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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 5818

Field report for 2007 the CCGS Louis S. St-Laurent seismic cruise to the Canada Basin

H.R. Jackson, Editor

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Canada

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

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Summary: Cruise 2007 Louis S. St. Laurent

During the period of August 30 to October 11, the CCGS Louis S. St. Laurent (LSSL) collected 2987 km of seismic reflection profiles perpendicular to the margin and along a line 350 nm from the coast (Figure 1). The data were acquired in order to meet the requirements of Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS) so that Canada can claim an extended continental shelf.

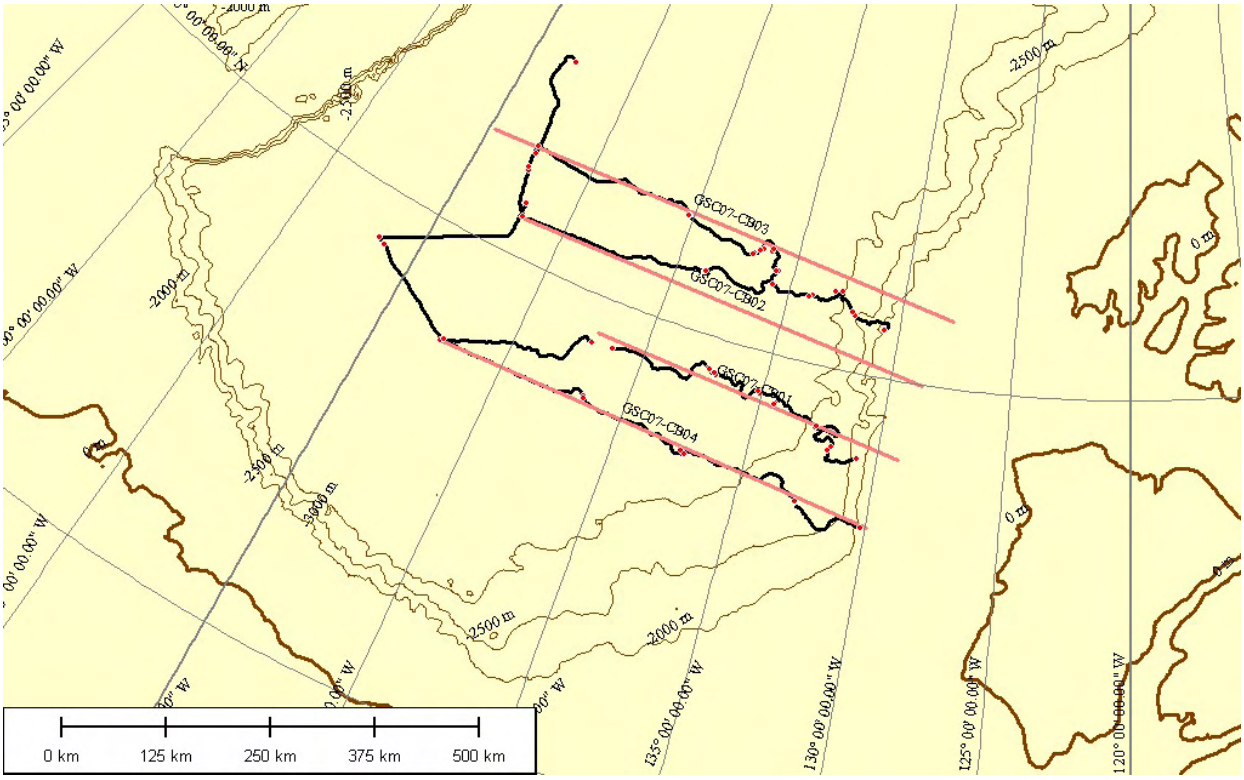


Figure 1. The red lines show the planned track. The black lines the actual track

Near the 350 nm maximum possible limit of the claim, the seismic reflection profiles exhibit 3.5 s of flat-lying reflectors interpreted as sedimentary strata overlying a lower frequency undulating basement typical of igneous rocks. Refractions from the 22 sonobuoys launched will enable the time to be converted to depths necessary to meet the requirements of Article 76.

A variety of reflection events occur on the profiles. Near the 2500 m contour diapiric structures are present. Seaward of these features the sedimentary section for tens of line kilometers is chaotic. Further seaward a clearly stratified sequence is observed cut by faults. A thick sedimentary section is revealed throughout the survey region. The seismic reflection sections will be useful in defining the petroleum prospectivity of the region as well as clarifying the geological history.

In order to collect seismic reflection data in ice covered waters the “over-the-side” equipment must be specially constructed. Overall the equipment functioned well and it is a credit to those

who designed, built and maintain it. The main components of a seismic reflection system consist of a compressor and a sled from which both a sound source (the air gun array) and the sound receiver (the hydrophone array) are attached. The compressor, just shipped from the factory, had a number of defects and was not set up to operate in cold conditions. To keep it running safely required a concerted effort from the technical support team and the ship's engineering department. Although it was possible to suspend 3 airguns from the sled, two were sufficient to produce an excellent quality record while not damaging the sled as much as three collided with each other and the sled. The new streamer performed well and was the single most important factor in data quality improvements compared with last year's test cruise.

The quantity and quality of the seismic reflection profiles exceeded expectations. The U. S. National Snow and Ice Data Center reported that the extent of the Arctic Ocean ice pack was 4.13 million sq. km this year, an historical minimum. The average extent of ice at the end of summer is 6.74 million sq. km. This record low in the ice concentrations contributed to our success in data collection.

The rotten ice at the seaward end of lines 1 to 3 contributed to the low noise level and high quality of the seismic reflection profiling. In areas with thicker ice it was occasionally necessary to have 110 revs on the ship's engines for the ship to move forward. Although these conditions may risk loss of the gear, the quality of the seismic data was adequate to determine the thickness of the sedimentary section. Furthermore, the weather throughout the cruise was favorable for operations. A persistent area of high pressure to the north of our area of operations gave us light to moderate easterly winds with very little precipitation. However, the increasingly longer nights accompanied by snow covering the leads required the seismic operations to be stopped overnight. At night, in ice conditions with large old floes in high concentrations, officers on the Bridge were unable to distinguish a path through the ice that would not stop the ship, given that only two propellers were available.

7783 km of bathymetry were collected that were supported by velocimeter, XCTD and SVP. In addition, 180 spot soundings were acquired. Bathymetric data are needed to determine the Foot of the Slope (FOS) for the extended continental shelf claim. The bathymetry will also be used to update Canadian hydrographic charts.

Marine mammal monitoring by experienced observers from Paulatuk, N.W.T. took place 24 hours a day during seismic acquisition. Observations from the Bridge during transits were also recorded. Polar bears were the most commonly sited animal. On the sea ice three walruses were spotted and in the open water four bowhead whales were seen in the transit from Tuktoyaktuk.

On September 27, 2007 the ship received an official visit from the Minister of Indian and Northern Affairs (Chuck Strahl) to express the Canadian governments ongoing support for this program. His visit, highlighting the UNCLOS program on the LSSL, was televised on the CBC National News the same evening.

1. Recommendations

1) start the seismic expedition two weeks earlier in mid August to take advantage of smallest concentrations and weakest ice, and the maximum amount of light
2) two Icebreakers are required for the next mission - only regions with significant ice cover remain
3) the hydrophone streamer should be on a drum, perhaps located on the Upper deck "mezzanine"
4) a substantial rebuild of the Hurricane compressor is necessary plus a second one as back up, both compressors must have sufficient spare parts
5) address the freeze up problems of air lines to the airguns in sub-zero temperatures
6) the ship's networking facilities are inadequate for our needs, see report for how to correct this problem
7) the ability to superimpose the ship's tracks on the Satellite imagery in real time would be useful for the submission to the Commission on the Limits of the Law of the Sea
8) address renewal of staff, both scientific and technical
9) a back-up 12 KHz sounder is needed but cannot be installed until dry docking in 2009

2. List of Ship's Company

Scientific Staff

1.	Jon Biggar	Chief Hydrographer
2.	Borden Chapman	Chief Technical Support
3.	Jim Etter	contractor technical support
4.	Paul Girouard	contractor navigation
5.	Dr. Ruth Jackson	Chief Scientist
6.	Fred Learning	contractor technical support
7.	Joe Manning	hydrographer
8.	Jonah Nakimayak	contractor technical support
9.	Rodger Oulton	contractor technical support
10.	Ryan Pike	contractor technical support
11.	Dwight Reimer	contractor technical support
12.	John O. Ruben	contractor technical support
13.	Nelson Ruben	Chief marine mammal observer
14.	Robert Rowland	USGS representative
15.	Mike Ruxton	hydrographer
16.	John Shimeld	data processing

Ship's Officers and Crew

1.	Andrew McNeill	Commanding officer
2.	Bryon Gibbons	Chief Officer
3.	Rodney Strowbridge	First Officer
4.	Carol Dudfield	Second Officer
5.	Marian Punch	Third Officer
6.	Marie-Josee Beaudoin	Third Officer

7. Don Strotts	Chief Engineer
8. Michael Willis	Senior Engineer
9. Gerald MacDonald	First Engineer
10. Julien Marceau	Second Engineer
11. Joshua McInnis	Third Engineer
12. Anthony Engbers	Electrical Officer
13. Norm Robinson	Electrical Officer
14. Larre Sweeney	Logistic Officer
15. Joe Lucas	Electrician
16. Blaine Blinkhorn	Boatswain
17. Gary Morgan	Carpenter
18. Rico Amamio	Winchman
19. Stephen Archibald	Leading Seaman
20. Samuel Wilson	Leading Seaman
21. James Ayers	Leading Seaman
22. Al Jarvis	Seaman
23. Michael Worth	Seaman
24. Terry Rhino	Seaman
25. Paul Porter	Seaman
26. Brian MacKenzie	Seaman
27. Daniel Staples	Seaman
28. Dave Ramsey	E/R Technician
29. Daniel MacEachern	E/R Technician
30. Kenneth Pettipas	E/R Technician
31. Jeff Doane	E/R Technician
32. Donald Lawson	E/R Technician
33. Stephanie Ramsay	E/R Technician
34. Raine Jones	E/R Technician
35. Bryant Culhane	E/R Technician
36. Richard Handy	E/R Technician
37. Randy Turner	Chief Cook
38. Michael Gaudet	StoreKeeper
39. David Wallingham	StoreKeeper
40. Vera Dunne	Second Cook
41. Catherine Munroe	Second Cook
42. Thomas McMahon	Second Cook
43. Jamie Mizuik	Stewart
44. Denise Cooper	Stewart
45. Florence Carter	Stewart
46. Alfred Haines	Stewart
47. Joanne MacEachern	Stewart
48. Adrian Godin	Helicopter Pilot
49. Jim Myra	Helicopter Pilot
50. Williamd Duff	Helicopter Engineer
51. John Reid	Electronics Technician
52. Ken Derouin	Ice Observer
53. Myrella Bellerose	Medical Officer

Staff Portraits


Fred Learning


John Shimeld


Jim Etter


Dwight Reimer

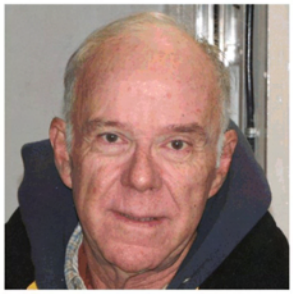

Borden Chapman


Paul Girouard


Joe Manning


Ryan Pike


Ruth Jackson


Robert Rowland


Rodger Oulton


Mike Ruxton


Jonah Nakimayak


John Ruben


Nelson Ruben


Jon Biggar

3. Diary of the Chief Scientist

Day 242 - August 30, 2007 - Thursday (all times are local):

The scientific staff began their trip early in the morning to join the CCGS Louis S. St. Laurent (LSSL) anchored off of Kugluktuk, Nunavut. The ship is named after the Prime Minister of Canada, who served from 1948-1957. The purpose of the expedition was to collect data in order to determine the extent of Canada's extended continental shelf in the western Arctic.

The scientific staff that work at BIO in Dartmouth met at the main entrance at 03:30 hours. From there two vehicles drove to the Holiday Inn to pick up the out of town participants. We then drove to the Canadian Coast Guard Base. There we did a head count and reported to the Captain that 13 scientific staff were present. This tally was far easier for us than the ships crew with 50 individuals milling about in the darkness on the wharf. It was a pleasant warm night.

Three buses took the ship's company to the Halifax Stanfield International Airport. First Air left at 06:10 hours to fly first to Iqaluit. Once there we were required to stay on the aircraft. We then flew on to Kugluktuk, which took about 3 hours. From there I called the three marine mammal observers at the Coppermine Hotel: Nelson Ruben, John Ruben and Jonah Nakimayak. They caught a taxi to the airport to wait with us for the helicopter to transport us to the ship.

A helicopter safety briefing was given before getting on board. We were then shuttled in groups of four to the ship. After arrival on the ship we went to the logistic officer to get the updated cabin assignments. Then we climbed the ladders to our state rooms, had lunch and at 14:30 hours half of the scientific staff received a safety briefing. Those in the first briefing would be busiest tomorrow. Our marine mammal observers were given a tour of the ship by Ryan Pike as part of their orientation.

I have not yet met with the Captain other than briefly on the dock at the Canadian Coast Guard Base in Dartmouth. There are a number of issues to be discussed including: time for sailing tomorrow, number of hours before we reach the first line, hydrographic survey for foot of slope and ice conditions.

The scientific staff met at 18:00 hours in the boardroom. Simultaneously, the CCGS Sir Wilfred Laurier was tying up to LSSL so that scientific equipment from the previous cruise could be transferred. We did round table introductions. We had a number of housekeeping items including: how to log onto the internet (name and password must be given to the ship's technician - John Reid), telephone lists, schedule of activities. Robert Rowland agreed to meet with Sarah Zimmerman to discuss her needs for us to check on their salt water pump. John Shimeld mentioned that GXTechnolgy will be collecting seismic reflection that might interfere with our work. I will give a summary of the UNCLOS program tomorrow at 09:00 hours in the boardroom to those who are not familiar with it.

Ken Derouin from Canadian Ice Services has agreed to attend the meetings and give us weather and ice forecasts. We planned for tomorrow's presentation at 09:00 hours in boardroom number 428A. Borden Chapman will hold a more specific meeting with his group afterwards.

I found the bird identification guides that I had brought for the marine mammal monitors. They picked them up and were reading through them enthusiastically.

The first meeting with Captain Andrew McNeill took place at 19:00 hours. We discussed sailing time: tomorrow after supper. It is an additional 12 hours to the start of the first line. The ice conditions in that area are at least nine-tenths. We will start with a hydrographic survey so that Borden will gain time to get the array ready. The Captain will send the helicopter out to do reconnaissance on the ice. He will also require testing of the A-frame. The Captain and Heads of departments will meet with the science staff in the boardroom at 10:30 hours tomorrow.

Day 243 - August 31, 2007 - Friday, sunny with flat calm open water

At 08:10 hours we held our first safety meeting in the seismic laboratory at the stern of the superstructure in the Av gas compartment just forward of the Quarter deck. The laboratory had been built for this expedition. Fred Learning pointed out that they would be laying out cables today and they could cause a tripping hazard.

At 08:30 hours the remainder of the scientific staff had the safety briefing and orientation from the third Officer (Marian Punch). The nurse (Myrella Bellerose) and the Canadian Ice Service employee (Ken Derouin) attended as well. We all put on survival suits, learned where the first aid kits were, how to deactivate the water tight doors, etc. We had a thorough tour of the ship and a review of the ship's etiquette.

At 10:30 hours the Captain held a meeting to greet the scientific staff and explain his style of management. With a total of 66 persons on board a 119 m long ship with complex ladders, companion ways and bulk heads, it is critical to meet with key staff and officers to promote teamwork. After the meeting, the Chief Engineer (Don Strotts) set Borden and myself up with pagers to minimize the number of pipes on the ship so that those individuals sleeping during the day shift will not be disturbed

It took some time to locate the projector for my Power Point presentation. Eventually, Larry Sweeney, the Logistic Officer, found it. I was set up and running by lunch time. Actually the set up of the projector went without a hitch. At 13:00 hours the marine mammal monitors: Nelson, John, Jonah and Bob Rowland attended my presentation on Canada's UNCLOS activities in the north. Bob added several insights into the rules that I found valuable.

I gave each of the marine mammal observers copies of the Environmental Impact Screening Committee and Canadian Environmental Assessment Act screening so that they were clearly informed of the content of the documents to give them a full understanding of their role in the program. Jonah requested a chair to sit on while working on the flying Bridge. I discussed this with the Captain and he said it would be easily arranged.

John Shimeld and Paul Girouard are struggling to get the computers set up on the ship's network

system. The ship's technical support is busy with his principal tasks and it is a slow process. Paul also entered the marine mammal log into Excel data base. The spreadsheet for the mammal observations was made available for Nelson, John and Jonah to review.

Borden Chapman reported good progress today: the cables for the sonobuoy transmissions have been run from the radio room to the laboratory, the firing line connects the seismic lab to the Quarter Deck, all hardware on the tow sleds was installed and the electronics packages are out of their crates. Paul Girouard is working to establish data links for the navigation to the seismic processing computer.

A fire and boat drill took place after supper. All scientific staff went promptly to their muster station in the hangar. Jonah said he liked the drill and hoped it happened every day. The ship sailed away from Kugluktuk after the boat drills were completed.

At 18:00 hours the staff held their regular meeting and at 19:00 hours. I met with the Captain on a number of issues. Safety - Rodger Oulton reported that he cannot hear alarms in the compressor container. The Captain suggested installing a flashing light. He will bring this up with the Chief Engineer. I provided the Captain with copies of the Canadian Environmental Assessment and Environmental Impact Screening Committee recommendations. The guidelines for using the airgun have been distributed to the Captain, the marine mammal monitors and the airgun crew. Ryan Pike has been given permission to get life vests for the staff that will be on deck during deployment and retrieval of the airguns.

Tomorrow at 10:30 hours, Jon Biggar, the Captain and I will meet to discuss charts, plans and ice conditions. The Second Mate (Carol Dudfield) wanted to know how many walkie-talkies we will need. The marine mammal observers working on the bridge will require one for a regular fifteen minute check-in with the Bridge. I have to ascertain how many others will be needed.

Day 244 - September 1, 2007 - Saturday, grey perhaps 10 knot breeze colder than yesterday

At 07:00 hours we were steaming through Dolphin and Union Strait. The ETA for the possible beginning of line is 06:00 hours tomorrow. At the safety meeting at 08:00 hours, I learned Ryan had hurt his back lifting heavy objects. He will see the nurse first thing this morning. Extra help from the crew was solicited for lifting the heavy airguns out of their shipping crates. Due to the winds and the cold all the staff working on the helicopter deck are putting on their insulated coveralls. I showed Nelson where the coveralls and steel toed boots for his team were located. We talked in his office about the work schedule for his team. We will review the set up of the observer's log. I put a list of the marine mammals on a memory stick to incorporate in the log as suggested by Jonah.

Robert made a suggestion to on a paper on the difficulty of collecting data to Article 76 standards in the sea ice. I was enthusiastic about the project because it addresses a problem that had been troubling me for some time.

I sent the first email message to our Director, Jacob Verhoef, reporting that we had sailed and were preparing the equipment for seismic acquisition. On my second attempt I got the email to the Oden sent off. An ongoing concern is the lack of network capability on the ship; as yet I do not

have it in my cabin. Paul Girouard expressed his frustration because we cannot get any computers connected to the ship's network. Then Paul and I met with Nelson to incorporate the suggestions of mammal monitors into the spreadsheet that records their observations.

The sonobuoy antenna was installed improperly. The arrow indicating direction of transmission was misunderstood as an up arrow. Jim Etter has been in the crow's nest correcting this. Meanwhile, back at the compressor, there are issues with the position of the compressors exhaust pipe being located near the fueling point. The exhaust must be covered. The hydrophone array has been laid out on the helicopter deck. It has been discovered that the manufacturer put a vibration dampening link in where Borden Chapman was planning to be able to disconnect for quick retrieval. The ends of the various sections are not labelled and John Shimeld is assisting with this and other work related to the array because Ryan Pike is resting in bed with back problems.

The Captain, Ken Derouin and I met to discuss the archiving of ice charts and images. Ken will place lines on all ice charts and put one in a paper file for me. All satellite images will be archived with the ship's track so that they can be useful for describing problems in the collection of seismic data in ice-covered waters.

I talked to the Second Mate about our need for VLF radios - 3 in all: one for the seismic crew working on the deck, one for the marine mammal observers and one for hydrography in the seismic lab. She will provide chargers and get them set up.

At 17:00 hours we were abeam of the southwestern tip of Banks Island. It was bright and sunny, and the sea was calm with open water with ice in strips and patches. At 18:00 hours we held the regular meeting of the staff. Ryan was able to crawl out of his bunk to join us after spending hours with ice on his back. The meeting began with Ken giving us a summary of the weather and ice conditions.

By tomorrow morning we will be travelling along the 2500 m contour collecting bathymetric data. At $74^0$38.3 N, 129^0 47.4 W we turn into the Arctic Ocean. The end of line (EOL) is $75^0$00.5N, 143^0 06.3W. Jon Biggar gave me the waypoint for the turn. At the start of line (SOL) we will stop and do velocimeter measurement. The hydrographers need to get to the engine room to measure the transducer location. This requires permission and an engineer capable of deciphering the mechanical drawings.

The network or probable server problems are not solving themselves. The hydrographic group is not getting heading and log. We also need this data for the seismic headers. Furthermore, we cannot get our computers connected to the network. Can we get John Reid to spend a few hours working with Paul Girouard and Mike Ruxton to solve these problems?

Day 245 - September 2, 2007 - Sunday, overcast skies, snow on the deck and ice infested waters

At 07:30 hours the officers on the Bridge were wearing their number one uniforms with white shirts. The Captain gave me a tour of the IceNav System purchased with UNCLOS funds. On the IceNav screen the RADARSAT input clearly shows the large floes with pressure ridges and thin

grey ice in between. The display covers an area that is four hours steaming when we are towing the seismic gear. The ship cut through the ice at 11 knots all night. We are traversing along the 2500 m contour toward the mid point of our lines.

08:00 hours - Safety meeting with the seismic crew. Borden Chapman noted that the decks were slippery due to the light dusting of snow. Borden also pointed out that the walkie-talkie's direct line to the Bridge was not installed in the seismic lab. It was set on channel 1 and if you happen to change channels when you mean to increase the volume, be sure to reset it. The Medical Officer sent me a note indicating that Ryan would need continued rest for his back.

Robert Rowland (Bob) asked to join the technical team in getting the gear ready. He got out his heavy warm working clothing and has been assigned an assortment of activities in preparation for getting the seismic equipment ready. He will also support Rodger Oulton in preparing the compressor for operation. Nelson and John also volunteered to work with the seismic crew. They built a fine-looking work bench.

Rodger gave Bob and me an overview of the new compressor. He pointed out the major components, motor, fans, radiators and the four stages. He explained how the air was compressed with oil and how the oil was removed. He was concerned that the container was cold. He felt it was going to be rather difficult to get it started. The air vents draw too much air through the container when the ship is moving because it is facing forward. Due to its construction it cannot be turned at sea. Another design problem is the muffler, it is inside the container and should be moved out. This will aggravate the heating up of the pipe that leads to the muffler. It would be serious to put your hand against the muffler when the ship lurched while breaking ice. The solution to these problems was to spray the exhaust with a heat resistant material.

The Captain and Chief Engineer supervised the lowering of the A-frame today and it passed inspection. The hydrographers started a velocimeter measurement at 10:30 hours. Paul Girouard, Mike Ruxton and John Reid are working hard to get the data streams that contain log and speed stored with the bathymetric readings. Network/server problems are continuing. Progress was made today on the data links.

The Chief Officer was asked to ensure that the helicopter deck would be available for spooling the eel and high pressure lines. I spoke with Jon Biggar and he does not need it until tomorrow. We have a plan so long as the ship does not need ice reconnaissance then.

John set up a printer in my office because the network is having continuing problems. I was able to print out watch schedules and cabin assignments with telephone numbers. Now I can circulate them for verification. More importantly, John and I looked at the start of line for the seismic reflection and there was not a 5 km overlap. So we have adjusted the start of line to give to the Bridge.

After lunch several activities were taking place, including the Captains rounds; so the ship was as tidy as possible, dare I say ship shape. The Captain has Sunday dinner in his mess. I received an invitation from the Logistics Officer. It immediately brought to mind the expression "What will I wear"? Note that all the Officers are in crisp white shirts and pressed dark pants. With several on the Bridge at one time it can be rather dazzling.

The hydrographers did a velocimeter cast to 1300 m and a bar test to 400 m. This test requires a bar or cone that reflects the pulse from the sounder to be lowered on a measured cable and compare the reading on the sounder output to the cable length. Therefore, the ship was stopped. The helicopter was preparing for an ice reconnaissance flight. The ice analyses prepared by CIS indicate nine-tenths ice but the IceView images and observations from the Bridge verified by Ken indicate it is only seven-tenths ice. (Ice Nav. is the name of the system the ship uses in conjunction with the RADARSAT to navigate its way through the ice.) In ice with this character we should be able to collect seismic reflection data.

At 14:00 hours the helicopter left on an ice reconnaissance flight. The pilot (Adrian Godin) was with me on the Nares Strait cruise in 2001 (also based from the LSSL). I read over Robert's EOS paper on the UNCLOS submissions to date and think that it is important benchmark informing the US geophysical community of UNCLOS and its implications.

On Sunday an elaborate meal was served in the Captain's mess. The ship's company are invited in turn to the table that seats a maximum of ten. The multi-course meal was of gourmet quality. Salad with snow peas (appropriate in the Arctic), lobster on puff pastry laced with a mustard based sauce, red berry sorbet, roast beef with Yorkshire pudding, a mango mouse. Due to the lengthy meal I had to postpone the science meeting until 19:00 hours. At the meeting Ken Derouin reported that the winds will increase to 10-20 knots tomorrow and the temperature will stay in the -2^{o}C range. The ice conditions on the flight along Line 1 are about 6-7 tenths.

Hydrography's calibration of the sounder went well. The maximum depth of the velocimeter measurement was 1360 m. The soundings have begun and the watches started. The carpenter built a tray for the transducer so oil would not be spilled in the helicopter. The engineers have to open a tank to determine the exact location of the transducer. It is hoped that this task will be completed tonight. It is necessary to get accurate soundings.

Borden's group has the sonobuoy receiving system working. The WiNRADiO for receiving the sonobuoy's signal was set up in the radio room behind the Bridge, not in the seismic lab. The tow sleds are not ready, the airguns are not attached to them as yet. The first test of the compressor was satisfactory with only a few starting problems due to the cold. Dwight Reimer has completed the set up for the digital streamer. Tomorrow the bundles of electrical and air hoses will be assembled on the compressor deck. John, who has carefully read the manual, pointed out to Borden that wrapping of the cable was required because screws were not flush in all cases.

Paul has managed to get the log and gyro feed to the hydrographic data. The plan is to use serial ports on the computers and avoid GPS gate and the ship's network whenever possible because it is not reliable. At about 20:00 hours a polar bear with a meal was spotted on the starboard side. Nelson judged the bear to be about 8 feet long. The bear was not intimated by the ship. My final activity of the day was to hand pictures of the scientific staff and watch schedules to the Bridge and post pictures near the ship's office and in the seismic lab.

Day 246 - September 3, 2007 - Monday, low visibility in nine-tenths ice

07:30 hours - ship stopped while third engine was put on line to power through the ice. The bathymetric soundings are sporadic with the additional engine. Mike Ruxton completed his first

12 hour watch alone in the lab. It was long and will be less tedious when the seismic watches begin. At 08:00 hours during the safety meeting Ryan was back at work but there is no heavy lifting for him. The decks are expected to be slippery. The ship's TV also has a reminder that the decks are icy and slippery.

John and I spoke with Ken about ice and weather conditions. In a few hours we will be in an area with fewer tenths of ice. The ice conditions at the western and northern ends of our lines are still favorable. We next went to the Bridge and the Captain gave us a tour of IceNav. The latest satellite image of the ice is shown on one screen and the radar image is juxtaposed. On the radar image the floe's edges are well defined and pressure ridges can even be seen. The 9 nm radius of the image will allow for several hours planning of the ship's route through the ice with the seismic gear out.

The Captain, Jon and I tried calling the Oden for about a half hour with no success. I had hope to have a conversation with them about their recent experience breaking ice and towing seismic gear in the eastern Arctic. There may have been important insights that they could pass on to us.

The ice was at least nine-tenths all day. The distance travelled during 12 hours was about 60 nm. Technical progress was made assembling the air hoses and electrical cables into a bundle on the helicopter deck. Getting the cables enclosed in their protective wrap is a labour intensive job. Nelson and Robert have been an integral part of the team. The hydrophone array is ready as is the navigation system called Regulus. Paul has a minor problem with the GPS time, it must be converted to decimals. John will write a program to solve the problem.

The hydrographic team is ready to fly tomorrow to collect spot bathymetric measurements. They are also refining the onboard parameters for calculating water depth by accurately determining the position of the transducer on the ship. They know which tank it is in but not exactly where in the tank. Eventually they learn the tank cannot be opened at sea. They wanted this information to accurately locate the sounder relative to the GPS on board ship. John Shimeld has the position of the GPS antenna relative to the stern of the ship accurately determined for input into the SEGY headers. He and Dwight worked all day determining the parameters for the seismic reflection logging.

At the staff meeting at 17:30 hours (half an hour early because the Captain required the boardroom) several health and safety issues were brought up. 1) on the Quarter Deck the non burnable garbage is stored next to the hose for venting high pressure air - the crew should be notified; 2) all officers, crew and staff should be aware of the high noise levels on the Quarter Deck and wear ear protectors; 3) garbage is accumulating in the Seismic lab - we must make an effort to clean it up. We still do not have any network connection on the ship. Hopefully on Tuesday after the long weekend there will be support from John Reid to solve the server problems.

The scientific staff were working as a team on the Quarter Deck to assembled the bundle of hoses for the second tow sled. I hope my pictures will show the cooperation required to get the work accomplished.

Day 247 - September 4, 2007 - Tuesday, ice conditions are about six-tenths of rotten ice

At breakfast the ship was about 30 nm from the SOL at 07:30 hours. The ice conditions were favorable for running seismics; however, another patch of ice with higher concentration of thicker and older floes is expected at the beginning of Line 1 about 75^0N, 142^0W. The 08:00 hours safety meeting has now been given the moniker of the group hug. The hydrophone array and guns should be deployed today so a reminder to wear safety boots and hard hats was given. Fred Learning pointed out that you should never step in the loop of a hose of cable that is going over the side.

John Shimeld is sending a message to GXTechnology that we are planning to begin firing our air guns today. Because calling turned out to be difficult, he sent them an email. I tried calling Christian Marcusson, Chief Scientist on the Oden, on the Iridium phone today on two different numbers, but no luck.

Before the active seismics begin there a number of things that must be done. The bundles of electrical and high pressure hoses have to be moved from the Helicopter Deck to the Quarter Deck this morning. The drogue has to be tested prior to attaching it to the tail of the hydrophone array. A pull of 200 lbs would be ideal. The ship must come to a halt and gradually build up speed. The test should take about half an hour.

Due to the ice conditions at the planned SOL 1, the ship maneuvered to about 7 nm to the south of the proposed line to an area with open water in order to have optimum conditions to launch the airgun and hydrophone arrays. After lunch, Jon Biggar had planned to do spot soundings but the fog rolled in and prevented the helicopter from flying. As soon as the open water was reached, a velicometer measurement was done to 3000m. During this time the cable bundles were carried to the Quarter Deck.

As soon as the cast was finished and the ship could move forward, the drogue was put in the water and pull tested to 90 to 110 pounds using Borden's carefully calibrated bathroom scales. Many photographs were taken of this test. At 16:00 hours the hydrophone array was man handled over the stern. Many of the sections of the array were tightly spooled in their packing cases and this made paying them out difficult. Dragging them in the water behind the ship for several hours will probably solve this problem.

The new A-frame facilitates lowering of the airguns and their tow sled into the water. The entire operation required about half an hour. More time was required to fix a pressure gauge on the high pressure bottles before the airguns could be fired.

When we were ready to fire the airguns, we called the marine mammal observers, Jonah and John, who were on watch and asked if they had seen any mammals in the last half hour. They had not. The guns were slowly ramped up. In fact they had flooded during deployment and it took at least half an hour to get them to fire reliably. Then gun number two failed so the sled had to be brought back in. No lose connecters were found so the gun was exchanged with one on the other sled. The guns were redeployed. We had three guns firing for an hour and then one failed. All the technical support staff were too tired to bring them in after working 12 hour days in the cold since we arrived on the ship. If the problem was in the bundled cables, it would take hours and several people working diligently to discover the nature of the problem. The two remaining guns were giving an adequate signal.

John and Dwight were struggling with the data recording system. The system has rigid input parameters, some of which cannot be changed after the system is started up. John was still uncertain of the number of hydrophones in each segment and the layback of the active section. He fortunately noted that only every second shot was being recorded and corrected this.

The streamer and guns are towed at a depth of 10 m. The configuration for the eel is deck cable, tow cable, stretch section, two active sections, another stretch section and the drogue. The two active sections are configured to record 16 channels, 8 per section. John is running Claritas software to process the data.

Meanwhile I reviewed the latest ice imagery on Ice Nav with the Captain and the Second Mate. They have a route to the end of Line 1 planned. We are thinking of working on the lines to the north, 2 and 3. We may even attempt partial lines north of 75^0N. On the return to the southernmost Line 4 we can pick up any missed segments.

Day 248 - September 5, 2007 - Wednesday, sunny changing to misty

The seismic reflection system ran overnight. The compressor required a valve adjustment, looked after by Fred. During the early morning the electronics for the eel reported a leak. The ice concentrations were about 5- 8 tenths rotten ice with snow cover and low visibility making it difficult for the officers on the Bridge to pick the best route. The route taken required a detour of around 7 nm to the south of the track. At about 04:00 hours stronger ice was encountered; there may be more noise in the data but until we process it this will not be certain.

07:30 hours - Discussions on the Bridge with the Captain took place regarding how far the Mates could deviate from the planned line due to ice conditions. A rule of thumb that we decided on for the amount of deviation from the planned seismic line is 5.4 nm (10 km perpendicular) to it. The planned lines are 50 nm apart due to the UNCLOS minimum spacing specification of 60 nm.

At 08:00 hours we had our safety meeting. Two points were brought up: 1) could the Quarter Deck lights be turned on at dusk?; 2) in the racks beside the lab there are steel plates that have sharp edges that could hurt someone if they fell against them. I spoke to the Chief Mate about these concerns. The steel belongs to the engine room so he will have to speak with the Chief Engineer. For the lights he suggested calling the Bridge when needed.

John is carefully assessing the setup of the seismic system and the parameters entered into the recording system. He has found several discrepancies. He calculates the distance to the nearest hydrophones to be 174 m but measuring along the array he can only find 125 m. This may be related to the twists in the yellow lead in cable and this will be accurately measured when the cables are pulled back on deck. The geometry of the geophones is confusing. He is recording 16 channels with real data. There are two 50 m active sections with geophone groups 2 meters apart. Thus, there should be 8 channels. The A/D converter must be simulating twice the number of recorders.

The decision was made this morning to continue collecting data rather than pulling the sled to re-establish firing of the third gun. At the time the ice concentration was high and it would result in a data gap. Therefore effort is now being put into getting the first sonobuoy deployed; we have 29

on board.

In order to put any equipment over the side, the Bridge must be notified. I spoke to the Captain. The procedure is to notify the Bridge of the impending launch and to contact the seaman on his pager 600 to assist in the toss. This is part of the safety routine on the ship so we will abide by the rules.

The helicopter ice reconnaissance and bathymetry measurements were cancelled in the morning today due to the fog closing in and a program on Jon Biggar's laptop malfunctioned, wiping out the location of many of the predetermined locations for collecting data.

At about 11:00 hours the sonobuoy was put in the water. It sank and then surfaced. The signal strength was 78% less than Borden had hoped. The direct, bottom reflection and multiples were clearly visible. The ship is in a large lead and this will certainly improve the data quality. Unfortunately the sonobuoy recorded out to only 7 nm. Borden will check with the manufacture to determine if the antenna is mounted properly.

John in working on processing the data to brute stack to present at the18:00 hours meeting. He is not expecting an industry quality record. However, the data did show vast improvement with a brute stack. Packages of sedimentary arrivals are visible as well as the basement. We compared it with available data in the region and it looked compatible. With future processing it should even be better.

More problems with our inability to get on the ship's network. Paul prepared two possible suggestions for me to hand to the Captain that would solve the problem. At this moment we cannot move our data from the seismic lab to John's computer for storing and processing.

After supper the visibility was sufficient for the helicopter to fly. Jon was able to take spot soundings with the helicopter hovering over the water and dipping the hydrophone into it. Flying at 90 miles an hour with the door opened is rather cold work.

At supper time Borden explained that the compressor had to be stopped to have its filter changed and that it had an air leak in the high pressure stage. With one gun down and the day shift getting ready to retire, the Bridge was asked to begin a slow turn. It was discovered that the compressor manufacture had sent the wrong oil filter. Therefore, the oil was changed, the filter rinsed and replaced. The damaged O-ring was replaced and the compressor was back up and running. The airgun sled was brought on deck. The seismic crew learned that the electrical connections on the gun that was not firing was damaged due to the two of the guns slapping against each other and mangling the connectors. The chains were shortened and the firing lines repaired. The gun sled was put back in the water.

After checking with the marine mammal monitors the guns were ramped up. All three fired and the seismic reflection data looks better, more reflectors are visible on the display.

The 18:00 hours meeting was held without the seismic technical support who were working on the Quarter Deck on various repairs. Ken, the ice observer, had returned from a reconnaissance flight. He reported that the ice concentrations are continuing to disperse, especially along Line 4, the

most northerly planned line. John gave an overview of the seismic processing and Paul discussed data back-up: two copies on DVD of all data sets. This was followed by a brief meeting with the Captain on the Bridge. I gave him two different scenarios for dealing with the networking problems that I hope he will consider.

Jonah who has stood several days of marine mammal watches reported succinctly that "he was glad he did not live here because he would starve to death". The Quarter Master also pointed out that he had not seen even a bird since leaving Kugluktuk. The lack of marine mammals may be the reason we saw the polar bear standing over the dead cub presumably ready to eat it.

John Ruben spent a cold night alone on Monkey's Island doing a marine mammal watch. Today, Jonah, the Quarter Master and others spent some time getting him a comfortable spot on the Bridge. He is rather shy. We hope to ensure in the future that he will be physically comfortable and feel welcome as well.

The compressor developed a leak in the high pressure stage at about 21:30 hours. The ship was asked to slow down during a minor repair. After hours of work, it became clear that the repairs would take a substantial length of time so that the Bridge was asked to circle. The repairs were complicated by a wrench being dropped into the machinery that entailed an extra hour to extract it. Nelson was an enormous help sliding under the machine to get nuts and bolts taken off and replaced. At first the problem was thought to be related to the improper size or type of an O-ring. Near midnight a complex section of high pressure pipe and a flange were removed. A crack in the flange was observed. The Chief Engineer roused to assess the problem. There is hope that the engine room may be able to salvage and rebuilt this section. If not, the compressor is inoperable and the program is over.

At midnight the guns and hydrophone array were brought on board. It took about fifteen minutes. An exhausted seismic crew went to bed after at least 16 hours of labour following days working for 12 hours. The ship was motionless for the night.

Day 249 - September 6, 2007 - Thursday

I ate breakfast with the hydrographic group to ensure that they knew that the compressor was under going major repairs. They will be doing deep velocimeter and XTD casts. There is no purpose in them collecting spot bathymetric soundings today because they are restricted to a limited range from the ship and all those within reach have been done.

08:00 hours - Safety concerns from yesterday were addressed. The sharp metal sheets in the storage racks next to the seismic lab were wrapped in case any one fell against them.

The engine room staff have taken the damaged pipes from the new compressor in an attempt to manufacture a workable solution. Rodger is working on building a spreader to prevent the airguns from colliding and damaging the electrical and high pressure air hose fittings. Jim Etter had the NOTOX 2 (antifreeze) injector system apart.

John Reid spoke to me about which computers are required to be on line to enable the science program to work. My priorities are to get data from the seismic lab to John Shimeld's computer in

the boardroom for processing and back-up of the data. Today John Reid put several of our computers on line. John, Paul and I are now connected to the network and data transfer is possible. John can use his hard drive for backing up data. The backup will be done on two hard drives and two DVDs. Paul also delivered simplified navigation files to me so I can plot our positions on Global Mapper.

All day long the Engineering Department on the ship worked fabricating the high pressure pipes and flange for the compressor. The Senior Engineer (Mike Willis) did the machining of the pipes and the First Engineer (Gerald MacDonald) did an outstanding job on the welding. By suppertime the complex piping was installed, the compressor ran up and was tested under load. Fortunately, no leaks were found. The airgun bracing was also set up, which consisted of a steel strut that separates the two airguns that are mounted beside each other. The final problem was the leak in the hydrophone array at the connector. The entire team was struggling with this problem until 21:00 hours. Two of the pins were entirely corroded away. Two pins that were not in use were soldered to connect them. There was a lot of material applied to control leakage and it was described as a kluge by Jim Etter, one of its architects.

On Borden's request, I called the Captain and told him we needed more time. When I went to the Bridge the Captain showed me the route they would have used through the ice floe last night . If we had not had compressor problems we would have found ourselves trapped in heavy ice.

At 19:30 hours the drogue on the hydrophone array was put in the water. The streaming of the hydrophone array was slow because its coils were disturbed when the connectors were being checked. The ship was moving slowly forward at two knots as the array was paid out hand overhand. It was attached to the sled and the sled lowered on the A-Frame, tugger winch and crane.

The Bridge was called to confirm that the marine mammal monitors had no sightings in the last half hour. Then the airguns were ramped up. The shock at the back of the ship is pronounced. John Shimeld initiated the data logging. The resistance in the cable now reads 10, rather 1086, and the signal is vastly improved from the first segment of the line. Borden's tired crew left the seismic lab for their cabins.

Day 250 - September 7, 2007 - Friday at 13:00 hours - 6.3^{0}C, winds 8 knots from the east

The seismic system operated overnight. One gun stopped firing around 23:00 hours and the second at 07:00 hours this morning. At the same time the resistance on the hydrophone array started going up more consistently. Borden tried restarting the guns by putting antifreeze into the line. All the guns were firing but the solenoids were frozen. This meant the entire system has to come in. This is a cold wet job.

John Shimeld carefully compared the ship's engine rpms with the noise on the seismic profile. Rpms jumps of up to 60 show no effect on the data quality. The ship also made a number of sharp turns during the night that were not expected in the lab. The Captain reported that the Bridge called him and the ice conditions necessitated the turn.

Jim Etter has been testing the injector for antifreeze. He thinks the problem is that it is running to

cold. The system will be moved to a warmer spot nearer to the air storage bottles. This requires Rodger to do a significant amount of plumbing from the compressor to the injector to the air bottles. The spreaders to the port and starboard guns have to be rebuilt and this is occurring. Borden and Ryan ate in the engineers' duty mess so that they did not have to remove their coveralls and could get back to work as soon as possible. The problem with the leakage in the hydrophone array has not been tackled as yet.

18:00 hours - the regular science meeting was held. The weather is staying the same and the ice is consolidating slightly. At 18:30 hours Borden indicated that the gear was ready to put in the water. The ship had been drifting and the engines had to be started. It took about half an hour to get into position so that there was a significant overlap in the line. The gear went into the water without any problems. The marine mammal watchers were consulted and they gave permission to begin shooting the airguns. Then the guns were ramped up. All three new guns fired, although at first their time breaks were unstable. The noise level on the data is the lowest observed so far.

The ice conditions deteriorated during the night. John Shimeld was up during the night to adjust the acquisition parameters. The led between two floes that the ship had been following closed, so it was necessary to reverse directions. During this time the compressor was turned off for maintenance. It has a noise problem that is not diagnosed. Later, at 02:30 hours, the ship came to a halt in the ice and I was called in case it was necessary to haul the gear on deck. Luckily the ship broke through the ice without damaging the gear so I went back to bed.

Day 251 - September 8, 2007 - Saturday, 3.5 ^{0}C winds 10 knots from the east, new ice forming

Three airguns fired all night, however, the compressor was turned off when Borden arrived on watch because of a hot bearing. A careful check of the compressor was made and grease (at least 100 shots) was applied. The compressor is not running hot, yet it is loading the diesel. The company will be called today. The drawings in the compressor manual are of insufficient detail to determine what the problem is and to repair it.

08:00 hours - safety meeting was called and there were no new issues. Time was spent talking to the seismic group and hydrographers about the plans as we approach the EOL 1. At the 2400 m contour the seismic gear will be retrieved. This depth was chosen because the sounders are not calibrated and the reading are too deep. We will continue up the slope for 25 nm then turn to the north, running the sounder.

At this point several factors influence the decision of what we will do next: the ice distribution, heaviest on the inner parts of the line, the increasing speed of the winds, the state of seismic equipment, airguns and the hydrophone array, and most importantly, the condition of the compressor. Although the transit time to the westerly end of the line will take a day and a half, we will also collect another bathymetric traverse and get a close examination of the ice.

Because we have only two deck cables, and one has received major damage to the connector pins, we are considering asking the Danish team, whose cruise ends on September 16th, to send up theirs if the pins match.

The Captain, Chief Engineer, Borden and I met to discuss the activities during the week. We have been operating successfully in up to 8/10 ice concentration with three engines on line. There are modifications to the deploying and retrieving of the airgun array that would facilitate the procedure. The roller block could be changed to a V-sheave. A third tugger winch would eliminate the use of the crane. This would require the installation of an I- pad on the deck. These are not difficult or expensive changes to make.

The considerable problems with the compressor were mulled over. A joint report from the Chief Engineer and Borden will be written. The Chief recommends that it have a major refit to streamline its functionality to meet our specific needs. Ways to keep the compressor warm were considered. The lack of grease, the wrong spare parts and the major parts failures are all difficult to deal with.

The Chief Engineer inspected the compressor and made suggestions on where to look to determine the exact nature of the latest problem. After clearing the fuel filter, Rodger announced that "the cat was purring".

At 18:00 hours we had our regular science group meeting. All data have been backed up to date. The drive for the seismic processing computer is down. This is temporary and will be fixed on Monday when advice from Steve Perry can be sought. The reflection data show strong evidence of side swipe and the possibility of canyons on the slope came to mind. The swath bathymetry on the Alaskan side of the Beaufort Sea suggests this is possible.

A number of major repairs to the seismic system are being considered for the two day run to the west end of Line 2. The compressor needs a bearing replaced and we have the part on board. One of the extra stretch sections will be cannibalized for its connector and attached to the deck cable. Modifications of the tow sled to deal with the collision of the two guns that are mounted side-by-side are being considered.

Communications with the sonobuoy manufacture indicated the antenna on the sonobuoy had only a 1 degree above the horizon view. This was extremely frustrating because they had encouraged us to buy and mount an expensive antenna higher on the ship. I think the only possibility of getting any data would be to fly a Taurus and the radio receiver to a floe near to the sonobuoy and recorder from that spot for three hours.

The seismic system ran continuously over night. The configuration of the ice necessitated a large loop.

Day 252 - September 9, 2007 - Sunday, -5.3^{0}C, winds from the east, overcast, nilas ice

07:00 hours - call from the seismic lab: the streamer is wrapped around the tow sled. There were substantial multi-year ice floes all night and our track was south to north not west to east. At the 08:00 hours safety meeting, individuals were reminded to be particularly careful of the cables while hauling up the sled. They were to stand well back from the operations. The most dangerous part of the lift would be just before the sled was brought on deck. Red waterproof lined gloves were distributed to keep their hands protected while handling the cold damp hydrophone array.

When the gear was brought on board, the spreaders between the guns were lost or bent into a U. One of the guns was hanging from only one chain. For the rest of the line we will run with two guns only. The damage looked worse than it actually was, in Borden's opinion. By noon the guns and streamer were ready to be put back in the water. The delay this time was due to the fact that there was a problem getting the bathymetry display to change scale. This was solved and the gear streamed. The ship had to move south to avoid ice and by 19:10 hours it had reached the 2500 m contour and, with heavier ice visible, the gear was retrieved. Line 1 was completed. We will be steaming up the slope, then north to a position between Lines 2 and 3 to run a bathymetric line parallel to the seismic lines. This will give us time to repair the compressor.

At the 18:00 hours meeting, John Shimeld discussed his progress on transferring seismic data, backing it up, adding navigation to the headers and doing deconvolution. He took time to explain to Bob and Nelson the purpose of deconvolution. Nelson explained that although no marine mammals had been sighted he felt that a more rigorous logging system was required. He will have his team make hourly weather observations.

We had a round-table discussion about the difficulty of collecting seismic data in this area and discussed how a regional approach could be taken to prove a thick sedimentary basin. Robert gave me the first draft of his paper on collecting seismic reflection profiles in the Arctic for UNCLOS.

A weekly message was composed and sent to Jacob. A copy was given to Jon Biggar to send to his Department head. An email from Thomas Funck on the Oden indicated they were willing to ship their lead in cable to us at the end of their cruise. Now I will have to arrange it.

Day 253 - September 10, 2007 - Monday, grey ice forming

08:00 hours - safety meeting: Fred reported that there were no issues overnight. Ryan noted that several valves leading from the compressor had their hoses removed due to freeze up, therefore only the forward facing door of the container should be used. The decks are slippery: caution is required when walking on them.

Today, the compressor maintenance begins with complete oil and filter changes. Also, a cable must be run to get a camera lead to the compressor container and the leaking section of the array must be drained and refilled. The airgun chains will be shortened in an attempt to prevent damage to the guns and connectors. We do not carry enough spares to replace them every 12 hours.

I checked with the Captain and he has not had final word on the refueling date. This information is important for determining the order of the seismic lines. Another significant factor in planning the survey is the possibility of a medical evacuation (medivac) for one of the scientific staff with a back problem. After the nurse consulted with the appropriate medical authorities onshore it was decided that the safest place for the patient was onboard. A medivac in a helicopter and small aircraft is not likely to improve a bad back.

I called Jacob to discuss a number of items including: the refueling date for the ship; shipping of gear from the Oden; the confidential nature of the seismic profile 1g; permission to work in waters of 2000 m. He seemed pleased with the outcome of the cruise to date. Due to the fact the ship's email is down, I cannot send him the data to view.

After the discussion with Jacob, John and I spoke to the Captain to tell him about the exciting results. He asked if they could be announced to the ship's company in a seminar in about a week's time to pick up the morale on the ship, about mid point in the cruise. We agree not to spread the word with the exception of Borden who had put so much effort into acquiring the data.

I attended a session on the procedures for when the ship is on security Level 2. Then I informed the scientific staff of their duty to muster in the Seismic lab. I also attended the debriefing after the event. Their exercise in marine security procedures required little involvement of the staff.

At the 18:00 hours science meeting, Ken's ice images showed the pack ice consolidating in the eastern end of Line 1. At present we are in 10/10 ice and backing and ramming when we hit thicker floes. The sun is bright and it looks lovely. Robert reported that the seismic profile was 340 km in length and we actually covered 596 km or 1.8 times the distance.

When the compressor was examined today, the linkage between the caterpillar motor and the John Deere components was found to be out of alignment. The steady bearing had to be replaced and the drive shaft changed. Had we not shut down for end-of-line, we would have had a catastrophic failure of the compressor. There was no quality control done on the manufacture of this machine. Ryan has strung a cable from the compressor container to the Seismic Lab so that the gauges can be monitored remotely. The leak in the section of the array was found. The fitting had not been properly potted. Borden is waiting for an email from the company to determine what product should be used to seal it.

Day 254 - September 11, 2007 - Tuesday, 1.3^{0}C, low visibility, heavy ice backing and ramming

From about 23:00 hours last night until 06:00 hours this morning the ship was not moving. The upside of this lack of progress to our destination is that it did make sleep possible. In the morning, the ship slowly started moving through ice of 6 feet or more in thickness. The ice charts, not updated by new satellite imagery for several days, indicate a consolidation of the ice pack in our working area. The overall size of the pack is shrinking at its edges. Careful studies of the ice conditions are required to determine where and when to start seismic operations. The repairs to the gear should be complete by the end of the day so a plan needs to be developed by then.

At 08:00 hours the daily safety meeting occurred. Because the battery cables on the compressor went up in smoke last night, all will be removed and crimped. The clasps on the compressor are faulty and could cause fingers to be jammed. Rodger will adjust them today.

At about 09:30 hours an area with thin grey ice was found to do a velocimeter station. By noon the seismic gear was ready to go over the side. The ship was moving more readily through the ice, and the number of engines was reduced from three to two. The Captain and I discussed the possibility of deploying the seismic system. We are 75 nm north of Line 1, however the ice on the shelf was too thick to transit through and we may not be able to return to this area. The plan had been to steam west until we reached the far end of Line 2 to deploy the airguns. A polynya was sighted and the airguns will be deployed until we reach the end of the region with loose ice. It took 15 minutes to deploy the airguns and streamer. Although three guns were on the sled, John felt two would produce enough energy.

After several hours, John played the data back and yes, there was another diapir. After the 18:00 hours science group meeting where the weather, the maintenance issues on the equipment and the data processing were summarized, the significant question was when will the guns come in. I discussed matters with the Captain and he felt the ice conditions were sufficiently light that we could run overnight.

At about19:30 hours Jonah spotted a bear with three cubs. The guns were turned off until they were 1 km away. In the mean time the ship's company had an opportunity to watch the bears. When we were 1 km past the bears, the guns were turned back on and began firing immediately. Nelson reported that neither he nor Jonah had ever seen a bear with three cubs before. Robert has another interruption to seismics in the Arctic that you do not have in warmer waters to add to his paper.

Mike Ruxton is feeling well enough to get up for meals now. He has even made it to the lab. His back is improving but he is getting a cold now.

At 23:00 hours I was called to the seismic lab, there was only one gun firing. The sled was brought in. In the dark and the cold Borden and Ryan worked to repair the guns. When the sled went back in the water only two guns fired and at 02:30 hours in the morning another one stopped.

Day 255 - September 12, 2007 - Wednesday, bright and sunny, by supper time -5.3^{0}C

At 07:00 hours the Bridge was contacted and we began circling prior to bringing the array aboard. The region of open water was shrinking with consolidated pack ice ahead. At the 08:00 hours safety meeting there was a reminder to be careful and not fire even a partially armed air gun on the deck. Then the activity began to bring the airguns and the streamer on board. The shortening of the chain on the airgun array seems to have solved the problem of the guns smashing together and damaging the firing lines. The reason the two guns were not firing was related to freezing. The warm air from the compressor at perhaps 70^{0}C cools to around 40^{0}C by the time it reaches the gun. The condensate can freeze up in the solenoid causing it to remain shut or open. Jim Etter spent the day adjusting the amount of antifreeze that is piped into the airguns. The frozen guns were taken apart and reassembled. Meanwhile, the lack of heat in the compressor room, the consequences of which is the freezing up of gauges, was dealt with by sealing the vent on the container roof and cutting one in the floor.

The seismic line was interrupted because of an 11 km wide floe. It was not possible to move through this until the major repairs were done on the airguns.

I called Jacob Verhoef and discussed our progress, shape and distance between the lines and the refueling date. After that, Jon Biggar and I met with the Captain for a detailed discussion of our plans. I then wrote an email home that addressed the issues.

The hydrographic team did a deep water station and then the array was put in the water. Only two guns fired consistently. NOTOX2 was pumped into the system, no luck with the guns initiating. While Borden was at supper, Ryan tried more NOTOX2 in the system. Fortunately, he got the gun to fire.

18:00 hours at the regular science meeting the track plan for the cruise was reviewed. Borden reported that the compressor issues seemed to be solved. The deck cable that was leaking has been flushed several times, the leaking area monitored and no fluids are visible, and a pin had been potted in the connector. After 24 hours this section of the streamer should be viable again and will allow us to swap two sleds and significantly shorten the times the ship is not collecting data. The chains on the second airgun sled will not be shortened until the first one clearly demonstrates that this is the solution to keeping the guns from crashing together.

John Shimeld suggested that we should consider hiring Nelson for the ARTA ice camp. He is a versatile hard worker and a bear hunter. Nelson flew on the ice reconnaissance flight today and reported that there were no signs of marine mammals.

Paul Girouard is working hard to keep all the logs: seismic, compressor and marine mammals up to date and ready to file in the cruise report. Mike Ruxton was able to do part of a watch for the first time in several days. His back is better but he has laryngitis. Mike was required to watch the sounder while Jon Biggar was flying in the helicopter to acquire spot soundings.

Day 256 - September 13, 2007 - Thursday, -5^{0}C, 22 knots of wind, perhaps the wind is preventing the ice from forming significant leads

All three air guns fired overnight. John was up late processing the seismic data. He noticed that he was getting the third and fourth multiples as artifacts on the data. He had the firing rate reduced to 20 seconds. He also spent time studying the data and wondering why there was so little penetration in water depths of 3500 m. Closer examination provided evidence of a Bottom Simulating Reflector (BSR). The wide zone beneath it with little seismic character suggests that free gas is present as well.

At the 08:00 hours safety meeting it was mentioned that care must be taken in changing lubricating oils on the compressor, especially near the belt so that fingers are not caught in it. The plans for the day include Ryan rebuilding an airgun. Borden was sending emails to get more information on how to solve the problems with the compressor and the streamer sections and getting a list of pieces of equipment we would like to have.

John called Steve Perry to get information on how to make his storage drive for the seismic data work again just as the Captain was trying to participate in a conference call on the refueling date. There was no way to know this would happen. I took part in the conference call. All parties: the CCG, NRCan and DFO were content with late September, the timing that suited the science party.

I then met with the Logistic Officer (Larry Sweeney) on where to send the gear for pick up at the refueling location:

MCTS
Canadian Coast Guard Base Inuvik
Attn: Louis S. St. Laurent
Hold at the airport

At about 13:00 hours one of the airguns started to leak air. The compressor could not keep up with it so it was shut off. The pressure to the remaining guns was increased from1500 to 1800 psi and

we are continuing to shoot until we reach a region with more open water. John Shimeld would prefer to have the guns pulled and all three made operational because he can now readily see basement on the seismic profile. For operational reasons related to the ice conditions the decision was made to carry on with two guns until a convenient place could be found to extract the guns.

Near 16:00 hours the airgun array was brought aboard when the first major polynya was encountered. Ryan noticed that the sled had major damage. The outer I-beams have cracked. They are galvanized steel and cannot be welded. The two abreast airguns and the sled structure above them were badly scarred from the concussion as the guns swung with each shot.

It was suppertime so the Captain put the bow of the ship into the ice while we have time to consider our options. Borden and I agreed that we would put the second sled into the water with only two guns. The spreader bars for the G-guns will be sent from GSC Atlantic and attempts to repair the damaged sled made it the meantime. The port call is becoming more important.

By 20:30 hours the second sled was in the water and the two airguns suspended from it were now firing. At 23:00 hours the automatic firing of one of the guns failed. Antifreeze was pumped into the gun but it did not solve the problem. The gun was fired manually all night.

Day 257 - September 14, 2007 - Friday, -5^{0}C, winds gusting to 30 knots, grey, many tenths of rotten ice (honeycombed on the bottom)

07:00 hours - both guns firing but not synchronized. The compressor and the streaming are performing well.

John played back the data. Basement is visible and that is the most important feature required for UNCLOS work. The plan for the day is to take the guns out of the water after lunch and switch guns so that the signal can be synchronized. Jon Biggar wants to collect bathymetry data from flights in the afternoon. The Captain has approved the plans.

Back in the lab, Ryan managed to get the guns synchronized and also gave me his photos from the trip to date. Borden is trying to come up with a technique for repairing the shattered I-beams. The Chief Engineer and Borden have discussed ways of repairing the damaged sled. The repairs are stopgap measures. The broken sled will only be used if the remaining sled is damaged. Meanwhile, I-beams will be ordered and sent to Inuvik in time for the refueling date.

I spoke with Jacob and gave him an update of our seismic profiling for the last two days, including the damaged sled. I discussed shortening Line 3 and he agreed. I called Barb and got the name and billing code for the Customs Brokers. I then sent this information to Thomas Funck on the Oden. I have not had a reply acknowledging receipt of my emails.

John Shimeld wrote a program to plot the seismic profile vs. distance. He will now be able to bin the data and produce better plots. I provided scans of data in the MacKenzie Delta that show shale diapirs and a location figure from a paper by Art Grantz.

Other activities during the day included a discussion with Robert about his paper on the difficulties of collecting bathymetry data, especially swath data in waters with heavy ice concentrations. I

helped Jonah find pictures of the ship on the P drive and Nelson needed warmer boots that we acquired through the ship's stores. It is a cold day to be doing mammal observation outside.

At the 18:00 hours science meeting, Ken noted that the winds will remain at 25 knots. The temperatures are dropping and we are travelling through soft, honeycombed, rotten ice. Although the ice charts show many tenths, it is not a problem for the ship to sail through it. John discussed the apparent poor quality of the data and the possibility of bottom simulating reflectors (BSR) or other geological features causing it. In addition, for significant sections below the BSR there are a few reflectors, perhaps due to trapped gas. The seismic profiles indicate it is rather extensive. The basement is seen on the section. We are near the point where Art Grantz postulated a spreading centre. The basement topography shows the same character.

Borden reported that the seismic acquisition was running smoothly at present, and he was ordering spares. He also mentioned that, even though the airgun was firing on manual last night, it should not have drifted more than 100 microseconds. This is not significant when the centre frequency of the gun is 40 Hz. The seismic crew on watch requested that they get a special presentation on the data because they would not be able to attend the 19:00 hours seminar.

Day 258 - September 15, 2007 - Saturday, -5^{0}C, winds around 25 knots, the sea ice has vanished and the ship is rolling

Overnight the ship began to roll in winds of 25 knots. The winds have apparently dissipated the sea ice. We reached the end of line by about 06:30 hours and the ship turned to the north. This decreased the amount of rolling. In a discussion with Borden he indicated his preference to leave the gear in the water. This pleased the Chief Mate and the boatswain who would be the ones to be pulling the gear in this rough weather. The Captain, Chief Engineer and I discussed the merits of leaving the gear in the water and collecting seismic data along the 350 nm maximum claim line. A consensus was reached. New co-ordinates were given to the Bridge.

There once was a fellow named Borden
Let's call him the seismic warden
He'd be having great fun
When firing on all guns
With the crust of the earth retortin'

Fred Learning

John Shimeld played back the seismic section from last night. It had high frequencies not observed on the data before. This could be due to the termination of a BSR or noise produced by the open water swells of several meters. The gear was left in the water until 14:00 hours. The signal to noise ratio improved as we changed direction relative to the wind. By noon another four hours of data were processed and they were less noisy. When the ship reached the ice edge, the swell dropped so it was easier to bring the gear onboard. An inspection of the over the side equipment prior to the beginning of Line 3 was needed. The timing of the check was planned based on an estimate that most repairs that would be needed on the airgun array would be completed before 20:00 hours.

The sled was fine. Unfortunately, the rope bridle was cut off, level with the guns, and the eel was

being towed directly. The deck cable had pulled out of the bundle relative to the other cables in it. It will be an effort to reseat the cables.

It was cold working on the deck. In the loose ice conditions the Captain does not want to drift so the ship is tracking back and forth over a 5 km line. Borden, Ryan and Jim were actively adjusting and securing all parts of the system. The cable bundle from the other sled was moved to the usable sled. The harness was switched and the guns inspected.

John Shimeld was scheduled to give his presentation on the seismic result at the same time that the gear will go into the water. We have to wait until the last minute to announce the talk. The gear went into the water at 18:00 hours. This caused the regular science meeting to be shortened but it meant the scheduled talk could proceed.

John's seminar on how seismic reflection works, the equipment we are using and the salient features of the seismic reflection profiles was well attended. He pointed out the thickness of sediment must be in the order of 5 km. Therefore, we could extend our claim to 500 km from the FOS. He showed evidence of a diapiric province and noted that gas and oil are often found in such structures. Furthermore he looked at the lack of penetration in segments of the record and attributed this to Bottom Simulating Reflectors (BSR) and the possibility of free gas. The Captain followed up the seminar with the information that the Minister of Indian and Northern Affairs was planning to visit the ship on September 27 (fueling date) to announce the UNCLOS program.

There is a general consternation about the Regulus display not putting the ships track near the planned lines. This is caused by the Mercator projection with only two points forming lines of 350 km. I talked to the First Mate and he assured me the ship was travelling on a great circle route. Regulus should be configured to do the same. Paul is looking into the options in the software package.

Day 259 - September 16, 2007 - Sunday, -6^{0}C, winds 10 knots, many tenth's rotten sea ice, foggy in the morning cleared later in the day

07:45 hours at the safety meeting it was noted that not only were the decks slippery but also the handrails. The Captain signed off on safe operating procedure for the Deployment/Recovery of seismic equipment on the CCGS Louis S. St. Laurent. I talked to Borden about writing a safe operating procedure for the compressor. He will get the template from the Chief Officer.

The airguns fired all night and there is low noise on the seismic display. We will try and leave the system undisturbed for as long as possible. The cable bundle that was damaged yesterday must be repaired today. We discussed putting a sonobuoy over the side and preparations were begun.

Borden and Ryan worked on setting up the sonobuoy for deployment. The frequency was 156.250 MHz. The hydrophone depth chosen was 30 m and the time of recording reduced to four hours. The sonobuoy was lobbed into the water by Ryan who had been given instructions on how this should be done by the manufacturer. Borden monitored the signal strength while Ryan watched the sine wave. The signal was observable for two hours or 15 km. The data and a parameter file were given to John for plotting purposes.

At 15:50 hours the Captain, Chief Engineer, Chief Officer, Borden and I reviewed the week's activities. During open water retrievals of the gear with swells, only the ship crew will be involved in the operation. Improvements to the system were suggested including a florescent color for the drogue and a weak link to connect it with the rope, a third tugger winch, a 40" drum reel for the hydrophone array mounted on the deck above the Quarter Deck, supports for the A-frame in heavy weather. A winter maintenance list should be put together.

At the science meeting, Ken reported the winds will continue to stay below 15 knots. This will produce seismic section with low noise. The ice analysis for the next 75 nm suggests similar conditions to those we are now ploughing through with ease. Canadian Ice Services has expanded its ice analyses to 80°N to meet our survey needs with less than 24 hours notice. The service is excellent. Most importantly, at the meeting we were able to report that the airgun system has worked well for 24 hours.

Nelson, Jonah and John attended the dinner laid on in the Captain's dining room. As usual the participants were impressed with the meal and thought it a grand occasion.

Ruth is happy
All the time
Collecting data
Line by the line
Guns are firing
Eels a-tow
the UNCLOS project
is go go go

Ryan Pike

Day 260 - September 17, 2007 - Monday, -6^{0}C, winds 10 knots, at least nine- tenth's rotten sea ice, clear sunny day

The day started with a shot of adrenaline. At 07:00 hours a block of ice was snagged between the tow sled and the stern of the ship. The First Mate slowed the ship down and was able to maneuver to free the block of ice. To establish the extent of damage to the system the airguns were brought on board. The inspection revealed only minor damage to the bushings on the shackles. These were replaced as well as tie raps on the bundle. At this time, the opportunity was taken to search for the source of the new noise in the compressor. The connection between the John Deere compressor and the Caterpillar engine had been working loose and was tightened. The seismic array was put back in the water and shooting began again. We have been acquiring seismic data for 36 and 42 hour periods for a total of 78 hours with only 4 hours downtime.

John gave me the sonobuoy data from yesterday. We recorded for an hour after that we could not detect any arrivals on the scope. The direct arrivals, water bottom and the first multiple were all clear for 3.8 hours and then stopped abruptly before there were any refractions. The sonobuoy was set to scuttle at four hours. The 12 Hz noise was still visible and Borden checked the various electronics like the Krohn-Hite filter for the noise but could not detect it. The speaker for the WiNRADiO radio has a repeated "sshhh" that may indicate the 12 Hz is coming the sonobuoy itself. As soon as the gear was in the water and following the launch of the helicopter, we put

another sonobuoy in the water.

The third sonobuoy lobbed over the side recorded only 461 shots. Fortunately from 400 to 406 we recorded our first refraction from a sedimentary layer. The velocity estimate was 2.95 m/s. That may be high, but is not an unreasonable estimate.

We had our regular 18:00 hours science meeting. Nelson reported that he saw 12 sets of polar bear tracks yesterday but not a single bear. I went to see the Captain at 19:00 hours. It is becoming increasingly difficult to pick a route through the ice as we move shorewards and at night the degree of difficulty intensifies. To be prudent, we decided to haul the sled and the hydrophone array onto the deck at about midnight when the last large pool in this ice was visible on the RADARSAT-1 image. At midnight the seismic gear came onboard and the ship put its bow into the ice and the propulsion engines were turned off.

The ship is consuming about 26 cu m of fuel a day. This is the amount generally run through when they are travelling at 6 knots through the ice. Even though the ship is doing only 4 knots, our program required three engines to have sufficient revs to control the ship because we cannot use the centre shaft.

Day 261 - September 18, 2007 - Tuesday, -6^{0}C, winds 10 knots, at least nine-tenth's rotten sea ice with large old flows, foggy

Overnight Fred changed the oil on the Caterpillar. The drogue had been damaged by the ice yesterday. Fred repaired it; however, in heavy ice it will be replaced with shackles. Fred also inspected the sled and repaired damage done on the last tow. At the safety meeting it was brought to the attention of all that when the compressor is started up there could be parts of it with frozen lines. Starting of pumps to warm the container up was recommended.

I was confused about the oil change. A second one was needed on the John Deere. This meant the ship started its engines several hours earlier than necessary. The compressor oil change was finished at 09:30 hours and then the ship was brought in to position to continue the line. The guns were put in the water but they would not fire. Therefore we requested that the ship circle. Eventually the freeze-up in the hoses on the ship was cleared and the guns were firing again without being pulled from the water. We had to come back onto the line again. By this time it was lunch hour for the crew and the work was halted.

At about 14:00 hours the array was pulled from the water because the ice was too thick to transit through without all propellers working. The Captain was trying to clear a path, return and put the gear back in the water. This was a trial for next year for work in heavier ice with a single ship. The Chief Mate expressed the hope that next year we would have a winch and reel for the hydrophone array. Pulling it in by hand is tedious hard cold work and it requires the entire deck crew of eight.

It took about six hours to break a path more than 6 nautical miles long. The ice at the far end was closing in at the end of the traverse. Therefore working in heavy ice with one ship one could calculate an average speed of 1 nm. The gear came in at 23:00 hours as the path around a large flow could not be determined in the dark.

Today we will have to decide whether to continue on Line 3 to the 2500 m contour or if ice conditions demand it, we will try and link up with Line 2. This means we should also fill the missing data section in Line 2 so that we have a complete loop.

Day 262 - September 19, 2007 - Wednesday, -13^{0}C, winds 10 knots, forming grey-white ice at least nine- tenths ice with old flows

The ship started moving at 06:00 hours to search for a path around the large floe that stopped them last night. The technical staff were tired this morning because they were required to retrieve the guns near midnight and put them out again at 08:00 hours. Thus, they did not get a good nights sleep. John played back the data collected when we were travelling through the ice with four engines on line and basement is still visible.

The guns were ready for deployment at 09:00 hours but the ship had not returned to the starting point of the line until about 10:15 hours. The guns were launched efficiently but they iced up. One gun was made to fire with copious amounts of antifreeze but the second would not fire. The airguns (but not the hydrophone array) were brought back on deck. By about 11:30 hours they were within five minutes of putting the guns back in the water when Captain McNeill had the streamer brought on deck. He then brought the ship's speed up to 12 knots and headed to the last known position of the helicopter. The helicopter radioed in and we returned to the start of line. The deployment will not begin until well after lunch because the deck crew had to assist in the helicopter landing. This situation left the seismic group frustrated.

The Captain wants the sounding operation from the helicopter run differently, preferable in a safer fashion. He will send one of his crew out with the hydrographic team to ensure that good communications are kept. He had a few words with the helicopter pilots and staff. He also talked to me about the issues. I am in full agreement that safety is the paramount issue.

The airguns went into the water at about 13:30 hours and fired the first time. I am trying to complete the circuit between Lines 2 and 3. There is multi-year ice and it is not easy. The large number of revs up to 110 is forcing large volumes of water and blocks of ice past the sled.

At 18:00 hours we reviewed the day's activities. Many of the staff are showing the strain from the last several days of difficult ice conditions. Jon Biggar had problems sounding through the ice and would like to be in an area with less ice. The server was down on the ship today and log and heading were not being fed to the various programs that require navigation. The ship's technician was trying to address the issues.

At 20:30 hours the ship came to a halt; it was pinched between floes just before a long section of thin ice. The Captain was willing to continue to finish the last 9 nm of this portion of the line that completes the loop of Line 3 to 2 but Borden was adamant that he did not have sufficient spares to fix the bundle if it were damaged. Because discretion is the better part of valor, we halted for the night. It took until midnight for Borden and Ryan to complete the maintenance on the array in preparation for an 08:00 hours start in the morning.

Day 263 - September 20, 2007 - Thursday, -6^{0}C, overcast in the morning then clearing in the afternoon followed by fog later in the day light winds

07:45 hours - no safety issues were brought up when the question was asked. At the shift change, the night crew reported their activities. Fred continued to address the many problems the compressor inherited from the factory. They continue to remove metal filings and solder the clog valves.

08:00 hours - the Captain maneuvered the ship to the start of line, the guns went in the water and fired without freeze-up problems. The temperatures, warmer than yesterday, helped. Paul restored the GPS data stream to my computer. It is easier to plan the days activities when I have an accurate record of where the ship has been and its present location.

The seismic record from last night was not as noisy as I expected. I checked with the Bridge and they had up to 110 revs on the engines to get through the ice. John is unable to plot the sections because the plotter has been removed from the network while the room where it is located is being painted. This is unfortunate because he has just done a series of parameter tests for filters and would like to present the results Friday night in the Boardroom.

Today we completed the section of Line 2 that links to Line 3 by 11:30 hours and the gear was on deck in 11 minutes and 30 seconds. The time includes hauling in by hand 250 m of the hydrophone array. Jon Biggar tested his sounders and transducer. He now has a combination that he can use for the rest of the trip. Then the ship set out through heavy ice to get to the position of the gap in seismic Line 2. We had to “back and ram”.

18:00 hours - at the meeting Borden mentioned two items related to safety: one is that the deck crew was rushing too much on deployment and retrieval to the detriment of the seismic gear. He has spoken to the Boatswain (Blaine Blinkhorn) about his concern. The other is preparing a safe operating procedure for the compressor. He also worked on the Krohn-Hite filter today and he believes he has solved the noise problem.

Day 264 - September 21, 2007 - Friday, first year ice beginning to form

At 06:45 hours I was called to the Bridge to verify our starting location for the short line. This line fills the data gap in Line 2 that was due to a large floe that had required the crew to pull the airguns out of the water. By 08:00 hours the ship was ready to stream the gear. Due to the cold, the air lines to one of the airguns froze and the sled had to be retrieved. The airgun that would not fire was replaced. The guns were firing by 10:30 hours. The seismic reflection profiling continued until 16:20 hours when the gear was brought onboard. John plotted the data and it was among the best quality we have collected so far.

John Shimeld was ready to plot the data he had been processing when the printer was moved for painting. The printer will work with my computer but not his UNIX-BASED laptop computer. So I have a color 11 by 17 inch printer connected to my computer, compliments of the ship.

Due to the incident of the pilot landing on the ice and losing contact with the ship, I called Isa and cancelled the order for the Taurus. He was gracious about this. We will have to get the expendable sonobuoys to work.

The Minister of Indian and Northern Affairs Chuck Strahl plans to visit the ship. The date of the visit and the number of visitors has changed several times today and consequentially our scientific operations have to be adjusted. The plan at present is to go east until we reach the 2500 m contour and then transit to the southernmost planned line. This itinerary will allow the most flexibility for getting to the refueling and Public Relations stop and cause the least disruption to the program.

The Chief Engineer had a canvas cover built for the air vent on the roof of the container. Rodger and Rico participated in its manufacture. The container was warmer although Rodger thought it would cool off significantly overnight. Furthermore, he was concerned about the difficulty of getting the canvas on and off before and after use.

At about 19:00 hours the ship was brought to a halt by an old floe; actually the ship barely dented it. All five engines were brought on line, and the ship retreated. At that point the Captain asked Jon Biggar to modify the plan. The ship then changed direction and proceeded south and east to the 2500 m contour.

Day 265 - September 22, 2007 - Saturday, -10^{0}C, winds 10 knots heavy ice nine-tenths ice with old floes, the ship has to back and ramp

Overnight the ship made a good 22 nm. We have to transit 150 nm to reach the beginning of seismic Line 3. At 08:00 hours the seismic crew reported for the change of shift and continued dismantling the damaged sled. The airguns were being moved inside with the use of the crane so that backs would not be injured. Hard hats were distributed to those who had forgotten to put them on. This was the first safety lesson of the day. Fred mentioned that the compressor container was warmer and perhaps they should have a more comfortable chair in it.

My search for some video of the ship with the airguns firing has been futile. The video that was taken by the Chief Officer cannot be downloaded. The video that Ryan and Borden had taken of the airguns firing was screened on the television screen in the lab. It was difficult to find footage that would be useful for the Minister's visit.

I participated in an ice reconnaissance flight from the MB 105 helicopter. The melt patterns on the old floes looked liked sand traps on golf courses from the air. We saw a few sets of polar bear tracks. The pilot (Jim Myra) and Ken from Canadian Ice Services tried to map the route for the ship with the thinnest ice. They searched for leads that would allow the ship to avoid breaking and ramming old ice. When the latest RADARSAT-1 image was downloaded, the route that Ken had mapped out by helicopter was abandoned.

There was a fire and boat drill after lunch. These drills are necessary because it seems difficult for the ship's company to pay attention to the instruction. Our muster station was changed and announced on the loud speaker and several individuals still arrived at the wrong spot. The drill was followed by a movie on what to expect if you had to abandon ship and spent time in a life raft. The final event in this training session was lead by the Chief Engineer. He took a group of mostly scientific staff to the other side of the aviation gas space where the seismic lab is located and showed us the Aqueous Film Forming Foam (AFFF) pump. In case of an emergency the staff could be called upon to refill the drum.

An official from CCG Central and Northern Region will be aboard the ship for one night. Jon Biggar drew the short straw and had to vacate his stateroom for the night of September 26 to accommodate the visitor. This move of course was not welcomed but done without protest.

At 18:00 hours we had our regular meeting. The technical staff have stripped the broken sled and are carefully cleaning the airguns that were mounted on it so that they are ready to be shipped home. The compressor controls were removed, cleaned and replaced. The seismic equipment will be ready for 08:00 hours.

Day 266 - September 23, 2007 - Sunday, -5.3^{0}C, winds gusting 22-35 knots, ice concentrations as low as 5/10 at 07:00 hours

By 11:30 hours last night the ice concentrations dropped and the ship's speed increased. However, at 07:00 hours I was on the Bridge and it was obvious we would not be deploying the seismic equipment until after lunch. We are fortunate that the ice conditions along Line 4 should be light except for the beginning of the line. At the 07:45 hours safety meeting, Borden mentioned that one of the dignitaries would be carrying spare parts and that the I-beam should be at its destination on Monday, ready for transport to the ship.

When the ship came on station, a cast was taken so that the hydrographers could calibrate their sounder. At the SOL 3, small fragments of ice (less than one tenth's concentration) were floating in a dark grey sea, nearly open water conditions. The winds are gusting to 40 knots. They were not predicted to be this high. If they do not dissipate soon, we are going to have a swell to contend with. In the meantime, the film of ice on the water is keeping the sea surface smooth.

Sonobuoy 4 was in radio contact for nearly six hours. At this point the recording was stopped and another launched. When Ryan tried to write a CD, the computer recording the data locked up and had to be rebooted. So, the first ten or fifteen minutes of recording was lost. John then loaded the sonobuoy data into CLARITAS software and we could clearly see a refractor.

It was Dwight's birthday and the pastry chef made him a cake and provided a card that had been signed by those in the crew's mess. He was also invited to Sunday dinner in the Captain's dining room. He pronounced his birthday celebration to be an all round pleasant occasion.

Said the handsome young fellow named Dwight
While standing the watch from Dusk to Daylight
"Let's tow gently the sled
And leave Borden in bed
He's a grump when you go bump through the night"

Mike Ruxton

At 23:00 hours the airguns were firing and the ice conditions light.

Day 267 - September 24, 2007 - Monday, -3.5ºC, winds to 10 knots overcast in the morning clearing during the day

At 07:00 hours the ship was jammed in the ice and could not move forward. It was constrained

from reversing out of the ice because the seismic array was in the water. The technical staff and deck crew were awakened so that the gear could be brought safely aboard. A careful inspection was done on the sled, guns and streamer and no damage had been done to it. The crew went to breakfast and returned as soon as possible to get the system back in the water before freeze up of the guns occurred. The guns did freeze up, had to be removed and replaced with a second set. Fortunately the guns fired without a problem this time.

The ice here is still threatening for the gear. The ice has large old floes with limited leads between them for at least the next 10 nm. The ice chart suggests that beyond this distance the ice in less concentrated, but the images are 5 days old. The helicopter was launched for ice reconnaissance.

At about 11:00 hours the ice conditions were about 5/10 old floes and we launched a sonobuoy after receiving permission from the Bridge. The sonobuoy hydrophone was set deeper to 60 m. We are testing to see if the 12 Hz noise could be related to the suspension of the hydrophone. In addition, we had the Bridge turn the radar off for two minutes to see if it was interfering with the reception on the WiNRADiO.

I attended the monthly safety meeting on the ship. The report of the number of accidents, write-ups on safe operating procedures and standards for marine safety operations were discussed. The Captain stressed that not only was he concerned about the safety of equipment installed on the ship but also the mental health of the ship's company during a 42-day operation.

This was followed by a meeting with the Captain, Logistic Officer and Chief Officer to plan the visit of the Minister of Indian and Northern Affairs, Chuck Strahl. The scientific staff has been allocated 10 minutes for a presentation and 20 minutes for a tour of the equipment.

I passed this information on at the regular science group meeting at 18:00 hours. I circulated a draft agenda for the cruise report and asked for comments in the next couple of days. Technical issues during the day reviewed by Borden included: one of the airguns has also developed a leak but it continued to operate satisfactorily through the day, the heater put in the compressor container is not delivering heat. Rodger and the compressor are not operating as well as possible in the cold. Another problem is the last eight sensors on the array are noisier than the first. It is postulated that the lack of a drogue due to the ice conditions may be the cause of this problem.

Before 20:00 hours, sonobuoy 6 was terminated and the data were plotted. There is one refractor but the data are degraded by a signal that starts after about 350-400 milliseconds on each trace. The noise is made up of 12, 25, 40 etc. peaks and is almost but not time synchronous along the sonobuoy. The information was brought to Borden to contemplate. Sonobuoy 7 was launched and did not start to record; therefore, another was lobbed over the side and appeared to have a satisfactory signal to noise ratio.

Day 268 - September 25, 2007 - Tuesday, -5.7^{0}C, winds to 10 knots ice conditions variable

At 06:45 hours the seismic lab reported that all the gear had operated all night. The single trace data on the monitor looked clean although the last eight traces were reporting higher noise levels.

At 07:45 hours at the safety meeting, Fred reminded the group that the rails and ladders were

slippery. He had remedied the situation by salting the deck. The second stage valve on the compressor is releasing air at a higher pressure than the manual indicates it should. It is doing this reliably. The Hurricane compressor company has been sent an email to ask for assistance on this problem.

Borden copied the sonobuoy data to DVD and it was brought to John for playing back. At least one refractor is clearly visible, but the high noise makes it impossible to pick the reflectors. Borden and Ryan are trying to address the problem.

The Captain had the gear brought on board at 08:30 hours. The hydrographers did a cast and a bar meter test. We then headed for Tuktoyaktuk.

In the afternoon, the Captain, Chief Engineer, Chief Officer, Borden and I met to coordinate long term use of the ship science issues: rebuilding of the sled (only if required), networking issues, refueling and return to the science program by Friday evening.

At the 18:00 hours science meeting I gave an overview of the presentation for the Minister. This was done so that those who would be demonstrating the equipment afterwards (but would not be in the meeting) would know what background the dignitaries had been given. It also gave me the opportunity to ask for suggestions for improvements. Bob thought that I should avoid the word experiment and John had suggestions for improving the data slide. Jon Biggar can give me a CHS crest.

By 19:30 hours there were sustained winds to 35 knots with gusts to 45 knots. The spray was lashing against the windows in my stateroom as we travelled at 13 knots towards Tuktoyaktuk. There were a number of individuals who were seasick. Jonah said it was the first time an Inuit had become a white man.

Day 269 - September 26, 2007 - Wednesday, -1^{0}C, winds to 20 knots open water, at anchor

At 07:00 hours the ship dropped anchor about 30 nm off Tuktoyaktuk. The water depths are too shallow for the ship to get any closer to the mouth of the MacKenzie Delta. The barge will not arrive until later today. The timing of fueling is awkward. The flights to pick up essential spares for the science equipment, fresh groceries and for Jonah to visit his grandson must be complete before fueling begins. The ship may have to fuel overnight to have this completed prior to the visit of the Minister, Chuck Strahl. It is a strain on the Captain.

The fuel barge is rescheduled to arrive tomorrow at 14:00 hours. This means the synflex hose, airgun spares and beams can be transported by the fuel barge. At 12:15 hours, Nelson and Jonah will be flown into Tuktoyaktuk so Jonah can see his grandson. Nelson will ensure he meets his flight back at 15:30 hours.

There once was a lady named Ruth
Who was tasked with obtaining strong proof
-Indisputable evidence-
That Santa's main residence
Was sufficiently North of Duluth

The staff continued to work hard when we were at anchor. Jim Etter solved the problem with the low pressure valve on the Hurricane compressor not releasing air at the pressure listed in the manual. The seismic lab deck was washed, and hydrographic charts were put up and the lab readied for the Minister of Indian and Northern Affairs visit. John plotted all the deconvolved seismic sections. He also plotted Line 3 at an enlarged scale to show the distinguished visitors tomorrow. I worked on my presentation and printed out seven handouts to be part of the CCG brochure that will be given to the dignitaries. Jonah and Nelson had the opportunity to fly into Tuktoyaktuk to visit relatives. Nelson seemed pleased that he was able to pick up a local newspaper as well.

There was a meeting with the Captain, Brian LeBlanc, Larry Sweeney, Don Strotts, and Bryan Gibbons in preparation for the Minister's visit in the morning. The ship had been made even cleaner as usual, the plastic covers taken off the boardroom tables, dishes laid out for coffee. The plan for the timing of flights using the LSSL helicopter and the Sir Wilfred Laurier's was gone over carefully. The weather predictions for the morning were reviewed and, to my surprise, it was suggested that if the weather was unsuitable for flying, I could be ferried in the Fast Rescue Craft and taken 30 nm into Tuktoyaktuk for the presentation. The Chief Engineer announced I would be frozen long before the three-hour ride was over. I was appreciative of his comment.

After the meeting I gave Larry seven handouts of my presentation to be put in the brochures to be given to our distinguished guests. I also set the projector, computer and slide screen up in the boardroom. I had John and Paul review the slides for spelling errors.

Day 270 - September 27, 2007 - Thursday, -2.3^{0}C, at anchor, good flying weather for the Ministerial visit

The entire ship was waiting for the arrival of the Minister. The helicopter was off at 08:00 hours to meet his aircraft that was arriving in Tuktoyaktuk. We all waited and waited. His aircraft was late landing and the Captain was starting to think about how to rearrange the rest of the time. The longer I waited the more nervous I was becoming about the presentation.

Eventually the guests arrive on board, probably three quarters of an hour late. The Captain and Brian LeBlanc, dressed in their number 1 uniform, are the official greeting committee. The guests were supposed to go directly to the boardroom but immediately scattered all over the ship to get better photographs.

I was pleasantly surprised by Chuck Strahl, but he put me quickly at ease. He looked like a double of John Shimeld with his goatee. Later I took their picture together. After the group milled about for about ten minutes, I was asked to start my presentation. The Minister sat directly opposite me and paid strict attention to everything I said. I tried not to be distracted by Sasa Petricic, who was filming within one feet of me. Chuck also had a sense of humor. After I showed the irregular track due to the ice, he queried the Captain about a drinking problem. The Captain retorted he had both hands on the wheel. The point of the talk was that there was sufficient sediment to allow the maximum claim to 350 nm. John Shimeld completed the presentation with a large paper record laid out on the table showing the stratified layers and the irregular basement. The Minister said he

could see it clearly since it had been pointed out.

From here, the group moved outside to view the seismic equipment. The Captain gave the commentary on the seismic gear on the deck to Borden's disappointment. He was allowed to explain the electronic equipment in the lab. The dignitaries then toured the ship and had lunch in the crew's mess. Here I chatted with his adviser from INAC. I note that there is confusion about whom we are claiming the territory from and whether border disputes are significant issues. I would recommend Jacob giving a presentation to INAC the next time he was in Ottawa.

The announcement on the Quarter Deck was a mere photo opportunity. The Minister, when interviewed by Sasa was asked to explain what Canada was doing to protect its sovereignty, missed the critical point that the data we were collecting was sufficient to make the claim because UNCLOS was signed by 159 countries. At the end of the interview I explained this to him and he seemed pleased.

Later in the day, I asked Borden to meet with the Captain, and Brian LeBlanc. During our waiting around together, I noticed he had ideas about the type of icebreaker we needed that did not match our reality. The Captain was quite focused at the meeting and made suggestions that I thought were much more workable for us and less damaging to the fleet operations.

The Terry Fox is the only viable icebreaker in the CCG fleet. It should join the LSSL no later than two weeks after the seismic surveying begins. This can be done by replacing the Fox's second supply run with another ship in the fleet. The LSSL should not be the last boat out of the Arctic. This could be done by one of the icebreakers from the Quebec region. This makes for a longer season.

The Captain needs to contact the Oden's Captain and learn exactly what problems the Oden had in following the nuclear icebreaker. Was the difference in the width of the ship significant? This is critical to determine because the LSSL is wider than the Terry Fox.

The CCGS Sir Wilfred Laurier is at anchor less than 1 km away. The gang plank was lowered and the staff and crew from the Laurier toured the LSSL. I showed Rodger Francois, a geochemist from the University of British Columbia, around and talked about our mission.

At 16:00 hours the fuel barge was alongside, a day and a half late. The company who runs the refueling is not reliable. Later in the day, Borden told me that the spares and I-beams he had ordered had been brought on board from the barge.

Day 271 - September 28, 2007 - Friday, -2.3^{0}C, at anchor at 08:00 hours

At 04:00 hours this morning, the fuel barge finished fueling 1,000,000 cu m and at 08:00 hours the port side anchor was brought aboard. The Fast Rescue Craft was put over the side in order to check on the ship's trim. I checked with the Captain on the probable sailing time and got the latest ice information from Ken. I passed the sailing time onto the seismic lab and then started to work on the itinerary for the rest of the expedition.

It is 248 nm to the start of seismic operations. I assume this is 20 hours. However, the Engineers

are concerned about the port shaft and are doing a series of tests with the ship steaming at specified speeds, such as four or seven knots. At present we are using only the centre shaft while the port one has the brake on and the electricians are examining the problem. This is an example of the difficulty of using average speed to determine a time to a destination.

After lunch I went up to the Bridge to discover if the engine problems had been solved and they were. John Ruben was steering the ship so I went to get my camera to take a picture. Just as I arrived back on the Bridge, I had a view of a Bowhead whale's v-shaped spout about three times before it dove with its tail flukes fully visible.

Borden has determined the noise on the sonobuoy is produced by a combination of the digitizer and the power supply. The question is whether he can find a way around this on the ship.

We had our regular 16:00 hours meeting and at 20:15 hours John discussed the data for the week with the science staff. I put together a map showing the distribution of true oceanic crust. I had an email from Keith Louden that indicated that the UNCLOS presentation had made it on the National News. Later I received a fax asking for an interview by a CBC reporter. Bob Rowland is getting reports from the US Senate hearings on UNCLOS ratification.

In the lounge the guitarists had their regular Friday gig.

Day 272 - September 29, 2007 - Saturday, -5.5^{0}C, winds averaging 15 knots steaming to mid point of Line 4

At 07:00 hours the ship was 25 nm from the start of line. Overnight the ship threaded its way through the ice using the RADARSAT image it had used on the way out, just shifting it by the estimated amount of the drift. I lost my GPS input to Global Mapper and requested Paul to help replace it. This took a considerable length of time because the license had expired. This meant that the original disks had to be found. Eventually he had the ship's icon displayed.

The gear went into the water about 10:30 hours with no hassles. The line will overlap but be offset from the previous one due to a large floe. Next, a sonobuoy was lobbed over the side. It started to transmit immediately and you could clearly hear the direct, bottom and several multiples of the bottom but they were not discernible above the noise on the scope. Borden was able to diagnose the problem of poor signal to noise on the WiNRADiO receiver for the sonobuoy data. The digitizer for the signal had the channel wires crossed. The data quality from the WiNRADiO now looked superb. For the record, he missed his lunch to correct this problem.

I got the latest RADARSAT mosaic from Ken and, under John's guidance, got it rectified into Global Mapper. The question we have is whether to go north along a lead or to head north and east to SOL 5. We need additional information from Ken who is not available for an hour or so.

At the 18:00 hours meeting, I learned that the compressor had a serious leak in its cooling system. The repair will take a minimum of two days. Borden and Rodger hope to nurse it along until the end of this line. John Shimeld presented noise analysis of the streamer and showed a 99 Hz noise that is not a problem for our work but would be for those using for high resolution data collection.

The latest sonobuoy was played back. It has excellent signal-to-noise ratio with three refractors. Sonobuoy number 10 was promptly launched. The plan is to put one over the side every eight hours.

Day 273 - September 30, 2007 - Sunday, -5.5^{0}C, winds averaging 10 knots drizzle not a good morning for flying

The compressor was nursed along overnight but by morning the crack had increased in length. By 08:45 hours the airguns were shut down and the gear was onboard. A temporary repair will be attempted that will hopefully last us until the end of the program. Gerry McDonald, the First Engineer, did the welding on the aluminum tank. The Chief Engineer believes the tank was built with material that was too thin to sustain the vibrations it receives.

Meanwhile, the hydrographers did a cast. They had problems with the sounder losing track of the bottom last night and recovered eventually by restarting the computer and the Knudsen sounder. Dawn arrived today at 09:00 hours. The new ice analyses show the areal extent of the ice increasing.

I made a rough calculation of the three refractors on sonobuoy 9; first verifying the sound of water as using the technique as 1.51 km/s. There are two velocities typical of sedimentary rocks of 2.92 km/s and 3.79 km/s and a third of 5.09 km/s usually assigned to oceanic crust. Sonobuoys 10 and 11 also had high signal to noise ratio and had three to four easily identified refractors.

The compressor repair was completed and the airguns went back into the water. The guns fired immediately. The drogue had been reinstalled on the end of the eel and the noise on the array was the lowest yet for the experiment. After about 55 shots, Rodger came down to the lab from the container and announced a leak in the medium pressure stage of the compressor. This is a safety issue and the guns were shut off and the gear retrieved. There was some delay in pulling the gear due to the water being pumped over the Quarter Deck so that the deck crew could not get to the winch controls.

The crew was annoyed that the drogue had been put back on the hydrophone array. It is physically harder work to remove the array from the water with it. This drogue was replaced with a shackle because the ice was collecting in it. However, the last eight channels had significantly higher noise levels without it. As we were in open water it was felt we should try and achieve the best data possible by using the drogue. It will be removed again when the ice concentrations increase.

By 16:00 hours, the second repair to the cooling system on the 600 psi leak had been welded over by the Senior Engineer Mike. The gear went back in the water, the guns fired and data was recorded.

There were changes in the watch schedule so that Jim, Rodger and Paul could attend Sunday dinner in the Captain's dining room. Jon Biggar was asked to attend but the conditions for flying had improved so he opted to collect bathymetry spot soundings. He may get eight spot soundings in total today.

At the 18:00 hours science meeting, Ken mentioned that the winds were picking up to 25 knots

tomorrow and we would be in open water. The ship will roll and it may make picking up the gear difficult. I described the three best sonobuoys and how to interpret them. The meeting had small attendance due to the number dining formally.

Near 21:00 hours, John delivered to me a package with all 11 sonobuoys plotted. The improvement in data quality and range is well illustrated.

Day 274 - October 1, 2007 - Monday, -5.5^{0}C, winds averaging 15 knots, the ship is rolling

All first year ice becomes second year ice today. Happy Birthday.

At 06:45 hours, the ship was rolling in open water. I called the lab and the airguns had fired flawlessly all night, the compressor was operating well and the track was a straight line. The end of line should occur about 16:00 hours this afternoon. At the change of shift safety meeting at 07:25 hours, I asked Borden to determine how much time he would need to pack up. This will determine how many more days of data collection we have. A plan should be given to the Captain today. Because the ship is rolling, care will have to be taken in bringing in the gear. The helicopters cannot fly today because the motion of the ship is too great.

I put together a plan for the last portion of the cruise in consultation with John. I then took the plan to the Captain for discussion and he approved it in principle. The plan was then posted in the seismic lab. At the end of Line 4 the ship will steam north as far as the end of Line 3. The array will be deployed and seismic data will be collected until stopped by the ice. The ship will then turn to the east and collect data until the ice conditions prevent further motion. If this line is completed, we will run a tie line from the end of Line 2 that crosses Line1 and then onwards to Line 4.

Three sonobuoys were launched today. After lunch a sonobuoy was put into the water that did not operate properly so a third was put over the side at a different frequency. Unfortunately the signal of the first interfered with the second.

The seismic reflection profiling continued until 17:00 hours when the end of the line was crossed. The gear was pulled and the shipped started to steam north to the SOL 5.

At the regular science meeting, Ken started by reporting the weather. High winds will continue into tomorrow and the ice pack is changing shape and rapidly expanding. John Shimeld showed the latest seismic reflection profiles with evidence of a sharp fault cutting the sedimentary section from basement to within two seconds of the seabed. The fault may be listric or strike-slip.

Nelson, Jonah and I met to discuss the best way for them to fly home. We have booked a charter flight from Kugluktuk to Paulatuk. Nelson and I preferred the fixed wing aircraft while Jonah was hoping for a helicopter ride. The weather in October is not reliable for flying helicopters and the decision to stay with the fixed wing flight was made. I will contact Polar Continental Shelf Project (PCSP) to confirm the flight tomorrow.

The northern lights danced during the clear evening but only those on watch saw them.

Day 275 - October 2, 2007 - Tuesday, clear morning sunrise near 10:00 hours, 7.9^{0}C winds 15 knots

At 07:00 hours I talked to the Captain about the science plan for the morning and about the flight for Nelson, Jonah and John from Kugluktuk to Paulatuk. The hydrographers will do a cast to 3000 m followed by the seismic group launching of the airguns and array. At this point, an airgun calibration will take place, both amplitude and shape of the signal will be monitored. The marine mammal monitors' flight will be booked for 14:00 hours in the afternoon on October 11.

At 08:00 hours the ship was on station. The hydrographers had to wait for half an hour before they were given the okay from the Bridge to begin their cast. This delay propagated to the launch of the airguns. It's cold this morning and the guns would not fire. The sled has to be retrieved and one gun switched: cold miserable work. Only one gun fired on the second attempt and the airguns had to be retrieved again. As soon as one of the guns was taken out of the water it flash froze with a quarter inch coating of ice. Borden is having antifreeze pumped through the high pressure hoses but there still seems to be a blockage. This is discouraging work. Borden's single comment was he wished he was some other place. On the third attempt the airguns fired successfully and the calibration was begun.

The test hydrophone was lowered over the side. Ryan was careful that it did not rest on the sled. The guns were fired one at a time and then as a pair. Part way through the second guns firing sequence the signal from the hydrophone dropped dramatically. Borden thinks salt water got into the test hydrophone cable. The shape of the pulse was textbook perfect and the delay for each gun was the same. The data must be processed by Peter Simpkin to get absolute levels calculated.

At 13:30 hours the helicopter was preparing to take Jon Biggar on a flight to collect spot soundings. It is now bright and sunny. All afternoon the ship moved through grey-white ice in pancake sized floes. This thin ice was silently sliced as the icebreaker progressed north. The noise levels on the streamer were only 3mbars. Bordon and Ryan launched a sonobuoy after their late lunch and it lasted only a short time. They had to throw an additional one over the side. I studied sonobuoy 13 that has 5 refractors, 4 are sedimentary and the fifth is the crust. Sonobuoy 15 had just three refractors but the third refractor was recorded over a significant distance and produces a slope that is consistent with an arrival from the Moho.

The regular 18:00 hours meeting was held. Nelson saw two walruses today that were 2 km away from the ship. Jon Biggar did a cast to 3000 m, 8 spot soundings and the continuous soundings are being logged. Bob is recovering from his cold and hopes to be able to resume work on his paper on collecting seismic reflection data in ice for UNCLOS tomorrow.

I had to wait for the ice reconnaissance flight to determine if we would be able to continue with seismics for the night or if we have to move to the south and totally rethink the seismic plan. By travelling west the ship can stay in the pancake ice until about 03:00 hours tomorrow morning. After this we will have to move south again.

Day 276 - October 3, 2007 - Wednesday, clear morning sunrise near 10:00 hours,- 7.9^{0}C winds 15 knots

All night the ship worked its way north and west to $77^0$11N, $148^0$22W, avoiding the edge of the heavy pack ice in the dark. The course took us to the west of the 350 nm cut off for UNCLOS but this is the course dictated by the ice. At the 07:45 hours safety meeting Rodger took his flashlight because sections of the deck are now dark on the way to the compressor container. I asked Paul to produce a digital file with the location of all sonobuoy locations. The seismic reflection system worked well all night.

At about 10:30 hours, the ship came to a halt in the ice and the equipment was retrieved from the water. During retrieval damage was done to the streamer around the cable blocks. This will mean getting new sections from those stored on the hangar deck. The hydrographers did a cast at this our northernmost point. Then Jon Biggar acquired a number of spot soundings from the helicopter. After he was through his spot soundings, the helicopter deck was needed to lay out streamer cable. In the heavy ice, several sections of the streamer were damaged. It was a mistake to have the drogue on in such conditions. The streamer will not be ready to deploy until 08:00 hours tomorrow morning.

John and I contemplated the best options for the remaining days of the cruise. I called Jacob to assess the possibilities of trading data with the US to get the seismic profile line run by Art Grantz. He was confident that we would receive a copy of the line. Therefore, John and I put together a plan that involved collecting data along another transit. I gave the modified plan to the Captain who approved it.

A walrus was sighted on the starboard bow after lunch within 100 m of the ship. I took a few pictures but Carol's (the Second Mate) were much better.

By 19:00 hours, Borden had the array ready to put back in the water. One stretch section was replaced the active section was reclamped and no drogue will be put on it. The active section will go back to the company for repair at the end of the trip. A new section was not brought out at this time or we may have had two damaged sections before the end of the trip.

Day 277 - October 4, 2007 - Thursday, clear morning sunrise near 10:00 hours, - 5.1^{0}C winds 15 knots

The ship stopped during the night and did not reach the start of line until 09:00 hours. The array was put in the water and the first gun that had air pumped into it froze up. It is not the cold soaking of the guns but the condensation in the air lines that seems to cause the problem. The sled was brought back in and a different gun put on the sled and then both guns fired.

I had a number of emails to answer about timing of meetings and thesis defense when I get home. I called to find out if Nelly had confirmed the information on the flights, but she had no luck. I asked her to look into it again.

Paul gave me a list of locations where marine mammals were spotted and I plotted them. I was surprised at the lack of mammals on Lines 2 and 3. The ice in this region was the most continuous. The majority of our work has been in areas with the thinnest possible sea ice.

The Captain has increased the speed of the ship to 5 knots so that we will finish the survey 12

hours earlier. I hope it is not putting undue strain on the gear. I checked with Borden who was on watch so that the speed would be carefully monitored. The predictions for winds in the next few days have changed to be more in our favor. We are in the middle of a high that should produce winds of no more than 15 knots. Most of the sea surface for the remaining lines have a light veneer of ice except for large floes at the end of the survey (west end of Line 1).

I tried calling the Principal at Paulatuk school but got only an answering machine so I left a message about cancelling the trip to the LSSL. The scientific equipment will be packed up and there will be little for the school children to see. This is complicated by the fact it does not get light until after ten in the morning so the window for flying the helicopter is short. Therefore, the ship would have to be in Paulatuk at a specific time that is difficult to arrange in advance.

Nelson and I worked on a draft of the marine mammal observers' contribution to the cruise report. Drafts of the picture and the text were printed out for Jonah and John to read over and modify as they saw fit.

At the 18:00 hours science meeting, Ken's weather and ice report indicated favorable ice conditions until the end of the survey on Saturday. This is probably the end, regardless of whether we complete the planned track. John Shimeld said he spent the day considering whether the G-gun calibration improves the data quality. The sedimentary layers are sharper but the basement is not as good as his other processing sequences. Since the survey is aimed at defining the basement, he will probably not use it.

Bob is planning a presentation called "The Law of the Sea: looking back and trying to look forward". He is willing to give it twice to accommodate watch schedules.

Day 278 - October 5, 2007 - Friday, - 5.6^{0}C winds 30 knots in open water waves to 2.5 m

Overnight, we continued along the 350 nm limit of the claim as far as the U.S. Exclusive Economic Zone. This is our most westerly point. We made the turn around 07:00 hours and travel in a southeasterly direction just east of the 200 nm boundary of the U.S.

The compressor's universal joint ran hot over night. The compressor must be stopped. At the 07:45 hours safety meeting the problem was discussed and the plan to replace it initiated. The parts list did not include a universal joint. A search of the boxes produced the desired part.

The Captain, who was at breakfast, was notified of the problem and said he could not circle in these weather conditions. After breakfast I went to the Bridge to see if he could at least reduce the speed while the repairs were taking place.

The universal joint between the John Deere and the Caterpillar was replaced in about an hour. The ship then had to get back on line. The ship made a sharp turn and steamed back along the line for about half an hour. The Captain wanted the guns on before he made the turn in case the guns did not fire. Borden did not want the airguns to fire beside the array. I asked the Captain to make the turn. The guns were activated and we continued along the line. Sonobuoys are being launched every eight hours and I am working on a plot that displays their distribution along the seismic lines.

John has concerns about the noise level on the data. Is it simply due to speed or to the fact that the winds are causing waves? As soon as we reach ice the noise levels will probably be drastically reduced.

I tried calling the Principal of Paulatuk school at 10:45 hours today and only got the answering machine again.

At the 18:00 hours science meeting, I circulated recommendations for next year's program and asked for comments. I am amending the list based on the input I was given. John held his Friday night data review at 20:15 hours. It was well attended by scientific staff, a member of the crew and the First Mate.

Day 279 - October 6, 2007 - Saturday, - 6.2^{0}C winds 25 knots in open water, approaching the edge of the pack ice

The 07:45 hours safety meeting was held at the change of watches. Overnight, the low pressure stage of the compressor was running slightly above normal operating temperature at 190^{0}C. A careful watch had been kept on it and the heaters near it were turned off. Rodger will pay particular attention to it today. The rest of the equipment had operated flawlessly. It is about 20 hours to the end of the line.

At about 08:15 hours, sonobuoy 26 was put in the water. Up to this point 21 have recorded useful data. The ice concentration increased throughout the day. The ship is moving through grey-white ice up to 8-10 inches thick and it requires more power to push through it than the new ice that we have been going through. The ride is generally quiet and smooth except when the older floes cannot be avoided.

At the 16:00 hours science meeting, Ken reported that the ice was continuing to consolidate and that the winds would be abating over the next few days. Borden wanted to do another calibration of the airguns because the leakage that occurred in the cable during first test did not produce reliable data for the power and signature with two guns firing. This information is useful for environmental assessments and processing the seismic profiles. Jon wanted a bar-meter test that could be done following the airgun calibration. The Captain was happy to oblige.

At the 20:00 hours change of watch meeting, Rodger announced the compressor was working so well it scared him.

Day 280 - October 7, 2007 - Sunday, - 14^{0}C winds 25 knots in heavy ice, ship stopped at 05:30 hours, the new moon is surrounded by stars

The airguns fired overnight until 05:30 hours when the ice stopped the ship. The guns were brought on board. At 08:00 hours, a calibration on the airguns was to be run. Of course when the guns went back in the water, they did not fire. It was too cold and miserable to do a gun change and the other guns had been cleaned and prepared for shipping. The airgun calibration should have been done when the ship came to a halt in the ice in the early morning. Thus, the seismic acquisition for the cruise is complete.

Jon Biggar asked that the bar test be put off until light. He cannot read the numbers for the calibration. The ship is steaming toward port now and will stop in a lead after daybreak to do the cast.

John worked at reprocessing the data and I was plotting the sections for him. Paul brought me the final navigation and spreadsheets. At the 16:00 hours meeting, John Reid asked me to tell the staff that their email accounts would be disabled at 09:30 hours on Wednesday and they would then be given their bills.

John gave me the line km of seismic based on the navigation in the in the SEGY files.

Line km of seismic
148.556
9.3964
89.0987
36.8085
73.0883
115.08
56.8347
61.3391
49.4067
166.8
239.797
56.9492
51.8648
27.7256
22.4848
99.5134
15.5945
39.7365
42.2688
20.4422
112.286

172.298
155.928
195.603
149.168
198.737
8.8171
136.138
435.491
Total: 2987.2513

Day 281 - October 1, 2007 - Monday, - 10^{0}C winds 15 knots

The ship was steaming toward Kugluktuk and we reached 72.125^{0}N, 140.322^{0}W by 07:30 hours. Overnight the gear continued to be disassembled and packed up. Fred had the bundles taken apart. The tow sleds were stripped.

I cannot do any more plotting until the printer in the drafting office is reset and I asked John Reid to help me. I hope it does not take all day because there is a network failure as well. In the meantime, I cut the paper record sections up so they could be laid out as a continuous record. During the day, John reprocessed the seismic profiles and I plotted them. Borden's group was busy disassembling the seismic equipment. Fred who had been on the night shift was now up and busily taking the gear apart as well. The hydrographers were continuing to collect underway bathymetry.

At 19:00 hours, Bob Rowland, who had been part of the US delegation to the UNCLOS treaty negotiations, gave his insights into the UNCLOS history and the development of the seemingly chaotic rules for extending some countries continental shelf. The seminar was well attended by the ship's company.

Day 282 - October 9, 2007 - Tuesday, - 9^{0}C winds 15 knots

The ship was in the Amundsen Gulf at breakfast: 70^{0}38N, 125^{0}05W. Nelson, Jonah and John may be leaving today, if the weather permits, by helicopter. If not, I have to make arrangements for them to fly home from Kugluktuk. I talked to the Captain and then called Nelly to ask her to contact Polar Continental Shelf Project to keep Aklak Air informed about the possibility of canceling their fixed wing flight.

In the meantime, I finished cutting up the seismic sections and John told Larry we would be prepared for a data presentation tonight. When I was talking to Nelly, I booked the AGC Boardroom for Friday afternoon so that we could lay out the data for Jacob.

Nelson, Jonah and John left after lunch on the helicopter for Paulatuk with lots of fond farewells

from the ship's company. Nelson would like to return next year in the capacity of airgun technician and John as a marine mammal monitor. They would be warmly welcomed back. The coast around their home in Paulatuk was snow-covered and the sea was full of round pancake (the size you eat for breakfast) sea ice. Nelson mentioned he wished the ice would stay flat to make it easier to travel on in the winter to his hunting camp that was just visible.

I continued to write DVDs with pictures of the cruise for those that requested them. The pieces of the cruise report are gradually being assembled. I worked with John on the figures he needed for his seismic report.

John and I laid the entire data set out on the boardroom table. This gave us an excellent chance to look at the myriad of features on the seismic profiles and compare them along and a cross strike. Our opinions on the origin of the strong double sub-bottom reflection is changing. Because it is seen on all four dip lines, in context it may actually be the base of a major slump or the base of the Quaternary, when patterns in sedimentation changed abruptly. The number of strike/slip faults involving the basement is striking. This is a key feature in the tectonic development of the basin.

At 19:00 hours we had piped that the data set would be available for the ship's company to view. The turn out was substantial, perhaps 15 people, and the questions continued until 20:15 hours.

Day 283 - October 10, 2007 - Wednesday, - 3.6^{0}C winds 30 knots, open water

At breakfast there was a rosy fingured dawn. Now that are longitude is reduced to 115^{0}W, our sunrise is compatible with the ship's time. We are in Dolphin and Union Strait. The work on the Cruise Report continues at full pace. I went over the Diary, correcting grammar and spelling problems and rearranging sentences. I got the ice and weather section of the report from Ken. John was over to check straight line distances on the Global Mapper program against the actual distances in order to produce a table.

Bob, John and I met to discuss his paper on the difficulties of collecting seismic data for UNCLOS in ice. The figures were discussed, particularly their intent, so that when we are off the ship and have many other projects going on we will be able to focus on the spirit of what is required in the figures. This paper must be discussed with Jacob to ensure that it is within the framework of the tasks we are to be completing for the UNCLOS project.

At 10:30 hours, the scientific email accounts were shut off. We were asked to report to Larry for our bill payment. Due to the complications of my bill, they asked me to return later. I was astounded at the size of my telephone bill for a mere 10 calls. At 14:30 hours, the ship was dropping anchor off Kugluktuk. During the day it rained. Just about everyone is involved in packing up equipment and personal belongings.

Day 284 - October 10, 2007 - Thursday, above freezing

The rain ceased overnight. This was convenient because our luggage must be slung ashore by helicopter. At 07:30 hours, they piped all luggage to the hangar. This caused a rush at breakfast time. Now we will all wait for the opportunity to be flown ashore.

The following are the cabin assignments for the LSSL scientific staff

301 - Chief Scientist - Washroom; Ruth Jackson, phone 191
302 - 2 bunks, with washroom; Jon Biggar, phone 192
303 - 2 bunks, with washroom; John Shimeld, phone 193
304 - 2 bunks, with washroom; Borden Chapman, phone 194
308 - 1 bunk, no washroom; Nelson Ruben, phone 158
309 - 1 bunk, no washroom; Joe Manning, phone 316
315 - 1 bunk, with washroom; Robert Rowland, phone 198
404 - 1 bunk, no washroom; Dwight Reimer
405 - 1 bunk, no washroom; Jim Etter
406 - 1 bunk, no washroom; Mike Ruxton, phone 313
416 - 1 bunk, no washroom; Rodger Oulton
418 - 1 bunk, no washroom; Paul Girouard
506 - 1 bunk, no washroom; Jonah Nakimayak
519 - 1 bunk, no washroom; John O. Ruben
515 - 1 bunk, no washroom; Fred Learning
523 - 1 bunk, no washroom; Ryan Pike

Watches

Mammal Monitors
08:00-16:00 308 - Nelson Ruben, phone158
16:00-24:00 506 - Jonah Nakimayak
00:00-08:00 519 - John O. Ruben

Hydrography
08:00-20:00 309 - Joe Manning, phone 316
20:00-08:00 313 - Mike Ruxton, phone 313

Helicopter Operations
302 - Jon Biggar, phone 192

Seismic Operations
08:00-20:00 304 - Borden Chapman, phone 194 pager
08:00-20:00 523 - Ryan Pyke
20:00-08:00 515 - Fred Learning
20:00-08:00 404 - Dwight Reimer
08:00-20:00 416 - Rodger Oulton, phone 324
08:00-20:00 405 - Jim Etter

Weekly Messages

Sunday, September 9, 2007: -3^{0}C winds, 22 knots good visibility at 13:00 hours

Seismic: Seismic reflection acquisition began at the west end of priority Line 1 on Tuesday September 4, 2007. The seismic track varies 15 km from the nominal track to avoid thick old floes. The seismic track is captured on the ice radar for documentation purposes. The ends of line at present are 74^{0}31N, 142^{0}19W and 74^{0}01N, 131^{0}59W. As of last night, we have fired 16, 276 shots over a time period of 63 hours for a distance of 458 km. We are about 30 km from the end of the first line. The seismic reflection profiles are significantly better quality than last year. At the seaward end of the line there are 5 seconds two-way time of sedimentary strata overlying a well defined basement. After initial start up issues the compressor seems to be functioning. The first sonobuoy launched recorded for a distance of only 7 km. Correspondence with the Oden indicates they are getting the same insufficient range. I may request several Taurus to be sent up to Tuktoyaktuk when we refuel.

Hydrography: The hydrographic team has collected 1150 km of good quality continuous soundings along the seismic line and a line parallel to it half way between Lines 1 and 2 at 74^{0}36N, 129^{0}48W and 75^{0}00N, 141^{0}57W. This line was run while the seismic gear was being set up and to correlate the ice charts with actual ice conditions. An additional benefit was when we were able to initially deploy the guns and streamer in optimal conditions. The ice is of less concentration in the west than the east of our survey area. A total of 7 casts XSV, XCTD and SV2 have been completed and 24 spot soundings depths 3566 to 2138 metres.

Marine Mammal Monitors: Our three marine mammal watchers are part of the team and are great to work with. There has been little wild life to observe. Jonah Nakimayak reported succinctly that "he was glad he did not live here because he would starve to death". The Quarter Master also pointed out he had not seen a bird since leaving Kugluktuk. The paucity of marine mammals may be the reason we saw a polar bear eating a polar bear cub before the initiation of the seismic program.

Resolute: The Captain's plan to take the ship into Resolute will increase the number of working days we have. The ice to the north of our survey area is unusually light for this region. If the conditions remain stable we will gradually work north leaving the southern and most accessible line for another year. The distance to Resolute from the north section of our survey area is shorter than the distance back to Kugluktuk, saving more time. Jon Biggar may also have unused drummed fuel on board, perhaps 80-90 drums, that could be offloaded in Resolute in preparation for ice camp work. Furthermore, if we refuel on October 7, 2007 there will be no point in returning to the survey area causing the loss of two days of ship time. An earlier fueling actual may save two days.

The Captain, Deck Officers, Engineers and crew have been consistently helpful. Without the support of the engineers the survey would be over because the new compressor had a failure that required significant machining. The seismic group under Borden works a minimum of 12 hours a day. More often it is 16 hours, to keep the system operational. The IceNav system has proved invaluable. There is a fifty-fifty chance of a medical evacuation tomorrow.

If you name a time I can call you or I can be reached 24 hours a day. Please acknowledge receipt of message.

Cheers Ruth

*****

Sunday, September 16, 2007

Seismic: Line 2 was successfully completed over a erratic track 829 km long from the 2500 m contour seaward to maximum allowable claim. In the deepest water of over 3500 m, basement is visible even on the noisiest of the record sections. With low winds and rotten ice, the data quality are excellent.

The compressor and airguns are working more reliably than along the first line. Freezing up of the airguns remains a problem, in spite of the antifreeze injected into the air hoses. Major damage was done to one of the tow sleds when we were firing three airguns and it is now inoperable. We are now using only two guns with a total capacity of 1040 cu in. The refueling stop on September 27, 2007 provides the opportunity to get an I-beam to repair the sled.

Hydrography: The hydrographic team has collected 1124 line km of bathymetry, 42 spot soundings to date utilizing 9.3 helicopter hours, a total of 3 SVP (Sound Velocity Probe) casts and 4 XCTD (Expendable Conductivity, Temperature and Density) were completed.

Marine Mammal Monitors: Our three marine mammal watchers have kept constant watch. There have been few mammals or birds to observe. One polar bear with three cubs was sited on the ice this week. The airguns were shot down until we were 1 km away from them.

Ice Conditions: We had winds for several days of 25 knots and the honeycombed rotten ice dissipated at the west end of Lines 2 and 3. For 24 hours we experienced open ocean conditions with wave heights of several meters. Actually the sea state degraded the overall quality of the data but it made it easier to do continuous data collection. The winds dropped, we are back in the ice pack and the data quality improved.

*****

Sunday, September 23, 2007

Seismics: Profile 3 at approximately $76^0$10'N was successfully completed over an erratic track 615 km long. This line forms a loop that connects with line 2 because the ice conditions prevented the ship from towing seismic gear near the slope. A gap in seismic Line 2 was filled so that we have complete coverage to the 2500 m contour. The data quality are excellent and the processing that is being done by John Shimeld continues to refine the records. Freezing up of the airguns after remaining on the deck at -13^0C remains a problem, in spite of the antifreeze injected into the air lines.

The ship is steaming to the start of the southernmost planned line. On this fourth line the seismic

acquisition equipment will be in the water up to the time required to travel to Tuktoyaktuk for refueling and the Minister of Indian and Northern Affairs visit to the ship.

Hydrography: Sounding operations took place all week: 1018 km of bathymetry were acquired and 28 spot soundings were collected. We used 7.5 helicopter hours. Also accomplished was 1 SVP (Sound Velocity Probe) cast and 1 XCTD (Expendable Conductivity, Temperature and Density).

Marine Mammal Monitors: The three marine mammal watchers have frequently sighted polar bear tracks. Two bears were observed close to the ship when we were not firing the airguns.

Ice Conditions: At the eastern end of Line 2 the ice conditions increased to nine-tenths with old floes. There is now a snow cover on the ice, making it difficult for the Officers on the Bridge to find a way through the floes in the dark. Towing the seismic gear in these conditions puts it at risk for severe damage and/or loss. For three nights in a row it was necessary to stop collecting seismic profiles from midnight to 08:00 hours in the morning.

*****

Sunday, September 30, 2007

Seismics: Profile 4, the southernmost reflection line in the survey, was initiated a week ago. High quality data were recorded along nearly half the line before it was necessary to steam to Tuktoyaktuk for refueling and the Minister's visit. The line was picked up on Saturday, September 29, 2007 at 10:00 hours. Then the Hurricane compressor developed leaks in the cooling system. The first one discovered was in the low pressure section of the compressor. It was nursed along overnight and took four hours to repair. The second leak was found after restarting the compressor in the middle stage at 600 psi constituting a safety issue as well. The seismic gear was back in the water by 16:00 hours Sunday evening. The total length of seismic reflection profiling this week was 270 km.

Borden was able to diagnose the problem of poor signal to noise on the WiNRADiO receiver for the sonobuoy data. The digitizer had been built with the channel wires crossed. The data quality has improved dramatically. On the last three sonobuoys launched, we recorded three good reflections from the sedimentary section to the basement.

Hydrography: This week, 1724.5 km of continuous soundings have been collected. There were 2 XCTD, 1 bar check and 1 SVP. In addition, 11 spot soundings were made.

Marine Mammal Monitors: In open water between Tuktoyaktuk and the edge of the ice four bowhead whales were sited when we were steaming back to the survey lines. This week three polar bears were sited. Only one bear was close enough to the ship during seismic reflection profiling to necessitate the shutting down of the airguns.

Fuel: The fuel barge did not arrive on time. We waited until 16:00 hours on the second day for fueling to begin and it lasted into the night. We sailed on Friday morning. The new I-beams, Synflex hose and spare parts for the Hurricane compressor were delivered to the ship by this barge.

Minister Visit: While at anchor, the Minister of Indian and Northern Affairs flew to the ship. Chuck Strahl exhibited clear interest in the UNCLOS program and the success we were having in collecting the data to fulfill the requirements for claiming the maximum territory possible in the western Arctic. I have received a request for an interview from Mark Winkler, a CBC Reporter, tel. 876-777-7617. How should I reply to him?

*****

Sunday, October 7, 2007

Seismic: We collected 1124 km of seismic reflection profiles this week and the total for the cruise is 2987 km. The total number of sonobuoys that recorded refractors is 22.

The cruise track was complex this week. We completed Line 4, the southernmost and last of the four priority lines in the cruise plan. Next we steamed to the west end of Line 3, the farthest north line. We acquired seismic data over a distance of 149 km until stopped by the ice at $76^0$38N, $157^0$31W. Profile 6 was run along 350 nm maximum claim boundary. This line continued until we reached the Exclusive Economic Zone (EEZ) of the U.S. Line 7 starts east of the U.S. EEZ and extends to the west end of Line 4. Line 8 starts at the west end of Line 4 and continues to near the west end of Line 1.

The seismic operation has ended and the equipment is being prepared for packing up and storage on the ship until it returns to home port. The hydrographic program is ongoing.

Hydrography: This week 1447.2 km of continuous soundings have been collected. here were 3 XCTD, 1 bar check, 4 XSV and 2 SVP. In addition, 54 spot soundings were made.

Other: The seismic group (Borden Chapman, Bob Rowland, John Shimeld and myself) would like a debriefing meeting with you on Friday, October 12, 2007 at 02:00 hours. Please let us know if this is possible. The scheduled flight from Kugluktuk to Halifax is to land at midnight on October 11, 2007.

*****

Hi Dick and Jacob:

Response to refueling date question: The Captain, Jon and I met in the chart room with a map. We went over the program, i.e. the four lines submitted to the Coast Guard. There is no significant difference in the working days with a refueling during or at the end of the cruise.

We estimate that it will take 7.5 days to finish Lines 2 and 3. This provides a natural break in the program. About three days transit will be required for the refueling that would occur on or about September 25, 2007 and that date would leave us two weeks to work. The ship would head north of the proposed survey and work where the ice conditions allow. The Captain proposed to be at the western end of the southern line, called 4 on our plans, on October 2, 2007.

It is important that there is a mid-cruise break. The seismic gear sustains damage every day that

takes hours to repair. These repairs are stop gap measures. The seismic equipment will need significant attention including time-consuming modifications that can take several days. Having an extra two days in Kugluktuk at the end of the cruise does not address this need. The technical team has been working 16 hour days; in particular, one individual is critical for the operation. I suspect that the long term operation of the array is related to him getting to sleep at regular hours.

We would like specific spares: the compressor company shipped the wrong filters. The ice has damaged a significant number of high pressure air hoses and fittings as well. The Danes are willing to ship us one of their deck cables for the hydrophone array. These are specially manufactured by Geometrics and have lead time of many months to build once you have the purchase order. One of the two we bought leaked on its first deployment. (The company claimed that this is the first leak that has ever occurred in their fitting.) If we damage the other deck cable, major fabrication will have to take place at sea. This includes cannibalizing of other sections of the streamer for parts and attempting to water proof the connectors that may or may not prove to be effective.

The sonobuoys are not producing sufficient range to give us velocity information. The Danes on the Oden (Thomas Funck) experienced the same problem. I would like two Taurus shipped from Ottawa to see of we can up an alternate way of recording the wide angle reflections. We need to start working on a solution to the velocity to depth conversion problem.

The Captain, Jon and I agreed that a mid-cruise refueling has advantages for the science program.

Cheers Ruth

*****

Hi Thomas:

The name of the GSC Atlantic custom broker is Atlantic Custom Brokers. Our account number is B0201. There telephone number is 902-422-1225, the fax is 902-429-3350. The bill for shipping can be sent to GSC Atlantic, 1 Challenger Drive, P.O. Box 1006, Dartmouth, NS B2Y 4A2, Attn: Barb Vetese.

Last night, when its was necessary to haul the airgun array to enable the third gun again, it was discovered that two of the I-Beams on the sled had cracked. This was caused by the two stern guns colliding with them repeatedly. The chains had been shortened to prevent damage to the fittings on the airguns. The sled is not reparable at sea. We are down to one sled for the duration.

You must be ready to leave the ship now. See you in Halifax. Ruth

4. A Technical Review of the Operation of an Ice Strengthened Towed Seismic System

Prepared for Natural Resources Canada
Geological Survey of Canada (Atlantic)

October 2007

C. Borden Chapman, etc.

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Preamble

In the late summer of 2007, Natural Resources Canada supplied equipment and personnel to undertake a seismic program to determine sediment thickness in the area of Canada Basin. The program used the Canadian Coast Guard Ship Louis S. St. Laurent as the operational platform for the six week period commencing August 30th and running until October 11, 2007.

Background

In 2006, NRCan employees were involved in testing of a prototype seismic tow system designed to work in Artic ice conditions. This work included evaluating the performance of a prototype "tow sled" capable of withstanding interference from sea ice as it was towed from the stern of the CCGS Louis S. St. Laurent. They also looked at ship board deployment and recovery methods to determine where improvements in overall procedures could be made. Recommendations were made in report form and submitted to both CCG and NRCan managements.

The results of these recommendations were evaluated and acted upon. During the lay-up of the ice breaker in 2006-7, extensive modifications were made both to the ship and to the NRCan towing system. The modifications have yielded a robust and capable system for the collection of seismic data in ice conditions up to 8/10 ice coverage.

Equipment

In order to carry out a seismic program of this kind there are three principle groups of equipment that have to be assembled. This report will deal with each group, describing the specific components in that group and elaborating on areas of how it functioned, where problems arose throughout the program, solutions to those problem areas and possible recommendations for future modifications or additions to make the process more streamlined.

The three major components to be described are: a) Tow sled and G Gun equipment; b) Compressor and air distribution system; c) GeoEel streamer system and Sonobuoy system.

Three Appendices were provided as attachments to this report: Appendix A covered the safe deployment of the seismic equipment over the stern of the vessel; Appendix B, a copy of spreadsheets for the compressor covering the complete operational period; and Appendix C outlined the safe start up procedure for the Hurricane air compressor.

Part A

The Tow Sled Systems

Figure 4:1. Port Tow sled in its bench with three G-guns fitted (2006).

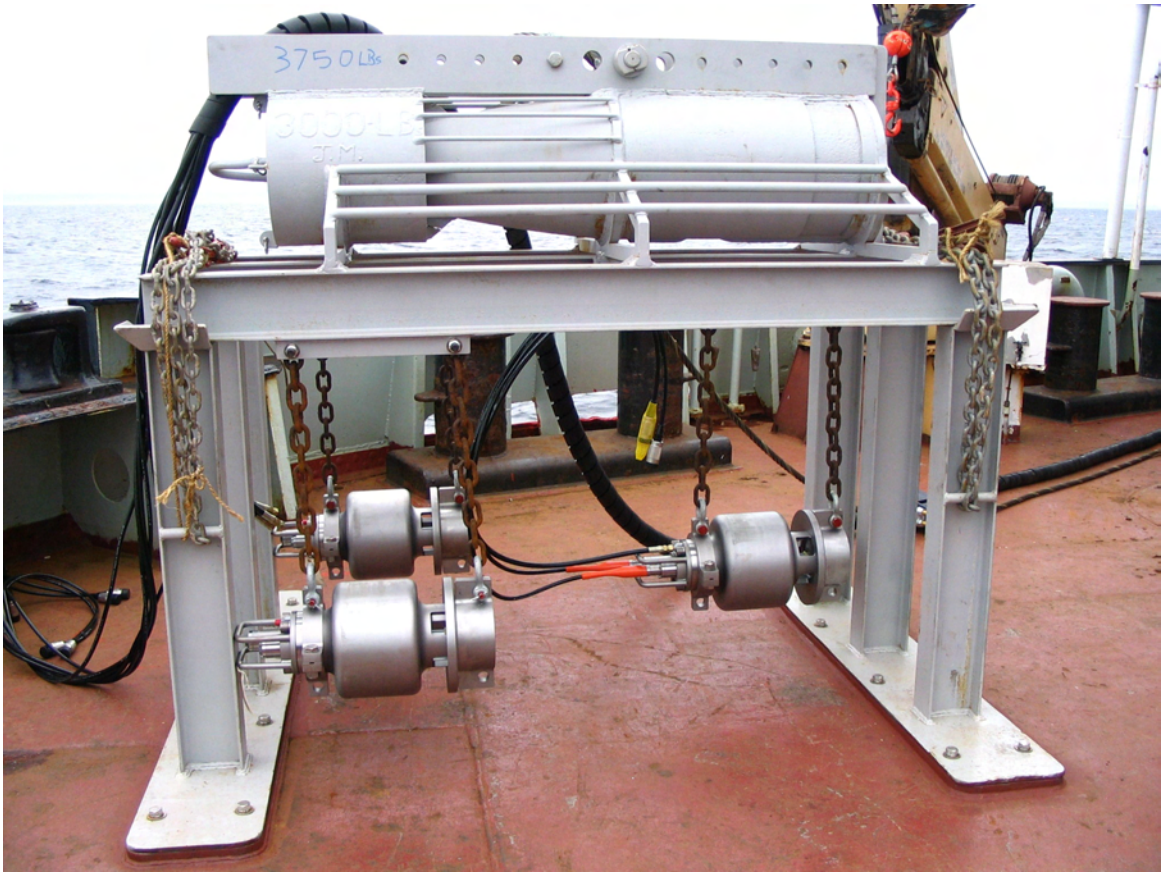


Figure 4:1 shows the tow sled system incorporating a hydrodynamic depressor weight salvaged from a 16" artillery shell casing and filled with lead. This shell casing was affixed to a cradle that supported three steel "I" beams. In turn the "I" beams supported the three airguns. Suitable pull and lift points are positioned on the top of the sled which allow for towing and recovery of the sled. The sled footprint has been deliberately kept small to reduce the surface area available for contact with the sea ice. Dimensions are approximately 40" (1 meter) wide by 70" (2 meters) in length by 40" (1 meter) high. Total weight for the sled, with guns fitted, is approximately 5000 pounds (2300 kg).

A bench was fitted to the vessel to allow the sled to rest on deck as shown in Figure 4:1. The bench also allows access to the three Sercel 520 cubic inch G-guns mounted under the sled and to the piping and electrical connections to and from the guns. While submerged, the tow sled follows the vessel with very little yaw or attitude change even during times when heavy power is applied to the ship’s propellers.

Suitable bars and guards were added to the body of the sled to accommodate the hoses and electrical cables. These protect the air and electrical cables from contact with the ice during towing and also during deployment and recovery. A duplicate tow sled system was built and installed on the vessel in 2007.

Figure 4:2. An aerial view of the newly fitted A Frame and two Tow Sleds.

Pull Cable and Cable Bundle

The sled was attached to the vessel using a 1" (2.54 cm) steel cable. The inboard end of the "pull cable" was affixed to the centre bollard amidships of the quarterdeck. The overall length of the pull cable was 75' (23 meters). This provides for a fixed pull depth of 9 meters to the top of the sled and a gun depth of 10 meters. The pull cable had a breaking strength of 100k pounds. On the pull cable there were a series of "eyelets" installed at 12' (3 meter) spacing starting at 12' from the top of the sled. These ½" steel cable eyelets were nicropressed onto the 1" pull cable. They served as pull cable "lift points" during deployment and recovery. See Figure 4:

Figure 4:3. Pull cable showing one of the fitted recovery lift points.

During the program the sled encountered numerous incidents of direct ice contact. Some of the bars and guards were bent due to this ice impact but no damage to the cabling occurred as a result in these ice impacts.

The pull cable also served to support the cable bundle. The cable bundle or simply "bundle" was fitted to the pull cable by a total of seven bundle clamps (see Figure 4:3). These bundle clamps rotate freely about the pull cable but grab the plastic bundle wrap securely. Because the bundle

clamps freely rotate on the pull wire, the cable bundle can contact ice and be deflected behind the pull wire and away from the ice. The pull cable will actually help to deflect ice away from the cable bundle in this manner.

The cable bundle consists of the following individual components:
(a) 3 - 2 conductor electrical cables for delivering firing signal voltages to the G-gun solenoids
(b) 3 - 2 conductor electrical cables for sending the time break signals from the guns to the shipboard control computer
(c) 3 - ½"Synflex air hoses for delivering air to each of the three G-guns
(d) Armored multicore cable for the GeoEel system.

All the cables and hoses were wrapped by a product known as Omni Wrap. This heavy plastic wrap served to protect the bundle components and offered good protection under survey operating conditions such as during ice contact. It also offered limited access to specific areas of the cable components if one cable was damaged by ice and needed minor repair. The wrap could be completely removed and reinstalled if one component inside the bundle needed to be replaced. One of the greatest benefits of the product is that although it does an excellent job of containing the bundle components, it allowed the individual components to move or "give" inside the bundle in the event of ice contact. This served to greatly reduce the problem of repair downtime. As there are no special armored cables or custom made umbilical's, the cost of repair becomes quite insignificant.

Figure 4:3. Assembled bundles showing pull cable and bundle clamps fitted for deployment.

Airguns

The airgun used for this program was chosen specifically for its compact size, peak power and the low frequency spectrum of the emitted pulse. Program requirements were for the gun array to produce enough of a pressure wave in the very low frequency range (1 to 120 Hz) to penetrate up to 5 km of bottom sediment. The 520 cubic inch Sercel gun has a centre frequency of 40 Hz and peak power of 6.5 b-m at a tow depth of 10 meters.

Spacing of the guns on the sled was set to specifications provided by Sercel. From port to port to port of the three guns, distance was 1 meter. This distance was set to produce an optimum focused pulse.

The three G-guns were suspended below the tow sled "I" beams using three sets of two- 45 cm long, grade 80- 5/8" chain.

Early in the program damage to the two aft gun electrical connectors was an ongoing problem. Although there was expected to be some moderate recoil associated with the G-gun when fired, there was enough movement when the guns fired to cause the two aft guns to contact each other. This repeated contact severely damaged the gun connectors and air lines thus requiring frequent recovery and repair.

Figure 4:4. Aft G-guns on the starboard sled fitted with improvised spreader bars.

Several options to eliminate the gun impacts were tried. Firstly, spreader bars were constructed and installed fore and aft between the lower "ears" of the aft guns on the starboard sled. (See Figure 4:4). This reduced the wear and tear but also posed a new problem by increasing the contact area of the sled and guns to sea ice. On the last recovery using the spreader bars, one of the bars was completely torn free of the guns and the second was bent to 60 degrees as a result of ice contact. The spreader bars were discarded from further use.

A second approach to reduce gun collision was implemented. On the starboard tow sled the 45 cm chains were shortened. This proved to be quite effective but produced a much more undesirable affect on the sled structure. The energy released when the gun fired caused a severe torque affect that was transferred to the sled “I” beams. This repeated twisting, which under earlier shooting conditions was dampened by the 45 cm chains, caused metal fatigue and resultant failure to the “I” beams. Cracks developed in both lateral and longitudinal directions immediately above the gun

suspension points.

Figure 4:5A. Starboard Tow Sled showing lateral “I” beam damage (port side of sled).

Figure 4:5B. Starboard Tow Sled showing lateral “I” beam damage.

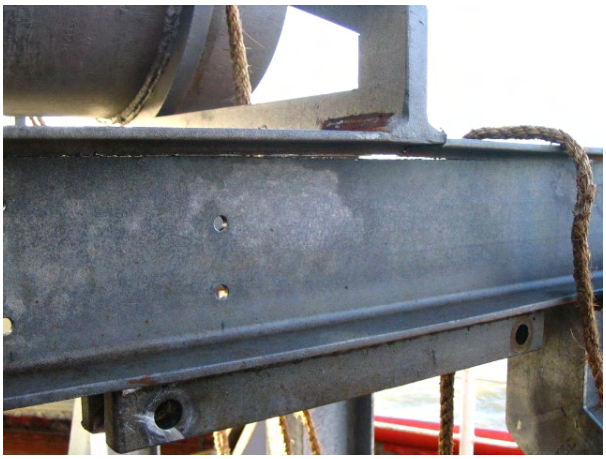


Figure 4:5C. Starboard Tow Sled showing longitudinal “I” beam damage (port side of sled).

There was no immediate way to repair the damage on the starboard sled. An order for replacement beams was made to NRCan (GSC Atlantic) and arrangements were made to have replacement "I" beams delivered to the ship during re-fueling in late September. This would allow for repairs to be made to the starboard sled if failure to the port sled occurred.

The damage to the starboard sled was realized as an engineering flaw, the 45 cm chains were again fitted to the after guns on the port sled. It was further decided that the use of three guns, although desirable, was not really necessary for the program. From that point onward, two guns were fired rather than three. The net affect was a great reduction in down time repairing the sled system and extended towing periods between repairs, often exceeding 36 hours between recoveries. Data quality suffered little from the loss of the third gun.

Throughout the remainder if the program, only the port sled equipped with two 520 cubic inch guns was used to collect seismic data.

One of the conclusions drawn from the trials of 2006 was the issue regarding the need for protective collars around the top of the guns. Stainless steel half shell clamps were fabricated and proved effective in preventing damage to electrical connectors and air lines. As stated previously, the incidents of aft gun collisions was eliminated by using only two guns on the sled. The collars sustained severe damage while the three guns were operating, but it is felt that without these collars, damage to the gun fittings would have been much more severe and occurred more frequently.

Figure 4:5D. G-gun with collar protectors fitted.

Deployment of the Sled System

In 2006 the deployment of the sled system was very difficult. After many trials using various deployment methods it was decided that to best address handling and safety issues an A frame must be fitted to the vessel. During the winter months of 2006-7, a satisfactory system was designed and a contract let for the fabrication and installation of the A frame. Installation was completed in the late spring of 2007, prior to the ship's departure. Having the A frame allowed for an improvement in safety handling the heavy weight and also allowed for two identical systems to be installed under the A frame on the quarterdeck. Having two systems meant that if one system required repair, the second system could be swapped out quickly. This reduced down time and maximized ship usage.

Two tugger winches were fitted to the forward end of the quarterdeck. Each winch was used to deploy and recover respective port or starboard tow sleds. It was realized that the second tugger winch could be used to better handle the pull cable and bundle during the recovery procedure. This became quite easy to do when the starboard sled failed and so the starboard tugger winch was used exclusively to recover the port bundle.

Figure 4:6. Showing port and starboard tugger winch locations.

Part B

Compressor and Air Distribution System

The seismic program required that the air delivery system must be capable of supplying enough compressed air to fire the three Sercel 520 cubic inch G-guns at a maximum shot rate of 12 seconds. This required an air compressor capable of producing the compressed air at volume and maintaining the pressure at a preset 1850 PSI. NRCan (GSC Atlantic) procured a Hurricane Compressor Model 6T-276-44SB/2500 which is an air cooled, self contained compressor system. The power source is a C13 Caterpillar engine which drives the 4 stage compressor capable of developing 600 SCFM @ 2500 PSI compressed air. This compressor was mounted inside a custom designed enclosure which provided protection from the marine and Arctic environment.

This enclosure was mounted on a newly fitted structure that has now been called the boat deck extension on the starboard side of the vessel next to the hangar. This extension was added during the winter of 2007, to accommodate the 12' x 20' container. Total weight of the enclosure and the contents is approximately 11 tons.

Fuel for the diesel compressor was supplied by the ship. During the entire program, approximately 8000 liters of diesel were burned by the compresspr. A total of 325 operating hours was tallied over the program period. NRCan and its contractors provided the day to day maintenance and watch standing personnel. A record of all compressor status readings is included as Appendix 2 of this report.

The compressor system was able to supply the necessary air for the seismic program. It did however, require an inordinate amount of service especially for a new machine, which when delivered, had a total of only 25 running hours on the clock.

A brief list of difficulties encountered while operating the compressor is shown below.

(a) Fuel gauge reads inaccurately.
(b) Numerous freeze-up issues associated with water trapped in the gauges and control lines.
(c) Pillow block bearing failure.
(d) Automatic moisture dump system on the 2nd stage failure.
(e) Oil leak in the drain valve of the Cat.
(f) Drive coupling loose.
(g) Numerous bolts loose or shearing from vibration.
(h) 4th stage air discharge pipe fitting broke at discharge head.
(i) Incorrect spares supplied by the manufacturer.
(j) Pop valve assembled incorrectly and incorrect spare supplied.
(k) Universal joint failure on forward end of drive shaft.

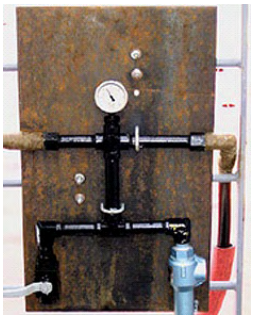
Fortunately, with the help of the engine room staff, NRCan contract personnel were able to address and rectify all the above problems. By program's end the compressor was performing as expected.

A second safety shut down switch was mounted next to the forward end access door of the enclosure to permit immediate shut down of the compressor from outside the enclosure if

necessary. This was not used during the program but was tested before start up of the compressor as part of the safe start-up procedure which is in Appendix 3 of this report.

Discharge air from the compressor was delivered to a safety/dump valve manifold mounted on the rail outside the aft inboard end of the compressor enclosure.

Figure 4:7. Safety relief manifold with blow down valve outside of compressor enclosure.



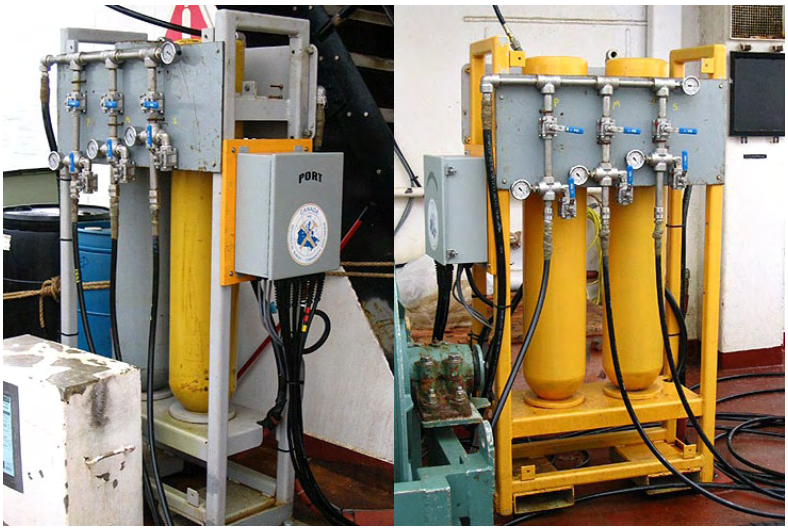
This manifold was installed to act as a safety relief and blow off system located outside the compressor in the event that there was a dangerous situation inside the compressor enclosure. There was a safety "pop" valve set at 2250 PSI and a manual dump valve located on the steel plate mounted to the after rail in the boat deck extension.

High pressure air from the safety relief manifold ties directly into a 1" delivery pipe that runs to the starboard side of the quarterdeck area. At this location a gauge and dump valve are located along with a "T" fitting which is the supply point for the air reservoir tanks and gun supply manifolds.

Figure 4:8. Air dump and pressure monitor gauge at bulkhead Quarterdeck area, starboard side.

Air was delivered to the two sets of reservoir tanks, port and starboard side of the quarterdeck from this manifold by ¾" Synflex air line. The ¾" Synflex air line was wrapped with red water hose and protective steel channel was placed over the hose and welded to the deck. This provided safety to ship's personnel and protected the air line from traffic damage.

Figure 4:9. Air reservoir tanks Port and Starboard side.



The reservoir tank manifold system provided individual monitoring and control of the delivery of high pressure air to each airgun. Each set of tanks was equipped with a check valve. This prevented high pressure air from escaping to atmosphere in the event of a break in the ¾" Synflex air line running from the bulkhead distribution point on the starboard side of the quarterdeck to the tow sets of tanks.

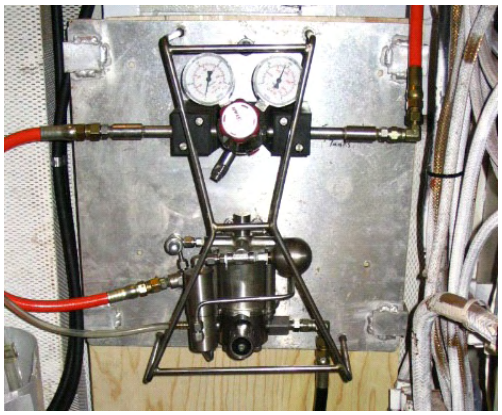
The manifold on each reservoir allowed an individual gun to be charged or air dumped by a set of valves specific to the gun being worked. Gauges were provided on both sides of each valve to indicate the presence of high pressure air. This was the connection point for the air lines in the cable bundle.

The manifold reservoirs also served as a point where the electrical lines from the bundle mated to the firing control system lines running from inside the seismic lab. In Figure 4:9 the port side junction box is labeled with a GSC crest and a "PORT" designation. These boxes allow the technician access to the electrical lines running to the tow sled. Here continuity and resistance measurements can be made to check gun electrical performance.

Figure 4:10. Electrical junction box for starboard sled showing internal wiring**.**

Antifreeze Injection System

Figure 4:11. Antifreeze Injection System.



Throughout the seismic program, the gun system was operated at temperatures where freezing of water trapped in air lines was an issue. To reduce the affect of freezing on the air system, an injector pump was employed to introduce bio-degradable food grade antifreeze into the high pressure air system. This antifreeze is sold under the brand name of “NoTox2” and is safe to use in high pressure air delivery systems such as aboard the vessel.

The injection system used control air of 80 PSI to run a pump that drew small amounts of antifreeze into the pressure chamber. Then a piston forced open a check valve to dump the antifreeze into the high pressure air reservoirs. The timing cycle of the injection could be adjusted from several seconds per cycle to 1.5 minutes per injection. This finite control was accomplished using a small needle valve which controlled the amount of air pushing on the injector piston. It was determined, by trial, that a 45 second cycle rate was optimum.

This is a very unique system and was a “one of a kind” when purchased. At the start of the cruise a hardware problem caused the pump not to draw antifreeze from the supply container. This was traced to an input check valve seat which was replaced with a new part, from spares.

Initially the injection system was setup inside the compressor enclosure. As the ambient air temperature inside the enclosure was at or just above freezing the pressure regulator that supplied the 80 PSI needed to run the injection pump, continually froze. The injector system was then moved inside the Av Gas area, port side, aft. Because it was relocated inside the Av Gas area and close to the air reservoirs, it was not delivering antifreeze through the entire distribution system, only from the reservoirs to the guns.

It is suspected that the majority of ice locked in the air distribution system originated in the approximately 175 feet of 1” steel line that ran from the compressor to the quarterdeck. This posed a logistical problem as temperatures dropped to -10°C and below. The ice-up condition increased in frequency during system start up as temperatures dropped, resulting in frequent icing of the guns when first fired. Measures were taken to reduce the start up icing issue by first delivering a small amount of antifreeze directly into the bundle air hoses at the air reservoirs. After some trials, it was found best to open the air lines at the guns, with the compressor running, and dump the lines just before deployment. This helped to remove moisture trapped in the lines before the guns were deployed. It proved to be the best defense against freezing but did not guarantee that the guns would not ice after the first shot.

It is estimated that at an injection rate of 1 pump every 45 seconds, the program used approximately 30 gallons (130 liters) of NoTox2 antifreeze over the 6 week period.

Air Delivery Summary

Issues with the operation and maintenance of the compressor were sorted out over the program period. Much knowledge has been gained into the operation and the required maintenance of this machine. The compressor will be discussed in detail later in the report.

During the program there was only one incident of a damaged air line. This was due to chafing of the line on the steel of the port sled. This problem was addressed and corrective measures to prevent the chafing were taken.

On one 24 hour deployment the air line connection at the mid ship gun loosened but this did not greatly impact the gun performance so it was left to leak until the sled was recovered. It is believed that the connection backed off due to a twist/ misalignment of the air hose during installation.

The Sercel G-guns performed extremely well with no incidence of time lost due to gun mechanical failure. Icing issues were addressed and a "work around" was developed which proved less than successful. Additional work is needed to address the icing issue for future years.

The overall performance of the air distribution system was judged favorable. Issues which have been deemed important for future years will be addressed prior to future programs.

Part C

GeoEel Digital Seismic Streamer and Deck System

The Geometrics GeoEel digital streamer system was used throughout the survey to acquire reflection seismic data. The streamer was towed from the aft end of the tow sled at a depth of 10 meters. The streamer was configured in such a way as to obtain good reflected seismic signals while keeping the total overall streamer length as short as possible thus minimizing the possibility of ice contact. Two active 50 meter sections were employed in this configuration.

The seismic signals were received by Geopoint hydrophones in the active streamer sections. These signals were digitized by 24 bit A/D modules which form part of the streamer system. The digitized seismic signals were sent up the cable as UDP data packets to the surface deck unit and transferred there onto the acquisition system where display, control and logging features were available. The software program called Stratavisor was run to do these functions.

Included in the Stratavisor software was a streamer depth monitoring option. Depth sensors were fitted within the active sections of the streamer. The depth sensor signals were sent to the deck unit via RS232 wires in the streamer. The active section tow depth was displayed at the bottom of the Stratavisor program run screen.

Also fitted to the streamer sections were modem coils for an altitude control system available from I/O Systems called a DigiBird system. This option was not used during this program as there was the possibility for contact with sea ice that might result in damage to the DigiBirds or the streamer itself. To this end, a drogue chute or tail weight was used to reduce streamer vibrations and keep good tension on the array while being towed. During the program one drogue chute was damaged by ice contact. While in heavy ice areas the drogue was substituted by a simple shackle on the end of the 30 meter tail rope.

Table 4:1. The GeoEel Deck System as fitted.

The Deck System, as supplied by Geometrics, is made up of these key components:

1. Rack enclosure
2. PC based 3.00GHz Computer with 2GB memory, 2-500GB Hard drives
3. Geometrics Stratavisor NX Version 4.51 Operational Software
4. Geometrics GeoEel SPSU Deck control Unit With Aux/Depth
5. Xantrex XFL 60-20 DC Power Supply Unit
6. APC Smart-Ups 2200 Battery Back-up Unit
7. Lab to Deck Cable - SN DC01063 25M

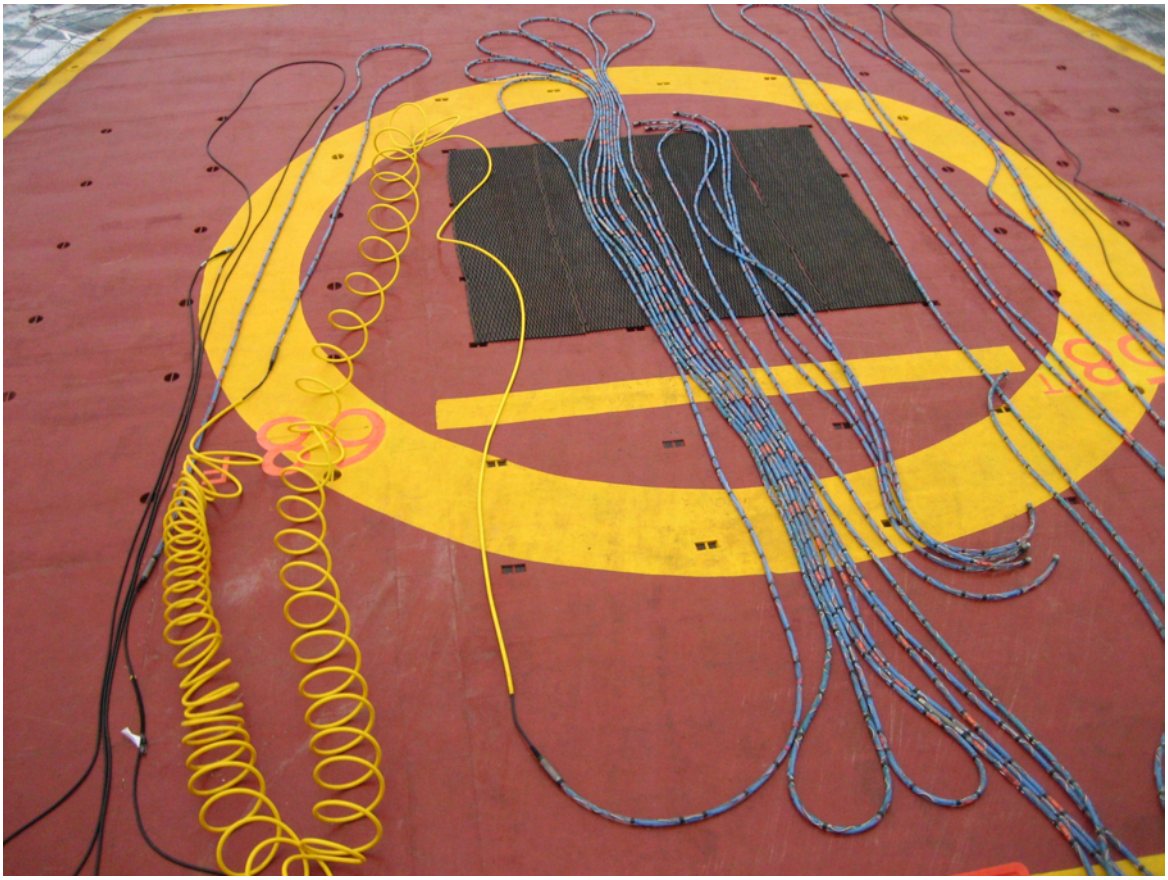
Figure 4:12. GeoEel Deck System in the Seismic Lab of LSSL 2007**.**

Table 4:2. GeoEel Streamer Configuration - Wet End.

1. Armored Deck Cable with Flexterm and Kellum Grip section
   SN DC1067 (Runs out through Control/Air Bundle) 50M
2. Repeater Unit SN RP1084
   Tow Cable with Floatation with Flexterm section SN TC1066 100M
3. Repeater Unit SN RP1085
   Stretch Section SN S01077 25M
4. 8 Channel A/D Converter Unit SN DG01172
   Active Hydrophone/Depth Section SN ARD1057 50M
5. 8 Channel A/D Converter Unit SN DG01176
6. Active Hydrophone/Depth Section SN ARD1052 50M

7. Stretch Section SN S01074 25M
8. Tail Swivel Connector SN TS01002
   Shackle, Rope and Drogue net/Weight 30M

Figure 4:12. Digital Streamer System on Flight Deck of LSSL -2007.



A GeoEel armored deck cable was included within the cable "bundle" lines for each tow sled, both Port and Starboard. A Kellum Grip, affixed to the outboard end of the armored deck cable, was attached to the 4 point tow bridal which was secured to the rear of the tow sled. This served as the streamer tow point.

The GeoEel sections were attached to the streamer in the order listed it Table 4:2. Each connection was tightened using the tool provided by Geometrics, cleaned, and taped over using 3M Scotch 130C Splicing tape, 3M Scotchkote Electrical Coating, and 3M Scotch Super 88 Vinyl Tape. As per Geometrics suggestions, the oil filling screws and set screws were covered by the tape.

The overall length of the streamer aft of the tow sled was approximately 305 meters, 275 meters of streamer and 30 meters of rope/drogue.

The Analog to Digital Converter Module converts 8 analog hydrophone inputs plus depth data and transmits this digital data via TCP/IP on an Ethernet cable to the SPSU (part of the receiving system) and then onto the host computer. It re-transmits Ethernet packets up or down the streamer

to or from other A/D modules. Depth data from active sections fitted with a depth sensor are also sent up the streamer on a separate line.

The 50 meter Active streamer hydrophone sections consists of 8 individual analog channels having 64 hydrophones arranged in groups of 8 hydrophones per channel at 6.25M group interval or 4 individual analog channels having 64 hydrophones arranged in groups of 16 hydrophones per channel at 12.5M group interval. See software manual.

The Ethernet Repeater units are required at either end of sections that are 100 meters in length. In our configuration, the Wet tow cable is 100 meters long and requires a Repeater module at each end.

Issues arising with the GeoEel System

It was intended that the GeoEel streamer would be recovered using a winch placed on the Starboard side of the quarterdeck. The streamer was to separate from the lead in deck cable at a connector located just behind the tow sled. It would then be attached to the recovery winch and pulled inboard by the winch. Unfortunately this was not to be for two reasons.

The winch chosen for the recovery of the streamer was inadequate for the task. The drum size, although ok in diameter, at one meter, was not large enough to hold the total streamer length of 300 meters.

The second reason the winch could not be used was a mix-up in manufacturing. The streamer deck lead, as supplied from Geometrics was equipped with a 10 meter vibration section attached to the deck cable. This was not supposed to be the case. The vibration and then stretch sections were to form part of the streamer that was to be separate from the lead in cable. This would allow ship personnel to better manage the transfer of the outboard streamer from the deck cable to the recovery wire on the winch.

These problems will be rectified over the winter of 2007.

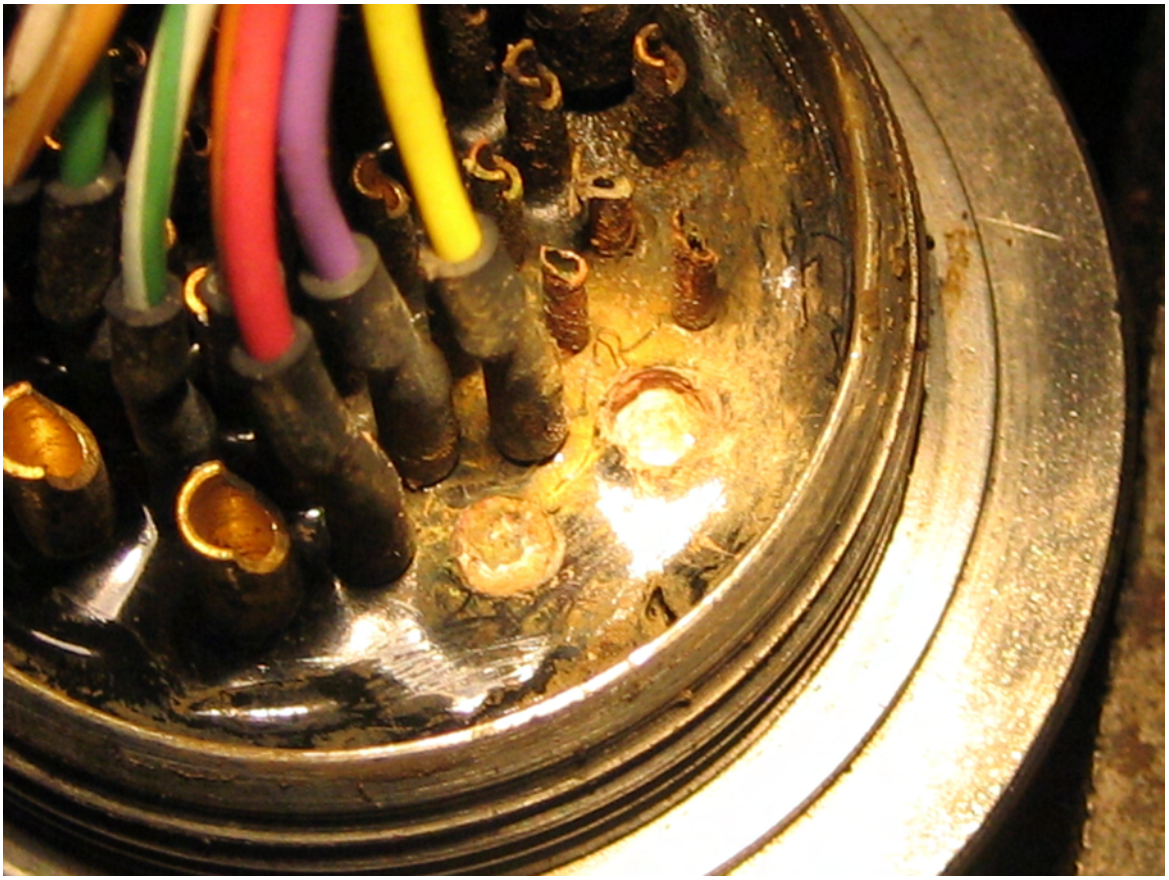
There was water ingress onto the vibration section of the deck cable attached to the port side bundle. This leak occurred after a short deployment period of less than 12 hours on the first day of the cruise. The water collected at the inboard end of the vibration section contaminating the fluid and causing considerable damage due to electrolysis in the electrical connector.

The streamer was disassembled upon recovery and the starboard tow sled was deployed. The streamer cable was removed from the cable bundle and repairs were attempted.

During disassembly it was noted that the salt water had corroded the two +60 VDC supply pins completely from the connector on the outboard end of the vibration section of the deck cable (see Figure 4:13). The remains of the pins were carefully cleaned and new wires were soldered onto the pins. The repaired vibration section was flushed twice with new fluid to rid the salt water from the system, and then reassembled.

Unfortunately the repair was not successful after redeployment. More sea water ingressed the vibration section on redeployment. A second attempt was made to repair the system.

Figure 4:14. Connector after disassembly showing the +60VDC pin damage. This connector was on the outboard end of the GeoEel deck/ vibration section, port bundle.

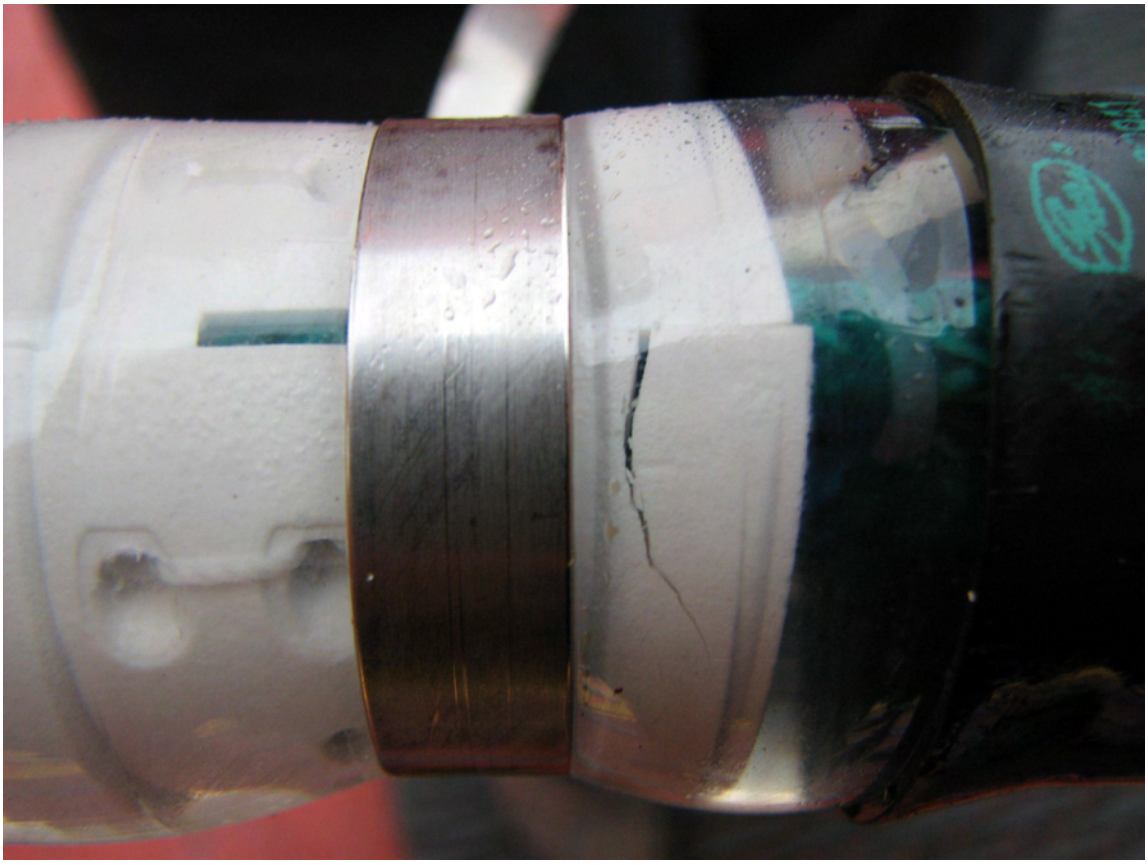


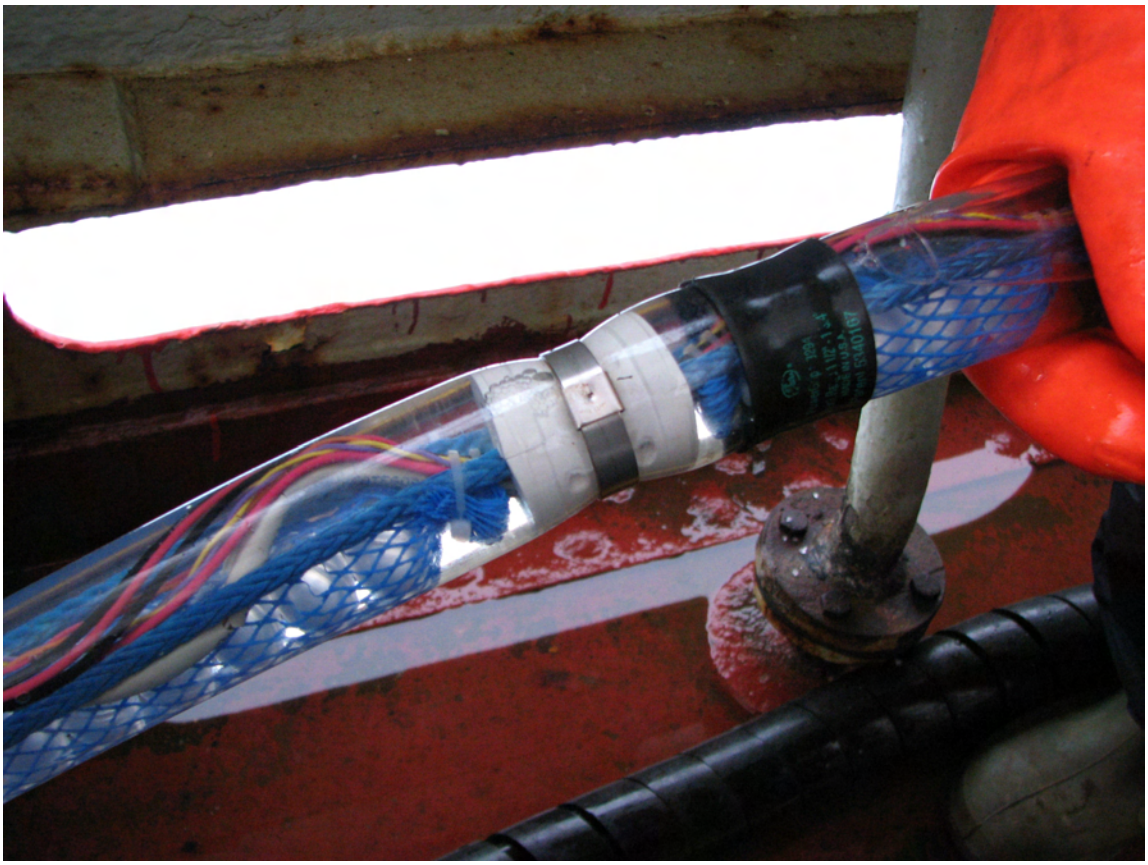
Further repairs were made. Upon inspection it was noted that the inboard end of the vibration section of the deck cable was the location of the leak, not the outboard end. After closer studies the coupling connection where the armored deck cable mates to the vibration section was found to be the failure point. Insufficient potting compound had been applied inside the connector housing to close off the coupling half shells. The sea water was leaking between the coupling parts and into the streamer. After a thorough cleaning of all parts, RVT sealant was used to pack the coupling from the top of the existing potting into the vibration section of the streamer proper. This was left to cure for 24 hours. Once the RTV sealant cured, the streamer was reassembled. Epoxy cement was used to secure the wires to the +60 VDC pins and help to protect the wires from twisting off the pin remnants.

Although the conductivity tests showed extremely high leakage values on the deck electronics, the repaired section did not leak to sea water any further and worked as required on the port sled for the duration of the program. The starboard bundle was installed onto the port sled at midpoint through the cruise and the original port bundle was set aside as a spare but was not required.

On line 5 the vessel encountered fairly heavy multiyear ice. The drogue chute was caught in ice. This placed tension on the streamer and damaged the stretch section #01077. The damaged section was replaced with spare section #01073. This section seemed to bear the greatest amount of damage but evidence of stress to the entire streamer was evident. Subsequently the drogue was removed from the tail section and the heavy 1" shackle was reinstalled for the remainder of the program.

Figure 4:15 and 4:16. GeoEel System stretch section damage showing internal cracks to spacers and heat shrink movement about the eel jacket.





All streamer sections appeared to sustain damage but no ingress of sea water occurred. Conductivity measurement value remained in the single digit range.

Sonobuoy System

Two Winradio VHF sonobuoy receiver systems were installed in the radio room on board the vessel. An Andrews DB292 VHF antenna, cut to respond to frequencies between 150 and 160 MHz was fitted to the aft railing of the port side of the "crow's next". Suitable coaxial cable was run from the crow's nest to the radio room to couple antenna and receivers. A single coaxial cable and Cat-5 cable were run from the ship's radio room to the seismic lab. The RG-6 coaxial cable carried the sonobuoy analog signal from the Winradio/ K-H filter in the ship's radio room to the GSC_DIG #4 data logger located in the seismic lab.

The Cat-5 cable was to be used to carry control signals via RS232 to and from the seismic lab logging PC to the Winradio. Unfortunately the RS232 would not work over the +300 foot length of cable, so the laptop was connected directly to the Winradio receiver in the radio room. Once the radio setup was complete the laptop could be removed without disruption to the Winradio internal settings.

During the early phase of the program, a KroHn- Hite MODEL 3700 analog filter was installed in the radio room to provide a +20db boost to the Winradio analog output. Filter settings were set to "high pass" 0.1Hz to 120Hz. The analog radio signal was fed from the Winradio receiver into only one section of the K-H filter. After initial setup issues, it was determined that the K-H filter

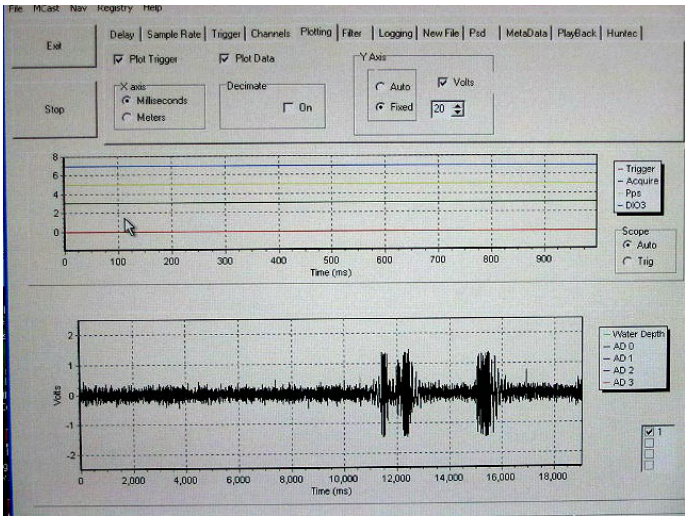
was producing some unwanted noise and so the filter was removed and the Winradio signal was input directly into the RG-6 coaxial cable fed to the seismic lab. This proved to be a better setup.

The GSC_DIG #4 computer was initially setup in the seismic lab. It was later moved to the radio room and thence back to the seismic lab for the final days of the program. The setup and monitoring of the DIG system proved to be better handled in the seismic lab and required less travel for watch keepers. The interface box for the DIG was found to be wired incorrectly. The four analog inputs were wired by the manufacturer in reverse sequence, with Channel #1 being #4 and #2 being #3 etc. This posed initial data problems with the first several sonobuoys as the gain within the DIG had to be increased to record a signal to a level where background white noise was interfering with the sonobuoy signals. Once this wiring error was realized and corrected, data from the sonobuoy system was judged to be extremely satisfactory with receive ranges up to 12 miles in good weather conditions.

Figure 4:17. GSC_DIG #4

Analog data from the Winradio sonobuoy receiver was digitized by the 24 bit A/D card within GSC_DIG #4. The acquisition trigger was provided from the Frydecky timing control box. Navigation data was recorded as a header file. GSC_DIG #4 received navigation data from the GPS RS232 repeater in the seismic lab. When the GSC_DIG was located in the radio room, the navigation and time were received from the vessel GPS receiver and taken from the ship's network. To accomplish this, GPSGate software was run on the digitizer.

Figure 4:18 Sonobuoy #25 record on GSC_DIG at range of 10 miles from deployment.



Sonobuoy Summary

There were initial start up issues with the sonobuoy receiving and logging system. After these difficulties were overcome, the system performed as expected. A total of 28 drops were made and data was judged as acceptable from all but five of the buoys. One buoy lost the modulation shortly after deployment. It was assumed that the hydrophone may have been damaged as the buoy was deployed in heavy ice conditions.

Operational range for all the buoys was beyond the expected 10 nautical miles and in some cases exceeded 15 miles, this being well beyond the manufacturer's predicted operational distance.

Moderate ice conditions during some of the deployments did not seem to have as great an effect as originally forecast on buoy performance.

After the first several deployments a standard deployment configuration for each buoy was adopted.

(1) Standard transmit frequency for the buoy was set to 156.250 MHz, Channel 86
(2) Standard Hydrophone depth was set to 60 meters (D2)
(3) Standard buoy duration was set to 8 hours of transmission

During this 2007 program, the complete inventory of sonobuoys was extinguished. More buoys will need to be acquired prior to the 2008 program.

Part D

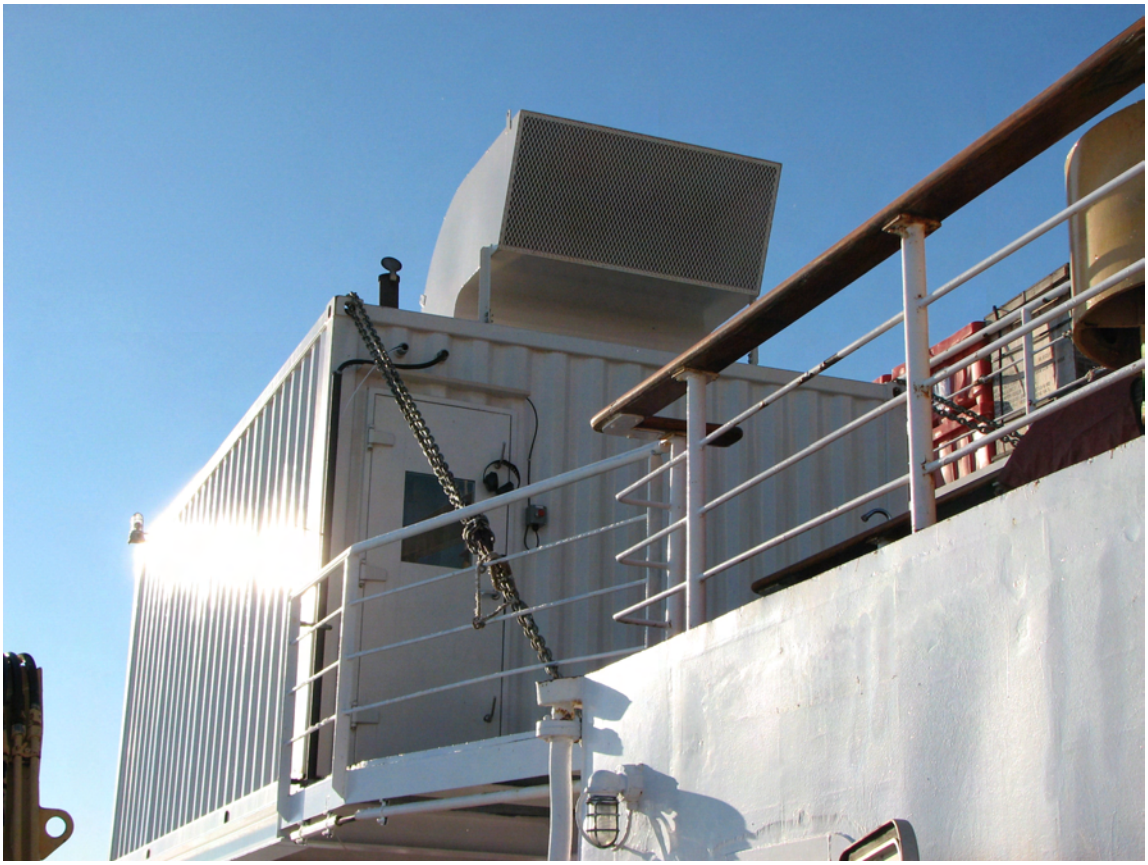
Specific Issues Related to Hurricane Compressor Problems During the 2007 Program

The Hurricane air compressor was purchased by NRCan in the late fall of 2006. This compressor was chosen for three prime reasons:

(1) Price: The compressor was priced at about 30% of the cost of an equivalent system, even after the cost of spares and a suitable enclosure were factored into the final total.
(2) Air Cooled: The machine does not need any ship board services except for electrical connections for heat and lights. It utilizes a forced air radiator to cool the engine and forced air intercoolers on each stage of the compressor.
(3) Capacity: the Hurricane compressor is capable of providing 2500 PSI air pressure at 600 SCFM (standard cubic feet per minute).

Unfortunately some of the features that were desirable turned out to be the source of problems during the program.

Figure 4:19. The Hurricane Compressor as fitted to the LSSL.



The huge amount of air required to cool the compressor is taken in through louvered ducts on the inboard side of the compressor enclosure. The air is then pushed out through the aft end of the enclosure through the Caterpillar diesel engine radiator and through the plenum fitted to the front of the heat exchangers mounted on the forward end of the compressor and discharged through the enclosure roof (see figure 4:X).

Early on in the program the ambient air temperatures were lowering below zero degrees Celsius, and with the high flow rate through the enclosure this created an extremely uncomfortable working environment for the operator. Wind chill became a real issue and concern.

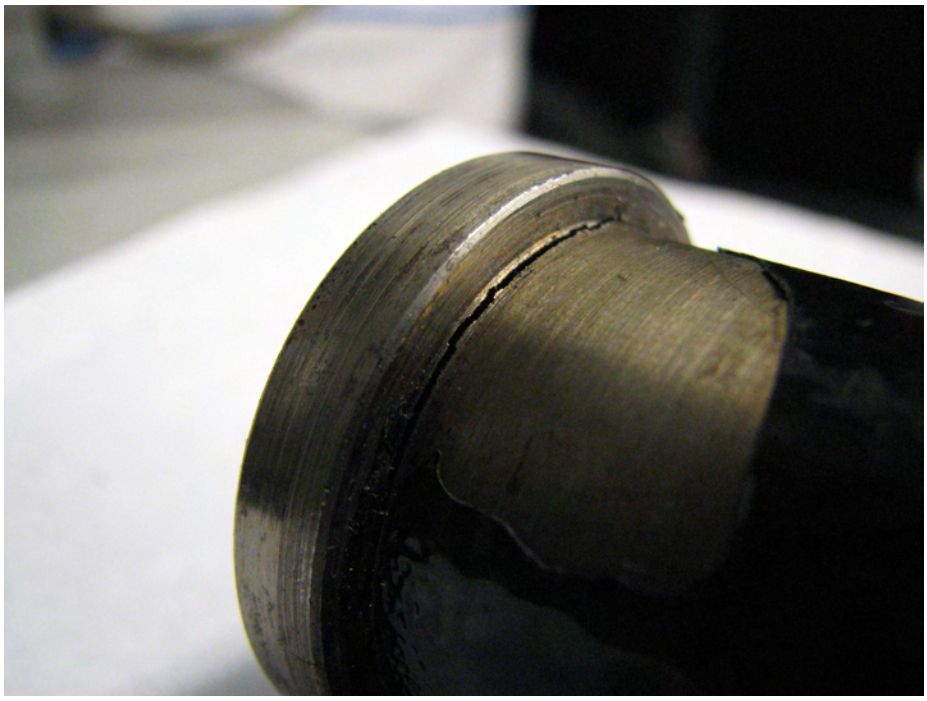
In addition to the operator discomfort, the low air temperature caused freeze-up problems with moisture trapped in the air control and monitor systems of the compressor. These freezing conditions were a safety concern and time was taken to evaluate the best method to alleviate the situation. It was decided to cut an opening in the forward discharge plenum to recover and redirect into the compressor enclosure, some of the warm air that was being exhausted through the roof.

A 12" high by 48" wide opening was cut in the forward end of the plenum at approximately 60" off the enclosure deck. This greatly improved the comfort level for the operator but also served to reduce some of the icing issues. Later in the program, the ship provided a 4500 Watt @ 220VAC electric heater that was installed overhead of the equipment with discharge air from the heater aimed specifically at some of the key components where freezing was still an issue.

Figure 4:20. Plenum showing opening created to increase heat inside enclosure.

The high pressure discharge pipe from the output of the fourth stage cracked. This posed a serious safety hazard and jeopardized the program as no spare was provided. The ship's engineering staff was able to fabricate a replacement coupling and weld the coupling to the existing pipe. This repair proved to be effective and the equipment was put back into service.

Figure 4:21. 4th stage air discharge pipe coupling showing failure.



Immediately after the repaired coupling was installed an attempt to start the diesel failed when the battery connector flashed over. New ends were installed by the ship's electrical officer, Mr. Norm Robinson. All six ends on the three cables were very loose and two actually came off with a slight tug.

Figure 4:22. Battery connector after flash over. All six were replaced.

On one particular occasion the safety relief (pop) valve tripped and discharged a large amount of oil and air from the oil/ air separator tank. This problem was traced to a faulty valve which was

disassembled and found to be assembled incorrectly. Once the valve was properly reassembled, the issue was not repeated.

Gauges were freezing continuously. Water trapped in side the lines would migrate to the gauges in the monitoring panel. At one point all the control lines for every component were removed, blown out and reinstalled. This provided a great improvement in performance of the machine but when the moisture returned so did the problem.

The second stage automatic moisture dump stopped operating. It was removed from the system. The lower float ball had separated from the support rod. It was re attached by ships engineers but failed to operate properly. During the disassembly a number of pieces of welding slag were removed from the accumulator tank.

Figure 4:23. 2nd Stage moisture dump vessel as fitted.

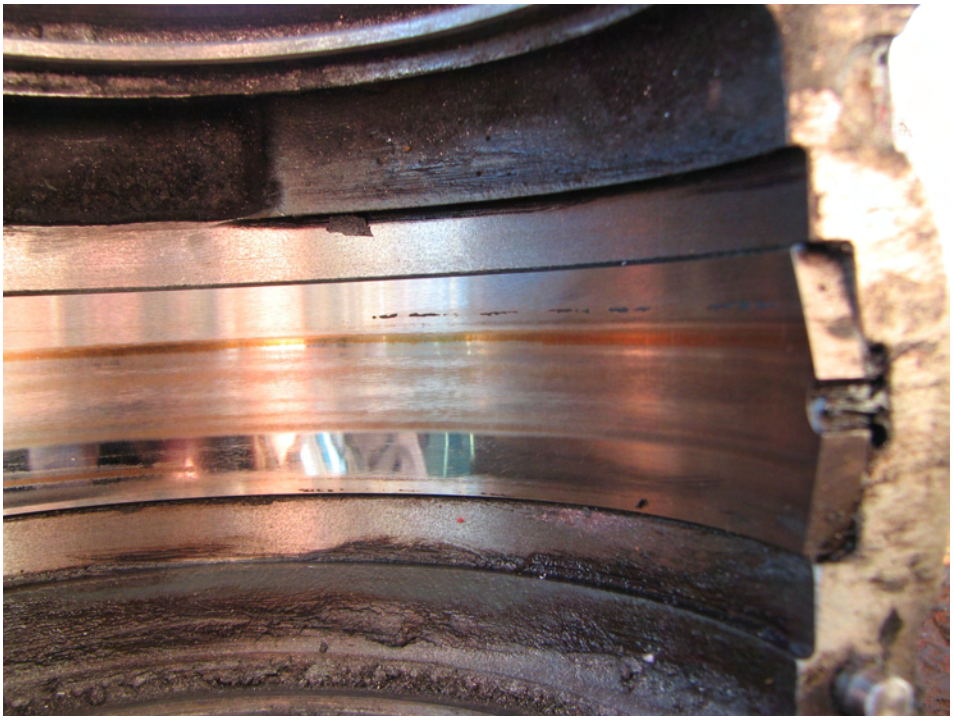
Figure 4:24. Welding Slag removed from 2nd stage moisture dump vessel.

At approximately the 350 hour mark a crack developed in the first stage air intercooler tank. This was found to be an aluminum tank which made repair difficult. The ship's 1st engineer, Mr. Jerry MacDonald was able to weld the cracked seam and installed an additional piece of aluminum to the outer corner of the tank to better strengthen the tank. Shortly after this repair a second crack was found. This crack was located on the discharge side of the third stage intercooler. Since this was steel the weld was easier to apply. The ship's Senior Engineer, Mr. Mike Ellis performed this repair.

Figure 4:25. 1st Stage air intercooler after repairs.

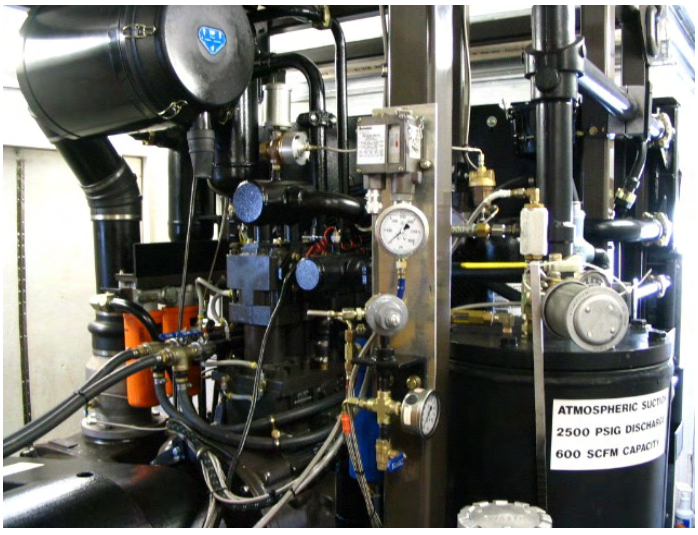
The pillow block bearing on the inlet shaft to the John Deere pumper failed early in the program. On removal there was very little evidence of grease in the bearing. A spare was fitted. During installation it was determined that the bearing was almost 80 thousandth out of alignment. Suitable shim stock was placed under the bearing to correct the misalignment. No further problems were encountered. Proper greasing procedures were commenced.

Figure 4:26. Internal view of pillow block bearing removed after failure occurred.



The small hose carrying the 2000 PSI air pressure to the Barksdale regulator switch was extremely short. To prevent a failure and reduce this safety concern, the gauge and switch were relocated to an area near the air/oil separator tank. At that time all air lines were checked and color coded to aid in future service efforts.

Figure 4:27. Compressor showing new mounting location for Birkdale regulator.



The third and fourth stage moisture accumulators were plumbed to dump the moisture over the side of the vessel. The icing issue caused these lines to clog. A dump system using a bucket and hoses was instituted. This proved satisfactory but a better system should be considered in future.

Cracks developed in the discharge plenum on the forward end of the compressor. A better vibration isolation system is required to reduce the problem of metal fatigue in this area.

The 440VAC step down transformer must be relocated as it poses a safety issue for operators. It is currently located at about 5 feet off the floor and has extremely sharp corners that could cause cuts in rough weather. It is assumed that a larger transformer will be required to provide more heat inside the compressor enclosure.

Figure 4:28. Interior of enclosure showing current location of fitted 10 kVa transformer.

Towards the end of the program the forward universal joint on the drive shaft failed. This was replaced from spares.

Part E

Recommendations for Future UNCLOS Technical Work Aboard the LSSL

(1) Fiber connections directly from the radio room to the seismic lab
(2) Primer type "N" by Locktite
(3) Install electrical gauges for compressor monitoring
(4) Secondary set screws to secure drive coupling on JD drive shaft
(5) Caterpillar and J-D block circulating heater
(6) Filter for the inlet side of the antifreeze injector pump
(7) Shop air for running injector pump
(8) Regulus monitors to combine into one monitor and angled down for better operator view
(9) Eel winch for GeoEel, perhaps 2 eels on one drum
(10) Mount streamer winch controls at winch
(11) Re-rack geometrics streamer system into ½ rack

(12) Address single serial port access issue on geometrics PC
(13) Better method of taping streamer connectors
(14) More spare O rings for GeoEel
(15) Spare connectors for GeoEel
(16) Relocate Frydecky control PC
(17) Single monitor for XCEL and Regulus display
(18) Shroud or automatic shutters for Caterpillar radiator
(19) Shutters for inlet air supply on compressor enclosure
(20) Oily rag storage container in the compressor enclosure
(21) 110VAC outlets along out board wall of the compressor enclosure
(22) Shelving for storing manuals and tools
(23) Proper oiling cans for diesel and J-D
(24) Second oil transfer pump for the oil changes
(25) Check oil type currently in the screw
(26) Possible floor insulation
(27) Water accumulator/ separator for the 4th stage
(28) Wire mesh guards for the faces of the manifold gauges
(29) Whip lines on Synflex hoses (3/16 wire and nicropress tool to install)
(30) Lockout controls for the real Time System gun controller
(31) Safety signs for the compressor and HP Air areas
(32) Inspection cover for air plenum and move vibration coupling to compressor and secure the plenum to the enclosure deck
(33) Air ducting to move some of the warm discharge air to other areas inside the enclosure
(34) Vent outside the discharge air from the sump vents of the J-D and Caterpillar and blow off valve
(35) Relocate the antifreeze injector pump to supply antifreeze directly into the reservoir gun lines
(36) Box in the reservoirs and supply heat inside the boxes
(37) Install an A frame TV Camera
(38) Install a 3rd tugger winch
(39) Purchase suitable oil filter wrenches
(40) Improve roller on the quarterdeck to accommodate the bundle clamps
(41) Install a strobe light visual communications system inside the compressor
(42) Install support bracket on the caterpillar fan belt guard to reduce vibration
(43) Increase the size of opening in/ around the screw to reduce chafing
(44) Install bracket for the 2nd stage air cooler to reduce the effect of vibration
(45) 2’ deep basin to allow for dip cleaning the guns and parts into fresh water
(46) Additional bundle clamps and spares
(47) Shelving for high use spares inside the workshop or front of the lab
(48) Mufflers for reducing the noise level from bleed off air
(49) Monorail system for moving guns into Av Gas area
(50) Hard piping on Tow Sled to eliminate intermediate hoses
(51) Heating tape on air lines from Compressor lines to quarterdeck
(52) Aerosol can disposal container in Av gas area
(53) USB ports mounted to the front of the GSC_DIG #4
(54) Extend the gun protector clamps
(55) Drill bits, common sizes

(56) Suitable tool box and tools for compressor enclosure
(57) Tie down points on the roof top of the seismic lab
(58) Install Line Splitter for LOG GYRO and NovaTel signals at bridge
(59) Install Line Splitter for data feed directly from Knudsen to seismic lab
(60) Increase DHCP capacity for science use
(61) Possible upgrade to a 1 GHz backbone on main and network system
(62) Move the 10kVa transformer in the compressor to a safer height

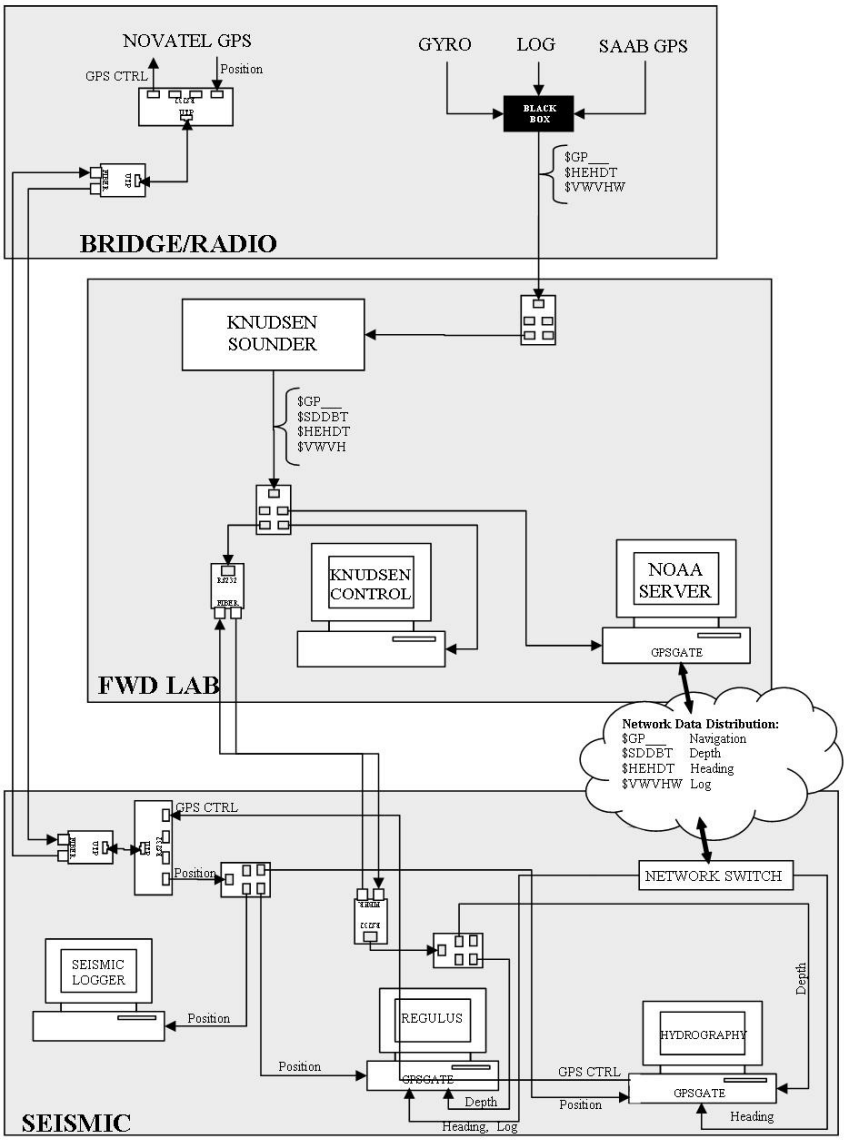
Part F (by Paul Girouard)

LSL 2007 Navigation and Data Distribution and Processing

The data streams required by the various systems in operation in the seismic lab were provided through various modes of data transfer. Differential GPS navigation was provided by the science Novatel receiver. NMEA sentences from this system were distributed to the seismic lab via a dedicated fiber connection. The log and gyro were distributed to the lab by the NOAA computer which broadcast the data over the ship's network. The bathymetry was distributed to the lab via a dedicated fiber connection from its location in the forward scientific lab via the network. The Regulus navigation system, running Build 28894 of the software, was used to view and log the scientific navigation. A second monitor was attached to the system through a video splitter allowing for the concurrent display and updating of the electronic log.

The navigation data were cleaned and merged using a text editor and the standard GSC Atlantic 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 GSC Atlantic archiving. All seismic and sonobuoy data as well as their related log files were also backed up to DVD for archiving. In addition, the compressor watch keepers and mammal observers maintained paper records of their observations. These were reviewed on a daily basis and transferred to digital spreadsheets.

In general, the systems and data distribution worked well but the various modes of data distribution resulted in some complications in the efficient distribution of this data to the various systems as explained in some detail below. The state of the ship's network also was cause for some concern as it was impossible to connect any new computers to the network for the first week. In addition, several switch related malfunctions also caused some interruptions in the services. The speed of the network left much to be desired. It was more efficient to go to the lab and retrieve data using a memory stick or a network connection through the lab network switch than to try to transfer the data over the network. It should e pointed out that at no time did any of these problem compromise our ability to carry out our program except for the hydrographers' ability to control the sounder which is accomplished over the network.



2007 Louis S. St.-Laurent Data Distribution

Major concerns

* The NOAA computer is used for data distribution throughout the ship. This requires the use of GpsGate on both the NOAA computer to initiate the distribution, and all other computers that need to receive the data. There were several occurrences where the data stream was interrupted either because of problems with the network switches or GpsGate hanging on the NOAA server. It was often necessary to restart the computer in order to get GpsGate to function.

* Because the Knudsen sounder is being used to multiplex all the NMEA strings for distribution, two GGA (position) strings are being distributed to the seismic lab. This requires the use of GpsGate to filter out the GGA string from the Saab receiver whether one is using a direct feed from the network distribution or a serial feed from the serial line splitter. The GGA string from the Novatel receiver is the one used, through a direct feed to the lab.

* Three data sources are required to collect all the required in formation: one for the navigation, one for the log and gyro and one for the bathymetry. This is a problem for programs such as the seismic logging software which allows for the use of only one serial source.

* DHCP service was unavailable for the first week of the cruise because of a problem with the server. The problem was aggravated by the fact that although 30 IP numbers were dedicated to the static pool, all were already assigned. No new computers could be attached to the network during this period. Network services were again disrupted when the backbone switch in the forward scientific lab developed a fault. This stopped all data distribution from the NOAA server as well as interrupted the Knudsen control which is performed over the network from all locations.

* Two further network interruptions occurred as a result of the fiber link between the aft scientific lab. In the first instance the problem was eventually traced to a defective fiber patch cable between the seismic lab network switch and the fiber drop in the lab. In the second instance the problem was corrected by re-seating the patch cable between the fiber termination and the fiber/UTP converter on the aft scientific lab network patch cable.

* The network speed is painfully slow. Data transfers between 2 computers connected through the seismic lab switch are at least 5 times faster than between the seismic lab and other parts of the ship. This is significant when one is required to transfer several hundred megabytes of data.

Recommendations:

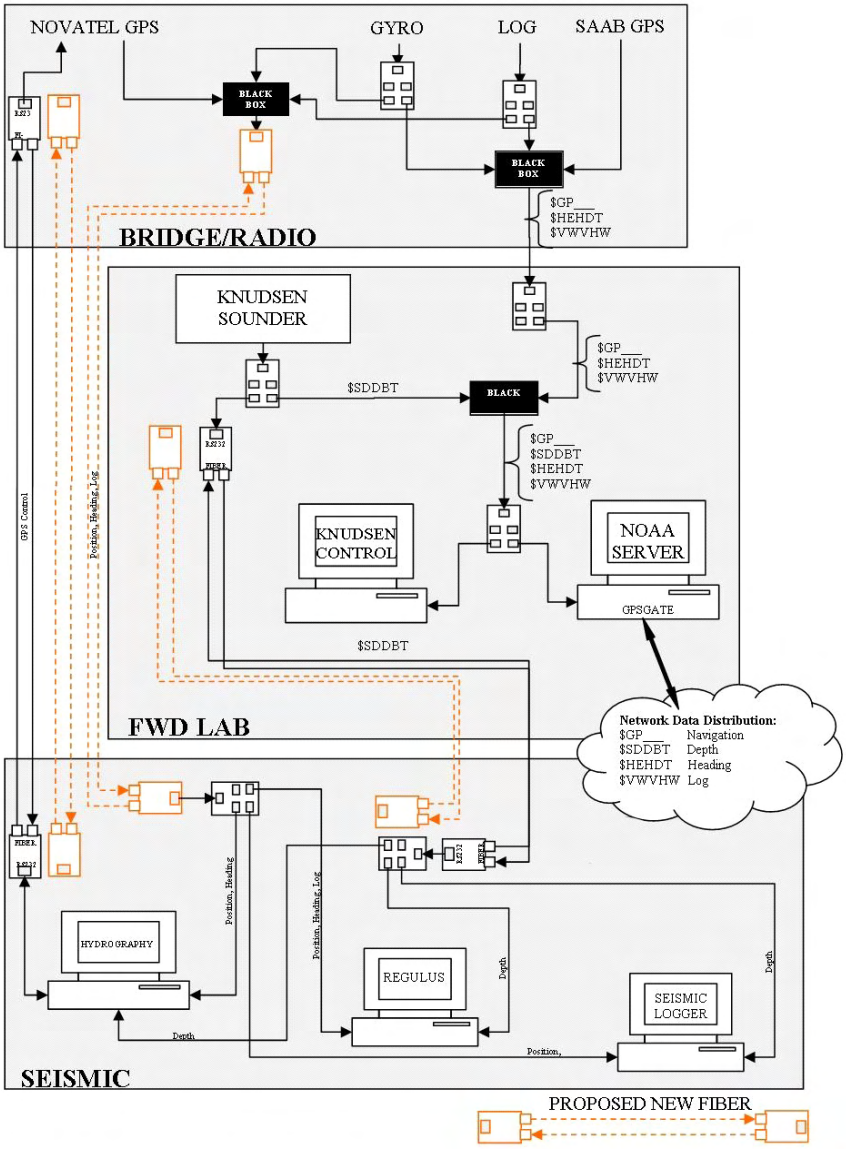
The following recommendations would result in direct serial links between the various data sources and destinations. This would remove any reliance on the network or software based systems such as GpsGate for data distribution to the seismic lab without changing or compromising the existing shipboard data distribution setup.

* A serial data splitter should be installed on the outputs of both the log and gyro providing a feed to both the present Saab nav/log/gyro data multiplexer on the bridge and to a new data

multiplexer to be installed which would multiplex the log and gyro with the Novatel nav. This would be then feed directly to the seismic lab through a new direct fiber link. This change would provide the seismic lab with a single serial feed of the required nav, log and gyro. It will also eliminate the use of GpsGate to filter out the Saab nav. The present Saab nav/log/gyro feed to the forward scientific lab would be preserved in its present state.

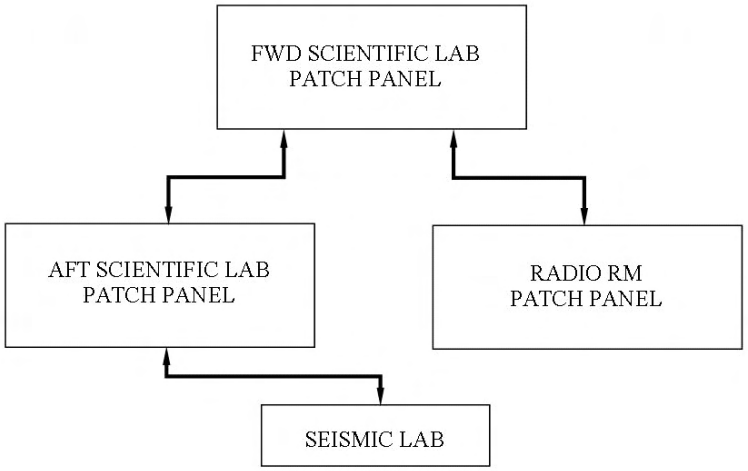
* A “black box” data multiplexer should be used in the forward scientific lab to multiplex the Saab nav, the log, gyro and bathymetry rather than use the Knudsen sounder for this purpose. This would allow, with the addition of a serial line splitter on the Knudsen output, for a feed of the bathymetric data only to the seismic lab over the existing fiber link, unencumbered by the Saab nav and the log and gyro. This would also preserve the present network data format and distribution on the NOAA server.

* A router should be added in the seismic lab to isolate the lab network from the main ship’s network. This would both isolate the lab from any major ship network problems as well as allow the computers in the lab to use an IP address structure different than the ship’s, all while preserving the connection between the two networks. It would be especially useful if this router could be linked directly to the main backbone switch in the forward scientific lab. This may help to improve the speed of the network connectivity.

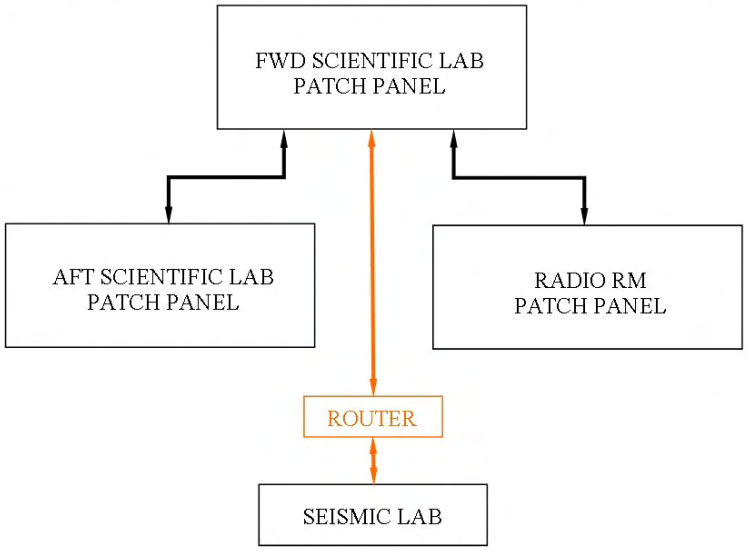


Proposed New Louis St.-Laurent Data Distribution

LOUIS S.ST.-LAURENT 2007 NETWORK SETUP



PROPOSED LOUIS S.ST.-LAURENT NETWORK SETUP



* The installation of at least three more fiber links to the seismic lab. One, as stated above, to feed the Novatel nav and the log and gyro from the bridge, the other being two spare links to the forward scientific lab and radio room for future use for data distribution. The two fiber links installed in the av gas area for a previous cruise and no longer required could be used to accommodate two of these.

* The slow speed of the network is likely due to the saturation of the bandwidth. Although this could not be confirmed at the time of writing, the backbone speed of the network is probably 100Mbps. This may have been more than adequate at the time of the original installation, but increases in network use due to new technology and science requirements would probably justify an increase in bandwidth to 1Gpps.

PART G

Acknowledgements

The author wishes to thank the following for their contribution to the success of the program:

Captain, Officers and Crew of the Canadian Coast Guard Ship "Louis S. St. Laurent" and particularly to the engineering staff for without their expertise the program would not have been a success;

The Technical Support Crew

Mr. Jim Etter: Hydraulics, electronics and watch keeping
Mr. Fred Learning; Air gun tow sled, compressor mechanical, watch keeping
Mr. Dwight Reimer: GeoEel system, air gun control and watch keeping
Mr. Paul Girouard: navigation, network, and data curation
Mr. Ryan Pike: Inventory control, air gun mechanical, watch keeping
Mr. Rodger Oulton: Compressor and diesel mechanical and watch keeping

These individuals worked long and hard to accomplish a task that at times, seemed to us impossible;

Staff of Shared Services at GSC (A) in Dartmouth NS

Barb Vetese, Cheryl Boyd and Terry Hayes: Without the cooperation and hard work of these individuals, the program would not have been a success.;

And to **Dr. Robert Rowland**, the ever helpful, always present, helping hand.

Appendix A

Guide to Seismic Sled Deployment and Recovery

September 21, 2007
Chief Officer

Summary

This Guide to Seismic Sled Deployment and Recovery was developed during Arctic Season 2007.

The following steps are a brief point summary for deployment of seismic equipment. The remaining pages are meant to amplify/clarify this summary.

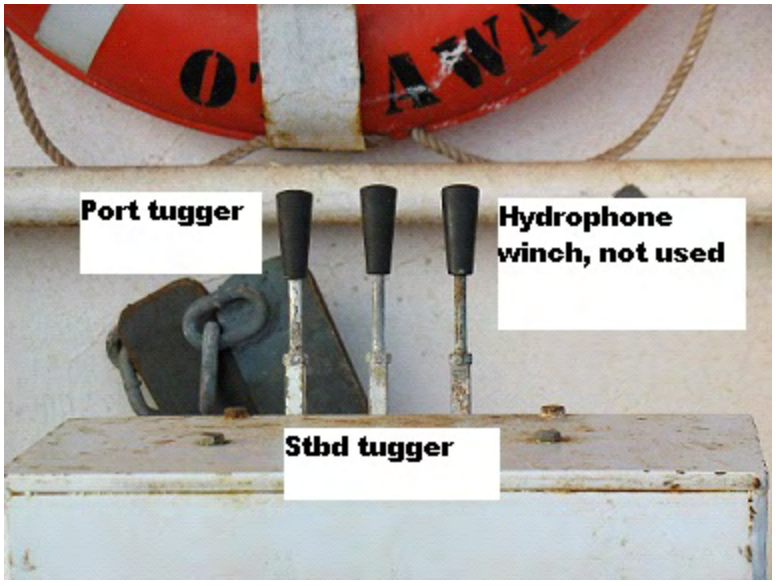
(1) Check shutoff buttons on Hydraulic power pack (steering gear compartment) and Aft capstan control box. Reset if required. Turn on power pack.
(2) Turn tugger winches on and select the Push to Enable button on the A-frame contol.
(3) Deploy drogue and hydrophone array. Ship must steam ahead 1 to 2 kts.
(4) Extend A-frame out 6-8 inches and lift sled clear of bench. Take care with air gun control cables.
(5) Extend A-frame to full reach and utilize Tico crane to begin deploying tow wire/umbilical.
(6) Lower sled and tow wire / umbilical until sled at water level. Guns can now be charged with air to test for leakage.
(7) Spare tugger to hold tow wire / umbilical and crane hook removed. Leave attached to lower remaining tow wire / umbilical and to act as a preventer.
(8) Lower sled and tow wire / umbilical until tow wire has weight of sled. Slack both tugger wires.
(9) Retract A-frame until sled tugger wire hoist is close to the stern.
(10) Secure tow wire with rope straps to minimize jumping when guns fire.

Cautions:
1. Control cables leading from sled to air guns can become tangled in sled bench supports on deployment and recovery.
2. If A-frame is not extended approx. 6 8 inches prior to lifting sled, it will slide forward into bench support possibly damaging the air gun.
3. The narrow side of the wedge shaped umbilical blocks need to go into the overboard sheave when using the tugger for the last part of the deployment. If not the tow wire and the umbilical will jump out of the sheave and a partial recovery of the tow wire / umbilical and seismic sled will be required.

Photo of hydraulic power pack control panel, located in steering gear compartment

Ensure hydraulic power pack in steering gear compartment is turned on. The hydraulic system for the aft A-frame is supplied by the same hydraulic pack for the aft capstans.

Note: in the event of a failure of the A-frame hydraulics, the hydraulic system default position is to the aft capstans.



Tugger controls, hydrophone winch is not currently in use.

Photo of tugger winch on/off control panel.

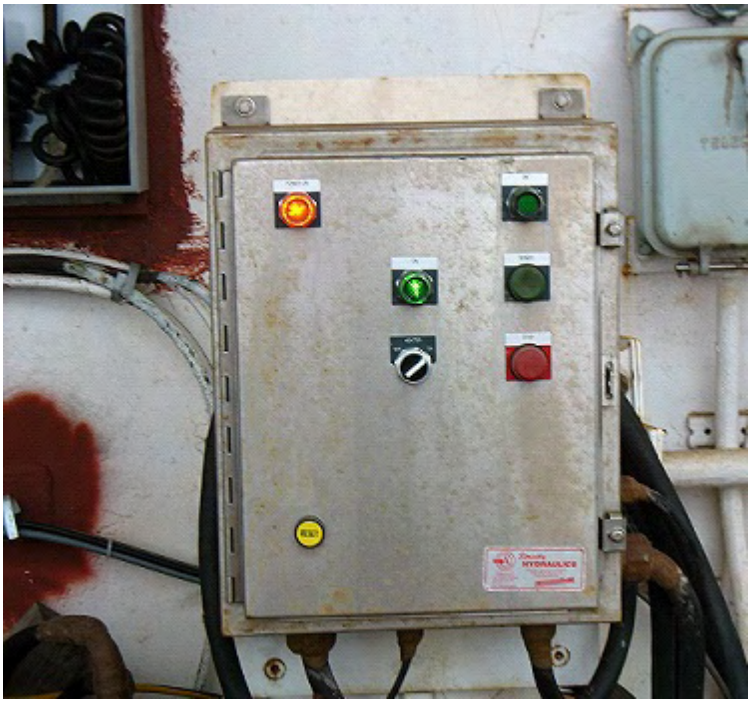
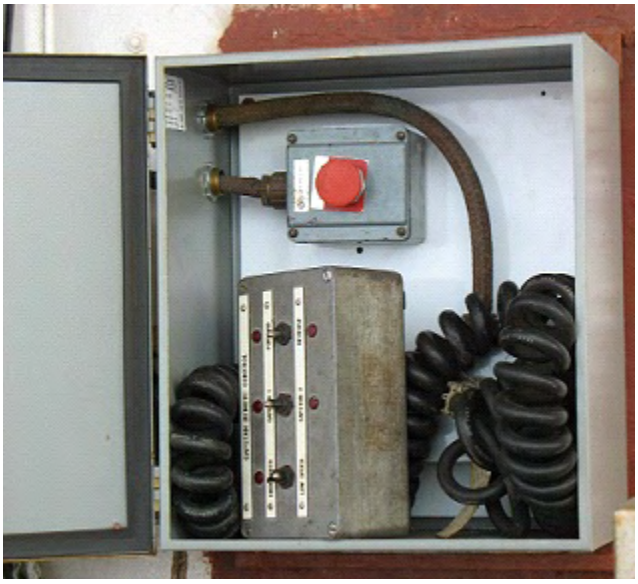


Photo of A-frame control panel.

The Push to Enable button and the Push to Disable button do not turn the hydraulic power pack on/off. These buttons control where the hydraulic fluid is flowing to. Either the capstans, when disabled or to the A-frame when enabled.

Photo of Aft Capstan control box



The red button is the remote shut off for the hydraulic power pack. Ensure shut off is reset prior to starting power pack in steering gear compartment.

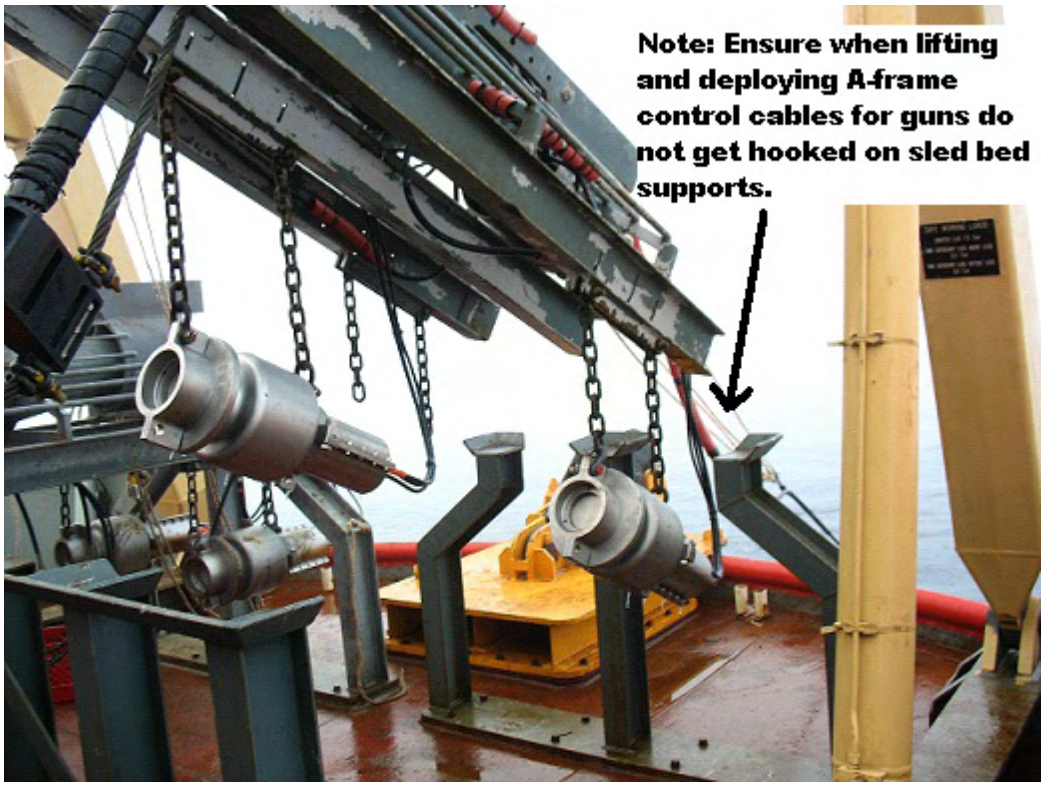
The first item to be deployed is a standard drogue (sea anchor). The drogue is on a line of approximately 100 feet. This is followed by the hydrophone array, floatation cable (yellow in color), a small section of shock absorber(which has the same appearance as the hydrophone array) and finally a 4 legged rope bridal. The four legged bridle is shackled to the aft end of the seismic sled. Total length of the hydrophone array including drogue is 400 meters.

4 legged bridle attached to rear of seismic sled.

The tow wire is placed over the forward bit of the center line bollards. This allows better placement of lifting points during deployment/recovery.

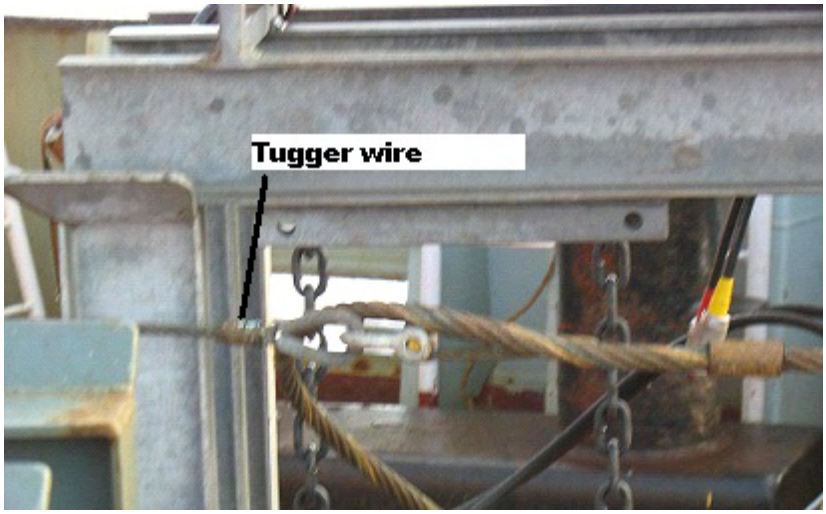
Prior to deployment the A-frame should be extended from fully stowed position approx. 6 to 8 inches outboard. This prevents the seismic sled from swinging forward when it is raised from the sled bench.

As A-frame is extended, it has been noted, the control cables attached to the aft guns on the sled get caught in the sled bench supports. Care must be taken to ensure the cables are clear at this stage of deployment.



The hook from the Tico crane is hooked into the second lifting eye of the tow wire/ umbilical assembly and lifted off the deck, prior to the sled being lifted clear of the bench. As the A-frame is extended, the crane is slewed outboard to begin deployment of the tow wire / umbilical. As the sled is lowered on the tugger wire the runner for the crane is lowered. The sled and the tow wire/umbilical need to be lowered together to avoid excess slack in the umbilical.

The second tugger wire is shackled to the last eye in the tow wire/umbilical. On deployment it is used to take the strain of the tow wire, this enables the Tico crane hook to be removed. The remainder of the tow wire / umbilical can be lowered using the second tugger wire. This part of the process goes smoother if the large black bundle blocks are fed through the sheave narrow side down (see photo below).



Tow wire/umbilical prior to second tugger wire being utilized and Tico crane hook being removed. The narrow part of the bundle blocks can be seen. Once the tow wire/umbilical is placed in the sheave the bundle blocks can be easily turned to allow smoother deployment.

Upon completion of the deployment the tow wire bears the weight of the seismic sled and hydrophone array. The tugger used to lower the sled overboard should be slack. The A-frame is retracted to bring the tugger wire closer to the hull to help avoid ice catching in the wire. The second tugger wire is left attached to the last eye of the tow wire as a preventer. As the guns fire there is some jumping of the tow wire. To minimize this rope straps attached to the centerline bollards and the sled bench were used to secure the wire.

Seismic sled, tow wire/umbilical and tugger wire in final deployed positions.

Final Note: Recovery is reverse of Deployment.

Appendix A Safe Operating Procedure for the Startup of the Hurricane Air Compressor

(1) Read and understand all safety rules and procedures about the operation of the Hurricane Air Compressor as outlined in the Hurricane Manual for this machine.

(2) Check all fluid levels.

(3) Drain fluid remaining in accumulator tanks and leave valves open.

(4) Do not attempt to start the compressor with air in the compressor system.

(5) Ensure compressor discharge valve is in the OPEN state.

(6) Ensure Emergency Stop switches are disengaged (extended condition).

(7) Turn the “Unload/ Auto load” switch to the “Unload” state.

(8) Turn the “Off/ Run/ By-Pass” switch to the Bypass position and hold.

(9) Check for tripped tattle tale breakers and reset if necessary.

(10) Push and hold the “Start” button until the engine starts. Do not hold this switch and allow the diesel engine to turn over for more than 15 seconds. After 15 seconds release the “Start” button for 60 seconds to allow starter to cool and then repeat the start procedure.

(11) Observe engine RPM and maintain the RPM at 1200.

(12) While holding the “Off/ Run/ By-Pass” switch observe the 1st stage Pumper oil pressure. Keep the “Off/ Run/ By-Pass” switch engaged in the “By-Pass” position until Pumper oil pressure exceeds 20 PSI. If the oil pressure does not climb quickly shut the engine down immediately and investigate the reason for lack oil Pumper oil pressure before restarting the system again.

(13) Do not load the compressor until diesel engine and Pumper 1st stage operating temperatures reach 130 degrees Fahrenheit.

(14) Close Moisture Dump Valves on Accumulators.

(15) Turn “Unload/ Auto Load” switch to Auto Load and adjust engine RPM as load demands.

5. Seismic Data Recording and Processing

by John Shimeld

5.1 Introduction

A total of 2967.4 line km of 2-D single-channel seismic reflection data were acquired along crooked tracks through the variable sea ice conditions encountered during the survey. Projected along straight lines between the start and end points of each line segment, the total effective line coverage is 2358.2 km, implying that the ice conditions over the entire survey necessitated roughly 25% percent more acquisition than would have been required under ice-free conditions. This is actually an underestimate since the trend of some line segments deviates significantly from that of the original plan, and because significant portions of the survey area were within ice-free regions beyond the summer ice pack (c.f. Section 1).

Individual line segments were named with the prefix GSC07 and the suffix CAP (Canada Abyssal Plain) followed by a line number and a letter indicating the line segment. For example, GSC07-CAP3C indicates segment C of line 3. Each line segment was acquired until adverse ice conditions or equipment failure prevented further progress, or until the end of the originally planned line was reached. In total, 29 segments were acquired along 8 lines. Regional-scale trackplots showing the start and end of each line segment are shown on figures 5.1, 5.2, and 5.3.

5.2 Source and Receiver Geometries

The source and receiver offsets are shown on Figure 5.4 relative to the position of the Global Satellite Positioning (GPS) antenna that was used as the fixed spatial reference point on the ship. The source array, which is described in Section 4, was designed to operate with three 520 cubic inch G-guns. However, the force generated by three airguns caused excessive stresses in the tow sled and so, for the majority of the survey, the source array was operated with two airguns (forward and aft port guns) firing simultaneously for a total source volume of 1040 cubic inches.

The GeoEel receiver array comprised two 50 m active streamer sections with a total of 128 hydrophones (c.f. Section 4). The receiver array was configured to operate with 8 hydrophones per group at a group interval of 6.25 m, making a total of 16 channels over the two 50 m active streamer sections. An exception to this configuration occurred during acquisition of line segments GSC07-CAP2A, 2B, and 2C, when the receiver array was configured with 8 channels (i.e. 16 hydrophones per group, 12.5 m group interval). This was done to reduce the volume of data and should have been straightforward to accomplish with the user interface provided by the Geometrics CNT-2 software. However, subsequent processing revealed that the change to the receiver array configuration had not been made as intended. Instead, the receiver array was still configured with the original 8 hydrophones per group and, rather than logging 4 channels from each of 2 active sections, the software was logging 8 channels from only the inboard active section, and none from the outboard section. Rather than experiment further with the set-up, the original 16-channel configuration was used for the remainder of the survey. The problem was likely due to a misunderstanding of the set-up procedure since both the software user interface and the documentation were written for 100 m streamer sections rather than the 50 m sections supplied for the project.

5.3 Shot Interval

Where water depths were less than 3 seconds of two-way travel time (TWT), the source was fired once every 14.011 seconds to yield an irregular shot interval of between about 20 and 42 m as a function of the varying current and ice conditions. Over deeper water, the firing rate was once every 20.000 seconds to allow more attenuation of coherent noise in the water column from seafloor multiple energy. Typically this firing rate yielded a shot interval of 40 to 60 metres.

5.4 Data Recording Parameters

Seismic reflection data were recorded using the Geometrics GeoEel system described in Section 4. With this system, analog hydrophone signals are converted to 24-bit digital traces by analog-to-digital converters in the streamer and are automatically summed for each receiver group. Data are broadcast, via ethernet connection in the streamer, to the multithreaded CNT-2 software running under the Windows NT operating system on a personal computer onboard the survey vessel. The CNT-2 software provides a user interface for configuring the GeoEel system, for monitoring the data quality during acquisition, for testing the receiver array, and for recording the data to magnetic disk drive and/or magnetic tape. Additional data such as geographic position or source signature information can also be logged by the CNT-2 software through a serial communications port.

The recording parameters that were used during the survey are listed on Table 5.1 in the order that they are typically encountered when performing the GeoEel system set-up with the CNT-2 user interface.

Table 5.1: Recording parameters used during acquisition with the Geometrics GeoEel system.

PARAMETER	VALUE
Group interval	Default setting (listed as 12.5 m on screen, but should actually be 6.25 m with the streamer system manufactured for the GSC)
Expected capacitance/channel	128 nF (8 phones per channel at 16 nF per phone)
Auxillary channels	not enabled
Serial input baud rate byte size COM port parity bit stop bits terminator SEG-D external block size for input serial string serial input setup shot/file number comparison	enabled for logging of GPS navigation 9600 baud 8 4 none 1 LF fixed block size: 29 blocks store one string; only log GGA strings; use GPS for shot time not enabled
Sample interval	2.000 ms
Final record length	13.5 seconds
Delay	0.0 seconds (maximum delay accepted by software is 0.5 seconds)
Active channels	start channel: 1 end channel: 16 no channels disabled
Preamp gains	All data channels at 5 dB
Transconductance	20 Volt/bar
Noise peak threshold	18 microbar
Noise average threshold	9 microbar
Noise low cut frequency	6 Hz

5.5 Data Storage

Digital shot records were stored on magnetic disk drive, one file per shot record, in the Society of Exploration Geophysicists SEG-D 8058 Revision 1 format. Included in each SEG-D file is a 928 byte (29 blocks) fixed header containing a GPS navigation string (GGA-string) with the Universal Coordinated Time (UTC) and the geographic position in degrees and decimal minutes (reference ellipsoid: World Geodetic System, 1984).

As a backup, the SEG-D files were copied every half-hour onto a separate magnetic disk drive installed in the recording computer. The data were also transferred via ethernet connection to a third magnetic disk drive attached to a computer used for processing. Upon completion of each line, all associated shot records and log files were copied onto two duplicate optical DVD disks for archival.

5.6 Data Quality Monitoring and Seismic Watchkeeping

During acquisition the CNT-2 user interface was used to automatically plot each shot record, a bar graph of root-mean-squared (RMS) noise levels, a log of diagnostic messages, and a simple brute-stack record section. An example monitor display is shown on Figure 5.5. This provided immediate, shot-by-shot feedback on the GeoEel system performance and confirmation that the data were of acceptable quality. During seismic acquisition, watchkeepers kept a half-hourly log of the following system parameters: calendar day, UTC time, latitude, longitude, line segment, water depth, course over ground, heading, speed over ground, speed through water, streamer leakage, streamer current, streamer voltage, field file identification number, total source volume, number of airguns, firing rate, delay, streamer depth, maximum RMS noise, and average RMS noise. A copy of the watchkeepers' log is provided in Appendix 2, and a summary of data pertaining to each line segment is given below in Table 5.2.

Table 5.2: Data summary for each line segment

Segment	Firts Shotpoint	Last Shotpoint	Wiggly Line km	Straight Line km	Channels	Comments
GSC07 CAP1A	1	5213	148.6	118.1	1:16	compressor shutdown, Sps 4702:4730
1B	10001	10341	9.4	9.4	1:16	3 guns used
1C	20001	23087	89.1	57.8	1:16	started with 3 guns; down to 2 guns at SP 1080; down to 1 gun at SP 2640
1D	30001	31290	36.8	24.5	1:16	3 guns used
1E	40001	42494	73.1	57.3	1:16	started with 3 guns; compressor shutdowns at SP 300 and SP 1610; down to 2 guns at SP 2300
1F	50001	54275	115.1	29.6	1:16	started with 3 guns; down to 2 guns at SP 3781

Segment	Firts Shotpoint	Last Shotpoint	Wiggly Line km	Straight Line km	Channels	Comments
1G	60001	61953	56.8	36.3	1:16	2 guns
2A	1	2169	61.3	40.0	1:8	2 guns
2B	2500	4481	49.4	33.1	1:8	2 guns; down to 1 gun at SP 2950
2C	4500	9364	166.8	133.0	1:8	3 guns, down to 2 guns at SP 8900
2D	9600	15606	239.8	148.4	1:16	2 guns; 3 6 m swells; high RMS noise
2E	16000	17408	56.9	55.4	1:16	2 guns
2F	13600	14886	51.9	41.3	1:16	2 guns; 2 5 m swells, high RMS noise
3A	1	705	27.7	24.7	1:16	2 guns
3B	800	6641	224.8	200.9	1:16	2 guns; heavy ice; guns shut down at SP 5200 due to polar bear sighting
3C	7000	9689	99.5	89.5	1:16	2 guns; heavy ice conditions
3D	9800	10238	15.6	13.4	1:16	2 guns; heavy ice conditions
3E	10500	11495	39.7	14.3	1:16	2 guns; highly variable ice conditions
3F	11600	12885	42.3	26.2	1:16	2 guns; heavy ice conditions
3G	13000	13498	20.4	18.0	1:16	2 guns
4A	1	2978	112.3	82.9	1:16	2 guns; guns shut down at SP 1000 due to polar bear sighting; heavy ice after SP 2200
4B	3000	7265	172.3	149.1	1:16	2 guns; heavy ice Sps 3895 3913
4C	7500	11372	155.9	138.0	1:16	2 guns; guns shut down at SP 8504 due to polar bear sighting
4D	11600	16223	195.6	184.1	1:16	2 guns
5A	1	3728	149.2	118.1	1:16	2 guns; guns shut down at SP 1850 due to polar bear sighting; heavy ice near end of line
6A	1	3813	198.7	198.7	1:16	2 guns; open water; 2 3 m swells
7A	4000	4179	8.8	8.8	1:16	2 guns; open water; 2 5 m swells

Segment	Firts Shotpoint	Last Shotpoint	Wiggly Line km	Straight Line km	Channels	Comments
7B	4200	6807	136.1	132.0	1:16	2 guns; open water; 1 2 m swells
8A	7000	12194	213.2	175.0	1:16	2 guns; heavy ice SP 8800 onward
			total: 2967.4 km	total: 2358.2 km		

5.7 Data Processing

A commercial software package called Globe Claritas (version 4.3.1, developed by the New Zealand Institute of Geological and Nuclear Sciences) was used to process the seismic data during the cruise. It proved to be an efficient and versatile tool for evaluation of the data quality, assessment and verification of field acquisition parameters, and production of processed seismic sections suitable for interpretation in the field. An additional benefit is that some of the initial processing tasks, such as editing traces and binning shot gathers, have been completed and this work will contribute directly to future processing efforts. The Globe Claritas software was installed on a dual-processor laptop running under the Fedora Linux operating system (version 2.6.22). An external 500 gigabyte, universal serial bus hard-drive was used to store copies of both the raw and processed datasets.

5.7.1 Production of brute stack record sections

Brute stacks of the data within each line segment were produced every 6--8 hours during acquisition using the following steps:

1. scan SEG-D files to extract latitude and longitude of each shotpoint;
2. interpolate values for any missing geographic coordinates;
3. calculate x,y coordinates using Polar Stereographic projection (central meridian at 140°W);
4. calculate cumulative distance along ship track for each shotpoint;
5. create 1-D bins every 80 m along the ship track and assign a bin number to each shot ensemble;
6. apply 51 ms bulk shift to traces to account for mechanical firing delay of airguns;
7. bandpass filter (2/8/200/250 Hz);
8. balance traces within each shot ensemble;
9. stack traces within each shot ensemble to produce 1 normalized trace per shotpoint;
10. stack all traces within each bin;
11. apply F-X coherency filter to suppress steeply dipping events (5-trace running mix; maximum preserved dip of 9 ms/trace);
12. decimate traces to 4 ms sampling rate using anti-alias filter;
13. apply automatic gain control (750 ms window; double median algorithm);
14. generate raster plot (vertical scale: 2.5 cm/s; horizontal scale: 45 traces/cm).

The raster plots of the brute stack record sections are stored in tagged image formatted files (.tiff) on the accompanying CD-ROM (Appendix 1).

5.7.2 Sources of noise recognized on the shot records

A sample of consecutive shot records from GSC07-CAP1A is shown on Figure 5.6. Various events are present on the records including the direct wave arrivals, seafloor and sub-seafloor reflections, random noise, and coherent noise. The direct wave has a first arrival on the near channel of 107 ms and an apparent group velocity of 1430 m/s. Seafloor and sub-seafloor reflections are horizontal events on the shot records since normal moveout is neglible over the 93.75 m offset between the near and far traces (Figure 5.4).

Coherent noise is present on all shot records in the form of high amplitude dipping events with dominant frequencies typically between 8 and 20 Hz (Figure 5.6). Apparent phase velocities range between 275 and 750 m/s in both the positive and negative dip directions (i.e. some of the energy is backscattered). The most likely explanation is that, because the streamer was attached directly to the source, some energy traveled along the streamer after each shot impulse. The stretch sections in the streamer should reduce this phenomenon, but it is possible that more dampening is needed.

Stratification of ocean waters in the survey region is evident on plots of density and sound speed measurements that were taken in the water column during the survey (e.g. Figure 5.7). Some of the energy in the water column might therefore travel as dispersive guided waves within distinct layers. This could potentially create dipping events on the record sections, but the effect is expected to be minimal. Modelling of the guided waves would help to determine their significance.

Another source of coherent noise is manifested by the sinusoidal curve that is superimposed over all channels of the shot records shown on Figure 5.8. The noise has a clearly defined central frequency of 98.6 Hz and it is present on a significant portion of the shot records, although the amplitude generally ranges between one-third and half of that seen on Figure 5.8. Fortunately the noise has a higher frequency than the signals of interest, and it does not have the same phase across all channels so it was effectively removed by stacking. Communication with Geometrics confirmed that no components of the GeoEel system could generate the coherent noise. The most plausible explanation is that the noise was caused by electromagnetic interference from a large transformer that is part of the ship's main propulsion unit. However it was not possible to test this theory with the equipment onboard the vessel and, since the noise did not adversely affect the records, the issue was not pursued.

Random noise generated by the ship's propellers is present on shot records, particularly in regions where heavy ice conditions were encountered. The example on Figure 5.9 is at shotpoint 6309 of GSC07-CAP3B, where it was necessary for the ship to break through 2--3 m thick floes of multiyear ice using propeller speeds in excess of 80 rpm. This created high amplitude random noise with frequencies ranging between 8 and 25 Hz (Figure 5.9) that effectively obscured most signals in the record. Ice conditions and propeller speeds were logged by the bridge crew every half hour and also whenever significant changes were encountered (Appendix 5). In general, propeller speeds of 35--40 rpm were used whenever whenever ice conditions permitted, and these propeller speeds produced little discernible noise on the records. The quietest shot records acquired during the survey were from regions of thin (20--40 cm) first-year ice and brash ice.

In open-water regions away from the pack ice, waves were significant source of random noise. For example, 2--6 m swells generated by 40 knot winds during acquisition of line segments 2D

and 2F caused average RMS noise levels that were consistently greater than 12 microbars and occasionally greater than 20 microbars (Appendix 2). Nonetheless, brute stacks and filter tests demonstrated that imaging of seismic basement along these line segments was adequate to determine sediment thickness and that there was therefore no need to alter acquisition plans.

5.7.3 Production of filtered record sections

The following processing sequence was used to suppress some of the noise identified on the shot records and to produce filtered record sections that could be used for preliminary interpretations in the field:

1. interpret seafloor horizon and store the associate two-way travel times for each shot record;
2. identify and remove bad shots and noisy traces;
3. apply symmetrical F-K filter to shot ensembles to remove coherent dipping events (maximum dip preserved: 3.5 ms/trace);
4. apply trace muting for times within the water column and from the first seafloor multiple to the end of the record;
5. scale trace amplitudes to compensate for geometrical spreading and attenuation of the wavefront;
6. balance trace amplitudes across shot ensembles;
7. apply predictive deconvolution to suppress short-period multiples (gap length: 50 ms; filter length: 400 ms; design window: 70--6000 ms relative to seafloor horizon);
8. apply spiking deconvolution to compress the seismic wavelet energy (gap length: 2 ms; filter length: 50 ms; design window: 70--6000 ms relative to seafloor horizon);
9. define 2-D circular bins every 80 m along a smooth vector interpolated through shotpoint locations;
10. assign every trace to the nearest bin and, within each bin, sort the traces by absolute distance from the bin centre;
11. stack all traces within each bin;
12. attenuate random noise using two passes of F-X deconvolution (first pass filter dimensions: 30 traces by 120 ms with 20 trace and 50 ms window overlaps; second pass filter dimensions: 60 traces by 240 ms with 40 trace and 100 ms window overlaps);
13. apply automatic gain control to balance traces horizontally across the record section (750 ms window; smooth normal algorithm);
14. re-apply mutes within water column and below seafloor multiple.

The raster plots of the filtered record sections are stored in tagged image formatted files (.tiff) on the accompanying CD-ROM (Appendix 1).

5.8 Measurement of the source wavelet

On day 275, just before starting acquisition of GSC07-CAP5A, recordings of the source wavelet generated by the G-guns were made using a Neptune Sonar Type T49 calibrated hydrophone (c.f. Section 4). The hydrophone was lowered vertically from the quarterdeck of the stationary vessel to a depth of 100 feet below the sea surface. The airguns were suspended 11 m below the sea surface. A number of shots were recorded from each of the forward gun, the aft port gun, and the two guns firing simultaneously. These are plotted on Figure 5.10.

A stacked trace (normalized by the number of shots) of the two guns firing is plotted on Figure 5.11A. The peak-to-peak amplitude of this trace is 238 mV. However signal strength dropped by 62.5% between the 12th and 13th shots of the aft port gun (Figure 5.10B) and remained low during the remainder of the experiment. It was discovered afterwards that seawater had leaked into a connector and it is therefore likely that the trace amplitudes recorded during firing of the two-gun combination are not accurate.

The peak-to-bubble ratio of the two-gun source wavelet is 4.8. A ghost reflection from the sea surface occurs 13.6 ms after the first trough, which broadens the source wavelet and creates a 15 dB notch in the frequency spectrum between 60 and 80 Hz (Figure 5.11B). For most surveys the source would be towed at a shallower depth, perhaps 8 m rather than the 11 m used during this survey, to minimize the effect of the source ghost. However, an 11 m tow depth was necessary during this survey to ensure that both the source and the streamer remained below the sea ice during icebreaking operations.

5.9 Sonobuoy Data

A total of 28 sonobuoys were launched during the seismic acquisition and recorded using the GSC-DIG#4 recorder configured for a record length of 19.1941 seconds and a sampling rate of 3.571 milliseconds (c.f. Section 4). After balancing and bandpass filtering the traces (3/8/80/120 Hz), plots of the sonobuoy data were generated at a scale of 22 traces/cm and 1.1 cm/second. These plots are stored in .tiff format on the accompanying CD-ROM.

Significant coherent noise is present on the recorded traces from sonobuoys 1 through 8 in the form of high amplitude periodic spikes at multiples of 12.3 Hz (i.e. 12.3, 24.6, 36.9, etc.; Figure 5.12). Although events are recognizable on these records, the noise is so severe that it is difficult to correlate the events accurately across the records. Several attempts at troubleshooting eventually identified the cause of the problem which, due to an improper connection in the digitizing unit (c.f. Section 4), was causing very low signal levels against the background noise. Fixing the problem caused dramatic improvement in the signal to noise ratio.

Figure Captions

Figure 5.1 Map showing start and ends of segments comprising lines GSC07-CAP1, 4, and 8.
Figure 5.2 Map showing start and ends of segments comprising lines GSC07-CAP2, 3, and 5.
Figure 5.3 Map showing start and ends of segments comprising lines GSC07-CAP6, 7, and 8.
Figure 5.4 Schematic diagram of the source and receiver geometry used during the survey.
Figure 5.5 Screen capture of the CNT-2 user interface used to configure the GeoEel system and to monitor seismic acquisition.
Figure 5.6 Sample shot records from GSC07-CAP1A.
Figure 5.7 Sample plots of physical property measurements made in the water column during the survey with an XCTD#2 (expendable conductivity, temperature, and density probes) on calendar day 257 (data courtesy of Joe Manning, CHS) . A) Speed of sound versus depth in the water column. B) Density versus depth in the water column.
Figure 5.8 A) Shot record from GSC07-CAP4D showing medium amplitude sinusoidal coherent noise which varies in phase from trace to trace.

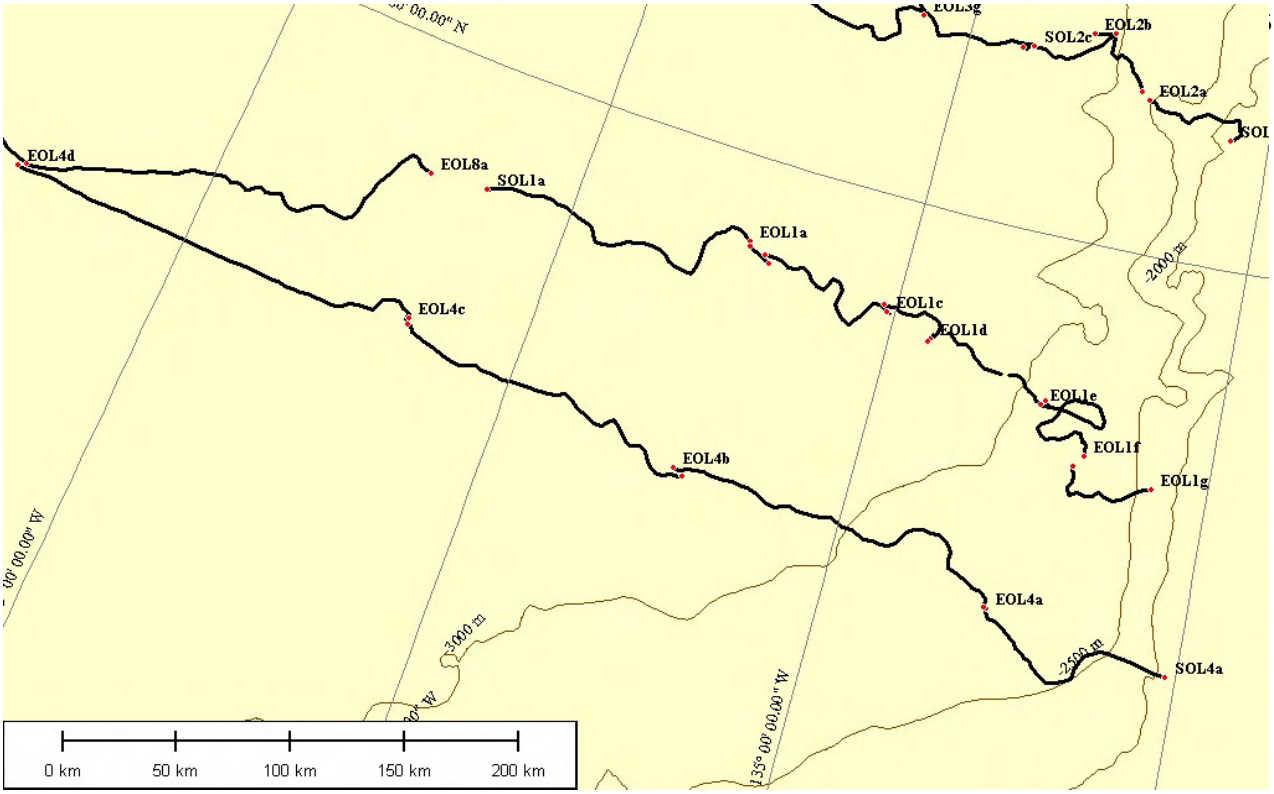


Figure 5.1

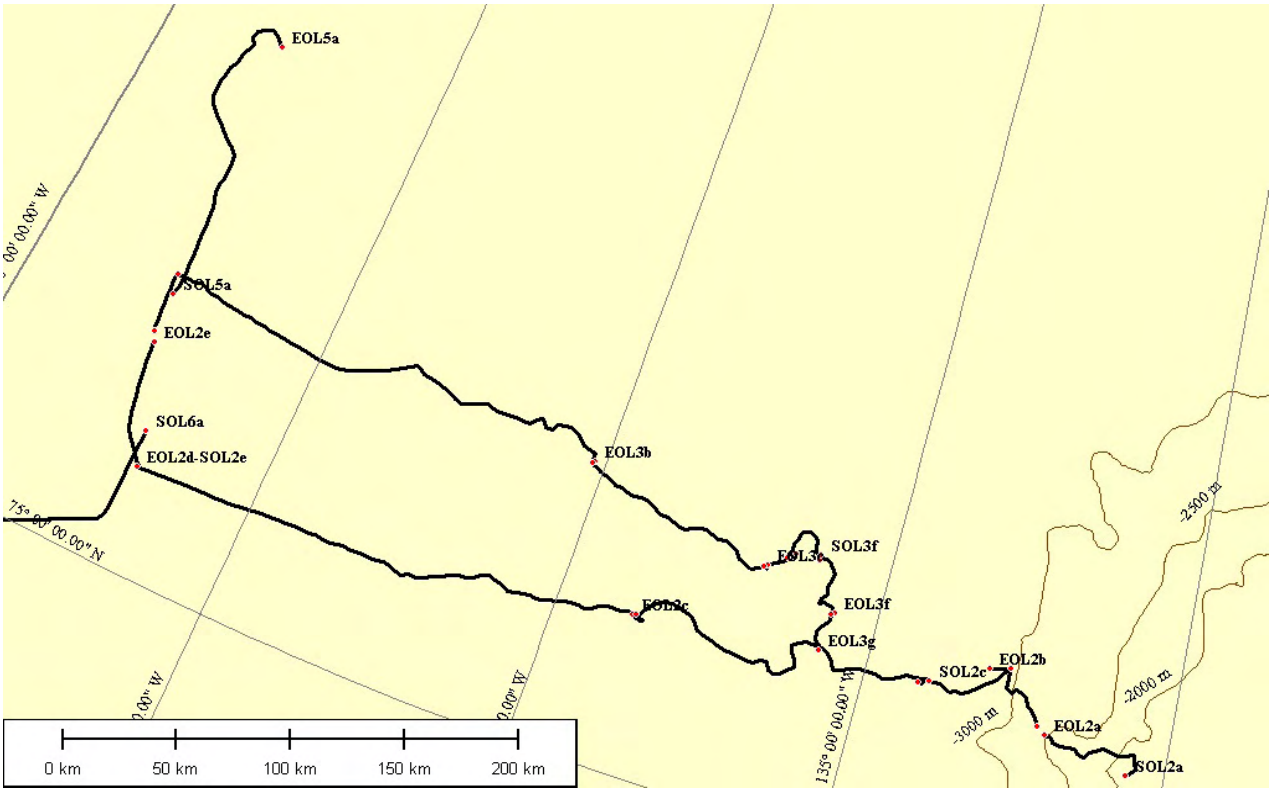


Figure 5.2

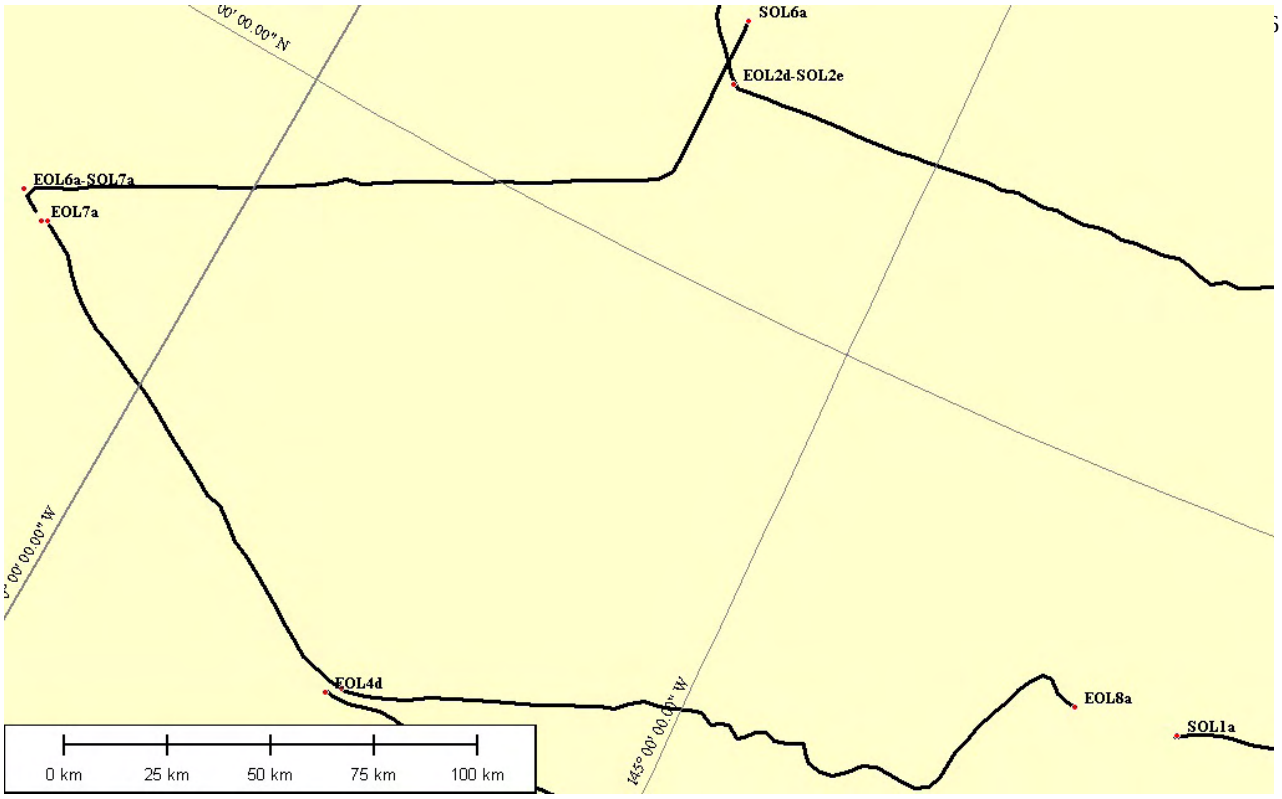


Figure 5.3

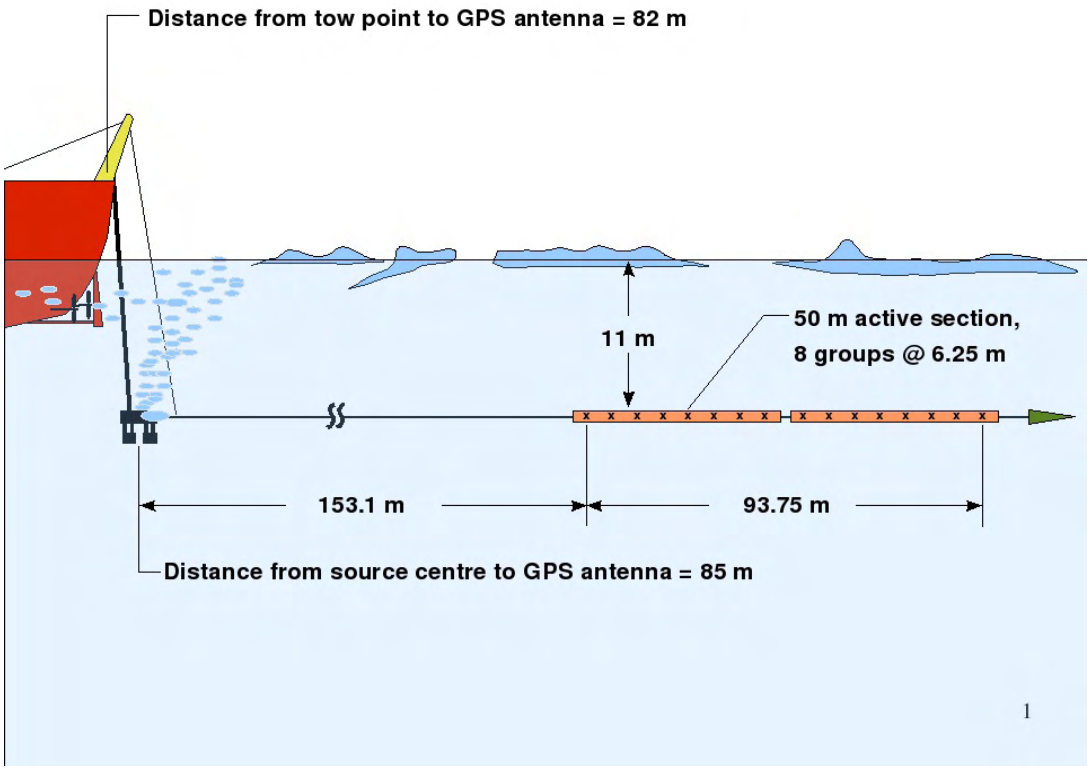


Figure 5.4

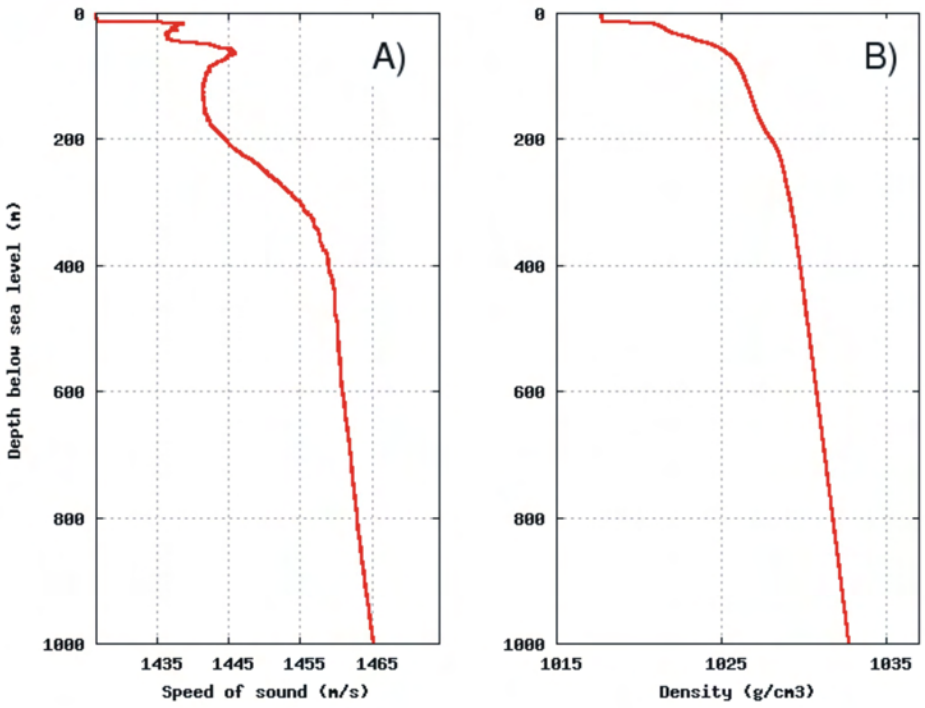


Figure 5.5

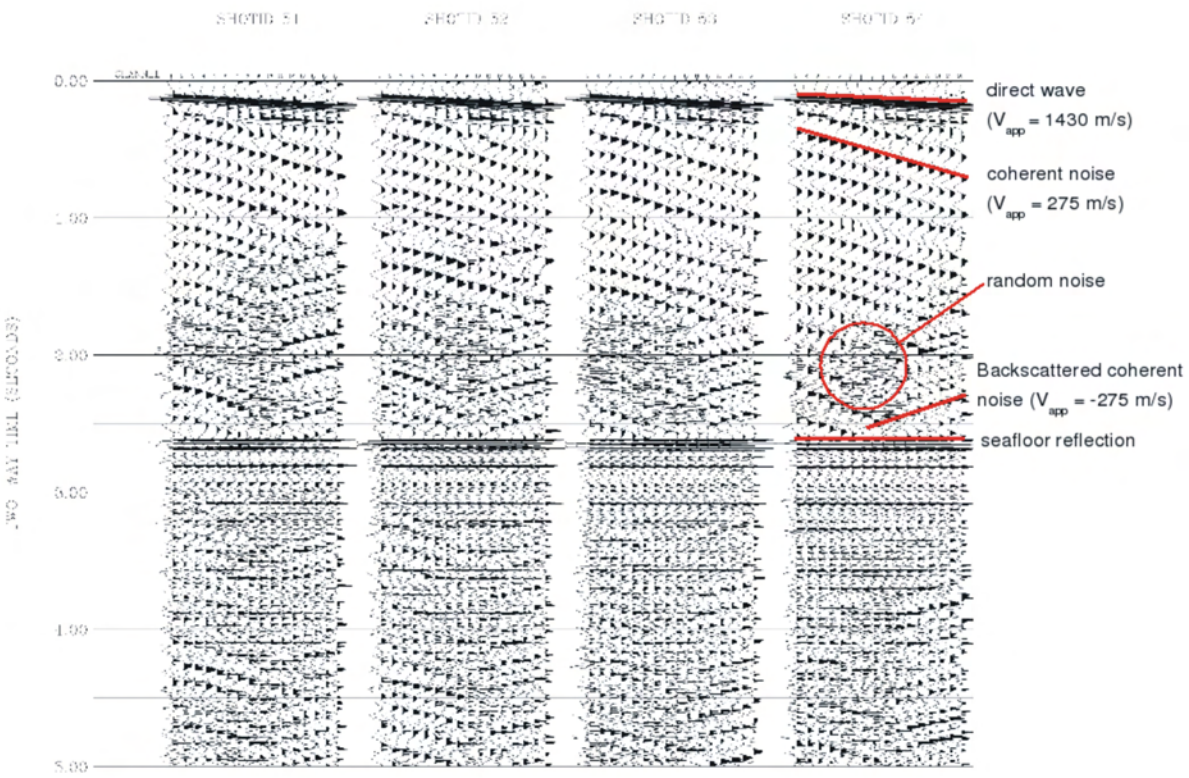


Figure 5.6

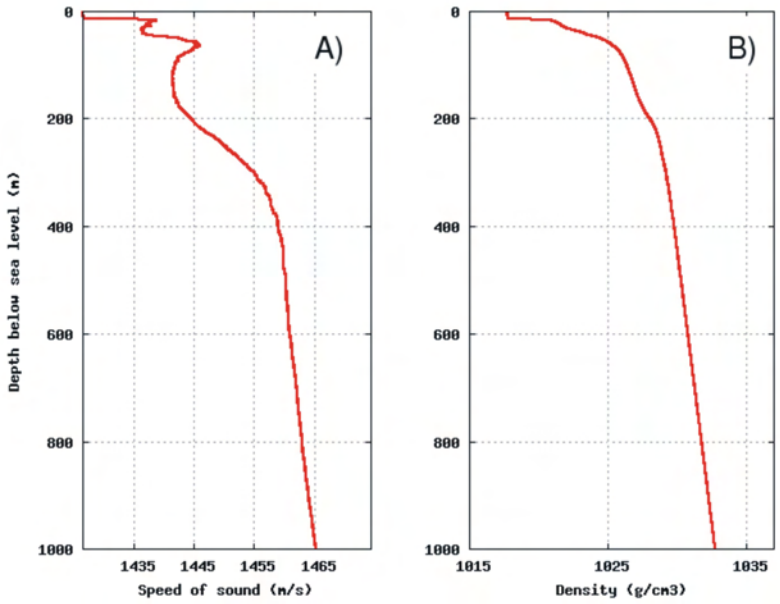


Figure 5.7

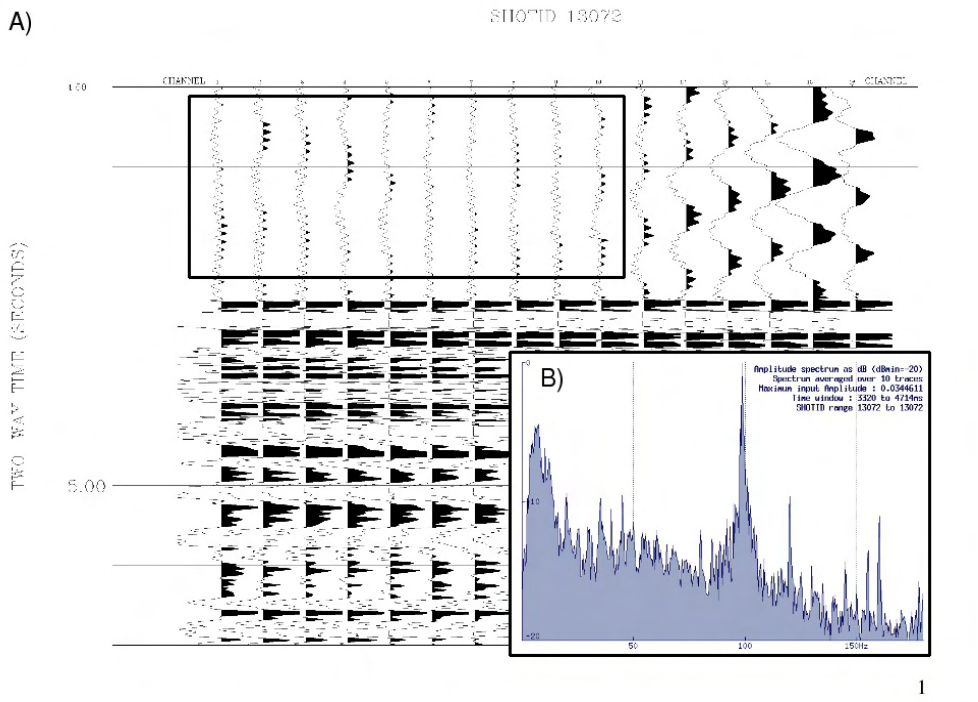


Figure 5.8

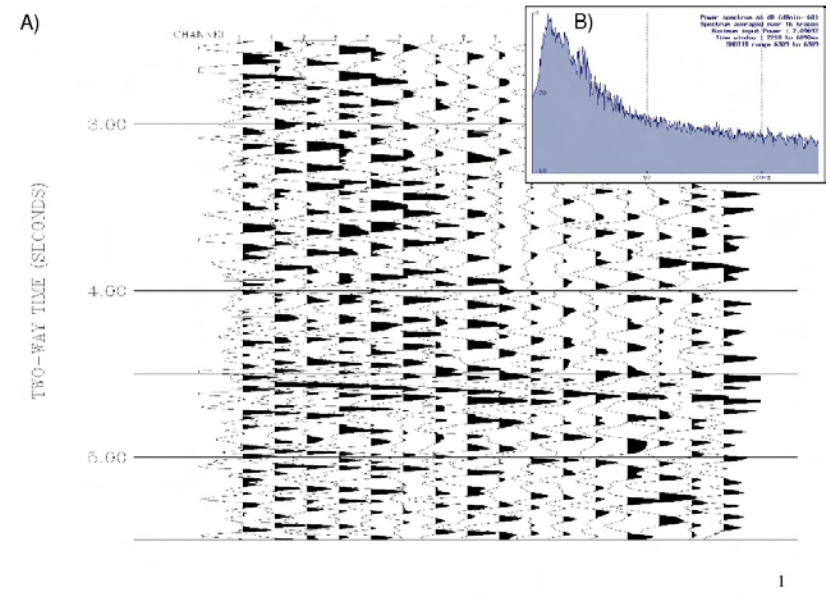


Figure 5.9

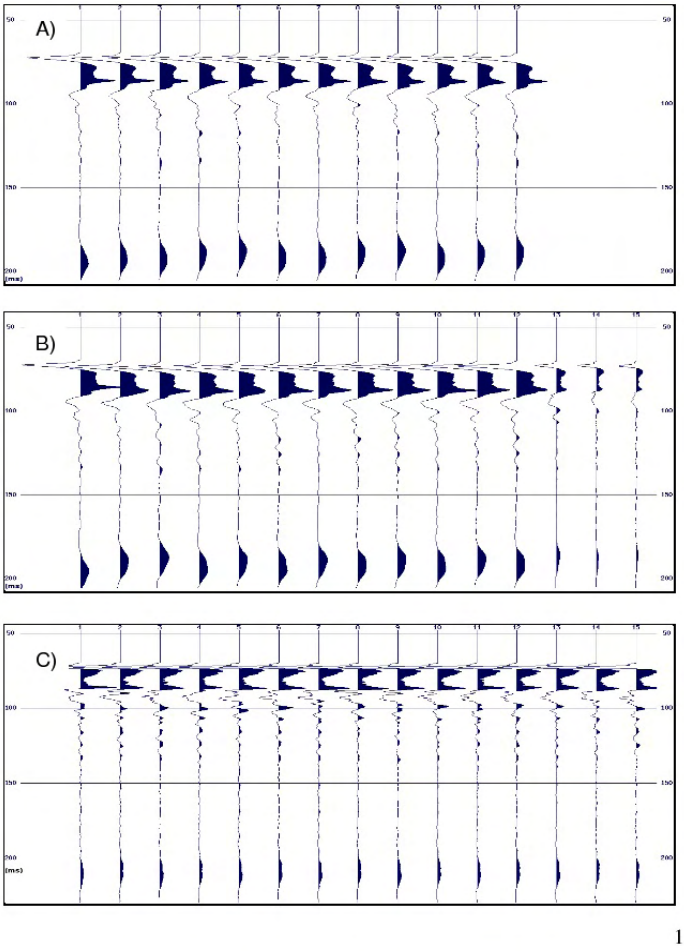


Figure 5.10

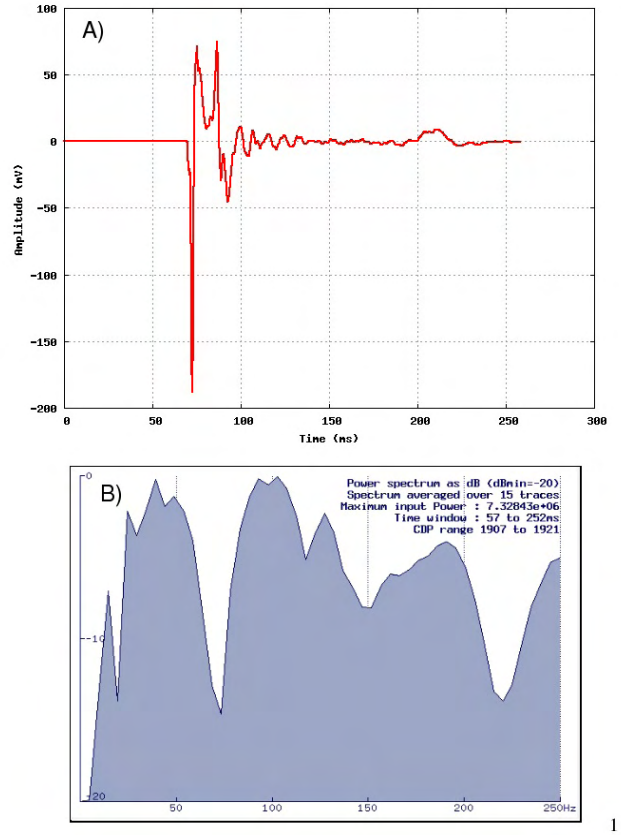


Figure 5.11

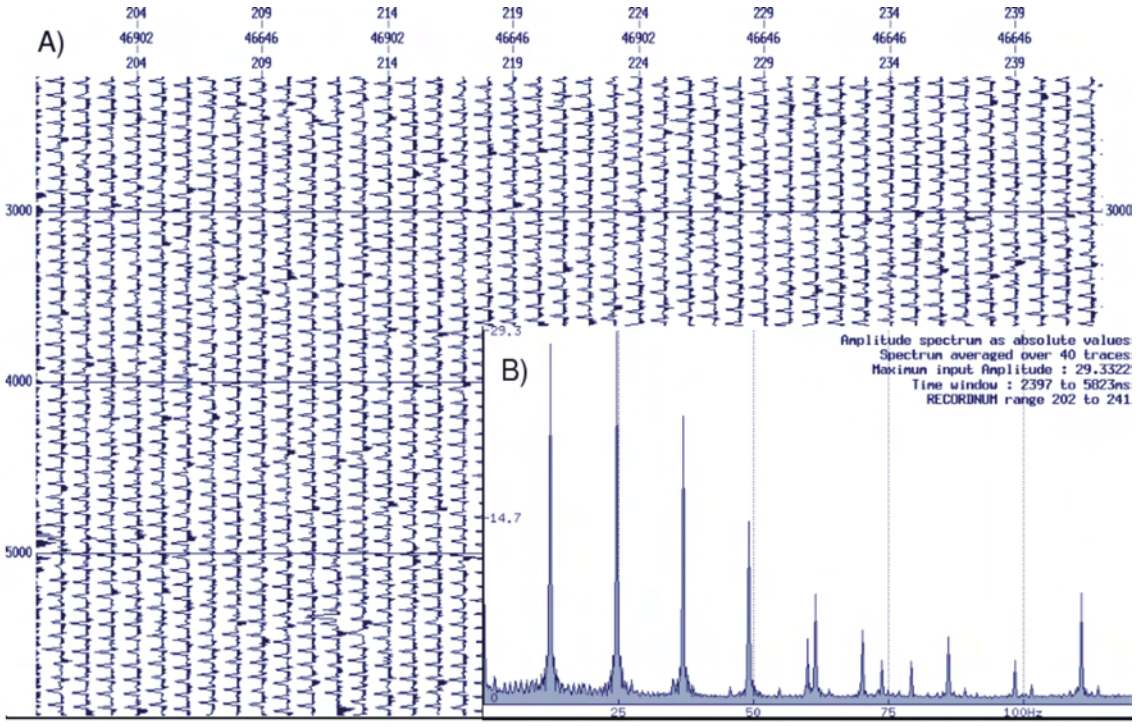


Figure 5.12

6. LSSL 2007 Navigation and Data Distribution and Processing

by Paul Girouard

The data streams required by the various systems in operation in the seismic lab were provided through various modes of data transfer. Differential GPS navigation was provided by the science Novatel receiver. NMEA sentences from this system were distributed to the seismic lab via a dedicated fiber connection. The log and gyro were distributed to the lab by the NOAA computer which broadcast the data over the ship's network. The bathymetry was distributed to the lab via a dedicated fiber connection from its location in the forward scientific lab via the network. The Regulus navigation system, running Build 28894 of the software, was used to view and log the scientific navigation. A second monitor was attached to the system through a video splitter allowing for the concurrent display and updating of the electronic log.

The navigation 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. All seismic and sonobuoy data as well as their related logfiles were also backed up to DVD for archiving. In addition, the compressor watchkeepers and mammal observers maintained paper records of their observations. These were reviewed on a daily basis and transferred to digital spreadsheets.

In general, the systems and data distribution worked well but the various modes of data distribution resulted in some complications in the efficient distribution of this data to the various systems as explained in some detail below. The state of the ship's network also was cause for some concern as it was impossible to connect any new computers to the network for the first week. In addition, several switch related malfunctions also caused some interruptions in the services. The speed of the network left much to be desired. It was more efficient to go to the lab and retrieve data using a memory stick or a network connection through the lab network switch than to try to transfer the data over the network. It should e pointed out that at no time did any of these problem compromise our ability to carry out our program except for the hydrographers' ability to control the sounder which is accomplished over the network.

Major concerns:

* The NOAA computer is used for data distribution throughout the ship. This requires the use of GpsGate on both the NOAA computer to initiate the distribution, and all other computers that need to receive the data. There were several occurrences where the data stream was interrupted either because of problems with the network switches or GpsGate hanging on the NOAA server. It was often necessary to restart the computer in order to get GpsGate to function.
* Because the Knudsen sounder is being used to multiplex all the NMEA strings for distribution, two GGA (position) strings are being distributed to the seismic lab. This requires the use of GpsGate to filter out the GGA string from the Saab receiver whether one is using a direct feed from the network distribution or a serial feed from the serial line splitter. The GGA string from the Novatel receiver is the one used, through a direct feed to the lab.

* Three data sources are required to collect all the required in formation: one for the navigation, one for the log and gyro and one for the bathymetry. This is a problem for programs such as the seismic logging software which allows for the use of only one serial source.
* DHCP service was unavailable for the first week of the cruise because of a problem with the server. The problem was exasperated by the fact that although 30 IP numbers were dedicated to the static pool, all were already assigned. No new computers could be attached to the network during this period. Network services were again disrupted when the backbone switch in the forward scientific lab developed a fault. This stopped all data distribution from the NOAA server as well as interrupted the Knudsen control which is performed over the network from all locations.
* Two further network interruptions occurred as a result of the fiber link between the aft scientific lab. In the first instance the problem was eventually traced to a defective fiber patch cable between the seismic lab network switch and the fiber drop in the lab. In the second instance the problem was corrected by re-seating the patch cable between the fiber termination and the fiber/UTP converter on the aft scientific lab network patch cable.
* The network speed is painfully slow. Data transfers between 2 computers connected through the seismic lab switch are at least 5 times faster than between the seismic lab and other parts of the ship. This is significant when one is required to transfer several hundred megabytes of data.

Recommendations:

The following recommendations would result in direct serial links between the various data sources and destinations. This would remove any reliance on the network or software based systems such as GpsGate for data distribution to the seismic lab without changing or compromising the existing shipboard data distribution setup.

* A serial data splitter should be installed on the outputs of both the log and gyro providing a feed to both the present Saab nav/log/gyro data multiplexer on the bridge and to a new data multiplexer to be installed which would multiplex the log and gyro with the Novatel nav. This would be then feed directly to the seismic lab through a new direct fiber link. This change would provide the seismic lab with a single serial feed of the required nav, log and gyro. It will also eliminate the use of GpsGate to filter out the Saab nav. The present Saab nav/log/gyro feed to the forward scientific lab would be preserved in its present state.
* A “black box” data multiplexer should be used in the forward scientific lab to multiplex the Saab nav, the log, gyro and bathymetry rather than use the Knudsen sounder for this purpose. This would allow, with the addition of a serial line splitter on the Knudsen output, for a feed of the bathymetric data only to the seismic lab over the existing fiber link, unencumbered by the Saab nav and the log and gyro. This would also preserve the present network data format and distribution on the NOAA server.
* A router should be added in the seismic lab to isolate the lab network from the main ship’s network. This would both isolate the lab from any major ship network problems as well as allow the computers in the lab to use an IP address structure different than the ship’s, all while preserving the connection between the two networks. It would be especially useful if this router could be linked directly to the main backbone switch in the forward scientific lab. This may help to improve the speed of the network connectivity.
* The installation of at least three more fiber links to the seismic lab. One, as stated above, to feed the Novatel nav and the log and gyro from the bridge, the other being two spare

links to the forward scientific lab and radio room for future use for data distribution. The two fiber links installed in the av gas area for a previous cruise and no longer required could be used to accommodate two of these.

* The slow speed of the network is likely due to the saturation of the bandwidth. Although this could not be confirmed at the time of writing, the backbone speed of the network is probably 100Mbps. This may have been more than adequate at the time of the original installation, but increases in network use due to new technology and science requirements would probably justify an increase in bandwidth to 1Gpps.

7. Hydrographic Program

CCGS
Louis S. St Laurent Arctic
UNCLOS Project
2007

by Jon Biggar

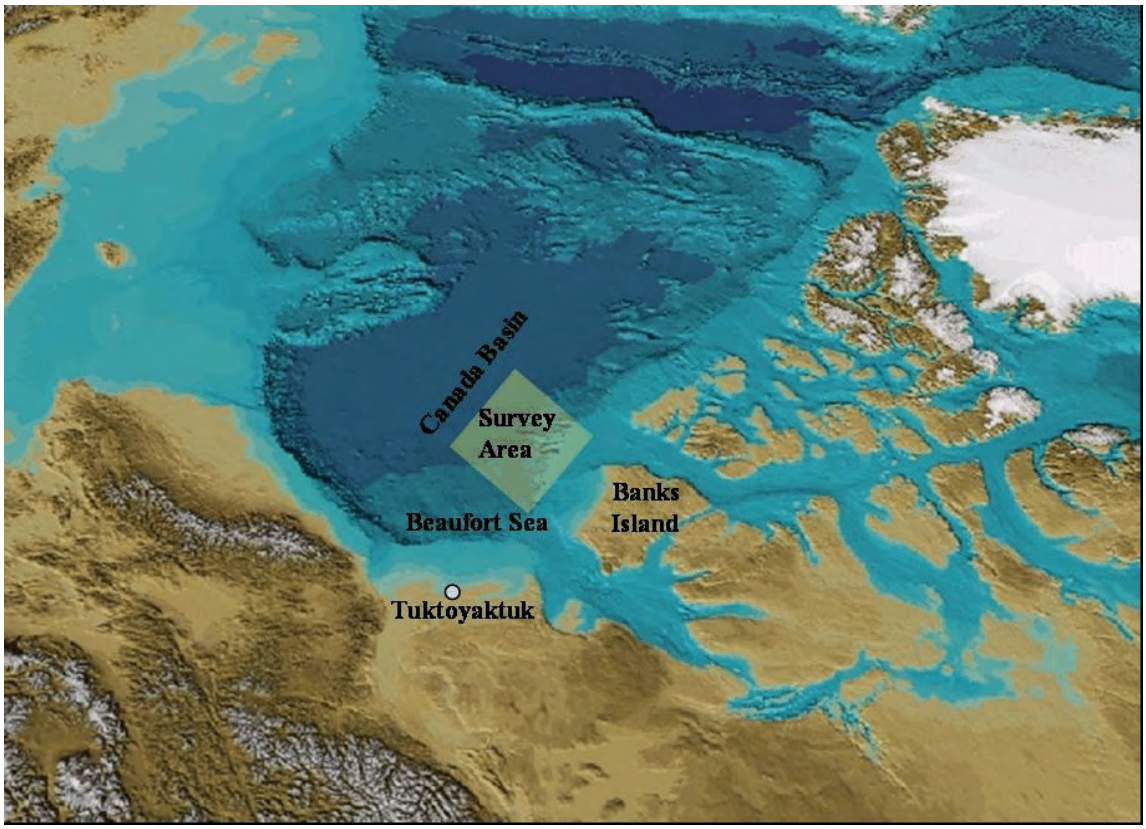
Background

The Canadian Hydrographic Service (CHS) is responsible for a number of conditions under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS) to delineate/survey/establish the continental shelf for Canada's territorial claim :

mapping baselines from which the extent of the territorial sea is measured,
mapping he 2500 metre isobath and the Foot of the Slope
Optimising the location of boundary lines at calculated distances. (60, 100, 200 and 350 nautical miles)
Populating data bases with the above data and outputting in the form of charts, maps and diagrams

Summary

The CHS program was conducted in conjunction with the NRCan seismic operations. The bathymetry collected on this program will be used to augment and refine the historical information that will be used to establish and support Canada's UNCLOS claim. The Canadian Hydrographic Service team consisted of Jon Biggar (Central and Arctic Region), Joe Manning (Newfoundland Office) and Mike Ruxton (Atlantic Region). Two sounding techniques were employed; conventional ship configuration and helicopter spot soundings. The ship navigated along predetermined transects and helicopter was deployed to collect spot sounding data between the lines. The ship logged 7783 line kilometers and the helicopter collected 180 spot soundings (Figure1). Virtually the same equipment was used for both platform setups. (See Appendix 1 for equipment list) The success of this year's program can be contributed to the dedication and hard work of the captain and crew of the CCGS Louis S St Laurent.



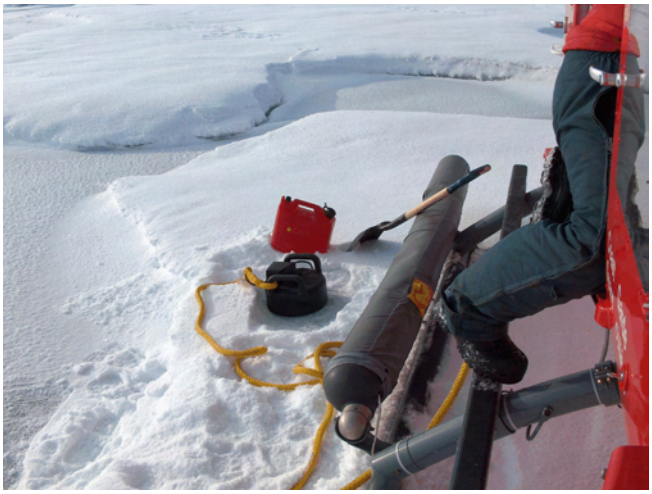
(Figure 1 - Survey area)

Sounding Methods

The ship collected sounding using the Knudsen 320B/R Plus sounder attached to a 12 KHz transducer. The system used Chirp pulse generation technology. The echo sounder preformed well although the settings in deep water (2500 metres plus) were set at maximum values to acquire the data. As normal with sounding in an ice breaker situation, bottom detection was lost due to interference from ice. Knudsen Echo Control Client V1.74 and SounderSuite, PostSurvey V1.55 software were used for acquisition and viewing during post processing of the data. No major electronic problems were encountered. Periodically the Knudsen sounder and computer interface would lock up and require a system reboot. This problem was related to the ship's computer network system.

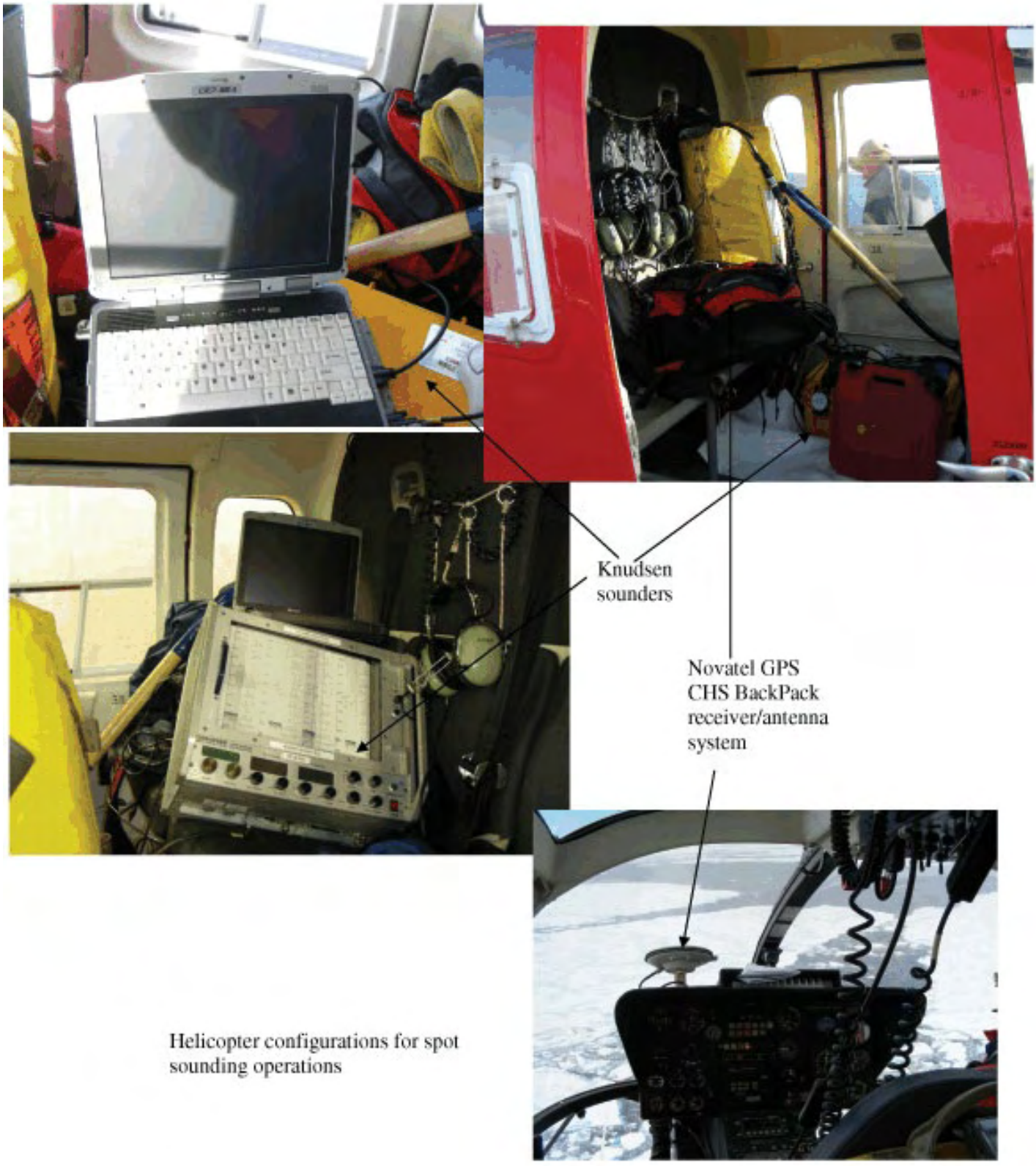
The spot sounding procedure employed two methods, open water and ice surface mounted transducer. Normally in the Arctic conditions, an echo sounder transducer cannot not be placed directly in contact with the water. This means that sound wave must travel through the ice into the water, echo off the bottom, and return through the ice back to the transducer. At each boundary some of the sound is reflected and lost. The best reflector is the air/ice interface creating the largest acoustic impedance. To minimize the impedance the sounder transducer is adhered/bonded to the ice surface using a thin layer of food grade gear oil. A number of different models of

Knudsen echo sounders using a fixed frequency of 12 KHz were used for testing/comparison to determine best performance. The spot sounding depths were collected at a fixed velocity of 1500 ms/sec and then corrected to an average true velocity derived from the Sound velocity casts. Because of the difficulty in knowing the nature of the ice conditions, an estimate of ice thickness was recorded and divided by two and applied to the measured depth as a positive correction. The assumption was made that speed of sound travels at a speed of approximately 2250m/sec through the ice column. For open water, two marks were placed on the tether to which the pilot would submerge the transducer to and this number was applied as a draft value to the sounding. The whole process under ideal conditions was expected to take 5 to 10 minutes per location. The ice conditions were in most cases multiyear with snow thickness up to 30 cm. Newly formed first year ice is not a good surface for acquiring spot soundings because of the entrapped air within and below the ice. The open water technique was achieved by slinging the transducer below the helicopter and placing into the water while in a hover. In both cases the data was logged to a laptop and processed. The helicopter logged 47.1 hours of flight time to collect 180 spot soundings.

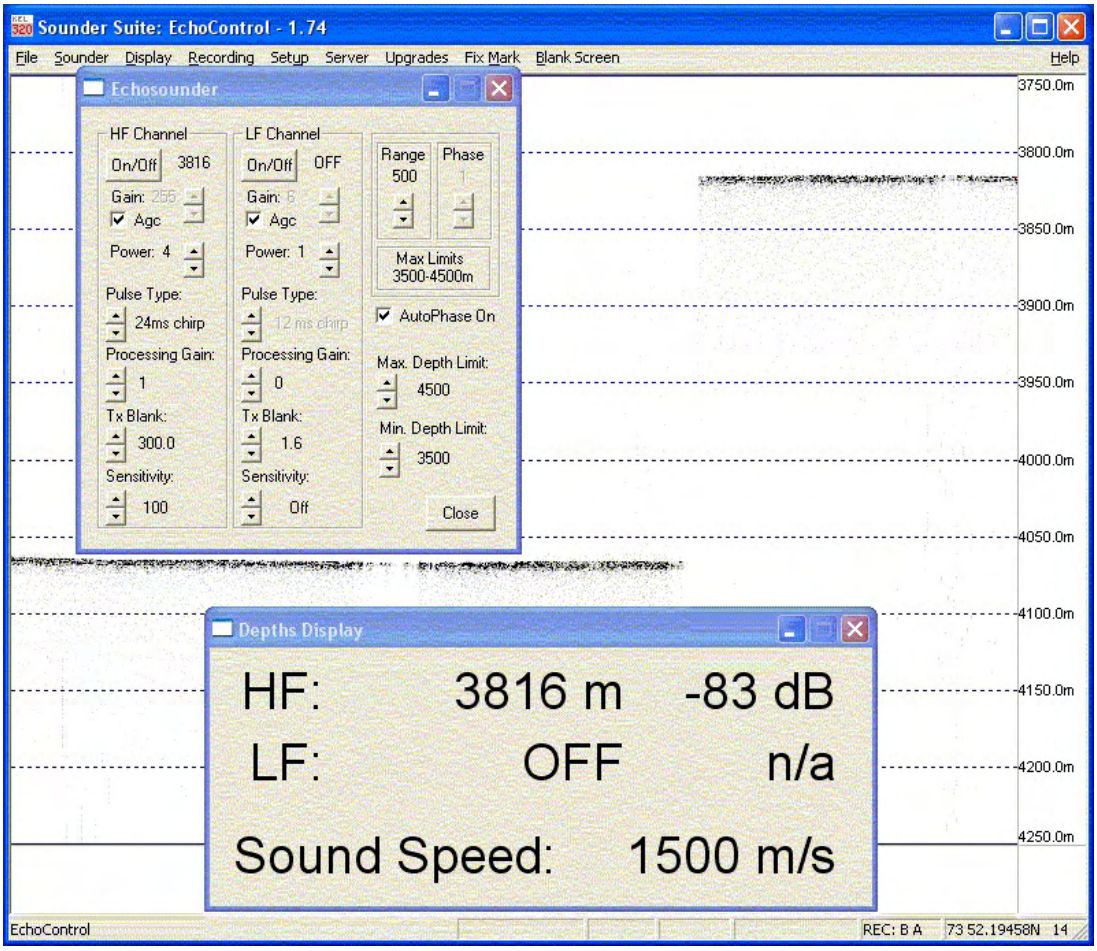


Spot sounding on the ice, showing 12 Khz on the ice surface

Spot sounding in open water, showing transducer slung below helicopter



Helicopter configurations for spot sounding operations



Knudsen interface EchoControl used to monitor sounder status and log bathymetry information

Positioning Methods

The positioning system used for both methods of data collection were the Novatel Propak V3 GPS receivers with L2 antennas. Differential corrections were received from the nation-wide CDGPS service by means of MSAT satellite communications. The correction data is based on algorithms developed by Natural Resources Canada (NRCan) and positioning data from Canadian reference stations. The estimated positional accuracy was 2.0 metres in static mode. Differential corrections were received 95% of the time. The only problem was the loss of satellites due to blockage because of the GPS antenna placement in the helicopter on the front dash board. Normally this is not a problem but the combination of northern latitudes and the satellites being at lower elevations resulted in an increase in outages. All equipment preformed well overall.

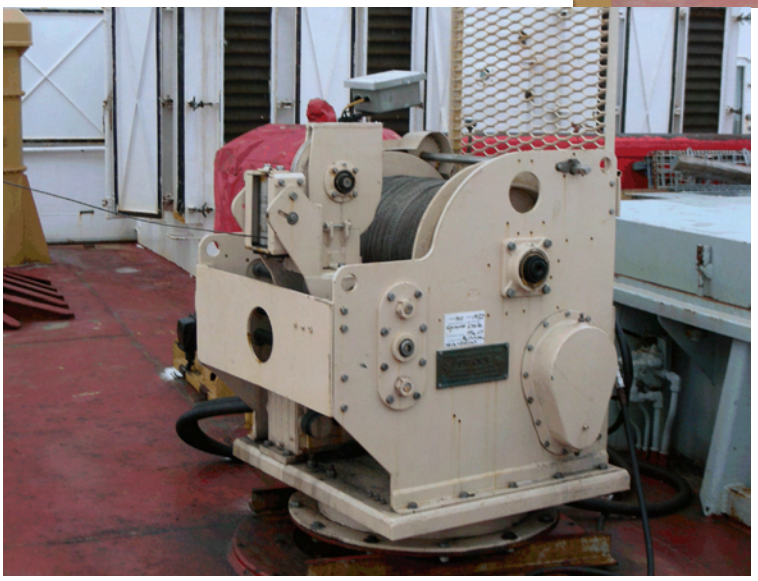
Novatel software interface used to configure and monitor GPS receiver status

Data Collection

For navigation and planning, Hypack V6.2 (single beam survey module) was used to monitor and collect the survey data. Sound velocity casts varying from 900 metres to 3000 metres (capacity of winch) were performed over the entire survey area, using an Applied Microsystems SV Plus (SVP) V2 (sound velocity meter) with a depth range of 5000 metres (Figure 2). The data used Smartalk V2.27 software was used for data download. Expendable Conductivity, Temperature and Density (XCTD) and Expendable Sound velocity (XSV) probes were also deployed over the entire survey area. The XCTDs provided science programs with additional data for the area and sound velocity corrections for the CHS program.

NRCan Seismic lab onboard CCGS LSSL showing CHS data collecting and processing station

SV Plus V2 being set for deployment with science winch



Science winch

Processing Methods

CARIS (Computer Assisted Resource Information System) GIS V4.4 was used for managing, compiling, and visualization of the results of the processed bathymetric data. CARIS HIPS/SIPS V6.1 (Hydrographic Information Processing System/Sonar Information Processing System) was used for survey data processing of positions and depths.
The processing steps consisted of: file conversion from Hypack to the HIPS/SIPS format,

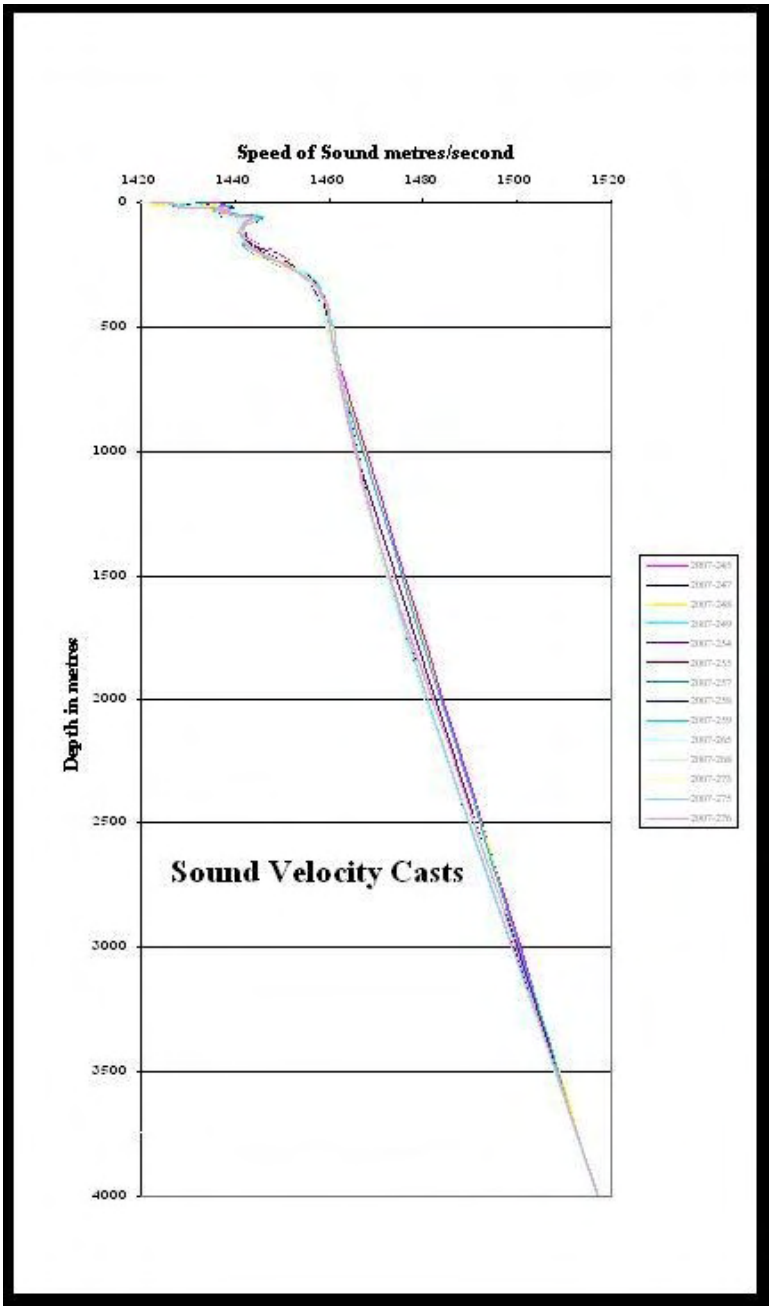


Figure 2
SVP / XCTD
/ XSVP profiles

navigation editor to clean/edit 'vessel' position, single beam editor to clean/edit depth information and line processing which merges final position and depth files while applying tide reductions and sound velocity corrections. (Figure 3) The ship's gyro information was logged and applied to the data to correct for GPS/transducer offsets.

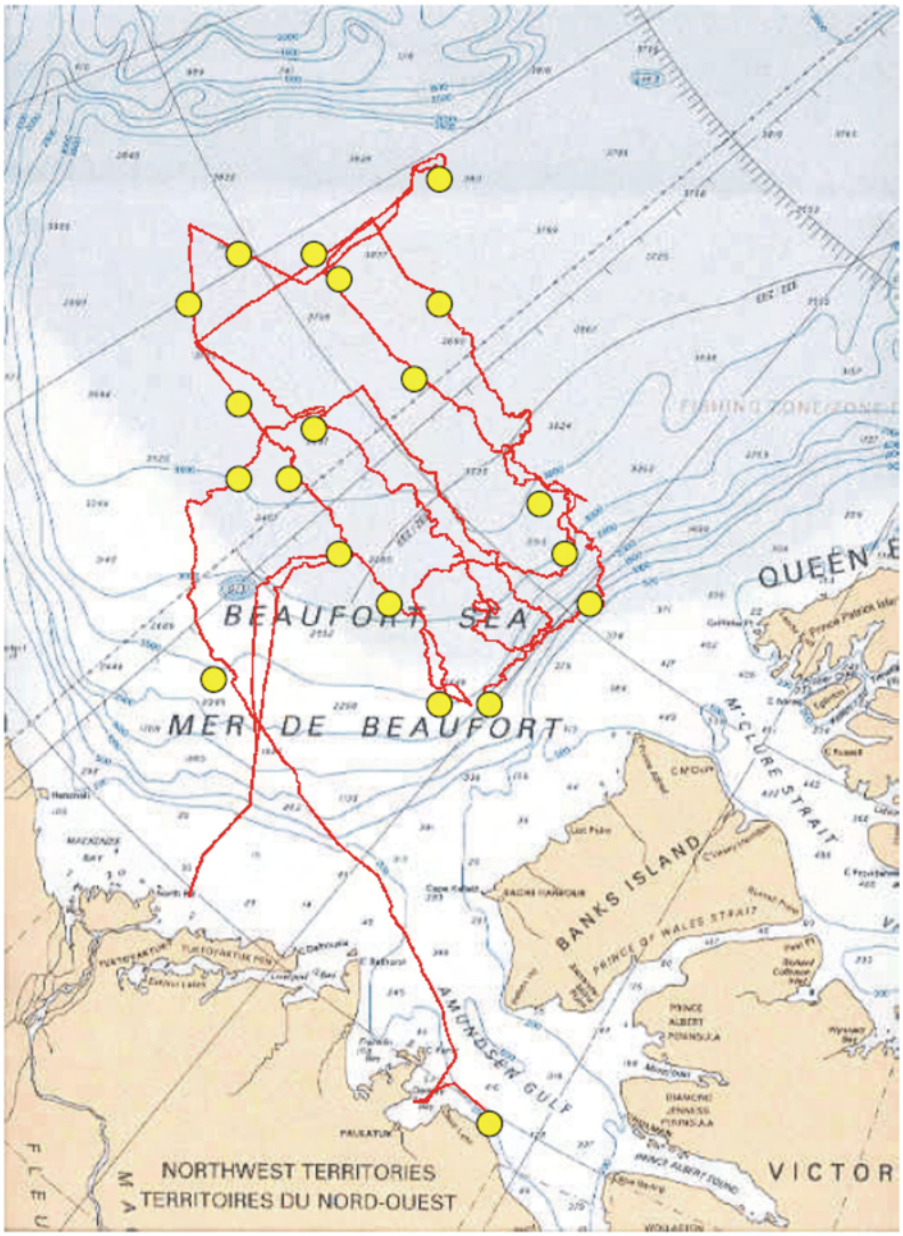


Figure 3

Tracklines

SVP/CTD locations

Recommendations

The ship needs to be outfitted with another 12 or 3 kHz transducer for backup. If for some reason the existing system fails there is no alternate method for bathymetry collection in deep water. For helicopter sounding in open water, a quick disconnect is required for the transducer during sling operations. Knudsen sounder tests revealed that using a tone signal generation pulse with a paper graph for bottom detection (alternative is CHIRP pulse/laptop) is better/more user friendly for helicopter spot sounding operations. In addition, two helicopter pilots are not necessary because of limited flying opportunities. If two icebreakers are involved in future years, helicopter resources could be shared between the platforms. GPS planning software needs to be employed for ship/helicopter operation for the elimination/reduction and awareness of GPS satellite status and or outages while surveying. An additional concern is the ship network connections for the Knudsen sounder control and data logging. The NRCan group will be addressing these issues. Three CHS staff is sufficient for sounding operations onboard ship.

Appendix 1
Major Equipment and Software Programs

CCGS Louis S St Laurent
Knudsen 320B/R Plus sounder
12 kHz transducer

Novatel DL V3 GPS receiver / Novatel L Band antenna

Desk top computer / Hypack software / Knudsen software / CARIS software

SV Plus V2 (sound velocity meter) depth range 5000 metres (SVP)
XSV02 (Expendable Sound Velocity Probe)
XCTD (Expendable Conductivity, Temperature and Density Probes)

CCG Helicopter 363 (B105)
Knudsen 320A sounder (variable frequency capacity)
Knudsen 320M sounder 12/24 kHz
Knudsen 320BP plus sounder 12/24 kHz
Knudsen Chirp 3210 sounder 12/24 kHz
12 kHz Giff transducer
12 kHz Knudsen transducer

Novatel Propak V3-RT2 GPS receiver / Novatel L Band antenna

GoBook XR-1 laptop / Hypack software / Knudsen software

Appendix 2
Weekly Reports
UNCLOS – CCGS Louis S. St Laurent
Highlights: departed Burlington, bathymetry program started, ice conditions in area look promising for project

Weekly Summary: Aug 29 to Sept 3
Aug 29 Wednesday departed Burlington, over night in Dartmouth
Aug 30 Thursday departed early morning from Coast Guard base to airport, departed 6 AM for Kugluktuk, stop over in Iqaluit for air crew change and fuel, arrived Kugluktuk at 1 PM, onboard ship later that afternoon, settled in
Aug 31 Friday finding and sorting gear, ship orientation and safety meeting, fire drill, creating survey lines for ship to run until seismic equipment is operational departed Kugluktuk late afternoon for survey area
Sept 1 Saturday preparing and checking equipment for ship and helicopter collection, planning lines, safety and spot sounding briefing with helicopter crew, unable to locate aluminum box with 24 KHz transducers and assorted equipment (placed onboard in Dartmouth)
Sept 2 Sunday bar check in AM down to 400 metres, after lunch SVP to 1350 metres, downloaded information, no problems, started 24 hour sounding operations late afternoon, proceeded north to run a bathymetric line between seismic line #1 and #2, positioned ship's transducer and GPS antenna for vessel configuration file
Sept 3 Monday fog, snow and overcast, ship sounding in heavy ice, configuring helicopter sounding equipment, problems with new Knudsen 3210 sounder verifying transducer frequencies, sounders are operational, GPS Backpack working with Hypack, helicopter deck being utilized for prepping seismic equipment

Plans: continue sounding operations, start helicopter spot sounding program, NRCAN deploy seismic gear

UNCLOS – CCGS Louis S. St Laurent
Highlights: seismic and sounding operations have started, 1,150 line kms of bathymetry collected, includes one transit over the 2500 metre contour, 24 spot soundings collected to date, a total of 7 casts XSV, XCTD and SV2 have been completed

Weekly Summary: Sept 4 to Sept 9

Sept 4 Tuesday- overcast and fog, prepared for afternoon flight, standby for weather, SVP cast to 3000
metres, completed bathymetry line, started seismic line #CB01, running east
Sept 5 Wednesday - cool and clear in AM, attempt flight at 8:30, problem with Hypack accepting target file
in UTM, deployed Expendable Sound Velocity probes (XSV) worked to 600 metres, two flights collected 13 spot soundings, late evening compressor problems, ship on standby
Sept 6 Thursday clear and cool, -7C, repairing compressor and air guns, tried flight in AM, dirty fuel then fuelling system leaks, flight cancelled, flight after lunch, fuelling from drums, 5 spot soundings collected SVP cast and XSV cast, seismic equipment repaired and operational by 8 PM
Sept 7 Friday sunny, seismic gear problems with air guns and hydro phones, drifting for

the day, processing spot sounding files, ship processing update

Sept 8 Saturday overcast, problems with seismic compressor, afternoon flight, problems with GPS drop outs, change antenna lead and antenna prior to next flight, 6 spot soundings collected, Mike Ruxton (CHS) hurt his back, work shifts adjusted to compensate for one less person

Plans: continue sounding operations, continue helicopter spot sounding program, run bathometry line over the 2500 metre contour west splitting seismic lines CB02 and CB03, deploy seismic gear and steam east, ice conditions are more favorable at the west end of the lines for seismic equipment deployment.

UNCLOS – CCGS Louis S. St Laurent

Highlights: seismic and sounding operations continued all week, 1,124 line kms of bathymetry collected, 42 spot soundings collected to date utilizing 9.3 helicopter hours, a total of 3 SVP (Sound Velocity Probe) casts and 4 XCTD (Expendable Conductivity, Temperature and Density) were completed

Weekly Summary: Sept 10 to Sept 16

Sept 10 Monday overcast, heading north to start of line, NRCAN group servicing equipment, slow going because of old ice, ship stopped at 11 PM for the night, standby operations

Sept 11 Tuesday light rain, started sounding operations at 6AM, working our way north to start of a splitter line, SVP cast to 1050 metres, seismic gear in the water late afternoon

Sept 12 Wednesday cool cloudy/sun, deep water SVP cast in the afternoon (3000 metres), evening helicopter flight, 6 spots soundings collected 1.5 helicopter hrs

Sept 13 Thursday cool and cloudy/sun, -5c, Mike Ruxton returned to work, 2 helicopter flights, afternoon and evening, 20 spots soundings collected, seismic equipment damaged, second system deployed, 4.2 helicopter hrs

Sept 14 Friday cool and windy, -6c, 2 helicopter flights, afternoon and evening, 16 spots soundings collected, XCTD deployed, 3.6 helicopter hrs

Sept 15 Saturday cool and windy, no flying because of winds and sea state, traveling between lines, stopped to repair seismic equipment, SVP cast to 3000 metres, sounding and seismic operations under way that evening

Sept 16 Sunday foggy, light winds, weather standby for helicopter operations, sounding and seismic data collection, 2 helicopter flights, afternoon and evening, 16 spots soundings collected

Plans: continue sounding and seismic program, continue helicopter spot sounding program, a combination ship refueling and visit by the Minister of Department of Indian and Northern Affairs is tentatively scheduled for Sept 27th in the Tuktoyaktuk area.

UNCLOS – CCGS Louis S. St Laurent

Highlights: seismic and sounding operations operational all week, 1,018 line kms of bathymetry collected, 28 spot soundings were collected requiring 7.5 helicopter hours, 1 SVP (Sound Velocity Probe) cast and 1 XCTD (Expendable Conductivity, Temperature and Density) were completed

Weekly Summary: Sept 17 to Sept 23

Sept 17 Monday clear sun cool, -6C, light winds, 2 flights afternoon and evening, 17 spot soundings, GPS drop outs in afternoon due to lack of visible satellites during helicopter flights, sounding and seismic operations all day, stopped at midnight because of ice conditions

Sept 18 Tuesday fog, standby for flights, broke track with ship for data collection, deployed/recovered seismic gear, stopped at midnight because of ice conditions

Sept 19 Wednesday fog, standby for flights, deployed seismic gear, working south to tie into the shore side of line #3, 2 flights afternoon and evening, 3 spots soundings, unsuccessful with Knudsen 320BP sounder and 12 kHz Giff transducer when used on the ice, repositioned GPS antenna to avoid satellite drop outs, operations ceased at 20:30 because of ice conditions

Sept 20 Thursday overcast, helicopter down for scheduled servicing/maintenance, seismic and sounding operations, all four Knudsen sounder types and 2 types of transducer for were tested over stern to find best configuration for ice sounding operations, water depth of 3600 metres, first impressions is that the 320A has the best S/N return echo using the Giff transducer, followed by 320M and the 320BP chirp, all the units have a strongest return signal using the 12 KHz Giff transducer compared to the new Knudsen 12 KHz transducer, problems with the new Knudsen 3200 chirp system, believe the system is only transmitting at 24 kHz

Sept 21 Friday foggy in AM, standby for helicopter flights, after numerous trials and Software configurations it was discovered that one of two electronic boards was faulty on the new Knudsen 3200 sounder, operating only at 24 KHz, the working board was configured to operate with 12 KHz, no water test, finished seismic line, heading east to survey 2500 metre contour, broke off because of heavy ice, started south to beginning of line CB04 (first line)

Sept 22 Saturday fog and sun, boat safety drill, heading south to start of line, during the day the ship traversed the 2500 m contour twice

Sept 23 Sunday overcast, lighter ice conditions, tried XCTD early AM, problems with laptop computer, no deployment, traveling to start of line, SVP cast, seismic operations started on line CB04, running west on line

Plans: continue sounding and seismic program, continue helicopter spot sounding program until the scheduled ship refueling and visit by the Minister of the Department of Indian and Northern Affairs Sept 26/27th in the Tuktoyaktuk area.

UNCLOS – CCGS Louis S. St Laurent

Highlights: seismic and sounding operations suspended mid week during ship fueling, 1,724 line kms of bathymetry collected, 21 spot soundings were collected requiring 5.4 helicopter hours, 1 SVP (Sound Velocity Probe) cast to 3000 metres, 1 bar check to 400 metres and 2 XCTD (Expendable Conductivity, Temperature and Density) were deployed, Minister of Indian Affairs and Northern Development and Federal Interlocutor for Métis and non-status Indians (INAC) Chuck Strahl visited the ship Thursday morning, a CHS presentation was given illustrating data acquisition process

Weekly Summary: Sept 24 to Sept 30

Sept 24 Monday sun and cloud, still in thin ice, XCTD late evening, running all day with no issues,

Sept 25 Tuesday sun/cloud and light snow on deck, recovered seismic gear at 9 AM,

XCTD done, bar check completed to 400 metres, departed for Tuktoyaktuk for fuel and stores resupply, sounding operations continue

Sept 26 Wednesday anchored 25 miles off Tuktoyaktuk at 7AM, preparing for Minister of INAC visit

Sept 27 Thursday Minister arrived around 10:30AM, meet and greet, UNCLOS presentation, tour of work area, lunch and departed, NTCL tug and fuel barge arrived 16:00, started fuel pumping operations

Sept 28 Friday fog, barge departed during the early hours, ship departed mid morning for work area, sounding operations started

Sept 29 Saturday overcast -4C, started seismic line at 11AM, light ice conditions, Mechanic problems with compressor, flight after dinner, helicopter icing, 3 spot soundings, 1.7 helicopter hours

Sept 30 Sunday fog, -6C, mechanic compressor problems, repairs done twice, back operation around 15:30, afternoon and evening flight, 17 spot soundings, 3.7 helicopter hours

Plans: continue sounding and seismic program, continue helicopter spot sounding program working to the north in reduced ice areas

UNCLOS – CCGS Louis S. St Laurent

Highlights: seismic and sounding operational all week , seismic program ended Sunday AM, 1,447 line kms of bathymetry collected, 54 spot soundings were collected requiring 11.5 helicopter hours, 1 SVP (Sound Velocity Probe) cast to 3000 metres, bar check to 400 metres and 2 XCTD (Expendable Conductivity, Temperature and Density) and 3 XSV (Expendable Sound Velocity)were deployed

Weekly Summary: Oct 1 to Oct 7

Oct 1 Monday overcast windy, standby for flights, XCTD in AM pulled seismic gear around 18:00, headed north to start new line #5, sounding continues

Oct 2 Tuesday sunny and cool, SVP at 8:00 to 3000 metres, calibration of the seismic air guns, problems with air guns freezing, helicopter flight after lunch, 8 spot soundings, 1.6 helicopter hours

Oct 3 Wednesday snowing, surveying line #5, into heavy ice, pulled gear, heading south, XSV deployed to 2000 metres, afternoon flight 7 spot soundings, moving south into lighter ice, surveying along 350 mile boundary line, stopped at 22:30 for the evening, XSV deployed, 1.2 helicopter hours

Oct 4 Thursday started up at 4:30AM heading for start of line, guns froze on start up, surveying started at 9:30AM, afternoon and evening helicopter flights, 21 spot soundings, XCTD deployed over night, helicopter hours 4.2

Oct 5 Friday windy, rough seas for helicopter ops, standby, problem with universal joints on compressor, repaired in AM, changed sounder in helicopter to the new unit - Knudsen Chirp 3210 sounder 12/24 kHz, XSV after dinner deployed

Oct 6 Saturday survey operations continue, 2 helicopter flights back to back, problems with Knudsen Chirp 3210, replace with Knudsen 320M, 18 spot soundings, helicopter hours 4.5

Oct 7 Sunday snow, sun and -15C, heavy ice, stopped, pulled guns at 6AM, tried air gun calibration at 8AM but guns frozen, end of seismic program, sounding continuing, bar check, SVP cast to 3000metres, last helicopter flight after supper cancelled because of weather

Plans: continue ship sounding program working towards Kugluktuk, pack and store equipment, travel south Thursday, Oct 11th on crew change flight to Halifax, overnight in Dartmouth, travel Burlington on Oct 12th

8. Marine Mammals Monitor Report

by Nelson Ruben, John Ruben and Jonah Nakimayak

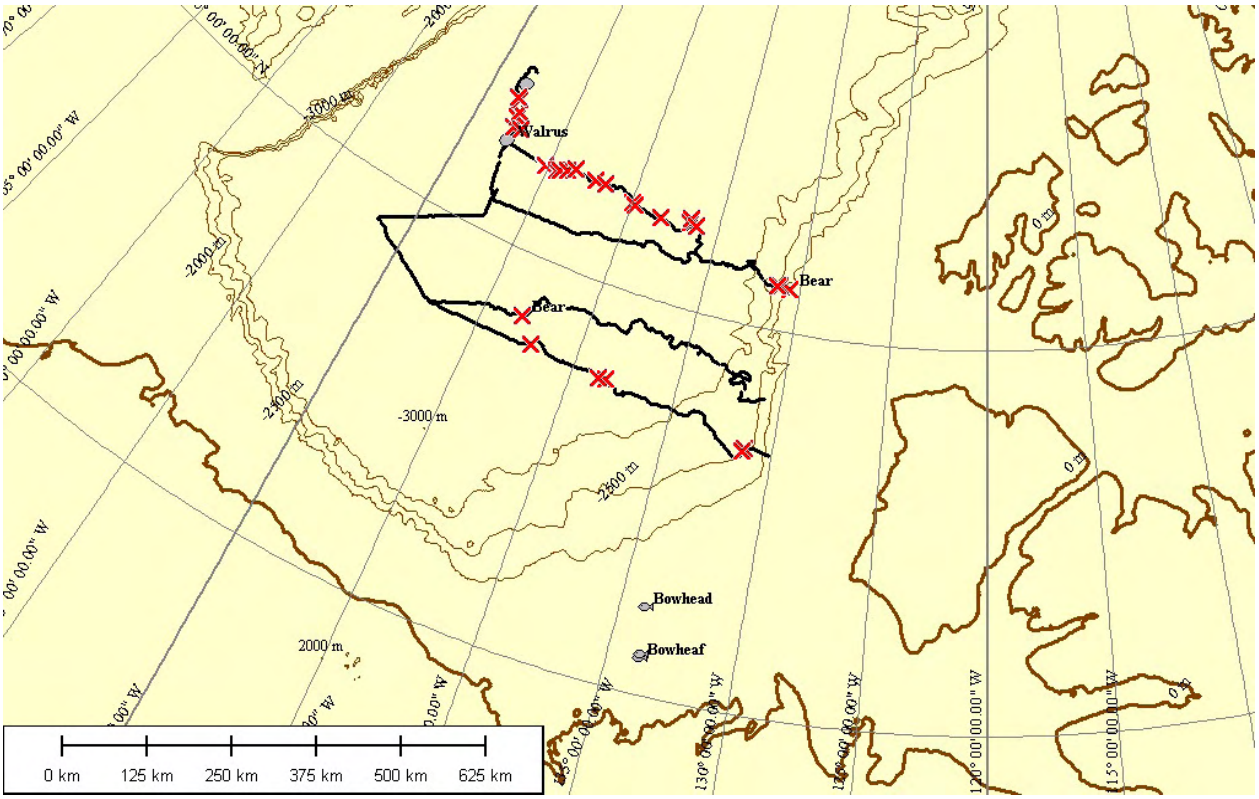
The Environmental Impact Screening Committee (EISC) of the Inuvialuit was asked to consider the affects of seismic surveying in the Canada Basin in waters deeper than 2500m. The surveying was required to collect data that would enable Canada to claim an extended continental shelf in the western Arctic. The EICS decision was the seismic surveying survey would have no effect on the wild life harvesting. On rendering its decision that the project could go forward, it required that trained marine mammal observers be on watch whenever the seismic operation was taking place.

Three marine mammal observers were chosen from Paulatuk because it was the community nearest to where the ship would sail from i.e. Kugluktuk. Nelson Ruben and Joe Roy Jr. Outfitting and Guiding Service had been contracted the previous year and had provided two skilled monitors for the trials in 2006. This year three trained marine mammal observers were needed for 24-hour operation. The company advised that notification of the need for observers should to be sent to the Paulatuk Hunters and Trappers Committee. This was done and no response was returned by fax or phone. Therefore, the science project continued to use the company that had been successful previous year.

The Captain, Andrew McNeill, wrote into the safe operating procedures for launching the airgun array that the marine mammal monitors be contacted prior to the first airgun shot. Observations always began half an hour prior to shooting. The watches were done from the deck above the Bridge with the usual name of Monkey's Island. The watch schedule was: Nelson Ruben 08:00-16:00 hours, Jonah Nakimayak 16:00-24:00 hours and John Ruben 00:00-08:00 hours. The monitor had a walkie-talkie to communicate with the Bridge and the Bridge called the seismic lab where the air guns controls were located. Once shooting was started a continuous 24 hour watch was maintained in 8 hour shifts. Any marine mammal that was observed within a one kilometer radius required the airgun array to be shut off until the animal was outside this range. As soon as the call was made the airguns were silenced. A spread sheet was filled out hourly.

During the cruise numerous bears, three walrus and three bowhead whales were sighted. The three bird species were: Kittiwakes, glaucous Gulls, and a Snow Bunting that stayed on the ship for several days. The distribution of the mammals is shown in the figure below.

The whales were spotted in open water while in transit to Tuktoyaktuk. The bears were the most common mammal observed. They were seen on pack ice mostly. The three walrus were on top of the ice at the northwest of the survey near the ice edge. The water depth was 3800 m. What were they eating? No seals were sighted and few fish were observed. Jonah commented if he lived in the area he would starve.


Walrus
Bear
Bear
Bowhead
Bowheaf
-3000 m
2000 m
0 km
125 km
250 km
375 km
500 km
625 km

9. Ice Service Specialist Report

by Ken Derouin

Travel/Area of Operation

* I travelled from Ottawa to Dartmouth on 29 August 2007. I joined the crew on 30 August 2007 to travel on the Coast Guard charter from Dartmouth to Kugluktuk.
* The area of operation for the vessel was the Canada Basin/Beaufort Sea in the western arctic, in support of the 2007 Beaufort Sea UNCLOS Program.

ICEVU Computer/Printer

* The ICEVU computer located in the Ice Office performed properly with no major problems. There were however a few minor inconveniences that are more related to the Operating System than the actual user-specialized software. These were again only minor glitches such as printer-spool errors, etc. As requested by the SEW Tech, the computer was shutdown and rebooted every 2-3 days in order to allow for the most current anti-virus definitions to be updated via the LAN.
* The printer performed well throughout the period except for one minor inconvenience; when using MS Word, and requesting the printer to print a range of pages (example: page 5 to 11), the printer would not process the print job. I tried troubleshooting this problem but to no avail.

ICEggs (ICEBREAKER-22) Tablet Computer

* Hardware: The tablet computer worked quite well except for one inconvenience. On one flight, ICEggs was receiving inconsistent GPS data. This problem was quickly solved when it was realized that the GPS antenna used by Canadian Hydrographic Services (CHS) on their flights was preventing the ICEggs GPS from capturing data. The problem was quickly rectified by simply removing the CHS's GPS antenna.
* One recommendation I would have would be to have 2 GPS antennas per ICEggs computer. This would allow one antenna to be semi permanently installed on the bridge/ice office as well as a second antenna that would be used for helicopter flights. The length of the cord for the antenna that would be used on the helicopter could then be shortened to 2-3 feet which would be more than enough. I also found that the cord currently used is simply too long and could pose a potential hazard in the event of an emergency egress as all of the excess cord tends to bundle up in an area at the feet and rudder pedals.
* Software: The ICEggs 4.06 software worked well during my tour. A few freezes had occurred from time to time however, on the September 12th reconnaissance flight was plagued with numerous software freezes/unexpected errors. However, I had not done a complete shutdown and reboot procedure for a number of days preceding, once this was done the problem seemed to be resolved.

Communications Uplink/Downlink Systems

* Inmarsat 64k Sat-B Uplink/Downlink: During the first three weeks of our voyage the 64k connection SatB HSD worked rather inconsistently. Keeping in mind that we were working in an area north of 75° longitude and west of 135° latitude, even with strong signal strength, our link would frequently get dropped. Although there were some times when this interruption could be attributed to the antenna rewinding or other times when the vessel was breaking through some significant ice, there were

frequently times when communications dropped off for no apparent reason. Also there were times where dialling into Ice Centre in Ottawa required as many as 10 attempts in one session. This could at times prove problematic in the event of a "hard failure" as in my case where I only had temporary problems, technical support was very limited.

* TheWS_FTP Pro software worked well with very few problems.

Weather Observations

* Weather observations were taken and transmitted automatically by the AVOS system. In addition to the hourly observations, I would make synoptic observations at the required times. There were a few discrepancies primarily with regards to air temperature and wind speed and direction. The readings on the AVOS system proved to be erroneous when compared to actual conditions. These inaccuracies are most likely due to the location of the AVOS's measuring equipment. Also, the sea surface temperature must be entered manually, a bucket and thermometer are located on the aft deck. Finally, the vessel heading must also be verified as the heading on the AVOS system was incorrect most of the time.

Ice Centre Support

* Upon my arrival, most of the required weather and ice products were already in the vessel's standing order (ftp box). We did require some supplementary products to be added and these were done immediately. Ice Centre was also very prompt when we required that we needed ice analysis beyond 76°N.
* Particular thanks is extended to Laurie Weir and Luc Desjardins at CIS in Ottawa as well as François Guay in at the CCG Ops Centre in Sarnia for their assistance.

Tactical Support from TGO 922

* TGO 922, the Transport Canada Dash-7 flew over our area on September 3rd and 4th. The aircraft was based out of Innuvik over this period of time. Unfortunately, low visibility and ceilings were a limiting factor over this period of time, however, we did get a certain amount of data which proved valuable. A second flight was scrubbed for the period of Oct. 4th and 5th due to aircraft being unable to depart Iqaluit.

Ice Conditions

* Ice conditions as a whole have been exceptionally lighter this year in the Beaufort Sea than have been seen in the past number of years. Last year, for instance, the southern edge of the ice pack extended all the way southwest to Point Barrow AK with multi-year ice to within 60 miles off Point Barrow. Whereas for the same period this year, the ice edge is over 230 miles to the northeast of Point Barrow with multi-year ice being present more than 30 miles beyond that.
* Moreover, ice conditions in our area of operations were significantly lighter than forecasted, especially towards the western end where we encountered less multi-year ice as well as considerably more rotten ice in advanced stages of melting than anticipated. As expected with such large areas devoid of multi-year ice throughout the season, we began seeing significantly more new and young ice forming in these sections as temperatures began to decrease.
* A total of 27 CGBN Ice Charts were produced and sent into Ottawa. 15 were produced from ship-board observations as well as 12 from helicopter flights.

Weather Conditions

* A persistent area of high pressure that has remained mostly to the north of our area of operations gave us light to moderate easterly winds with very little precipitation. Localized fog and associated low visibility were encountered frequently. Seasonal temperatures were observed throughout most of the reporting period.

UNCLOS Program Support

* Daily ice and weather briefings to the UNCLOS scientific, technical and support staff at their 18:00 hours meetings. These briefings proved to be a valuable tool in their planning.

It was a great pleasure serving with the crew of the Louis over the past 6 weeks. The professionalism and hospitality that was shown is something to be very proud of indeed.

10. Accompanying data

on CD stored in GSCA repository

1) seismic sections as tiffs
2) watch keepers electronic log
3) compressor log
4) Bridge log
5) marine mammals observers log
6)sonobuoy log
7) ice charts