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Hudson 2004-024 Cruise Report: Geohazards on the continental margin off Newfoundland

D.J.W. Piper

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2005

Available from
Geological Survey of Canada Atlantic
1 Challenger Drive, Dartmouth, NS B2Y 4A2

Piper, D.J.W.
2005: Hudson 2004-024 Cruise Report: Geohazards on the continental margin off Newfoundland, Geological Survey of Canada, Open File 4965, 55 p.

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Contents of cruise CD

- Log book
- Navigation (10 sec fixes)
- 5 minute digitised bathymetry (in fathoms and metres, at V = 1463 m/s, depth below transducer)
- Station, samples and geotechnical measurements listings
- Tapes and records listings

Acknowledgements

We thank the Master and the entire ship's complement for their expertise and cooperation that ensured the success of the scientific program. This help included the full support of the Master for the science program, the hard work of the Engine Dept. in repairing damaged dredges, making core pushers, and much other help, excellent station keeping and efficient deck operations from the Deck Dept., and good food and service.

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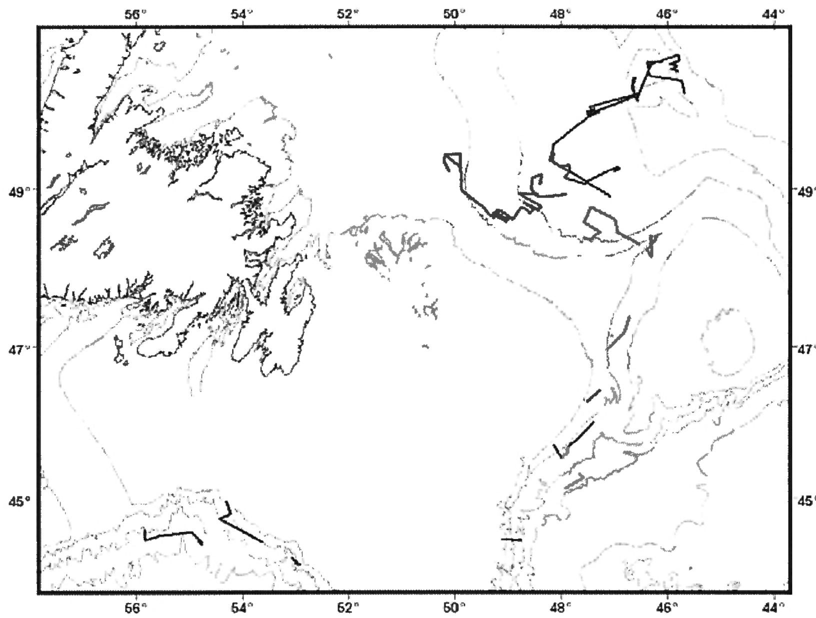
SUMMARY OF CRUISE

HUDSON 2004-024 SUMMARY				Samples				Lines		
Date	JD	Area, activity	Purpose	Piston core	Box core	IKU/dredge	Camera	Seismic	Sidescan	3.5 kHz only
Jun 17	169	Steam BIO to Banquereau margin								
Jun 18	170	Upper slope sampling; steam; seismic on lower St Pierre Slope.	Understanding of the mid-upper slope, for pipeline routes and slope stability	1		3, 4	2	1-5		
Jun 19	171	Upper slope off Whale Bank; seismic towards Narwhal well.		5-9		[10]		6-8	6-7	
Jun 20	172	Upper slope near Desbarres Canyon; seismic (DDH) in canyon head; steam.		11-12, 15-16		13	14	9-11		
Jun 21	173	Steam across Grand Banks; seismic on E. Grand Banks slope at 42 25'N; steam.	Geohazard assessment of Salar basin and Flemish Pass					12		13-14
Jun 22	174	Sampling, seismic and DDH, Salar basin.		17- 19		[20]	21	15-16		
Jun 23	175	Sampling, Salar basin; sidescan, seismic, Flemish Pass		22				18-19	17	
Jun 24	176	OBS experiment, Mizzen well; seismic in SE Orphan basin.	Gas hydrates and failure					20-25		
Jun 25	177	Sampling SE Orphan basin	Geohazards, environmental and shallow drilling conditions in SE Orphan basin	23	24	HF		26-29		
Jun 26	178	Sampling SE Orphan basin		26-29				30-32		
Jun 27	179	Piston cores E Orphan basin; steam to SW Orphan Knoll		30-33				33-39		
Jun 28	180	Sampling mounds on western Orphan Knoll	Paleoclimate studies of the Labrador Sea; origin of enigmatic mounds on Orphan Knoll	34-35			36			40-47
Jun 29	181	Dredging on Orphan Knoll				37-40		48-51		
Jun 30	182	Box core SE of Orphan Knoll, core on Knoll, dredging; seismic to Orphan basin		42	41	43-44		52-56		
Jul 1	183	Sampling, heat flow around local high in central Orphan basin. Regional seismic.	Geohazards, environmental and shallow drilling conditions in SW Orphan basin	45-47		HF		57-62		
Jul 2	184	Sampling and seismic in west Orphan Basin near 2000 m isobath		49-51	52		53	63-68		
Jul 3	185			54-55	56	HF		69-72		
Jul 4	186			58-62	63		64	73-77		
Jul 5	187			65-68				78-85		
Jul 6	188	Sampling and seismic on southwest Orphan Basin slope		69-73				86-90		
Jul 7	189			74-78					91-92	
Jul 8	190	arrive St Johns								



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OBJECTIVES AND ACCOMPLISHMENTS

Program framework

This cruise meets requirements of GSC Project X-27 8004 East Coast Offshore Geohazards, within the Geoscience for Ocean Management program, specifically workpackage C2.2 Geological framework and hazard assessment, slopes of northern Grand Banks. The work involved regional investigations in deep water offshore Newfoundland in order to provide the Canada Newfoundland Offshore Petroleum Board and the petroleum industry with advice on geohazards and shallow drilling conditions in deep-water frontier areas.

For the last four years, field studies have been carried out on the Newfoundland margin and have been followed up by laboratory interpretation and synthesis. In previous years, our efforts have focussed on Flemish Pass, with some work in deep water areas of Salar basin, South Whale basin, and the Laurentian basin. Many of the scientific issues are common to all these regions, but may be best solved in one particular area. In 2003, we carried out some reconnaissance studies in Orphan basin.

On cruise 2004-024, our principal effort was focussed on Orphan basin, but some work was done in other areas to fill gaps in previous studies. Our work in Orphan basin took into account suggestions of the industry partnership holding lease blocks there and we provided accommodation for a wildlife observer contracted by industry.

Specific objectives

Specific objectives were:

1. investigate upper slope tills by seismic and coring
2. detailed slope stability studies, Salar basin and Flemish Pass
3. seabed conditions in Orphan basin
4. origin of mounds on Orphan Knoll
5. seafloor geochemistry studies from box cores
6. OBS experiment for gas hydrates in Flemish Pass
7. benthic habitat photography and sampling on the deep water margin off Newfoundland

Accomplishments

General investigation of the upper slope from 200 m to 800 m below sea level, using data from all basins around the Grand Banks. This is an area that would be critical for pipeline routes following any discovery either off Newfoundland or Nova Scotia, yet is very poorly understood. The upper slope is underlain by glacial till, commonly to 600 m water depth, has in the past been scoured by icebergs, and is swept by strorm-driven currents. We were for the first time successful in obtaining samples of till from the upper slope, both in piston cores and IKU grabs. Acoustic data included three sidescan transects and two deep digital hydrophone lines, in addition to Huntec sparker and GI gun seismic profiles.

Geohazards in Salar basin and Flemish Pass. We have followed up on the Toews (2002) report by collecting additional high-resolution seismic reflection profiles, cores, and sidescan. In addition, we ran high-resolution seismic lines through most of the 2002 Harrison cores donated by industry
.

Geohazards and drilling conditions on the floor of Orphan basin have been investigated using

Huntec sparker profiles (100 m penetration, 1 m resolution), high-resolution airgun profiles (1 km penetration, 10 m resolution) and piston cores. Mass transport deposits and debris flows are widespread in Orphan basin within the upper few hundred metres of sediment. Some of these may have an underconsolidated and/or gas charged matrix, given the presence of diapiric structures through overlying sediment. Blocks are likely overconsolidated and will substantially slow jetting operations. Gravel lags occur in some channels and rare scattered boulders will be present everywhere as a result of ice rafting; both could impede drilling. Recurrence interval of sediment failure is likely on the order of many thousands of years, as elsewhere on the southeastern Canadian margin; it therefore does not pose a threat on the low slopes found in Orphan basin. Piston cores for laboratory analysis have been collected over and within mass-transport deposits and in transects across channels, in order to provide a chronological stratigraphic framework and measurements of geotechnical properties. These data can then be extrapolated to other sites using the Huntec sparker data.

Geological framework of Orphan basin. Heat flow measurements were made by Dr Keith Louden, Dalhousie University, at three locations in Orphan basin. Underway magnetic field measurements will be used by Stephen Kearsey, Memorial University, in his M.Sc. thesis on the structure of Orphan basin.

Studies on Orphan Knoll. On Orphan Knoll, we studied enigmatic mounds that may be related to release of hydrocarbons to the seafloor, obtaining seismic profiles, cores and bottom photographs. We also attempted unsuccessfully to dredge corals at a variety of water depths, for paleoclimate studies.

Benthic habitat studies in Orphan basin. A few box cores and deep camera stations were obtained in Orphan basin for evaluating benthic biology. Subsamples were provided to industry for seabed chemistry and benthos studies. Subsamples were also provided to UQAM for studies of near-seabed geochemical processes and for dinoflagellate distribution.

Gas hydrate near the Mizzen well was studied using an Ocean Bottom Seismometer (OBS) wide-angle reflection/refraction experiment to determine the velocity structure of the upper kilometre of sediment. Some data was made available by Petrocanada that aided in site selection. The preliminary results show a clear velocity inversion beneath the widespread bottom-simulating reflector, which occurs at precisely the sub-bottom depth expected for the base of the hydrate stability field, given the temperature conditions in Flemish Pass.

Technology development

- Successfully tested the deep-water digital camera and developed software.
- Three successful lines run with the deep digital hydrophone; tested deck software and developed software to give a true-depth display.
- Incremental developments of the GSCDIG digitiser system.

Data statistics

Collected 53 piston cores, 3 successful grab samples, 5 box cores, 6 camera stations, 10 heat flow stations. Ran 1732 line-km GI gun seismic, 1604 line-km Huntec, 54 line-km sidescan, 142 line-km magnetometer, 3461 line-km 3.5 kHz profiles and 12 kHz soundings.

NARRATIVE

The narrative is lightly edited from daily plans. Positions are those planned rather than those actually accomplished. Refer to cruise CD with navigation and tables of data for precise information.

Thursday 17th June JD169
Ship eventually sailed at 1230 ADT, fire and boat drill in Bedford Basin, then good speed across the Scotian Shelf in sun and light winds.

Friday 18th June JD170

Stood watch in GP lab 1 hour before core site, run 3.5 kHz and 12 kHz sounders
arrived at core site at 0800 ADT
Core 1 44° 16.8' N 57° 47.4'W 30 ft piston core
Recovered ~25 cm of muddy sand, over very gravelly muddy sand in core catcher. Liner damaged.

Camera station 2, from core site away to SE
Took about 15 frames. Principally a test of the camera. Hard gravelly bottom at beginning of transect, passing into sandy bottom with ripples at end of run.

IKU sample 3
44° 16.218'N 57 49.362'W
recovered only a single cobble caught in jaws

repeat at same station, IKU sample 4
recovered pebbles and cobbles with coarse sand overlying pinkish till

Then steamed to B:
B 44° 33.408 55° 49.914
1 mile before point, slowed and deployed Huntec sparker
Run lines at 4.5 knots through the water
Line 1 B to C
C: 44° 25.026 55° 50.346
GI gun and eel deployed in middle of line 1 (not previously ready)
Line 2 C to D
D: 44° 29.130° 55° 32.526

Saturday 19th June JD171

Line 3 D to E
E: 44° 31.728 54° 58.560
Line 4 E to F
F: 44° 23.838 54° 45.606

Line 5: reciprocal line to line 4, but 2 miles to SW

brought in seismic gear at 0600 and steamed to core site 5
core 5, 50 ft piston core 44° 28.4503'N 54° 53.1760'W
then steamed to core site 6
core 6 30 ft 44° 45.558'N 54° 22.956'W
after lunch, steamed to core site 7
core 7 30 ft 44° 55.866'N 54° 26.862'W
short piston core, only two of four flaps of ODP catcher closed.
Tried again as core 8, recovered 40 cm of Holocene muddy sand with gravel at the base
core 9 30 ft approx position 44°55.212'N 54° 28.758'W
Recovered 60 cm of very dense silty mud: no evidence seen that it was till.
IKU 10 on gentle scarp 44° 55.437'N 54° 28.082'W
made three attempts - none of them tripped, suggesting hard bottom.

when sampling completed, steamed to point G and deployed sidescan, Huntec and seismic.
Ran the following lines at 4.5 knots.

G 44° 57.144'N 54° 18.816'W
Line 6 G to H 44° 46.908'N 54° 13.668'W
Line 7 H to I 44° 42.876'N 54° 26.268'W
brought in sidescan half-way down line 7, at water depth of about 600 m
Line 8 I to J 44° 20.232'N 53° 28.374'W

Sunday 20th June JD172
broke off seismic line at 0600, close to Narwhal well and steamed to core site.
Core 11 30 ft 44° 25.194'N 53° 26.994'W 2001043 227/0422
Core 12 30 ft 44° 24.414'N 53° 23.778'W 2001043 227/0234
IKU 13 44° 20.91'N 53° 24.18'W 2001043 227/0152

area with scarp on Huntec, but not particularly steep when we crossed it. Recovered 40 cm of uniform Holocene fine sand; jaws must have stopped at the hard top of till. Lots of shell hash saved, one small dead cup coral.

Camera 14, 20 frames, across the IKU site.
Core 15 50 ft 44° 15.936'N 53° 24.744'W 2001043 227/0054

chosen in an area where the stratified section is thin, in an attempt to reach H2

Core 16 50 ft 44° 11.922'N 53° 15.690'W 2001043 226/2252

backside of levee of Desbarres Canyon, in an attempt to sample sands moving down the canyon. Some gas in lowest sections.

in late afternoon:
Started Huntec profile at L
L 44° 06.102'N 53° 01.086'W
Ran line 9 at 4.5 knots through the water to:
M 44° 05.574'N 52° 53.998'W
This completed a line ran in 2001. Brought in Huntec

Steamed to N and deployed deep hydrophone (DDH), streamer and GI gun
Ran the following lines at 2 knots down the southern tributary of Desbarres Canyon

N	44° 07.746'N	52° 56.904'W
Line 10 to O	44° 08.196'N	53° 00.432'W
Line 11 to P	44° 11.412'N	53° 04.278'W

recovered gear and steamed at full speed to Q at about 2200. Wind getting up from SE.
Q 44° 25.632'N 48° 55.362'W
No watch maintained on steam across Grand Banks.

Monday 21st June JD173
made good time across Grand Banks, but then turned to head to St Johns for Medevac. Eventually done by helicopter. Resumed program at about 1900 ADT.
deployed Huntec, GI gun and streamer 1 mile before point R
ran line 12 from R to S at 4.5 knots through the water

R	44° 26.268'N	49° 06.594' W
S	44° 25.05' N	48° 44.004'W

recover gear at S and steamed to T
T 45° 07.188'N 47° 54.774'W

Tuesday 22nd June JD174
then reduced speed and ran the following lines at 8 knots using the hull-mounted 3.5 kHz profiler

Line 13 to U	45° 15.648'N	47° 34.614'W
Line 14 to V	45° 20.544'N	47° 40.800'W

then steamed to core site

Core 17	40 ft	45° 15.0678'N	47° 35.9993'W
Core 18	30 ft	45° 15.4028'N	47° 35.2093'W
Core 19	50 ft	45° 27.828'N	48° 11.556'W
IKU 20		45° 34.8047'N	48° 18.7525'W

this is located near the top of the shallower of two scarps at 450-500 m water depth
Camera 21 in same vicinity, coming away to south

then deployed DDH and GI gun at X
X 45° 42.354'N 48° 08.610'W
eel was deployed, but wind was blowing it across the airgun. Brought it back in.
ran line at 2 knots to the SE
after about 3 hours, retrieve DDH and deploy Huntec and eel.
ran line 16 at 4.5 knots through the water, to pass through numerous Harrison cores, through the points below:

SOL16	45.5301	-47.9853
a	45.5546	-47.9582
b	45.5852	-47.8849
c	45.6543	-47.8748
d	45.7159	-47.8071
e	45.7604	-47.7251

f	45.8359	-47.6197
g	45.8628	-47.5612
EOL16	46.005	-47.3928

Wednesday 23rd June JD175
Brought in seismic at 0615, at intersection with northernmost 2001 line in Salar basin.

Core 22 40 ft 45° 59.6716'N47° 24.3283'W
located near pinchout of shallow debris-flow deposit.

when core completed, steamed to point Y
Y 46° 16.518'N 47° 30.882'W
deployed sidescan only
ran line 17 at 3 knots from Y most of the way to Z, in water depths of 200-400 m
Z 46° 27.474'N 47° 11.610'W
brought in sidescan by 1400
then steamed to SOL 18 and deployed seismic and Huntec
SOL18 46° 57.108'N 47° 08.19'W
ran lines at 4.5 - 5 knots through the water
to SOL 19 47° 10.134'N 46° 48.834'W
to EOL 19 47° 21.558'N 46° 42.846'W

recovered gear and steamed to arrive at OBS launch site before 0600 Thursday morning

Thursday 24th June JD176
Shortly after 0600, deployed three OBS's at a spacing of about 100 m (0.5 cable) about a central position A
along the line joining B - A - C
The ship then steamed to 1 mile beyond B, deployed the 2-gun array and eel, and ran line 20 from B through A to C at 4 knots through the water.
On reaching C, speed was increased to 5 knots to come round to point D
Then ran line 21 from D through E and A to F at 4 knots
At F, retrieved the gear and returned to A to recover OBS's

A	48° 17.49'N	46° 18.00'W
B	48° 21.786'N	46° 12.900'W
C	48° 13.692'N	46° 22.518'W
D	48° 08.982'N	46° 17.502'W
E	48° 10.53' N	46° 17.59'W
F	48° 24.522'N	46° 18.420'W

Last OBS recovered at 1800. Then steamed to SOL 22 and deploy one GI gun, streamer and Huntec and ran the following lines at 4.5 knots through the water:

SOL 22	48° 19.044'N	46° 34.240'W
SOL 23	48° 26.976'N	46° 56.220'W
SOL 24	48° 36.876'N	46° 59.160'W

SOL 25 48° 45.456'N 47° 26.376'W
EOL 25 48° 33.066'N 47° 34.368'W

Friday 25th June JD177
broke off line 25 about 1 mile from beginning and brought in gear. Huntec a little noisy because streamer trapped under fish.
stopped for 30 minutes to check a shaft problem on the ship

Core 23 40 ft 48° 45.0264'N 47° 26.6712'W 2004-024 177/0900 on well stratified sediment
decided to switch to box coring because of poor weather forecast for tomorrow. Attempted Core 24, box core, at the same site. First attempt tripped in water about 100 m off the bottom. Second attempt successful.

then steamed to Station 25, HF1-1 48°47.3'N 47°27.0'W
and deploy heat flow probe
ran line to HF1-2 pogo-ing probe into bottom approx. every mile
HF1-2 48° 45.5'N 47° 22.1'W

then steamed back to SOL 26 and ran GI gun, eel, Huntec and GEM magnetometer at 4.5 knots
SOL 26
SOL 27
SOL 28
SOL 29
towards A

Saturday 26th June JD178
broke off line at 0610 ADT
steamed 14 nmi to:
Core 26 40 ft 48° 33.750'N 47° 44.628'W [2003-033 177/2327]
on terrace beside channel; recovered bed of gravel about 1.5 m below surface
Core 27 40 ft 48° 38.2084'N 47° 31.0988'W [2004-024 178/0136]
hit a rock, rather short
Core 28 50 ft 48° 37.4912'N 47° 31.4929'W [2004-024 178/0146]
hit a rock, only 1 m recovery
then steamed across likely position of channel. Channel identified on 3.5 kHz, returned to low terrace on SE side of channel at 1271 fm. Core actually taken 1.5 cables south of track, but at same water depth.
Note that channel appears to be very narrow on reciprocal track.
Core 29 40 ft 48° 39.1917'N47° 38.0395'W [2004-024 178/1819]
wind 25-30 knots from SW; unfit for box core or camera.
then steamed to SOL 30 and deployed Huntec, GI gun, eel and magnetometer.
Ran lines 30, 31 and short line 32 overnight

Sunday 27th June JD179
Brought in seismic gear at 0555 ADT.

Core 30	40 ft	49° 13.926'N	47° 03.102'W	179/0107

hit sand, only one barrel, liner broke and stuck in barrel.

Core 31	40 ft	49° 18.222'N	47° 00.408'W	179/0155
Core 32	40 ft	49° 30.402'N	46° 52.728'W	179/0411
Core 33	50 ft	49° 32.754'N	46° 51.210'W	179/0437

then steamed to SOL33, deployed one GI gun, streamer and Huntec
Ran lines 33-38 at 4.5 knots through the water.
Wind got up, heavy rain

Monday 28th June JD180
Wind at 30-35 knots. Bring in gear at 0800. Damaged Huntec eel during recovery of Huntec. Air gun lines got badly tangled. Weather unsuitable for coring, so ran bathymetry lines at 8 knots.
By noon, seas had abated.

Core 34	40 ft	50° 15.4989'N	46° 38.9623'W	on Nader mound
Core 35	40 ft	50° 09.5304'N	46° 36.2046'W	on Einarsson mound at 0446

when core 35 completed, camera station 36 at the same site
some problems with wire angle, leading to early termination of the camera station.
then deployed DDH and one GI gun and ran a 3 nmi long line across Einarsson mound with the hydrophone as far out as possible
recovered DDH at midnight.

Tuesday 29th June JD181
Ran bathymetry lines 41-47 across the crest of Orphan Knoll and out on the northeast side to find dredge stations at 3000 m.
Ended surveying at 0730 ADT

Dredge 37
start 50° 31.2567'N 45° 52.2114'W
end 50° 31.2914'N 45° 52.4911'W
no recovery. Thought this was due to insufficient wire out (pinger was 30 m off bottom and 100 m above dredge).

Dredge 38
start 50° 33.2724'N 45° 52.2769'W
end 50° 33.1373'N 45° 52.8466'W
Pinger was 30 m off bottom and 400 m above dredge. No recovery.
Decided that the dredge was not towing well. Worked on straightening the tow bar.

Repeated Dredge 39 at position of dredge 37

Dredge 40 at 181/0622
start 50° 38.7333' N 46° 10.6813' W
ran to WSW

deployed Huntec, GI gun, eel and magnetometer

ran lines 48-51 at 4.5 knots through the water
magnetometer died at about 0300 ADT. Unrepairable deck unit.

Wednesday 30th June JD182
Box core 41 at ODP site SE of Orphan Knoll.
Seas flat, no wind.
Piston core 42, 50 ft 50° 22.6896'N 46° 12.6668'W 182/0339'15
Stratigraphic core on the southern part of Orphan Knoll.
Dredge 43

Start	50° 07.4894'N	46° 39.9007'W	180/0404
End	50° 07.5572'N	46° 39.6312'W	180/0406

Dredge 44

Start	50° 09.7569'N	46° 36.3246'W	180/0449
End	50° 09.5304'N	46° 36.2046'W	180/0446

then deployed seismic gear and ran lines 52-56 all night, generally to the west and around the bedrock high.

Thursday July 1st JD 183
low winds, foggy
retrieved seismic gear at 0600 ADT

Piston core 45 50 ft	49° 58.2202'N	47° 17.9095'W	179/2255
Piston core 46 40 ft	49° 56.9337'N	47° 23.0204'W	179/2208
Piston core 47, 40 ft	49° 57.0459'N	47° 24.0128'W	182/0805

Heat flow station

HF2-1	49° 57.1' N	47° 23.0'W
HF2-2	49° 52.8' N	47° 11.8'W

started at HF2-1 and take stations going towards HF2-2

Deployed GI gun, eel and Huntec sparker and ran seismic lines 57-62 generally to the SW

Friday July 2nd JD 184
low winds
retrieved seismic gear at 0600 ADT

Piston core 49, 40 ft	49° 28.5714'N	48° 09.8172'W
Piston core 50, 50 ft	49° 25.4832'N	48° 10.7724'W
Piston core 51, 50 ft	49° 23.4894'N	48° 11.7654'W

Box core 52 at same site as core 51
Camera station 53 across box core site

Deployed GI gun, eel and Huntec sparker and ran seismic lines 63-68, generally to the SE

Saturday July 3rd JD 185
low winds
retrieved seismic gear at 0600 ADT

Piston core 54 50 ft 49° 16.0752'N 47° 59.2566'W
no damage to cutter, but penetrated only 25 ft and recovered only 2 m. ?Hit a pebble somehow. Located in stratified sediment overlying a debris flow.

Piston core 55 50 ft 49° 10.7610'N 47°52.6254'W
Long stratigraphic core in stratified sediments at margin of debris flow. Need to review Huntec data carefully at core site. 3.5 kHz showed some side echoes.

Box core 56 at same site

then steamed for heat flow transect

Start HF3-A	49° 03.4'N	48° 07.6'W
End HF3-B	48° 58.6'N	47° 55.2'W

completed heat flow at 2000 ADT
then steamed to SOL 69

Deployed GI gun, eel and Huntec sparker and ran seismic lines 69-72, generally to the W

Sunday July 4th JD 186
low winds, sunny
retrieved seismic gear at 0600 ADT

Piston core 58	50 ft	49° 08.5950'N	48° 28.2774'W	185/0712
Piston core 59	50 ft	49° 07.6014'N	48° 32.5182'W	185/0640

cutter damage, 30 ft penetration but only 2 m recovery

Piston core 60	40 ft	48° 57.2922'N	48° 30.9378'W	185/0435
Piston core 61	40 ft	48° 55.7364'N	48° 29.2578'W low levee	185/0413
Piston core 62	30 ft	48° 56.0278'N	48° 29.8752'W channel floor	185/0418

Box core 63 at same position as PC62
Camera 64 start at same position as PC62, drift to NW

deploy GI gun, eel and Huntec sparker at 2000 ADT and ran lines 73-77 at 4.5 knots through the water.

Monday July 5th JD 187
winds 20 knots, foggy, wind increased during the morning.
retrieved gear at 0700. Then lost 1.5 hours for work on port shaft. Then steamed to core site.

Piston core 65	40 ft	48° 46.4782'N	48° 33.7044'W	187/0720 terrace
Piston core 66	30 ft	48° 46.3444'N	48° 33.3799'W	187/0717 channel

over lunch, steamed to core site

Piston core 67	50 ft	48° 50.3643'N	48° 34.4359'W	187/0726½ "levee"
Piston core 68	30 ft	48° 49.3261'N	48° 29.8600'W	187/0419½ df

Deployed Huntec, GI gun and eel at 1700 ADT

Tuesday July 6th JD 188
winds light, foggy, some swell
retrieved gear at 0615. Then took the following cores:

Piston core 69 40 ft	48° 40.8423'N	49° 17.4612'W	188/0427 ?slump or stripped off
Piston core 70 40 ft	48° 41.3613'N	49° 16.3140'W	188/0417 ?debris flow
Piston core 71 30 ft	48° 39.2754'N	49° 06.7043'W	188/0754½ talweg on small df
Piston core 72 30 ft	48° 36.8644'N	49° 00.7416'W	188/0659½ talweg on main df
Piston core 73 30 ft	48° 37.3453'N	49° 01.9674'W	188/0710½ main df

Then steamed to SOL 86 and deployed seismic gear at 1430 ADT
Ran lines 86-90 along lower slope and then up to the upper slope off Trinity Trough.

Wednesday July 7th JD 189
light winds, clear, damp
brought in seismic gear at 0700 ADT

Piston core 74 40 ft	49° 15.8007'N	49° 53.4308'W	189/0954 upper df
Piston core 75 40 ft	49° 17.1505'N	49° 55.8857'W	189/0935 lower df
Piston core 76 30 ft	49° 22.6264'N	50° 05.9648'W	189/0810½
Piston core 77 30 ft	49° 24.3928'N	50° 09.2589'W	189/0741
Piston core 78 30 ft	49° 23.4115'N	50° 07.3999'W	189/0757½

bottom barrel snapped at coupling on PC 78

then deployed sidescan and Huntec at 1400 ADT and ran lines 91 and 92 on upper slope at 3 knots

At 1730, recover gear and steam to St Johns.

Thursday July 8th JD 190
Arrive St Johns. End of cruise.

SUMMARY OF SEISMIC AND SIDESCAN LINES

Lines 1-11. Slope off western Grand Banks.

Line 1. Huntec only. Dip line on western St Pierre Slope. Very incoherent upslope, more stratigraphic continuity at southern end.

Lines 2, 3. Strike line on lower St Pierre Slope. Possible BSR.

Lines 4, 5. Strike lines on lower slope off Green Bank. Shows well stratified sediment, some shallow faulting.

Lines 6, 7. Upper slope south of Haddock Channel from 100 - 500 mbsl. In shallow water, very few features, then a zone of ?pits or ?pockmarks and finally a zone of large relict scours (leopard facies).

Line 8. Long strike line on lower slope between Haddock Channel and Narwhal surveys, upslope from the 1991 line of Pass et al. Dissected by numerous slope valleys.

Line 9. Huntec only. Continuation upslope of 2001 Huntec line south of Desbarres Canyon. Stratified sediment continues only a short distance upslope from previous line, then passes into ?till and then a steep slope up to 300 mbsl.

Lines 10, 11. DDH and surface streamer down the southern tributary of Desbarres Canyon.

Lines 12-17. Slope off eastern Grand Banks.

Line 12. Huntec and GI gun at 42° 25'N. Hard bottom, but no clear till limit or till tongue. Lack of till-like progradation as in Salar basin. Inconclusive on whether glacial or not.

Lines 13, 14. 3.5 kHz in southern Salar basin to look for core sites.

Line 15. DDH line across the upper slope, Salar basin

Line 16. Long GI gun/Huntec line through numerous Harrison cores from Salar basin.

Line 17. Sidescan line from 200 - 400 m on upper slope of southern Flemish Pass. Line stopped where elevation of fish became too great. Deepest parts of line shows abundant scours, otherwise appears to be current-swept sand and gravel.

Lines 18-21 Flemish Pass

Lines 18, 19. GI gun/Huntec lines through Kyle lobe and east of Gabriel lobe, to provide a seismic tie within central Flemish Pass.

Lines 20, 21. Two GI guns over OBS experiment north of the Mizzen well.

Lines 22-33 Orphan Basin

Lines 22-25. From Sackville Spur to basin floor. Note side echo problems, may have run along channel floor.

Lines 26-29 in SE Orphan Basin. Line 26 shows apparent small-scale sediment waves on channel levee. Line 29 has large scale sediment waves about 0.3 s subbottom.

Lines 30-32 over MTDs in eastern Orphan Basin.

Line 33. Line from isolated bedrock high to SW margin of Orphan Knoll

Lines 34-51 Orphan Knoll

Lines 34-39. Seismic and Huntec lines over mounds on SW Orphan Knoll.

Line 40. DDH line with one GI gun over Einarsson mound.

Lines 41-47. 12 kHz and 3.5 kHz lines over crest of Orphan Knoll and the northeastern margin.

Lines 48-50. Crest of Orphan Knoll, across several mounds and through DSDP Site 111. Some peculiar ?small buried mound features. Or are they current-swept bedforms?

Line 51. Southeast of Orphan Knoll, parallel to base of slope. Some interesting mass-transport deposits.

Lines 52- 88 Orphan Basin

Line 52. Transect from SE Orphan Knoll to "bedrock high"

Lines 53-57. Profiles around bedrock high. Strange mound-like feature on profiles 56 and 57, ?sediment drift at foot of main scarp. Some evidence for young faulting.

Lines 58-69. Principally over mass-transport deposits in central Orphan basin. 185/2345: young faulting in Huntec and GI gun.

Line 70. Broad reflective channel at south end, passing northward into stacked mass-transport deposits.

Lines 71-72. Stacked mass-transport deposits.

Lines 73-77. Very interesting relationships between stratified sediments, mass-transport deposits, and channels.

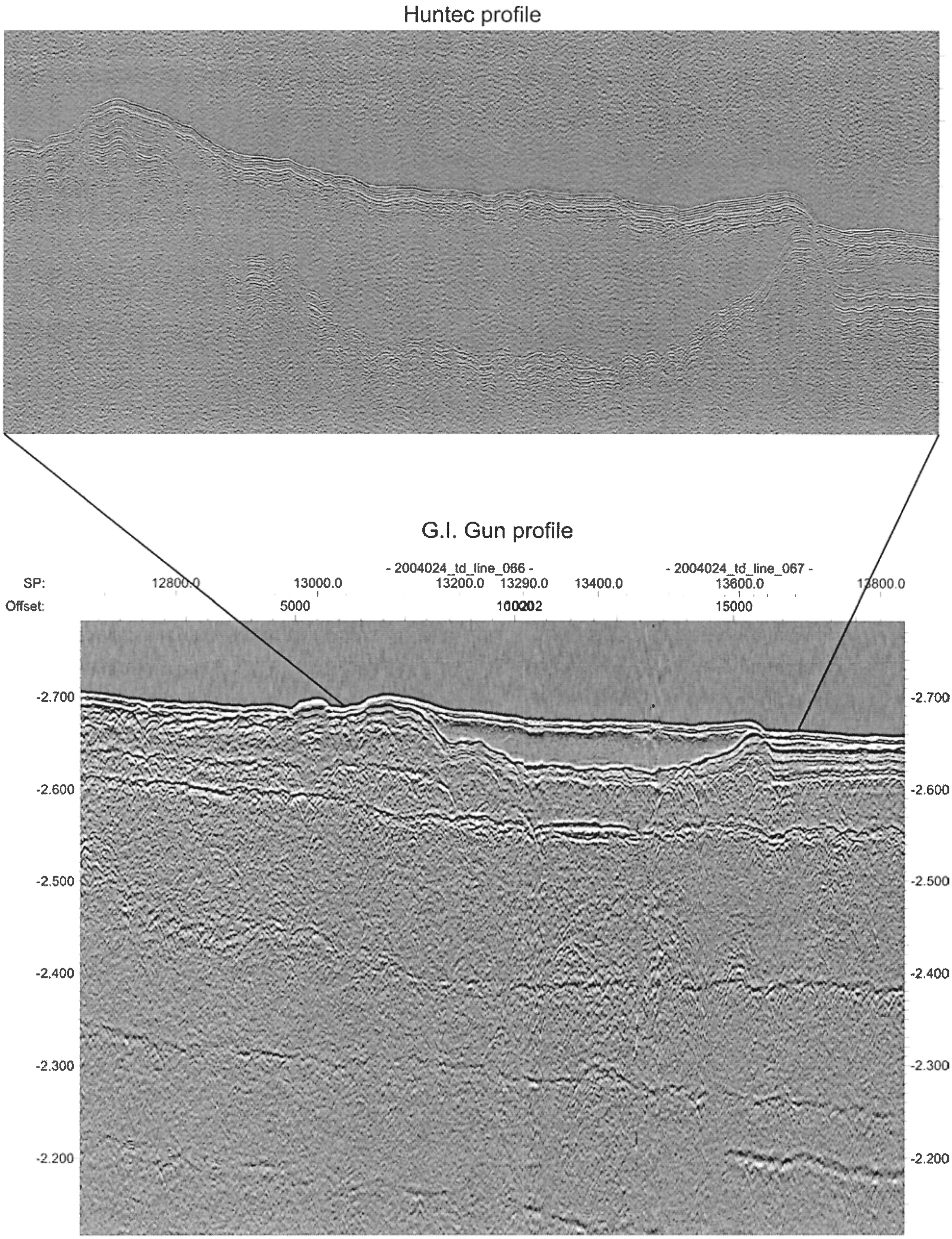
Lines 78-85. Stratified lower slope, with large mass-transport deposits in channels of various sizes. Some evidence of local slope failure.

Lines 86-88. Strike line along lower slope. Stratified, with mass-transport deposits in places.

Lines 89-92 Upper slope off Trinity Trough

Lines 89-90. Dip lines showing major acoustically incoherent units, either till or mass-transport deposits. In <600 mbsl, iceberg scoured.

Lines 91-92. Strike lines at about 300 mbsl with Huntec and sidescan only. Some fresh looking scours at 320 mbsl.



GI gun and Huntec profile across mass-transport deposit, Orphan Basin.

SUMMARY OF STATIONS

No	*mbsl*	*length*	*twc length*	
Eastern Banquereau				
1 PC	293	1.34	0	Muddy sand over gravelly muddy sand. *Iceberg scoured terrace above which till has failed.*
2 C	323	15 frames		Cobble bottom, passing into rippled sands
3 IKU	272			One rock in jaws
4 IKU	269			Cobbles and coarse sand overlying stiff pinkish sticky clay till with sparse clasts.(Definite diamict).
Slope off Haddock Channel - Whale Bank				
5 PC	2056	12.55	1.52	Long stratigraphic core
6 PC	585	4.11	0.40	Fine sand above stiff grey mud. *Downslope limit of incoherent sediment*
7 PC	311	0	0.49	No sample, ODP catcher did not close
8 PC	310	0.40	0.22	repeat: 40 cm of Holocene sandy mud.
9 PC	525	0.60	0	60 cm of very dense silty mud.
10 IKU	431			three attempts, no recovery, presumably hard bottom
11 PC	337	0.19	0	Very stiff muddy sand with scattered granules, likely sandy till, in CC
12 PC	349	0.66	0	Holocene sand; stiff muddy sand with granules on outside of CC, no CC sample.
13 IKU	598			~ 20 cm Holocene sand; jaws probably did not bite into underlying hard bottom.
14 C	598			Across IKU 13, sandy bottom
15 PC	1045	14.00	1.55	Long stratigraphic core in area NW of Desbarres Canyon
16 PC	1394	10.85	0	Long stratigraphic core on back of levee of Desbarres Canyon, to look for sandy units.
Eastern Grand Banks slope				
17 PC	2682	9.15	0	Stratigraphic core *on intergully ridge in SE part of block.* ?H layer in CC.
18 PC	2713	7.20	1.55	*Core on adjacent gully floor*
19 PC	1273	11.49	1.55	Long stratigraphic core on Fig. 9 of Toews (2002).
20 IKU	468			Three attempts, all tripped and came up completely empty. *From upper part of prominent scarp at 450-500 m.*
21 C	470	20 frames		*Same vicinity as 20, coming to S.* Sandy bottom.Frame 702 shows cobbles; frame 701 has fish and possible till outcrop.
22 PC	1502	9.33	0.80	Stratigraphic core at northern end of Salar basin.
eastern Orphan Basin				
23 PC	2432	10.30	1.36	Long muddy core.
24 BC	2432			At same site, good muddy box core.
25 HF				Bottom 100 m has different temperature, suggesting a current. May

				relate to tripping of BC-24 100 m off the bottom.
26 PC	2250	9.33	1.33	Mud with bed of gravel about 1.5 m below surface. *Terrace beside channel*
27 PC	2377	4.50	1.41	Mud, hit a rock, rather short. *Stratified sediment over small lens of ?MTD.*
28 PC	2352	0.97	1.03	Hit a rock, only 1 m recovery of mud. *Intended as a long stratigraphic core.*
29 PC	2325	8.3	1.43	Terrace beside channel.
30 PC	2696	3.00	0.24	Recovered < 4 m; liner broke and very sandy, stuck in barrel. *Stratified sediment over MTD.*
31 PC	2732	0.94	1.41	*Edge of MTD just beyond pinchout, at low ridge between two channels.*
32 PC	2805	7.03	1.43	*Top of very transparent MTD*
33 PC	2823	8.95	1.55	*Long stratigraphic core beyond pinchout of MTD*

Orphan Knoll

34 PC	1975	7.42	0	Alternating sandy mud and grey mud. *Nader mound.*
35 PC	2114	7.16	0.97	Alternating sandy mud and grey mud. *Einarsson mound.*
36 C	2120	22 frames		
37 Dredge				Empty, not enough wire out
38 Dredge				Empty, decided that problem was bent towing point
39 Dredge				Full of rocks
40 Dredge				Full of rocks
41 Box	3447			Excellent muddy box core. *ODP site SE of Orphan Knoll.*
42 PC	1875	11.75	1.28	Long stratigraphic core from top of Orphan Knoll
43 Dredge				A few rocks. *Possible mound on flank of Knoll.*
44 Dredge				A few rocks. *Einarsson mound, ending at camera 36.*

western Orphan Basin

45 PC	2753	12.53	0.24	Long stratigraphic core *just east of bedrock high*
46 PC	2617	10.80	1.55	Long muddy core; sand at surface. *On top of bedrock high.*
47 PC	2691	10.75	0	Long muddy core *just west of bedrock high, on peculiar positive sediment deposit.*
48 Heat flow				*off basement high*
49 PC	2322	11.05	1.55	Long stratigraphic core
50 PC	2293	10.28	1.55	Stratigraphy over major mass-transport deposit.
51 PC	2277	9.37	1.45	Stratigraphy over major mass-transport deposit.
52 Box	2277			Good mud. No macrobenthos recovered when sieved.
53 Camera		40 frames		
54 PC	2341	1.17	1.44	Hit a cobble; only 1 m recovered. *Stratified over mass-transport deposit.*
55 PC	2363	11.16	1.55	*Stratified at edge of mass-transport deposit.*
56 Box	2363			Thick mud.
57 Heat flow				*over deeper basin*
58 PC	2145	9.35	1.49	9 m of stratified sediment, did not penetrate to mass-transport deposit. *Stratified over mass-transport deposit.*

59 PC	2114	3.02	1.55	Cutter damage, hit cobble, little recovery. *Stratified over mass-transport deposit.*
60 PC	2121	3.42	1.50	Abundant fine sand, liner stuck in barrels. *Rough seafloor away from channel.*
61 PC	2125	6.85	0.41	Sand at base of TWC; gravel near top of PC, over thick mud. *Low terrace beside channel floor.*
62 PC	2123	4.52	0.47	Good core, alternating mud and sand. *Flat channel floor.*
63 Box	2123			Good muddy core.
64 Camera		29 frames		Mud
65 PC	2015	1.04	1.49	1 m of graded gravel to fine sand. *Low terrace.*
66 PC	2022	7.07	1.55	Stiff mud, apparently erosional channel. *Channel axis.*
67 PC	2073	12.37	0.38	Long stratigraphic core
68 PC	2095	5.01	0.30	TWC has 10 cm Holocene over stiff mud; PC has 30 cm diamict over stiff mud. *Top of blocky debris flow.*
69 PC	1278	7.89	1.20	Mud, some sand turbidites. *Either rotational slump or stripped off sea floor.*
70 PC	1344	7.11	1.44	Mud. *Transparent lens of debris flow deposit*
71 PC	1572	5.70	1.41	Stiff mud. *Talweg in smaller debris flow deposit*
72 PC	1691	6.15	1.46	Stiff mud. *Talweg in major debris flow deposit.*
73 PC	1684	4.65	0.59	Stiff mud, capped by 1 m gravel to sand bed, Maldaniid worm tubes in overlying mud. *Regional top of major debris flow deposit.*

Slope off Trinity Trough

74 PC	805	5.73	1.54	Mud, stiff near base. *"Mass-transport unit"*
75 PC	746	7.13	1.46	Mud, stiff near base. *Stratified sediment over "mass-transport unit"*
76 PC	435	1.42	0.35	Definite till in catcher: sandy mud with scattered granules on freshly broken surfaces.
77 PC	325	0.10	0	Very short core: one cobble over 5 cm of grey till as before. Includes distinctive pink granite as seen in core 76 PC.
78 PC	380	0.52	0	Broken barrel. Sand and gravel recovered in PC, short length of muddy grey till in cutter.

GEOPHYSICAL EXPERIMENTS

Digital Deep Hydrophone

Dave Heffler

Conventional surface seismic systems suffer from side echos in deep water where the seafloor has large relief. Echos from off vertical hills arrive before the vertical reflections from the seafloor and from sub-bottom reflectors. To alleviate these problems, we built a Digital Deep Hydrophone in 2000 and used it in 2001 and 2002. The system was deployed three times on Hudson 2004-024.

Day 172	deployed 172/2115 - 173/0051 in a tributary of Desbarres Canyon. This was a test to evaluate its effectiveness in areas of very steep topography
Day 174	deployed 174/2058 - 175/0049 on the upper slope of Salar Basin. This was to evaluate results on a planar seafloor with thick glacial till.
Day 180	deployed 180/2348 - 181/0131 over sediment mounds on southwestern Orphan Knoll in 2100 m water depth.

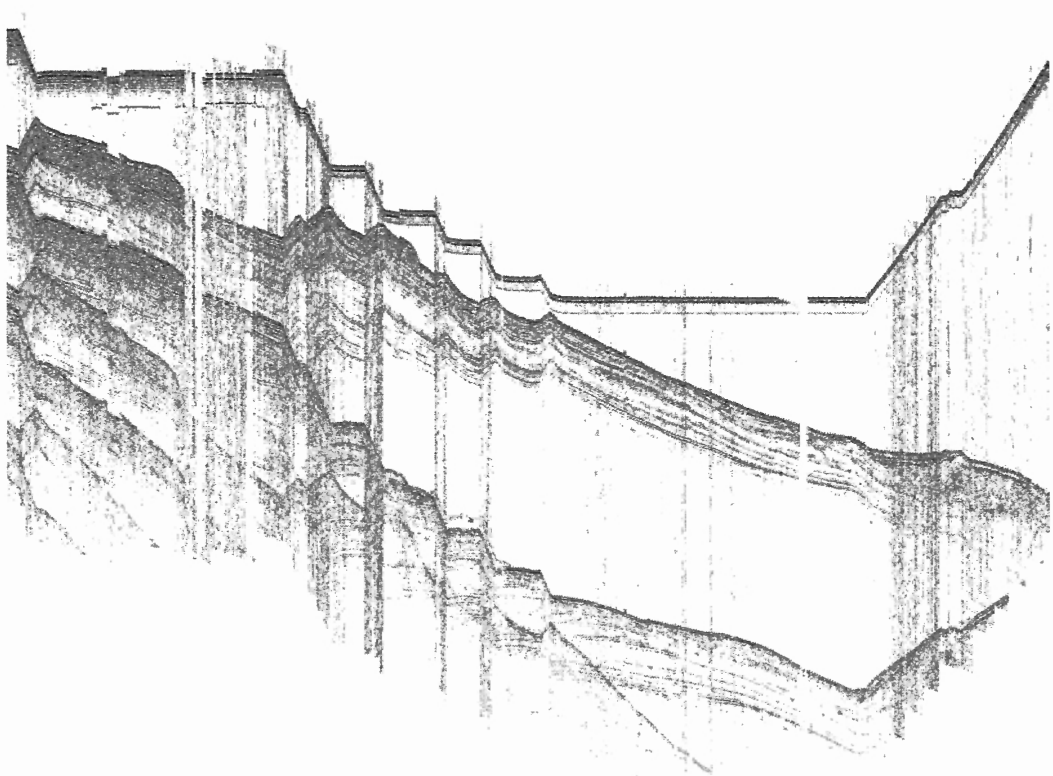


Figure 1 Raw DDH data, upper slope, Salar Basin, Day 174.

The system worked properly on all three deployments. There was a high noise level on the Day 180 deployment which was in deeper water and during heavy weather.

I spent some time developing processing techniques for the Day 174 data set. We do not have any direct measurement of the depth and layback of the hydrophone. I solved this from analysing the direct, bottom and multiple arrival times for each shot. Figure 1 shows the reflection data corrupted by varying hydrophone depths and unknown sampling delays. Figure 2 shows the signal with the bottom refection corrected for both hydrophone depth and delay.

The underwater unit was the same as 2002 with a possible rewiring of the hydrophone connector. The program that runs on the ship end computer was significantly simplified. The winch and cable, the sampling computer, data telemetry and shipboard data logging worked well and are ready for use on the subsequent cruises. Analysis of the data is not yet routine and needs more refinement.

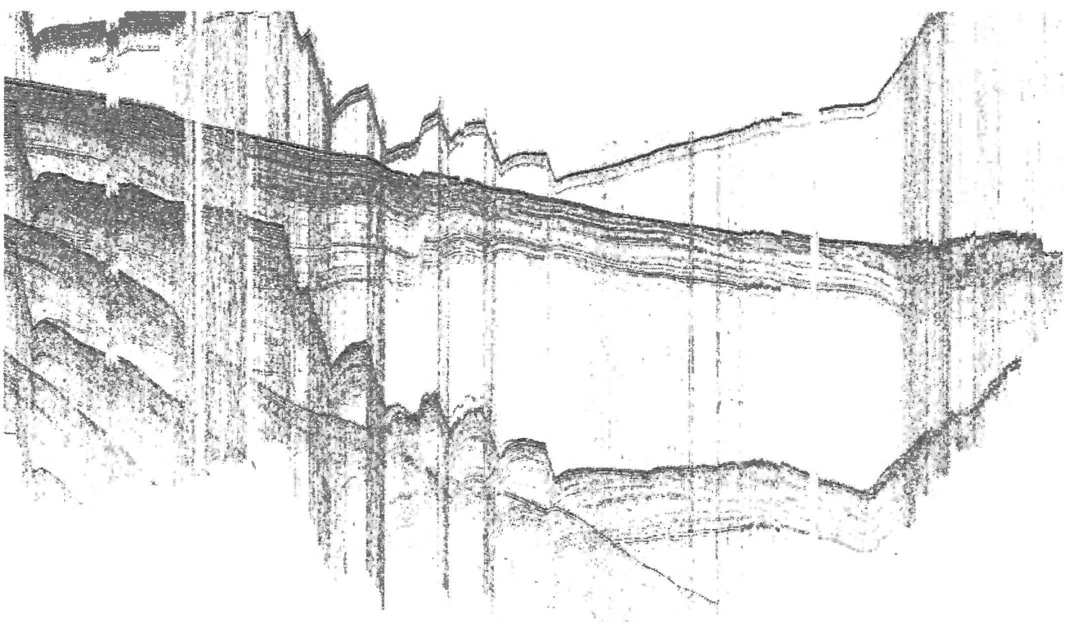


Figure 2. Reflection data from DDH corrected for depth and delay, Salar Basin upper slope, Day 174

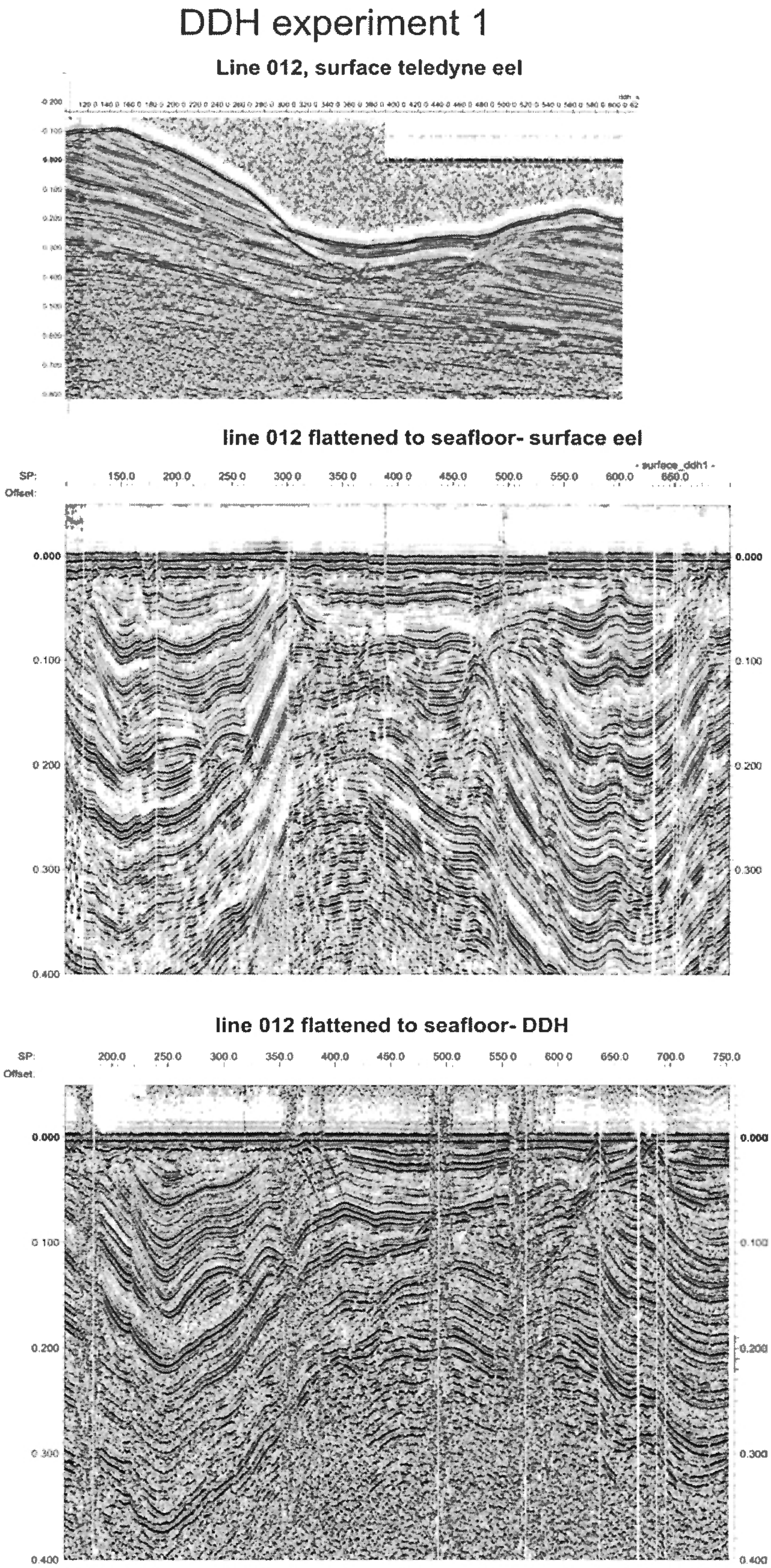


Figure 3 DDH data (flattened to seafloor) compared with conventional surface hydrophone data, Desbarres Canyon, Day 172.

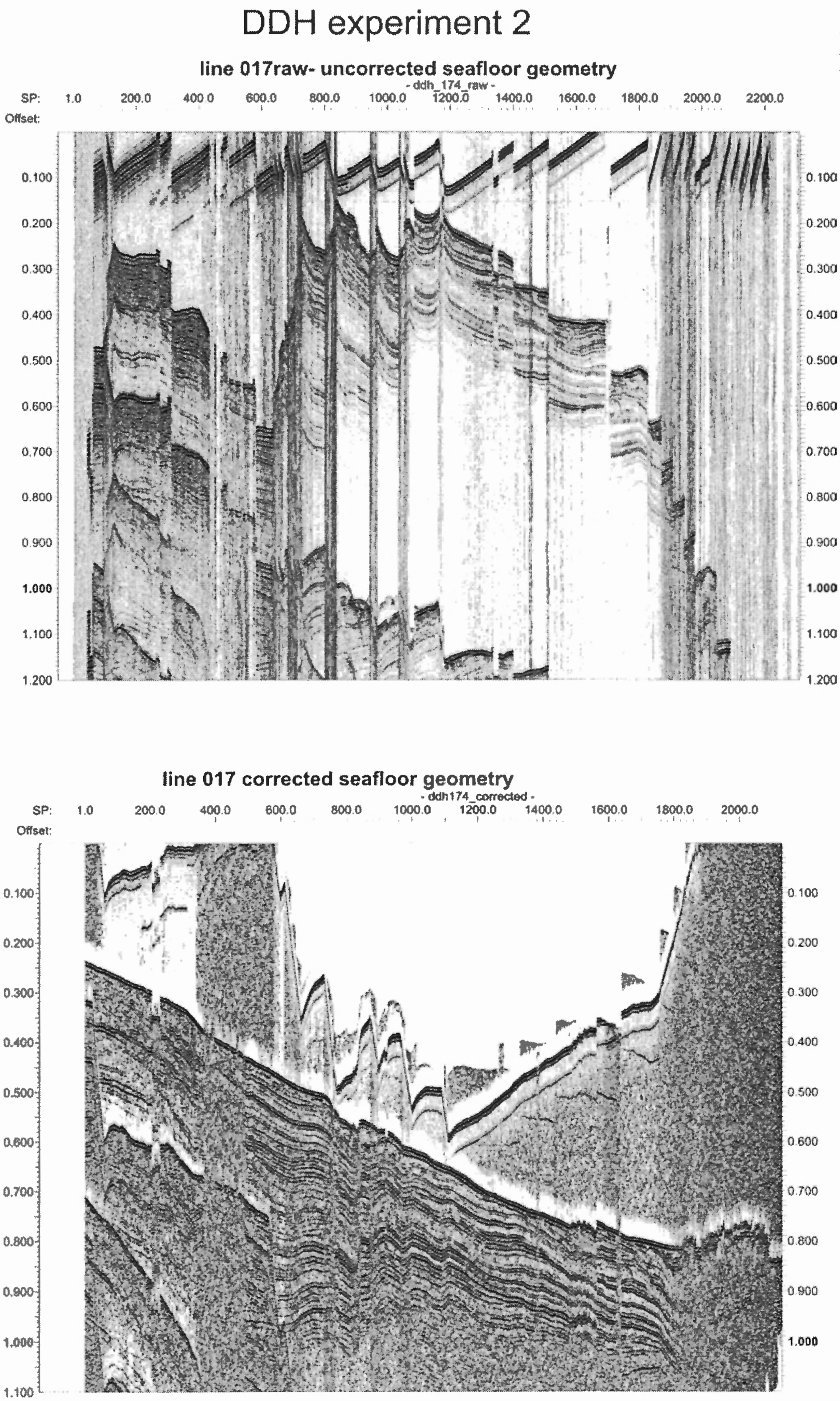


Figure 4 DDH profiles from Salar Basin

Ocean bottom seismic profiles for gas hydrates

Keith Louden, Department of Oceanography, Dalhousie University

Summary. Three Ocean Bottom Seismometers (OBS) were deployed in the vicinity of the Mizzen exploration borehole in Flemish Pass. The purpose of this brief survey was to make preliminary determinations of the velocity structure of the upper sediment layers, and in particular of velocity anomalies due to the likely occurrence of gas hydrates. The presence of gas hydrates in this location is expected due to the existence of a bottom simulating reflector (BSR), which had been previously identified from GSCA and industry reflection profiles.

Logistics. The three OBS used were of the new GSC type and were prepared by M. Uyesugi (Geoforce). There were deployed at the mid-point of the shooting line with approximately 100 m spacing on the early morning of 24 June 2004 (DN 176). They were successfully recovered in the late afternoon for a deployment period of approximately 10-11 hours. A sampling rate of 500 Hz @ 16 bits and gain settings of 46 dB (hydrophone) and 66 dB (geophones) were used. Burn rates for the wire releases were typical (ie ~10 mins). Table 1 gives details of the deployments.

Following deployment of the OBS, a 2-gun array of GI guns with total volume of 420 cu. in. were fired at 6 sec intervals. Both compressors were used to provide the required air. Shot times were triggered and logged by the Dalhousie Zyfer GPS clock in order to ensure exact firing times. A few shots at the beginning of shooting used the GSC clock, but these proved to be unstable with a large drift. Times logged in the shot table were taken from the clock time break (CTB) output of the Real Time Systems Long Shot seismic source controller. These times are the aim point shot times with a 50 msec delay following the trigger.

Two profiles were shot: profile 20 (1000-1240 UTC) along the OBS deployments within the BSR zone and profile 21 (1347-1702 UTC) transverse to them through the Mizzen well site. Fig. 1 shows locations of the profiles, OBS positions, and the Mizzen borehole.

Data. Data recorded on the OBS hard drives were downloaded to PC and written to CD. All OBS channels successfully recorded. Note that all OBS times are advanced by one day because the OBS acquisition program did not recognize leap years. In addition, the OBS times have a one second offset (advance). This 1 sec advance was also noticed during initial use of the new OBS in Davis Strait (Aug 2003).

Preliminary segy files were generated using the Zyfer GPS navigation and OBS deployment positions. Shot times were advanced by one day (minus 1000 msec) to compensate for the OBS timing errors. Fig. 2 gives an example for the hydrophone channel of OBS T following bandpass filtering (15-150 Hz). The data are of excellent quality showing a strong wide angle reflection from the BSR as well as strong refractions. (Note that the BSR is difficult to identify on the reflection profiles due to the flat seafloor and highly reflective sediment layering. It is only clear on the northern end of profile 21 as it crosses the shallower seafloor of Sackville Spur.) The direct arrival is sharp with minimal ringing. The only problem with the data is brief overloading of the amplifiers from the direct wave when directly over the OBS. Ringing is more persistent on the geophone channels.

__Recommendations__

(1) The 2-GI gun source proved excellent for the purpose of recording high quality wide-angle seismic data on the OBS for offsets of at least 10 km.
(2) The OBS data are of excellent quality for determination of velocity anomalies associated with the BSR even when the BSR is not clearly identified on normal incidence profiles.
(3) The timing problems of the new OBS acquisition program should be fixed.
(4) Use of a 24-bit ADC for future upgrades of the OBS would eliminate the problem with overloading by the direct wave.

Table 1 **Ocean Bottom Seismic Profiles**

Station	OBS	deg N	min N	deg W	min W	day	launch	recovery	depth
1	T	48	17.485	46	17.991	24-Jun-04	9:21:53	19:14:00	1065
2	A	48	17.450	46	18.039	24-Jun-04	9:25:36	20:11:00	1065
3	P	48	17.410	46	18.082	24-Jun-04	9:29:06	20:50:00	1065

	clock set	time	offset (msec)	clock cal	time	drift (msec)	drift rate (msec/hr)
OBS T	6/23/04	22:46:05	0	24-Jun-04	19:25:11	1.425	0.069
OBS A	6/24/04	00:36:48	0.125	24-Jun-04	20:17:37	0.225	0.005
OBS P	6/24/04	02:33:11	0.100	24-Jun-04	20:58:53	-1.325	-0.077

SHOOTING PROFILES **24-Jun-04 DN 176**

Line	SOL	EOL	shot points of closest approach OBS T	OBS A	OBS P
20 (strike)	10:00:00	12:40:00	1746	1752	1759
21 (cross)	13:47:00	17:02:00	4093	4089	4080

GPS NAVIGATION

offset (m)	Ship's Nav GPS aft	starboard	Shotlog GPS aft	starboard
GPS-stern	58.1	3.7	23.5	-1.5
stern-gun	45.7	3.0	45.7	0.0
TOTAL	103.8	6.7	69.2	-1.5

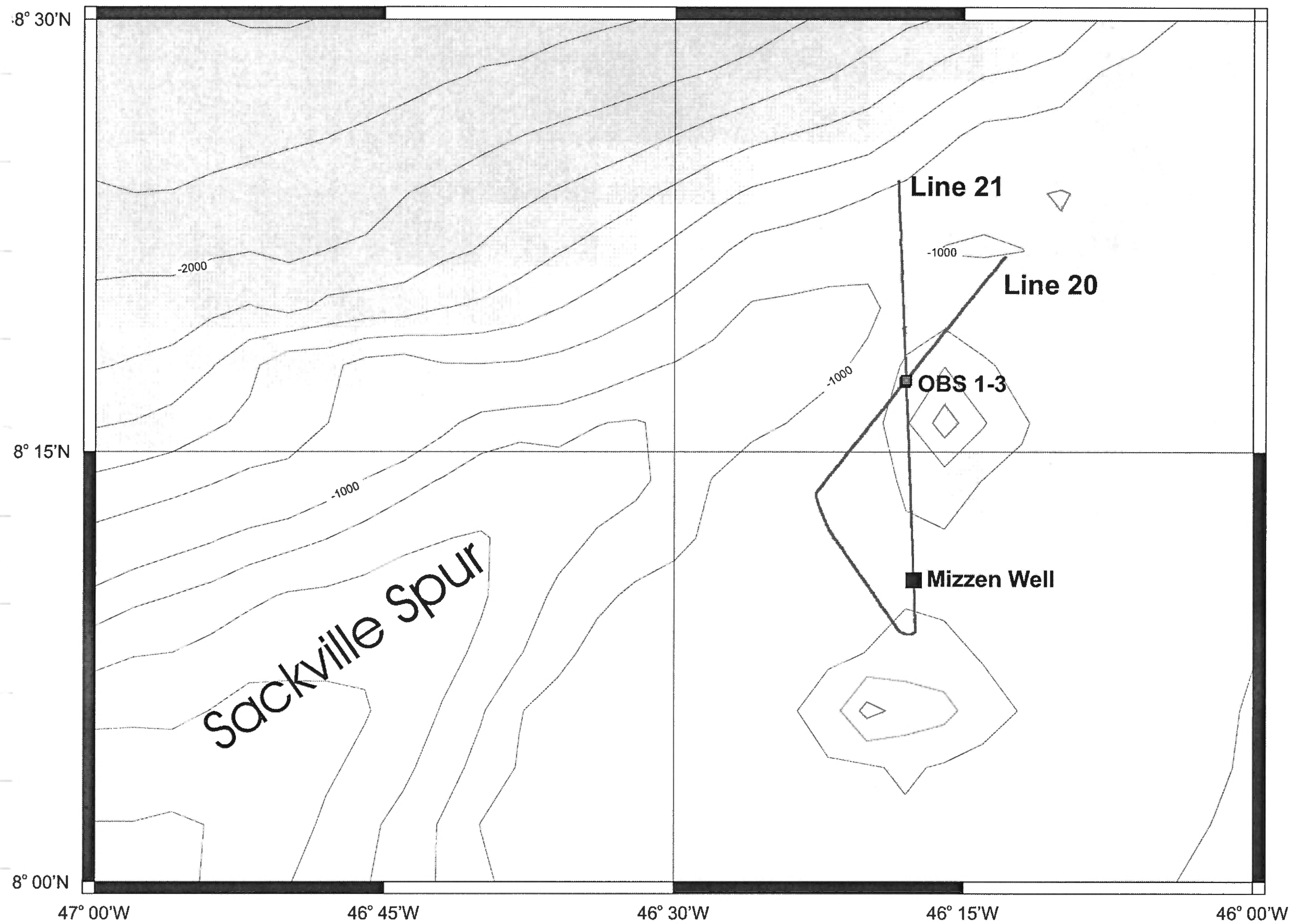


Figure 1. Positions of Mizzen Well, Ocean Bottom Seismometers and GI gun profiles in Flemish Pass.

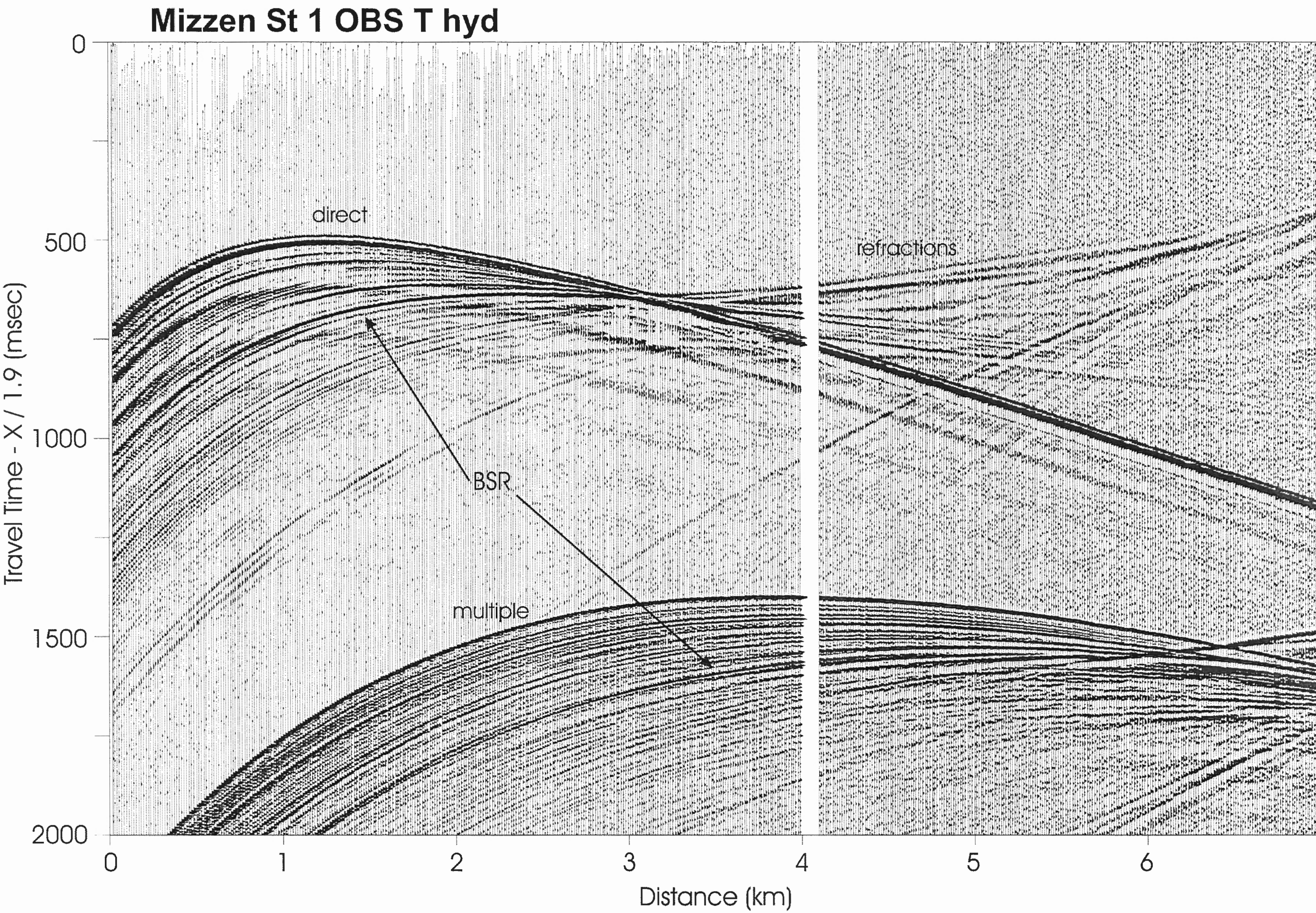
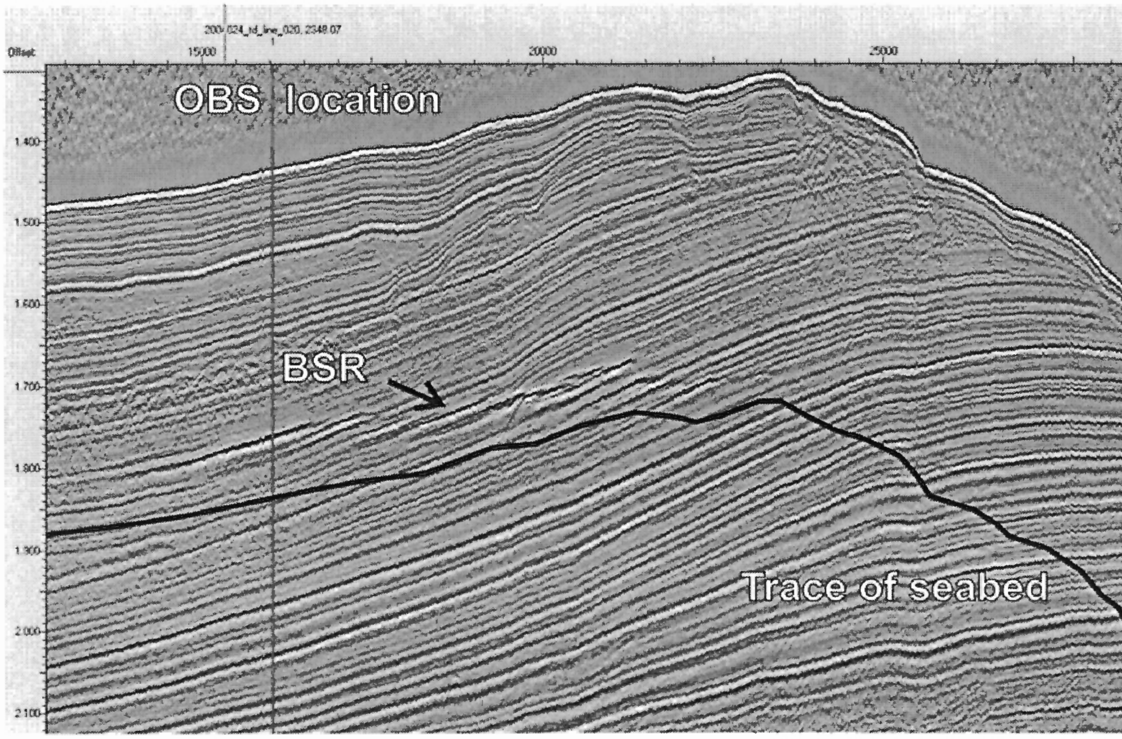
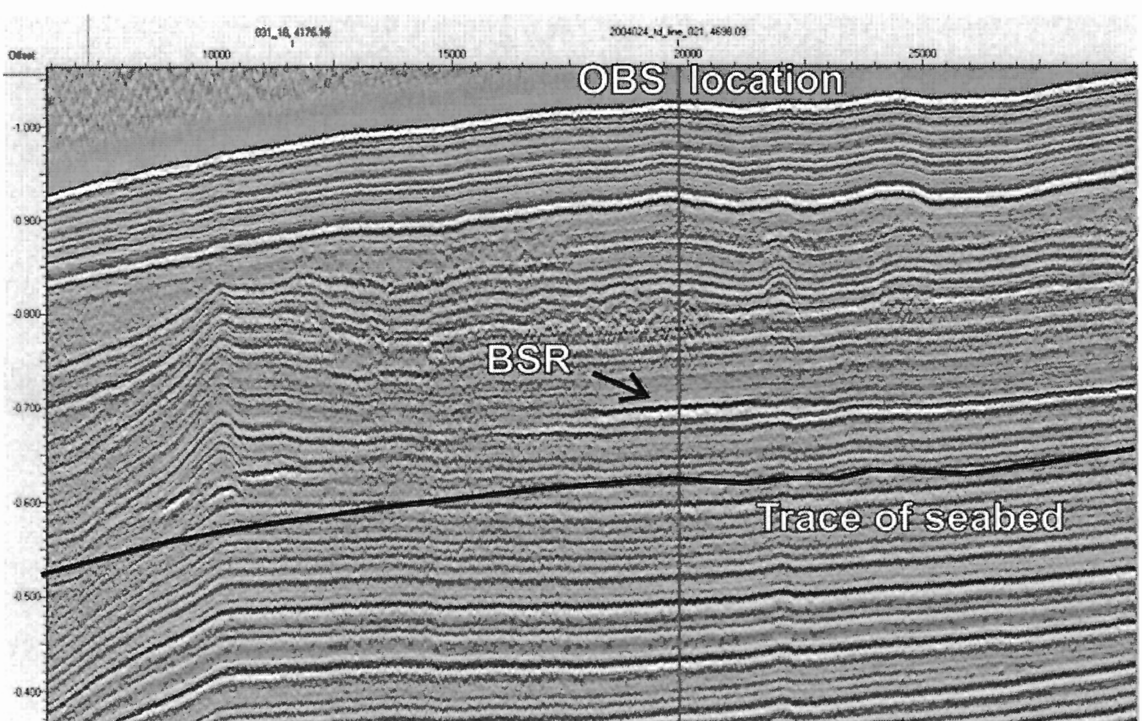


Figure 2. Example of seismic data recorded on OBS T (hydrophone) plotted as reduced travel time versus distance. A very clear wide-angle reflection is observed from the BSR.

Sackville Spur BSR OBS experiment



2004-024 line 21



2004-024 line 20

Dalhousie Heat Flow

Keith Louden, Department of Oceanography, Dalhousie University

Summary. Heatflow measurements were taken using the Dalhousie heat flow probe and Seabird 19 CTD at 3 locations in the Orphan Basin as a preliminary assessment of its thermal regime. A total of 10 successful measurements were made using a 4-m long probe and 32-sensor thermistor string.

Operations. Deployment of the heat flow probe and CTD was made during the afternoons of June 25 (DN 177), July 1 (DN 183) and July 3 (DN 185). Details of station locations and times are given in Table 2. A total of 10 successful stations were made using a 4-m long probe: Site 1 (3 stations), Site 2 (3 stations) and Site 3 (4 stations). Fig. 3 shows the location of the stations. The weather was excellent for all deployments and the instrument performed well. During Site 2, a malfunction in the instrument occurred when data was written to the flash card. The probe was retrieved 1-hr early, but the fault was not serious and no data was lost. During the deployment at Site 2, the vessel's engine and all power was lost while the probe was in the bottom. Fortunately, winds were light and the ship did not drift very far during the 30 min period until power was restored. The unusually long time-series of data at this station will be useful for error analysis.

Data. The data are of good quality, although 8 of the 32 sensors on the thermistor string were not functional. Preliminary results indicate that the measurements will be useful in placing some initial constraints on the regional heatflow. In addition, a very high value was measured immediately adjacent to an uplifted basement block at Site 2 (Figs 4-5). The location of existing deep MCS profiles at this location (Fig. 4) makes this a worthwhile target for future more detailed measurements. Strong bottom water gradients in the 50-100m immediately above seafloor were measured at Sites 1 and 2 by the CTD, as well as non-linear gradients in the upper 2-m of the heat flow probe. This is indicative of a strong bottom boundary flow in this region. Further work will be required to more fully determine the affects of these variations. Finally, zones of high conductivity were determined at most stations, which can be investigated by comparison to variations in sediment properties in adjacent cores.

I would like to thank David Piper for kindly allocating time for these measurements and for enabling them to be made during days of particularly nice weather conditions.

Table 2 Orphan Basin Heat Flow Survey
HUDSON 2004-024

ID	Latitude	Longitude	Pen	DEPTH	Time on bottom	BWT	Tilt
	N	W		m	m	°C	deg
OB11	48° 47.02'	47° 26.67'	4	2490	177 1800	2.22	2
OB12	48° 46.93'	47° 25.97'	4	2492	177 1916	2.24	3
OB13	48° 46.54'	47° 24.93'	4	2495	177 2031	2.24	15
OB21	49° 56.61'	47° 21.74'	4	2800	183 1654	2.05	1
OB22#	49° 56.36'	47° 21.06'	4	2800	183 1741	2.03	7
OB22a	49° 56.36'	47° 21.08'	4	2800	183 1829	2.03	2
OB23	49° 55.87'	47° 19.77'	4	2815	183 1940	2.04	11
OB31	49° 03.40'	48° 07.60'	4	2320	185 1648	2.59	1
OB32	49° 01.90'	48° 03.72'	4	2348	185 1828	2.56	2
OB33	49° 00.40'	47° 59.85'	4	2359	185 2001	2.45	1
OB34*	48° 58.86'	47° 55.84'	2	2381	185 2134	2.12	9
OB34a	48° 58.91'	47° 55.89'	4	2381	185 2203	2.17	3

Notes:
Ship's power lost during penetration
* partial penetration

Operational Statistics	Site	HF 1	HF 2	HF 3
	start	177 1700	183 1600	185 1600
	stop	177 2145	183 2100	185 2300
	total hours	4.8	5.0	7.0

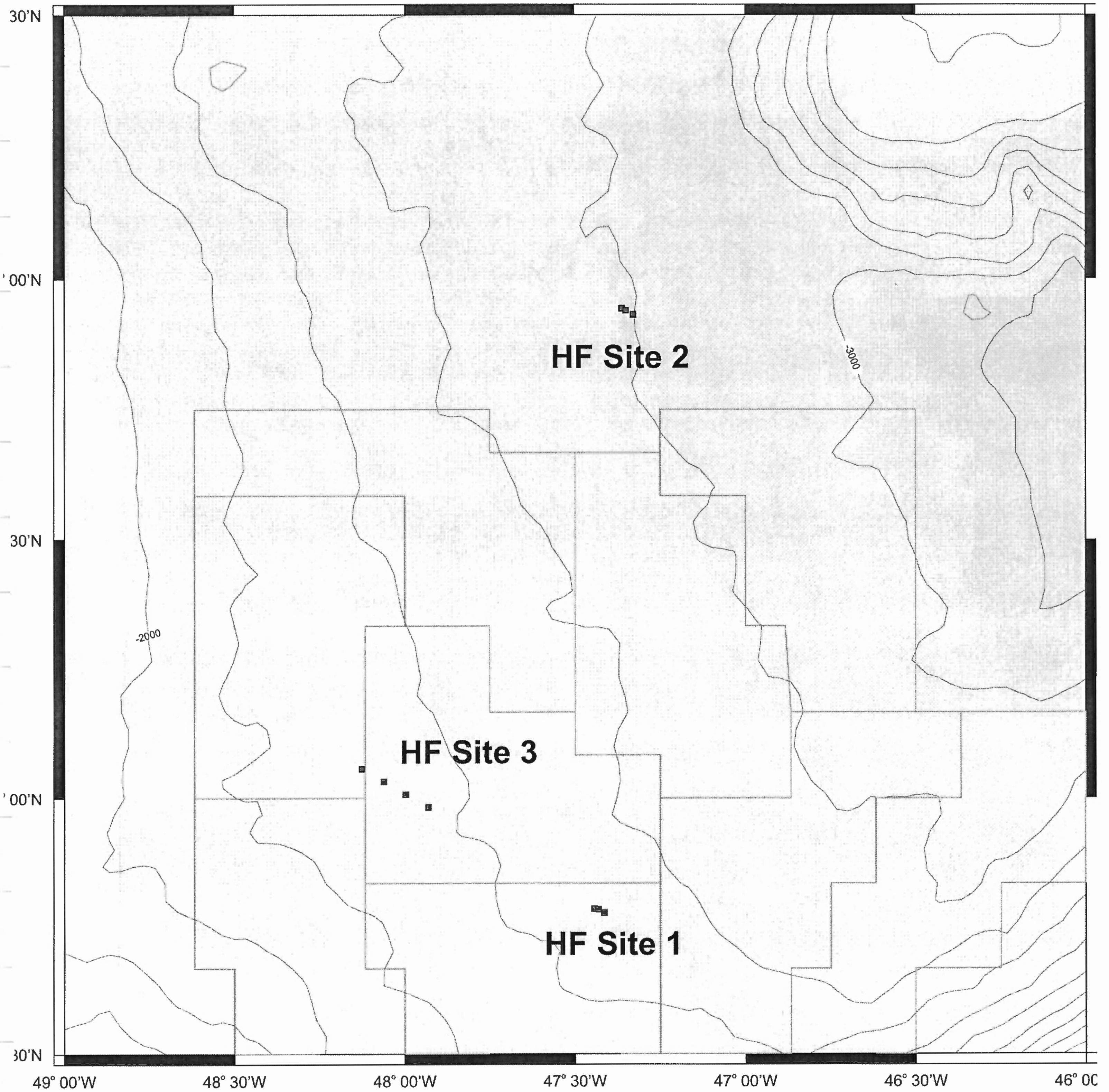


Figure 3. Location of heatflow stations 1-3 in Orphan Basin with generalized bathymetry and boundaries of exploration blocks.

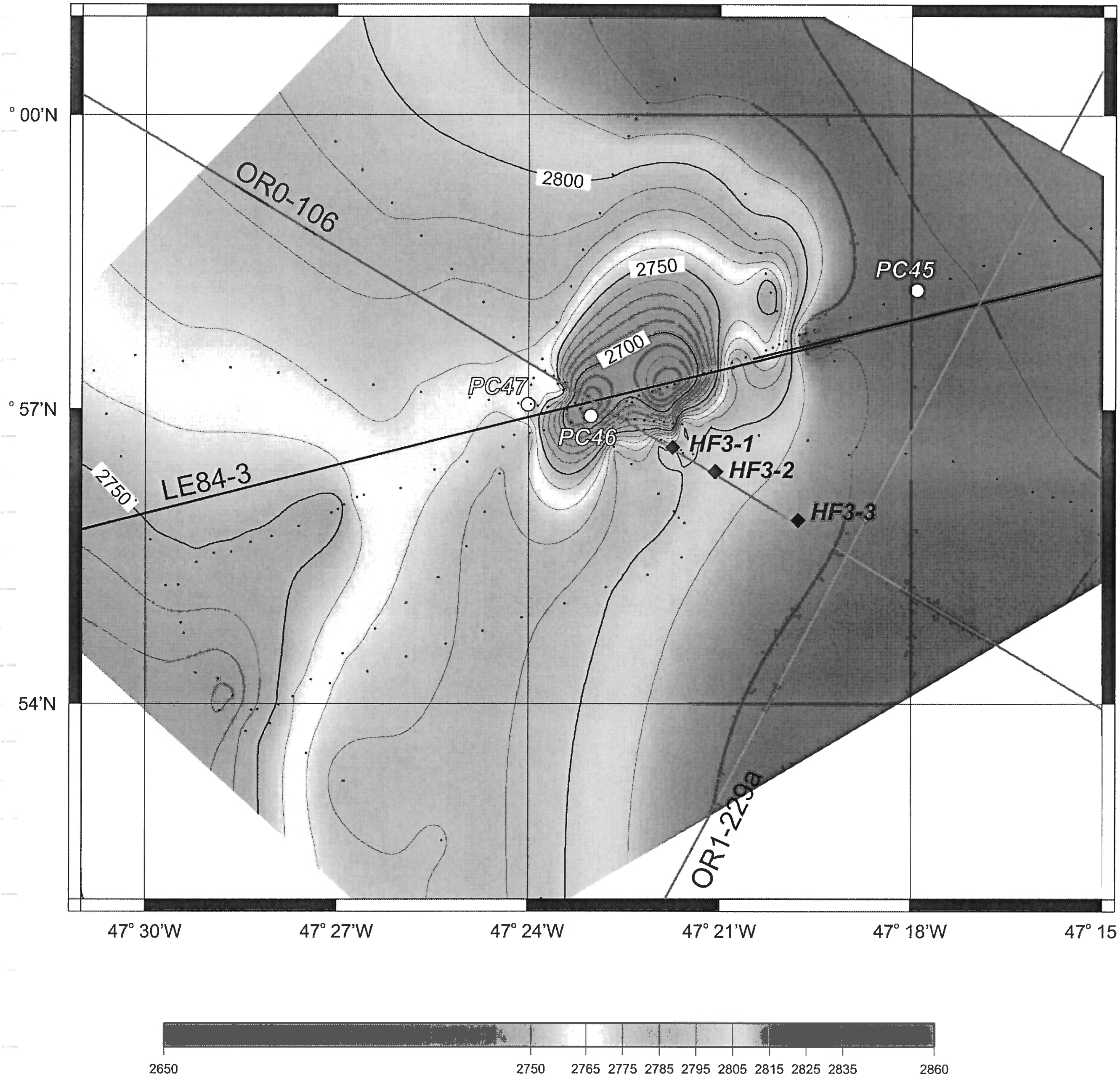


Figure 4. Preliminary bathymetry and heatflow (HF), piston core (PC) and seismic profile locations in vicinity of faulted basement high. Dots indicate locations of soundings.

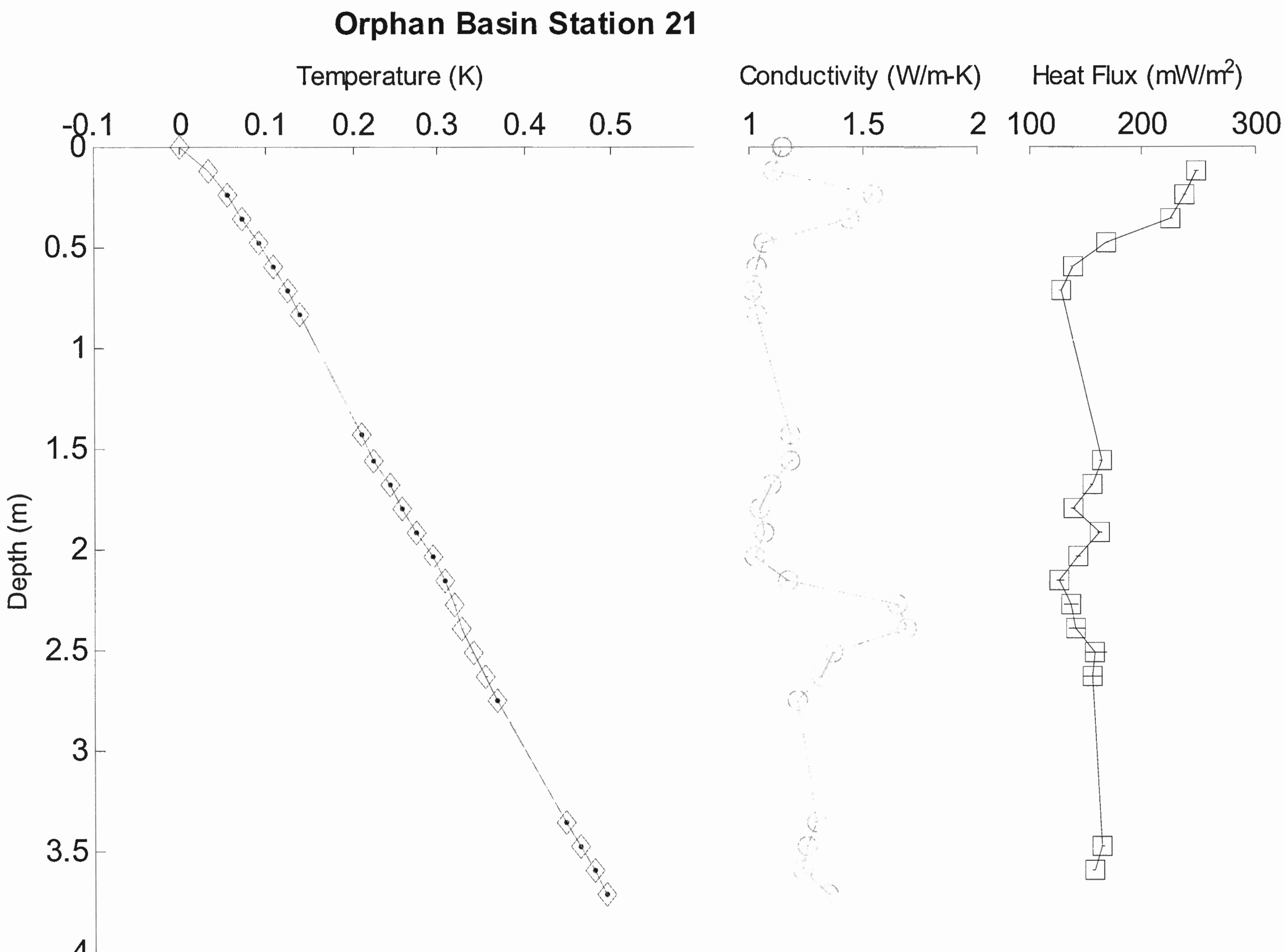


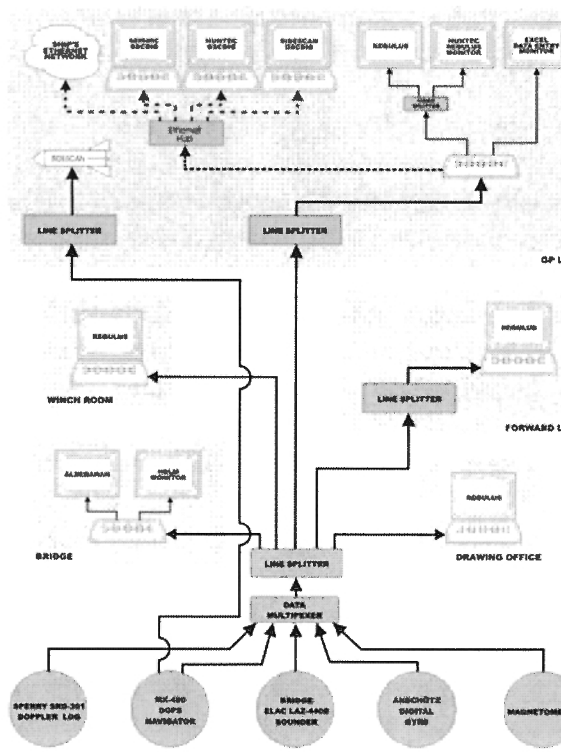
Figure 5. Values of temperature, conductivity, and heat flow versus depth for station 21.

EQUIPMENT

Navigation and data processing

P. Girouard

Differential GPS navigation was provided by the ship's MX400 series receivers. NMEA sentences from these systems were combined with the NMEA sentences from the ship's log and gyro through a Baytech Multiplexer in the NAV centre. Data from the magnetometer, when available, was also fed through the NAV centre multiplexer for logging on the Regulus systems. Data from the multiplexer was then forwarded to a Black Box line splitter for distribution throughout the ship at 9600 baud. A second navigation feed, directly from the MX400 GPS receiver, was provided to the Sidescan system through the GP Lab 4800 baud Black Box line splitter. In addition, the GP Lab Regulus system rebroadcast all the received NMEA sentences over the Ethernet network to the three GSCDIGS systems in the GP Lab.



Hudson 2004-024 Navigation Data Distribution

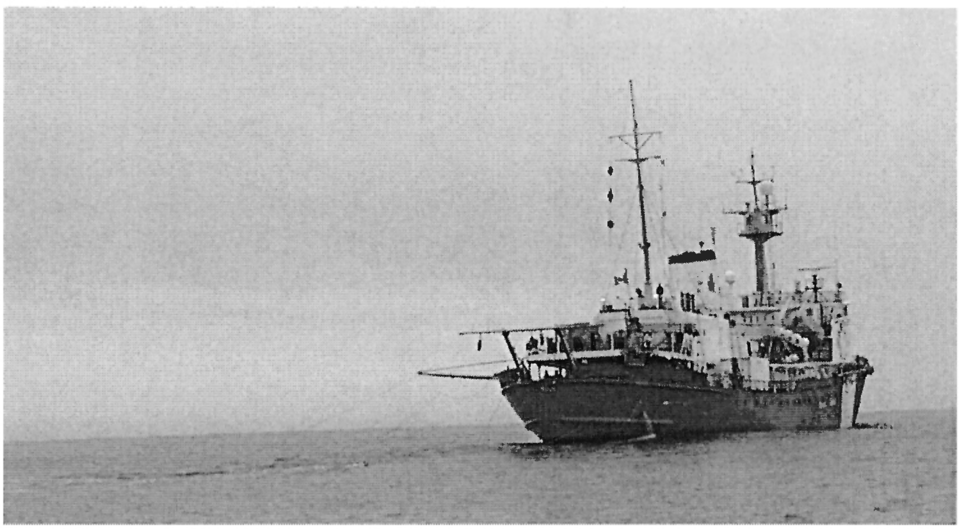
Four Regulus systems were in use on the ship to view and log the scientific navigation. All systems were running the latest version of Regulus, Build 27001. These systems were set up in the Drawing Office, the Winch Room, the Forward Lab and the GP Lab. The GP Lab Regulus system was used as the primary data logger. The data was copied over the network to the shipboard NT server on a daily basis, enabling access to the files from a variety of networked workstations. The data were cleaned and merged using a text editor and the standard GSCA programs ETOA, INTA and APLOT. Raw E-format, raw A-format and cleaned and edited 10 second A-format files were saved on a daily basis and transferred to CD for GSCA archiving. 60 second A-format files were supplied to the GIS system on a daily basis, for display of the lines on the GIS system. A second monitor was attached to the GP Lab Regulus system through a video splitter. This allowed for the concurrent display of the navigation data for the benefit of the Huntec operator. A monitor was also attached to the second video output on the GP Lab Regulus system for display and editing of the electronic log and 12kHz bathymetry log.

Most problems reported during the last field season appear to be resolved in this latest release. The only apparent problem still persisting is the feature which allows an individual to retrieve a position, based on time, from the Regulus voyage file. A position showing a latitude of approximately half its actual value is occasionally returned when this is attempted. This problem can be sidestepped when it occurs by entering a time one second off from the desired time.

Acoustic Systems

K. Asprey, D.C. Campbell, C B. Chapman, and W.A. Boyce

The following systems were used during this mission:
1. Single channel airgun systems consisting of a combination of airgun[s] source and single channel hydrophone streamer.
2. Huntec Deep Tow Boomer /Sparker System (1000 J) using internal hydrophone and external deep-towed streamer.
3. An ORE 4.0Khz hull mounted sonar array profiler.
4. A Simrad992 STABS deep tow Sidescan sonar.
5. Raytheon 12 kHz Echo Sounder.
6. GEM Systems Magnetometer



Towing seismic gear from CCGS Hudson

1. Single channel airgun system

GSC (A) provided equipment used in the collection of seismic data during HN2004-024 Mission. The equipment included a Sodera 210 cubic inch GI gun system, air compressors, firing control and receiving systems.

Throughout most of the seismic program, a single 210 cubic inch Sodera GI gun was employed as sound source. A one-meter Norwegian float kept the GI gun system towing approximately one meter below the surface.

Acoustic data was acquired using the Teledyne single channel tuned hydrophone array with depth control provided by an I/O Devices “DigiCourse 5000 series” bird.

Gun Source:

The airgun used throughout most of the program was a single- 210 cubic inch GI gun towed from the aft port side ship’s rail. The gun was configured to operate in the “harmonic mode” with no generator or injector volume reducers and with medium discharge ports installed. The gun was deployed and recovered using the ship's quarterdeck crane and two winches located on the port side of the flight deck, immediately behind the workshop container. One winch, a small tugger winch, was used to lift and stream the gun assembly and the second, the "Swan winch", held the 50-meter air lines and pull wire bundle.

The towing location of the single GI gun, and the use of a 50- meter long air and electrical umbilical, functioned well. Initial problems with tangling of the 3-air and 2-electrical lines were rectified by taping these lines into two separate bundles for air and electrics. During deployment these two groups were taped together then separated on recovery. The electrical lines were coiled on deck, by hand, on recovery.

The gun was fired at a 6 second interval with both trigger and delays originating from the MITS timing control system. Shot signals to the gun solenoids were initially controlled by MITS and GSC (A)'s old shot system, but later the RTS- Long Shot gun control system was installed. Fixed delay between the G and I solenoids was dialed into the Long Shot software.

During the DOBS deployment, the timing pulses to the Long Shot were delivered from the Dalhousie University satellite clock. Time stamping of all shots was logged to a shot file.

During the short sidescan operation, the GI gun was towed from the outboard end of the port outrigger. This prevented the gun bundle and the sidescan cable from becoming entangled.

Compressed air, typically 1750 PSI, was supplied from the Price, model W2 electric compressor located on the main deck, port side. The compressor was driven by a 200 HP electric motor through a variable speed drive system allowing for control of air volume by varying the compressor motor speed. With the single GI gun system deployed, the compressor was operated at approximately 730 RPM.

Gun Firing:

The RTS-Long Shot system was used to control GI gun firing. The GI gun will optimally fire at 6-second intervals. This 6-second interval allows the GI gun to refill with air to maximum supply pressure. The long refill time is a function of the gun design. The shot firing interval was controlled by the MITS system which provided a trigger to the Long Shot system. The time interval between the generator and the injector firing was set within the software of the Long Shot gun controller. It was observed that the optimal interval between "G" and "I" firing was 35 msec for the gun tow depth of approximately one meter.

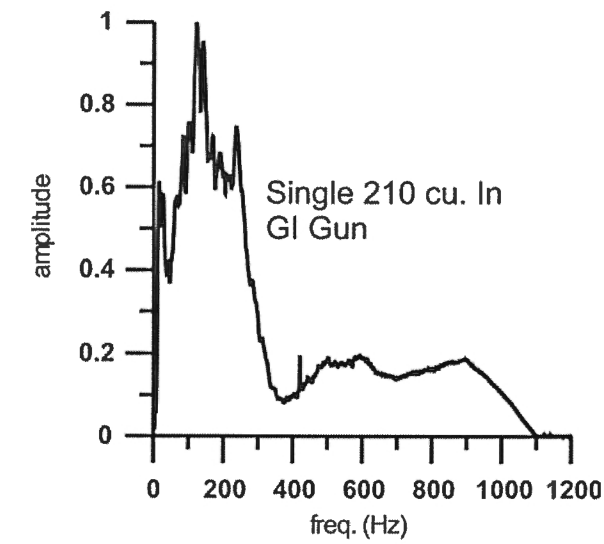
All data was collected using the "shoot on time" scenario. The MITS timing system provided all synchronization for the GI gun firing system, 3.5 kHz ORE Sounder and Huntec DTS systems.

Seismic Data Recording:

GSC (A)'s Teledyne eel array, model 28420, was used throughout the survey. The hydraulic winch used to deploy and recover the eel was located on the starboard side of the quarterdeck. Power for the eel winch was provided by the hydraulic power pack located next to the winch. A roller cluster, attached to the ship's rail, was employed for deployment and recovery. The eel is constructed using Teledyne B1 acceleration canceling hydrophones. Active length of the array is 148.3 feet, with 2 interlaced sets of 3 groups making up a total of 6 groups of phones. There are a total of 16 phones in each group separated by 3.14 feet. Each companion group is separated by .75-feet. The six groups are delivered to a summing amplifier in the lab.

The data from the Teledyne array was amplified by the summing interface amplifier and filtered at 85 Hz through 500 Hz by the K-H Filter and displayed on an EPC9800 graphic recorder. Depending on water depth, additional gain of 20 dB was added through the output side of the K-H filter.

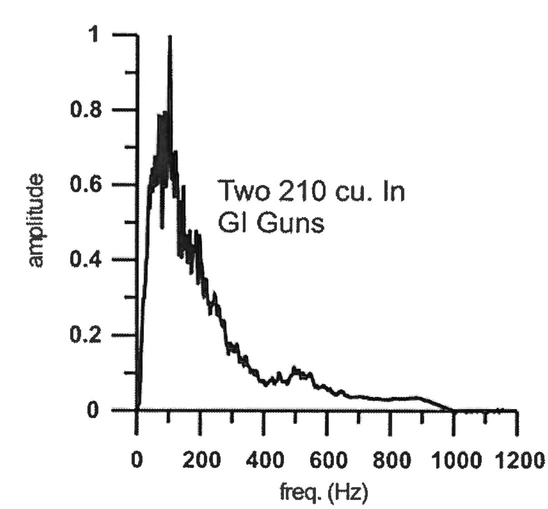
A data logger, GSCDIG #8, was used to record raw unfiltered data along with GPS information. The logging system was configured to sample at 4-kHz (250uSec) with 8192 samples per trace and a record window of 2 seconds. Delays were adjusted using the DIG software, adjusting the 2 second logging window as required. Data and parameters were logged to the GSCDIG hard drive and then transferred to DVD and copied over the network to back up all files. The latest version of the DIG software writes UTM coordinates to the segy trace headers. The coordinates are converted from lat/longs delivered from the GPS system and the UTM zone is chosen automatically by the logger based on the longitude, or it can be forced to a UTM zone if desired. This should be considered if surveying across multiple UTM zones.



Frequency spectrum for single GI gun

The MITS timing system provided the necessary trigger and delay signals to the EPC recorders and the loggers. As noted, during the DOBS deployment, Dal's satellite clock was the source of timing pulses for the logger and Long Shot system.

The DigiCourse system controlled the depth of the array. A single 5000 series bird was attached to the front of the eel and a lead sheet weight and shackle were affixed to the rear of the eel. A PC located in the GP lab controlled the eel array depth by monitoring the depth transducer in the bird, and adjusting the bird's wing plane. It was noted that the length of the "lead in" cable deployed had a direct affect on the ability of the bird to control the depth. Too much "lead in" cable caused the eel to sink and too little "lead in" cable deployed, the bird could not "sink" the eel. Further investigation on placing positive buoyancy devices on the lead in cable should be undertaken. It was clear that the optimum tow distance placed the front of the eel adjacent to the GI gun, a distance of 50 meters behind the vessel.



Frequency spectrum for the two GI gun system

Two Gun System:

During the cruise 2004-024, a new towing method was tested. Two GI 210cubic inch guns were mounted on a 3 meter 4" I beam. Gun port to port spacing was set to 6 feet. The guns were floated by 2 Norwegian floats and towed 50 meters behind the vessel. The electrical/ air lines and lift/ recovery system were similar to the single GI gun method.

The tow system, although more difficult to deploy, functioned well, providing good results as expected. The array required twice as much air capacity to shoot at the required 6 second fire rate. The Price, model W2 diesel compressor, located on the starboard flight deck provided the extra air.

On recovery, the array was inspected for wear or damage and no modifications to the tow system were required for the next deployment. DOBS instruments were deployed away from the vessel and the Teledyne eel array was towed while the 2-gun system was in the water.

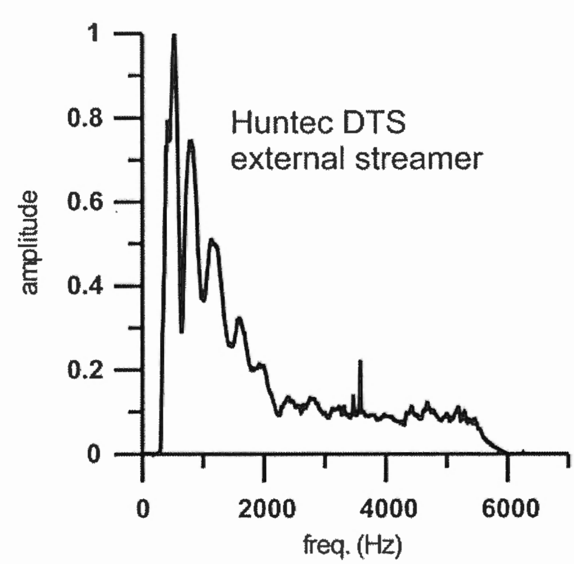
Compressor Operations:

The compressed air for the GI gun(s) was supplied by the two Price air compressors supplied by GSC (A). There was a low oil pressure problem early in the program on the high pressure sump of the electric compressor. The sump was drained and the pump cartridge and sump screen was removed and inspected. Last season, substitute oil was obtained and proved near disastrous to the compressors. Large amounts of carbon built up in the lubrication system and around the valves of each compressor. The diesel was disassembled and repairs were completed prior to leaving Dartmouth base. The electric compressor was not disassembled.

After disassembly of the oil feed system of the electric compressor, large amounts of carbon had accumulated and clogged the oil sump screen. The screen was removed and cleaned and the cartridge was cleaned and re-installed. Oil was changed twice after this cleaning operation and sump oil pressure has returned to normal. The fourth stage pistons were removed and inspected. It was discovered that the wrist pin on the cross head piston was not rotating freely and had to be forcibly removed from the piston. The carbon from the oil used last year had lodged in the piston bearings and caused the wrist pin to stick in place. The two pistons, rings and wrist pin were replaced from compressor spares. Compressor operation seems to be within normal specification again.

2. Huntec Deep Towed System: (see also GeoForce Client Report)

The Huntec Deep Tow Seismics System [DTS] with the 1000 joule sparker sound source was deployed during most surveys to produce ultra-high resolution seismic reflection profiles. The fish was deployed to tow depths of up to 100 m and



Frequency spectrum for the Huntec system data were received on the internal LC10 hydrophone [heave compensated], and external GF24/24 element linear towed streamer. Information on the performance of this system can be found in the Geoforce Consultants contractor's Mission Report. The internal hydrophone and extrenal streamer data were acquired digitally using the GSCDIGS system, sampled at 50 microsec. (0.05 ms), and 8192 samples. The 25 foot towed streamer data was recorded on an EPC9802 channel graphic recorder at a 1/4 second scan.

3. ORE 3.5 kHz Hull Profiler

The 4.0kHz ORE transceivers powered the 16 tranducer hull array profiler and was recorded to an EPC9800. The profiler was set to 0.2 and 0.5 millisecond pulse length and 2.0 kHz bandwidth settings, with 1/2 sec. scan on the graphic, delayed by the MITS trigger unit. This provided surficial seismics both while station keeping and during survey lines.

4. Sidescan Sonar

The Simrad Model 992 dual frequency Side Scan Sonar was deployed while rigged to an Open Seas "STABS" (**S**ubmersible **T**owed **A**pparatus **B**uoyancy **S**ystem) and depressed by a 120 kg. depressor, all attached to an 800 metre coaxial tow cable on a remotely controlled Markey winch. Sonograms of 200m. to 800m. ranges were generated during shallowest survey lines. The 120 kHz data recorded to an Alden 9315 CTP printer with 1:1 speed correction and ship position on the hardcopy. A 3 to 4 minute layback of towed vehicle from ship position was common at 3.5 to 4.5 knot survey speeds.

Simrad Sidescan data were stored to GSC-Digitizer at 83 microseconds sampling rates as follows:

Channel 1 = 120kHz left side data;	Mean TVG: 120kHz; A=32, B=50, C=10-12,
Channel 2 = 120kHz right side data;	L=125;
Channel 3 = 330kHz left side data;	Mean TVG: 330kHz; A=32, B=60, C=22-24,
Channel 4 = 330kHz right side data .	L=125;

Due to deep water depths during most of this mission, the Simrad Sidescan was only deployed on the shallowest survey lines 6-7; 17; and 91-92.

The data were recorded to the GSCDIG system and backed up to DVD.

5. Raytheon 12 kHz Echo Sounder:

CCGS Hudson is equipped with a ram-mounted 12 kHz transducer. The system recorded water depths to Raytheon LSR graphic throughout the cruise. Soundings were hand-digitized at 5 minute intervals.

6. GEM Systems -GSM.19 Overhauser Magnetometer:

The GEM Magnetometer was deployed for a few nights survey line to generate total field measurements by one second polarization generating an RS232 string which was routed to the

Regulus GPS data storage system. It only produced one night's data before exhibiting both tow unit [tuning] and deck unit [stoppage] problems.

PERFORMANCE:

Sea conditions were "good to excellent" throughout the entire program. All systems worked well. As noted, some issues with GSC (A)'s 25 year old compressors arose. Compressor replacement should be considered. Spare parts inventory for the compressors must be updated before next year's programs. Estimated cost could be as high as $20,000.

Additional floatation should be considered for the Teledyne eel array lead in cable. This would allow the DigiCourse system better control of the eel altitude.

The GEM Magnetometer, which was just back from repairs by the manufacture, lasted only one nights towing. The next night's deployment started OK but stopped recording [generating an RS232 string] at midnight and had to be manually restarted. It then exhibited poor tuning, both auto and manual modes, and was not used when that night's data the next day was found useless.

To generate five minute marks for the Raytheon 12kHz graphic, the TSS 312B Annotator was used controlled by the GSC ships clock.

The two Edo Western 248-e Transceivers previously used for the obsolete BIO Sidescan 72kHz system were modified back to a 4.0kHz Transmitter/receiver system to be used as a "more" up-to-date replacement for the aging ORE140 transceivers. These were tested on the Hudson hull array at 2kwatts with very good results considering the very low impedance of the hull array. More refinements will be performed on later missions.

Overall the program was deemed a success from the technical perspective. Thanks to the deck and engineering staff for their professional assistance throughout the program.

Coring

Owen Brown and Greg Middleton

Core equipment

The piston coring system used was the AGC Long Piston Corer, which consists of a weighted core head combined with coupled barrel sections to produce a desired coring length. The 909 Kg core head is 3m long, 0.6m diameter and provides the initial stable downward force. Additional core barrels add substantially to this force. A single core barrel is comprised of a 300 cm length of 108 mm ID, 127 mm OD extra heavy seamless steel BI pipe with double grooves at each end. These barrels are butt-joined using bevelled edge sleeve couplings 46 cm long with sixteen 3/4"NC cup point Gr. 8 Allen setscrews (4 each opposed at 90 degrees). The setscrews fasten securely into the barrel grooves. The cores are collected in 300 cm sections of extruded CAB clear plastic liners slid inside the barrels and end joined with clear 50 mm packing tape. The liner section is held in place at the bottom by a core catcher (used at all coring sites to prevent the sediment from being sucked out by the vacuum created by the receding piston during retrieval). An externally tapered cutter (designed to initially penetrate the sea floor) slides over the last core barrel and is secured by the same setscrew/groove combination.

The piston core is activated by a separate pilot core or trigger weight core (TWC). The TWC is supported by a trip arm connected to a 108 mm diameter gravity pilot corer with a 136 Kg weighted head, a single 183 cm barrel, catcher and liner. It is calibrated to hang 15.25 m below the tip of the piston core. When the TWC contacts the bottom sediment, a trip arm releases the piston core in a controlled free fall to the seabed sediment.

The ship's crew rig, position, deploy and raise cores using the Pengo winch in combination with a hoist boom and block extended outboard of the ship's starboard. Sounding and hoist wire meter blocks measure water depth. The Pengo winch uses ¾"dia 6 X 19 IWRC cable and a 316 SS swivel head. Upon surfacing, piston cores were safely secured and stabilized by the core handling system which included the rotating core-head cradle, swivelling outboard support brackets, an overhead monorail transport system with chain hoists and brake, and a processing half-height sea going container complete with a pendant controlled hydraulic boom crane and manually controlled hydraulic core extruder. From here the cores were taken to the GP lab for on board processing as described below.

The piston corer used the following dimensions for a 1200cm core: head 2.74 m, scope, barrels and cutter 1250 cm; trip arm dip 91cm, 15.75m wire rope, trigger weight core 3.81m. The scope is appropriate for 1.83m penetration of the trigger weight core.

Additional bottom sediment sampling equipment included a 1 cubic metre IKU grab sampler, a box corer, and the BIO small tow dredge.

On-board sample processing and subsampling

During the cruise 53 piston cores yielded 338 m of core and 63 m of trigger weight core. All cores were processed according to the standard GSC Atlantic core procedure manual (GSC Open File #1044).

All cores were identified alphabetically by section at the time of dismantling individual 10ft core barrels from the bottom to the top, commencing with the bottom-most core barrel and proceeding to the upper-most barrel containing sediment. Samples for physical properties (penetrometer and constant volume), were taken from the top and bottom of each 1.5m section. For the constant volume determination, stainless steel cylinders of known volume were introduced at a constant rate and immediately removed in the GP lab onboard ship. At this time the sediment was extruded from the cylinder, placed within a 1 oz screw-top glass bottle of a known recorded weight and sealed to prevent further desiccation. The sample will be later weighed, dried at 105°C for 24 hours and re-weighed to determine bulk density, dry density and water content. Once the constant volume cylinder was removed, inert packing was placed within the created voids, and then the ends of each core section were taped and sealed in wax to prevent further oxidation and drying, until splitting at the GSC Atlantic core repository within the coming months.

The 1.5 metre core sections of whole round core, were individually stored onboard during this program within the confines of a modified 20ft refrigerated seagoing container (AGC #9), adapted for ease of core storage and transport. All core sections were logged as to their individual locations within the container. All core lengths were measured at the time of extrusion from the individual core barrels, labelled and stored upright within this container. Most of the core cutters and catchers were likewise measured and stored accordingly to preserve sediment integrity. Any and all extruded core sections due to sediment expansion or core processing handling were likewise labelled and stored. All core sections, pieces and associated cutters/catchers have been documented on master field sheets as well as in the ED (Expedition) database.

Five one cubic meter IKU's were deployed with two returning a total 50 cm depth of sediment. This was sub-sampled for benthic and sediment characteristics for analysis at BIO.

Five 0.15 cubic meter Box Cores were successful in a collecting a total of 183 cm of sediment. GSCA and GEOTOP (UQAM) retrieved push cores from these stations. GEOTOP also sampled the surface. Two 10 litre pails were sieved by GSCA for biology, whish were preserved and taken back to BIO for analysis. LGL Limited, (Exxon Mobil's representative) sub sampled four by taking two 250 ml glass jars for surficial sediments, and a 10 litres pail of mixed sediment.

Sampling equipment generally worked quite well. Core cutters were damaged on five stations from contact with rocks. One core equipped with a new type catcher failed to return a sample. This catcher was tried again the following day with success..

The ED at Sea database was used throughout this cruise in order to document and edit cruise expedition sample data. While the data has been documented on paper field sheets, corresponding data was also entered into the ED database onboard. Data has been backed up and will be verified before downloading into the main ORACLE sample database. The station data will be made available in a timely manner on *http:// margin.bio.ns.ca/geocol*

Although the GSC provided the equipment the work could not have been done with out the expertise of the deck crew and the quartermasters.

ADOC camera system

A. Atkinson

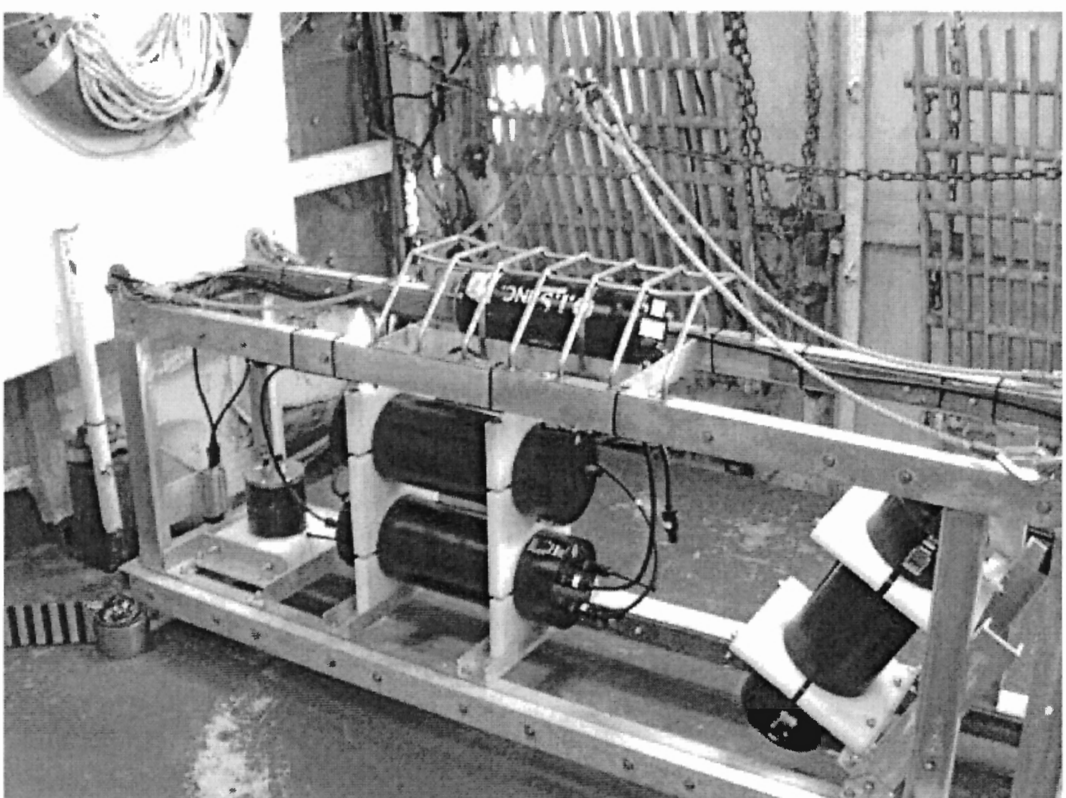
Introduction

Hudson 2004-024 was the first use of the ADOC camera system. The system is based on GSCA's Scorpio Insite TriTech underwater digital camera. The camera's flash photos are controlled by the ADOC microcontroller that senses bottom contact via a bottom contact switch and pinger arrangement. This novel configuration allows serial commands to be sent from the ADOC microcontroller to the Scorpio Digital Camera. The new system mimics the old Benthos Camera.

What Was Done

Photo events were recorded on the Regulus computer each time the pinger recorded a bottom contact on the topside echo sounder. The ADOC microcontroller also incorporates a data logger. Records of day/time, compass heading, pitch, roll, and depth were recorded by the data logger for each photo. The Scorpio camera also recorded the day/time of each photo, but unfortunately it does not display seconds, just minutes.

While the bottom photography was underway, the ship was allowed to drift, creating a transect of photos across the bottom. Sea state impacted the quality of the bottom photos. When conditions were a bit rough, the camera rig moved up and down with the wave action and a longer trigger lead had to be used to ensure the camera rig did not slam into the seabed during the down swells.



ADOC Rig in CCGS Hudson Winch Room

Table 1 Synopsis of ADOC Stations

Day of the Year	Station #	Number of Photos	Depth (metres)
170	2	15	376
172	14	20	604
174	20	19	474
180	35(36)	21	2126
184	53	40	2283
186	64	30	2200

Organization of the Data

The photos and their associated data are organized in day-of-the-year folders. On this mission only one station was done on a particular day. The folder with the station number holds the raw photos from the camera as well as an info.txt fill generated by the camera that holds information about the camera settings. The info file entries also have the camera's time for each photo number to the minute.

There may be a "High Grade" folder in the day folder. This folder contains the best photos from that station. The day folder contains three other folders. There is a .csv folder. This one contains the raw EVENT Day/Times and fixes from Regulus. The .csv folder can be opened with Excel. The second file is the STN_xx.TXT file generated by the ADOC data logger. This space delimited text file contains Day/Time data with seconds, uncorrected magnetic heading, pitch and roll on the camera rig, and depth of the camera. Records are written to this file upon each picture/bottom contact event. This file can be opened with Excel. The "consolidated nav folder is an Excel spreadsheet that contains this salient collated data from the .csv file, the ADOC data logger .txt file, and the camera info.txt file. This is the only file normally needed to obtain information about pictures.

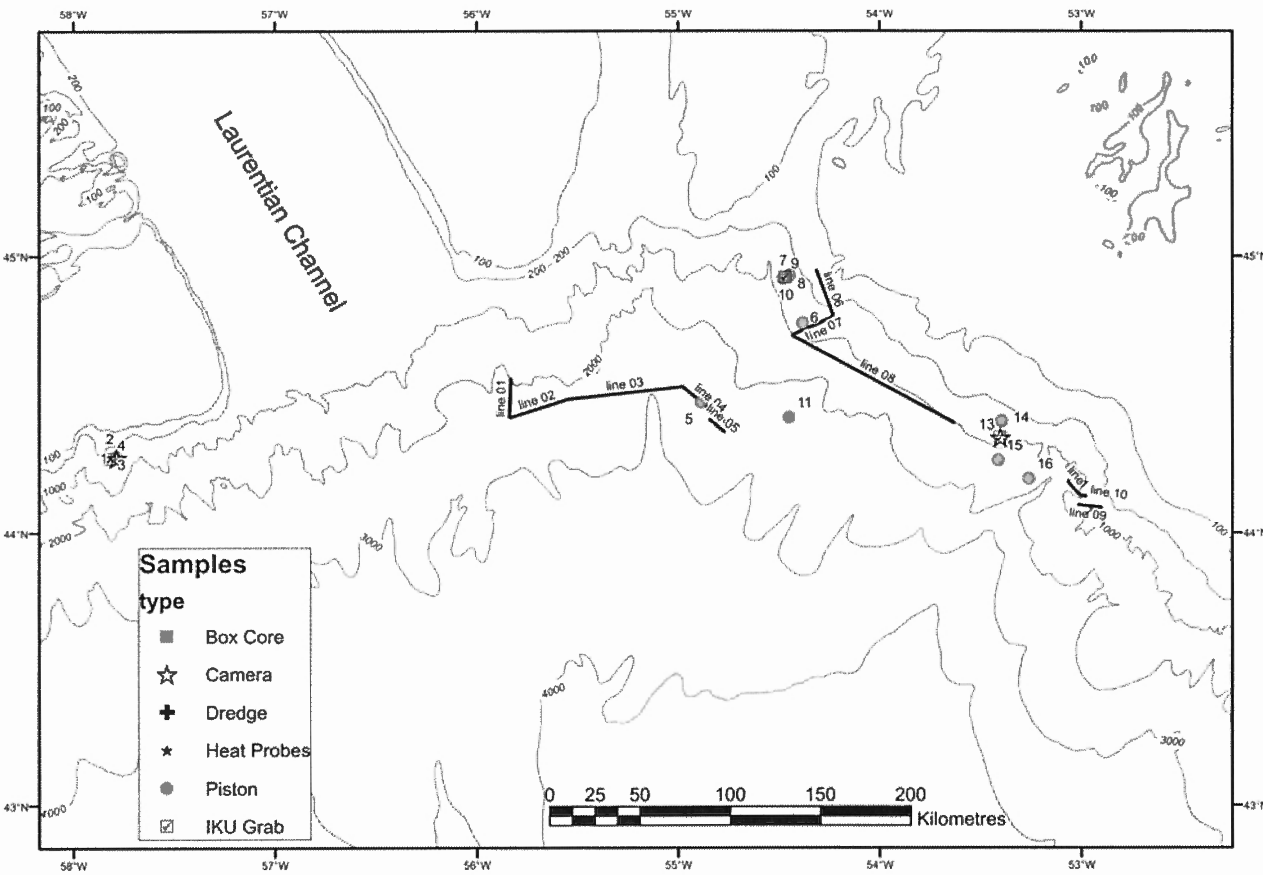
Future Developments

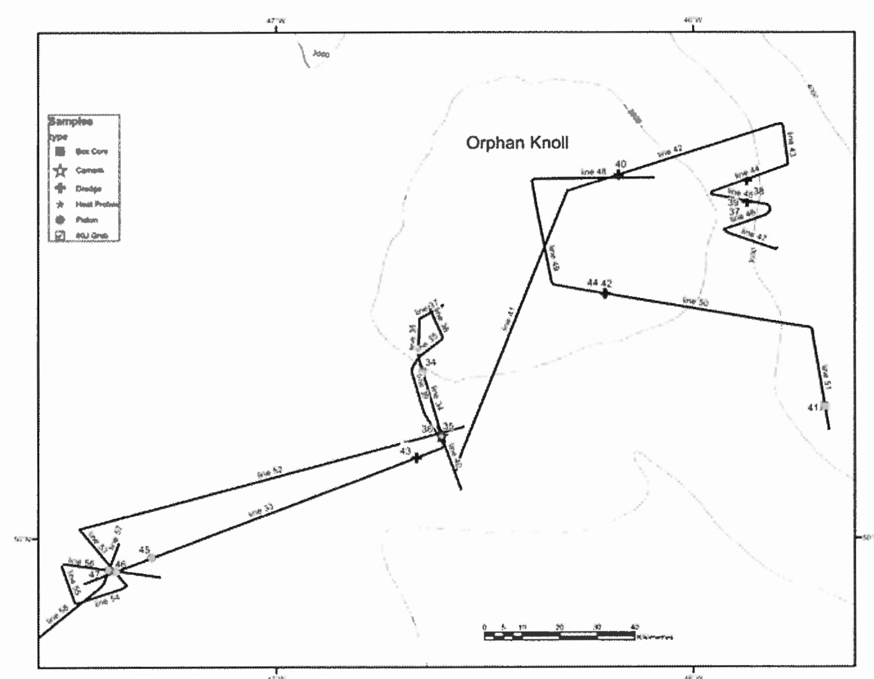
I am planning to acquire a laser distance measuring device before the next usage of this system. That will allow the trigger weight to be placed out of the field of view because it will no longer be needed as an object to show scale.

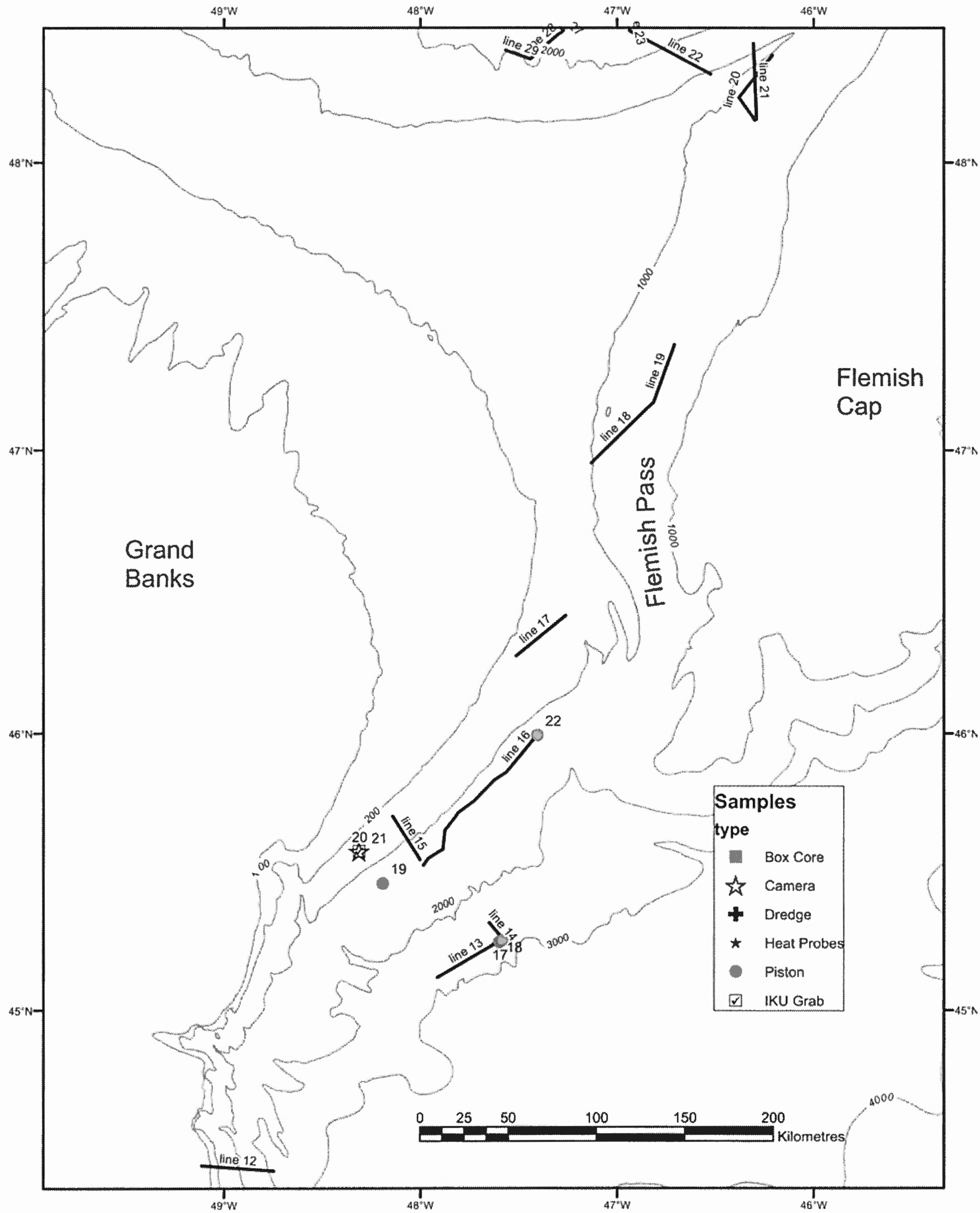
The system could achieve greater depth capability if we had a greater safety factor for the ADOC pressure cases. To this end, I will attempt to acquire some high strength aluminum for these pressure cases. The present rating is 2500 metres. This modification would allow the working depth to exceed 3000 metres with an appropriate safety factor.

Another area of concern is the hydro cast wire in the winch room of CCGS Hudson. This wire is old and should be replaced before any more of this type of camera work is done. The camera rig will normally weigh between four and five hundred pounds. The existing wire has been tested to destruction at 2000 pounds. This yields a safety factor of about 4 to 1, but there is no guarantee that this is uniform along the wire.

APPENDIX


Laurentian Channel
Samples
type
Box Core
Camera
Dredge
Heat Probes
Piston
IKU Grab
0 25 50 100 150 200
Kilometres


Orphan Knoll


49°W
48°W
47°W
46°W
48°N
47°N
46°N
45°N
line 29
2000
line 22
line 20
line 21
1000
line 19
line 18
Flemish Cap
Flemish Pass
1000
Grand Banks
line 17
line 16
22
200
line 15
20 21
19
2000
line 14
line 13
17
18
3000
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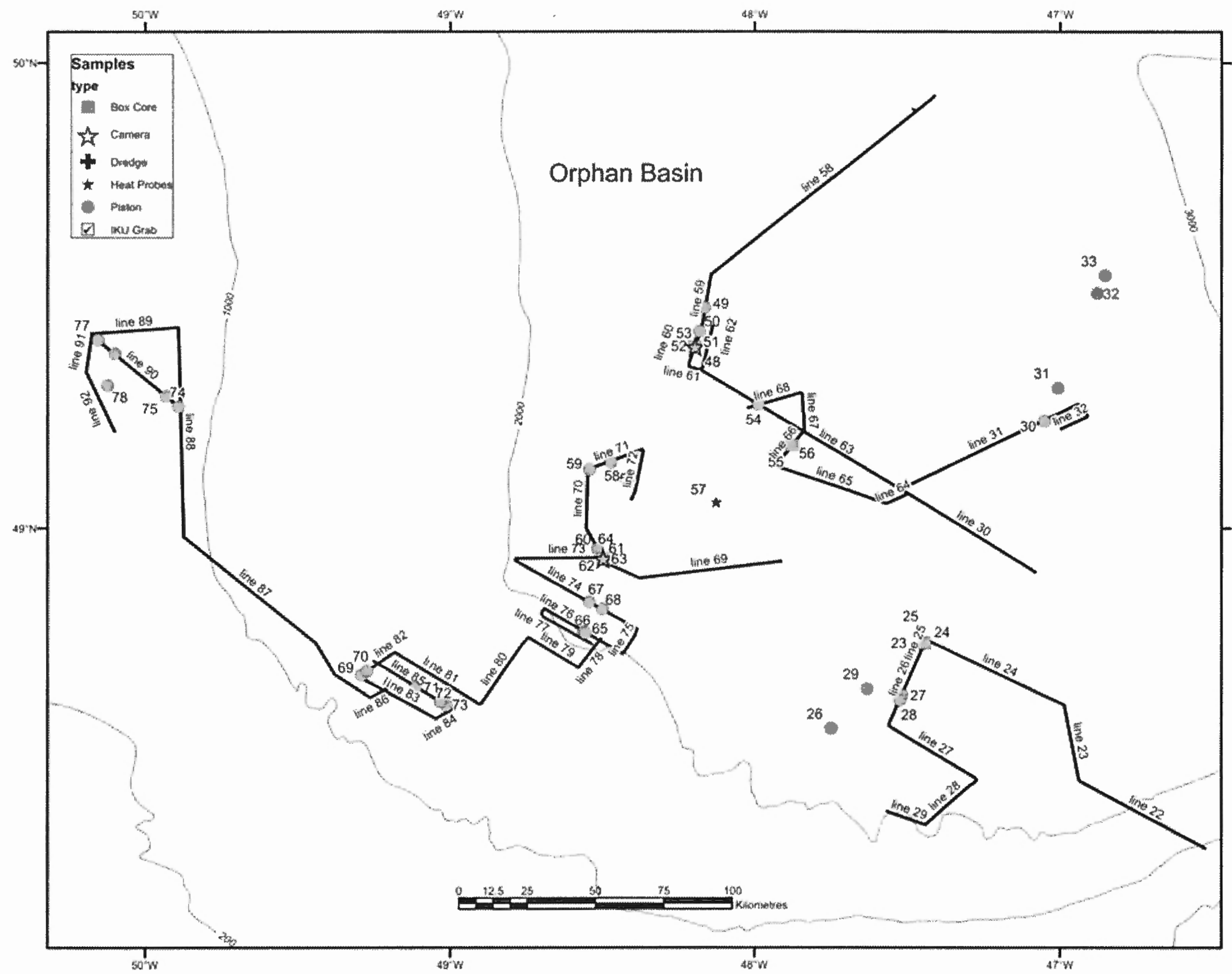
150
200
Kilometres
line 12


Samples
type
Box Core
Camera
Dredge
Heat Probes
Piston
IKU Grab
Orphan Basin
50°W
49°W
48°W
47°W
50°N
49°N
Kilometres

2004024 Station Summary

CCGS HUDSON 2004024

D. PIPER 17-Jun to 8-Jul, 2004

STN	SAMPLE TYPE	DAY/TIME	LAT	LON	DBT DEPTH m	SEISMIC RECORD Cruise	SEISMIC RECORD Day/Time	CUMULATIVE SAMPLE TYPE	PISTON CORE LENGTH	PISTON CORE RECOVERY PC	PISTON CORE RECOVERY TWC	CAMERA # of images	IKU depth cm	BOX CORE depth cm	HEAT PROBE qty	SMALL DREDGE recovery events
1	Piston	170 / 1111	44.279998	-57.789946	293	2003033	1680240	1	900	134	0	-	-	-	-	-
2	Camera	170 / 1215	44.274028	-57.788325	323	2003033	1680240	1	-	-	-	15	-	-	-	-
3	IKU Grab	170 / 1300	44.270196	-57.8228	272	2003033	1680001	1	-	-	-	-	0	-	-	-
4	IKU Grab	170 / 1310	44.270326	-57.822351	269	2003033	1680001	2	-	-	-	-	20	-	-	-
5	Piston	171 / 1037	44.4742	-54.886135	2056	2004024	1710610	2	1500	1255	152	-	-	-	-	-
6	Piston	171 / 1408	44.75929	-54.382446	585	2003033	1710315	3	900	411	40	-	-	-	-	-
7	Piston	171 / 1615	44.931046	-54.447515	311	2003033	1710645	4	900	0	49	-	-	-	-	-
8	Piston	171 / 1710	44.93099	-54.447635	310	2003033	1710645	5	900	40	22	-	-	-	-	-
9	Piston	171 / 1825	44.919513	-54.480905	525	2003033	1710702	6	900	60	0	-	-	-	-	-
10	IKU Grab	171 / 1910	44.923916	-54.467998	431	2003033	1710656	3	-	-	-	-	0	-	-	-
11	Piston	171 / 1027	44.41995	-54.449938	337	2001043	2270422	7	900	19	0	-	-	-	-	-
12	Piston	171 / 1143	44.406976	-53.396256	349	2001043	2270234	8	900	66	0	-	-	-	-	-
13	IKU Grab	171 / 1251	44.348586	-53.403058	598	2001043	2270054	4	-	-	-	-	30	-	-	-
14	Camera	172 / 1400	44.34809	-53.4023	598	2001043	2262252	2	-	-	-	20	-	-	-	-
15	Piston	172 / 1541	44.265675	-53.413316	1045	2004024	1740801	0	1500	1400	155	-	-	-	-	-
16	Piston	172 / 1826	44.198878	-53.261523	1394	2004024	1740806	10	1500	1085	0	-	-	-	-	-
17	Piston	174 / 1017	45.25104	-47.599885	2682	2004024		11	1200	915	0	-	-	-	-	-
18	Piston	174 / 1222	45.25714	-47.586526	2713	2004024		12	900	720	155	-	-	-	-	-
19	Piston	174 / 1603	45.463688	-48.192866	1273	99-031	2200700	13	1500	1149	155	-	-	-	-	-
20	IKU Grab	174 / 1743	45.579745	-48.312808	468	99-031	2200522	5	-	-	-	-	0	-	-	-
21	Camera	174 / 1853	45.578647	-48.31398	470			3	-	-	-	19		-	-	-
22	Piston	174 / 1024	45.994393	-47.405418	1502	2004024	1750904	14	1200	933	80.5	-	-	-	-	-
23	Piston	177 / 1148	48.75037	-47.444426	2432	2004024	1750900	15	1200	1030	126	-	-	-	-	-
24	Box Core	177 / 1542	48.750406	-47.444345	2432	2004024	1750900	1	-	-	-	-	-	42	-	-
25	Heat Probes	177 / 1903	48.781974	-47.43291	2435			1	-	-	-	-	-	-	4	-
26	Piston	178 / 1107	48.564161	-47.748946	2250	2003033	1772327	16	1200	933	133	-	-	-	-	-
27	Piston	178 / 1356	48.63696	-47.517841	2377	2004024	1780136	17	1200	450	141	-	-	-	-	-
28	Piston	178 / 1659	48.624853	-47.524881	2352	2004024	1780146	18	1500	97.5	103.5	-	-	-	-	-
29	Piston	178 / 1919	48.650543	-47.632238	2325	2004024	1781819	19	1200	832	143.5	-	-	-	-	-
30	Piston	179 / 1024	49.23209	-47.05171	2696	2003033	1790107	20	1200	300	24	-	-	-	-	-
31	Piston	179 / 1229	49.303813	-47.006681	2732	2003033	1790155	21	1200	94	141	-	-	-	-	-
32	Piston	179 / 1536	49.50758	-46.878268	2805	2003033	1790411	22	1200	703	143	-	-	-	-	-
33	Piston	179 / 1741	49.546036	-46.852991	2823	2003033	1790437	23	1500	895.5	155	-	-	-	-	-
34	Piston	180 / 1549	50.25827	-46.64938	1975	2004024	1801406	24	1200	742.5	0	-	-	-	-	-
35	Piston	180 / 1736	50.158868	-46.603023	2114	2004024	1800466	25	1500	715.9	97	-	-	-	-	-
36	Camera	180 / 2010	50.159333	-46.60333	2120	2004024	1800466	4	-	-	-	21	-	-	-	-
37	Dredge	181 / 1209	50.519945	-45.871635	2650	2004024	1810913 1/2	1	-	-	-	-	-	-	-	0
38	Dredge	181 / 1419	50.55365	-45.872426	3000	2004024	1810837	2	-	-	-	-	-	-	-	0
39	Dredge	181 / 1746	50.520218	-45.871351	3200			3	-	-	-	-	-	-	-	1
40	Dredge	181 / 2045	50.562018	-46.178908	1780			4	-	-	-	-	-	-	-	1
41	Box Core	181 / 1109	50.204565	-45.685583	3447			2	-	-	-	-	-	41	-	-
42	Piston	182 / 1410	50.378196	-46.211153	1975	2004024	1820339 1/4	26	1500	1175	128.5	-	-	-	-	-
43	Dredge	182 / 1733	50.125238	-46.66359	2633			5	-	-	-	-	-	-	-	1
44	Dredge	182 / 1410	50.159731	-46.602875	2165			6	-	-	-	-	-	-	-	1
45	Piston	182 / 1029	49.97028	-47.298473	2753	2004024	1792255	27	1500	1253	24	-	-	-	-	-
46	Piston	182 / 1253	49.948851	-47.383568	2617	2004024	1792208	28	1200	1080	155	-	-	-	-	-
47	Piston	183 / 1454	49.950746	-47.400085	2691	2004024	1820805	29	1200	1075	0	-	-	-	-	-
48	Heat Probes	183 / 1653	49.943443	-48.362273	2600			2	-	-	-	-	-	-	3	-
49	Piston	184 / 1026	49.47627	-47.163693	2322	2004024	1840611	30	1200	1105	155	-	-	-	-	-
50	Piston	184 / 1245	49.424741	-48.179533	2293	2004024	1840617	31	1500	1027.5	155	-	-	-	-	-
51	Piston	184 / 1453	49.391383	-48.195953	2277	2004024	1840709	32	1500	937	145	-	-	-	-	-
52	Box Core	184 / 1654	49.391546	-48.196053	2277	2004024	1840709	3	-	-	31	-	-	31	-	-
53	Camera	184 / 1836	49.391493	-48.196158	2277	2004024	1840709	5	-	-	-	40	-	-	-	-
54	Piston	185 / 1017	49.267945	-47.987528	2341	2004024	1850845	33	1500	117	144	-	-	-	-	-
55	Piston	185 / 1225	49.17934	-47.877013	2363	2004024	1851431	34	1500	1116	155	-	-	-	-	-
56	Box Core	185 / 1429	49.179371	-47.877021	2363	2004024	1851431	4	-	-	-	-	-	33		-
57	Heat Probes	185 / 1650	49.056633	-48.126596	2000	2004024	1851732	3	-	-	-	-	-	-	4	-
58	Piston	186 / 1019	49.143195	-48.471368	2145	2004024	1860712	35	1500	935	149	-	-	-	-	-
59	Piston	186 / 1207	49.126778	-48.542048	2114	2004024	1860640	36	1500	302	155	-	-	-	-	-
60	Piston	186 / 1407	48.954973	-48.515713	2121	2004024	1860435	37	1200	342	150	-	-	-	-	-
61	Piston	186 / 1618	48.929021	-48.487686	2125	2004024	1860413	38	1200	684.7	41	-	-	-	-	-
62	Piston	186 / 1802	48.933763	-48.498025	2123	2004024	1860418	39	1000	452	47	-	-	-	-	-
63	Box Core	186 / 1931	48.933808	-48.497981	2123	2004024	1860418	5	-	-	-	-	-	35.5	-	-
64	Camera	186 / 2100	48.9339	-48.4982	2173	2004024	1860418	6	-	-	-	30	-	-	-	-
65	Piston	187 / 1238	48.774673	-48.561453	2015	2004024	1870720	40	1200	104	149.5	-	-	-	-	-
66	Piston	187 / 1425	48.772528	-48.556188	2022	2004024	1870717	41	1000	707	155	-	-	-	-	-
67	Piston	187 / 1659	48.839696	-48.542021	2073	2004024	1870726 1/2	42	1500	1237	38	-	-	-	-	-
68	Piston	187 / 1901	48.82437	-48.498806	2095	2004024	1870419 1/2 df	43	1000	501	30	-	-	-	-	-
69	Piston	188 / 1012	48.680646	-49.291108	1278	2004024	1880427	44	1200	789	120	-	-	-	-	-
70	Piston	188 / 1132	48.689278	-49.27196	1344	2004024	1880417	45	1200	711.5	144	-	-	-	-	-
71	Piston	188 / 1312	48.6546	-49.111978	1572	2004024	1880754 1/2	46	1000	570	141	-	-	-	-	-
72	Piston	188 / 1439	48.614361	-49.012261	1691	2004024	1880659 1/2	47	1000	615.5	146	-	-	-	-	-
73	Piston	188 / 1608	48.622498	-49.032761	1684	2004024	1880710 1/2	48	1000	465.5	59	-	-	-	-	-
74	Piston	189 / 1057	49.263261	-49.89049	805	2004024	1890954 upper df	49	1200	573.5	154	-	-	-	-	-
75	Piston	189 / 1210	49.28573	-49.931391	746	2004024	1890935 lower df	50	1200	713.5	146	-	-	-	-	-
76	Piston	189 / 1336	49.377105	-50.099285	435	2004024	1890810 1/2	51	1000	142	35	-	-	-	-	-
77	Piston	189 / 1440	49.406543	-50.154121	325	2004024	1890741	52	1000	10	0	-	-	-	-	-
78	Piston	189 / 1603	49.309098	-50.123248	380			53	1000	52	0					
							Total	cm		33773.1	6285	145	50	182.5	11	4
								feet		1108.0	206.2					
												CAMERA # of images	IKU depth cm	BOX CORE depth cm	HEAT PROBE # of penetrations	SMALL DREDGE recovery events

3.5 KHZ Records

Record #	Start Time	End Time	Line #	Record #	Start Time	End Time	Line #
1	170/0935	171/0906	1 to 5	2	171/0913 172/0025	171/2157 172/0140	6 to 8
3	172/0145 172/1437 172/1828 172/1947	172/1323 172/1809 172/1921 173/0034	8 to 11	4	173/2212 174/0117 174/1104 174/1935	173/2331 174/0937 174/1831 175/0915	12 to 16
5	175/0920 175/1910	175/1851 176/1706	17 to 21	6	176/2105 177/1238 177/2113 178/1110	177/1120 177/1652 178/1032 179/0231	22 to 30
7	179/0239 179/1034	179/0955 180/1820	30 to 40	8	180/2132 181/1345 182/0640	181/1317 182/0622 182/0913	41 to 51
9	182/0935 182/1735 183/2017	182/1642 183/1523 184/0917	52 to 62	10	184/0920 184/2023	184/1448 185/0647	63 to 66
11	185/0650 185/1730 185/1910 185/2045 185/2239	185/1620 185/1756 185/1931 185/2107 186/0903	67 to 72	12	186/0911 186/2230	186/2004 188/0919	73 to 85
13	188/0923	189/2027	86 to 92				

12 KHz Records

Record #	Start Time	End Time	Line #	Record #	Start Time	End Time	Line #
1	170/1025 170/1243 171/1040	170/1150 171/0946 172/1805	1 to 8	2	172/1833 173/2153 174/1145 174/1249	173/0139 174/0930 174/1222 175/1842	9 to 16
3	175/1853	176/1706	17 to 21	4	176/2103 177/2113 178/1110 178/1925	177/1651 178/1032 178/1845 179/0945	22 to 32
5	179/1028 179/1232 179/1540 179/1748	179/1148 179/1503 179/1652 180/1515	33 to 39	6	180/1605 180/2130	180/1700 181/1025	40 to 47
7	181/1921 181/2203 182/1114 182/1805 182/2028 183/1035 183/1301 183/1502 183/2010	181/2010 182/0909 182/1635 182/1901 183/0922 183/1207 183/1348 183/1531 184/0845	48 to 62	8	184/0925 184/1858 185/1431 185/2240	184/1400 185/1356 185/1620 186/0900	63 to 72
9	186/0904 186/2235 187/1740	186/2000 187/1632 188/0916	73 to 85	10	188/0918 188/1446	188/1349 189/1008	86 to 90
11	189/1012	189/2026	91, 92				

Sidescan Records

Record #	Start Time	End Time	Line #	Record #	Start Time	End Time	Line #
1	171/2204	172/0011	6, 7	2	175/1249	175/1647	17
3	189/1714	189/1836	91	4	189/1838	189/2025	92

Teledyne Records

Record #	Start Time	End Time	Line #	Record #	Start Time	End Time	Line #
1	170/2124 171/0110 171/2134	171/0034 171/0900 172/0900	2 to 8	2	173/2253 175/0110 175/2011	174/0137 175/0915 176/0238	12, 16, 18, 19
3	176/1025	176/1701	20, 21	4	176/2221 177/2350 178/2239	177/0910 178/0925 179/0857	22 to 32
5	179/2125 181/2251 182/0025	180/1047 1820010 182/0859	33to39,48to51	6	182/2128 183/2124	183/0902 184/0912	52 to 62
7	184/2038 185/0009 185/2325	184/2351 185/0900 186/0858	63 to 72	8	186/2320 187/2024 188/1743	187/1001 188/0913 189/1003	73 to 90

Huntec Records

Record #	Start Time	End Time	Line #	Record #	Start Time	End Time	Line #
1	170/1941 171/0245	171/0154 171/0857	1 to 5	2	171/2126	172/0223	6 to 8
3	172/0228	172/0902	8	4	172/2028 173/2228 175/0115	172/2122 174/0136 175/0915	9, 12, 16
5	175/2014	176/0238	18, 19	6	176/2209 177/2331	177/0910 178/0907	22 to 29
7	178/2223	179/0854	30 to 32	8	179/2114 181/2234	180/1028 182/0134	33 to 39,48,49
9	182/0138 182/0645	182/0627 182/0857	49 to 51	10	182/2210 183/2120	183/0858 184/0900	52 to 62
11	184/2035 185/2325	185/0900 186/0859	63 to 72	12	186/2313	187/1000	73 to 77
13	187/2014	188/0330	78 to 81	14	188/0331	188/0913	82 to 85
15	188/1738	189/1002	86 to 90	16	189/1717	189/2026	91, 92

DVD's / CD's

Huntec

DVD #	Start Day	End Day	Line #
1	170/1955	172/2121	1 to 9
2	173/2229	176/0238	12, 16, 18, 19
3	176/2211	179/0854	22 to 32
4	179/0031	182/0857	30 to 39 48 to 51
5	182/2132	185/0900	52 to 68
6	185/0218	189/0914	64 to 85
7	188/0107	189/2025	81 t0 92

Sidescan

DVD #	Start Day	End Day	Line #
1	171/2139	172/0011	6, 7
2	175/1247	175/1641	17
3	189/1709	189/2034	91, 92

3.5 KHz

DVD #	Start Day	End Day	Line #
	188/1805	189/1632	86 to 90

Teledyne

DVD #	Start Day	End Day	Line #
1	170/2126	173/0022	2 to 11
2	173/2245	176/1703	12, 15, 16 18 to 21
3	176/0004	179/0923	19 to 32
4	179/0348	182/0857	31 to 39 48 to 51
5	182/0043	185/0923	49 to 68
6	185/0200	189/1005	64 to 90

DDH

DVD #	Start Day	End Day	Line #
1	172/2222	173/0030	10, 11
2	174/2058	175/0050	15
3	180/2348	181/0220	40

Line	Start	End	Seismics				Huntec		Sidescan		3.5 Khz	12 KHz	Mag.
			Teledyne		DDH	Gun							
			Rec. #	DVD #	CD #	Vol.	Rec. #	DVD #	Rec. #	DVD #	Rec. #	Rec. #	
1	170/1940	170/2120					1	1			1	1	
2	170/2126	171/0003	1	1		210 c.i.	1	1			1	1	
3	171/0003	171/0504	1	1		210 c.i.	1	1			1	1	
4	171/0504	171/0742	1	1		210 c.i.	1	1			1	1	
5	171/0814	171/0900	1	1		210 c.i.	1	1			1	1	
6	171/2123	171/2320	1	1		210 c.i.	2	1	1	1	2	1	
7	171/2329	172/0113	1	1		210 c.i.	2	1	1	1	2	1	
8	172/0119	172/0900	1	1		210 c.i.	2, 3	1			2, 3	1	
9	172/2027	172/2121		1		210 c.i.	4	1			3	2	
10	172/2222	172/2248		1	1	210 c.i.					3	2	
11	172/2248	173/0030		1	1	210 c.i.					3	2	
12	173/2230	174/0130	2	2		210 c.i.	4	2			4	2	
13	174/0607	174/0808									4	2	
14	174/0808	174/0845									4	2	
15	174/2108	175/0050		2	2	210 c.i.					4	2	
16	175/0117	175/0915	2	2		210 c.i.	4	2			4	2	
17	175/1230	175/1635							2	2	5	3	
18	175/2012	176/0003	2	2		420 c.i.	5	2			5	3	
19	176/0003	176/0302	2	2, 3		420 c.i.	5	2			5	3	
20	1761026	1761240	3	2, 3		420 c.i.					5	3	
21	1761347	1761702	3	2, 3		420 c.i.					5	3	
22	176/2218	177/0222	4	3		210 c.i.	6	3			6	4	
23	177/0228	177/0435	4	3		210 c.i.	6	3			6	4	
24	177/0437	177/0853	4	3		210 c.i.	6	3			6	4	
25	177/0853	177/0910	4	3		210 c.i.	6	3			6	4	
26	177/2347	178/0228	4	3		210 c.i.	6	3			6	4	X
27	178/0238	178/0455	4	3		210 c.i.	6	3			6	4	X
28	178/0503	178/0728	4	3		210 c.i.	6	3			6	4	X
29	178/0728	178/0907	4	3		210 c.i.	6	3			6	4	X
30	178/2246	179/0247	4	3		210 c.i.	7	3, 4			6, 7	4	
31	179/0302	179/0744	4	3, 4		210 c.i.	7	3, 4			7	4	
32	179/0824	179/0855	4	3, 4		210 c.i.	7	3, 4			7	4	
33	179/2126	180/0431	5	4		210 c.i.	8	4			7	5	
34	180/0431	180/0617	5	4		210 c.i.	8	4			7	5	
35	180/0617	180/0646	5	4		210 c.i.	8	4			7	5	
36	180/0646	180/0724	5	4		210 c.i.	8	4			7	5	
37	180/0724	180/0818	5	4		210 c.i.	8	4			7	5	
38	180/0818	180/0902	5	4		210 c.i.	8	4			7	5	
39	180/0902	180/1045	5	4		210 c.i.	8	4			7	5	
40	180/2348	181/0220			3	210 c.i.					7	6	
41	181/0334	181/0554									8	6	
42	181/0554	181/0748									8	6	
43	181/0748	181/0816									8	6	
44	181/0816	181/0855									8	6	
45	181/0855	181/0924									8	6	

Line	Start	End	Seismics				Huntec		Sidescan		3.5 Khz	12 KHz	Mag.
			Teledyne		DDH	Gun							
			Rec. #	DVD #	CD #	Vol.	Rec. #	DVD #	Rec. #	DVD #	Rec. #	Rec. #	
46	181/0930	181/0953									8	6	
47	181/0955	181/1022									8	6	
48	181/2241	182/0038	5	4		210 c.i.	8	4			8	7	
49	182/0043	182/0239	5	4, 5		210 c.i.	8, 9	4			8	7	
50	182/0239	182/0713	5	4, 5		210 c.i.	9	4			8	7	
51	182/0713	182/0856	5	4, 5		210 c.i.	9	4			8	7	
52	182/2130	183/0400	6	5		210 c.i.	10	5			9	7	
53	183/0400	183/0540	6	5		210 c.i.	10	5			9	7	
54	183/0540	183/0643	6	5		210 c.i.	10	5			9	7	
55	183/0643	183/0724	6	5		210 c.i.	10	5			9	7	
56	183/0724	183/0900	6	5		210 c.i.	10	5			9	7	
57	183/2124	183/2212	6	5		210 c.i.	10	5			9	7	
58	183/2212	184/0523	6	5		210 c.i.	10	5			9	7	
59	184/0523	184/0640	6	5		210 c.i.	10	5			9	7	
60	184/0640	184/0734	6	5		210 c.i.	10	5			9	7	
61	184/0738	184/0752	6	5		210 c.i.	10	5			9	7	
62	184/0758	184/0900	6	5		210 c.i.	10	5			9	7	
63	184/2038	185/0216	7	5		210 c.i.	11	5			10	8	
64	185/0221	185/0250	7	5, 6		210 c.i.	11	5, 6			10	8	
65	185/0252	185/0538	7	5, 6		210 c.i.	11	5, 6			10	8	
66	185/0545	185/0645	7	5, 6		210 c.i.	11	5, 6			10	8	
67	185/0645	185/0740	7	5, 6		210 c.i.	11	5, 6			11	8	
68	185/0743	185/0900	7	5, 6		210 c.i.	11	5, 6			11	8	
69	185/2330	186/0310	7	6		210 c.i.	11	6			11	8	
70	186/0310	186/0636	7	6		210 c.i.	11	6			11	8	
71	186/0636	186/0758	7	6		210 c.i.	11	6			11	8	
72	186/0758	186/0900	7	6		210 c.i.	11	6			11	8	
73	186/2323	187/0145	8	6		210 c.i.	12	6			12	9	
74	187/0151	187/0521	8	6		210 c.i.	12	6			12	9	
75	187/0526	187/0610	8	6		210 c.i.	12	6			12	9	
76	187/0612	187/0828	8	6		210 c.i.	12	6			12	9	
77	187/0838	187/1000	8	6		210 c.i.	12	6			12	9	
78	187/2030	187/2128	8	6		210 c.i.	13	6			12	9	
79	187/2133	187/2310	8	6		210 c.i.	13	6			12	9	
80	187/2321	188/0104	8	6		210 c.i.	13	6			12	9	
81	188/0108	188/0328	8	6		210 c.i.	13	6, 7			12	9	
82	188/0330	188/0428	8	6		210 c.i.	14	6, 7			12	9	
83	188/0431	188/0625	8	6		210 c.i.	14	6, 7			12	9	
84	188/0626	188/0650	8	6		210 c.i.	14	6, 7			12	9	
85	188/0653	188/0913	8	6		210 c.i.	14	6, 7			12	9	
86	188/1747	188/1820	8	6		210 c.i.	15	7			13	10	
87	188/1821	189/0022	8	6		210 c.i.	15	7			13	10	
88	189/0024	189/0526	8	6		210 c.i.	15	7			13	10	
89	189/0530	189/0726	8	6		210 c.i.	15	7			13	10	
90	189/0732	189/0959	8	6		210 c.i.	15	7			13	10	
91	189/1715	189/1841					16	7	3	3	13	11	
92	189/1845	189/2025					16	7	4	3	13	11	