-3	47.36816	-63.33049	100 m SW of barge
96-4	47.36786	-63.32886	175 m S of barge
96-5	47.36828	-63.32884	100 m S of barge
96-6	47.36898	-63.32902	25 m S of barge
96-23	47.37056	-63.33056	175 m NW of barge
96-24	47.36972	-63.32889	50 m NE of barge
96-25	47.37000	-63.32944	75 m N of barge
96-26	47.37028	-63.32917	100 m N of barge
96-27	47.36958	-63.32861	50 m E of barge
96-28	47.36944	-63.32769	100 m E of barge
96-50	47.34950	-63.36783	
control	47.21650	-63.55375	
EC96-2	47.36867	-63.32883	100 m S of barge
EC96-4	47.36817	-63.32767	150 m SE of barge
EC96-6	47.36917	-63.32767	100 m E of barge
EC96-7	47.36900	-63.32817	75 m E of barge
EC96-8	47.36883	-63.32733	150 m E of barge
EC96-9	47.36883	-63.32667	200 m E of barge
EC96-11	47.36883	-63.32917	25 m S of barge
EC96-16	47.36917	-63.33067	50 m W of barge
EC96-17	47.36950	-63.33133	100 m W of barge
EC96-18	47.36950	-63.33200	150 m W of barge
EC96-20	47.36967	-63.33067	100 m NW of barge
EC96-21	47.37000	-63.33067	125 m NW of barge
EC96-22	47.37033	-63.33117	150 m NW of barge

Table 1. Locations of samples taken in the 1996 sample programs near the barge IRVING WHALE. Samples labelled 96-1 to 96-50 were taken from the CCGS Earl Grey during May 1996. Samples labelled EC96-1 to EC96-22 wre taken by Environment Canada during June 1996.

Access to Geophysical Data

The sidescan sonar data collected during this survey are archived at the Geological Survey of Canada - Atlantic, in Dartmouth Nova Scotia. For access to the geophysical data and samples contact the senior scientist for the survey, Russell Parrott (902-426-7059) or Susan Merchant of the GSC-A Curation group (902-426-3410). Available data consist of the field collected graphical records for the sidescan sonar digitally processed sidescan sonar mosaics, ExaByte tapes containing the sidescan sonar data in SEG-Y format, and a CD-ROM containing the sidescan sonar data in SEG-Y format.

Proposed Future Work

This present survey has defined the seafloor conditions at the site of the barge IRVING WHALE prior to salvage operations. The survey has defined the presence of several sediment types and provided background data to assist in planning salvage operations. Indications of reworking of the seafloor sediments by modern seafloor processes have been found.

After the salvage operation has been completed, it is recommended that a follow-up sidescan sonar survey be performed to assess the impact of the salvage operation on the seafloor, and to identify potential unsalvaged debris.

References

Department of Fisheries and Oceans, and Environment Canada. The furhter assessment of the recovery of the IRVING WHALE in the light of the presence of PCBs. March 1996.

Department of Fisheries and Oceans - Science Branch. Potential consequences of a PCB spill from the barge IRVING WHALE on the marine environment of the Gulf of St. Lawrence. Contribution from DFO-Science to the Further Environmental Impact Assessment of the proposed recovery of the IRVING WHALE. Feb 1996

Josenhans, H., Zevenhuizen, J., and MacLean, B. Preliminary seismostratigraphic interpretations from the Gulf. of St. Lawrence; in Current Research, Part B, Geological Survey of Canada, Paper 90-1B, p.59-75, 1990.

Loring, D.H. and Nota, D.J.G. Morphology and sediments of the Gulf of St. Lawrence: Fisheries Research Board of Canada Bulletin 182. 1973

Parrott, D.R Irving Whale sidescan sonar survey. Unpublished GSC report submitted to Transport Canada and Environment Canada. Oct 1994

Parrott, D.R Irving Whale sediment sampling program 16-20 October 1995. Geological Survey of Canada Open File Report No. 3250 Nov 1995

Piper, D.J.W., Mudie, P.J., Fader, G.B., Josenhans, H.W., MacLean, B. and Vilks, G., Quaternary Geology, Chapter 10 in Geology of the Continental margin of Eastern Canada, M.J. Keen, , and G.L. Williams, (ed.); Geological Survey of Canada, Geology of Canada, no. 2; .475-607 (also Geological Society of America, The Geology of North America, v. I-1), 1990.

Syvitski, J.P.M. Marine geology of Baie des Chaleurs. Geographie physique et Quaternaire, 1992, vol. 46, no. 3, p. 331-348.

Appendix A

Survey Particulars

Name of Vessel:	CCGS Earl Grey
Dates of Survey:	20-26 May 1996
Area of Operation:	Gulf of St. Lawrence
Senior Scientist:	Russell Parrott, GSC

Personnel

Atlantic Geoscience Centre	Environment Canada
Russell Parrott	Sinclair Dewis
Austin Boyce	
Darrel Beaver	

Equipment Specifications and Performance

The area was surveyed with sidescan sonar between 20-26 May 1996 from the CCGS Earl Grey. The sidescan sonar towfish was deployed from the port side of the afterdeck of the vessel, and operated from an equipment room on the main deck. Navigation equipment was placed on the bridge of the vessel, and a display of current ship's position wasprovided to bridge personnel for running lines and station keeping.

SIMRAD MS992 SIDESCAN SONAR

The Simrad MS992 digitally controlled Sidescan Sonar was used to generate high resolution acoustic images of the seabed at a 100 metre range each side of the survey track (200 metre swath). at a line spacing of 75 metres. About 210 metres of towcable were deployed. Data (both 120 and 330 kHz) were digitized and stored on an AGCDIG 4-channel digital data recorder. A hardcopy graphic record of the sidescan sonar data was produced on an Alden 9315CTP thermal recorder. The sidescan sonar system was capable of resolving objects down to a size of about 25 cm. The digital gain settings for the system were logged on field sheets. The Simrad sidescan sonar was deployed from the port side of the vessel.

DIGITAL DATA ACQUISITION

The sidescan sonar data were digitized and logged on an AGCDIG data acquisition system. The clock in the AGCDIG was synchronized to the navigation data logger. All four channels of sidescan sonar were acquired at a sample interval of about 100 microseconds. No gains or geometric corrections were applied to the raw logged data. Channel configurations for the logged data were:

Channel	Use
0	120 kHz port
1	120 kHz starboard
2	330 kHz port
3	330 kHz starboard

Data were also collected on a MUSE Euterpe Sonar Workstation. All four channels of sidescan sonar were acquired at a sample interval of about 100 microseconds. Channel configurations for the logged data were the same as for the AGCdig system. No gains or geometric corrections were applied to the raw logged data. A slant range correction was applied to the data on the MUSE system before display to both a video display and a thermal recorder. Data containing images of the IRVING WHALE were replayed for display after the survey.

BATHYMETRY
Bathymetry data were collected by using the ship's echo sounder. The sounding rolls were annotated with time of day and retained as part of the geophysical data set.

SAMPLING EQUIPMENT
Samples of the surficial sediment in the area were obtained using a Shipeck grab sampler deployed from the port side of the vessel.

NAVIGATION
Navigation was by a differential Global Positioning System. Real Time differential corrections were obtained from the Coast Guard beacon at Port aux Basques, Newfoundland. Accuracy of the navigation was about 4 m.

Data processing

The sidescan sonar records were interpreted in the field to provide an overview of the surficial geology of the survey area.

After the survey, digital sidescan sonar data were recovered from the ExaByte tapes recorded on the digital data recorder and processed by the Geological Survey of Canada to remove geometric distortions present in sidescan sonar data. The geometrically corrected data were then integrated with navigation and processed to remove the effects of varying sensor gain with angle. The sidescan sonar data from adjacent survey lines were then integrated to produce a sidescan sonar mosaic of the harbour using software developed at the Geological Survey of Canada.

Summary of Activities

Friday 17 May 1996 - Mobilization
Geophysical equipment for the survey, consisting of sidescan sonar and the digital data logger were loaded into the GSC vehicle.

Monday 20 May 1996 - Transit to Charlottetown
GSC personnel drove from Dartmouth to Charlottetown, PEI, to join the CCGS Earl Grey.

Tuesday 21 May 1996 - Mobilize and test gear
The CCGS Earl Grey arrived at the dock around 07:00. The survey gear was loaded unto the vessel, and preliminary arrangements made for electrical power and equipment deployment. The sidescan sonar, towfish motion logger, and AGCDIG and MUSE digital data loggers were installed in the workroom on the main deck. The towcable was run to the port side of the main deck where a capstan was available for recovery of the system. The navigation system (AGCNav) was installed on the bridge where it would be visible by the helmsman, and accessible to the officer of the watch. Problems were reported with the shaft of the vessel which delayed sailing.

Wednesday 22 May 1996 - Continue with mobilization
Some problems had been encountered with the differential correction for the GPS navigation system. The problem was isolated to problems with the differential GPS antennae used by the GSC. The differential signal was finally taken from the antennae used by the vessel.

Thursday 23 May 1996 - Transit to site
The CCGS Earl Grey departed Charlottetown at about 18:00 hours and steamed to the IRVING WHALE site.

Friday 24 May 1996 - Deploy weather buoy, perform sidescan sonar survey and seafloor sampling
The vessel arrived at the site at about 06:00. The Environment Canada weather buoy was deployed and checked. A drifter buoy was deployed near the weather buoy. Detailed sidescan sonar survey lines were then run at 100 m range (200 m swath) and an offset of 75 metres between lines. The site was surveyed, before survey operations stopped. Excellent quality records were obtained. Several sediment samples were taken before the winds increased, making station keeping and sampling operations quite difficult and hazardous for those on deck. Sampling was suspended at about 23:00.

Saturday 25 May 1996 - Sampling and transit to Charlottetown
Seafloor sampling resumed at 06:00. Wind velocity had increased making operations difficult and hazardous for those on deck. Sampling operations were suspended at 08:00 and the vessel steamed to Charlottetown. The GSC gear was demobilized and transported back to Dartmouth