GEOLOGICAL SURVEY OF CANADA
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The Banquereau Surf Clam Dredging Impact Study "Ten Years After" and Seabed Photography of Laurentian Channel:

Technical Report on the CCGS Hudson Cruise 2008-015, First Leg. Fisheries and Oceans Canada (DFO) and the Geological Survey of Canada - Atlantic (GSC-A) June 10–14, 2008

E.L. King and A. Atkinson

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Publications in this series have not been edited; they are released as submitted by the author.

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1.0 SUMMARY

Leg 1 of DFO Hudson Cruise 2008015 was conducted from June 10 to 14 on Banquereau and the outer Laurentian Channel. A joint DFO (Department of Fisheries and Oceans) and NRCan-GSCA (Natural Resources Canada, Geological Survey of Canada) expedition included a resurvey of the DFO Dredge Impact Study area on outer Banquereau, Scotian Shelf, using sidescan sonar, to assess the nature of long-lived dredge tracks 10 years after their creation, followed by seabed photography in Laurentian Channel.

The Banquereau site had changed significantly by the tenth year following 5 years of less significant change. Bedforms, mainly 3-D megaripples from storm event(s) have modified most dredges so as to be invisible. A seabed features map has been compiled.

At three sites in the Laurentian Channel seabed video, still photography and limited sampling was used to assess the nature of the seabed which gives rise to high backscattering on sidescan sonograms (from 2006 and 2007) on mud in pockmarked and iceberg soured areas. A long video transect across mud of highly variable local thickness (0-10 m) at the outer Laurentian Channel showed Holocene age muds cover a relict iceberg scoured till which outcrops only locally, exposing gravel and cobbles with attached biota. A thin (cm) mud dusting is apparently penetrated by the sidescan sonograms to register a high backscatter return, thus under-representing the extent of the very thin mud. The properties of the backscattering medium which give rise to small circular patches at the base of small pockmarks remains uncertain.

A long videograb transect across scattered pockmarks on the east flank of Laurentian Channel failed to indicate the nature of strong central backscattering (“eyed pockmarks”) in thick muds. This suggests that the ubiquitous dusting of nepheloid layer (brownish mud up to several cm in the grab samples) covers the backscattering targets. It suggests little or no recent gas escape activity.

A long video and still transect across the Scaterie Moraine to substantiate anecdotal reports of the coral Lophelia and to observe seabed stability demonstrated varied biota and a large sponge community and no apparent modern retrogressive mass sediment failure on early post-glacial slump scars.

2.0 BANQUEREAU SIDESCAN SURVEY

This cruise was in support of the DFO Surf Clam dredging impact study "Ten Years After". Cruise objective from the Natural Resources Canada (Geological Survey of Canada-Atlantic) was to collect a repeat sidescan sonar survey of the DFO Dredge Impact site by Kent Gilkinson and Dale Roddick, DFO, Environmental Sciences Division.

The cruise started at BIO June 10th (JD 163) and after several tests and safety procedures in Bedford Basin, proceeded to the Banquereau survey site. Health matters required an emergency return to land initiated just before surveying was to commence and a port call was made to Louisbourg where an FRC transfer of the first officer to port was completed. Remaining officers resumed ship operations without any crew replacements and we immediately proceeded back to the Banquereau site, having essentially lost one day of science operations. Operations proceeded to video and still camera transects in Laurentian Channel. These made use of the DFO CamPod and the VideoGrab. These commenced in the late hours of JD 164. One very long (CamPod; live video and stills on demand), a medium length (VideoGrab; live video and grab on demand) and a short transect CamPod were conducted. These operations were completed by late JD 165 and the studies moved to a topographic high (Scatarie Moraine), situated in St Ann's Basin, off Cape Breton where a long CamPod transect

The Dredge impact study area is situated across and to the south of the base of the southern flank of Eastern Shoal. In the study area are two boxes, X and Y, were dredged in 1998. Box X was dredged only, while Box Y was both dredged and the harvested tests discarded across the site.

A series of sidescan sonar mosaics (before and after dredge) and multiparameter sampling operations have been conducted at the DFO study site. These included previous sidescan sonar re-surveys which showed the dredges to be visible after several years (Gilkinson et al. 2005). GSCA had collected similar data sets on behalf of DFO in the initial years of the study and again on their Hudson 2003029 cruise. Even after six years the dredging was visible from the sonar (Josenhans et al. 2004).

As background, and for comparisons with the new survey, readily available mosaic images were re-accessed (R.O. Miller, GSCA and Robert Benjamin and Dale Roddick). Not all impact site survey images were available in a digital mosaic form; some had to be georeferenced from other sources. These and all sidescan-derived files (including the georeferenced mosaic) along with planning and metadata files were supplied to the DFO senior scientist on DVD.

2.1 SURVEY EQUIPMENT AND PARAMETERS

The primary system used for this work was the GSCA Klein 3000 side scan sonar. This was augmented by the Chesapeake SonarMap mosaicing package and the Knudsen 3260 Sub Bottom profiler. Fish positioning was with the ORE Track Point II system and a test of real-time data cleaning was performed.

2.1.1 GSCA Klein 3000 Sonar (A. Atkinson)

The Klein 3000 was used with the SUBS body and Markey winch. Layback was calculated by SonarPro using wire out from the Totco meter wheel. Just before the cruise, the system ram was upgraded to 3 Gigabytes. This should prevent lagging sonar pings online while files were being copied to the USB hard drive. A new version of SonarPro (11.2) was installed on the Klein computer prior to the cruise. This version has provisions to handle data from Klein's sub bottom profiler option (not installed).

The sonar was used on a 100 meter range. The data was recorded on the system hard drive then burnt on DVDs and backed up on a USB hard drive later.

Data quality was excellent, in part due to a calm sea state. Table 1 is the log of sidescan operations.

2.1.2 ORE TrackPoint II USBL Positioning System

The ORE was used to get the relative position of the sonar fish and these XY coordinates were saved on the Regulus navigation system. The Klein 3000 has a responder mounted on it. This configuration requires the use of external key in on the TrackPoint and this setup proved trouble free and seamless during operations on this cruise. The trigger from the Klein is a divided down multiple of the sonar's ping rate. A divisor of 8 was used with the 100 meter range. The TrackPoint was set to receive on 24 KHz returns from the Klein. Table 2 lists the possible reply frequencies of the Klein responder. Depths were entered manually on the front panel of the TrackPoint. XY coordinates were stored on the Regulus system in the GP lab. The fish tracks were also shown on the labs Regulus.

A grid of six east-west lines, each about 2.5 km long and spaced about 150 to 200 m apart were laid out over an existing (Hudson 98015, JD150) mosaic placed to optimize the dredges illumination. A looping pattern generated three survey lines across the northern (dredge and dump) site, each run in a west to east direction, and three across the southern (dredge only) site. This layout minimizes the appearance of layback error. The

Table 1

WATCHKEEPER'S LOG - Side Scan Sonar and 3.5 kHz

DATE:		Latitude	Longitude				2008015	VESSEL: Hudson										CLIENT:DFO	
Day / Time				Data Annotation			Environmental						Sonar Settings						
Julian Day	Time UTC			Operation	Line #	Disk/DVD File	Hdg.	Log Spd.	Fish Depth	Fish Altitude	Cable Out(m)	Sea State	LF	HF	Range (m)	Knutsen 3.5 operating	Knutsen 3.5 File	Track Pt	Comments
164	1023	44.505322	-58.034331	Deploy sidescan; DFO Con4	run-in to lines		130	4.5	35		60	1	x	x	100			4	dual frequency; 15 min files ca. 200 MB; layback setting (cable out) corrected for ships antenna
164	1035	44.496189	-58.019144	start recording sidescan															
164	1117	44.461111	-57.958109	alter course to line up for survey			150												
164	1118	44.460036	-57.957049	start recording 3.5kHz												x	x		
164	1139	44.437111	-57.936290	alter course to line up for survey			95	4.4	29	20	56	1	x	x	100	x		4	
164	1147	44.496189	-58.019144	SOL 1	2008015-1	sonar_data_080126112000	87	4.6	51	18	137	1	x	x		x		4	very recent (sharp) trawls on seabed; month wrong on filename; changed for next file
164	1151			line 1	2008015-1	sonar_data_0806121157	92	4.9			156	1	x	x	100	x	2008_164_1159_001.keb	4	filename fixed… was wrong month
164	1211	44.437286	-57.879960	EOL 1	2008015-1		86	4.8	50	22	202	1	x	x	100	x		4	cable in on turn
164	1227	44.431414	-57.878605	SOL 2	2008015-2		359	3.9	60	24	117	1	x	x	100	x		4	swing a bit wide
164	1248	44.431736	-57.916956	EOL 2	2008015-2	sonar_data_0801261243	263	4.9	60	28	142	1	x	x	100	x		4	
164	1311	44.436016	-57.917423	SOL 3	2008015-3	sonar_data_08061312	93	4.5	53	18	130	1	x	x	100	x	2008_164_1319_005	4	
164	1331	44.435710	-57.880639	EOL 3	2008015-3	sonar_data_08061249	86	4.9	56	27	180	1	x	x	100	x		4	no sign of old trawls; bedforms and shell specks
164	1346	44.430267	-57.879508	SOL 4	2008015-4		270	6.8	35	50	100	1	x	x	100	x		4	very good (stable) trackpoint data
164	1404	44.430546	-57.916581	EOL 4	2008015-4	sonar_data_08061401	20	3.5	32	45	50	1	x	x	100	x		4	sign of southern trawl box but subdued
164	1429	44.434511	-57.906197	SOL 5	2008015-5	sonar_data_08061406	89	6.5	35	44	104	1	x	x	100	x	2008_164_1439_009	4	avoid vessel; late start on this line; reduce speed
164	1442	44.434913	-57.880772	EOL 5	2008015-5	sonar_data_08061421	87	4.2	53	31	148	1	x	x	100	x		4	
164	1455	44.428831	-57.878990	SOL 6	2008015-6	sonar_data_08061421	270	4.8	61	26	150	1	x	x	100	x	2008_164_1452_010	4	
164	1513	44.429260	-57.916905	EOL 6	2008015-6	sonar_data_08061510	256	4.3	60	20	109	1	x	x	100	x	2008_164_1503_011	4	end of trawl box survey
164				run-in to line 7	2008015-6to7		280	4.3	58	30	24	1	x	x	100	x	2008_164_1520_012	4	turning on to line 7
164	1534	44.424520	-57.950607		2008015-6to7	sonar_data_08061534													
164	1546	44.423679	-57.948085	SOL 7	2008015-7	sonar_data_08061547	53	6.4	27	33	82	1	x	x	100	x	2008_164_1541_013	4	dropping speed at SOL
164	1608	44.477847	-57.865241	Line 7	2008015-7	sonar_data_08061602	77	3.9	32	18	62	1	x	x	100			4	heading back on line; vessel traffic
164	1645	44.469617	-57.874498	EOL 7 EO survey	2008015-7	sonar_data_08061632	39	4.6	30	20	60	1	x	x	100	x	2008_164_1554_014	4	end of Banquereau survey
164	1653	44.477847	-57.865241	slight overrun and new file		sonar_data_08061647													

Table 2. Possible Klein 3000 Responder Reply Frequencies			
24 KHz	24.5 KHz	25 KHz	25.5 KHz
26 KHz	26.5 KHz	27 KHz	27.5 KHz
28 KHz	28.5 KHz	29 KHz	29.5 KHz
30 KHz	30.5 KHz	31 KHz	31.5 KHz

Clearwater Fine Foods Ltd. vessel "Ocean Concord" was on site (just outside the DFO working area) during the survey, and its presence was the cause of two variations off the planned survey course but also afforded a sidescan view of very recent dredges (days to possibly weeks old).

In addition to the grid, a transect was run along the approximate 50 m contour of Eastern Shoal, at the top of a 10 to 25 m slope break, where dredging log data showed activity of the vessel "Ocean Concord" between the 21st and 24th of May, 1999. This was done with the aim to assess if dredges disappeared from sidescan sonograms during this nine year span in an area with presumably greater storm sensitivity. As testing of a new Knutsen 3.5 kHz sub-bottom and 12 kHz echosounder profiler was underway, these data were collected and recorded simultaneously. The profiler afforded no sub-bottom penetration in these sandy sediments.

Table 3 shows the sidescan survey line parameters (start and end times and positions) and Table 4 shows the corresponding DVDs.

Table 3

Hudson 2008015								
Line	Start	End	Position				Sidescan	
			Start		End			
			Latitude	Longitude	Latitude	Longitude	Rec. #	DVD #
1	1641035	1641211	44.49619	-58.01914	44.43729	-57.87996	none	1 and 2
2	1641227	1641248	44.43141	-57.87861	44.43174	-57.91696	none	1 and 2
3	1641311	1641331	44.43602	-57.91742	44.43571	-57.88064	none	1 and 2
4	1641346	1641404	44.43027	-57.87951	44.43055	-57.91658	none	1 and 2
5	1641429	1641442	44.43451	-57.90620	44.43491	-57.88077	none	1 and 2
6	1641455	1641513	44.42883	-57.87899	44.42926	-57.91691	none	1 and 2
7	1641546	1641653	44.42368	-57.94809	44.47785	-57.86524	none	1 and 2

N.B. no paper records; DVD #1 is .sdf format; Disk 2 is .xtf format

Table 4

Hudson 2008015				
NB. No Paper Records				
Sidescan				
DIGS DVD's				
DVD #	Start Time	End Time		Line #
1 and 2	164103500	164164700		1 to 7

N.B. DVD #1 is .sdf format; Disk 2 is .xtf format

2.1.3 Knudsen 3260 Chirp Dual Channel Sounder (A. Atkinson)

This sub-bottom profiler system is a new piece of equipment presently being brought into service by GSCA. Though not necessary for the dredge impact study its performance was evaluated on this leg. It seems to be completely working at this writing. The only deficiency is an up-to-date manual for the 3260 model.

The 3260 as configured operates a 3.5KHz sub bottom profiler channel and a 12 kHz sounder channel The 3.5 kHz was used with the in hull array and the 12 kHz was used with hull mounted transducer #2.

A firmware upgrade to the DSP software was performed on the system during basin trials before Hudson left Halifax Harbour.

Both KAP and KEB files may be recorded, but it seems that the XTF and Segy formats have not been implemented and were grayed out of the menu. This probably needs to be changed. The system works well when auto gain is used, but auto phasing has trouble with steep changes in the seabed. Submarine canyons with hyperbolae also give the system trouble.

It looks like the 3260 will support an Alden 9315, EPC 9800, or EPC 1086 via a parallel printer interface on the computer

All in all the system performed as expected and is now ready to be used for science operations.

Table 3

Hudson 2008015								
Line	Start	End	Position				Sidescan	
			Start		End			
			Latitude	Longitude	Latitude	Longitude	Rec. #	DVD #
1	1641035	1641211	44.49619	-58.01914	44.43729	-57.87996	none	1 and 2
2	1641227	1641248	44.43141	-57.87861	44.43174	-57.91696	none	1 and 2
3	1641311	1641331	44.43602	-57.91742	44.43571	-57.88064	none	1 and 2
4	1641346	1641404	44.43027	-57.87951	44.43055	-57.91658	none	1 and 2
5	1641429	1641442	44.43451	-57.90620	44.43491	-57.88077	none	1 and 2
6	1641455	1641513	44.42883	-57.87899	44.42926	-57.91691	none	1 and 2
7	1641546	1641653	44.42368	-57.94809	44.47785	-57.86524	none	1 and 2

N.B. no paper records; DVD #1 is .sdf format; Disk 2 is .xtf format

Table 4

Hudson 2008015				
NB. No Paper Records				
Sidescan				
DIGS DVD's				
DVD #	Start Time	End Time		Line #
1 and 2	164103500	164164700		1 to 7

N.B. DVD #1 is .sdf format; Disk 2 is .xtf format

2.2 SONAR PROCESSING

A total of 34 standard .xtf and Klein Systems .sdf format files (each) were generated; a new file was created every 15 minutes and at the start and end of lines. Initial on-board processing was conducted using the Chesapeake "Sonar Wiz" (version 4.01) software while a new version was used post-survey (4.03) which eliminated some layback and resolution issues onboard. The files were imported as .sdf format.

Georeferenced sidescan mosaics were generated for both the low and high frequency transducers. The low resolution (low frequency) image was not able to recognize the "cable out" readings embedded in the SEGY files. It appeared that layback was not turned on due to a possible bug in the Klein software. Consequently, a fixed layback of 100 m was utilized. The outcome is that while the southern (covers box X) and the northern (covers Box Y) sets of three lines of the survey are internally coherent (ie. features from line to line are well aligned), the two sets may not be aligned relative to each other. A similar positional error in absolute position of the images was also expressed in the older surveys. These issues are not present in the high resolution image.

In addition to the georeferenced sonar images, a more "raw" form of the image (.jpg) was produced for each file, for both high and low resolution transducers (included on the Sidescan Data DVD). These are not georeferenced but potentially have greater preserved detail, not subject to the trade-off between resolution and file size as are the georeferenced tiff files. This is evident, for example, in file "sonar_data080612134600.jpg " which depicts weak remnant traces of the 1998 dredges in the "Box X" box not as visible in the georeferenced image. The high resolution images suffer from a lower gain on the port side. This shortcoming is compensated in the mosaic and the cause is uncertain.

Sidescan data file names generally reflect their consecutive date and time or collection but the first six files have incorrect dates and times. In addition, several "real time" screen grabs were preserved and are included in the data files.

Processing of the files was optimized through some trial and error. Settings included automatic gain control, full slant range correction and water column removal, a layback of 150% of cable out to compensate for a stern position well behind the GPS antenna. Survey track crossovers suggest that this layback setting brought features to within 10 or 20 m of true position.

Table 5 provides a listing of the georeferenced sidescan mosaic images generated from both the low and high frequency sonar data in addition to those from an earlier cruise.

Table 5. DFO Impact Trawl georeferenced Sidescan Survey images used and generated for HN 2008015

Filename	Description	Source
Hudson 98015 cruise		
BanquereauHN98_015_JD149HiRes.TIF	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS with superimposed grid as reference points	Hudson 98015 cruise, Julian Day 149
BanquereauHN98_015_JD149_2.JPG	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS using above map as reference points for image limits	Hudson 98015 cruise, Julian Day 149
BanquereauHN98_015_JD150_hires.TIF	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS with superimposed grid as reference points	Hudson 98015 cruise, Julian Day 150
BanquereauHN98_015_JD150.JPG	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS using above map as reference points for image limits	Hudson 98015 cruise, Julian Day 150
BanquereauHN98_015_JD151HiRes.TIF	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS with superimposed grid as reference points	Hudson 98015 cruise, Julian Day 151
BanquereauHN98_015_JD151.JPG	Corel draw file generated by GSCA, RO Miller, in GRASS GIS and exported to Corel and then georeferenced by N King, in ArcMap GIS using above map as reference points for image limits	Hudson 98015 cruise, Julian Day 151
Hudson 2008015 cruise; Low Frequency data		
2008_015_BanqMosaic0125m.TIF	High resolution (0.125 m) image of the two trawl sites only	Hudson 2008015 cruise, Julian Day 164
2008_015_BanqMosaic025m.TIF	Medium resolution (0.25 m) image of most of the survey site	Hudson 2008015 cruise, Julian Day 164
2008_015_BanqMosaic05m.TIF	Medium to low resolution (0.5 m) image of most of the survey site	Hudson 2008015 cruise, Julian Day 164
2008_015_BanqMosaic1m.TIF	low resolution (1.0 m) image of most of the survey site	Hudson 2008015 cruise, Julian Day 164
2008_015_BanqMosaicNW05m.TIF	Medium to low resolution (0.5 m) image of the entire survey site	Hudson 2008015 cruise, Julian Day 164
Hudson 2008015 cruise; High Frequency data		
2008_015SS_entire_025m.TIF	High resolution (0.25 m) image of the entire survey area with layback	Hudson 2008015 cruise, Julian Day 164
2008_015SidescanTrawlsites025m2.tif	High resolution (0.25 m) image of the DFO work area and environs with layback	Hudson 2008015 cruise, Julian Day 164

This is a complete listing of 2008015 geotiffs generated through onboard and post-cruise processing

3.0 SURVEY RESULTS

High quality sidescan sonar records were obtained though there was some degradation in the final mosaic display. The seabed features are spatially variable. The Eastern Shoal area is considered separately from the Dredge Impact area. Figure 1 shows the entire survey area and location of the following figures.

3.1 EASTERN SHOAL AREA: OUTSIDE THE DFO WORK AREA

3.1.1 Seabed texture and features

The survey area has been classified into five zones based mainly on the bedform occurrences and patterns: One dominates the DFO work area and the others outside. Sub zones have also been differentiated, mainly on the basis of lower-order pattern or degradation aspects of these bedforms or the state of dredge tracks. Figure 2 shows the distribution of the zonations. On the survey approaches to the dredge sites, on top of Eastern Shoal, the four zonations include.

1. **1-LWR**: Large wave ripples (coarse sand, 0.5 to 1m wavelength) with few other features (Figure 3 insert).
2. **3(a or b)-SW**: Regular and alternating sand and gravel patches. These conform in wavelength to small sandwaves but are very low relief. Some have a preferred E-W and NNE-SSW orientation and superimposed megaripples (map unit **3a-SW**). The two directions may reflect a 3-D nature of the bedforms yet some are more curvilinear and preserved enough to recognize a 50 m wavelength and a NE-SW crestline orientation (map unit **3b-SW**) with superimposed 3-D megaripples (10 m crest spacing). See Figure 4.
3. **4-Patch**: This seabed comprises irregular sand patches (lighter tones) with intervening fields of large wave ripples (ca. 1 m wavelength, bifurcating crestlines, nearly N-S crestline orientation), sometimes occurring in slight depressions (Figure 3). Map unit **4-Patch-LWR** shows the distribution. These depressions probably comprise coarse sand and up to pea-size gravel. The patch patterns are quite irregular to curvilinear but bear little resemblance to any large scale bedform. Some of the sandier patches display a mottled pattern suggesting some variability of texture, probably remnants of degraded smaller dunes (3-D megaripples).
4. **5(a to c)-M**: Mottled sidescan texture, mainly related to degraded megaripples (Fig. 5). Most are small dunes (megaripples) with a 3-D form and generally about 10 to 15 m spacing or wavelength. The bedforms are best preserved in the shallower NE part of the survey (map unit **5b-M**) though some in the SE are quite visible (map units **5a-M-DT** and **5a-DT-M**). The troughs of these bedforms are coarser, invoking a higher backscatter than the surrounding sand. The trough pattern can be circular to circular but with irregular edges, apparently randomly distributed or occasionally in chains.

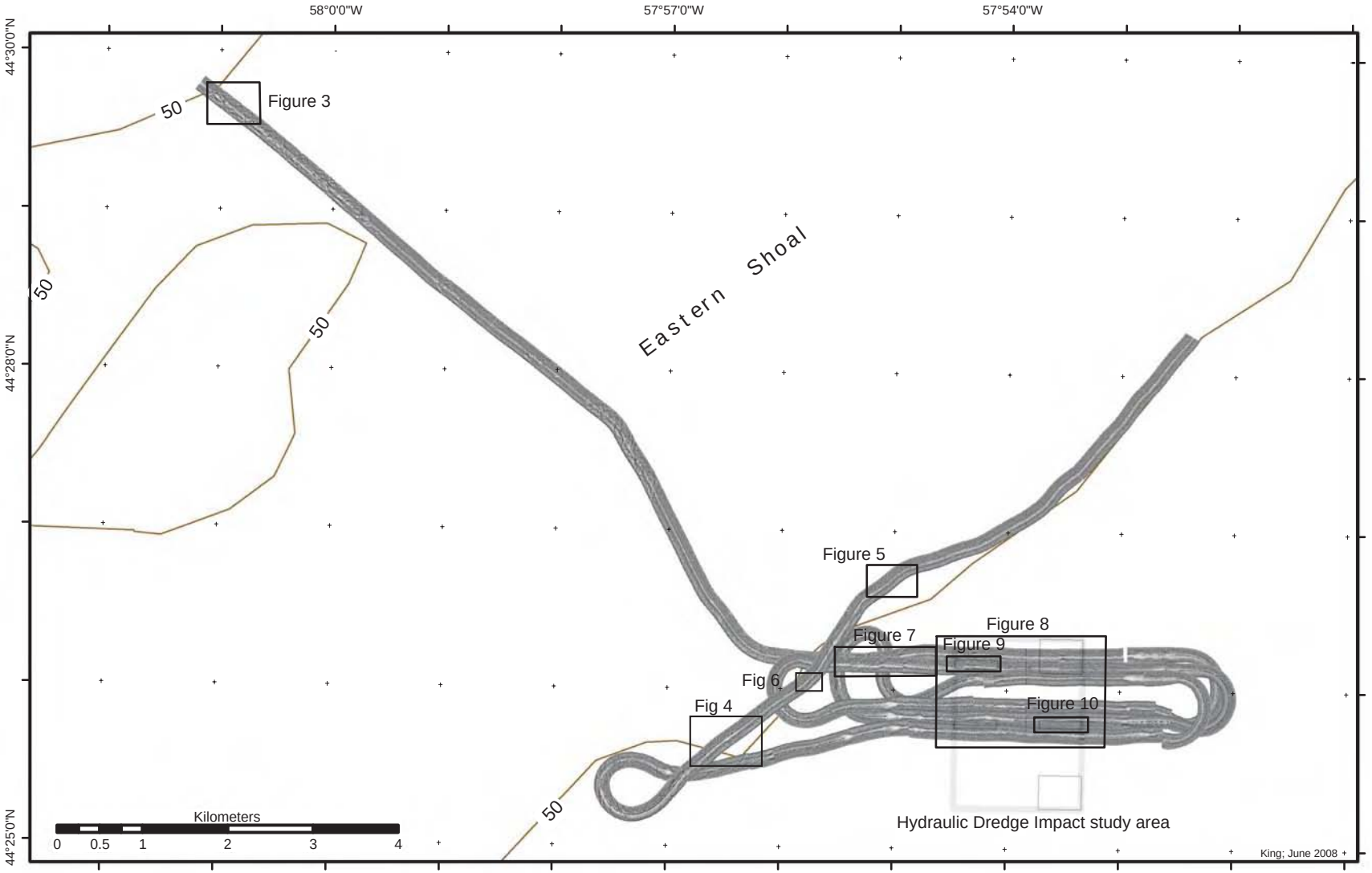

Figure 1. Extent of the 2008015 sidescan survey and location of illustrations.

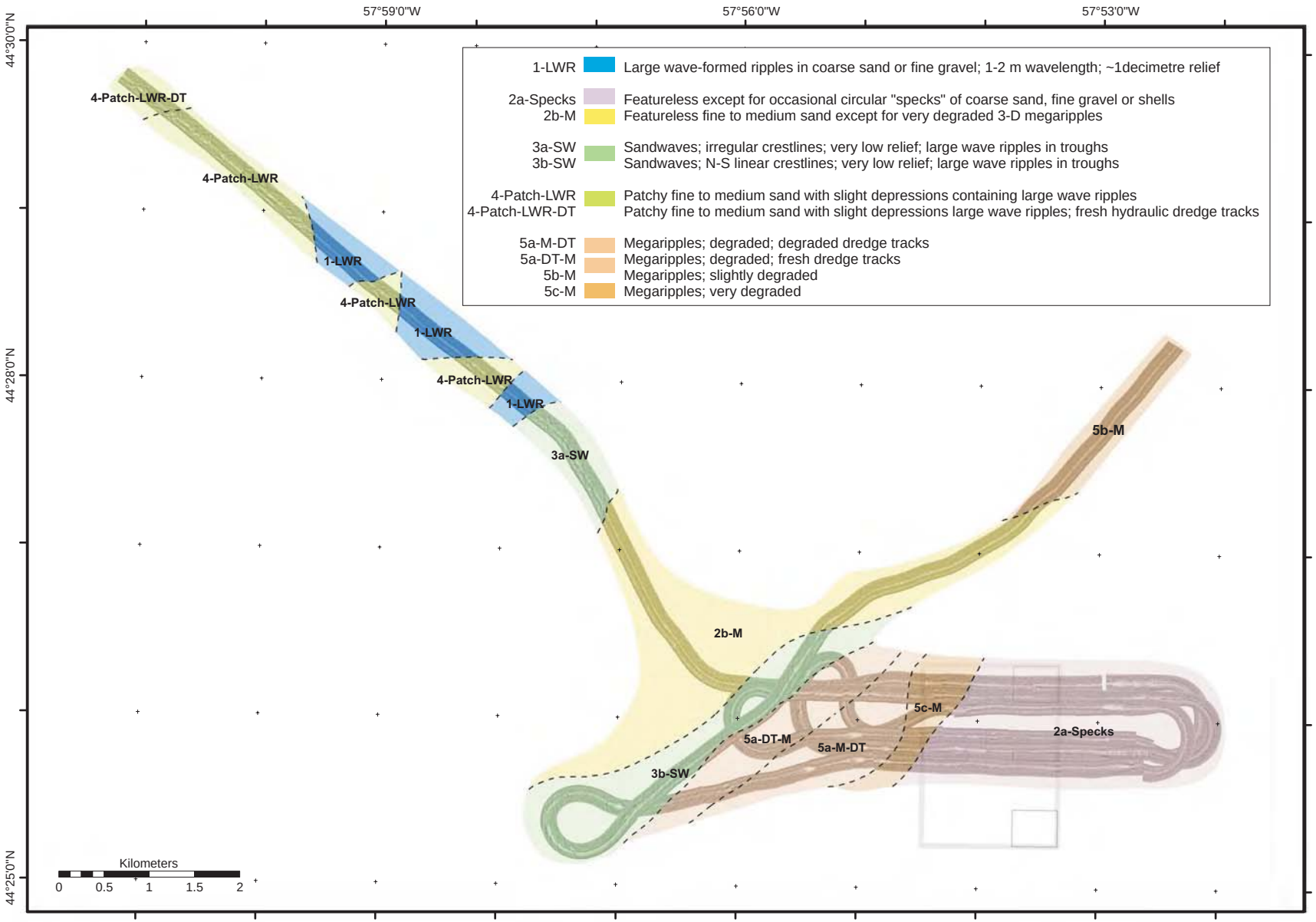

Figure 2. Zonation of seabed features derived from the sidescan sonar survey.

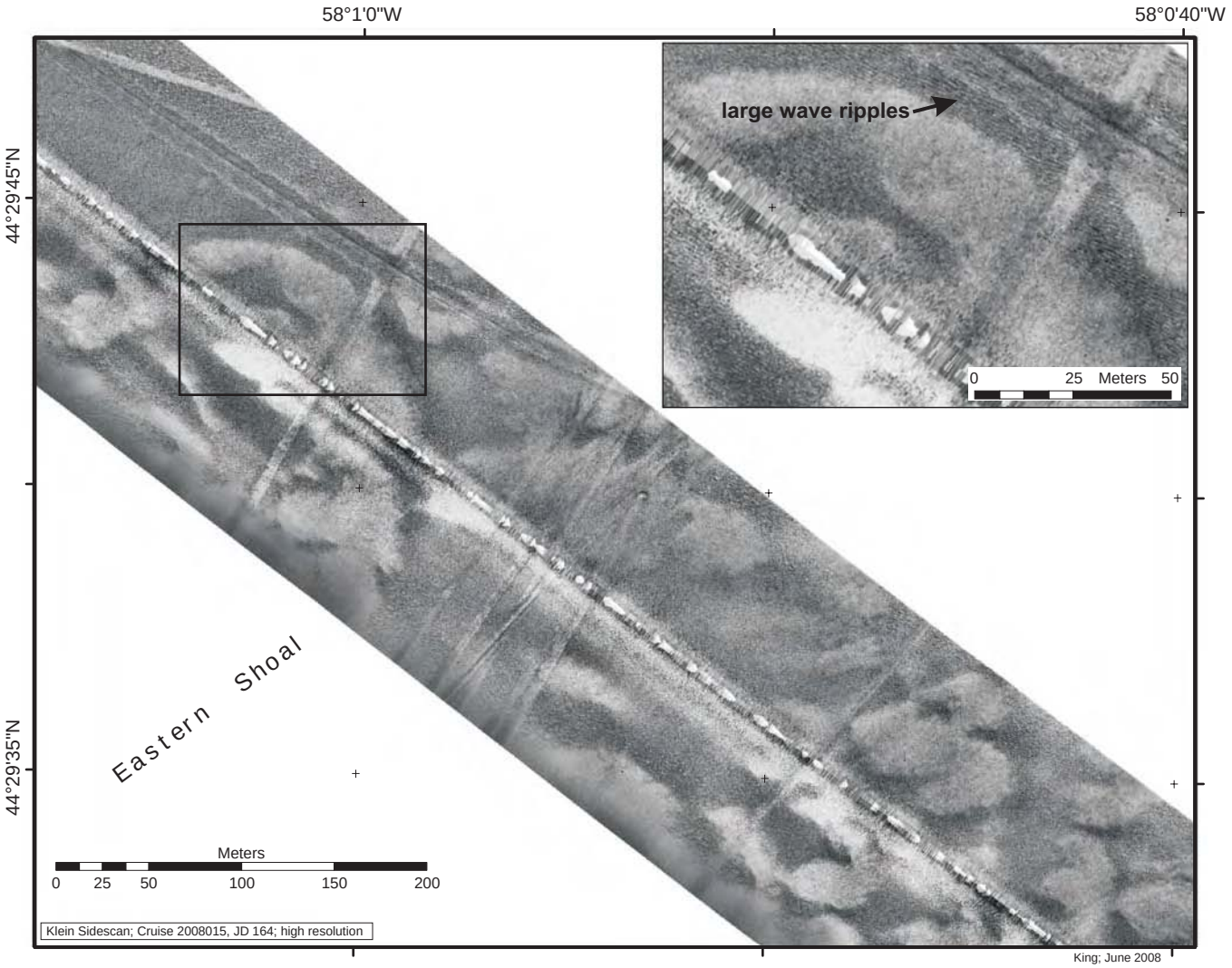

Figure 3. Trawls across irregular patches of sand (light tone) and fine gravel to coarse sand worked into large wave ripples.

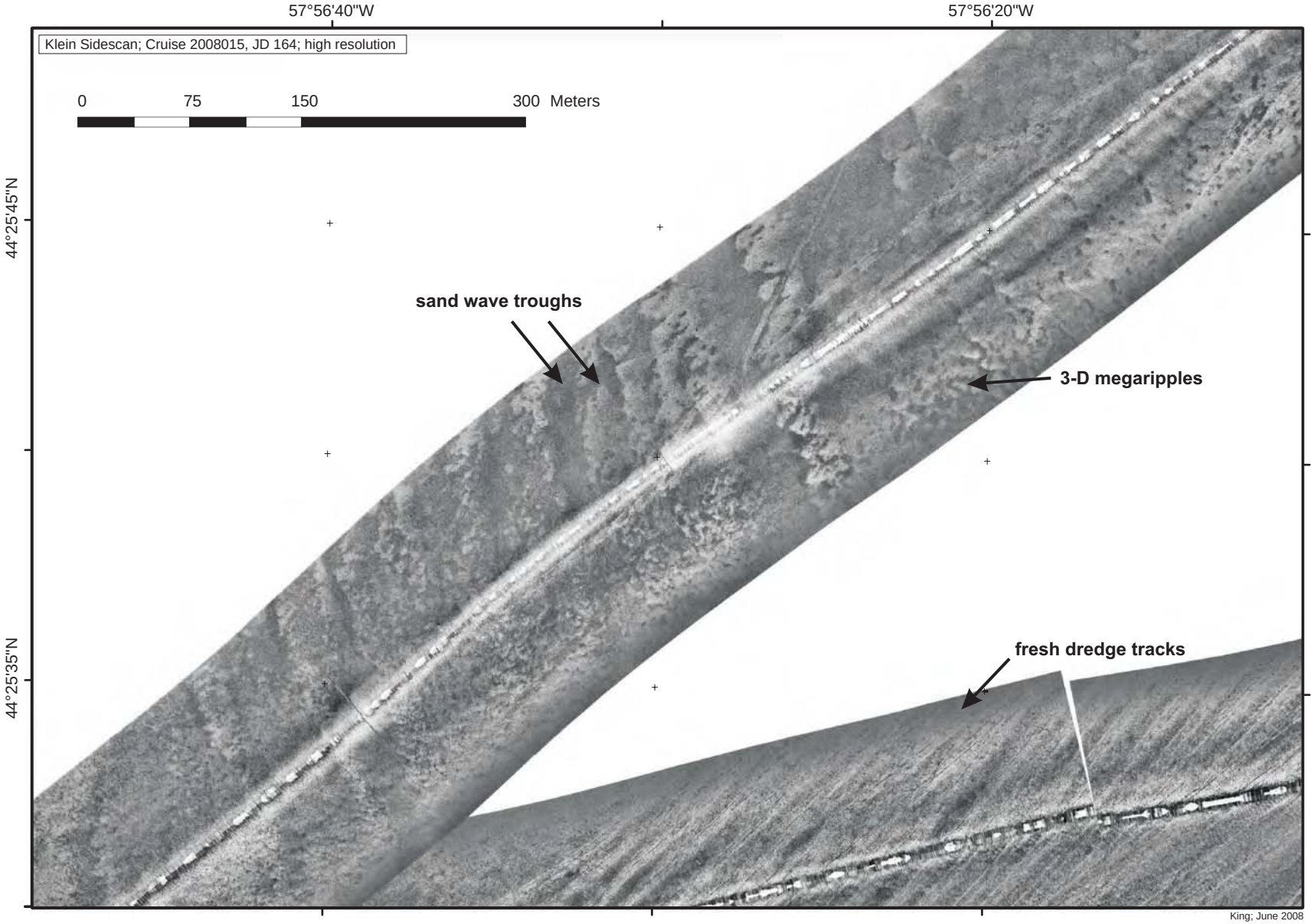

Figure 4. Sandwaves with superimposed 3-D megaripples and occassional dredge tracks characterizing map unit 3b-SW.

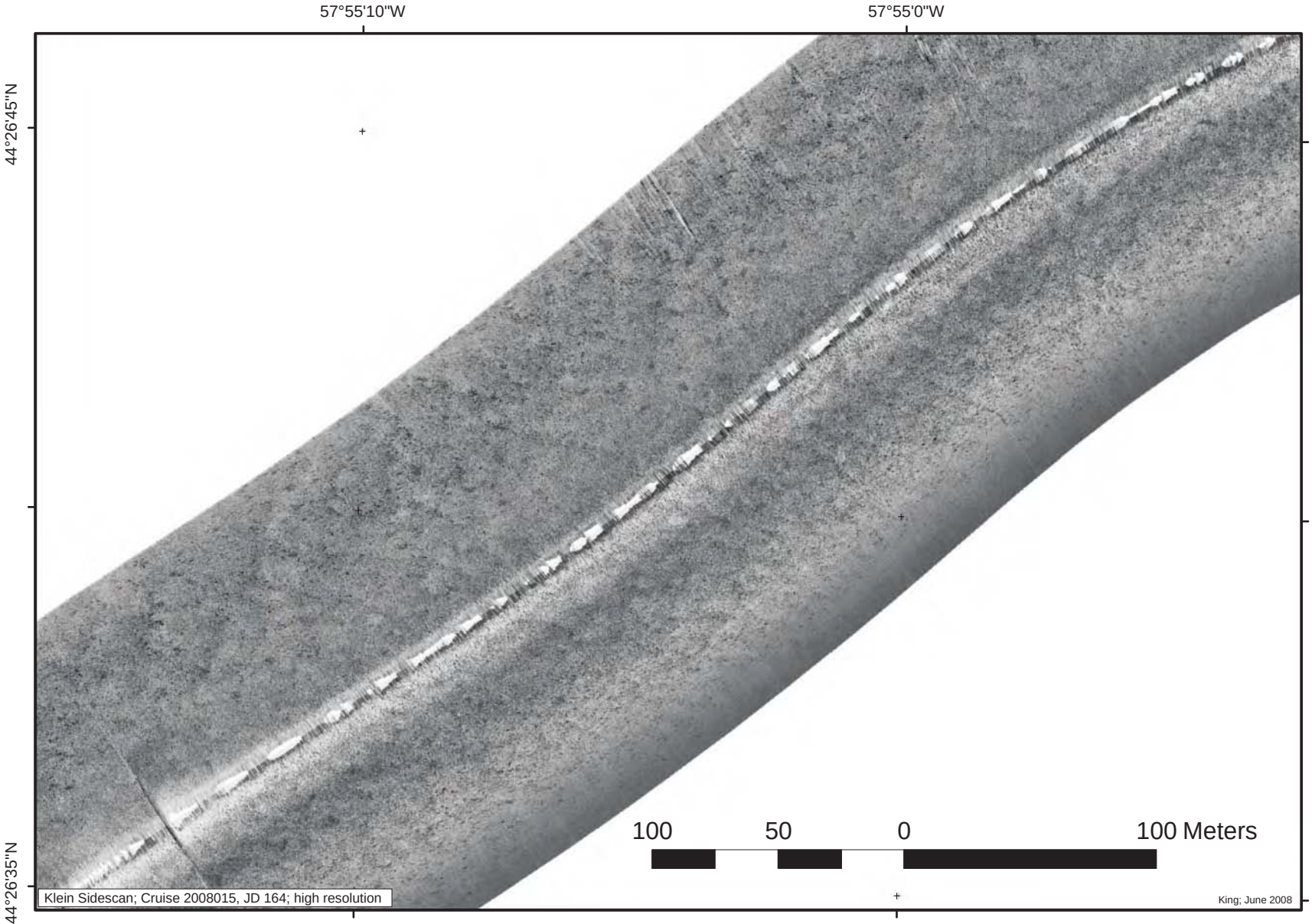

Figure 5. Three-dimensional megaripples degraded to the point that a mottled seabed results. Texture likely ranges from fine sand (light tone) to coarse sand in the bedform troughs.

There is a rough correlation between mid-scale seabed features (ie. the three zonations above) and larger scale morphology (kilometers broad and metres relief) but this needs further investigation. The same phenomenon has been recognized on Sable Island Bank (Li and King 2007).

3.1.2 Dredge tracks

Both fresh (distinct) and degraded hydraulic dredge tracks are present, locally in a dense network (map unit **5a-DT-M**). Older, more degraded dredges are present east of this zone (map unit **5a-M-DT**). They are ca. 5 m diameter, do not always appear to be paired, and generally, though not always, display a lesser backscatter than the surrounding seabed. This suggests sand or disturbed sand infill. Some have the large wave-formed ripples superimposed with only the outer flanks suggesting remnant disturbance and some have apparently been reworked by small dunes (megaripples). Occasionally the dredges demonstrate some relief and the "freshest" exhibit a strong return on the immediate flank of the cut. Occasionally they begin (or end) with a pit or a pair of pits, some 3 to 5m across and deep enough to create an acoustic shadow which allows a calculated pit depth of 30 to 40 cm (Fig. 6). Some of these were probably only hours or days old as the clamming vessel "Ocean Concord" was on site (Fig 7). Cut depth estimates derived from acoustic shadows suggest the deeper cuts are in the order of 10 to 20 cm or equal to about two times the height of the large wave ripples. There is no general pattern of orientation except along the southern edge of Eastern Shoal where the dredging was generally along the contours. The very degraded dredges correlate to the position of "Ocean Concord" from 24-05-99.

3.2 DREDGE IMPACT STUDY AREA

3.2.1 Seabed texture and features

The DFO work area is much more homogeneous and featureless in seabed texture. The base of the flank of Eastern Shoal (just outside Box X) shows a transition to a seabed heavily worked into small sand dunes (megaripples) as shown in Fig. 8 (map unit **5c-M** of Fig. 2). They have wavelengths of 5 to 10 m and undetermined relief, probably less than one decimeter. They are predominantly the "3-D" variety, linguoid, without linear crestlines and indicate sand mobility in currents between 40 cm/s and perhaps 60 cm/s, generally under the influence of both wave and storm and/or tidal currents. The general lack of observed relief suggests a degraded nature, either through subsequent storms which did not generate currents strong or lengthy enough to generate the bedforms, or by a combination of bioturbation and reworking by wave ripples smaller than can be resolved on the sidescan. In the vicinity of DFO Boxes the megaripple troughs are all sand covered and the seabed is generally featureless with the exception of scattered "specks" (Fig. 8). This is map unit **2a-Specks** in Figure 2. These are interpreted to be coarse sand or fine gravel. There is little evidence for their presence in the earlier survey.

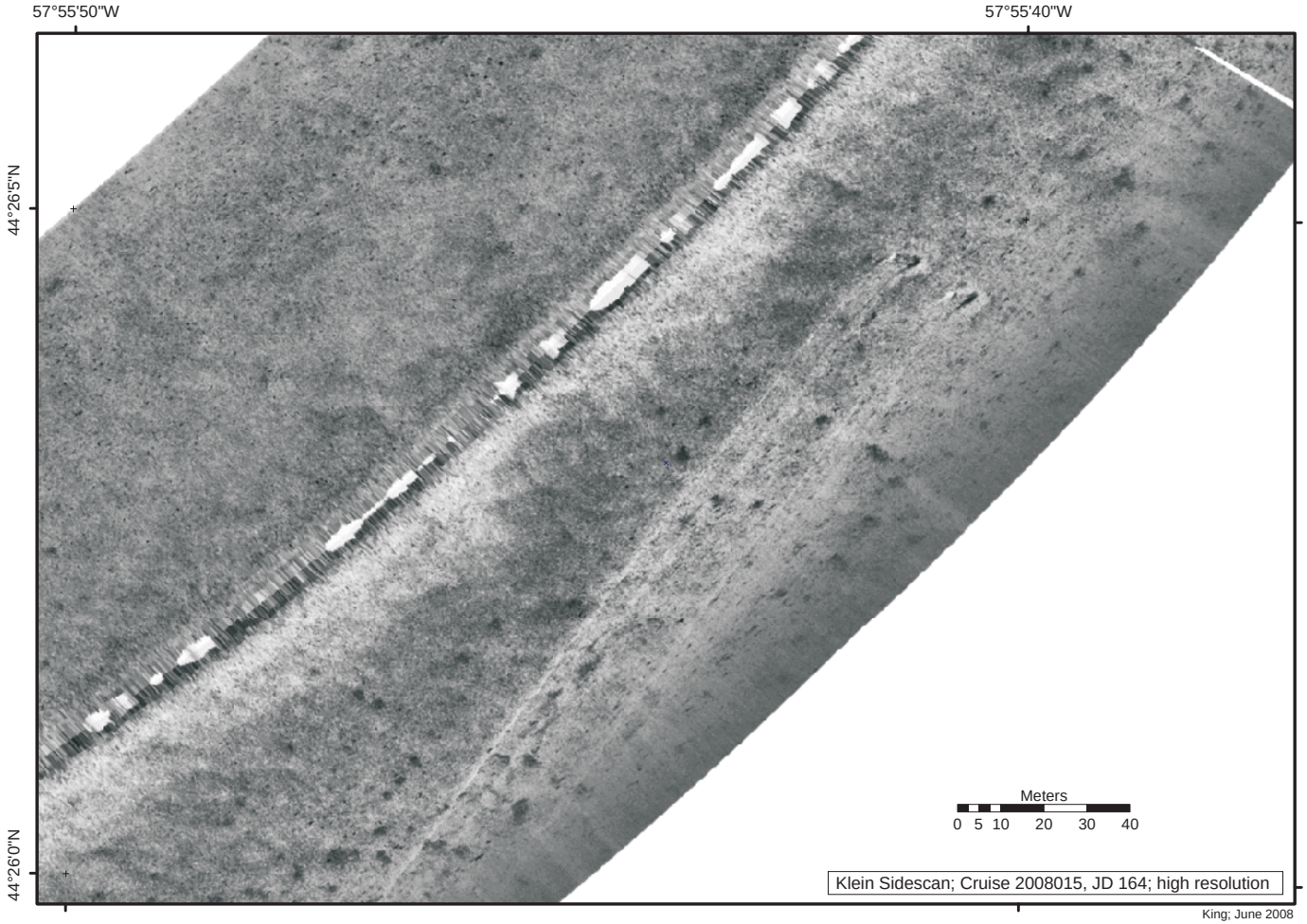

Figure 6. Fresh dredge track pair beginning (or ending?) in a pair of pits. These are estimated at 30 to 40 cm depth while the linear tracks have left a cut relief less than 20 cm. The dredge tracks appear to be affected by the degraded megaripple pattern as evidenced by the coarse patches preserved within the dredge path, suggesting they “survived” a mid-magnitude storm event.

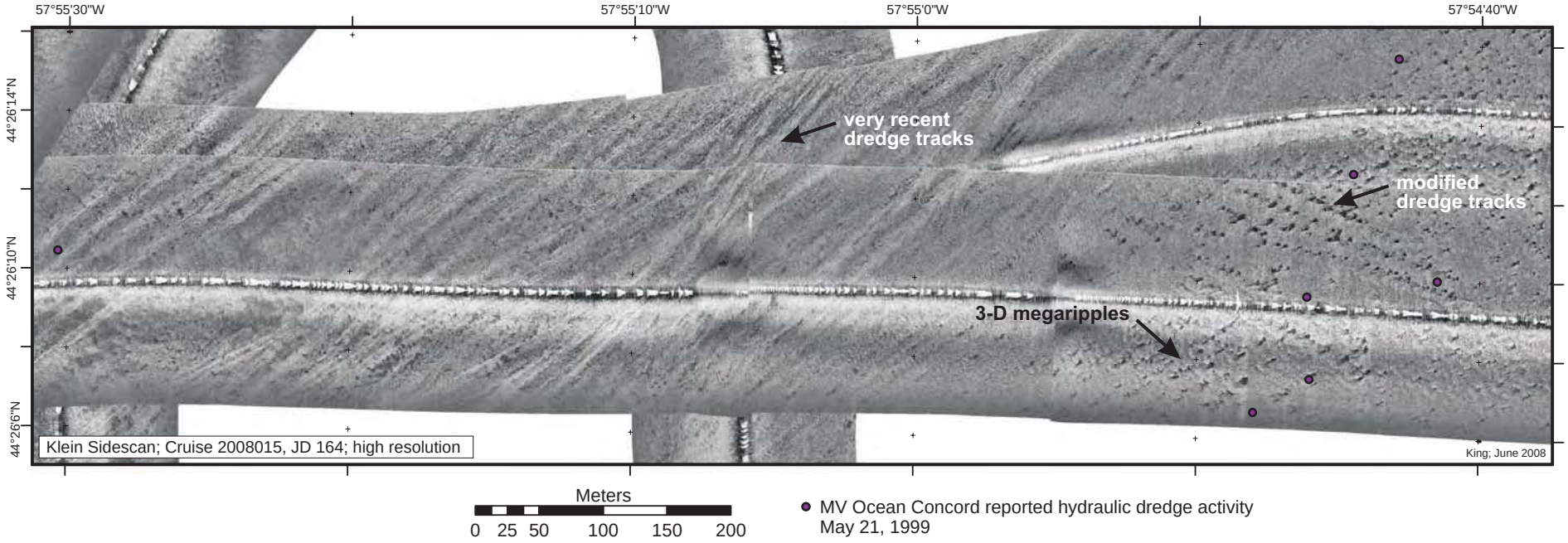

Figure 7. Sidescan sonar image in an area of intense recent hydraulic dredging immediately west of the DFO work area. These are very sharp and have cut the bedforms. They are only days old or less. The fine white lineations allow a depth of cut estimate of between 10 and 20 cm. The modified tracks, likely from 1999 dredging, appear to have preferentially developed small 3-D megaripples or at least their signature is enhanced by a greater number of gravel (or shell) exposures in the bedform troughs. Elsewhere nearby, these are similarly enhanced with gravel or have been obliterated by bedform mobility.

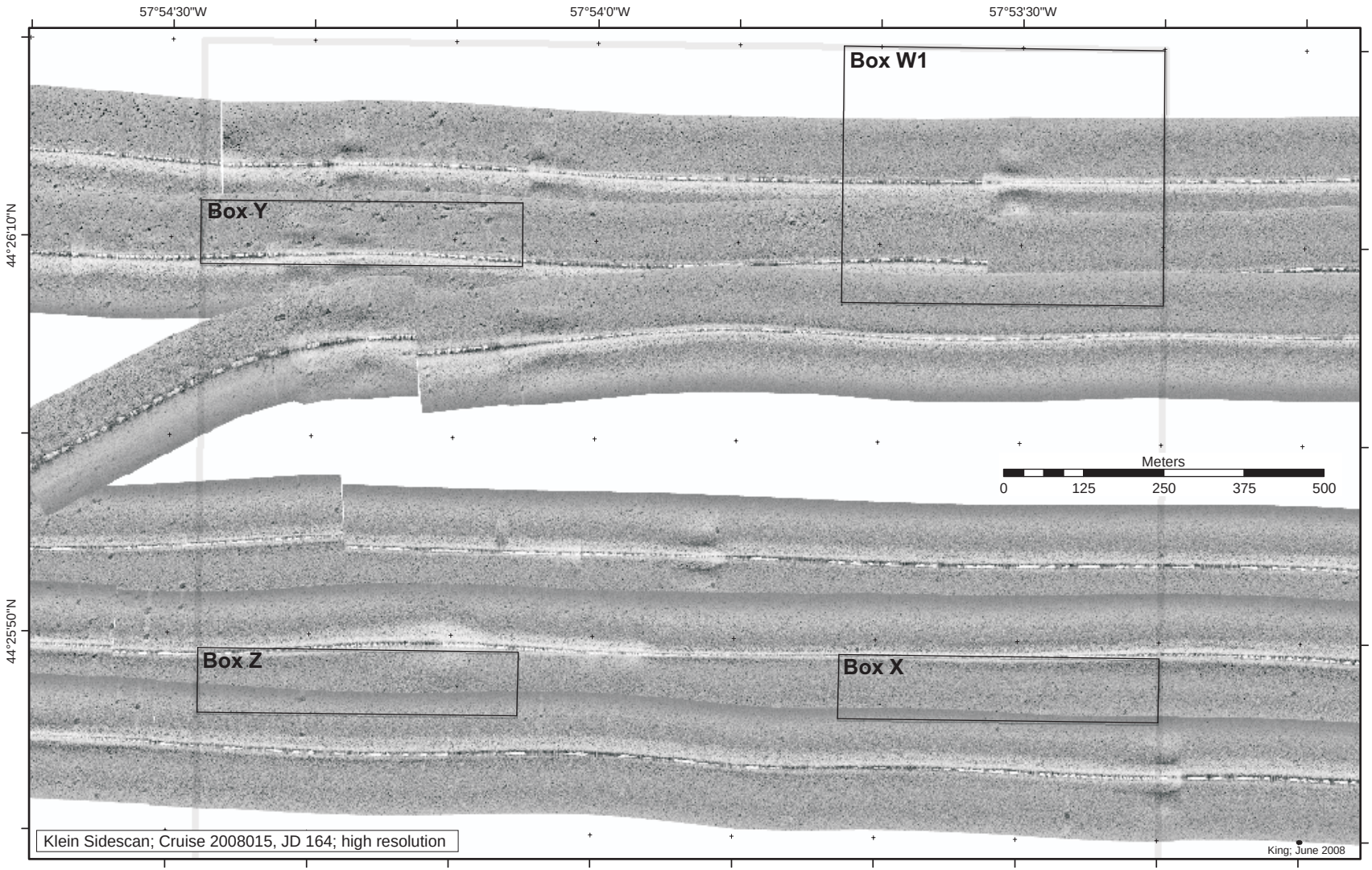

Figure 8. Sidescan sonar image of the DFO hydraulic dredge impact work area. Figures 9 and 10 illustrate blow-ups of the Box X and Box Y 1998 dredge sites. Box W1 is a control box where no seabed activites were conducted, and Box Z is the site of shell discarding only (in 1998).

3.3 SERIAL COMPARISON OF DREDGE TRACKS

The dredge tracks visible in 1998, 1999 and 2003 in Box Y are now completely invisible. Figure 9 shows the 2008 and 1998 comparison in Box Y and Figure 10 in Box X. Where the dredges were all highly visible, including clear relief at some of the dredge track flanks, they are now fully degraded. The seabed is generally featureless sand, not unlike the pre-dredge condition. A few small, coarser patches have developed which were not a characteristic of the pre-dredge seabed.

The complete or near complete degradation and disappearance of the clam dredges is coincident with a major change in the seabed features, especially presence of bedforms. The process by which this occurred is unclear. The generation of 3-D megaripples and sandwaves in the general vicinity (including in slightly deeper water than Box Y), attests to storm and wave currents. That the dredges survived at least 5 years and then degraded by the 10^{th} suggests it is event related. This, together with the bedform changes suggests one or more storm events are responsible. Hurricane Juan and tropical storm Noel are two post 2003 survey events and possible significant seabed events in the area. Future work should involve study of a record of drilling rig storm observations (from Sable Island Bank) to determine the largest event during the 2003 to 2008 span. This would help define the minimum storm magnitude necessary to degrade the dredges at this depth. Thus the new survey provides an opportunity to compare natural mobility of sediment with dredge degradation. The appearance of bedforms not previously recognized in the general area indicates that seabed mobility events within the last 5 years have exceeded those in the previous 5 years and that these events have caused the final dredge degradation.

Dredge degradation, apparently including complete removal, has also occurred over shorter time spans; the 1999 dredges have both visible and fully degraded and invisible examples. However, the hydraulic and the seabed geology may be quite different on top of the Eastern Shoal ridge, where these observations are made, in comparison to the Box X and Y study sites. Further monitoring (sidescan survey) may be warranted given the fresh scours just west of the boxes (Fig. 7) and on top of Eastern Shoal (Fig 3), to help determine the degradation rate with greater precision.

Though the dredges are no longer visible in the sonograms, this does not necessarily mean that the seabed has reverted back to its pre-dredge state. Nevertheless, the sonar has proven to be very sensitive to dredge affects on the sands, as sampling observations do not detect the physical differences (Gilkinson et al. 2005).

Estimates of the natural seabed mobility layer (depth of storm event-related remobilization) are difficult because the heights of the bedforms are unknown immediately after their formation. It may not be valid to estimate heights based on the general literature (equilibrium megaripples have a known range in height to length) as this does not seem to apply on nearby Sable Island Bank (Li et al. 2007). However, a 2 to 3 decimetre height estimate for the megaripples, based on Sable Island Bank examples, would indicate at least a 10 to 15 cm thick mobile layer. Even the smaller, but well

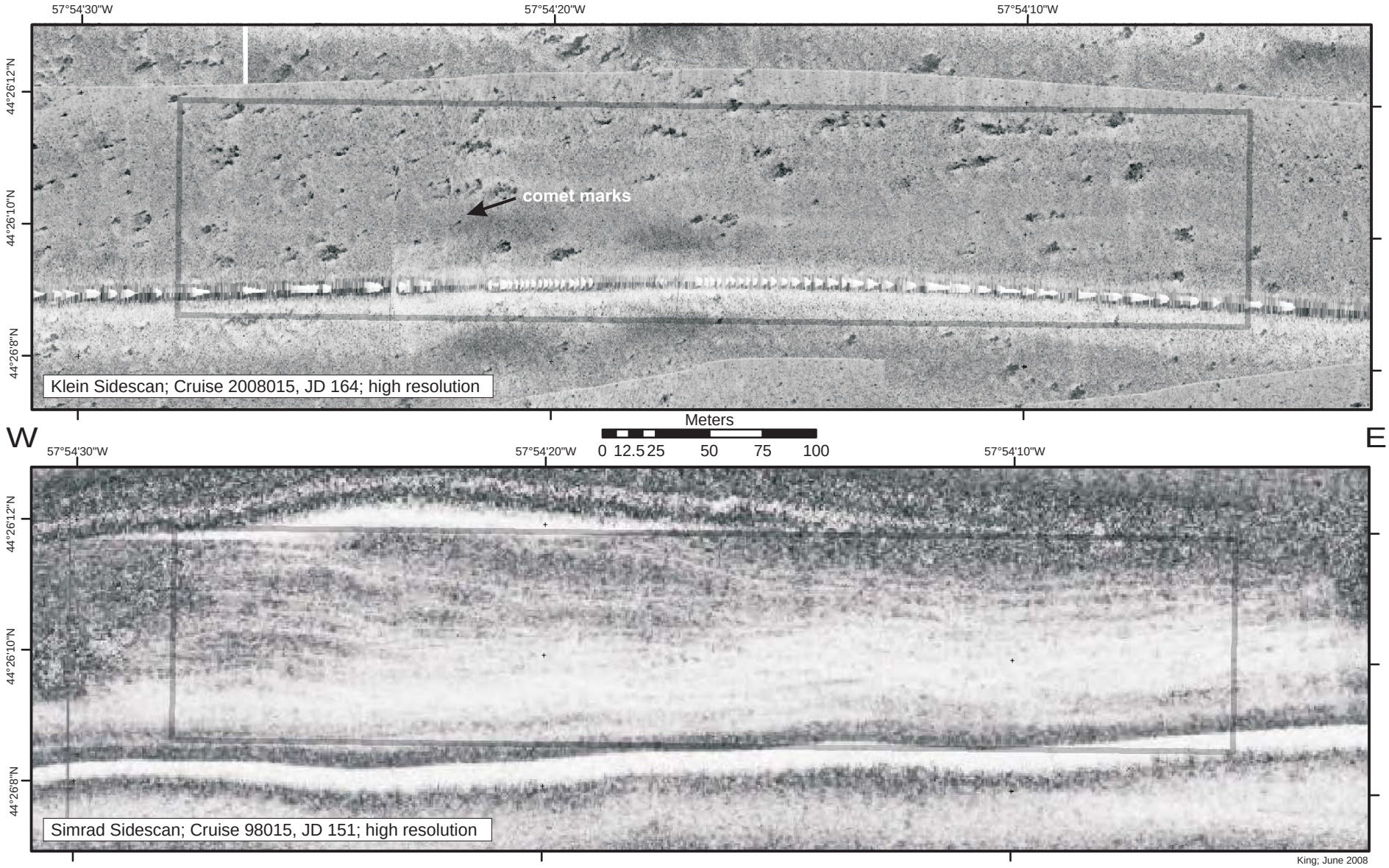

Figure 9. Georeferenced sidescan sonar images showing the state of the 1998 hydraulic dredge tracks at the **Box Y** site (grey outline) in two subsequent surveys. The upper box is from June 2008 and the lower from May 1998. Tracks were clearly visible a year after their creation and were only partially degraded five years after dredging (pg. 9, Josenhans et al. 2005). The seabed character has now changed significantly and the tracks have been eradicated, or nearly so by 2008. The dark patches may be coarse sand or fine gravel but disarticulated bivalves and whelks (spekcs) have been observed nearby (Gilkinson, 2003) and would generate similar backscatter. They occur in the troughs of small sand dunes (megaripples) which have since degraded. Currents along the bathymetric contours have created subtle comet marks to the west of some of the gravel/shell patches. This imparts a linearity which may be confused with local remnants of the dredge tracks. The 1998 data are displayed at lower resolution than the original data while the 2008 data are presented with very little degradation. Relative georeferencing of the sidescan images may be inaccurate within 20 to 30 m.

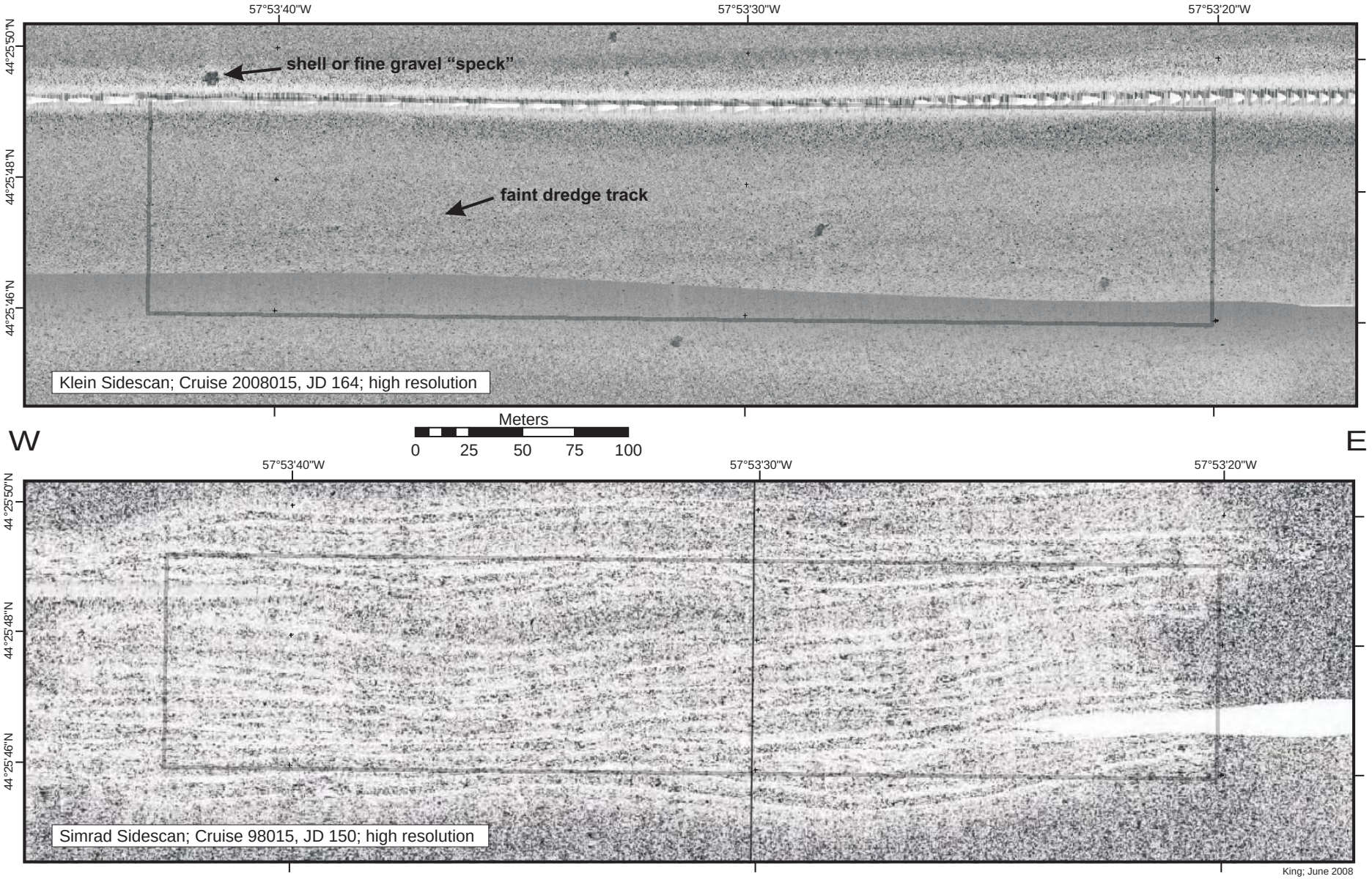

Figure 10. Georeferenced sidescan sonar images showing the state of the 1998 hydraulic dredge tracks at the **Box X** site (grey outline) in two subsequent surveys. The upper box is from June 2008 and the lower from May 1998. As for Box X, tracks were clearly visible a year after their creation and only partially degraded five years after (pg. 9, Josenhans et al. 2005). They have been nearly eradicated by 2008. The round dark patches in the 2008 survey are interpreted to be coarse sand or fine gravel but they may comprise scattered shells. They apparently developed after the intial survey. The tracks are now very faint but still visible. The 1998 data are displayed at lower resolution than the original data while the 2008 data are presented with very little degradation from the original. Relative georeferencing of the sidescan images may be inaccurate within 20 to 30 m.

developed wave-formed ripples evident in the sidescan sonograms have estimated amplitudes of 1 to 2 decimetres, suggesting periodic reworking to at least half this amplitude. Given the maximum 20 cm relief observed on the nearby dredges, it seems likely that formation and degradation of the bedforms in the area could be responsible for most of the dredge degradation.

4.0 LAURENTIAN CHANNEL PHOTOGRAPHIC OPERATIONS

4.1 THE OBJECTIVE

Table 6 lists the pre-cruise potential targets and planned operations. All three sites were investigated and an additional site added (Scatarie Moraine) en route to Louisbourg. Figure 11 shows the sites and photo/video transects in detail. Table 7 provides a listing of the sample and video transect stations. Table 8 is a ship-board running commentary of video operations. Table 9 is a listing of the still photography and brief description from all transects.

Table 6. Laurentian Channel Planned Stations and Rational

Target	Position Tolerance	Operations	Priority	Water Depth, m approx.	Source/Target DataBasis	Longitude	Latitude
v large ice scour? pits 5-10 deep w gravel?; dense scatteerd eyed pockmarks; specks; 5-10 m dia; 75 m space	200 m start or end	Campod drift; maybe 2km; prob videograb followup	1	385	2006048 GSCA sidescan; 2691103	-56.444719	44.748574
v large ice scour? pits 5-10 deep w gravel?; dense scattered eyed pockmarks; specks; 5-10 m dia; 75 m space	200 m start or end	Campod drift; maybe 2km; prob videograb followup	1	375	2006048 GSCA sidescan; 2691046	-56.462301	44.767731
shallow eyed pockmarks on channel flank; targets 15 to 20 diameter; 350 m spacing	200 m; don't go shallower than this	Campod drift; min 500 m; poss videograb followup	2	284	2007016 GSCA sidescan; 1622222	-56.532256	45.498053
shallow eyed pockmarks on channel flank; targets 15 to 20 diameter; 350 m spacing	200 m start here; work uphill	Campod drift; min 500 m; poss videograb followup	2	324	2007016 GSCA sidescan; 1622159	-56.558484	45.477285
linear scour berms and occassional specks; berms oriented 135 deg; spacing 2 km; specks spacing 300m	200 m start to south of this	Campod drift; min 500 m; poss videograb followup	3	420	2007016 GSCA sidescan; 1621903	-56.799900	45.404098
linear scour berms and occassional specks; berms oriented 135 deg; spacing 2 km; specks spacing 300m	200 m	Campod drift; min 500 m; poss videograb followup	3	416	2007016 GSCA sidescan; 1621920	-56.772108	45.400947
deepest exposed iceberg scour berms; 35% seabed is gravel?; occassional specks	200 m	Campod drift; maybe300m; poss videograb followup	4	350	2006048 GSCA sidescan; 2691155	-56.428859	44.680759

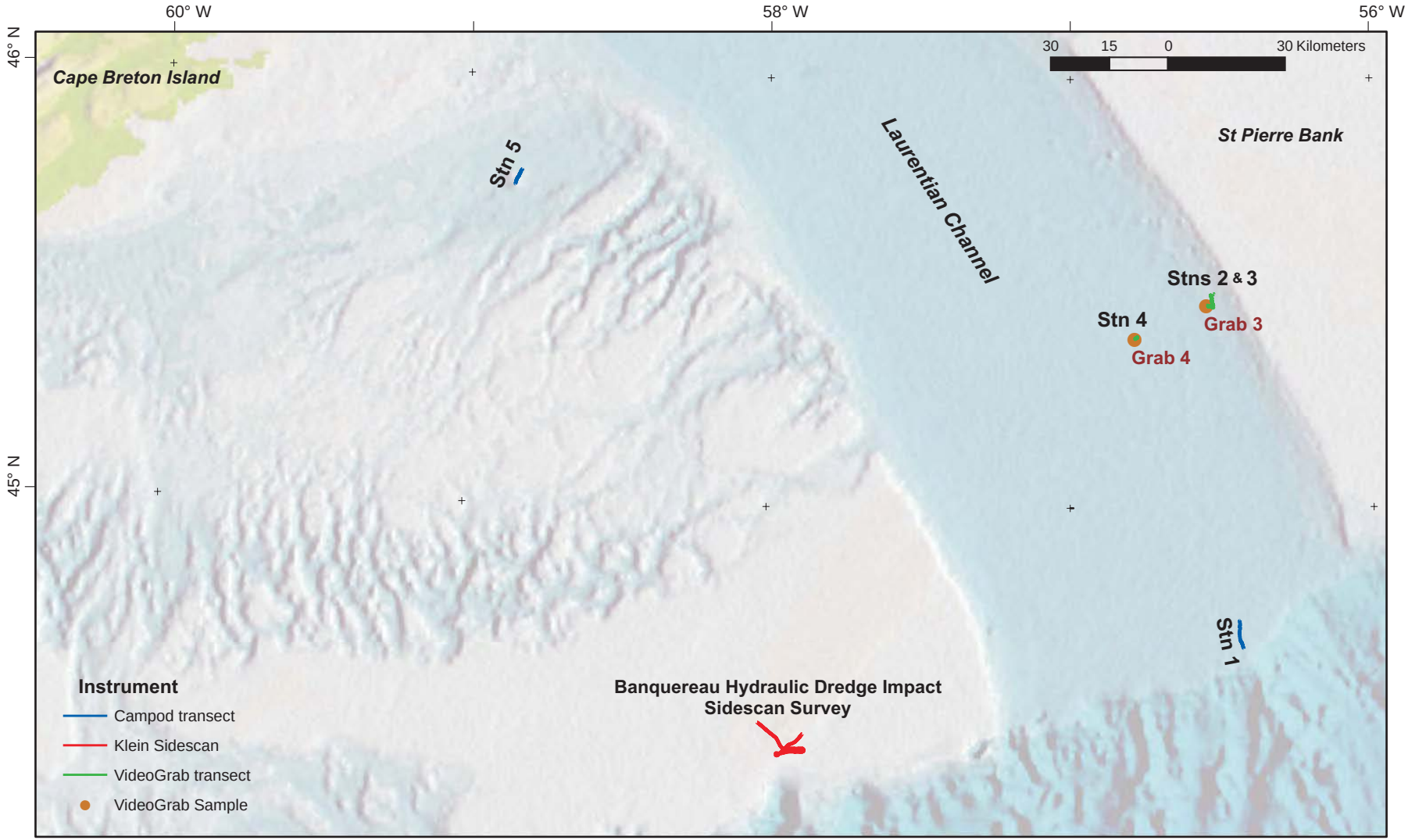

Figure 11. Location of operations including sidescan survey, photography (Campod) and sample stations.

Table 7. Stations Listing

GSC Station	DFO Station	Sample Type		Day	Time, UTC	Latitude	Longitude	DFO-VCR Tape ID	Location	Comment
1	LC-5	CamPod	Start	164	223855	44.737990	-56.444725	v1	Outer Laurentian Channel	95 photographs; ca. 7.8 km transect; all photos with descriptions online
1	LC-5	CamPod	Stop	165	034738	44.671459	-56.431484	v1	Outer Laurentian Channel	
2	LC-6	VideoGrab	Start	165	094203	45.499348	-56.525649	vg1o	Mid- Laurentian Channel	ca. 0.4 km transect
2	LC-6	VideoGrab	Stop	165	100343	45.498899	-56.521235	vg1o	Mid- Laurentian Channel	
3	LC-7	VideoGrab	Start	165	104016	45.496290	-56.533250	vg1o	Mid- Laurentian Channel	ca. 6.0 km transect
3	LC-7	VideoGrab	Grab	165	140732	45.472592	-56.548885	vg1o	Mid- Laurentian Channel	Grab Sample
3	LC-7	VideoGrab	Stop	165	140749	45.472568	-56.548873	vg1o	Mid- Laurentian Channel	
4	LC-8	VideoGrab	Start	165	165753	45.398864	-56.778225	vg2o	Mid- Laurentian Channel	ca. 1.0 km transect
4	LC-8	VideoGrab	Grab	165	174813	45.395510	-56.786592	vg2o	Mid- Laurentian Channel	Grab Sample
4	LC-8	VideoGrab	Stop	165	174838	45.395521	-56.786622	vg2o	Mid- Laurentian Channel	
5	LC-9	CamPod	Start	166	034622	45.778539	-58.825042	cp3-v	Scatarie Moraine/St Ann's Basin off Cape Breton	90 photographs; ca. 4.5 km transect; all photos with descriptions online
5	LC-9	CamPod	Stop	166	050135	45.742233	-58.847001	cp3-v	Scatarie Moraine/St Ann's Basin off Cape Breton	

Table 8. Video Transect Description

Station	Type	Day	Time, UTC	Description	Comment
1	CamPod	164	223858		Outer Laurentian Channel; on bottom
1	CamPod	164	223903	mud	
1	CamPod	164	224117	cobble surrounded by mud	
1	CamPod	164	224823	soft mud with siphon holes and occassional pits;red fish; sea pens	
1	CamPod	164	230026	cobble and gravel	drift too fast
1	CamPod	164	230904	small mounds; pits; trails; flock	
1	CamPod	164	231507	furrow or trough 0.25 m wide 15 cm deep	covered about 1 km since deployment
1	CamPod	164	232200	cobble?	
1	CamPod	164	232827	cobbles and gravel	
1	CamPod	164	232853	cobbles; scattered; mostly mud	
1	CamPod	164	232942	large rounded pits; 0.5 m diameter ca. 10-20 cm deep	
1	CamPod	164	233125	gravel and rare cobbles continued to time 2333	
1	CamPod	164	233440	end of gravel	
1	CamPod	164	233631	photo of cobble; continues to time 2337 then mud	
1	CamPod	164	234240	mainly mud but occassional gravel and cobbles	
1	CamPod	164	234743	sculpted seabed; some linear 0.25 to 0.5 m across	
1	CamPod	164	235500	small gravel patch	
1	CamPod	164	235539	sculpted mud; 0.5 m diamter or smaller; smooth and round	
1	CamPod	165	000333	wave forms in mud; linear crested; less than 0.5 m wavelength	
1	CamPod	165	000555	occassional cobbles; photo on edge of long linear furrow	
1	CamPod	165	001239	cobbles in mud; scattered	
1	CamPod	165	002501	large smooth-sided pit maybe 75 cm wide-elongated and 20 cm? deep	see photographs and descriptions
1	CamPod	165	010213	large furrow with vertical edge eroded	see photographs and descriptions
1	CamPod	165	010341	increase in gravel content; probably iceberg scour area	see photographs and descriptions
1	CamPod	165	010345		end station; retreive gear; steam to next site
2	VideoGrab	165	065754	turbid views due to impact with seabed	Eastern L channel flank; in water for about 20 min
2	VideoGrab	165	071500		bring grab to deck to adjust oblique camera angle
3	VideoGrab	165	074300	on bottom and recording; mud; sea pens	
3	VideoGrab	165	074334	small shell patch	regulus event 597
3	VideoGrab	165	?	shells and unidentified mounds of mud	regulus event 598
3	VideoGrab	165	080650	continuous mud and sea pens; occassional white specks, probably sponge; soft	
3	VideoGrab	165	110631	no more variability in mud and fauna so stop transect	grab sample
4	VideoGrab	165	165753		Central Caurentian Channel; DFO site Con8
4	VideoGrab	165	174838	circa 75 minute transect summarized: mud; possibly more sand than on flank. Fewer sea pens and more abundant corals and anenomes. Higher degreee of traces and scupting of the seabed. Some anenomes attest to a hard substrate just below the mud line while pens attest to the thicker mud. No outcropping gravel or cobbles as per sidescan record.	Grab bar often hitting seabed and picking up several kg which then clouds the cameras as it erodes and falls. Heave causing severe yo-yo problems and poor visibility. Grab sample
5	CamPod	166	034622	no running commentary	Scatarie Moraine; see photographs and descriptions

Table 9. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
001	1	Img2008-06-12 223844.JPG	44.737964	-56.444720	223901	280.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation	linear traces
001	2	Img2008-06-12 223922.JPG	44.737812	-56.444638	223939	285.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation	linear traces; anemone
001	3	Img2008-06-12 224002.JPG	44.737675	-56.444532	224019	288.00		grey mud with thin surficial flocculate and bioturbation	linear traces; anemone; pen
001	4	Img2008-06-12 224042.JPG	44.737552	-56.444458	224059	279.00		grey mud with thin surficial flocculate and bioturbation; worm tubes	linear traces; tubes
001	5	Img2008-06-12 224128.JPG	44.737434	-56.444381	224145	282.00	partial photo only	grey mud with thin surficial flocculate and bioturbation	
001	6	Img2008-06-12 224228.JPG	44.737322	-56.444327	224245	275.00		grey mud with thin surficial flocculate and bioturbation; worm tubes	linear traces; anemone; tubes; redfish
001	7	Img2008-06-12 224600.JPG	44.737083	-56.444222	224617	286.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes	linear traces; tubes; redfish
001	8	Img2008-06-12 224738.JPG	44.736719	-56.444393	224755	297.00		grey mud with thin surficial flocculate and bioturbation; worm tubes	linear traces; anemone; tubes
001	9	Img2008-06-12 224914.JPG	44.736054	-56.444578	224931	307.00		grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric	linear traces; anemone; sponge?; tubes
001	10	Img2008-06-12 225020.JPG	44.735551	-56.444606	225037	329.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric	linear traces; anemone; pen
001	11	Img2008-06-12 225524.JPG	44.732969	-56.444269	225541	352.00		grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric	linear traces; tubes
001	12	Img2008-06-12 230008.JPG	44.730544	-56.443862	230025	333.00		rounded gravel with intersticial mud and flocculate; various pebble lithologies; tubes; sponge?	sponge?
001	13	Img2008-06-12 230014.JPG	44.730493	-56.443850	230031	336.00		cobble and rounded gravel with intersticial mud and floculate; anemone; worm and sponge?	anemone; worm and sponge?
001	14	Img2008-06-12 230030.JPG	44.730355	-56.443813	230047	341.00		grey mud with thin surficial flocculate and bioturbation; worm tubes and flatfish	worm tubes and flatfish
001	15	Img2008-06-12 230142.JPG	44.729730	-56.443670	230159	340.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes and seapen	worm tubes and seapen
001	16	Img2008-06-12 231202.JPG	44.725951	-56.444468	231219	339.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric	linear traces; anemone; pen
001	17	Img2008-06-12 231404.JPG	44.725502	-56.444774	231421	338.00		grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric; crab	linear traces; tubes; crab
001	18	Img2008-06-12 231408.JPG	44.725485	-56.444778	231425	368.00	partial photo only	grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric; crab	linear traces; tubes; crab
001	19	Img2008-06-12 231814.JPG	44.724416	-56.444883	231831	345.00		grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric; redfish	linear traces; tubes; redfish; seapen
001	20	Img2008-06-12 232424.JPG	44.723024	-56.444653	232441	345.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; sponge?	worm tubes; sponge?
001	21	Img2008-06-12 232504.JPG	44.722865	-56.444612	232521	345.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes and seapen	linear traces; pen
001	22	Img2008-06-12 232752.JPG	44.722188	-56.444403	232809	344.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes	small demersal fish; white branching coral?
001	23	Img2008-06-12 232814.JPG	44.722103	-56.444368	232831	344.00	interpolated water depth	rounded gravel with intersticial mud and flocculate	worm tubes
001	24	Img2008-06-12 233024.JPG	44.721582	-56.444203	233041	343.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; mud ejecta from worm hole	worm tubes
001	25	Img2008-06-12 233108.JPG	44.721391	-56.444180	233125	343.00		fine gravel with intersticial mud and minor flocculate; various pebble lithologies; tubes?; tunicate?	anemone
001	26	Img2008-06-12 233204.JPG	44.721163	-56.444114	233221	343.00	interpolated water depth	scattered gravel and cobble with thin mud and flocculate cover; sponge? and various growths on cobbles	sponge?
001	27	Img2008-06-12 233306.JPG	44.720918	-56.444042	233323	342.00	interpolated water depth	scattered gravel and cobble with thin mud and flocculate cover; worm tubes; white sponge?	worm tubes and sponge?
001	28	Img2008-06-12 233614.JPG	44.720191	-56.443753	233631	341.00		scattered gravel and cobble with thin mud and flocculate cover; sponge? and various growths on cobbles	worm tubes and sponge?
001	29	Img2008-06-12 233716.JPG	44.719985	-56.443644	233733	341.00		mud with surficial flocculate; worm tubes; eel; cucumber?	worm tubes; eel; cucumber?
001	30	Img2008-06-12 233750.JPG	44.719868	-56.443627	233807	336.00		scattered cobble with thin mud and flocculate cover; anemone; mud ejecta from worm hole	worm tubes; anemone
001	31	Img2008-06-12 233816.JPG	44.719772	-56.443633	233833	338.00		grey mud with thin surficial flocculate and bioturbation; anemone	worm tubes; anemone
001	32	Img2008-06-12 233908.JPG	44.719586	-56.443597	233925	343.00		grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric	worm tubes; anemone; cucumber?
001	33	Img2008-06-12 234234.JPG	44.718951	-56.443326	234251	338.00		scattered gravel and cobble with thin mud and flocculate cover; current fabric; linear traces; various growths on cobbles	
001	34	Img2008-06-12 234338.JPG	44.718778	-56.443262	234355	340.00		cobble and gravel with thin surficial flocculate; various growths on cobbles; redfish	various growths on cobbles; anemone; redfish

Table 9; Continued. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
001	35	Img2008-06-12 234700.JPG	44.718176	-56.443174	234717	315.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; crab; small cucumbers?	crab; small cucumbers?
001	36	Img2008-06-12 235442.JPG	44.717325	-56.444711	235459	302.00		cobble and gravel with intersticial mud and floculate; sponge?; redfish	sponge?; redfish
001	37	Img2008-06-12 235626.JPG	44.717225	-56.444947	235643	303.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes; current fabric; anemone; small cucumbers?	anemone; small cucumbers?
001	38	Img2008-06-12 235848.JPG	44.716999	-56.445127	235905	305.00		cobble with thin surficial flocculate; various growths on cobbles; anemone; small cucumbers?	anemone; small cucumbers?
001	39	Img2008-06-13 000538.JPG	44.716313	-56.445274	000555	301.00	interpolated water depth	grey mud with thin surficial flocculate and linear traces of bioturbation; worm tubes	linear traces; tubes
001	40	Img2008-06-13 000700.JPG	44.716222	-56.445465	000717	298.00		cobble and fine gravel with thin surficial flocculate; various growths on cobbles; redfish; anemone	redfish; anemone
001	41	Img2008-06-13 000708.JPG	44.716224	-56.445472	000725	267.00		cobble with anemone and sponge?	anemone; sponge?
001	42	Img2008-06-13 001212.JPG	44.715076	-56.445209	001229	378.00		scattered gravel with mud and flocculate cover; linear traces; small cucumber?; mud ejecta from worm hole	small cucumber?
001	43	Img2008-06-13 001724.JPG	44.712655	-56.445320	001741	343.00		scattered gravel with mud and flocculate cover; linear traces	anemone; eel; dead bivalves
001	44	Img2008-06-13 002256.JPG	44.711092	-56.445440	002313	326.00		cobble and scattered gravel with thin mud cover and flocculate	cobble with branching growths
001	45	Img2008-06-13 002826.JPG	44.710159	-56.445637	002843	327.00		grey mud with thin surficial flocculate and bioturbation	sea pen?
001	46	Img2008-06-13 003104.JPG	44.709312	-56.445590	003121	342.00		grey mud with thin surficial flocculate and bioturbation; worm tubes	crab; anemone; worm holes
001	47	Img2008-06-13 003354.JPG	44.708492	-56.445559	003411	339.00		grey mud with thin surficial flocculate and bioturbation	soft coral; small sea cucumber?
001	48	Img2008-06-13 003428.JPG	44.708352	-56.445549	003445	341.00	interpolated water depth	cobble and fine gravel with thin surficial flocculate; various growths on cobbles	eel; disarticulated bivalves
001	49	Img2008-06-13 003530.JPG	44.708122	-56.445496	003547	342.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation	large worm holes; redfish; gastropod; pen
001	50	Img2008-06-13 003806.JPG	44.707560	-56.445624	003823	344.00		cobble and fine gravel with thin surficial flocculate; various growths on cobbles	soft coral?; small sea cucumber?
001	51	Img2008-06-13 004324.JPG	44.706531	-56.445652	004341	340.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation	small demersal fish
001	52	Img2008-06-13 004340.JPG	44.706476	-56.445641	004357	325.00	interpolated water depth	scattered gravel with mud and flocculate cover; linear traces	sea pen
001	53	Img2008-06-13 004534.JPG	44.706103	-56.445541	004551	316.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; mud ejecta from worm hole	small worm holes
001	54	Img2008-06-13 004830.JPG	44.705410	-56.445534	004847	308.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; mud ejecta from worm hole	small worm holes
001	55	Img2008-06-13 005134.JPG	44.704645	-56.445471	005151	295.00	interpolated water depth	cobble with mud and flocculate cover; linear traces; growths on cobble	small sea cucumber; growths on cobble
001	56	Img2008-06-13 010208.JPG	44.702570	-56.445398	010225	287.00		grey mud with thin surficial flocculate and bioturbation; large burrow	large burrow; sea pen; anemone;
001	57	Img2008-06-13 010324.JPG	44.702410	-56.445310	010341	293.00		cobble and scattered gravel with thin surficial flocculate; various growths on cobbles	small worm holes
001	58	Img2008-06-13 011200.JPG	44.701102	-56.444944	011217	280.00	interpolated water depth	cobble and scattered gravel with thin surficial flocculate; limited growth on cobbles	sponge or bryozoans?
001	59	Img2008-06-13 011734.JPG	44.700376	-56.444103	011751	267.00		grey mud with thin surficial flocculate and bioturbation	small worm holes; eel
001	60	Img2008-06-13 012208.JPG	44.699742	-56.444005	012225	280.00		grey mud with thin surficial flocculate and bioturbation	small worm holes; sea pen
001	61	Img2008-06-13 012954.JPG	44.698629	-56.444094	013011	280.00		cobble with thin surficial flocculate; anemone on cobble	anemone; worm holes; gastropod
001	62	Img2008-06-13 013022.JPG	44.698547	-56.444144	013039	278.00	interpolated water depth	cobble; thin mud; flocculate; worm holes and ejecta	worm holes; anemone; redfish
001	63	Img2008-06-13 013306.JPG	44.697968	-56.444252	013323	277.00		cobble and scattered gravel with thin surficial flocculate; various growths on cobbles	anemone; worm tracks; sponge?
001	64	Img2008-06-13 013326.JPG	44.697908	-56.444230	013343	280.00	interpolated water depth	scattered gravel mainly covered with flocculate and mud	worm holes
001	65	Img2008-06-13 013808.JPG	44.697022	-56.444001	013825	281.00	interpolated water depth	cobble and scattered gravel with thin surficial flocculate; limited growth on cobble	growths on cobble
001	66	Img2008-06-13 014006.JPG	44.696561	-56.444060	014023	283.00		cobble and scattered gravel with thin surficial flocculate; limited growth on cobble	growths on cobbles
001	67	Img2008-06-13 014014.JPG	44.696532	-56.444056	014031	278.00		cobble and scattered gravel with thin surficial flocculate; growths on cobbles	growths on cobbles; dead bivalves; worm holes
001	68	Img2008-06-13 014814.JPG	44.694203	-56.443619	014831	290.00	interpolated water depth	cobble with thin surficial flocculate; sponge? on cobble	growths on cobbles; dead bivalves; worm holes; soft coral?
001	69	Img2008-06-13 015104.JPG	44.693596	-56.443405	015121	299.00		grey mud with thin surficial flocculate; bioturbation and two large burrows	anemone; crill?
001	70	Img2008-06-13 015620.JPG	44.692167	-56.443075	015637	327.00		grey mud with thin surficial flocculate; bioturbation	worm holes; anemone?
001	71	Img2008-06-13 015632.JPG	44.692119	-56.443077	015649	320.00	interpolated water depth	grey mud with thin surficial flocculate; bioturbation	worm holes; sponge?

Table 9; Continued. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
001	72	Img2008-06-13 020250.JPG	44.690736	-56.442628	020307	314.00		cobble and scattered gravel with thin surficial flocculate; growths on cobbles	crab; anemone; worm holes
001	73	Img2008-06-13 020440.JPG	44.690306	-56.442139	020457	378.00		grey mud with thin surficial flocculate; bioturbation	sea pen; anemone; worm holes
001	74	Img2008-06-13 020500.JPG	44.690236	-56.442082	020517	380.00		cobble and scattered gravel with thin surficial flocculate; growths on cobbles	sponge?; anemone; worm holes
001	75	Img2008-06-13 020550.JPG	44.690055	-56.441999	020607	370.00	interpolated water depth	cobble and scattered gravel with thin surficial sand and flocculate; growths on cobbles	sponge?; anemone; worm holes; redfish
001	76	Img2008-06-13 020924.JPG	44.689109	-56.441473	020941	360.00	interpolated water depth	grey mud with thin surficial flocculate; bioturbation	anemone; sea pen
001	77	Img2008-06-13 022132.JPG	44.686257	-56.439216	022149	350.00	interpolated water depth	grey mud with thin surficial flocculate; linear trail bioturbation	worm tubes; soft coral?
001	78	Img2008-06-13 022212.JPG	44.686074	-56.439022	022229	340.00	interpolated water depth	cobble and scattered gravel with thin surficial flocculate; limited growth on cobble	sponge?; redfish; worm tubes
001	79	Img2008-06-13 023126.JPG	44.683664	-56.437063	023143	327.00		grey mud with thin surficial flocculate; bioturbation	small demersal fish
001	80	Img2008-06-13 023646.JPG	44.682739	-56.436886	023703	331.00		grey mud with thin surficial flocculate; bioturbation	sea pen; worm holes
001	81	Img2008-06-13 024214.JPG	44.682063	-56.436730	024231	320.00	interpolated water depth	grey mud with thin surficial flocculate; bioturbation	soft coral?; anemone; worm tubes
001	82	Img2008-06-13 024640.JPG	44.681724	-56.436240	024657	310.00	interpolated water depth	grey mud with thin surficial flocculate; bioturbation	soft coral?; worm tubes
001	83	Img2008-06-13 024736.JPG	44.681576	-56.436273	024753	300.00		cobble with thin surficial flocculate; limited growth on cobbles	anemone?; brittle star; worm tubes
001	84	Img2008-06-13 024850.JPG	44.681390	-56.436269	024907	285.00	interpolated water depth	cobble and scattered gravel with thin surficial flocculate; limited growth on cobble	worm holes; redfish; coral on cobble
001	85	Img2008-06-13 025408.JPG	44.680639	-56.435891	025425	271.00		grey mud with thin surficial flocculate; bioturbation	anemone; worm tubes
001	86	Img2008-06-13 025926.JPG	44.679774	-56.435447	025943	270.00	interpolated water depth	cobble and scattered gravel with thin surficial flocculate; little growth on cobbles	redfish; brittle star; worm tubes; sponge?
001	87	Img2008-06-13 025936.JPG	44.679744	-56.435446	025953	270.00		cobble and scattered gravel with thin surficial sand and flocculate; little growth on cobbles	coral?; bryozoan?
001	88	Img2008-06-13 030142.JPG	44.679405	-56.435226	030159	270.00		grey mud with thin surficial flocculate and bioturbation; linear trails; worm tubes	worm tubes
001	89	Img2008-06-13 030916.JPG	44.677938	-56.434756	030933	273.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; worm tubes	worm tubes; eel
001	90	Img2008-06-13 031500.JPG	44.676856	-56.434661	031517	274.00	interpolated water depth	cobble and scattered gravel with thin surficial sand and flocculate; little growth on cobbles	worm tubes
001	91	Img2008-06-13 032512.JPG	44.675007	-56.433899	032529	276.00	interpolated water depth	grey mud with thin surficial flocculate and bioturbation; linear trails; worm tubes and ejecta	worm tubes
001	92	Img2008-06-13 032742.JPG	44.674663	-56.433561	032759	280.00		cobble and scattered gravel with thin surficial sand and flocculate; little growth on cobbles	worm tubes; limited growth on cobble
001	93	Img2008-06-13 033410.JPG	44.673705	-56.432914	033427	281.00	interpolated water depth	scattered gravel and grey mud with thin surficial flocculate and bioturbation; degraded linear trails	worm tubes
001	94	Img2008-06-13 033640.JPG	44.673380	-56.432589	033657	283.00		grey mud with thin surficial flocculate and bioturbation; degraded linear trails	worm tubes; linear trails
001	95	Img2008-06-13 033654.JPG	44.673347	-56.432565	033711	283.00		cobble and scattered gravel with thin surficial sand and flocculate; growth on cobbles	small cucumber?; brittle star
005	1	Img2008-06-14 034738.JPG	45.777800	-58.825564	034755	212.00		mud with surficial flocculate; bioturbation; worm tubes; linear traces	worm tubes; burrows; linear tracks
005	2	Img2008-06-14 035552.JPG	45.774232	-58.829181	035609	186.00	interpolated water depth	cobble sand and surficial mud	anemone; brittle stars; bryozoa?; sea pen?
005	3	Img2008-06-14 035640.JPG	45.773866	-58.829490	035657	192.00	intensity and contrast adjustment	cobble and surficial mud; linear traces	bryozoa?; worm tubes; redfish
005	4	Img2008-06-14 035938.JPG	45.772247	-58.829850	035955	197.00		cobble sand and surficial mud; burrow; linear traces; worm tubes	sponge?; bryozoa?; worm tubes; soft coral?; redfish
005	5	Img2008-06-14 040036.JPG	45.771656	-58.830153	040053	198.00	interpolated water depth	cobble sand and surficial mud; burrow; linear traces; worm tubes	sponge?; bryozoa?; worm tubes; soft coral?
005	6	Img2008-06-14 040038.JPG	45.771647	-58.830178	040055	199.00	interpolated water depth; intensity and contrast adjustment	cobble sand and surficial mud; burrow; linear traces; worm tubes	sponge?; bryozoa?; worm tubes; soft coral?
005	7	Img2008-06-14 040220.JPG	45.770815	-58.831008	040237	199.00	intensity and contrast adjustment	scattered gravel with covering mud and flocculate	sponge; worm tubes; linear tracks; bryozoa?
005	8	Img2008-06-14 040230.JPG	45.770760	-58.831080	040247	218.00	interpolated water depth	scattered gravel with covering mud and flocculate	sponge; worm tubes; linear tracks; bryozoa?
005	9	Img2008-06-14 040246.JPG	45.770638	-58.831188	040303	228.00	intensity and contrast adjustment	cobble and surficial mud; burrow; linear traces; worm tubes; growth on cobbles	sponge; anemone; worm tubes; linear tracks; bryozoa?
005	10	Img2008-06-14 040504.JPG	45.769637	-58.831861	040521	275.00	intensity and contrast adjustment	mud; burrow; linear traces; worm tubes	sponge; worm tubes; linear tracks; starfish; bryozoa?
005	11	Img2008-06-14 040514.JPG	45.769552	-58.831900	040531	235.00	interpolated water depth; intensity and contrast adjustment	cobble and surficial mud; burrow; linear traces; worm tubes; growth on cobbles	sponge; worm tubes; linear tracks; bryozoa?; shrimp?

Table 9; Continued. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
005	12	Img2008-06-14 040536.JPG	45.769331	-58.831996	040553	195.00		cobbles and surficial mud; linear traces; worm tubes; growth on cobbles	sponge; anemone; worm tubes; linear tracks; bryozoa?; shrimp?
005	13	Img2008-06-14 040920.JPG	45.767701	-58.833094	040937	232.00		cobbles and surficial mud; linear traces; worm tubes; burrows with ejecta; growth on cobbles	sponge; anemone; brittle star; worm tubes; linear tracks; bryozoa?
005	14	Img2008-06-14 040940.JPG	45.767592	-58.833216	040957	237.00		mud; grey with surficial flocculate; burrows	sponge; anemone; brittle star; white star; worm tubes; linear tracks; bryozoa?; unidentified white globular forms
005	15	Img2008-06-14 041038.JPG	45.767275	-58.833580	041055	245.00		mud; grey with surficial flocculate; burrows	skate; anemone; worm tubes; linear tracks; bryozoa?; shrimp
005	16	Img2008-06-14 041348.JPG	45.765737	-58.834306	041405	253.00	intensity and contrast adjustment	mud; grey with surficial flocculate; burrows	dead bivalve; anemone; brittle star; worm tubes; linear tracks
005	17	Img2008-06-14 041512.JPG	45.764949	-58.834843	041529	161.00		gravel with surficial mud and flocculate; burrows	brittle star; white star; worm tubes; linear tracks; bryozoa?; unidentified white globular forms
005	18	Img2008-06-14 041528.JPG	45.764846	-58.835005	041545	164.00	intensity and contrast adjustment	cobble; minor gravel with surficial mud and flocculate; worm tubes; growth on cobble	worm tubes; linear tracks; bryozoa?; anemone
005	19	Img2008-06-14 042218.JPG	45.761380	-58.836139	042235	156.00	interpolated water depth; intensity and contrast adjustment	mud; grey with surficial flocculate; burrows with ejecta	worm tubes; brittle stars; burrows; bryozoa?
005	20	Img2008-06-14 042344.JPG	45.760710	-58.836984	042401	149.00		mud; grey with surficial flocculate; burrows	worm tubes; brittle stars; burrows; bryozoa?; anemone; soft coral?
005	21	Img2008-06-14 042432.JPG	45.760362	-58.837533	042449	147.00	intensity and contrast adjustment	mud; linear traces; worm tubes; burrows	worm tubes; linear tracks; bryozoa?; unidentified white globular forms
005	22	Img2008-06-14 042438.JPG	45.760320	-58.837612	042455	148.00	intensity and contrast adjustment	cobble; minor gravel with surficial mud and flocculate; worm tubes; growth on cobble	sponge; worm tubes; linear tracks; bryozoa?; unidentified white globular forms
005	23	Img2008-06-14 042456.JPG	45.760213	-58.837836	042513	146.00		mud; grey with surficial flocculate; burrows with ejecta	anemone; bryozoa?; brittle star; linear tracks; burrows
005	24	Img2008-06-14 042520.JPG	45.760098	-58.838146	042537	145.00		mud; grey with surficial flocculate; worm tubes; burrows	worm tubes; burrows
005	25	Img2008-06-14 042558.JPG	45.759955	-58.838628	042615	145.00	intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes; burrows	worm tubes; burrows
005	26	Img2008-06-14 042638.JPG	45.759809	-58.839076	042655	145.00	interpolated water depth	mud; grey with surficial flocculate; worm tubes; burrows with ejecta	sponge; soft coral?; anemone; burrows; linear tracks
005	27	Img2008-06-14 042706.JPG	45.759660	-58.839317	042723	146.00		mud; grey with surficial flocculate; worm tubes; burrows with ejecta	anemone; worm tubes; burrows; bryozoa?; linear tracks
005	28	Img2008-06-14 042734.JPG	45.759504	-58.839530	042751	156.00	intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes; burrows	shrimp; brittle star; worm tubes; burrows; bryozoa?; linear tracks
005	29	Img2008-06-14 042808.JPG	45.759316	-58.839746	042825	146.00		mud; grey with surficial flocculate; worm tubes; burrows	white starfish; worm tubes; bryozoa?
005	30	Img2008-06-14 042900.JPG	45.758954	-58.840006	042917	146.00	interpolated water depth	mud; grey with surficial flocculate; worm tubes; burrows	brittle star; white starfish; worm tubes; soft coral?
005	31	Img2008-06-14 042932.JPG	45.758732	-58.840130	042949	146.00		cobble; minor gravel with surficial mud and flocculate; worm tubes; growth on cobble	worm tubes; bryozoa?
005	32	Img2008-06-14 043030.JPG	45.758261	-58.840300	043047	146.00	interpolated water depth; intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes; burrows with ejecta	worm tubes
005	33	Img2008-06-14 043042.JPG	45.758166	-58.840348	043059	146.00	partial scan only	mud; grey with surficial flocculate; worm tubes	brittle stars; worm tubes; linear tracks; soft coral?
005	34	Img2008-06-14 043114.JPG	45.757884	-58.840494	043131	145.00		mud; grey with surficial flocculate; worm tubes	worm tubes; soft coral?
005	35	Img2008-06-14 043138.JPG	45.757635	-58.840608	043155	145.00	intensity and contrast adjustment	mud; grey with surficial flocculate; burrows; worm tubes	anemone; brittle stars; worm tubes; linear tracks; soft coral?; bryozoa?
005	36	Img2008-06-14 043154.JPG	45.757502	-58.840733	043211	143.00		mud; grey with surficial flocculate; worm tubes	worm tubes; linear tracks; bryozoa?
005	37	Img2008-06-14 043218.JPG	45.757278	-58.840887	043235	143.00	interpolated water depth	mud; grey with surficial flocculate; worm tubes; burrows with ejecta	worm tubes; burrows; linear tracks; bryozoa?
005	38	Img2008-06-14 043230.JPG	45.757154	-58.840960	043247	143.00	intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes	brittle star; anemone; worm tubes; bryozoa?
005	39	Img2008-06-14 043338.JPG	45.756568	-58.841470	043355	142.00	intensity and contrast adjustment	cobble; with surficial mud and flocculate; worm tubes; growth on cobble	sponge; brittle star; anemone; worm tubes; bryozoa?
005	40	Img2008-06-14 043352.JPG	45.756451	-58.841558	043409	142.00		cobble; with surficial mud and flocculate; worm tubes; burrows with ejecta; growth on cobble	anemone; linear tracks; soft coral?; sponge?; bryozoa?; dead sand dollar
005	41	Img2008-06-14 043412.JPG	45.756268	-58.841697	043429	142.00	intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes	anemone; brittle stars; worm tubes; unidentified white globular forms; bryozoa?
005	42	Img2008-06-14 043450.JPG	45.755927	-58.841975	043510	142.00		mud; grey with surficial flocculate; worm tubes	sponge; brittle stars; worm tubes; unidentified white globular forms; bryozoa?
005	43	Img2008-06-14 043500.JPG	45.755870	-58.842022	043517	141.00		mud; grey with surficial flocculate; worm tubes	brittle stars; worm tubes; burrows; unidentified white globular forms; bryozoa?

Table 9; Continued. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
005	44	Img2008-06-14 043654.JPG	45.755036	-58.842811	043711	141.00		mud; grey with surficial flocculate; worm tubes; burrows with ejecta	anemone; worm tubes; burrows; bryozoa?; dead bivalve
005	45	Img2008-06-14 043728.JPG	45.754804	-58.843020	043745	141.00	intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes	worm tubes; burrows; unidentified white globular forms; bryozoa?
005	46	Img2008-06-14 043734.JPG	45.754762	-58.843053	043751	141.00	interpolated water depth; intensity and contrast adjustment	cobbles; with surficial mud and flocculate; worm tubes; burrows; growth on cobble	sponge; linear tracks; worm tubes; bryozoa?
005	47	Img2008-06-14 044006.JPG	45.753749	-58.843791	044023	150.00	interpolated water depth; intensity and contrast adjustment	mud; grey with surficial flocculate; worm tubes	worm tubes; burrows; dead bivalve
005	48	Img2008-06-14 044052.JPG	45.753372	-58.844002	044109	160.00	interpolated water depth	cobble; mud; grey with surficial flocculate; burrows	sponge; brittle star; dead bivalve; burrows
005	49	Img2008-06-14 044334.JPG	45.751709	-58.844802	044351	170.00	interpolated water depth	cobble; some sand; mud; grey with surficial flocculate; worm tubes	worm tubes; dead bivalve
005	50	Img2008-06-14 044410.JPG	45.751416	-58.844764	044427	188.00		mud; grey with surficial flocculate; worm tubes	worm tubes; starfish; soft coral?; bryozoa?
005	51	Img2008-06-14 044444.JPG	45.751169	-58.844639	044501	163.00	interpolated water depth	cobble; mud; grey with surficial flocculate; growth on cobbles	sponge; bryozoa?; soft coral?; unidentified white globular forms; anemone
005	52	Img2008-06-14 044454.JPG	45.751087	-58.844624	044511	139.00		cobble; mud; grey with surficial flocculate; growth on cobbles	sponge; bryozoa?; linear tracks
005	53	Img2008-06-14 044504.JPG	45.751002	-58.844627	044521	139.00		cobble; gravel with surficial mud and flocculate; worm tubes; growth on cobble	sponge; soft coral?; anemone; brittle stars; worm tubes; white starfish; unidentified white globular forms; bryozoa?
005	54	Img2008-06-14 044512.JPG	45.750928	-58.844638	044529	139.00		gravel with surficial mud and flocculate; worm tubes	brittle stars; white starfish; linear tracks; sponge?; worm tubes
005	55	Img2008-06-14 044526.JPG	45.750782	-58.844684	044543	139.00		cobble; gravel with surficial mud and flocculate; worm tubes; limited growth on cobble	sponge; anemone;linear tracks; worm tubes; unidentified white globular forms; bryozoa?
005	56	Img2008-06-14 044540.JPG	45.750632	-58.844745	044557	140.00	interpolated water depth	cobble; gravel with surficial mud and flocculate; worm tubes; growth on cobble	sponge; soft coral?; anemone; worm tubes; unidentified white globular forms; bryozoa?; crab
005	57	Img2008-06-14 044546.JPG	45.750565	-58.844780	044603	142.00	interpolated water depth; intensity and contrast adjustment	cobble; gravel; sand; with surficial mud and flocculate; worm tubes; growth on cobble	sponge; soft coral; worm tubes; unidentified white globular forms; bryozoa?
005	58	Img2008-06-14 044554.JPG	45.750470	-58.844830	044611	143.00	interpolated water depth; intensity and contrast adjustment	cobble; gravel; sand; with surficial mud and flocculate; worm tubes; limited growth on cobble	sponge; soft coral; anemone; worm tubes; unidentified white globular forms; bryozoa?
005	59	Img2008-06-14 044602.JPG	45.750382	-58.844892	044619	144.00	interpolated water depth; intensity and contrast adjustment	cobble; gravel; sand; with surficial mud and flocculate; worm tubes; growth on cobble	worm tubes; dead bivalve; unidentified white globular forms; bryozoa?
005	60	Img2008-06-14 044618.JPG	45.750202	-58.845030	044635	145.00		cobble; gravel; sand; with surficial mud and flocculate; worm tubes; growth on cobble	worm tubes; sponge?; bryozoa?
005	61	Img2008-06-14 044642.JPG	45.749940	-58.845260	044659	146.00		cobble; gravel; sand; with surficial mud and flocculate; worm tubes; growth on cobble	sponge; soft coral?; anemone; worm tubes; unidentified white globular forms; dead bivalve; bryozoa?
005	62	Img2008-06-14 044650.JPG	45.749861	-58.845326	044707	147.00	intensity and contrast adjustment	gravel with surficial mud and flocculate; worm tubes	worm tubes; dead bivalve; bryozoa?
005	63	Img2008-06-14 044700.JPG	45.749765	-58.845422	044717	148.00		cobble; minor gravel; surficial mud and flocculate; worm tubes; limited growth on cobble	sponge; soft coral?; worm tubes; brittle stars; bryozoa?
005	64	Img2008-06-14 044742.JPG	45.749382	-58.845770	044759	154.00		cobble; minor gravel; surficial mud and flocculate; worm tubes; limited growth on cobble	sponge; soft coral?; anemone; worm tubes; brittle stars; bryozoa?; dead bivalve
005	65	Img2008-06-14 044850.JPG	45.748830	-58.846138	044907	159.00	interpolated water depth	sand; minor gravel; some mud and flocculate; worm tubes	sponge; soft coral?; worm tubes; brittle stars; bryozoa?; dead bivalves
005	66	Img2008-06-14 044936.JPG	45.748406	-58.846208	044953	165.00	partial scan only; intensity and contrast adjustment	cobble; minor gravel; sand and surficial mud and flocculate; worm tubes; growth on cobble	sponge; soft coral?; worm tubes; linear tracks; bryozoa?
005	67	Img2008-06-14 045048.JPG	45.747727	-58.846294	045105	172.00	intensity and contrast adjustment	sand and minor gravel; worm tubes	sponge; soft coral?; anemone; brittle stars; worm tubes; bryozoa?
005	68	Img2008-06-14 045112.JPG	45.747529	-58.846274	045129	176.00	intensity and contrast adjustment	cobble; minor gravel; sand and surficial mud and flocculate; growth on cobble	sponge; soft coral; brittle stars; linear tracks; bryozoa?
005	69	Img2008-06-14 045126.JPG	45.747420	-58.846270	045143	178.00		cobble; minor gravel; sand and surficial mud and flocculate; growth on cobble	sponge; soft coral; anemone; dead bivalve; linear tracks; bryozoa?
005	70	Img2008-06-14 045144.JPG	45.747264	-58.846303	045201	182.00	interpolated water depth	gravel with surficial mud and flocculate	sponge; soft coral; brittle stars; worm tubes; linear tracks; bryozoa?
005	71	Img2008-06-14 045226.JPG	45.746856	-58.846538	045243	186.00		sand with surficial mud and flocculate	sponge; soft coral; brittle stars; shrimp; anemones; dead bivalve; worm tubes; linear tracks; bryozoa?

Table 9; Continued. Still seabed photography listing and general description

STA-TION	Serial No.	FILE NAME	Latitude	Longitude	UTC Time	WATER DEPTH	COMMENTS	GEOLOGY DESCRIPTION	BIOLOGY DESCRIPTION
005	72	Img2008-06-14 045232.JPG	45.746797	-58.846592	045249	187.00	interpolated water depth	sand with surficial mud and flocculate	sponge; soft coral; brittle stars; anemones; dead bivalve; worm tubes; unidentified white globular forms; linear tracks
005	73	Img2008-06-14 045240.JPG	45.746718	-58.846662	045257	188.00	interpolated water depth	sand with surficial mud and flocculate; burrows with ejecta	sponge; anemones; worm tubes; unidentified white globular forms; bryozoa?
005	74	Img2008-06-14 045250.JPG	45.746621	-58.846758	045307	189.00	interpolated water depth	sand surficial mud and flocculate; worm tubes	sponge; soft coral; anemones; worm tubes
005	75	Img2008-06-14 045258.JPG	45.746552	-58.846826	045315	190.00	interpolated water depth	sand with minor gravel; surficial mud and flocculate; worm tubes	sponge; sea pen; white starfish; dead gastropod; soft coral; anemones; worm tubes; bryozoa?
005	76	Img2008-06-14 045312.JPG	45.746420	-58.846929	045329	190.00	intensity and contrast adjustment	sand with minor gravel and flocculate	sponge; brittle stars; dead bivalve; soft coral; worm tubes; bryozoa?
005	77	Img2008-06-14 045324.JPG	45.746318	-58.847008	045341	190.00	interpolated water depth; intensity and contrast adjustment	sand with minor gravel and flocculate	sponge; white starfish; shrimp; crab; dead bivalve; soft coral; worm tubes; bryozoa?
005	78	Img2008-06-14 045402.JPG	45.746018	-58.847168	045419	191.00		sand with minor gravel and flocculate	sponge; anemone; shrimp; soft coral; bryozoa?
005	79	Img2008-06-14 045444.JPG	45.745624	-58.847170	045501	191.00	interpolated water depth	sand with minor gravel and flocculate	sponge; brittle stars; linear tracks; anemone; bryozoa?
005	80	Img2008-06-14 045506.JPG	45.745393	-58.847145	045523	191.00	interpolated water depth	sand with minor gravel and flocculate	sponge; soft coral; brittle stars; worm tubes; sand dollar; linear tracks; anemone; bryozoa?
005	81	Img2008-06-14 045514.JPG	45.745314	-58.847142	045531	190.00	interpolated water depth; intensity and contrast adjustment	sand with minor gravel and flocculate	brittle stars; worm tubes; sand dollar; linear tracks; anemone; bryozoa?
005	82	Img2008-06-14 045554.JPG	45.744914	-58.847282	045611	189.00	intensity and contrast adjustment	sand with minor gravel and flocculate	brittle stars; worm tubes; linear tracks; anemone
005	83	Img2008-06-14 045612.JPG	45.744729	-58.847407	045629	187.00	interpolated water depth; intensity and contrast adjustment	sand with minor gravel and minor flocculate	brittle stars; worm tubes; linear tracks; anemone; soft coral; bryozoa?
005	84	Img2008-06-14 045624.JPG	45.744623	-58.847500	045641	186.00		sand with minor gravel and minor flocculate	sponge; brittle stars; worm tubes; burrows; linear tracks; anemone; soft coral; bryozoa?
005	85	Img2008-06-14 045658.JPG	45.744307	-58.847715	045715	184.00		sand with minor gravel and minor flocculate	sponge; brittle stars; worm tubes; burrows
005	86	Img2008-06-14 045720.JPG	45.744098	-58.847794	045737	182.00		gravel and sand and minor flocculate	sponge; worm tubes; bryozoa?
005	87	Img2008-06-14 045730.JPG	45.744007	-58.847815	045747	181.00	interpolated water depth	sandy mud	sponge; worm tubes; white starfish; anemone; bryozoa?
005	88	Img2008-06-14 045744.JPG	45.743883	-58.847824	045801	181.00		cobble; minor sand and gravel; surficial flocculate; growth on cobble	sponge; worm tubes; white starfish; brittle stars; bryozoa?
005	89	Img2008-06-14 045814.JPG	45.743618	-58.847750	045831	178.00		cobble; minor sand and gravel; surficial flocculate; growth on cobble	sponge; worm tubes; white starfish; linear tracks
005	90	Img2008-06-14 045906.JPG	45.743211	-58.847420	045923	174.00		sandy mud	anemone; unidentified white globular forms; burrows; soft coral; linear tracks

All descriptions by E. King; biology may have inaccuracies

4.2 OUTER LAURENTIAN CHANNEL

Numerous small diameter (3 to 10 m diameter, 100 m or more spacing) circular, high backscatter targets on the surface of Holocene muds in outer Laurentian Channel were identified from sidescan sonar surveys on GSCA Hudson cruises 2006048 and 2007016. They are though to be small pockmarks (with little relief) as they transition from clear pockmarks to the north. They occur in an area with deep depressions (up to several metres) in the mud which bottom out on an iceberg scoured till surface. This becomes exposed over a greater proportion of the seabed farther south. A several kilometer-long CamPod transect covered both areas. The objective was to establish the nature of the backscattering target in the small circular features and to establish the nature of the exposed till surface and associated biota.

Station 1 (DFO LC5 and LC6) was a long video transect across mud of highly variable local thickness (0-10 m) at the outer Laurentian Channel. Descriptive observations are summarized in Table 6. It showed Holocene age muds cover a relict iceberg scoured till which outcrops only locally, exposing gravel and cobbles with attached biota. A thin (cm) mud dusting is apparently penetrated by the sidescan sonograms to register a high backscatter return, thus under-representing the extent of the very thin mud. Both small and large patches of gravel or gravel with shells and gravel with cobbles were observed. It was difficult to assess if the instrument was in one of the large depressions. Rather the presences of the cobbles on the video was used as confirmation of the till outcrop. The soft mud was habitat for siphoning infauna, unidentified large burrows (up to 10 cm across), smoothed depression under 1 m diameter, various trails, sea pens and redfish. A complete biota description was performed by DFO personnel onboard.

The properties of the backscattering medium which give rise to small circular patches at the base of small pockmarks remains uncertain. Small, gravelly patches (with some shell hash) are thought to represent the small diameter targets. As these are thought to sit on relatively thick mud their origin remains enigmatic. Perhaps erosion associated with a regional event which caused an unconformity in the late post-glacial mud sequence is related but their stratigraphic equivalence remains to be demonstrated.

4.3 EASTERN FLANK OF LAURENTIAN CHANNEL

Conical pockmarks of several metres diameter and 1 to 3 m depth occur in thick muds flanking the eastern Laurentian Channel. They have been mapped using sidescan sonar and high resolution sparker profiles from the two recent GSCA cruises. The objective was to establish the nature of small (1-3 m) high-backscatter targets on the sonograms through drifting of the videograb. The targets were 15 to 20 diameter with a 100 to 350 m spacing. The videograb was used to take advantage of the sampling capacity should a target be identified.

Station 2 (DFO LC6) is a short videograb transect. It was terminated to adjust the oblique angle lighting to compensate for poor visibility. The grab at the end of this traverse yielded a full box of cohesive grey silty mud with some sulphide staining in the upper 20 cm, probably from bioturbation. A soft upper layer was probably washed considerably upon raising through the water column.

Station 3 (also DFO LC7) was a continuation but longer transect in the general vicinity of the Station 2 transect. Drift conditions were difficult in a strong NE wind and generally too fast. Other than one small patch of shell material, the entire transect crossed soft mud with numerous sea pens.

4.4 CENTRAL LAURENTIAN CHANNEL

Objectives here were the same as the other sites; to groundtruth sonar targets. This site was similar to the outer channel site, with linear scour berms and occasional specks suspected to be pockmarks. The berms are oriented 135 deg with a spacing of about 2 km and the “specks” are spaced about 300 m apart.

Station 4 (DFO LC8) from the mid Laurentian Channel showed mud, possibly more sandy than on the flank, and with a higher degree of small-scale sculpting; probably bioturbation. There were fewer sea pens than on the flank but more abundant corals and anemones. Some of the anemones attest to a harder substrate immediately below the nepheloid layer. The horizontal bar on the videograb often dug into the substrate and lifted a mass of mud which, as it gradually eroded, masked the cameras. There was no indication of a backscattering target with the exception of the shells, but the patch was estimated to be very small.

4.5 SCATARIE MORAINE

Anecdotal and proven sitings of the deep water hard coral Lophelia from the Scatarie moraine, in St Ann’s Basin, off Cape Breton combined with. this being a site of supposed early post-glacial mass failure made this a site of interest. A transect was planned across the moraine, intersecting failure scarps, small morainic ridges and a variety of seabed types. The GSCA aim was to establish if later retrogressive failure may have occurred and be visible in the CamPod photography.

Station 5 (DFO LC9) made an approximately N to S transect across the moraine. Both muddy and gravelly seabed was encountered. Biota was varied and included a large sponge colony on the southern flank. The relatively steep flanks, thought to be failure scarps were mainly mud draped with some hard substrate but none appeared to be affected by recent slumping.

5.0 REFERENCES

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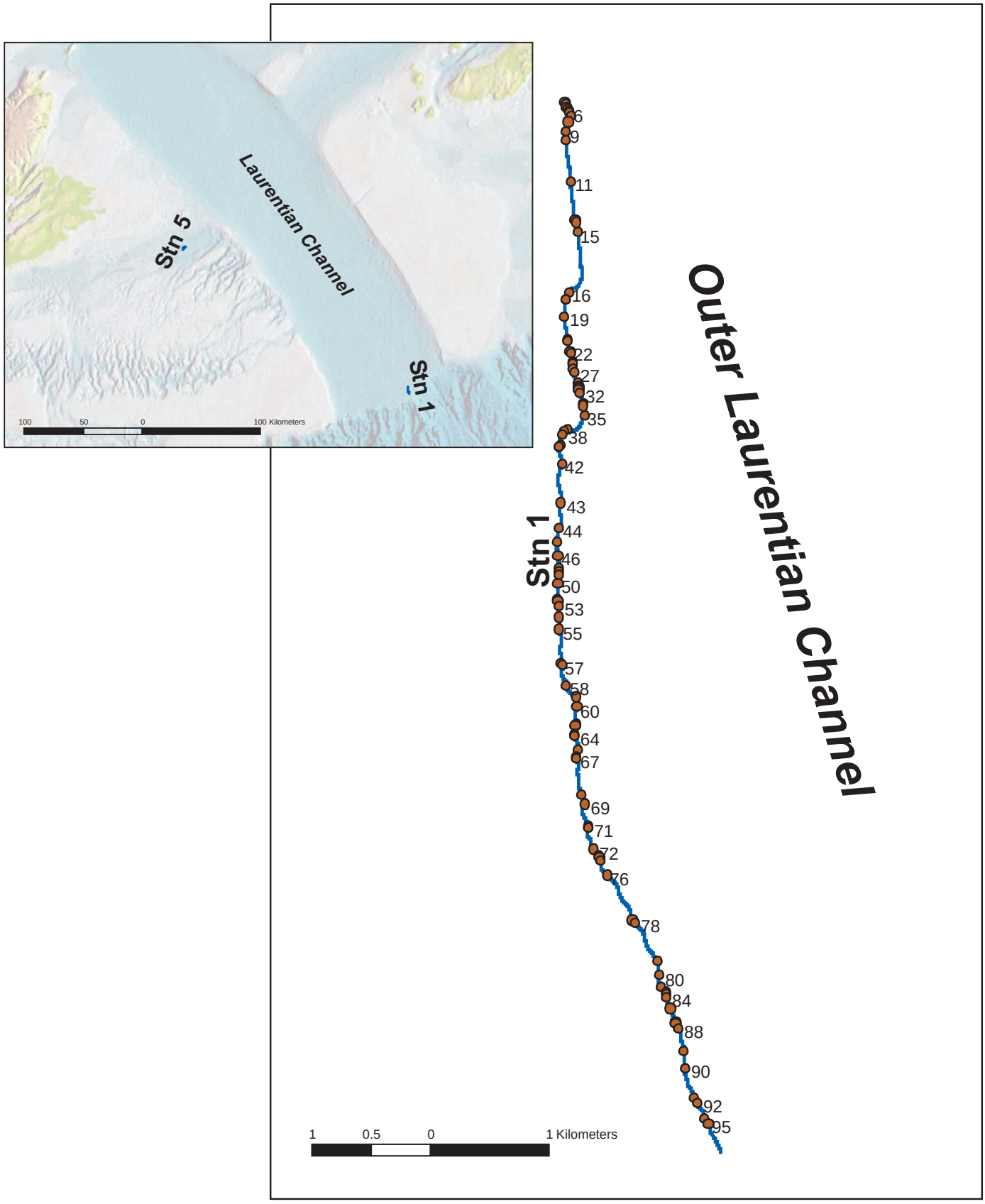
Appendix IA: Seabed Photographs; Station 1



Locations are ship's position; Campod towfish was generally located up to several hundred metres astern. Numbers are serial shots as per Table 9 and the labels on the following photographs.

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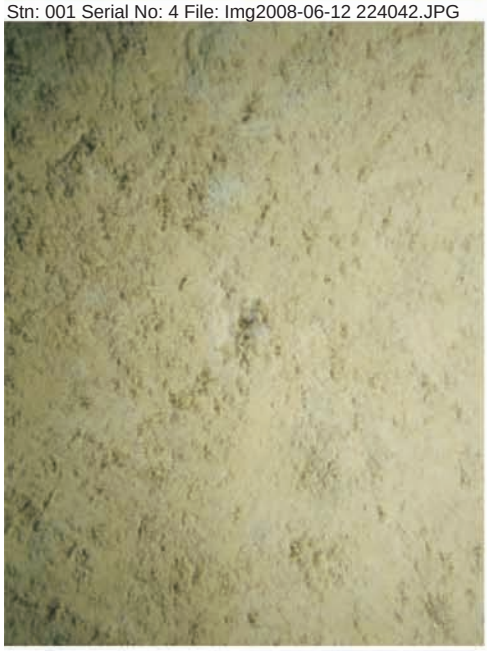

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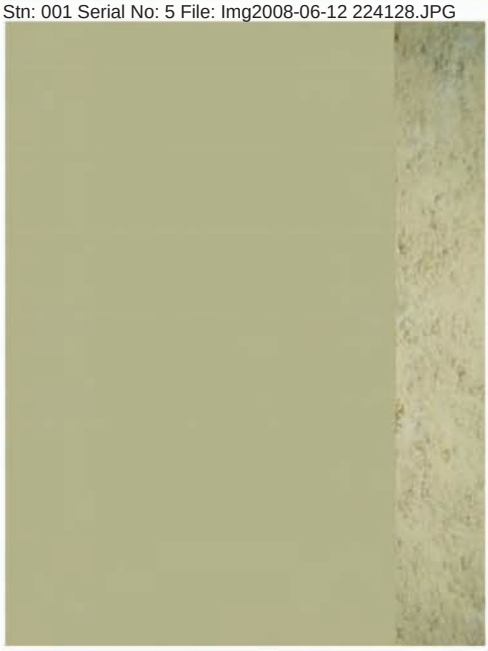

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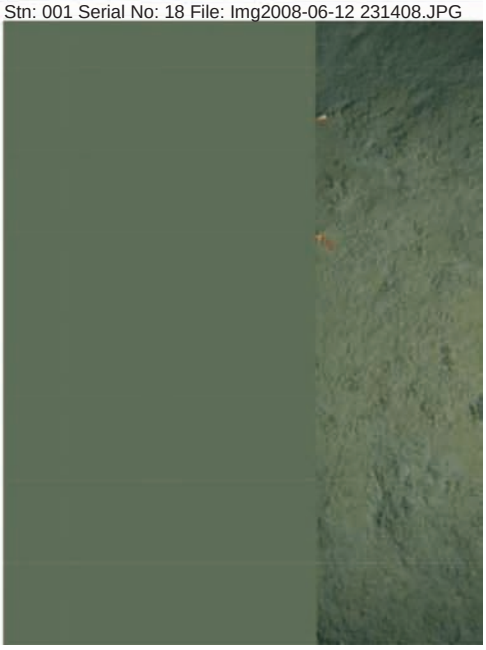

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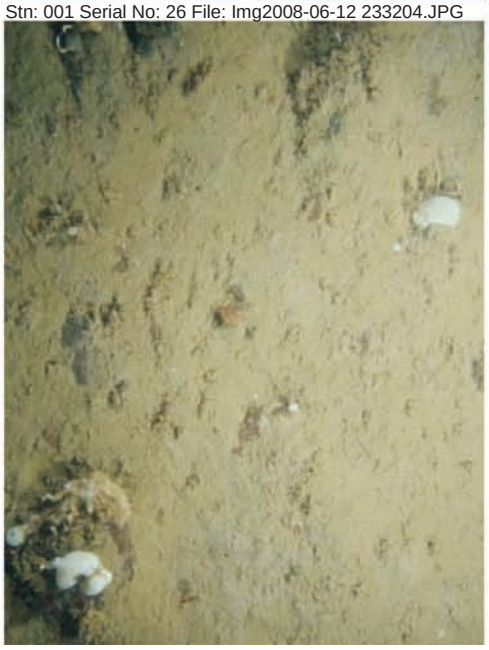

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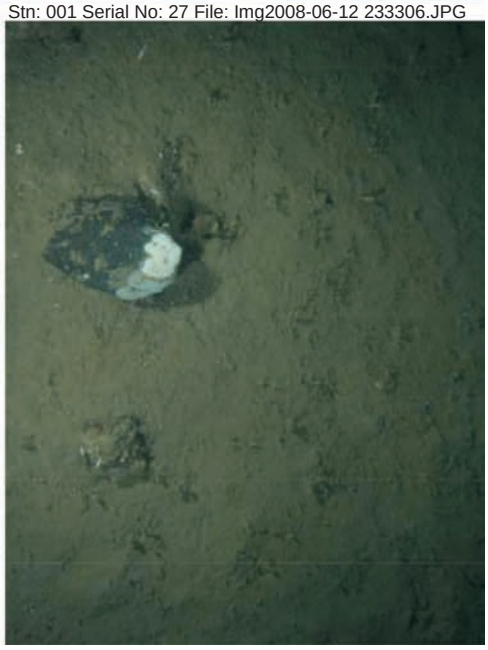

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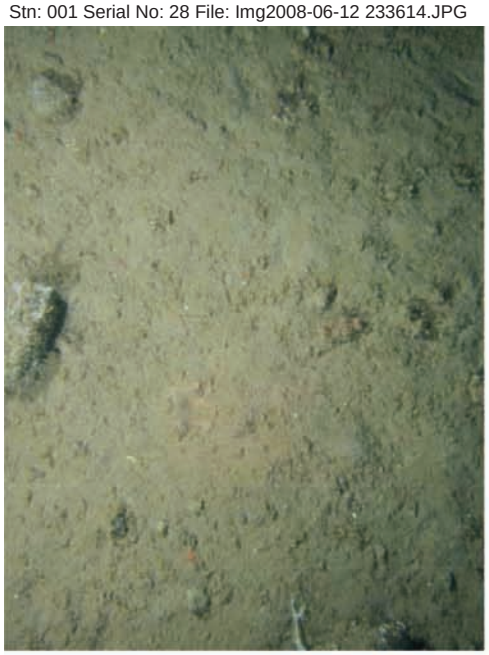

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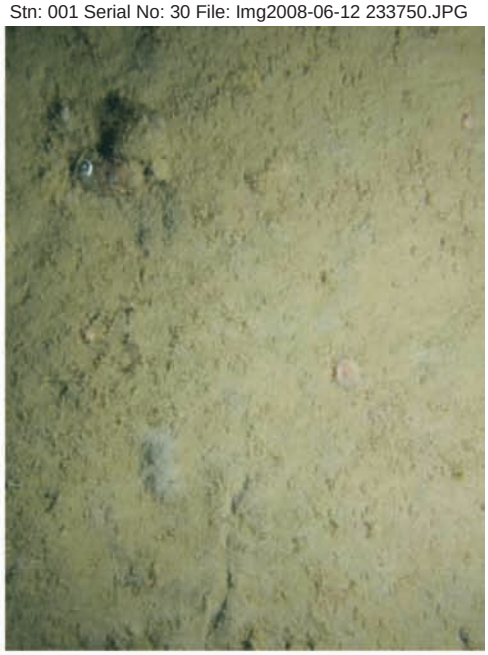

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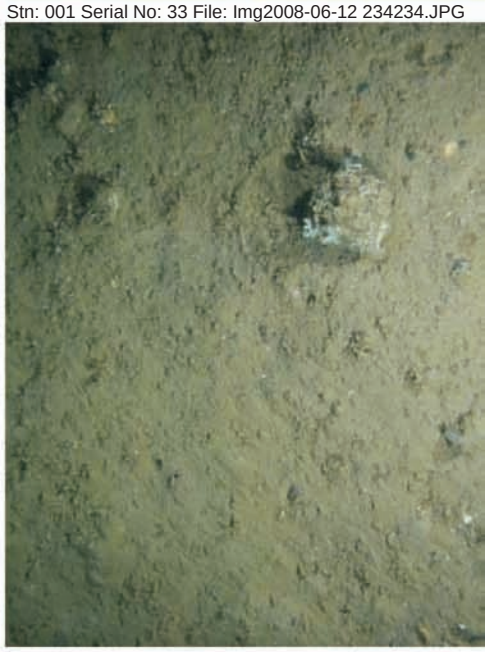

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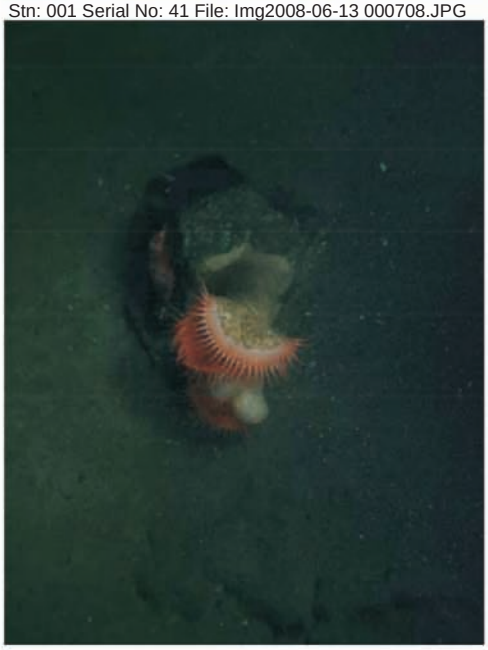

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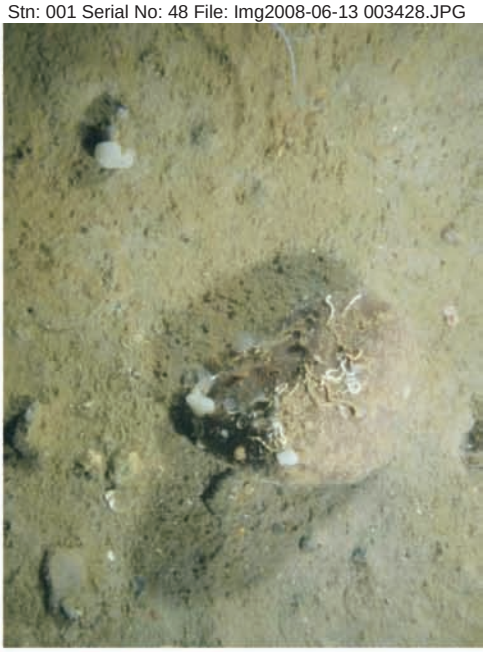

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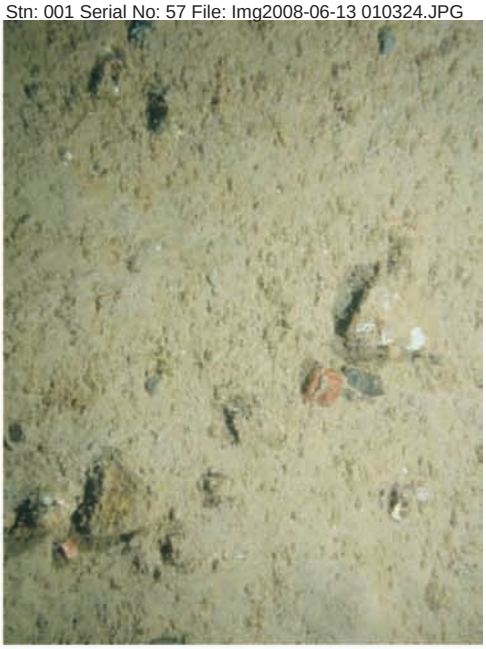

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Stn: 001 Serial No: 62 File: Img2008-06-13 013022.JPG

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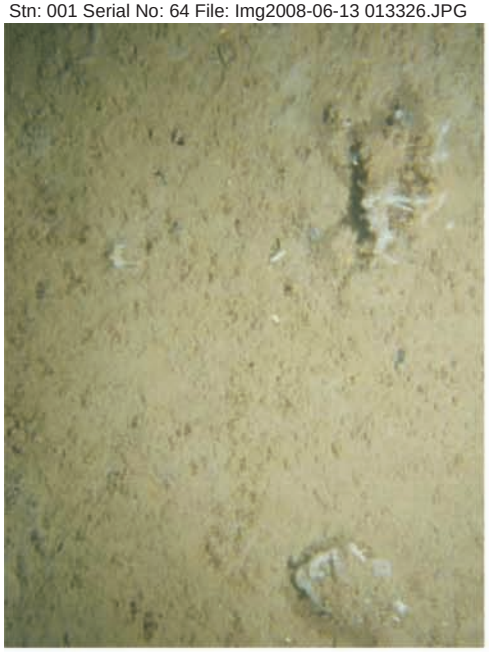

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Stn: 001 Serial No: 68 File: Img2008-06-13 014814.JPG

Stn: 001 Serial No: 69 File: Img2008-06-13 015104.JPG

Stn: 001 Serial No: 70 File: Img2008-06-13 015620.JPG

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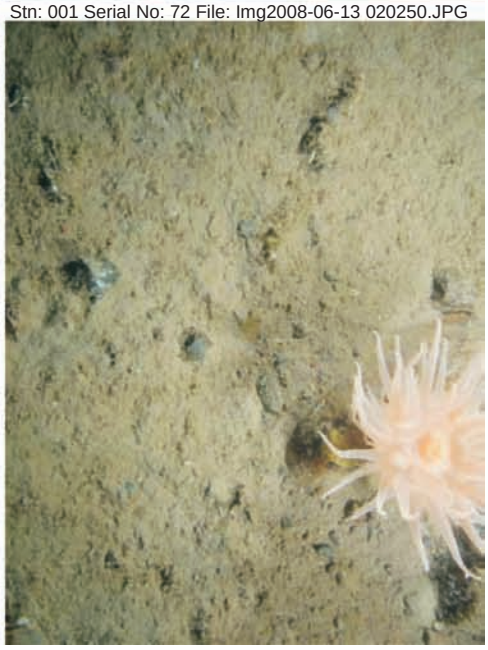

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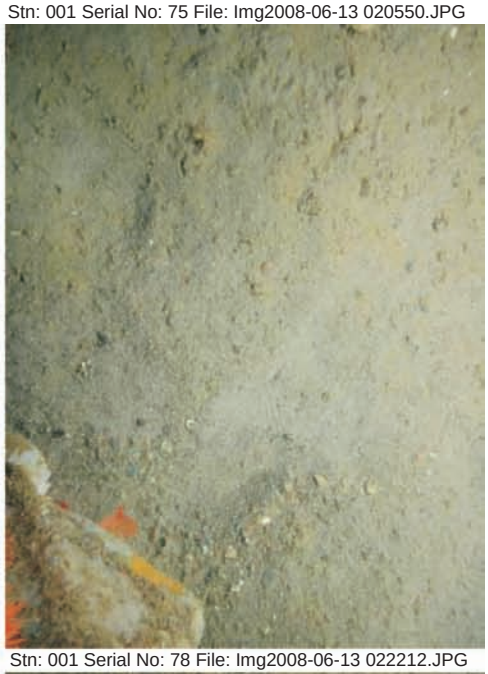
Stn: 001 Serial No: 75 File: Img2008-06-13 020550.JPG



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Stn: 001 Serial No: 78 File: Img2008-06-13 022212.JPG

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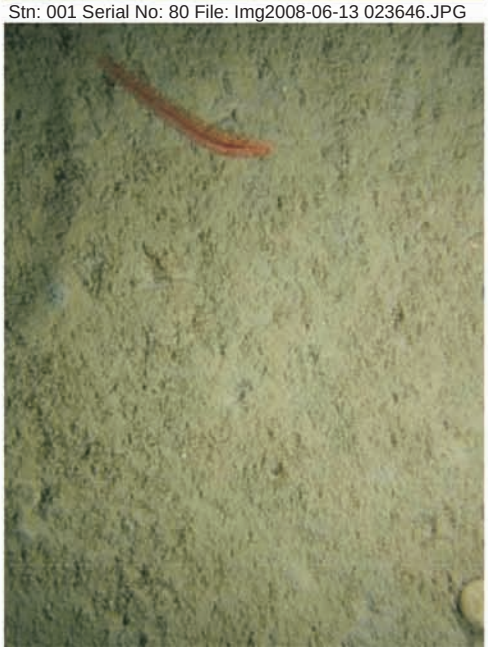
Stn: 001 Serial No: 80 File: Img2008-06-13 023646.JPG



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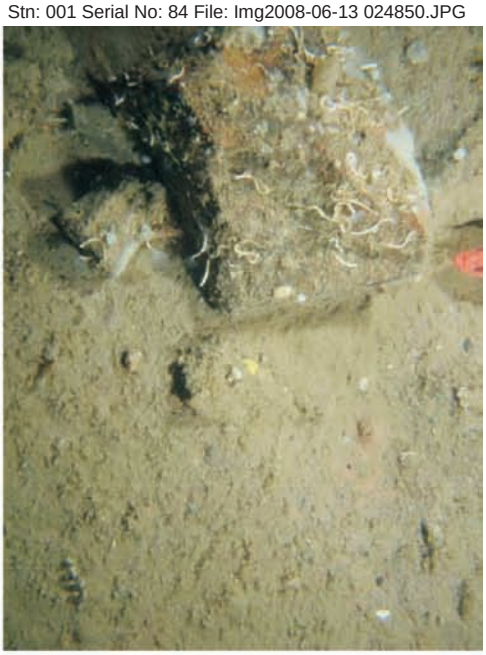

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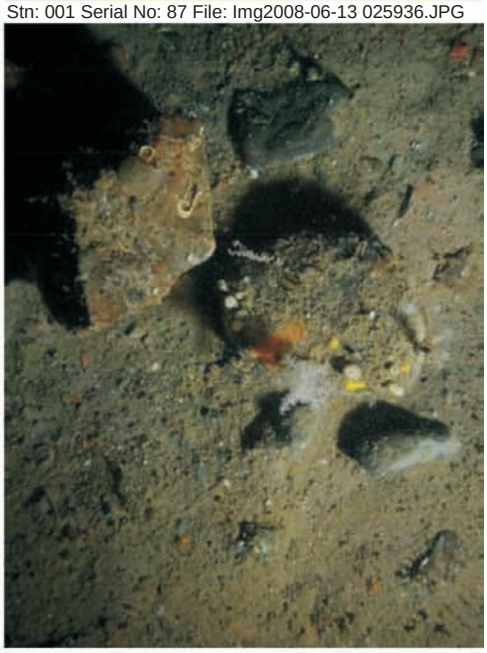
Stn: 001 Serial No: 87 File: Img2008-06-13 025936.JPG



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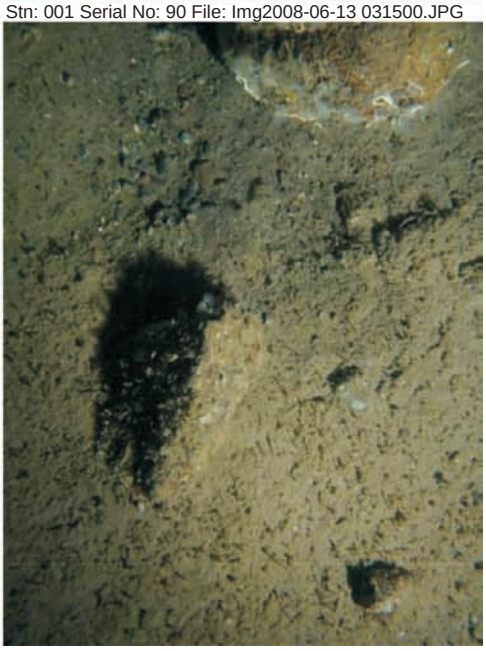
Stn: 001 Serial No: 90 File: Img2008-06-13 031500.JPG



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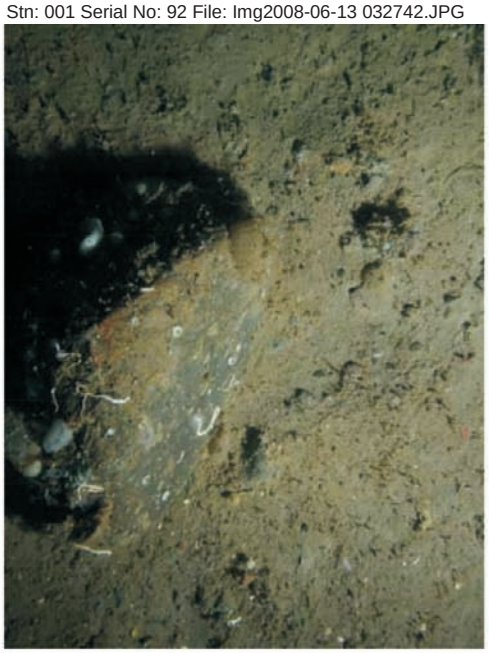

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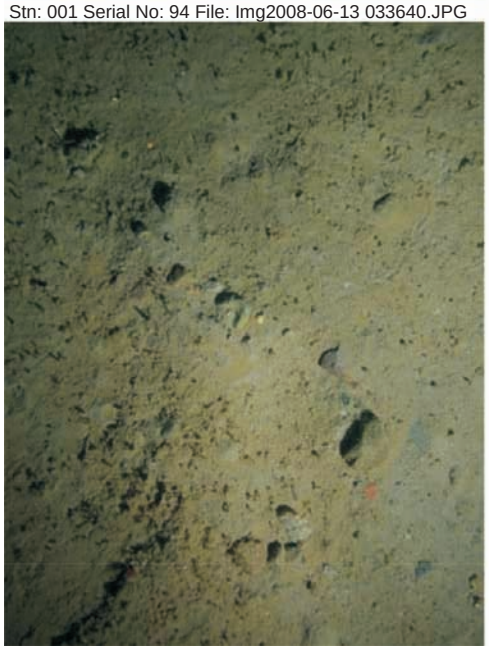

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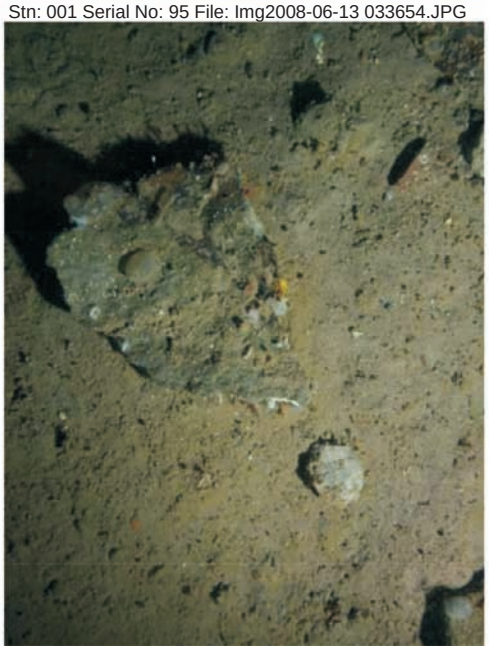
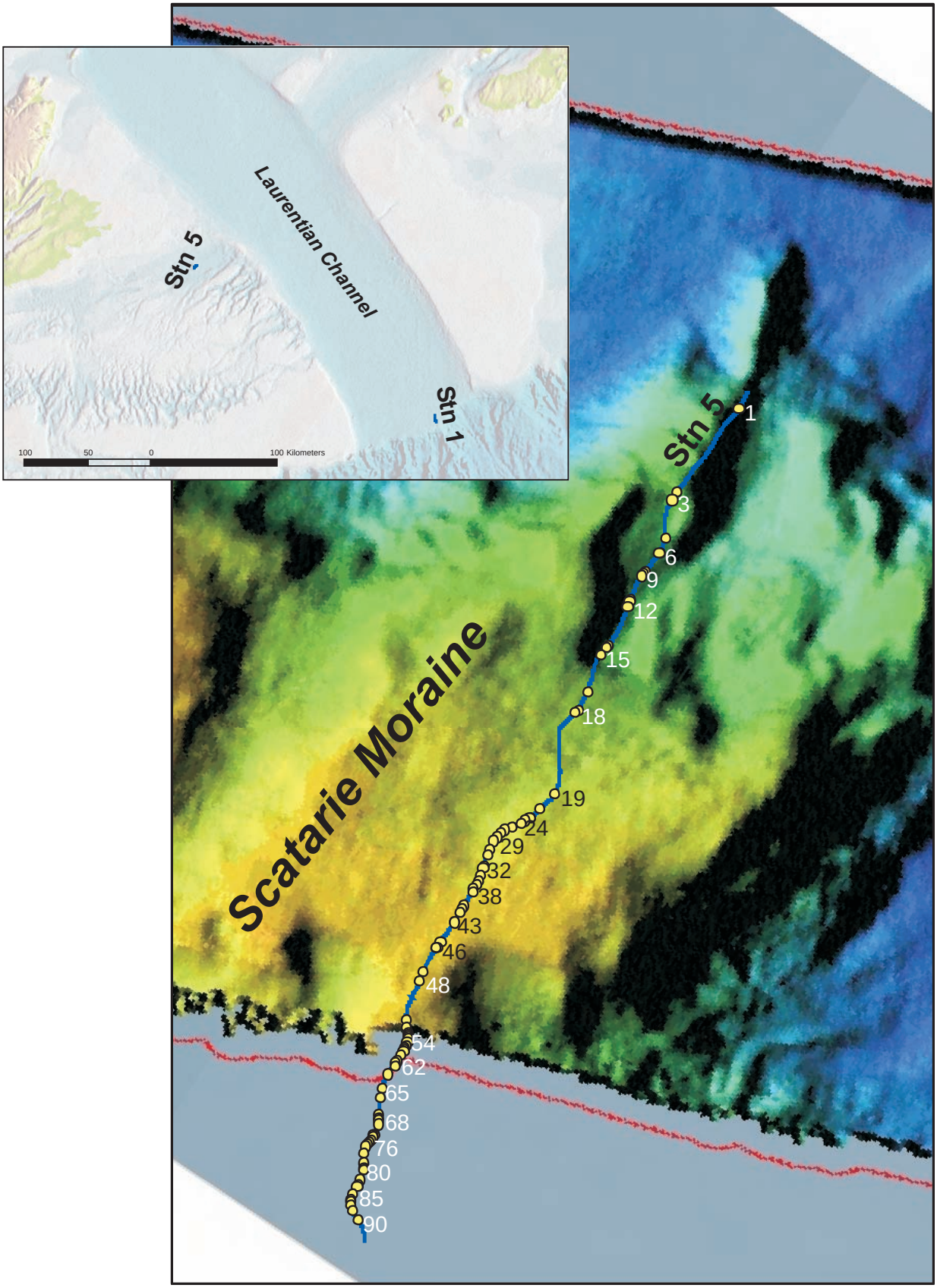


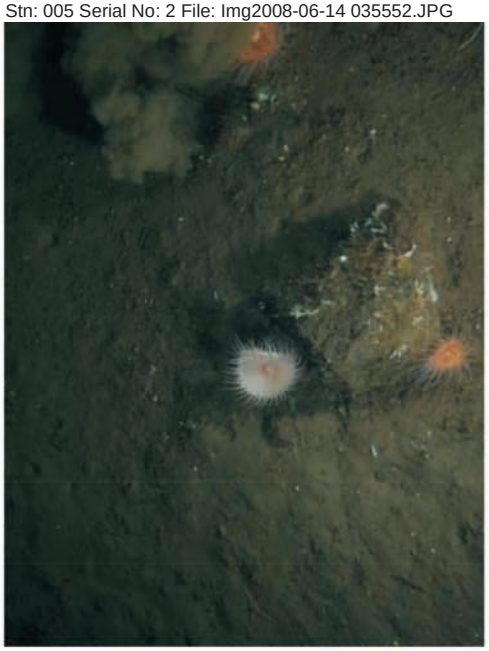
Appendix IB: Seabed Photographs; Station 5



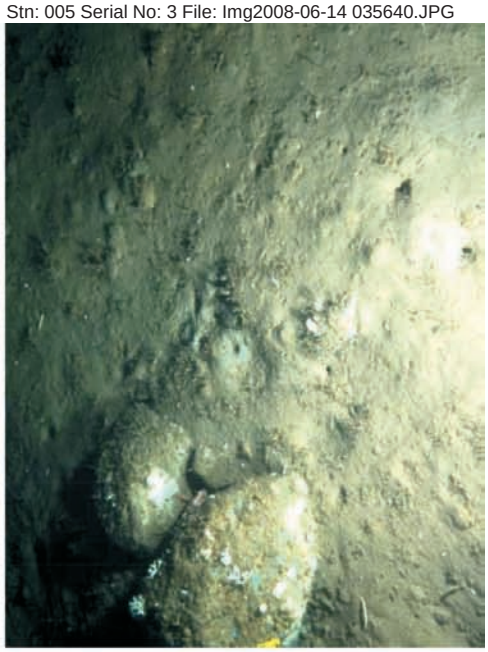
Locations are ship's position; Campod towfish was generally located north and east of this transect by up to several hundred metres. Numbers are serial shots as per Table 9 and the labels on the following photographs.

Stn: 005 Serial No: 1 File: Img2008-06-14 034738.JPG

Stn: 005 Serial No: 2 File: Img2008-06-14 035552.JPG

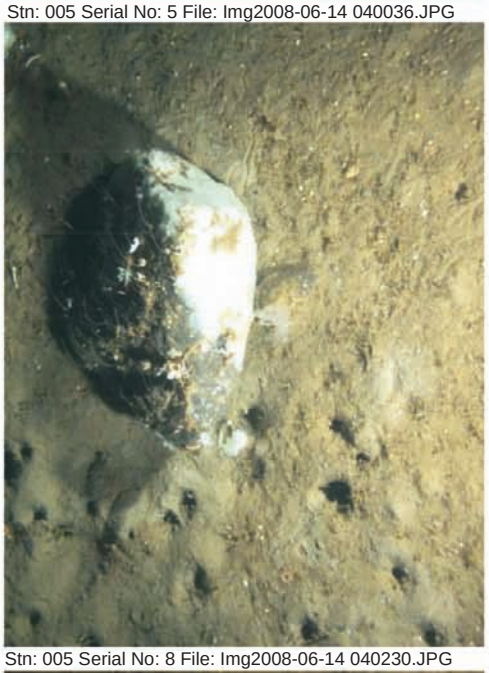


Stn: 005 Serial No: 3 File: Img2008-06-14 035640.JPG

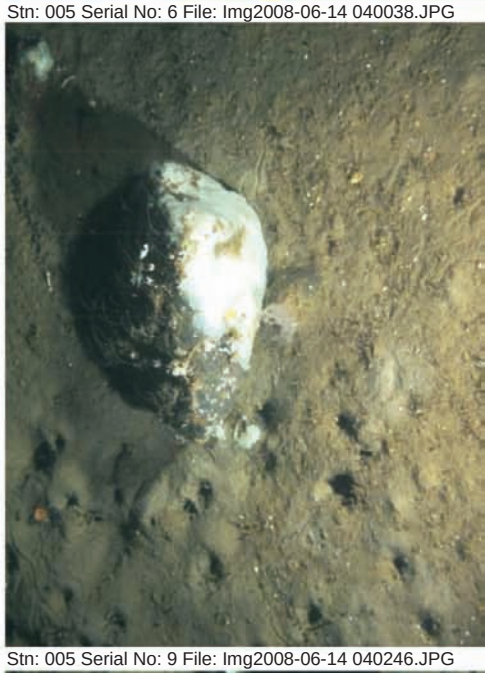


Stn: 005 Serial No: 4 File: Img2008-06-14 035938.JPG

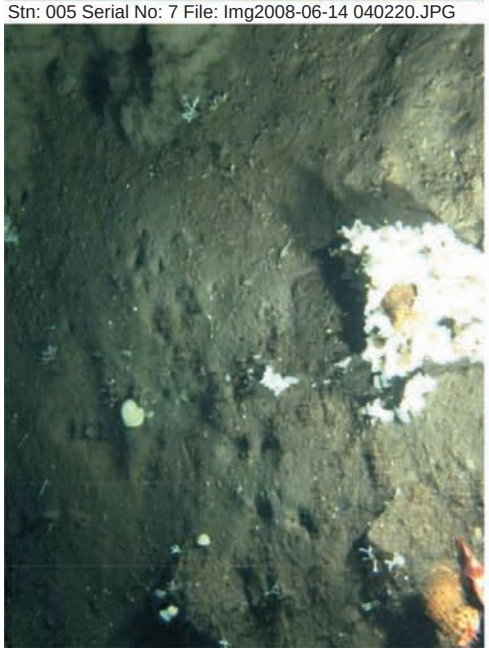
Stn: 005 Serial No: 5 File: Img2008-06-14 040036.JPG



Stn: 005 Serial No: 6 File: Img2008-06-14 040038.JPG



Stn: 005 Serial No: 7 File: Img2008-06-14 040220.JPG



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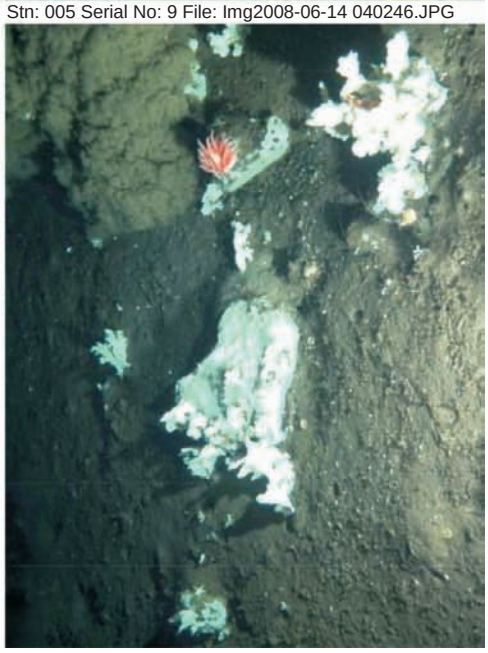
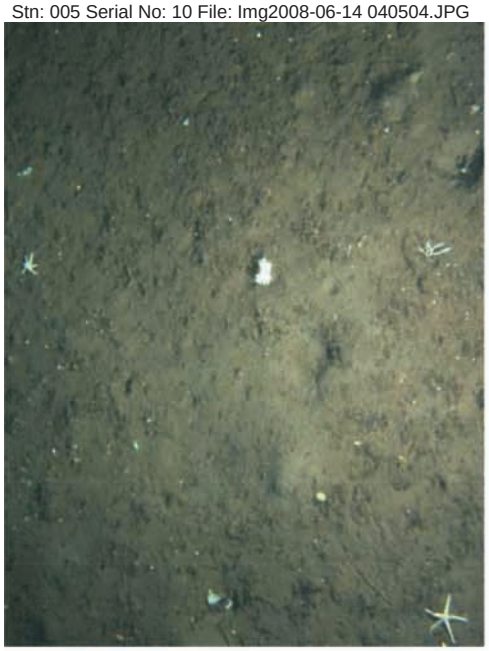
Stn: 005 Serial No: 9 File: Img2008-06-14 040246.JPG



Stn: 005 Serial No: 10 File: Img2008-06-14 040504.JPG



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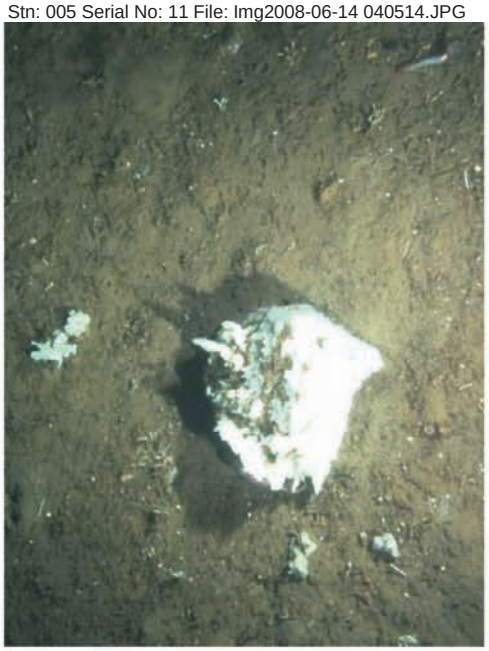

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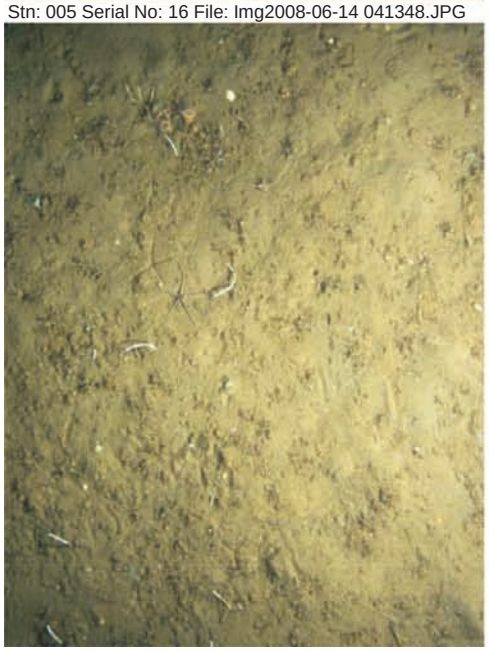
Stn: 005 Serial No: 14 File: Img2008-06-14 040940.JPG

Stn: 005 Serial No: 15 File: Img2008-06-14 041038.JPG

Stn: 005 Serial No: 16 File: Img2008-06-14 041348.JPG



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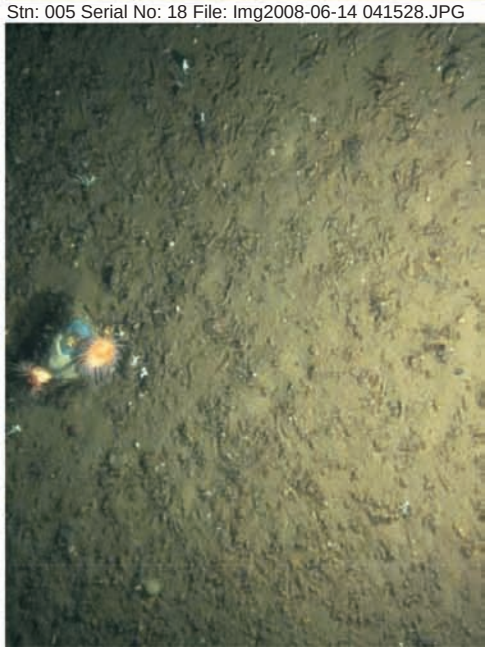
Stn: 005 Serial No: 18 File: Img2008-06-14 041528.JPG



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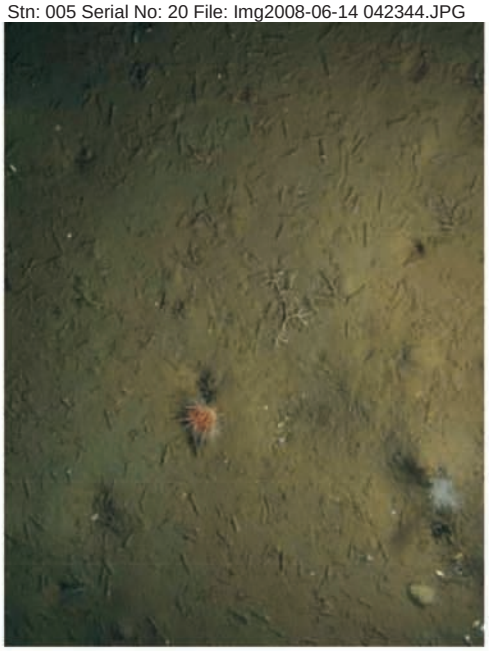
Stn: 005 Serial No: 20 File: Img2008-06-14 042344.JPG



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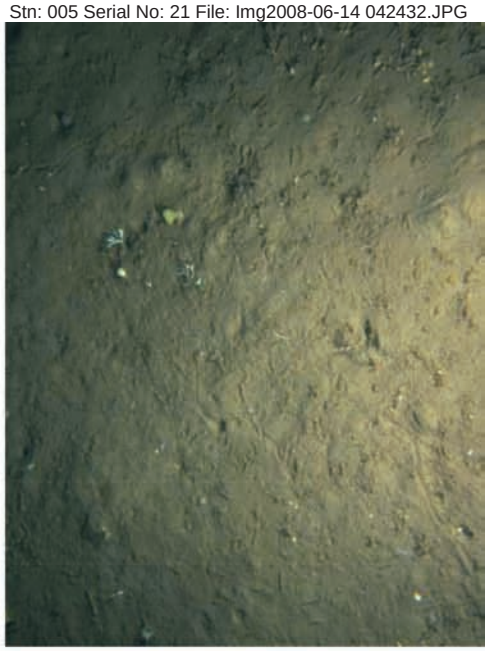

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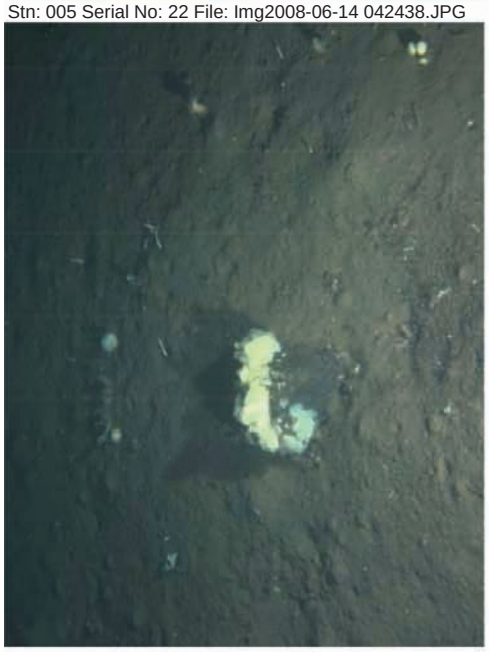

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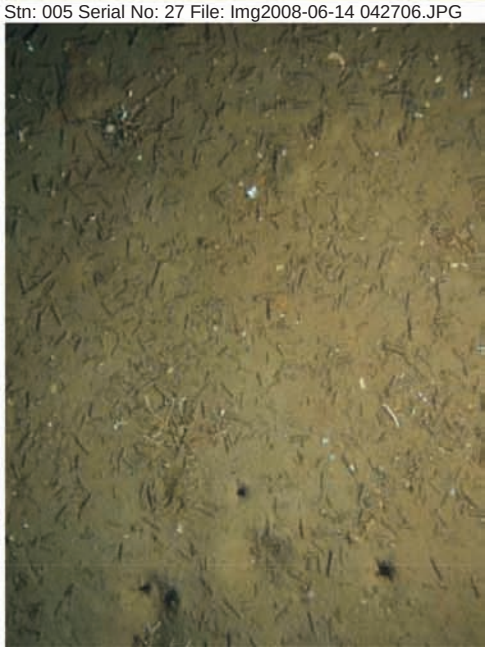
Stn: 005 Serial No: 25 File: Img2008-06-14 042558.JPG

Stn: 005 Serial No: 26 File: Img2008-06-14 042638.JPG

Stn: 005 Serial No: 27 File: Img2008-06-14 042706.JPG



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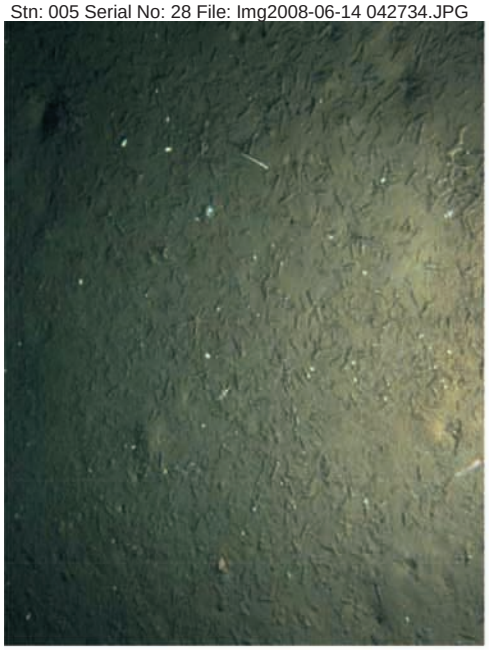

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Stn: 005 Serial No: 32 File: Img2008-06-14 043030.JPG

Stn: 005 Serial No: 33 File: Img2008-06-14 043042.JPG

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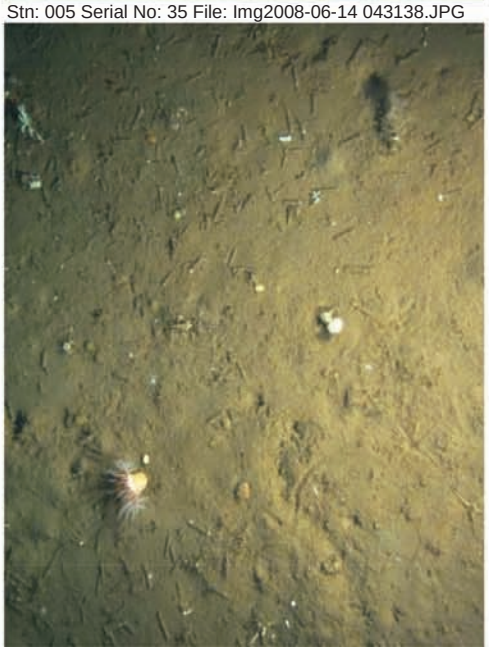

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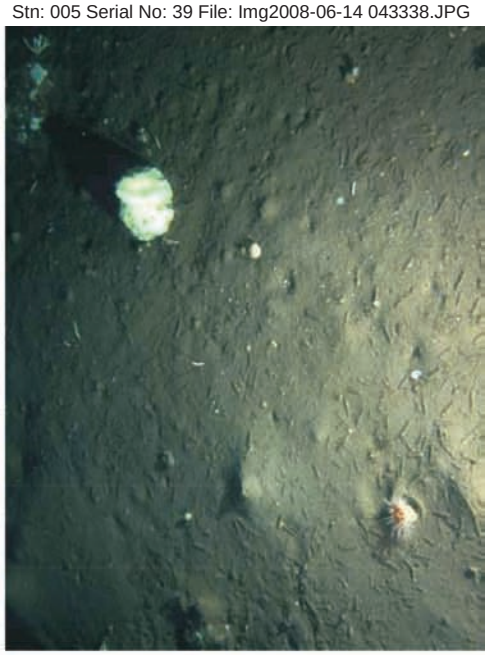

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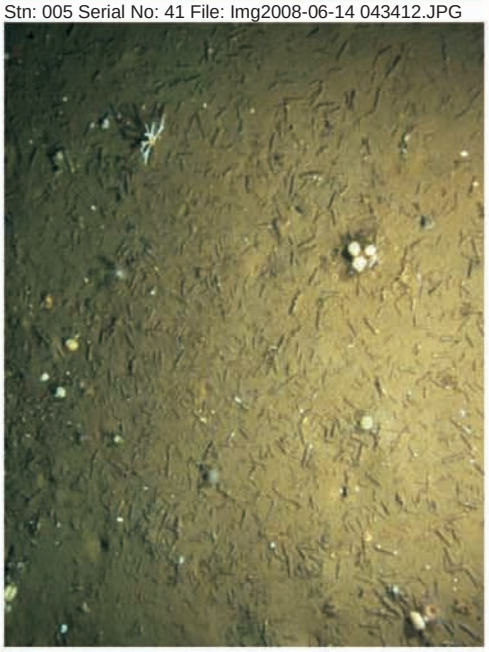
Stn: 005 Serial No: 41 File: Img2008-06-14 043412.JPG

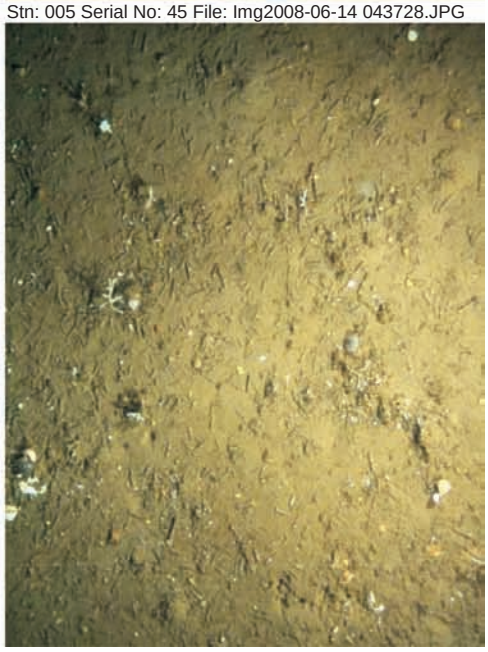


Stn: 005 Serial No: 42 File: Img2008-06-14 043450.JPG

Stn: 005 Serial No: 43 File: Img2008-06-14 043500.JPG

Stn: 005 Serial No: 44 File: Img2008-06-14 043654.JPG

Stn: 005 Serial No: 45 File: Img2008-06-14 043728.JPG



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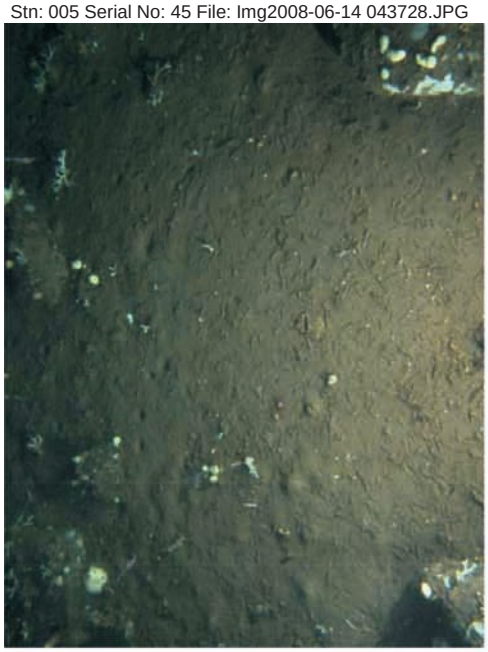

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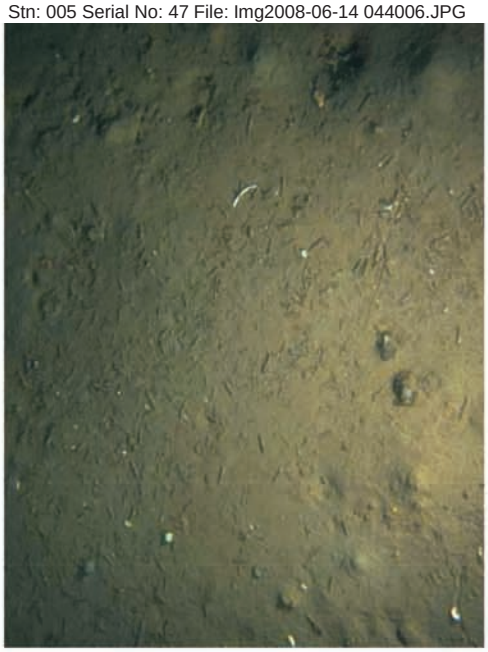

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Stn: 005 Serial No: 51 File: Img2008-06-14 044444.JPG

Stn: 005 Serial No: 52 File: Img2008-06-14 044454.JPG

Stn: 005 Serial No: 53 File: Img2008-06-14 044504.JPG

Stn: 005 Serial No: 54 File: Img2008-06-14 044512.JPG

Stn: 005 Serial No: 55 File: Img2008-06-14 044526.JPG

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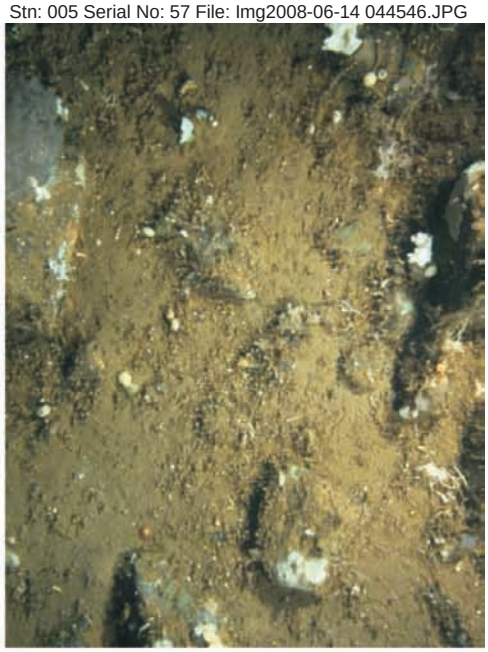

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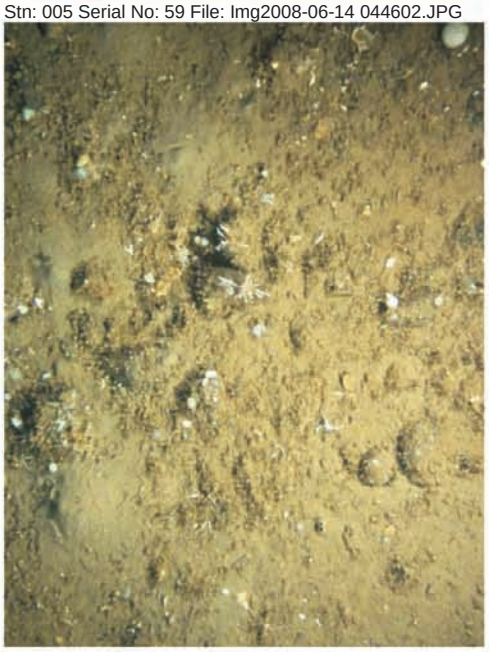

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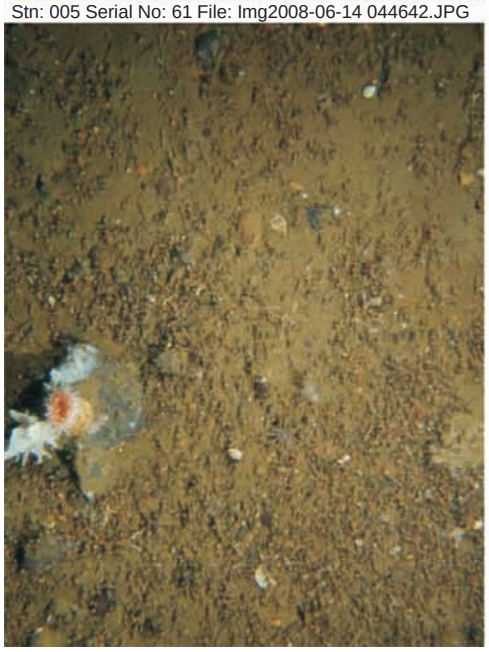

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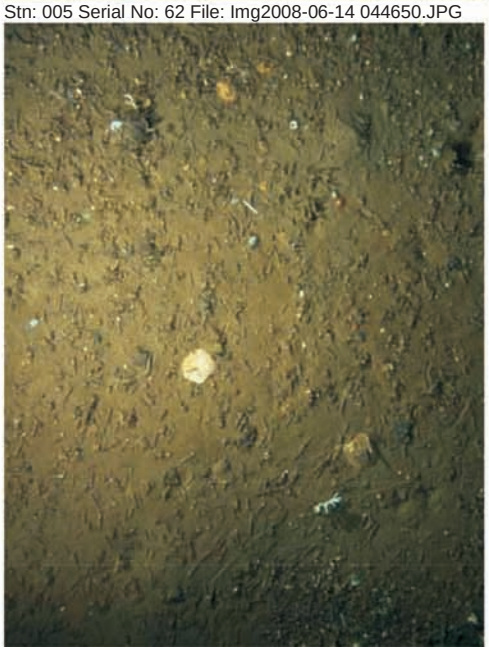

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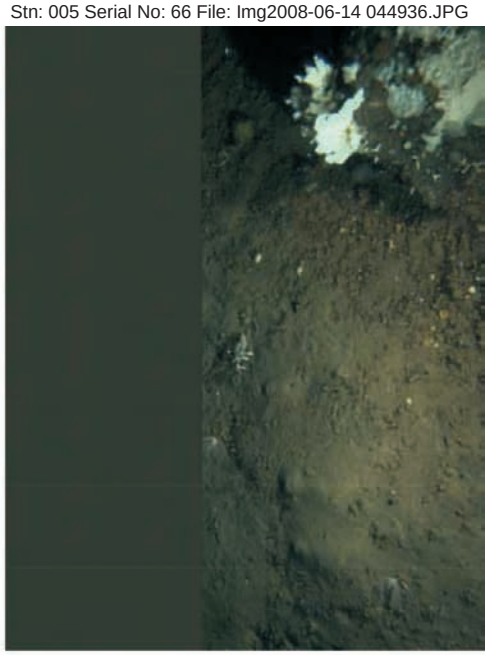

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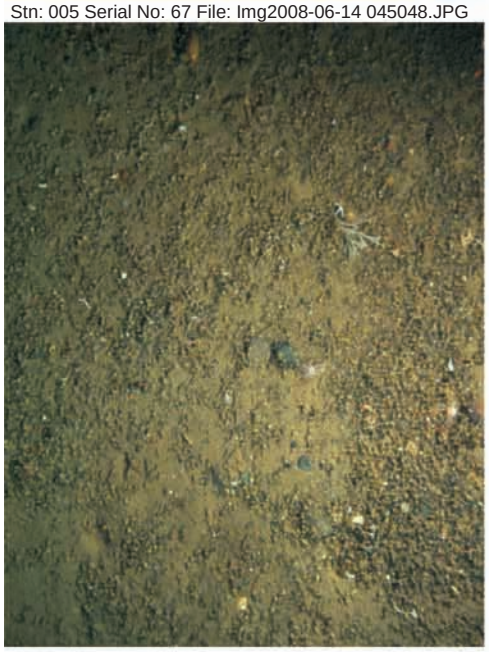

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Stn: 005 Serial No: 70 File: Img2008-06-14 045144.JPG

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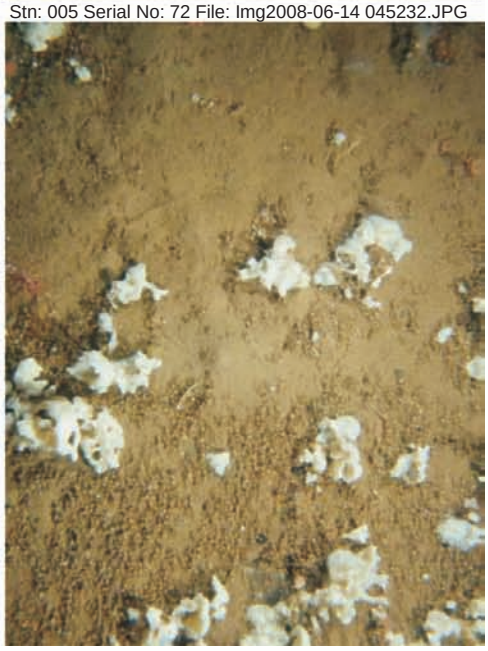

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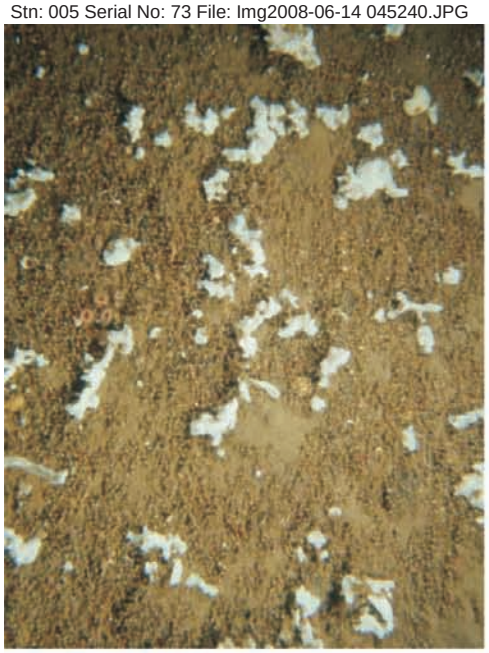

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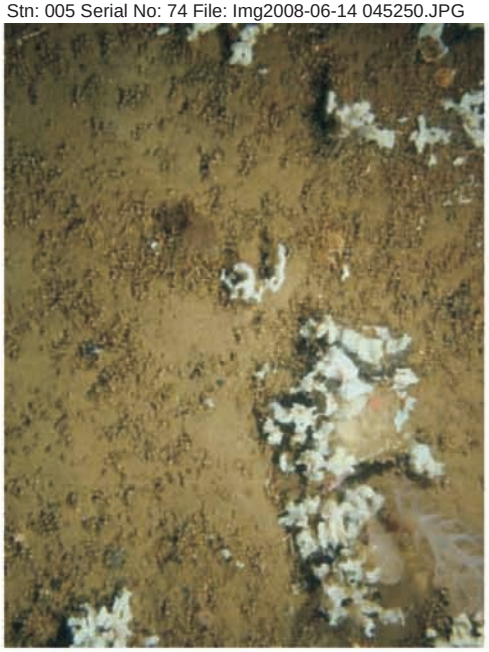

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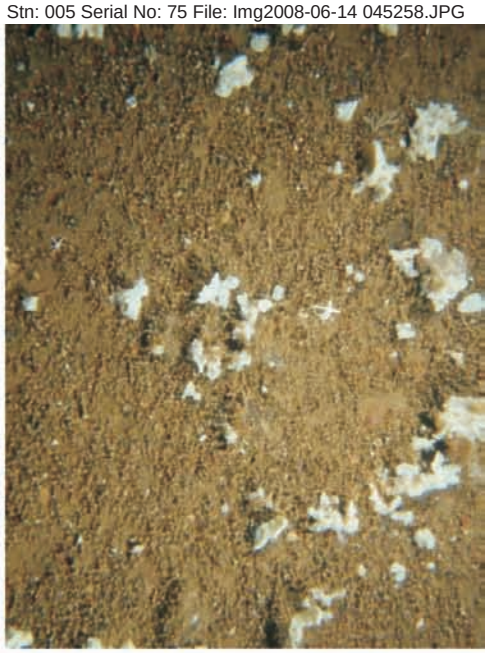

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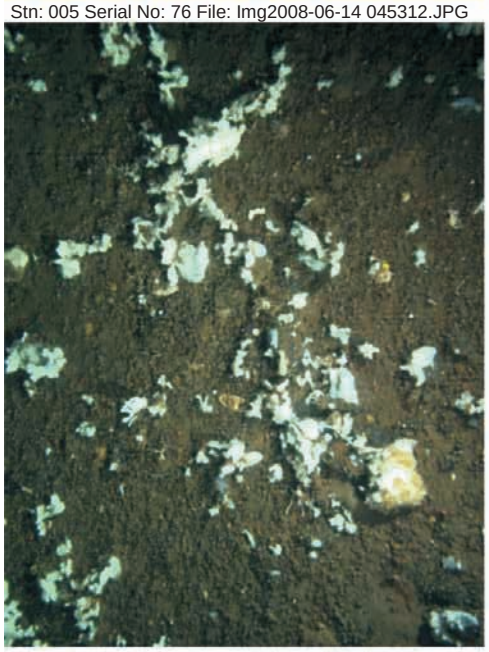

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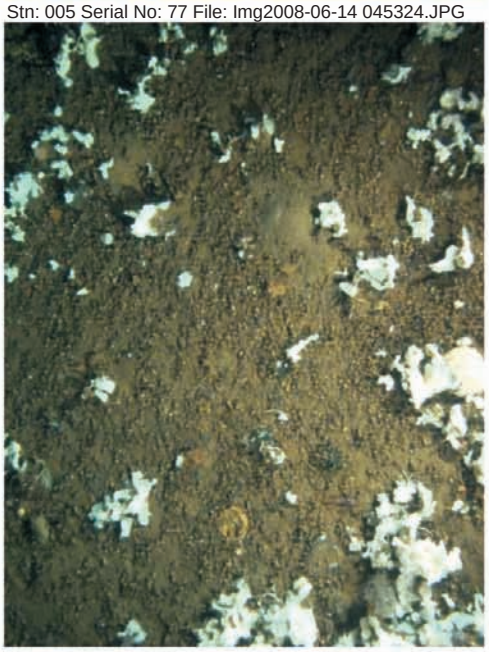

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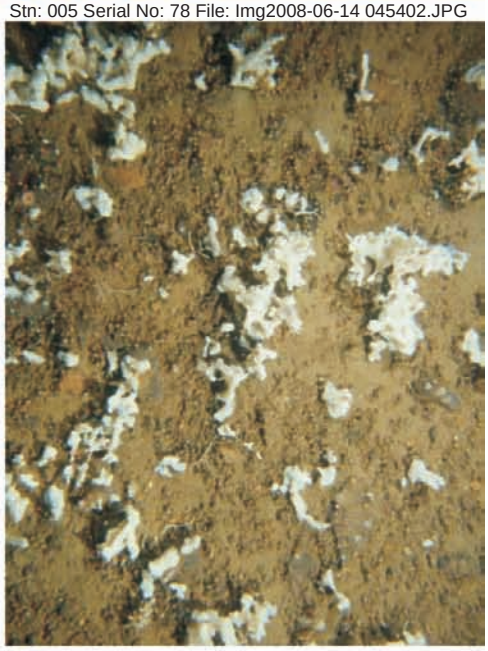

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Stn: 005 Serial No: 82 File: Img2008-06-14 045554.JPG

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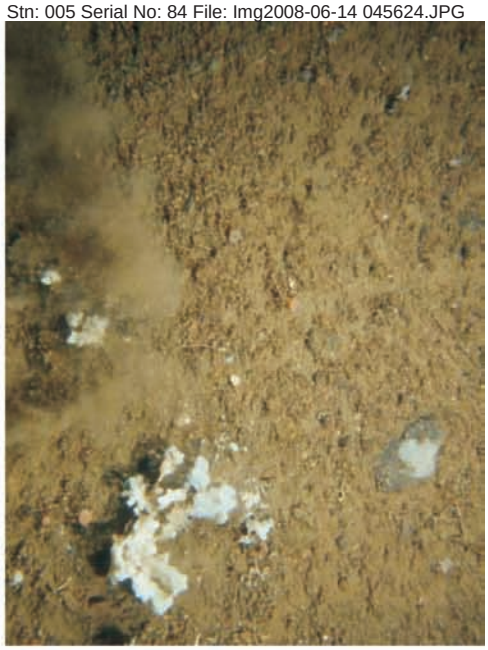

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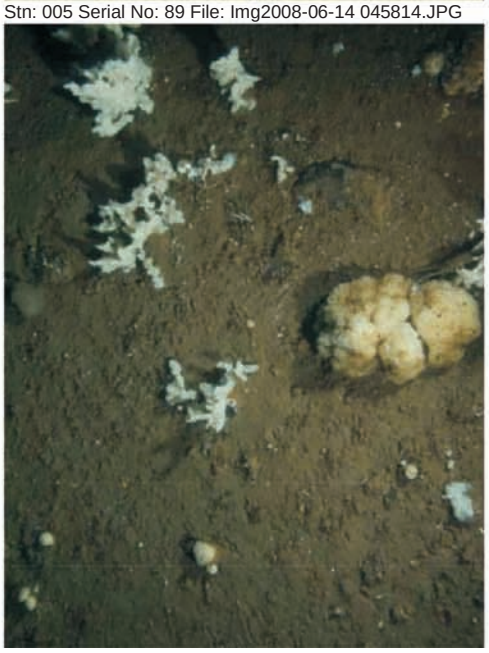

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