DRAFT Cruise Report

R/V Maurice Ewing, Cruise EW0408: Sedimentation, Paleoceanography, and Paleoclimatology of Southeast Alaska

Newport Oregon to Kodiak Alaska
21 August 2004 to 23 September 2004

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Xxx October 2004
DRAFT 19 Sept. 2004

OVERVIEW

This document provides a summary of shipboard operations and preliminary scientific results for cruise EW0408A of R/V Maurice Ewing, a program to study sedimentary geology of the NE Pacific Ocean off Southeast Alaska. The cruise departed Newport Oregon on 21 August and arrived in Kodiak Alaska on 23 September 2004.

The science program was built from two proposals, both funded by NSF. The first, (*Developing a Paleoceanographic and Paleoclimatic Record from the Fjords and Continental Margin of Southeast Alaska*, Mix, Pisias, Prahl, Mayer, PI's) has primary scientific goals of assessing whether rapid climate oscillations known from historical records are recorded in fjord and continental margin sediments, whether climate changes of the past ~10,000 years and their biological responses are linked to changes in regional ocean conditions, and whether rapid melting of Alaskan glaciers observed over recent decades is an unprecedented anomaly associated with greenhouse warming or a natural oscillation that has happened repeatedly. The second program (*Establishing Quaternary Climate/ Terrestrial/ Oceanic Linkages in Southern Alaska, and IODP Site Survey*, Jaeger, Cowan, Finney, Gulick, Powell, Stoner, PI's) adds research elements focused on understanding how sediments accumulate at exceptionally high rates in the region (*e.g.,* > 10 m ka^{-1} on the continental shelf and slope, and in thick fan deposits in the deep Pacific) in response to interactions of tectonic uplift, climate forcing, erosion by ice and water processes, and transport into the open ocean. The scientific goals and operational strategies of the two programs are highly compatible, and the shipboard party operated as a single group with common objectives.

Both projects share the goal of providing site survey information for possible future drilling and detailed study under the auspices of the Integrated Ocean Drilling Program. Given this goal, shipboard operations include a significant focus on geophysical survey (high-resolution swath bathymetric and backscatter imaging, shallow sub-bottom profiling, and where permitted, high-resolution seismic reflection profiling), in a series of relatively small target areas where sediment accumulations may be favorable for drilling by shipboard or alternate platforms. To assess the quality of sediments and the utility of geologic proxies of ocean and climate in each survey area, the operational program includes wireline coring, with a variety of tools including gravity coring, piston coring, and multi-coring. To assess water-column properties in the survey areas, the ship's uncontaminated seawater line was monitored continuously with a thermosalinograph, and water samples were filtered on station to collect particles from the water column. Discrete sampling within the water column employed both CTD and bottle casts. Laboratory operations on the ship included processing of seismic and bathymetric survey data, processing of sediment cores for physical properties and visual descriptions, and preservation of seawater samples and filtered particulate materials for post-cruise study.

A key consideration for this cruise was compliance with regulations for minimizing impacts on marine mammals and fisheries. A particular concern is the potential impact of sounds generated by seismic reflection air guns. Environmental Assessments were filed by LGL Associates, and an Incidental Harrassment Authorization (IHA) permit for operations were obtained from NOAA National Marine Fisheries Service (NMFS). Additional permits for operations were provided by the National Park Service (Glacier Bay National Park), from the Army Corps of Engineers, and the Alaska State Department of Fish and Game (ASDF&G). Native populations that rely on subsistence hunting and fishing were informed of cruise activities prior to sailing, and during the cruise local fisheries managers were kept informed of our schedule of operations in their area. At the time of sailing, the NOAA-NMFS permit was not received, and as a result, no seismic operations occurred prior to 02 August 2004. Given the significant population of marine mammals in the region, and the need for more basic information on mammal distributions, we recorded observations of mammals in each survey area whether or not seismic operations were planned. A list of all permits obtained for this cruise is provided in **Table 00-1**.

Xxx insert table 1. Full list of permits and contacts. .

OPERATIONS
The cruise included ~xxxxnm of transit, ~xxxx nm of survey lines (for a total cruise distance of ~xxxx nm) in 30 detailed survey and station areas outlined in **Table 00.2**, and illustrated in **Figure 00.1**. Site designations include a 2 or 3-letter location code (POW= Prince of Wales Island, BAR = Baranof Island, JUN = Juneau area, GOA = Gulf of Alaska, MS = Malaspina Slope, MI = Middleton Island area, KB = Kayak Slope Basin), a sequential number within each area, and a letter (B here indicates our second revision on each site, C indicates the third, and so on). Most survey areas included water sampling using CTD and hydrocasts, and coring using both multicore and piston core.

TABLE 00.1: Permits for operations.
Agency, permit number, date filed.

TABLE 00.2: Survey areas with list of coring sites (xxx REVISE POST-CRUISE).

Station	Station	Latitude		Longitude		Depth	Cum
Code	**Name**	**Deg.**	**Min.**	**Deg.**	**Min.**	**(m)**	**Days**
Port	Newport OR	44	37.5	-124	-2.6	Na	0.00
POW-1	Cordova Bay	54	58.0	-132	-44.0	550	3.5
POW-2	Dall Island	54	51.0	-133	-19.0	200	4.5
POW-4	Gulf of Esquibel	55	36.0	-133	-31.0	200	5.5
POW-5	Sumner Trough	55	32.5	-134	-43.5	400	6.6
BAR-1	Crawfish Inlet	56	45.8	-135	-9.3	200	7.6
BAR-XXX	TBA	xx	xx	xx	xx	xx	8.4
BAR-3	Deep Inlet**	56	57.9	-135	-15.9	90	9.1
BAR-4	Sitka Sound	57	6.5	-135	-30.2	190	9.8
BAR-5	Sitka Slope	56	50.5	-136	-10.0	1200	11.1
JUN-1	Slocum Arm	57	32.1	-136	0.0	200	12.0
JUN-2	Cross Sound – Lisianski Inlet	58	4.0	-136	-24.6	200	13.1
JUN-4	Skagway Arm	59	20.0	-135	-22.5	430	14.8
JUN-3	Lynn Canal	58	7.5	-134	-56.5	600	15.5
GOA-12A	Icy Strait	58	6.9	-136	-35.5	200	16.8
GOA-13A	Muir Inlet (A)	59	0.0	-136	-8.0	100	17.9
GOA-14A	Muir Inlet (B)	58	56.0	-136	-6.0	300	18.3

GOA-07A	Malispina shelf	59	36.8	-140	-5.4	150	20.4
GOA-11A	Yakutat Bay	59	41.0	-140	0.0	140	20.8
GOA-10A	Disenchantment Bay	59	58.0	-139	-34.0	230	21.5
MS-1	Malispina Slope	59	39.8	-142	-9.9	190	22.8
ICY-1	Icy Bay – TENTATIVE	60	5.0	-141	-17.0	130	23.5
GOA-06A	Shelf Basin 1	59	54.8	-143	-10.5	145	24.8
GOA-05A	Shelf Basin 2	59	57.0	-143	-43.0	150	25.5
GOA-03A	Copper River Delta	60	9.0	-145	-40.0	120	26.4
GOA-02A	Lower Prince William Sound	60	35.5	-146	-53.4	420	27.6
GOA-01A	Upper Prince William Sound	60	40.0	-147	-40.0	750	28.2
GOA-04A	Shelf off PW Sound	59	40.0	-145	-7.0	170	29.3
KB-1	Khitrov Basin	59	19.8	-143	-53.2	3000	30.4
GOA-16B	Surveyor Fan	58	42.6	-144	-51.3	2500	31.9
Port	Kodiak, AK	57	47.0	-152	-25.7	0	32.8
							Total
							32.8 d

Fig. 00.1 – Summary Map of survey tracklines and names of survey areas

A typical operational plan for most survey areas was as follows:

1) Hydrocast with a Seabird SB19 CTD, for purposes of calibrating sound velocity model for swath mapping. In most cases this CTD was followed by a bottle cast for postcruise analysis of water samples. The purpose of this cast is to measure temperature, salinity, density, and (in some areas) oxygen concentration with the CTD, and to take water samples for measurements of salinity, $\delta^{18}O$-H_2O, $\delta^{13}C$-DIC, and nutrients, in the upper water column (typically 200 m or to the sea floor). Water sampling stations are noted in **Table 00.3**, and a summary figure of T and S properties is provided in **Fig. 00-2**.
2) Continuous recording of surface-water T and S in four different sensors. First, a Seabird SB19 CTD was mounted on the Simrad transducer, at ~6m depth. Second, the ship's hull-mounted T-S sensor was mounted at ~4 m depth. Third, the water intake for the ship's uncontaminated seawater line, at a nominal depth of ~5 m, has a temperature sensor mounted near the intake (upstream of the pump), and pumps water through a a Turner Thermosalinograph in the laboratory.
3) High-resolution bathymetric mapping using a portable Simrad EM-1002 swath mapper in shallower waters, and the R/V Ewing's Hydrosweep system in deeper waters (with an approximate transition depth of 800m).
4) High-resolution digital 3.5 kHz "chirp" shallow sub-bottom profiling, using an ODEC Bathy-2000 system. .
5) Where permitted, digital multi-channel seismic reflection profiling using high-resolution, low-energy, "GI" sound sources, and streamers of 750-1500 m length
6) Based on survey operations, coring sites were selected, and sediment coring utilized an eight-tube multicore, small diameter or large diameter gravity cores, and a large-diameter piston core. Coring strategies at each site varied based on

scientific goals and character of sea-floor sediments. A map of coring sites is provided in **Fig. 00-3**.

Laboratory operations (methods documented in the appendix) in each survey area included the following operations:

1) At each hydrocast station, particulate material from the ship's uncontaminated seawater line, was sampled on xxx glass filters. Xxx FRED FILL IN.
2) Archiving of water samples, including poisoning of one subsample with mercuric chloride.
3) X-ray imagery of one multicore tube at each site, extrusion and slicing of one tube with rose-bengal staining and preservation with in buffered formalin, extrusion and slicing of one tube for measurements of short-lived radioisotopes (e.g., ^{234}Th, ^{7}Be) and Chlorophyll-*a* to measure sediment accumulation and bioturbation rates. Other multicore tubes were archived for future study.
4) Analysis of core physical properties in the OSU lab van (Gamma Density, magnetic susceptibility, P-wave velocity, and non-contact resistivity) (**Fig. 00-4**)
5) Visual core descriptions (and limited sampling for purposes of core descriptions).
6) Storage of core materials in the OSU Refrigerator van (A-deck). Following the cruise, archived cores were returned to the NSF core repository at OSU.

Scientific Results:

Xxx cruise summary to be written postcruise.
General Comments
Prospects for future drilling.

RESULTS BY AREA:

1) POW2 (Trough West of Dall Island)

A) Introduction

Survey Area POW-2 is an open-ocean site midway between Dall Island and Forrester Island. Water depths in the survey area are typically between 150 and 250 m. The goal of survey and coring here is to obtain long sedimentary records that may extend to the Last Glacial Maximum or beyond. The region may have been open marine water during the low stand of sealevel of the Last Glacial Maximum, or perhaps a freshwater lake enclosed on the west by a peninsula that is now represented by Forrester Island, on the north by ice descending from Prince of Wales Island, on the east by a locally glaciated Dall Island, and on the south by an ice stream that filled Dixon Entrance, emanating from Clarence Strait (Carrarra et al., 2003).

Operations in the area began on the afternoon of 8/24/04 and ended on the morning of 8/25/04, with transit to Survey Area POW-1 (Cordova Bay). At time of survey, NMFS permit for seismic operations has not been received, so no seismic operations occurred. Operations in the survey region included CTD and water sampling from the surface to the sea floor, filtering of surface waters for plankton and other particulates, XBT deployment, bathymetric mapping using the EM1002 system, Chirp sub-bottom profiling using the ODEC Bathy-2000 system, and sediment coring.

Fig. 1.A.1: May include a figure or two of published background if appropriate.

B) Swath Bathymetry and Backscatter

Survey operations commenced at 0220Z 25 August 2004 and concluded at 0823Z with 9 survey lines run. The EM1002 operated in +/- 60 degree mode throughout the survey with fixed 400 m maximum swath width. The absorption coefficient was set at 27db/km. Bathymetry was gridded at 10 m and backscatter mosaiced at 5 m.

Table 1.B.1: List of lines with starting and ending times.

Fig. 1.B.1: navigational chart with lines and core site.
Fig. 1.B.2: map view bathy with survey lines
Fig. 1.B.3: oblique view bathy with core site mark
Fig. 1.B.4: some view of backscatter

The bathymetry and backscatter maps reveal a broad region of soft sediment accumulating in a moderate to deep locations between Dall Island and Forrester Island. Near the northern end of the survey area, a narrow, relatively deep, trough suggests erosion of sediment, which we speculate may be the influence of tidal currents. Bathymetric highs generally display high backscatter, suggesting that they are comprised of either bedrock or dense glacial deposits. Some apparent striations in the backscatter data, oriented at ~295^{o}, suggest a possible glacial flow path from northeast to southwest.

Relatively steep features on a broad bathymetric high hear the southern end of the survey area suggest peaks, perhaps nunataks, that were not covered by continental ice. A relatively straight scarp,oriented along 210^{o}, perhaps a fault trace, forms the southern boundary of the bathymetric high.

C) Chirp subbottom profiles

Survey lines are the same as those in Table 1.B.1.

Fig. 1.C.1: (a-xxx as needed) images of 3.5 kHz lines.
Fig. 1.C.2: (zoom in detail if needed)

Interpretation: Xxx short paragraph on interpretation.

D) Multichannel Seismic Reflection Profiling

No seismic reflection studies were performed here, due to delays in permitting.

E) Water Column Properties and Particle Filtering

A CTD cast of temperature, salinity, and pressure was performed on August 24, 2004, at 17:29z. The surface mixed layer was 10 m deep, and had temperatures of 15.0-15.1, and salinities of 30.58-30.67. Beneath this surface layer, a steep thermocline and halocline is present from ~11 - 60 m depth, with a series of discrete steps of decreasing temperature and increasing salinity. near sea floor (190 db) values for temperature of 6.08 ^{o}C, and salinity of 33.48.

Water samples were taken at each cast depth for $\delta^{18}O$, $\delta^{13}C$(DIC), salinity, and nutrients (phosphate, nitrate, nitrite, silicate).

Table 1.E.1: – list of hydrocasts, XBT's, bottle depths, and samples taken for each hydrocast in the area.

SAMPLE ID	ITEM	LAT DEG.	LAT MIN.	LON DEG.	LON MIN.	BOTTOM DEPTH m	DATE (GMT)	TIME (GMT)	HYDRO-CAST DEPTH m	NOTES
01HC	Hydrocast	54	48.9595	-133	-16.7020	193	8/25/04	00:26		6 depths
03NB	Multicore Niskin	54	49.9054	-133	-17.4185	201	8/25/04	12:18	200	

Fig. 1.E.1: T, S, vertical profiles and T-S diagram in area POW2, from CTD data at station EW0408-01HC.

Fig. 1.E.3: a) surface T variations in map or transect, b) S variations in map or transect, c) Fluorescence in map or transect.

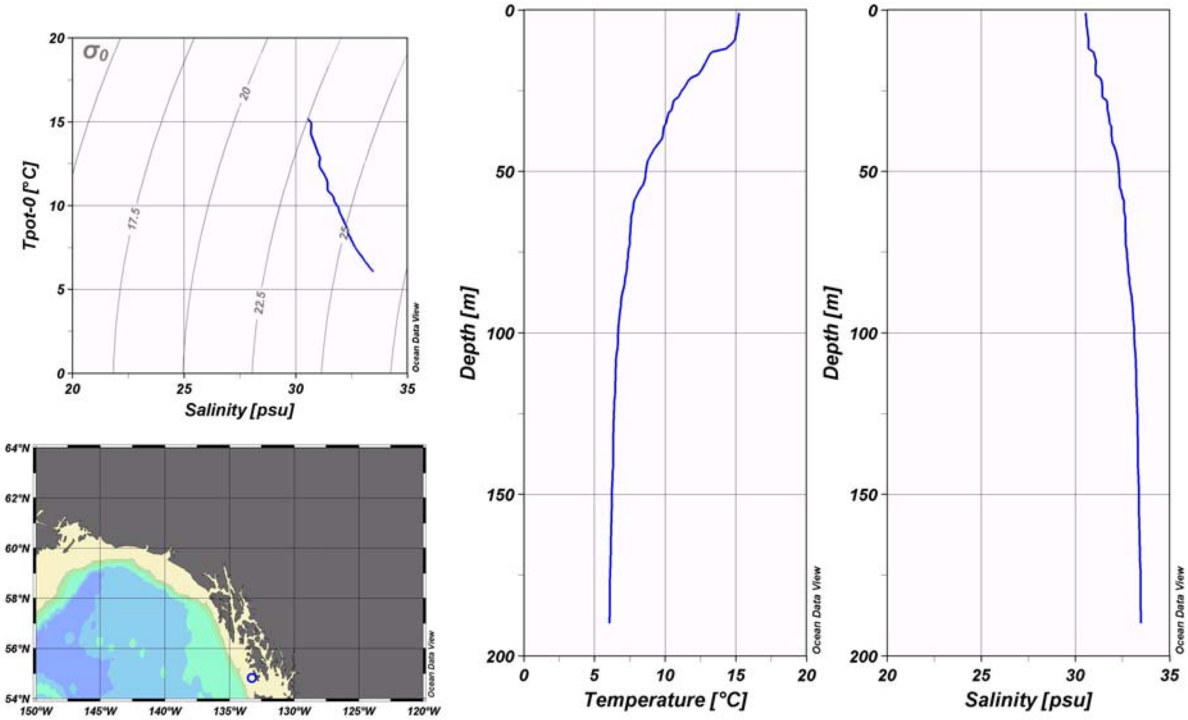


Fig. 1.E.3: a) surface T variations in map or transect, b) S variations in map or transect, c) Fluorescence in map or transect.

F) Sediment Coring

Operations: Uncertainties about sediment composition based on limited penetration of 3.5 kHz chirp sub-bottom profiles led us to start coring with a 2.5" diameter gravity core. This core was recovered full (~1.5 m) of soft mud, but was washed on the deck and not archived. Next, the sea floor was sampled with the multicore, and the jumbo piston core rigged with 40' of pipe. Recovery is listed in **Table 1.F.1**.

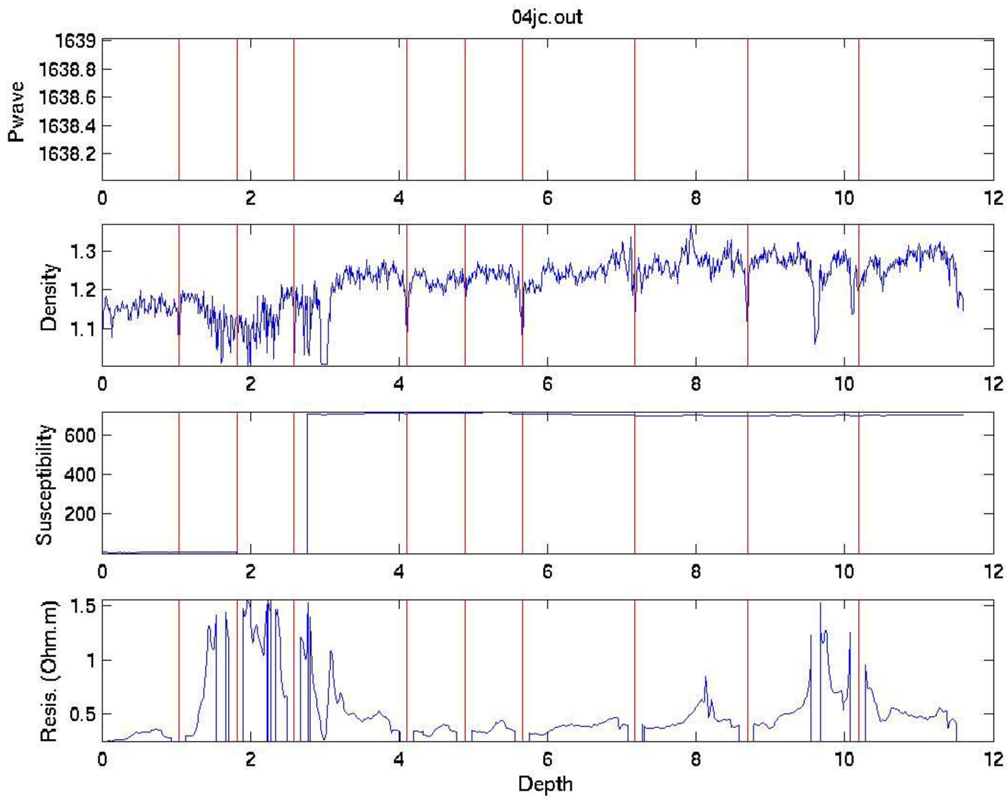
Core logging data from piston core EW0408-04JC are illustrated in **Fig. 1.F.1**. Magnetic susceptibility data are suspect in the first two sections. End cap effects have not been removed. Track misalignment led to some erroneous patterns of variation in resistivity that repeated in each section. P-wave velocities were culled due to low signal strength.

Table 1.F.1: – list of cores taken in the survey area, with latitude, longitude, depth, length, and comments (include note on archiving method, and samples taken).

SAMPLE ID	ITEM	LAT DEGR.	LAT MIN.	LON DEGR.	LON MIN.	BOTTOM DEPTH m	DATE (GMT)	TIME ON BOTTOM GMT	CORE LENGTH cm
02GC	2.5" Benthos Gravity	54	49.8919	-133	-17.4518	200	8/25/04	10:40	0
03MC1	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	43
03MC2	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42
03MC3	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	37
03MC4	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42

03MC5	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42
03MC6	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42
03MC7	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42
03MC1	Multicore	54	49.9054	-133	-17.4185	201	8/25/04	12:18	42
04JC	Jumbo Piston	54	49.8810	-133	-17.4028	201	8/25/04	14:18	1162
04TC	Trigger Core	54	49.8810	-133	-17.4028	201	8/25/04	14:18	28

<u>Fig. 1.F.1</u>: Shipboard core logging data for core EW0408-04JC – Gamma Density, Mag Sus, P-wave, NCR.



Spikes in the core logging data are generally associated with end caps between core sections. The apparent low in density associated with high resistivity, from 1-3 m, is likely an artifact associated with gas expansion. Magnetic susceptibility data are suspect, at least in the upper three sections, due to track problems. P-wave velocity estimates were all discarded because of poor signal strength.

<u>Fig. 1.F.2</u>: X-Ray image of multicore (add postcruise).

<u>Fig. 1.F.3</u>: Digital image of cores (add postcruise).

Interpretation: xx short paragraph linking coring results to regional context including bathy and 3.5 kHz, and observations on logging data and smear slides.

G) Marine Mammal Observations:
Nine to eleven humpback whales were sited during survey and station operations in area POW2.

Table 1.G.1: – Table of sitings.

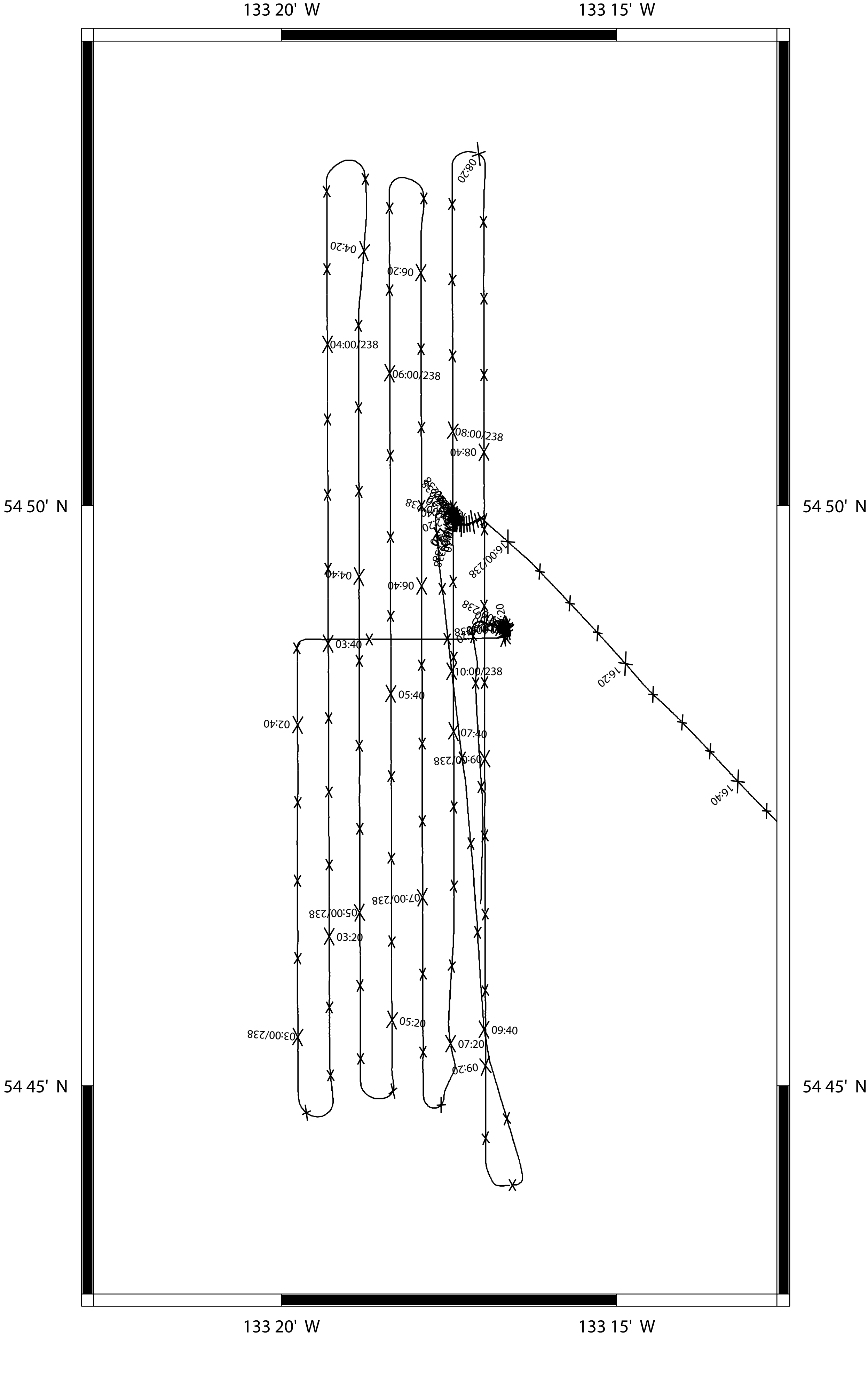
Date	Time GMT	Species	Number	Dist. from ship
8-25	03:02	Humpback whale	1	1579
8-25	0310	Humpback whale	1	1958
8-25	0316	Humpback whale	1	2729
8-25	0340-0409	Humpback whale	4-6	~1200
8-25	0428	Humpback whale	2	1427

H) Area Summary: Excellent sediment recovery and strategic location make POW2 a superb site for further analysis of oceanographic and climatic history. Unfortunately, the lack of seismic reflection data due to delays in permits prevent us from making firm estimates of sediment thickness beyond a minimum of xxx. Followup studies will be needed to fully contrain sedimentation patterns and provide necessary background for drilling.

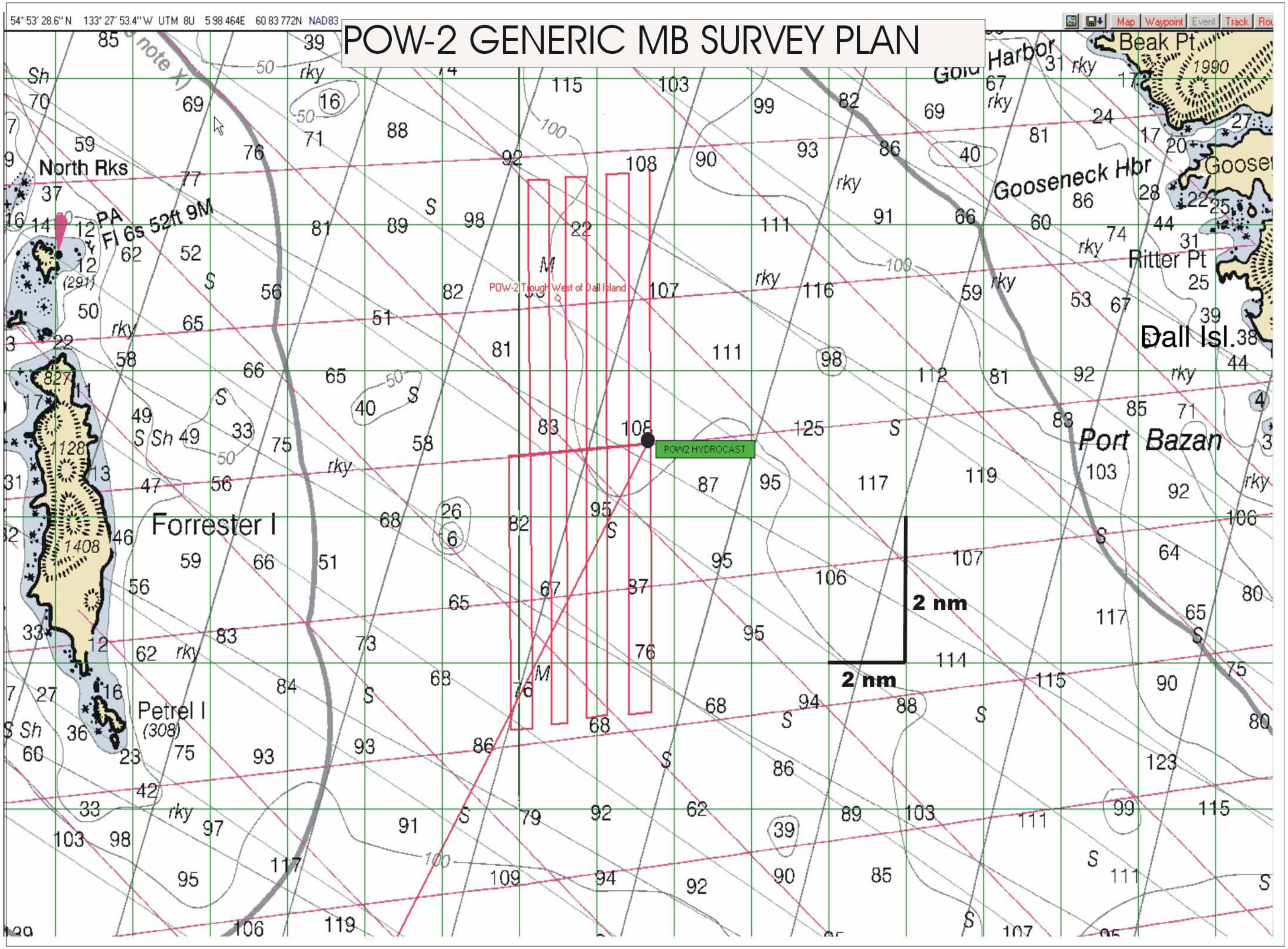
I) References:

Carrara, P.E., T.A. Ager, J.F. Baichtal, and D.P. VanSistine (2003) Map of glacial limits and possible refugia in the southern Alexander Archipelago, Alaska, during the Late Wisconsin glaciation. Miscellaneous Field Studies Map MF-2424 Version 1.0, U.S. Geological Survey, Denver CO.

POW2 Trough West of Dall Island



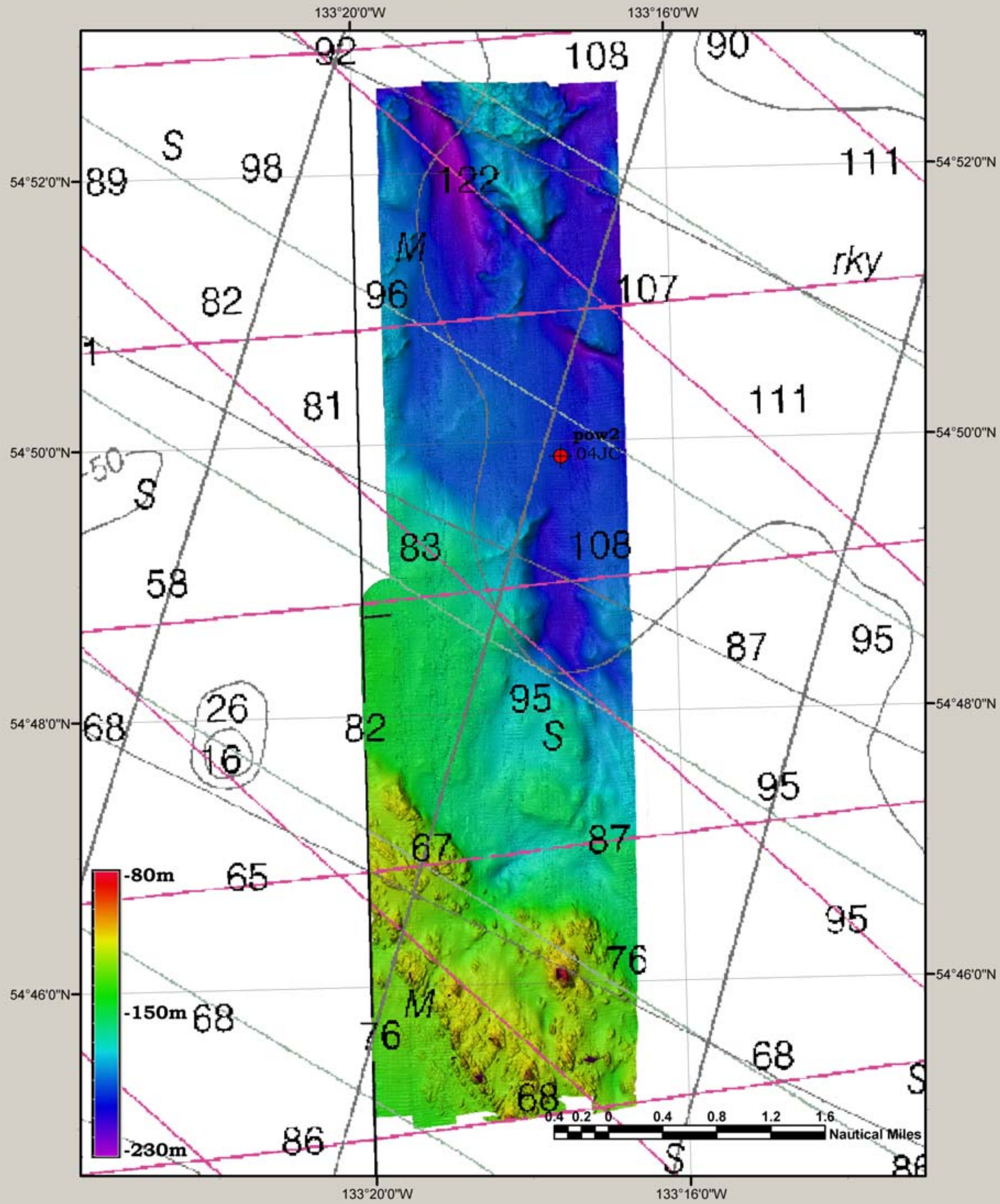
POW-2 GENERIC MB SURVEY PLAN



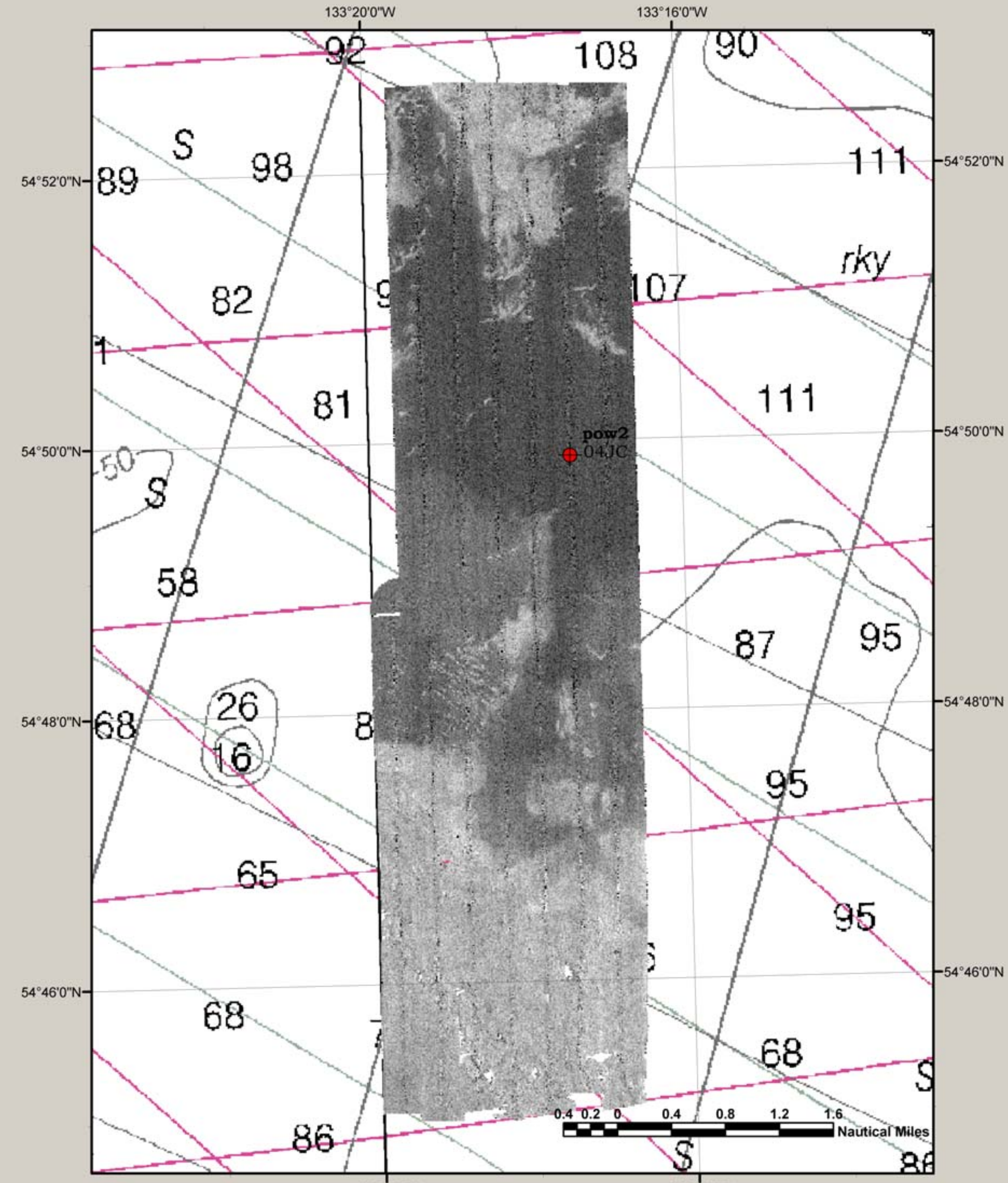
POW-2: DALL ISLAND WEST

Survey operations commenced at 0220Z 25 August 2004 and concluded at 0823Z with 9 survey lines run. The EM1002 operated in +/- 60 degree mode throughout the survey with fixed 400 m maximum swath width. The absorption coefficient was set at 27db/km. Bathymetry was gridded at 10 m and backscatter mosaiced at 5 m.

POW-2 Trough West of Dall Island



POW-2 Trough West of Dall Island



Index to appendices:

1) Coring Protocols (xxx Nick will write)
2) Core Archiving Protocols
3) Sediment visual description protocols
4) Water sampling protocols
5) Filtering and biomarker protocols
6) Multicore preservation and staining protocols
7) Swath mapping protocols
8) Chirp sub-bottom profiler protocols
9) Seismic acquisition and processing protocols
10) Mammal observation protocols (xxx – Steve, could you write one page documenting your methods).

Index to full database products:

1) Navigation Files (filed at NGDC, www.xxx.ngdc.noaa.gov)
2) Bathymetry (filed at NGDC, www.xxx.ngdc.noaa.gov)
3) Backscatter (documented here)
4) Digital Chirp subbottom profiles (filed at Univ. Texas Austin, www.xxx.edu)
5) Digital multichannel seismic reflection profiles (filed at Univ. Texas Austin, www.xxx.edu)
6) XBT (documented here)
7) CTD (documented here)
8) Surface Seawater (T, S, Fluorometer, documented here)
9) Sample Logs, documented here
10) Core Locations and logging data (filed at NGDC curator's database, www.xxx.ngdc.noaa.gov)

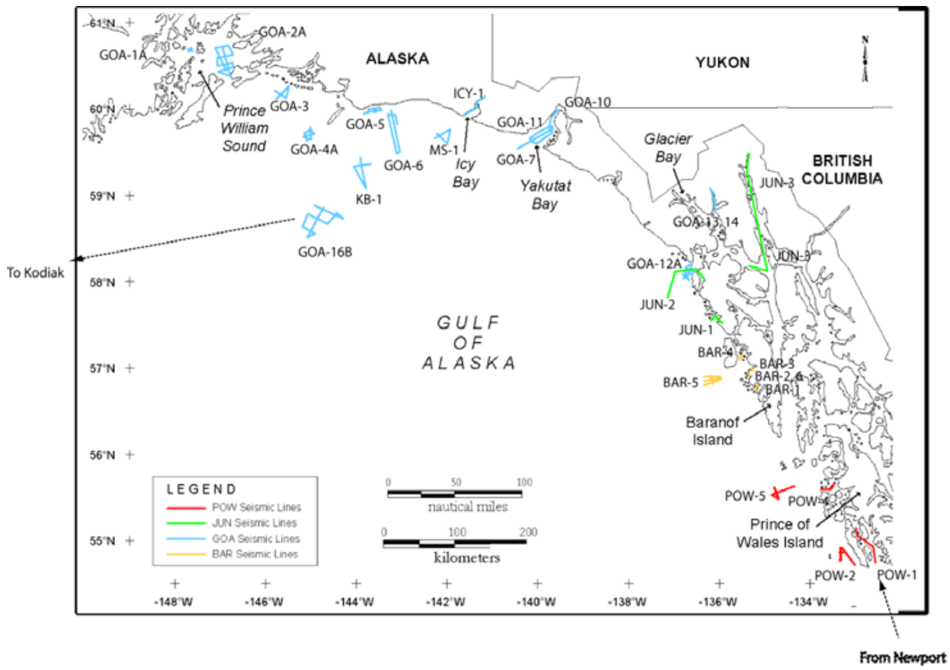


Figure 00-1. Tracklines and survey lines for cruise EW0408. (xxx REVISE FIGURE POST-CRUISE)..

Fig. 00-2 Summary of T and S properties. (Prahl)

Fig. 00-3 Map of Coring Sites xxx

Fig. 00-4 Summary of Core Logging Data. (Pisias)

References:
Xxx add as needed.

Appendix 1: Coring Protocols

CORING OPERATIONS
8-21-04 Cruise EW0408

Coring gear was provided by, and coring operations were run by, the Oregon State University Coring facility. Coring devices were an Ocean Instruments 8-tube multicore (on loan from University of Alaska), equipped with an OSU Niskin Bottle, a Benthos 2.5” by 10’ gravity core, and the OSU jumbo piston core (4” by as much as 70’). In most cases, the piston core was rigged for either 40’ or 60’ cores, based on rail length on R/V Ewing.

The multicore was deployed from the stern “A” frame, using R/V Ewing’s 0.680 conducting cable. The jumbo piston core was deployed from the starboard “A” frame, using R/V Ewing’s 9/16” trawl wire. The Benthos gravity core was deployed from the starboard “A” frame using the ¼” Hydrowire.

Launch and recovery of the piston core employed two HIAB articulated cranes mounted on the ship’s “A” deck), one supplied by R/V Ewing, and another (with a capstan attachment) supplied by the OSU Coring Facility.

After processing, sediment cores were stored in a refrigerated 20’ container van supplied by the OSU Coring Facility.

Appendix 2: Core Archiving Protocols

CORE CURATION
8-21-04, Cruise EW0408

Core Labeling

1. After corer is brought onboard, each piece of core liner will be labeled using the coring sheet positions as a guide. If core is longer than 152 cm, it should be cut into two pieces. Arrows indicating top of section should be marked on core liner and appropriate identification given in indelible ink. DO NOT USE ARROWS FOR ANY OTHER PURPOSE THAN IDENTIFYING THE "UP" DIRECTION OF A CORE SECTION. Labeling format for cores follows:

Cruise-site-hole-core number-core type-section number

For example: EW0408-01JC Sec. x or EW0408-01MCx

Represents ***Cruise: EW0408, i.e. Ewing, 2004, August, first leg.***
Site: 01, first site in cruise
Core type: JC = jumbo piston core, x=section number
TC = trigger core,
GC = gravity core,
MC=multicore
Section number: x. For JC,TC,GC may have sections to each core, 1 is top (shallowest) section of core. For MC, x = MC tube number (1-8). If temporary section numbers are used as the core is being extracted from the core pipe, only Roman numerals should be used.

Whole cores are stored in an upright position in barrels, or in horizontal racks in the logging van, until they can be split.

2. If standing water has accumulated on top of the core section, it is drained. Carefully siphon off so as not to disturb the sediment. (This usually only applies to tops of cores, not downcore sections.)

3. Before capping core, core liner should be cut so that it is even with the top of the sediment. Core can then be capped and sealed with black tape. Top endcap should have TOP written on it. Determine final lengths of sections. And write in indelible ink on the core sections.

4. **Make sure coring data sheet is completely filled out**.

5. Cores are now ready to be run through the GEOTEK core logger. Logger expects core sections from top to bottom and numbers its files that way. Stage the cores in the

lab van racks (horizontally). Make sure the up arrow always points in the same direction. See core logging protocols for detailed information on this operation.

Core Splitting

1. Before splitting, labels should be etched using an engraver on each side of the core liner. Use the same label format as before, and include the depth interval of each section. Label one half of the core WORK (without magnetic stripe) and the other half ARCH (with magnetic stripe). Scribe an "UP" arrow next to the label. For example, a scribed label would look something like this:

    EW0408-999JC   Sec. 3   250-401 cm WORK
    <---

2. Position core on splitter trough, so that labels appear on either side of the core liner and are away from the cutting edge (but are ideally just under the cutting edge so they are visible). Cut so that the paleomag stripe is centered (i.e. on the bottom of) the archive section.

3. After splitting, set core section on table and wipe off excess plastic chips created by the core cutter. Cut endcaps with a knife. If the core is firm, cut the sediment by dragging the piano-wire down the length of the core starting at the top, then turn the core so that the cut is vertical, bounce it gently on the table to separate the halves, and pull the two halves apart by rotating outward. . If the core is soft and soupy, the core-splitting "knives" should be used, in pairs (three sets, inserted in pairs, rotate outward and remove by scraping across the core section. If you encouter rocks, nodules, lithified sections, or dropstones, work the piano wire or knives gently around the stones. Do not continue to pull on the wire if you feel resistance.

4. Manually remove any small liner chips embedded in the sediment.

5. Using a palette knife, gently scrape across the core surface **(NOT DOWNCORE OR UPCORE)** to remove material dragged out of place by splitting system to create a smooth surface.**CLEAN THE PALETTE KNIFE BETWEEN SCRAPES TO PREVENT CONTAMINATION.**

6. Lay sections along measuring tape and place white plastic depth markers every 20cm down the core, drawing a line across the center of the marker.

7. Describe core using the standard description sheets. (see Visual Description notes)

Appendix 3: Sediment visual description protocols

VISUAL DESCRIPTION

1. Using standard description sheets enter the full Core Name, Section Number, Location and Water Depth and Interval Depth. There should be one description sheet for every section of core.

2. Examine the core section for changes in lithology; note distinct intervals. Indicate where the contacts between lithologies occur, by drawing a line across the core description sheet. On that line, mark an "X" in the contact column, for sharp, gradational, or mottled contact. Record the centimeter location of each contact under interval. Within these contact lines, that particular lithologic unit is described.

3. Using the Munsell color chart, match the color of the unit using a tiny sample of sediment on the tip of a toothpick and enter the color code in the color column. Write the color word description under remarks. If large mottles are present, indicate the color of the mottles in remarks. Follow the color with the general composition of the sediment, for ex. Dark olive green clay.

4. Identify presence and/or abundance of biogenic sediment components (foraminifera, radiolarians, diatoms, calcareous nannofossils, mollusks). These data may come from careful visual descriptions with a handlens, from examinations of smear slides (see below) or from sieving (at 62μm) of a small sample scooped with a narrow spatula under tap water.

5. Grain size parameters used are clay (<4μm, here used to imply grain size, not mineralogy), silt (4μm to 62μm), sand (62μm -2mm) and gravel (>2mm). The grain size of the sediment can be determined by taking a small sample between your fingertips. Enter an "X" in the appropriate grain size column. The grain size may include more than one category, e.g. silty clay. Enter the grain size category in the remarks column with the dominant grain size first if there is more than one category.

6. Dominant structural features of this lithologic unit should be noted with an "X" in the appropriate structure column, (e.g. massive, cross bedded, graded, banded, or laminated).

7. Note in remarks column, any unusual features, ex: foram sand, turbidite, shells, ash layer, etc.

8. Take smear slides, if possible near top of each section, and/or in major intervals of visually similar lithology, and at bottom of last section. Note on description sheet in remarks column, depths where smear slides are taken, e.g. ss 15cm. See below for smear slide preparation. **Please do not skip this step. It takes <2min. on an already open core; it takes us much longer if we have to reopen the core to do it later.**

9. Wrap with plastic wrap, tape with masking tape at top and bottom; label top with core ID, section, cm increment, and either WORK or ARCH, as needed.

10. Put core section in D-tube, tape end cap on, label D-tube and endcap with Core ID, length, and WORK or ARCH. (WORK and ARCH if both pieces will fit in same tube).

11. Look at smear slide and/or sieve under microscope and fill out Biogenous Mat. section of description.

Smear Slides

1. **Label one end of a slide with core name, section, depth of sample taken**
2. **Place slide on hot plate to warm, adding dab of mounting medium (e.g., Picolite will become less viscous as it warms)**
3. Put a couple drops water on the cover slip
4. Using a toothpick, smear a few grains of mud from the core on the cover slip, dispersing the grains in the water. Be careful not to get too much mud.
5. Put the cover slip on the hotplate to dry.
6. When dry, invert cover slip onto large slide, into the mounting medium
7. Put slide in the UV Light box to cure for ~20 minutes.

Appendix 4: Water sampling protocols

Water Sampling

8-21-04, Cruise EW0408

Sea Water

Four sample bottles are to be filled for each sea water Niskin deployment, taken from hydrocasts, a niskin bottle on the multicore frame, and from water above sediment in one multicore tube. Two of these will be poisoned with HgCl, and will be analyzed for 13C of the inorganic carbon. One sample bottle is filled for Salinity, and one filled for 18O analysis of the water.

The labels should be labeled as follows:

EW0408-xxNByy 13C POISON	(xxx cc septum-seal vial)
EW0408-xxNByy 18O	(xxx cc septum-seal vial)
EW0408-xxNByy SAL	(xxx cc glass salinity bottle)
EW0408-xxNByy NUT	(xxx cc Nalgene bottle).

Where xx is the wire event number (hydrocast, or if niskin bottle on multicore frame, the multicore event number), NB indicates Niskin Bottle, and yy is the bottle number of the cast.

Or for headspace water from a multicore tube

EW0408-xxMWyy (and the various sample type indicators) where MW is "Multicore Water", and xx and yy are as above.

Collection Procedure

B. ASAP after Samples are on Deck
- Fit collection tube over nipple of Nisksin
- Open vent valve of Niskin
- Push in collection valve and regulate for a steady low-volume flow rate
- Allow 100-200 ml to flush through tube
- Continue the flow, and begin filling each of the four samples bottles. Fill and dump each bottle twice before filling for the final sample.
- Fill from the bottom on the last fill, and withdraw the fill tube slowly, allowing a meniscus to form on the top.
- Cap immediately with the Septa-seal cap

- Order of sample collection:
  - 13C
  - 18O
  - Salinity
  - Nutrients

- Continue until all samples are collected.
- Take samples into the lab for poisoning

C. Mercury Poisoning

- Separate out the 13C sample bottles
- MAKE SURE YOU ARE POISIONING THE CORRECT BOTTLES
- PUT ON GLOVES!
- Remove the stock solution of HgCl from the Styrofoam container
- Remove a syringe from the box inside the zip-lock bag
- Invert the stock solution of HgCl, insert the syringe into the septa and withdraw 15 units, (150 ul) , then depress plunger back to 10 units while still inside the stock solution. This should clear any air bubbles from the tip of the syringe.
- Inject 5 units (50 ul) into each of the sample bottles through the septa.
- Return the syringe into the box inside the zip-lock bag
- Use a Kimwipe to remove any water drops that form on the top of the sample bottles. Dispose of this Kimwipe in a labeled containment bag.
- Return the stock solution of HgCl to its Styrofoam container
- Use Kimwipes to absorb any drops or spills of HgCl solution, and place them in the containment bag. Rinse area with water and use paper towel to absorb all liquid. Place towel in containment bag.

D. Sealing the Sample Bottles with parafilm

- Rinse the outside of all sample bottles with fresh water, and wipe dry with a paper towel
- Wrap parafilm around cap (in a direction to keep cap tight). Tape around parafilm.
- Place salinity and isotope sealed sample bottles in the cooler (do not freeze). Place nutrient bottles in freezer.

E. Post Collection

- Rinse Collection tube with ships fresh water and store in zip-lock bag.
- Dispose of needles in sharps container.
- Dispose of any kimwipes in the hazardous waste container.

Appendix 5: Filtering and biomarker protocols

Shipboard Filter Sampling for Biomarkers

18 August 2004 (F. Prahl).

At each of the coring sites (anticipate 30 total), suspended particulate material will be isolated for alkenone, POC/PN, stable isotopic analysis of POC/PN and HPLC phytoplankton pigments by filtration of water from the shipboard, uncontaminated seawater line on the RV Maurice Ewing.

Protocol for Alkenone Filtration

1. Put a pre-combusted 142mm GFF filter into polycarbonate holder. Record time and initial volume of totalizer in notebook.
2. Turn on shipboard flow-through system at a rate of 3-5L per minute. Filter for at least 60 minutes (or until filter clogs).
3. Turn off shipboard flow-through system. Transfer hose leading to filter inlet to peristaltic pump. Use peristaltic pump to remove residual water from the surface of the filter. Record time and final volume of totalizer in notebook.
4. Fold filter into quarters with forceps. Wrap sample in pre-combusted Al foil, label and put into the freezer for storage until needed for analysis back in the lab.

Using the T-connector, collect water from shipboard flow-though system while filtering as described above in the 4L polycarbonate carboy. Take 1/3rd of the 4L volume at 0 minutes, 1/3rd of the volume at 30 minutes and the final 1/3rd of the volume at 60 minutes. Shake carboy to homogenize and put 500mL aliquots into three different HDPE containers for POC/PN, delPOC/PN and HPLC Pigment Analysis (see below)

Protocol for POC/PN Filtration (Carlo Erba)

1. Put a pre-combusted 25mm GFF filter into polycarbonate holder on manifold.
2. Filter 500mL in HDPE through filter using gentle vacuum. Using a graduated cylinder, subsample the homogenized 4L polycarbonate carboy appropriately if more volume could easily be passed through the filter.
3. Record the total volume filtered in the notebook.
4. Fold the filter in half with forceps. Wrap sample in pre-combusted Al foil, label and put into the freezer for storage until needed for analysis back in the lab.

NOTE: Be sure that the filtrate collection vessels do not overflow. Empty whenever necessary!

Protocol for delPOC/PN Filtration (Carlo Erba – Delta XL)

Repeat procedure for POC/PN

Protocol for HPLC Pigment Filtration

Repeat procedure for POC/PN

Appendix 6: Multicore preservation and staining protocols

Multicore sampling and staining for living benthic organisms.
8-15-04 Cruise EW0408

Note that samples should be processed as soon as reasonably possible after core comes up.

1. Prepare in advance 125cc Nalgene sample bottles by wrapping yellow tape around middle of each one, ready for labeling. Make sure that the yellow tape overlaps itself.

2. Any standing water should be siphoned from the top of the multicore before it is extruded (NOTE – ONE WATER SAMPLE WILL ALREADY BE TAKEN BY THE WATER SAMPLING TEAM FROM ABOVE THE MUD IN THE CLEANEST MC TUBE).

3. Using OSU sediment extruding system, the multicore should be carefully extruded. Sample at 2 centimeter intervals from 0-10cm. The 2-cm spacer ring should be placed on top of multicore tube and the sediment slowly extruded until it has reached the top of the spacer ring. Then the plastic plate should be slipped below the spacer ring to separate the sample. Using a spatula, the mud sample can then be scraped off the plate into a prepared sample bottle. A funnel might be useful here since the mouth of the sample bottle is fairly narrow. Don't overfill the sample bottle. Put about 50-60cc of mud into each sample bottle (i.e, the bottle will be about half full).

4. Label bottle clearly with core name and depth interval. Label format should be as follows:
   e.g. EW0408-xMCy 0-2 cm
   where ship = EW, year = 04 , month = 08, station number= x, device = MC, tube = y (typically 1-8), depth in sediment= 0-2 cm oof 2-4 cm, or 4-6 cm, etc….),)

5. Make sure spacer ring, plate, funnel and spatulas are washed before the next interval of sediment is extruded.

6. When the sampling has been completed, the remainder of the core should be extruded in 4cm intervals and stored in Ziploc bags and labeled accordingly.

7. When the extrusion process has been completed, the bottled samples should be taken to the hydrolab immediately for further processing. There are bottle crates available so that the samples can easily be carried together.

8. Working in the sink and wearing gloves, pour the formalin solution from the carboy into the sample bottle. Add about the same amount of formalin solution in the sample bottle as there is mud leaving some headspace (i.e, about 50 cc muid, and 50cc formalin). Close lid tightly and shake bottle so that solution mixes with the sediment. Secure tape around cap of bottle and place in Ziploc bag.

9. Samples should then be stored together in black plastic garbage bag and placed in refrigerated van.

10. RECORD EVERYTHING IN THE LOG BOOK.

***Appendix** 7*: Multibeam mapping protocols

SIMRAD EM1002 MULTIBEAM SONAR:

Given the preponderance of relatively shallow sites to be surveyed during EW0408, NSF provided funding to lease a mid-frequency, mid-water-depth multibeam sonar system. After investigating a number of options, scientists from the University of New Hampshire's Center for Coastal and Ocean Mapping, selected the EM1002 as the most appropriate sonar for the water depths to be surveyed. C&C Technologies of Lafayette, LA., was contracted to provide, install and operate the EM1002 on board the EWING. The EM1002 transducers were installed in the EWING's ADCP well while the EWING was in drydock in Tampa FL. (July 2004). Topside electronics were installed by C&C personnel on August 2nd during the EWING's port call in San Diego. Patch tests and system acceptance trials were performed August 6th through August 8th at a well-known reference site off Pt. Loma Calif.

In addition to the Simrad supplied transducers and topside electronics, C&C Technologies provided all ancillary systems necessary for successful multibeam sonar operation as well as a fully capable data acquisition and line guidance system. Ancillary equipment included a C-NAV ultra-high resolution differential positioning system, a POS-MV inertial motion sensor, a YSI temperature and salinity sensor at the transducer head and a SeaBird SE19 Seacat CTD for determining the sound velocity structure of the water column. These systems were fully integrated with the EWING's navigation system and into the autopilot system of the vessel allowing planned lines to be fully guided by the sonar acquisition software. While the bridge officers were initially a bit leery of this approach to line running, they quickly adapted to it and soon requested it for almost all operations.

The EM1002 is a mid-water, high-resolution multibeam sonar designed for operating at 95 kHz for use in water depths of approximately 5m to 1000m. The system forms 111, 2 deg x 2 deg, electronically roll-stabilized beams. The opening angle (swath width) of the system varies with water depth with a maximum of 190 degrees (bank mode) in depths to about 200 m. More typically the system is operated with an opening angle of 150 degrees (7.4 x water depth) in these depths As the water depth increases attenuation prevents such a wide swath and the swath width is reduced (to a minimum of about 1-2 times water depth in approximately 800 m of water). While the swath width is reduced, the number of beams used (111) remains the same. The system is also capable of setting a maximum, fixed swath width (in meters) within the angular limits of the swath placing all 111 beams in the fixed swath width and thus increasing data density and quality. Most of the surveys during EW0408 were run with a maximum fixed swath width of 300 to 500 m (to either side of the vessel). The Simrad software integrates sound speed information (from CTD data), heave, pitch and roll data (from the POS-MV), knowledge of offsets between the transducer, the antenna and the motion sensor, and absolute positioning from C-Nav to produce a motion corrected time-series of ship-position relative depths.

The EM1002 is also capable of collecting near-quantitative, full time-series backscatter across each of the beam footprints thus providing a sidescan sonar-like image of the acoustic response of the seafloor. The EM1002 backscatter time-series is corrected for transmit level, all gains (fixed and time varying), for area of seafloor ensonification and for the angular dependence of backscatter (assuming a flat seafloor and using a Lambertian model). Each of these correction factors are recorded in the Simrad datagram and thus the EM1002 backscatter data can be used for quantitative studies of seafloor reflectivity.

Generic Survey Protocol:

For each survey area a CTD station was chosen at a site that was representative of the survey area (in terms of depth and location). CTD data was downloaded to the C&C acquisition system to be incorporated in the ray-bending correction algorithm and for converting travel-time to depth. Lines were designed to run parallel to contours, where possible, with a nominal swath-to-swath overlap of approximately 50 percent. Lines were numbered sequentially by area name (e.g. POW1-1, POW2-2); data was not recorded during turns. In those situations where watermass properties changed significantly in the course of the survey either another hydrocast was taken or an XBT was launched.

Processing Flow:

EM1002 data were acquired by C&C systems under the supervision of Peter Alleman. Data were recorded by C&C in both raw Simrad format (datagrams) and in C&C's own format. Real-time plots showing individual pings, waterfall plots and swath coverage provided instant feedback as to data quality and coverage. Upon completion of each line, data was transferred to a shared data server where the UNH team could access it. The UNH team accessed raw Simrad datagrams (.raw files) and brought them into the CARIS HIPS multibeam processing package. In CARIS HIPS, data were corrected for tide, and then transformed to depth vs absolute position. Data was cleaned (edited) either using the CARIS-HIPS swath editor or using the newly developed automated statistical processing algorithm CUBE) as implemented in the IVS Fledermaus software package.

Either CARIS HIPS or the CUBE algorithm was used to grid the data (using a weighted mean gridding algorithm) at a scale commensurate with the acoustic footprint for a given region (a function of depth). Typically data were gridded at 10 m spacing though the shallower surveys were gridded at 5 m and the deeper ones at 20 m grid spacing; details of grid spacing will be provided on a site by site basis. CARIS SIPS was used to mosaic the individual backscatter swaths into a single georeferenced backscatter image (geotiff). All georeferenced data products were produced using the WGS84 datum in Universal Transverse Mercator coordinates referenced to UTM Zone 8 N. CARIS-HIPS produces a gridded product in a propriety format (base-surface) unreadable by other software packages. UNH-developed code was used to convert the base-surface file into a more-standard gridded product. The converted gridded bathymetric data and the mosaiced backscatter data were then returned to the server for transfer to the visualization software.

The gridded and mosaiced data sets were then brought into the Fledermaus software package for merging and interactive 3D visualization. An appropriate color map was applied to the depth data and artificial sun illumination applied (typically from the NW – 315 deg. with a 45 deg sun elevation) and the data rendered into 3-D. Local charts were also brought into the scene to provide context. The entire processing path was typically competed within 5 minutes of the conclusion of the line allowing real-time survey decisions to be made. The IVS-Fledermaus software was also used to convert the UTM-based data sets into geographic coordinates. Two parallel product sets were archived, providing all visualization products in both UTM and geographic coordinates. Final hard-copy plots were produced through a combination of Fledermaus and ArcView software.

ATLAS HYDROSWEEP MULTIBEAM SYSTEM:

An STN ATLAS Hydrosweep DS-2 multibeam sonar is permanently installed on the EWING and offered as part of the ship's equipment. The Hydrosweep operates at 15.5 kHz forming 59 2.33 x 1 degree beams over either a 120 degree or 90 degree swath (user selectable and typically a function of water depth). During EW0408, the system was run only in the 120 degree mode. With the upgrade to the DS-2, the Hydrosweep can now also collect co-registered backscatter data. The backscatter data collected by the DS-2 is the average backscatter of the entire beam footprint as opposed to the full time series of backscatter values over the footprint provided by the EM1002. The system is integrated with a POS-MV motion sensor and with the ship' GPS systems. As with the Simrad system, sound speed at the transducer face is monitored in real time.

Processing Flow:

The Hydrosweep system was operated continouously during EW0408, though the data collected by it became the primary site survey data only at those sites deeper than about 800m. Data was acquired by the STN Atlas HydroMap software package and then read directly into MBSystem. Ungridded bathymetry and amplitude data was then brought into the IVS-Fledermaus package and gridded at an appropriate (for the depth) spatial footprint. Fledermaus was also used to convert the data from geographic coordinates into UTM.

Appendix 8: Chirp sub-bottom profiler protocols

ODEC BATHY 2000P Chirp Profiler:
9-19-04 L. Mayer

The Bathy 2000-P Chirp Subbottom profiler is a component of the R/V EWING's standard compliment of equipment (although apparently rarely used). The Bathy 2000P is a high-resolution subbottom profiling system designed to work in all ocean depths. The system uses the EWING's 12, hull-mounted TR-109 transducers to generate a broadband FM pulse (chirp – typically between about 2.5 and 6.5 kHz). The system performs matched filter correlation to provide fine-layer resolution with enhanced penetration. The system can be configured with a number of user selectable options; typical operations on EW0408 used a 5 msec pulse length in water depths less than 500m; a 10 msec pulse length in water depths between 500 and 2000 m and a 25 msec pulse length in water depths greater than 2000 m. Transmit levels and ping rates were adjusted automatically by the system to maintain constant source level as a function of depth. A Hamming window was used to shape the transmit pulse and the bottom detection was keyed to the first break of the received pulse. Receiver gains are also determined automatically by the system so as maximize the available dynamic range. All settings are digitally recorded with the seismic data. Transmit and receive levels change often in response to bottom type and depth; these levels should be preserved in the record headers of the SEG-y data recorded by the system.

The Bathy 2000P is designed to digitally record received data and instrumental parameters in a modified SEG-Y format. The LDEO system uses 270Mbyte Syquest disks as the recording medium for SEG-Y data. Upon arrival to the vessel in Newport, the scientific party discovered that the Bath2000 system had failed in San Diego and had been sent to the manufacturer for repair. The repaired unit arrived back to the vessel late in the day before departure. Upon installation and setup of the system it was discovered that the Syquest disks provided for this cruise were formatted for MAC only and not readable by the Bathy2000 system. The initial attempt to resolve this issue was to reformat the disks to a DOS-acceptable (FAT-16) format, but when this was successfully done, the Bathy2000 was able to write to the disks but neither the Bathy2000 nor any other DOS device was able to read what had been written on the disk. A solution was eventually found through the diligent efforts of the Johnson boys (Anthony and Kevin) who managed to replace the Syquest drive with a DOS FAT-16 formatted hard-drive. Given the DOS constraints the Bathy2000 could only recognize a 2 Gigabyte partition on the drive. The drive was "Velcroed" into the Bathy2000 and physically removed after each survey and brought to another machine where the data were downloaded onto the EWING's server. Not elegant but functional.

At sites POW-1 and POW-2, data were recorded as single files representing the entire survey. Upon reviewing the recorded data it became apparent that the Bathy2000 was not properly recording time or navigation information and so at subsequent sites individual files were opened and closed for each line segment corresponding to a multibeam line (so that we would at least know the accurate start and stop times of the lines). This approach will facilitate the eventual integration of the seismic data with the bathymetry. In addition to the digital recording of the data, paper records were generated on EPC recorders. The first recorder was slaved to the Bathy2000 and treated as a digital printing device driven entirely by the Bathy2000. All controls on the recorder are disabled in this mode and for the most part these records were barely visible. To compensate for this a second recorder was run using the EDO transceiver in passive reception mode. The received transmit pulse was used to externally trigger the EPC recorder and in this mode a clearer paper record of the returns was generated (though synch was often lost in this mode). Eventually the first recorder failed and the second recorder was used to display the Bathy2000 data. This recorder proved to provide a much improved paper record.

In general the ODEC Bathy2000 system demonstrated that it has the fundamental makings of an excellent high-resolution profiling system (good transmit power levels, sensitive receiver, and good noise suppression), however, the processing and recording options are very limited and extremely outdated. If LDEO wants to provide state-of-the-art (or anything near that) high-resolution subbottom profiling capability it must consider either upgrading or replacing this system.

Once transferred from the Velcro disk, data was processed using Chesapeake Technologies Sonar Web Pro software. This software offers a first-pass, limited capability processing path but does provide digitally enhanced images of the subbottom records very quickly after input of data. Further processing of the Bathy2000 data was attempted by the UTIG group using full-blown seismic processing packages. A description of this processing is presented in the seismic data processing section.

Appendix 9: Seismic acquisition and processing protocols

To be written – Sean Gulick.

Appendix 10: Mammal observation protocols (xxx – to be written, Steve MacLean).