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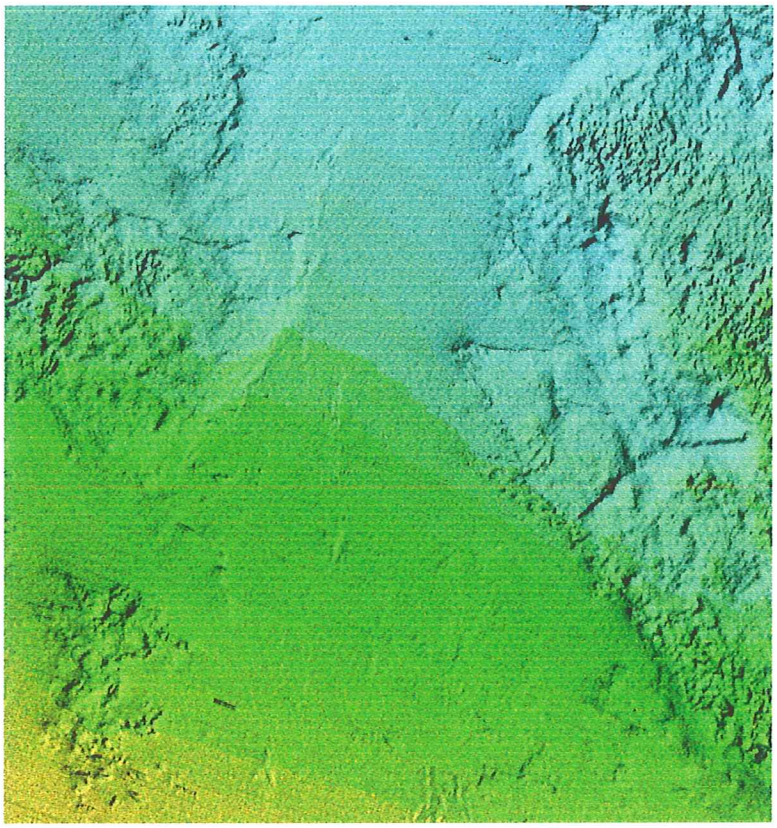
CRUISE REPORT
BIO 97093 & IML 98034C
NGCC/CCGS Frederick G. Creed

MULTIBEAM BATHYMETRIC SURVEYS, INNER SHELF OFF NORTHERN PRINCE EDWARD ISLAND

D.L. Forbes[1], A.G. Sherin[1], D. Beaver[1], D. Frobel[1] & R. Covill[3]
[1]Geological Survey of Canada, Natural Resources Canada, Dartmouth
[2]Tekmap Consulting, Fall River, Nova Scotia



GEOLOGICAL SURVEY OF CANADA
OPEN FILE 3816

Geological Survey of Canada (GSC-Atlantic)
Bedford Institute of Oceanography
1 Challenger Drive (PO Box 1006)
Dartmouth, Nova Scotia, B2Y 4A2

1999

Canada

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ACKNOWLEDGEMENTS

We wish to record our gratitude to the master and company of *NGCC* ***Frederick G. Creed*** during both missions described in this report. Their unstinting efforts and hospitality on board were greatly appreciated. We also note the contributions of CHS staff both from l'Institut Maurice Lamontagne and from the Bedford Institute of Oceanography, as well as support staff at GSC-Atlantic. R.B. Taylor and J. Shaw provided helpful comments on an earlier draft of the report.

CRUISE INFORMATION

Vessel	*NSC*[1]*/CSS*[1] ***Frederick G. Creed***
Dates	1997 - July 23-29 (days 204-210) 1998 - August 5-11 (days 217-223)
Area of operations	Inner shelf off North Shore of Prince Edward Island Gulf of St Lawrence
Operating from	Souris PEI
GSC personnel	Donald L. Forbes (senior scientist) Darrell Beaver (systems specialist) Andrew Sherin (mapping specialist) David Frobel (coastal surveys specialist)
Ship personnel 1997	Yves Gervais (Captain) Elie Bureau (First Officer) Jean Labrie (Chief Engineer) Gilles Beaulieu (Second Engineer) Emilian Sioch (Chef)
Ship personnel 1998	Yves Gervais (Captain) Philippe Cahn (First Officer) Richard Boisvert (Chief Engineer) Mario Fournier (Second Engineer) Emilian Sioch (Chef)

[1]Original prefixes in the two official languages. With the merger of the DFO and CCG fleets, the official prefixes to the names of ships in the scientific fleet have been changed to reflect Coast Guard practice. Thus the ship is now offically *NGCC/CCGS* ***Frederick G. Creed***.

INTRODUCTION

This cruise report describes multibeam survey operations in two successive seasons, covering parts of the outer shoreface and inner shelf off northern Prince Edward Island (Fig. 1) along a 30 km stretch of coast from Orby Head, west of North Rustico, to Point Deroche, between Tracadie Bay and Savage Harbour (Fig. 2). The 1997 survey (BIO 97093) covered the Brackley Bight (Harris Bay) coastal cell defined by Cape Turner and Covehead (Cape Stanhope). The 1998 survey extended this coverage to the next large coastal cell to the east, in the shallow embayment between Cape Stanhope and Point Deroche.

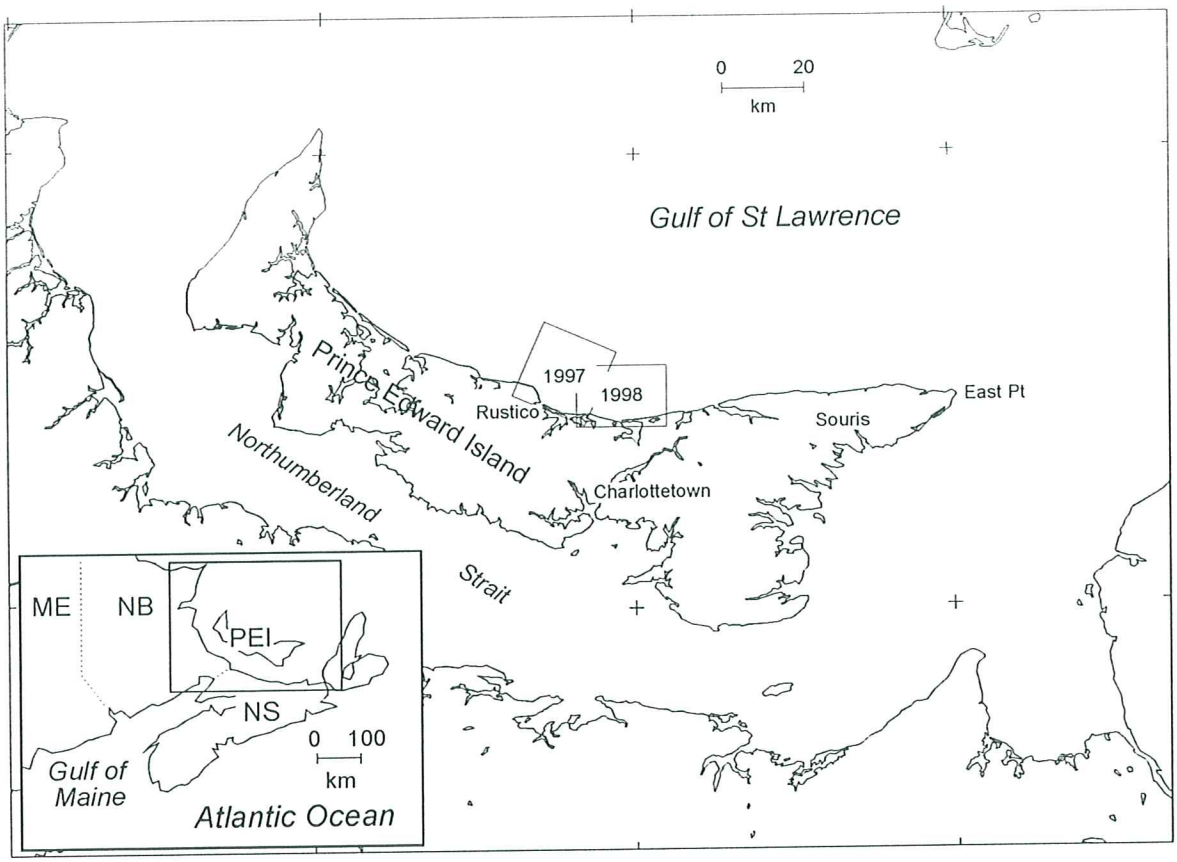

Fig. 1. Study area off northern Prince Edward Island, southern Gulf of St. Lawrence.

OBJECTIVES

To map the seabed over the inner shelf and outer shoreface off the central and eastern North Shore of Prince Edward Island, in order to determine the seaward extent of sand, the distribution and structure of bedrock exposures, the limits of submerged river valleys, evidence of glacial erosion or deposition, and evidence of modern sediment transport or erosion processes. The mapping program is intended to support coastal process studies aimed at understanding long- and short-term response to rising relative sea levels, sand budgets, beach and nearshore bar dynamics, tidal inlet processes, and coastal dune evolution and stability. In view of the limited bathymetric data previously available from the study area, an effort was made to collect data acceptable for the production of navigation charts by CHS.

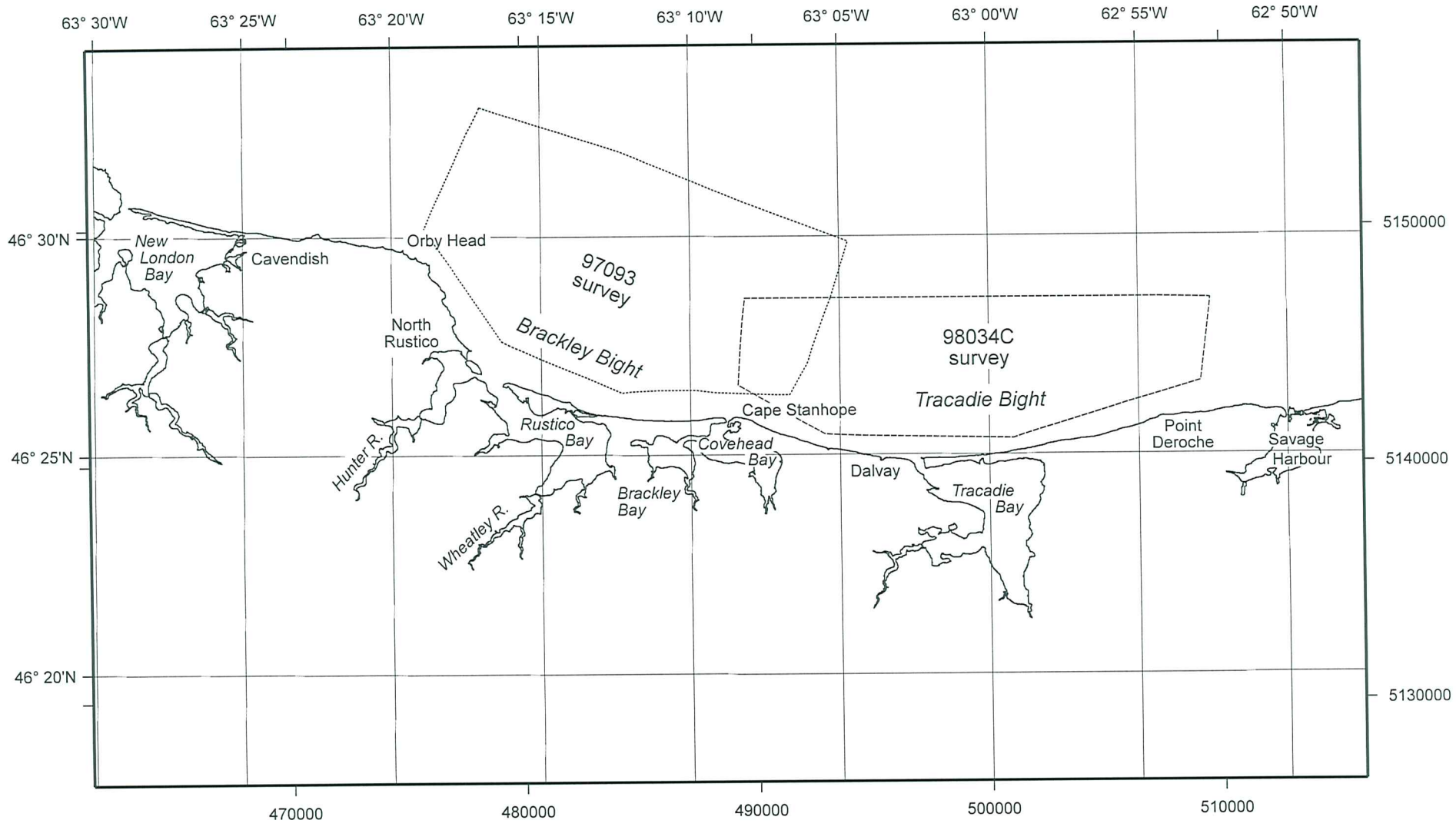

Fig. 2. Survey coverage in 1997 and 1998 off central North Shore of Prince Edward Island.

SURVEY LOGISTICS

In 1997, the vessel was mobilized at Souris (PEI) for the previous cruise over Milne Bank (Shaw, 1997 [cruise BIO 97092]). In 1998, the vessel was mobilized at St Albans (Newfoundland) for surveys in Bay d'Espoir (Shaw et al., 1998 [cruise IML 98034A]). The second phase of the combined 1998 survey operated out of Chéticamp on the west coast of Cape Breton Island (senior scientist H. Josenhans [cruise IML 98034B]).

For the PEI surveys in 1997, Beaver and Frobel remained with the ship from the preceding program [cruise 97092], along with one government vehicle. Forbes drove to PEI with a rental car a few days prior to the cruise for coastal field work along the North Shore [expedition 97304] and to meet with PWGSC staff running sweep surveys in the nearshore at North Rustico (Forbes et al., 1999a). This vehicle was taken to Dartmouth by Frobel who returned with a government vehicle. Sherin also used a rental car for travel to Souris via the Caribou to Wood Islands ferry, the car being used by Shaw for his return to Dartmouth. At the end of the cruise, all four scientific staff returned to Dartmouth in the two government vehicles by road via the Confederation Bridge. The first day of the cruise (23 July 1997) was a crew change day. Forbes, Beaver, and Sherin travelled to North Rustico to install a DGPS base station in the North Rustico Light. At the end of the cruise, this base station was dismantled by Beaver and Frobel, while Forbes and Sherin visited the PEI National Park offices in Dalvay and then returned the lighthouse key to the Coast Guard in Charlottetown. In 1998, we did not install a DGPS base station.

For the PEI surveys in 1998, Beaver remained with the ship from the preceding phase [cruise IML 98034B] and Girouard also travelled with the ship from Chéticamp. A technician from Brooke Ocean Technology Ltd met the ship in Souris on the morning of August 5 to carry out repairs to the moving vessel sound velocity profiler [MVP]. Sherin and Forbes travelled to Souris from Dartmouth in a government car via the ferry from Caribou to Wood Islands. Frobel travelled to Souris in a government vehicle via the Confederation Bridge and Charlottetown. Girouard returned to Dartmouth in the afternoon, using the government car brought out by Sherin and Forbes. At the end of the cruise, Beaver and Frobel remained with the ship for the succeeding phase [IML 98034C] in Baie des Chaleurs. Forbes and Sherin returned to Dartmouth by road in the government vehicle.

Because there is no harbour accessible to *Creed* along the North Shore of Prince Edward Island, it was necessary to operate the vessel from the nearest accessible port at Souris. Because the ship's travel time between the survey area and Souris is approximately 5 hours, it was necessary to operate these surveys on a 24-hour basis. For this purpose, a second engineer was added to the crew. The ship's personnel and scientific staff worked a schedule of two 6-hour watches per day (6 on/ 6 off).

SURVEY PLANNING

There are no suitable navigation charts for use as background to the multibeam surveys off the North Shore of PEI. Except for small surveys near the entrances to Tracadie Bay, Covehead, and North Rustico (Chart 4467), the most detailed one available is Chart 4023 (Northumberland Strait) at a scale of 1:300 000. In 1997, raster images were created by scanning the NTS 1:50 000 topographic sheets, but these were not found to

be particularly useful. Instead, a high-quality shoreline vector file was assembled from digital 1:10 000 topographic maps provided through the Government of Prince Edward Island. There are two files in ATS77 coordinates (*parkeast* and *parkwest*). These were combined as *PARK.comb* to provide a shoreline vector file for the entire study area. Survey data were brought together using GRASS in *Project=Rustico*, which in 1998 was set up on an HP UNIX workstation (di01) aboard ship in `/dskw1/users/creed98`.

Survey lines were established using AGCNAV software. Blocks of lines were created with distinctive numbers at appropriate line spacing as a function of minimum water depth along track. In 1997, these were created independent of other survey data. In 1998, baseline coordinates were determined through raster queries on the 1997 survey image in GRASS and the line blocks were created in the GRASS Survey Builder, then saved as .agc files for import into AGCNAV. In both years, inshore blocks were run at 40 m line spacing, consistent with the nominal minimum survey depth of 10 m. Lines were spaced at wider intervals with increasing depth and distance seaward. In each case, the inner limit of the survey area was defined by running a shore-parallel line slowly under daylight conditions approximately along the 10 m isobath. In practice, the inner limit extended to shallower depths in some areas, particularly in 1998 when the raster chart on the bridge navigation display gave the ship's master a better feel for the limit of safe navigation. In this case, some of the innermost lines were spaced at less than 40 m.

SUMMARY OF OPERATIONS

Unless otherwise states, all times are Coordinated Universal Time [UTC = ADT+3 h].

1997

Cruise BIO 97093

Day **204** (Wednesday 23 July 1997)

Sherin drove from Dartmouth to Souris via the Caribou to Wood Islands ferry. Forbes had arrived in Souris by road the previous evening, after completing two days of beach and dune surveys along the North Shore [expedition 97307]. Beaver, Forbes, and Sherin drove to North Rustico to install the DGPS base station in the lighthouse there. In North Rustico, they missed the PWGSC sweep survey crew but met GSCA staff Kimberley Edwardson, Ray Cranston, and Fred Jodrey, who were conducting a coring program in Rustico Bay using a local lobster boat. In Souris, the new crew shift for *Creed* arrived by taxi from Charlottetown and the old shift departed. The ship's draft was measured at 2.45 m after refuelling and before casting off. *Creed* cast off from Souris at 22:41 and proceeded north to round East Point, then west along the North Shore of Prince Edward Island.

Day **205** (Thursday 24 July 1997)

Creed arrived in the study area during the night at ~04:30. A Vemco Minilog® temperature/depth logger was deployed at 04:41 at 46°27.4694'N 63°06.1841'W in 23.5 m water depth (this turned out to be slightly deeper than the saturation depth for the depth logger, so only temperature data were recorded). A sound velocity profile was collected using the MVP system at 05:04 in ~23 m water depth (file *svp205.004*). A second velocity profile was measured at 09:31 in 21 m water depth (file *svp205.005*).

Creed began running 3000 series lines (block 3) in deeper water overnight (lines 3000, 3007, 3001, 3008, 3002). In the morning, a shore-parallel line (4000) was run in about 10 m water depth to define the inner limit of the *Creed* survey. The rest of the day was devoted to running lines in shallow water (lines 0, 13, 1, 14, 2, 15, 3, 16, 4, 17, 5, 18, 6, 19, 7, 20, 8, 21, 9, 22, 10, 23, 11, 24, 12, 25, 32, 26, 28, 31). Draft adjustments were made at 08:11, 12:00, 16:00, and19:52 (a 3 cm reduction in each case). The navigation display went down for 5 minutes from 22:41 to 22:46. The sweep launch *Scotian Surveyor* called on channel 68 at 22:22.

The wind was calm at 05:30 and SW 7 to 10 knots from 07:00 on. A light chop developed at 07:00 (0.5 m estimated wave height) and then diminished to 0.3 m by 13:00.

Day **206** (Friday 25 July 1997)

Creed continued line running throughout the day (lines 30, 29, 1003a, 1003, 27, 1004, 1017, 1005, 1018, 1006, 1019, 1007, 1020, 1008, 1021, 1009, 1022, 1010, 1023, 1011, 1024, 1012, 1025, 1013, 1029, 1026, 1014, 1027, 1015, 1028, 1016, 2000, 2013, 2001). A sound velocity profile was collected with the MVP system at 10:49 in >15 m water depth (file *svp206.001*). Draft adjustments were made at 00:00, 04:00, 08:04, 12:16, and16:00 (a 3 cm reduction in each case). The 20:00 draft reduction was missed. Mermaid died and data logging had to be restarted at 07:29.

The wind was SW 10 to 16 knots throughout the day, but blowing offshore. Sea state was minimal (0.3 m estimated wave height) throughout the day.

Day **207** (Saturday 26 July 1997)

Creed continued line running throughout the day (lines 2002, 2015,2003, 2016, 2004, 2017, 2005, 2018, 2006, 2019, 2007, 2020, 2008, 2021, 2009, 2022, 2010, 2023, 2011, 2024, 2012, 2025, 2028, 2027, 2026, 2029, 4013, 4020, 4113, 4113a, 4100, 3009, 3003). A sound velocity profile was collected with the MVP system at 10:28 in >20 m water depth (file *svp207.002*). Draft adjustments were made at 00:00, 04:00, 08:05, 12:11, 16:03, and 20:13 (6 cm at 00:00 and a 3 cm reduction in each case thereafter). Data logging failed at 20:04 and was restarted at 20:08. Another sound velocity profile was collected with the MVP system at 23:57 in ~30 m water depth (file *svp207.004*). Course alterations to avoid fishing vessels were necessary at 07:47 and 18:31 and speed was reduced passing the tourist boat *Julie Ann Jaimie* at 22:31.

The wind increased to SW 20 knots at 08:50, then dropped to SSW 7 knots at 15:00 and went calm from 17:00 to 20:00. The bridge log reported NE 13 knots at 21:00, swinging to ExN 7 knots at 24:00. Wave height increased to 0.5 m during the morning but diminished to 0.3 m or less in the afternoon.

Day **208** (Sunday 27 July 1997)

A 3 cm draft reduction was applied at 00:00, bringing the estimated draft to 1.91 m. *Creed* continued running lines until about 04:00 (lines 3010, 3004, 3011, 3005, 3012). The vessel then proceeded to Souris for fuel and water, arriving alongside at 09:10. The ship's draft was measured at 2.49 m after replenishing. *Creed* cast off again from Souris at 15:40 and proceeded back to the study area. A sound velocity profile was collected using the MVP system at 21:15 in ~25 m water depth (file *svp208.001*). The ship resumed running survey lines at 21:22 (lines 3006, 3013, 3020, 3014). Draft adjustments were made at 19:35 and 23:37 (a 3 cm reduction in each case).

A northeasterly swell of 1.5 to 2.0 m with wavelength approximately equal to the ship's length was reported in the general cruise log at 21:22. The ship's bridge log

reported wave heights diminishing from 1.3 m at 22:00 to 1.0 m at midnight. Winds were light to moderate easterly (8 to 10 knots) throughout the day.

Day **209** (Monday 28 July 1997)

Creed continued running lines throughout the day (lines 3021, 3015, 3022, 3016, 3023, 3017, 3024, 3018, 3025, 3019, 3026, 3033, 3027, 3034, 3028, 3029, 3032, 3031, 3030, 5006, 5001, 5007, 5002, 5008, 5003, 5009, 5004, 5010, 5005). A sound velocity profile was collected with the MVP system at 11:23 in ~25 m water depth (file *svp209.002*). Draft adjustments were made at 03:33, 07:30, 11:20, 15:30, 19:30, and 23:37 (a 3 cm reduction in each case). A course alteration was required to avoid a fishing boat at 17:10. The Simrad EM1000 system had to be rebooted at the end of line 3032 between 14:07 and 14:55.

Sea state diminished through the day from 0.8 to 0.3 m estimated wave height. The wind picked up to SSW 28 knots at 12:00, veering to W 15 after midnight.

Day **210** (Tuesday 29 July 1997)

A sound velocity profile was collected with the MVP system at 00:08 in 35 m water depth (file *svp210.001*). *Creed* continued the survey until 11:40 (lines 5505, 5011, 5017, 5012, 5018, 5013, 5019, 5014, 5020, 5015, 5021, 5016, 4823 [filling in line 23 at east end], 4817 [17 east], 4808 [8 east], 4822 [22 east], 4807 [7 east], 4820 [20 east], 4818 [18 east], 4821 [21 east], 4819 [19 east]. The Minilog® mooring was recovered at 12:00 and found to have good water temperature data but no reliable data on water levels. *Creed* then continued line running (lines 4900 [offset 40 m landward from line 0], 4800 [offset 80 m], 4913 [line 13 east], 4919 [19 east], 4914 [14 east], 4920 [20 east], 4915 [15 east], 4921 [21 east], 4916 [16 east], 4922 [22 east], 4917 [17 east], 4923 [23 east], 4918 [18 east], 4924 [24 east], and 4926 [26 east]). The ship then proceeded to run lines eastward from the main study area toward Point Deroche until 22:32 (lines 7000, 2000, 9000 [contour line], 6000, 6008, 6001, 6009, 6002). Draft adjustments were made at 03:38, 07:30, 11:30, 15:58, and 19:47 (a 3 cm reduction in each case).

The wind picked up to SW 25 knots at 05:00, then veered to WSW 32 knots by 12:15, W 22 gusting 30 knots at 19:00 and NNW 32 knots by 22:50. Wave height increased from 0.8 m at 07:00 to approximately 2.5 m by 22:50. With the worsening sea state, a decision was made to terminate the survey at 22:30 and *Creed* proceeded to Souris.

Day **211** (Wednesday 30 July 1997)

Creed arrived alongside in Souris at 02:50 (“fin de mission”). Beaver and Frobel drove to North Rustico to take down the GPS base station at the North Rustico Light. Forbes and Sherin followed, stopping at Dalvay for consultation with Parks Canada officials, then continued to North Rustico. Beaver and Frobel proceeded directly to Dartmouth via the Confederation Bridge. Forbes and Sherin detoured to Charlottetown to drop off the lighthouse key at CCG Charlottetown, then continued to Dartmouth via the bridge.

1998
Cruise IML 98034C

Day **217** (Wednesday 5 August 1998)

Brooke Ocean Technology Limited [BOT], designers and builders of the MVP, had been authorized by Mike Lamplugh of CHS to have a technician meet the ship in Souris to carry out repairs on the MVP system. Beaver and Girouard remained on board for the transit from Chéticamp the previous night. The new crew shift for *Creed* arrived in Souris from Charlottetown by taxi and the old shift departed. Sherin and Forbes arrived in Souris about 16:00 UTC via the 10:00 ADT sailing of *MV Holiday Island* from Caribou to Wood Islands. Frobel arrived in Souris about an hour later via the Confederation Bridge and Charlottetown. The MVP system was ready for testing at 17:52, when the ship cast off for a short run to deep water off Souris. A sound velocity profile was successfully collected in 33 m water depth at 46°17.28'N 62°19.53'W (file not retained). The ship returned alongside in Souris at 19:05. The ship's draft was measured at this time and found to average 2.30 m. Girouard and the BOT technician returned to Dartmouth, Girouard using the government car brought out by Sherin and Forbes.

Day **218** (Thursday 6 August 1998)

Creed cast off from Souris at 03:15 and proceeded north to round East Point. The ship arrived in the survey area early in the morning. A sound velocity profile was collected using the MVP system between 08:20 and 08:36, the last profile being taken at 46°29.01'N 62°53.50'W in approximately 30 m of water. Some difficulty was encountered with the system and three separate drops were made, but in the end it functioned properly and a valid profile was entered into the Simrad system (file *svp218.004*). The Vemco Minilog® temperature/depth logger was deployed 1 m off the bottom in about 12 m water depth at 46°26.9340'N 62°52.6725'W at 09:25.

Creed then began running lines, starting with a westward line in deeper water (line 107) before running inshore (line 1000) to run a shore-parallel limit line starboard side to the coast (line 1001). The latter was expected to follow approximately along the 10 m isobath, but extended into depths as shallow as 7 m or less in some places. The rest of the day was devoted to running shallow water lines (1002, 51 to 71, 1003 [infill], 50, 1004 [infill], 1005 [infill], 60o [oblique], 1060). Draft adjustments were made at 11:01 and15:01 (a 4 cm reduction in each case). The draft was further adjusted to 2.21 m at 21:09 to obtain the expected value for 19:00 (assuming 3 cm reductions at 4 hour intervals after 03:00) but the expected draft should have been 2.18 m at this time. A further 3 cm reduction in draft was applied at 23:30. The POSMV system had to be rebooted at 20:31 (end of line 68).

Late in the afternoon we became aware of an apparent roll bias in the data, evident both on the Simrad monitor and in the HIPS cleaning procedure. Beaver called Mike Lamplugh, who confirmed this. A vessel configuration file used for the German Bank survey was found on the computer and the roll bias values were copied into the file we were using. Beaver remerged the data previously processed without roll bias adjustment, producing a relatively clean preliminary relief image.

Wind light, sea almost flat, full moon.

Day **219** (Friday 7 August 1998)

Overnight, *Creed* continued line running (lines 49, 108, 102, 109, 103+903, 110, 104). LAN1 timeout errors were experienced at 04:15 on line 103 and the Simrad display froze. The line was continued as 903 after the problem was fixed. At 07:01 the vessel

stopped to attempt an MVP profile. This was unsuccessful because the system was not outputting fish depth and it produced no data file. The survey continued for another 2 hours (lines 105, 106). At 09:45 the vessel proceeded offshore to attempt another MVP drop in deeper water. The fish depth signal was coming and going and no data file was produced. As there was obviously a cable discontinuity somewhere in the system, we resorted to the standard SVP instrument, which produced a valid sound velocity profile at 11:15 in about 35 m water depth (file *svp219.rel*). During this operation, several small groups of pilot whales (*Globicephala melaena*) were observed feeding in the area. After collecting the sound velocity profile, *Creed* returned to running lines, beginning with a long reconnaissance run back toward shore (line 1010) and then a series of shallow water lines (48 to 40 in descending order, 39+939, and 38 to 33 also in descending order). The vessel drifted 23 m off line 48 at 12:16, but line-keeping was otherwise excellent. Logging was accidentally turned off part way along line 39 and restarted as line 939. Draft reductions of 3 cm were applied at 03:05, 07:00, 12:36, 14:56, 19:11, and 23:00.

Beaver called Mike Lamplugh (CHS) to check on the appropriate values to be used in the vessel configuration file. The German Bank config file from June 1998 was considered appropriate and was adopted for all survey data on this cruise. During the afternoon watch, the Chief Engineer opened up the MVP fish in an effort to isolate the signal problem. A bad RS232 plug was found and replaced on the switch box on top of the SVP computer. Tests for continuity revealed a problem in the cable. The sensor worked perfectly when connected at the slip-ring input and the slip-ring circuit was found to be fine. Several calls were made in an effort to arrange for technical support to repair the system, but nobody was available to meet the ship in Souris on the weekend. During the evening watch, the Chief Engineer rigged a snatch block on the boat launch boom and found a spool with 600 feet of nylon line for the SVP.

Winds were light and variable. During much of the day the sea was glassy.

Day **220** (Saturday 8 August 1998)

Line running continued through the night, moving from the shallow area inshore (line 32) to somewhat deeper water (lines 0, 11 [terminated because it duplicated 1060], 101, 1, 12, 2, 13, 3, 14, 4, 15, 5). At 10:47 we broke off the survey part way along line 5 to take a sound velocity profile in deeper water to the north. *Creed* proceeded out to an area in about 30 m water depth and the SVP cast was completed without difficulty at 11:02 (file *svp220.rel*). The water temperature was 20°C at the surface and 5°C at 30 m. On completion of the velocity profile, *Creed* resumed sounding along the discontinued line (905) and the survey continued for another 6 hours (lines 31, 30, 29, 28, 27, 26). Draft corrections were applied at 03:07, 07:00, 11:27 (following SVP cast at 11:02), and 15:00 (a 3 cm reduction in each case).

On completion of these lines at 17:27, *Creed* proceeded to Souris for refuelling. We took the opportunity to run a regional reconnaissance line roughly parallel to the coast during this transit. For convenience in data processing, the line was broken into four segments (lines 8000-8003). A further 3 cm draft reduction was applied at 19:00. The Simrad EM1000 system had to be restarted at 19:59 on line 8002. South of East Point near the end of line 8003, several porpoise (*Phocoena phocoena*) were running ahead and abeam. *Creed* tied up in Souris at 21:50 and took on fuel. A draft check was taken before and after refuelling.

The wind was light and variable and the sea calm throughout the day.

Day **221** (Sunday 9 August 1998)

The draft was set to 2.52 m. *Creed* cast off from Souris at 03:09 and proceeded north, passing *MV Madeleine* inbound to Souris from Cap-aux-Meules. A sound velocity profile was taken at 04:27 south of Milne Bank at 46°19.76'N 61°56.52'W in 40 m water depth (file *svp221-1.rel*). Because of a strong tidal current (~0.7 knots), the instrument was swept aft and did not reach bottom. We obtained a profile extending only to about 16 m. However, the strong currents probably caused well-mixed conditions to the bottom and the profile is considered acceptable. The vessel then proceeded to run patch test lines for pitch and time delay as well as roll bias on a north-south transect crossing the steep southern flank of Milne Bank (lines 9000-9003), with relatively flat surfaces extending for some distance at the top and base of the slope (Shaw et al., 1997).

On completion of these test runs, *Creed* resumed the passage back to the North Shore study area, rounding East Point at 06:24. As on the inward passage to Souris, the multibeam system was left operating in order to search for submerged valley features on the inner shelf off the northeast coast of PEI. The outbound survey (lines 8004-8007) was offset approximately 200 m from the inbound course. Because the water structure over Milne Bank was unlikely to prevail off the North Shore, the previous SVP file collected in the primary study area (file *svp220.rel*) was reloaded at the start of line 8004. *Creed* arrived off the east end of the study area at 09:30 and a sound velocity profile was collected in 37 m water depth at 09:40 (file *svp221-2.rel*). The wind was SW at about 15 knots and the profile showed a well-mixed surface layer with a velocity of 1511 m/s and water temperature of 19°C extending to about 7.6 m water depth. *Creed* began running lines again at 09:55 (lines 1025, 25, 24, 23). Because part of line 24 showed severe refraction errors, line 23 was cut short to take another sound velocity profile in the inner area where we were actively working. This drop at 12:40 was in 21 m water depth (file *svp221-3.rel*) and also showed a well-mixed surface layer, but the surface velocity was 1516 m/s in this slightly warmer water (21°C). At this time, the sound absorption was also adjusted to 22 dB/km. Line running was resumed at 12:51 with less refraction (lines 923 [continuation of 23], 22, 916 [replacing 16 with bad start], 6, 17, 7, 18, 8, 19, 9, 20, 10, 21). Draft adjustments were made throughout the day at 4 hour intervals – at 07:05, 11:00, 15:03, 19:00, and 23:00 (a 3 cm reduction in each case).

The wind was from the southwest and increased to 25 knots by 23:00. Because it was blowing offshore, wave height remained less than 1 m.

Day **222** (Monday 10 August 1998)

Creed continued line running throughout the day (lines 1105, 120, 1120 [resuming line 120 after SVP drop], 114, 121, 115, 122, 116, 123, 117, 124, 118, 125, 119, 112, 113, 1113, 111, 301, 306, 302, 307, 303, 2001, 2002, 2003, 1039 [filling hole in line 39], 304, 308). A sound velocity profile was taken at 01:15 in 29 m water depth about 1 km north of line 120 (file *svp222-1.rel*). *Creed* altered course at 13:42 on line 1113 to avoid collision with a fishing boat. Another sound velocity profile was obtained at 15:23 in 29 m water depth (file *svp222-2.rel*). Draft adjustments were made at 03:01, 07:00, 11:00, 17:00, and 19:00 (a 3 cm reduction in the first three cases, 4 cm at 17:00, and 2 cm at 19:00). At the end of line 1039 at 22:15, we stopped surveying to recover the Minilog® mooring, as the wind was blowing 30 knots and conditions deteriorating. Recovery was difficult but successfully accomplished.

The wind was picking up from the SW throughout the day. Wave heights were limited to 1.0 m in the lee of the land.

Day **223** (Tuesday 11 August 1998)

Creed continued line running for about 2 hours (lines 305, 309). It became difficult to maintain course on line with a following sea and 25 to 30 knot winds. As a result, the survey was terminated at 01:56 and the vessel proceeded toward Souris. Data acquisition continued (line 8008) until 02:09. At 07:48 the vessel was secured alongside the public wharf in Souris. Draft was measured on arrival and found to be 2.14 m. The last draft correction of the survey was at 222/19:00 (to 2.22 m). Had the program of corrections been maintained, with additional 3 cm reductions at 222/23:00, 223/03:00, and 223/07:00, the estimated draft would have been 2.13 m, just 1 cm less than the measured draft (within measurement error).

Beaver and Frobel remained with the vessel for the passage to Baie des Chaleurs. Forbes and Sherin drove to Dartmouth via Wood Islands, catching the 08:30 ADT sailing of *MV Holiday Island*.

SCIENTIFIC SUMMARY

Study area and related work

The study area is located off the central North Shore of Prince Edward Island adjacent to PEI National Park. It extends along the outer shores of three major estuaries —

- Rustico Bay (now divided into two separate parts),
- the combined Covehead Bay and Brackley Bay system, and
- Tracadie Bay.

Rising relative sea level over the past few thousand years (Scott et al., 1981) has led to flooding of northward-draining river valleys along this coast to form the estuaries. The largest terrestrial drainage areas feed into Rustico Bay, which occupies the flooded lower valleys of the Hunter River and Wheatley River. In recent years, coastal changes have led to division of Rustico Bay into two separate estuaries. Covehead Bay and Brackley Bay are fed by smaller streams. The large embayment at Tracadie has little freshwater runoff, its hinterland being drained by the Hillsborough River, which flows south to Northumberland Strait though Hillsborough Bay at Charlottetown.

The coast in the study area forms two broad embayments or bights, one lying between the high rock cliffs west of Rustico and the low cliffed shore at Cape Stanhope, the other extending from Cape Stanhope to Point Deroche east of Tracadie Bay. The presence of rock in the nearshore had been recognized in earlier work based on limited sidescan sonar surveys in 1989 (*MV Rustico Rover* surveys by the GSC, reported in Baird et al., 1990) and airphoto analysis at Point Deroche (Boczar-Karakiewicz et al., 1995), but its extent was poorly delineated. The new multibeam imagery generated during the 1997 and 1998 surveys provides spectacular definition of the areas of rock outcrop on the shoreface and inner shelf. The local bedrock is a typically friable red sandstone of Permian age (van de Poll, 1983). Some cliffs within the study area also expose glacigenic deposits (tills and ice-contact stratified drift) of variable thickness (Crowl & Frankel, 1970; Prest, 1973). Both the bedrock and the Quaternary ice-contact deposits serve as sources for lag accumulations of pebbles, cobbles, and boulders in the nearshore and across the inner shelf.

Between the rock headlands, sandy barrier beaches define the seaward margins of the estuaries —

- the west end of Rustico Island and its successor beach, Dune Bar, partially enclose Rustico Bay (part is also enclosed by rock and glacial deposits forming the main body of Rustico Island);
- Brackley Beach and associated coastal dunes lie across the northern limits of Covehead Bay, Brackley Bay, and part of Rustico Bay;
- Blooming Point and associated coastal dunes partially enclose Tracadie Bay,

Dalvay Beach and Stanhope Beach extend along a low (part woodland, part wetland, part cliffed) section of the coast west of Tracadie Bay. The beaches are low-angle, partially dissipative shores with (typically) two to four nearshore bars, often exposing lag gravel and occasionally rock in the bar troughs (Forbes et al., 1986, 1999a; Forbes, 1987; Boczar-Karakiewicz et al., 1995). The coastal dunes are typically less than 10 m high but locally up to 14 m or more (McCann, 1979; Forbes et al., 1999c).

Tidal inlets are present at Tracadie, Covehead, Rustico Bay 'New Channel' (at the west end of Rustico Island), and North Rustico Entrance Channel. The Rustico Bay inlets are ebb-dominated (Matsushita & McCann, 1988; Williamson, 1998), with well-developed ebb-tidal delta complexes, particularly at 'New Channel' (Forbes et al., 1999a; Forbes & Solomon, 1999), where the nearshore bar system is deflected seaward. A similar morphology is present at Tracadie Inlet. Extensive flood-tidal deltas are present at North Rustico Entrance Channel (Forbes et al., 1999a), Covehead, and Tracadie Inlet, as well as an abandoned flood-delta on the landward side of the Rustico Island Causeway (the former Little Harbour Inlet).

Large volumes of sand are present in the nearshore bars, barrier beaches, coastal dunes, and tidal inlet complexes. A major objective of the present study is to clarify the linkages between these coastal sand bodies and the distribution and dynamics of sand on the shoreface and inner shelf. Previous sidescan sonar and BRUTIV surveys in the area (Forbes et al., 1986; unpublished 1989 data cited in Baird et al., 1990) suggested that shoreface sand gave way to gravel in depths of about 10 to 11 m off Stanhope Lane and 12 to 14 m off Brackley Beach. There was no hint in the earlier data of more extensive sand sheets extending to deeper water off Rustico and Brackley.

A detailed program of field studies was carried out in the Rustico Bay area in 1997, in response to a community-based initiative to remove the Rustico Island Causeway. This work included:

- extensive nearshore sweep bathymetry and single-beam echosounding (Fig. 3); Forbes et al., 1999a), complementary to the multibeam surveys described in this report;
- current meter deployments, tidal measurements, and studies of benthic boundary dynamics in the estuaries (Amos et al., 1998);
- investigations of estuarine water quality (Brylinsky, 1998); and
- numerical modelling of circulation and sediment transport (Williamson, 1998; Anderson, 1998).

The following paragraphs provide a brief description of the seafloor topography observed in the 1997 and 1998 EM1000 imagery. All interpretations should be considered preliminary and provisional, pending further investigation with sidescan sonar, high-resolution sub-bottom profiling, underwater video, surface sampling, and coring. These ground-truthing efforts were begun in 1998 using *CCGS Matthew* (Forbes et al., 1999b) and we plan to initiate a coring program in 1999 with *CCGS Hudson*.

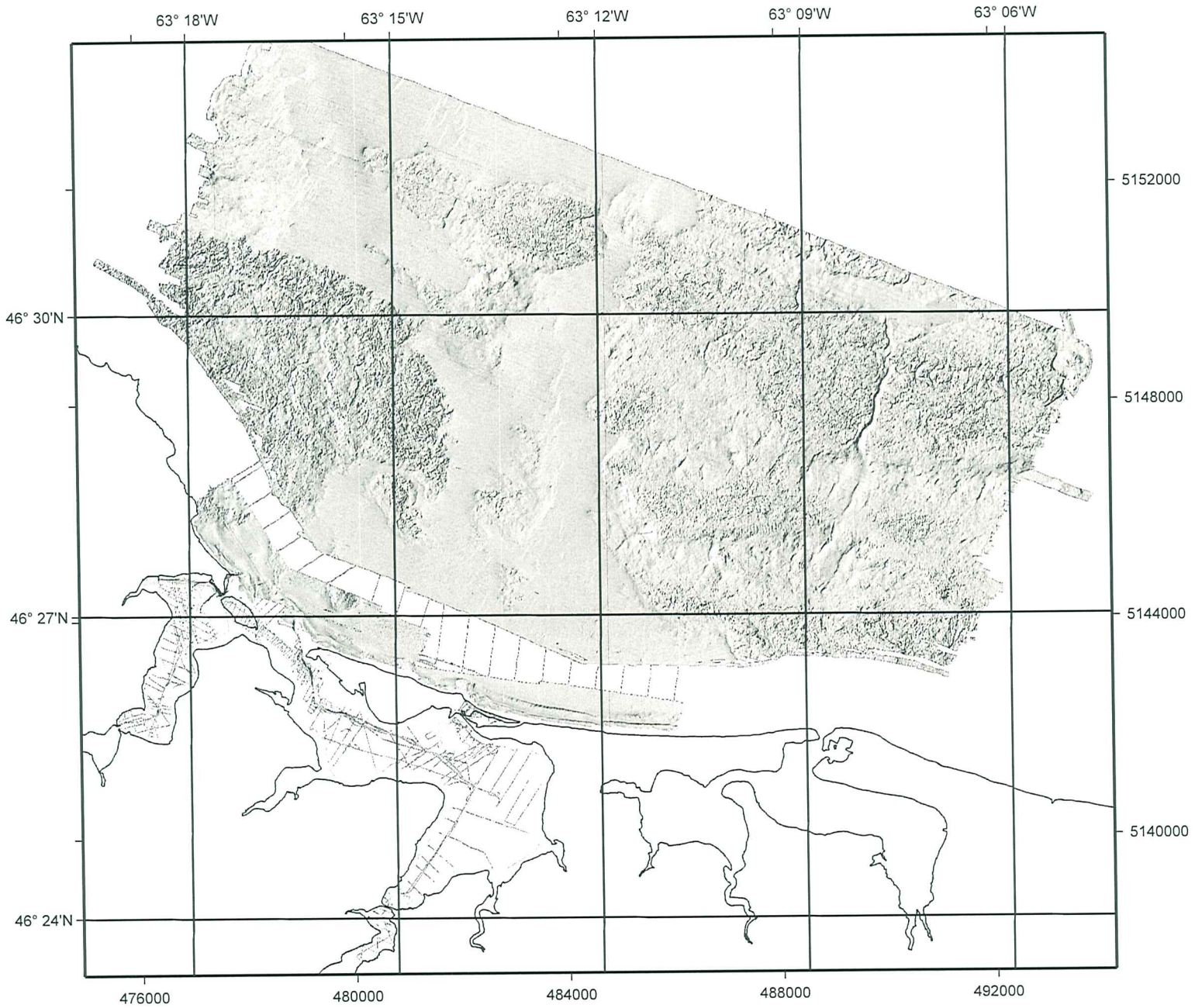

Fig. 3. Shaded-relief bathymetry from PWGSC sweep surveys and GSCA single-beam surveys in nearshore and estuary and 97093 *Creed* multibeam surveys offshore.

Seabed morphology and geology in Brackley Bight (Harris Bay) – 1997 survey area

The 1997 *Creed* multibeam survey extended from Orby Head to Cape Stanhope, a distance of about 18 km alongshore (Fig. 2). It covered an area out to about 10 km seaward of the beach, in water depths of at least 35 m (Fig. 4).

The shaded-relief bathymetric image (Fig. 3) shows an extensive erosional surface cut across sandstone bedrock with a thin cover of glacial sediment and lag gravel. Both the bathymetry and the multibeam backscatter imagery (Fig. 5) show gently sloping sand sheets delineating two broad valleys in the bedrock surface, more or less aligned with the Hunter River on the west and the Wheatley River on the east. These coalesce in an area about 7 km offshore and then continue seaward as a single valley to at least 35 m below present sea level. The sand cover in the valleys is coextensive with the shoreface sand on the seaward side of the nearshore bars. While it occupies depressions in the underlying surface, it appears to be mounded along its lateral margins with adjacent gravel or bedrock surfaces, possibly indicating lateral progradation, but more likely evidence for enhanced entrainment and reworking along the edge of the rougher surface. Numerous narrow depressions or channels interrupt the smooth sand surface, especially in depths of about 9 to 14 m. These have higher backscatter and are interpreted to be ribbons of large-scale coarse sand or gravel ripples.

A wide, rough, gravel-strewn outcrop surface extends seaward from the area of high rock cliffs west of Rustico. It terminates abruptly along an arcuate front with another sand sheet, west of the previously mentioned valley, about 6 km north of North Rustico. This sheet of sand continues seaward to the limits of the survey coverage. It is bounded to the west by an irregular terrain of uncertain origin, possible a till surface. A number of narrow ridges, aligned roughly NNE-SSW, are present on the sand sheet near its western margin and in a more scattered fashion further seaward. The origin of these ridges is unknown at present. They appear to be coarser than the surrounding sand and may arise from beneath it, in which case an esker origin should be considered. On the other hand, their regular spacing in places is suggestive of large-scale bedforms.

The bedrock and gravel surface east of the major valley is marked by three broad, east-west trending, shallow depressions with a smoother surface texture. The seabed in these depressions, particularly the inner two, is interpreted to be a gravel lag or pavement developed on glacial deposits. A number of east-facing scarps are present in the inner two depressions, perhaps consistent with glacial plucking under eastward ice flow. Alternatively, they may represent subglacial scour associated with ice flow and/or subglacial drainage toward the northeast. A narrow channel (about 100 m wide and several metres deep) cuts north-northeast across the outcrop ridge to the outer east-west depression, where it passes into a smooth surface in what appears to be a closed basin. The channel re-emerges on the north side and continues north beyond the limit of survey coverage. It is unclear at this time whether the basin contains former lake deposits and whether the channel was cut by a subaerial stream draining into the lake, or whether it may have originated earlier (perhaps as a subglacial channel). Numerous smaller channels cut across the rock elsewhere, some without apparent continuity, suggesting a possible subglacial origin.

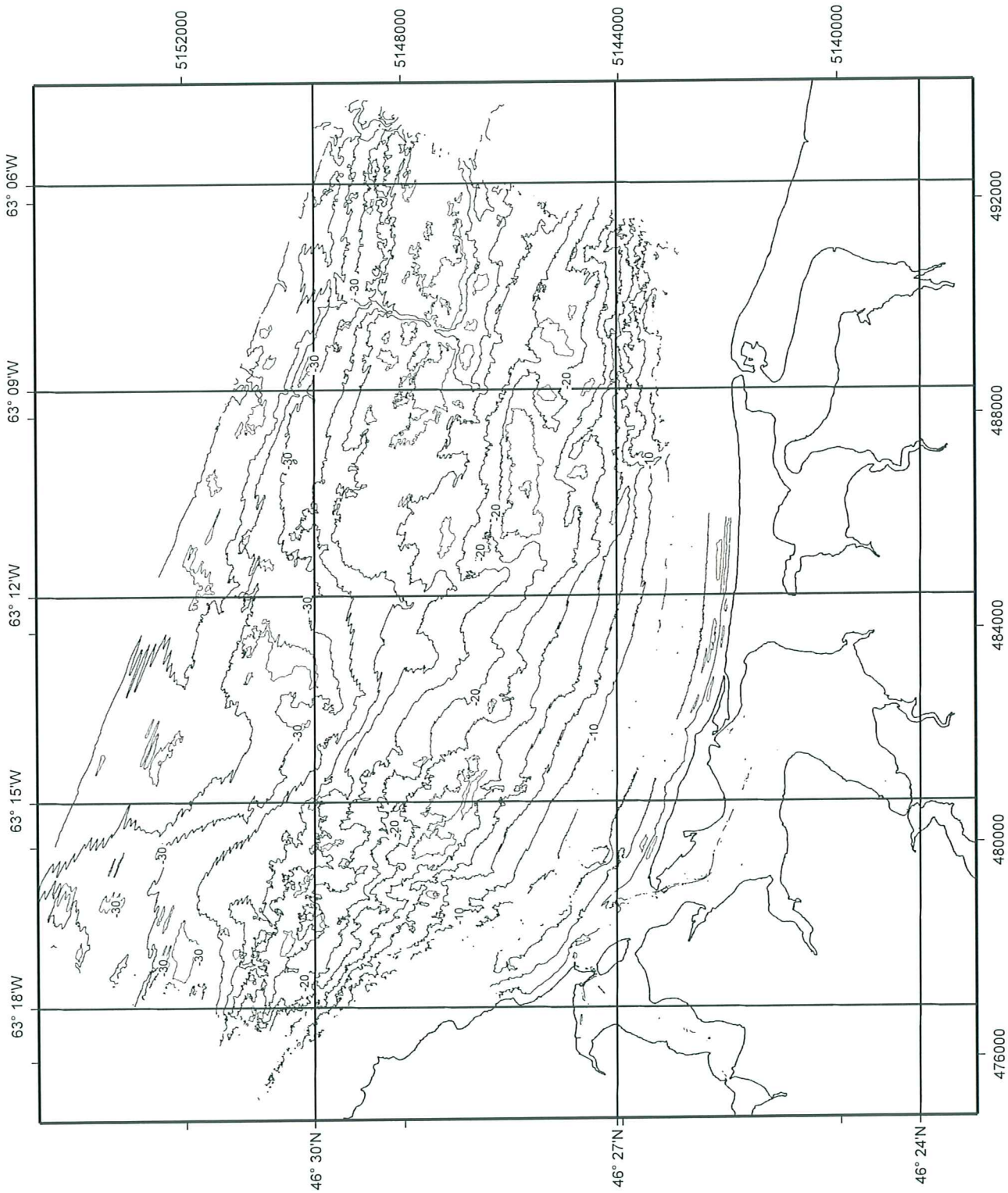

Fig. 4. Isobaths at 2 m intervals for 1997 sweep and multibeam bathymetry.

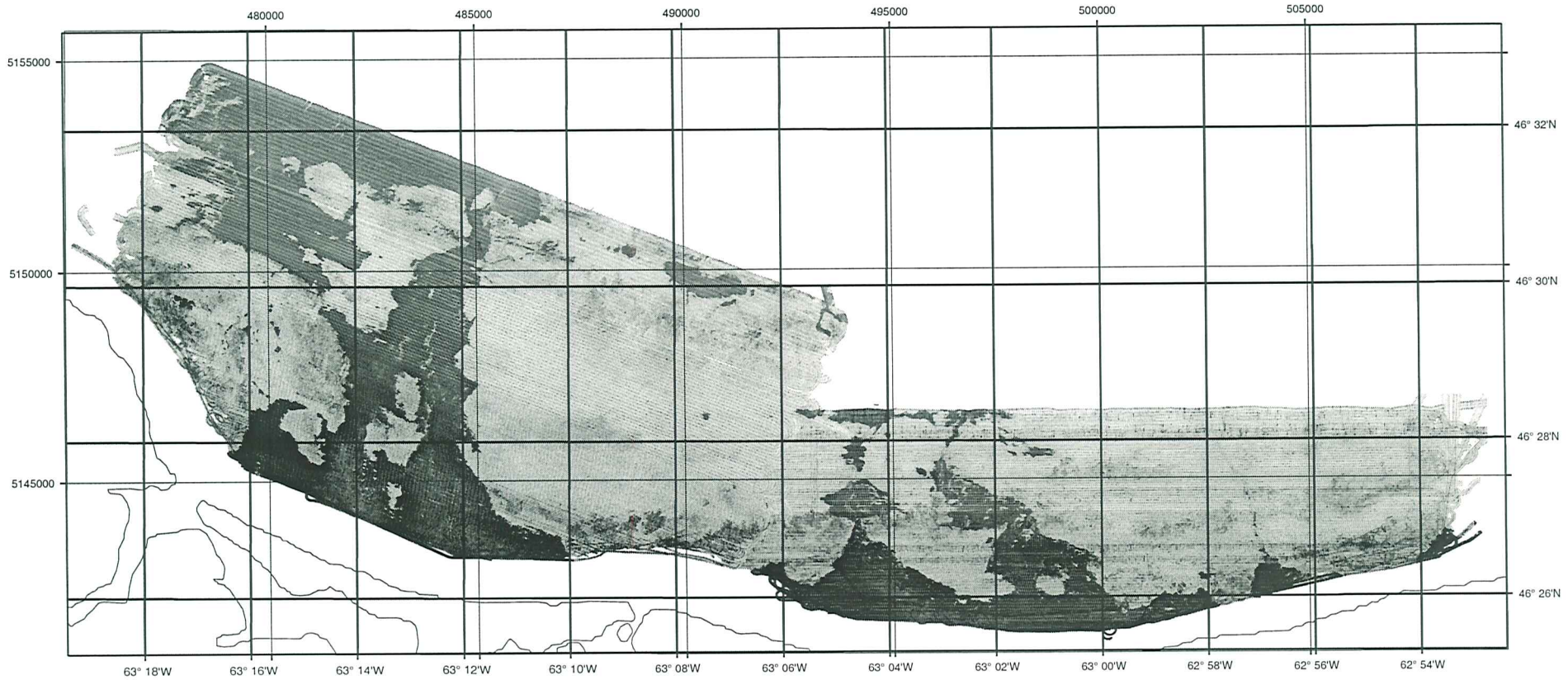

Fig. 5. Multibeam backscatter imagery for 1997 and 1998 *Creed* survey coverage.

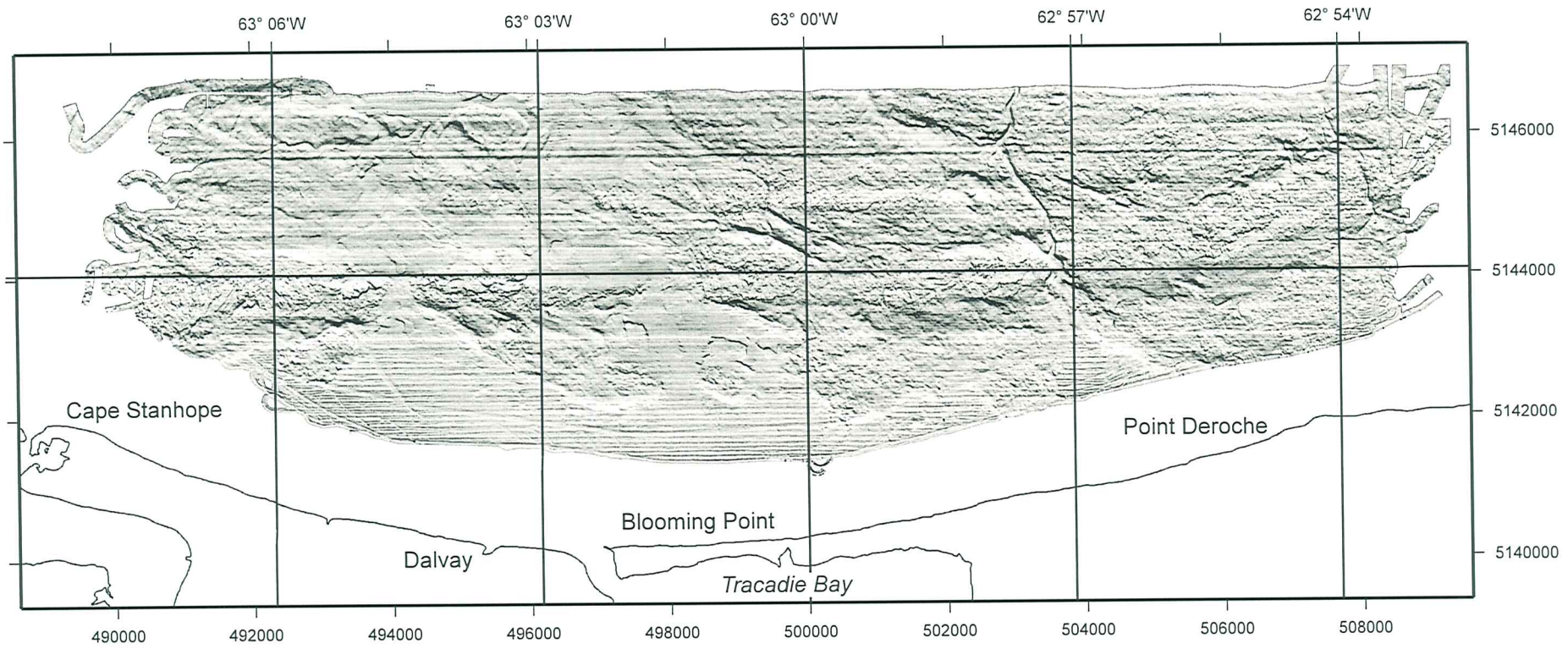

Fig. 6. Shaded-relief bathymetry from 98034C *Creed* multibeam surveys.

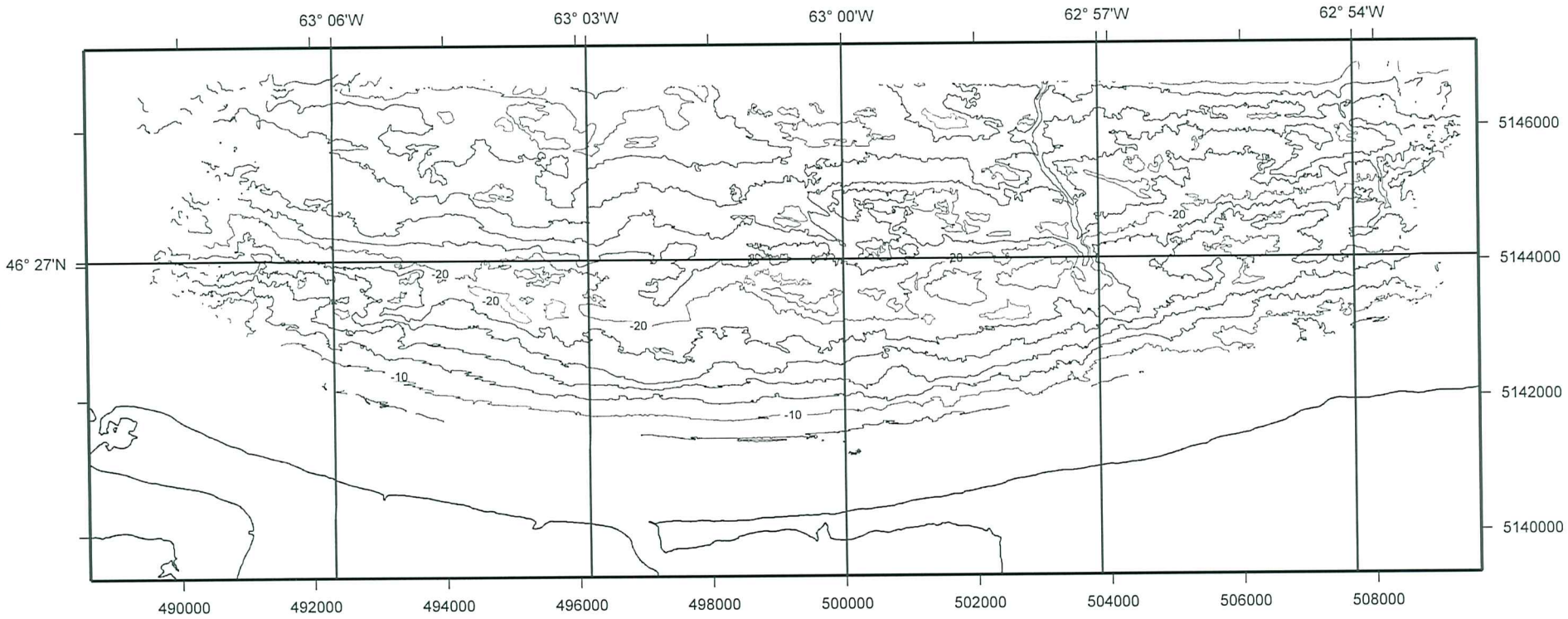

Fig. 7. Isobaths at 2 m intervals for 1998 multibeam bathymetry.

The most significant finding for coastal dynamics is the evidence for relatively bare rock surfaces extending seaward from the headlands at each end of the bight. This suggests a limited potential for longshore sand exchange between Brackley Bight and the major coastal cells to the east (off Tracadie Bay) and west (off New London Bay). The implication of this finding is that Brackley Bight has a closed sand budget, at least in the longshore direction, and functions largely as an isolated coastal system.

Seabed morphology and geology in Tracadie Bight – 1998 survey area

The 1998 Creed survey extended from Covehead in the west to Point Deroche in the east, a distance of at least 15 km (Fig. 2). The survey reached a little further inshore, imposing a penalty in narrower line spacing (Appendix 1). This resulted in less extensive coverage offshore than in 1997. Nevertheless, a large area of seabed was imaged and the seaward limits of shoreface sand were reasonably well delineated.

The shaded-relief bathymetry (Fig. 6) and backscatter data (Fig. 5) show much less extensive sand than in Brackley Bight, and no large valleys. The absence of the latter should not be surprising, given the restricted surface drainage area of Tracadie Bay. The limited sand cover is consistent with observations off Stanhope Lane some years ago (Forbes et al., 1986). It is particularly noteworthy that the shoreface sand extends no more than 1 km offshore from parts of the Blooming Point barrier, which has some of the largest coastal dunes in the region. In general, the shoreface sand is less extensive in this coastal segment and is also isolated from coastal sand systems to the east and west by extensive stripped rock surfaces.

The area of outcrop off Covehead extends almost due east as a discontinuous ridge connecting to the area of very extensive outcrop in the eastern part of the survey. A narrow channel, 2 to 4 m deep (Fig. 7), similar to the one seen in the eastern part of the 1997 data, cuts a sinuous path northward across this outcrop area (Fig. 6). A small triangular area of sand is present on the shoreface near the southern exposed limit of this channel.

In the central and western part of the 1998 survey, several low scarps are seen at the contact between smooth and rough surfaces on the outer shoreface. These require more detailed examination in the future. An irregular topography with some NE-SW lineation in the northwest corner of the Tracadie Bight survey is particularly intriguing. Some features there have the appearance of glacial fluting or small-scale drumlins. This area is also deeper and may have been occupied by a shallow estuary at some time during the transgression.

Reconnaissance surveys along northeast coast of PEI

Two strips of soundings and backscatter data were collected on quasi-parallel tracks during the passages to and from Souris on days 1998/220 and 1998/221 (Fig. 8). Typical depths along these tracks were 25 to 30 m, giving an image width of about 150 to 200 m, for a total coverage of about 300 to 400 m across track. Much of the area is characterized by bare to sparsely covered outcrop of sandstone or conglomerate, as seen in the prime study area off the central north coast. A major objective of these reconnaissance lines was to search for evidence of submerged valleys representing the

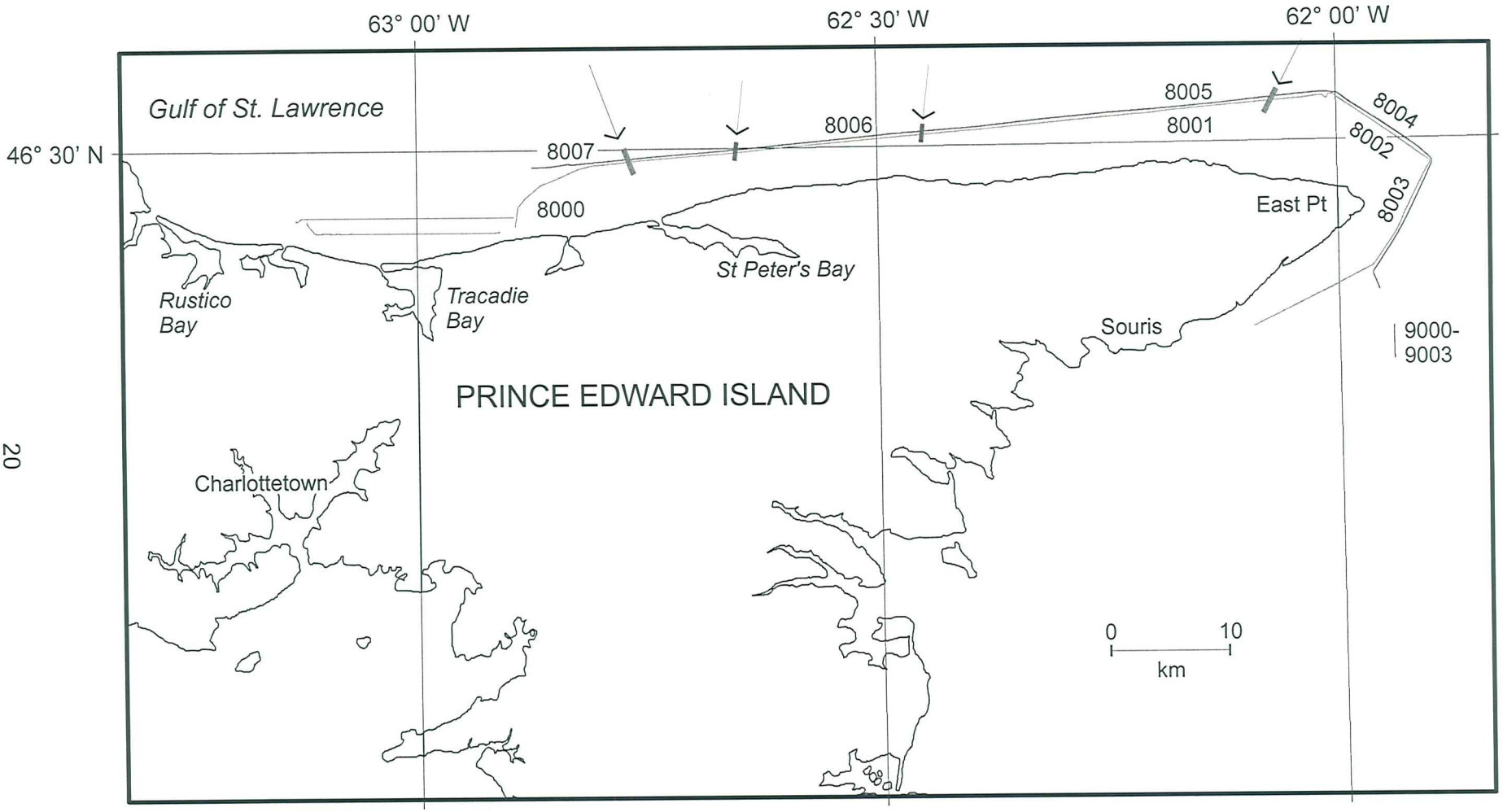

Fig. 8. Eastern part of Prince Edward Island, showing ship's tracks for reconnaissance lines from study area to Souris and back (return trip for fuel). Lines 8000-8003 are inbound lines on August 8 (day 220) and lines 8004-8007 are outbound lines on August 9 (day 221). Lines 9000-9003 are patch test lines on southern flank of Milne Bank (cf. Shaw et al., 1997). Arrows point to linear depressions interpreted as submerged fluvial channels or valleys.

seaward extensions of existing onshore drainage systems, again as observed seaward of Rustico Bay in the 1997 imagery.

Several shore-normal or -oblique linear depressions were recognized in a preliminary analysis of the survey strips onboard ship (Fig. 5). One of the larger ones is a valley-like feature trending northwest and aligned with the axis of St Peters Bay. This depression is 195 to 260 m wide and approximately 4 m deeper than adjacent seabed to the east and west in the area of the 28 m isobath. The largest linear depression, oriented toward the northeast, is aligned with the axis of North Lake, a short distance west of East Point (Fig. 5). This is 560 to 670 m wide and approximately 6 to 8 m deeper than adjacent seabed in the area of the 35 m isobath. Smaller channels or valleys are present in the vicinities of Cable Head (Schooner Creek?), Red Point (McAskill River?), Cow River, Naufrage River, east of Crooked River, west of Big Pond (Cross River?), and Priest Pond Creek.

These observations add to our knowledge of paleodrainage systems on the former land surface extending north from the present coast.

TECHNICAL OPERATIONS

Vessel

NGCC ***Frederick G. Creed*** (see Frontispiece) is a SWATH [Small Waterplane Area Twin Hull] vessel with a length overall of 20.4 m, a beam of 9.9 m, and a displacement of 68 tonnes. The vessel was constructed in San Diego in 1988 and is operated from l'Institut Maurice Lamontagne [IML]. Creed has accommodation for up to five crew members and four scientific staff and has an endurance of more than 100 hours at survey speeds of about 10 to 11 knots, the usual speed adopted for the work described in this report. The SWATH design and stabilizers give significant stability at survey speeds in moderate seas, although the vessel dimensons limit the effectiveness of these features in larger waves. Sea state became a limiting factor during the last few hours of the survey in both 1997 and 1998.

Digital bathymetric system

The survey system employed for this work was a hull-mounted Simrad Subsea A/S EM1000 multibeam echosounder operating at 95 kHz. This system can operate in depths from 3 to 1000 m, with an angular spread of up to 190° in shallow mode. Typical backscatter strength from the seabed is of the order of -30 to -40 dB. An array of 120 transducers is mounted in the starboard hull pod on *Creed*. When operated in shallow mode, appropriate for depths from 3 to 200 m, the depth resolution is 0.15 m. In this mode, each ping is detected through 60 roll-stabilized receiver beams at an angular spacing of 2.5°. On alternate pings, the beams are shifted by half the beam spacing in pointing angle, so that 120 soundings are obtained across-track over an interval of two pings. The swath sector is automatically selected to be 128°, 140°, or 150° roll-stabilized as a function of depth, bottom conditions (backscatter intensity), and the number of beams with valid detections. The maximum swath width in shallow mode is 7.4x water depth. Typical swath widths in this survey were approximately 6.1x water depth.

Critical input data for the bathymetric system include vessel configuration data (transducer/ antenna offsets, EM1000 and POSMV calibrations), sound velocity profiles,

and transducer depth. As noted in the cruise narrative above, an apparent roll bias was evident on the first day of the 1998 survey. This was traced to incorrect zero values in the vessel configuration file being used when we took over the ship in Souris. Substituting values from the German Bank survey earlier in the summer produced much cleaner results. Although no formal patch tests were performed on these surveys, a patch test was carried out off Souris in 1997 about 10 days before the start of our survey (day 194, Shaw et al., 1997) and comparable data were collected in 1998 over the southern margin of Milne Bank (day 221, lines 9000 to 9003) to enable validation of the vessel configuration used this year. Sound velocity profiles were collected on at least a daily basis, using the moving vessel sound velocity profiler (MVP) in 1997 and the conventional SVP probe in 1998. Occasional extra profiles were collected when refraction errors became apparent in the sounding profiles. The water was generally well mixed at the inshore limits of the survey (in 9 to 12 m depths) but pronounced thermoclines were found in deeper water in some profiles (Appendix 4). Transducer depth was measured prior to departing Souris on each occasion, taking the mean of the ship's draft fore and aft and subtracting 0.57 m. Some error was undoubtedly introduced by variable squat associated with differences in vessel speed during the survey. Most of the lines were run at speeds ranging from 11 to 12 knots in 1997 and 9 to 11 knots in 1998. Reconnaissance lines along contour inshore were typically run more slowly and occasional engine maintenance also affected line speed in some cases. In 1998, the 8000-series exploratory lines along the coast were run at about 15 knots and the 9000-series patch-test lines at 6 and 12 knots as appropriate. Transducer depth varies with time as fuel and water are consumed. Because the vessel remained at sea for several days, this was taken into account by subtracting 3 cm from the transducer depth every 4 hours, a correction that agreed within 1 cm with the measured draft when *Creed* returned to Souris at the end of the 1998 survey. It is worth noting, though, that the draft changes during each trip would not be linear with time, as the vessel proceeded to and from the study area at 15 knots, surveyed at 9 to 12 knots, and then returned to 15 knots for the 4 to 5 hour passage back to port.

Navigation and track planning

Positioning for the multibeam survey was determined using a Magnavox 4200 global positioning system [GPS] receiver located on the bridge. Differential corrections were received from the Coast Guard transmitter at Port aux Basques on 290 MHz. The differential signal was fed to a PC running AGCnav for line running and data logging and to the POSMV system running on a notebook computer, for integration with the gyro accelerometer to provide ~1 m positioning for the Simrad sounder. The positioning data were generally very clean, with typical errors in the range of 0.6 to 1.1 m and only occasional dropouts. In 1997, we established a separate base station on the North Rustico lighthouse, as a backup in case the Coast Guard corrections were unavailable. Brief testing indicated that better precision was obtained with the Coast Guard data (~1 m) than with the UHF link to our own reference station (~3 m).

Because no suitable chart was available in the study area (the best, apart from small harbour surveys, being Chart 4023 "Northumberland Strait" at a scale of 1:300 000), track planning in 1997 was done using AGCgrid and AGCnav, laying out parallel lines from an arbitrary base line. Lines were established in separate blocks of constant line spacing, the latter increasing as the survey extended seaward into deeper water. Block 0 and block 1 lines inshore were spaced at 40 m, while the outer block lines (block 5) were spaced at 100 m. In 1998, the lines were developed using the GRASS survey

builder, on an overlay of the image created from 1997 data. Although individual blocks were not designated, the lines were numbered to reflect line spacing (line numbers <100 mostly at 40 m but less for the innermost lines, 100-series lines at 60 m, and 300 series at 80 m).

Bridge and laboratory setup

The data acquisition system resided on the bridge and occupied all space in the port side aft corner. It included the Simrad EM1000 processing unit with the HP QS/20 (QAU) system on top. A PC monitor provided the EM1000 operating menu and beam display. In 1997, another monitor provided the Simrad QA display, usually set to plot successive pings in waterfall mode. Another PC provided AGCnav control and display, with a slave display mounted near the wheel for the helmsman. The POSMV controller resided on a Pentium notebook computer and the Simrad Mermaid data logging software operated on a Sun SPARC 10 Unix workstation. In 1998, this system also hosted Merlin, displaying the geographically referenced multibeam soundings in real time. This was a major improvement, providing better quality control, real-time confirmation of data coverage, a suitable display for conning the ship through data gaps, and preliminary data for geological interpretation.

The setup in the lab was essentially the same as described by Shaw et al. (1997) for cruise 97092. An HP Unix workstation (di01) was located near the deck locker on the main table on the starboard side. This was used primarily for cleaning EM1000 data in HIPS. Next to it, in 1997, was the HP Xterm used primarily for GRASS processing. The following year, in 1998, this unit was installed in the far port-side corner of the lab aft of the head. The shelf overhead contained the CPU for di01, with a CDROM reader and Exabyte tape drive on top. Two hard disks and an HP Laserjet 5M printer were also on the shelf, along with a Toshiba laptop computer running AGCnav. The MVP computer was placed amidship in 1997 and immediately inside the door on the port side in 1998. The other piece of equipment was a CDROM burner and controller (diburner).

Data management

Navigation and EM1000 data were logged on the Sun workstation on the bridge, generally saving each line as a separate file. These data were fed via an Ethernet link to the di01 workstation in the laboratory for further data processing. The navigation and sounding data were checked and cleaned using HIPS (Hydrographic Information Processing System), then imported into GRASS using menu-driven gridding and imaging procedures available through *agcmenu* (or the later version *agcmenu98*). The HDCS path in 1998 was /dsk0/users/hipsdata/HDCS_DATA and the GRASS path was /dskw1/users/creed98/Rustico/PERMANENT/WORK. The raw data and HIPS-processed (HDCS) data were backed up on Exabyte tapes and CDs.

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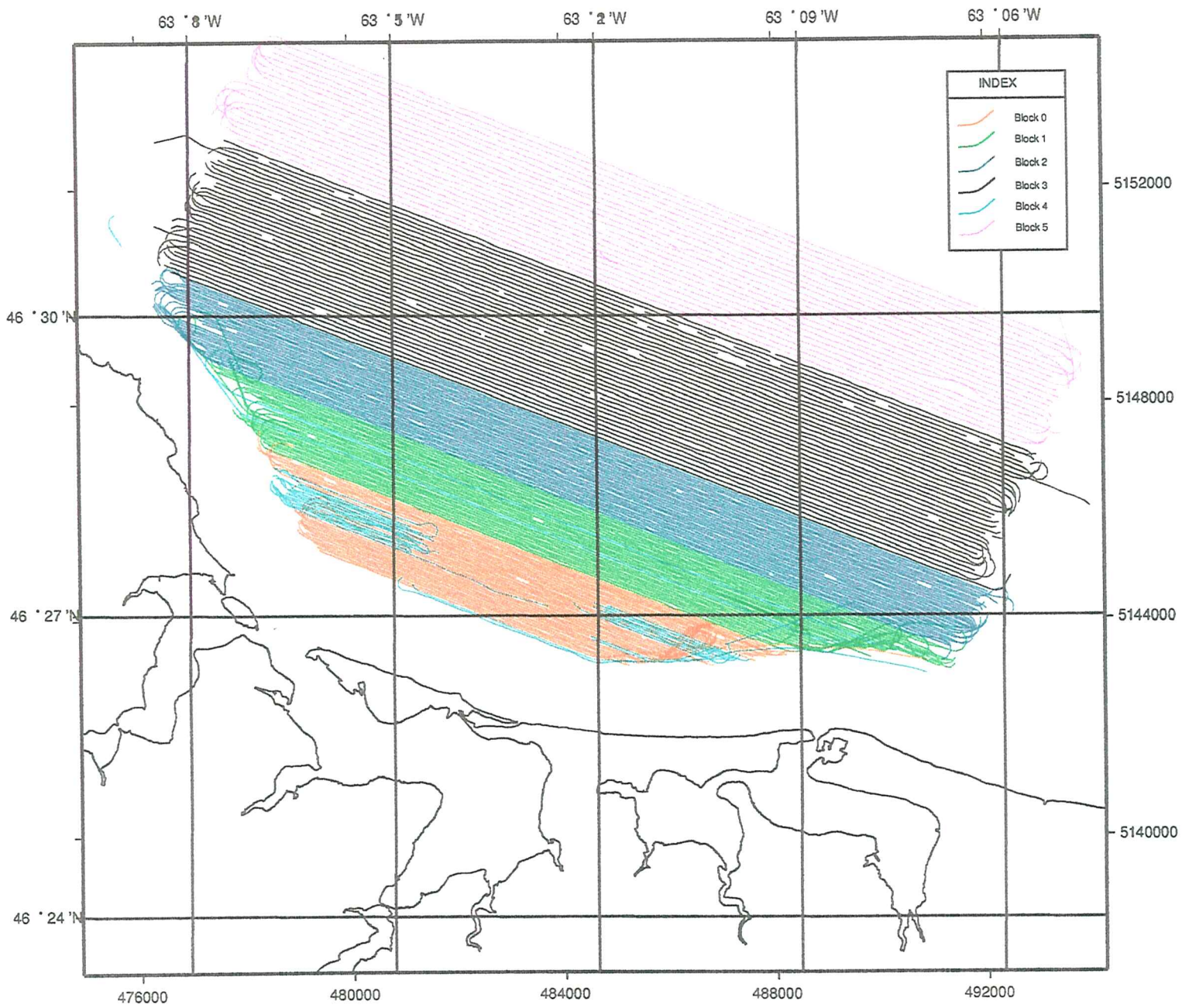
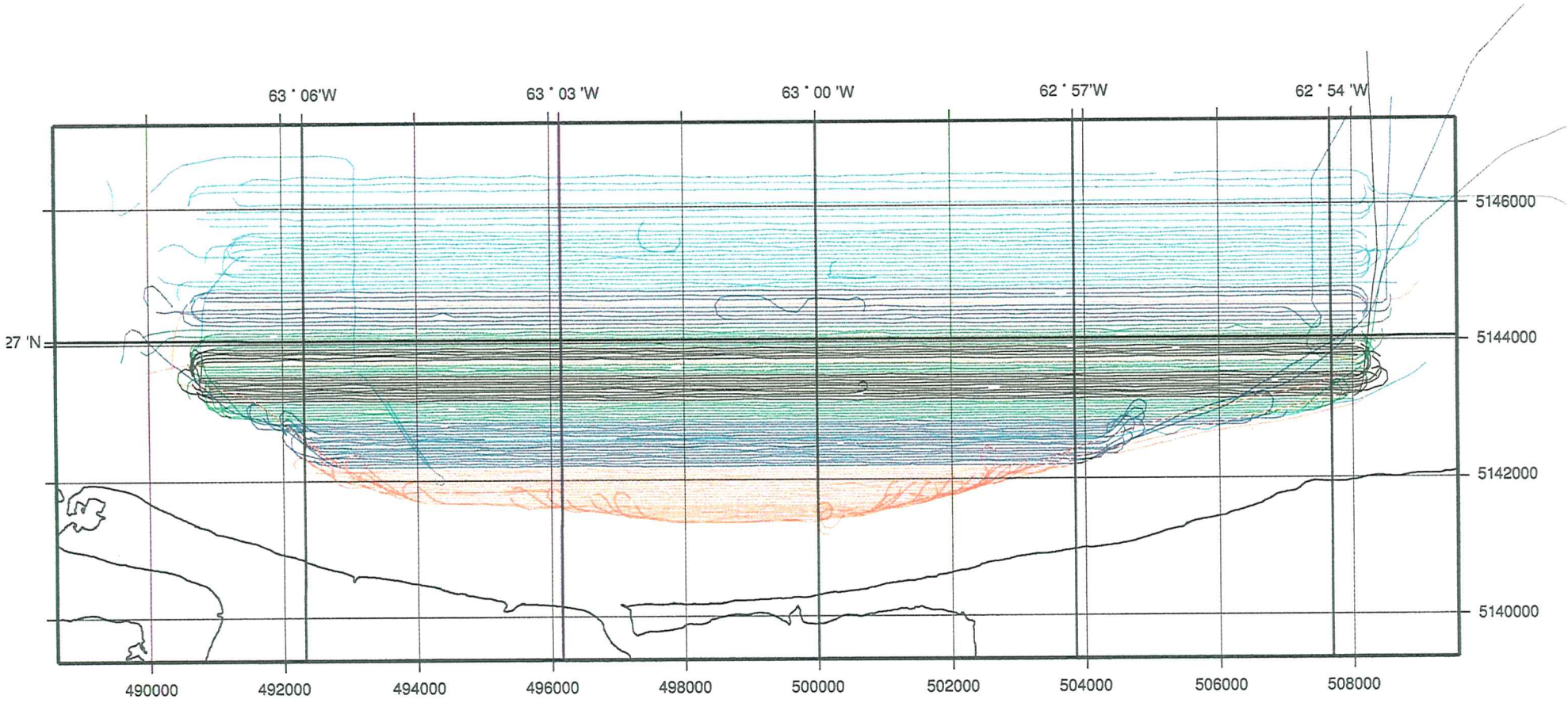
Appendix 1 Track plots

Fig. A1-1. 1997 *Creed* tracks colour-coded by block (blocks 0-5).

Fig. A1-2. 1998 *Creed* tracks colour-coded by day (August 6-10).


63 ° 12 'W
63 ° 09 'W
63 ° 06 'W
INDEX
Block 0
Block 1
Block 2
Block 3
Block 4
Block 5
46 ° 30 'N
46 ° 27 'N
46 ° 24 'N
5152000
5148000
5144000
5140000
476000
480000
484000
488000
492000



INDEX

Aug. 6, 1998	Aug. 9, 1998
Aug. 7, 1998	Aug. 10, 1998
Aug. 8, 1998	

Appendix 2 Compact Disks

BIO 97093 (1997)

97093-01	block 0	raw datagrams backup (lines 0000-0032)
97093-02	block 1	raw datagrams backup (lines 1003-1029)
97093-03	block 2	raw datagrams backup (lines 2000-2019)
97093-04	blocks 2+4	raw datagrams backup (lines 2020-2029, 4000,4020, 4100,4113)
97093-09	block 3	raw datagrams backup (lines 3000-3019)
97093-11	block 3	raw datagrams backup (lines 3020-3034)
97093-12		raw datagrams backup (lines 48nn, 49nn, 60nn, 70nn, 9000)
97093-13	block 5	raw datagrams backup
97093-05	day 205	HDCS processed depths
97093-06	day 206	HDCS processed depths
97093-07	day 207	HDCS processed depths
97093-08	day 208	HDCS processed depths
97093-10	day 209	HDCS processed depths
97093-14	day 210	HDCS processed depths

IML 98034C (1998)

98034C-01	day 218	HDCS processed depths
98034C-02	day 219	HDCS processed depths
98034C-03	day 220	HDCS processed depths
98034C-04	day 221	HDCS processed depths
98034C-05	day 222	HDCS processed depths
98034C-06	day 218+223	raw datagrams backup
98034C-07	day 219	raw datagrams backup
98034C-08	day 220	raw datagrams backup
98034C-09	day 221	raw datagrams backup
98034C-10	day 222	raw datagrams backup

Appendix 3 Exabyte Tapes

BIO 97093 (1997)

97093-01	day 205	raw datagrams backup	./rawdata1/peinp
97093-02	day 205	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-03	day 205pm	raw datagrams backup	./rawdata1/peinp
97093-04	day 206am	raw datagrams backup	./rawdata1/peinp
97093-05	day 206am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-06	day 206pm	raw datagrams backup	./rawdata1/peinp
97093-07	day 206pm	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-08	day 207am	raw datagrams backup	./rawdata1/peinp
97093-09	day 207am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-10	day 207pm	raw datagrams backup	./rawdata1/peinp
97093-11	day 207pm	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-12	day 208am	raw datagrams backup	./rawdata1/peinp [-0 & 1]
97093-13	day 208am	raw datagrams backup	./rawdata1/peinp [-0 & 1]
97093-14	day 208am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-15	day 208am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-16	day 209am	raw datagrams backup	./rawdata1/peinp [-0, 1, 2]
97093-17	day 209am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-18	day 209pm	raw datagrams backup	./rawdata1/peinp
97093-19	day 209pm	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-20	day 210am	raw datagrams backup	./rawdata1/peinp
97093-21	day 210am	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-22	day 210pm	raw datagrams backup	./rawdata1/peinp
97093-23	day 210pm	raw datagrams backup	./rawdata1/peinp
97093-24	day 210pm	HDCS_BACKUP	/dsk0/users/HDCS_DATA
97093-25	day 210pm	HDCS_BACKUP	/dsk0/users/HDCS_DATA [sidescan files removed]
97093-A	files FTPed from Sun:/data/proc/peinp to di01:/sunstuff/peinp		
97093-B	copy of Sun proc/peinp directory [write error: unexpected EOF]		

IML 98034C (1998)

98034C-01	day 218	raw datagrams backup	/rawdata/RUSTICO
98034C-02	day 218	HDCS_DATA	/users/hipsdata
98034C-03	day 219	raw datagrams backup	/rawdata/RUSTICO
98034C-04	day 219	HDCS_DATA	/users/hipsdata
98034C-05	day 220	raw datagrams backup	/rawdata/RUSTICO
98034C-06	day 220	HDCS_DATA	/users/hipsdata
98034C-07	day 220	Merlin Sun (bridge)	/d1/data/proc
98034C-08	day 221	raw datagrams backup	/rawdata/RUSTICO
98034C-09	day 221	HDCS_DATA	/users/hipsdata
98034C-10	day 222	raw datagrams backup	/rawdata/RUSTICO [final]
98034C-11	day 222	HDCS_DATA	/users/hipsdata [final]
98034C-12	day 222	Merlin Sun (bridge)	/d1/data/proc/RUSTICO

Appendix 4 Sound velocity profiles - file list

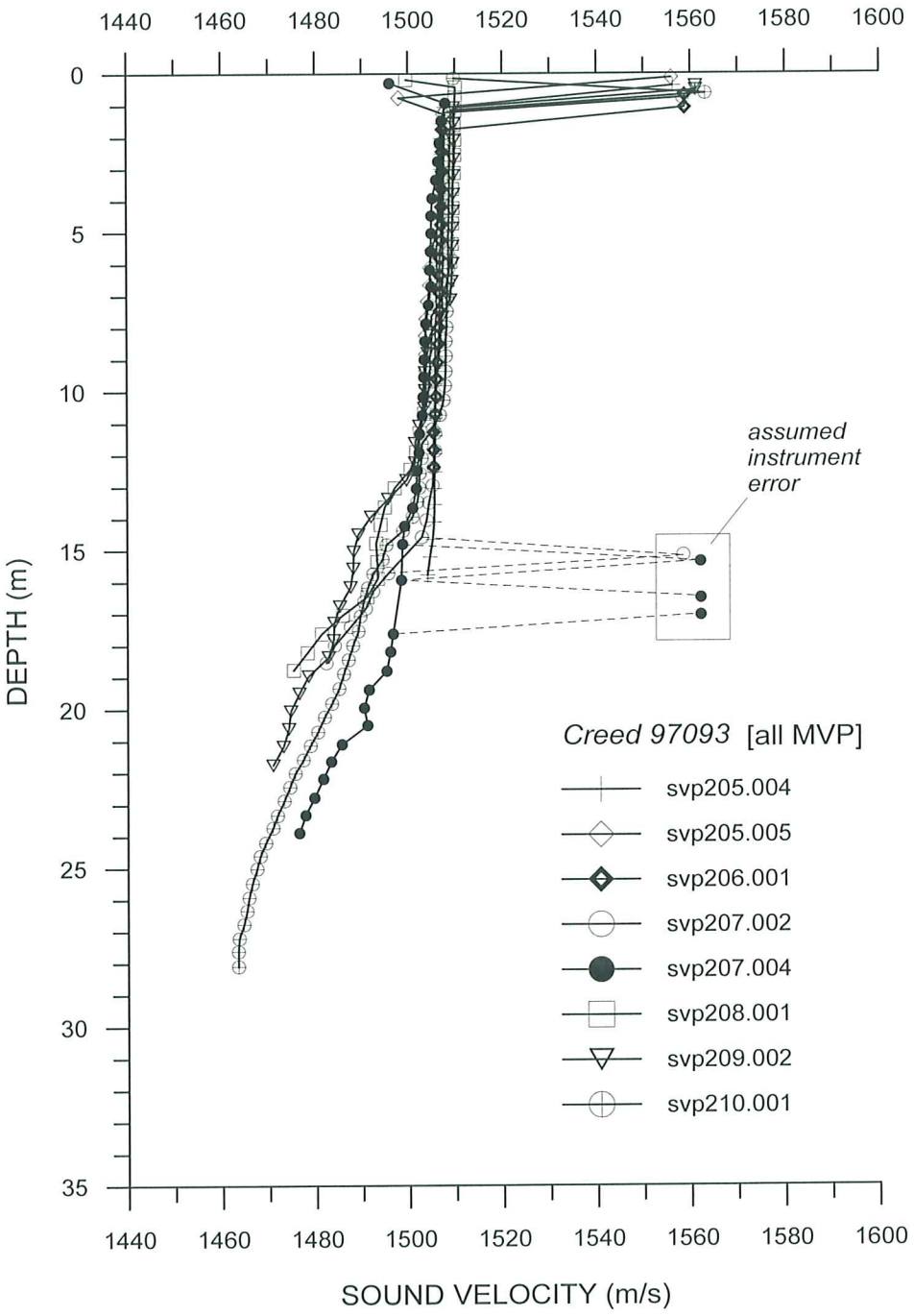
In the following list, the day of year appears in the file name.
Latitude and longitude are in degrees and decimal minutes.

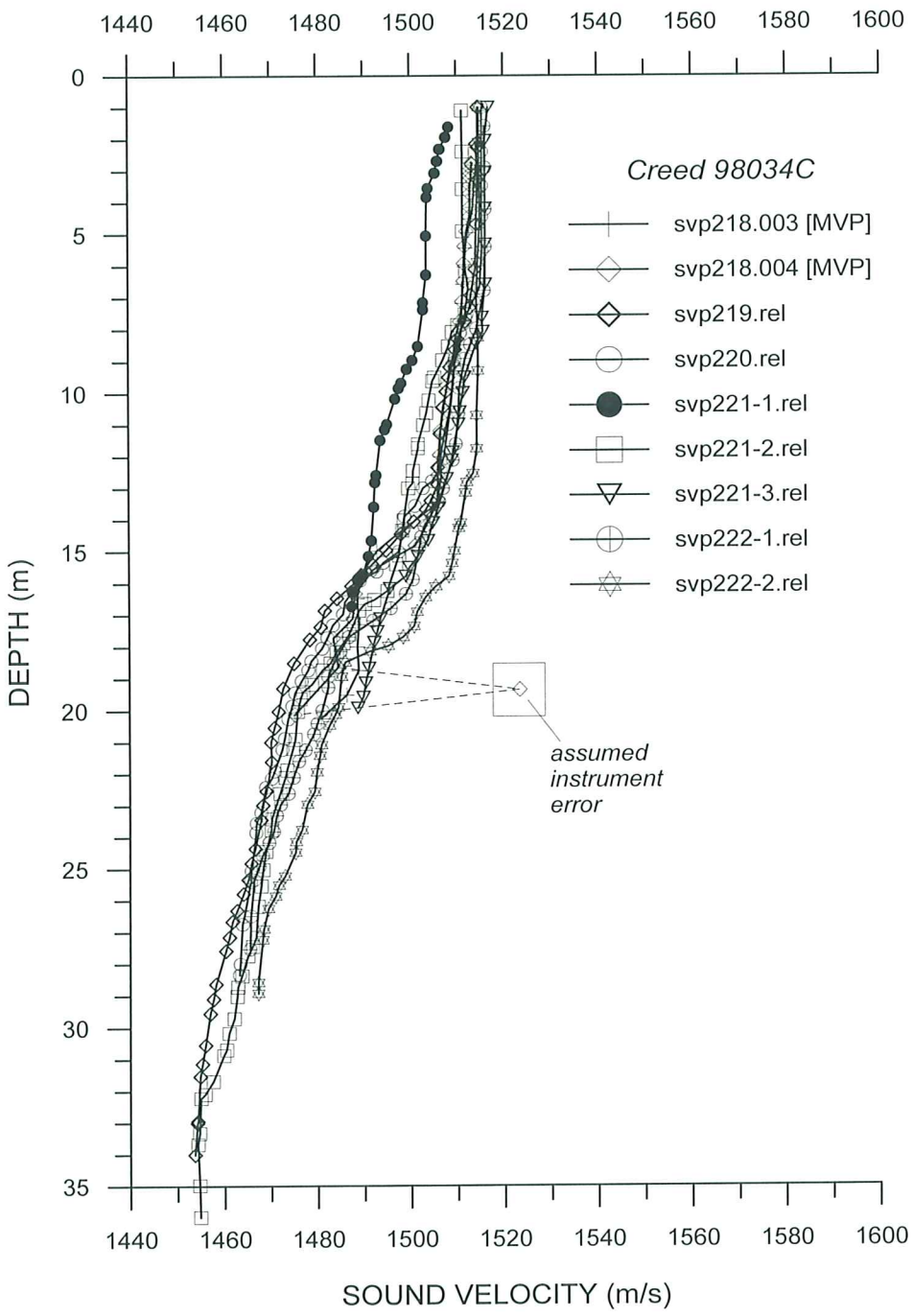
BIO 97093 (1997)

file	time	latitude	longitude
MVP			
svp205.004	0504	46 28.1610N	063 07.0058W
svp205.005	0931	46 30.8186N	063 19.4426W
svp206.001	1049	46 27.6054N	063 08.6781W
svp207.002	1028	46 28.2024N	063 07.3073W
svp207.004	2357	46 31.8616N	063 17.2654W
svp208.001	2115	46 27.8925N	063 05.7129W
svp209.002	1123	46 29.4903N	063 05.8420W
svp210.001	0008	46 31.3787N	063 11.5177W

IML 98034C (1998)

file	time	latitude	longitude
MVP			
svp218.003	0832	46 29.0012N	062 54.1175W
svp218.004	0835	46 29.0145N	062 53.6291W
SVP			
svp219.rel	1115	not recorded	not recorded
svp220.rel	1102	46 27.9205N	063 01.6056W
svp221-1.rel	0427	46 19.7646N	061 56.5191W
svp221-2.rel	0940	46 29.8605N	062 53.6483W
svp221-3.rel	1240	46 26.6051N	062 59.5660W
svp222-1.rel	0115	46 28.2508N	063 01.3013W
svp222-2.rel	1523	46 28.9076N	062 56.3920W


1440
1460
1480
1500
1520
1540
1560
1580
1600
0
5
10
15
20
25
30
35
DEPTH (m)
assumed
instrument
error
Creed 97093 [all MVP]
svp205.004
svp205.005
svp206.001
svp207.002
svp207.004
svp208.001
svp209.002
svp210.001
SOUND VELOCITY (m/s)


1440
1460
1480
1500
1520
1540
1560
1580
1600
0
5
10
15
20
25
30
35
DEPTH (m)
SOUND VELOCITY (m/s)
Creed 98034C
svp218.003 [MVP]
svp218.004 [MVP]
svp219.rel
svp220.rel
svp221-1.rel
svp221-2.rel
svp221-3.rel
svp222-1.rel
svp222-2.rel
assumed
instrument
error

Appendix 5 Water levels during 1998 surveys

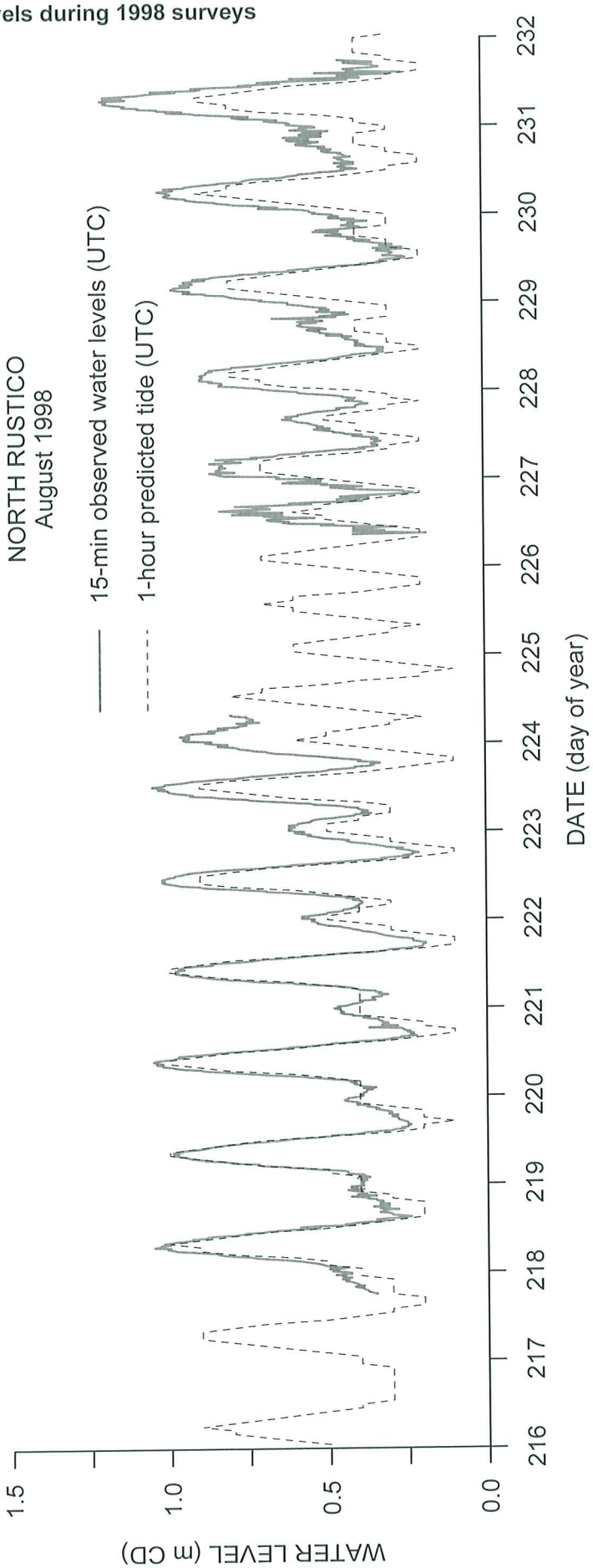


Fig. A5-1. Measured and predicted water levels at North Rustico, PEI, 4-20 August 1998.

Appendix 6 Sea state, weather, and water temperatures

Fig. A6-1. Water temperature at 22 m depth off Cape Stanhope during 97093 and 11 m depth off Point Deroche during 98034C (Minilog data).

Fig. A6-2. Visually estimated wave height and anemometer wind speed and direction (from bridge log) with Minilog water temperature data off North Shore of PEI during multibeam surveys in 1997.

Fig. A6-3. Visually estimated wave height and anemometer wind speed and direction (from bridge log) with Minilog water temperature data off North Shore of PEI during multibeam surveys in 1998.

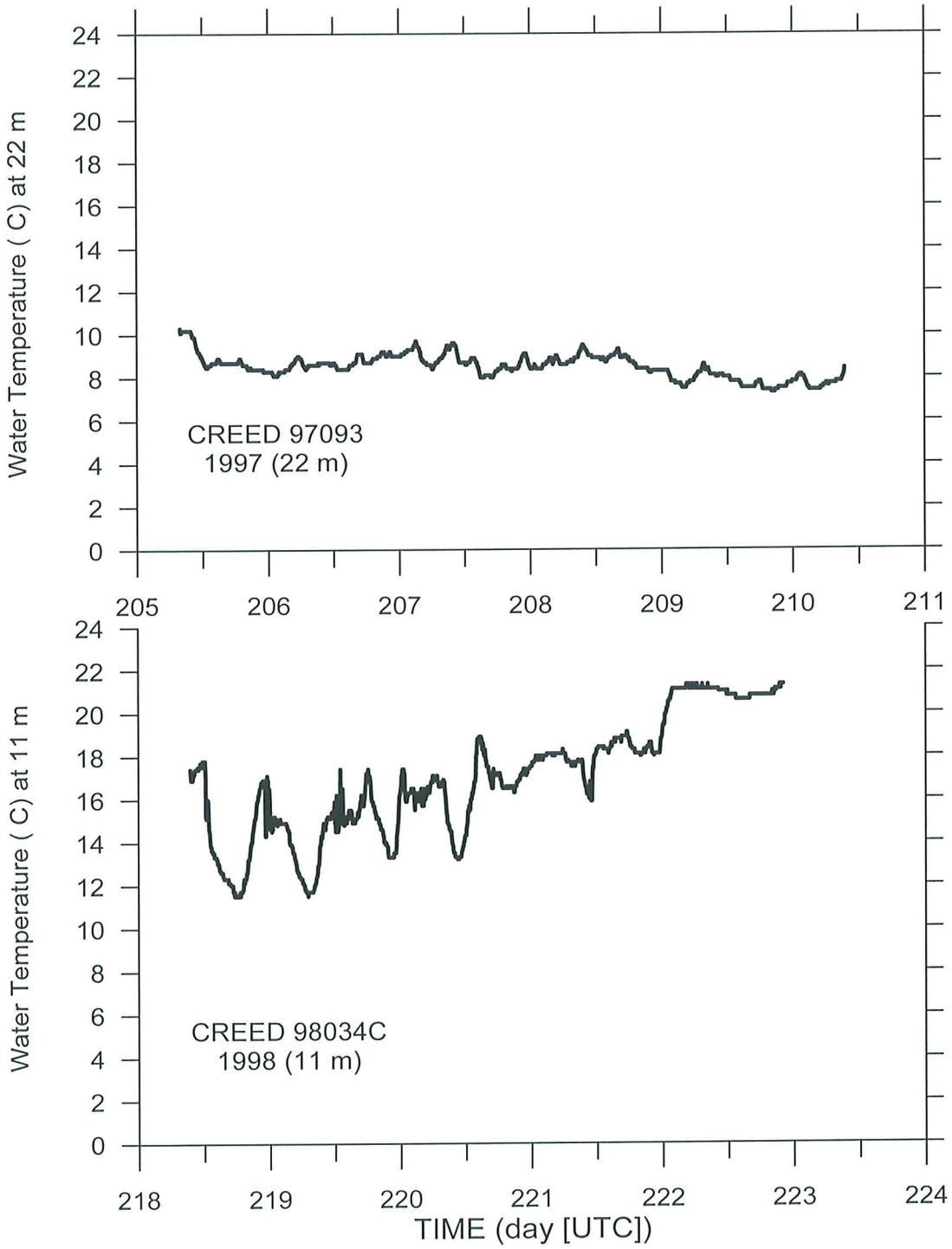


Fig. A6-1. Water temperature at 22 m depth off Cape Stanhope during 97093 and 11 m depth off Point Deroche during 98034C (Minilog data).

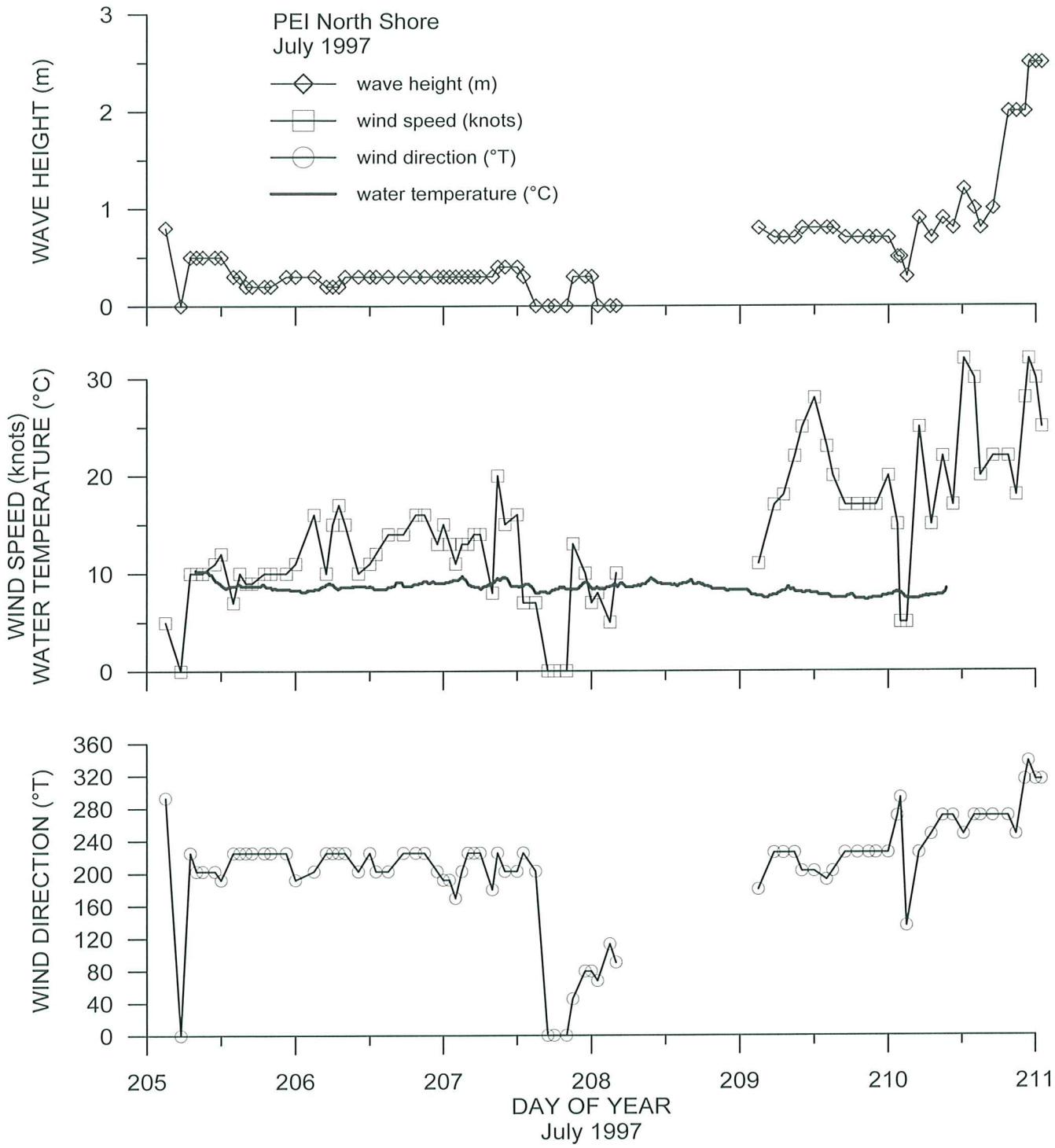


Fig. A6-2. Visually estimated wave height and anemometer wind speed and direction (from bridge log) with Minilog water temperature data off North Shore of PEI during multibeam surveys in 1997.

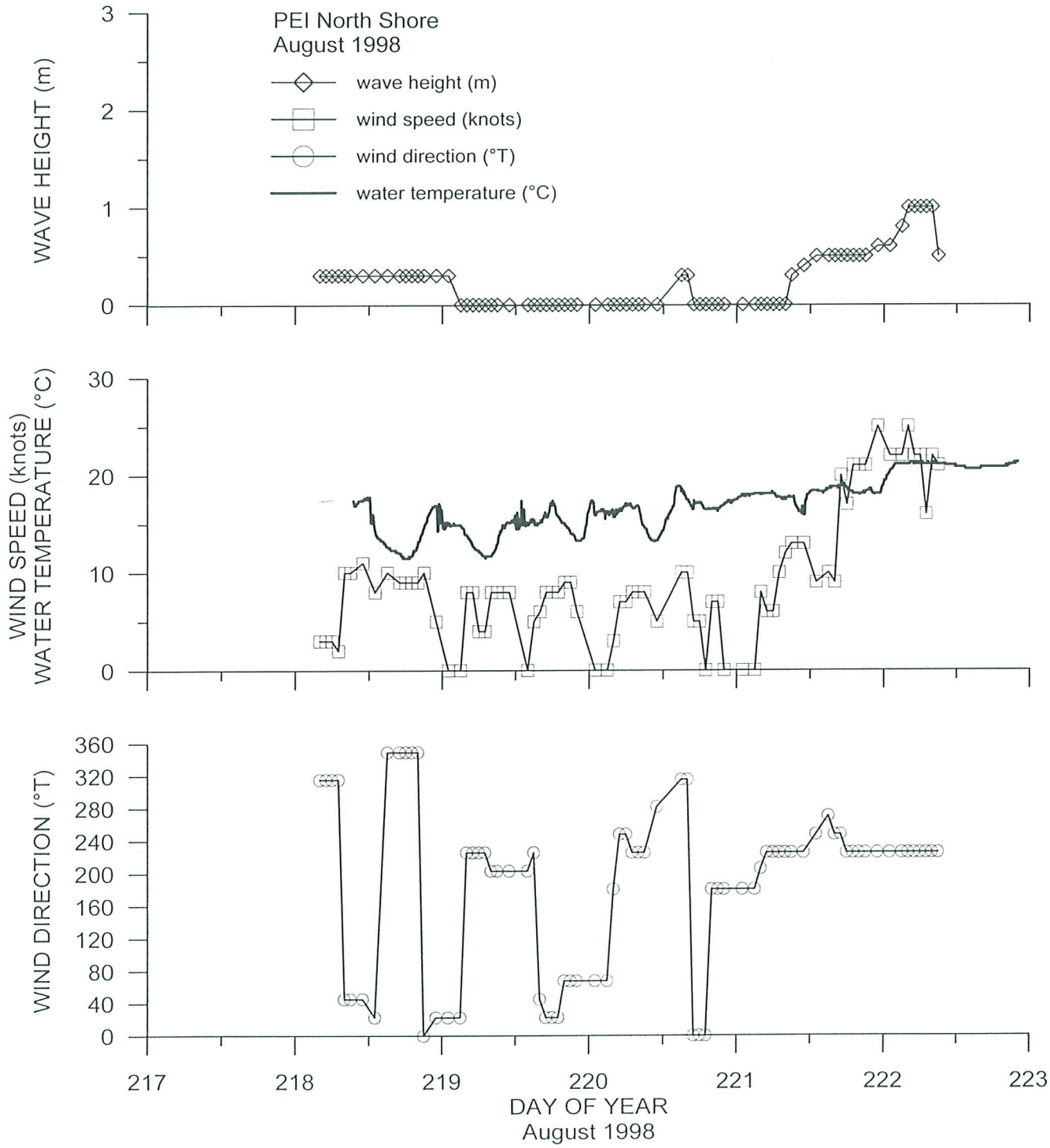


Fig. A6-3. Visually estimated wave height and anemometer wind speed and direction (from bridge log) with Minilog water temperature data off North Shore of PEI during multibeam surveys in 1998.