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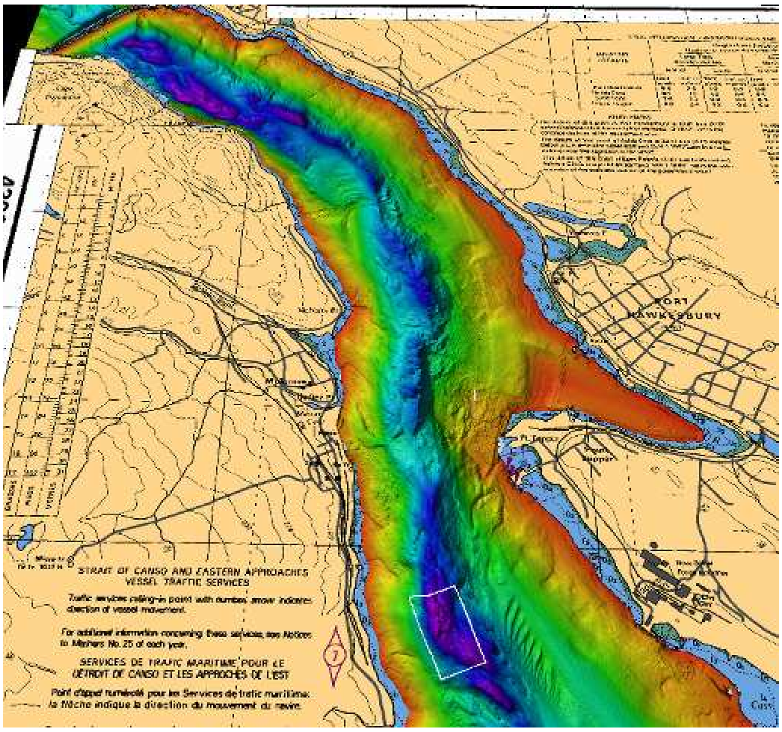
Cruise Hart 2004010 Geophysical and Photographic Surveys in the Strait of Canso, NS, 27 April – 14 May 2004



Multibeam bathymetry of the Strait of Canso showing the location of the offshore disposal site

D.R. Parrott

2010

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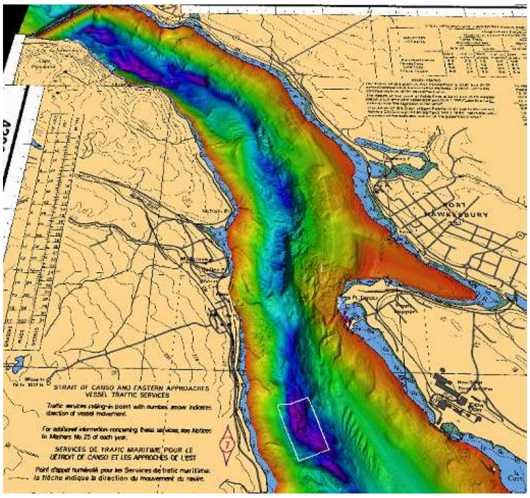

Multibeam bathymetry of the Strait of Canso showing the location of the offshore disposal site

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Background

Canada's ports and harbours require routine dredging to maintain operational viability and allow passage of deep-draft vessels. Dredge spoils from these operations are often placed in offshore disposal sites. Monitoring of these disposal sites is required to understand the long-term fate of the dredged materials.

The Geological Survey of Canada (GSC), a division of Natural Resources Canada (NRCan) have initiated a project "Assessing Marine Environmental Quality in coastal Waters of Eastern Canada", that is designed to assess the effects of human activities in marine environments. The project will provide decision makers with geoscience information to resolve user conflicts and balance competing demands for seafloor use and development with conservation. One of the project priorities is to assess the impact of marine disposal of dredge spoil. Conceptual models will be developed for the behaviour of dredged material at disposal sites in various marine environments, ranging from quite sheltered areas to exposed sites with high wave and tidal current stress. The project focuses on sites with differing degrees of human impact, management, and user conflict. The project will provide outputs, consisting of maps conforming to new marine-mapping protocols, databases in high-priority areas, conceptual models and reports. The primary outcome of this project will be that ocean-management decisions made by stakeholders will be based on sound scientific information collected by NRCan.

Environment Canada (EC) is mandated with the responsibility to administrate the Disposal at Sea Regulation under Part 7 of the Canadian Environmental Protection Act (CEPA). CEPA requires the Minister of Environment to monitor disposal sites.

NRCan and EC have formed a joint program to study the effects of offshore disposal of dredged material with the intention that collaborative efforts will contribute to, and accelerate, objectives of both departments.

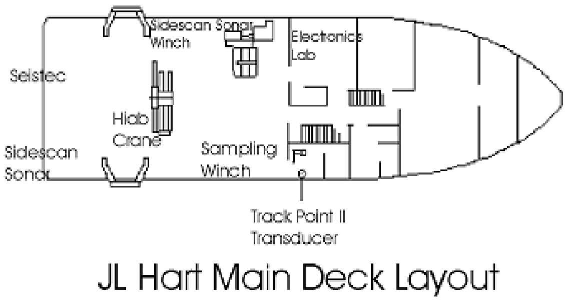
During 2004, several sites were selected for monitoring which provide an opportunity for case studies of the effects of disposal activities in unique environments: a sheltered coastal inlet in Port Hawkesbury, NS; a tidal estuary in Miramichi, NB; and a high energy site in Saint John, NB. The result of the monitoring will be used to compare and contrast the impact of disposal activities in these sites, as well as to establish the boundaries of the effected areas and determine the stability of material placed in the sites.

Survey Hart 2004010 was conducted from 27 April – 14 May 2004, to provide information on the character and distribution of seafloor sediments around offshore disposal sites near Port Hawkesbury, NS, where about 178,000 m^3 of material has been dredged from near the docks of Port Hawkesbury and Mulgrave and placed in offshore disposal sites since 1993.

A multidisciplinary suite of data was collected from the CCGS *J.L. Hart* (Figure 1) and hydrographic survey launch Plover. Geophysical and multibeam bathymetry surveys were performed to determine if material had been transported away from the disposal area. Seafloor photographs, underwater video transects and seafloor samples were taken to provide additional information of the character and composition of the sediments on the seafloor.

a) 

b) 



c)

Figure 1. a) The geophysical survey and seafloor sampling program were performed using the CCGS *J.L. Hart* shown in a) above. b) Multibeam bathymetry data were collected with the hydrographic launch Plover equipped with a Simrad EM3000 sytem. c) The survey and sampling equipment were deployed and operated from the main deck of the *J.L. Hart*.

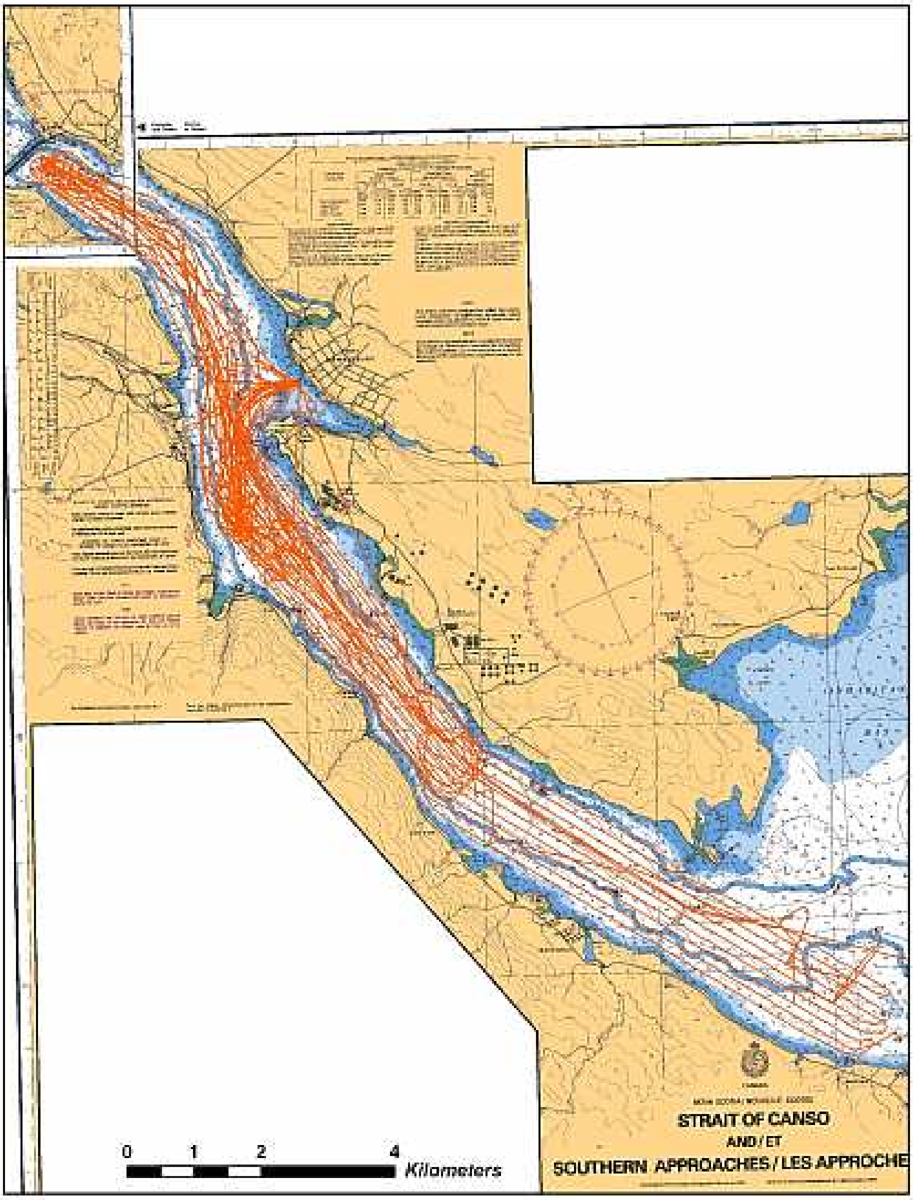


Figure 2. Survey tracks during survey Hart 2004010 in Canso Strait, NS. Sidescan sonar and Seistec® data were collected on a grid with 75 metre line spacing. Ship's track between stations and during camera transects are also shown

Data Acquisition and Equipment

The following geophysical and sampling equipment was used during survey Hart2004010:

- Simrad MS992 sidescan sonar system in a neutrally-buoyant tow configuration
- IKB Seistec® high resolution sub-bottom profiler
- GSCDig 4-channel digital geophysical data acquisition system
- Regulus survey navigation package with input from differential GPS
- Simrad EM3000 multibeam bathymetry system
- Linux workstations running GRASS GIS with GSCA extensions
- Caris HIPS multibeam bathymetry data cleaning software running on Windows NT
- GSCA icehole camera
- van Veen grab sampler
- Fisheries and Oceans TOWCAM camera and video system
- Insite Tritech Scorpio digital still camera (3.34 megapixel) with continuous video output
- Small gravity corer
- Predicted and Measured Tides

Sidescan Sonar

High-resolution, acoustic images of the seabed were produced with a Simrad MS992 dual frequency (120 and 330 kHz) sidescan sonar system. The towfish was deployed about 50 metres behind the vessel and run over the track lines shown in Figure 2. The system consisted of a neutrally-buoyant towbody and deployed 13 metres behind a dead weight depressor (a 40 kg. weight) as shown in Figure 3. This configuration was chosen to reduce artifacts seen on the sidescan sonar records due to vessel-induced heave. The sidescan sonar system was capable of resolving objects down to a size of about 0.15 m. A hardcopy graphic record of the 120 kHz portion of the sidescan sonar data was produced on an Alden 9315CTP thermal recorder.

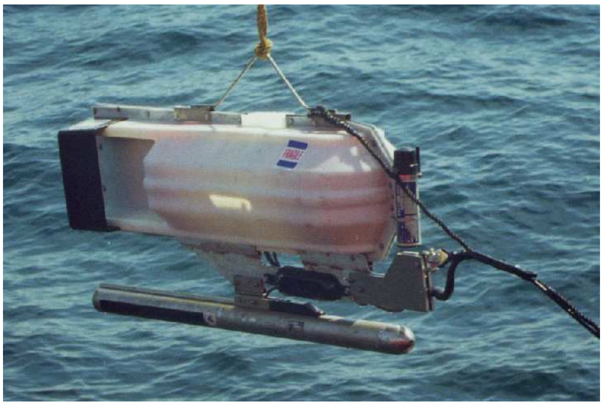


Figure 3. Neutrally buoyant sidescan sonar towfish used by GSCA. The towfish was towed about 13 metres behind a deadweight depressor. A TrackPoint II tow-fish positioning beacon is visible on the front of the towfish.

The sidescan sonar data were collected at 100 metre range for all lines providing a swath of 200 metres. The lines were typically run 75 metres apart. Sidescan sonar data from survey Hart 2004010 (both 120 and 330 kHz) were collected digitally using a GSCDig digitizer with version 2.3 software. A sample interval of 80 microseconds was used. 1700 samples per ping were collected at the nominal 100 metre range setting. Digital gain settings for the sidescan sonar system and digitizers were logged on field sheets. During the survey, data were imported into a Linux workstation. The seafloor was detected and slant range and beam corrections were applied to the raw data to remove geometric distortions present in sidescan sonar data. The data were integrated with navigation and imported into GRASS GIS at 0.25 metre resolution. The sidescan sonar data from adjacent survey lines were integrated to produce a sidescan sonar mosaic at 0.5 metre resolution.

IKB Technologies Seistec® Sub-bottom profiler

An IKB Technologies Seistec® high-resolution, sub-bottom profiler system was used to map the thickness and structure of materials on the sea floor and provide information on the genesis of the sediments. The system uses an electro-dynamic (boomer) source to produce a repeatable impulse-like output providing a vertical resolution of 0.25 metre or better. The Seistec® system was equipped with an internal line-and-cone array and an external streamer. The boomer and line-and-cone array are contained in a small catamaran as shown in Figure 4. Additional information on the Seistec® system is currently available on the IKB Technologies website at www.seistec.com .

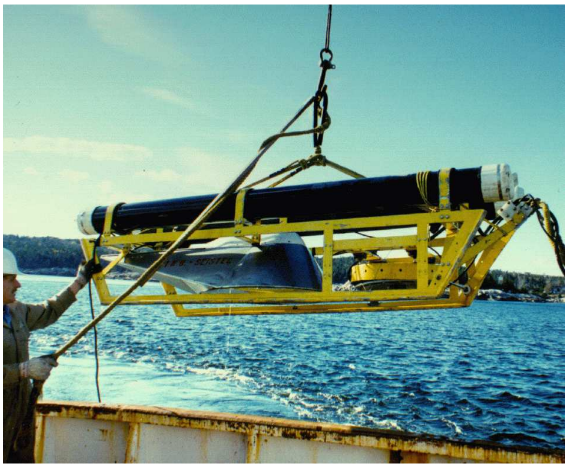


Figure 4. Seistec® sub-bottom profiler showing the surface-towed catamaran used to support the boomer and line-and-cone array. Power and signals are contained in the tow cable bundle on the front of the catamaran.

The external streamer was attached to the front of the catamaran, so that the lead-in section of the streamer was positioned under the boomer and line-and-cone array with the receiving elements trailing behind the catamaran. The catamaran was deployed by crane and towed at the surface on the port side of the vessel. The system was fired 2 times per second, or faster, and graphic records were displayed on an EPC9802 thermal graphic recorder set for 125 millisecond scans in two channel mode. The power supply to the boomer was operated at a nominal setting of 175 Joules. Data were sampled at a 20 microsecond interval for 124 milliseconds.

Digital Data Acquisition

Data were recorded on the new GSCDig system for digitizing sub-bottom profiler and sidescan sonar data. The system is highly oriented to networking and modular components, and mainly consists of a digitizer/logger module and a simple real time or file display. The digitizer program, called GDAim (Analog Input Module) runs on a computer containing high speed sigma delta digitizer boards. In addition to the A/D, the computers have DVD Burners and 180 GByte hard disk drives. The computers were connected to a small network controlled by a cable modem router using dynamic IP allocation.

The following configuration was used

Sidescan sonar - 80 microseconds sample interval

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

Sub-bottom profiler – IKB Seistec® - 20 microseconds sample interval

Channel	Use
0	STB Seistec line cone receiver
1	STB GF10/15P streamer hydrophone

A separate GSCDig system was placed on the bridge of the vessel and used for real time monitoring of data quality and software program development.

Navigation
Navigation was provided by a Global Positioning System utilizing differential corrections broadcast by the Canadian Coast Guard. Accuracy of the navigation was about 4 m. Tracks and survey lines were run with the Regulus navigation package by ICAN Limited, Mount Pearl, NF.

Multibeam Bathymetry
Multibeam bathymetric data were collected using a Simrad EM3000 multibeam bathymetry system mounted in the hydrographic survey launch Plover (Figure 1b). The EM3000 system uses 300kHz transducer with 127 beams with a beamwidth of 1.5 x 1.5^o. The system provides a depth resolution of 1 cm with an accuracy of 5 cm RMS. Each beam insonifies an area of approximately 1.35 m^2 at 50 metres water depth.

The Plover uses an Applied Analytics Corporation POS-MV 320 attitude sensing system with integrated differential GPS navigation system to determine the position and attitude. The systems integrate data from an inertial measurement unit and differential GPS signals. A positional accuracy 0.5 to 4 metres can be obtained using the phase differential of the GPS carrier frequency when using DGPS, and of 0.02-0.10 metres when using an RTK source. This survey was performed using DGPS data for an accuracy of 0.5 to 4 metres. A heading aiding accuracy of 0.1^o - 0.5^o can be obtained from the raw GPS data. A Kalman filter is used to improve the heading estimate to 0.05^o - 0.1^o. Vessel attitude is measured using an inertial measurement unit to provide an accuracy of 0.0003^o for pitch, roll and heading. More information on this system can be found at www.applanix.com.

Survey lines were run throughout the area to provide 200 percent coverage (100% overlap) of the seafloor in water depths greater than about 20 metres. During the survey, data were processed using version 5.0 of the HIPS data cleaning program (CARIS by Universal Systems Limited, Fredericton, NB) on a Windows NT workstation to remove spurious soundings and navigation data and to correct for tidal variations. Data were also imported into a Linux based workstation and processed using the MB-System software developed by the Lamont-Doherty Institute (http://www.mbari.org/data/mbsystem/html/mbsystem_home.html). The processed data were imported into GRASS (Geographic Resources Analysis Support System) GIS (Geographical Information

System) where shaded-colour relief images were generated and overlaid on bathymetry maps of the area. The GRASS GIS system is an Open Source, free software. More information on the GRASS GIS cab be found at http://grass.baylor.edu.

Multibeam Backscatter

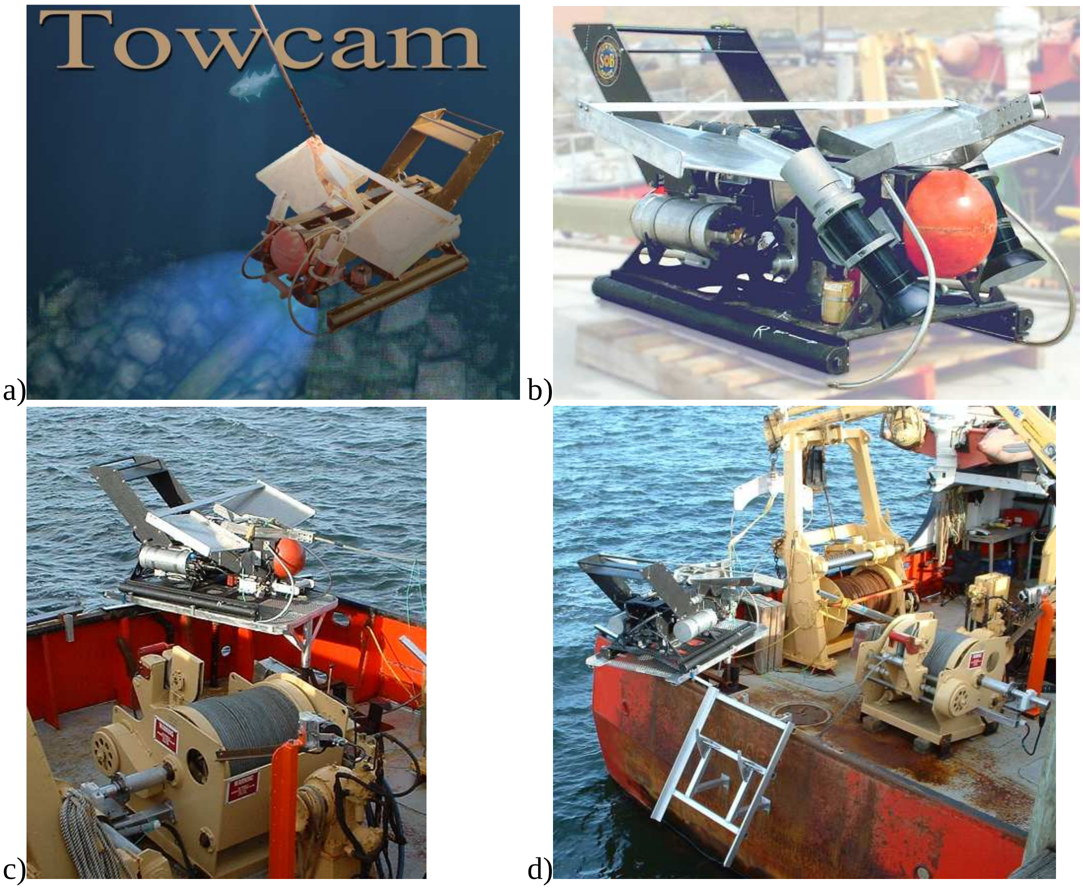
The strength of an echo from the seafloor is known as the acoustic backscatter intensity. Acoustic backscatter intensity values are controlled by the physical properties of the seafloor sediments such as the velocity of sound, grain size, the density and roughness of the sediment. Backscatter generally increases as the sediments on the seafloor become denser and less porous, and increase in grain size. Mapping the distribution of backscatter provides valuable information on the character and distribution of sediments within an area. Backscatter data were processed using the MB-System software developed by the Lamont-Doherty Institute. The processed data were imported into GRASS GIS, where shaded-colour relief images were generated and overlaid on bathymetry maps of the area.

TOWCAM

Gordon et al. (2004) describe TOWCAM as a towed body system that collects continuous composite colour video imagery and digital images of the seabed. The cameras provide a field of view about 1-2 m wide when towed at a constant altitude (generally about 2-4 m above the seabed). Long transects can be surveyed at a speed of about 1-2 m/s (i.e. about 2-4 knots).

The aluminum body (Figure 5b) is of open construction and depends upon a combination of dead weight and adjustable wings to generate a depressing force. It is 1.9 m long x 1.7m wide x 1.1 m high and weighs 327 kg on deck. It is fitted with the following:

- Sony XC-999 colour video camera
- Two Nuytco Research Ltd. Model HMI 600W metal halide (HMI) gas discharge lights
- Insite Tritech Scorpio digital still camera (3.34 megapixel)
- Quantum Q Flash T1 strobe (150 watt/sec)
- Harbor Branch Oceanographic Institution Model LSR-6000-635-10-6 laser scale (10 mW, red-orange)
- Mesotech 807 acoustic altimeter (30 m range)
- Pitch, roll, pressure and water temperature sensors



a) b) c) d)

Figure 5. a) Artists conception of the TOWCAM system showing the towfish deployed near the seafloor. b) The lights are clearly visible on the front of the towbody. c) The TOWCAM was stored on a platform attached to the port rail on the stern of the J.L. Hart for servicing and during transit and deployed from another platform on the stern of the vessel d) for survey operations.

The TOWCAM was stored on a platform attached to the port rail on the stern of the *J.L. Hart* for servicing and during transit (Figure 5c). The towfish was lifted from the storage platform by crane and placed on another platform on the stern of the vessel (Figure 5d) before deployment for survey operations.

Electrical power is supplied to the body from the surface via the tow cable to enable long transects. Digital camera storage capacity and strobe battery life limit enable approximately 300 images to be acquired per tow. An acoustic transponder attached to the body establishes location relative to the ship using a Trackpoint II ultra-short baseline acoustic tracking system.

The body is towed on a ¾ inch double armoured galvanized steel conductor cable manufactured by South Bay Cable Corp. When deployed on smaller survey vessels such as the CCGC *J.L. Hart*, a lightweight aluminum Harrison and Robbins 20 HP winch is used with about 400 m of cable to provide a working depth to about 150 m. Constant altitude above the seabed is maintained by adjusting the length of the tow cable.

Real-time video and low-resolution still imagery are displayed in the laboratory. The former is also displayed on the bridge to assist in ship handling. Video imagery and navigation data are recorded on both a digital VCR and a DVD recorder for later analysis. Time-referenced data on towbody behaviour are recorded on a computer. Photos from the digital camera can be taken manually or automatically at preset intervals (as short as 3-4 seconds). Images are previewed in the laboratory in real time and recorded internally in the underwater camera. After each tow, the photos are downloaded and matched to the navigation and body attitude data in order to define their precise geographic positions and the area imaged.

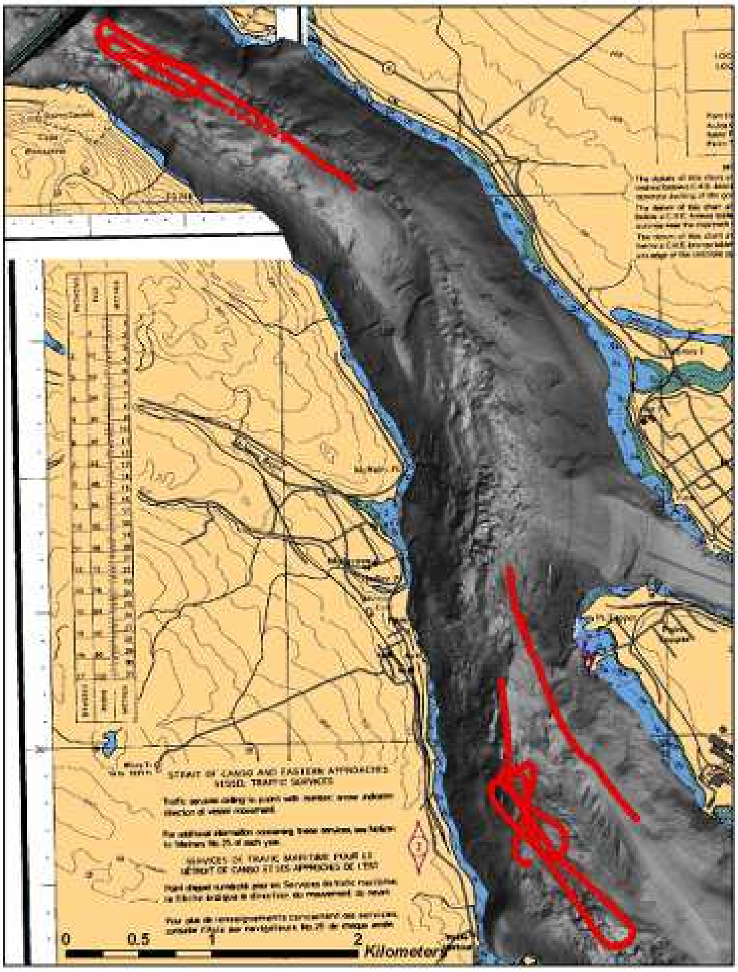


Figure 6. Location of TOWCAM transects, shown by the red circles overlain on a shaded relief image of bathymetry, taken during survey Hart 2004010 in April 2004. The positions are provided in Table 1.

The resolution of the video imagery depends upon water clarity, the altitude of the body over the seabed and the towing speed, which are all influenced by current and sea state. Under reasonable conditions, it is possible to discern physical features of the seabed as well as surface-dwelling organisms such as sand dollars, brittle stars, sea cucumbers and various species of fish. The laser beams (spacing 10 cm) allow the scaling of seabed features and organisms. High resolution still images from the digital camera are burned to CDROM. The footprint of the image depends on the altitude of the body but is generally on the order of 1 m^2. Images are analyzed on a computer using Adobe Photoshop software. Resolution can be further enhanced by manipulating the contrast, brightness, colour and grain of the image such that it is possible to resolve features on the order of a few millimeters. Such post-processing of CD images greatly improves the resolution of physical and biological features, and allows the examination of organism-microhabitat associations in an undisturbed state.

The photograph locations are shown in Figure 6 and are provided in Table I. Many of the digital images are incorporated as ‘hotlinks’ in an ArcView GIS data base to provide geographically referenced access to the images. Low-resolution copies of all available sample are presented in this report in Appendix V.

Seafloor Grab Samples

Figure 7. Seafloor samples were collected with a van Veen grab sampler.

A 0.1 square metre van Veen grab sampler was used to collect sediment samples in the survey area (Figure 7). The sample locations are shown in Figure 8 and are provided in Table II. Digital images were taken of most of the grabs and are incorporated as ‘hotlinks’ in an ArcView GIS data base to provide geographically referenced access to the images. Low-resolution copies of all available grab sample images are presented in this report in Appendix III.

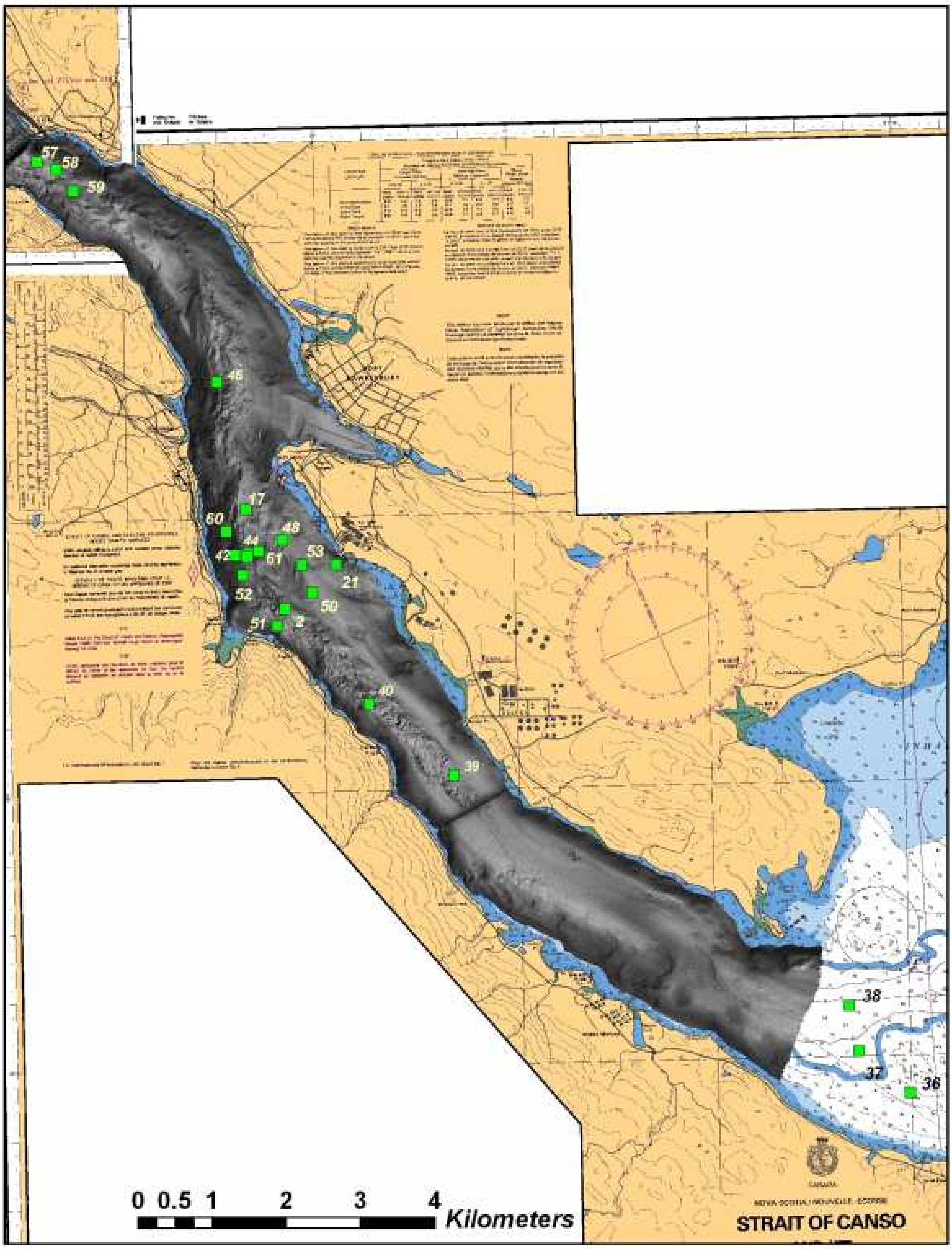


Figure 8. Location of grab samples (shown by the green squares) taken during survey Hart 2004010 in April 2004. The sample positions are provided in Table 2.

Seafloor Photographs

Figure 9. Icehole camera used to collect seafloor photographs during Hart 2004015.

Seafloor photographs were taken with the Icehole camera developed by GSCA (Figure 9). Images were obtained on transects through the disposal site and surrounding area using 200 ASA colour print film. Films were developed at a local "one-hour" processing facility to ensure that the camera was functioning properly and to provide images of the seafloor sediments to assist with the interpretation of geophysical information. After the survey, the negatives were digitally scanned and stored on CD-ROM. The digital images were incorporated into an ArcView GIS project as a series of "hotlinks" to enable viewing of the images in a geographically referenced context. A list of photograph locations is provided in Table 3 and shown in Figure 10. Thumbnails of the photographs are provided in Appendix IV.

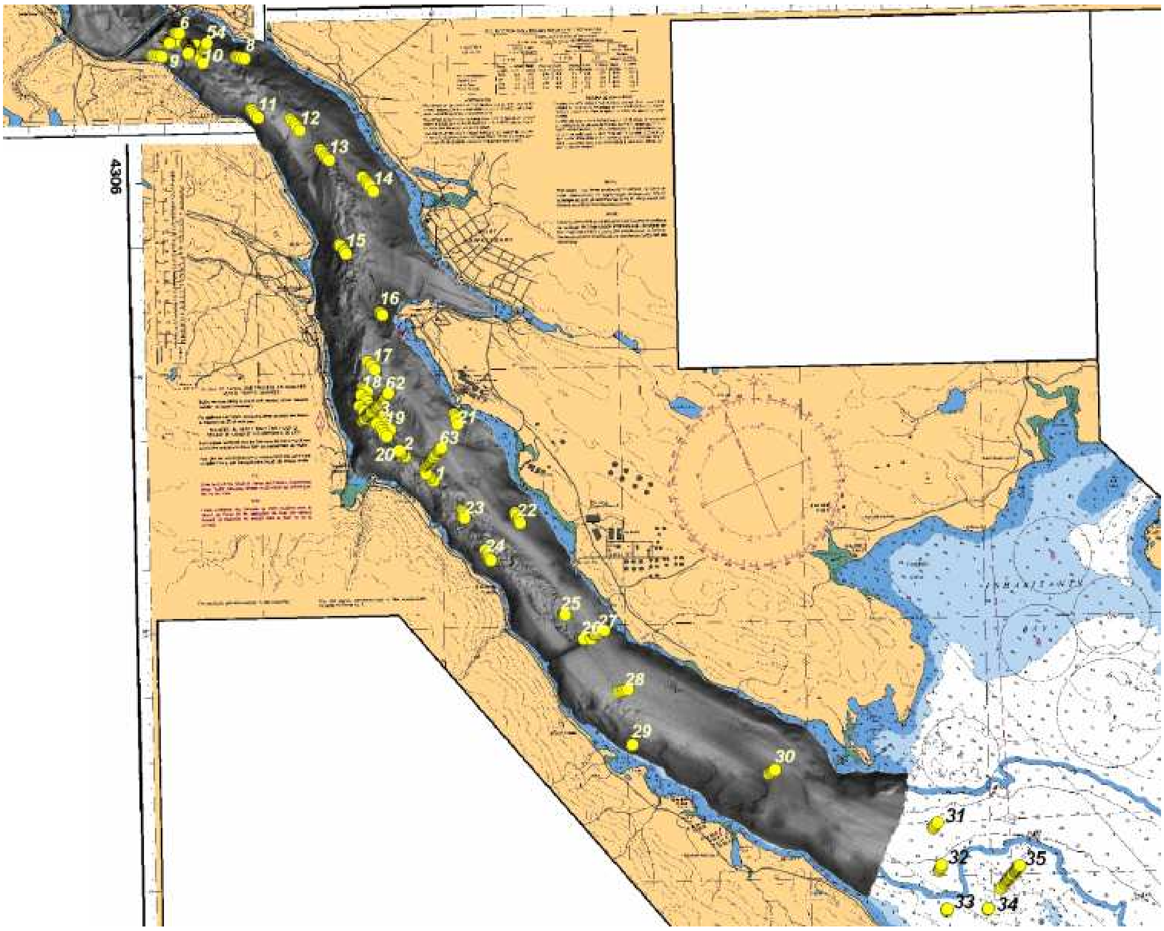


Figure 10. Location of seafloor photographs, shown by the yellow circles, taken during survey Hart 2004010 in April 2004. The positions are provided in Table 3.

Digital Video and Still Photographs

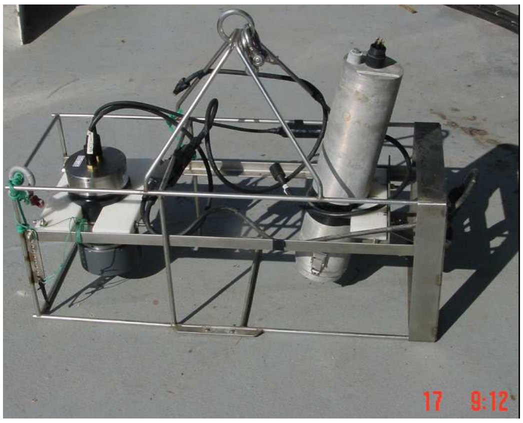


Figure 11. Digital video system used to collect video and digital still images during Hart 2004010.

Digital video and still images of the seafloor photographs were obtained with an Insite Tritech Scorpio model 6kM digital still camera. The system consists of a Nikon E995 model camera (3.34 megapixel) in a pressure housing rated for 6000 metre. In Figure 11, the Scorpio camera is shown on the left of the frame, with the flash and flood light on the right of the frame. Images and video were obtained on transects through the disposal site and surrounding area. Video was recorded on a SONY DSR-20 Digital Videocassette Recorder. Still Images were recorded internally in the Nikon digital camera and downloaded to a computer at the end of the day. The camera was deployed from the hydrographic winch on the starboard side of the *CCGS J.L. Hart*, and used to collect images as the vessel drifted along a transect.

The digital images were incorporated into an ArcView GIS project as a series of “hotlinks” to enable viewing of the images in a geographically referenced context. A list of video transects and photograph locations is provided in Table 4 and shown in Figure 12. Thumbnails of the photographs are provided in Appendix VI.

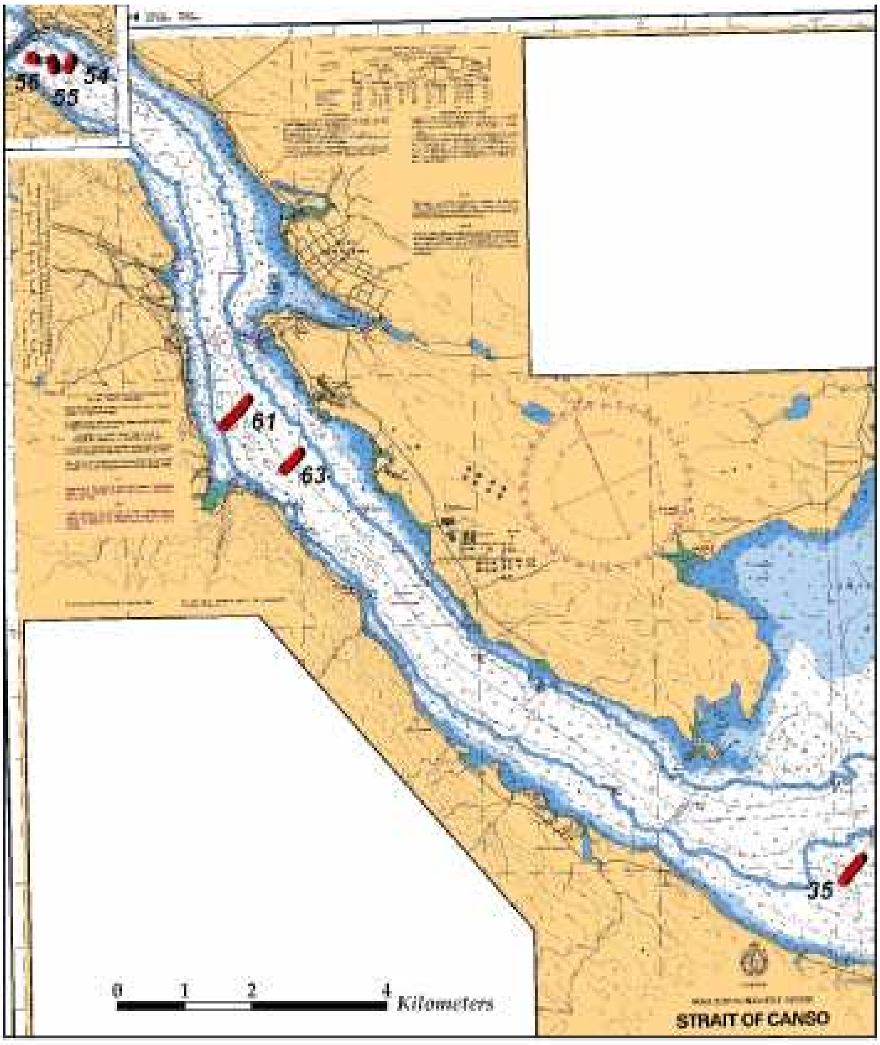


Figure 12. Location of digital video transects taken during survey Hart 2004010 in April 2004 using the Scorpio camera. The position of each of the red circles indicates where digital still images were obtained. The positions are provided in Appendix IV.

Tides

Prior to the survey, tides for the survey area were calculated using the program Tides and Currents Pro by Nautical Software Inc. As shown in Figure 13, a tidal range of about 1.5-2.0 metres was predicted for Port Hawkesbury, NS during the period of the survey. A listing of the predicted tides, in 30 minute increments, is provided in Appendix VII. Times are shown in Atlantic Daylight Time and tide heights are shown in centimeters.

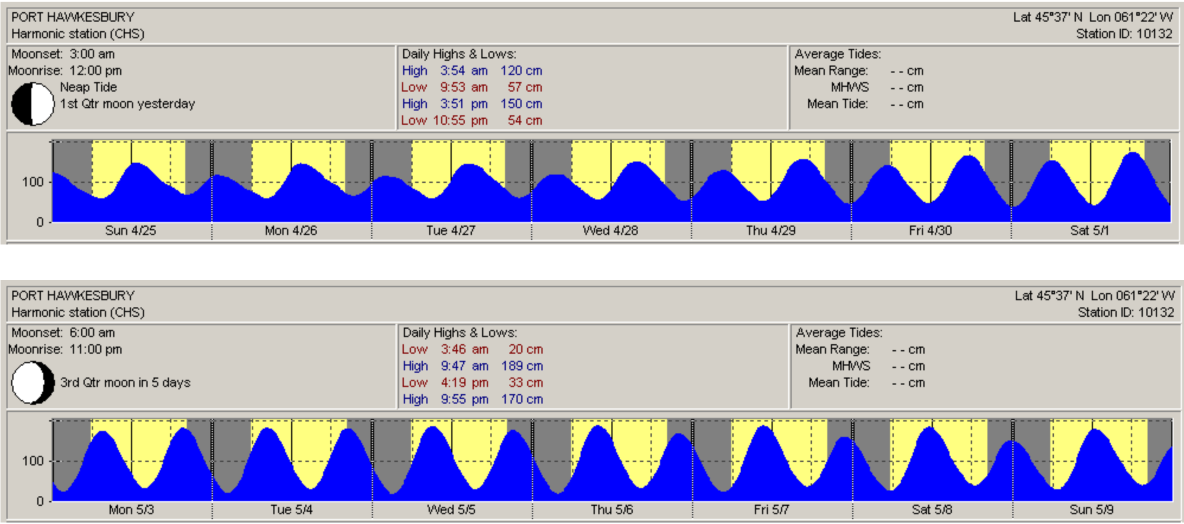


Figure 13. Predicted tides for Port Hawkesbury from the program Tides and Currents Pro.

A tide gauge, consisting of a Sutron 8200 series data logger and a transducer in a stilling well, was installed at the marina in Ship Harbour, Port Hawkesbury and used to measure the actual tidal range during the survey. The tide gauge data, shown in Figure 14 and presented in Appendix VIII, were used to correct the multibeam bathymetry data.

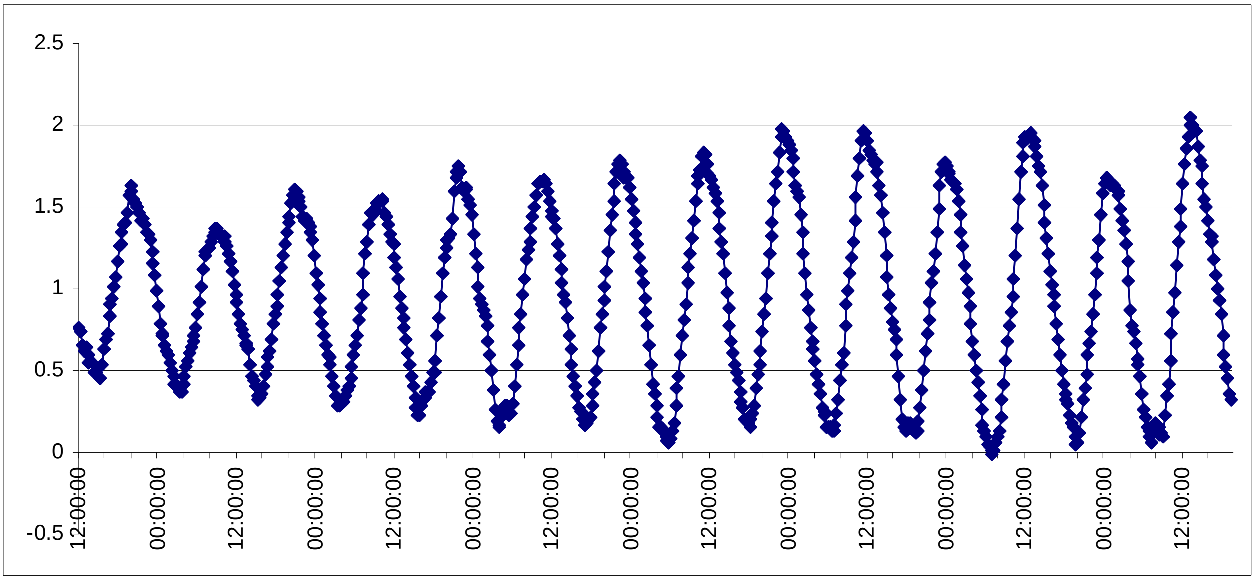


Figure 14. Measured tides for 30 April – 7 May 2004 from a tide gauge at the marina in Port Hawkesbury

Preliminary Results

As part of the environmental assessment for the Bear Head LNG Terminal, Jacques Whitford Environment Limited (JWEL 2004) provide a summary of the surficial geology near Port Hawkesbury. JWEL (2004) report that the area is characterized by till with a highly variable thickness present along both sides of the Strait of Canso. Geological evidence suggests that the tills have been locally derived from the parent bedrock (Stea *et al*., 1992) and, as a consequence, the till cover is generally a homogeneous mixture of sandstone and shale rock reduced to sand, gravel and cobble sizes in a matrix of reddish brown clayey silt or clay. Post-glacial surficial sediments of varying thickness overlie the till sheet.

Prior to construction of the Canso Causeway in 1955, the Strait of Canso provided a zone of mixing between the waters of the Atlantic and the Gulf of St. Lawrence (Vilks et al. 1975). Fothergill (1954) reported currents of 2.7 m/s (9.6 km/h) south-going and 2.1 m/s (7.6 km/h) north-going before construction of the causeway. A tidal difference of about 1 m between the northern and southern portions of the Strait gave rise to a net water flow southward of 4250 m^3/sec (3.68 * 10^8 m^3/day); about the equivalent of one-half of the daily discharge of the St. Lawrence River (Buckley et al., 1974) The high current velocities resulted in the erosion of seafloor sediments and generally prevented the deposition of fine-grained marine sediments on the seafloor in the Strait. After construction of the causeway, the Strait of Canso exhibits conditions more closely related to a tidal inlet, or fjord, with an average current velocity of 0.04 m/s (0.18 km/h) reported near the site of the oil refinery (Lawrence et al. 1973), and is much more prone to deposition of fine-grained sediments.

The multibeam bathymetry data (Figure 15) show the presence of features on the seafloor such as sand waves and erosional flutes, which confirm that strong currents had been acting on the sediments. An overview of the area in Figure 15a, shows the Strait to be a relatively narrow body of water between 0.8 and 2.0 km wide throughout its 27 km length. Water depths of 60 m occur at the deepest part of the channel, at the location of the causeway. A noticeable change in the character of the seafloor occurs below about 38 m depth, corresponding to a low stand of sea level about 9 ± 1 ka B.P. (Forbes et al., 1995). Above – 38 m, the seafloor generally has a gentle slope, with a relatively smooth seafloor. Below –38 m, the seafloor generally has a steeper slope with a much rougher surface. MacLean et al. (1977) mapped the occurrence of the Sable Island Sand and Gravel unit (gravel, sand, silt and clay (highly variable)) in the near-shore portions of the Strait, indicating transgression during a low stand of sea level. The deeper portions of the Strait were mapped as LaHave clay (clayey and sandy silt with minor gravel). The nature of the seafloor adjacent to the causeway is presented in Figure 15b, and shows a deep channel near the center of the strait. An offshore disposal site is located in 60 m water depth near Pt. Tupper (Fig 15c and 15d). A small zone of high backscatter, about 75 m across, within the disposal area may be related to disposal of coarse material at the site. The majority of dredge spoils detected were located within the boundaries of the disposal site. Several areas exist where dredge spoils were present outside the zone and may predate the initiation of controlled disposal at the site. Sandwaves are present east of the disposal site, and probably date to before the construction of the causeway. Erosional flutes are present throughout much of the Strait and indicate erosion of sediments by current scour. Analysis of the shapes of the sandwaves and the orientation of the flutes, indicate strong northerly currents. This differs from earlier studies of current flow in the Strait indicated that the dominant tidal current was southerly (Fothergill 1954). Further investigation of these features may be warranted.

Analysis of the multibeam bathymetry data also shows the presence of numerous small-scale features such as anchor furrows and depressions left by the spud cans from dredge barges and jackup oil rigs. A large dredged area is present near the gypsum wharf in Pt. Tupper. A pipeline, which provides fresh water to the paper mill, is evident on the seafloor just north of the disposal site in Figure 15d and the gas pipeline across the Strait to Port Hawkesbury is evident in the southern portion of Figure 15a.

Sidescan sonar data from the area have been processed and combined into a mosaic (Figure 16). The data provides additional information on both the distribution of sediments, and fine-scale features such as dredge spoils and anchor furrows. The presence of coarse sediments in the near-shore portions of the Strait, is indicated by zones of high backscatter (shown by the darker colours) in Figure 16a.

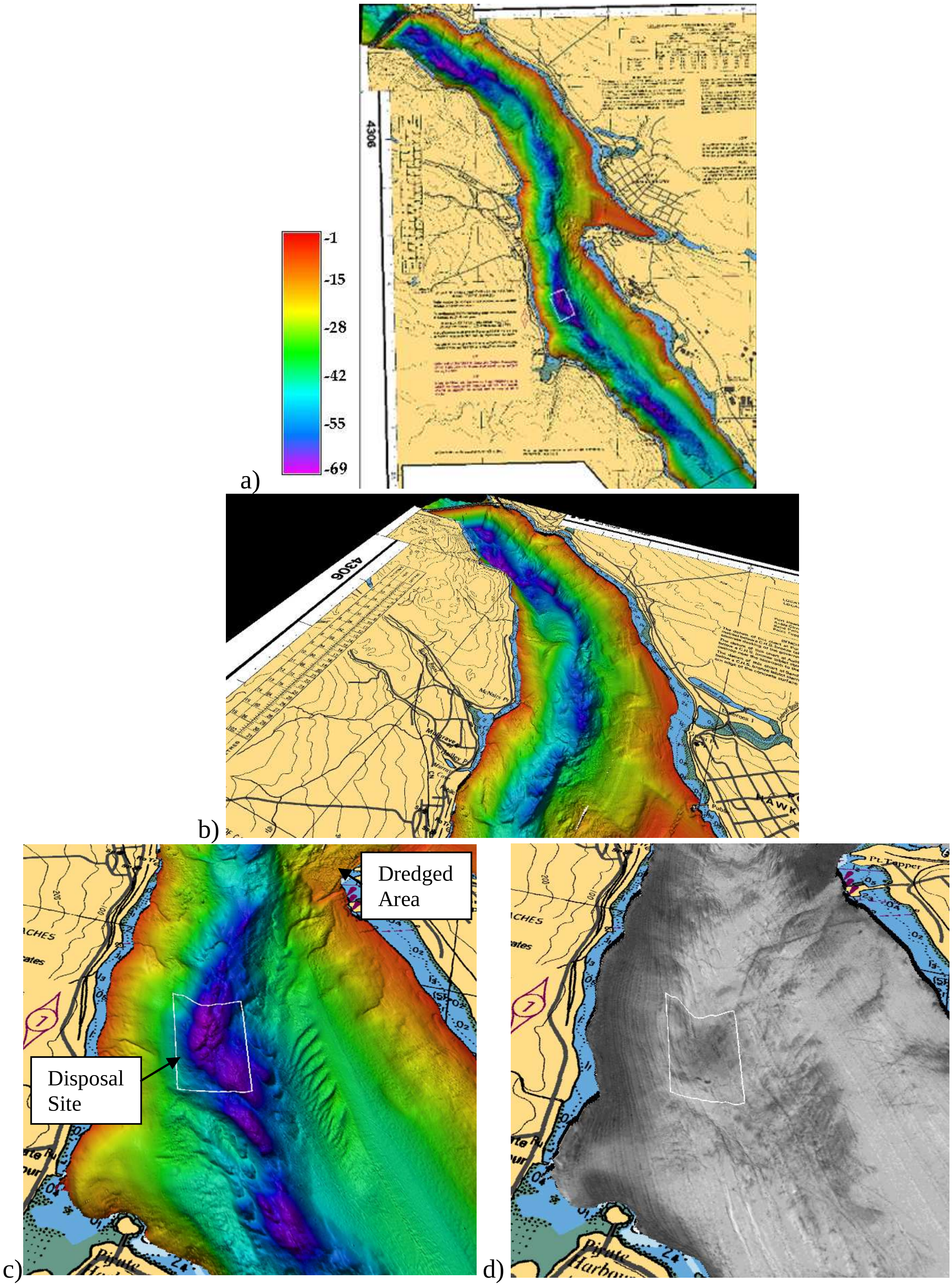


Figure 15. Multibeam bathymetry data from the Strait of Canso showing a) an overview of the Strait and the colour bar used for depth data, b) the nature of the seafloor adjacent to the causeway, c) the offshore disposal site (shown by the white rectangle and d) backscatter intensity from the disposal site. The outline of the disposal site is about 350 metres wide.

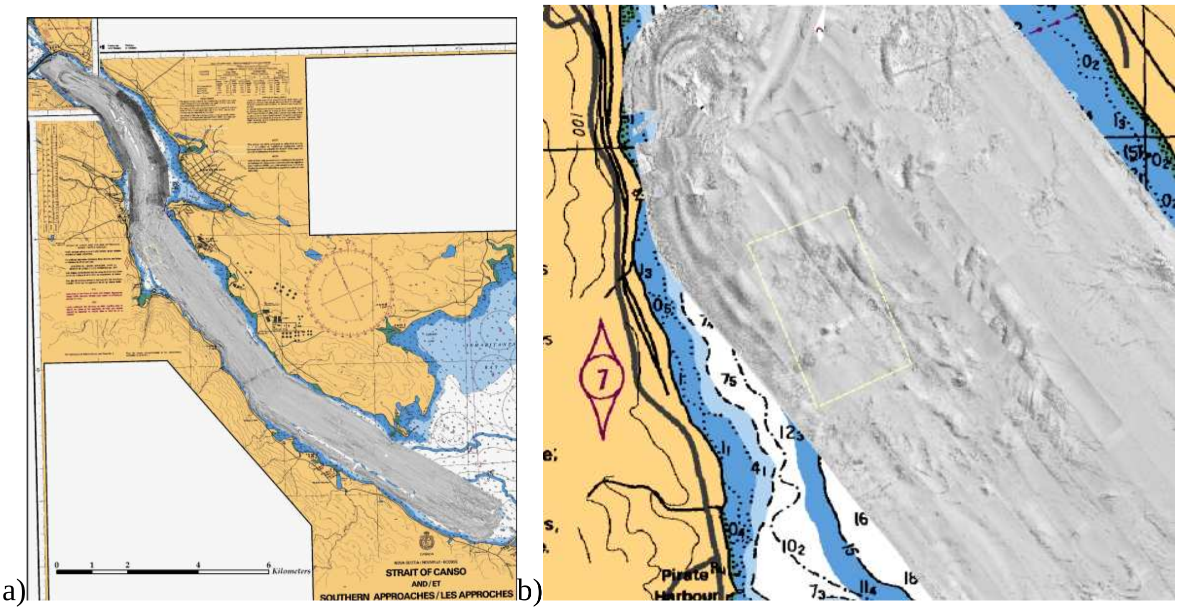


Figure 16. Sidescan sonar data collected in Strait of Canso during survey Hart 2004010, showing a) the coverage of data available and b) seafloor character at the disposal site, shown by the yellow rectangle.

Sub-bottom profiler data provide information on the thickness of surficial sediments and insight into the nature and genesis of sediments below the seafloor. Data collected immediately south of the causeway showed the presence of coarse sediments, probably till, overlying bedrock over much of the seafloor, with small pockets of glaciomarine or glaciolacustrine sediments. The seafloor at the disposal site, near Pt. Tupper, is composed of coarse sediments, probably till, overlying bedrock. An accumulation of about 1 m of recent sediments in this area is probably related to the recent disposal of dredge spoils at the site as shown in Figure 17. Sub-bottom profiler records will be used to determine the thickness of accumulated material throughout the disposal site. Near the refinery, thick deposits of glaciomarine or glaciolacustrine sediments are present and have been eroded to form flutes (Fig. 18). Several episodes of erosion and deposition are evident. The protective berm over the gas pipeline is quite evident.

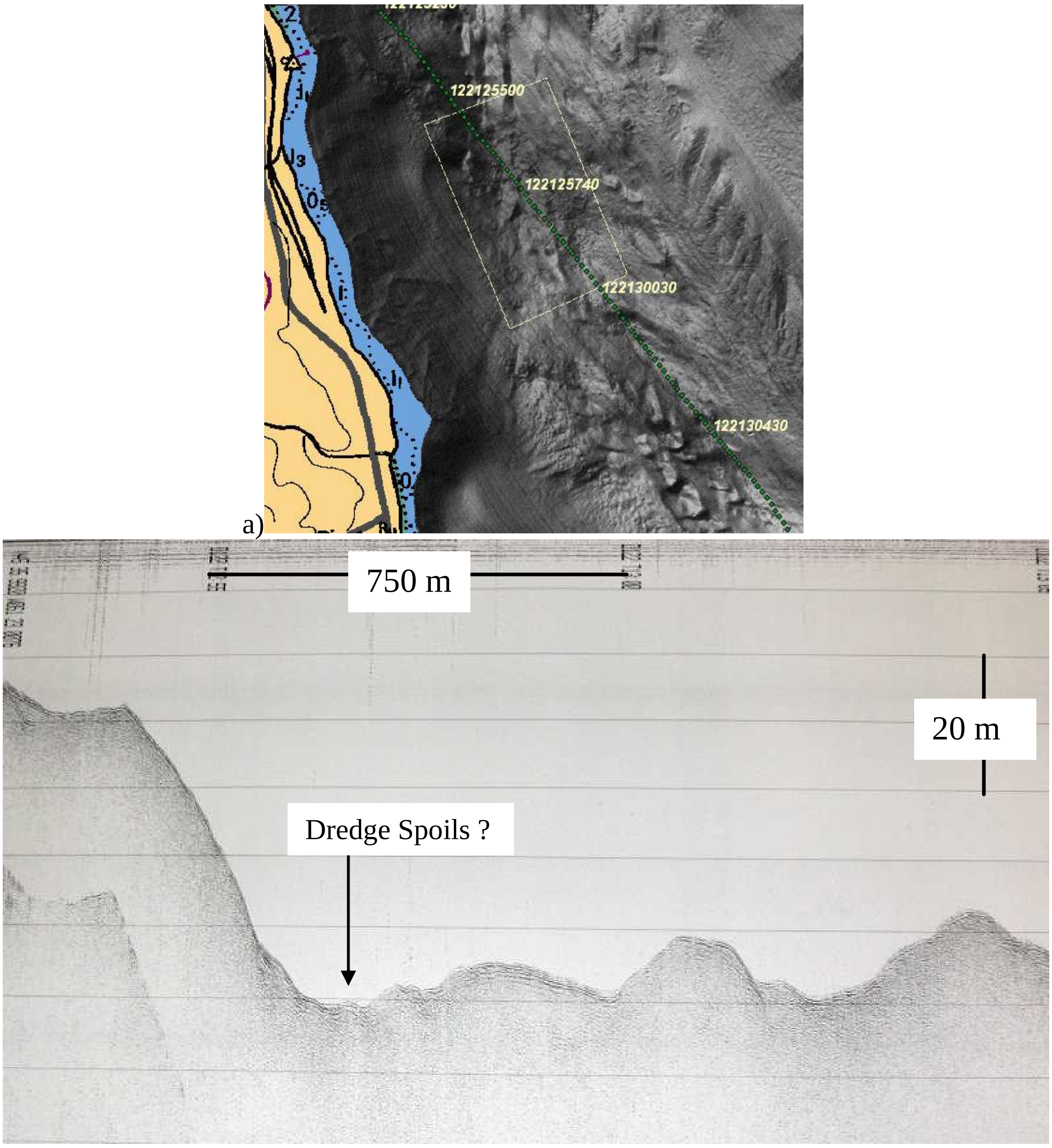


Figure 17. Location a) and Seistec sub-bottom profiler data b) through the disposal area. The Seistec data is shown from Day 122 12:53 to 13:05.

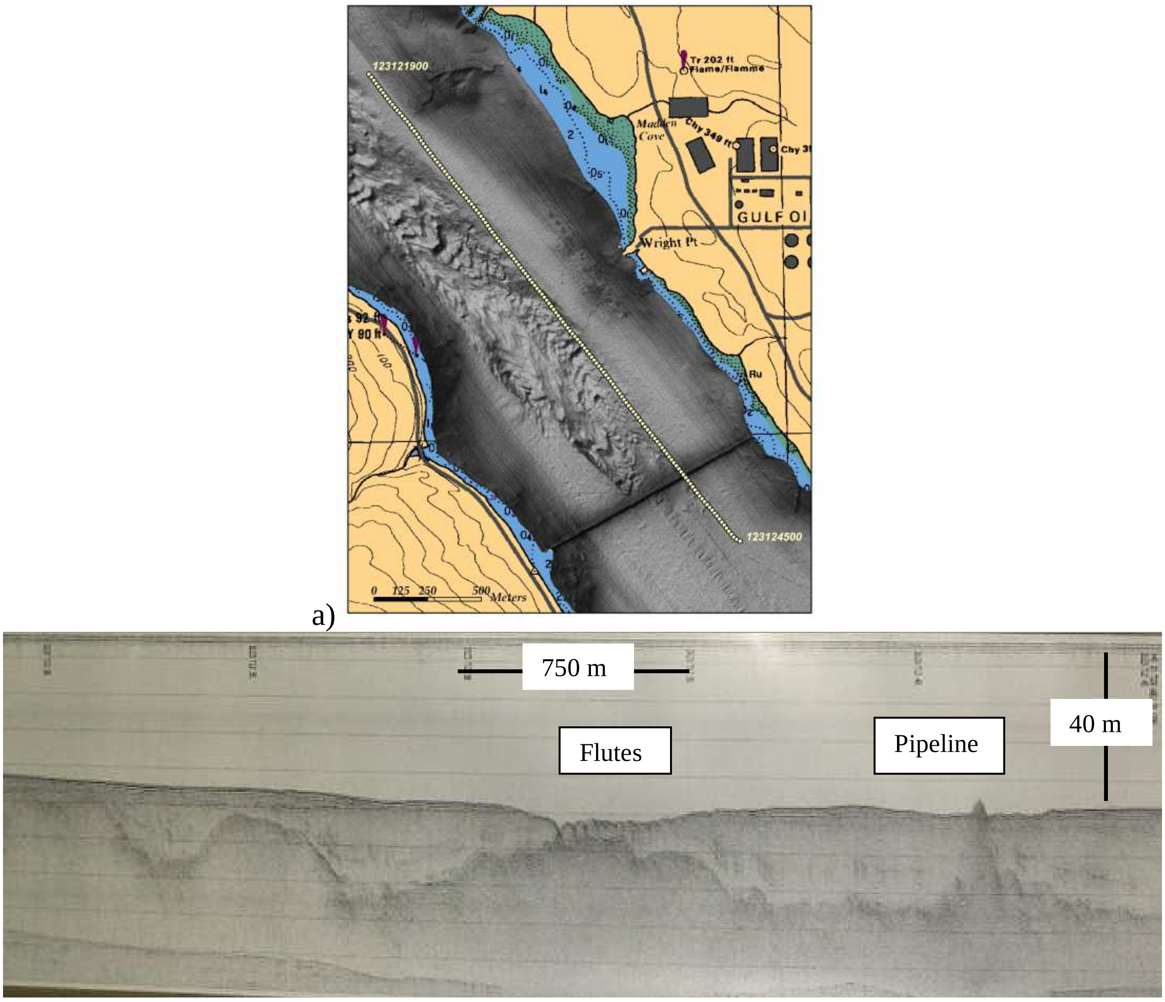
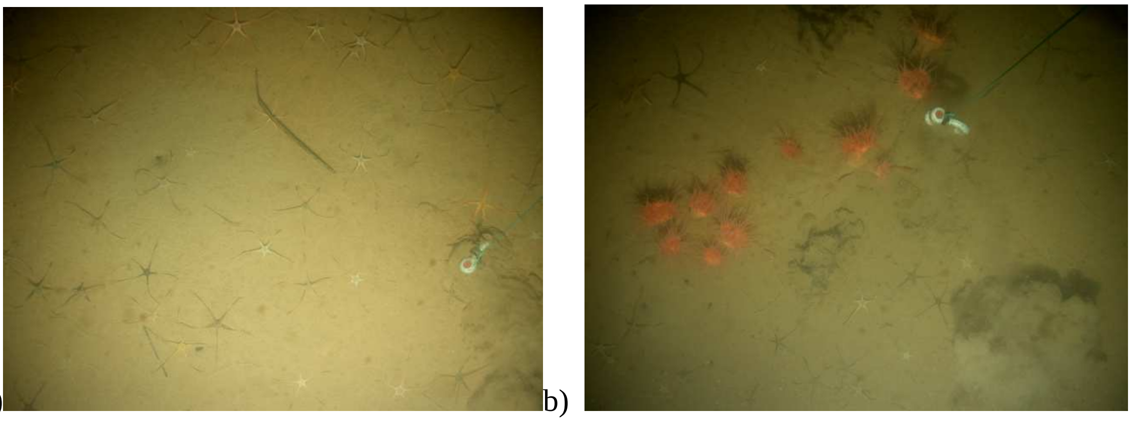


Figure 18. Location a) and Seistec sub-bottom profiler data b) through the erosional flutes, and over the gas pipeline. Note the thick accumulation of sediments. The Seistec data is shown from Day 123 12:19 to 12:45.

Seafloor photographs east of the Canso Causeway, show that much of the seafloor is covered by a veneer of fine sediments and densely populated with brittle stars (Figure 19a). Sea anemone, which generally anchor themselves on a hard substrate, are visible in many images as shown in Figure 19b and indicate the presence of coarser material under the fine surface veneer. Seafloor samples show a veneer of fine sediments which overly coarser material in places. Note how the range marker for the digital camera used for these images (a 5 cm shackle) disturbed the seafloor sediments, and caused suspension of the fine material at the seafloor. Photographic transects through the disposal site showed the presence of boulders, cobbles and gravel, along with assorted debris including tires, trees, wood and a trailer.



a) b)

Figure 19. Seafloor photographs from Canso Strait showing a) the soft sediments and high density of brittle stars present throughout much of the area. Sea anemone b) were present in many areas, indicating the presence of hard substrate under the fine sediments. Note how the range marker for the camera (a 5 cm shackle) caused suspension of the fine material.

The presence of sandwaves and erosional flutes attest to the high current flow regime present in the Strait of Canso before construction of the Canso Causeway. The reduced flow regime, which developed after construction of the causeway, has resulted in more benign conditions allowing the deposition of fine-grained sediments and preserving seafloor features such as anchor furrows and marks from spud cans.

Access to Data and Samples

The sidescan sonar, sub-bottom profiler and grab samples 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 GSCA Curation group (902-426-3410). Graphical records for the sidescan sonar and subbottom profiler, digitally processed sidescan sonar mosaics, ExaByte tapes containing the sidescan sonar data in SEG-Y format, CD-ROMs containing the sidescan sonar and sub-bottom profiler data in SEG-Y format, ExaBytes tapes of the raw data of a CDROM with the seafloor images and grab sample photographs are available for viewing. For some data, access can be achieved by logging on to the Geological Survey of Canada Atlantic site at http://gsca.nrcan.gc.ca and the Canadian Geoscience Knowledge Network http://cgkn.net/.

Acknowledgements

The captain and crew of the CCGS Hart provided assistance with data and sample collection. David McKeown generously donated his time to provide TowCam coverage in April 2004. Darrell Beaver, Robert Murphy, Austin Boyce, Anthony Atkinson, Carmen Reid and Owen Brown provided field, technical and laboratory support. Eric Patton provided field and GIS support and prepared many of the diagrams. This report benefited from critical review by Michael Li. This project was jointly funded by Natural Resources Canada through the Geoscience for Ocean Management program of the Earth Sciences Sector, and the Environmental Protection Branch of Environment Canada.

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Tables

Table 1 - TOWCAM transects

JulianTime	Latitude	Longitude
118113500	45.590158	-61.366918
118114000	45.592265	-61.371636
118114500	45.593887	-61.375721
118115000	45.595550	-61.378147
118115500	45.598779	-61.377282
118120000	45.595955	-61.376038
118120500	45.593300	-61.378404
118121000	45.594525	-61.376729
118121500	45.597228	-61.377709
118122000	45.594840	-61.376652
118122500	45.593598	-61.378643
118123000	45.594471	-61.375662
118123500	45.595901	-61.374638
118124000	45.595115	-61.379252
118124500	45.594402	-61.375459
118125000	45.593225	-61.371959
118125500	45.590410	-61.369422
118130000	45.590452	-61.370674
118130500	45.593487	-61.373744
118131000	45.594514	-61.378039
118131500	45.597490	-61.378523
118132000	45.601200	-61.378378
118132500	45.604694	-61.378823
120092500	45.596718	-61.377552
120093000	45.593753	-61.378143
120093500	45.593529	-61.379647
120094000	45.596501	-61.378424
120094500	45.598060	-61.379476
120095000	45.596034	-61.381230
120095500	45.593328	-61.377689
120100000	45.594207	-61.375265
120100500	45.596432	-61.379151
120101000	45.597741	-61.378803
120101500	45.594485	-61.378318
120102000	45.591752	-61.376023
120102500	45.589143	-61.373656
120103000	45.587282	-61.370766
120103500	45.589308	-61.370778
120104000	45.591475	-61.373909
120104500	45.593764	-61.376886
120105000	45.596351	-61.379454
120105500	45.599560	-61.380116
120110000	45.602798	-61.380500
120110500	45.606101	-61.380964
120115500	45.633847	-61.392229

120120000	45.635641	-61.395437
120120500	45.637611	-61.398687
120121000	45.639479	-61.402236
120121500	45.641286	-61.406310
120122000	45.643090	-61.410517
120122500	45.644548	-61.414739
120123000	45.641999	-61.412249
120123500	45.640469	-61.408558
120124000	45.641305	-61.406191
120124500	45.642506	-61.410162
120125000	45.643490	-61.414173
120125500	45.641853	-61.409690
120130000	45.640269	-61.406189
120130500	45.637804	-61.400121
120131000	45.635512	-61.395381
120132500	45.609778	-61.379679
120133000	45.606390	-61.378306
120133500	45.601975	-61.377712
120134500	45.610921	-61.379849
120135000	45.607517	-61.378915
120135500	45.604580	-61.377353
120140000	45.601280	-61.375562
120140500	45.598576	-61.372783
120141000	45.595914	-61.370018
120141500	45.593620	-61.367045
120142000	45.591201	-61.364328
120142500	45.588039	-61.362605

Table 2 - Location of van Veen Grab Samples

STATION	STATION_TYPE	DAY/TIME	LATITUDE	LONGITUDE	DEPTH
38	Grab	127 / 1641	45.528840	-61.266270	15
39	Grab	127 / 1655	45.534030	-61.274956	34
40	Grab	127 / 1712	45.539583	-61.276483	46
41	Grab	127 / 1749	45.568525	-61.343841	54
42	Grab	127 / 1809	45.577361	-61.358235	64
43	Grab	127 / 1830	45.589061	-61.372465	60
44	Grab	127 / 1847	45.595735	-61.380916	49
45	Grab	127 / 1903	45.595673	-61.379093	65
46	Grab	127 / 1923	45.595980	-61.378553	61
47	Grab	127 / 1936	45.595458	-61.378796	65
48	Grab	128 / 1052	45.616756	-61.384633	43
49	Grab	128 / 1108	45.601207	-61.378968	53
50	Grab	128 / 1132	45.597455	-61.372675	34
51	Grab	128 / 1147	45.594355	-61.363453	18
52	Grab	128 / 1203	45.590983	-61.367673	37
53	Grab	128 / 1221	45.587036	-61.373808	43
54	Grab	128 / 1236	45.593265	-61.379601	39
55	Grab	128 / 1250	45.594381	-61.369385	35
60	Grab	128 / 1630	45.643851	-61.413691	63
61	Grab	128 / 1646	45.642853	-61.410446	58
62	Grab	128 / 1703	45.640220	-61.407528	54
63	Grab	128 / 1756	45.598543	-61.382353	28
64	Grab	128 / 1814	45.596141	-61.376735	55

Table 3 - Location of Seafloor Photographs with GSC IceHole Camera

STATION	TYPE	DAY/TIME	LATITUDE	LONGITUDE	DEPTH
1	Camera	125 / 1828	45.585945	-61.367436	49
2	Camera	125 / 184334	45.589155	-61.373073	62
3	Camera	125 / 1859	45.593545	-61.376696	58
4	Camera	125 / 1913	45.595826	-61.379270	63
5	Camera	126 / 1129	45.643446	-61.413701	68
6	Camera	126 / 1143	45.644338	-61.413713	65
7	Camera	126 / 1159	45.643028	-61.411375	64
8	Camera	126 / 1217	45.641313	-61.402210	28
9	Camera	126 / 1240	45.641730	-61.417795	35
10	Camera	126 / 1258	45.641816	-61.410053	53
11	Camera	126 / 1334	45.634455	-61.399643	53
12	Camera	126 / 1352	45.633001	-61.392483	52
13	Camera	126 / 1407	45.628990	-61.387090	48
14	Camera	126 / 1425	45.625350	-61.379250	40
15	Camera	126 / 1511	45.616666	-61.383913	38
16	Camera	126 / 1528	45.607883	-61.376675	12
17	Camera	126 / 1559	45.601451	-61.379045	60
18	Camera	126 / 1620	45.598116	-61.380061	63
19	Camera	126 / 1632	45.597146	-61.380246	59
20	Camera	126 / 1706	45.595735	-61.380730	50
21	Camera	126 / 1802	45.594353	-61.363220	18
22	Camera	126 / 1829	45.581500	-61.352383	15
25	Camera	126 / 1850	45.582011	-61.362206	53
26	Camera	126 / 1906	45.576713	-61.357918	63
27	Camera	127 / 1136	45.568306	-61.343810	54
28	Camera	127 / 1152	45.565093	-61.340105	50
29	Camera	127 / 1211	45.566502	-61.338715	51
30	Camera	127 / 1254	45.558053	-61.333911	45
31	Camera	127 / 1316	45.551145	-61.331716	15
32	Camera	127 / 1349	45.547016	-61.306393	45
33	Camera	127 / 1419	45.539535	-61.276405	45
34	Camera	127 / 1511	45.534020	-61.275451	35
35	Camera	127 / 1532	45.528791	-61.274223	28
36	Camera	127 / 1544	45.528821	-61.266685	15

Table 4 - Start and End Point of Seafloor Video & Digital Still Transects

STATION	TYPE	EXPOSURE	DAY/TIME	LATITUDE	LONGITUDE	DEPTH
37	Video/Still	1	127/160400	45.531446	-61.264166	15
37	Video/Still	29	127/162103	45.534455	-61.260526	15
56	Video/Still	1	128 /141100	45.642075	-61.408303	53
56	Video/Still	13	128/141700	45.643145	-61.407628	53
57	Video/Still	14	128/150700	45.643380	-61.411796	62
57	Video/Still	49	128/153157	45.641895	-61.411181	62
58	Video/Still	1	128/155200	45.643546	-61.416270	58
58	Video/Still	13	128/160520	45.643277	-61.414548	58
65	Video/Still	1	128/183254	45.593800	-61.380470	57
65	Video/Still	44	128/185700	45.597355	-61.375413	57
66	Video/Still	1	128/191728	45.587866	-61.368910	50
66	Video/Still	27	128/193631	45.590104	-61.365751	50

Appendices

Appendix I - Survey Particulars

Name of Vessel:	*J.L. Hart*
Dates	27 April – 14 May 2004
Vessel captain:	Pierre Leger
Area of Operation	Canso Strait, NS
Senior Scientist:	Russell Parrott

List of Participants

Geological Survey of Canada Atlantic

Russell Parrott	Senior Scientist
Darrell Beaver	Navigation + Simrad EM3000 multibeam
Robert Murphy	Sampling and seafloor photography
Austin Boyce	Electronics
Anthony Atkinson	Electronics and digital photography

Other

Eric Patton	GIS, navigation, sampling and photography

Appendix II - Cruise Log (all times in GMT)

26 April 2004 Monday

15:00 Parrott and Reid arrive in Port Hawkesbury after driving from Argentia NF upon completion of the cruise Matthew 2004008. Rendezvous with personnel on *J.L. Hart* to verify schedule for TowCam survey with D. McKeown. Arrange use of various tools. Install tide gauge for use on upcoming multibeam bathymetry at the marina in Ship Harbour, Port Hawkesbury.
Describe upcoming program to Billy Joe MacLean, Mayor of Port Hawkesbury.

21:00 Make contact with D. McKeown and visit *J.L. Hart* to finalize plans for TowCam survey in morning. The *J.L. Hart* was docked at the government wharf in Ship Harbour, Port Hawkesbury.

27 April 2004 Tuesday

10:00 Parrott, Patton and McKeown arrive *J.L. Hart*

11:15 Deploy TowCam. Laser markers with a spacing of 10 cm on vehicle. Initial problem with hydraulic valve when trying to payout cable. Problem becomes less severe after fluids warm up and McKeown whacks the valve with a rather large wrench a few times.
Transect 1 was run in the vicinity of the disposal site near Port Hawkesbury and shows a predominately silty seafloor with abundant brittle stars. A variety of large angular boulders with occasional tires and metal are scattered throughout the area.
Transit 2 was run over the shallow water site. More brittle stars were observed over a silty sand bottom, with dish shaped holes about 20 cm wide. A small zone of probable dredge spoils was observed.

14:30 Recover TowCam

15:00 Problems encountered with ships hydraulic system. Return to Port Hawkesbury and wait for personnel from hydraulic company to arrive and fully diagnose problem. A leak around the holding tank has resulted from a crack in the cover and filter for the unit.

28 April 2004 Wednesday

Hydraulic repairs on *J.L. Hart*. No surveys performed. The cover was welded and a new unit is on order.
Connect computers and attempt to get network running.

29 April 2004 Thursday

09:00 Parrott, Patton and McKeown arrive *J.L. Hart*.

09:30 Deploy TowCam for surveys over near Point Tupper. The TowCam shows a predominately silt/sand seafloor with abundant brittle stars and occasional sea anemones. A variety of large angular boulders, cobbles and gravel with occasional tires and metal are scattered throughout the area.

11:55 Deploy TowCam near the causeway. The TowCam shows a predominately silt/sand seafloor with abundant brittle stars, kelp and occasional sea anemones. A variety of large angular boulders and metal are observed throughout the area.

13:00 Recover TowCam

14:20 Recover TowCam near Stora Enso dock

15:00 Arrive Mulgrave and start demobilization of TowCam system.
Beaver, Boyce, Heffler, Jodrey, Murphy, Reid, Vaas had earlier arrived from Dartmouth for demobilization of gear. Demob all TowCam gear and load into rental van. TowCam and winch loaded unto a Coast Guard truck for transit to BIO.

19:00 Vaas, Jodrey and McKeown depart vessel to return to Dartmouth.
Continue with mobilization of geophysical gear and digitizers.
21:00 Mobilization of geophysical gear partially complete.

30 April 2004 Friday

10:30 Parrott, Patton, Boyce, Murphy, and Heffler arrive *J.L. Hart* and continue with mobilization of gear and digitizers. Development system for GscDig placed on bridge for Heffler's use.
Beaver and Reid upgrade installation of tide gauge.
13:37 Depart jetty at Port Howksbury and prepare to survey disposal sites.
14:10 Deploy Seistec, Simrad MS992 sidescan sonar and TrackPoint II towfish positioning system. Perform surveys over disposal site off Point Tupper. Heffler monitors programs and makes some changes to software.
19:54 Recover geophysical survey gear and return to dock. CCGS Matthew arrives with survey launch Plover. Matthew docks in Mulgrave to deploy launch and to unload computer gear from the lab. Murphy drives Beaver and Reid to Mulgrave to retrieve the launch. Matthew departs for Halifax.
21:00 Finish backup of data to DVD. Launch Plover secured to inside portion of yacht wharf to protect the boat from onshore waves.
21:00 Beaver and Reid return to jetty.

1 May 2004 Saturday

09:00 Beaver and Reid arrive Plover, depart for survey site and continue survey of Canso Strait
10:30 Parrott, Patton, Boyce, Murphy, and Heffler arrive *J.L. Hart*. Heffler upgrades GscDig software. Depart for survey site. GscDig development system on bridge used to monitor data quality and provide a real time display of data acquisition.
11:05 Deploy gear and commence survey of disposal site
20:00 Recover survey gear and return to jetty.
21:00 Beaver and Reid return to jetty.

2 May 2004 Sunday

09:00 Beaver and Reid arrive Plover, depart for survey site and continue survey of Canso Strait
10:30 Parrott, Patton, Boyce, Murphy, and Heffler arrive *J.L. Hart*. Heffler upgrades GscDig software. Heffler departs for BIO.
10:45 *J.L. Hart* departs for survey site.
11:00 Repair sidescan sonar umbilical.
11:36 Deploy gear and commence survey of disposal site
19:41 Recover survey gear and return to jetty.
21:00 Beaver and Reid return to jetty.

3 May 2004 Monday

09:00 Beaver and Reid arrive Plover, depart for survey site and continue survey of Canso Strait
10:30 Parrott, Patton, Boyce and Murphy arrive *J.L. Hart*.
11:00 *J.L. Hart* departs for survey site.
11:15 Deploy gear and commence survey of disposal site
14:41 Retrieve all gear for transit.
18:30 Deploy survey gear
20:15 Recover survey gear and return to jetty.
21:00 Beaver and Reid return to jetty.

4 May 2004 Tuesday

09:00 Beaver and Reid arrive Plover, depart for survey site and continue survey of Canso Strait
10:30 Parrott, Patton, Boyce and Murphy arrive *J.L. Hart*.
10:45 *J.L. Hart* departs for survey site.
11:00 Deploy gear and commence survey of disposal site.
16:14 Recover sidescan and continue with survey of crosslines with Seistec only.
18:00 Recover Seistec and commence start of camera stations 1 to 4
19:00 Recover gear and return to jetty. Take film to Photo lab for to get test film processed and ensure that the camera is functioning properly.
21:00 Beaver and Reid return to jetty.

5 May 2004 Wednesday

10:00 Boyce, Beaver and Reid arrive Plover. Boyce starts repair of sliprings on SVP winch on Plover.
Plover departs for survey site and continue survey of Canso Strait
10:30 Parrott, Patton, and Murphy arrive *J.L. Hart*.
10:45 *J.L. Hart* departs for survey site and commences camera stations. Stations 5-26 completed.
14:00 Plover departs for survey site and continue survey of Canso Strait.
Tony Atkinson arrives from GSCA during the afternoon and A. Boyce returns to GSCA.
20:00 *J.L. Hart* returns to jetty. Take films out for processing.
21:00 Beaver and Reid return to jetty.

6 May 2004 Thursday

10:00 Beaver and Reid arrive Plover and depart for surveys area.
10:30 Parrott, Patton, Atkinson and Murphy arrive *J.L. Hart*.
10:45 *J.L. Hart* departs for survey site and commences camera stations 27-36. Atknison commences mobilization of GSC Scorpio digital video/still camera.
16:03 Start transects with Scorpio digital camera. Station 37.
16:41 Start grab sample program. Grabs 38-47
19:36 End grab sample program
20:00 *J.L. Hart* returns to jetty. Take films out for processing.
21:00 Beaver and Reid return to jetty.

7 May 2004 Friday

10:00 Beaver and Reid arrive Plover and depart for surveys area.
10:30 Parrott, Patton, Atkinson and Murphy arrive *J.L. Hart*.
10:45 *J.L. Hart* departs for survey site and commences grab stations 48-55
12:50 End of grab samples.
16:03 Start transects with Scorpio digital camera. Station 56-66.
Tentative arrangements are made to dock the Plover at the Coast Guard base in Port Bickerton.
19:36 End video transect program
20:00 *J.L. Hart* returns to jetty. Start demobilization of system.
21:00 Beaver and Reid return to jetty. Recover tide gauge. Plover tied at marina to allow early departure of *J.L. Hart*.

8 May 2004 Saturday

08:00 *J.L. Hart* departs for transit to BIO
11:00 Beaver and Reid arrive Plover and depart Port Bickerton. Weather poor with high winds.

10:30 Parrott, Patton, Atkinson and Murphy demobilize gear from hotel rooms. Atkinson downloads digital images from Scorpio camera. This is traditionally a very slow process due to problems with the camera software.

14:00 Patton, Atkinson depart Port Hawkesbury for BIO. Parrott and Murphy depart with 2 vehicles to meet the Plover in Port Bickerton and deliver a GSC vehicle to Beaver and Reid.

18:30 Parrott and Murphy arrive in Port Bickerton and make contact with the Coast Guard base. Final arrangements are made to dock the Plover at the Coast Guard Jetty.

19:00 Plover arrives in Port Bickerton and is secured to the jetty.

19:30 Beaver, Reid, Parrott and Murphy depart Port Bickerton for Sherbrook. While en route to Sherbrook, the weather forecast calls for increasingly strong on-shore winds, which would preclude any surveys in the area for the following day. All personnel decide to return to Halifax/Dartmouth.

22:00 Arrive at BIO

9 May 2004 Sunday

12:00 Beaver and Reid depart BIO for transit to Sherbrook.
No survey operations due to high winds.

10 May 2004 Monday

10:00 Beaver and Reid depart Sherbrook and drive to Port Bickerton and join Plover.
11:30 Plover departs Port Bickerton for transit to Isaacs Harbour.
12:42 Start of survey in Isaacs Harbour. Lines 1-101
19:49 End of surveys in Isaacs Harbour.

11 May 2004 Monday

09:00 Beaver and Reid depart Sherbrook and drive to Port Bickerton and join Plover.
10:00 Plover departs Port Bickerton for transit to Isaacs Harbour.
11:05 Start of survey in Isaacs Harbour. Lines 1-76
14:52 End of surveys in Isaacs Harbour due to winds.

12 May 2004 Tuesday

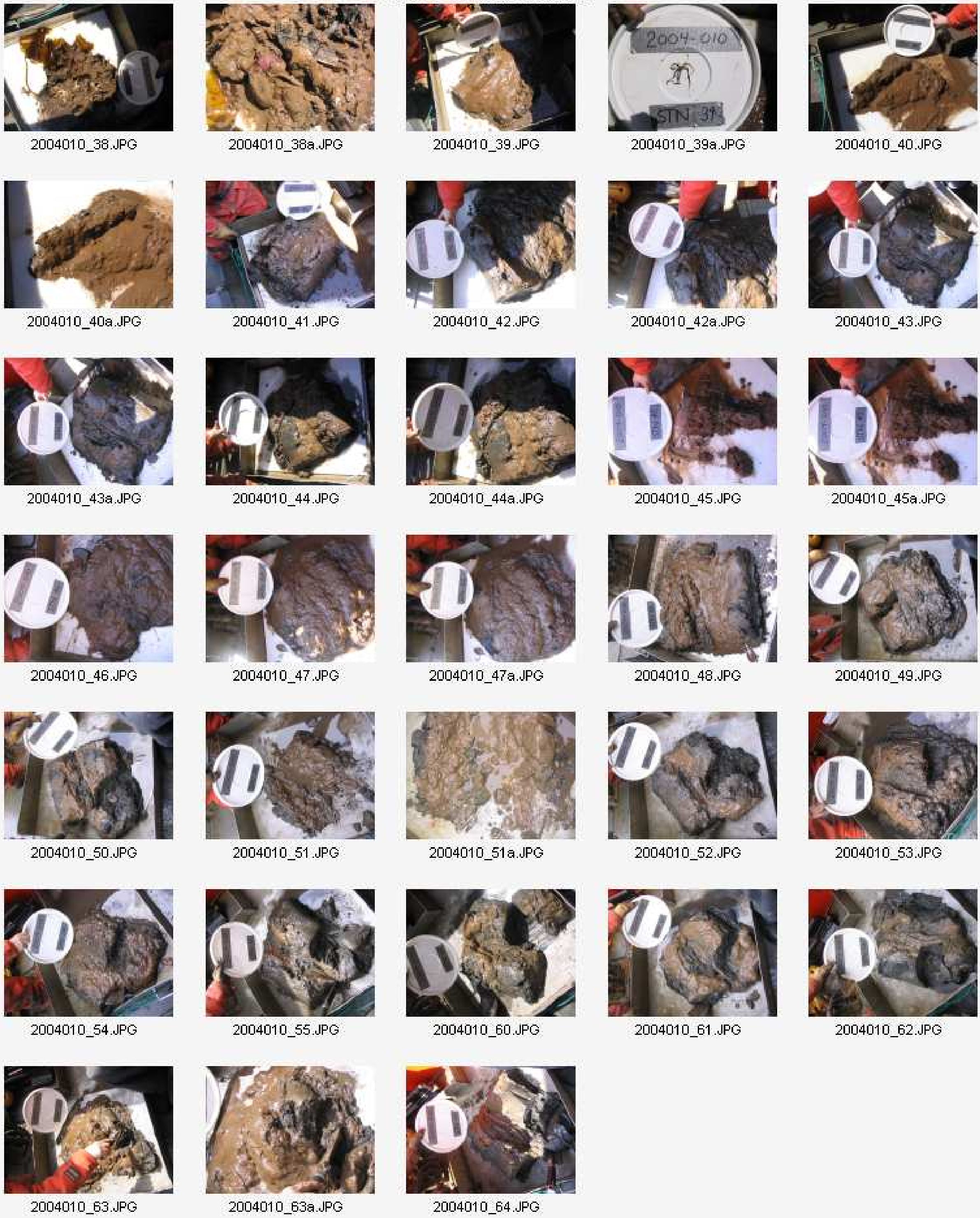
09:00 Beaver and Reid depart Sherbrook and drive to Port Bickerton and join Plover.
10:00 Plover departs Port Bickerton for transit to Seal Harbour.
11:30 Start of survey in Seal Harbour. Lines 1-61
19:25 End of surveys in Seal Harbour.

14 May 2004 Thursday

09:00 Beaver and Reid depart Port Bickerton and transit Plover back to BIO.

Appendix III - Grab Sample Photographs

2004010 Grab Stations



Grab sample photographs

Appendix IV - Seafloor Photographs from GSC Icehole Camera

2004010 Camera Stations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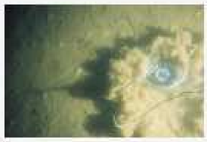
2004010_26.JPG


2004010_26a.JPG


2004010_27.JPG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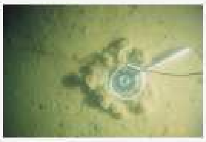
2004010_28a.JPG


2004010_28b.JPG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2004010_29.JPG


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2004010_29d.JPG


2004010_29e.JPG

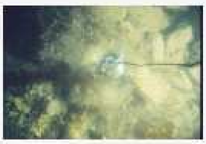

2004010_29f.JPG


2004010_29g.JPG


2004010_29h.JPG


2004010_29i.JPG


2004010_29j.JPG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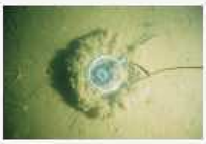
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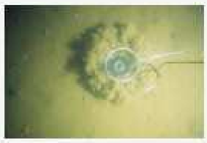
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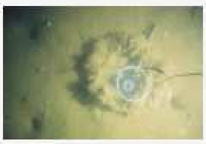
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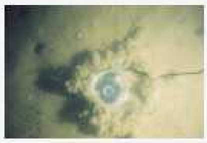
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2004010_30d.JPG

Seafloor photographs

2004010 Camera Stations


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2004010_19.JPG


2004010_19a.JPG


2004010_19b.JPG


2004010_19c.JPG


2004010_19d.JPG


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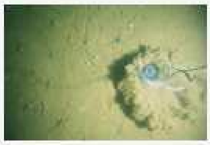
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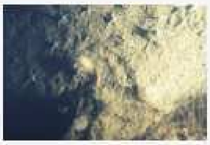
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2004010_20d.JPG


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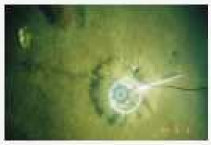
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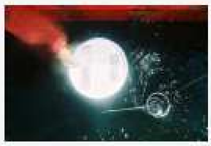
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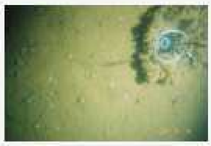
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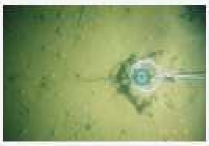
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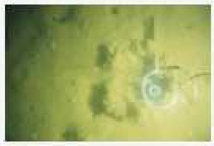
2004010_25d.JPG

Seafloor photographs

2004010 Camera Stations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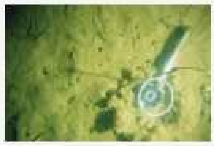
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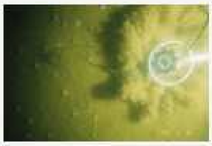
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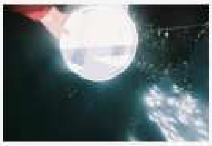
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2004010_35d.JPG


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2004010_36.JPG


2004010_36a.JPG


2004010_36b.JPG


2004010_36c.JPG


2004010_36d.JPG


2004010_36e.JPG


2004010_3a.JPG

Seafloor photographs

2004010 Camera Stations

Seafloor photographs

2004010 Camera Stations

2004010_9c.JPG

2004010_9d.JPG

2004010_9e.JPG

Seafloor photographs

Appendix V - Digital Seafloor Images – TowCam

Port Hawksbury April 2004

Day 118 AM TowCam Images

Port Hawksbury April 2004

Day 118 AM TowCam Images

Port Hawksbury April 2004


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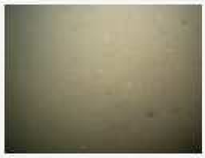
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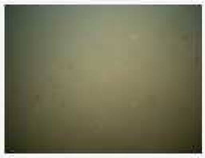
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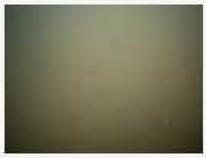
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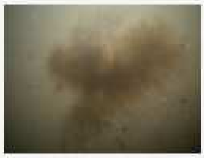
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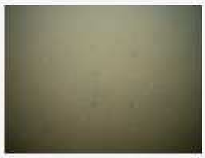
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Day 118 AM TowCam Images

Port Hawksbury April 2004


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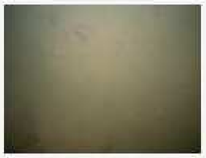
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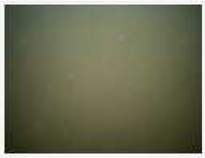
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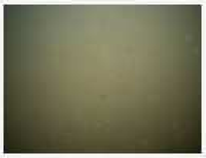
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Day 118 AM TowCam Images

Port Hawksbury April 2004


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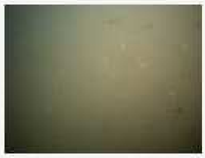
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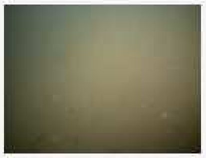
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Day 118 AM TowCam Images

Port Hawksbury April 2004


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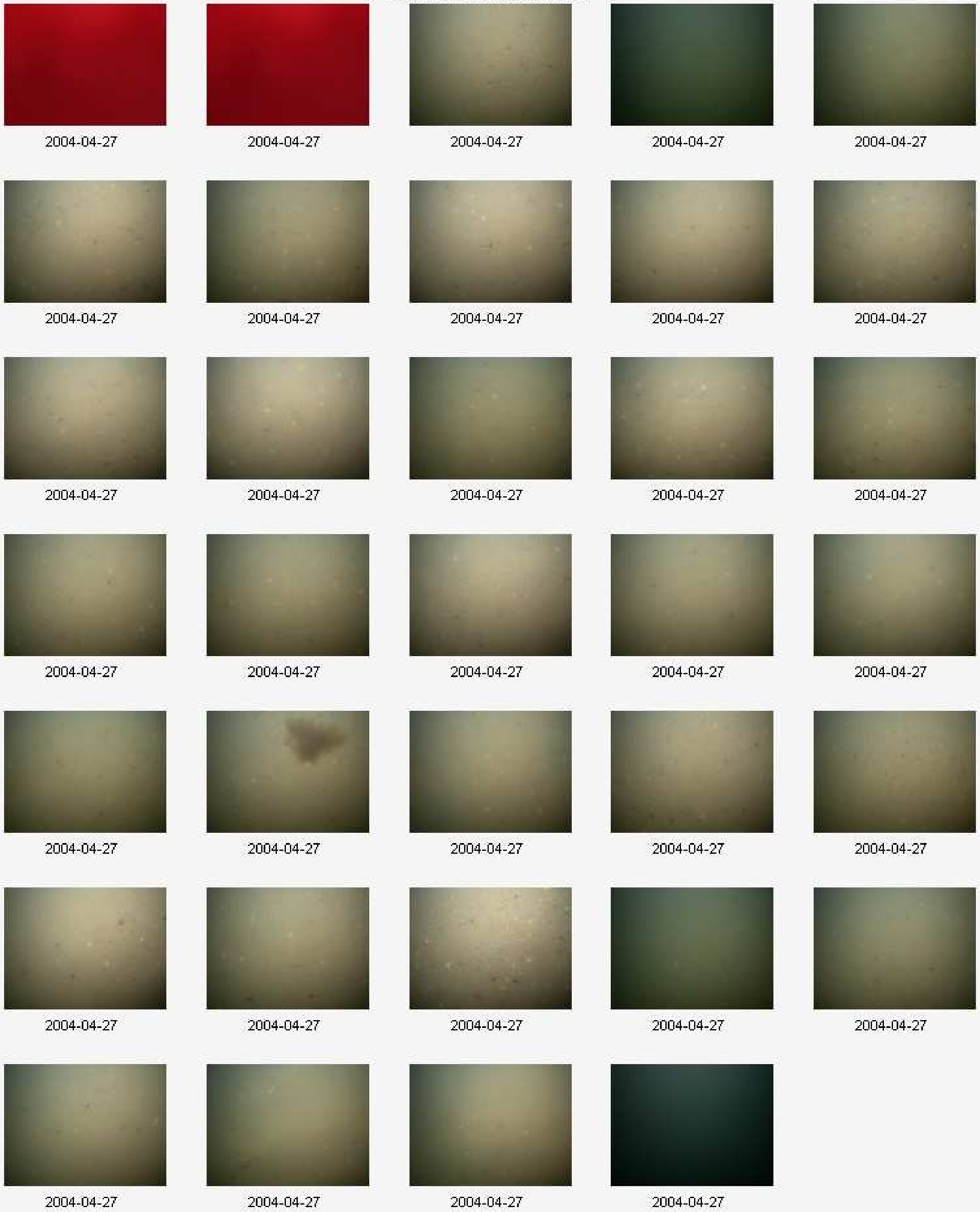
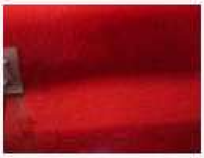
Day 118 AM TowCam Images

Port Hawksbury April 2004



Day 118 PM TowCam Images

Port Hawksbury April 2004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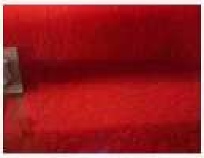
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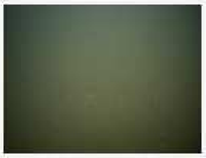
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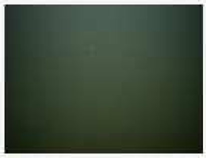
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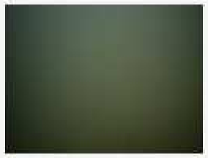
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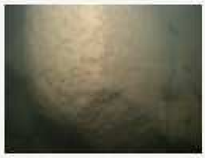
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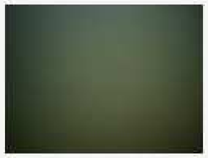
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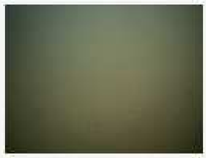
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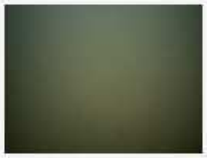
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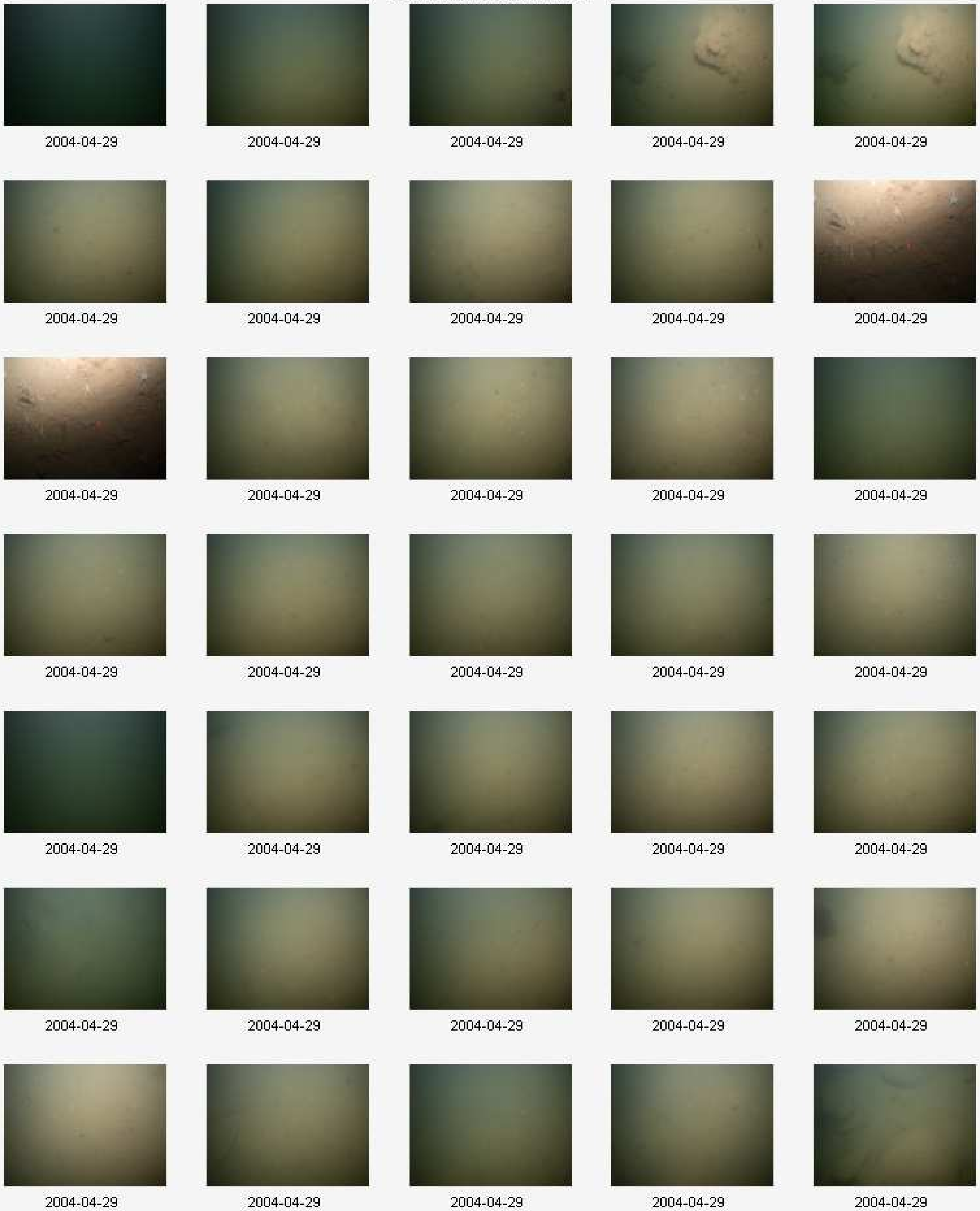
Day 120 TowCam Images

Port Hawksbury April 2004



Day 120 TowCam Images

Port Hawksbury April 2004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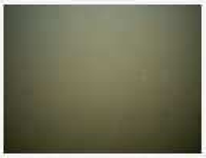
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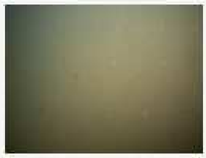
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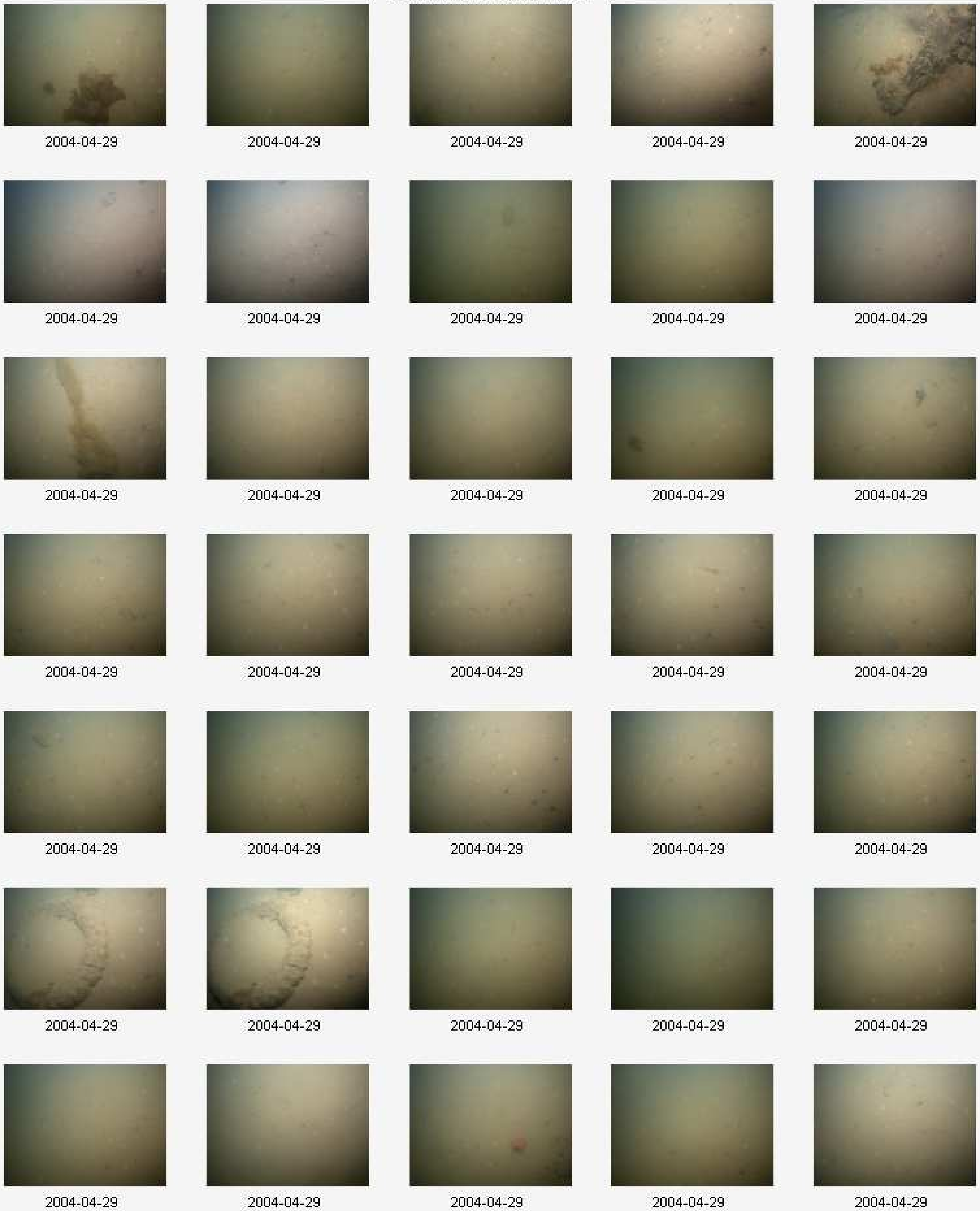
Day 120 TowCam Images

Port Hawksbury April 2004



Day 120 TowCam Images

Port Hawksbury April 2004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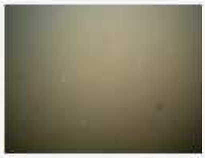
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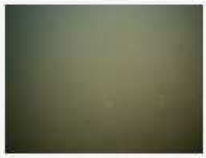
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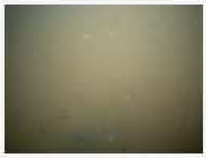
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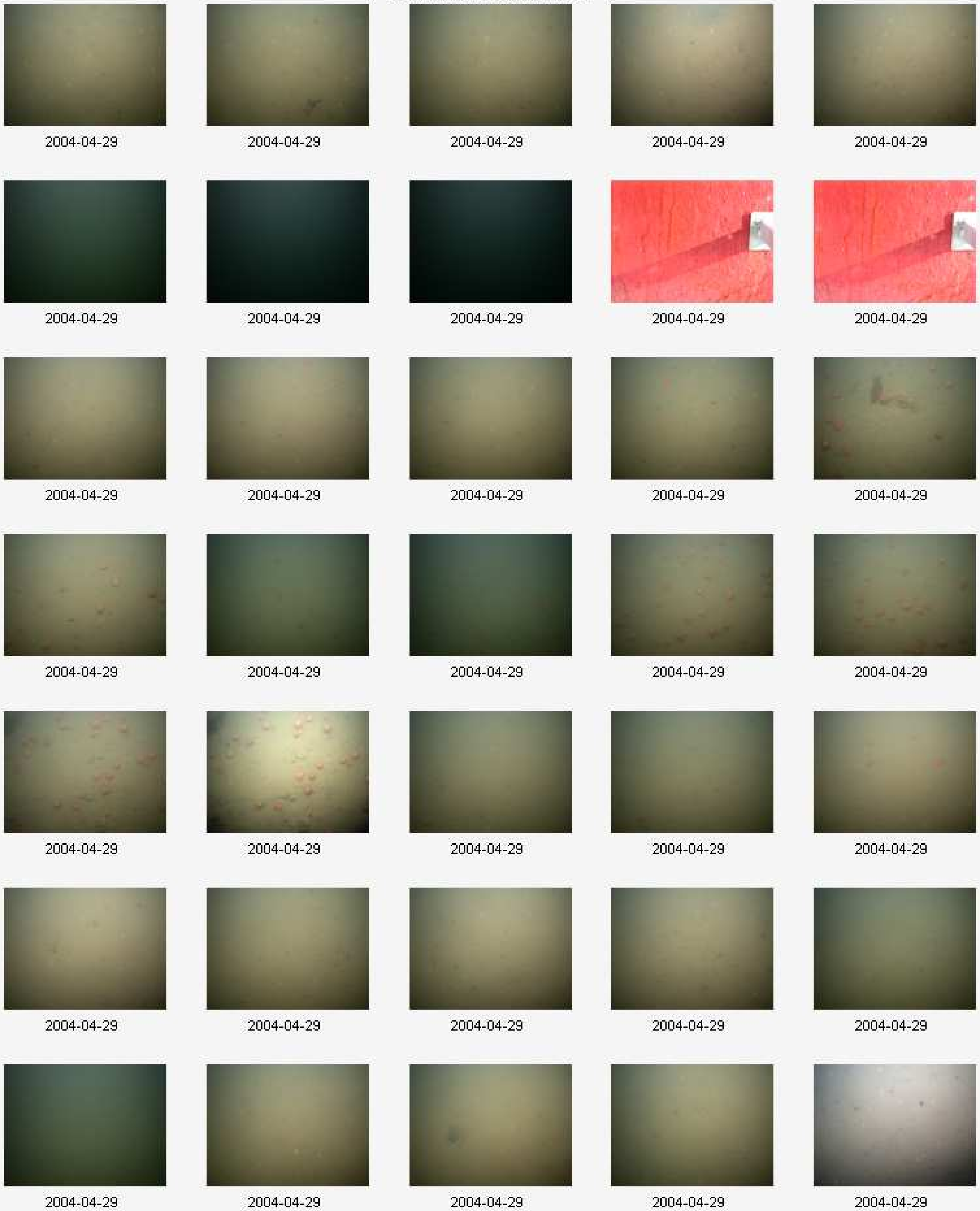
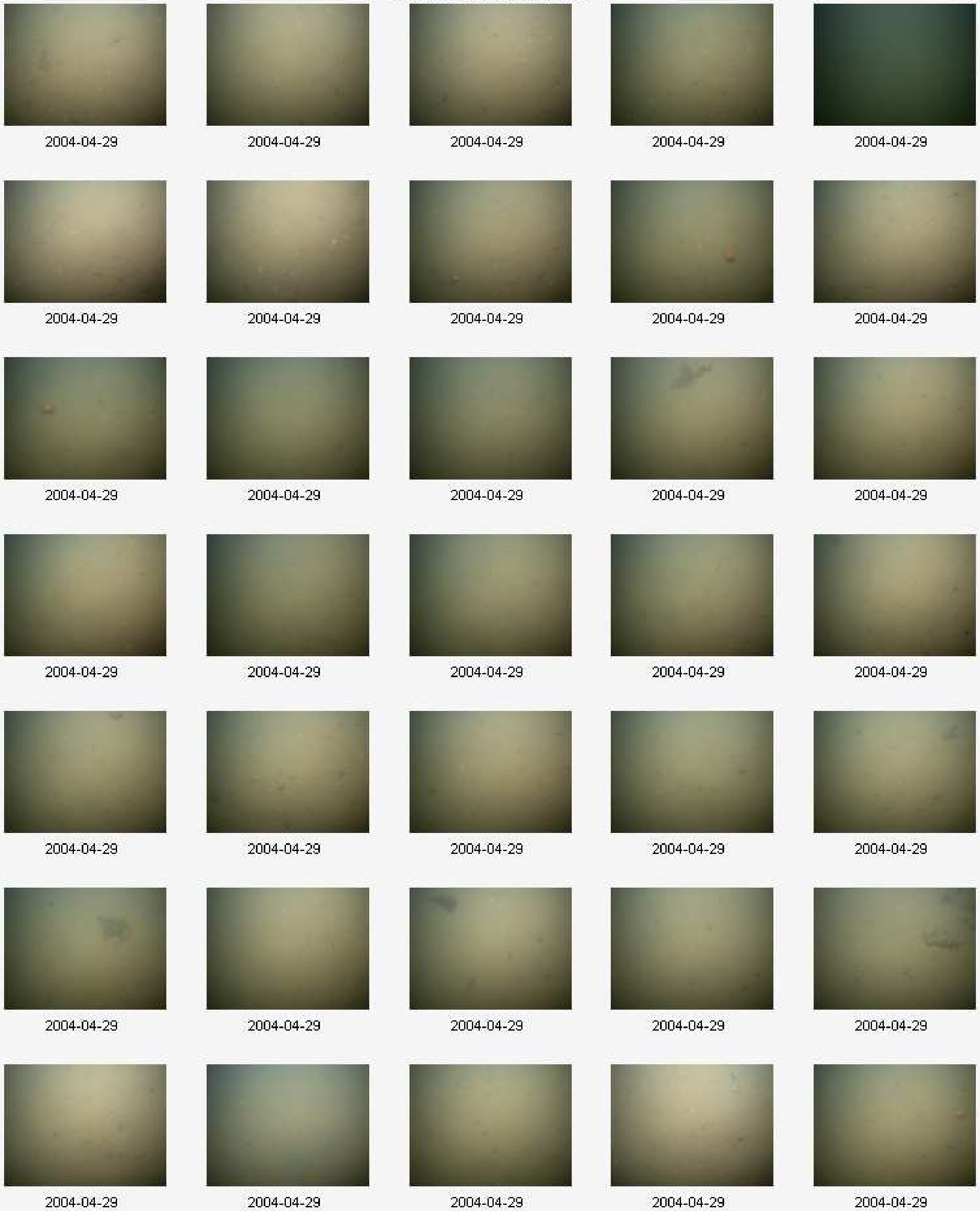
Day 120 TowCam Images

Port Hawksbury April 2004



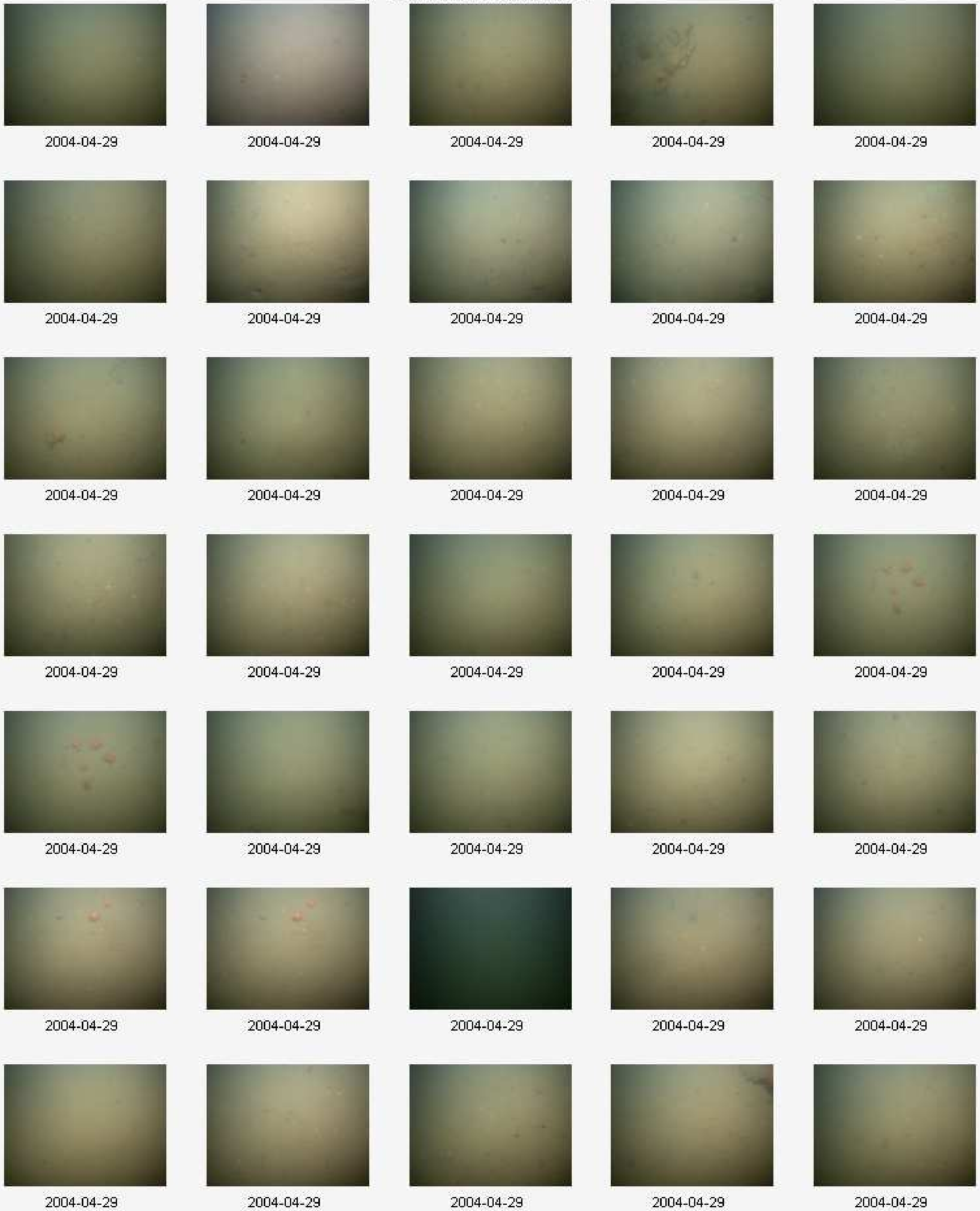
Day 120 TowCam Images

Port Hawksbury April 2004



Day 120 TowCam Images

Port Hawksbury April 2004

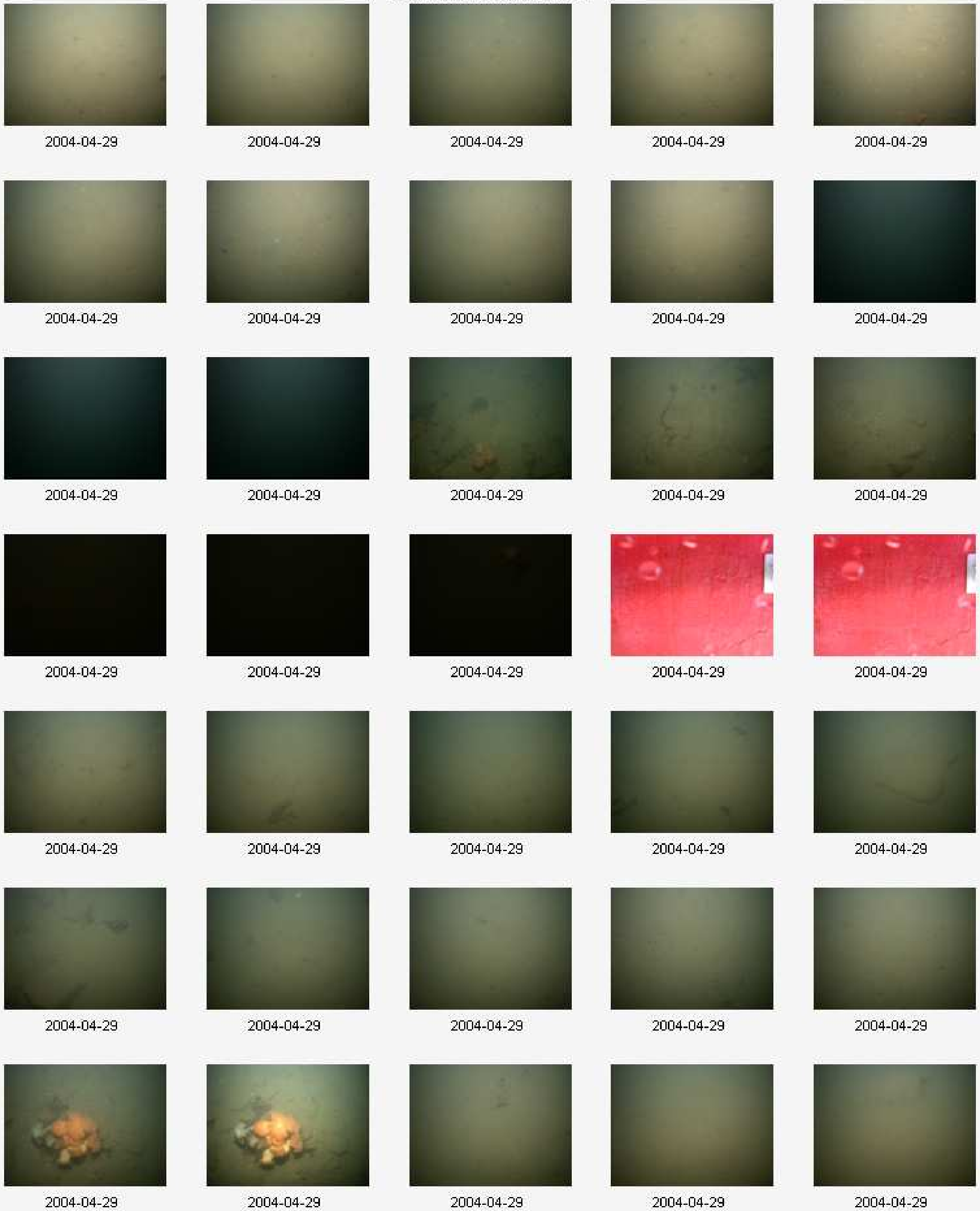


Day 120 TowCam Images

Port Hawksbury April 2004

Day 120 TowCam Images

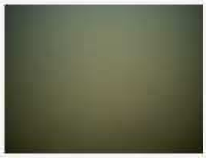
Port Hawksbury April 2004



Day 120 TowCam Images

Port Hawksbury April 2004


2004-04-29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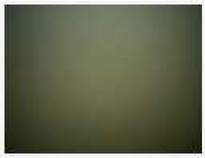
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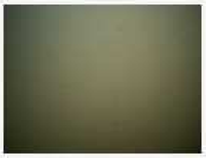
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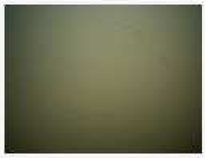
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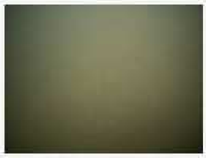
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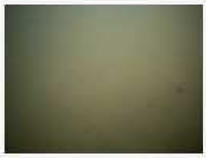
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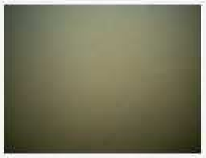
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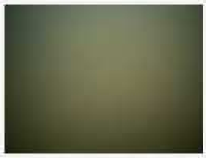
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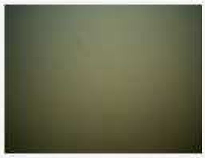
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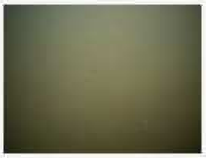
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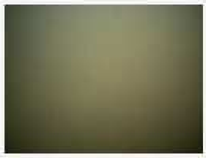
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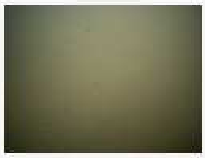
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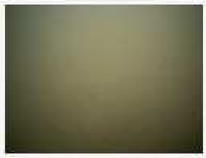
2004-04-29


2004-04-29

Day 120 TowCam Images

Port Hawksbury April 2004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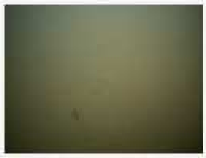
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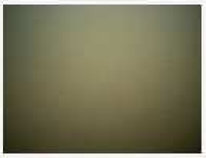
2004-04-29


2004-04-29


2004-04-29

Day 120 TowCam Images

Appendix VI - Digital Seafloor Images – Scorpio Camera

Port Hawksbury April 2004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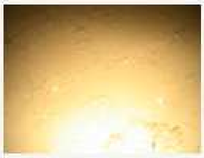
DSCN0401.JPG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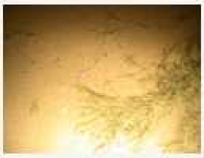
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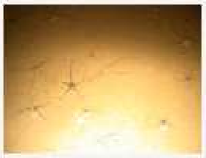
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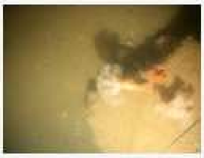
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DSCN0410.JPG


DSCN0411.JPG


DSCN0412.JPG


DSCN0413.JPG


DSCN0414.JPG


DSCN0415.JPG


DSCN0416.JPG

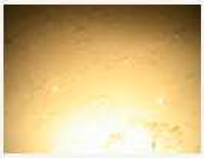
Day 128 Scorpio Images

Port Hawksbury April 2004


DSCN0399.JPG


DSCN0400.JPG


DSCN0401.JPG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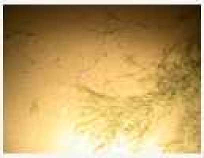
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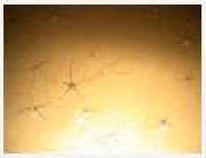
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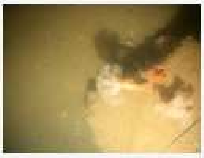
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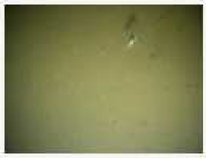
DSCN0416.JPG

Day 128 Scorpio Images

Port Hawksbury April 2004


DSCN0454.JPG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DSCN0459.JPG


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DSCN0462.JPG


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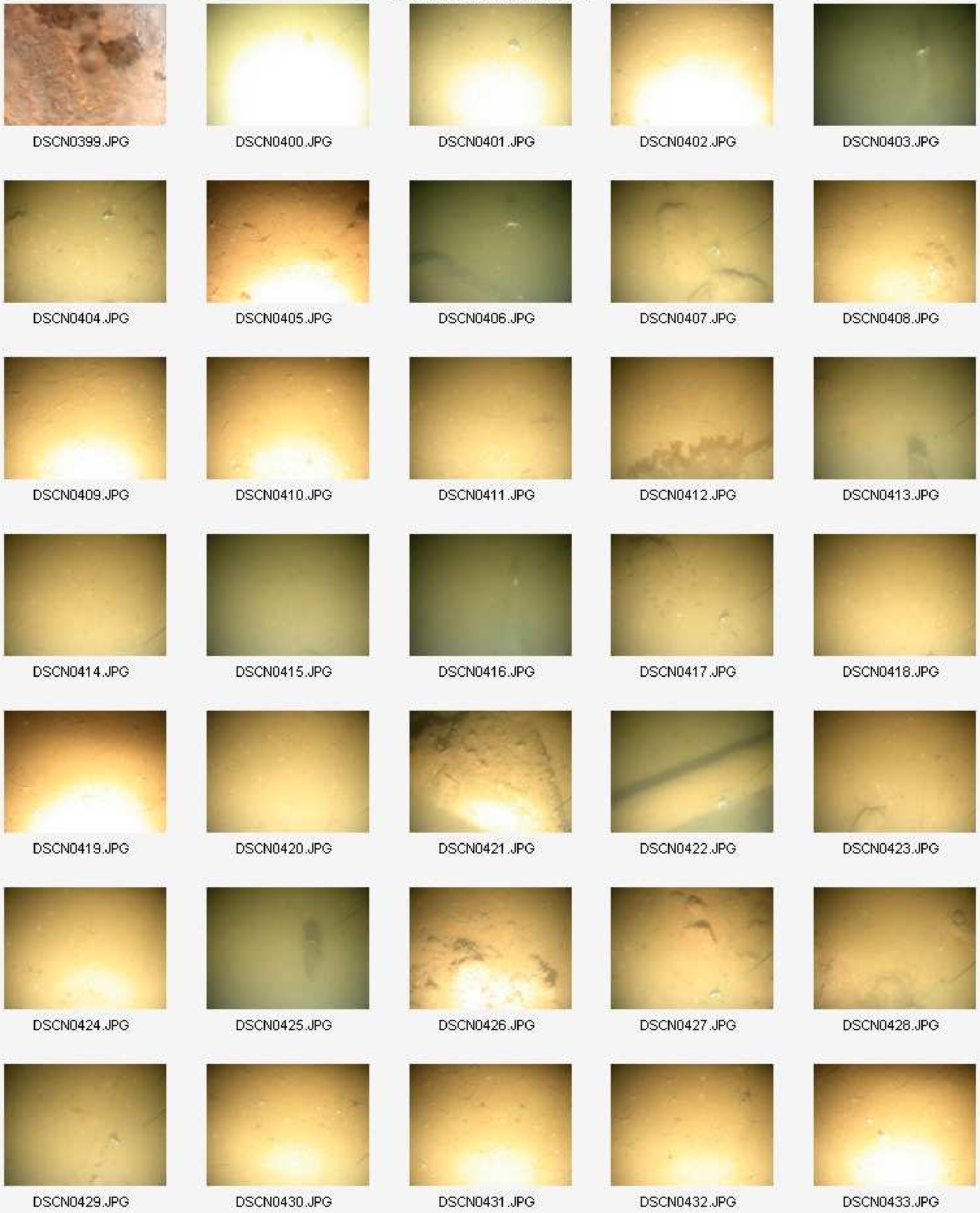
DSCN0465.JPG


DSCN0466.JPG

Day 128 Scorpio Images

Port Hawksbury April 2004



Day 128 Scorpio Images

Port Hawksbury April 2004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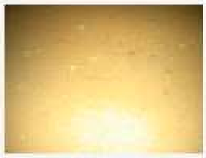
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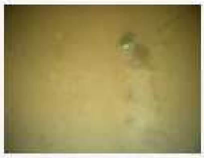
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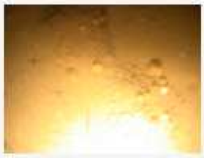
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Day 128 Scorpio Images

Port Hawksbury April 2004


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DSCN0450.JPG


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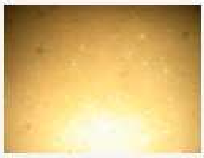
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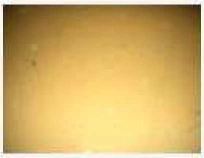
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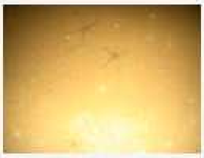
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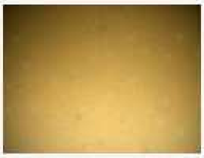
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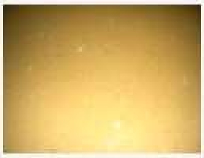
DSCN0475.JPG

Day 128 Scorpio Images

Appendix VII - Predicted Tides for Port Hawkesbury NS 26 April – 17 May 2004

Tides generated by the program Tides and Currents Pro

Times are given in Atlantic Daylight Time and depths in centimeters

Year	Month	Day	Hr	Min	Tide	Tide	Tide	Tide	Tide	Tide	Tide	Tide	Tide	Tide	Tide	Tide
2004	Apr	26	0	0	114	117	117	116	113	110	107	101	95	89	84	80
2004	Apr	26	6	0	77	73	68	63	60	61	64	71	80	91	105	119
2004	Apr	26	12	0	132	141	146	147	145	142	138	133	126	118	110	104
2004	Apr	26	18	0	99	95	89	82	75	70	67	67	68	72	79	87
2004	Apr	27	0	0	97	106	112	115	115	114	114	112	109	104	97	91
2004	Apr	27	6	0	86	82	77	72	66	61	59	61	65	73	83	95
2004	Apr	27	12	0	109	122	134	142	145	146	145	143	140	135	128	120
2004	Apr	27	18	0	112	105	99	93	85	76	69	64	61	62	65	70
2004	Apr	28	0	0	77	87	98	107	113	117	119	120	120	119	115	108
2004	Apr	28	6	0	101	94	87	81	75	68	62	58	57	59	65	74
2004	Apr	28	12	0	85	97	112	125	137	144	148	150	150	149	146	139
2004	Apr	28	18	0	131	121	112	103	95	87	77	67	60	55	54	56
2004	Apr	29	0	0	61	68	78	89	102	112	120	125	128	130	130	127
2004	Apr	29	6	0	121	113	103	94	86	79	71	63	57	53	53	57
2004	Apr	29	12	0	65	74	86	100	115	130	142	150	155	158	158	156
2004	Apr	29	18	0	151	142	131	119	108	97	87	77	66	56	49	47
2004	Apr	30	0	0	48	52	59	69	82	96	110	122	131	137	141	142
2004	Apr	30	6	0	140	135	126	115	103	93	83	74	65	57	51	48
2004	Apr	30	12	0	49	55	63	75	88	105	122	138	151	160	165	167
2004	Apr	30	18	0	166	162	153	141	127	113	100	88	76	64	53	44
2004	May	1	0	0	39	39	43	50	60	74	90	107	124	137	146	152
2004	May	1	6	0	154	153	149	140	128	114	101	89	79	68	58	49
2004	May	1	12	0	44	42	46	53	63	77	93	112	131	148	161	170
2004	May	1	18	0	174	175	171	163	151	136	119	103	89	76	63	50
2004	May	2	0	0	40	33	31	34	41	52	66	83	102	122	139	152
2004	May	2	6	0	161	165	165	162	154	142	127	112	97	84	72	61
2004	May	2	12	0	50	42	37	38	43	53	66	82	101	122	142	159
2004	May	2	18	0	171	178	180	178	171	160	145	127	109	92	76	62
2004	May	3	0	0	49	37	29	25	26	33	44	58	75	96	117	138
2004	May	3	6	0	155	167	173	175	173	167	156	141	125	108	92	78
2004	May	3	12	0	65	53	42	35	33	36	44	56	72	90	111	133
2004	May	3	18	0	153	168	178	182	181	176	166	152	135	115	96	79
2004	May	4	0	0	64	50	37	27	21	21	26	36	50	67	87	109
2004	May	4	6	0	131	152	168	178	182	182	177	168	155	138	120	102
2004	May	4	12	0	86	71	58	45	36	31	31	37	48	62	79	99
2004	May	4	18	0	120	142	160	173	180	181	178	170	158	142	123	103
2004	May	5	0	0	84	67	53	40	29	22	19	22	30	42	58	77
2004	May	5	6	0	98	121	144	163	177	185	187	185	178	167	151	133
2004	May	5	12	0	114	95	79	65	52	41	33	31	34	42	53	68
2004	May	5	18	0	86	105	127	146	163	173	177	176	170	161	147	130
2004	May	6	0	0	110	91	74	58	46	34	26	21	21	26	36	49
2004	May	6	6	0	66	85	107	131	153	171	182	188	189	184	176	163
2004	May	6	12	0	146	126	107	90	74	61	49	40	34	34	38	47
2004	May	6	18	0	58	73	90	109	129	147	161	168	170	167	160	150
2004	May	7	0	0	136	118	100	82	67	54	43	34	27	23	25	31
2004	May	7	6	0	41	55	72	92	114	138	159	175	185	188	187	181
2004	May	7	12	0	171	157	139	120	102	86	73	61	50	42	38	38
2004	May	7	18	0	42	50	61	74	91	109	128	144	155	161	161	157
2004	May	8	0	0	150	140	126	110	94	78	65	54	45	36	30	27
2004	May	8	6	0	29	35	45	59	76	97	120	143	162	176	183	185
2004	May	8	12	0	182	175	165	151	134	117	100	87	75	64	54	46
2004	May	8	18	0	41	41	44	50	60	73	89	107	124	138	148	151
2004	May	9	0	0	151	148	141	132	120	107	92	79	68	58	49	40
2004	May	9	6	0	33	30	32	37	48	62	80	101	124	145	162	174
2004	May	9	12	0	179	180	176	170	160	147	132	116	102	90	79	68

2004	May	9	18	0	57	48	43	41	43	48	57	70	86	103	119	132
2004	May	10	0	0	139	143	143	141	137	130	120	108	95	84	73	63
2004	May	10	6	0	52	43	35	32	33	39	50	64	82	103	125	145
2004	May	10	12	0	160	169	173	174	172	166	158	146	133	119	106	94
2004	May	10	18	0	83	70	58	48	41	38	39	45	53	66	82	98
2004	May	11	0	0	114	125	133	137	139	140	137	132	123	112	100	89
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2004	May	12	0	0	79	95	110	122	130	137	141	143	142	137	128	117
2004	May	12	6	0	105	94	82	69	56	45	37	34	36	42	53	67
2004	May	12	12	0	85	105	124	140	153	161	167	170	171	168	161	150
2004	May	12	18	0	137	124	111	97	82	66	51	40	32	30	31	37
2004	May	13	0	0	47	61	78	95	111	123	133	141	147	149	148	142
2004	May	13	6	0	132	121	108	96	84	70	57	45	38	35	37	44
2004	May	13	12	0	54	68	86	105	124	140	152	162	169	173	173	170
2004	May	13	18	0	161	150	136	122	108	93	76	60	45	34	28	26
2004	May	14	0	0	29	36	48	63	81	99	116	129	140	148	154	156
2004	May	14	6	0	153	145	135	122	110	97	84	70	56	45	38	36
2004	May	14	12	0	38	45	56	70	88	107	126	142	155	164	171	175
2004	May	14	18	0	174	169	159	146	132	117	102	86	69	53	39	29
2004	May	15	0	0	25	25	29	38	52	70	89	108	125	138	149	157
2004	May	15	6	0	161	161	156	146	135	122	110	97	83	69	55	44
2004	May	15	12	0	38	37	40	47	59	74	93	113	131	147	159	167
2004	May	15	18	0	173	175	172	164	152	138	124	109	94	78	61	45
2004	May	16	0	0	33	26	24	27	34	45	61	81	101	120	135	148
2004	May	16	6	0	157	163	165	163	156	145	133	121	108	95	81	66
2004	May	16	12	0	53	44	39	39	43	52	65	81	100	120	137	151
2004	May	16	18	0	162	168	172	171	165	155	142	128	114	99	84	68
2004	May	17	0	0	53	39	30	26	27	33	42	56	74	94	114	132
2004	May	17	6	0	146	156	163	167	167	162	153	142	130	117	105	91
2004	May	17	12	0	77	63	51	44	41	43	49	59	73	90	109	127
2004	May	17	18	0	143	154	162	166	166	163	155	143	130	116	102	88

Appendix VIII - Measured tides for Port Hawkesbury NS 30 April – 7 May 2004

Tides downloaded from the tide gauge in Port Hawkesbury NS

Times are given in GMT, depths in meters, temperatures in Celsius

8200 DATA FROM: PH DATE: 04/30/2004 to 05/07/2004

Date	Time	Battery	Tide	Temperature
4/30/2004	11:00:00	12.99	1.01	5.29
	12:00:00	13.06	0.76	5.75
	13:00:00	13.08	0.64	5.77
	14:00:00	13.11	0.55	5.99
	15:00:00	13.12	0.45	7.68
	16:00:00	13.14	0.69	6.48
	17:00:00	13.15	0.94	7.17
	18:00:00	13.15	1.26	6.55
	19:00:00	13.15	1.41	6.47
	20:00:00	13.15	1.6	6.43
	21:00:00	13.14	1.46	7.71
	22:00:00	13.14	1.39	7.48
	23:00:00	13.13	1.23	7.32
5/1/2004	00:00:00	13.12	0.89	7.38
	01:00:00	13.11	0.65	7.34
	02:00:00	13.1	0.5	7.23
	03:00:00	13.08	0.4	6.91
	04:00:00	13.07	0.47	6.59
	05:00:00	13.07	0.64	6.72
	06:00:00	13.06	0.84	6.81
	07:00:00	13.05	1.2	6.93
	08:00:00	13.05	1.29	6.78
	09:00:00	13.04	1.37	6.78
	10:00:00	13.02	1.32	6.88
	11:00:00	13.04	1.17	6.93
	12:00:00	13.04	0.92	7.17
	13:00:00	13.05	0.72	7.25
	14:00:00	13.06	0.53	7.73
	15:00:00	13.07	0.34	7.91
	16:00:00	13.08	0.41	8.5
	17:00:00	13.08	0.62	8.14
	18:00:00	13.09	0.89	8.44
	19:00:00	13.09	1.2	8.72
	20:00:00	13.09	1.44	8.74
	21:00:00	13.08	1.6	8.59
	22:00:00	13.08	1.44	8.49
	23:00:00	13.07	1.38	8.64
5/2/2004	00:00:00	13.06	1.1	8.62
	01:00:00	13.06	0.78	8.59
	02:00:00	13.05	0.58	8.48
	03:00:00	13.05	0.34	8.46
	04:00:00	13.05	0.3	8.42
	05:00:00	13.04	0.41	8.38
	06:00:00	13.04	0.66	8.37
	07:00:00	13.04	0.96	8.33
	08:00:00	13.04	1.39	8.31
	09:00:00	13.04	1.49	8.27
	10:00:00	13	1.55	8.11
	11:00:00	13.03	1.39	8.14
	12:00:00	13.03	1.19	8.16
	13:00:00	13.04	0.88	8.14
	14:00:00	13.04	0.61	8.22
	15:00:00	13.04	0.33	8.35
	16:00:00	13.05	0.29	8.3
	17:00:00	13.05	0.37	8.43
	18:00:00	13.05	0.49	8.52
	19:00:00	13.06	0.95	8.2
	20:00:00	13.05	1.3	8.04
	21:00:00	12.97	1.59	8
	22:00:00	13.04	1.72	7.98
	23:00:00	13.04	1.61	7.95
5/3/2004	00:00:00	13.05	1.33	7.94
	01:00:00	13.05	0.94	7.95
	02:00:00	13.04	0.77	7.94
	03:00:00	13.04	0.38	7.96
	04:00:00	13.04	0.17	7.98
	05:00:00	13.04	0.29	7.96

	06:00:00	13.04	0.3	7.95
	07:00:00	13.04	0.76	7.95
	08:00:00	13.04	1.18	7.95
	09:00:00	13.04	1.44	7.9
	10:00:00	13.04	1.66	7.92
	11:00:00	13.04	1.64	7.95
	12:00:00	13.03	1.44	7.95
	13:00:00	13.04	1.2	7.98
	14:00:00	13.04	0.92	8.01
	15:00:00	13.04	0.54	8.1
	16:00:00	13.04	0.27	8.15
	17:00:00	13.04	0.17	8.26
	18:00:00	13.05	0.28	8.3
	19:00:00	13.04	0.62	8.27
	20:00:00	13.04	1.01	8.18
	21:00:00	13.04	1.45	8.12
	22:00:00	13.04	1.76	8.1
	23:00:00	13.04	1.68	8.14
5/4/2004	00:00:00	13.03	1.55	8.16
	01:00:00	13.04	1.27	8.18
	02:00:00	13.03	0.94	8.17
	03:00:00	13.03	0.53	8.2
	04:00:00	13.03	0.21	8.12
	05:00:00	13.03	0.12	8.13
	06:00:00	13.03	0.08	8.08
	07:00:00	13.03	0.39	8.14
	08:00:00	13.02	0.81	8.11
	09:00:00	13.02	1.21	8.07
	10:00:00	13.02	1.64	8.04
	11:00:00	13.02	1.83	8.06
	12:00:00	13.02	1.69	8.06
	13:00:00	13.02	1.53	8.11
	14:00:00	13.02	1.21	8.14
	15:00:00	13.03	0.77	8.17
	16:00:00	13.02	0.49	8.18
	17:00:00	13.02	0.27	8.19
	18:00:00	13.02	0.16	8.21
	19:00:00	13.02	0.39	8.21
	20:00:00	13.02	0.74	8.22
	21:00:00	13.03	1.22	8.12
	22:00:00	13.03	1.64	8.1
	23:00:00	13.02	1.98	8.11
5/5/2004	00:00:00	13.02	1.88	8.12
	01:00:00	13.03	1.63	8.12
	02:00:00	13.03	1.34	8.15
	03:00:00	13.03	0.87	8.16
	04:00:00	13.03	0.56	8.16
	05:00:00	13.03	0.27	8.16
	06:00:00	13.03	0.15	8.17
	07:00:00	13.03	0.17	8.15
	08:00:00	13.02	0.54	8.13
	09:00:00	13.02	0.99	8.06
	10:00:00	13.02	1.42	8.05
	11:00:00	13.02	1.9	8.12
	12:00:00	13.02	1.9	8.2
	13:00:00	13.03	1.76	8.39
	14:00:00	13.04	1.57	8.59
	15:00:00	13.05	1.07	8.81
	16:00:00	13.06	0.75	8.93
	17:00:00	13.06	0.32	8.88
	18:00:00	13.07	0.14	8.69
	19:00:00	13.07	0.13	8.78
	20:00:00	13.08	0.27	8.75
	21:00:00	13.08	0.73	8.85
	22:00:00	13.08	1.11	8.94
	23:00:00	13.08	1.63	8.93
5/6/2004	00:00:00	13.07	1.75	8.98
	01:00:00	13.06	1.65	9.31
	02:00:00	13.06	1.45	9.29
	03:00:00	13.05	1.06	9.45
	04:00:00	13.04	0.68	9.33
	05:00:00	13.04	0.35	9.27
	06:00:00	13.03	0.09	9.19
	07:00:00	13.02	-0.01	9.13
	08:00:00	13.02	0.13	9.09

	09:00:00	13.01	0.56	8.46
	10:00:00	13.01	0.95	8.75
	11:00:00	13.01	1.55	8.91
	12:00:00	13.02	1.93	8.71
	13:00:00	13.04	1.92	8.76
	14:00:00	13.05	1.75	8.94
	15:00:00	13.07	1.4	9.6
	16:00:00	13.08	1.02	10.16
	17:00:00	13.08	0.69	11.75
	18:00:00	13.08	0.36	11.97
	19:00:00	13.08	0.18	12.65
	20:00:00	13.08	0.06	12.98
	21:00:00	13.08	0.39	13.17
	22:00:00	13.08	0.74	11.49
	23:00:00	13.07	1.19	11.74
5/7/2004	00:00:00	13.06	1.64	10.58
	01:00:00	13.06	1.63	10.41
	02:00:00	13.05	1.59	10.18
	03:00:00	13.04	1.36	10.46
	04:00:00	13.04	0.87	10.5
	05:00:00	13.03	0.57	10.6
	06:00:00	13.03	0.26	10.65
	07:00:00	13.03	0.09	10.54
	08:00:00	13.03	0.13	10.41
	09:00:00	13.03	0.1	10.37
	10:00:00	13.03	0.56	10.25
	11:00:00	13.03	1.14	10.23
	12:00:00	13.03	1.64	9.97
	13:00:00	13.03	2	10.22
	14:00:00	13.04	1.97	10.15
	15:00:00	13.04	1.64	10.25
	16:00:00	13.04	1.33	10.32
	17:00:00	13.05	1.08	10.48
	18:00:00	13.05	0.71	10.64