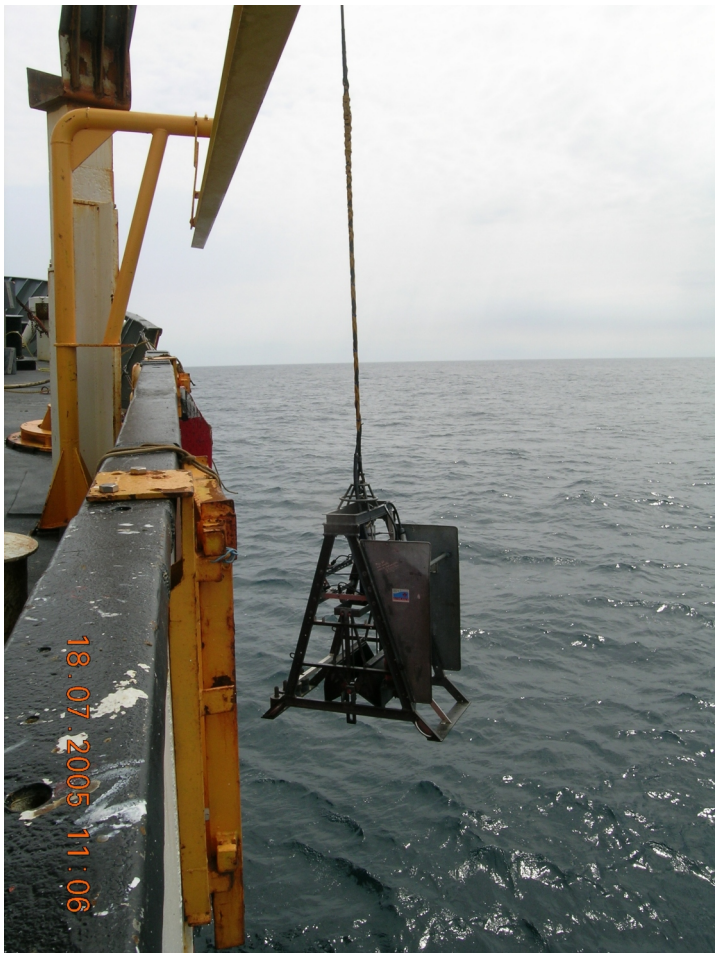
GEOLOGICAL SURVEY OF CANADA
OPEN FILE 5394

HUDSON 2005033A CRUISE REPORT: VIDEOGRAB AND REPEAT GEOPHYSICAL SURVEYS FOR GEOHAZARD ASSESSMENT ON SABLE ISLAND BANK, SCOTIAN SHELF

Michael Z. Li and Edward L. King

with contributions from: Ken Asprey, Owen Brown, Borden Chapman, Paul Girouard



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1 CRUISE SUMMARY SHEET

Ship CCGS HUDSON

Cruise Number 2005033a

Duration 16 - 21 July, 2005

Survey Areas Sable Island Bank and eastern Scotian Shelf

Summary of Accomplishments

(1) Completed videograb survey/sampling and sidescan survey at 6 selected areas
(2) Occupied 25 videograb stations and collected 25 videograb samples
(3) Collected approximately 10 hours of seabed video imageries using the DFO Videograb system (both forward and downward looking views)
(4) Obtained 306 km sidescan survey lines, including 14 km from the DFO Sable South quahaug habitat survey site
(5) Recovered three Ocean Bottom Seismometers at the Gully for DFO

Scientific Staff

Li, Michael (m)	GSCA	Senior scientist
King, Ned (m)	GSCA	Second senior scientist
Asprey, Ken (m)	GSCA	sidescan survey
Brown, Owen (m)	GSCA	sampling/curation
Chapman, Borden (m)	GSCA	Videograb
Fraser, Paul (m)	GSCA	sampling/sidescan watch keeping
Girouard, Paul (m)	GSCA	Navigation/data logging
LeBlanc, Bill (m)	GSCA	sampling/sidescan watch keeping
Middleton, Greg (m)	GSCA	videograb/sidescan watch keeping
Goss, Shawn (m)	Dal Student	sampling/sidescan watch keeping
Uyesugi, Marty (m)	Geoforce	Huntec (for OBS recovery)

Ship's Personnel

Captain	David Martin
Chief Officer	Byron Samson
Second Officer	Karie Allen
Third Officer	Brett Reiben
Supernum. Mate	Megan Carter
Chief Engineer	Peter Brick
Senior Engineer	Chris Longley

First Engineer	William Wilson
Second Engineer	Alicia Smith
Third Engineer	Ariel G. Broas
Electrical Officer	James Ward
Logistics Officer	David Archibald
Ship’s Nurse	Myrella Bellerose
Ship’s Tech	Richard Malin
Off. Cadet	Luke Razauskas
Off. Cadet	Josh McInnis
Off. Cadet	Todd Smith
Boatswain	Claude Warren
Leading Seaman	Edgar Maillet
Leading Seaman	D. Gregory MacClellan
Leading Seaman	Matthew Reeves
Seaman	David Boyd
Seaman	Donald Johnson
Seaman	Brent Sallans
Seaman	Andrew G. Ward
Seaman	John G Baker
Seaman	Arthur W Wilson
Oiler	Stephanie Sparks-Ramsay
Oiler	John F Haley
Chief Cook	Tyrone Saunders
Cl/Storekeeper	David Bartlett
Steward/Cook	Shane Rideout
Steward/Cook	Stephen Coggan
Steward	James Lindsay
Steward	Jeff Whittle
Steward	Ronald J Cameron

2 INTRODUCTION

Data and information on the nature and severity of geohazards (e.g. bedform stability, iceberg seabed scours, susceptibility of seabed to sediment failure) are an integrated part of the geoscience knowledge for oceans management as they directly affect offshore oil and gas developments and contribute to resolving sea-floor use conflicts. For these reasons, the Offshore Geohazard project (X27) was established in the current Geoscience for Oceans Management (GOM) program at the Geological Survey of Canada to provide regulators, federal departments and industry with a knowledge base to assess geohazard risk, set regulatory policy and evaluate development plans (see GOM web site http://gom.gsca.nrcan.gc.ca/index_e.php).

Two sub-projects, Continental Shelf Seabed Stability and Geological Framework, were established in X27 to obtain integrated understanding of the types, distribution and mobility or potential risk of bedforms and geohazards on Sable Island Bank, and to understand the foundation condition and framework to put geohazards in time and process context. An initial geological-geophysical expedition to eastern Scotian Shelf was conducted in July 2004 to establish the nature and distribution or risk potential of bedforms and other geohazards at several study areas on Sable Island Bank (Li and King, 2006). The scientific objectives of this Hudson cruise are (1) to conduct repeat sidescan surveys at some of these selected study areas to assess the mobility of targeted bedforms over one winter season, and (2) to collect seabed video imageries and bottom samples at known morphological locations across bedform profiles to determine the surficial sediment grain size and its variation across various bedforms.

The CCGS Hudson was mobilized from 14-15 July, and left BIO in the morning on July 16. The ship arrived at St. John's on 21 July for staff and crew change, marking the end of this short cruise. Under the direction of Captain David Martin, the ship's officers and crew did an excellent job in assisting our surveys and sampling. The scientific team included 9 GSCA staff, 1 staff on contract, and 1 student volunteer. The general work schedule on Hudson 2005033A was to undertake videograb survey and sampling in the daytime and run repeat sidescan surveys in the night. The cruise roster and each staff member's responsibility are shown in Table 2-1. This schedule worked reasonably well, despite some required steaming from the end of the night survey to sites of day-time sampling and visa versa. Weather was excellent to good, though foggy weather toward the end of the cruise did result in a few hours of weather down-time. Videograb surveying/sampling and geophysical surveys were successfully completed at six areas, including the repeat sidescan survey at the DFO Sable South quahaug habitat survey site (Figure 2-1). A total of 25 videograb stations were occupied and 25 grab samples was collected. Approximately 10 hours of seabed video imageries were recorded using the DFO Videograb system (for both forward and downward looking views). 306 km sidescan survey lines were obtained, including 14 km from the DFO Sable South quahaug habitat survey site. Toward the end of the cruise, three Ocean Bottom Seismometers (OBS) were successfully recovered from the Gully area for DFO. Figure 2-1 shows the survey areas, videograb stations, and tracks of sidescan surveys achieved on this expedition. Appendix 1 lists the date/time, position, water depth, target feature and the description of videograb survey and samples for the stations occupied on this cruise.

Table 2-1 Hudson 2005033A cruise roster and staff responsibility.

0600-0800	0800-1000	1000-1400	1400-1800	1800-2000	2000-2200	2200-0200	0200-0600
Li	Li	Li	King	King	King	Asprey	Asprey
Chapman	Chapman	Chapman	Chapman	Asprey	Asprey	Goss	Fraser
Brown	Brown	Brown	Brown (6-3)	LeBlanc	LeBlanc (3-9)		
Middleton	Middleton	Middleton	Middleton				
LeBlanc		Goss	LeBlanc (3-9)				
			Fraser				

Watches	0600-0800	0800-1000	1000-1400	1400-1800	1800-2000	2000-2200	2200-0200	0200-0600
Activities	Geological Sampling				Geophysical Survey			
sampling and photography	Li Chapman Brown Middleton LeBlanc	Li Chapman Brown Middleton	Li Chapman Brown Middleton Goss	King Chapman Brown(6-3) Middleton Fraser LeBlanc(3-9)				
Sidescan					King, Asprey LeBlanc	King Asprey LeBlanc	Asprey Goss	Asprey Fraser
Regulus/data logging	Girouard (10 - 6)							

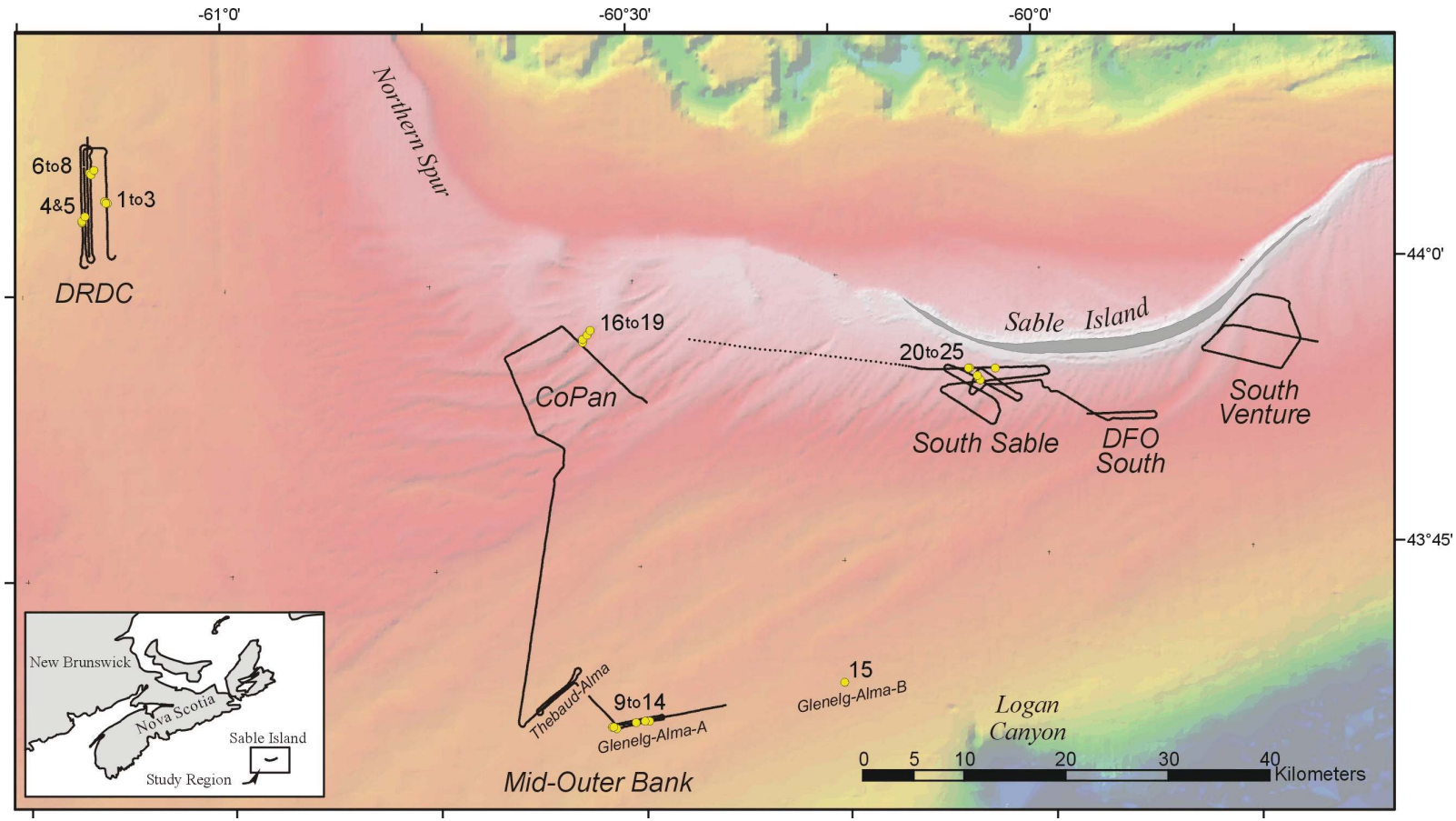

Fig. 2-1 Location map showing vidograb stations (yellow dots) and sidescan survey tracks (black lines) achieved on Hudson 2005033A expedition. General survey sites are also named.

A list of all the sidescan survey lines are given in Appendix 2 and a list of all the videograb tapes obtained on this mission is given in Appendix 3. This report is intended to provide a description of the day-to-day activities, an overview of the technical aspects of the equipment and methods used, and a summary of some preliminary results.

3 NAVIGATION AND DATA PROCESSING (modified from contribution of P. Girouard)

Differential GPS navigation was provided by the ship's MX400 series receivers. NMEA sentences from these systems were combined with the NMEA sentences from the ship's log, gyro and the Trackpoint positioning system through a Baytech Multiplexer in the NAV centre. Data from the multiplexer was then forwarded to a Black Box line splitter for distribution throughout the ship at 9600 baud. In addition, the GP Lab Regulus system rebroadcast all the received NMEA sentences over the Ethernet network to the Drawing Office Regulus system.

Three Regulus systems were in use on the ship to view and log the scientific navigation. All systems were running the latest version of Regulus, Build 27001. These systems were set up in the Drawing Office, the Forward Lab and the GP Lab. The GP Lab Regulus system was used as the primary data logger. The data were copied over the network to the shipboard NT server on a daily basis, enabling access to the files from a variety of networked workstations. The data were cleaned and merged using a text editor and the standard GSCA programs ETOA, INTA and APLOT. Raw E-format, raw A-format and cleaned and edited 10 second A-format files were saved on a daily basis and transferred to CD for GSCA archiving. 60 second A-format files were supplied to the GIS system on a daily basis, for display of the lines on the GIS system. A second monitor was attached to the GP Lab Regulus system through a video splitter. This allowed for the concurrent display of the navigation data for the benefit of the Huntec operator on the next phase of the cruise. A monitor was also attached to the second video output on the GP Lab Regulus system for display and editing of the electronic log.

The Drawing Office Regulus system was found to be unbootable at the beginning of the cruise and the problem was traced to a failed hard drive. The Winch Room Regulus computer was substituted and arrangements were made for the delivery of a replacement hard drive during the St. John's staff and crew change.

The only apparent problem still persisting is the feature which allows an individual to retrieve a position, based on time, from the Regulus voyage file. A position showing a latitude of approximately half its actual value is often returned when this is attempted. This problem can be sidestepped when it occurs by entering a time one second off from the desired time. Three of the systems were newly purchased and running Windows XP. There is a problem with this operating system that causes any data input to the COM port to be viewed as input from a mouse. Soon after data is fed to the port the system assumes that new hardware is attached and the input is viewed as instructions from a mouse. The result is a completely uncontrollable and therefore unusable system. The problem was overcome by disabling the automatic hardware recognition.

4 EQUIPMENTS

The following is the list of equipment brought on this mission:

van Veen grab
DFO videograb
A Nikon Coolpix 5400 digital camera (for on-deck photos of grab samples)
sample description kit
DGPS navigation
ED at Sea laptop
various logging sheets
Simrad Mesotech 992 dual frequency sidescan
ORE TrackPoint II (on sidescan)

The DFO videograb system and the Simrad sidescan system and their operation are described in the next two sections.

4.1 The DFO VideoGrab System (with contribution from B. Chapman and O. Brown)

The DFO videograb is a clam-shell type bottom grab sampler equipped with video cameras and hydraulically operated jaws for collecting high-resolution video imagery of the seabed as well as a sample of sediment and associated organisms over precisely chosen bedform features or micro-habitats on the seafloor (Schwinghamer et al., 1996; Gordon et al., in prep.). It was designed to minimize disturbance to the sampling area and to provide the operator the ability to visually select the sampling area on the seabed, close and open the bucket remotely, and verify that the bucket closed properly prior to recovery. Figures 4-1-1 and 4-1-2 show the videograb and its control system respectively. The videograb is equipped with both a oblique-looking and a vertical thru-grab digital video camera. The obliquely-mounted camera provides a forward-looking, wide-angle view over the seabed during drifting, while the downward-looking camera is mounted directly above the open grab and provides thru-grab imageries of the seabed to be sampled and the closure condition of the grab. The grab is closed and opened hydraulically with a sampling area of 0.5 m^2. Sampling depth is on the order of 10-25 cm and at full penetration the sediment volume is about 100 L. Large fins align the videograb with the current and counteract any tendency to rotate. The weight of the videograb is 1136 kg on deck and the frame height is approximately 2.5 m. The deployment of the videograb is through a customized 50 HP winch with approximately 500 m of 1.25 inch Kevlar multi-conductor cable. Current operating depth is limited by cable length to about 500 m. The operation of the system is handled with the lab control unit (Fig. 4-1-2) which essentially consists of two racks: the left rack contains the camera controls, winch/hydraulic motor control and video-light power supply, and the right rack contains high-resolution color monitors and two Sony digital video recorders (DVR). Sony 2-hour digital video cassette (PDV-124N) were used for video recording throughout this mission.

Fig. 4-1-1 Photograph of the DFO Videograb used on Hudson 2005033a.

Fig. 4-1-2 Photograph of the Videograb control unit showing the left rack that contains (from top down) camera controls, winch/hydraulic motor control and video-light power supply, and the right rack that supports high-resolution color monitors and two Sony digital video recorders (DVR).

The supporting system for the scientific operation of the videograb was set up on the left (relative to Hudson heading) part of the Forward Lab (Fig. 4-1-3). To the right of the control unit, two TV monitors and a Regulus terminal were set up where scientific staff monitors seabed features and log data onto the logging sheet. A GIS computer was set up on the counter to the left of the videograb control unit. The navigation (ship's cursor) was fed to the GIS computer and shown on the background sidescan or multibeam images to facilitate scientists to determine the position of the vessel relative to the seabed features and the direction of vessel drifting.

The operation of the videograb requires a scientist and several scientific staff to work together. The technical operation requires two scientific staff: one operates the control unit (Borden Chapman on this cruise) and another one (Gregg Middleton) works with the deck crew for the deployment and retrieval of the videograb. The scientist works with additional one or two scientific staff to observe seabed features and log data on the logging sheet. When on station, the deck crew will be initially in charge in deploying the videograb. An operator on deck controls the winch by using a video monitor beside the winch that provides depth, distance off the bottom and water temperature, as well as real time video imagery. Once the seabed comes into view, the staff at the control unit will take over the operation in the Forward Lab via remote control. Ship's cursor and bedform features shown on the GIS computer are used to determine the drift direction. This is usually normal to the crestlines of bedform features. The ship is allowed to slowly drift with the videograb suspended just above the seabed to explore the target features and the general bottom properties. The scientist also determines when to create an event on the Regulus (by pressing Ctrl-e) and dictates the observed features at each event to the logging-sheet keepers during the video transect. A new GSCA logging sheet was created to accommodate the information logging in videograb operations. Besides the general info and grab sections, this logging sheet contains a third Video Comments section that allows the recording of video tape number, video tape counts, and information on the start, stop and events of the video transect. When the feature of interest is found, the videograb will be lowered to the seabed. Once landed, the open grab is poised 20 cm above the bottom. By paying out slack cable, the videograb is decoupled from the motion of the ship and high-resolution video of the seabed is recorded looking through the open grab. Closure of the grab simultaneously closes a retractable lid which reduces (but does not eliminate) washout of the sample during recovery. Careful ship-handling is necessary to keep the vessel over the videograb while it is on the bottom. A video monitor is also placed on the bridge to assist the quartermaster in ship handling. Video imagery and navigation data are recorded on digital video tapes for later analysis.

Once the videograb is secured on the front deck, the grab sample is dumped on a wood sample tray. A Nikon Coolpix 5400 digital camera is used to photograph the grab sample. All station photos, together with photographs of equipment and staff, were put on a CD and submitted to GSCA archive. Sedimentological and biological descriptions are then done before subsamples for grain size and other analysis are taken.

Trackplots of the Videograb were compiled into GIS in two versions, one from the standard web-accessible Expedition Database (ED) with one-minute position intervals (available under the

Fig. 4-1-3 Photograph showing the set up of the supporting system for the scientific operation of the videograb that include the control unit (center racks), additional TV monitors and a Regulus terminal (forefront), and a GIS computer (background).

Seismic Parameters (not Station) domain identified as "towed camera" at the following url http://gsca.nrcan.gc.ca/ed/GSC/ed-f-menu.cgi. This is presented in both point (julianday/time attributed) and line (start-time and end-time attributed) shape files. These are included as Appendix 4 of this report (see folder Appendix 4 on the CD). The other videograb track version is a higher resolution (ten second interval) position points with attributes of year-day/time, Latitude and Longitude, station number, and video tape number. Videograb stations and tracks, superposed on previously collected sidescan/multibeam images, are shown in Figure 2-1 (stations only) and several other figures in section 6. A further compilation procedure will be to attribute this in terms of observations from the video and the sample.

The DFO videograb system worked well through the entire mission. Approximately 10 hours of seabed video imagery was recorded (see Appendix 3). Besides allowing the collection of grab

samples over precisely chosen bedform and geohazard features, the video surveys provided interesting information on sediment texture, superposed small bedfroms and biological characteristics on target bedform and geohazard features. Our experience suggests that the downward-looking camera needs to be adjusted constantly to get the best resolution of the seabed. Sometimes better resolution can be achieved if the camera is raised slightly higher above the seabed. In future cruises, the GIS computer should be set up near the TV monitors for easier check of the position of the videograb relative to the target bedform feature. A second GIS computer could be set up on the bridge to help with the visualization of the drift direction and the steering of the vessel.

4.2 Sidescan System (with contribution from B. Chapman and K. Asprey)

The GCSA Simrad MS992 sidescan sonar was part of the equipment pool used throughout the Hudson 2005033A cruise.

The Simrad MS992 dual frequency side scan and STABS, Submersible Towed Apparatus Buoyancy System were towed behind a 120 kg yellow depressor weight attached to a 700 meter armored cable (see Figure 4-2-1). The 700 meter cable was wrapped on a remotely-operated Markey DEWS-8 winch. The Simrad sidescan generated dual frequency beams at 120 kHz and 330 kHz. Most data collected was of rippled coarse sand and pebble bands.

Throughout the program the MS992 was set to display a 200 meter wide swath, that is to say, 100 meters to the port and 100 meters to the starboard of the towed fish. Fish depth or altitude was maintained by remotely controlling the amount of cable from the winch. Typically fish depths were between ten and twenty meters above the bottom. Working in water depths of between 20 to 80 meters for most of the program, required a 3:1 or 4:1 fish layback to water depth ratio. Track Point beacon #5 was mounted onto the STABS and was used to monitor fish layback. While surveying, ship speed was maintained at speeds generally just over 4.5 knots, over ground.

The side scan signals collected by the towed body were processed and recorded by the lab equipment as seen in Figure 4-2-2. Sonograms were recorded to hard copy using an Alden Model 9315 CTP thermal printer and throughout the program the 330 kHz images were displayed on this printer. Also, both the 120 kHz and 330 kHz were recorded to ExaByte digital tape using the AGC_Dig, Serial #002. This is a four- channel digitizer operating at a 65 micro-sec sample rate with 2048 samples per scan, yielding a full 100 meter swath record for each channel. Channels one and two recorded the 120 kHz port and starboard beam signals and channels three and four recorded the 330 kHz channel data.

Gain control settings for the Simrad MS992 were as follows:

- Channel 1 & 2 operated at 120 kHz, TVG settings A=25, B=30 C=26 and L=125.
- Channel 3 & 4 operated at 330 kHz, TVG settings A=38, B=80, C=18 and L=125

Figure 4-2-1. Simrad system with neutrally buoyant package (white) and depressor weight (lower left).

Figure 4-2-2. Topside setup of the Simrad sidescan. Though the photograph shows the GSC -DIG system (white) the old AGC DIG was used for recording on this mission.

During the scientific survey there was damage done to the female connector on the pull wire wet end termination which required the replacement of the SeaConn power connector. Approximately four hours of data collection time was lost due to the time required to complete this repair. All sidescan survey lines are listed in Appendix 2. The sidescan Electronic Log Excel file (2005033A Electronic Log.xls) and the Excel file listing the sidescan records and tapes (2005033a Records.xls) form Appendix 5 of this report (see Appendix 5 folder on this CD).

5 CRUISE ITINERARY

The following is a daily account of activities on Hudson 2005033A. All times in this itinerary are in Universal Time Coordinated (UTC) unless specified as Atlantic Daylight-saving Time (ADT). ADT is three hours earlier than UTC.

Julian Day (JD) 196, July 15, Friday

A meeting of all scientific staff with the Captain and ship's officers was held at 14:00 ADT on July 15 and an introduction tour was conducted for new staff.

JD197, July 16, Saturday

All staff boarded at 0830 ADT and Hudson left the dock at 0900 ADT. A safety and lifeboat drill was conducted at 09:30 ADT. A track point test was conducted in the harbor. The track point test was completed at approximately 10:30 ADT and Hudson sailed to western Sable Island Bank.

Immediately after leaving Halifax harbor, a brief scientific meeting was held to discuss cruise objectives and watch shifts. Borden Chapman and Greg Middleton explained the videograb system and operation. A group of staff discussed the procedures of videograb operation and logging. It was decided that Ken Asprey would provide instructions of sidescan watch and logging to new staff when sidescan survey starts.

JD198, July 17, Sunday

0140 Arrived at the Defense Research and Development Canada (DRDC) sediment acoustic property test site and sidescan gear deployed. The objective was to obtain repeat sidescan survey for assessing bedform variability with time at this open mid-outer bank location.

Survey started at 0151 and continued until 0904. Collected survey lines include DRDC-1 to DRDC-4, DRDC-7. The repeat sidescan survey for the DRDC area was completed. These sidescan survey lines are shown in Fig. 2-1 and their detail can be found in Appendix 5.

1032 Station 01, 44.082751 -61.144958 57.9 m depth
With a short steam, Hudson arrived at the first videograb station of the DRDC study area at 0945. The planned station is DRDC-a3 and the target bedform is a sand ribbon trough. Videograb was in water at 0945. The video transect lasted from 0950 to 1031 The grab was on the bottom at 1031 and a vial subsample was taken for grain size analysis.

1108 Station 02, 44.081688 -61.143038 57.9 m depth
At the planned station DRDC-a1 and target bedform is a sand ribbon bank. Video transect started at 1059 and stopped at 1108. The videograb was on bottom at 1108 and a vial subsample taken for grain size anlaysis.

1256 Station 3, 44.082090 -61.144288, 57.9 m depth
At added station DRDC-a4 and target bedform is a sand ribbon trough. Two video transects were undertaken with no grab attempted in transect 1. Video transect 1 was from 1128 to 1152. Video transect 2 was from 1231 to 1256. Grab sample taken at 1256.

1437 Station 04, 44.066548 -61.174423 57.9 m depth
At the planned station DRDC-C1; target bedform is a megaripple trough. Two video transects were taken. Grab attempt in transect 1 failed. Video transect 1 was from 1404 to 1413. Video transect 2 was from 1427 to 1437. Grab sample taken at 1437.

1535 Station 05, 44.070527 -61.170720 59.0 m depth
At planned station DRDC-C2; target bedform is a megaripple crest. Video transect was from 1527 to 1535. Grab sample taken at 1535.

1624 Station 06, 44.108591 -61.163752 65.0 m detph
At planned station DRDC-B1; target bedform is a bank between scour depressions. Video transect was from 1617 to 1624. Grab sample taken at 1624.

1732 Station 07, 44.106695 -61.162083 64.0 m depth
At planned station DRDC-B2; target bedform is large-wave ripples in scour depression. Video transect was from 1703 to 1732. Grab sample taken at 1732.

1825 Station 08, 44.110883 -61.158717 64.0 m depth
At added station DRDC-B3; target bedform is large-wave crests. Video transect was from 1812 to 1825. Grab sample taken at 1825.

Videograb survey and sampling at the DRDC area were completed.
Hudson was then in transit to the CoPan area for night sidescan survey.

2120 Arrived at the CoPan area. Sidescan gear deployed. The objective was to obtain repeat

sidescan survey along sand ridge transects for assessing bedform variability at this open bank-top location.

Survey at the CoPan area started at 2140 and continued until 0100 of JD199. Collected survey lines include Copan-1, Copan-2 and Copan-3. The repeat sidescan survey for the CoPan area was completed. These sidescan survey lines are shown in Fig. 2-1 and their detail can be found in Appendix 5.

JD199, July 18, Monday

0100 Sidescan survey continued along a tie line (CP_AT tie line) from the CoPan area to the Alma-Thebaud mosaic area on the mid-outer bank (see Fig. 2-1 and Appendix 5). CP_AT tie line was completed at 0339.

0347 - 0552
Sidescan survey at the Alma-Thebaud mosaic area to obtain repeat sidescan survey for assessing bedform variability at this less energetic mid-outer bank location. Completed survey lines are AT_MOS1 to AT_MOS3

At the completion of the Alma-Thebaud repeat survey, a tie line between the Alma-Thebaud and Glenelg-Alma-A mosaic areas (AT_GA tie) was surveyed from 0604 to 0632.

0636 - 0814
Sidescan survey at the Glenelg-Alma-A mosaic area to obtain repeat sidescan survey for assessing bedform variability at this less energetic mid-outer bank site. Survey lines GA1 to GA3 were completed.

A tie line (GA_AG tie) from Glenelg-Alma-A mosaic area to Glenelg-Alma-B mosaic area was partially completed from 0814 to 0904. All sidescan gear was on board at 0910. Repeat survey was not done at the Glenelg-Alma-B mosaic area on this mission.

Hudson was almost on site for the videograb survey and sampling at the Glenelg-Alma-A mosaic area.

1014 Station 09, 43.614886 -60.493849 58.8 m depth
At planned station A_G-A2; target bedform is a sand ribbon trough. Video transect was from 1002 to 1014. Grab sample taken at 1014. Station position is shown in Fig. 2-1 and detailed station information, observed seabed features and on deck description of the grab sample can be found in Appendix 1.

1054 Station 10, 43.614798 -60.499098 58.8 m depth

At planned station A_G-A1; target bedform is a sand ribbon bank. Video transect was from 1046 to 1054. Grab sample taken at 1054.

1209 Station 11, 43.614186 -60.511350 59.7 m depth
At added station A_G-D; target bedform is the northeast edge of a scour depression. Video transect was from 1158 to 1209. Grab sample taken at 1209.

1347 Station 12, 43.609569 -60.535300 58.8 m depth
At added station A_G-B3; target bedform is the base of a speck (concentrated shell beds). Video transect was from 1334 to 1347. Grab sample taken at 1347.

1410 Station 13, 43.609860 -60.540041 58.8 m depth
At planned station A_G-B2; target bedform is the base of a speck. Video transect was from 1405 to 1410. Grab sample taken at 1410.

1449 Station 14, 43.609764 -60.537542 58.8 m depth
At added station A_G-B4; target bedform is the base of a speck. Video transect was from 1430 to 1449. Grab sample taken at 1449.

Hudson then steamed to the Glenelg-Alma-B mosaic area.

1718 Station 15, 43.643032 -60.255557 57.0 m depth
At planned station A_G-C1; target feature is a low reflectivity patch. Video transect was from 1618 to 1718. Grab sample taken at 1718.

Videograb survey and sampling at the Mid-Outer Bank area completed and Hudson steamed north to conduct videograb surveys and sampling at the CoPan area.

Arrived at CoPan area at 1942.

2008 Station 16, 43.949041 -60.562317 29.9 m depth
At planned station CP-A1; target bedform is the crest of a megaripple. Video transect was from 1942 to 2011. Grab sample taken at 2008.

2031 Station 17, 43.951007 -60.562300 32.0 m depth
At planned station CP-A2; target bedform is the trough of a megaripple. Video transect was from 2027 to 2031. Grab sample taken at 2031.

2147 Station 18, 43.955393 -60.556694 25.0 m depth
At planned station CP-B1; target bedform is the stoss or crest of a megaripple. Video transect was from 2115 to 2147. Grab sample taken at 2147.

2211 Station 19, 43.959043 -60.552625 26.8 m depth

At planned station CP-B2; target bedform is the trough of a linear megaripple. Video transect was from 2205 to 2211. Grab sample taken at 2211.

Videograb survey and sampling at the CoPan area were completed and Hudson was on her way to sidescan survey at the South Sable area.

2343 Arrived at about 20 km west of the South Sable study area. Sidescan gear deployed. The objective was to obtain repeat sidescan survey along sand ridge transects and several other repeat survey lines for assessing bedform variability at this partially sheltered bank-top site.

The survey first ran in from west of the South Sable mosaic site, approaching the Thebaud rig (Fig. 2-1), and repeat surveys then followed. Survey at the South Sable area started at 2352 and continued until 0742 of JD200. Completed survey lines are SS-1 to SS-9. Detailed survey line information can be found in Appendix 5.

JD200, July 19, Tuesday

A tie line (SS-9) between South Sable area and the DFO Sable South quahaug habitat survey site was surveyed from 0649 to 0742.

0742 - 0902

Two survey lines, SS-10 and SS-11, were obtained at the DFO Sable South quahaug habitat survey site. SS-10 was a repeat line along the center of the 2004037 mosaic and SS-10 was just north of the 2004 mosaic. The purpose was to establish changes in area of intensive and relatively deep hydraulic clam (quahaug) dredge scars. The location of these survey lines are shown in Fig. 2-1 and their detailed information can be found in Appendix 5.

Sidescan survey at the DFO Sable South quahaug habitat survey site was finished and sidescan gear was on deck at 0908. Hudson steamed northwest to conduct videograb survey and sampling at the South Sable area.

1013 Station 20, 43.906179 -60.078113 19.5 m depth
At planned station SS-A2; target bedform is the trough of a linguoid megaripple. Video transect was from 0948 to 1014. Grab sample taken at 1013. Station position is shown in Fig. 2-1 and detailed station information, observed seabed features and on deck description of the grab sample can be found in Appendix 1.

1118 Station 21, 43.904620 -60.075782 17.5 m depth
At added station SS-A5; target bedform is wave ripples on sand ridge stoss (western) flank. Video transect was from 1030 to 1118. Grab sample taken at 1118.

1200 Station 22, 43.908339 -60.079467 15.3 m depth
At added station SS-A6; target bedform is possibly linear megaripples on lee flank of sand ridge. Video transect was from 1133 to 1200. Grab sample taken at 1200.

1256 Station 23, 43.914685 -60.087817 14.2 m depth
At added station SS-B1; target bedform is the bank of a gutter (cross-shore erosional channels) or sand ribbon. Video transect was from 1240 to 1256. Grab sample taken at 1256.

1332 Station 24, 43.915056 -60.090582 14.6 m depth
At planned station SS-B2; target bedform is a gutter trough. Video transect was from 1310 to 1332. Grab sample taken at 1332.

1512 Station 25, 43.914288 -60.057352 14.6 m depth
At added station SS-C; target bedform is a shallow water pit. Video transect was from 1419 to 1512. Grab sample taken at 1512.

As heavy fog was forecast for next day and the transit to St. John's would take longer time, the Captain requested to finish the cruise a few hours earlier than planned. Thus videograb survey and sampling at South Sable was stopped at 1600 and Hudson was on her way to the South Venture area for repeat sidescan survey.

1722 Arrived at the South Venture area. Sidescan in water. The objective was to obtain repeat sidescan survey along three transects for assessing bedform variability at this sheltered shallow bank-top site on southeastern Sable Island Bank.

The sidescan survey at the South Venture area started at 1730 and continued until 2110. Completed survey lines include SV-1 to SV-7. These sidescan survey lines are shown in Fig. 2-1 and their detail can be found in Appendix 5.

2115 Repeat survey at South Venture completed and sidescan gear was on deck. Hudson was on transit to the Gully to recover three OBS for DFO.

2330 Arrived at the first OBS site and recovery proceeded.

JD201, July 20, Wednesday

0500 All three OBS were recovered and Hudson was on transit to St. John's.

JD202, July 21, Thursday

Arrived at St. John's at 0830 (ADT) for crew change. This marked the end of Hudson2005033a expedition. King and Li flew back to Halifax and the rest of the scientific

team continued on Hudson2005033b mission.

6 PRELIMINARY RESULTS

Twenty five videograb stations in four study areas were occupied during the Hudson 2005033a expedition (Fig. 2-1). From these stations, 25 grab samples and approximately 10 hours of video images were obtained. Thirty five sidescan survey lines of 306 km total length were conducted in six areas, including the DFO Sable South quahaug habitat survey site. Some of the preliminary results are presented in the following sections.

6.1 DRDC Area

The Defense Research and Development Canada (DRDC) sediment acoustic property test site is located approximately 80 km west of Sable Island in ~ 70 m water depth. Compared with the Mid-Outer Bank area on the southern Sable Island Bank (Fig. 2-1), the DRDC site represents an area under more open and dynamic mid-outer bank condition. Bedform features targeted by the videograb survey and sampling at the DRDC site include sand ribbons, megaripples, rippled scour depressions, and large-wave ripples on the bottom of the scour depressions. Eight stations and approximately 162 minutes of video transects were obtained at the DRDC site. Five repeat sidescan survey lines in 61 km length were conducted. The videograb stations and sidescan tracks from the DRDC area are shown in Fig. 2-1. Detailed station information, observed seabed features and on-deck description of the grab samples can be found in Appendix 1.

Sand ribbons

Stations 1 to 3 were planned to obtain video surveys and grabs over sand ribbons at the DRDC area. The video transects and grab locations are shown in Fig. 6-1-1. The water depths for these stations are approximately 58 m. The video images suggested that station 2 was over a sand ribbon bank, while stations 1 and 3 were over sand ribbon troughs. Mid-way through station 2, degraded long wave ripples were observed. Small current ripples were observed toward the end of the video transect just before the grab was taken. At the earlier part of station 3 transect, a high concentration of shells possibly in a sand ribbon trough was observed. Shortly after this, the videograb moved on to the sand ribbon bank where shell abundance was significantly less and small ripples were observed. On-deck examination of the grab samples indicated that the sediment in the sand ribbon troughs is generally composed of medium to coarse sands with abundant shells, and that sand ribbon banks are covered with fine sand with much lower shell concentration (Fig. 6-1-2). An anoxic layer, with pebbles up to 1.5 cm in diameter at its base, was observed from the station 3 grab.

Megaripples

The target feature for stations 4 and 5 is megaripples. The video transects and grab locations

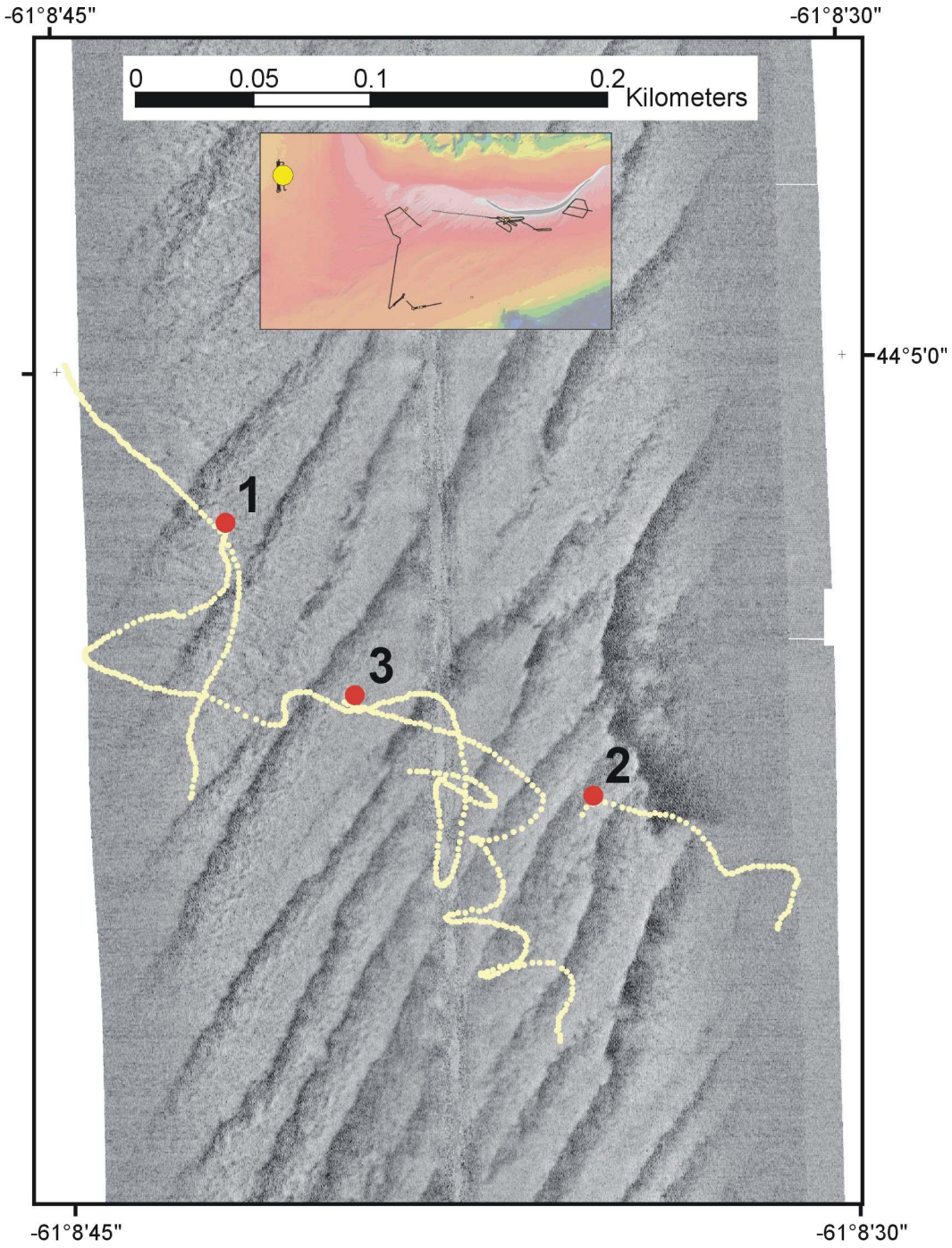

Fig. 6-1-1 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 1 to 3 from the DRDC study area. These are superimposed on a sidescan mosaic produced in 2000 by DRDC (courtesy of J. Osler and A. Crawford). The yellow dot in the inset map indicates the location of the DRDC area.

(A)

(B)

Fig. 6-1-2 Photographs of videograb samples collected from (a) station 2 on a sand ribbon bank and (b) station 3 over a sand ribbon trough from the DRDC study area.

for these stations are shown in Fig. 6-1-3. The water depth at station 4 was 58 m and that at station 5 was 59 m. The planned targets for stations 4 and 5 are megaripple troughs and crests respectively. Within the positioning accuracy, Fig. 6-1-3 suggests that the transect of station 4 crossed some degraded megaripples and the grab was possibly taken over large-wave ripples in the relict sand wave trough. The video transect at this station indeed showed degraded large current ripples and degraded megaripples with shell fragments. On-deck inspection of the grab sample indicated buff-color coarse sand overlying well sorted grey fine sand, with clumps of organic and siltier sediment and occasional pebbles. The video survey at station 5 started over large-wave ripples in a relict sand wave trough and ended over degraded megaripples (Fig. 6-1-3). Video transect showed degraded megaripples with shell fragments and the imagery taken at the moment the videograb was on bottom showed a smooth surface with no wave-formed ripples. On-deck inspection of the grab sample indicated coarse buff sand on surface that transits downcore to coarser sand with pebbles and a few shells.

Rippled Scour Depressions

"Rippled Scour Depressions (RSD)" are persistent patches of prominently rippled coarse sand within relatively featureless fine-sand plains (e.g. Cacchione et al., 1984). Conventionally RDS are thought to be formed by intensified cross-shelf currents (particularly downwelling bottom currents), though sidescan surveys from Sable Island Bank showed relict (barchan-shaped or linear) sand wave troughs with coarse sand large-wave ripples that are similar to RSDs (Li and King, 2006). The target features for stations 6, 7 and 8 are the rippled scour depressions and the large wave ripples on the bottom of these depressions. The video transects and grab locations for these stations are shown in Fig. 6-1-4. The water depths at these stations range from 64 to 65 m. The grab of station 6 probably landed on the bank between scour depressions and its video transect crossed degraded current ripples and a smooth sand wave crest (Appendix 1). The grab sample indicated fine sand surficial sediment with some shell fragments and abundant worm tubes (Fig. 6-1-5a). The videograb of station 7 was probably taken over large wave ripples in a rippled scour depression (Fig. 6-1-4). The video transect at station 7 crossed several scour depressions with large wave ripples on their bottoms. At one location the edge of the scour depression was estimated to be about 20 cm high. The grab sample (Fig. 6-1-5b,c) at this station shows 20 cm thick buff to brown coarse sand with gravel, cobble, and abundant shell fragments. The sand layer overlies a grey mud layer. The videograb of station 8 was probably taken over the crest of large wave ripples in a scour depression. The video survey started over the flat bank between scour depressions and crossed at least one scour depression patch. The grab sample indicated coarse to very coarse sand with abundant shell fragments and some granules. The sediment became slightly finer at 20 cm from the surface with increased shell hash.

6.2 Mid-Outer Bank Area

The Mid-Outer Bank study area is located between the 50 m and 100 m depth contour lines, approximately 45 km to the southwest of Sable Island. Compared with the DRDC area, it represents a more sheltered, less dynamic mid-outer bank environment. Bedform features

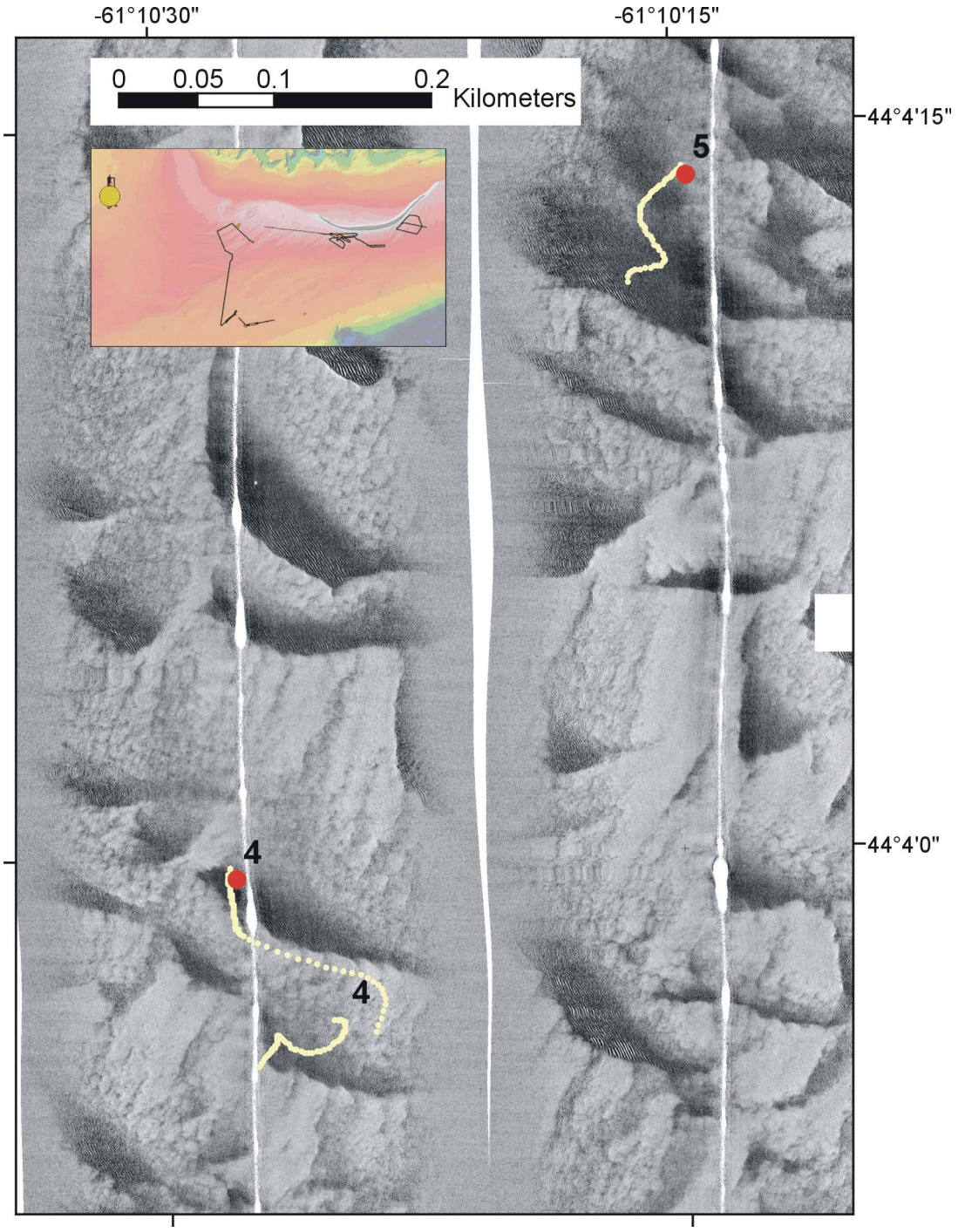

Fig. 6-1-3 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 4 and 5 from the DRDC study area. These are superimposed on a sidescan mosaic produced in 2001 by DRDC (courtesy of J. Osler and A. Crawford). The yellow dot in the inset map indicates the location of the DRDC area.

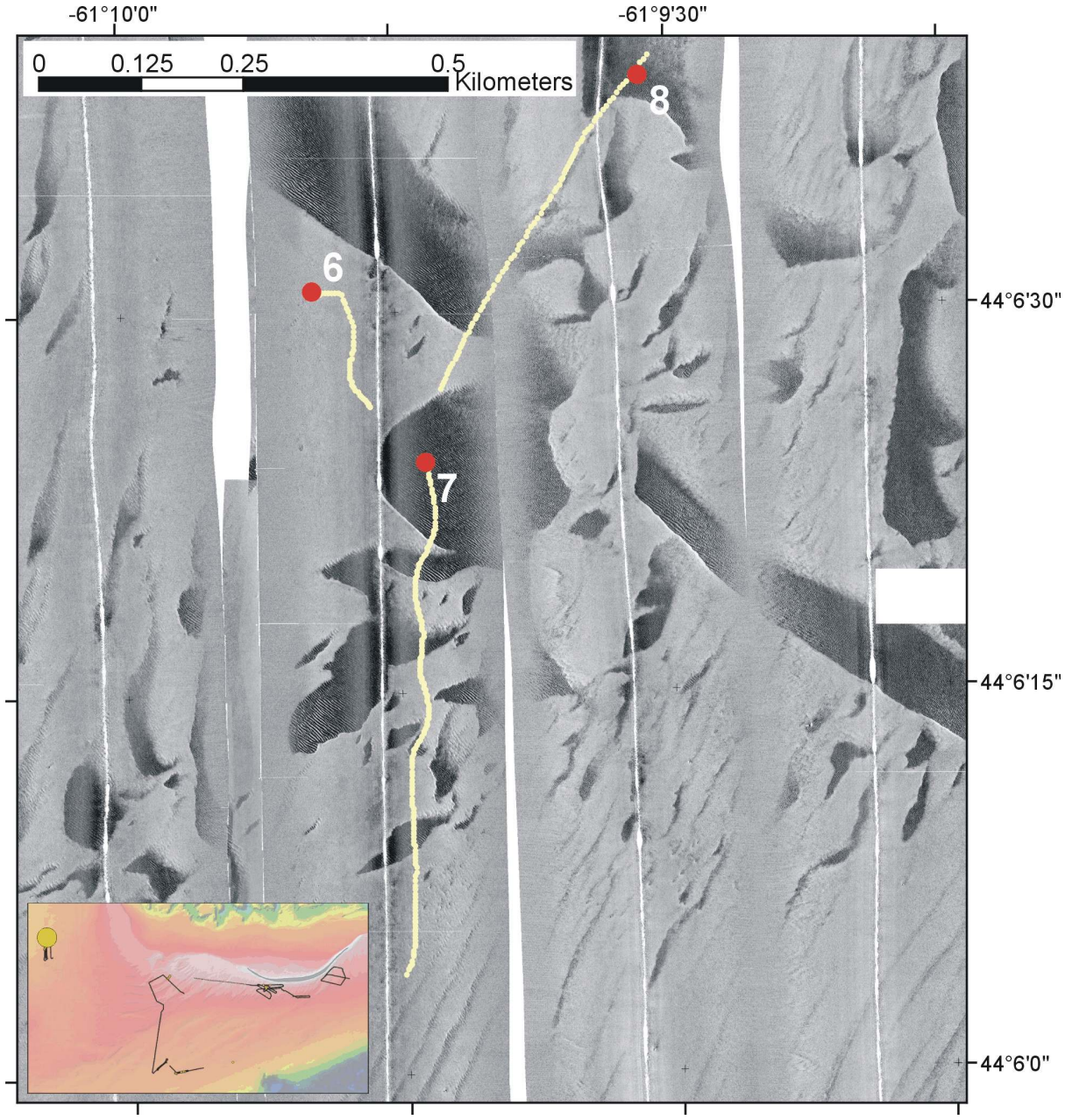

Fig. 6-1-4 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 6 to 8 from the DRDC study area. These are superimposed on a sidescan mosaic produced in 2000 by DRDC (courtesy of J. Osler and A. Crawford). The yellow dot in the inset map indicates the location of the DRDC area.

(A)

(B)

(C)

Fig. 6-1-5 Photographs of videograb samples collected from (a) station 6 over the bank between scour depressions, and (b, c) station 7 over large wave ripples on bottom of a scour depression from the DRDC study area.

targeted by the videograb survey and sampling from this mission include sand ribbons, rippled scour depressions, specks (concentrated shell beds) and low reflectivity patches in large irregular specks. A total of 7 stations and approximately 131minutes of video transects were obtained at the Mid-Outer Bank area. Eight sidescan survey lines in 48 km length were conducted. Due to time constraint, repeat sidescan survey was not conducted at the Glenelg-Alma-B mosaic area though a videograb station (station 15) was obtained. The videograb stations and sidescan tracks from the Mid-Outer Bank area are shown in Fig. 2-1, and detailed station information, observed seabed features and on deck description of the grab samples can be found in Appendix 1.

Sand Ribbons and Rippled Scour Depression

The target features for stations 9 and 10 are sand ribbons at the Gleneg-Alma-A mosaic area under more sheltered mid-outer bank condition. The water depth for these two stations is 59 m. Though the target feature for station 9 is sand ribbon bank and that for station 10 is sand ribbon trough, the grab locations and video transects in Fig. 6-2-1 suggest that video surveys crossed several sand ribbons for both stations and the actual grabs were probably taken from the sand ribbon banks. Video survey at station 10 showed decrease in shell abundance and occurrence of current ripples on smooth surface just before the grab was taken. These are evidence that the grab at station 10 was taken over a sand ribbon bank. The grab samples from both stations showed homogeneous fine to medium sand with some anoxic layering and very few shell fragments.

The feature targeted by station 11 is a rippled scour depression (or relict sand wave trough). The survey started over the sand ribbons south of the scour depression and crossed the eastern end of the depression before the grab was taken at the northeastern edge of the scour depression (Fig. 6-2-1). Degraded current ripples were observed 4 minutes from the start of the transect. The edge of the scour depression, in association with a reduction of the presence of sand dollars, was observed 6 minutes into the video survey. Small current ripples over smooth seabed surface were observed at the end of the transect. The grab sample showed homogeneous medium sand with sparse shells and some black organic clumps on the surface (Fig. 6-2-2). An anoxic layer was observed at approximately 15 cm below the sample surface.

Specks

The target feature of stations 12 to 14 was specks (concentrated shell beds) at the Mid-Outer Bank area. The video transects and grab locations for these stations are shown in Fig. 6-2-3. Combination of video transects and on-deck examination of the grab samples (Appendix 1) suggests that the grab of station 12 was probably taken on the flank of specks, while stations 13 and 14 occupied speck bases. This section briefly describes the video surveys and grab samples collected at these stations. A more detailed description of the speck morphology, sediment texture and biology is given in section 6.5.

Smooth seabed surface with few shells and degraded current ripples was observed at the start of the video transect at station 12. Moderate concentration of shells and current ripples were

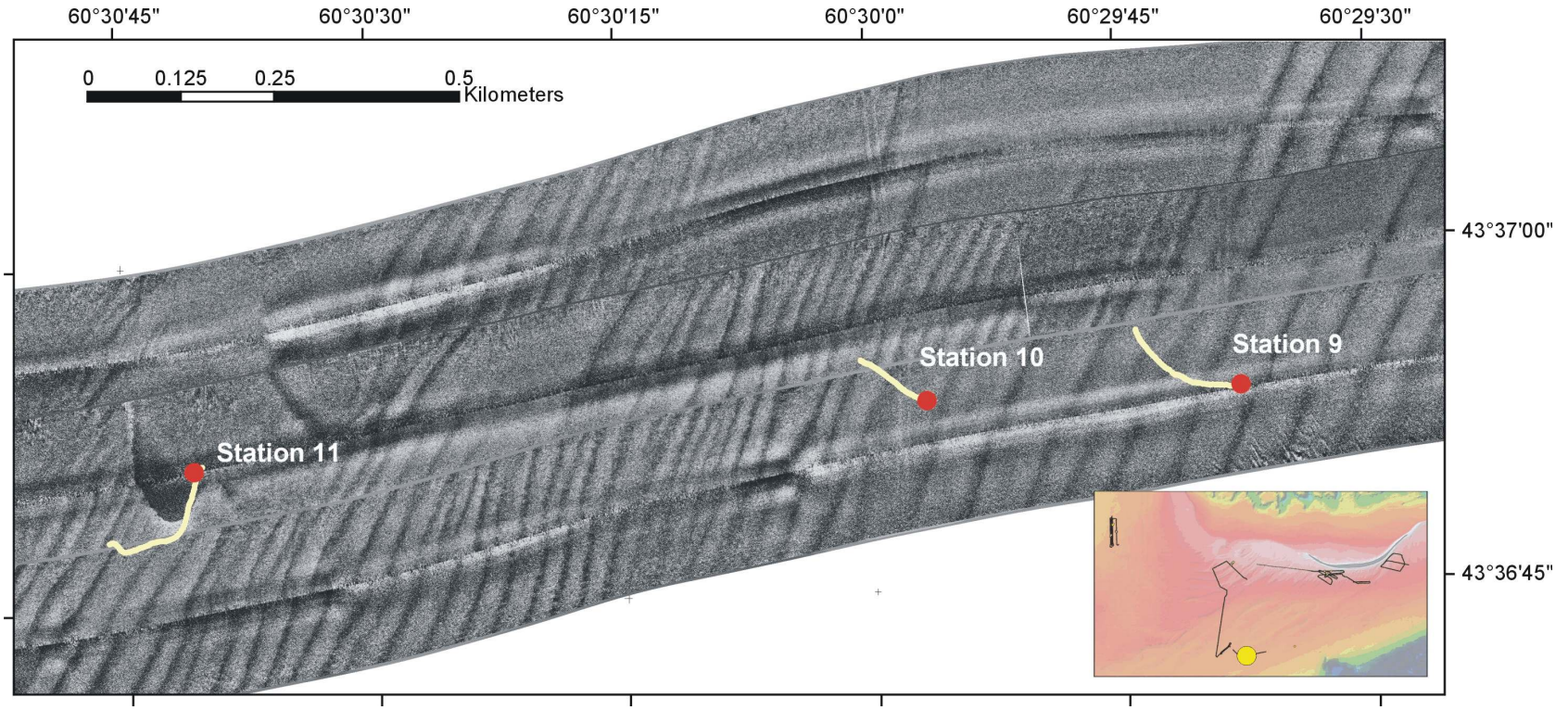

Fig. 6-2-1 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 9 to 11 from the Mid-Outer Bank study area. These are superimposed on sidescan from the 2004037 survey. The yellow dot in the inset map indicates the location of the Mid-Outer Bank area.

(A)

(B)

Fig. 6-2-2 Photographs of videograb samples collected from station 11 over the northeastern edge of a scour depression from the Mid-outer Bank area: (a) over view, (b) close up of black organic clumps.

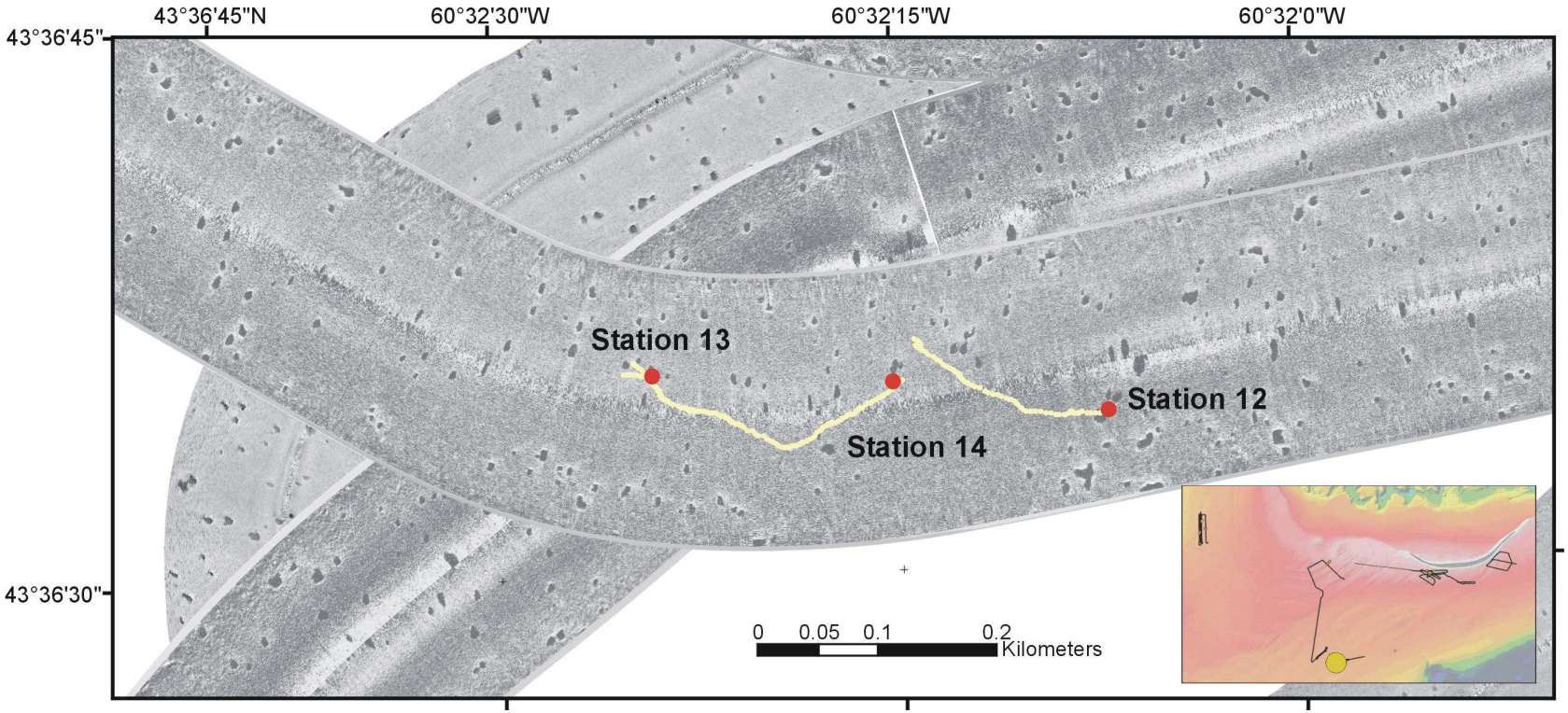

Fig. 6-2-3 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 12 to 14 from the Mid-outer Bank study area. These are superimposed on sidescan images obtained from the 2002021 and 2004037 surveys. The yellow dot in the inset map indicates the location of the Mid-Outer Bank area.

observed at the time the grab was taken. The grab sample (Fig. 6-2-4a) showed fine to medium sand with moderate coverage of shells. An anoxic layer was present at 10 cm from the surface. The speck base was identified immediately after the start of the video transect at station 13. The speck was irregular in shape, surrounded by fine sand, and covered by dense shells with mix of sand. The bottom sediment was silty fine sand dominated with high concentration of shells (Fig. 6-2-4b). The video transect at station 14 crossed an small irregular speck about 14 minutes after the start of the survey and the grab was probably taken over the base of another irregular speck (Fig. 6-2-3). The seabed was dominated with high concentration of shells with a mix of grey to dark grey well sorted fine sand (Fig. 6-2-5a). 85% of the shells lay on top of the sediment. They were separated into different species and counted (Fig. 6-2-5b; see detailed description in Appendix 1). Selected species were also put in sample bags.

Low Reflectivity Patch

The objective of station 15 was to obtain video surveys and bottom samples from low reflectivity patches in large irregular specks in the Mid-Outer Bank area. The grab location and survey transect for station 15 are displayed in Fig. 6-2-6. The video transect crossed several irregular specks and the grab was taken over a low-reflectivity patch just to the west of a large irregular speck. Some linear shell beds and degraded ripples were also observed (Appendix 1). The bottom sediment from station 15 was olive-colored well sorted very fine sand with few scattered shell fragments (Fig. 6-2-7). Organic layers were present at approximately 5 cm below surface.

6.3 CoPan Area

The Cohasset Panuke (CoPan) study area is located about 35 km to the west of Sable Island (Fig. 2-1) in approximately 30 m water depth. It represents an open, dynamic bank top environment in intermediate (30-50 m) depths. The target bedform features at the CoPan area are the low-relief 3-dimensional megaripples in the trough or on the lower stoss (western) flank of sand ridges, and the linear megaripples on the lee (eastern) flank of sand ridges. Four videograb stations and 78 minutes video surveys were obtained. Four sidescan survey lines in 78 km length were completed. This included repeat surveys along the sand ridge transects and the tie line between the CoPan area and the Thebaud-Alma mosaic area on the southern mid-outer bank. The videograb stations and sidescan tracks from the CoPan area are shown in Fig. 2-1, and detailed station information, observed seabed features and on deck description of the grab samples can be found in Appendix 1.

Linguoid Megaripples

Recent surveys and sand ridge morphodynamics study have established that low-relief (ca. < 30 cm) 2-D and/or linguoid megaripples commonly occur over gravelly coarse sand sediment in the sand ridge trough or on the lower stoss flank of sand ridges (Li et al., 2003; Li and King, 2006). The objectives of stations 16 and 17 were to obtain video surveys and grab samples from

(A)

(B)

Fig. 6-2-4 Photographs of videograb samples collected from (a) station 12 probably on the flank of a speck and (b) station 13 in the base of a speck from the Mid-outer Bank area.

(A)

(B)

Fig. 6-2-5 Photographs of videograb sample collected from station 14 in the base of a speck from the Mid-outer Bank area: (a) grab sample, (b) separated shells.

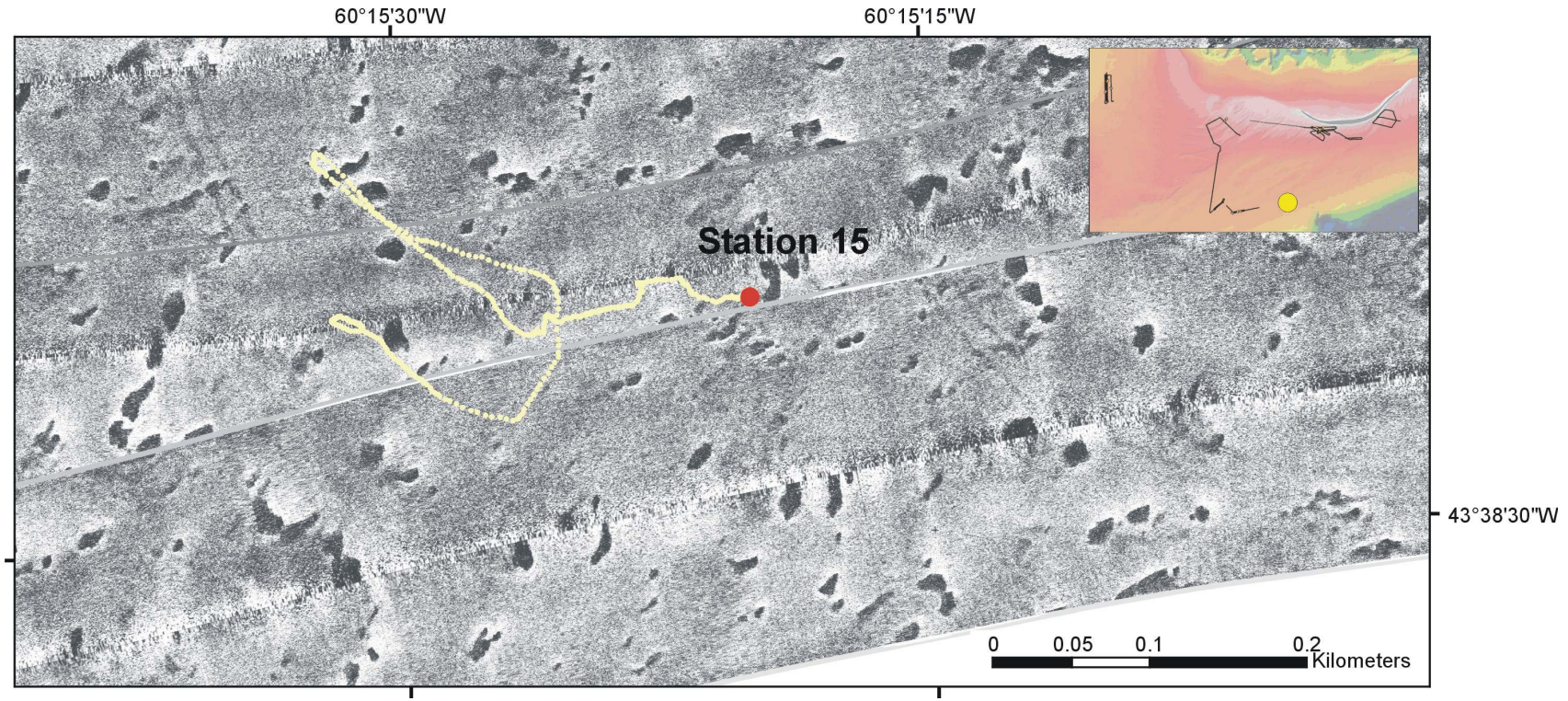

Fig. 6-2-6 Grab location (red dot) and video track (yellow lines) for videograb station 15 over a low-reflectivity patch in large irregular specks from the Mid-outer Bank area. These are superimposed on the sidescan image obtained from the 2004037 survey. The yellow dot in the inset map indicates the location of the Mid-Outer Bank area.

Fig. 6-2-7 Photograph of videograb sample collected from station 15 over a low-reflectivity patch near a large irregular speck from the Mid-outer Bank area.

the crest and trough of these megaripples. The grab locations and video transects of these two stations are shown in Fig. 6-3-1. These are superimposed on the multibeam image obtained from surveys conducted from 1996-1998. The sidescan image along a sand ridge transect from the 2004037 survey is also included to demonstrate the superimposed megaripples (see insets) and the marked change of sediment texture across the sand ridge trough.

The target features of stations 16 and 17 were linquoid megaripple crest and trough respectively. The actual video surveys proved that the low relief megaripples were difficult to identify on the video either because they degraded over the summer season or the textural changes were too subtle to discern on the video. Nevertheless station 16 was probably on the crest of a megaripple while station 17 was taken from the trough of a megaripple. Fig. 6-3-1 shows that the video survey at station 16 started on the lower stoss flank just to the southeast of the sand ridge trough. The transect moved to the northwest to cross the sand ridge trough and then moved toward the southeast to cross the ridge trough again. Wave ripples over fine sand were observed on the lee (eastern) flank of the sand ridge. Coarser sediment with shell fragments were observed when the videograb crossed the sand ridge trough again (Appendix 1). The bottom sediment at this station was uniform, buff colored, well sorted medium sand with rare small pebbles (Fig. 6-3-2a). The video survey for station 17 started on the lower stoss flank to the

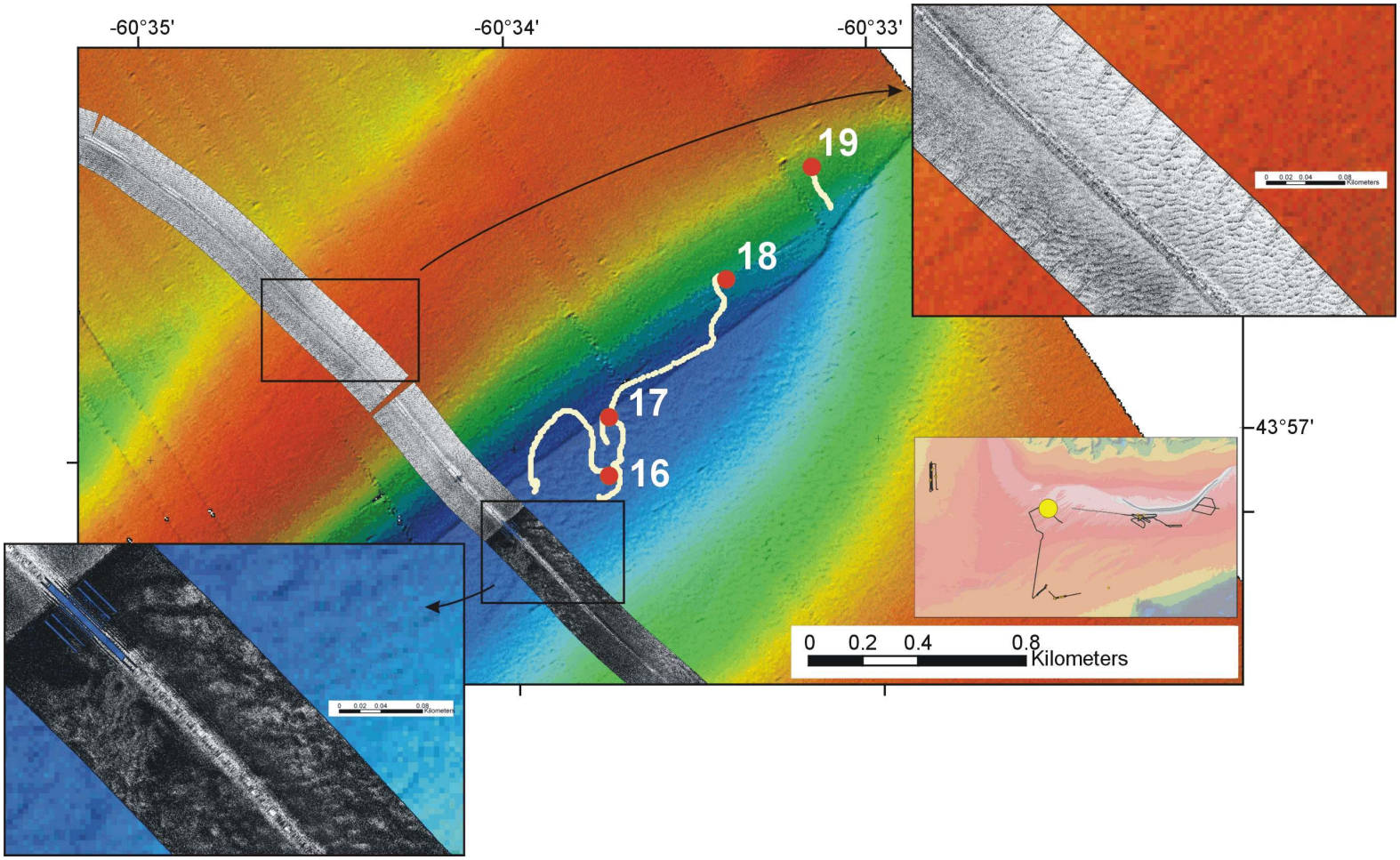

Fig. 6-3-1 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 16 to 19 from the CoPan study area. These and the sidescan image along a sand ridge transect from the 2004037 survey are superimposed on the multibeam image based on surveys conducted from 1996-1998. The yellow dot in the inset map indicates the location of the CoPan area.

(A)

(B)

Fig. 6-3-2 Photographs of videograb samples collected from (a) station 16 over megaripple crest, and (b) station 17 from megaripple trough in the CoPan area.

southeast of the sand ridge trough. The transect then drifted to the northwest and the final grab was taken almost exactly in the sand ridge trough (Fig. 6-3-1). On-deck examination of the grab sample indicated buff-colored coarse sand with granules and some shell fragments (Fig. 6-3-2b). A gravel lag was found at the base of the grab sample.

Linear Megaripples

Recent surveys (Li et al., 2001; Li and King, 2006) and sand ridge morphodynamics study (Li et al., 2003) have shown that linear megaripples sometimes occur in fine sand sediment on the eastern (lee) flank of sand ridges on Sable Island Bank (see upper-right inset in Fig. 6-3-1). The linear megaripples were also observed from the video surveys at stations 18 and 19 of this mission.

The video tracks in Fig. 6-3-1 indicate that while the survey for station 19 was short and on the lower eastern (lee) flank, the survey for station 18 started on the lower stoss (western) flank of the ridge, drifted to the northwest to cross the sand ridge trough and ended on the lower eastern flank. The video survey for station 18 showed that the seabed was flat with wave ripples on the lower western flank of the sand ridge. Once the sand ridge trough was crossed, sediment changed to fine sand with small wave ripples developed on top. The videograb was probably taken in the trough of a linear megaripple and the bottom sediment was buff-colored, well sorted fine sand. Sharp-crested linear megaripples were observed from the video survey at station 19 on the lee flank of a sand ridge. The wavelength of these linear megaripples reached several meters with well-developed linguoid current ripples occurring in their troughs. The grab sample was probably taken either in the trough or on the lee side of a megaripple and showed very fine sand bottom sediment.

6.4 South Sable Area

The South Sable study area is located immediately (1-2 km) to the south and southwest of Sable Island (Fig. 2-1). The depth at this site ranges from 15 to 30 m. The South Sable area represents a partially sheltered bank top environment and offers a wide range of bedform features, ranging from sand ridges, through sand waves, megaripples, to large wave ripples and erosional gutters (Li and King, 2006). Bedform features targeted by the videograb survey and sampling from this mission include linear and linguoid megaripples, large wave ripples, gutters and a sediment failure pit. Six videograb stations and 200 minutes video surveys were obtained from the South Sable area in this mission. A total of 86 km sidescan survey lines was obtained. These included repeat surveys along four sand ridge transects, three repeat lines along E-W transects over the multibeam mosaic covering shallow and intermediate depths, and a tie line that links the South Sable area with DFO Sable South quahaug habitat survey site (Fig. 2-1). The grab locations and video transects of the six videograb stations for the South Sable area are shown in Fig. 6-4-1. Detailed station information, observed seabed features and on deck description of the grab sample can be found in Appendix 1.

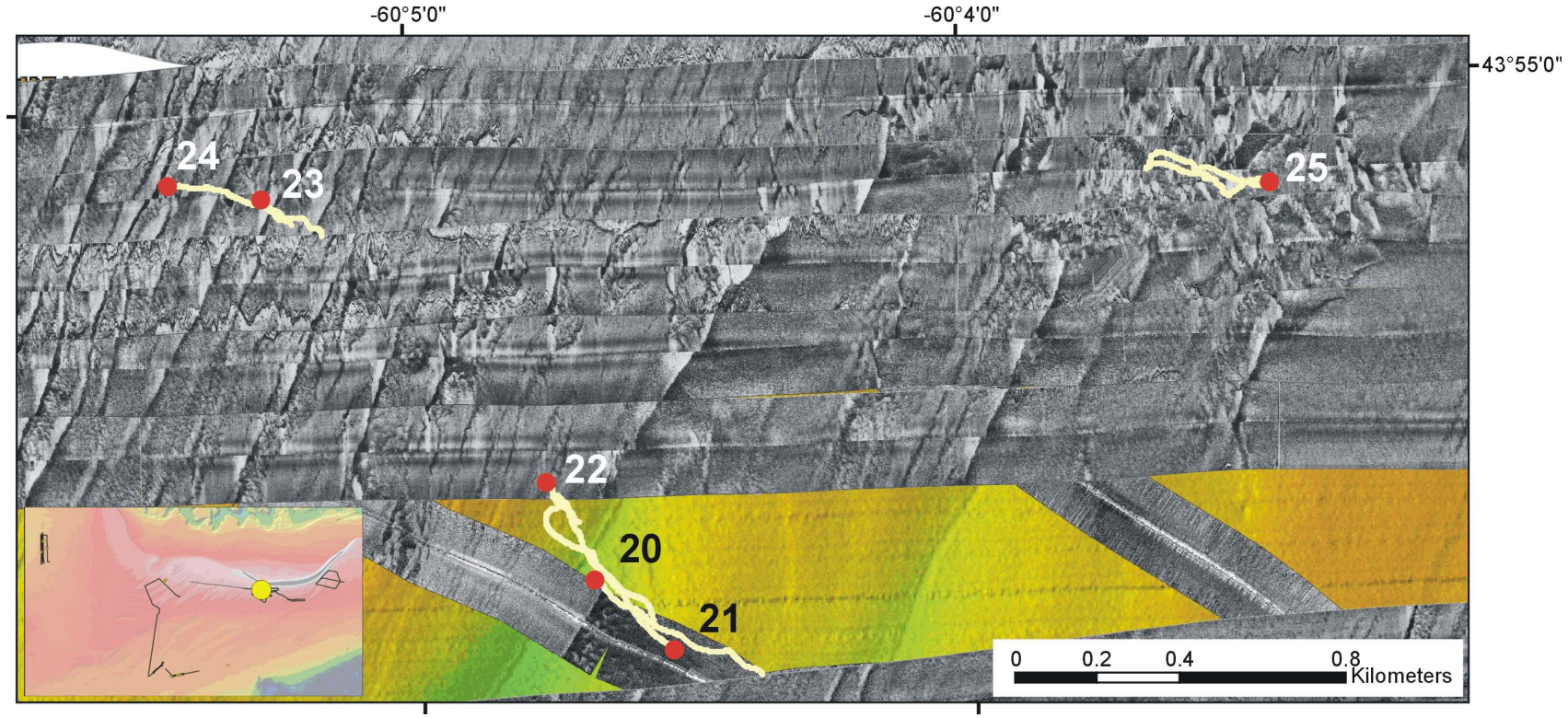

Fig. 6-4-1 Locations of grabs (red dots) and video tracks (yellow lines) for videograb stations 20 to 25 from the South Sable study area. These, the sidescan mosaic image from the 2004037 survey and the sidescan image along two sand ridge transects from the 2000030a survey, are superimposed on the 2000 multibeam image. The yellow dot in the inset map indicates the location of the South Sable area.

Linear and Linguoid Megaripples

The target bedforms for videograb stations 20 and 22 are the linguoid megaripples on the lower stoss (western) flank of sand ridges and the linear megaripples on the eastern flank of sand ridges respectively. Fig. 6-4-1 indicates that the video survey for station 20 started roughly over the sand ridge crest and moved northwesterly towards the sand ridge trough. Asymmetric current ripples in fine sand sediment were observed at the mid-upper stoss flank of the sand ridge. Degraded large wave ripples with shells and boulders were observed in the sand ridge trough just before the grab was taken. The grab sample showed buff colored medium sand with an anoxic layer about 8 cm below surface (Fig. 6-4-2a).

The video survey for station 22 started on the lower stoss (western) flank of a sand ridge, drifted northwesterly to cross the sand ridge trough, and ended on the lee (eastern) flank of the next sand ridge. Medium sand with degraded wave ripples, 3-D ripples and shells were observed on the lower stoss flank of the sand ridge. When the videograb crossed the sand ridge trough and moved onto the lower lee flank of the sand ridge, fine sand with small current ripples was observed. The seabed showed fine sand with degraded wave ripples at the end of the transect. On-deck examination of the grab sample suggested very well-sorted, uniform medium sand void of shells and infauna (Fig. 6-4-2b).

Large wave ripples

The target bedforms for station 21 were large wave ripples on the lower western sand ridge flank. The video transect started on a sand ridge lee (eastern) flank, drifted to the southwest to cross the sand ridge trough and stopped on the mid-upper stoss (western) flank of the adjacent sand ridge (Fig. 6-4-1). Degraded current ripples in fine sand were observed on the lee flank of the sand ridge. Once the sand ridge trough was crossed, sediment became medium sand with degraded wave ripples, linear asymmetric wave ripples, and shell fragments. Shells became sparse and seabed was covered by combined linear and 3-D ripples at the end of the transect. The grab sample indicated very well-sorted homogeneous medium sand void of shells and infauna.

Gutters

Gutters are near shore-normal, highly linear channels with low vertical relief. Originally recognized in the rock record (Myrow, 1992), similar features were identified on the Sable Island shoreface and were studied recently for their morphology, distribution, and formation processes (Li et al., 1999; Amos et al., 2003). It is generally recognized that these are erosional channels maintained by the seaward flowing downwelling currents due to storm set up. In a 2004 survey (Li and King, 2006), seabed photographs, van Veen and IKU grabs were obtained to study the sediment composition, superimposed small bedforms, and shallow sub-surface sedimentary structures over several gutters in the South Sable area. However, positioning inaccuracy limited our certainty of the precise morphological locations of the seabed photographs and samples in that survey. Videograb offered the possibility of real time observation and sampling at known

(A)

(B)

Fig. 6-4-2 Photographs of videograb samples collected from (a) station 20 over linguoid megaripples, and (b) station 22 over linear megaripples in the South Sable area.

location over the gutters during this mission.

The target bedform features for stations 23 and 24 are the gutter banks and troughs respectively (Fig. 6-4-1). The video survey for station 23 started on a gutter bank and traveled to the northwest to cross two gutters before the grab was collected on the bank between two gutter troughs. The video survey showed the presence of degraded wave ripples and superimposed current ripples in fine sand in one of the gutter trough (Appendix 1), and fine sand with linear wave ripples on the gutter bank. The grab sample (Fig. 6-4-3a) indicated fine to medium well-sorted sand void of shells and fauna. Grain size increased slightly towards the base to become medium sand with few pebbles. The video survey for station 24 started on a gutter bank, traveled north-northwesterly to cross at least two gutters, and ended with a grab sample probably from a gutter trough (Fig. 6-4-1). Linear wave ripples, sometimes with current ripples, in fine to medium sand were observed on the gutter banks. Degraded wave ripples with linguoid current ripples in fine sand were observed probably in the trough of a small gutter. The grab sample from this station indicated well-sorted homogeneous fine-medium sand void of sand dollars and shell fragments (Fig. 6-4-3b).

Shallow-water sediment failure pits

Small sediment failure pits on the shoreface south of Sable Island have been examined in previous studies (c.f. King, 2002). A survey in 2004 (Li and King, 2006) identified several additional pits which are typically several to tens of metres across, up to 3 m deep and arise in partially cohesive sediments that are being exhumed on the shoreface, likely due to failing under wave action. Repeat surveys show limited evidence of periodic sand infill and presumably subsequent flushing. The objective of station 25 from this mission was to obtain video surveys and a grab at a known morphological location over a shallow-water (14.6 m depth) sediment failure pit.

Fig. 6-4-1 shows that the survey started on a bank between gutters, drifted for about 300 m to west and then drifted back to the east to stop nearly at the location the transect started. Linear wave ripples in fine sand were observed on one gutter bank, while fine to medium sand with two types of wave ripples, fresh shorter wave ripples superimposed on degraded longer wave ripples, were observed on another gutter bank. Fine to medium sand with degraded wave ripples and sharp 3-D current ripples were detected possibly in the bottom of a gutter. At the place the grab was taken, the video survey showed outcropping cohesive silt with occasional thin sand cover (Appendix 1). On-deck examination of the grab sample (Fig. 6-4-4) indicated outcropping olive grey clayey silt that is slightly friable and shows no stratification. The clayey silt is covered by a thin (~ 1 cm) layer of medium sand with rare shell fragments. The upper 4 cm of the mud deposit is more compact and heavily bored by living worms.

6.5 Sidescan "Specks" or Shell Beds (E. King)

So-called "specks" on sidescan sonograms in sandy bank areas have been recognized for

(A)

(B)

Fig. 6-4-3 Photographs of videograb samples collected from (a) station 23 over a gutter bank, and (b) station 24 over a gutter trough in the South Sable area.

(A)

(B)

Fig. 6-4-4 Photographs of the videograb sample collected from station 25 over a shallow water pit in the South Sable area: (a) overview of the grab sample and (b) close-up of the compact, slightly friable mud with abundant worm holes.

nearly two decades (Amos and Nadeau, 1988; Fader, 1991). They are best recognized on sidescan sonograms as discreet, generally circular patches of high backscatter with a random or regular, rhythmic pattern, sometimes extending to a bead on string pattern (for example, Figure 6-2-3, western end). They have been noted variously as specks, shell communities, shell beds, benthic community on maps and numerous Sable Island Bank industry wellsite survey reports. They have been identified through submarine observation, dredge and photographs as shell beds (quahaugs, clams, horse mussels) but also as sea cucumber communities, on Grand Bank (Fader, 1991). They have been recognized as a variety of living and dead communities.

This cruise offered the possibility of video observation and targeted precision sampling of these features. Sidescan sonograms on the two Glenelg-Alma mosaic areas display abundant "specks" (Li and King, 2006). Videograb transects and samples were taken at the site of three such specks (see grab locations and video tracks in Figs. 6-2-3 and 6-2-6). Stations 13 and 14 are from the more western mosaic and station 15 covered part of the more eastern mosaic. The latter mosaic area was not resurveyed on this cruise but the videograb transect was based on a 2004037 sidescan image.

The western mosaic area displays relatively randomly distributed, more circular "specks" with spacings typically 10-30 m and diameters of 5-10 m. The eastern mosaic area is dominated by irregular "specs" but they have preferred orientation and tend to have some linear distribution to form the “bead on string” pattern (Fig. 6-2-6), suggesting possible control by bedform-current interaction. The video surveys showed that the patches comprise rounded to slightly irregular shaped collections of shell material. The sidescan shows patches up to 50 m in length, while patches as small as 2 to 3 metres across were observed on the video. The larger of the corresponding patches could be identified on the sidescan data (on the ArcMap monitor with real-time ship's position superimposed on the georeferenced 2004 sidescan mosaic) but the smaller ones were less easily correlated. This may have been more a georeferencing issue than a sidescan resolution issue. The speck patches do not appear to have any significant relief. The speck boundary is a rather sharp transition from fine sand with occasional shell debris to a seabed dominated by shell debris to the extent that no sand is visible.

At station 15, a correlation was also noted between an intermediate backscatter tone on the sidescan and increased shell concentration observed on the video (generally under 5% by area), indicating a sensitivity of the acoustics to the shells. Much of the scattered shell debris is large, whole but disarticulated tests facing concave up, commonly with a minor sand infill. The grab sample indicated a large dominance of quahaug (Arctica Islandica) shells (Figure 6-2-5a). The immediate seabed contains 100 % coverage of dead and disarticulated bivalve tests and the fine sand immediately below contains numerous living shell specimens, apparently within the upper 20 cm. They range in size typically from 4 to 20 cm along the long axis (Fig. 6-5-1).

Shells at station 14 were sorted into categories (Fig. 6-2-5b and description in Appendix 1):

1. living quahaugs

Fig. 6-5-1 Photograph of living shells in fine sand at station 14 from the specks in the Mid-outer bank area.

2. whole, disarticulated tests with most of the dark, chitinous cover intact
3. whole, disarticulated tests with signs of abrasion or little chitinous material remaining
4. shell hash
5. elongated clam shells of different species
6. gastropods and
7. soft-bodied infauna

Each category was documented with photographs and a rough count performed. The quahaug specimen counts (categories 1 to 3, above) at Station 14 showed that the living specimens numbered 48 (each contains 2 tests) and the dead specimens comprise about 100 disarticulated tests. This means that of the entire assemblage, the living specimens represent about half. It is unknown how much post-mortem transport in or out of the "speck" may have occurred but only a small percentage has lost its pericardium, suggesting limited transport. A similar-sized grab sample outside but nearby the "speck" (station 12) includes only 18 living specimens but a higher living to dead ratio (Appendix 1 and Fig. 6-2-4a). Nevertheless, this represents a much greater concentration of living (and dead) specimens within the "speck" as opposed to outside. However it remains to be investigated if this is a universal phenomenon.

Current compilation of speck distribution across Sable Island Bank will allow a good regional

sense of the quahaug distribution and offers the potential for rough biomass estimates. Such a mapping/assessment product could then be compared with the regional (bank-wide) DFO hydraulic trawl random stratified sampling study by D. Roddick where quahaug and "bycatch" biomass was recorded in a rigorous manner.

6.6 Re-Survey at DFO Quahaug Habitat Disturbance South Site (E. King)

Two sidescan survey lines (Fig. 2-1) were conducted across the 2004 DFO South multiple trawl test site in order to compare with the Hudson 2004037 sidescan survey conducted immediately after the hydraulic trawl experiment (Li and King, 2006; King, in prep.). One line was along the mosaic centre and the other was just north of the mosaic. The more recent data were more beset with water column stratification noise than the previous year, however data quality remained good. The entire DFO mosaic area displayed changes with respect to the previous year. Locally, area of high backscatter and large wave ripples are covered with large megaripple crests such that fine to medium/coarse boundaries change by up to 10 metres. Also the seabed textural contrasts became more subtle. The small relict sand wave trough at the western end of the trawls, for example, presents only a subtly darker tone along two narrow N-S bands whereas the 2004 survey showed two distinct bands of coarser sediment and a transitional western edge, grading to finer sand. Likewise, the major sand ridge trough east of the trawls (western flank of Harcourt Cameron ridge) is more sand covered but with sub-metre wavelength large wave ripples.

Two or three of the hydraulic trawl marks are only faintly visible in comparison to distinct pits and troughs immediately after trawling. This indicates a near-complete "healing" of the seabed in terms of texture and morphology over a one year term. As noted in King (in prep.), however, a healing of this nature does not necessarily constitute a return to pre-trawl sediment conditions, especially as the original cuts probably exceed natural erosion depths. Nevertheless, this "heal" rate contrasts with similar comparative studies on Banquereau where such healing is not complete after over 10 years (Gilkinson et al., 2003).

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Appendix 1 Videograb station summary and video survey description.						
STN	**Stn. Type**	**DAY/TIME (Regulus Event Record)**	**LATITUDE**	**LONGITUDE**	**Water Depth (m)**	**DESCRIPTION**
001	video grab	2005.07.17 Day 198 10:32:33	44.082751	-61.144958	57.9	DRDC; planned station DRDC-A3: ribbon trough; medium to coarse SAND with shell fragments; sand dollars; live worms; 2 quahogs; anoxic layer in lower part of grab; homogeneous throughout; video transect: tape 1; start 09:50:45; stop 10:32:33
002	video grab	2005.07.17 Day 198 11:08:14	44.081688	-61.143038	57.9	DRDC; planned station DRDC-A1, sand ribbon bank; clean fine SAND with anoxic layering ca.14cm below surface with shell fragments in this layering; surface clean; live sand dollars on surface; also noted some slight brown layering ca. 1cm; polycheate tubes; sand flea; live worms; scallop shell: Video transect: tape 1; start 10:59:57; 11:06:21 degraded long wave ripples; 11:08:14 small current ripples; end 11:08:14
003	video grab	2005.Jul.17 UTC day 198; 12:56:46	44.082090	-61.144288	57.9	DRDC; added DRDC-A4, sand ribbon trough; two video transects; no grab attempted in transect 1; Video transect 1: tape 1; at beginning of transect noted shell layering; these did not reappear during remainder of transect; decided to abandon station and resume at a point ca. 100m below original station where this feature was noted; start 11:32:15; 11:40 across ripples; live sand dollars; starfish 11:33:42 sand bank top small current ripples 11:41:31 small ripples; 11:52:49 some shells; stop 11:52:49; Grab description: clean coarse sand with abundant shell hash; live sand dollars; anoxic layering; pebbles up to 1.5cm, some larger, at base of anoxic layer; Video transect 2: tape 1; start time 12:31:12; tape count 1:19:07 lots of shells; 1:21 out of shell area; 1:22 sand ribbon bank; few shells; small ripples; 1:40 eel; stop time 12:56:46.
004	video grab	2005.07.17 Day 198 14:37:19	44.066548	-61.174423	57.9	DRDC; planned stn DRDC-C1, megaripple trough; two video transects; grab attempt in video transect 1 failed; coarse sand; buff color overlying fine grey sand well sorted; clumps of organic and siltier sediment; occasional sand worms; large bivalves; sand dollars (living and dead); some articulated plus fragments; occasional pebbles; sedimentary and mixed lithologies; Video transect 1: tape 1; start 14:04:40; stop 14:13:45; Video transect 2: tape 2; start 14:27:12; 14:35:14 degraded large current ripple; 14:36:20 degraded large megaripple and shell fragments; stop 14:37:19
005	video grab	2005.07.17 Day 198 15:35:33	44.070527	-61.170720	59.0	DRDC; planned stn DRDC-C2, megaripple crest; clean; very coarse buff sand on surface; transition to a coarser sand with pebbles and a few shells; live red worms; live sand dollars on surface; rare anoxic layering; video transect: tape 2; start 15:27:30; 15:29:03 degraded large megaripple; shell fragments; 15:35:21 large megaripple; 15:35:33 smooth surface; no waveform ripple; few shells; stop 15:35:35;
006	video grab	2005.Jul.17 UTC day 198; 16:24:54	44.108591	-61.163752	65.0	DRDC; planned stn DRDC-B1, bank between scour depressions; fine sand; shell fragments; abundant worm tubes ca. 2mm diameter at surface; some anoxic layering ca. 10cm below surface; rare scattered pebbles at surface; live sand dollar; red worms and sand fleas; homogeneous sand; Video transect: tape 2; smooth surface with degraded current ripples; start 16:17:07; 16:17:53 sand wave crest; smooth; stop 16:24:54;
007	video grab	2005.Jul.17 UTC day 198; 17:32:37	44.106695	-61.162083	64.0	DRDC; planned stn DRDC-B2, over large-wave ripples in scour depression; 20 cm thick buff to brown coarse sand and gravel with cobble over grey mud; cohesive fine sand with clay/silt; sand has assorted lithologies; numerous articulated and fragmented bivalves; quahogs/scallops; occasional clumps at sand/clay interface; size of gravel varies up to 15-20cm; shrimp; hermit crabs; Video transect: tape 2; start 17:04:29; 17:10:08 large ripple modified by current with shells in trough partly over edge of scour depression ~ 20 cm in height; 17:12:55 end of scour patch; drifting North; banks between depressions; 17:16:35 large wave ripple field; 17:17:14 out of wave ripple field; 17:21:56 large wave ripple field; 17:23:44 end of scour patch; 17:26:50 edge of depression; large wave ripple modified by current; shells in trough; 17:28:01 end of depression; 17:29:12 start of large wave ripples; stop 17:32:37
008	video grab	2005.Jul.17 UTC day 198; 18:25:12	44.110883	-61.158717	64.0	DRDC; added stn DRDC-B3, large wave ripple crest; coarse to very coarse sand with some granules; piece of coal and assorted pebble lithologies; uniform grain size in upper 20 cm; at 20cm depth sample slightly finer with more shell hash; < 2% gravels with size up to 10 cm; whole quahogs and sand dollars; 5% shell hash; gastropod; elongated clams; Video transect: tape 2; start 18:12:01; 18:13:55 in flat bank between scours; still see cobbles; 18:17:43 shells and gravel; 18:24:58 edge of depression; 18:25:12 on bottom taking sample from crest; stop 18:25:12;
009	video grab	2005.07.18 Day 199 10:14:13	43.614886	-60.493849	58.8	Alma_Glenelg; planned stn A_G-A2, sand ribbon trough; Grab: fine to medium sand; homogeneous throughout with anoxic layering; sand lances; live worms and sand dollars; shells; 2 mm worm tubes on surface; red worms and brittle stars; Video transect: tape 2; start 10:02:44; smooth surface; shell frags; lots of sand dollars and brittle stars; 10:14:13 grab taken over smooth surface with shells and frags; stop 10:14:13
010	video grab	2005.07.18 Day 199 10:54:50	43.614798	-60.499098	58.8	Alma_Glenelg; planned stn A_G-A1, sand ribbon bank; Grab: fine to medium sand through out; some anoxic layering; a few shells; many worm tubes on surface; red worm; a blood worm; 5 mm live quahog on surface; sand dollars; brittle stars; video transect: tape 2; start 10:46:26; smooth surface; few shells; numerous brittle stars; lots of sand dollars; 10:49:19 increase in shells and fragments; 10:51:12 decrease in sand dollars and increase in shell frags; 10:54:50 sample; smooth surface; plenty of sand dollars; very few shell frags; possibly sand ribbon bank showing small current ripples; stop 10:54:50;

STN	Stn. Type	DAY/TIME (Regulus Event Record)	LATITUDE	LONGITUDE	Water Depth (m)	DESCRIPTION
011	video grab	2005.07.18 Day 199 12:09:01	43.614186	-60.511350	59.7	Alma_Glenelg; added stn A_G-D, northeast edge of a scour depression; homogeneous medium sand with black clumps on surface; resemble mud but likely organic matter; worm tubes ca. 2 mm dip on surface; sand lances and large bivalves present; small red worms; sparse shell; anoxic layer approx 15 cm below surface; video transect: tape 2; start 11:58:50; tape count 01:42:00, smooth surface, few shells, brittle stars, sand dollars, scalpin crabs; 12:04:50 degraded current ripples; changing direction of ship to point north; 12:06:36 over edge of scour depression; reduction in presence of sand dollars; 12:09:01 took sample; sand lances; smooth surface with small current ripples; transect stopped
012	video grab	2005.07.18 Day 199 13:47:39	43.609569	-60.535300	58.8	Alma_Glenelg; added stn A_G-B3, speck base; fine to medium sand; anoxic layer at 10 cm from surface; shell frags; quahogs 18 live 15 dead; clams; small worm tubes at surface 1-2 mm rare 4 mm dia; sand dollars; brittle stars; video transect: tape 3; start 13:34:56; 13:36 smooth surface with few shells, crabs, degraded current ripples; 13:46 increase in shell concentration; 13:47 sample; moderate bed of shells over current ripples; transect stopped.
013	video grab	2005.Jul.18 UTC day 199; 14:10:50	43.609860	-60.540041	58.8	Alma_Glenelg; planned stn A_G-B2, speck base; dominated by shells with a bit of silty very fine sand; lots of life; clams; quahogs; high concentration of shells; live hermit crabs; coarse material could be shell fragments; some anoxic layering; video transect: tape 3; start 14:09:25; 14:10:25 speck base found; 14:10:50 sample taken; speck shape irregular surrounded by fine sand; dense shells with mix of sand; eel worms seen; transect stopped;
014	video grab	2005.Jul.18 UTC day 199; 14:49:25	43.609764	-60.537542	58.8	Alma_Glenelg; added stn A_G-B4, speck base; grey to dark grey well sorted fine sand; occasional dark organic clumps; assorted end fauna (see pics); hermit crabs; baby sea cucumbers; 85% shell material laying on top of sediment; quahogs live 48 dead 92 with chitious shell; dead abraded 5 still articulated (97); 10 articulated clams with long B-axis #19; disarticulated sand dollar #1 scallops #2; selected various species for bag samples; Video transect: tape 3; start 14:30:32; 14:41:32 smooth surface with scattered shells_brittle stars; drifting south east; 14:44:44 small irregular spec; 14:49:25 sample taken; transect stop;
015	video grab	2005.Jul.18 UTC day 199; 17:18:50	43.643032	-60.255557	57.0	Alma_Glenelg; planned stn A_G-C1, low reflectivity patch; well sorted very fine sand in olive color; few scattered shell fragments; none whole just hash; organic layers ~ 5cm below surface; 20 live quahogs 3 live large bivalve (geoducks?) clams 2 live sand dollars; video transect: tape 3; start 16:18:44; sea urchins; spec beds irregular shapes; crabs; hermit crabs; sand dollars; 16:21:24 smooth surface with shell fragments (5%); crabs; sea urchins; small degraded ripples; 16:25:49 increase in shell fragment concentration; brittle stars; sand dollars; drifting south east; 16:28:12 passed edge of spec base; 16:28:56 passing small spec base in field?; 16:30:03 small spec not quite as round; few sea urchins; 16:34:51 passing edge of small spec; irregular shape; degraded ripples; 16:36:08 linear shell bed; possible edge filling?; 16:53:55 skirting a spec while drifting south east; 16:54:52 in linear shell bed spec; 17:02:05 irregular spec; 17:04:30 edge of shell bed; degraded ripple marks; 17:15:26 coral with shell fragments; 17:17:06 apparent reduction of shell fragments; 17:18:50 sample taken; transect stop;
016	video grab	2005.Jul.18 UTC day 199; 20:08:14	43.949041	-60.562317	29.9	CoPan; planned stn CP-A1, megaripple crest; well sorted medium sand buff in color; uniform throughout; rare small pebbles; infauna; Video transect: tape 3; start 19:42:28; 19:49:24 small scallop; lingoid ripples; 19:51:52 fine sand with wave ripples on lee side of ridge; sand dollars; 20:00:29 coarser material with shell fragments; could be sand wave trough; 20:08:14 sample taken; transect stopped;
017	video grab	2005.Jul.18 UTC day 199; 20:31:26	43.951007	-60.562300	32.0	CoPan; planned stn CP-A2, megaripple trough(?); buff colored coarse sand with granules; rare gravels up to 5cm; rare shell fragments (5%); quahogs; sand dollars; black organic staining in lag; gravel lag at base; gneiss; sandstone; basalt; assorted lithologies; Video transect: tape 4; start 20:27:01; 20:31:26 sample taken; transect stop;
018	video grab	2005.Jul.18 UTC day 199; 21:47:38	43.955393	-60.556694	25.0	CoPan; planned stn CP-B1, linear megaripple stoss or crest; well-sorted fine buff-coloured SAND; small peat fragments; occasional sand dollars; 1 quahog; 1 worm; Video transect: tape 4; start 21:15:01; 21:21:09 flat seabed;small wave ripples; sand dollars; 21:30:29 nature of sand changed to fine sand with abundant sand dollars and small wave ripples on lee side of sand ridge; 21:37:26 fine sand with ripples and sand dollars
019	video grab	2005.07.18 Day 199 22:11:59	43.959043	-60.552625	26.8	CoPan; planned stn CP-B2?, linear megaripple trough; very fine SAND; area of linear ridges with several meters spacing; well developed lingoid ripples in troughs; more subdued on crests; Video transect: tape 4; start 22:05; first grab at 22:08:49 failed; second try at 22:11:59 was good and sampled on sand ridge lee side small sharp-crested megaripple probably on trough or lee of megaripple; stop 22:12:30.
020	video grab	2005.Jul.19 UTC day 200; 10:13:29	43.906179	-60.078113	19.5	South Sable site; planned stn SS-A2, linguoid megaripple trough; buff colored medium SAND; anoxic layer ca. 8cm below surface; few small red worms; Video transect: tape 4; start 09:48:38; 09:58:57 fine sand; asymetrical ripples; direction NW; 10:13:04 degraded large wave ripples with scattered shells in sand ridge trough; boulder; sand dollars; degraded wave ripples; stop 10:13:29

STN	Stn. Type	DAY/TIME (Regulus Event Record)	LATITUDE	LONGITUDE	Water Depth (m)	DESCRIPTION
021	video grab	2005.Jul.19 UTC day 200; 11:18:37	43.904620	-60.075782	17.5	South Sable; added stn SS-A5, wave ripples on sand ridge stoss; very well-sorted homogeneous medium SAND void of shells and infauna; Video transect: tape 4; start 10:30:18; 10:34:28 degraded current ripples on lee side of sand ridge; fine sand; 10:51:00 fine sand with degraded 2D-3D current ripples on lower lee flank; 10:52:49 fine sand with scattered shell frags; abundant sand dollars; 10:58:38 degraded wave ripples; medium sand with shell frags in sand ridge trough; 11:02:00 medium sand with linear asymetric wave ripples; 11:18:37 combined linear and 3-D ripples; mid stoss side of sand ridge; no sand dollars; no shells; stop 11:18:37
022	video grab	2005.Jul.19 UTC day 200; 12:00:49	43.908339	-60.079467	15.3	South Sable; added stn SS-A6, possibly over linear megaripples on lee flank of sand ridge; very well-sorted medium grained SAND void of shells and infauna; uniform distribution throughout; much like Stn 021sample; Video transect: tape 5; start 11:33:50; 11:39:13 linear asymetric current ripples; possibly in sand wave trough; 11:41:35 medium sand with degraded wave ripples showing biforcations; one boulder; 11:43:57 still medium sand; 3-D ripples with sand dollars; some shells; close to sand ridge trough; 11:47:28 fine sand; small ripples on lower lee flank of sand ridge; 11:51:15 3-D ripples on sand ridge lee flank with some sand dollars; 12:00:49 fine sand; degraded wave ripples; stop 12:00:49
023	video grab	2005.Jul.19 UTC day 200; 12:56:38	43.914685	-60.087817	14.2	South Sable; planned stn SS-B1, gutter (or sand ribbon) bank; fine to medium well-sorted SAND void of shells and fauna; slightly coarser towards base; medium sand (possibly storm deposition); few pebbles; ca. 5cm pink granite; Video transect: tape 5; start 12:40:41; 12:42:49 fine sand degraded linear wave ripples with superimposed current ripples 12:47:36 fine sand; linear wave ripples; few sand dollars; on sand ribbon bank; 12:56:38 fine sand; linear wave ripples; stop 12:56:38
024	video grab	2005.Jul.19 UTC day 200; 13:32:37	43.915056	-60.090582	14.6	South Sable; planned stn SS-B2, possible gutter trough; well-sorted homogeneous fine-medium SAND void of sand dollars and shell fragments; blood worms; Video transect: tape 5; start 13:10:50; 13:16:56 fine to medium sand; linear wave ripples on sand ribbon bank;13:26:33 fine material; linear wave ripples with small current ripples on sand ribbon bank; 13:29:07 fine sand; degraded wave ripples with linguoid current ripples; probably small sand ribbon trough; 13:32:27 fine to medium sand; linear wave ripples with superimposed current ripples; stop 13:32:32
025	video grab	2005.Jul.19 UTC day 200; 15:12:15	43.914288	-60.057352	14.6	South Sable; added stn SS-C, shallow water pit; outcropping olive grey clayey cohesive SILT; slightly friable; almost no clay; upper 4 cm is more compact; rare shell fragments mainly in upper sand; rare pebbles; no stratification; lagoonal sediment?; 1 cm cover of sorted medium sand; upper 4 cm is heavily bored by living worms 1 mm by 1 cm with vertical orientation; sand dollar; Video transect: tape 5; start 14:19:36; 14:21:46 fine sand; linear wave ripples; bank of gutter; 14:26:33 fine to medium sand; degraded wave ripples and 3-D current ripples (sharp) possibly the bottom of gutter; 14:33:26 fine to medium sand; see 2 patterns of wave ripples; fresh shorter wave ripples superimposed on degraded longer wave ripples on bank between gutters; 15:12:15 outcroppping cohesive silt (exhumed paleolagoonal?) with occassional thin sand cover; stop 15:12:15

Appendix 2 List of sidescan survey lines collected on Hudson 2005033a.

Line	Start	End	Sidescan	
			Rec. #	Tape #
AT_GA tie	199/0604	199/0632	3	2
AT_MOS1	199/0347	199/0429	3	2
AT_MOS2	199/0448	199/0515	3	2
AT_MOS3	199/0528	199/0552	3	2
CP_AT tie	199/0100	199/0339	2, 3	2
Copan-1	198/2140	198/2239	2	2
Copan-2	198/2242	198/2324	2	2
Copan-3	198/2327	199/0100	2	2
DRDC-1	198/0151	198/0259	1	1
DRDC-2	198/0338	198/0439	1	1
DRDC-3	198/0455	198/0557	1	1
DRDC-4	198/0618	198/0719	1	1
DRDC-7	198/0738	198/0837	1	1
GA1	199/0636	199/0659	3	2
GA2	199/0713	199/0736	3	2
GA3	199/0755	199/0814	3	2
GA_AG tie	199/0814	199/0904	3	3
SS-1	199/2352	200/0105	4	3
SS-2	200/0122	200/0226	4	3
SS-3	200/0236	200/0313	4	3
SS-4	200/0332	200/0411	4	3
SS-5	200/0424	200/0504	4	3
SS-6	200/0518	200/0542	4	3
SS-7	200/0548	200/0600	4	3
SS-8	200/0615	200/0649	4, 5	3
SS-9	200/0649	200/0742	5	3
SS-10	200/0742	200/0811	5	3
SS-11	200/0819	200/0902	5	3
SV-1	200/1730	200/1753	6	4
SV-2	200/1755	200/1814	6	4
SV-3	200/1816	200/1840	6	4
SV-4	200/1842	200/1903	6	4
SV-5	200/1906	200/1953	6	4
SV-6	200/1955	200/2013	6	4
SV-7	200/2016	200/2110	6	4

Appendix 3 List of videograb tapes obtained on Hudson 2005033a

tape#	start day/time	end day/time	stations
1	198 10:32	198 14:13	1, 2, 3, 4
2	198 14:27	199 12:09	4, 5, 6, 7, 8, 9, 10, 11
3	199 13:34	199 20:08	12, 13, 14, 15, 16
4	199 20:27	200 11:18	17, 18, 19, 20, 21
5	200 11:33	200 15:12	22, 23, 24, 25

Note: each tape# includes a Forward tape and Down-looking tape.