



Natural Resources  
Canada

Ressources naturelles  
Canada

**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 7622**

**CCGS Vector 2013007PGC  
Cruise Report**

**P.R. Hill**

**2015**

**Canada**



**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 7622**

**CCGS Vector 2013007PGC  
Cruise Report**

**P.R. Hill**

**2015**

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada, 2015

doi:10.4095/296203

This publication is available for free download through GEOSCAN (<http://geoscan.nrcan.gc.ca/>).

**Recommended citation**

Hill, P.R., 2015 CCGS Vector 2013007PGC Cruise Report; Geological Survey of Canada, Open File 7622, 57 p. doi:10.4095/296203

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

**CCGS Vector 2013007PGC  
Cruise Report**

**November 1 – 11, 2013**

**CCGS Vector**

Captain Bob Bennett  
Bosun Rob White  
Red Crew

**Scientific Personnel**

Phil Hill (NRCan, Chief Scientist)  
Vaughn Barrie (NRCan)  
Bob Murphy (NRCan)  
Peter Neelands (NRCan)  
Robert Kung (NRCan)  
Cooper Stacey (NRCan)  
Graham Standen (Geoforce)  
Cindy Wright (DFO), November 6 only  
Jessica Heke (CHS), November 7 only

**Objectives**

- Conduct geophysical surveys and coring to estimate the age of inventoried fjord wall submarine slides, Douglas Channel.
- Conduct geophysical surveys and coring to estimate ages of debris flows and slope failures on the Kitimat Delta and Squamish Delta.
- Collect cores for geotechnical characterization of fjord wall glaciomarine sediments.
- Conduct multibeam re-survey of Kitimat Arm.

**Equipment List**

Coring winch  
Huntec winch  
Piston corer  
Gravity corer (trigger core)  
Pedersen corer  
Van Veen grab  
Shipek grab  
Huntec deep tow seismic system  
Knudsen Chirp sonar system  
DIGS seismic acquisition system  
Kongsberg Maritime EM710 Multibeam Echosounder  
IMU Applanix POSMV V5GNSS Positioning system  
PC PACHydro 7 Processing

## **Summary of Activities**

### *1. Positioning and Data Management*

All positioning for the scientific work was taken from the ship's DGPS, providing typical accuracy of 10 metres or less. A GNSS base station was established for the multibeam survey on November 7 (see Annex 2).

The DGPS feed was logged continuously into a navigation file, regardless of activities. DGPS feeds were also provided to Hunttec DTS and chirp sonar data acquisition systems and recorded in the data files. Event positions were recorded in the navigation log for all samples at the time the sampler impacted on the seabed, and for line start and end times of geophysical surveys (Table 1).

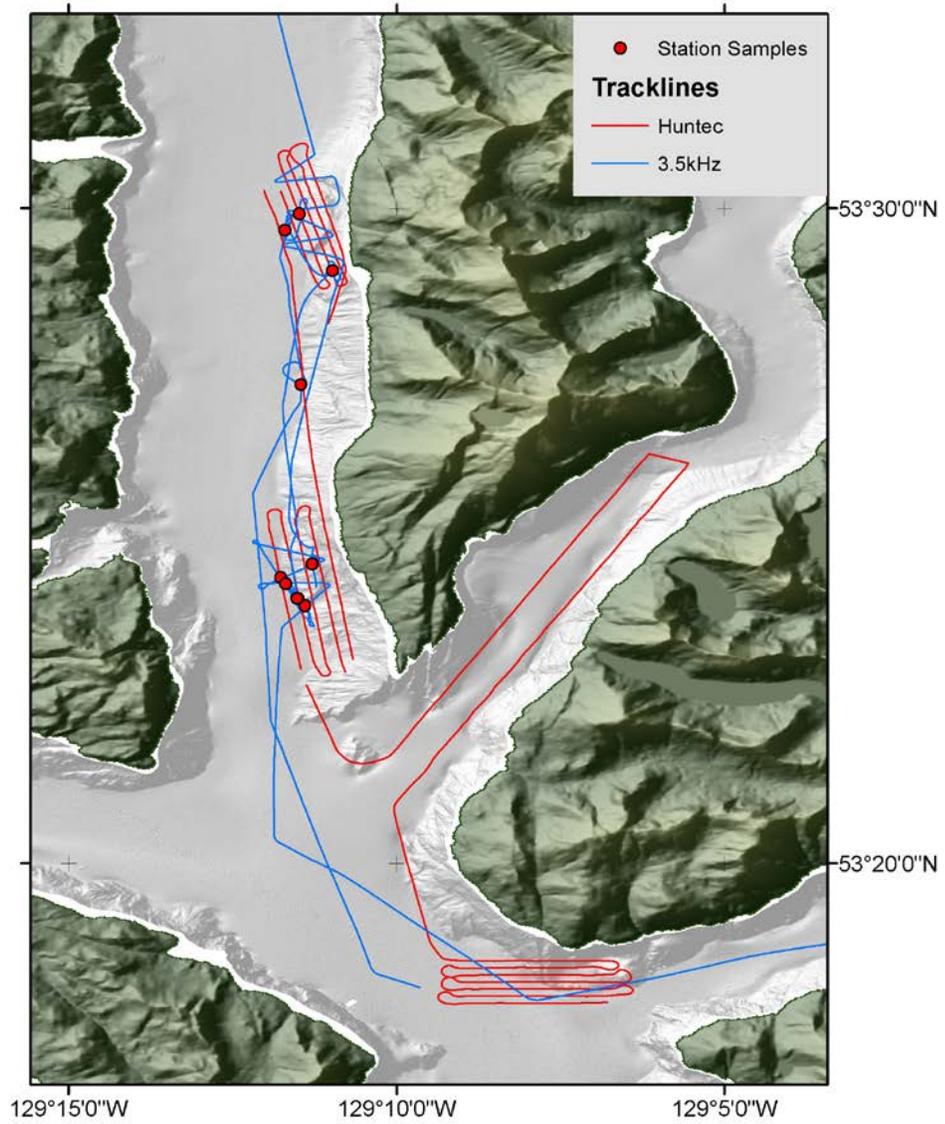
Navigation and sample data were archived in the Expedition Database (ED) where they will be accessible via ED\_Online at: [http://ed.gdr.nrcan.gc.ca/index\\_e.php](http://ed.gdr.nrcan.gc.ca/index_e.php).

Figures 1, 2 and 3 show the track lines and station locations for the cruise.

### *2. Submarine Slide Hazard Assessment, Douglas Channel*

Conway et al (2012) identified two submarine slides and a bedrock fault system in Douglas Channel, near Hawkesbury Island and the community of Hartley Bay from multibeam data collected by the Canadian Hydrographic Service. These features were evaluated to be potentially tsunamigenic and the objectives of the study were to evaluate the age of the slides and the history of fault movement. Sub-bottom profiles using Hunttec Deep Tow Seismic and Knudsen chirp sonar systems were run across the features and nine piston cores were obtained at locations selected from shipboard review of the sub-bottom profiles (Fig. 1; Annex 2). Several unsuccessful attempts were made to sample the tops of the possible slide features.

Some initial results of this work is presented in the September 4 Daily Report (Annex 4). There does not appear to be a significant sediment drape over the slide feature, but possible glaciomarine and postglacial sediments seem ponded against the downslope side of the feature, suggesting that it was emplaced in glacial times. However more comprehensive analysis is required to confirm this preliminary interpretation. Initial review of the data indicates that interpretation will be difficult due to the steep slopes, hard bottoms associated with the slide features and apparent moating of overlying sediments around the features.



**Figure 1.** Location of sub-bottom profile lines and sample stations, Douglas Channel area.

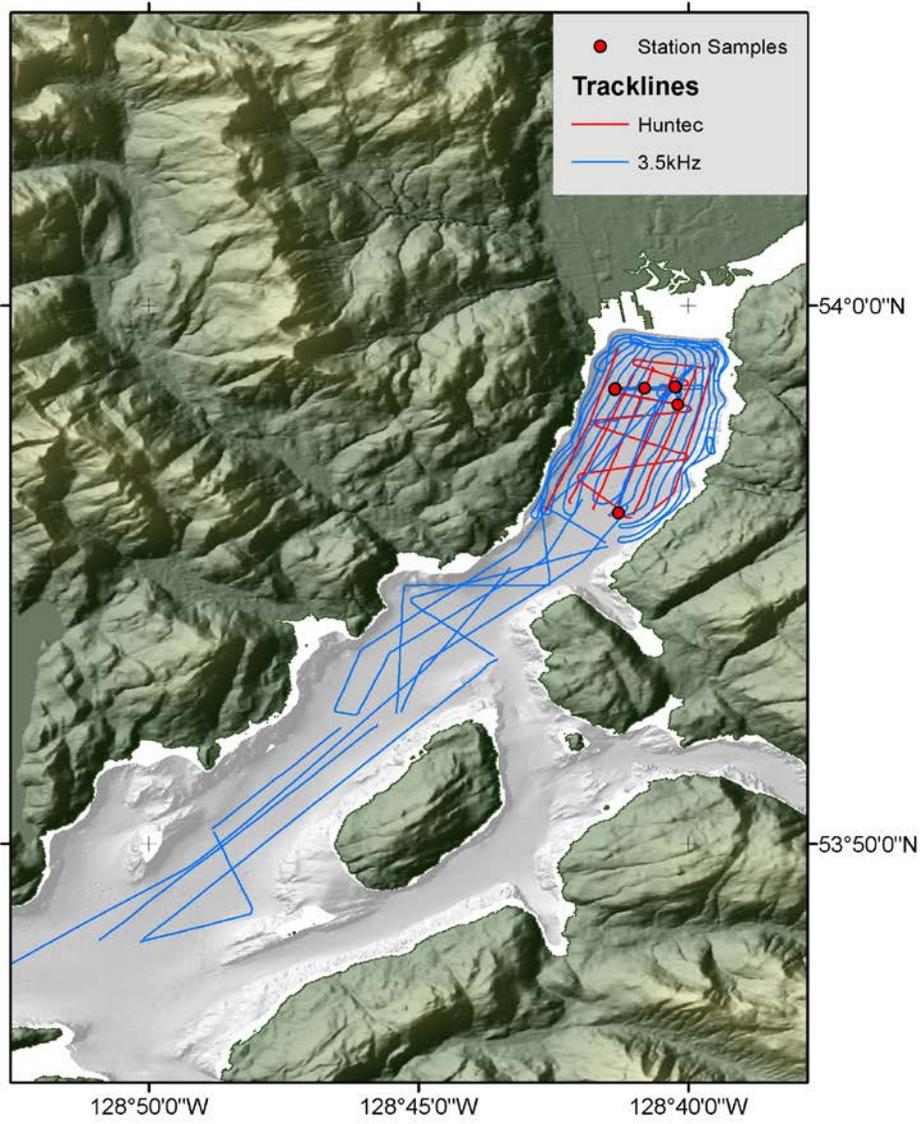
### *3. Submarine Slide Hazard Assessment, Kitimat Arm*

Kitimat Arm is the site of several known submarine landslides in historic times, some of which have generated tsunamis, with the largest documented case in 1975 having a wave height of 8.2 m (Luternauer, J. L., and Swan, D., 1978; Murty, 1979). A sidescan sonar survey of the Kitimat Arm seabed carried out in 1979 indicated the presence of rubbly submarine slide deposits over much of the proximal region of Kitimat Arm (Prior et al., 1982). A modern multibeam sonar survey in 2009 provided detailed bathymetric data over this region and the resulting shaded relief imagery provided a clearer picture of the slide morphology (Annex 4, Daily Report November 2-3).

To assess the return frequency of tsunamigenic submarine slides in Kitimat Arm, a Hunttec DTS and chirp sonar survey was conducted in conjunction with a coring program (Fig. 2). Piston cores were collected to evaluate the stratigraphic distribution of mass transport deposits (Annex 2; Annex 4, Daily Report November 6). Short Pedersen cores were recovered to establish sediment accumulation rates over the slide deposit. In addition a repeat multibeam sonar survey was carried out to determine morphologic change since the previous survey in 2009 and identify any new slide events (Annex 3; Annex 4, Daily Report November 7).

Initial results of the sub-bottom survey indicates that at least one mass transport deposit (slide/debris flow) occurs some 15 m below the seabed and therefore probably pre-dates the known historical events of 1974 and 1975 (Annex 4, Daily Report November 2-3). Strategically placed cores collected on the cruise have the potential for placing an age on this older event.

The repeat multibeam sonar survey revealed that no major slide event has occurred since the 2009 survey. The only significant morphologic changes were observed on the upper delta slope where sediment accumulation occurred as lobes around a few small active slope gullies (Annex 4, Daily Report November 7).



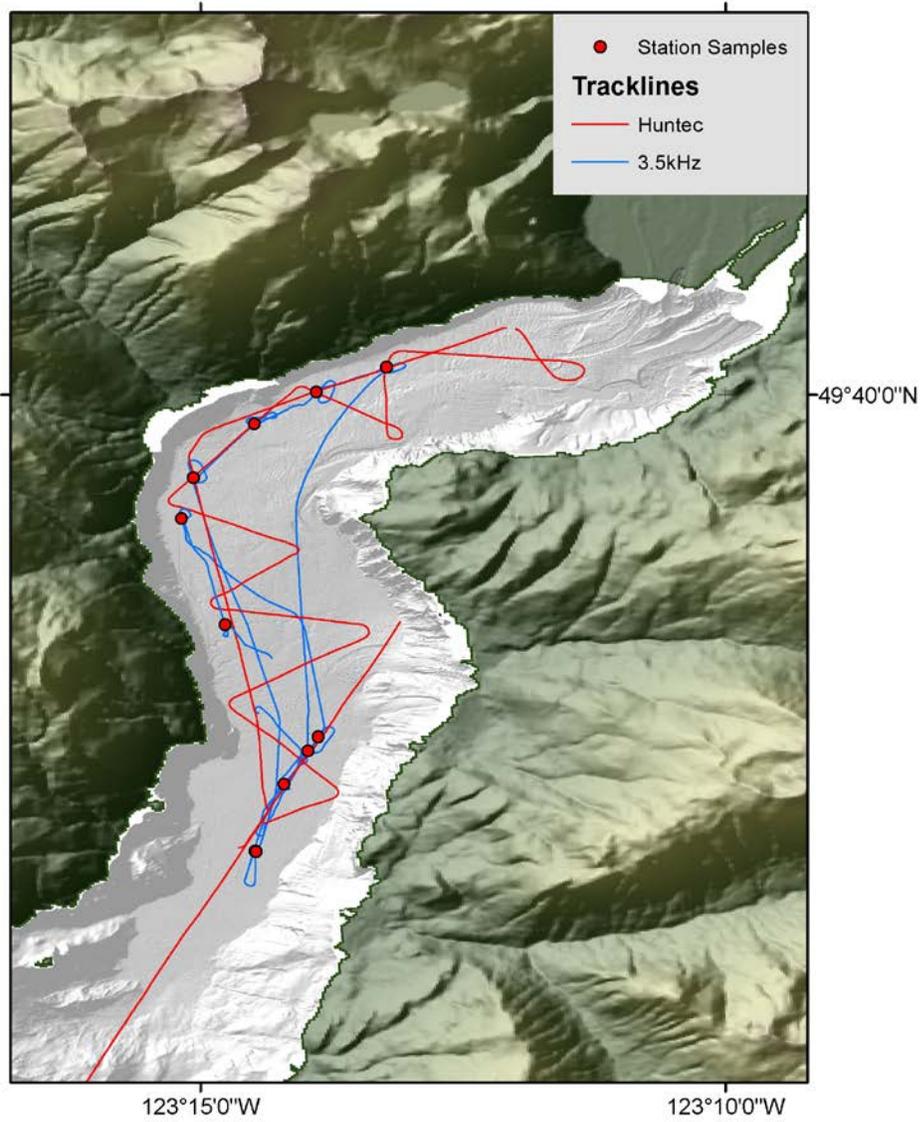
**Figure 2.** Location of sub-bottom profile lines and sample stations, Kitimat Arm area.

#### *4. Submarine Slide Hazard Assessment, Squamish River Delta and Howe Sound*

Howe Sound is the location of research on how records of past submarine landslide events are recorded in fjord basin deposits and whether such deposits can be used to determine the return period and scale of past events. Recent work by Hughes-Clarke (2012; 2013) has shown that turbidity currents are generated almost daily from the Squamish delta front during flood conditions in the spring. They travel down the westernmost submarine channel on the delta front and a train of sediment waves or cyclic steps indicate that they continue along the western margin of the fjord.

Cores from a cruise in 2011 showed that thick sand beds are preserved in the deepest part of the ponded basin of upper Howe Sound. These sands potentially represent large volume failures, most likely from the Squamish delta front, but possibly also from smaller sources such as Britannia Creek.

Piston cores were collected to complete an examination of the two potential transport pathways supplying sediment to the ponded basin (Annex 2). Sub-bottom profiles were collected when transiting into the area and to supplement previous surveys.



**Figure 3.** Location of sub-bottom profile lines and sample stations, Howe Sound.

## **Equipment Performance**

All equipment functioned normally and no major problems occurred.

It is recommended that a Trackpoint positioning system be used for future Hunttec DTS surveys. In the present system operation, the towfish cannot be accurately located with respect to seabed features due to variations in heave, pitch and yaw.

It is recommended that GSC document its data acquisition protocol with respect to coordinate systems recorded in SEGY headers for both Hunttec and chirp sonar data. This would facilitate reading of these data into Kingdom Suite software. It is also recommended that Kingdom Suite software be brought on future cruises as a check that data files are being correctly formatted.

## **Acknowledgements**

Many thanks to Captain Bob Bennett, Bosun Rob White and the ship's officers and crew for making the cruise a success; to all the members of the GSC scientific party; and to Cindy Wright and Jessica Heke for their professional participation. Special thanks to Cooper Stacey for creating the figures in Annex 2.

## **References**

*Conway, K.W., Barrie, J.V, and Thomson, R. E., 2012. Submarine slope failures and tsunami hazard in coastal British Columbia: Douglas Channel and Kitimat Arm. Geological Survey of Canada, Current Research (Online) no. 2012-10, doi:10.4095/291732*  
<http://geoscan.nrcan.gc.ca/starweb/geoscan/servlet.starweb?path=geoscan/showrte.web&search1=R=291732>

*Hughes Clarke, J.E., Brucker, S. Muggah, J., Hamilton, T., Cartwright, D., Church, I. Kuus, P., 2012. Temporal progression and spatial extent of mass wasting events on the Squamish prodelta slope: 11th International Symposium on Landslides, Conference Proceedings, Banff, June 2012, in press.*

*Hughes Clarke, J.E., Videra Marques, C.R., Pratomo, D., 2013, Imaging active mass wasting on a fjord delta, Squamish, British Columbia. In Submarine Mass Movements and their Consequences, VI, in review.*

*Luternauer, J. L., and Swan, D., 1978. Kitimat Submarine Slump Deposit(s): A Preliminary Report. Current Research, Part A, Geol. Surv. Can., Paper 78-1A, p. 327-332.*

*Murty, T. S., 1979. Submarine slide-generated water waves in Kitimat Inlet, British Columbia: Journal of Geophysical Research, v. 84, p. 7777-7779.*

*Prior, D.B., Bornhold, B.D., Coleman, J.M., and Bryant, W.R., 1982. Morphology of a submarine slide, Kitimat Arm, British Columbia. Geology, 10, 588-592.*

**TABLE 1****Operations Log**

<b>Day</b>	<b>Time (UTC)</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Line #</b>	<b>Event</b>	<b>Operation</b>	<b>Depth (m)</b>
308	1546	53.000709	-128.522071	Line1	SOL1	3.5	158
308	1947	53.392325	-129.195974	Line 2	EOL1_SOL2	3.5	844
308	2025	53.414713	-129.202704	Line 3	EOL2_SOL3	3.5	404
308	2049	53.401994	-129.193262	Line 4	EOL3_SOL4	3.5	416
308	2121	53.406040	-129.196171		STN001	Piston	424
308	2221	53.398398	-129.189536	Line 5	EOL4_SOL5	3.5	410
308	2306	53.398913	-129.189916		STN002	Piston	402
308	2357	53.404271	-129.194874	Line 6	EOL5_SOL6	3.5	421
309	032	53.404539	-129.194855		STN003	Piston	422
309	0045	53.444420	-129.195109	Line6	EOL6	3.5	424
309	0202	53.470737	-129.184030	Line7	L7_SOL	Huntec	200
309	0428	53.504537	-129.196253	Line7	L7_EOL	Huntec	358
309	0432	53.503918	-129.200187	Line8	L8_SOL	Huntec	362
309	0604	53.385130	-129.177786	Line8	L8_EOL	Huntec	263
309	0609	53.382675	-129.179973	Line9	L9_SOL	Huntec	293
309	0821	53.382477	-129.190950	Line9	L9_EOL	Huntec	425
309	0824	53.377716	-129.189153	Line10	L10_SOL	Huntec	392
309	0844	53.359939	-129.169863	Line11	L11_SOL	Huntec	446
309	0951	53.438352	-129.101852	Line11	L11_EOL	Huntec	191
309	0958	53.434863	-129.092718	Line12	L12_SOL	Huntec	254
309	1114	53.350590	-129.165291	Line12	L12_EOL	Huntec	425
309	1114	53.350571	-129.165308	Line13	L13_SOL	Huntec	425
309	1147	53.308566	-129.150678	Line14	L14_SOL	Huntec	502
309	1440	53.297880	-129.111466	Line14	L14_EOL	Huntec	583
309	1505	53.297880	-129.162294	Line15	SOL15	3.5	505
309	1606	53.449929	-129.191554	Line16	EOL15_SOL16	3.5	348
309	1615	53.460644	-129.193616	Line17	EOL16_SOL17	3.5	375
309	1659	53.455121	-129.190932	Line17	STN004	Piston	359
309	1726	53.456839	-129.190106	Line18	EOL17_SOL18	3.5	348
309	1754	53.496798	-129.194720	Line19	EOL18_SOL19	3.5	355
309	1829	53.494362	-129.195060	Line19	STN005	Piston	359
309	1840	53.494242	-129.195638	Line20	EOL19_SOL20	3.5	364
309	2021	53.498598	-129.191472	Line21	EOL20_SOL21	3.5	329
309	2027	53.498602	-129.191473	Line21	STN006	Piston	333
309	2119	53.482725	-129.181151	Line22	EOL21_SOL22	3.5	108
309	2143	53.484083	-129.182941	Line22	STN007	Piston	140
309	2230	53.449778	-129.195672	Line23	EOL22_SOL23	3.5	386
309	2335	53.400664	-129.191769	Line23	STN008	IKU	380
309	2352	53.400664	-129.192002	Line23	STN009	IKU	384
310	0005	53.401299	-129.190649	Line24	EOL23_SOL24	3.5	362
310	0029	53.409475	-129.188028	Line24	STN010	IKU	266
310	0038	53.409502	-129.188090	Line24	STN011	IKU	267

310	0050	53.410482	-129.118256	Line25	EOL24_SOL25	3.5	283
310	0150	53.487843	-129.183629	Line26	EOL25_SOL26	3.5	162
310	0241	53.513728	-129.187714	Line27	EOL26_SOL27	3.5	325
310	0819	53.939059	-128.703418	Line30	L30_SOL	Huntec	199
310	0853	53.980803	-128.682556	Line30	L30_EOL	Huntec	142
310	0857	53.980736	-128.677831	Line31	L31_SOL	Huntec	138
310	0935	53.936863	-128.696073	Line31	L31_EOL	Huntec	213
310	0938	53.934963	-128.689947	Line32	L32_SOL	Huntec	212
310	1017	53.979691	-128.670972	Line32	L32_EOL	Huntec	137
310	1028	53.979625	-128.664782	Line33	L33_SOL	Huntec	134
310	1109	53.934561	-128.684129	Line33	L33_EOL	Huntec	210
310	1110	53.934286	-128.684798	Line34	L34_SOL	Huntec	210
310	1312	53.980412	-128.660979	Line34	L34_EOL	Huntec	116
310	1558	53.964979	-128.690515	Line35	L35_SOL	3.5	171
310	1645	53.974075	-128.664590	Line36	EOL35_SOL36	3.5	153
310	1704	53.974231	-128.689258	Line36	STN012	VanVeen	156
310	1721	53.973985	-128.689367	Line36	STN013	Pederson	154
310	1733	53.974099	-128.689422	Line36	STN014	Pederson	154
310	1743	53.974097	-128.689137	Line37	EOL36_SOL37	3.5	154
310	1759	53.974473	-128.680235	Line37	STN015	Pederson	156
310	1803	53.974505	-128.680312	Line38	EOL37_SOL38	3.5	157
310	1816	53.974831	-128.670812	Line38	STN016	Pederson	153
310	1825	53.974760	-128.670632	Line38	STN017	Pederson	153
310	1833	53.974728	-128.670654	Line38	STN018	Pederson	152
310	2017	53.974764	-128.670565	Line38	STN019	Piston	168
310	2107	53.969285	-128.669968	Line38	STN020	Pederson	154
310	2323	53.974774	-128.670545	Line38	STN021	Pederson	154
310	2331	53.974803	-128.670731	Line38	STN022	Pederson	156
310	0035	53.935866	-128.688294	Line38	STN023	Piston	210
311	0225	53.974413	-128.671730	Line39	EOL38_SOL39	3.5	161
311	0245	53.938586	-128.708912	Line40	EOL39_SOL40	3.5	88
311	0451	53.940464	-128.699194	Line40	L40_EOL	3.5	201
311	0504	53.938015	-128.685636	Line41	L41_SOL	3.5	204
311	0605	53.873750	-128.755889	Line41	L41_EOL	3.5	296
311	0606	53.873750	-128.755889	Line42	L42_SOL	3.5	296
311	0729	53.926073	-128.691698	Line42	L42_EOL	3.5	433
311	0730	53.925402	-128.691682	Line43	L43_SOL	3.5	433
311	0820	53.890918	-128.725851	Line43	L43_EOL	3.5	249
311	0821	53.890383	-128.725795	Line44	L44_SOL	3.5	249
311	0951	53.803376	-128.835458	Line44	L44_EOL	3.5	358
311	0957	53.803182	-128.835408	Line45	L45_SOL	3.5	359
311	1037	53.837834	-128.813813	Line45	L45_EOL	3.5	311
311	1038	53.838122	-128.813807	Line46	L46_SOL	3.5	311
311	1113	53.872854	-128.769122	Line46	L46_EOL	3.5	298
311	1121	53.870128	-128.762810	Line47	L47_SOL	3.5	302
311	1234	53.803591	-128.848639	Line47	L47_EOL	3.5	351
311	1812	53.969379	-128.681679	Line48	L48_SOL	3.5	94
311	1905	53.945535	-128.699477	Line49	L49_SOL	3.5	200

311	1959	53.940396	-128.710907	Line50	L50_SOL	3.5	153
311	2109	53.982695	-128.693546	Line51	L51_SOL	3.5	113
311	2200	53.977435	-128.664656	Line52	L52_SOL	3.5	141
311	2259	53.975037	-128.660535	Line53	L53_SOL	3.5	112
311	2358	53.958963	-128.660888	Line54	L54_SOL	3.5	107
312	0100	53.985986	-128.691289	Line55	L55_SOL	3.5	86
312	0133	53.987729	-128.679113	Line55	L55_EOL	3.5	97
314	0054	49.391957	-124.007822	Line56	L56_SOL	Huntec	396
314	0432	49.360700	-123.566202	Line56	L56_EOL	Huntec	175
314	0432	49.360709	-123.566139	Line57	L57_SOL	Huntec	175
314	0838	49.538475	-123.280574	Line57	L57_EOL	Huntec	156
314	0838	49.538535	-123.280563	Line58	L58_SOL	Huntec	156
314	1053	49.677251	-123.201877	Line58	L58_EOL	Huntec	150
314	1054	49.677074	-123.199858	Line59	L59_SOL	Huntec	138
314	1317	49.597819	-123.241526	Line59	L59_EOL	Huntec	280
314	1322	49.594908	-123.243059	Line60	L60_SOL	Huntec	280
314	1354	49.630513	-123.218379	Line60	L60_EOL	Huntec	227
314	1441	49.615990	-123.240889	Line61	L61_SOL	3.5	272
314	15:41	49.604729	-123.236766	Line61	STN 24	Piston	280
314	16:36	49.594066	-123.241306	Line61	STN 25	Pederson	202
314	16:59	49.594008	-123.241202	Line61	STN 26	Pederson	204
314	18:00	49.653482	-123.251207	Line61	STN 27	Piston	234
314	18:57	49.661992	-123.241444	Line61	STN 28	Piston	222
314	20:16	49.667097	-123.231598	Line61	STN 29	Piston	207
314	21:02	49.671043	-123.220485	Line61	STN 30	Piston	189
314	22:04	49.609975	-123.232998	Line61	STN 31	Piston	279
314	23:02	49.612257	-123.231369	Line61	STN 32	Piston	277
314	2340	49.648303	-123.253216	Line61	EOL61_SOL62	3.5	327
314	2355	49.646965	-123.253028	Line62	STN 33	3.5	236
315	0045	49.630127	-123.246085	Line 62	STN 34	3.5	255
315	114	49.624623	-123.238569	Line62	L62_EOL	3.5	264

## ANNEX 1

### Chief Scientists Log

#### *Friday November 1 (JD 305)*

08h00 Pacific Daylight Savings Time (GMT-7hr)  
Loading winches. Most of loading had been completed Thursday because Vector was at dock during training week.

14h00 Familiarization briefing by 1st mate (Shane)

#### *Saturday November 2 (JD 306)*

07h00 Depart IOS. Aiming for 5 pm tide at Seymour Narrows.  
Weather: Northerly wind, 10 knots, rain.

10h00 40 km winds from N entering Strait of Georgia. Making very little headway.

12h30 SOG 3 kn. Off Tsawwassen terminals.

17h00 Still south of Nanaimo. Wind and seas coming down but will miss 11 pm tide at Seymour.

18h30 Off Nanaimo. SOG 7.3 kn.

#### *Sunday November 3 (JD 307)*

00h00 Clocks change to Pacific Standard Time (GMT – 8hrs)

06h00 Have passed through Seymour Narrows. Weather has improved. Steaming at 12 kn through Johnstone Strait.

10h30 Met with Captain to provide survey waypoints and discuss strategy for next few days.

12h30 Fire and boat drill. Weather sunny, calm and sea glassy.

15h30 Exiting Queen Charlotte Strait and entering more exposed Queen Charlotte Sound. 1-metre swell.

19h15 Entering Inside Passage (Fitz Hugh Sound).

***Monday November 4 (JD 308)***

- 06h00 Making good progress up Princess Royal Channel. ETA for Douglas Channel is noon. Weather: overcast, calm.
- 07h46 Start 3.5 kHz profiling in Princess Royal Channel.
- 09h54 Possible landslide scar visible on west side of Princess Royal Channel (Event # PR Slide1) 53.265 N 128.863 W. Photos 142, 143 on Peter's camera. False alarm? Vaughn suggest may be remnants of "A-frame" clear cutting, a common practice in the area.
- 11h05 First crossing of the fault at the top of Whale Channel mapped by Conway et al. (2012). A thick transparent unit overlies well stratified (glaciomarine?) unit. At fault crossing, stratified unit dips into a trough but no obvious rupture of sediments, but ship was doing a turn at the time. Surprising lack of gas in the sediments.
- 11h48 Starting 3.5 kHz line across southern Douglas Channel slide. Decided to run a minimal 3.5 survey in lieu of Hunttec in order to maximize daylight hours for coring. Several sites selected by Vaughn. Good quality profile. Mass transport deposit siting at boundary between stratified and transparent units.
- 12h55 Begin coring operations at STN001. 20 ft core in pinch out of transparent unit against the slide.
- 13h21 Piston corer on bottom.
- 14h05 Piston core recovered. 20 ft almost full. Postglacial to glaciomarine transition observed?
- 14h38 Begin core STN002. 30 ft piston core.
- 15h06 Corer on bottom
- 16h00 Core recovered. Approx 5 m terminating in stiff grey (glaciomarine?) mud.
- 16h10 Begin STN003. 30 ft piston core.
- 16h30 Corer on bottom.
- 17h15 Core recovered and processed. 7.68 m recovery.
- 18h02 Start Hunttec survey at DC4-1.

*Tuesday November 5 (JD 309)*

- 06h00 Huntec surveying continuing. Core sites being determined by Vaughn. Decided to attempt samples from the top of the slides using IKU grab.
- 06h40 End Huntec. Steaming towards DC4 area for coring.
- 09h00 First core coming up. STN004.
- 10h00 Good recovery: 8.17 m. Preparing corer for next site.
- 10h30 Corer on bottom.
- 11h15 Core recovered and processed. STN005. 7.37 m.
- 12h27 STN006. Corer on bottom.
- 13h26 STN006. Core recovered and processed.
- 13h39 STN007. Corer going down.
- 13h43 STN007. Corer on bottom. 145 m.
- 14h20 STN007. Core recovered and processed. Barrel bent and cutter flattened so must have hit bedrock or large boulder. 3.04 m. Trigger core had gravel on top and consisted of sandy mud over grey (glacial?) mud.
- 14h50 3.5 kHz survey for first IKU sample. Objective is to sample hard bottom on tops of slides.
- 15h15 Start IKU grab.
- 15h35 On bottom
- 15h45 On deck but did not trigger. STN008
- 15h52 On bottom (same location).
- 15h58 On deck, but did not trigger again. There is mud on the sampler and wire response suggest that the bottom is soft. STN 009
- 16h36 After third attempt at this site (STN 010), moved to next site. First attempt did not trigger (STN011).

- 16h45 Second attempt failed. Grab appears to have fallen sideways but not triggered suggesting very hard bottom; certainly looks hard in 3.5 kHz.
- 17h20 Steaming northward towards DC4 area to do some 3.5 kHz lines before heading to Kitimat Arm.

***Wednesday November 6 (JD 310)***

- 05h45 Huntec survey complete –spectacular record across slide masses. Checking coring sites.
- 07h00 Preparing Zodiac to pick up Cindy Wright.
- 09h28 Cindy on board. Completed 3.5 kHz survey over sample site.
- Grab sample confirms mud at seabed. OK for Pedersen corer.
- First Pedersen corer unsuccessful. Adding weight..
- 11h30 Spent all morning dealing with issue related to Hartley Bay call to NRCan and to marine mammal issue.
- Two Pedersen cores obtained STN's 014 and 015.
- Third attempt with long liner came up with sediment but it fell out as it came out of the water. Will retry later with short barrel.
- 12h30 Piston core STN019 on deck.
- 13h45 Preparing for Pedersen core but ordered by Coast Guard to suspend operations until a meeting had been called about the Hartley Bay phone call. Ship had been contacted by MCTS Prince Rupert to indicate that a caller had asked what were we up to? The Captain replied by reading the objectives from the cruise plan.
- 15h30 Given go ahead to continue work. Called Carmel Lowe who also indicated that it was OK to continue work but asked that we not do any further work off Hartley Bay. Pedersen core at third site, STN022. Moving to STN23 for 40 ft piston core.
- 17h00 Full piston core recovered. 10.8 m STN23.
- 18h30 Cindy returned to shore.

20h00 No further communication from DFO, so decided not to do Hunttec work. Running 3.5 kHz lines. Also making observations of cell phone signal strength for Gwyn Lintern and Mike Schmidt.

***Thursday November 7, 2013 (JD 311)***

07h00 Boat being launched to pick up Jessica. She is installing RTK GPS antenna on shore.

09h38 Start multibeam survey. Ship contacted by CRA Surveyor conducting some kind of survey. Have two port side pole mounts and say that they are towing a streamer.

10h12 Start 3.5 kHz profiler after initial issues configuring for external trigger (for compatibility with multibeam).

12h36 Cooper noticed strange patterns on multibeam and 3.5 kHz. Further analysis indicates that they are point reflections/backscattering in the water column. They are ephemeral because the next pass does not show them. They occur in the mid slope region i.e above the slide masses. They are possibly sediment suspensions – flows like on Squamish?; or whales/schools of fish? or kelp masses?

17h00 Multibeam survey almost complete.

19h00 Jessica put ashore by Zodiac. Heading south, no systems running.

22h00 Multibeam data processed. Difference map shows small changes at head of delta. Small gullies show net erosion. Small depositional lobes down slope of them with sediment waves on them.

***Friday November 8 (JD 312)***

In transit

11h00 Received marine mammal advice note from DFO.

12h00 Briefed captain on same.

***Saturday November 9 (JD 313)***

07h00 Waiting to pass through Seymour Narrows.

- 12h30 In Strait of Georgia, off Comox.
- 15h30 Begin marine mammal surveillance.
- 16h54 Start Huntec surveying, central Strait of Georgia, running into Howe Sound to Squamish.

***Sunday November 10 (JD 314)***

- 05h55 Complete Huntec survey.
- 07h41 Piston core on bottom STN024.
- 09h10 Two attempts at Pedersen corer – first one fell out (STN025); second one only recovered ~10 cm – also fell out but retained as bucket sample (STN026).
- 10h27 STN027. Successful 20ft piston core. Organic rich mud with sandy interval on top? Trigger core empty.
- 11h10 STN028. Successful 20 ft piston core. Looks like sand/mud intervals with color change at top.
- 12h04 STN029. 3.5 kHz profile indicates that proposed site is just at base of a cyclic step. Good core. Sand over organic rich mud.
- 13h05 STN030. Core coming up.
- 14h46 STN031. Core full of gas and quite disturbed, but some coherent muddy (?) sections.
- 15h30 STN 032. On debris flow. Looks like mud and sand.
- 15h58 STN033. Coming up.
- 17h00 STN034. Completed. All coring objectives for the day met plus one bonus core.
- 18h00 Gear being dismantled and stowed for transit to IOS.

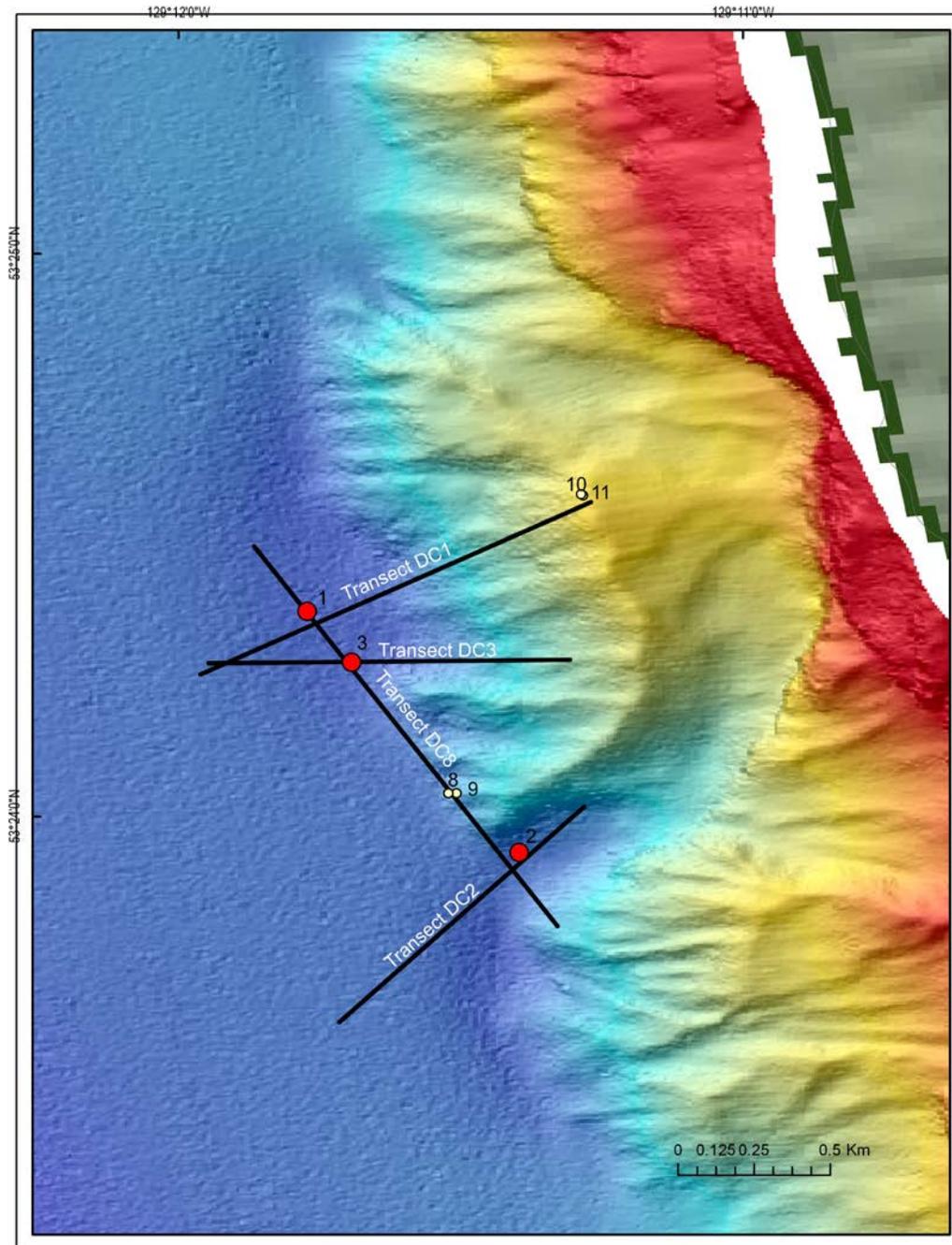
***Monday November 11 (JD 315)***

- 07h00 Approaching IOS dock.

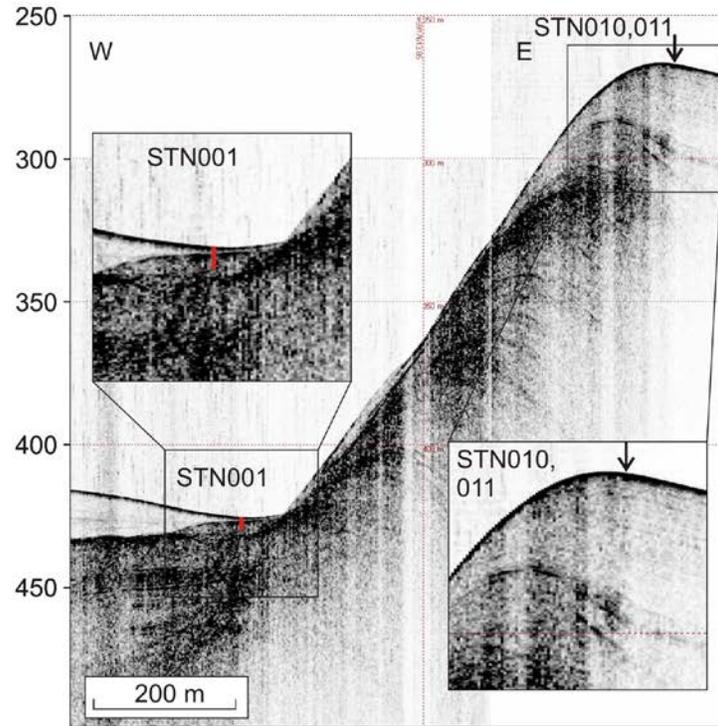
10h00      Equipment unloaded. Cores stowed in cold room.

## ANNEX 2

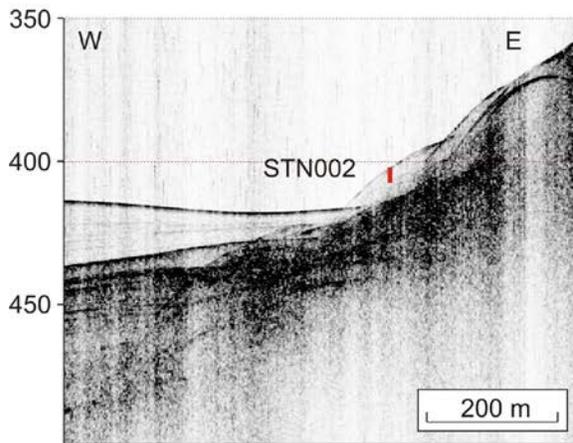
### Core Locations



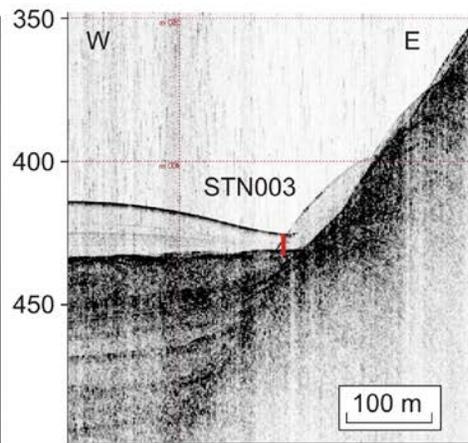
**Figure A2-1.** Sample locations on the southern slide in Douglas Channel. Red dots: piston cores; yellow dots: IKU grab attempts; black lines: 3.5 kHz profiles shown in Figure A2-2.



Transect DC1. 3.5kHz 308\_1946\_120269.

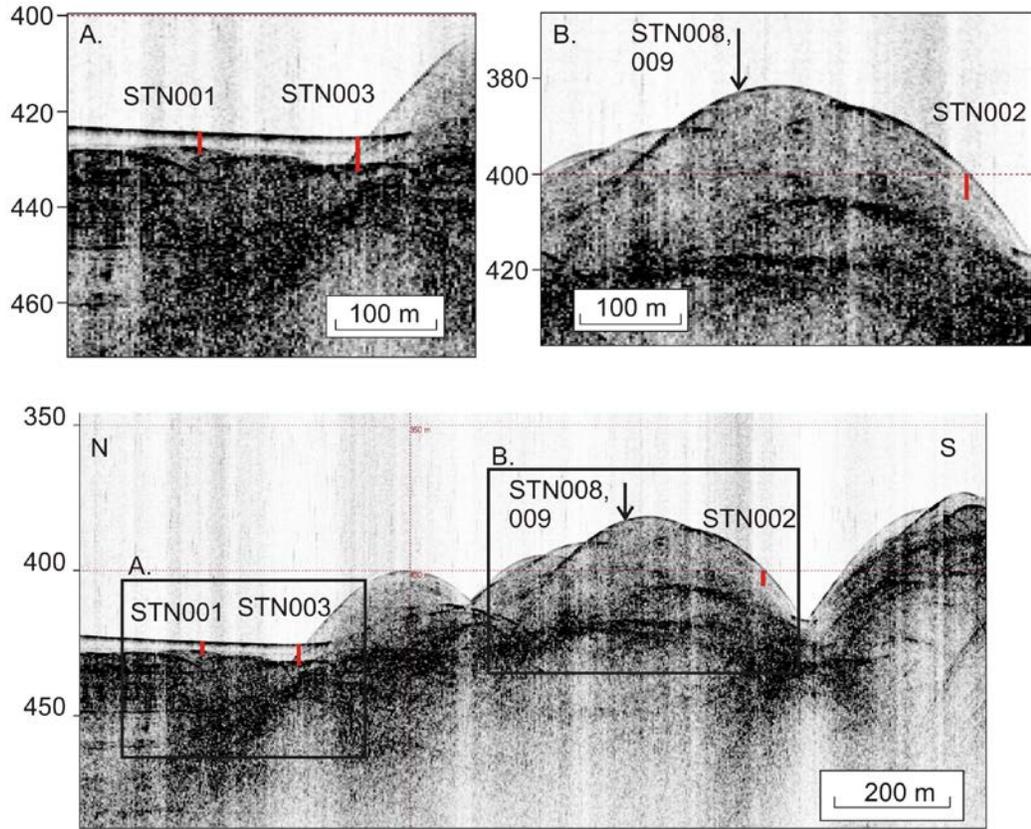


Transect DC2. 3.5kHz 308\_1946\_120269.



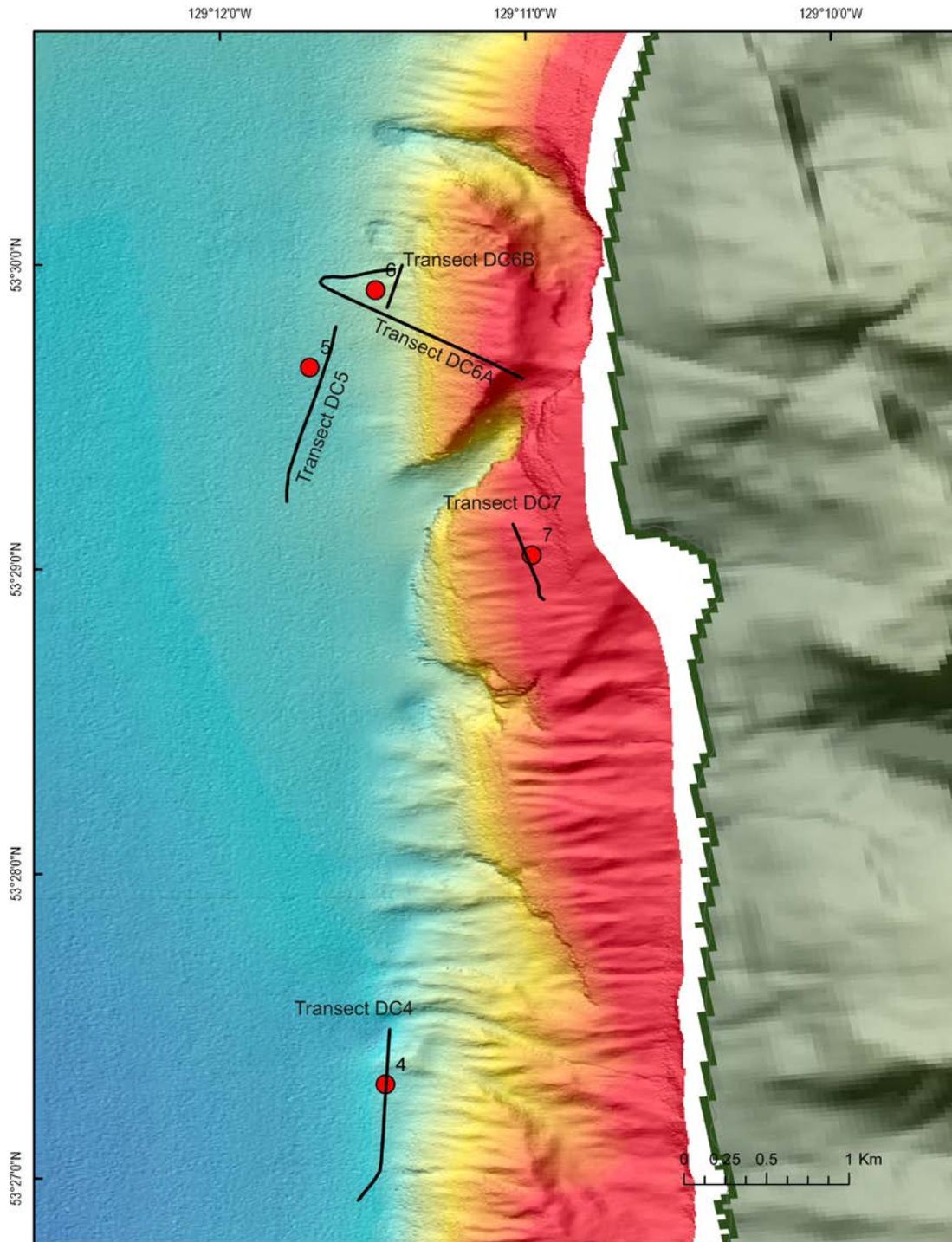
Transect DC3. 3.5kHz 308\_1946\_120269.

660

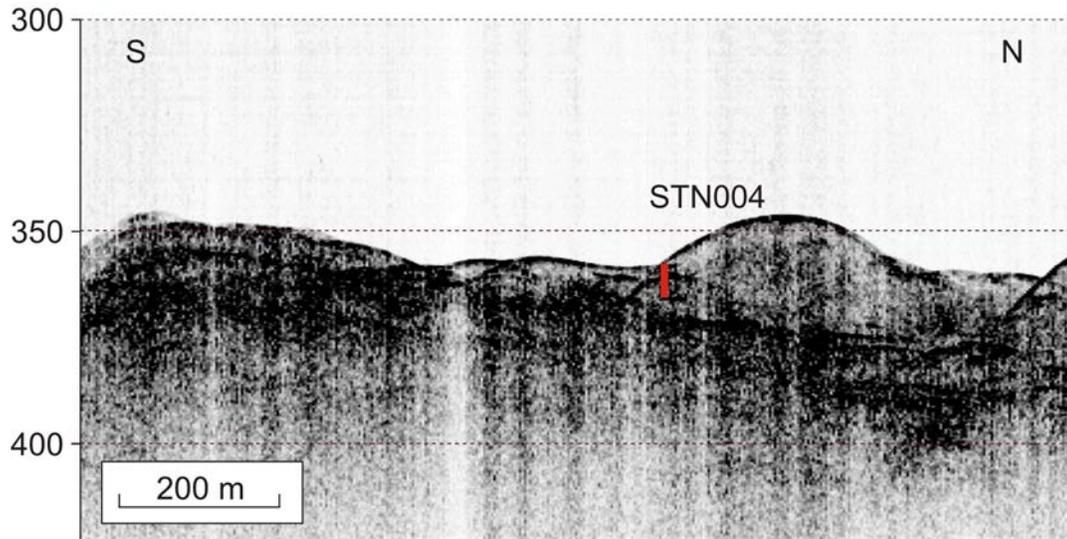


Transect DC8. 3.5kHz 308\_1946\_120269.

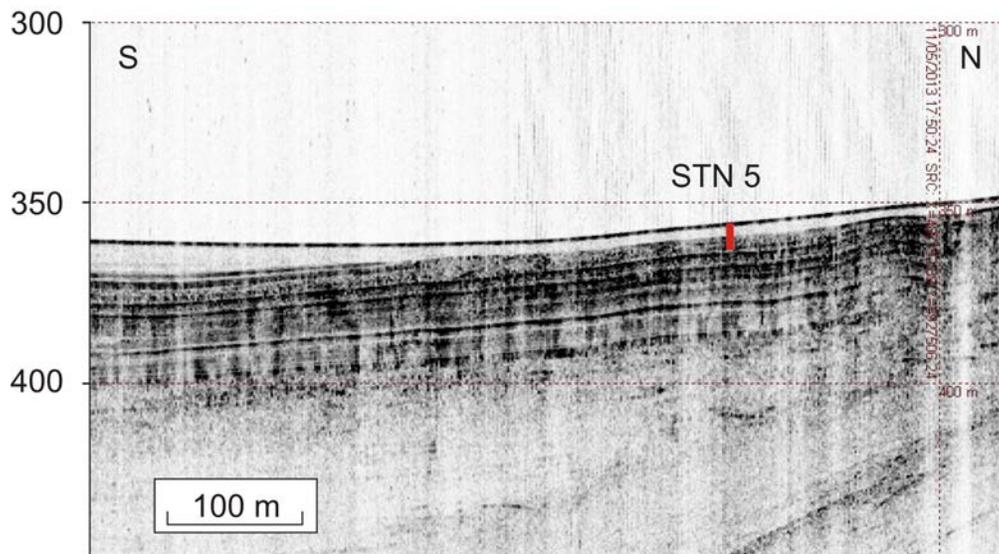
**Figure A2-2.** Sample stations located on chirp sonar profiles, southern slide of Douglas Channel (see Figure A2-1 for locations).



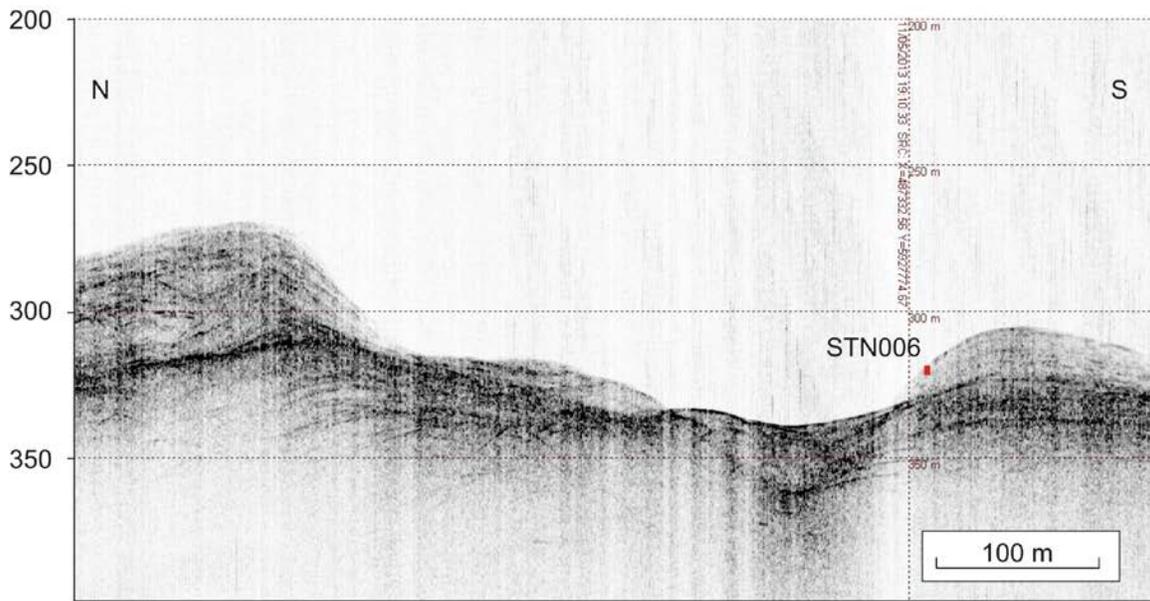
**Figure A2-3.** Sample locations on the northern slide in Douglas Channel. Red dots: piston cores; black lines: 3.5 kHz profiles shown in Figure A2-4.



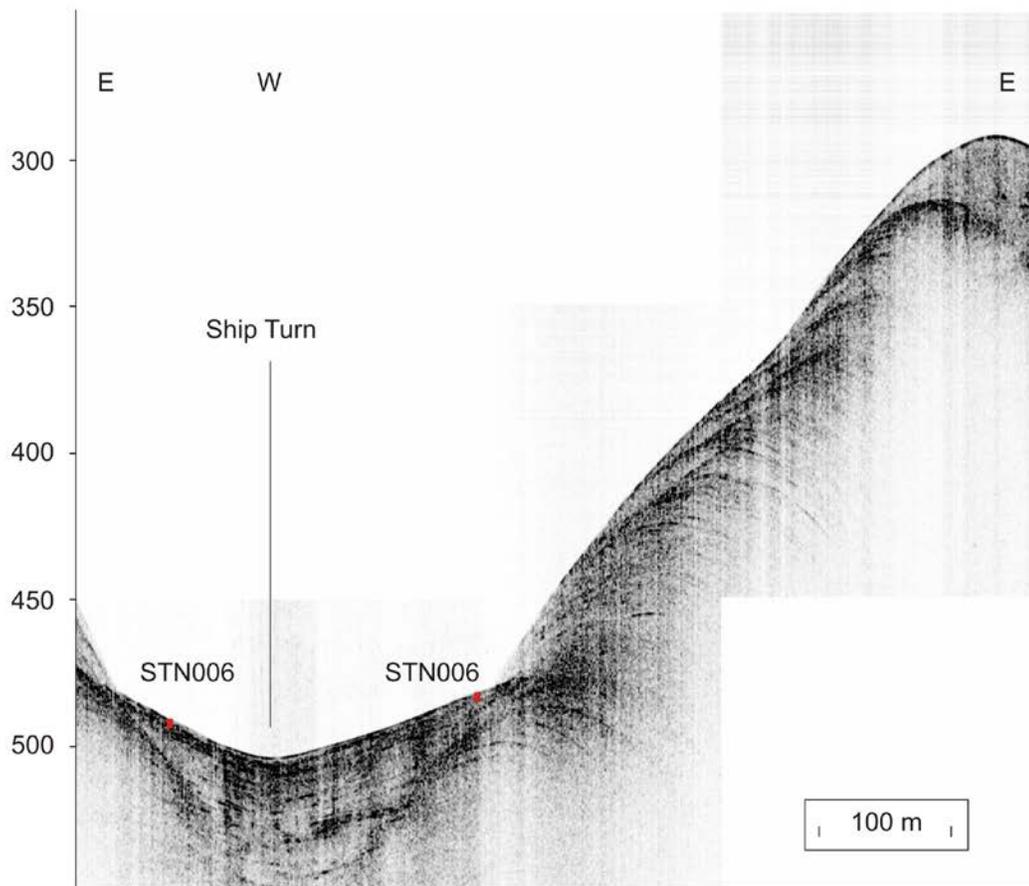
Transect DC4. 3.5kHz 309\_1605\_120269.



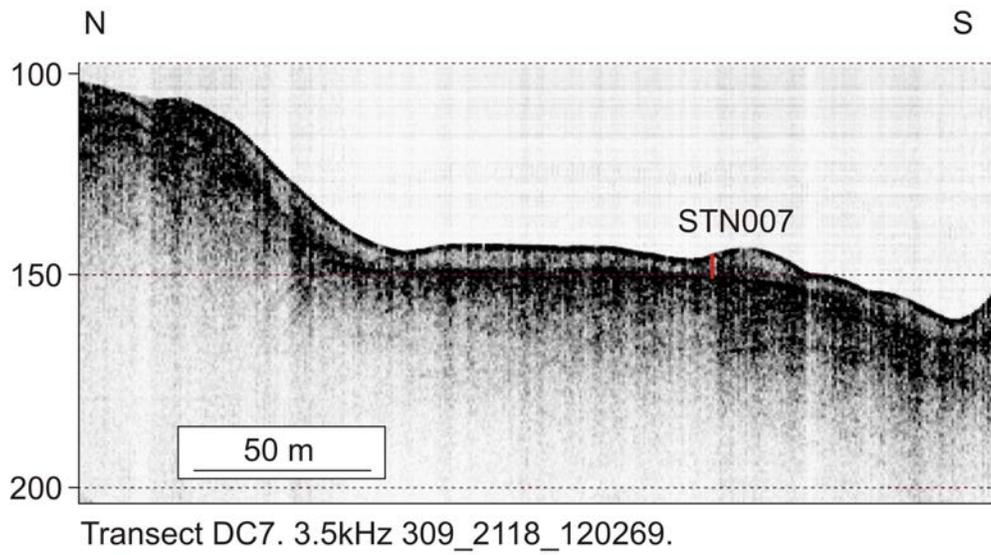
Transect DC5. 3.5kHz 309\_1725\_120269.



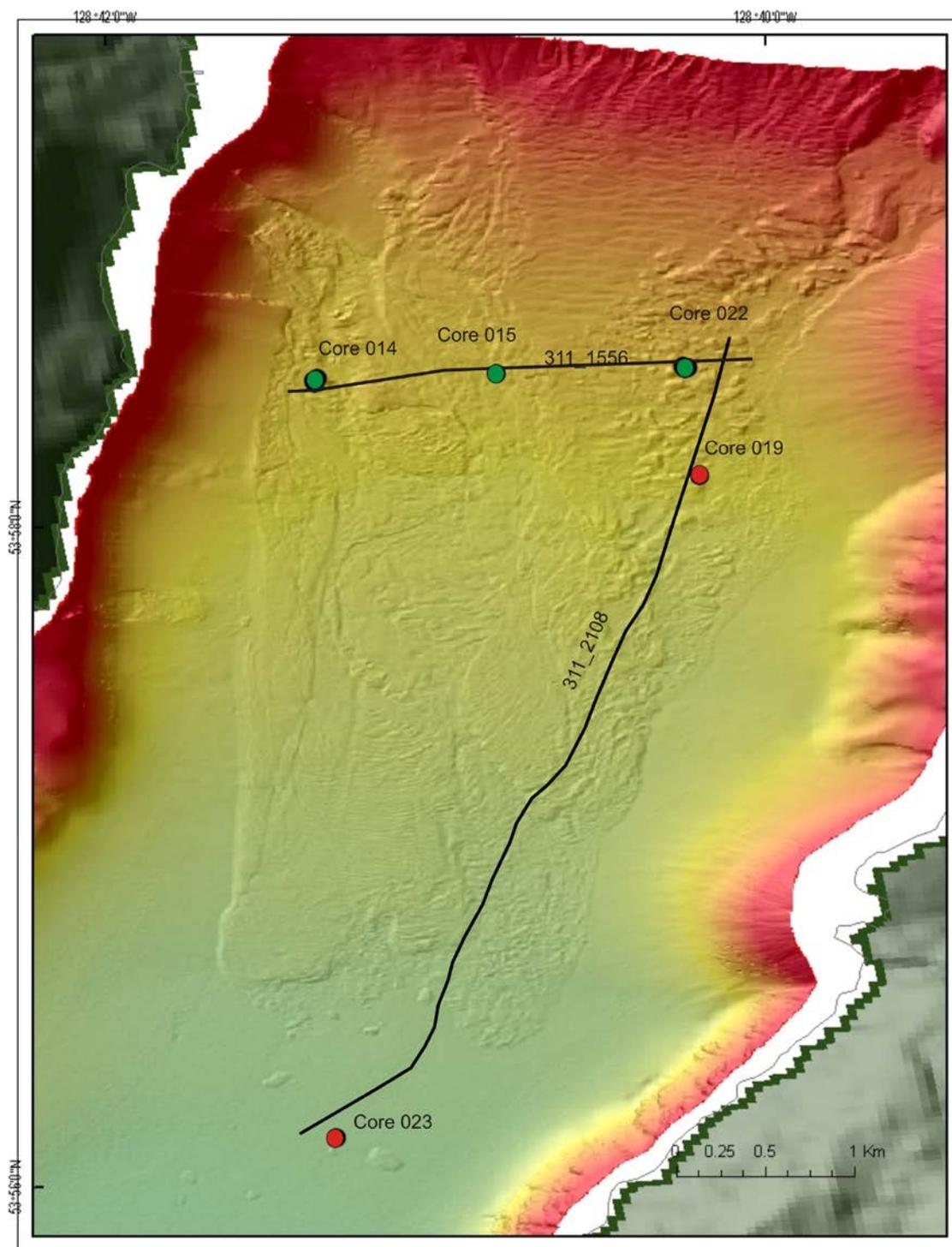
Transect DC6B. 3.5kHz 309\_1902\_120269.



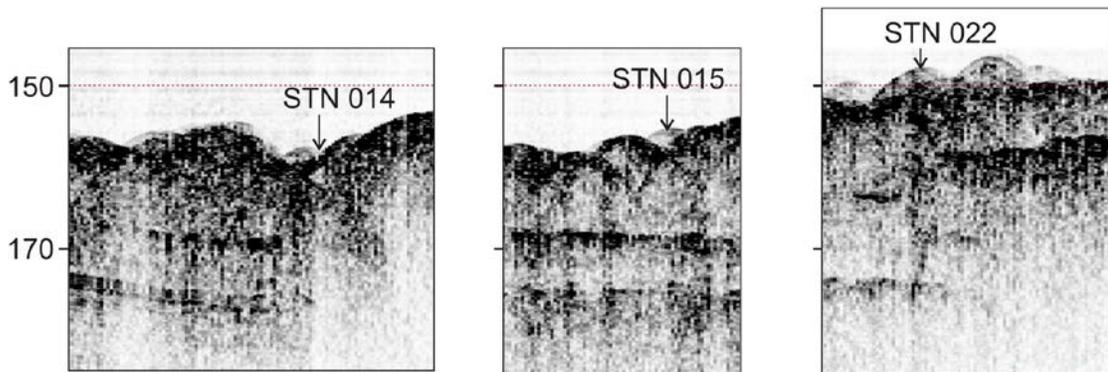
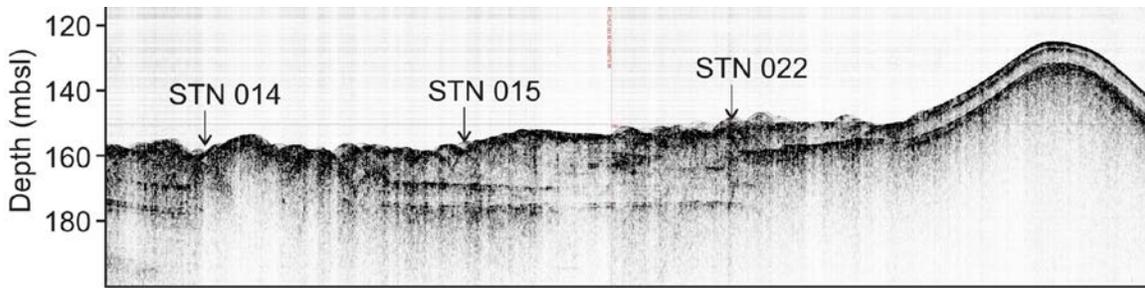
Transect DC6A. 3.5kHz 310\_1049\_120269.



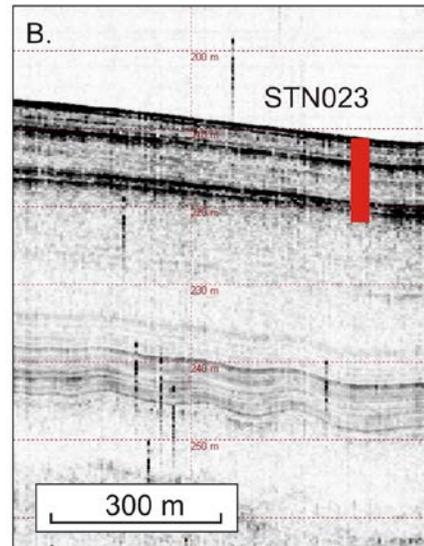
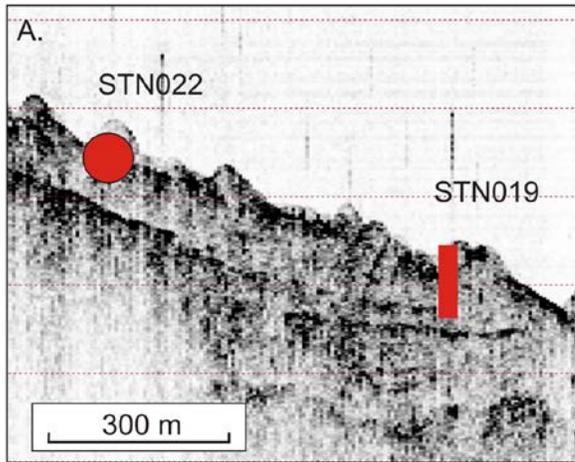
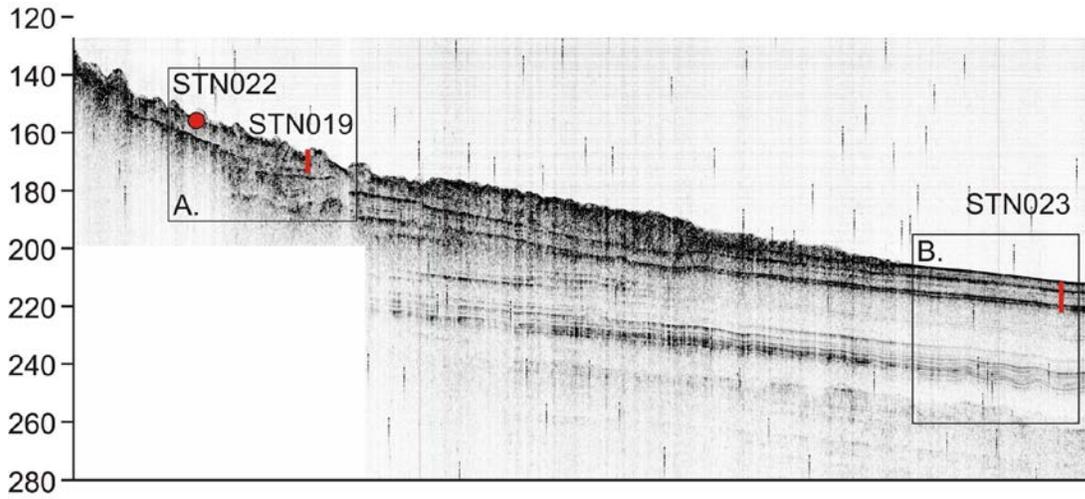
**Figure A2-4.** Sample stations located on chirp sonar profiles, southern slide of Douglas Channel (see Figure A2-2 for locations).



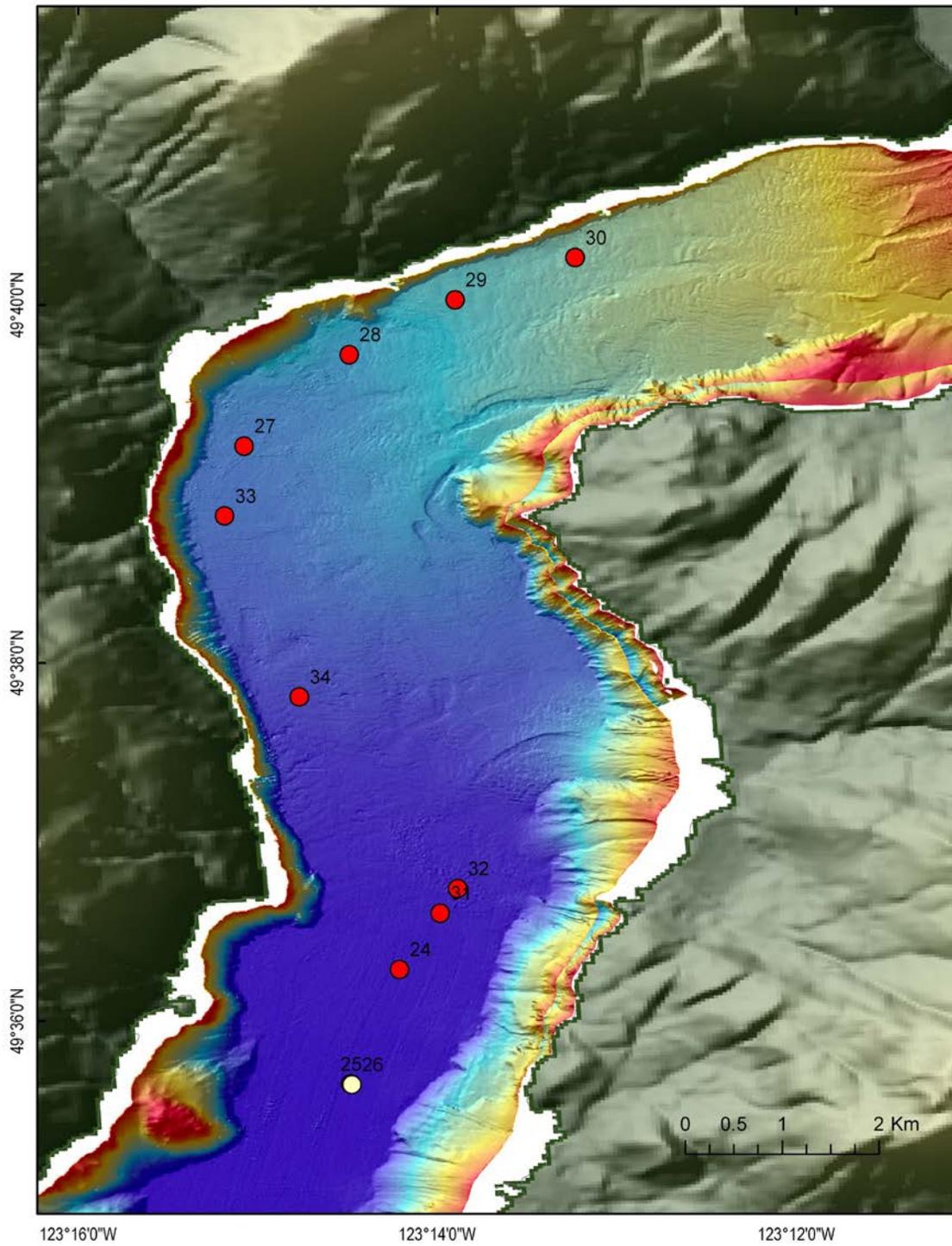
**Figure A2-5.** Sample locations in Kitimat Arm. Red dots: piston cores; green dots: Pederson cores; black lines: 3.5 kHz profiles shown in Figures A2-6 and A2-7.



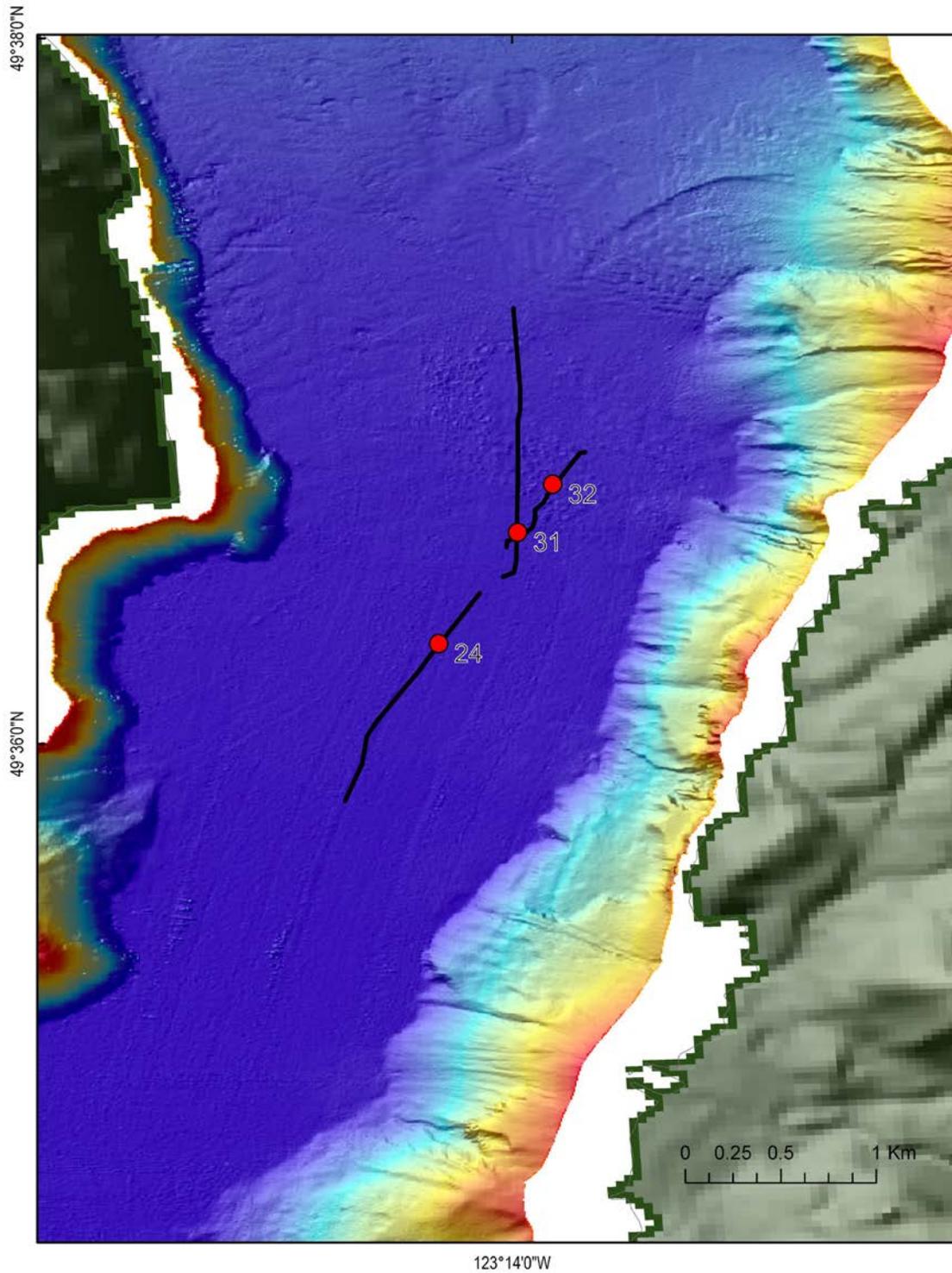
**Figure A2-6.** Pederson core sample stations located on chirp sonar profile (310\_1556), Kitimat Arm (see Figure A2-5 for locations).



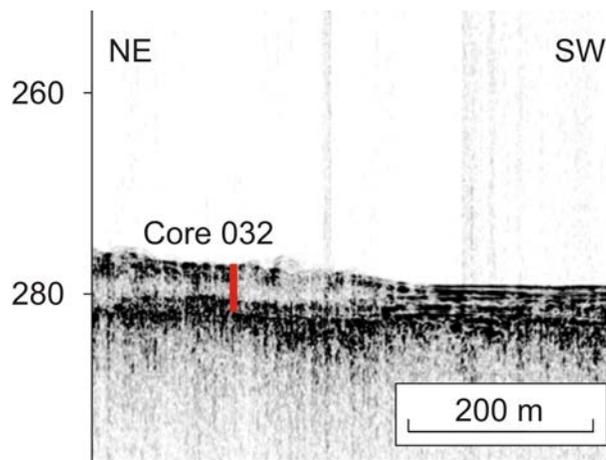
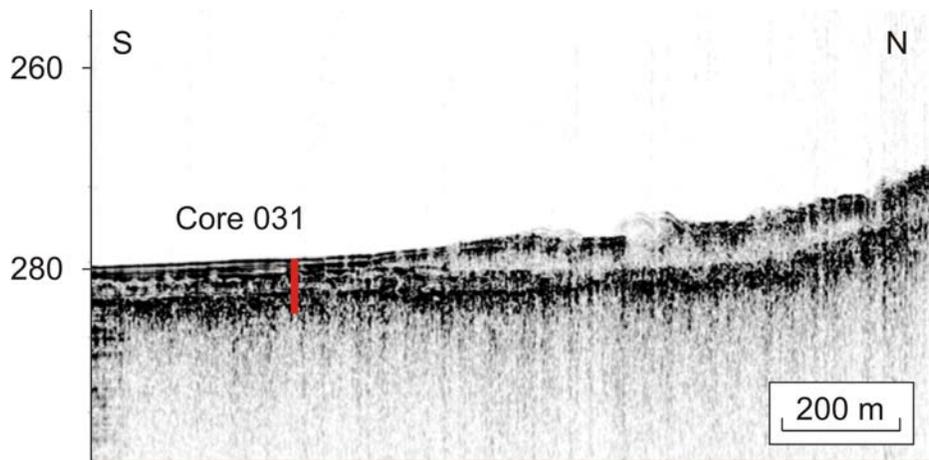
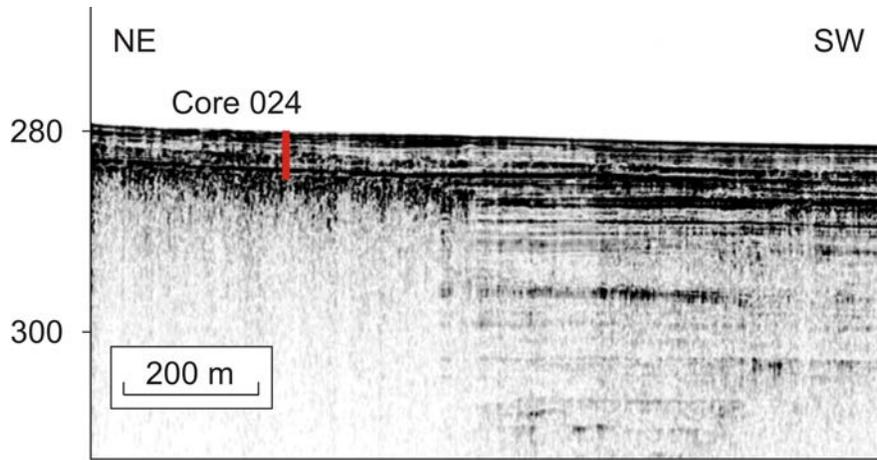
**Figure A2-7.** Piston core sample stations located on chirp sonar profile (311\_2108), Kitimat Arm (see Figure A2-5 for locations).



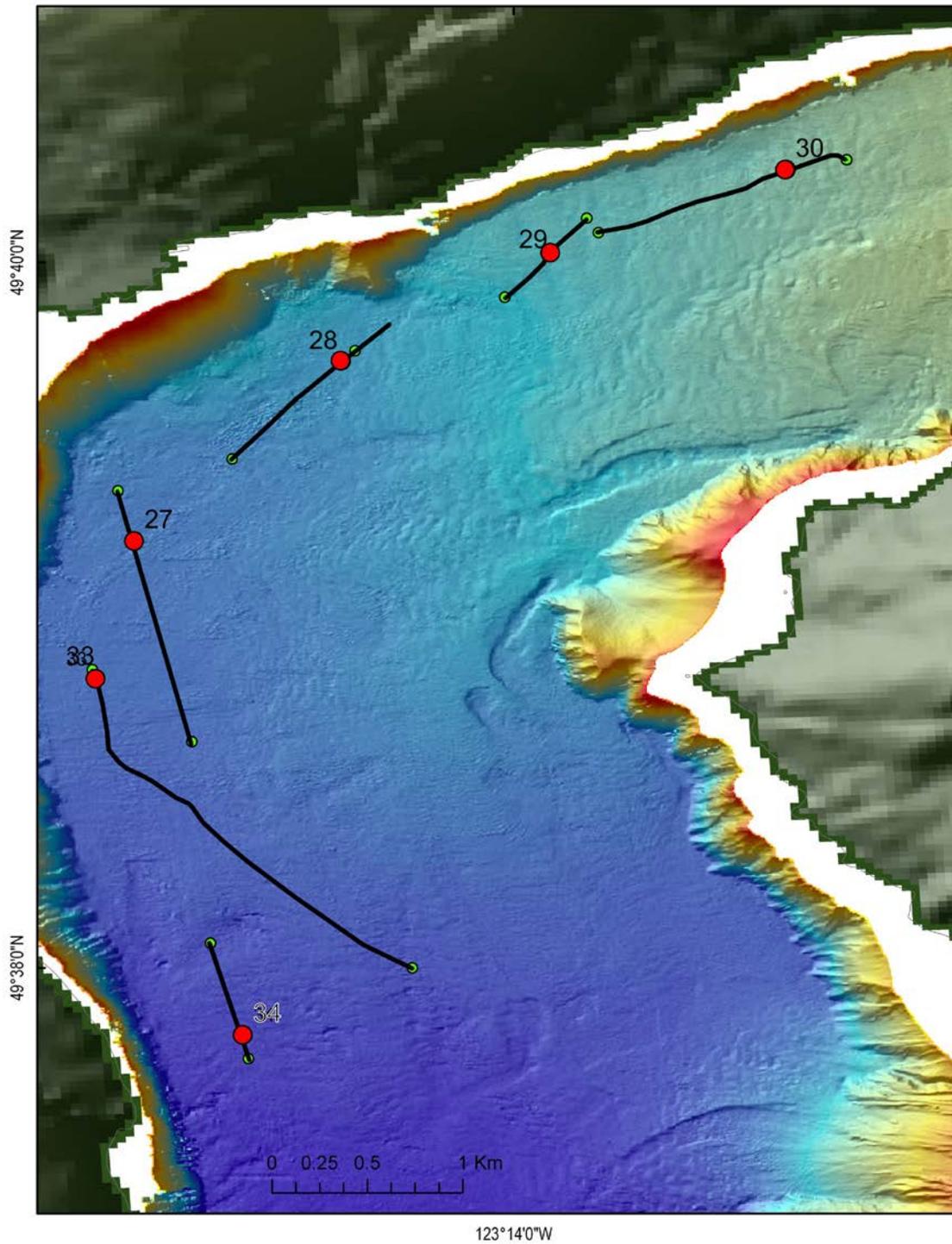
**Figure A2-8.** Sample locations in Howe Sound. Red dots: piston cores; yellow dots: Pederson cores; black lines: 3.5 kHz profiles shown in Figures A2-10 and A2-12.



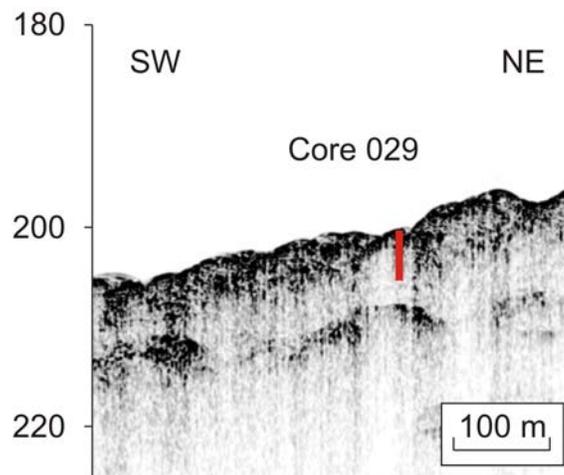
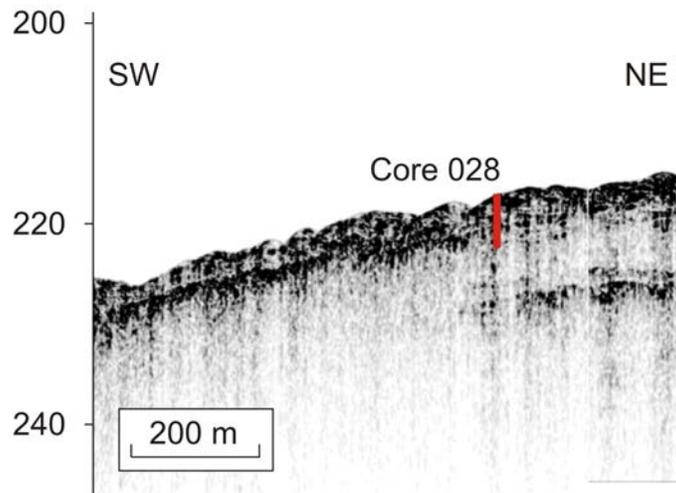
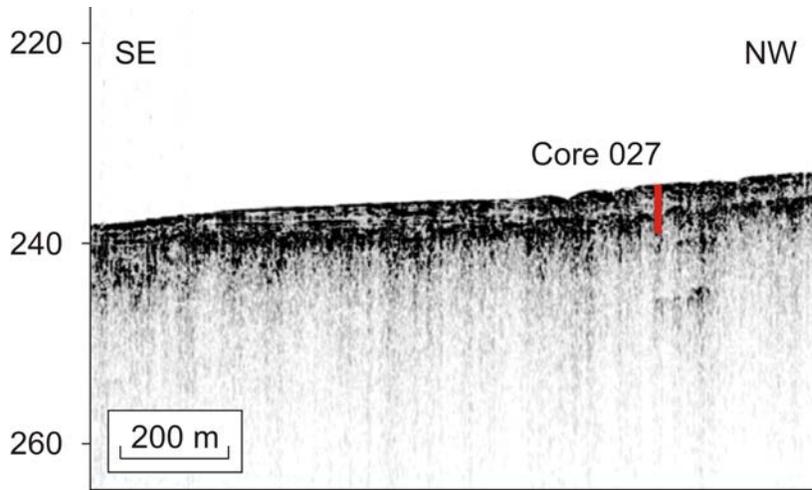
**Figure A2-9.** Sample locations in Howe Sound off Britannia Creek. Red dots: piston cores; black lines: 3.5 kHz profiles shown in Figure A2-10.

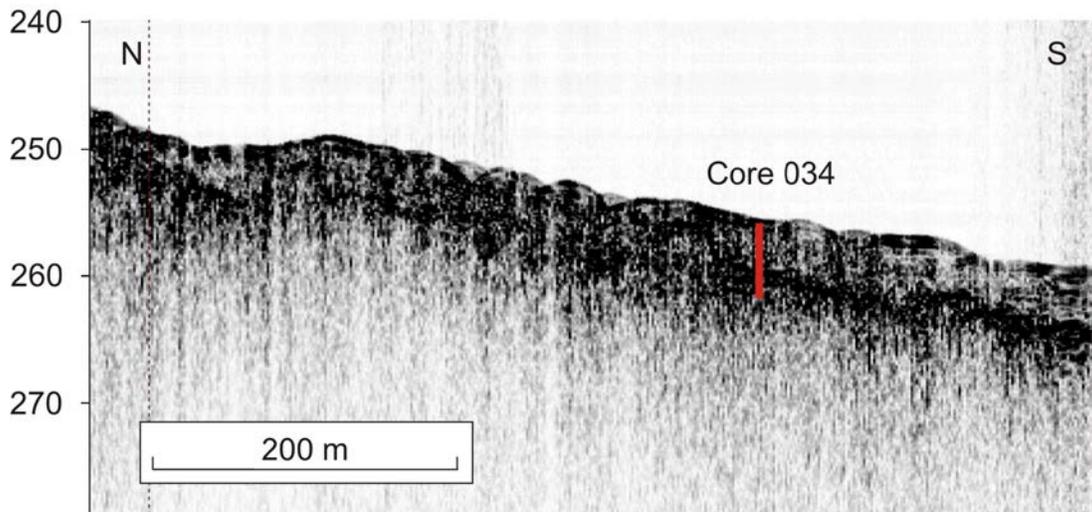
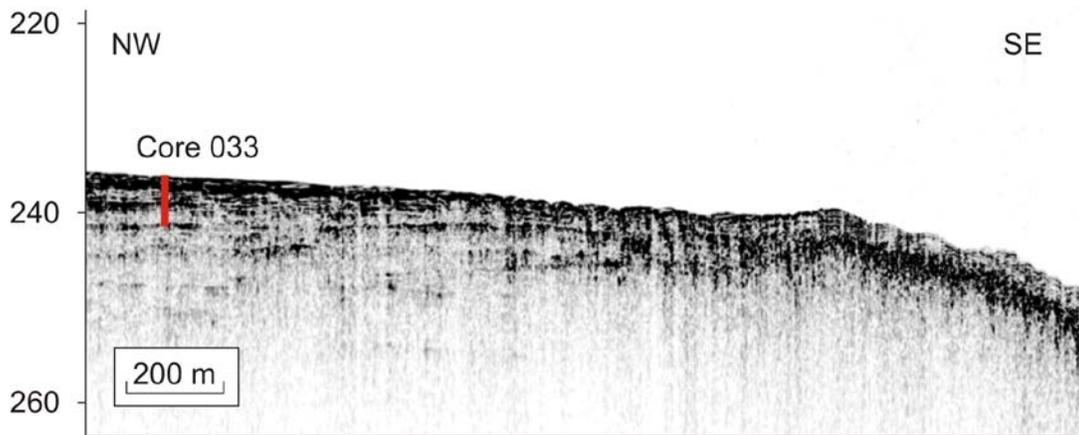
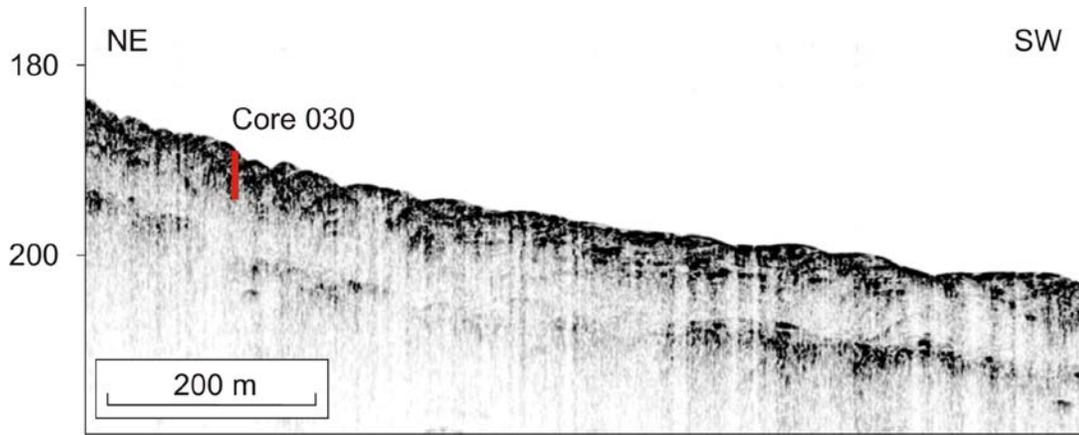


**Figure A2-10.** Piston core sample stations located on chirp sonar profile, Kitimat Arm (see Figure A2-9 for locations).



**Figure A2-11.** Sample locations in Howe Sound off Squamish Delta. Red dots: piston cores; black lines: 3.5 kHz profiles shown in Figure A2-12.





**Figure A2-12.** Piston core sample stations located on chirp sonar profiles, Kitimat Arm (see Figure A2-11 for locations).

## ANNEX 3

### CHS Field Report

**Project Title:** 2013 Kitimat Arm

**Vessels:** CCGS Vector

**MDH:** Jessica Heke

**Geographical Areas:** Douglas Channel

**Project Sites:** Kitimat Arm

#### **NRCan Cruise Objectives**

- Conduct geophysical surveys and coring to estimate the age of inventoried fjord wall submarine slides.
- Conduct geophysical surveys and coring to estimate ages of debris flows and slope failures on the Kitimat Delta and Squamish Delta.
- Collect cores for geotechnical characterization of fjord wall glaciomarine sediments.
- Conduct multibeam survey of Kitimat Arm.
- Should bad weather prevent access to Douglas Channel, we will have contingency plans to conduct similar work in Howe Sound, Sand Heads, Bute Inlet and Knight Inlet.

**Charts Affected:** 3908, 3977 (Dec 2013)

#### **List of Personnel**

Phil Hill	Chief Scientist	NRCan - GSCP	
Vaughn Barrie		NRCan - GSCP	
Bob Murphy		NRCan - GSCP	
Peter Neelands		NRCan - GSCP	
Robert Kung		NRCan - GSCP	
Cooper Stacey		NRCan - GSCP	
Graham Standen		Contractor	
Cindy Wright		DFO	November 06
Jessica Heke		CHS	November 07

*CCGS Vector* – Red Crew. Captain B. Bennett

#### **List of Major Equipment (*Vector*)**

Multibeam: Kongsberg Maritime EM710 Multibeam Echosounder  
IMU Applanix POSMV V5  
Preliminary Processing PC PACHydro 7

## Primary Software

Kongsberg Maritime SIS vers 3.9.2  
Caris HIPS/SIPS 7.1.2 service pack 2

## Work Accomplished

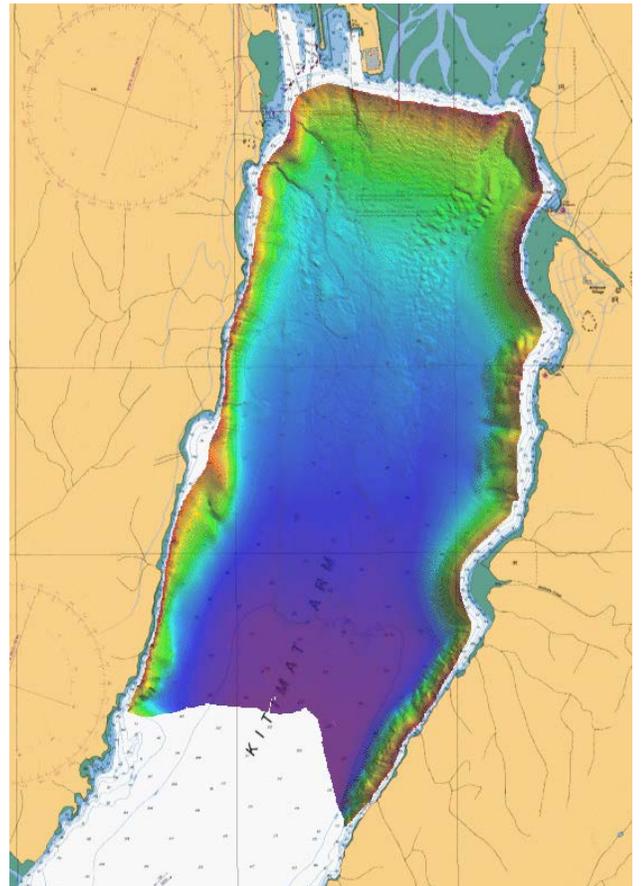
Install and recover GNSS base station at Kitimat BM# M12C9011  
Download temporary tide gauge at Kitimat Stn#9140  
Conduct multibeam survey of Kitimat Arm

## Chronology of Events

- Nov 06 Arrive in Terrace, drive to Kitimat to verify tide gauge is functioning and download missing data requested by J.Gagné for September 19, 2013. Reconnaissance of GNSS site.
- Nov 07 Install GNSS base station at Kitimat BM# M12C9011. Transfer to the Vector and conduct multibeam operations of Kitimat Arm. Transfer from Vector to GNSS site to recover equipment. Download Kitimat tide gauge.
- Nov 08 Pack and secure equipment for flight to Victoria.

## Statistics:

- Total Area sounded : (Nov 07) 18.34 km<sup>2</sup>



### **Problems/Recommendations**

- Last minute replacement computer (PACHydro 7) was not adequate for survey operations.

### **Notes of Thanks**

- A big thank you to Jake Ferrier, Ralph Loschiavo and Alan Thomson for their hard work preparing the equipment and installing everything necessary for the multibeam survey aboard the Vector.
- Phil Hill's NRCan Science crew for all their help and enthusiasm.
- Vector Red crew for their patience and help.

## **ANNEX 4**

### **Daily Reports**

During the cruise, daily reports were prepared and sent to a mailing list of interested personnel at GSC. This annex contains these reports.

# GEOLOGICAL SURVEY OF CANADA –PACIFIC

## DAILY CRUISE REPORT

2013007PGC

CCGS Vector

November 2-3, 2013

As to be expected for a November cruise, a powerful weather system had an immediate impact on the cruise plan. We left as scheduled at 7 am Saturday morning with the hopes of making it to Seymour Narrows for the ebbing tide. Tidal currents in Seymour can exceed 7 knots so it is only possible for the Vector to pass through when the tide is running in the right direction. However a storm was forecast for the Strait of Georgia and indeed, as we exited Boundary Pass, it was evident that wind and sea state was going to slow us down. Running against the northerly winds, most of us were laying down by mid morning and only two made it to lunch. By this time, we were making only 3 knots over the ground and it was obvious we would not meet the 5 pm or 11 pm tides at Seymour. By late afternoon, the wind had decreased and the ride in the evening was more comfortable.

By 06h00 Sunday morning, we had passed through Seymour Narrows and entered Johnstone Strait under sunny skies and glassy calm seas. The next potential weather challenge was to cross the corner of Queen Charlotte Sound before entering the Inside Passage. Fortunately, the weather held fair and at the time of writing, we are in Hugh Sound part of the Inside Passage (Fig. 1)

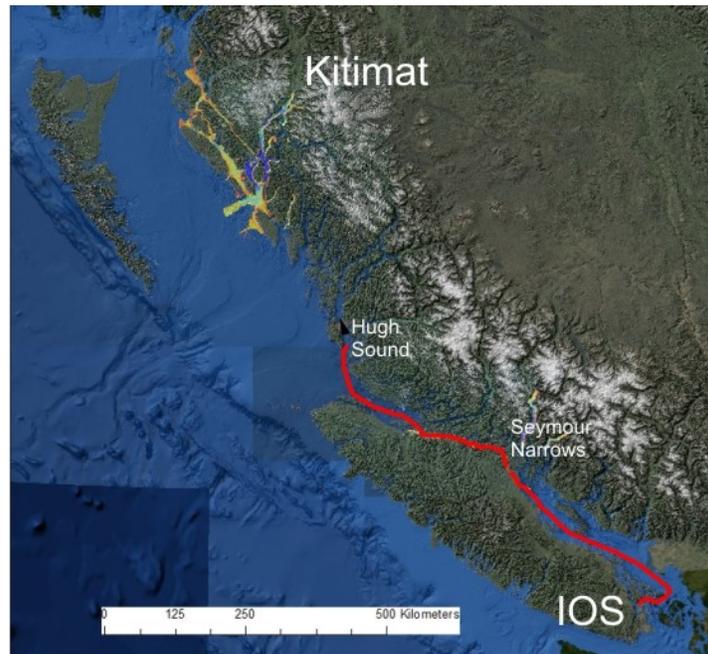


Figure 1. Ship's track to date.

Once we have arrived in Douglas Channel, the objectives of the cruise are to conduct geophysical surveys and coring to estimate the age of submarine slides in Douglas Channel and Kitimat Arm. Submarine slides in fjord settings are known to have caused local tsunamis and there are examples in both Canada and Norway. Last year, Kim Conway discovered two large submarine slides with rockfall characteristics in Douglas Arm (Fig. 1) that would have likely caused significant tsunamis when they occurred. Our aim is to better understand the stratigraphic setting of these features to determine their likely age, so we will be conducting seismic surveys and coring at strategic locations for this purpose.

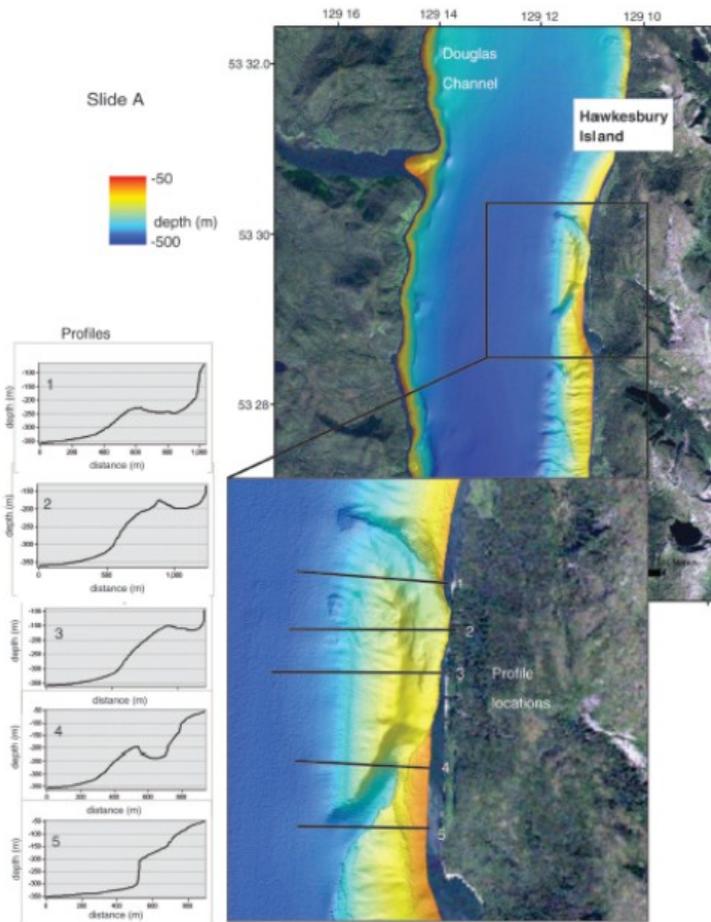


Figure 2. Submarine Slides in Douglas Channel area.

At the head of the fjord, in Kitimat Arm, two submarine slides in 1974 and 1975 are known to have occurred and the latter is thought to have caused a significant local tsunami of 8 m height. Recent multibeam survey data shows that the front of the Kitimat Delta is characterized by several debris flows that originated from submarine slides (Fig. 2). Despite earlier interpretations based on lower quality sidescan sonar data, it is not clear which of these flows originated from the known 1974 and 1975 events, both

possibly the result of construction activity on the shore, or if there is evidence for other natural events. We aim to better characterize the shallow stratigraphy of these deposits using high resolution seismic profiling and to collect cores in an attempt to separate the ages of the flows.

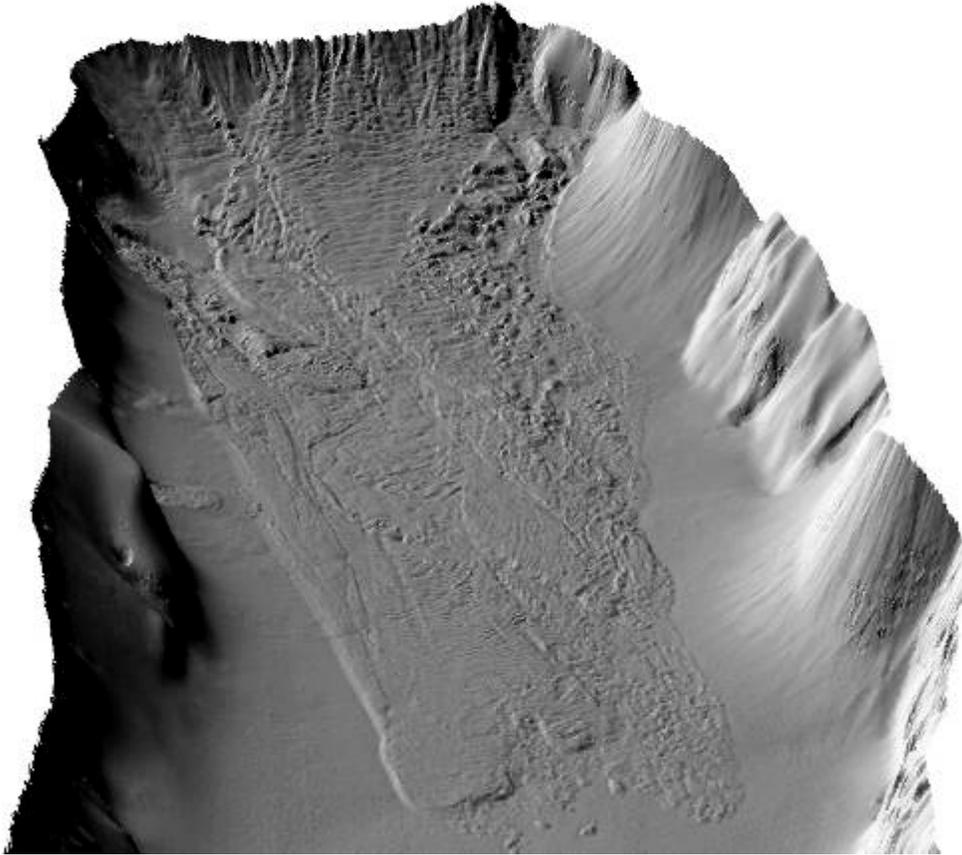


Figure 2. Submarine slides and debris flows in Kitimat Arm (3-D rendering of shaded relief multibeam image).

#### **Scientific Personnel**

Phil Hill (NRCan - GSCP)  
Vaughn Barrie (NRCan - GSCP)  
Bob Murphy (NRCan - GSCA)  
Peter Neelands (NRCan - GSCP)  
Robert Kung (NRCan - GSCP)  
Cooper Stacey (NRCan - GSCP)  
Graham Standen (contractor)

# GEOLOGICAL SURVEY OF CANADA – PACIFIC

## DAILY CRUISE REPORT

2013007PGC

CCGS Vector

November 4, 2013

We finally made it to Douglas Channel at 11.45 this morning. The rest of the journey through the spectacular Princess Royal Channel was uneventful, although the weather by this morning had turned to overcast and cold. Later in the day we would see a lot of rain and even some snow flurries.

The original plan would have had us arriving in Douglas Channel late the previous afternoon. Because we have no previous seismic data from the area on which to base coring stations, this would have been perfect timing for some Hunttec work before a day of coring. However, coring can only be done in the daylight and we did not want to lose the half a day of daylight we had available, so we decided to do a quick 3.5 kHz survey on the more southern of the Douglas Channel rock slides, hoping to obtain good enough data to select some coring sites (Fig. 1).

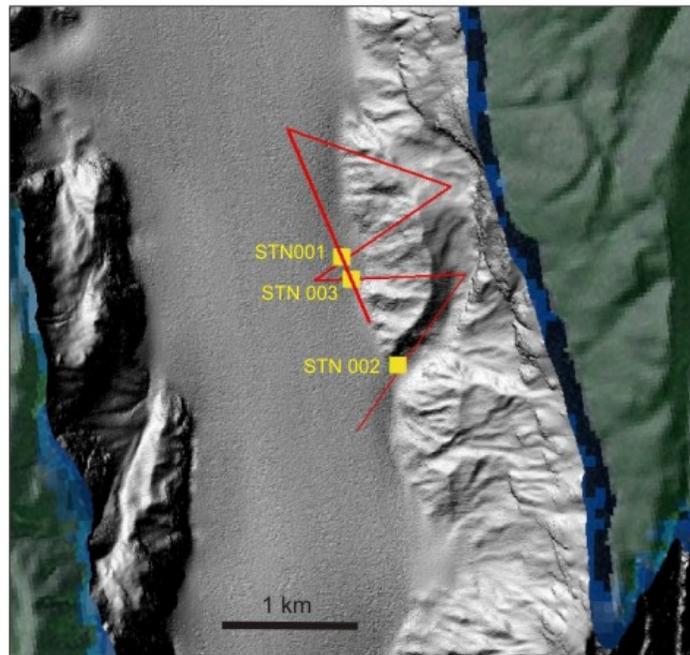


Figure 1. “Quick” 3.5 kHz survey prior to coring and our first three core sites.

Luck was with us because the quality of the 3.5 kHz profiles was excellent. They exceeded our expectations because we expected the sediments to be largely masked by shallow gas, but instead we saw no gas at all in the profiles. The low resolution image below (Fig. 2) loses the quality of the original profiles, but they were more than adequate

for picking several core sites. We aimed at sites where we would obtain a relatively condensed and datable section of sediments overlying the rock slide. In this rapid survey, we did not see any evidence for sediment draping over the slide, but the possible glaciomarine and marine sediments appeared to be ponded against it, supporting Kim Conway's hypothesis of a relatively old age for the slide. However, Hunttec seismic work this coming night will provide much better evidence for or against this hypothesis.

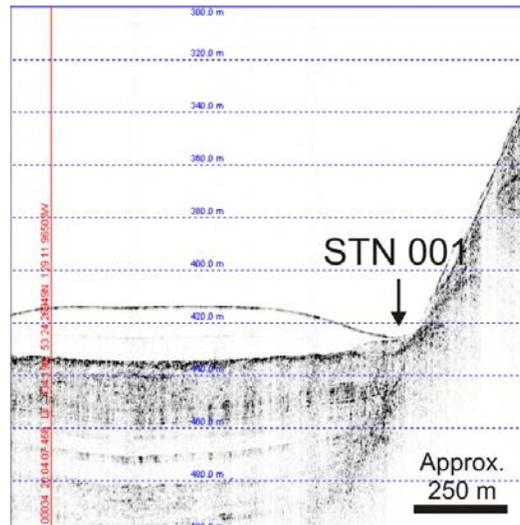


Figure 2. 3.5 kHz sub-bottom profile across the base of the southern Douglas Channel slide. Horizontal lines are separated at 20 m intervals.

By 1 pm the coring team (Peter and Murph on deck with Cooper, Vaughn and Phil in support to process the cores) was in action. Despite heavy rain at times and quite cold conditions, the operations went very smoothly and safely, resulting in three excellent cores (Fig. 1) ranging from 4.8 to 7.4 m in length. They seemed to penetrate through postglacial mud into possible glaciomarine sediments.

In summary, it was a successful day of work, collecting the first marine geological data from this region. At the time of writing, the Hunttec survey has begun (Graham, Rob and Vaughn on duty) and more coring sites are planned for tomorrow. More rain is in the forecast but morale is high for another successful day.

### Scientific Personnel

Phil Hill (NRCan - GSCP)  
Vaughn Barrie (NRCan - GSCP)  
Bob Murphy (NRCan - GSCA)  
Peter Neelands (NRCan - GSCP)  
Robert Kung (NRCan - GSCP)  
Cooper Stacey (NRCan - GSCP)  
Graham Standen (contractor)

# GEOLOGICAL SURVEY OF CANADA – PACIFIC

## DAILY CRUISE REPORT

2013007PGC

CCGS Vector

November 5, 2013

It takes...



...planning...



...hard work...



...careful attention to detail...



...and sometimes multiple attempts...

...to get good data at sea.

It was another good day at sea in Douglas Channel. Overnight, Hunttec profiles provided us with a number of targets in the second (more northerly) slide area. It was wet on deck but the coring team recovered four good long cores that will provide a solid basis for interpreting and dating the slide. The last of the cores terminated in something very hard – hard enough to bend a barrel and destroy a core cutter. We had finally pushed to the limit of what a piston corer can accomplish! The debate about the interpretation of the seismic profiles and cores – are we seeing glacial moraines or mass transport deposits or

deformation resulting from a sliding rock mass – will continue well after the cruise, but it's clear that we have an interesting data set to examine.



A break in the weather.



A crushed core cutter.

The data set does not, as yet, include any IKU grab samples. To try and sample the top of the slide, we made multiple attempts with the large grab at two sites, but could not get the sampler to trigger. We're not sure why, but concluded that there must be a better way, starting with a bottom camera system (but on another cruise).

Tonight we move up the channel to Kitimat Arm where we will do some more Huntex seismic profiling. In the morning, we will pick up Cindy Wright (DFO) to help us with some coring and sub-sampling for Pb-210 dating of the submarine slides in that region.

### **Scientific Personnel**

Phil Hill (NRCan - GSCP)  
Vaughn Barrie (NRCan - GSCP)  
Bob Murphy (NRCan - GSCA)  
Peter Neelands (NRCan - GSCP)  
Robert Kung (NRCan - GSCP)  
Cooper Stacey (NRCan - GSCP)  
Graham Standen (contractor)

# GEOLOGICAL SURVEY OF CANADA – PACIFIC

## DAILY CRUISE REPORT

2013007PGC

CCGS Vector

November 6, 2013

Today's activities were dedicated to trying to obtain age estimates on some of the mass transport deposits seen on multibeam and sub-bottom records in Kitimat Arm. "Mass transport deposits" or MTD's as they are known in the geoscientific literature is a general term used to describe deposits that originate from submarine landslides but may transform as they descend the slope into debris flows. Several MTD's stand out in multibeam imagery of the seabed (Fig. 1).

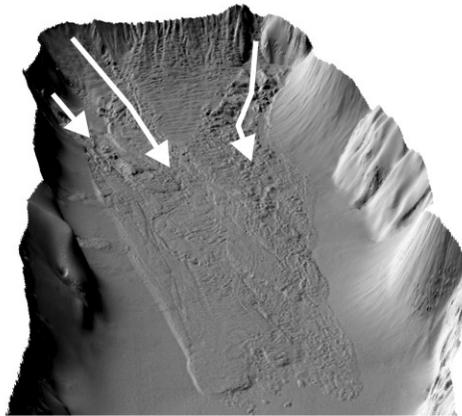


Figure 1. Multibeam image showing multiple mass transport deposits at the head of Kitimat Arm indicated by arrows.

While some of these surface MTD's can be convincingly shown to be related to historical failure events in 1974 and 1975, one of the key geohazard questions about them is whether they were caused by construction activities on the fjord margins or are they natural features? The profile shown in Figure 2 provides some evidence that some may be natural. A buried MTD can be seen some 15 m below the seabed and therefore probably pre-dates the known historical events of 1974 and 1975. It can be traced laterally into a set of strong reflectors that, further down slope, provided an excellent coring target to verify it's age.

In the daytime, we set about trying to establish the ages of these events. We welcomed Cindy Wright on board, who helped us take and process some shallow cores (Fig. 3) taken on top of the seabed MTD's, which we will date with Pb-210 isotope measurements. We took one core from each of what appear to be three distinct MTD's from different sources on the Kitimat Delta and sidewall of the fjord (Fig. 1).

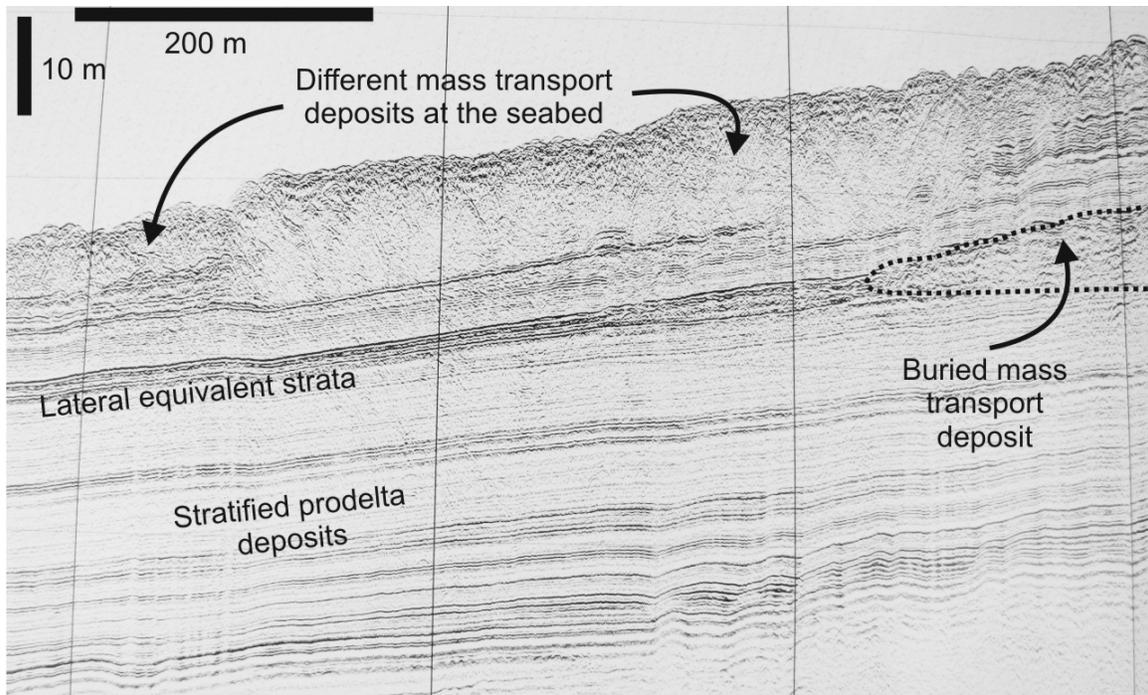


Figure 2. Sub-bottom profile from Kitimat Arm showing surface and sub-bottom mass transport deposits.

The Pb-210 analysis is aimed at separating these three events in time. Despite a short delay in the afternoon, we were also able to take two piston cores, one which we hope penetrated into and through one of the MTD's and one through that set of acoustic reflectors that are laterally equivalent to the buried MTD. With any luck, we will be able to obtain an age estimate on this older event.



Figure 3. This core is about to be sliced into 1 cm intervals for Pb-210 dating

**Scientific Personnel**

Phil Hill (NRCan - GSCP)  
Vaughn Barrie (NRCan - GSCP)  
Bob Murphy (NRCan - GSCA)  
Peter Neelands (NRCan - GSCP)  
Robert Kung (NRCan - GSCP)  
Cooper Stacey (NRCan - GSCP)  
Graham Standen (contractor)

and for today...

Cindy Wright (DFO)

# GEOLOGICAL SURVEY OF CANADA – PACIFIC

## DAILY CRUISE REPORT

2013007PGC

CCGS Vector

November 7, 2013

Today we had another day visitor on board. Jessica Heke from the Canadian Hydrographic Service joined us to conduct a multibeam bathymetry survey of the head of Kitimat Arm. Whereas most of our work has been based on existing multibeam bathymetry collected in 2009 by CHS, conducting repeat bathymetric surveys on other deltas, such as the Fraser and the Squamish deltas, has proved to be a useful method for detecting changes related to submarine mass movements and for understanding the processes involved. So we thought it would be a useful technique to employ here. Our questions were: is the Kitimat Delta prograding and the delta slope becoming steeper, thus increasing the chances of slope instability? Is there any evidence for more recent mass transport deposits than the ones visible in the 2009 survey?

The day demonstrated the efficiency of modern multibeam mapping. Jessica was able to

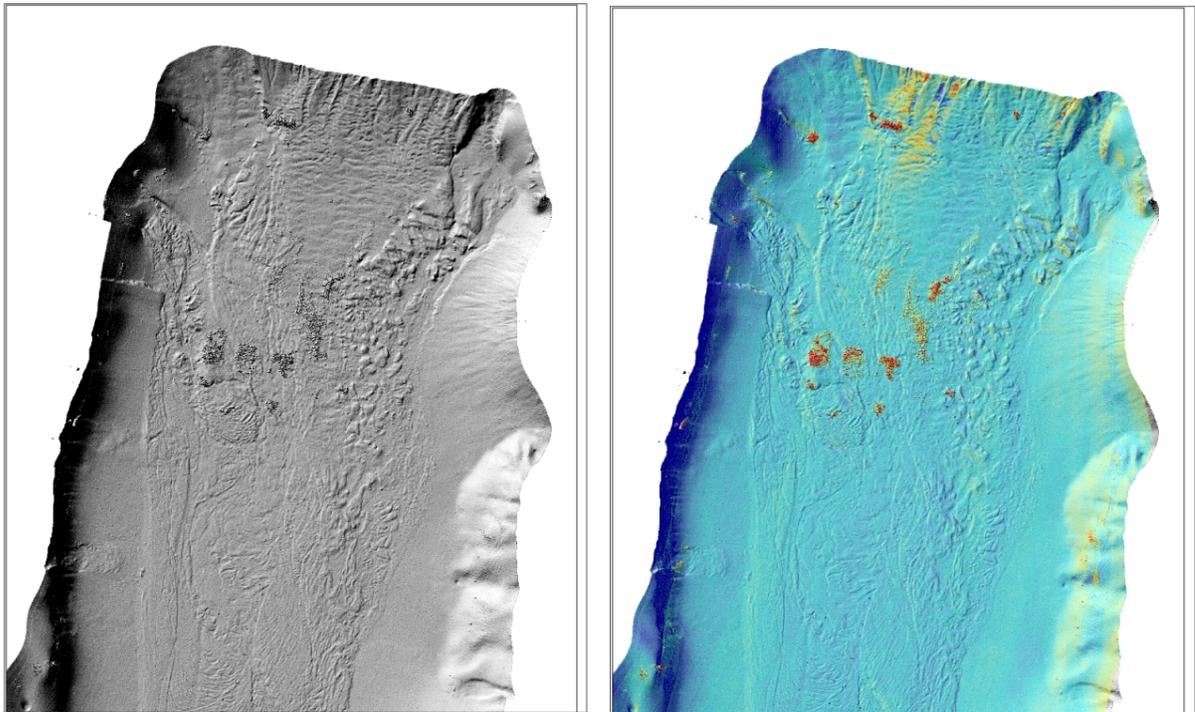


Figure 1. Left: Multibeam shaded relief image of today's survey in Kitimat Arm. Right: Difference map showing changes between 2009 and 2013.

complete a survey of the study area within one day and produce a merged data set, which Rob Kung was able to convert into a GIS raster file in the evening (Fig. 1 left). The final step of the early analysis was to subtract the old bathymetry raster file from the new bathymetry raster file to produce a difference map (Fig. 1 right). The hot colour represent sediment accumulation, up to 3 m, whereas the cold colours represent net erosion. The background light blue indicates no change. These images are very preliminary and the data needs to be cleaned and processed but a few initial interpretations can be made.

The first thing that strikes you is that, compared to other deltas like the Fraser and the Squamish, there is very little detectable change. Both these other deltas show many metres of accumulation at the lip of the slope each year. Kitimat, in contrast shows sediment accumulation only in association with a few small active slope gullies (Fig. 2). Similar to gullies on the Fraser delta, the sediment accumulations show small depositional slope lobes, characterized by sediment waves. The gullies are the only places where net erosion is reliably detected. But there seems to have been no new mass transport events over the past four years.

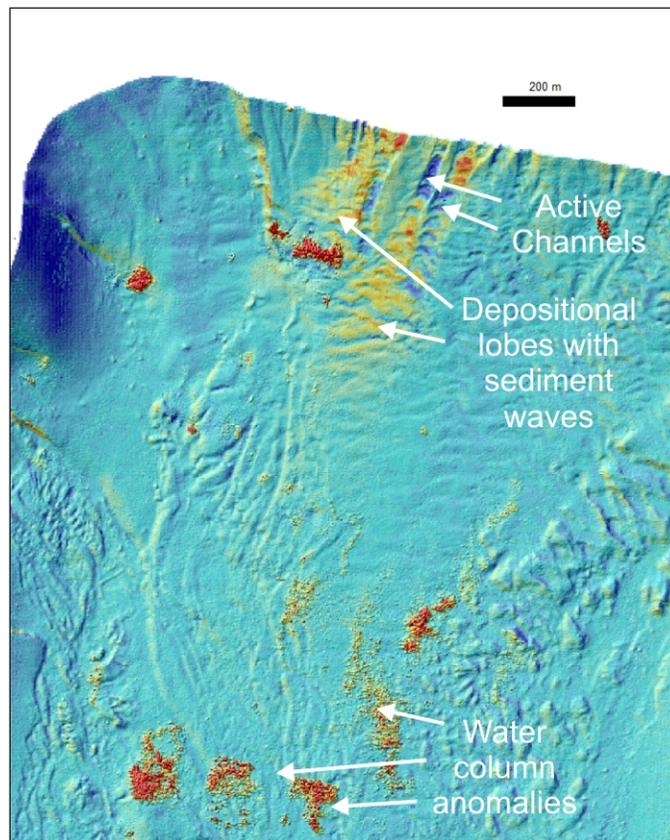


Figure 2. Details of the difference map at the head of the delta.

A curious observation during the survey were the clusters of water column anomalies that occurred, particularly in the mid part of the basin. These anomalies would be edited out of the bathymetry map but nevertheless represent something real in the water column, possibly gas escaping from the seabed or suspended sediment clouds? Something to follow up on for sure.

That's it for our time in Kitimat. After dropping Jessica back off on shore, the ship started its long journey back to Sidney. The science team took a welcome break and sampled some of Cooper's excellent home brew that he had brought along. If we are lucky with the weather, we may be able to spend one more day coring in Howe Sound, but the bulk of the work is done and the main objectives have been met.

### **Scientific Personnel**

Phil Hill (NRCan - GSCP)  
Vaughn Barrie (NRCan - GSCP)  
Bob Murphy (NRCan - GSCA)  
Peter Neelands (NRCan - GSCP)  
Robert Kung (NRCan - GSCP)  
Cooper Stacey (NRCan - GSCP)  
Graham Standen (contractor)

and for today...

Jessica Heke (CHS - DFO)

# **GEOLOGICAL SURVEY OF CANADA – PACIFIC**

## **DAILY CRUISE REPORT**

2013007PGC

**CCGS Vector**

**November 10, 2013**

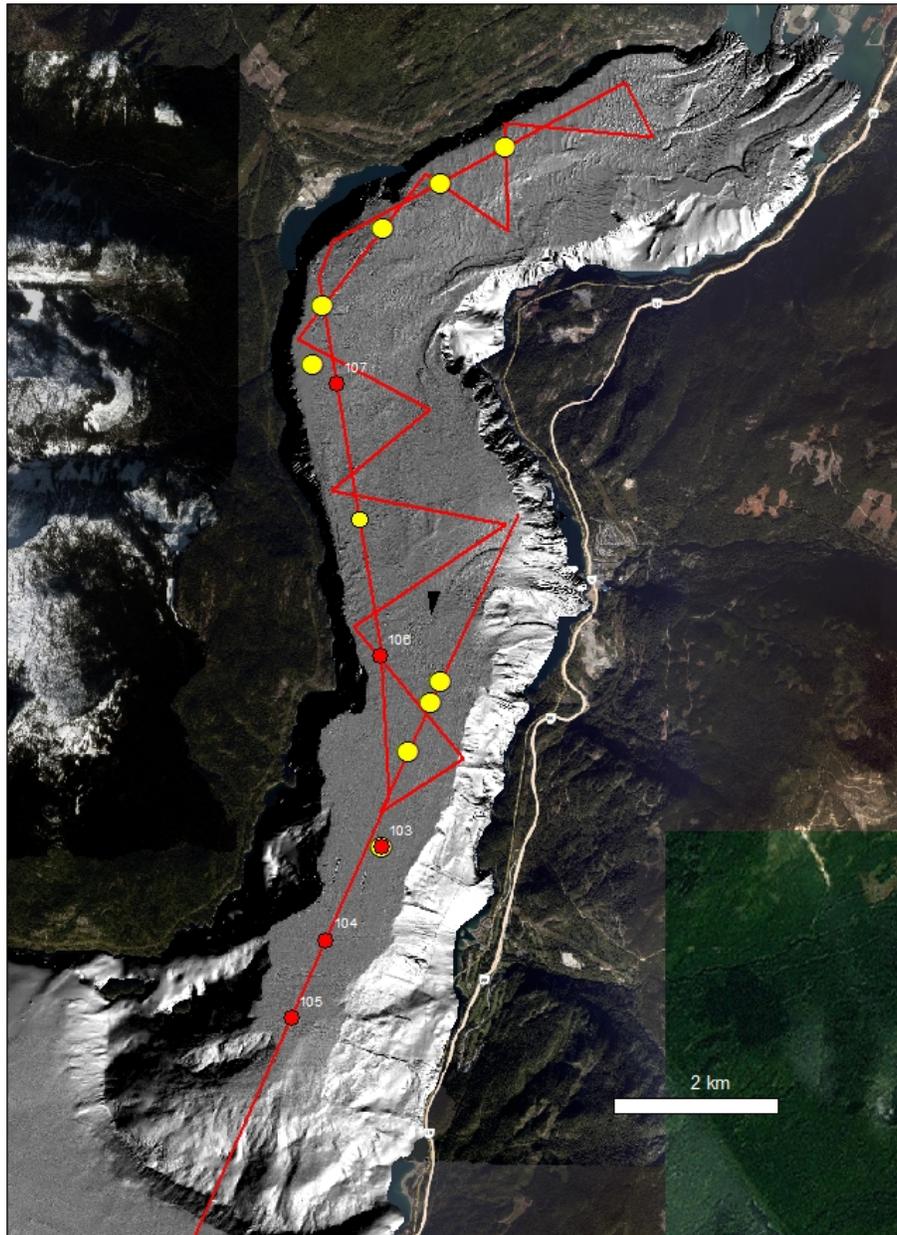
After avoiding bad weather on the two day transit back south, we arrived in the Starbuck Strait of Georgia with time to deploy the Huntec for a survey in Howe Sound a day of coring off the Squamish Delta (Fig. 1). This effort complements previous work in this interesting “field laboratory”. The objective of this work is to figure out if and how records of past submarine landslide events are recorded in fjord basin deposits. If these deposits yield a record of past events, we can use that to determine the probable return period and scale of future events.

Cores from a cruise in 2011, shown in the figure as red dots, showed that thick sand beds are preserved in the deepest part of the basin. These sands potentially represent large volume failures, most likely from the Squamish delta front, but possibly also from smaller sources such as Britannia Creek (Fig. 1). But the basin is a long way from the Squamish delta and it is not clear how sediments are transported there.

Recent work by John Hughes-Clarke has shown that turbidity currents are generated almost daily from the Squamish delta front during flood conditions in the spring. They travel down the westernmost submarine channel on the delta front and a train of sediment waves or cyclic steps indicate that they continue along the western margin of the fjord. Some of today’s cores were aimed at examining this transport pathway. It seems unlikely that many of the flows reach the deep basin and the early indications support this. Most of the cores from this transport pathway contained less than 1 to 2 m of sand before penetrating into organic rich silts and clays.

The nine cores that we were able to collect today (yellow dots in Figure 1) will be used to fill in the gaps of our knowledge of these transport pathways. We are beginning to put together a conceptual model for how turbidity currents are generated and then flow down through the basin. This will provide a sound basis for trying to reconstruct the hazard represented by submarine slope failures, both in this basin and in other fjords along the BC coast.

That’s it for this cruise. We’re heading back to IOS for demob. We hope you have enjoyed this shipboard blog.



**Figure 1** Multibeam image of the Squamish delta front and fjord basin in Howe Sound. Hunttec survey (red lines), previous cores (red dots) and new core stations from this cruise (yellow dots).

**Scientific Personnel**

Phil Hill (NRCan - GSCP)

Vaughn Barrie (NRCan - GSCP)

Bob Murphy (NRCan - GSCA)

Peter Neelands (NRCan - GSCP)

Robert Kung (NRCan - GSCP)

Cooper Stacey (NRCan - GSCP)

Graham Standen (contractor)