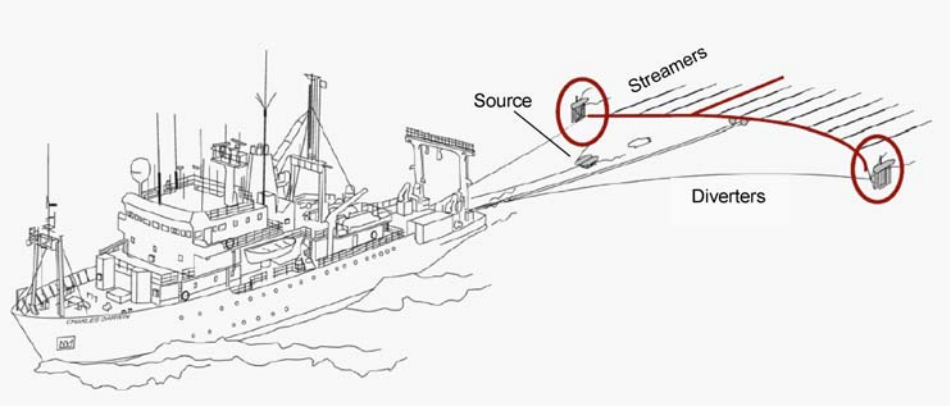
TGT 220 Cruise Report
R/V Thompson

Hydrate Ridge Ultra-High Resolution 3D Seismic Study

June 30, 2008 – July 19, 2008



Hydrate Ridge Survey Area

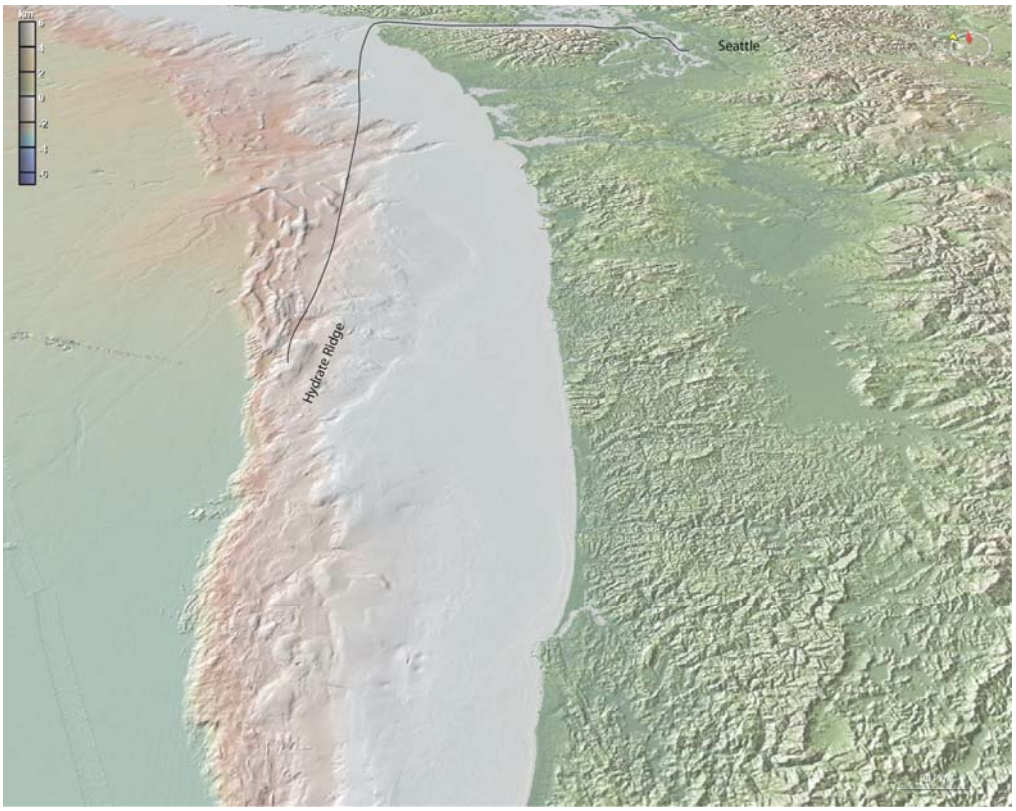


Figure 1. A bathymetric map of the Oregon/Washington coast, shelf and slope. The black line is the track line for the transit to south Hydrate Ridge.

Summary

Summary of TN 220 – High Resolution 3D survey of south Hydrate Ridge

June 30 – July 19, 2008
R/V Thompson

During this cruise we conducted a seismic survey of an area approximately 60 nm west of Newport Oregon to examine the subseafloor structures beneath an area called Hydrate Ridge. Hydrate Ridge is a gas venting system that is actively releasing free gas at the seafloor. The survey was acquired to image the subsurface gas migration system.

The survey was acquired using two GI airguns as a sound source. The GI guns had a total volume of 300 in^3 and were fired at an interval of 6 sec. The seismic signals were

recorded on the P-Cable system. This system consisted of two paravanes towed behind the ship. The paravanes were connected to a crosswire that ran perpendicular to the ship's path, which towed 10 (initially 12, but reconfigured to 10 during the cruise) single-channel streamers trailing behind the ship attached to the crosswire. The streamer spacing was 12.5 m covering a swath of 125 m.

The cruise time was spent doing the following:

Delay:	1 day
Transit:	3 days
Equipment deployment, retrieval, and data acquisition:	10.5 days
Weather delay:	5 days
Marine mammal shutdowns:	10 hrs.

(note: There were 13 total marine mammal shut downs. Each one required reshooting the lines of the survey that could only be partially completed due to the shut down. Each one of these required an additional 1.5 – 2.0 hrs to reshoot. The total impact of the marine mammals should include an additional day lost to reshooting the lost data.)

We completed a 3D seismic volume that covered a 3 x 6 km area. We acquired 56, 5- km N-S lines spaced at 50 m, which formed the 3D grid, and a series of 4 E-W crossing lines. Some of these lines required multiple passes to complete due to marine mammals, equipment problems, and difficulty with steering the towed array in windy conditions.

There are no preliminary results to speak of due to the extensive 3D data processing that was needed to do any preliminary interpretation. The processing began during the cruise, but did not get beyond navigation.

Participants

Thompson TN220 Scientific Party

1- Nathan Bangs – Chief Scientist
2- Matt Hornbach – Scientist
4- Christian Berndt – Scientist / Pcable 3D streamer system
3- Steffen Saustrup – Seismic technician
5- Jenny White – Airgun technician
6- Mike Barth – Streamer technician

Students
7- Kelley Brumley – University of Alaska, Fairbanks
8- Nabiel Eldam – University of Texas, Austin
9- Eric Anderson – University of Texas, Austin
10- Keith Nelson – University of Texas, Austin
11- Nick Perez – University of Texas, Austin
12- Jessica Dawson – Fort Valley State University, Georgia

Marine Mammal Observers (provided by LGL)
13- Michael Force - Head Observer
14- Sarah Ashworth - Observer #1
15- Kris Hartin - Observer #2

Survey Area

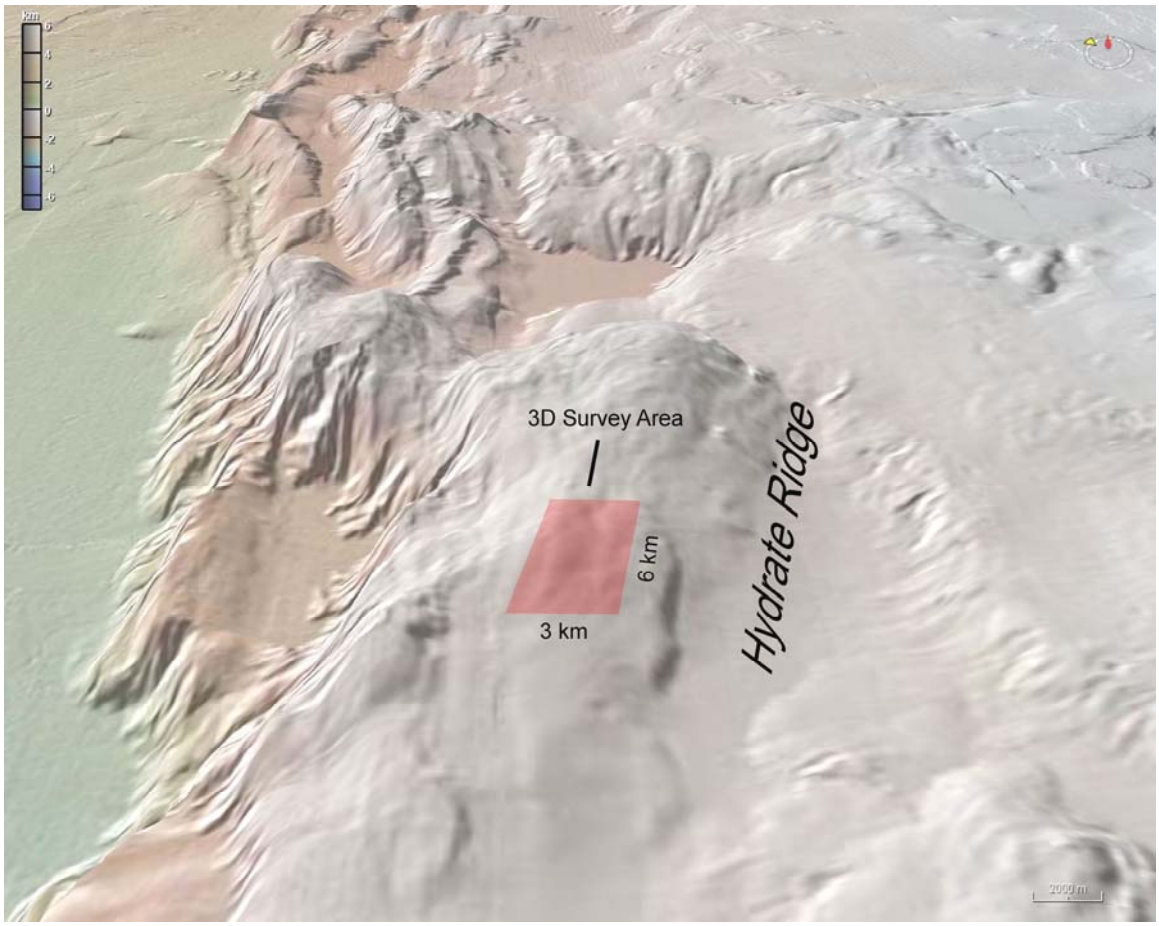


Figure 2. Bathymetric map of the area around Hydrate Ridge. The 3D acquisition area is the 6 x 3 km box across the summit of south Hydrate Ridge shown in red.

The survey covered a 3 x 6 km area of south Hydrate Ridge, approximately 60 nm west of Newport, OR (Figs. 1 and 2). The survey covered the area from the saddle between north and south Hydrate Ridge, up to the summit of south Hydrate Ridge, including the feature known as the “pinnacle”. The survey area covered most of the ODP Leg 204 drill sites.

Acquisition System

3D Seismic acquisition system

The P-Cable is a new type of low-fold, high-resolution 3D seismic acquisition system developed by Volcanic Basin Petroleum Research (VBPR) in collaboration with National Oceanography Centre, Southampton (NOCS), University of Tromsø (UiTø), and Fugro Survey AS, Oslo. For this cruise we have used the proto-type system of the National Oceanography Centre, Southampton.

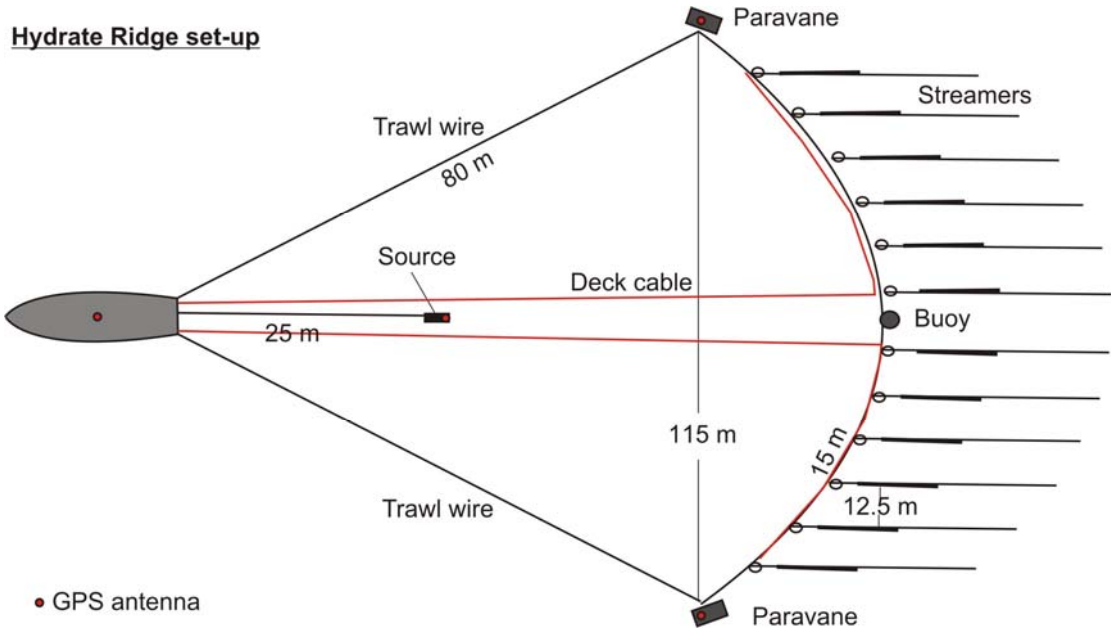


Figure 3. Initial P-Cable configuration for the Hydrate Ridge cruise until the 7/11/08.

The NOCS P-Cable system consists of a wire that is towed perpendicular to the ships steaming direction using two specially designed paravanes. Several single-channel Teledyne Geophysical Instruments analogue streamers are connected to this wire. The paravanes and a tail boat are supposed to keep the cross wire at approximately 1 m depth. The paravanes are towed behind the ship using reinforced power cables that power the GPS receivers on each door. Two data cables transmit data from the streamers back to the ship. A Geometrics Geode 24 seismic recording system digitizes the seismic data on-board.

Figure 4. Streamers laid out on deck prior to deployment. Each streamer is 30 m long and is summed into a single channel.

Figure 5. One of two Paravanes that connect to the cross wire and used to separate streamers. See Figures 3 and 9 for diagrammatic arrangement of the paravanes.

System Details

Recording system:	Geometrics – Geode 24
Data channels:	12 from 7/2 – 7/6/08
	10 from 7/11 – 7/17/08
Recording device:	Disk (no tape)
Record format:	SEGY
Record length:	3.0 s (6000 samples)
Sampling rate:	0.5 s
Deep water delay:	0
High cut filter:	
Low cut filter:	
Streamer:	
Group length:	
Streamer length	30 m
Streamer separation:	12.5 m

Seismic Source

Our seismic source was the Lamont High-Res system GI gun array consisting of two 75/75 in^3 GI airguns towed from F-11 floats at 2 m depth. Various gun towing arrangements were tried, but the most effective system was to tow one behind the other, with gun bundles of the farthest aft run through the hanger of the forward gun. Other side-by-side arrangements with various spacing proved to cause a great deal of tangling between the guns and the data cable. The position of the guns was initially ~ 20 m behind the stern, but was moved forward as far as possible to avoid gun tangling.

The air pressure was 1800 psi. A Hotshot gun controller triggers the guns every 6 s. Two GPS antennas were mounted on the gun array. A small "hockey puck" GPS antenna was attached to the net of the first float. The Seatrack 320 was mounted on a PVC pole attached to the chain on the aft airgun. Both antennas worked well, however, the "hockey puck" antenna had a vulnerable connecting wire that was severed when the guns tangled with the data cable. The Seatrack 320 GPS worked during the entire cruise.

Figure 6. Seismic source towed in line from umbilicals (lower right). The port paravane can be seen in the upper right, and the center float (red boat) appears in the upper left.

Source Details

Source Type:	2- GI Guns
Air Pressure:	1800 psi
Volume:	75/75 in^3
Source depth:	2 m
Depth control:	fixed chains from F11 floats
Shot interval:	6 s
Source controller:	Hotshot controller

Navigation and Positioning

The navigation data were recorded and calculated using the Kongsberg Seatex RGPS tracking system Seadiff, with four GPS antennas (one on the ship, two on the paravanes and one on the air gun float). GPS receiver locations were recorded at 1 s intervals with time and position of each receiver recorded in file hots.d***. This file was used to locate each individual receiver assuming a triangular geometry with paravanes, and center float at the corners of the triangles. The separation of the corners of the triangles were constrained by the GPS and the length of the crosswire.

Each of the shot triggers also triggered a time stamp from a separate GPS clock. These data were stored in the clok.d*** files along with the computer clock time.

The shot time recorded by the Geode was a computer clock time recorded at the end of each shot. These data were stored in files geod.d*** along with the ffid.

Navigation processing first read the "geod" file to get computer clock time at the end of the shot identified by ffid, and searched the "clok" file to find the corresponding gps clock time. Each ffid was assigned a trigger time based on this match of ffid to gps clock time.

The position was then retrieved from the "hots" file by matching ffid to position based on gps clock time.

Navigation Details

Survey datum:	WGS84
Map projection:	Transverse Mercator
Map projection system:	UTM Zone 10
Latitude of origin:	0° N
Central meridian:	123° W
Scale factor:	0.9996
Grid orientation:	181.5
Shot line spacing:	50 m
Positioning equipment:	Kongsberg Seatex RGPS tracking system, Seadiff

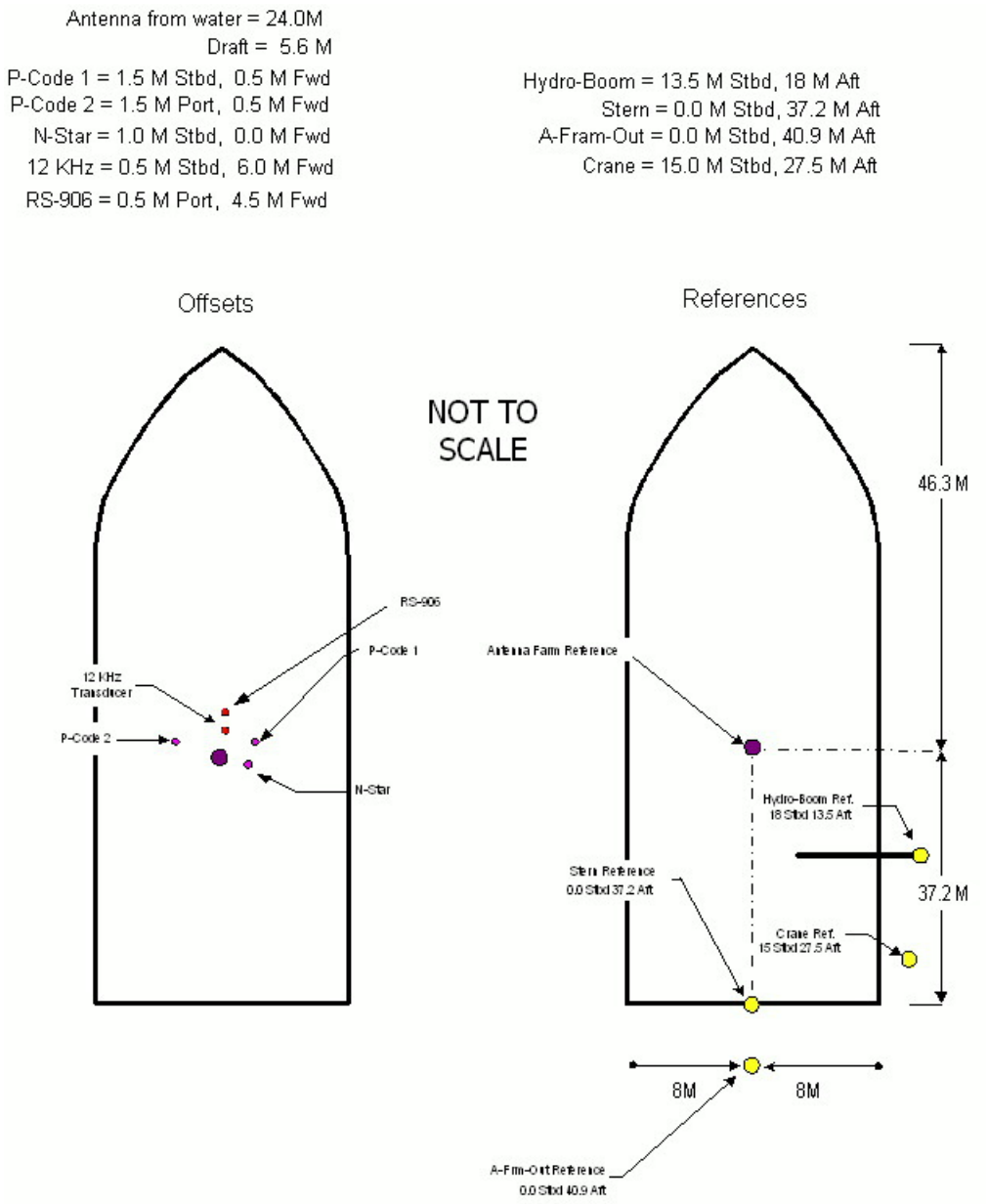


Figure 7. R/V Thompson Antenna locations.

Multibeam Echosounder

Kongsberg-Simrad EM300 Multibeam Echo Sounder

Manufactured by:
Kongsberg-Simrad AS
Horten, Norway

The Kongsberg Simrad EM 300 multibeam echo sounder is designed to do mapping from 10m depth down to approximately 5000 m depth with swath widths up to about 5000 m. Small transducers and compact electronics make the installation easy, and the system accuracy is generally well within the IHO standards.

The Kongsberg Sirnrad EM 300 is a complete system. All necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualization, and data logging are a standard part of the system, as is integrated seabed acoustical imaging capability (sidescan).

Operating frequency and coverage sector

Operating frequency and coverage sector The nominal sonar frequency is 30 kHz with an angular coverage sector of 135 beams per ping at 1 degree. The angular coverage sector and beam pointing angles may be set to vary automatically with depth according to achievable coverage. The beam spacing is normally equidistant with equiangle available.

Transmission

The transmit fan is split in several individual sectors with independent active steering according to vessel roll, pitch and yaw. This will place all soundings on a "best fit" to a line perpendicular to the survey line, thus ensuring a uniform sampling of the bottom and 100% coverage.

The sectors are frequency coded (30 to 34 kHz), and they are all transmitted sequentially at each ping. The steering is fully taken into account when the position and depth of each sounding is calculated, as is the refraction due to the sound speed profile, vessel attitude and installation angles. Pulse length and range sampling rates are variable with depth for best resolution, and in shallow waters due care is taken to the near field effects. The ping rate is mainly limited by the round trip travel time in the water up to a ping rate of 10Hz.

Transducer arrays

The EM 300 transducers are linear arrays in a Mills cross configuration with separate units for transmit and receive. The arrays are divided into modules that may be replaced by a diver. The arrays are 1 degree beamwidth for receive and transmit. The physical array lengths are 3.3 meters. A combination of phase and amplitude detection is used, resulting in a measurement accuracy practically independent of beam pointing angle.

CHIRP system

Knudsen 320B echosounder

Manufactured by:

Knudsen Engineering Limited
Perth, Ontario, Canada

We used the Thompson's Knudsen 320B chirp echosounder for subbottom profiling. The Knudsen system emits two chirp sources centered at 12.5 kHz and 3.5 kHz. The hull-mounted tranducers act both as sources and receivers. The sources are broad frequency "chirp" signals, centered at 3.5 and 12.5 kHz. The echo-returns detected by the transducers are deconvolved using the original source signal character, plotted on the screen real-time, and recorded in SEGY format. We collected data simultaneously at both 12.5 and 3.5 kHz frequencies during the cruise. The 3.5 kHz chirp source consisted of twelve hull-mounted KEL transducers. A heave sensor was connected to one of the Knudsen COM ports, enabling real-time corrections for ship heave. The ship's GPS position was also input into one of the Knudsen COM ports, and ship position was recorded for each shot. Shot interval was variable and directly dependent on water depth. The Knudsen system requires that only one source/echo travel through the water column directly below the ship at a time. Thus, in 750 m of water, the knudsen system fires a shot every 1 sec (assuming water velocity equals 1500 m/s).

In ideal conditions, where shallowly dipping soft marine muds exist, signal depth penetration using the 3.5 kHz system may exceed 50 m. Because much of Hydrate Ridge consists of highly fractured hard-bottom carbonate with sometimes steeply dipping slopes, signal depth penetration rarely exceeded a few meters across much of the 3D survey area, and out-of-plane reflection were common. Data from 12 kHz data shows even less depth penetration, although, we were able to use these data to estimate the location of gas seep sites, since these data showed evidence for hydrate/gas-bubbles in the water column in a few locations.

Immediately following the cruise, 3.5 kHz chirp data were loaded into Paradigm Geophysical's *Geodepth* program to create a quasi-3D image of the seafloor (Fig. 8). These chirp images, combined with other data, are currently being used to both assess and correct for tidal affects in the 3D seismic data.

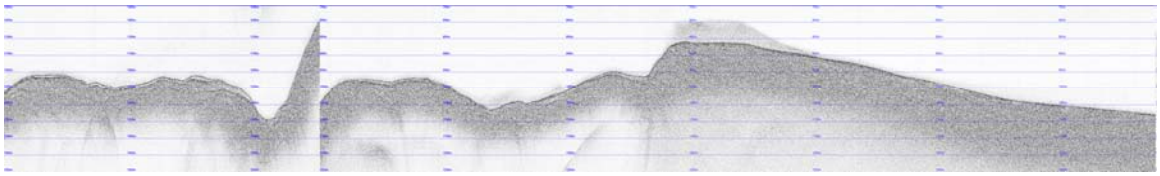


Figure 8. Chirp image from day 185, file 0007, shot along the flank of Hydrate Ridge. Deep reflections represent out-of-plane features. A relatively continuous thin veneer of sediment, perhaps 5-10 m thick may overlay part of the flank of the Ridge.

Cruise Narrative

Thompson TN220 Cruise Narrative

Friday, June 27, 2008

We made a short visit to the ship to assess equipment setup.

Saturday, June 28, 2008

The weather stayed good. We began to set up our equipment. We addressed issues with winches. Winches on board were either too difficult to use or already had wire that would have to be removed. We decided to load the mooring winch borrowed from Scripps.

Sunday, June 29, 2008

We rigged the starboard deck / data cable and began to set up the navigation system. In the afternoon we transferred from the UW docks to Pier 66. This was delayed because of problems with the draw bridge, which caused a backup at the locks.

Monday, June 30, 2008

Left Pier 66 and headed for fuel dock at 0700. We ordered 4 Yale grips to use as stoppers for the trawl wire for paravanes. We used the Yale grips because we have only one winch (a mooring winch borrowed from Scripps). Fueled until ~1200 and sat in dynamic positioning mode while we re-rig the fan tail to center the winch and move the tuggers forward to make more room on the fantail for the trawl wire. Waited overnight for the Yale grips.

The weather was calm but colder and greyer than on the days before.

Tuesday, July 1, 2008

Received the Yale grips at ~1100 and left for Puget Sound. Continued rigging gear on the fantail while we moved into the Straits of Juan de Fuca. Streamers were connected to the crosswire and strung out on deck. The trawl wire was wrapped onto the winch. The gun bundles were stretched out to attach GPS units to floats and wires to gun bundles. Weather calm in the morning, but turns cooler and windier.

Wednesday, July 2, 2008

We made final preparations for the deployment connecting everything up and rigging the gun GPS antenna. Arrived within 15 miles of the site at 1900 and began deployment. First we deployed the starboard paravane with the crane and tied it off with Yale grip at 10m. Then we deployed the port parvane and let it out to 10 m. Then we began deploying the crosswire and streamer sections. The first 6 of 12 were carried aft between the A frame and set into the water. Then the float (red boat) with strobe was lowered and

remaining 6 streamers deployed. The remaining trawl wire on the port side was fully deployed to 80 m from the fantail and tied off with the Yale grip. Then we deployed the starboard trawl wire to full position at 80 m.

The guns were deployed from the two winches and towed separately. The guns were set to 2 m in the 75/75 configuration at 25 m astern of the fantail. Everything was in the water by 21:30. The towing was fairly erratic with port side gun is trawling too far left. The port side gun with Christian's GPS unit tended to act as a rudder and it pulled to the port side and became too close to the data cables. The plastic pole that we used to attach the GPS unit was moved to the back of the float chain. That was tried and failed. The pole was shortened at the bottom and the helped but was still poor. At 23:30 we continued to shoot with two airguns at 6 s shot interval. The float was still trawling a little bit to the side, but not as much as before.

The weather was good. Low wind. Calm. We shot several lines on the EW grid, but had difficulties with the symmetry of the paravanes. The ship tended to be blown by the wind and the equipment in the water was pulled by the current.

Thursday, July 3, 2008

Tension on the data cable was high. Data cable was too short and was trawling the red sled. The airguns do not behave very well. They were always drifting apart up to 10 m with the port airgun float touching the data cables. At 8:00 we decided to move the towing point of the port gun to the same point as the starboard gun. This did not help very much and at 10:00 we retrieved so that Jenny could reconfigure the airguns to run in line. The trailing gun bundles were run through the channel with the gun bundles of the leading gun. The guns were back in the water at 12:30. This arrangement worked much better. We changed the recording length to 3 seconds. We reoriented the grid to a N-S grid and began shooting in that direction. This helped with the currents, which ran N-S. We shot several lines and began with the grid.

The port paravane was pulling out of the water at speeds greater than about 2.8-3 kts. The tension on the data cable was still high and we began to rig extension cables to lengthen the data cable and lower the tension.

The wind picked up to 2 Bft with light drizzle.

Friday, July 4, 2008

We replaced the double data cable with an extension from a single cable. This enabled us to slack off by about 5 feet and lessen the tension on the data cable. This dropped the sled back a bit and made a more even arc in the crosswire. We noted that there is a pronounced ghost in the data collected on the previous day - perhaps because the streamers were towed too deep indicating that we should have gone faster. The data cable

got enough slack after the cable was lengthened and the paravanes are towing up to 3.3 knots through the water, but the port side paravane was less stable. The port paravane was still coming out of the water at speed above 2.8 kts. Around 12:30 the data cable tangled with the gun array during a starboard turn. We had to shut down the guns, disentangle the cable, and restart shooting.

At 20:00 we recovered the portside paravane to see if we could improve its performance. It seemed the chains were twisted a half turn. We cleared this and redeployed. The paravane performed slightly better, but it seemed the streamers were still too deep. Back on line at 22:00, but the data cable became tangled in the guns. We lifted the guns with the A-frame and cleared the cable. We ramped up to shoot again at 23:30.

The weather was grey, 3 Bft.

Saturday, July 5, 2008

During the morning hours the data cable got caught again in the gun array. We disentangled it and decided to pull the guns towards the ship, so that this would not happen any more. We had to shut down two lines because of marine mammals. After last nights cold front the weather improved with sunny spells, 2 Bft and little swell.

Sunday, July 6, 2008

The weather was drizzling with a large swell. Winds calm. Guns tangled with the data cable running from the center float to the port rear quarter. The guns had to be pulled on board to untangle. Starboard paravane became tangled in the guns in a port turn. This was with the guns pulled in on a short hitch to prevent tangling in turns. Turns are 1.25 km diameter. There was a large swell that probably contributed to the guns going under the paravane wire. Slow speeds in the turn, 1.5 kts, may also have allowed too much slack in the trawl wires to the paravane. It was necessary to keep a speed of at least 2 kts during the turn to prevent this from happening.

Dolphins around and near the airguns were a particular problem. There seem to be large schools of them, 500 – 1000 and they will follow us for 1-2 hours. We seem to be going back and forth through them as we run the survey. Airguns were working well. We lost the “hockey puck” gps when the guns became tangled. The wire taped to the gun bundles got caught with the guns and was pulled apart. Up until then, this gps worked very well.

There was an 8 ft westerly swell coming in and the wind has picked up to 4 Bft.

During the afternoon we shot two more lines, but the guns became tangled in the data cable during several turns and the middle streamers were still too deep. We decided to take the system in, but the captain only wanted to recover the gun array and leave the rest for the next morning. During the night both the port GPS power supply and the starboard data cable got damaged.

Monday, July 7, 2008

At 8:00 we began to retrieve all gear to redesign and fix various problems. At 10:30 everything was on deck. We spent all day fixing gear. The cross wire was shortened by 30 m from the middle and the two inner streamers were removed (cf. Figs 3 & 9). Channel 1, the new streamer with the higher gain was removed. Channel 12 was removed and replaced channel 11, which had been noisy. The data cable had been sliced open near the guns and a GPS power supply conductor was broken at the break from the crosswire to the ship. There it had been pulled too hard, probably before we were able to lengthen it. The GPS line to the port paravane broke at the connection to the trawl line cable. This was resoldered and strengthened. The data cable was extended by using a length of the old black data cable for both sides on deck. The new wiring on the junction box was as follows: incoming port/geode channels pairs: 1-12, 2-11,3-10,4-7,5-8,6-9,7-1,8-2,9-3,10-6,11-5,12-4 (Fig. 10). Channels 6 and 7 was not used because we reduced the array to ten streamers. The bridle for the center float parted and was replaced. The "hockey puck" gps cable was repaired and works. The repairs were finished at 17:00. The last fix was to add fairing to the cross cable. This was done with about 4" streaming duct tape attached to the cable and data cable.

As the sea conditions are not very favorable (6 Bft) we decided to postpone the redeployment until the next morning.

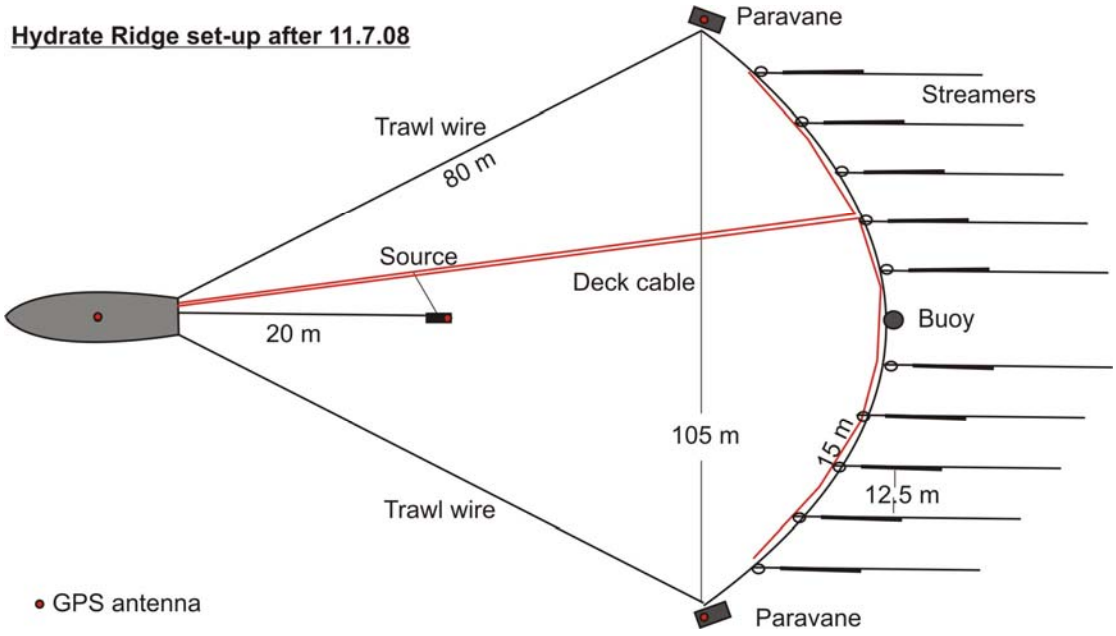


Figure 9. P-Cable configuration for the Hydrate Ridge cruise after the 7/11/08.

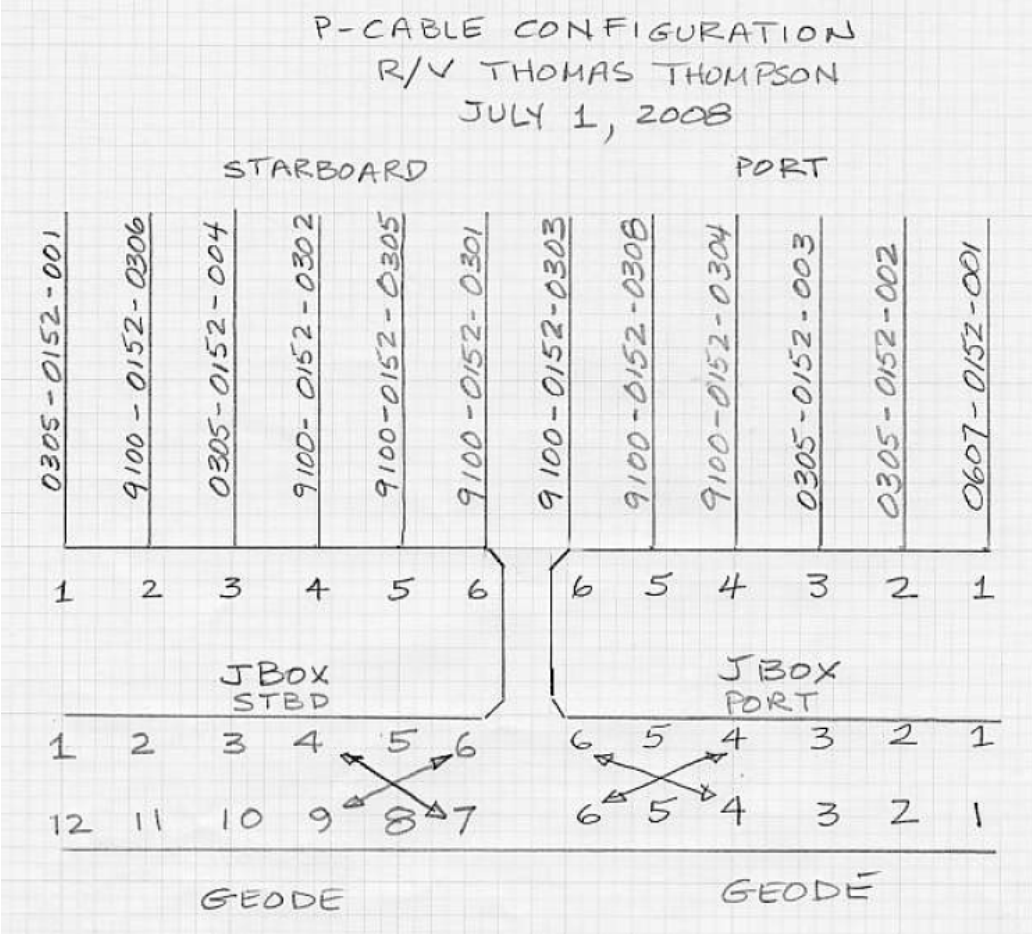


Figure 10. Wiring diagram for the streamer setup. After re-rigging on 7/11/08 streamer 9100-0512 was moved from channel 7 to channel 11 and streamer 0607-0152-001 was removed and replaced by streamer 9100-00152-0303 on channel 1. Channel 6 and 7 are recorded but not used.

Tuesday, July 8, 2008

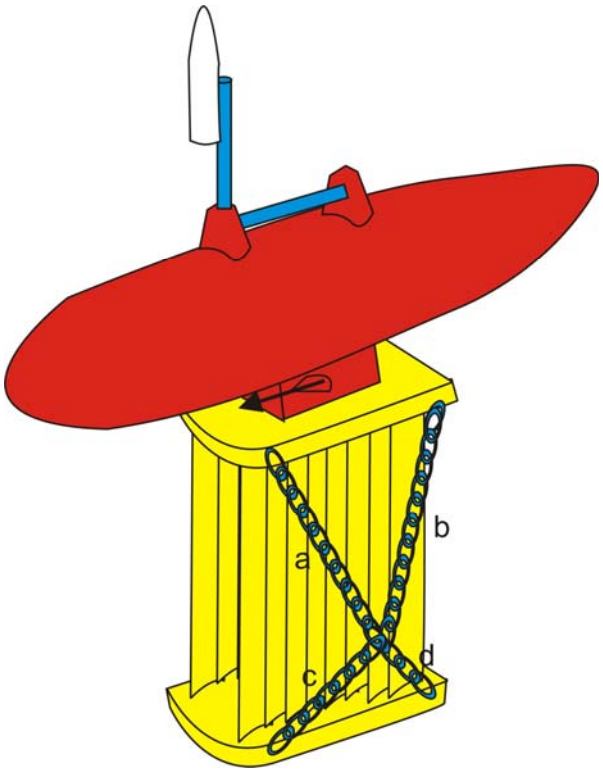
The swell droped, but high winds, 30 – 35 kts, and rough seas prevented us from redeploying the gear. The weather was not expected to improve greatly in the next day or so. We ran some chirp survey lines.

Wednesday, July 9, 2008

High winds still. Acquired Chrip, 12 Khz and 3.5 Khz data in a grid on SHR, but not seismic. Winds in the 25-30 kts range.

Thursday, July 10, 2008

More high winds, but slacked off a little. Down to 20 kts. At lunch time the wind was easing of to 4-5 Bft. We started deploying the system at 13:00. During the deployment the connection with the streamers was interrupted. We retrieved the center buoy and the system came up again. There was no sign of damage at the data cables close to the buoy. We deployed the whole system, this time with the modified 10 streamer design with fairing. Everything was deployed and the port paravane continued to be a problem with it pulling out of the water at 2 kts. It still tended to be pulled out of the water, especially with large waves. The swell was high today. Winds pick up to nearly 30 kts. We attempted to adjust the trim of the port paravane by adjusting the chains on the bridle. The starboard paravane, which worked well, had 19 links and an additional small shackle on top and 17 links on the bottom. The port paravane had 18 on the top and 17 on the bottom. We adjusted the top to 17 links and its behavior worsens. We switched to 19 links on top and only slightly better (Fig. 11). By then the wind has picked up to 6-7 Bft. After 3 attempts, we gave up. By 18:30 we decided to retrieve all gear rather than leaving it overnight in heavy seas.



Chain lengths after the re-rigging on the 7/11/08:

front top a=48 in
rear top b=48 in
front bottom c=42.5 in
rear bottom d=44.5

The float is adjusted to the centre arrow.

Figure 11. Paravane configuration after 7/11/08.

Friday, July 11, 2008

Winds still 25 kts. At lunch time the wind was down to 4-5 Bft. We waited until 2PM and decided to redeploy. We put streamers out in reverse by accident, but we simply

moved the data cable to the port side. There were some problems with the port set of streamers cutting out. This was probably because of too much tension on the data cables during deployment. The gear was working better this time. Winds were down slightly to 20 kts. The same chain length on the port side paravane as on the starboard side also readjusting the float direction to center. The paravanes tow nicely at 3.5 kts and at 19:30 we were collecting some good data in spite of the wind that had picked up to 6 Bft again. Data cable still interfered with guns. We pulled guns in close to avoid fouling. To avoid tangles of the streamers we kept the speed up to 3 kts with two people standing watch during the turns to make sure that no gear was fouled. The speed pulls the streamers up. Cut out continued, but not often. Data looked better than before. We acquired the best data yet. Began reshooting the SHR grid.

Saturday, July 12, 2008

Equipment was still working. Brought in trawl wire to redo Yale grips, which were beginning to chafe. Seas calmed down to 20 kt. It looked like the weather would hold to similar pattern for the rest of the cruise. Seismic acquisition continued until 19:00 when the eye for the lower rear chain of the port side paravane came out (Fig. 12). The paravane had to be recovered. It looked like we were finished, but decide to fabricate some steel pieces to bolt to the bottom of the paravane and make a place to hitch both bottom bridle chains (Fig. 13). We adjusted the chains to the approximately the same length as before, but this was difficult because the base plate eyes were sticking out from the paravane. Furthermore, we had to repair one of the air pipes to the gun array which had been damaged because the array was towed close to the ship to prevent tangling. This took several hours and finally the gear was redeployed about 1AM. The design seemed to need the bridle adjusted to bring in the bottom.

Figure 12. Damage after the lower rear chain of the port paravane was pulled out on the 7/12/08.

Figure 13. New steel frame that was mounted under the paravane after the towing point was damaged.

Sunday, July 13, 2008

At 01:30 the repairs were completed and we redeployed the port side paravane. The trim was not perfect with the paravane coming out of the water which meant it had to be recovered during the morning. We used the rest of the night to steam back to the survey area. In the morning we took the port paravane on board and took in one link on the lower front chain and two links on the lower rear chain. Afterwards the system was towing very well. It rode lower with the added weight and pulled better than before. We began acquiring data again Channel 8 is bad and 12 has spikes. The port cables tended to cut out on the turns, but returned when stress changes on the data cable. Marine mammal shut downs again were a problem. Dolphins keept appearing.

Monday, July 14, 2008

At 00:45 we had to stop shooting because the wind had picked up to 6-7 Bft and we could not risk turning because of the risk of tangling was too high when the wind was coming on the beam. We continued southwards at 2 kts. At 05:00 the weather had improved to 5 Bft so that we could continue shooting. Good data acquisition day. Data cable clearly

had a break in it that caused the channels to cut out when stressed. The solution was to maintain speed of ~ 3kts to lower cable stress and to go fast enough to maintain a shallow streamer. The streamer depth was apparent from the seafloor wavelet. Speeds above 3 kts seemed to pull the starboard paravane out of the water.

Tuesday, July 15, 2008

Weather remained good. Data acquisition ran smoothly. Acquired more grid lines.

The weather calmed down to 4 Bft.

Wednesday, July 16, 2008

Calm seas, improving to 2 Bft. Low winds ~ 10 kts. Overcast skies. Began adding to the east side of grid and filled in holes. Some dolphin-related shut downs in the afternoon, but otherwise continuous acquisition. The navigation processing programs worked and the first half of the navigation data up to FFID 54766 were processed using triangular geometry.

Thursday, July 17, 2008

Seas calm, winds 10 – 15 kts (overcast and 1 Bft). Continued to acquire data in 3D grid to fill gaps. Most of the morning was lost due to dolphin shut downs. Some of the schools had 1000s of animals. The dolphins seemed to be feeding in this area. Once they started following the ship, they continued for hours. We headed east to shoot some crossing lines and lose the dolphins. We shot two crossing lines and filled in the last of the major holes in the grid. Captain lets us continue past the 20:00 deadline due to dolphins. Dolphins followed us around a turn to come on to the last infill line. We got clearance as we came on to the line and began shooting. We pulled in gear at 21:30 and have all gear retrieved by 23:30. We started steaming back to Seattle, tied the streamers on deck and made back-ups of the data and processed the final navigation data.

Friday, July 18, 2008

On transit back to Seattle we packed the equipment, made backups, and wrote the report. The weather was calm (2 Bft) and overcast.

Saturday, July 19, 2008

Arrived at locks in Seattle at 8:00 AM. Arrived at dock on UW campus at 10:00 AM

QC

Data coverage

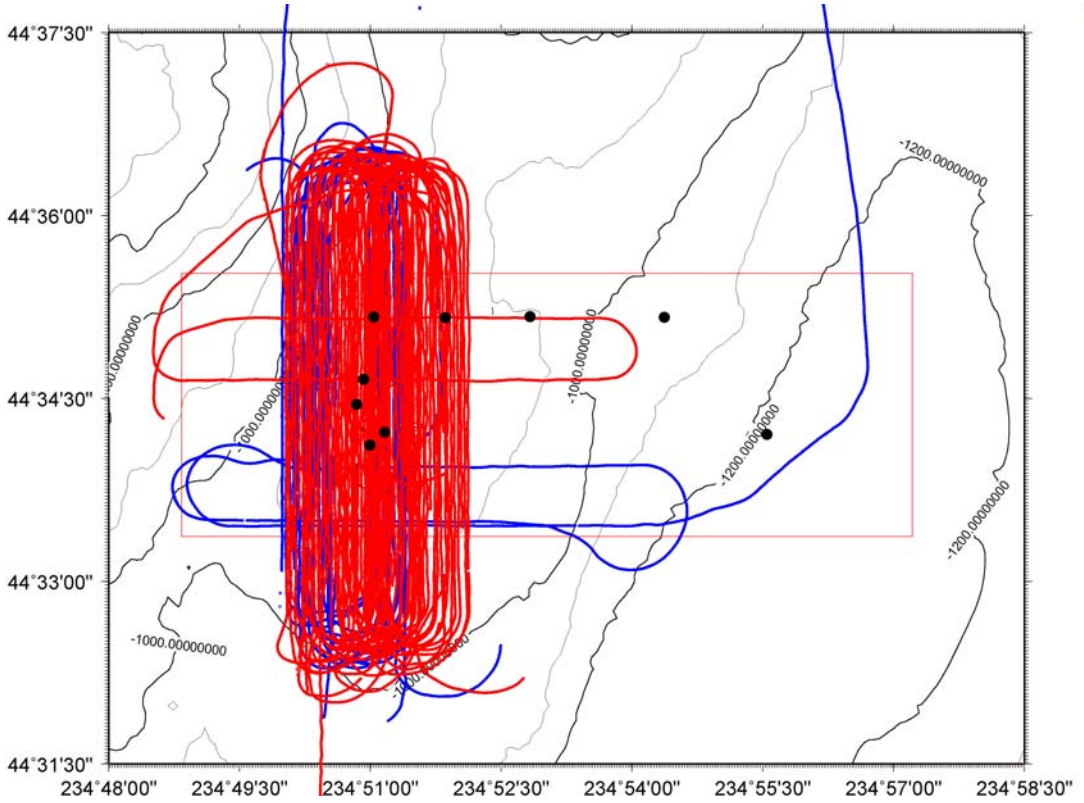


Figure 14. Survey track map. Blue lines are data acquired before July 11 with 12 streamer configuration shown in Figure 3. Red lines are data acquired after July 11 with 10 streamer configuration shown in Figure 9. Survey area is 3 x 6 km. Black dots are Leg 204 drill sites.

Figure 14 shows the track line for the entire survey including data acquired in the 12-streamer (blue) and 10-streamer (red) configurations. Fifty-six lines separate were acquired with 50 m line spacing. Many lines were shot multiple times to fill in holes left from equipment failures, poor tracking, and marine mammal shut downs.

A display of the data as monitored during acquisition is shown in Fig. 15. The high amplitude reflection in the middle of the trace is the seafloor return. During the cruise Channel 8 was typically not functioning, and Channel 12 was prone to noise bursts.

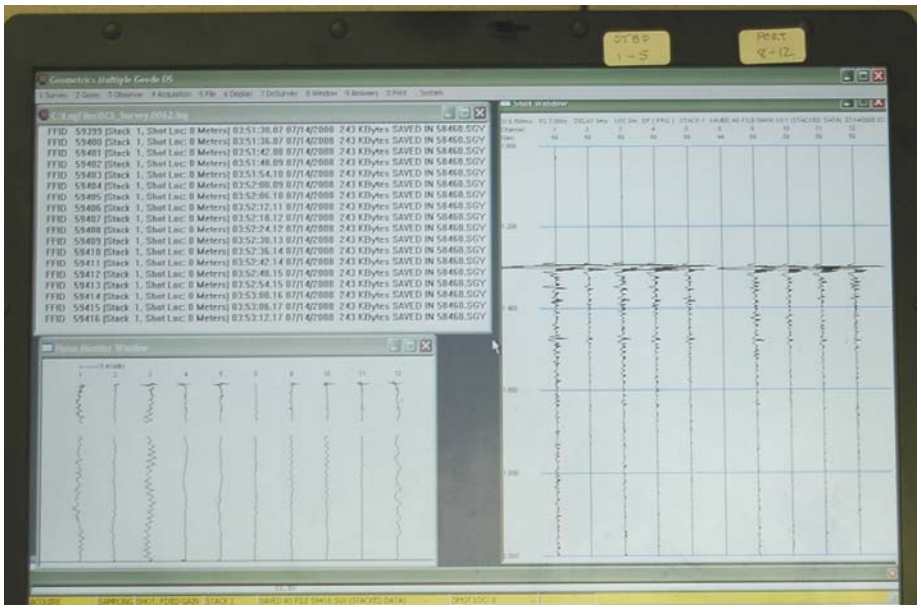


Figure 15. Display of seismic traces monitor. Record length is 3.0 s. This record was acquired with the 10-streamer configuration.

The data coverage (Fig. 16) for the binned data (12.5 m x 12.5 m bins) is nominally ~4 for most of the survey and somewhat better within the center of the survey (~ 6-8). Infill due to steering, equipment, and marine mammal interruptions directed multiple passes over the center of the survey to assure critical areas around the summit of south Hydrate Ridge were sufficiently covered. The result was the added coverage and increased nominal fold.

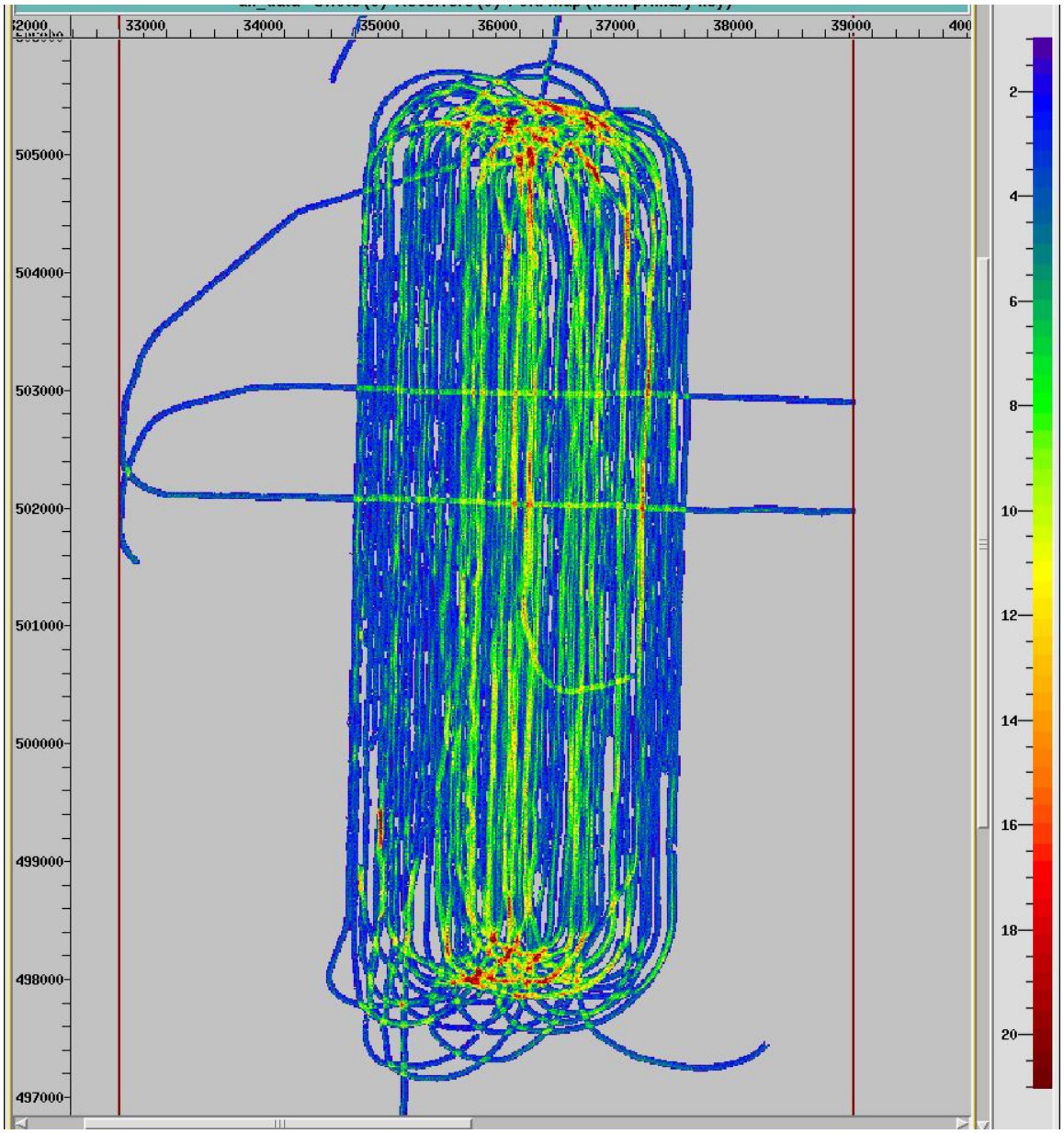


Figure 16. Bin fold coverage for data acquired in the 10-streamer configuration. The bin size is 12.5 x 12.5 m. Fold ranges from 0 – 18, with nominal fold of ~ 4. Coverage is best across the summit of south Hydrate Ridge with a nominal fold of ~ 6-8.

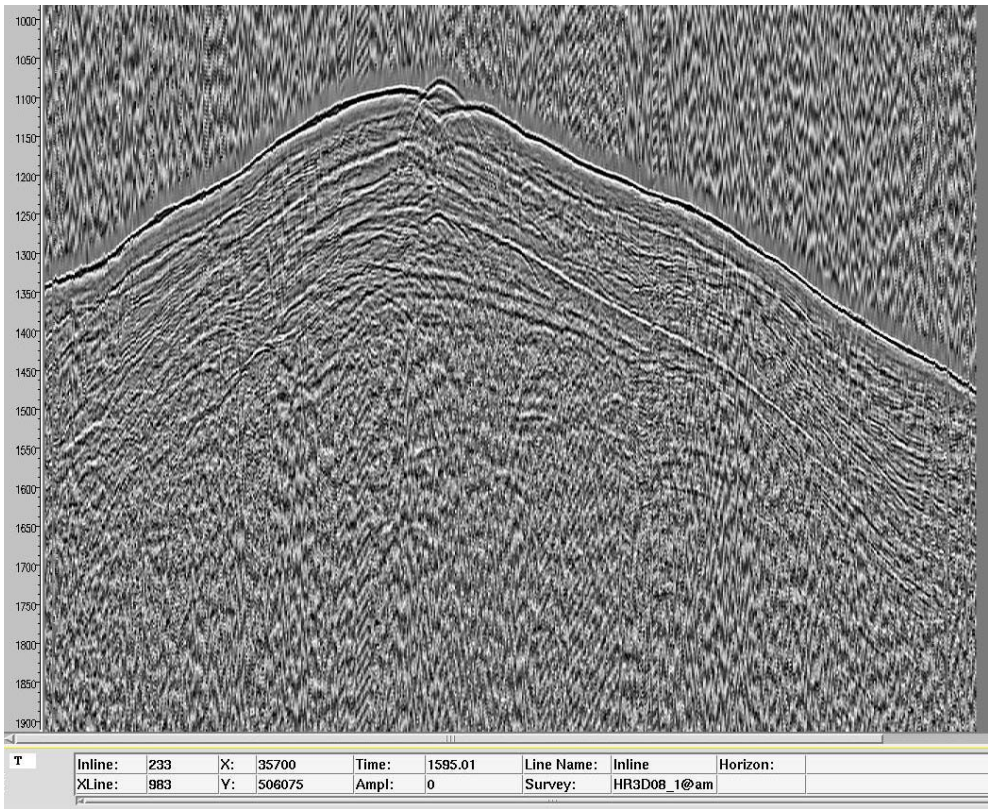


Figure 17. Preliminary stack of binned traces from Inline 233. Line length is ~ 6 km. Trace spacing is 12.5 m.

A preliminary stack of the binned traces is shown in Fig. 17. The targeted interval of the survey is the zone that is 250 ms below seafloor. Despite some noise issues seen throughout the section due to streamer noise and the low-fold stack, preliminary sections image the targeted areas sufficiently well to achieve the project objectives.

Marine Mammals

Marine Mammal Mitigation Weekly Report 1
Hydrate Ridge 3-D UTIG
TN 220
30 June to 7 July 2008

Visual marine mammal observation effort was maintained by at least two observers during all daylight hours while the GI guns were firing. Included in this report is the transit day from Seattle to the working grounds. The table summarizes 26 sightings of five species of cetaceans made in this period. Seven shutdowns occurred during seismic line shooting, some of which were fairly long in duration due to Pacific White-sided Dolphins' tendency to associate with and/or be attracted to the *Thomas G. Thompson* and ride the stern wake and to swim around the paravanes and seismic streamers. At times the shutdowns lasted for up to 2.5 hours while waiting for the animals to clear the safety radius.
There were no unauthorized incidental takes and all mitigation measures were in accordance with the Incidental Harassment Authorization (IHA) issued to the University of Texas, Institute of Geophysics, under the authority of Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C 1361 *et seq.*) by the Office of Protected Resources, National Marine Fisheries Service, dated 27 June 2008.

Michael Force, Lead Marine Mammal Observer
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Week 1 Sighting Summary

Date (GMT)	Time (GMT)	Sighting #	Species	Approx # of animals	Shutdown (Yes/No)	Line	Comments
2-Jul-2008	17:15:00	1	Dall's Porpoise	8	No		transit
2-Jul-2008	17:48:00	2	Pacific White-sided Dolphin	8	No		transit
2-Jul-2008	21:33:26	3	Humpback Whale	2	No		transit
2-Jul-	22:04:11	4	Pacific White-	18	No		transit

2008			sided Dolphin				
4-Jul-2008	1:47:53	5	Dall's Porpoise	12	No		
4-Jul-2008	2:45:00	6	Dall's Porpoise	2	No	11-1	
4-Jul-2008	18:00:50	7	Pacific White-sided Dolphin	80	Yes	18-1	approx 1.5 hours
4-Jul-2008	18:08:00	8	Northern Right Whale Dolphin	20	No		
4-Jul-2008	19:07:20	9	Humpback Whale	1	No		
4-Jul-2008	21:23:58	10	Pacific White-sided Dolphin	15	No		
4-Jul-2008	21:57:26	11	Short-beaked Common Dolphin	20	No		
4-Jul-2008	22:17:36	12	Pacific White-sided Dolphin	20	No		
5-Jul-2008	12:54:52	13	Pacific White-sided Dolphin	5	No	24-1	
5-Jul-2008	13:21:20	14	unidentified dolphin	unknow n	No		
5-Jul-2008	16:50:05	15	Pacific White-sided Dolphin	20	Yes	27-1	approx 10 mins
5-Jul-2008	23:14:14	16	Dall's Porpoise	5	Yes		approx 34 mins
5-Jul-2008	23:14:14	17	Pacific White-sided Dolphin	3	No		
5-Jul-2008	23:14:14	18	Northern Right Whale Dolphin and Pacific White-sided Dolphin	500	Yes		part of a large aggregation, PWSD followed ship for approx 34 mins
5-Jul-2008	23:29:12	19	Short-beaked Common Dolphin	120	No		
6-Jul-2008	14:55:50	20	Pacific White-sided Dolphin	20	No		
6-Jul-	14:55:50	21	Dall's Porpoise	10	No		

2008							
6-Jul-2008	16:48:50	22	Northern Right Whale Dolphin and Pacific White-sided Dolphin	200	Yes		approx 2 hours, 34 mins
6-Jul-2008	19:28:45	23	Pacific White-sided Dolphin	7	Yes		approx 1 hour, 35 mins
6-Jul-2008	23:26:39	24	Pacific White-sided Dolphin	4	No	36-1	
7-Jul-2009	0:06:00	25	Pacific White-sided Dolphin	1	No		
7-Jul-2009	1:04:34	26	Pacific White-sided Dolphin	7	Yes		approx 5 mins (guns secured for recovery)

Marine Mammal Mitigation Final Weekly Report
Hydrate Ridge 3-D UTIG
TN 220
8 to 17 July 2008

18 July 2008

Diurnal visual marine mammal observation effort was maintained by at least two observers aboard the *R/V Thomas G. Thompson* during all seismic operations (i.e., when the GI guns were firing). The table below summarizes twenty-seven sightings of five species of cetacean and one species of pinniped made in this period. Thirteen shutdowns occurred during seismic line shooting. With a few exceptions, all of the shutdowns were due to Pacific White-sided Dolphins entering the safety radius. This is an inevitable outcome of this species tendency to associate with and/or be attracted to the *R/V Thomas G. Thompson.* Rather than ride the bow pressure wave, behaviour typical for this species, the animals were attracted to the seismic gear, particularly the paravanes, where they would remain for extended periods of time. Other shutdown species were Dall's Porpoise, which also commonly exhibits ship-attraction behaviour, and Northern Right Whale Dolphin. The latter species commonly associates with Pacific White-sided Dolphin in large mixed herds. On some occasions the shutdowns lasted for up to 1 and three-quarter hours while waiting for the animals to clear the safety radius.

There were 53 sightings of marine mammals during the entire survey. This includes five species of cetacean (Humpback Whale, Minke Whale, Pacific White-sided Dolphin, Northern Right Whale Dolphin, Dall's Porpoise) and one pinniped (Northern Fur Seal).

There were no unauthorized incidental takes and all mitigation measures were in accordance with the Incidental Harassment Authorization (IHA) issued to the University of Texas, Institute of Geophysics, under the authority of Section 101(a)(5)(D) of the

Marine Mammal Protection Act (16 U.S.C 1361 *et seq.*) by the Office of Protected Resources, National Marine Fisheries Service, dated 27 June 2008.

Note that this expanded report includes the week of 8 to 14 July, when line shooting was cancelled for four days because of unfavorable weather conditions.

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Week 2 and 3 Sighting Summary

Date (GMT)	Time (GMT)	Sighting #	Species	Approx. # of animals	Line	Shutdown (Yes/No)	Comments
12-Jul-2008	01:09:21	27	Pacific White-sided Dolphin	2		No	
12-Jul-2008	03:29:15	28	Pacific White-sided Dolphin	4	12-1	Yes	18 minutes
12-Jul-2008	16:45:00	29	Humpback Whale	2	17-1	No	
12-Jul-2008	17:23:05	30	Dall's Porpoise	3	17-1	No	
12-Jul-2008	21:23:38	31	Pacific White-sided Dolphin	5	18-1	Yes	10 minutes
12-Jul-2008	22:05:29	32	Pacific White-sided Dolphin and Northern Right Whale Dolphin	200		Yes	30 minutes
12-Jul-2008	23:55:28	33	Pacific White-sided Dolphin	2	20-1	Yes	25 minutes
13-Jul-2008	18:19:19	34	Dall's Porpoise	10	22-1	Yes	15 minutes
13-Jul-2008	20:37:52	35	Pacific White-sided Dolphin	4		No	
14-Jul-2008	18:15:37	36	Dall's Porpoise	3	34-1	No	
15-Jul-2008	12:44:55	37	Pacific White-sided Dolphin and Northern Fur Seal	100	52-1	Yes	48 minutes; solitary fur seal associating with dolphins
15-Jul-2008	18:18:00	38	Pacific White-sided Dolphin	10	54-1	No	
16-Jul-2008	03:39:10	39	Pacific White-sided Dolphin	10	60-1	Yes	24 minutes
16-Jul-2008	17:34:00	40	Minke Whale	1	26-1	No	

16-Jul-2008	19:07:24	41	Pacific White-sided Dolphin and Northern Right Whale Dolphin	400	80-1	Yes	1 hour 22 minutes
16-Jul-2008	20:38:58	42	Short-beaked Common Dolphin	6	36-1	No	distant group, total number much higher
17-Jul-2008	02:55:00	43	Pacific White-sided Dolphin, Northern Right Whale Dolphin and Short-beaked Common Dolphin	700	45-1	Yes	47 minutes
17-Jul-2008	13:25:19	44	Pacific White-sided Dolphin and Northern Right Whale Dolphin	200	52-1	Yes	55 minutes
17-Jul-2008	14:41:29	45	Humpback Whale	2	16-1	No	
17-Jul-2008	16:55:04	46	Pacific White-sided Dolphin and Northern Right Whale Dolphin	400	60-1	Yes	1 hour 46 minutes
17-Jul-2008	19:25:53	47	unidentified dolphin	400	20-1	No	
17-Jul-2008	19:47:18	48	Pacific White-sided Dolphin	12		No	
17-Jul-2008	19:56:35	49	Pacific White-sided Dolphin and Northern Right Whale Dolphin	1500		Yes	1 hour 44 minutes; large ship-following aggregation, possible re-sight of sightings 46, 44 and 41
17-Jul-2008	22:47:35	50	Pacific White-sided Dolphin	1	83-1	No	
17-Jul-2008	23:36:23	51	Humpback Whale	2	84-1	No	

18-Jul-2008	02:38:12	52	Humpback Whale	2	No	
18-Jul-2008	03:08:21	53	Pacific White-sided Dolphin and Northern Right Whale Dolphin	300	Yes	29 minutes

Miscellaneous

Line acquisition and numbering

Completed lines (12 streamers)			Additional Comments	Completed lines (10 streamers)			Additional Comments	FFID (.sgy)
Nathan #	Ship #	Geode #		Nathan #	Ship #	Geode #		
116	43	38		125	12	40	MMO Shutdown MM3 to MM4	40340
138	38	37	(small gap)	101	13	41		41198
115a	41	36		126	14	42		42093
114	39	34		102	15	43		42878
113	37	32		138	38	44		43844
136	34	31		117	45	45		44776
112	35	30		139	40	46		45561
135	32	29		118	47	47		46476
111	33	28		140	42	48		47309
134	30	27	Same geode # for both 134/110	103	17	49		48176
110	31	27		127	16	50		49422
131a	24	26		104	19	51		50168
109	29	25		128	18	52		51068
132	26	24		105	21	53	MMO Shutdown MM5 to MM6	51810
107	25	21		129	20	54	MMO Shutdown, GPS, Geode Difficulties	52329
133	28	20		106	23	55	Port PV messed up…shut down	53166
106	24	19		107	25	56		54546
105	21	17		130	22	57	MMO shutdown MMO 7	54299
129	20	16		108	27	58		54766
104c	19	15		131	24	59		53688
104b	19	14		109	29	60		56581
103	17	11		132	26	61		57493
127	14	10		110	31	62		58460
102	15	9		133	28	63	light green = complete	59524
126	14	8		111	33	64	mid green = 2nd time shot	60442
101	3	7		134	30	65	dark green = 3rd time shot	61334
				112	35	66	yellow = problem, complete	62298
				135	32	67	red = incomplete	63367
				113	37	68		64265
				136	34	69		65192
				114	39	70		65982
				137	36	71		66854
				115	41	72		67711
				141	44	73		68614
				119	49	74		69528
				142	46	75		70576
				120	51	76		74532
				143	48	77		72472
				121	53	78		73344
				144	50	79		74275
				122	55	80		75245
				145	52	81		76139
				123	57	82		76927

146	54	83		77587
124	59	84		78469
146	54	85		79351
125	12	86		80145
147	56	87		81089
128	18	88		82007
148	58	90		82876
129	20	91		83737
149	60	921		84707
116	43	93		85371
150	76	94		86337
106	23	95		87360
151	77	96		88379
130	22	97		89458
152	78	98		90425
131	24	99		91279
153	79	100		92162
132	26	101		93016
154	80	102	MMO shutdown halfway	93866
137	36	103	MMO shutdown continued1/4 of line	94386
155	81	104		94774
125	12	105		95667
156	82	106		96730
117	45	107	MMO Shutdown 3/4 to EOL	97681
139	40	108	MMO Shutdown before profile start, shot btw lines	98441
119	49	109		99226
138	38	110		100145
122	55	111		101031
141	44	112		101840
121	53	113		102709
145	52	114	MMO shutdown after shooting 1/3 of line	103601
127	16	115		104098
149	60	116		104863
129	20	117	MMO shutdown for entire line	105706
150	76			
133	28			