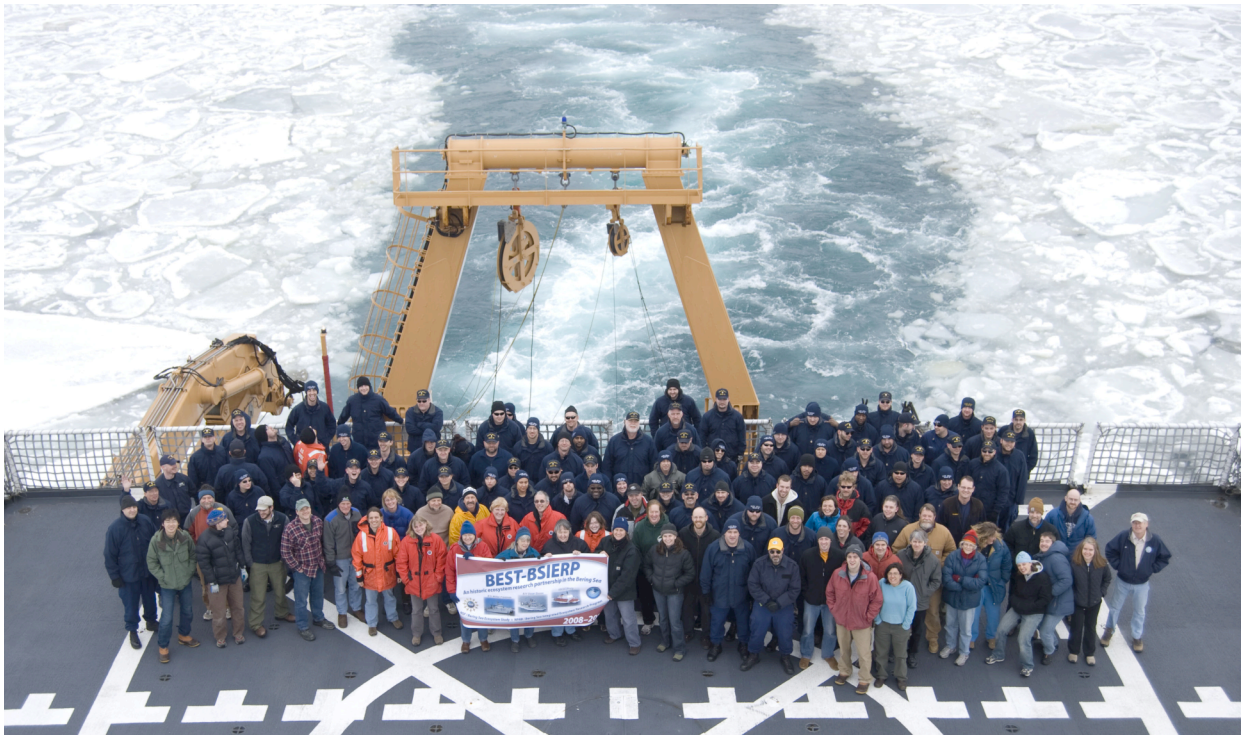
Cruise Report
Bering Ecosystem Study-Bering Sea Integrated Research Program
USCGC Healy Cruise HLY0802
March 31 – May 6, 2008
Dutch Harbor, AK – Dutch Harbor, AK

Carin Ashjian (WHOI) and Evelyn Lessard (UW), Chief Scientists



Funded by the National Science Foundation and the North Pacific Research Board

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Introduction

The overall objective of this cruise was to describe the lower trophic levels of the Bering Sea ecosystem under varying conditions of ice cover in order to better understand ecosystem response to ongoing changes in climate, ice cover (extent of ice cover and timing of ice formation and retreat), and accompanying oceanographic conditions. To this aim, twelve projects were supported on cruise HLY0802 on board the *USCGC Healy* in the Bering Sea during the period of March 31-May 6, 2008. The cruise was loosely divided into two segments because of a personnel exchange on April 20 at St. Paul, Alaska. Forty-six science party members were embarked for much of the first portion of the cruise; forty-one were embarked during the second portion.

Science Activities

Three major cross-shelf transects – the NP (southernmost east-west) line, the MN (central east-west) line, and the SL (northernmost east-west) line – were surveyed (Figure 1). The middle portion of the NP line was sampled three times during the cruise, ~14 days apart. A transect (W line) extending inshore from the 70 m line along which a series of moorings will be deployed during the summer 2008 cruise was also surveyed. Following completion of the major cross-shelf transects, work was conducted near the ice-edge and in open water to identify and track ice-edge blooms (ZZ transects). Starting at the end of April, the 70 m isobath line was surveyed from north to south, with process and ice stations occurring on 1-2 days at the beginning of the survey. Finally, 10 stations along the CN line were sampled with CTD only on the last day of the cruise.

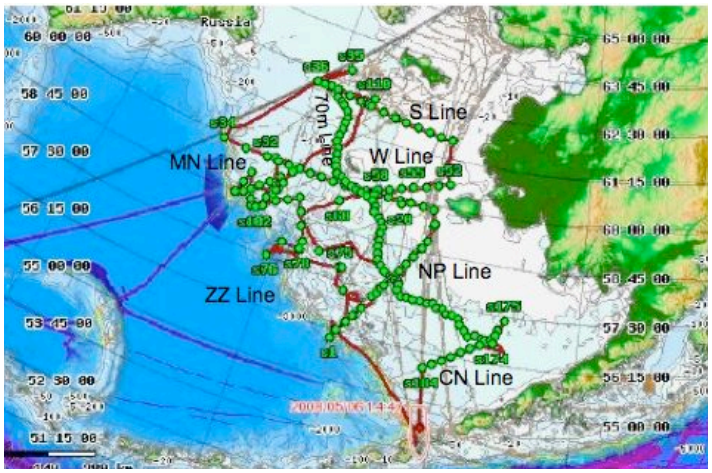


Figure 1. Cruise track. Track of ship shown in red; stations shown in green.

Each transect consisted of a series of stations at which several sampling activities were routinely conducted, including Conductivity-Temperature-Depth with rosette casts, Video Plankton Recorder casts, and CalVET net tows. At many locations, the benthic camera also was deployed to survey the benthos. More intensive sampling was conducted every other day at "Process" stations, where a fuller suite of sampling and experimentation was conducted to measure phytoplankton, microzooplankton,

mesozooplankton (copepods, krill), and benthic composition and selected rates (e.g., grazing, reproduction, nutrient regeneration, production). Other sampling (e.g., benthic grabs, plankton tows, benthic cores) also was conducted several times per day at selected locations. One hundred eight four stations were conducted, many with multiple deployments of different instruments and sampling devices including 241 CTD casts, 73 Video Plankton Recorder casts, 14 MOCNESS tows, 93 CalVET tows, 43 Bongo tows, 28 quantitative Ring Net tows, ~60 qualitative Ring Net tows, >150 Van Veen grabs, and ~34 Multicores. Floating sediment traps were deployed for 24 hours at three locations at the shelf-break (>300 m) when ice and weather permitted. The traps were easy to track and it was no trouble to re-locate them after each deployment.

On-ice sampling also was supported when in ice-covered regions through eight long (6 hour) and five short (2 hour) ice stations and through helicopter based ice core sampling at locations remote from the ship. Usually, a long ice station was conducted at least every other day in conjunction with the process stations while the short ice stations were conducted on intervening days, although occasionally long ice stations were conducted on successive days. On three occasions, when satisfactory ice could not be found in proximity to the ship, sampling was conducted from the helicopter. Up to seven research groups participated in the on-ice deployments.

Underway sampling of the surface water for temperature, salinity fluorescence, oxygen, and other chemical parameters, acoustic backscatter from krill and fish, water velocity, and seafloor topography from SeaBeam and underway observations of marine mammal and bird distributions and sea ice extent and type also was conducted. Underway sampling using the flow-through seawater system was compromised because the system periodically became clogged with ice. It appears that this resulted from the ice separator in the seawater system becoming clogged because of the increased volume of seawater required to furnish cooling water for the water bath/incubators on the bow of the ship (these incubators are where the rate process experiments for phytoplankton, microzooplankton, and mesozooplankton are conducted under near-ambient temperature and light conditions). The science party worked with the Coast Guard to set up a system whereby ambient seawater is pumped into a ballast tank while the ship is at station (to avoid in taking ice) and from there directly to the incubator, reducing the flow demand on the science seawater system and ice separator and preventing blockage of the underway science system by ice.

During the period of the cruise, the ice edge retreated to the N and the ice itself started to melt in the southern portion of the region (NP Line). Biological activity in the water column was low, in contrast to that of the sea ice that supported a bloom of ice algae and the organisms that utilize the algae. At times, gales in the Bering Sea limited our sampling at the ice edge and in open water.

Janet Scannell and John Allison from EOL developed a field catalog that includes a comprehensive event log as well as data from underway sensors, satellite imagery, reports, CTD data, and other useful information (http://catalog.eol.ucar.edu/best_hly-08-02). Steve Roberts served satellite imagery, including ocean color when possible,

underway data, and ship location through the map server. The Map Server program on the science network was used both by the science party and the Coast Guard and was extremely useful.

Outreach Activities

Multiple outreach activities focused on web based dissemination of information, local newspapers, presentations to local communities, and communication with high schools both informally and through the ARCUS Polar Trec Program. At least five on-line web logs[1] were established and maintained for most of the cruise. The cruise plans and activities were presented to the community of Unalaska (Dutch Harbor) prior to and following the cruise (facilitated by Reid Brewer, UAF Assistant Professor and Sea Grant Alaska Marine Advisory Agent in Unalaska). Several articles were published in the Tundra Drums newspaper from Bethel, AK, serving the Yukon-Kuskokwim Delta region, by Ann Fienup-Riordan, a BEST sociologist and specialist in Yupik culture who participated in the cruise for the first 2 weeks. Fienup-Riordan also sent four dispatches to local (Bering Sea) high schools. Chief Scientist Carin Ashjian and Healy Operations Officer LCDR Jeffrey Stewart visited Gambell, St. Lawrence Island on April 29 to discuss the cruise with the whalers there at the invitation of Merlin Koonooka, Alaska Eskimo Whaling Commissioner from Gambell. We met with Merlin Koonooka, Clement Ungott, Thomas Antaghame, Bruce Boolowan, Mike Apataki, and Dexter Irrigoo. In addition, Chief Scientist Carin Ashjian sent near daily reports of ship position, activities, weather, ice conditions, and marine mammal and oceanographic conditions to the communities of Gambell and Savoonga.

PIs David Shull and Al Devol and Western Washington University graduate student Emily Davenport participated in the ARCUS Polar Trec program during the cruise. Davenport maintained a web-based journal, communicating with high school and middle school students during the cruise and organized a "live event" (teleconference) on May 1 through ARCUS with approximately 110 students and educators, ARCUS, Healy science party members Davenport, Shull, Ashjian, Sherr, Kelly, and Whitefield and CG Marine Science Officer LTJG Stephen Elliott. During the event, the audience went through a previously prepared powerpoint presentation and asked questions of the researchers on board Healy. The event is archived at the ARCUS PolarTrec "Live from IPY!" Web site (http://www.polartrec.com/live-from-ipy/archive).

Independent journalist Gaelin Rosenwaks participated in the second portion of the cruise, covering multiple aspects of the research in a web log that was accessed by several schools as well as the general public. Rosenwaks will be preparing articles for several media outlets as well as preparing video to be broadcast after the cruise on NOAA's Ocean Live web site (www. oceanslive.org).

Acknowledgments

This was a highly successful cruise, achieving all of our planned objectives and more. This success could not have been achieved without the contributions of many people. In

particular, we would like to thank the Captain, officers, and crew of the USCGC Healy for their tireless efforts on our behalf and for keeping us warm, moving, and well fed. Particular thanks to Executive Officer CDR Dale Bateman, Operations Officer LCDR Jeffrey Stewart, Navigator BMCS Tim Sullivan, and Bosun CWO3 John Ward. Thanks also to Dave Forcucci for his assistance in planning and on-shore logistics prior to the cruise. Many thanks to Dale Chayes for finding the critically needed laboratory vans that we used on the cruise as well as for coordinating outstanding science support. Thanks to Bill Martin at UW for coming through with a van at the last minute, to Scott Hiller and Lynne Butler for their help and good spirits on the CTD (and VPR) watch as well as for their work on the underway seawater system, to Tom Bolmer and Steve Roberts for help keeping the science systems running and for the Map Server, and to Mike Merchant for cheerfully assisting us with our e-mail and computer glitches. Special thanks to our Marine Science Officer Stephen Elliott and to our Marine Science Technicians MSTC Mark Rieg, MST1 Chuck "Run-Amok" Bartlett, MST1 Rich Layman, MST1 Eric Rocklage, MST1 Tiffany Wright, MST3 Tommy Kruger, and LTJG Elizabeth Newton. Thanks to Merlin Koonooka (AEWC Commissioner from Gambell) and George Noongwook (AEWC Commissioner from Savoonga) for their interest and for their invitation to visit and to the communities of Gambell and Savoonga for their support of our science. Finally, a very special thanks to Captain Tedric Lindström for all of his enthusiasm, interest, and attention to our science.

[1] www.polartrec.com/bering-sea-benthic-studies
http://bsierp.nprb.org/cruises/healy/hly0802/0802logbook.html
http://www.ecofoci.noaa.gov/cruiseWeb/ice08/
http://arctic.globaloceanexploration.com/

[2] "Icebreaker Healy pursues scientific adventure in the Bering Sea", Ann Fienup-Riordan, Tundra Drums, Vol. 36, No. 5, April 10, 2008.
"Ever-changing sea ice provides show for observers", Ann Fienup-Riordan, Tundra Drums, Vol. 36, No. 6, April 17, 2008.
"Breaking ice with the Healy", Ann Fienup-Riordan, Tundra Drums, Vol. 36, No. May 1, 2008."

Impacts of sea-ice on the hydrographic structure, nutrients, and the distribution of chlorophyll-a over the eastern Bering Sea shelf – Rolf Sonnerup, Dean Stockwell, Terry Whitledge, Calvin Mordy, Phyllis Stabeno

Leg 1: Nancy Kachel, David Kachel, Carol Ladd, Jeremy Malczyk, Calvin Mordy, Dan Naber
Leg 2: Ned Cokelet, Rolf Sonnerup, Peter Proctor, Dylan Righi, David Strausz, Jeremy Mathis

The BEST Hydrography Group conducted 241 CTD casts at 184 oceanographic stations. The group conducted "standard" CTD casts each of which included nutrient samples from up to 12 Niskin bottles, six chlorophyll samples from the upper bottle depths, two or more Winkler oxygen samples for calibration of the CTD oxygen sensor, three O^{18} samples for Tom Weingartner, and one (on average) TOC/DIC/Alkalinity sample for Jeremy Mathis. Table 1 summarizes the sampling. At approximately one-third of the stations, six additional fractionated chlorophyll samples were collected to compare with the total chlorophyll analyses as typically done in the Bering Sea by scientists from NOAA's Alaska Fisheries Science Center. Scott Hiller and Lynne Butler, Scripps Institution of Oceanography, operated the CTD console during the cruise and analyzed salinity samples for calibration. We collected water samples and kept logs of the Niskin bottle samples taken for other groups.

Table 1. Sampling by Hydrographic Group, 29 March–6 May 2008

Hydrographic Stations	184
CTD casts	241
Nutrient Samples Analyzed	1191
Total Chlorophyll Samples	1068
Fractionated Chlorophyll Samples	330
Winkler Oxygen Samples	389
TOC Samples	250
DIC/Alk Samples	250
O^{18} Samples	400
Underway Samples	43
Total Chlorophyll Samples	43
Nutrient Samples	43
Ice Stations	12
Temp/Chlorophyll Cores Collected	12
Salt/Nutrient Cores Collected	12
Surface Water Samples Collected	5
Ice-Well Samples Collected	21

Calvin Mordy and Peter Proctor analyzed nutrients (nitrate, nitrite, ammonia, silicate and phosphate) on the standard CTD casts at high precision and quickly analyzed selected nutrient samples for the Sherr and Sambrotto groups to assist in determining appropriate levels for their incubations and experiments. Nutrients were also analyzed for the ice stations sampled by the Hydrography Group and the Gradinger, Shull and Prokopenko groups.

The Hydrography Group took samples at 10 ice stations, analyzing those and the samples from two more stations. We collected one core for temperature profile readings and total chlorophyll samples, and a second core for salinity and nutrient analyses. Each core was photographed and described during a visual inspection prior to sampling. PAR measurements were recorded both above and below the ice during the station. Ice wells were augured to 20 cm depth intervals. These filled with brine that was sampled for chlorophyll, salinity and nutrients upon return to the ship. At nine ice stations, a CTD cast was taken by lowering a pumped SeaCAT-19+ through an ice hole to a depth of ~15m. Many of these data were collected in collaboration with the ice-well oxygen experiments of Masha Prokopenko. Upon our return to the ship, 1000 ml of filtered seawater were added to each chlorophyll core section. Ice core segments thawed in the dark and sampled as soon as they melted, or stored in the refrigerator until sampling could take place. Two cores at the first nine ice stations were sampled for O^{18} for Tom Weingartner, University of Alaska Fairbanks.

Ned Cokelet arranged for the underway seawater sampling system to be augmented for this cruise, and Scott Hiller set up the instruments. Additions included an Aanderaa Optode oxygen probe (on loan from Brad Moran, University of Rhode Island), a WetLabs ac-9 optical absorption and attenuation meter, and a Satlantic ISUS nitrate meter (both on loan from Lisa Eisner, NOAA Auke Bay Laboratory). Seawater samples were collected from the system and analyzed for dissolved oxygen, nitrate and chlorophyll concentration for calibration.

Following are preliminary plots of some of the variables from across the transects or as measured by the underway seawater sampling system. For all plots, the measurements shown are uncalibrated and may change. For the underway data, values when the seawater flow rate was reduced due to ice jams are excluded.

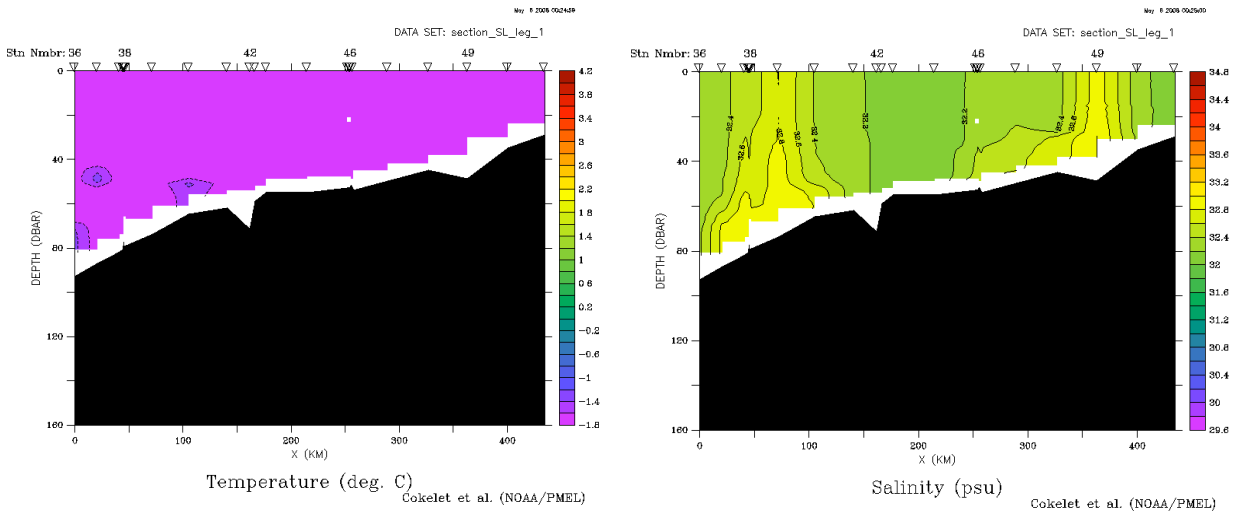


Figure 2. (a, left) Water temperature and (b, right) salinity along the SL (Saint Lawrence) transect.

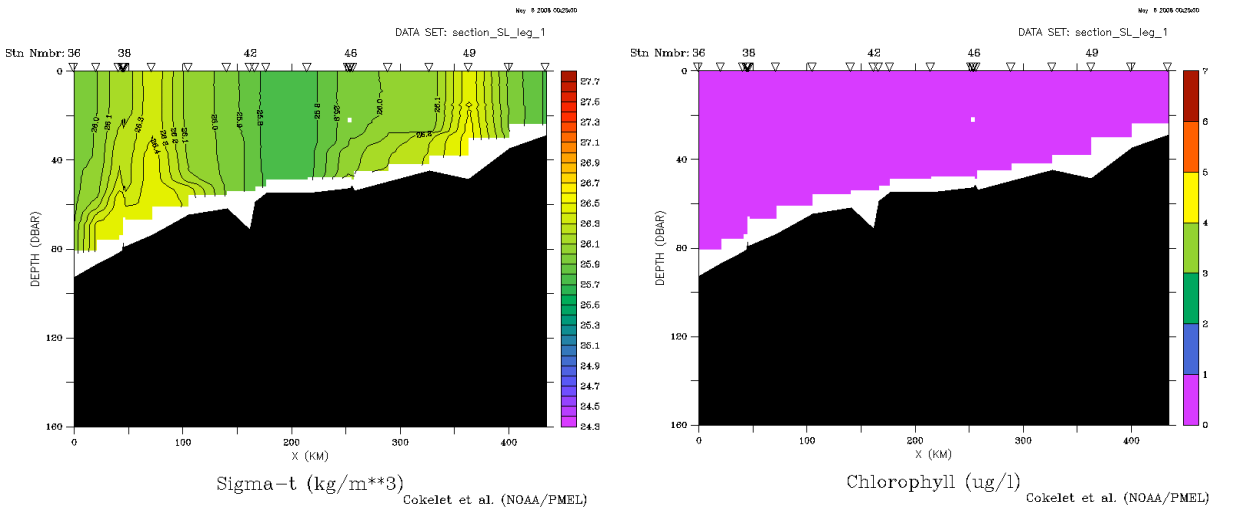


Figure 2. (c, left) Mass density (sigma-t) and (d, right) chlorophyll concentration (inferred from fluorescence) along the SL (Saint Lawrence) transect.

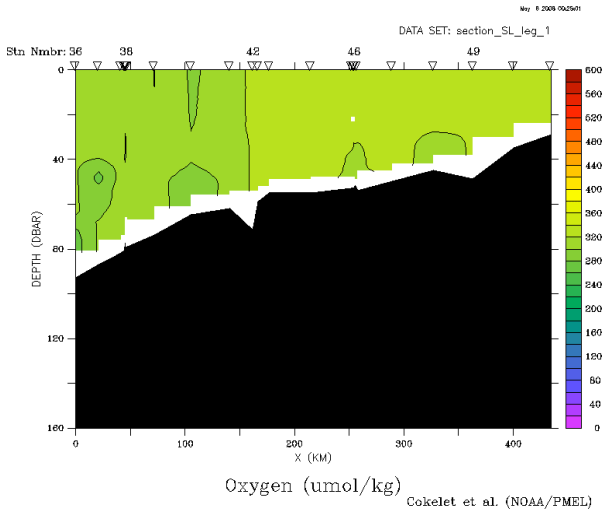


Figure 2. (e) Oxygen concentration along the SL (Saint Lawrence) transect.

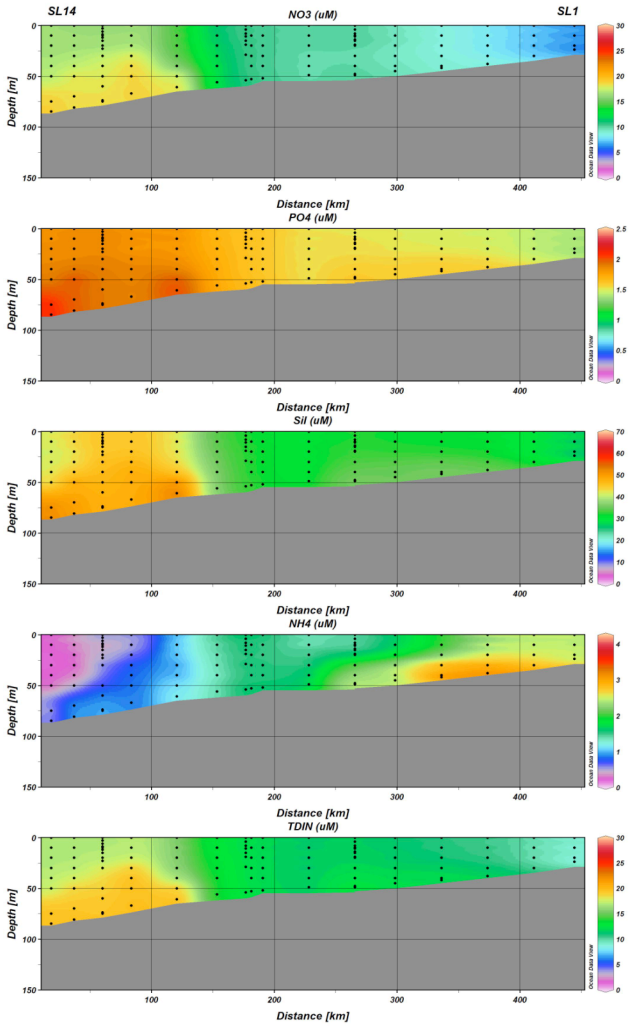


Figure 3. Nitrate, phosphate, silicate, ammonia and total dissolved inorganic nitrogen (TDIN) on the SL transect.

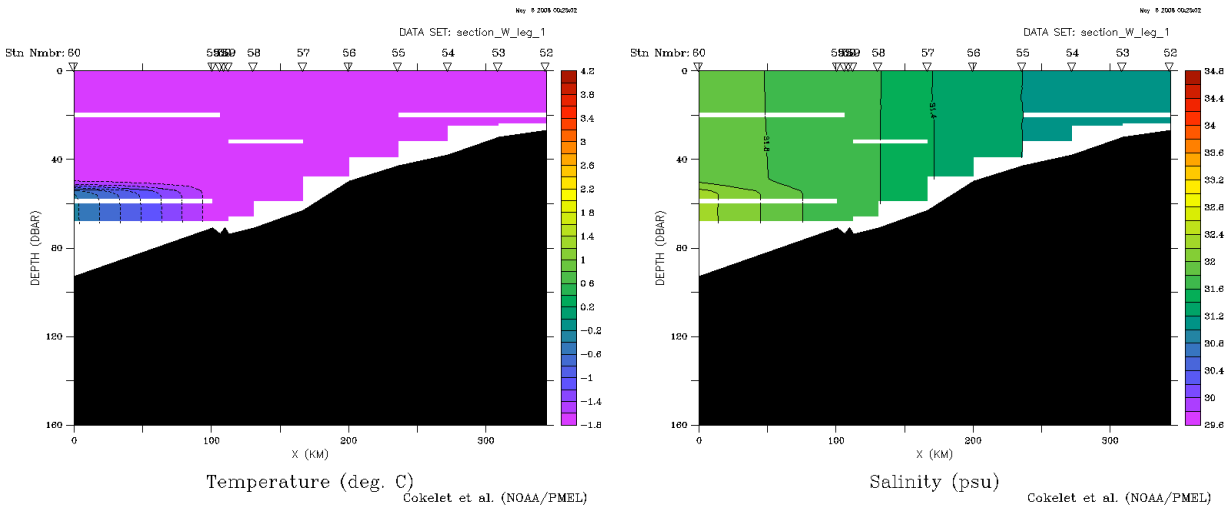


Figure 4. (a, left) Water temperature and (b, right) salinity along the W (Weingartner) transect.

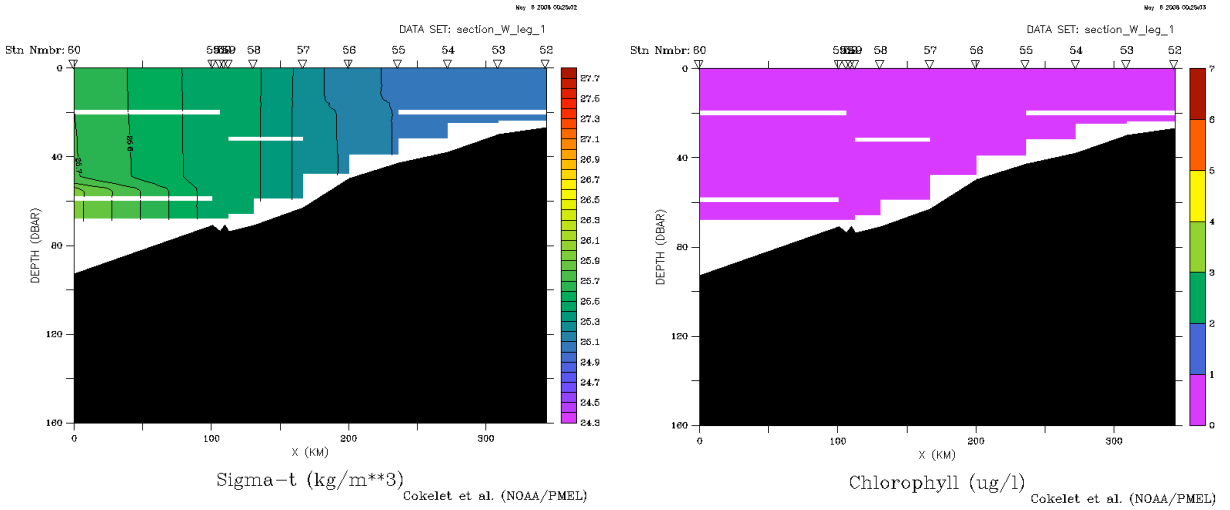


Figure 4. (c, left) Mass density (sigma-t) and (d, right) chlorophyll concentration (inferred from fluorescence) along the W (Weingartner) transect.

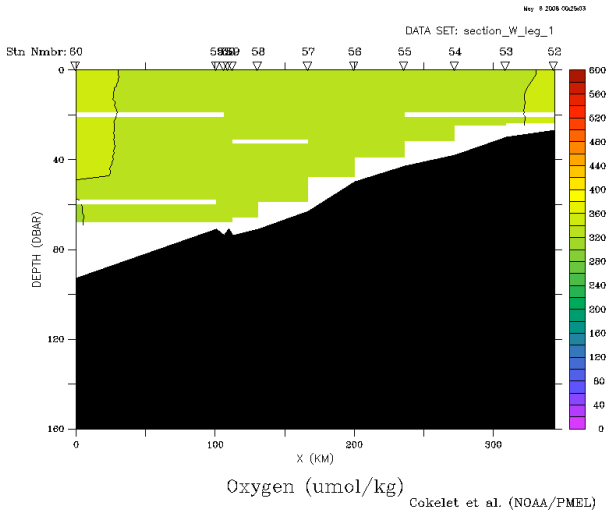


Figure 4. (e) Oxygen concentration along the W (Weingartner) transect.

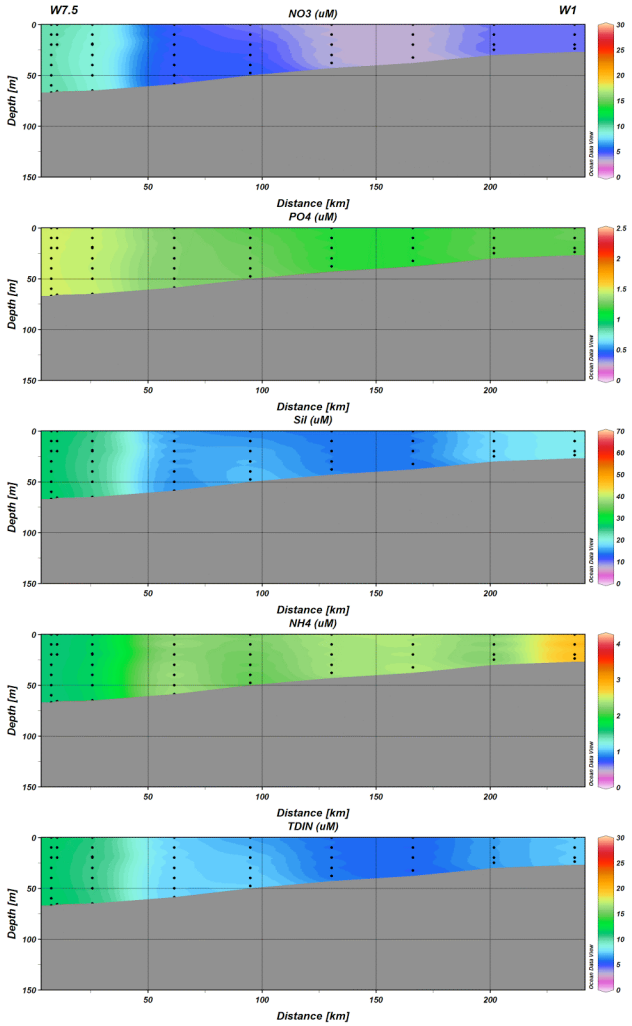


Figure 5. Nitrate, phosphate silicate ammonia and total dissolved inorganic nitrogen (TDIN) on the W (Weingartner) line.

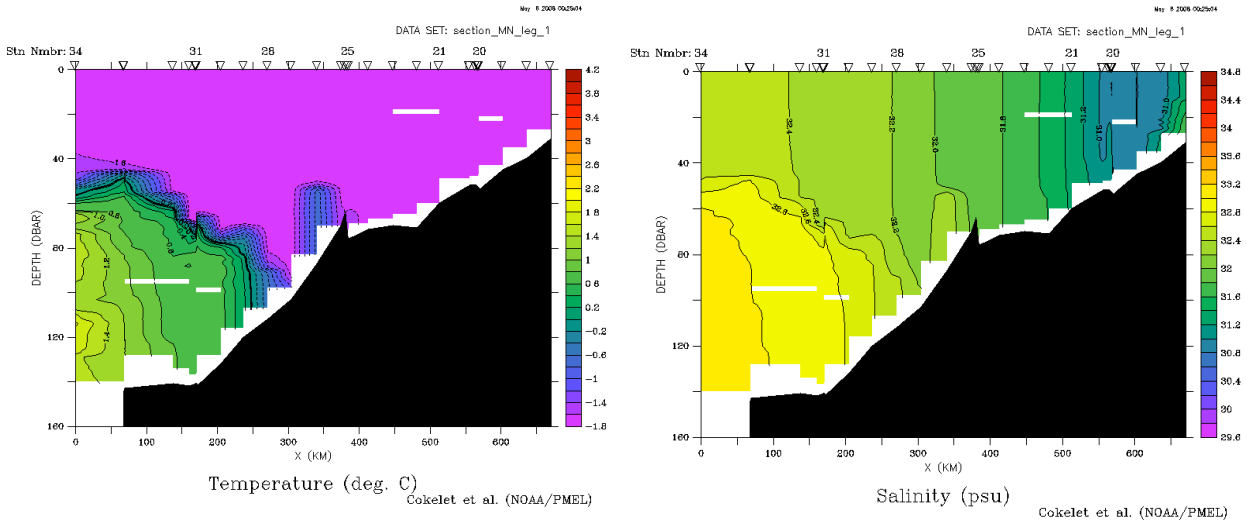


Figure 6. (a, left) Water temperature and (b, right) salinity along the MN transect.

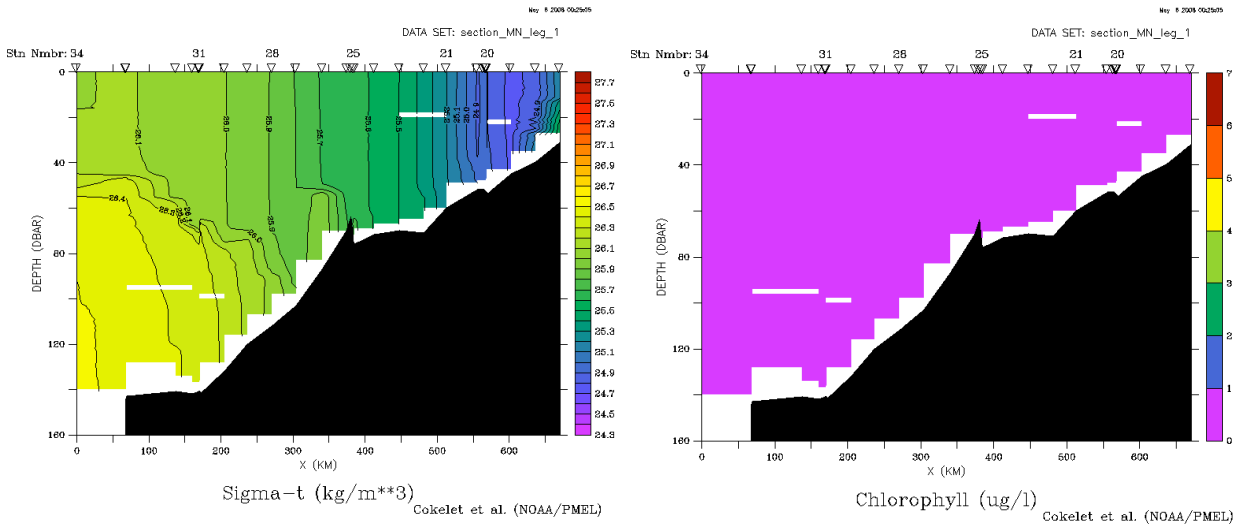


Figure 6. (c, left) Mass density (sigma-t) and (d, right) chlorophyll concentration (inferred from fluorescence) along the MN transect.

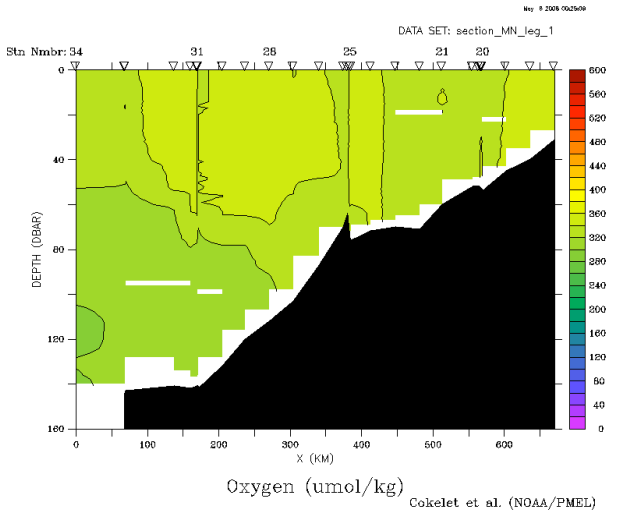


Figure 6. (e) Oxygen concentration along the MN transect.

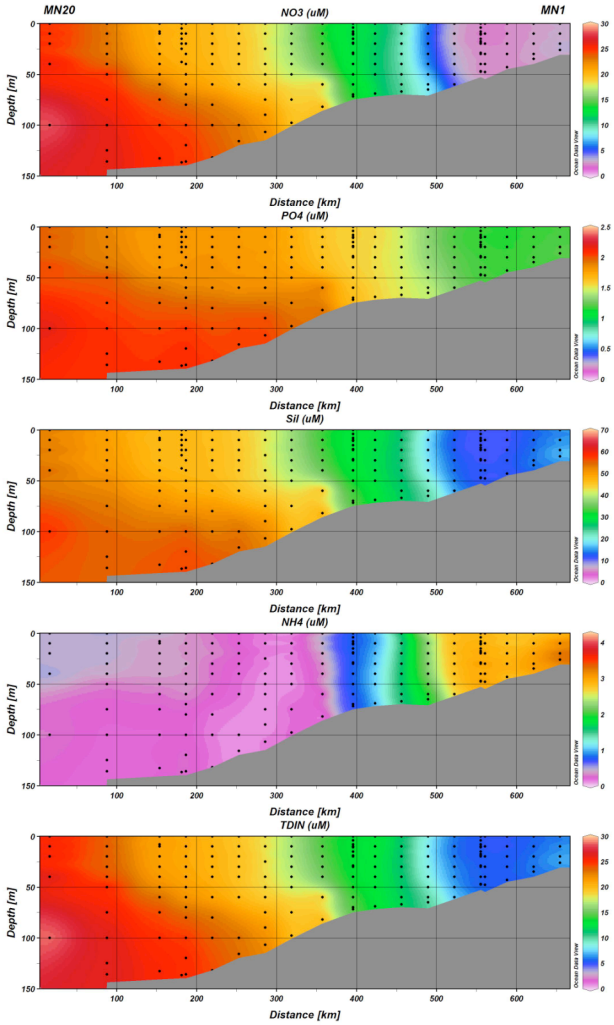


Figure 7. Nitrate, phosphate, silicate, ammonia and total dissolved inorganic nitrogen (TDIN) on the first transect of the MN line.

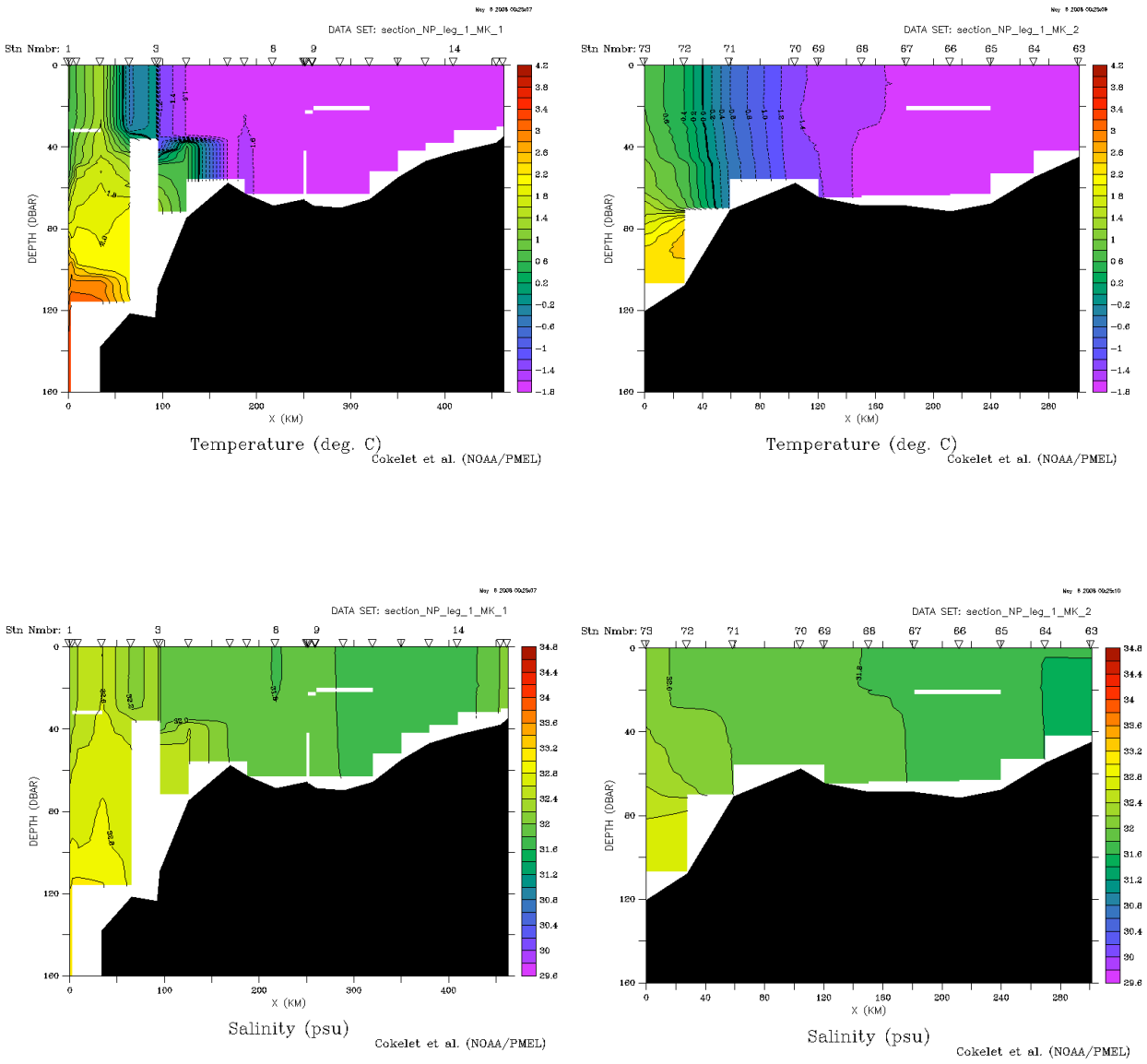


Figure 8. (a, b) Water temperature (upper row) and (c, d) salinity (lower row) along two occupations (March 20-Apriil 3, left; April 18-20, right) of the NP (Nunivak-Saint Paul) transect.

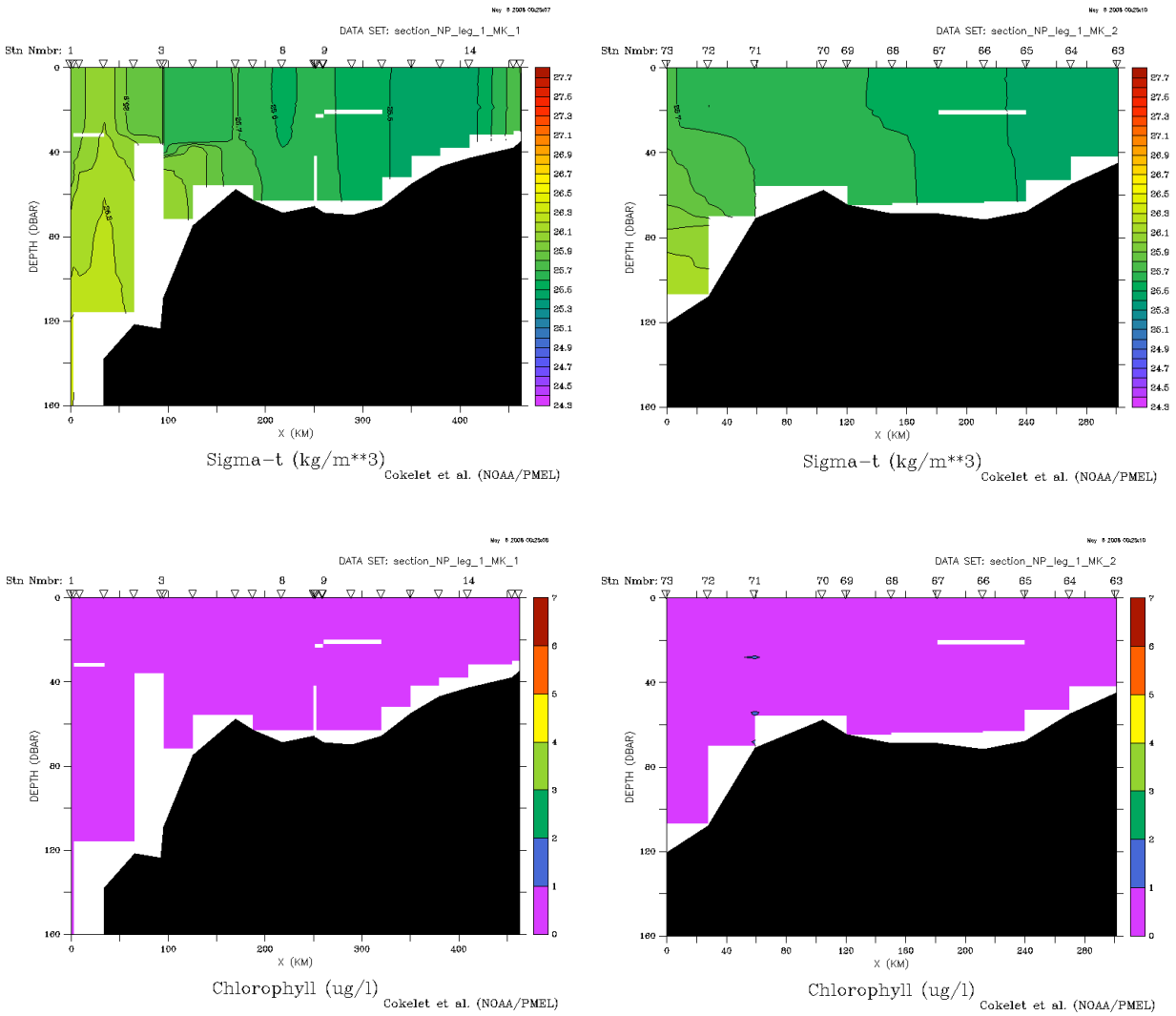


Figure 8. (e, f) Mass density (sigma-t) (upper row) and (g, h) chlorophyll concentration (inferred from fluorescence) (lower row) along two occupations (March 20-Apriil 3, left; April 18-20, right) of the NP (Nunivak-Saint Paul) transect.

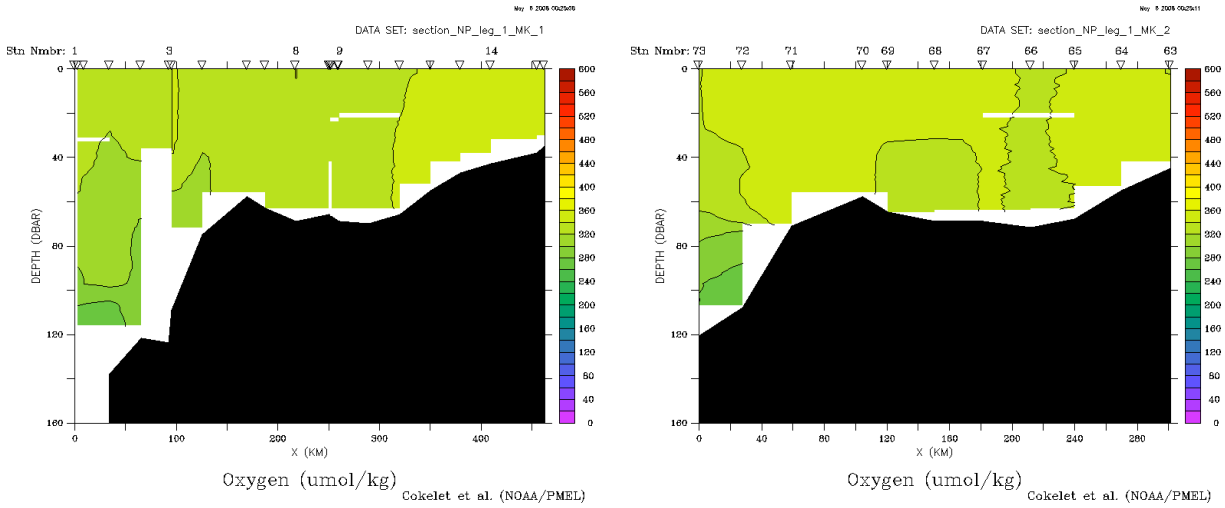


Figure 8. (i, j) Oxygen concentration along two occupations (March 20-Apriil 3, left; April 18-20, right) of the NP (Nunivak-Saint Paul) transect.

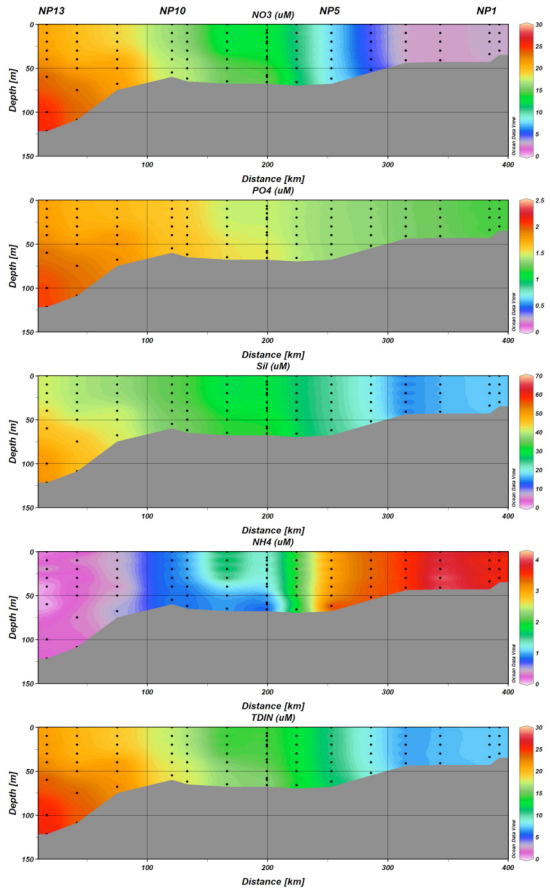


Figure 9. Nitrate, phosphate, silicate, ammonia and total dissolved inorganic nitrogen (TDIN) on the first occupation (March 30 – April 3) of the NP transect.

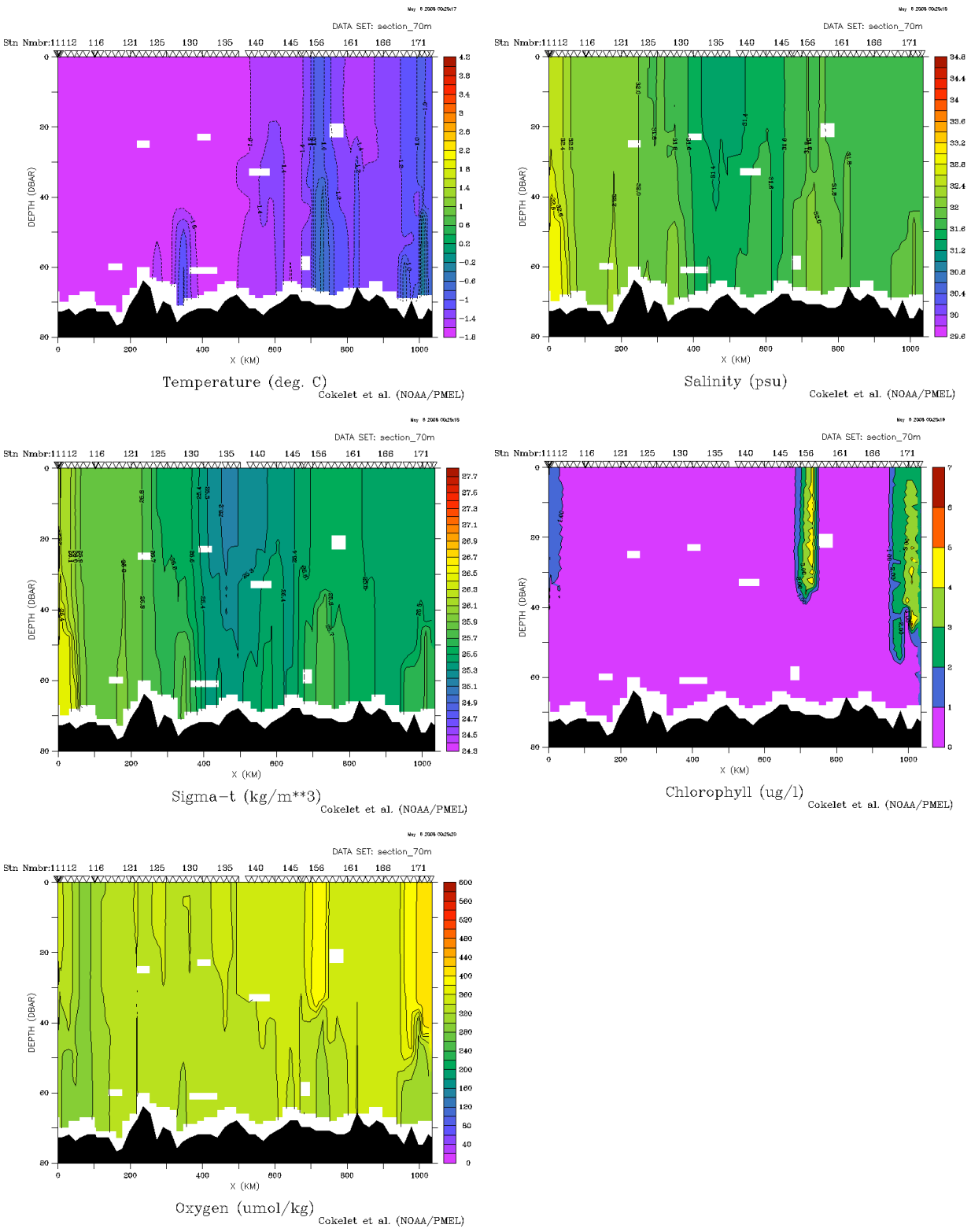


Figure 10. (a) Water temperature, (b) salinity, (c) mass density (sigma-t), (d) chlorophyll concentration (inferred from fluorescence) and (e) oxygen concentration along the 70-m transect.

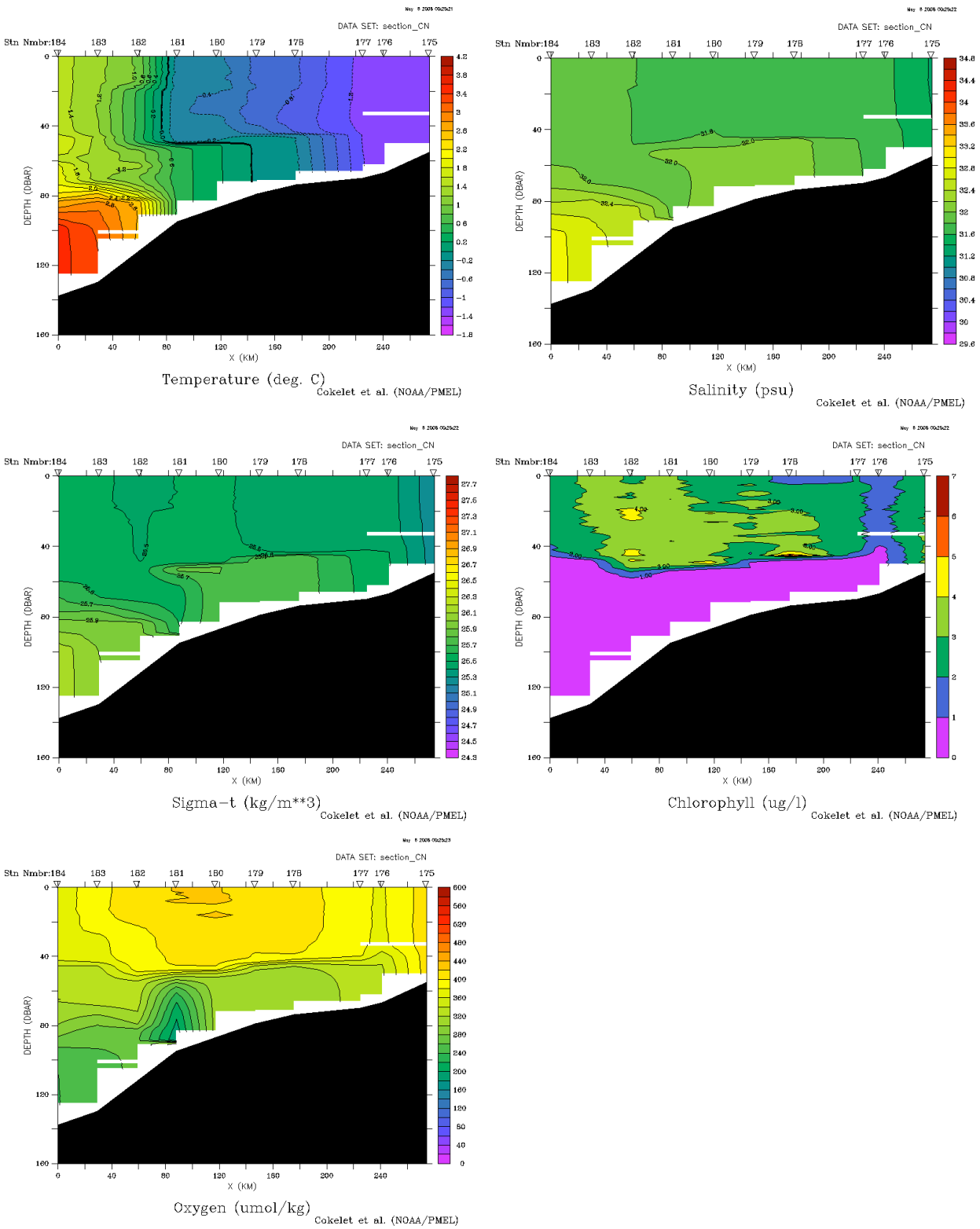


Figure 11. (a) Water temperature, (b) salinity, (c) mass density (sigma-t), (d) chlorophyll concentration (inferred from fluorescence) and (e) oxygen concentration along the CN transect.

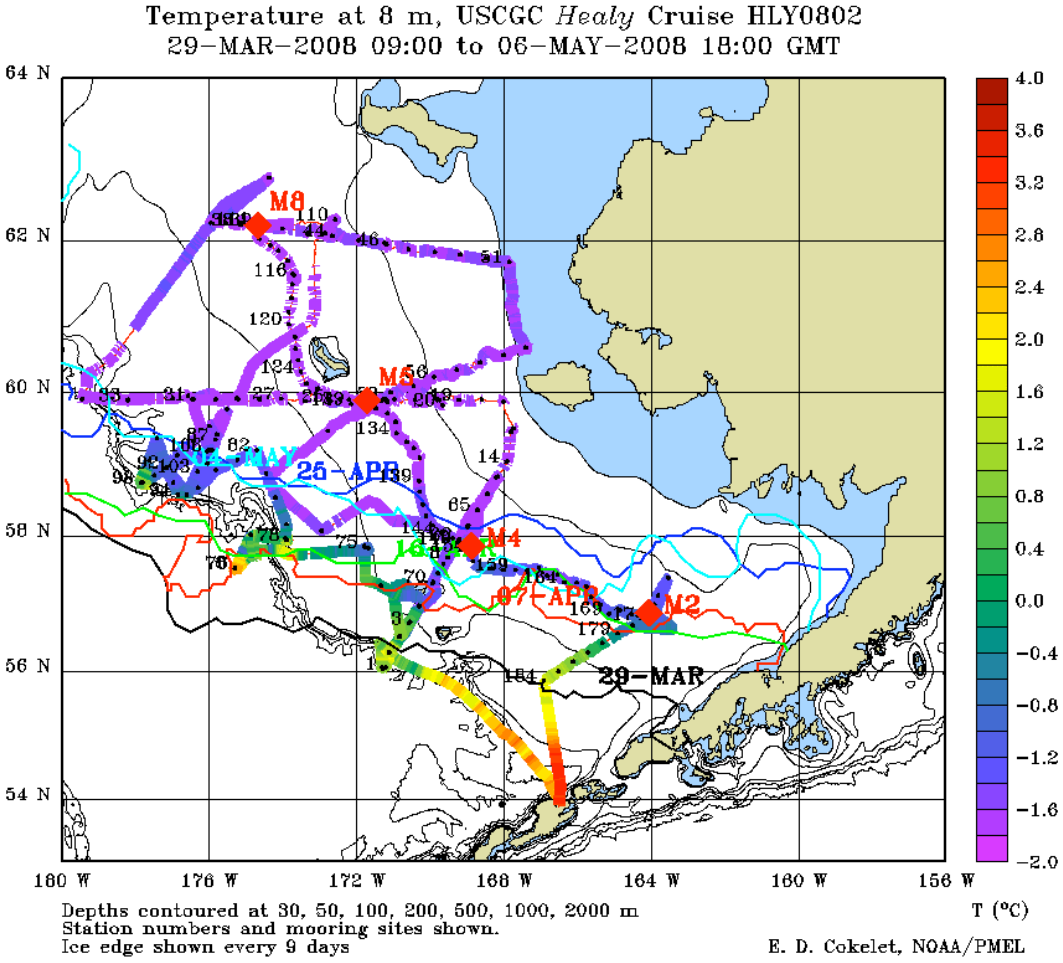


Figure 12. Water temperature at 8 m depth measured by the underway seawater sampling system. The outer boundary of the sea ice extent is shown every 9 days.

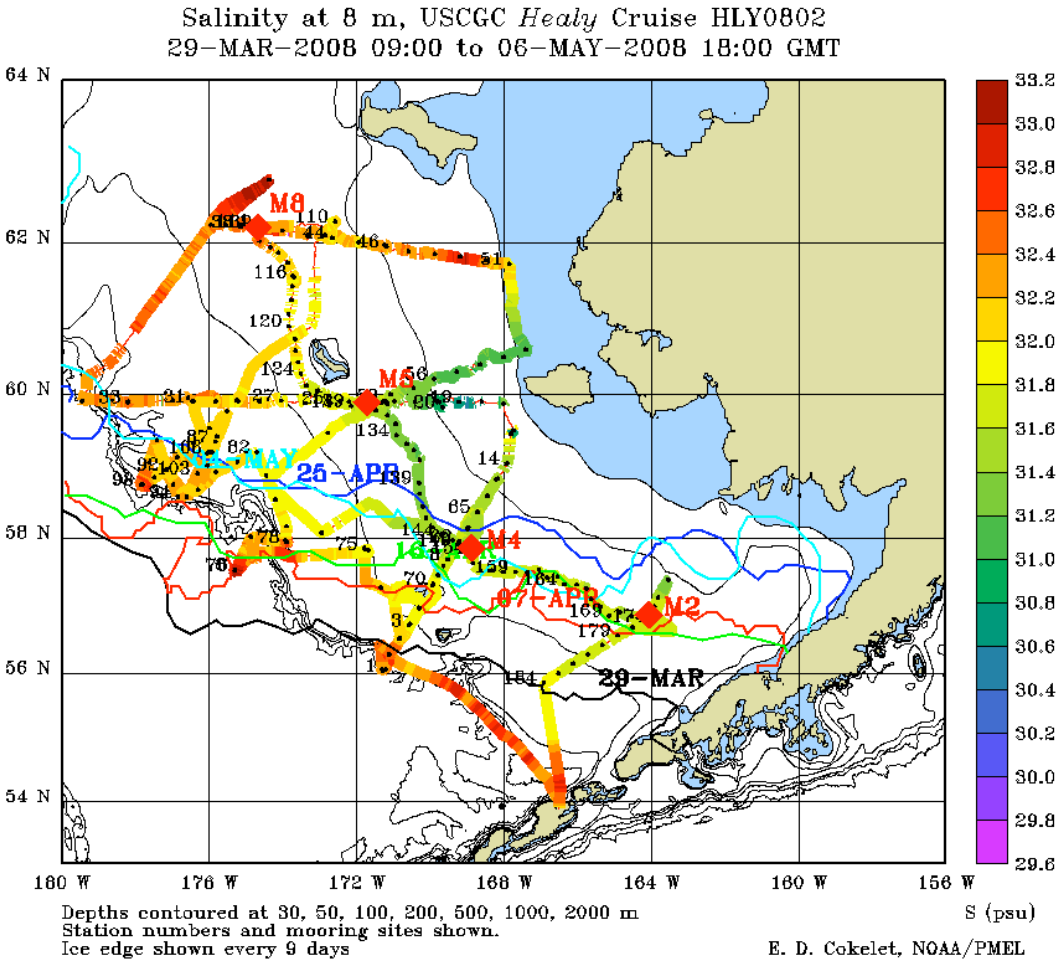


Figure 13. Salinity at 8 m depth measured by the underway seawater sampling system. The outer boundary of the sea ice extent is shown every 9 days.

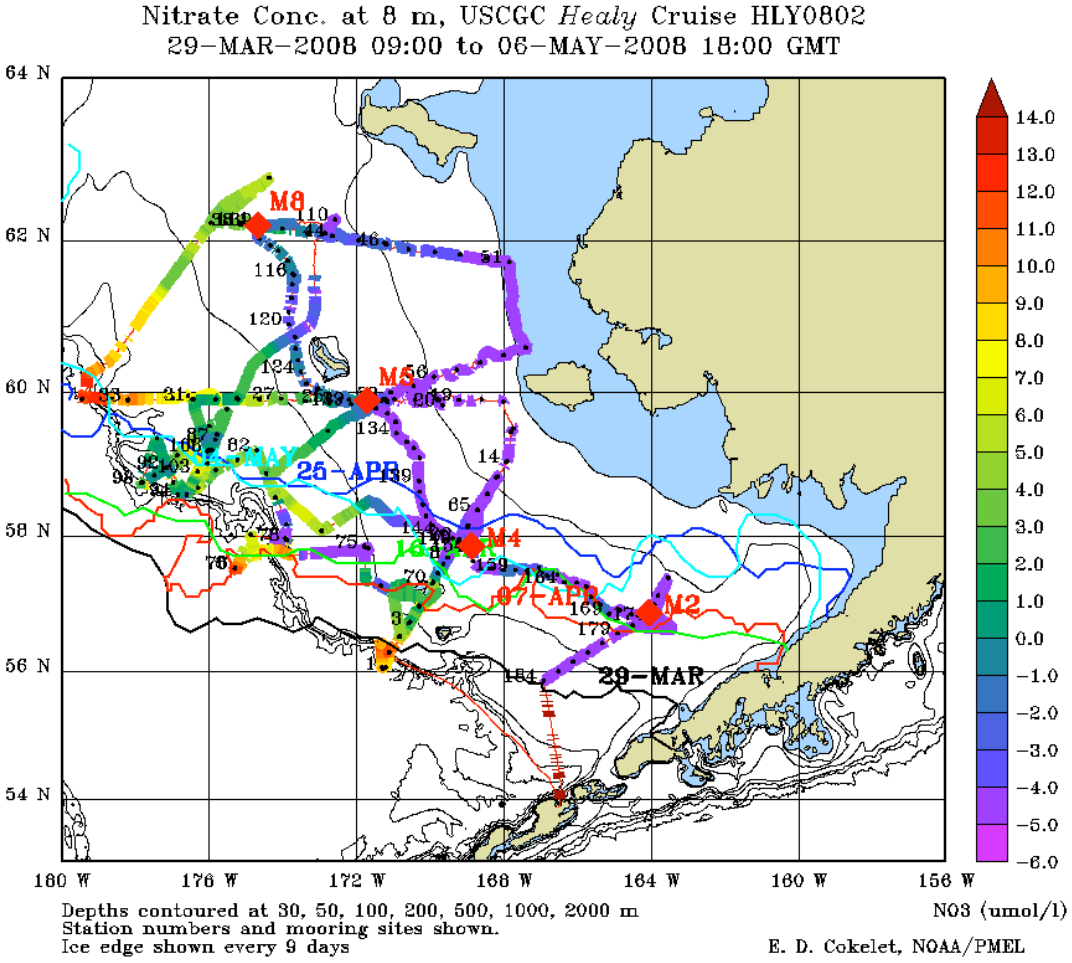


Figure 14. Dissolved nitrate concentration at 8 m depth measured by the underway seawater sampling system. The outer boundary of the sea ice extent is shown every 9 days.

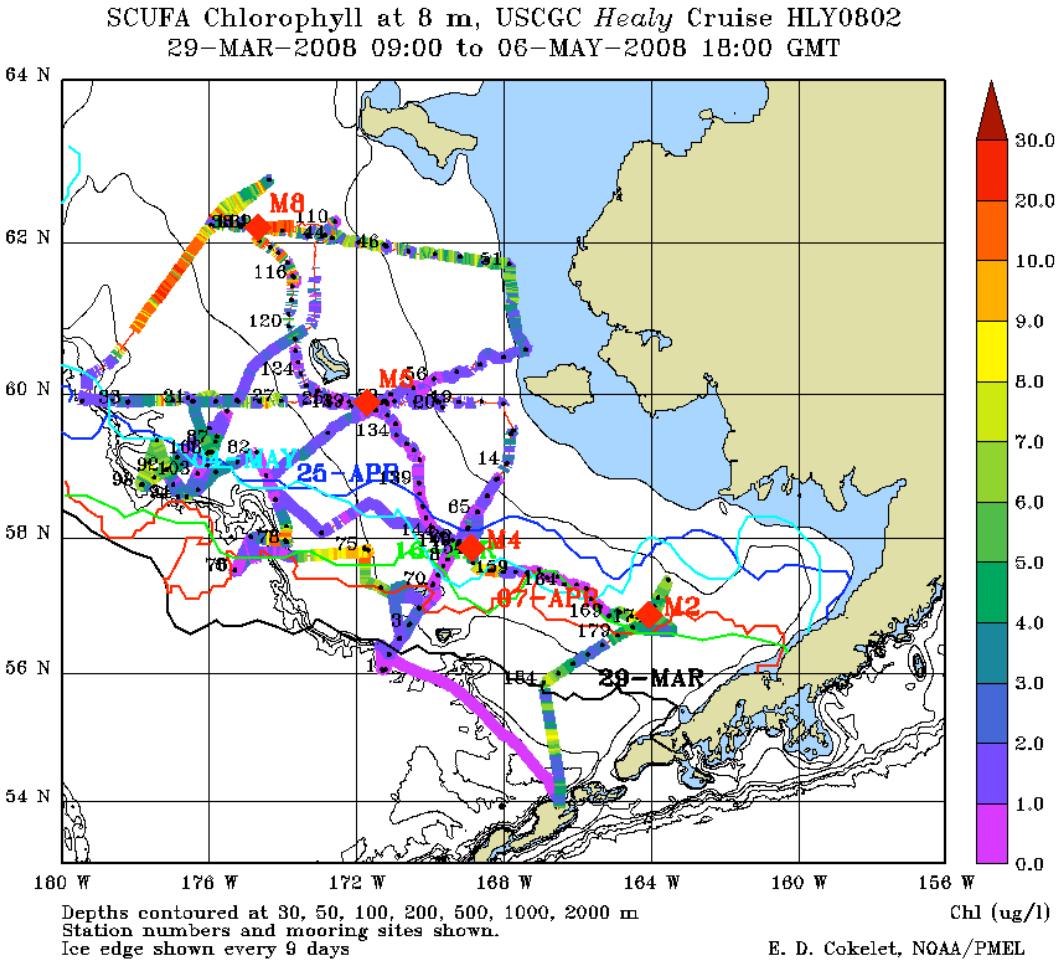


Figure 15. Chlorophyll concentration (inferred from fluorescence) at 8 m depth measured by the underway seawater sampling system. The outer boundary of the sea ice extent is shown every 9 days.

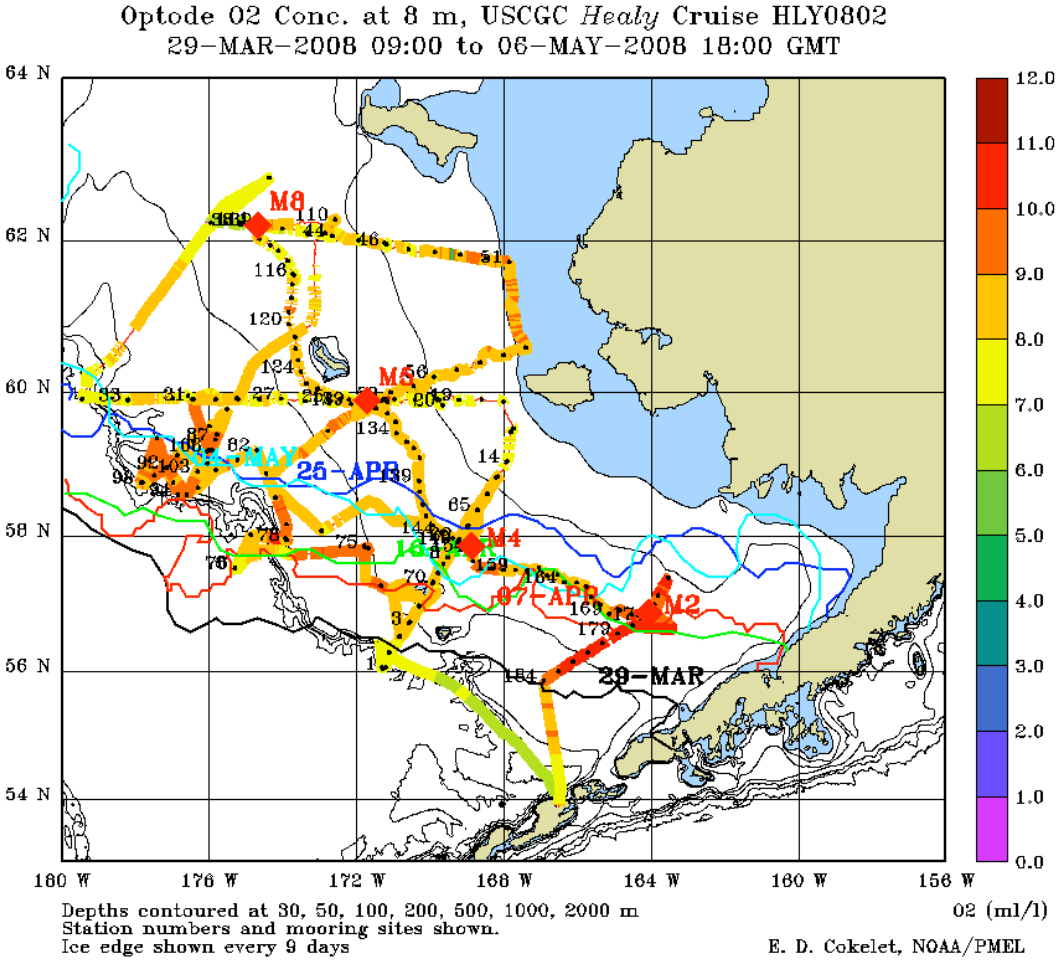


Figure 16. Dissolved oxygen concentration at 8 m depth measured by the underway seawater sampling system. The outer boundary of the sea ice extent is shown every 9 days.

The Role of Ice Melting in Providing Available Iron to the Surface Water of the Bering Sea. Jingfeng Wu

On-board Participants: Ana Aguilar-Islas and Robert Rember
Sample collection of seawater and ice for the analysis of dissolved iron, total dissolvable iron, soluble iron, and iron speciation was successful during the HLY0802 BEST cruise. Sampling took place from 30 March to 19 April 2008.

Water Column Sampling

Collection of seawater samples was focused on outer shelf, shelf break and offshore waters along the NP, MN, and SL lines. Collection at the WOCE station P14-4 was cancelled prior to 19 April due to weather. Adequate south-to-north sampling of our area of interest was accomplished. Trace metal-clean vertical profiles were collected using our UAF/ATE vane samplers at 12 stations. Water samples were also collected at ice stations using a pump and acid-cleaned Teflon tubing. Over 40 seawater samples were collected from depths ranging from immediately below the ice to 2500 m. To avoid contamination from the ship, samples were filtered in a class 100 laminar flow hood. Samples were filtered through 0.4 μm PCTE filters, collecting 1 L for Fe organic speciation (natural Fe-binding ligands), 500 ml for archival purposes, and duplicate 30 ml samples for dissolved Fe measurements. Additionally, a 30ml subsample for dissolvable Fe was collected using 0.02 μm Whatman anodisc filters. The remaining unfiltered sample will be used for the analysis of total dissolvable Fe (pH 2). Speciation samples were frozen on-board ship, and will be transported frozen to the lab at the University of Alaska Fairbanks.

Ice Sampling

Ice samples were collected from 9 stations on ice floes adjacent to the ship, and from 9 stations on ice floes reached by helicopter. Ice stations were located in the outer, mid and inner shelf along the NP, MN, SL, and W lines. These stations provided a variety of ice types and thicknesses (~20 cm to < 1m) including sediment-laden ice at a shallow station near Nunivak Island, to 'clean' ice at most other stations. Our goal to collect ~50 ice cores with better spatial coverage than achieved last year was accomplished during this cruise. Cores were frozen on-board ship, and will be transported frozen to the lab at the University of Alaska Fairbanks for processing. After processing, samples will be analyzed for total dissolvable iron, dissolved iron, and soluble iron.

In summary, HLY0802 was a successful cruise providing our research group with an excellent platform for sampling sea ice and the water column. The availability of the helicopter as transportation during ice sampling facilitated acquiring ice cores of different characteristics and from different locations in a time-efficient manner. This was important to our group's goal of better constraining the large variability in Fe content observed on last year's ice samples.

Relevance of Sea Ice-Derived Organic Matter for Pelagic and Benthic Herbivores.

Rolf Gradinger, Katrin Iken, and Bodil Blum

On Board Participants: Rolf Gradinger, Katrin Iken, Rebecca Neumann, and Sarah Story-Manes

Our research project focuses on the quality and quantity of organic matter produced by ice algal communities and its relevance for pelagic and benthic herbivores. As of 20 April 2008, we collected during HLY0802 sea ice (13 stations), CTD water (42 stations), plankton (32 stations) and benthic (25 stations) samples (Table 2).

Table 2: Overview of sampling events, for details regarding ice sampling see Table 3. "MUC" indicates benthic samples taken with the Multicore; all other benthic samples were collected using Van Veen Grabs.

Sta #	St name	Date	CTD water sampling	plankton sampling	benthic sampling	ice sampling
1	NP15	30-Mar-08	yes	yes	yes (MUC)	no
3	NP13	1-Apr-08	yes	yes	no	no
5	NP11	1-Apr-08	yes	no	no	no
6	NP10	1-Apr-08	yes	no	no	no
9	NP7	1-Apr-08	yes	yes	yes	no
11	NP5	2-Apr-08	yes	no	no	no
13	NP3	3-Apr-08	yes	yes	no	no
15	NP1	3-Apr-08	yes	no	no	no
16	NP1 – ice	3-Apr-08	no	yes	yes	yes
18	MN2	3-Apr-08	yes	yes	no	no
20	MN4	4-Apr-08	yes	yes	no	no
20	MN4 – ice	4-Apr-08	no	no	yes	yes
22	MN6	5-Apr-08	yes	no	no	no
23	MN7	5-Apr-08	yes	yes	yes	yes
25	MN8.5 – ice3	6-Apr-08	yes	yes	yes	yes
28	MN12	7-Apr-08	yes	yes	yes	no
31	MN15	8-Apr-08	yes	yes	yes	yes
34	MN20	9-Apr-08	yes	no	no	no
35	St 35	10-Apr-08	yes	yes	yes	no
36	SL14	10-Apr-08	yes	no	no	no
37	SL12	11-Apr-08	yes	yes	yes	no
40	SL10	11-Apr-08	yes	no	no	no
42	SL8.5	12-Apr-08	no	yes	no	no
43	SL8.25	12-Apr-08	yes	no	yes	yes
46	SL6	13-Apr-08	yes	yes	yes	yes
48	SL4	13-Apr-08	yes	no	no	no
51	SL1	14-Apr-08	yes	yes	no	no
52	W1	14-Apr-08	yes	yes	yes	yes
54	W3	15-Apr-08	yes	no	no	no
55	W4	15-Apr-08	yes	yes	no	yes
56	W6	15-Apr-08	yes	no	no	no

59	W7.5	16-Apr-08	yes	yes	no	yes
62	NP7/2	18-Apr-08	yes	yes	yes	no
63	NP3/2	18-Apr-08	yes	yes	yes	no
73	NP13/2	20-Apr-08	yes	yes	yes	no
75	BS1	21-Apr-08	yes	yes	yes	no
78	BS2	23-Apr-08	yes	yes	yes	no
79	BS3	23-Apr-08	yes	no	yes (MUC)	no
87	ZZ8	24-Apr-08	yes	yes	yes	no
101	ZZ13	26-Apr-08	yes	yes	yes	no
107	MN15/2	27-Apr-08	yes	yes	yes	no
110	St. 110	28-Apr-08	yes	yes	yes	yes
111	70M58	29-Apr-08	yes	yes	yes	yes
116	70M53	30-Apr-08	yes	yes	yes	yes
122	70M47	1-May-08	yes	yes	yes	no
149	NP7/3	3-May-08	yes	yes	yes	no

Table 3: Ice-sampling activity details

Date	**Station**	**Sea ice community analysis**	**Under-ice CTD**	**Sediment traps**	***In situ* incubations**	**Under-ice video**
4/3/08	NP1	X	X	-	X	X
4/4/08	MN4	X	X	X	X	X
4/5/08	MN7	X	X	-	-	X
4/6/08	MN8.5	X	X	X	X	X
4/8/08	MN15	X	X	X	X	X
4/12/08	SL8.25	X	X	X	X	X
4/13/08	SL6	X	X	-	-	X
4/14/08	W1	X	X	-	-	X
4/15/08	W4	X	-	-	-	-
4/16/08	W7.5	X	X	X	X	X
4/28/08	St. 110	X	X	X	X	X
4/29/08	70M58	X	X	X	X	-
4/30/08	70M53	X	X	X	-	X

12. April 2008 ice station Healy 0802

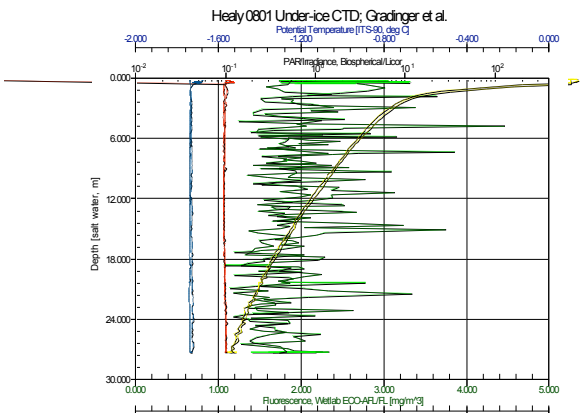


Figure 17: Example for under-ice CTD measurements with the following parameters: T (blue), S (red), PAR (yellow), algal fluorescence (green, rel. units).

Under-ice CTD

Under-ice CTD measurements were conducted with a Seabird 19plus equipped with additional PAR and algal fluorescence sensors. The instrument could be deployed at nine stations. The instrument malfunctioned at station W4 due to freezing of the pump.

The under-ice CTD measurements (Fig. 17) revealed a well mixed and homogenous water column structure.
The 1% light level was found at about 5 to 12m water depth below the ice.

Sea ice sampling

Ice cores for algal pigment, species composition and C and N stable isotope ratios were collected at 13 stations. Ice cores were partitioned into 2 to 10cm long sections and melted in the dark partially with addition of filtered seawater. After complete melt, samples were filtered onto GF/F filters and frozen (-80deg C) for further analysis in the home lab. Nutrient concentrations in the ice segments were determined by the BEST Service team (Mordy/Procter.). Subsamples were taken and fixed for count of ice algal abundances. We observed a distinct change in ice algal community at the late-April stations with sudden increases in *Pleurosigma* abundance. In addition, 200-500ml of melted ice were sieved through 20um gaze and the retained meiofauna was counted alive under a dissecting scope. Dominant meiofauna taxa were rotifers and nematodes. In addition, we regularly observed polychaete juveniles and harpacticoid copepods.

In situ incubations and sediment trap deployments

Ice algal primary productivity and N-uptake were determined with *in situ* incubations (4-5h) at 8 locations. Ice algal samples were incubated just at the ice-water interface, water samples (from 5m depth) at 5m with additions of stable isotope trace amounts of 13C and 15N.

Sediment traps were deployed through holes in the sea ice at 8 locations for about 5 hours in 5m depth. Collected material will be analyzed for algal pigment content, particle analysis, and POC/PON concentrations. At 5 locations, subsamples were provided to Moran et al. for Thorium measurements (see their report for details).

Under-ice video observations

A black-and-white video camera was lowered through a core hole and connected to a mini-DV camcorder at 11 locations during Healy 0802. One hour of tape was recorded at each station with the camera positioned directly under the ice. The core hole was covered with snow to reduce light effects. The particle composition differed between stations from day to day. For example, on April 5 (MN7) marine snow dominated, while on April 6 (MN8.5), dense accumulations of euphausiids (*Thysanoessa rashii*) were seen attached to the bottom of the ice, likely feeding on ice algal biomass.

Ice observations

More than 90 ice observations (period March 30 to May 3) were done every day during daylight hours, while the ship was in transit or on station. No observations were done during the dark night period or when the ship was completely out of sea ice region. The observations together with two digital images per observation were logged on the Healy ice observational sheet and are available on the Healy 0802 event catalog at http://192.168.10.94/cgi-bin/best_hly-08-02/research/index.

CTD water sampling

CTD water was sampled at 42 stations. At all stations, water from ~20m depth was filtered onto pre-combusted GF/F filters and frozen for later C and N stable isotope analysis of POM. At process stations, 20m depth water was also collected for chlorophyll analysis and bottom water (usually 5 m above bottom) for C and N stable isotope analysis of POM. All samples are kept frozen until further processing at our home lab. A small water sample was taken from 10m depth for $\delta^{18}O$ analysis.

Plankton sampling

Plankton samples were collected with a 150um hand net at 3 stations and with a 150um ring net (vertical haul) at 30 stations. After collection, samples were sorted alive and dominant taxa were frozen. Taxa collected at many stations, depending on their occurrence, included copepods (*Calanus marshallae*, *Metridia pacifica*, *Neocalanus cristatus*, *N. plumchrus/flamingeri*, *Pseudocalanus* spp., *Eucalanus bungi*), euphausids (mainly *Thysanoessa rashii*), chaetognaths (*Sagitta elegans*), cnidarians (hydromedusae), and occasionally ctenophores (*Beroe cucumis*, *Bolinopsis infundibulum*, *Mertensia ovum*). Samples were dried for later C and N stable isotope analysis at UAF.

Benthos sampling

For benthos, two van Veen grabs per station were collected at 25 stations and replicate surface sediment samples taken for chlorophyll and POM (stable isotope) measurements. At station 70M47, no surface samples could be taken because the sediment was gravelly and the grab did not close completely. While some fauna was retained, all fine materials

were washed out from the grabs, preventing sampling of the sediment surface. The remaining parts of the grab sediments were sieved through 1mm sieves and biota sorted immediately for stable isotope analyses. Main target groups were mollusks (e.g. *Yoldia hyperborea*, *Macoma calcarea*), polychaetes (Maldanidae, Spionidae, Polynoidae, Phyllodocidae and other families), amphipods (incl. *Byblis* spp., *Ampelisca* spp., and others), and cumaceans (various species). After freezing, samples were dried and will be further processed in the home lab at UAF for C and N stable isotope analysis. Occasional interesting finds included Hemichordata and Cudofoveata, which were preserved in ethanol for molecular analysis. In addition, selected polychaete, amphipod and mollusk species were preserved for molecular analysis.

Mesozooplankton-Microbial Food Web Interactions in a Climatically Changing Sea Ice Environment. Evelyn Sherr, Barry Sherr, Robert Campbell, Carin Ashjian

A. Microzooplankton Grazing on Phytoplankton and Herbivorous Protists as Food for Mesozooplankton

Evelyn Sherr, Celia Ross

The overall objective of our project is to collaborate with our colleagues Carin Ashjian and Bob Campbell to improve understanding of specific feeding interactions and thus pathways of carbon flow in the pelagic food webs of the Bering Sea during early season conditions of sea ice and spring blooms, focusing on a comparison of the roles of mesozooplankton and microzooplankton as herbivores, as well as on the importance of microzooplankton as a food resource for mesozooplankton. Our research is designed to evaluate the rates and impact of microzooplankton grazing on algae suspended in the upper water column, including sea ice algae when present, to describe the microzooplankton community composition and abundance under varying conditions of spring sea ice extent, and to assess the importance of microzooplankton as a food resource for key copepod and krill species present during spring sea ice conditions by collecting samples from the Ashjian/Campbell mesozooplankton grazing experiments.

During this cruise, we completed 14 microzooplankton grazing experiments. We compared the rates of algal growth in whole water and in 10% whole water diluted with particle-free filtered water over a 24 hour day-night cycle at light levels about 15% of ambient. We incubated our 10% diluted water samples on the Ashjan/Campbell plankton wheel incubator (Figure 18) and also in our flow through incubator when air temperatures were sufficiently warm to keep out drain hoses from freezing. In four of the experiments, there were separate treatments with and without added ice algae. Growth rates of algae were determined by change in chlorophyll-a concentrations from the initial to final times of the incubations. The results (Table 4) suggested low or no microzooplankton grazing in 8 experiments, and significant rates of microzooplankton grazing in 4 experiments. In the last experiment, chl-a concentrations were too low to determine growth and grazing based on change in chlorophyll, so we took an extra set of samples for flow cytometric analysis to evaluate the growth and grazing mortality of smaller sized phytoplankton by change in abundance. Phytoplankton growth rates in the 10% diluted water treatments

varied from negligible to about 0.3 day-1, while ice algal growth varied from 0.01 to 0.16 day-1. We took samples for each experiment at initial and final times for microzooplakton abundance and for flow cytometric analysis of abundances of small sized phytoplankton and potential changes in cell-specific fluorescence of larger algae, which would affect chlorophyll values

Table 4. Results of dilution experiments. Microzooplankton grazing rate is calculated as the difference between the 10% diluted water growth rate and the whole water growth rate. In some experiments, microzooplankton grazing was estimated for both ambient water algae and for ice algae added to the ambient water sample. Negative values (in bold) for micro-zooplankton grazing rate indicate microzooplankton grazing losses for algae in the water: values close to 0 or positive indicate net growth of algae and no apparent microzooplankton grazing.

Date of exp	Site	Depth sampled, m	To WW chl-a, ug/liter	10% diluted water growth rate, 1/day		Whole water growth rate 1/day		Microzoop grazing rate 1/day
				average	stn dev	average	stn dev	
4/2/2008	NP-7	15	0.28	0.095	0.159	-0.112	0.181	**-0.207**
4/4/2008	MN-4	16	0.20	-0.044	0.128	-0.038	0.026	0.006
4/6/2008	MN-8.5	10	0.17	0.080	0.155	0.092	0.228	0.013
4/8/2008	MN-15	2	0.88	0.136	0.065	-0.361	0.212	**-0.497**
			10.2	0.009	0.047	-0.128	0.028	**-0.137**
4/11/2008	SL-12	10	1.63	0.060	0.005	0.069	0.036	0.009
4/13/2006	MG-6	14	0.76	-0.064	0.005	0.087	0.095	0.152
			9.28	0.161	0.062	0.169	0.042	0.009
4/15/2008	W-7.5	2	0.17	0.008	0.295			
			6.73	0.074	0.031			
4/18/2008	NP-7	10	0.30	0.267	0.027	0.213	0.134	0.054
			5.75	0.179	0.042	0.068	0.109	**-0.111**
4/21/2008	BS-1	14	20	0.306	0.046	0.297	0.078	-0.009
		14	20	0.215	0.099	0.219	0.047	0.005
4/23/2008	BS-2	10	7.1	0.299	0.027	0.280	0.054	-0.019
				0.249	0.028	0.233	0.045	-0.016
4/25/2008	ZZ-14	20	6.4	0.232	0.029	0.148	0.041	**-0.084**
				0.311	0.036	0.215	0.003	**-0.096**
4/27/2008	ZZ-27	10	9.9	0.118	0.016	0.082	0.074	-0.036
				0.077	0.056	0.047	0.078	-0.030
4/29/2008	70m58	10	8.5	0.059	0.104	-0.027	0.058	-0.046
5/1/2008	70m47	2	0.2					

Sampling during the first part of the cruise was under heavy ice conditions with low algal biomass in the water column. Inspection of water and sea ice samples via epifluorescence microscopy, as well as additional images obtained by Evelyn Lessard on her FlowCam, confirmed that the phytoplankton stocks in the water were either very

small cells which most mesozooplankton likely can't utilize as food, or large and chain-forming diatoms which appear to be primarily sloughed off from the overlying ice. Images of such algae from previous work in the Arctic are shown in Figure 19. Similar ice algae are present in Bering Sea ice. During the second part of the cruise, diatom blooms were encountered which were composed of species similar to ice algae diatoms, as well as strictly pelagic diatom genera such as *Chaetocerous*. All the blooms consisted of a number of diatom species, including large single cell centric and pennate diatoms, as well as chains of pennate and centric diatoms of several sizes.

Microscopic and FlowCam analysis of water samples has also shown the presence of abundant microzooplankton, including large sized ciliates and heterotrophic dinoflagellates such as those shown in Figure 20. The heterotrophic dinoflagellates, which have been observed in all of our samples, are known to be able to ingest large sized diatoms and we speculate they could be feeding on ice algae suspended in the water. In high chlorophyll water samples with abundant diatoms, we observed numerous cases of heterotrophic dinoflagellates with ingested diatoms. We will make images of both the diatoms and the heterotrophic protists to post on our website: Sherr Lab, after our samples are returned.

We also inspected by epifluorescence microscopy fecal pellets produced by copepods and krill during the mesozooplankton grazing experiments (examples seen by light microscopy from previous work in the Arctic are shown in Figure 21). If the mesozooplankton were primarily ingesting algae, their fecal pellets would be expected to show chlorophyll or phaeopigment autofluorescence. Most of the fecal pellets we have observed showed little fluorescence, although some did have obvious red fluorescence indicative of feeding on algae.

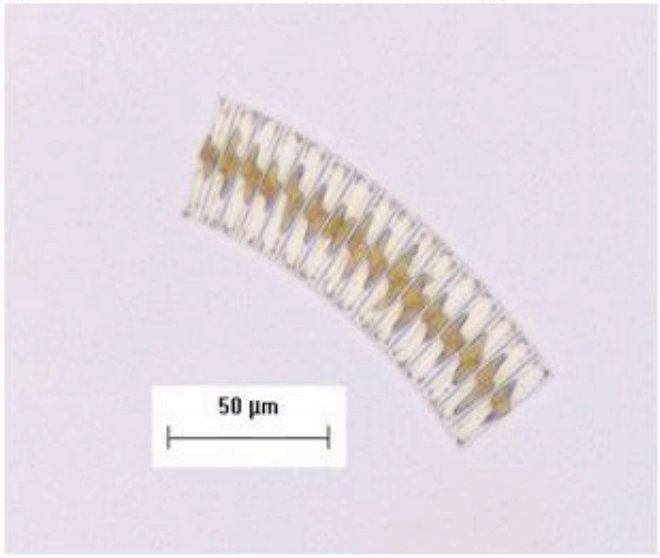
In addition to the grazing rate experiments, we collected profile samples for analysis of microzooplankton abundance and flow cytometric analysis of phytoplankton in the upper water column from depths sampled for primary production. These data will be used to put the water depth sampled for our grazing experiments either just after or just before the primary production cast in context of the overall distribution of microzooplankton in the water.

In addition to the 1-day grazing experiments, we did 5 longer term experiments of up to 12 days to determine growth rates of selected species or morphotypes of microzooplanktonic protists. Water was collected for 4 of these experiments at sites where diatoms were blooming, with initial chl-a values of 7 to 27 ug chl-a/liter. Samples were held in 2-liter bottles in the dark in an environmental chamber set at 0 to -1 oC for two of the experiments, and for two experiments samples were incubated both at 0 to -1oC and at 5 to 6 oC in a second environmental chamber. Samples were taken every 1 to 3 days for analysis of chl-a and microzooplankton abundance. One other growth experiment was done in the on-deck incubator at a light level of 25% of incident. Water for this experiment was collected at Site NP-7 when initial chl-a concentrations were low, about 0.3 ug/liter. Individual 2-liter bottles were sampled over a 12 day period. During the first 10 days, a mixed species diatom bloom grew up to a final chl-a concentration of

about 4 ug/liter (Figure 22). After that time, the remaining samples were incubated in the dark since the on-deck incubator froze up. The maximum growth rate of the diatoms was about 0.4/day. We will analyze samples for growth or grazing of small size phytoplankton via flow cytometry, and for potential growth of identifiable types of microzooplanktonic protists, in our laboratory. We saw numerous examples of heterotrophic protists, notably dinoflagellates, with ingested diatoms, and of dinoflagellates in various stages of division, during inspection of epifluorescence slides prepared during the growth experiments, so we are hopeful that we will be able to determine growth rates of the protists.

Figure 18. Ashjian/Campbell plankton wheel incubator, showing incubation bottles wrapped to simulate 15% in situ light level being placed on the plankton wheel. Bottles are slowly rotated for a 24 hour period while being immersed in flowing water at near surface seawater temperatures.

Ice algae diatom chain, seen by light microscopy



Mixed species of ice algae seen by epifluorescence microscopy

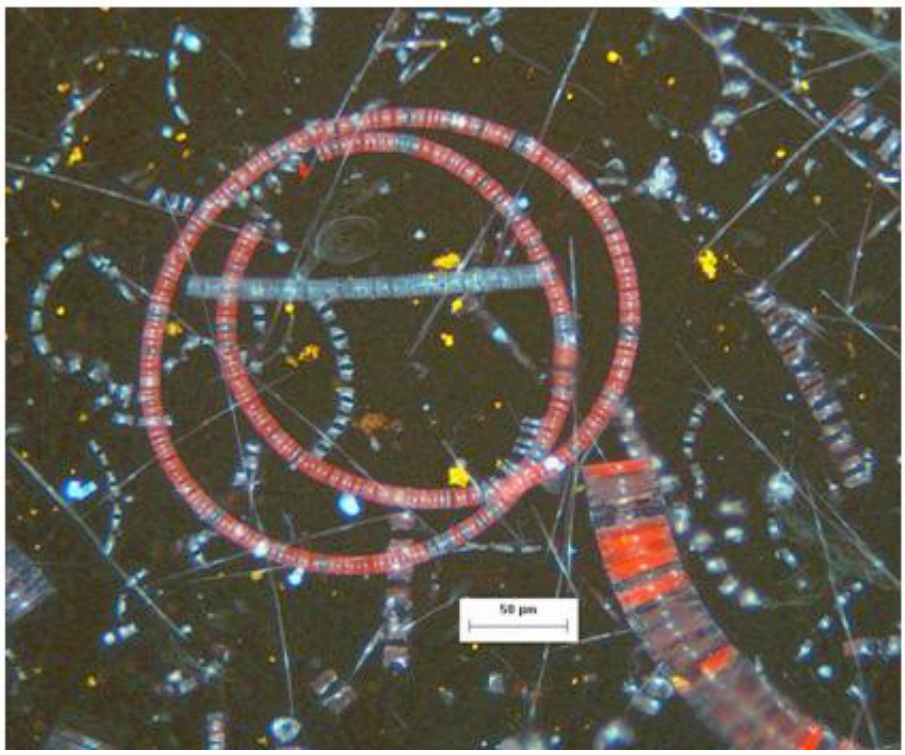


Figure 19. Examples of sea ice algae imaged by top: light microscopy after fixation with acid Lugol solution, and bottom: epifluorescence microscopy after fixation with formalin and staining with a blue-fluorescing dye that shows the nucleus and cytoplasm of individual cells.

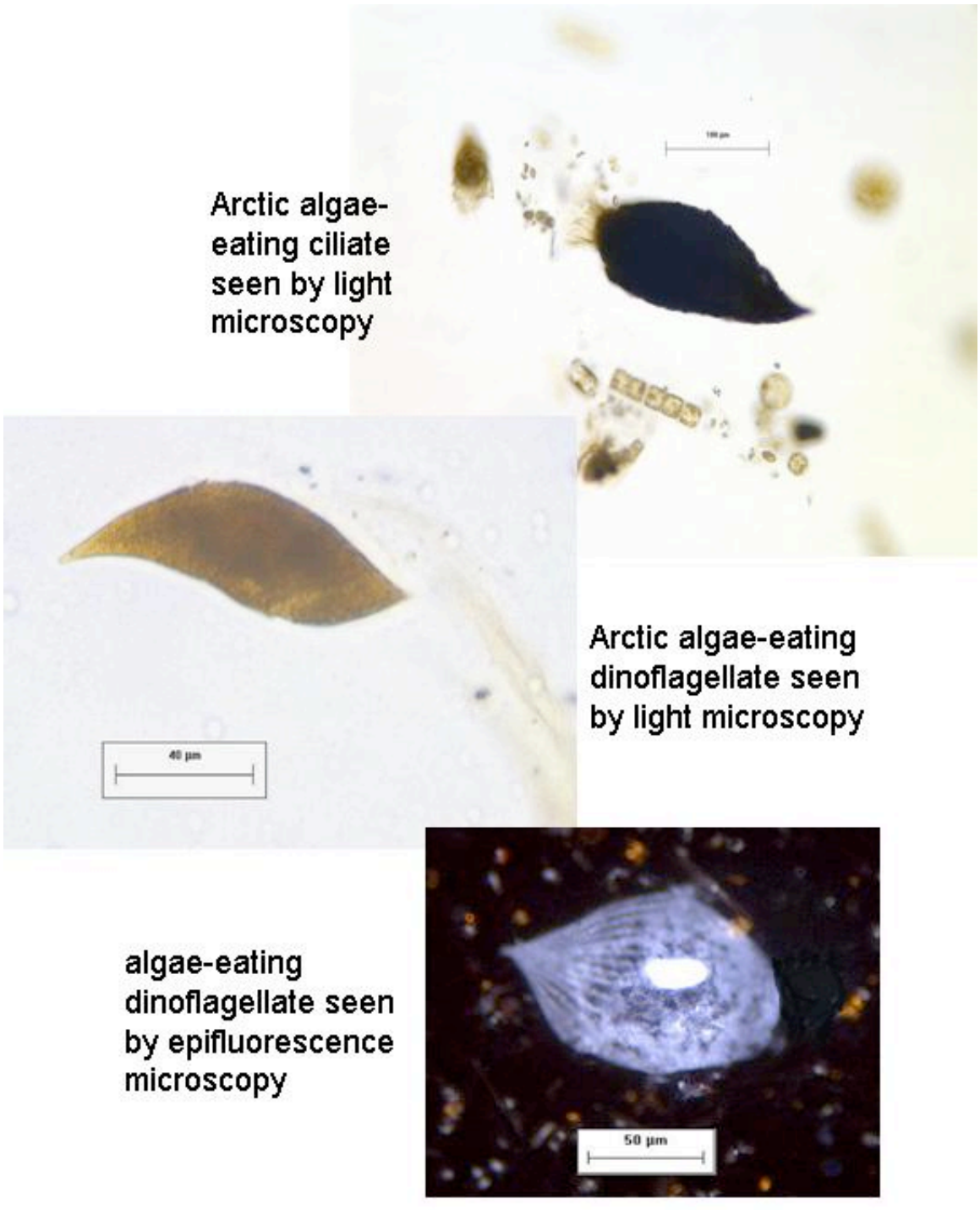


Figure 20. Examples of herbivorous protists in the microzooplankton seen in the Arctic Ocean. Similar protists have been observed during this cruise. Heterotrophic dinoflagellates known to ingest large sized diatoms appear to be especially abundant in our samples.

Figure 21. Examples of copepod fecal pellets like those we have inspected for the presence of chlorophyll autofluorescence in the mesozooplankton grazing experiments during this cruise, seen by light microscopy after preservation with acid Lugols solution.

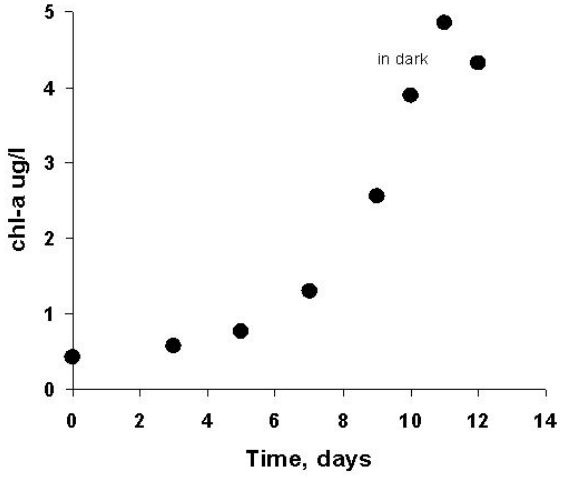


Figure 22. Increase in chl-s concentration over 10 days during a grow-up experiment in which water of initially low chlorophyll concentration and high nutrients was held at 25% light level for 10 days at about 0 ^{o}C, after which the incubator froze and the remaining samples were incubated in the dark at 0 to -1 ^{o}C. Mixed species of diatoms grew up at a maximum rate of 0.4 / day.

B. Mesozooplankton Feeding and Reproduction

Bob Campbell, Carin Ashjian, Philip Alatalo, Donna Van Keuren

Feeding experiments using the dominant mesozooplankton taxa were conducted at process stations. An on-deck plankton wheel/incubator was used to maintain the animals under *in situ* temperature and light conditions during the experiments. A total of 14 feeding experiments were conducted . The experiments were comprised of 6 different copepod (*Calanus marshallae*, *Pseudocalanus* spp., and *Metridia pacifica, Neocalanus cristatus, N. flemingeri/plumchrus, Eucalanus bungi bungi*) and 3 euphausiid (*T. raschii, T. inermis* and *T. longipes*) taxa. Chlorophyll concentrations were quite low (<0.2 µg chl *a*/l) at most process stations early in the cruise with concomitant low grazing on chlorophyll at those stations. Grazing rates were substantially higher later in the cruise at stations with higher chlorophyll concentrations (5 to 20 µg chl *a*/l) and also on ambient water enriched with ice algae. Samples from the experiments were taken to estimate feeding on microzooplankton and phytoplankton/ice algae taxa to be analyzed later.

There were problems supplying ambient science seawater to the incubators to maintain incubator temperatures while in heavy ice. The science seawater system clogged with ice and flow slowed or stopped completely resulting in frozen supply hoses. The Coast Guard worked with us to solve this problem using the ballast water system developed during SBI. The system was able to usually deliver water at temperatures a little more than 1 °C above ambient or about 0.5 °C higher than the science seawater system. Thus, it allowed us to keep the incubators running in heavy ice conditions. We still preferred to use the science seawater when it was available. We also note that during very cold weather (around –15 °C or below) the drains on most of the incubators froze, which resulted in water overflowing onto the deck and freezing, creating a hazardous situation. Our "Heatline" designed drains did not have a single problem. Even after water had not been flowing for more than 12 hrs they remained open and ice free. We highly recommend that all incubators use drains heated with heat tape or heated seawater on future cruises where similar temperature conditions are expected to keep the drains open and prevent flooding of the bow.

Egg production experiments were conducted with the dominant copepod species at selected stations. A total of 38 measurements were made with the three dominant species. Reproduction was initially low for *Calanus marshallae* but increased over the course of the cruise to very high rates. The highest rates are probably at or near maximum for this species at these temperatures. Reproduction of *Pseudocalanus* spp. and *Metridia pacifica* was much lower than *Calanus*.

Over 2500 samples were also collected for mesozooplankton morphometrics, carbon and nitrogen content, RNA and DNA content, and genetic sequencing from process stations and selected other locations.

Table 5. Summary of sampling activities by station. "Grazing" refers to locations where a grazing experiment was conducted and "EPR" refers to locations where egg production rates were measured. Copepods and euphausiids were collected also for analysis of RNA/DNA content, carbon and nitrogen content, and for genetic analysis at the indicated stations.

Date	St #	St Name	Grazing	RNA/DNA	CHN	Genetics	EPR
3/30/08	1	NP15		x	x	x	x
4/2/08	9	NP7	GE1	x	x		x
4/4/08	20	MN4	GE2		x		
4/5/08	23	MN7		x			x
4/6/08	25	MN8.5	GE3	x	x		x
4/7/08	27	MN11		x	x	x	x
4/8/08	31	MN15	GE4	x	x		x
4/11/08	38	SL12	GE5		x		
4/12/08	42	SL8.75			x		x
4/13/08	44	SL8		x		x	
4/13/08	46	SL6	GE6	x	x		x
4/15/08	55	W4		x	x	x	x
4/16/08	59	W7.5	GE7		x		
4/18/08	62	NP7	GE8	x	x	x	x
4/19/08	63	NP3		x			x
4/20/08	73	NP13		x	x	x	x
4/21/08	75	P14-3	GE9	x	x	x	x
4/23/08	78	BS2	GE10		x	x	
4/24/08	87	ZZ8		x	x		x
4/25/08	93	ZZ14	GE11	x	x	x	x
4/26/08	101	ZZ13		x			x
4/27/08	106	ZZ27	GE12	x	x		x
4/29/08	111	70M58	GE13	x	x		x
4/30/08	116	70M53		x	x	x	x
5/1/08	122	70M47	GE14	x	x	x	x
5/2/08	138	70M31		x	x	x	x
5/3/08	149	NP7		x	x		x

C. Fine Scale Vertical Distribution of Plankton and Particles from a Video Plankton Recorder

Carin Ashjian and Philip Alatalo

The fine scale vertical distribution of plankton and particles in association with hydrographic features and water column structure was described using a self-contained Video Plankton Recorder (see Ashjian et al., 2004 for more information on the instrument). Casts have been conducted at all stations across the cross-shelf transects, surveying the water column from the surface to 5 m off of the bottom or to 300 m depth where water depth exceeds that. Seventy-three casts were conducted across the NP, MN, SL, the second and third samplings of the NP lines, and at selected locations during the ice-edge bloom sampling. Casual viewing of the data has been conducted but only

limited progress has been made on image identification because of our intense work schedule. Qualitative assessment of the plankton and particles shows low particle/plankton concentrations at most locations and a predominance of small copepods. Complete analysis will be conducted in the laboratory following the cruise.

Figure 23. Philip Alatalo (L, WHOI) and Marine Science Officer LTJG Stephan Elliott (R, USCG) deploy the Video Plankton Recorder.

Meso-Zooplankton Distribution and Abundance - Alexei Pinchuk

The primary task of the mesozooplankton component was to assess the abundance, biomass and species composition of the mesozooplankton on the shelf-break/outer, middle and inner shelf domains of the southeastern Bering Sea. The data from these samples will aid in determining the fate of new and recycled production on the shelf. A total of 14 MOCNESS tows were taken: 9 west and northwest of Pribilofs in shelf-break and outer shelf regime and 5 east of Pribilofs and near a NOAA permanent mooring site (M2) in the middle domain. Heavy ice prevented us from deploying MOCNESS at other stations and in the inner domain beyond 50 m isobath. We obtained 93 CalVET samples at all CTD stations along NP, MN, SL and W transect lines and at evenly spaced selected locations along 70M line.

The large mesozooplankton component was sampled using a 1-m MOCNESS (Multiple Opening Closing Net and Environmental Sensing System), equipped with 0.5 mm mesh nets. The MOCNESS was equipped with salinity, temperature and fluorescence sensors to provide depth profiles of physical oceanographic data during the tows. Samples were consistently taken in 20 m depth increments from 100 m or the bottom to the surface.

The small mesozooplankton were sampled with a 25 cm CalVET (CalCOFI Vertical Egg Tow) net equipped with 0.15 mm mesh nets. The net was towed vertically from the bottom to the surface and from 100 m to the surface at sites deeper than 100 m. The nets were equipped with General Oceanics digital flow meters to monitor volume filtered. The CTD sample number was recorded with each net to facilitate comparison of CalVET samples with physical oceanographic data.

Samples were preserved in 10% formalin seawater and returned to the lab for processing. Samples will be split and organisms identified to the lowest possible taxonomic category. Copepods will be staged and wet weights will be determined for each species and stage. The above procedure will generate the species composition, abundance and wet weight biomass for all identified taxa from each tow.

Casual observation of the samples indicates that oceanic zooplankton species were common in the shelf-break and outer shelf region, but large copepods were rare or absent from the middle and inner domains stations. It appears that the mesozooplankton community was dominated by medium-sized and small copepods, gelatinous zooplankton and, at some stations, euphausiids. Oceanic *Neocalanus* spp., *Eucalanus bungii* and *Thysanoessa longipes* were common on the offshore ends of NP and MN transects indicating advection of oceanic water on the outer shelf (up to ~100 m isobath). *Calanus marshallae*, *Metridia pacifica* and *Thysanoessa raschii* were common on the middle shelf, while *Sagitta elegans* and small copepod *Pseudocalanus* spp. were abundant in all domains. Spawning of *T. raschii* as indicated by attached spermatophores and blue ovaries on ovigerous females appeared to start the first week of May. A detailed assessment of zooplankton abundance, biomass and distribution will be made after the samples have been processed.

Table 6. Summary of zooplankton net samples collected during HLY0802 by this project.

STATION ID	DATE	CalVET#	MOCNESS#
NP15	3/30/2008	1	MOC1
NP14	4/1/2008	2	
NP13	4/1/2008	3	MOC2
NP12	4/1/2008	4	
NP11	4/1/2008	5	
NP10	4/1/2008	6	
NP9	4/2/2008	7	
NP8	4/2/2008	8	
NP7	4/2/2008	9	
NP6	4/2/2008	10	
NP5	4/3/2008	11	
NP4	4/3/2008	12	
NP3	4/3/2008	13	
NP2	4/3/2008	14	
NP1	4/3/2008	15	
MN1	4/4/2008	16	

MN2	4/4/2008	17	
MN3	4/4/2008	18	
MN4	4/4/2008	19	
MN5	4/5/2008	20	
MN6	4/5/2008	21	
MN7	4/5/2008	22	
MN8	4/6/2008	23	
MN8.5	4/6/2008	24	
MN10	4/7/2008	25	
MN11	4/7/2008	26	
MN12	4/7/2008	27	
MN13	4/8/2008	28	
MN14	4/8/2008	29	
MN15	4/8/2008	30	
MN18	4/9/2008	31	
STLAW	4/10/2008	32	
SL14	4/11/2008	33	
SL13	4/11/2008	34	
SL12	4/11/2008	35	
SL11	4/12/2008	36	
SL10	4/12/2008	37	
SL9	4/12/2008	38	
SL8	4/13/2008	39	
SL7	4/13/2008	40	
SL6	4/13/2008	41	
SL5	4/13/2008	42	
SL4	4/14/2008	43	
SL3	4/14/2008	44	
SL2	4/14/2008	45	
SL1	4/14/2008	46	
W1	4/14/2008	47	
W2	4/15/2008	48	
W3	4/15/2008	49	
W4	4/15/2008	50	
W5	4/15/2008	51	
W6	4/16/2008	52	
W7	4/16/2008	53	
W7.5	4/16/2008	54	
NP7	4/18/2008	55	
NP3	4/19/2008	56	
NP4	4/19/2008	57	
NP5	4/19/2008	58	
NP6	4/19/2008	59	
NP7	4/19/2008	60	
NP8	4/19/2008	61	
NP9	4/19/2008	62	
NP10	4/19/2008	63	
NP11	4/20/2008	64	

NP12	4/20/2008	65	
NP13	4/20/2008	66	
BHS	4/21/2008	67	MOC3
T2(P14-4)	4/22/2008	68	MOC4
BS2	4/23/2008	69	MOC5
ZZ6	4/24/2008		MOC6
ZZ8	4/24/2008	70	
ZZ14	4/25/2008	71	MOC7
ZZ18	4/26/2008		MOC8
ZZ13	4/26/2008	72	
ZZ24	4/27/2008	73	
ZZ25	4/27/2008	74	
ZZ26	4/27/2008	75	
ZZ27	4/27/2008	76	MOC9
MN15	4/27/2008	77	
70M58	4/29/2008	78	
70M55	4/30/2008	79	
70M53	4/30/2008	80	
70M47	5/1/2008	81	
70M42	5/1/2008	82	
70M37	5/2/2008	83	
70M34	5/2/2008	84	
70M30	5/2/2008	85	
70M26	5/2/2008	86	
NP9	5/3/2008		MOC10
70M23	5/3/2008	87	
70M19	5/4/2008	88	MOC11
70M17	5/4/2008		MOC12
70M15	5/4/2008	89	
70M11	5/4/2008	90	
70M7	5/4/2008	91	
70M3	5/5/2008	92	MOC13
70M1	5/5/2008	93	MOC14

Underway Acoustics -Alex De Robertis

Project description: The focus of this work is to improve our understanding of the how temperature and sea ice cover alters the distribution of fish and euphausiids in the eastern Bering Sea. The Eastern Bering Sea supports very large fisheries, particularly for walleye pollock. Although the distribution of fish is well-known in the summer, little is known about their ecology and distribution during the months when much of the Bering sea is ice covered. In addition, little is known about how changes in ice extent might impact pelagic population of fish and their macrozooplankton prey. In this ancillary project, we instrumented Healy with calibrated scientific echosounders in order to continuously measure acoustic backscatter from fish and euphausiids. The work was supported by the Alaska Fisheries Science Center under the auspices of NOAA's loss of sea ice initiative.

Methods and instrumentation: Two transducers (120-7C and 38-120 were mounted 10 cm apart in a transducer well on Healy's hull which is at a depth of 8.4 m. The transducers were mounted 5 cm from the face of a composite urethane acoustic window which is bolted to the hull. The wells were filled with a 1.3 % propylene glycol and freshwater solution to prevent freezing of the water in the wells. The transducers were connected to Simrad EK60 120 and 38 kHz general purpose transceivers. The time on the logging computer was synchronized every 5 minutes to a timeserver aboard the ship to ensure that the echosounder time stamp matched that of other data streams. A standard sphere calibration of the system and transducer cabling was conducted prior to the installation. This calibration was conducted with a spare transducer window 5cm away from the transducer face to account for transmission losses associated with the acoustic window.

A sequential instrument triggering system was used avoid interference from other instruments. The trigger was based on the transmit pulse of a Seabeam 2112 system delayed by 0.75 seconds in order for the EK60 to receive after energy from the Seabeam transmission had attenuated. The EK60 ran at ~0.7 pings per second when not limited by travel time to the bottom (i.e. < ~750m depth). The Sperry SRD500 doppler speed log, which cannot be triggered, was turned off to avoid interference at 120 kHz. Acoustic data were logged continuously during Healy0801 and 0802.

Data processing: Two acoustic categories, one attributed to swimbladdered fish and one to euphausiids were developed based on the observed frequency response at 120 and 38 kHz (e.g. Figure 24). Experience on cruises on NOAA acoustic surveys the Bering Sea, where organisms are sampled to verify the acoustic backscatter in the Bering Sea as well as other studies suggest that this is a reasonable generalization (Korneliussen and Ona, 2002, Miyashita et al., 1997, De Robertis, unpublished data). Acoustic records were averaged into 5 ping by 5m cells, and the frequency difference was in each cell was computed. Cells with a S_{v120}-S_{v38} (Sv is a log10 unit of backscatter strength) in the range of –8 to -16 dB were assigned to the fish category and those in the range of 8to 30 dB were assigned to the euphausiid category (see figure 24). Acoustic backscatter in these categories was averaged into 0.5 nm elementary sampling distance units (EDSU's) in 5m depth cells along the vessel trackline. Backscatter passing the "fish" category was integrated at 38 kHz and fish passing the "euphausiid" category was integrated at 120 kHz using a -80 Sv integration threshold. Acoustic backscatter strength is given in s_A with units of m^2 nmi^{-2} averaged over the water column. s_A is a linear measure of backscatter strength (see MacLennan et al, 2002 for a good discussion of acoustic units).

Preliminary observations: Preliminary processing up to the date of April 17 was conducted during the cruise. The resulting preliminary maps can be seen in figure 25. Overall, backscatter from euphausiids and particularly backscatter from fish was lower in the northern and inshore parts of the vessel track, where cold water and ice cover was present.

Much of the fish backscatter (especially that near the shelf break near the Pribilof islands) is consistent in appearance and location with that of walleye pollock. The euphausiid backscatter performs clear vertical migrations, and a substantial portion of the

population migrates above the transducer during the night. In contrast to observations in on the 2007 Healy cruise, very little fish backscatter was observed north of 58 N. For example, the offshore portion of the MN line (>100 m depth) which was not ice covered in 2007 had substantial backscatter from fish, but this area of the outer shelf and shelf break was ice covered in 2008, and very little backscatter from fish was observed.

References:

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MacLennan, D. N., Fernandes, P. G., and Dalen, J. 2002. A consistent approach to definitions and symbols in fisheries acoustics. ICES J. Mar Sci 59: 365-369.

Miyashita, K., Aoki, I., Seno, K., Taki, K., and Ogishima, T. 1997. Acoustic identification of isada krill, *Euphausia pacifica* Hansen, off the Sanriku coast, north-eastern Japan. Fisheries Oceanography 6: 266-271.

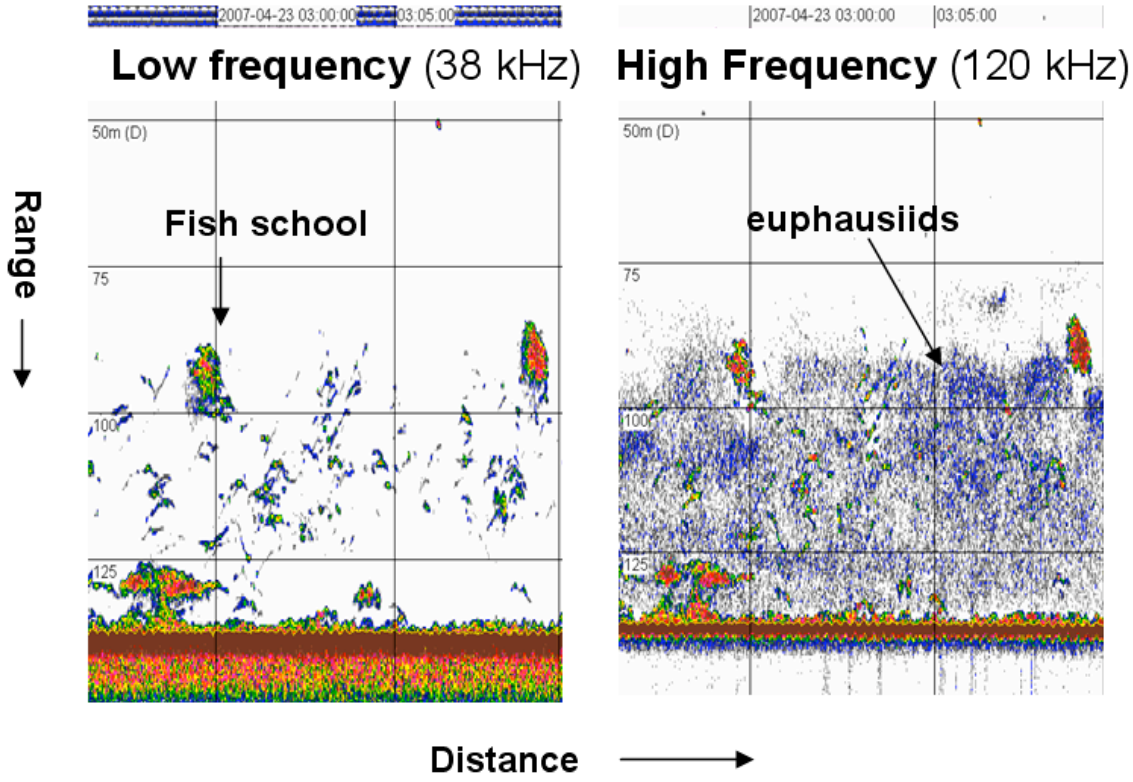

Figure 24. 38 and 120 kHz echograms from Healy showing backscatter from fish schools that are evident at 38 kHz. The fish are also visible at 120 kHz and 38 kHz, while the light blue backscatter from macrozooplankton which is much weaker at 38 kHz than 120 kHz. This frequency dependence is the basis for the classification used in this data set.

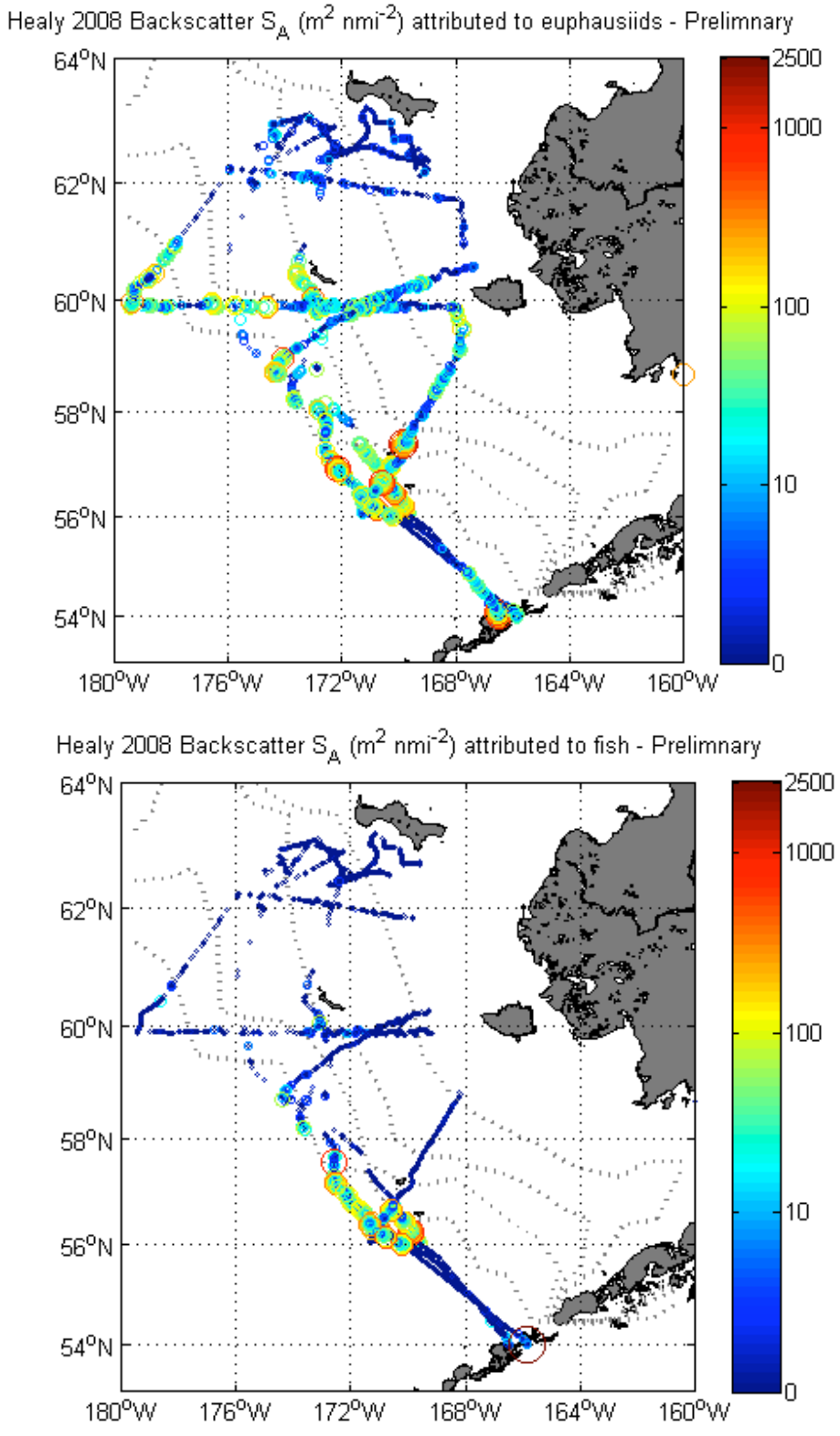

Figure 25. Acoustic backscatter (S_A m^2 nmi^{-2}) attributed to A) euphausiids and B) fish in along Healy's trackline in 2007 and 2008. The approximate position of the 200, 100, 70 and 50m isobaths are shown as gray dotted lines. Symbol size and color is proportional to the intensity of acoustic backscatter.

Denitrification and Globel Change in Bering Sea Shelf Sediments- Alan Devol and David Shull

Alan Devol and David Shull with Emily Davenport and Heather Whitney

The primary goal of the benthic group was to measure benthic denitrification rates, nutrient fluxes, and sediment bioirrigation rates in order to evaluate the role of the benthos in the nitrogen cycle of the Bering Sea. Cycling of P and Si were also investigated. A secondary goal was to measure gas exchange rates to help determine primary productivity in conjunction with measurements of the triple isotopes of dissolved oxygen. We also deployed an ROV under the ice to survey ice algae and krill and to test a method for future measurements of ice algal productivity.

Core samples

Seventeen stations were sampled using an Ocean Instruments MC-800 multicorer equipped with eight 10-cm diameter polycarbonate core tubes. Two drops were made at each station resulting in as many as sixteen cores per station. The actual number of usable samples averaged approximately thirteen. Cores were processed on deck and, depending upon the number of usable cores recovered, were generally allocated as follows:

2 - 3 flux cores (incubated for ca. 5d, overlying water sampled for N_2/Ar, O_2/Ar, nitrate, nitrite, ammonium, phosphate, and silicate). Following flux measurements, these were frozen for later CT-scanning of burrow distributions

1-2 squeeze cores
Profiles of dissolved oxygen measured by microelectrode and by optode
Profiles of dissolved nutrients (nitrate, nitrite, ammonia, phosphate, silicate) by whole-core squeezing

2 section cores cut at 0.5- or 1-cm intervals to 20 cm and centrifuged for later measurements of pore-water nutrients, dissolved Fe and Mn. Remaining sediment reserved for measurements of solid-phase elements (Fe, Mn, Al, OC, N, ^{210}Pb)

3 cores sectioned at 2-cm intervals for measurement of ^{222}Rn/^{226}Ra disequilibrium

2-3 cores sieved over 0.5-mm sieve and preserved in 10% formalin for later enumeration of benthic infauna

1 core for use in phosphate sorption experiment

1 core for determination of sulfate reduction rates

Water-column sampling

At all process stations, vertical profiles of ^{222}Rn/^{226}Ra were measured. The ^{222}Rn/^{226}Ra measurements will be used for determining gas exchange rates and, combined with oxygen isotope data collected by other BEST investigators, rates of net primary production.

Sea Ice surveys

At three ice stations, a mini ROV was deployed and used to survey ice algae and krill observable under the ice. At three ice stations vertical profiles of brine were collected and run for $^{222}Rn/^{226}Ra$ to investigate gas transport within sea ice.

Table 7. Multicore locations.

Stn	Date	Latitude	Longitude	Depth (m)	Measurements
1	3/30/2008	56º 5.18' N	171º 15' W	2608	All
9	4/2/2008	57º 56.1' N	169º 11.05' W	67	No pore water
21	4/5/2008	59º 52' N	170º 22.1' W	63	All
27	4/7/2008	59º 55' N	174º 1.4' W	103	All
31	4/8/2008	59º 55.9' N	176º 32.4' W	145	All
33	4/9/2008	59º 53.1' N	178º 12.7' W	145	All
38	4/11/2008	62º 14.4' N	175º 5.4' W	78	All
46	4/13/2008	61º 54.8' N	171º 10.8' W	53	All
59	4/16/2008	59º 52.5' N	171º 6.9' W	70	All
62	4/18/2008	57º 53.5' N	169º 8.8' W	70	Only flux cores
72	4/19/2008	56º 45.2' N	170º 31' W	110	All
75	4/21/2008	57º 48.4' N	171º 36.6' W	100	All
76	4/22/2008	57º 32.6' N	125º 17.6' W	3437	All
79	4/23/2008	58º 9.7' N	173º 52.7' W	120	All
94	4/25/2008	58º 34.6' N	176º 48.4' W	544	All
106	4/27/2008	59º 11.6' N	176º 2.5' W	140	All
110	4/28/2008	62º 15.3' N	172º 33.6' W	42	All

All = Oxygen microelectrode profile, measurements of fluxes of N_2/Ar, O_2/Ar, NH_4^+, NO_2^+, NO_3^+, P, Si, pore-water profiles of all five nutrients, profiles of $^{222}Rn/^{226}Ra$, benthic infauna, phosphate sorption experiments.

Attempted to core at stations 2, 20, 25, 63 but were unsuccessful at collecting usable samples.

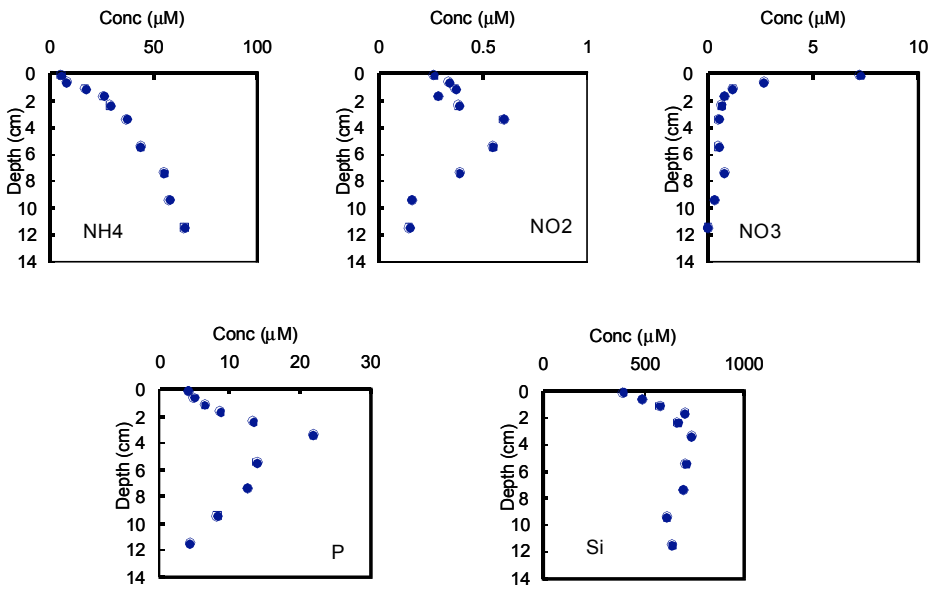

Figure 26. Examples of nutrient profiles (Stn. 27, water depth = 103 m)

Outreach Activities

PIs Shull and Devol and WWU graduate student Emily Davenport participated in the Polartrec program during the cruise. Davenport maintained a web-based journal, communicating with high school and middle school students during the cruise and organized a "live event" with approximately 110 students and educators. The Chief Scientist and five other researchers aboard the Healy participated in the live event. Shull responded to student questions during the cruise via both the web site and the live event.

Benthic Ecosystem Investigation - Jackie Grebmeier and Lee Cooper

Edward Davis and Boris Sirenko (On-Ship Team Members)

This benthic sampling component included sampling of bottom sediments with both a van Veen grab and HAPS multi-corer. Four benthic grabs were collected at twenty-one benthic stations for quantitative benthic community collections Organisms sieved from each of these grabs through 1-mm screens were preserved and will be returned to the laboratory for species identification and determinations of biomass. Expected laboratory processing time for these identification and data analyses will be approximately one year before data will be available. These species and biomass data will be compared to past collections at the sampled locations and in other areas of the northern Bering Sea. Additional grabs of the sediment were also undertaken at each station to provide surface sediments for determinations of sediment chlorophyll, total organic carbon, organic carbon: nitrogen ratios and potentially other sediment chemical parameters. Sediment chlorophyll was determined onboard, but the other data will be generated in shore laboratories. These sediment samples were collected out of the top of the grab before it was opened to obtain surface sediments; previous published studies have shown that bioturbation is significant enough in these sediments that additional care in collection of

surface sediments by using coring devices does not provide any additional margin for providing undisturbed surface sediments. Surface sediments and organisms will also be made available from additional grabs to support the work of Rebecca Neumann and Katrin Iken (ice-benthos connections research group).

The benthic camera system that was deployed is a new experimental system manufactured by A.G.O. Environmental Electronics, Ltd., Victoria, British Columbia. It consists of a weatherized sub-sea camera mounted in a stainless steel cage with two 33 watt green lasers to provide a size scale on the seafloor. The sub-sea camera was connected by a multi-conductor cable to the shipboard control system and a separate Canon GL1 video camera recording the bottom images on mini-DV tapes that will be transferred to computer storage for analysis of epibenthic communities on the sea floor using video imaging software. A video overlay box provides the capability for providing GPS coordinates, temperature and depth data on the videotape.

The camera wasdeployed at a total of thirty-eight stations. We thank Mr. Scott Hiller, the Scripps CTD technical support staff onboard for helping us work through initial problems with equipment freezing and focus. Several different ways of deploying the camera were experimented with; an efficient procedure for deployment using the starboard SeaMac winch was eventually resolved. Ship drift at high winds continues to pose some challenges for good video quality as well as surface swell.

Using the CTD casts at stations where we also deployed the camera and/or the Van Veen grab, we collected water samples for determinations of $d^{18}O$ values at forty-one stations from surface, bottom and a mid-depth rosette bottle.

Seabird and Marine Mammal Surveys Aboard HLY0802 (March 30 – April 15, 2008) Mid-cruise Report – Kathy Kuletz

Kathy J. Kuletz, Elizabeth A. Labunski, and Robert Ambrose

Project

We surveyed marine birds and mammals in conjunction with the National Science Foundation spring 2008 BEST cruise onboard the USCGC Healy March 30 – May 3, 2008. The seabird and marine mammal data will be archived in the North Pacific Pelagic Seabird Database (U.S. Fish and Wildlife Service, Anchorage, Alaska) and are part of the Bering Sea Ecosystem Integrated Research Program funded by the North Pacific Research Board (Anchorage, Alaska).

Methods

We surveyed marine birds and mammals from the port side of the bridge (22m above the sea surface), using standard survey protocol during daylight hours while the vessel was underway at cruising speeds over 5 knots. One observer scanned the water ahead of the ship using hand-held 10x binoculars and recorded all birds and mammals within a 300-m arc, extending 90^0 from the bow to the beam. Birds on the water, on ice, or foraging were counted continuously. Flying birds were counted during 'snapshots' at intervals that varied with ship speed, typically about once every minute. We recorded the animal's behavior as flying, on water, on ice, or actively foraging. We used strip transect methodology with three distance bins extending from the vessel: 0-100 m, 101- 200 m, 201-300 m. We determined the distance to bird sightings using geometric and laser hand-held rangefinders. Unusual sightings beyond the 300 m strip transect were also recorded for rare birds, for large bird flocks, and mammals.

We used the DLOG2 data entry program (Ford Ecological Consultants, Inc.) to record observations directly into a laptop computer interfaced with the Healy's global positioning system. Every entry by the observer was recorded with location, date, and time stamps, along with associated environmental and observer variables. Location data were also automatically written to the data file in 20 second intervals, and allowed us to simultaneously record changing weather conditions, Beaufort Sea State, ice type and coverage, and glare conditions. We recorded other environmental variables at the beginning of each transect, including wind speed and direction, air temperature, and sea surface temperature.

Preliminary Results and Discussion

Here we report on surveys through 3 May, although we will continue to survey enroute to Dutch Harbor. From 30 March to 3 May, we surveyed 123 transects totaling 3,774 km. During this time we recorded a total of 5,652 birds, of which 82 % were identified to species for a total of 28 species (Table 7). The majority of birds observed were Common and Thick-billed Murres (*Uria* spp.) which were 53 % of the on-transect bird observations. Species diversity was low, and only five species comprised 93 % of the identified birds; these were Common Murre, Thick-billed Murre, Black-legged Kittiwake, Glaucous Gull, and Northern Fulmar (Table 7). These locally-breeding species forage primarily on fish, but will also consume squid, euphausiids, and medusae.

During the first half of the cruise (March 30 – April 15), the Thick-billed Murre was the dominate species, but we observed more Common Murres later in the cruise. There was very low bird density in areas of heavy ice coverage, but we did observe pagophilic arctic species such as Ivory Gulls, Slaty-backed Gulls, and Black Guillemots in these areas. West of Nunivak Island, we also found a relatively high density of Kittlitz's murrelets in an area of heavy ice coverage; this is unique information on early spring locations for this rare, pagophilic species (a candidate for listing under the ESA). Kittlitz's murrelets feed on euphausiids and small crustacea in addition to fish, and underway acoustics of that

area showed moderately high levels of acoustic backscatter attributed to euphausiids (Fig. 25, Alex De Robertis data).

A preliminary examination of the broad-scale distribution of marine birds show that they were aggregated near the ice edge and open polynyas near their summer breeding areas. Murres were the most ubiquitous of the seabirds, but they were particularly abundant in the polynyas south of St. Mathew Island and northwest of the Pribilof Islands (Fig. 27). Black-legged Kittiwakes were also ubiquitous and abundant south of St. Mathew Island, but were also present farther north, in polynyas between St. Mathew and St. Lawrence islands, and south along the shelf edge (Fig. 28). The shelf edge and waters south of St. Mathew had generally high acoustic backscatter attributed to equphausiids and fish (Fig. 25).

As with the 2007 BEST cruise we observed few *Aethia* auklets (< 0.5 % of birds on transect), a group that dominates the avifauna of the north Bering Sea in summer, and are primarily plankton feeders. We retained one Least Auklet that apparently struck the bridge of the Healy and died. Aberrant shorebird and landbird observations for 2008 included a Short-eared Owl, Golden Plover, Dunlin, and McKay's Bunting, all of which briefly hitched a ride on the Healy.

Marine Mammals: We recorded 617 marine mammals of 9 identified species (including those > 300 m from the ship), plus one arctic fox (Table 8). Of those, 252 were 'on transect'. Spotted Seals were the most common marine mammal encountered, followed by Bearded Seal, Pacific Walrus, and Ribbon Seal. On April 10, we recorded a large concentration of Ribbon Seals (Fig. 29) in the northwestern part of the study area. We also observed a Minke Whale, Humpback Whales, and a group of 4 Beluga Whales north of Nunivak Island on April 14 (Fig. 30). With the exception of the Beluga whales, cetaceans were observed near the shelf edge in open water and Pinnipeds were more abundant to the north in the pack ice.

Table 7. Marine bird observations during the BEST cruise on the USCGC Healy, 30 March – 3 May, 2008. Preliminary density is the total number of birds of a given species per total km^2 surveyed (1132 km^2), and does not incorporate variance among transects.

Common name	Latin name	N	% of total	% of identified spp.	Preliminary Density (birds • km^{-2})
Laysan Albatross	*Phoebastria immutabilis*	1	0.02	0.02	0.001
Northern Fulmar	*Fulmaris glacialis*	648	11.46	14.00	0.572
Short-tailed Shearwater	*Puffinus tenuirostris*	1	0.02	0.02	0.001
Fork-tailed Storm-petrel	*Oceanodroma furcata*	3	0.05	0.06	0.003
Pelagic Cormorant	*Phalacrocorax pelagicus*	6	0.11	0.13	0.005
Red-faced Cormorant	*Phalacrocorax urile*	7	0.12	0.15	0.006
Unid. Cormorant	*Phalacrocorax spp.*	5	0.09		0.004
Common Eider	*Somateria mollissima*	1	0.02	0.02	0.001
Harlequin Duck	*Histrionicus histrionicus*	1	0.02	0.02	0.001
White-winged Scoter	*Melanitta fusca*	2	0.04	0.04	0.002
Golden Plover spp.	*Pluvialis spp.*	1	0.02	0.02	0.001
Dunlin	*Calidris alpina*	1	0.02	0.02	0.001
Parasitic Jaeger	*Stercorarius parasiticus*	1	0.02	0.02	0.001
Pomarine Jaeger	*Stercorarius pomarinus*	1	0.02	0.02	0.001
Herring Gull	*Larus argentatus*	5	0.09	0.11	0.004
Glaucous Gull	*Larus hyperboreus*	677	11.98	14.63	0.598
Glaucous-winged Gull	*Larus glaucescens*	114	2.02	2.46	0.101
Slaty-backed Gull	*Larus schistisagus*	11	0.19	0.24	0.010
Unidentified Gull	Family *Laridae*	34	0.60		0.030
Black-legged Kittiwake	*Rissa tridactyla*	891	15.76	19.25	0.787
Red-legged Kittiwake	*Rissa brevirostris*	26	0.46	0.56	0.023
Unid. Kittiwake	*Rissa spp.*	16	0.28		0.014
Ivory Gull	*Pagophila eburnea*	4	0.07	0.09	0.004
Common Murre	*Uria aalge*	1439	25.46	31.09	1.271
Thick-billed Murre	*Uria lomvia*	648	11.46	14.00	0.572
Unidentified Murre	*Uria spp.*	946	16.74		0.836
Black Guillemot	*Cepphus*	67	1.19	1.45	0.059
Pigeon Guillemot	*Cepphus columba*	4	0.07	0.09	0.004
Unidentified Guillemot	*Cepphus spp.*	3	0.05		0.003
Kittlitz's Murrelet	*Brachyramphus brevirostris*	43	0.76	0.93	0.038
Brachyramphus Murrelet	*Brachyramphus spp.*	2	0.04		0.002
Unid. Murrelet	Family *Alcidae*	4	0.07		0.004
Least Auklet	*Aethia pusilla*	25	0.44	0.54	0.022
Parakeet Auklet	*Aethia psittacula*	1	0.02	0.02	0.001
Unid. Small Dark Alcid	*Aethia spp.*	4	0.07		0.004
Unid. Alcid	Family *Alcidae*	4	0.07		0.004
McKay's Bunting	*Plectrophenax hyperboreus*	2	0.04	0.04	0.002
Short-eared owl	*Asio flammeus*	1	0.02	0.02	0.001
Unid. Bird	Class *Aves*	2	0.04		0.002

Table 8. Marine mammal observations during the BEST cruise on the USCGC Healy, March 30–May 3, 2008. Off transect counts were observations > 300 m from the ship's center line.

Common Name	Latin name	On Transect Counts			Off Transect
		N	% of total	% of identified	N
Beluga Whale	*Delphinapterus leucas*	4	1.6	1.9	0
Minke Whale	*Balaenoptera acutorostrata*	1	0.4	0.5	0
Humpback Whale	*Megaptera novaeangliae*	4	1.6	1.9	0
Killer Whale	*Orcinus orca*	0	0.0	0.0	4
Unid. Whale	*Cetacean*	0	0.0		5
Bearded Seal	*Erignathus barbatus*	44	17.5	21.2	66
Ribbon Seal	*Phoca fasciata*	38	15.1	18.3	43
Ringed Seal	*Phoca hispida*	1	0.4	0.5	1
Spotted Seal	*Phoca largha*	87	34.5	41.8	93
Pacific Walrus	*Odobenus rosmarus*	29	11.5	13.9	60
Unid. Pinniped		3	1.2		8
Unid. Seal		41	16.3		83

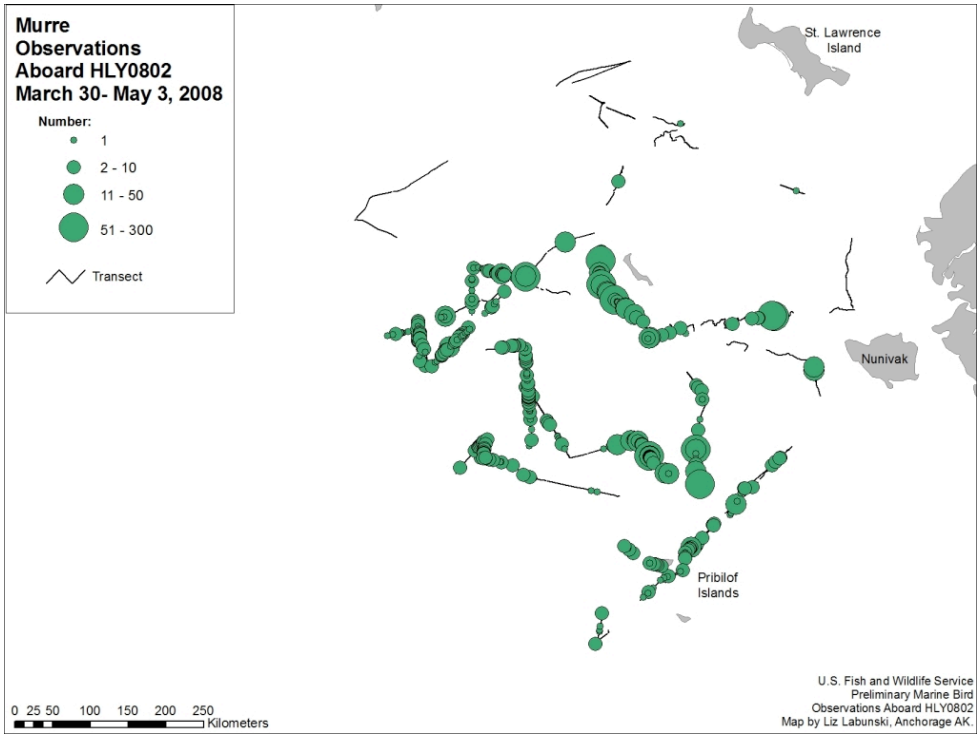

Figure 27. Common and Thick-billed Murre observations during surveys from the Healy, 30 March – 3 May, 2008. Black lines indicate survey track lines.

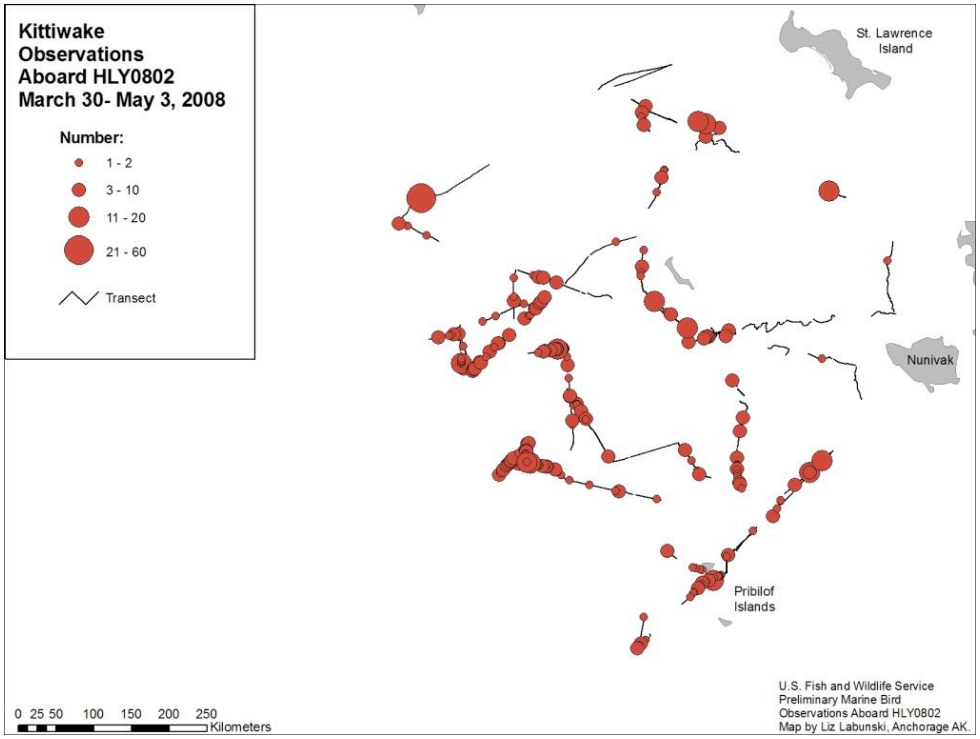

Figure 28. Black-legged Kittiwake observations during surveys from the Healy, 30 March – 3 May, 2005. Black lines indicate survey track lines.

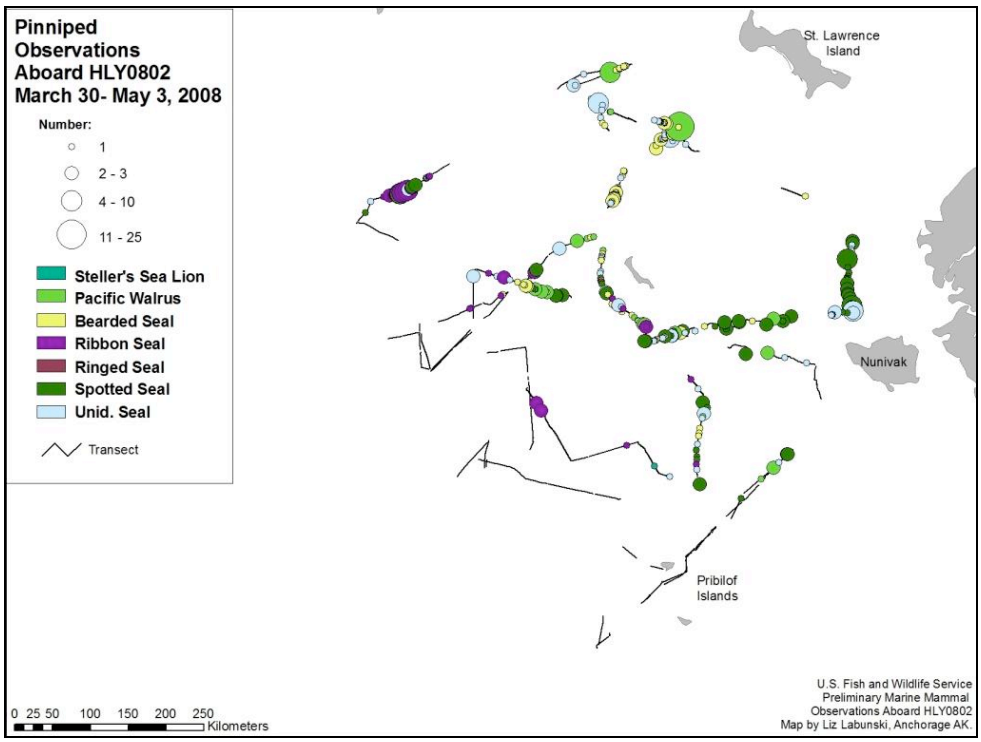

Figure 29. Pinniped observations during surveys from the Healy, 30 March – 3 May, 2008. Black lines indicate survey track lines.

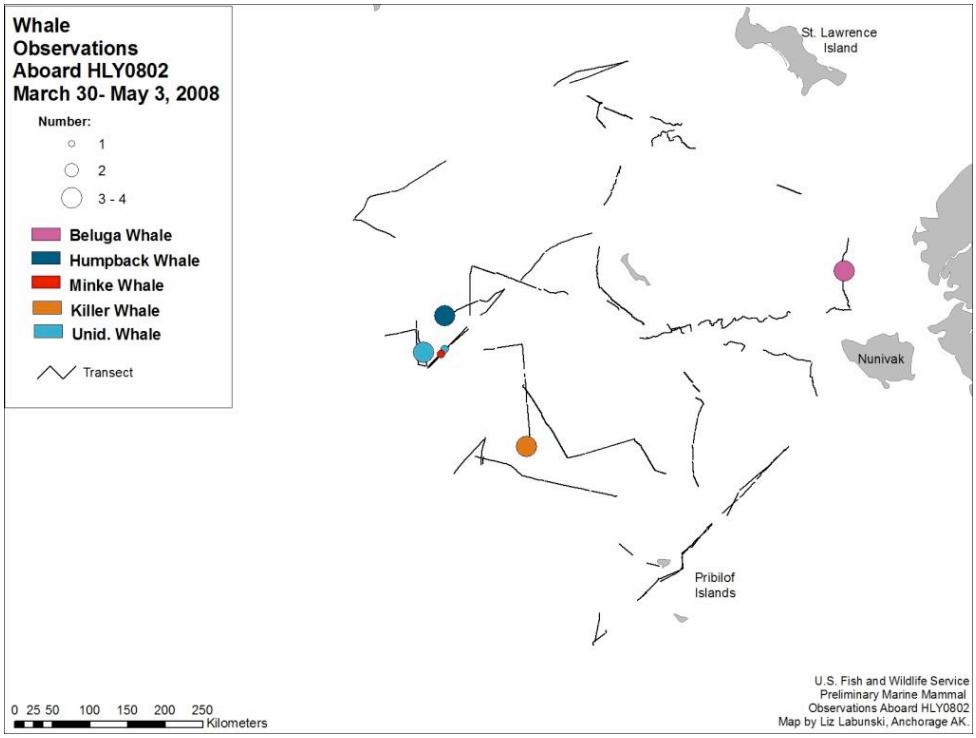

Figure 30. Cetacean observations during surveys from the Healy, 30 March – 3 May, 2008. Black lines indicate survey track lines.

Nitrogen Supply for new production and its relation to climatic conditions on the eastern Bering Sea Shelf- Raymond Sambrotto and Daniel Sigman

A) Sambrotto Component: Kris Swenson and Peng Wang (On-Ship Team Members)

The principal goal of our group was to access the primary productivity of the Bering Sea by taking ^{15}N & ^{13}C uptake profiles, derived from on-deck incubations of water from various depths, depending on the CTD PAR light sensor readings. Other sampling methods included filtration of whole water for natural abundance, analysis of urea in the water column, DNA filtration, preserved samples taken for phytoplankton identification, as well as samples taken for Dissolved Organic Nitrogen and Phosphate.

A final component of our sampling involved ice station sampling. In-situ incubations were performed at various ice stations, and were run in parallel with on-deck incubations, as far as incubation time, water depths, and light levels were concerned. A second component of our ice station sampling work involved analysis of ice cores for phytoplankton identification. These ice cores were obtained with the help of the Grandinger/Iken group.

The procedures and the stations that they were performed at can be seen in Table 9 and Figure 31, respectively.

Results and Conclusions

Throughout the cruise, we successfully completed on-deck incubations at all designated productivity process stations, and performed in-situ incubations at five ice stations. Our other sampling procedures listed above were all performed at spatially designated short and long stations.

A few problems that we encountered dealt with the on-deck and in-situ incubations. The frigid conditions that were experienced early in the cruise made it difficult to keep the incubators running, despite attempts at insulating and heating the connections and hoses that allowed the water to reach to and drain from the incubators. A switch to water from the ship's ballast tank provided temporary relief, until the pump for it went down. Using the science seawater was the best method for keeping a constant, ambient temperature for the seawater, although when it got clogged the science seawater froze the manifolds, and thus froze the rest of our incubation setup.

The conditions on the ice made it difficult for our in-situ incubations to take place, but we fought through the elements and collected six profiles, which will undergo isotopic analysis upon return to our lab at LDEO.

We feel that we have achieved our sampling goals for this cruise, and upon analysis of our samples, we hope to employ our findings to obtain a better understanding of the Bering Sea's primary productivity, and how it aids in the understanding of the Bering Sea ecosystem as a whole.

Acknowledgements

We would like to thank the Gradinger/Iken group for their assistance with on-ice work, as well as Tom Bolmer for his work with our sample station mapping.

Table 9. Summary of sampling activities by station.

Station	Cast	On-Deck Prod.	In-situ Prod.	Urea	DON/P	Nat. Abun. filt.(whole H2O)	Nat. Abun. filt. (5micron)	Nat. Abun. Filt (64micron)	Phyto ID	DNA
1	1			x	x	x			x	x
1	3	x								
2	4			x	x	x				
5	8			x	x	x				
7	10			x	x	x				
9	16	x								
10	18			x	x	x				
13	21			x	x	x				
17	25			x	x	x				
18	26			x	x	x				
19	27			x	x	x				
20	31		x	x	x	x				
23	35			x	x	x				
24	36			x	x	x				
25	38	x	x							
25	39			x	x	x				x
26	42			x	x	x				
29	45			x	x	x				
31	49	x		x	x	x			x	x
34	54			x	x	x			x	
38	59			x	x	x			x	
40	64			x	x	x			x	
42	66	x	x							
44	68			x	x	x				
46	73	x		x	x	x			x	
48	75			x	x	x				
50	77			x	x	x				
52	79			x	x	x				
55	82			x	x	x			x	x
57	84			x	x	x				
59	88	x								
62	95	x								
64	91			x	x	x				
73	106			x	x	x	x			
75	109			x	x	x			x	x
75	111	x								
76	112				x	x				
76	113				x	x				
77	115									

78	117			x	x	x			x	x
88	129			x	x	x				
93	136	x								
99	144			x	x	x	x	x		
105	150			x	x	x		x		
106	154	x								
109	157			x	x	x				
111	162	x	x							
112	164			x	x	x	x			
116	168	x	x							
116	168			x	x	x		x		
119	172			x	x	x	x			
122	177	x								
124	179			x	x	x	x		x	x
128	183			x	x	x	x		x	x
135	190								x	x
138	193								x	x
139	194			x	x	x	x			
147	202	x							x	
149	204								x	
151	207								x	x
152	208			x	x	x	x		x	x
160	216								x	x
162	218								x	x
172	228			x	x	x		x	x	x

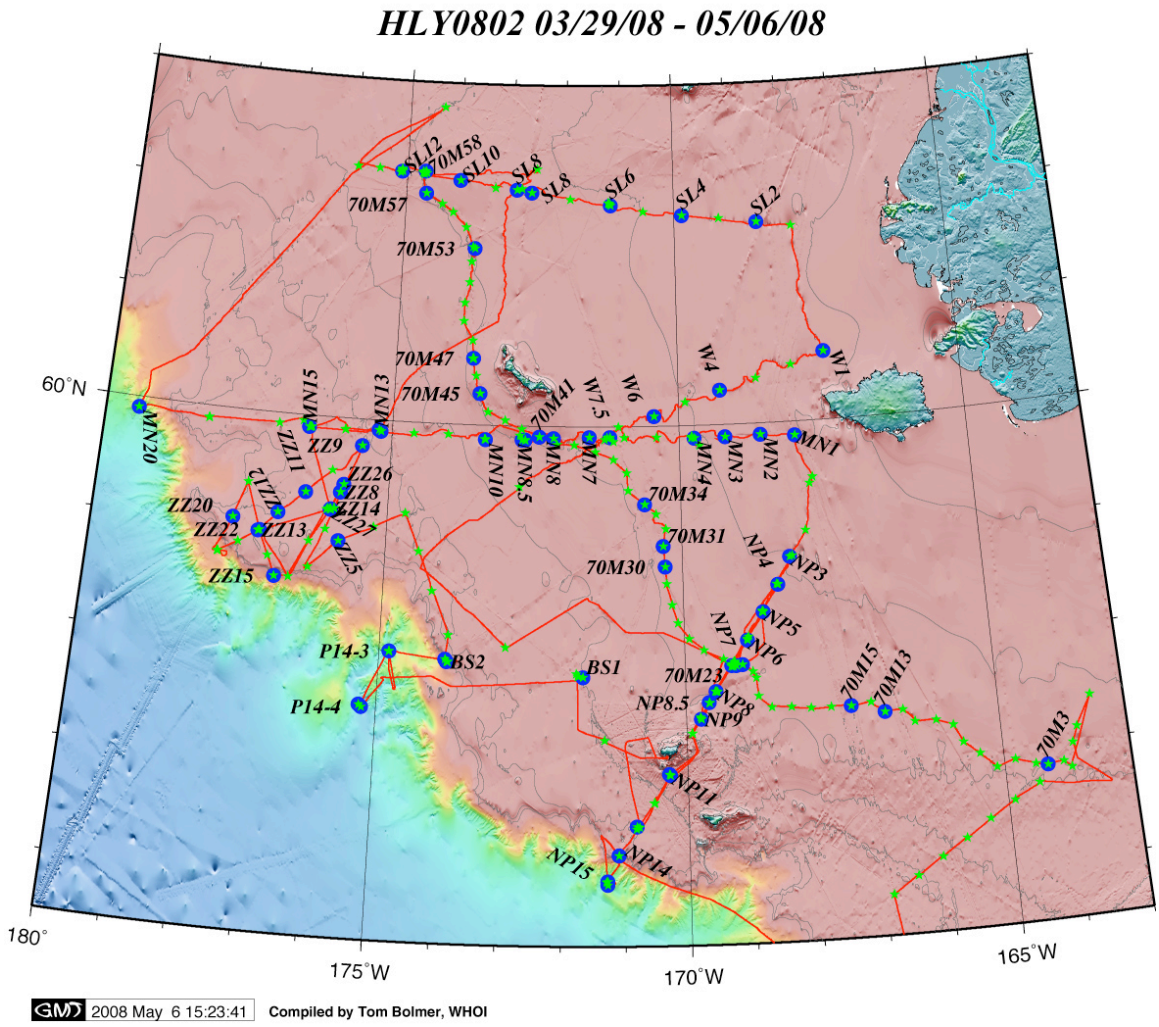

Figure 31. Locations of stations sampled by the Sambrotto group during HLY0802.

B. Sigman Component

Julie Granger – postdoctoral fellow (Princeton University), Maria Prokopenko – sailing scientist (USC)

Objective 1

To construct nitrogen budget for of the eastern shelf of the Bering Sea using natural abundance $\partial^{15}N$ and $\partial^{18}O$ of nitrate, $\partial^{15}N$ of the total dissolved nitrogen (TDN=Nitrate + DON + ammonium, if present), as well as Particulate Organic Nitrogen (PON). Isotopic analysis will be run in the laboratory of D. Sigman at Princeton University.

Corresponding activity (Table 10): Collected samples for $\partial^{15}N$ and $\partial^{18}O$ analysis of nitrate and $\partial^{15}N$ of TDN in the water columns ranging from under-ice "winter" water

column, across the winter ice floe edges, within the phytoplankton blooms along the shelf break and outer shelf regions, as well within the "ice edge" blooms, regions with elevated Chl concentrations encountered in the areas of recent ice melting events. Also, a few stations were sampled along 70 m isobath as the Healy was moving across the southern boundary of ice covered region to examine ice – open water transition not associated with onshore-offshore variability. Normally, in a well mixed under-ice water column 2 or 3 depths were sampled. Several underway samples were taken along the southern most part of the cruise track at the very beginning of the cruise, and in the middle of the cruise across the shelf break. At the sites two or more distinct water masses present 6-10 samples were collected. At selected stations (Table 10), samples of total PON and Size Fractionated PON (SFPON) were taken. For total PON, 60 ml of sea water collected from selected depths of the CTD casts was filtered through GF/F filters. For SFPON, 2L of sea water from CTD casts, was gravity filtered through 0.2 μm and 5 μm Millipore filters. Filters were frozen at -20 C for subsequent isotopic analysis. The isotopic composition of the total dissolved nitrogen (TDN) will be analyzed on the splits of samples taken for nitrate isotopic analysis. In some instances, separate water aliquots were taken for TDN. At two stations (see Table 10), TDN was collected by gravity filtration to compare with pressure filtered TDN samples. Also, at selected stations, mostly where SFPON was collected, individual zooplankton from Bongo nets (333 μm mesh) were hand picked and identified by Alexej Pinchuk (University of Alaska, Fairbanks). Individual animals were placed on GF/F filters and frozen in pre-combusted glass vials for subsequent isotopic analysis at Princeton. The main groups were found to be: *Calanus marshallae, Sagitta elegans, Metridia pacifica, Thysanoessa raschii, Neocalanos flemingeri, Parathemisto libellula, Neonysis ragii* (see Table 11 for complete list of stations and species).

Objective 2

To compare the ∂^{15}N signal of the water column nitrate to that of larger phytoplankton (diatoms). For this purpose, samples were collected for the ∂^{15}N analysis of diatom-bound nitrogen, or DBN. DBN is present in the organic matrix of diatom silica frustules, and is believed to be protected from bacterial degradation during early diagenesis, preserving the original ∂^{15}N. This can provide information on the ∂^{15}N of water column nitrate and regional nutrient status. Such property of DBN makes it an attractive paleoceanographic proxy for nutrient availability on geologic time scales. Information on ∂^{15}N of nitrate at locations of diatoms collection will help to ground-truth the validity of this proxy. Variations in ∂^{15}N of DBN in the context of ice distribution and associated hydrographic variability will be investigated as well.

Corresponding activity: At selected stations (Table 10), a small 50 μm-mesh net (referred to in the Event Log as a Russian Nyet) was towed from the A-frame through the upper 30-35 m of the water column vertically or obliquely if ice conditions permitted, at 2 knots per hour; at a couple of stations, the net was hand-held and lowered to 10 m (see Table 1o for these stations). Plankton biomass was collected and stored frozen at -20 C for subsequent isotopic analysis. Whenever available, surface sediments (upper 3 cm) were taken for our group at the locations of the net tow from multicore samples by the

members of Devol/Shull group and from Van Veen grabs by the members of Edwards/Sirenko group.

Objective 3

To quantify the net community production by determining the O_2 fluxes using the underway O_2/Ar ratios measured with Equilibrator Inlet Mass Spectrometer (EIMS). This work has been initiated by Julie Granger and Maria Prokopenko during the HLY0701 cruise; the HLY0802 season provides an excellent opportunity for inter-annual comparison between the two spring seasons.

Corresponding activity: EIMS is designed to continuously measure through the duration of the cruise dissolved gas ratios (N_2/Ar, O2/Ar and CO2/Ar). Discrete samples are collected into pre-evacuated gas-tight glass bottles from the underway system to calibrate the EIMS O2/Ar measurements to be run in the laboratory of M. Bender (Princeton University). Water column radon measurements by D. Shull, Washington Western University will be used to determine the rates of air-sea exchange necessary for calculations of oxygen fluxes. Also, discrete dissolved gases samples from the upper 8 - 10 m of the mixed layer are taken from selected CTD casts (for B.Moran group). Discrete gas samples from the CTD casts will be analyzed for O_2/Ar ratios, as well triple oxygen isotope ratios at the laboratory of M. Bender at Princeton University. The latter will be used to constrain the rates of gross photosynthetic production and evaluate net to gross community production ratios. Oxygen concentrations were measured in the underway system by the Optode provided by B. Moran (URI). Every 24 hours two calibration samples were taken from the underway system and oxygen concentrations were analyzed by Winkler titrations by the PMEL group. The O2 calibration file is to be submitted to the data base of HLY0802. Our group will also submit the final calibrated and salinity corrected underway oxygen data set measured by the optode (designated as oxygen sensor #2) to the data repository at UCAR website once it is completed.

Objective 4

To quantify the rates of photosynthetic production within seasonal sea ice by quantifying the O_2 fluxes through ice, and measuring O_2/Ar ratios and triple oxygen isotopes in the ice brines[1]. This work has been initiated during HLY0701 in collaboration with C. Mordy, N. and Kachel and Ned Cokelet (PMEL, NOAA) is continuing during HLY0802 expedition. This work has been done with the much appreciated assistance of Alex DeRobertis and Rolf Sonnerup (PMEL, NOAA).

Corresponding activity: Spatial variability in O_2 concentrations within an individual ice floe was investigated at two ice stations (IS # 3 and IS # 4). [O_2] were measured by immersing an optode into an ice holes drilled with an auger. The O_2 concentrations will be interpreted in the context of data collected on the same ice floes by the NOAA-PMEL group: PAR values, temperatures and salinities of ice and brines, ice porosities, depth-

[1] "Brine" is defined as saline water within ice pore spaces in thermal equilibrium with ice at a given temperature.

binned chlorophyll, etc. O_2 concentrations (not yet corrected for salinity) were found to vary from 600 to 900 μm in the bottom layers of the ice, where the most of algae biomass is found. D. Shull group has been collecting brine samples for Rn measurements to assist with quantification of gas exchange rates within atmosphere-ice-sea water system Composite depth-resolved brine O_2 profiles have been measured with the optode at Ice Stations 5, 9, 10, 11, 12, see Fig. 32 for the profile from IS # 5, 9 and 12). Dissolved O_2/Ar ratios were determined for several discrete brine samples introduced directly into EIMS within 0.5-2 hours of collection. The measured (but not calibrated yet) O_2/Ar indicated up to 200 % O_2 supersaturation, produced by algae photosynthetic activity in ice. 2-4 samples for Winkler O_2 determination were collected at each of sampled ice stations. At each ice station, a sample was collected for triple oxygen isotope analysis into a pre-evacuated bottle to determine the contribution of gross photosynthesis to the oxygen dissolved in brines.

Table 10

Location/Station/Cast	d15 N-NO3	d15N-TDN	d15 N-PON	d15N - SFPON	Ind. Zoop	Tow nyet	Surface sediments	O2/Ar and triple O2 isotopes
Slope/1/001	x	x					x	x (at 500 m)
Slope/1/002								x (at 300 m)
NP14/02/004	x	x						
NP13/03/005	x	x						
NP12/04/007	x	x						
NP11/05/008	x	x						
NP8/08/011	x	x						
NP7/09/012	x	x	x			x (hand held)	x	x
IS 1/16/24	x							x
MN3/19/027	x	x	x		x	x (hand held)		
MN4/20/032	x	x				x	x	
MN8/24/036	x	x				x	x (at sta 23)	
MN8.5/25/039	x	x			x	x	x	x
MN13/29/045	x	x				x	x (at sta 28 and 27)	
MN14/30/046	x	x				x		
MN15/031/047	x	x	x	x	x	x	x	x underway
MN16/32/051	x	x						x
MN18/33/053	x					x		
MN20/34/054	x	x					x	
SL14/36/056	x	x				x		
SL12/38/058	x	x		x	x	x	x	x
SL9/41/065	x					x		
SL8/44/068	x					x		
SL6/46/70 and 71	x					x	x	x
SL2/50/077	x	x						
SL1/51/078	x	x				x		
W3/54/081	x	x				x		
W7.5/59/086	x	x	x	x	x	x	x	x and x underway

NP3/63								x underway
NP5/65/098	x	x				x	x	
NP7/62/092	x	x		x	x	x	x	x
NP12/72/105	x	x		x		x	x	x
NP13/73/106	x	x			x	x	x	
BS1/75/108	x	x		x	x	x	x	x
P14-4/76/112 deep	x	x				x	x	
P14-4/76/113 shallow	x	x					x	
P14-4/77/115 shallow	x	x						
BS2/78/116	x	x gravity		x	x	x	at sta 79	x
BS3/79/120								x
ZZ5/84/125	x	x						
ZZ6/85/120	x	x		x		x		
ZZ8/87/128	x	x				x	x	
Zzline/91								x
ZZ13/92/133	x	x		x				
ZZ14/93/134	x	x		x	x	x	at sta 94	x
ZZ19/98/142	x	x				x		
ZZ13/101/146	x	x				x		
ZZ27/106/152	x	x				x	x	x
MN15/107/155	x	x			x	x		
IS10/110/158	x					x	x	
70m 58/111/159	x	x				x		
IS12/116/169	x					x		
70m 47/122/175	x				x	x	x	
70m 37/132/187	x	x				x		
70m 31/138/193	x	x				x		
NP7/149/204	x	x		x		x		
70m 17/158/214	x	x gravity		x		x		
70m 7/168/224	x	x				x		
70m 2/173/229	x	x				x @ 174		
CN13/183/240	x							

Table 11.

Station #	Zooplankton collected
19	*Calanus marshallae,Sagitta elegans, Thysanoessa raschii, Neomysis rayi*
25	*Calanus marshallae, Sagitta elegans, Metridia pacifica, Thysanoessa raschii*
31	*Parathemisto libellula, Sagita elegans, Thysanoessa raschii, Eucalanus bungii, Neocalanus flemingeri, Neocalaus cristatus, Calanus marshallae, Pareuchaeta elongata*
59	*Sagitta elegans, Calanus marshallae, Thysanoessa raschii*
62	*Parathemisto libellula, Thysanoessa raschii, Sagitta elegans, Crangon sp.*
	Calanus marshallae, Metridia Pacifica

65	*Parathemisto libellula, Sagitta elegans, Thysanoessa raschii, Neonysis ragii, Calanus marshallae*
73	*Sagitta elegans, Clione limacina, Thysanoessa ineruis, Metridia pacifica, Calanus, Neocalanus evistetus, Neocalaus plumchrous/flemingeri*
78	*Neocalaus cristata, marshallae Eucalaus bongii, Neocalaus plumchrous/flemingeri,Sagitta elegans, Thysanoessa ineruis, Clione limacina*
93	*Sagitta elegans, Neocalaus plumchrous/flemingeri, Metridia pacifica, Calanus marshallae, Thysanoessa raschii, Clione limacina*
106	*Sagitta elegans, Neocalaus plumchrous/flemingeri, Metridia pacifica, Calanus marshallae, Thysanoessa raschii, Clione limacina, Neocalaus cristatus*
122	*Neonysis ragii, Sagitta elegans, Calanus marshallae, Limacina helicina*

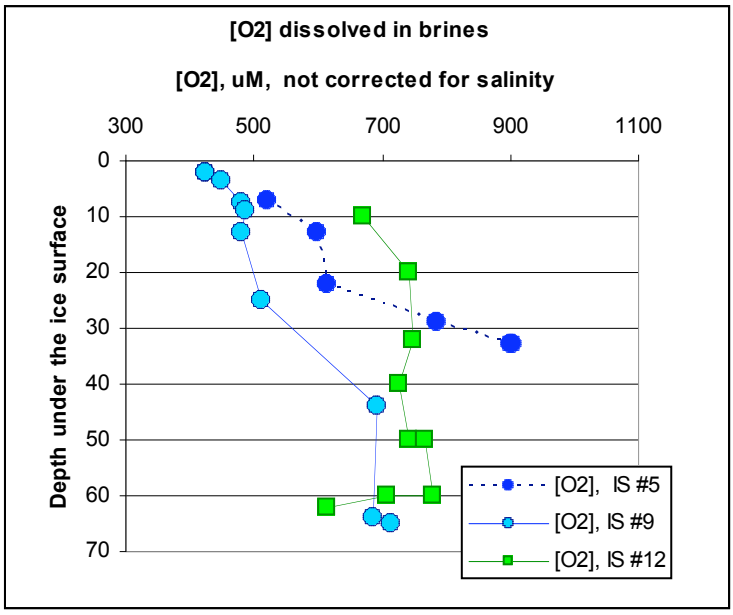

Figure 32.

The Impact of Changes in Sea Ice on Primary Production, Phytoplankton Community Structure, and Export in the Eastern Bering Sea – Brad Moran and Mike Lomas

A. Moran Component

Pat Kelly, on-board team member

Project Objectives:

1) Quantify the flux of particulate organic carbon (POC) from the surface water to the deep waters of the Bering Sea using ^{234}Th as a tracer of particle export.
2) Determine POC/^{234}Th ratio and phytoplankton community values for particles collected in drifting sediment traps at five different depths.
3) Estimate particle export using measurements of total ^{234}Th – ^{238}U disequilibrium in water column.
4) Estimate gross primary production using triple-oxygen isotope method. Collected in collaboration with Maria Prokopenko.
5) Measure dissolved oxygen using underway oxygen optode.
6) Estimate cross-shelf exchange using short-lived radium isotopes ($^{223, 224}$Ra).

Samples Collected:

Table 12. Samples collected from floating sediment traps

Station	Depths (m)	POC/^{234}Th samples	Pigment samples
T1	25,40,50,60,100	2 per depth	2 per depth
041208 RT*	5, 20	1 per depth, ^{234}Th only	NC
041608 RT*	5, 20	1 per depth, ^{234}Th only	NC
T2	25,40,50,60,100	2 per depth	2 per depth
T3	25,40,50,60,100	2 per depth	2 per depth
042808 RT*	5, 20	1 per depth, ^{234}Th only	NC
042908 RT*	5, 20	1 per depth, ^{234}Th only	NC
043008 RT*	5, 20	1 per depth, ^{234}Th only	NC

* These samples graciously provided by Rolf Gradinger et al. Numerical code corresponds to date of collection.

Table 13. Samples collected from the CTD for Small Volume ^{234}Th

Station	Depths (m)
1-NP15	1,10,20,30,40,60,150,250,300
9-NP7	1,10,20,30,40,50,60
25-MN8.5	1,8,20,30,40,50,70
32-MN15	10,20,31,40,60,80,100,120,136
34-MN20	1,10,20,40,100,300,600,800,1200,1500,2000, 2500
38-SL12	10,20,30,40,60,75
46-SL6	10,20,30,40,48
59-W8	10,20,30,40,50,60,67
62-NP7	10,20,30,40,60,65
75-OHS	10,20,30,39,60,75,98
76-P14-4	0,20,60,100,125,150,200,250,300
93-ZZ14	10,20,30,40,60,75,100,135
94-ZZ15	10,20,30,40,50,75,100,200,300
106-ZZ 27	10,20,30,40,50,75,100,135
111-70M58	1,10,20,30,40,45,69
122-70M47	10,20,30,40,50,60,66
148-NP8	10,20,30,40,50,65

Table 14. Samples collected from the CTD for Triple-oxygen isotopes

Date	Station	Depth (m)
3/30/08	1-NP15	500
3/30/08		500
4/3/08	16-MN1	10
4/7/08	25-MN8.5	8
4/8/08	31-MN15	Underway**
4/9/08	32-MN16	8
4/11/08	38-SL12	8
4/13/08	46-SL6	10
4/16/08	59-W7.5	8
4/16/08	59-W7.5	Underway**
4/18/08	62-NP7	8
4/19/08	63-NP3	Underway**
4/20/08	72-NP12	8
4/21/08	74/75	Underway**
4/21/08	75-OHS	20
4/23/08	78-BS2	8
4/23/08	79-BS3	8
4/25/08	91-ZZ12	8
4/25/08	93-ZZ14	8
4/26/08	98-ZZ18	Underway**
4/27/08	106-ZZ27	8

4/29/08	111-70M58	Underway**
5/2/08	131-70M38	Underway**
5/4/08	156-70M19	Underway**

** These samples collected using science seawater line.

Table 15. Samples collected from the CTD for Short-lived Radium isotope samples

Station	Depth (m)
NP-1	8
110-70M57	8
122-70M47	8
131-70M38	8
144-70M25	8
156-70M19	8
172-70M3	8

Data Summary

Trap Results:

Measurable quantities of ^{234}Th have been collected in the sediment traps, though further comment is unwarranted due to incomplete analysis. CHN and pigment analysis will be completed upon return to URI-GSO.

Small Volume Results:

Measurable quantities of ^{234}Th have been collected, though further comment is unwarranted due to incomplete analysis.

Triple Oxygen Productivity Results:

Samples will be analyzed post-cruise, no comment is warranted at this time.

Optode Results:

Underway oxygen data has been collected for the entirety of HLY-08-02. Some early cruise data may be compromised by sediment accumulation in optode flow-cell. Since that remediation, it has been observed that the optode does track generally well with the SeaBird oxygen sensor, though the optode offers less resolution. It is also

hypothesized that the oxygen values from the flow through system are compromised by icebreaking activities (bubble injection, for example).

Short Lived Radium Results:

Analysis of the only sample collected up to this point revealed low activities of ^{223}Ra and ^{224}Ra, with a trend of decreasing radium activity from north to south along the 70m line. More sampling is required to evaluate this observation.

B. Lomas Component

Jonathon Whitefield and John Casey

The Phytoplankton Ecology Lab (PEL) from the Bermuda Institute of Ocean Sciences (BIOS) sent two technicians on HLY0802. The project, part of a collaborative effort between BIOS and URI, is aimed at answering the question of whether climate-driven interannual variability in sea ice extent has altered the magnitude of gross and net primary production, its autotrophic community structure, and subsequently, carbon export, and degree of pelagic-benthic coupling in the eastern Bering Sea. This research contains a central hypothesis:

Climate-driven interannual variability in sea-ice extent and duration shifts the eastern Bering Sea autotrophic community between one of two states; marginal ice-zone (MIZ) blooms vs. open-water blooms. The MIZ bloom state is characterized by high biomass, diatom-dominated blooms, high pelagic export and tight pelagic-benthic coupling, whereas the open-water bloom state is characterized by lower biomass, flagellate blooms, low pelagic export, and reduced pelagic-benthic coupling.

On HLY0802 PEL began the research in to this hypothesis by taking a range of samples: micro- and picoplankton (FCM), Chlorophyll A, and two types of primary production – both C13 stable isotope and traditional C14 (see Table 16 for sample details). These samples will be analyzed at BIOS after the end of the cruise. PEL are also sharing the data from the URI sediment trap deployment – two samples from each of the 5 depths will have pigment samples run on an HPLC.

With the use of primary production to determine the rate of growth, and sediment traps to record the export, PEL is in a good position to answer its hypothesis.

Table 16. Summary of samples collected on HLY0802. * = no C14 production samples were collected at this station. ** = For the second leg of the cruise, DIC and TOC samples were collected by Jeremy Mathis (UAF).

Sample type	Number of samples	Stations sampled
C14 production	**1785** 7 depths / cast 17 samples / depth 3 x light incubation } 1 x dark incubation } Size fractionated – GF/F and 5um 1 x T0 } 1 x Specific activity t0 1 x incubated specific activity 5 x DOC14 / depth	NP15, NP7, MN8.5, MN4*, MN15, SL12, SL6, W7.5, NP7, BS1, BS2, ZZ14, ZZ27, 70M58, 70M47, NP8.5
ChlA	**224** 7 depths / cast 2 samples / depth } Size fractionated – GF/F and 5um	
HPLC / Pigments	**224** 7 depths / cast 2 samples / depth } Size fractionated – GF/F and 5um	
C13 Production	**48** 6 depths / cast	BS1, BS2, ZZ14, ZZ27, 70M58, 70M50, 70M47, NP8.5

FCM (pico plankton)	**177**	NP15, NP11, NP7, MN1, MN4, MN8.5, MN13, MN15, MN20, SL12, SL8.5, SL6, W1, W5, W7.5, NP7, NP11, BS1, P14-3, BS2, ZZ9, ZZ14, ZZ27, 70M58, 70M50, 70M47, NP8.5
Microplankton	**177**	
TOC	**79****	NP15, NP11, NP9, NP8.5, NP7, MN1, MN4, MN9, SL12, SL8, SL8.5, SL6, W5, W7.5, NP7, NP11
DIC	**189** 105 x 250ml bottles 84 x 500ml bottles	Every station except W line!!
VOLUME COLLECTED	763.85 litres	

The Trophic Role of Euphausiids in the eastern Bering Sea: Ecosystem Responses to Changing Sea-Ice Conditions - Rodger Harvey and Evelyn Lessard

The goal of our project is to understand how climatically-driven changes in sea-ice conditions may affect the ecology and population dynamics of euphausiids in the eastern Bering Sea. Our primary hypothesis is that seasonal and interannual variation in the timing and coverage of sea-ice and associated food resources will lead to differences in age structure, diet history, and nutritional condition for euphausiids, which ultimately translate into differences in production rates and availability as prey to higher trophic levels. To determine diet, nutritional condition, and feeding rates, we are performing shipboard krill feeding experiments to measure ingestion rates of specific prey taxa (phytoplankton, heterotrophic protists, copepods) and we are determining the lipid profiles of both euphausiids and prey field. We are also isolating and culturing specific prey species to identify prey biomarkers. Identifying the lipid profiles and specific biomarkers for different prey taxa (particularly the poorly known heterotrophic protists) will enable us to infer diets from lipid profiles of field-caught euphausiids. We are also measuring euphausiid growth and egg production rates and estimating euphausiid age using the lipofuscin method. Our colleague, Alexei Pinchuk, will conduct laboratory rearing to allow calibration of the lipofuscin aging method when eggs can be collected in the field.

A. WATER COLUMN PARTICLES AND KRILL COLLECTION

Rodger Harvey and Rachel Pluethner

Grazing Experiments for Determination of Euphausiid Grazing Rates and Food Source Preferences

Grazing experimental setup was detailed in the report from Lessard. For characterization of food resources and tracking of consumption, water taken from designated Niskin bottles was used for these grazing experiments (Table 17). This water sampled at T_0 was filtered through combusted GF/F filters for carbon and detailed lipid analysis to characterize the algal and detrital food available to krill. At the conclusion of each of the first thirteen grazing experiment conducted by Lessard, water was collected individually from each bottle containing animals and placed on separate particulate filters for lipid analysis to compare food amounts and potential for selective grazing. Water from each of the animal bottles was combined for the last six experiments, and likewise with the control samples. This was in an effort to conserve filters.

At the conclusion of each grazing experiment, the experiment animals were either sacrificed or frozen for later lipid analysis; refer to Table 18 for dates of animal storage. The eyes and eye stalks were removed for those who were sacrificed; both the lipofuscin (Part A) and protein content (Part B) in each pair of eyes were determined via flow-through fluorescence using an Agilent 1100 HPLC. The rest of each euphausiid was frozen in the -80ºC chest freezer for future lipid analysis.

Growth Experiments for the Determination of Age in Euphausiids Found in the Bering Sea

Ten growth experiments in total were performed over the course of the cruise (Table 17). These experiments have included animals of a large size range to provide a first estimate of lipofuscin indices in field animals of differing ages. Alexei Pinchuk will conduct growth experiments spanning the next two years in order to allow age calibrate the field specimen that have been analyzed.

LIPOFUSCIN SAMPLE ANALYSIS

High Performance Liquid Chromatography for the Identification and Quantification of Lipofuscin

Part A
Toward the beginning of the cruise, the optimal excitation and emission wavelengths for lipofuscin - an oxidation product that accumulates in euphausiid neural tissue - from *T. inermis* was determined by running a three-dimensional fluorescent scan of the extracted product present in a composite of samples of krill neural tissue (see Figure 33). That scan allowed a qualitative identification of lipofuscin for that species, and will be used to measure lipofuscin content in euphausiids for the duration of the cruise. A calibration curve using quinine sulfate allowed quantitative measurements of fluorescence intensity to be performed for each run.

Part B
For protein analysis, tryptophan fluorescence was measured using known excitation and emission wavelengths. This is a proxy for the quantification of protein in each pair of krill eyes. A calibration curve utilizing Bovine Serum Albumin (BSA) acts as a means to quantify protein in the eye tissues.

At the beginning of the analysis stages of Grazing Experiment 12, the HPLC quaternary pump began to malfunction, preventing sample runs for the remainder of the cruise. Consequently, all animals after that were frozen.

Lipofuscin analysis is performed for every krill sample, regardless of whether it originated from a grazing or a growth experiment. The dominant euphausiid species throughout the majority of the experiments has been *T. raschii*; however *T. inermis, T. spinifera, and T. longipes,* to name a few, were also caught and/or used in experiments.

Table 17: Water Sample Collection for Experiments

Experiment Type and No.	Station	T_0 filtration date	T_f filtration date
Grazing Experiment #1	NP-13	3/31/2008	4/1/2008
Grazing Experiment #2	NP-7	4/1/2008	4/2/2008
Grazing Experiment #3a	MN-5	4/5/2008	4/5/2008
Grazing Experiment #3b	MN-5	4/6/2008	4/6/2008
Grazing Experiment #4	MN-8.5	4/7/2008	4/8/2008
Grazing Experiment #5	MN-16	4/9/2008	4/10/2008
Grazing Experiment #6	SL-9	4/12/2008	4/13/2008
Grazing Experiment #7	W-7.5	4/16/2008	4/17/2008
Grazing Experiment #8	NP-7	4/18/2008	4/19/2008
Grazing Experiment #9	NP-13	4/20/2008	4/21/2008
Grazing Experiment #10	BS-1	4/21/2008	4/22/2008
Grazing Experiment #11	P14-4	4/22/2008	4/23/2008
Grazing Experiment #12	BS-2	4/23/2008	4/24/2008
Grazing Experiment #13	ZZ-5	4/24/2008	4/25/2008
Grazing Experiment #14	ZZ-14	4/25/2008	4/26/2008
Grazing Experiment #15	ZZ-18	4/26/2008	4/27/2008
Grazing Experiment #16	ZZ-27	4/27/2008	4/28/2008
Grazing Experiment #17	70M8	4/29/2008	4/30/2008
Grazing Experiment #18	70M47	5/1/2008	5/2/2008
Grazing Experiment #19	70M37	5/2/2008	5/3/2008
Growth Experiment #1	MN-4	N/A	N/A
Growth Experiment #2	MN-16	N/A	N/A
Growth Experiment #3	EL-1	N/A	N/A
Growth Experiment #4	NP-7	N/A	N/A
Growth Experiment #5	NP-5	N/A	N/A
Growth Experiment #6	NP-13	N/A	N/A
Growth Experiment #7	BS-1	N/A	N/A
Growth Experiment #8	BS-2	N/A	N/A
Growth Experiment #9	ZZ14	N/A	N/A
Growth Experiment #10	ZZ19	N/A	N/A

*All filters frozen in -80ºC immediately following filtration

Table 18. HPLC sample runs performed throughout the entire cruise, barring calibration curves. A malfunctioning HPLC quaternary pump prevented full analysis of Grazing Experiment #12 and any experiment thereafter.

Experiment No.	No. Animals in the Experiment	*Dominant Species*	Krill Eye Lipofuscin Analysis	Krill Eye Protein Analysis	Whole Samples Frozen	Total Whole Frozen	Storage date
Grazing Experiment #1	12	*T. inermis*	N/A	N/A	Yes	All	4/1/2008
Grazing Experiment #2	32	*T. raschii*	4/3/2008	4/4/2008	No		
Grazing Experiment #3a	24	*T. raschii*	4/6/2008	4/8/2008	No		
Grazing Experiment #3b	24	*T. raschii*	4/7/2008	4/8/2008	No		
Grazing Experiment #4	47	*T. raschii*	N/A	N/A	Yes	All	4/8/2008
Grazing Experiment #5	32	*T. inermis*	4/11/2008	4/11/2008	No		
Grazing Experiment #6	16	*50:50, raschii: inermis*	4/15/2008	4/15/2008	No		
Grazing Experiment #7	33	*T. raschii*	N/A	N/A	Yes	All	4/17/2008
Grazing Experiment #8	24	*T. raschii*	4/19/2008	4/21/2008	No		
Grazing Experiment #9	12	*T. inermis*	4/22/2008	4/22/2008	No		
Grazing Experiment #10	24	*T. raschii*	N/A	N/A	Yes	24	4/22/2008
Grazing Experiment #11	18	*T. inermis*	N/A	N/A	Yes	18	4/23/2008
Grazing Experiment #12	8	*T. inermis*	4/25/2008	N/A	No		
Grazing Experiment #13	16	*T. raschii*	N/A	N/A	Yes	16	4/25/2008
Grazing Experiment #14	24	*T. raschii*	N/A	N/A	Yes	24	4/26/2008
Grazing Experiment #15	16	*T. inermis*	N/A	N/A	Yes	16	4/27/2008
Grazing Experiment #16	24	*T. raschii*	N/A	N/A	Yes	24	4/28/2008
Grazing Experiment #17	12	*T. raschii*	N/A	N/A	Yes	12	4/30/2008
Grazing Experiment #18	24	*T. raschii*	N/A	N/A	Yes	24	5/2/2008
Grazing Experiment #19	27	*T. raschii*	N/A	N/A	Yes	27	5/3/2008
Growth Experiment #1	50	*T. raschii*	4/8/2008	4/9/2008	No		
Growth Experiment #2	51	*T. inermis*	4/13/2008	4/14/2008	No		
Growth Experiment #3	60	*T. raschii*	4/20/2008	4/20/2008	Some	23 of 60	4/20/2008
Growth Experiment #4	42	*T. raschii*	4/21/2008	4/21/2008	No		
Growth Experiment #5	76	*T. raschii*	4/21/2008	4/23/2008	Some	10 of 76	4/21/2008
Growth Experiment #6	24	*T. inermis*	4/24/2008	4/24/2008	Yes	24	4/22/2008
Growth Experiment #7	50	*T. raschii*	N/A	N/A	Yes	50	4/3/2008
Growth Experiment #8	50	*T. inermis*	N/A	N/A	Yes	50	4/25/2008
Growth Experiment #9	50	*T. raschii*	N/A	N/A	Yes	50	4/27/2008
Growth Experiment #10	50	*T. inermis*	N/A	N/A	Yes	50	4/28/2008

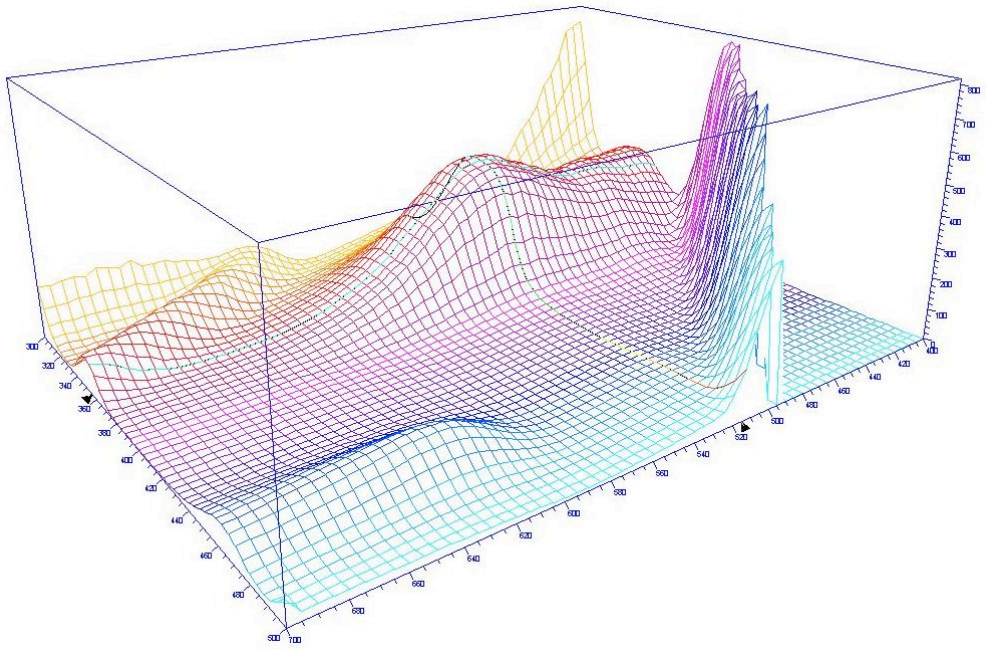

Figure 33: Three-dimensional scan of lipofuscin in T. inermis ocular and neural tissues.

B. Krill Collections and Experiments and Microplankton Distributions

Evelyn Lessard, Tracy Shaw, and Megan Bernhardt

The goal of our project is to understand how climatically-driven changes in sea-ice conditions may affect the ecology and population dynamics of euphausiids in the eastern Bering Sea. Our primary hypothesis is that seasonal and interannual variation in the timing and coverage of sea-ice and associated food resources will lead to differences in age structure, diet history, and nutritional condition for euphausiids, which ultimately translate into differences in production rates and availability as prey to higher trophic levels. To determine diet, nutritional condition, and feeding rates, we are performing shipboard krill feeding experiments to measure ingestion rates of specific prey taxa (phytoplankton, heterotrophic protists, copepods) and we are determining the lipid profiles of both euphausiids and prey field. We are also isolating and culturing specific prey species to identify prey biomarkers. Identifying the lipid profiles and specific biomarkers for different prey taxa (particularly the poorly known heterotrophic protists) will enable us to infer diets from lipid profiles of field-caught euphausiids. We are also measuring euphausiid growth and egg production rates and estimating euphausiid age using the lipofuscin method. Our colleague, Alexei Pinchuk, will conduct laboratory rearing to allow calibration of the lipofuscin aging method when eggs can be collected in the field.

Bongo net tows

We performed 43 Bongo tows (Figure 34, Table 19) to capture live euphausiids for feeding and growth experiments and for lipid, carbon and lipofuscin analyses. The

nets were towed obliquely when ice conditions permitted. As the MOCNESS sampling system is not towable in ice, we took 8 quantitative Bongo tows for assessing euphausiid species and biomass at selected ice-covered stations.

Feeding experiments with euphausiids

We performed nineteen feeding experiments (Table 20) under varying ice cover and in open water. For the feeding experiments, we captured live euphausiids with a Bongo net (Fig. 34) and added known numbers and species to bottles filled with seawater and incubated them for 12-24h on a rotating wheel in a flowing seawater incubator. The prey for each experiment were unaltered seawater plankton, ice protists (algae and heterotrophs) from ice cores that had been gently melted into seawater, or seawater supplemented with ice protists. Shipboard, herbivorous feeding was assessed by measuring changes in size-fractionated chlorophyll and by live plankton cell counting and identification using an automated imaging flow-cytometer (FlowCAM). Samples were also fixed for microscopic counts of phytoplankton and heterotrophic protists to be analyzed back in the laboratory.

Growth experiments

We performed 10 growth experiments, assessing instantaneous growth rates on 486 euphausiids (Table 21). We provided >500 euphausiids with species and size determinations, from the feeding and growth experiments, to Harvey for lipid profiles and lipofuscin content (an index of age).

Preliminary findings

Feeding and growth experiments were done under a wide range of conditions, from inner shelf to slope, in heavy early ice with healthy ice algal communities, under melting ice, and in an open water ice edge bloom. As expected, the dominant euphuasiid species on the mid to inner shelf was *Thysanoessa raschii*, with *Thysanoessa inermis* dominating on the outer shelf. During the first half of the cruise, phytoplankton biomass was low (<0.7µg chlor/l) and dominated by small (< 5 µm) pico- and nanoplankton (cyanobacteria, picoeukaryotes, small flagellates), with heterotrophic protists (dinoflagellates and ciliates) present in modest numbers. In the low biomass water, herbivorous feeding by euphausiids was not detectable based on chlorophyll measurements. However, preliminary FlowCAM assessments indicated that the larger heterotrophic dinoflagellates and ciliates were consumed. As the season progressed, ice algae were present in the water column under ice or which had been recently ice-covered and phytoplankton biomass increased substantially, except at the northern stations along the 70m isobath. When the plankton in experiments was supplemented with algae melted from ice cores (usually large single or chain-forming pennate diatoms, but also centric diatoms, particularly *Thalassiosira* spp.), or at those stations where ice algae appeared in the water column, very significant rates of herbivory were measured. Direct video observations by Shull and Gradinger showed euphausiids actively congregating and feeding on the bottom of the ice. Together, these observations show for the first time that

euphausiids exploit ice or ice-derived biota as an important food resource in the early spring in the Bering Sea.

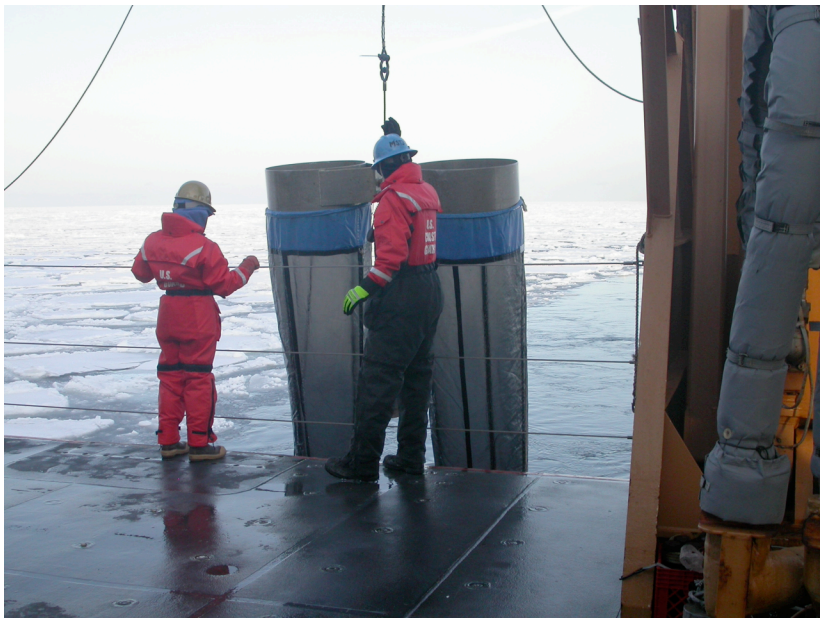

Figure 34. Sampling euphausiids with a Bongo net in the ice. Tracy Shaw (left) directing the operation with assistance from Tom Kruger, one of the excellent Coast Guard Marine Science Technicians.

Table 19. Euphausiid Bongo Tows

Station #	Station name	Cast #	Latitude (decimal)	Longitude (decimal)	Date (local)	Time (local)	Tow Type	Station Depth	Target Depth	Light	Surface Temp	Surface Chlor	Surface Salinity	Air Temp	Feeding Expt	Growth Exp	Quant-itative
1	NP15	1	56.040	171.292	3/31	310	oblique	3000	20	Dark	0.69	0.6	32.32				
3	NP13	2	56.519	170.827	3/31	2352	oblique	121	20	Dark	0.2		32.14		1		
8	NP8	3	57.681	169.525	4/1	2045	oblique	68	40	Light							
9	NP7	4	57.931	169.179	4/2	330	oblique	65	20	Dark					2		
13	NP3	5	58.634	168.199	4/3	134	vertical	45	35	Dark							
19	MN3	6	59.687	169.198	4/3	2310	vertical	45	25	Dark	-1.018		30.77				
20	MN4	7	59.903	169.795	4/4	310	oblique	54	45	Dark	-1.05		30.93				
20	MN4	8	59.822	169.655	4/4	1945	oblique	50	25	Light	-1.21		30.92			1	
21	MN5	9	59.671	170.365	4/5	110	oblique	64	20	Dark	-1.17		31.26		3		
24	MN8	10	59.695	172.195	4/6	255	vertical	72	55	Dark	-1.17				4		
25	MN8.5	11	59.924	172.766	4/6	2045	vertical	70	55	Light	-1.607		31.82				
29	MN13	12	59.926	175.230	4/7	2200	vertical	120	100	Light	-1.71						X
30	MN14	13	59.915	175.792	4/8	200	oblique	130	20	Dark	-1.59						X
31	MN15	14	59.953	176.555	4/8	2230	vertical	141	135	Light	-1.7						
32	MN16	15	59.910	176.966	4/9	50	vertical	136	70	Dark	-1.73				5	2	
36	SL14	16	62.229	175.934	4/10	2345	vertical	92	80	Twilight	-1.65		32.25				X
37	SL13	17	62.224	175.507	4/11	230	vertical	83	50	Dark	-1.64		32.26				
41	SL9	18	62.065	173.321	4/12	245	vertical	60	50	Dark	-1.63		32.22		6		X
46	SL6	19	61.964	171.220	4/13	500	vertical	52	45	Dark	-1.68	1.59	32.22				X
50	SL2	20	61.779	168.482	4/14	210	vertical	34	25	Dark	-1.68	1.19	32.54				X
50	SL2	21	61.779	168.482	4/14	220	oblique	34	20	Dark	-1.68	1.19	32.24				
54	W2.5	22	60.397	168.619	4/15	420	vertical	36	30	Dark	-1.45	0.31	31.16	-17			
54	W3	23	60.397	168.619	4/15	645	vertical	37	30	Twilight	-1.54	0.33	31.1	-17.4			
59	W7.5	24	59.894	171.287	4/16	330	vertical	73	65	Dark	-1.65	0.18	31.58	-5.29	7		
59	W7.5	25	59.894	171.287	4/16	345	vertical	73	65	Dark	-1.65	0.18	31.58	-5.29			
59	W7.5	26	59.894	171.287	4/16	400	vertical	73	65	Dark	-1.65	0.18	31.58	-5.29			
60	EL1	27	59.469	172.764	4/17	115	oblique	95	30	Dark	-1.65	0.44	31.88	0.31		3	
62	NP7	28	57.911	169.235	4/18	310	oblique	69	50	Dark	-1.64	0.32	31.73	-0.34	8	4	
62	NP7	29	57.911	169.235	4/18	320	oblique	69	50	Dark	-1.64	0.32	31.73	-0.34			
65	NP5	30	58.367	168.700	4/19	140	oblique	67	50	Dark	-1.68	0.29	31.62	-0.71		5	
73	NP13	31	56.534	170.820	4/20	100	oblique	125	50	Dark	0.971	1.14	32.07	0.2	9	6	
75	BS1	32	57.854	171.770	4/21	445	oblique	105	50	Dark	-1.034	6.88	31.85	0	10	7	X
76	P14-4	33	57.533	175.331	4/22	300	oblique	3491		Dark	2.47	0.53	33.02	1.46	11		
78	BS2	34	57.947	173.856	4/23	345	oblique	153	30	Dark	1.09	4.43	32.36	1.09	12	8	
84	ZZ5	35	58.927	175.802	4/24	30	oblique	136	35	Near dark	-1.34	2.52	32.17	-3.16	13		
93	ZZ14	36	59.202	175.919	4/25	405	oblique	142	30	Dark	-1.45	2.94	32.14	-3.92	14	9	
98	ZZ19	37	58.749	177.817	4/26	100	oblique	598	30	Dark					15	10	
106	ZZ27	38	59.196	175.981	4/27	300	oblique	142	30	Dark	-1.42	3.19	32.13	-1.46	16		
111	70m58	39	62.184	174.683	4/29	345	vertical	76	50	Dark	-1.72	4.7	32.47	-5.8	17		
114	70m55	40	61.862	174.111	4/30	240	vertical	74	50	Dark	-1.71	6	32.08	-3.22			
122	70m47	41	60.572	173.643	5/1	355	vertical	71	60	Dark	-1.68	1.96	31.91	-4.25	18		
122	70m47	42	60.572	173.643	5/1	410	vertical	71	60	Dark	-1.68	1.96	31.91	-4.25			
131	70m38	43	59.779	171.459	5/2	230	vertical	75	60	Dark	-1.67	0.35	31.54	-8.43	19		

Table 20. Euphausiid Feeding Experiments

Expt #	Station Name	CTD	Latitude (deg)	Longitude (deg)	Date (Local)	Time (Local)	Depth	Temp	Salinity	Ice Algae?	Total Chlor	>5 µm Chl	<5 µm Chl	Euphausiid spp.
1	NP13	6	56 30.39N	170 48.91W	04/01/08	0355	22m	-0.1	32.25	No	0.64	0.31	0.34	T. inermis
2	NP7	13	57 55.15N	169 11.58W	04/02/08	0155	15m	-1.72	31.88	No	0.28	0.12	0.14	T. raschii
3	MN5	33	59 54.22N	170 23.89W	04/04/08	2340	10m	-1.7	31.34	No	0.20	0.09	0.11	T. raschii
4	MN8.5	40	59 55.13N	172 46.34W	04/06/08	2010	5m	-1.7	31.86	No/Yes	0.18	0.08	0.11	T. raschii
5	MN15	50	59 57.19N	176 33.28W	04/08/08	2100	15m	-1.72	32.37	Yes	2.93	2.78	0.15	T. inermis
6	SL9	65	62 05.27N	173 19.69W	04/12/08	0200	10m	-1.74	32.29	No	0.44	0.29	0.15	T. raschii, T. longipes
7	W7.5	86	59 53.21N	171 17.88W	04/16/08	0306	10m	-1.7	31.65	Yes	0.64	0.56	0.07	T. raschii
8	NP7	92	57 54.47N	169 14.12W	04/18/08	0230	20m	-1.67	31.77	Yes	1.98	1.85	0.14	T. raschii
9	NP13	106	56 31.57N	170 48.55W	04/20/08	2340	15m	0.8	32.1	No	1.52	0.96	0.56	T. inermis
10	BS1	109	57 50.93N	171 46.38W	04/21/08	0342	10m	-1.09	31.86	No	24.41	23.94	0.27	T.raschii
11	p14-4	113	57 31.56N	175 16.48W	04/22/08	0432	20m	2.39	33.05	No	0.72	0.38	0.34	T.longipes
12	BS2	116	57 56.08N	173 52.46W	04/23/08	0300	10m	0	32.13	No	18.19	16.64	1.54	T.inermis
13	ZZ5	125	58 55.68N	175 48.02W	04/24/08	0011	10m	-1.4	32.21	No	5.72	5.55	0.16	T.raschii
14	ZZ14	134	59 12.26N	175 54.59W	04/25/08	0314	20m	-1.53	32.18	No	5.65	5.46	0.20	T.raschii
15	ZZ19	143	58 44.96N	177 49.00W	04/26/08	0035	10m	0.5	32.56	No	9.60	9.31	0.29	T. inermis, T. raschii
16	ZZ27	151	59 11.74N	175 58.91W	04/27/08	0210	20m	-1.5	32.17	No	7.90	7.66	0.23	T. raschii
17	70M58	159	62 10.97N	174 41.08W	04/29/08	0310	10m	-1.7	32.56	No	8.50	8.19	0.31	T. raschii, T. inermis
18	70M47	175	60 34.69N	173 38.51W	05/01/08	0452	10m	-1.7	32.1	Yes	2.42	2.21	0.21	T. raschii
19	70M37	187	59 42.75N	171 08.74W	05/02/08	0400	10m	-1.7	31.49	Yes	4.85	4.7	0.15	T. raschii

Table 21. Euphausiid Growth Rate Experiments

Expt #	Station #	Station Name	Start Date	Species	Stages	Days d	# bottles	# animals	Surf Chlor	Surf Temp	Depth
1	20	MN04	4/4/08	*T. raschii*	adults	2	50	50	0.20	-1.21	50
2	32	MN16	4/9/08	*T. inermis*	adults	3	51	44		-1.73	136
3	60	EL01	4/17/08	*T. raschii*	adults	2.5	60	60	0.44	-1.65	60
4	62	NP07	4/18/08	*T. raschii*	adults	2	42	41	0.32	-1.64	69
5	65	NP05	4/19/08	*T. raschii*	adults	2	76	76	0.29	-1.68	67
6	73	NP13	4/20/08	*T. inermis*	adults	2.5	24	24	1.14	0.97	125
7	75	BS01	4/21/08	*T. raschii*	adults	2.5	50	49	6.88	-1.03	105
8	78	BS02	4/23/08	*T. inermis*	adults	2.5	50	50	4.43	0.36	153
9	93	ZZ14	4/25/08	*T. raschii*	adults	2.5	50	49	5.65	-1.53	
10	98	ZZ19	4/26/08	*T. inermis*	adults	2.5	50	48	9.60	0.50	

LDEO Science Support Activities on HLY0802

Tom Bolmer and Steve Roberts

This is a brief summary of the performance of the Underway Science systems during the research cruise HLY0802 on the USCGC Healy, 03/29/08 – 05/06/08 from Dutch Harbor to Dutch Harbor, AK. A more complete log of events that affected the recording of data can be seen in the ELOG entries by the shipboard technicians for this leg. The Data Synopsis Report for HLY0802 has additional information.

Acoustic Data

SeaBeam 2112 Multibeam Sonar

The SeaBeam worked well for this leg. However, much of the cruise was in shallow water (less than 100 meters deep.) This water depth is less than optimal for the SeaBeam system. This data should be aggressively edited for use in mapping. The Center Beam data that was averaged in the 1-minute average file is a good summary of that data. A brief power outage appears to have corrupted the Magneto Optical(MO) disk and the system was down for a couple of hours to identify the problem and replace the disk. Also the internal Exabyte tape drive appears to have failed so we are no longer generating a backup copy of the data. These failures should serve as a reminder as to how fragile this system has become and the need for it to be replaced.

Knudsen 320BR Sub-Bottom Profiler

The Knudsen was run in the Low Frequency "CHIRP" (3 - 6 KHz) mode for the whole cruise. These data look good. Again, care must be taken when using this data, particularly if the desire is to use it for water depth. We do not recommend using subbottom profiler data for bathymetry. For this cruise the multibeam data is a better choice. They should be edited for spikes due to ice affecting the transducers and occasional bad picks of water depth by the system. The trigger for this was slaved off of the SeaBeam transmission to reduce interference with the EK60 fish sonar.

The Knudsen "KEL" formatted file saved in the SCS data directory Knudsen has the wrong internal time. The Knudsen adds about 22.8 seconds to it's internal clock each day. The time to use for this data is the SCS time stamp in the first columns of the file. The depth and location in the file are right.

We occasionally operated this system in 12kHz pinger mode to allow accurate depth determination of the multicorer.

ADCP 75

The ADCP 75 was operated for the whole leg. From quick looks at the data it appears to have recorded satisfactorily. This was also triggered from the SeaBeam transmission. Worked with Alex De Robertis of NOAA to install a trigger delay box provided by him to allow the ADCP to trigger at a ping interval of not more than 1.7 seconds. This allowed the ADCP to trigger at its optimal ping rate even while we were operating in deep water and not interfere with the NOAA supplied EK60 fish stock assessment sonar.

ADCP150

Like the ADCP75 it was determined that the ADCP150 interferes with the EK60. Unlike the ADCP75, this sonar cannot be externally triggered. So to avoid interference with the EK60 it was decided to leave this sonar off for the duration of the science cruise. No data was generated or collected by this sonar.

EK60 (NOAA "Fish Finder")

During the first phase of the cruise this sonar was maintained by Alex De Robertis of NOAA. During the second phase Alex departed the ship and the operation and monitoring became our responsibility. This sonar is a temporary installation.

Navigation

POS/MV-320

The POSMV recorded the ship's position, heading, pitch and roll well during the cruise.

Ashtech ADU5

The ADU5 operated well except for an occasional drop outs which are logged in the ELOG. There were also events where the receiver stopped producing heading and attitude data even though the data streams remained active. The ETs have take this

system up and down for repair and tests during the cruise. Be sure to check the ELOG entries if you are using this data.

Sperry Gyrcompasses

Two new Sperry Gyroscopes were added to the Healy to replace the old Sperry MK27s prior to this season. They have been up to 1.5 degree different from the POSMV and the ADU5 and show surprisingly large "wander" in heading. With its current behavior the systems have been shown to not be an acceptable fall back in the event of a problem with the POSMV. We do not recommend using this data. The ETs have done several tests and adjustments trying to improve the quality of the data during this cruise. We have been monitoring and generating plots for the ETs during this period.

Sea Water Flow Through data

Uncontaminated Sea Water

Early in the cruise the system experienced major and frequent blockages from ice getting past the ice separator. This caused significant interruptions to the TSG underway data collection. This behavior was completely at odds with the prior cruise where the system operated in similar ice conditions but without a single incident of ice blockage. The only thing different with this cruise was the addition of incubators on the bow drawing a substantial amount of water from the system. After monitoring the situation the consensus was that this extra draw on the system was the most likely cause of these ice blockage events. Eventually a separate system was set up by the ship crew to allow the incubators to draw most of their water from the ship ballast. However, about a week after the ballast system was set up the ballast pump failed so all the incubators were once again drawing all their water from the science sea water system. A few days after this the ship headed north and re-entered regions of significant ice and once again the science sea water system experienced several more episodes of ice blockages.

Thermosalinographs

New primary and a spare TSGs were installed by SIO/ODF (Scott Hiller) was installed for this season in the Biochem Lab. These appeared to operate satisfactorily when there was no ice blockage.

Dissolved Oxygen, Flurometer, and Flowmeter

In addition to temperature and salinity, dissolved oxygen, fluorescence and the rate of flow of the water through the TSG were also recorded. It appears that these systems worked satisfactorily.

Meteorological Sensors

New Meteorological sensors were installed for this season by SIO/ODF (Scott Hiller.) The sensors were operated in addition to the ship's existing sensors. These sensors operated satisfactorily for the leg. For the wind speed and direction 2D ultrasonic instruments were installed on the Yard Arm and the Jack Staff.

Mapserver

A web-based real-time GIS system (Mapserver) was actively maintained and kept up-to-date with the most current science cruise data and information.

RadarSat Images from the National Ice Center

RadarSat images were ftped from the National Ice Center roughly once a day and displayed using the Mapserver GIS interface.

Gravity

Two Bell BGM-3 marine gravity meters were installed in IC/Gyro prior to this season and appeared to operate satisfactorily.

Data Logging

LDS (Lamont Data System)

The LDS data logging system was run to record and store underway data for the leg. This system logged the Navigation, SeaBeam, the SIO MET data, gravity, and web camera images.

Underway Data Distribution

At the end of the cruise a set of DVDs containing all the underway data along with various documentation were created and provided to the chief scientist.

Data QC

Continuously monitored all underway data streams and addressed anomalies as they became apparent.

Terrascan

Monitored and maintained the Terascan system plus a separate laptop with a second Terascan license. This second laptop was used to generate various ice imagery for general science use and inclusion into the Mapserver. Since we were operating in the Fairbanks, Alaska station range circle all DMSP data was collected in unencrypted mode.

Web Cameras

Web cameras were operated in Aloft Con, Aft Con and the Board of Lies. Images from the cameras were logged on LDS. In addition once an hour an image from Aloft Con was emailed to shore for use in a web site there.

Appendix A. Science Party Members, March 31 – April 20, 2008

Name	Institution
Carin Ashjian	Woods Hole Oceanographic Institution
Robert Campbell	GSO-University of Rhode Island
Philip Alatalo	Woods Hole Oceanographic Institution
Evelyn Sherr	COAS- Oregon State University
Celia Ross	COAS- Oregon State University
Evelyn Lessard	University of Washington
Megan Bernhardt	University of Washington
Tracy Shaw	Hatfield Marine Center, NOAA
Rachel L. Pleuthner	University of Maryland
Rodger Harvey	University of Maryland
Alexei Pinchuk	University of Alaska
Ed Davis	University of Tennessee
Boris Sirenko	University of Tennessee
Maria Prokopenko	University of Southern California
Jonathan Whitefield	Bermuda Institute of Ocean Sciences
John Casey	Bermuda Institute of Ocean Sciences
Roger Kelly	GSO-University of Rhode Island
Nancy Kachel	University of Washington/JISAO
David Kachel	NOAA-PMEL
Carol Ladd	NOAA-PMEL
Calvin Mordy	Contractor Aquatic Solutions
Jeremy Malczyk	University of Washington/JISAO
Daniel Naber	University of Alaska Fairbanks
Elizabeth Labunski	U.S. Fish & Wildlife Service
Robert Ambrose	U.S. Fish & Wildlife Service
Alex De Robertis	NOAA-AFSC
Rolf Gradinger	Univ. of Alaska Fairbanks
Katrin Iken	Univ. of Alaska Fairbanks
Rebecca Neumann	Univ. of Oldenburg, Germany
Sarah Story Manes	Univ. of Alaska Fairbanks
Steve Roberts	UCAR
Tom Bolmer	Woods Hole Oceanographic Institution
Scott Hiller	Scripps Institution of Oceanography
Lynne Butler	GSO-University of Rhode Island
Paul Walczak	Oregon State University
Allan Devol	University of Washington
Heather Whitney	University of Washington
Ana Aguilar-Islas	University of Alaska Fairbanks
Rob Rember	University of Alaska Fairbanks
Peng Wang	Lamont Doherty Earth Observatory
Kris Swenson	Lamont Doherty Earth Observatory
David Shull	Western Washington University
Emily Davenport	Western Washington University
Ann Fienup-Riordan	Independent Researcher
Janet Scannell	NCAR
Donna Van Keuren	GSO-University of Rhode Island

Appendix B. Ship's Crew, Helicopter Support, and TAD, March 29 – April 20, 2008

Angelo, James YNC
Arakaki, Rebecca SK2
Ayers, Silas LT
Bartlett, Charles MST1
Baldwin, Robin FS3
Bateman, Dale CDR
Beasley, Corey HSCS
Beckmann, Rachel LTJG
Bender, Zachary ENS
Berringer, Mike ETC
Blas, Paul FN
Brogan, John MKC
Buford, Aimee BM2
Carr, Michael LTJG
Carter, John FS2
Cole, Tyler SN
Conroy, William BM3
Coombe, Jeffrey MK2
Dabe, Jeffrey IT2
Daem, Steven ET2
Davidson, Ash BM1
Davis, Jonathon ET2
Dull, Steven FS2
Dunning, Lara BM3
Elliott, Stephen LTJG
Fernandez, Chelsey SN
Finley, Nathan EM2
Ford, Angela SN
Galvez, Oscar R. LT
Glenzer, William BM1
Gonzalez, Fernando MK2
Ghosn, Kathleen FN
Hamilton, H. Mark FS3
Hammond, Mark LCDR
Harbinsky, Mark ET2
Harris, Daniel SK1
Hurtado, Daniell EM1
Manangan, Sorjen OSC
Mandrie, Montarno DC3
Marsden, George DCC
Mastrota, Leigh FN
McNally, Terence SK1
McManus, Gene SN
Meadowcroft, Brian LTJG
Merten, James SN
Miller, Valerie CWO2
Murphy, Nicholas MK2
Newton, Elizabeth LTJG
Olson, James EM3
Passalacqua, Joseph ETCM
Pentecost, James DC1
Podhora, Curtis EMCM
Quichocho, Robert MK1
Redd, Davion DC2
Rieg, Mark MSTC
Rivera-Maldonado, Abner SKC
Rocklage, Eric MST1
Rudibaugh, Kenneth MK1
Shaffer, Hans EM1
Siciak, Anthony MK3
Smith, Corey MK3
Smith, Josh LTJG
Stewart, Jeffrey LCDR
Sullivan, Timothy BMCS
Swanson, Shawn ET1
Thomas, Tasha ENS
Thompson, Emily SN
Tomlin, Mathew SN
Travers, Cynthia LTJG
Von Kauffmann, Daniel IT1
Wagner, Alexander FN
Ward, John CWO3
Whiting, Allan, MK2
Williams, Tony FSCS

Jacobs, Bryson ENS
Johnston, Garrett SN
Jones, Greg MKCS
Kidd, Wayne BMC
Kruger, Thomas MST3
Laisure, Jeremy SK2
Lambert, Douglas MK1
Layman, Rich MST1
Liebrecht, Brian ET1
Lindstrom, Tedric CAPT
Loftis, Jon MK1
Lyons, Sean R CWO3
Worrell, Kenneth EM1
Wright, Tiffany MST2
Yeckley, Andy BM3
Zitting, Arrene FS1
Cleveland, Christopher FNMK
Hickey, Anthony
Merchant, Mike
Newby, Vance IT2
Spink, Mike
Springer, Bill
Stanco, Lesley HS2
Starling, Wendy MK2

Appendix C. Science Party Members, April 20 – May 6, 2008

Name	Institution
Carin Ashjian	Woods Hole Oceanographic Institution
Robert Campbell	GSO-University of Rhode Island
Philip Alatalo	Woods Hole Oceanographic Institution
Evelyn Sherr	COAS- Oregon State University
Celia Ross	COAS- Oregon State University
Evelyn Lessard	University of Washington
Megan Bernhardt	University of Washington
Tracy Shaw	Hatfield Marine Center, NOAA
Rachel L. Pleuthner	University of Maryland
Alexei Pinchuk	University of Alaska
Ed Davis	University of Tennessee
Boris Sirenko	University of Tennessee
Maria Prokopenko	University of Southern California
Jonathan Whitefield	Bermuda Institute of Ocean Sciences
John Casey	Bermuda Institute of Ocean Sciences
Roger Kelly	GSO-University of Rhode Island
Edward Cokelet	NOAA-PMEL
Dylan Righi	University of Washington-JISAO
Rolf Sonnerup	University of Washington-JISAO
Peter Proctor	University of Washington-JISAO
David Strausz	NOAA/NOAA Corp, Lt JG
Jeremy Mathis	University of Alaska Fairbanks
Elizabeth Labunski	U.S. Fish & Wildlife Service
Kathy Kuletz	U.S. Fish & Wildlife Service
Katrin Iken	University of Alaska Fairbanks
Rebecca Neumann	University of Oldenburg, Germany
Sarah Story Manes	University of Alaska Fairbanks
Steve Roberts	UCAR
Tom Bolmer	Woods Hole Oceanographic Institution
Scott Hiller	Scripps Institution of Oceanography
Lynne Butler	GSO-University of Rhode Island
Paul Walczak	Oregon State University
Allan Devol	University of Washington
Heather Whitney	University of Washington
Peng Wang	Lamont Doherty Earth Observatory
Kris Swenson	Lamont Doherty Earth Observatory
David Shull	Western Washington University
Emily Davenport	Western Washington University
Gaelin Rosenwaks	Independent Journalist
John Allison	NCAR
Donna Van Keuren	GSO-University of Rhode Island

Appendix D. Ship's Crew, Helicopter Support, and TAD, April 20 – May 6, 2008

Angelo, James YNC
Arakaki, Rebecca SK2
Ayers, Silas LT
Bartlett, Charles MST1
Baldwin, Robin FS3
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Hammond, Mark LCDR
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Mastrota, Leigh FN
McNally, Terence SK1
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Meadowcroft, Brian LTJG
Merten, James SN
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Pentecost, James DC1
Podhora, Curtis EMCM
Quichocho, Robert MK1
Redd, Davion DC2
Rieg, Mark MSTC
Rivera-Maldonado, Abner SKC
Rocklage, Eric MST1
Rudibaugh, Kenneth MK1
Shaffer, Hans EM1
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Merchant, Mike
Newby, Vance IT2
Spink, Mike
Springer, Bill
Stanco, Lesley HS2
Starling, Wendy MK2

Appendix E: Sampling Plan

Types of Stations and Activities at Each:

1) Short Station:

A short station normally will consist of a CTD cast from the starboard A-frame to near bottom and, on cross-shelf transects and at the ice edge, a Video Plankton Recorder (VPR) cast from the 3/8" wire off of the stern to 10 m off of the bottom or to a maximum depth of 300 m at locations where the bottom depth is greater than 300 m, a Calvet Net tow from the 3/8" wire off of the stern to 10 m off of the bottom, and, at stations shallower than 150 m, a 20 min deployment of the benthic camera from the port side of the fantail. It is hoped that the benthic camera can be deployed at the same time as other operations. For all operations, the ship should be stationary. Calvet net tows will be conducted at a subset of the short stations (number presently undetermined). At some stations, an additional CTD cast may be necessary to accommodate the Fe sampling of Wu.

List of Activities at Regular Short Station (not in order):

CTD Cast
VPR Cast
Benthic Camera (< 150 m water depth)
Calvet Net Tow
(CTD cast for Fe)

Order of Operations:

The order of operations will alternate between stations between starting with operations on the starboard side and starting with operations from the stern. For starts from the starboard side, the order will be CTD, Fe sampling, VPR, Calvet net, Extra nets (see below) with benthic camera work occurring during the CTD and Fe sampling (if it works out that the benthic camera can be deployed simultaneously with other sampling). For starts from the stern, the order will be VPR, Calvet net, Extra nets, CTD, Fe sampling with benthic camera work occuring during one of the operations.

2) Short Station plus Extra Net Tow:

Once per 24 hour period a second net tow will be conducted usually during the morning using a ring net from the 3/8" wire off of the stern. This will be a vertical tow (ship not moving) to a maximum depth of 100 m or to 10 m off the bottom where the bottom depth is less than 110 m.

This is in addition to the activities described for a short station.

3) Short Station plus Krill Fishing during the Night:

1-2 net tows will be conducted from the 3/8" wire off of the stern to collect krill at night.

This is in addition to the activities described for a short station.

4) Process Stations:

The following activities will occur at each process station:

- ∞ CTD casts (at least 4) from starboard A-Frame– Hydro Team
- ∞ Fe CTD cast (1) at some locations - Wu
- ∞ VPR cast (1) from stern A-frame, 3/8" wire – Ashjian
- ∞ Plankton ring net tows (4-5) from stern A-frame, 3/8" wire – Campbell/Ashjian/Iken/Prokopenko
- ∞ Calvet net tow (1) from the stern A-frame, 3/8" wire –Pinchuk
- ∞ Bongo Net tows (2-3) at night – Lessard
- ∞ Multinet or MOCNESS net tow (1) from stern A-frame, 0.68" conducting – Pinchuk
- ∞ Benthic grabs from the stern A-frame, 3/8" wire – Cooper/Grebmeier team, Gradinger/Iken team
- ∞ Benthic camera cast (1) from the starboard aft quarter using portable spool of wire – Cooper/Grebmeier Team
- ∞ Multicore (2) from stern A-frame, 9/16" wire – Devol

The following activities will be <u>added</u> at process stations in ice:

- ∞ On-ice sampling and deployment of sub-ice sediment traps (helicopter retrieval of traps may be necessary; see section below for description of ice work)
- ∞ ROV surveys under ice deployed from ice-Shull
- ∞ Benthic camera deployed from ice-Cooper/Grebmier team
- ∞ If necessary, small boat work to access ice- Gradinger

At up to 5-6 process stations located over the slope:

- ∞ Deployment of floating sediment traps, requires small boat – Moran

At 5-6 Open Water Stations:

- ∞ Van Veen Grab sampling from stern A-frame, 3/8" wire, 3 replicates – Gradinger et al.

A minimum of four CTD casts will be conducted at each process station. One should occur in the morning of each day with succeeding casts interspersed with activities occurring on the stern in order to maximize efficiency and minimize down time while the CTD bottles are being emptied. The ship should remain stationary for all CTD casts.

VPR casts should be conducted as described above.

Benthic grabs and the multicore casts will be conducted with the ship stationary. Benthic sampling will likely occur at the end of the station or at a location slightly offset from the station location in order to minimize benthic disturbance at the station and in order to avoid washing sediment into the water column during sample sieving and processing and deck cleanup.

The benthic camera will be deployed for ~20 min using a manually spooled cable off of the aft deck. The ship should be stationary during the camera deployment. Camera deployment will only occur at stations of ≤150 m water depth.

The Multinet tow will be conducted with the ship stationary when in heavy ice or at a speed of 1-2 knots. The MOCNESS tow will be conducted at a speed of 1-2 knots.

At process stations in ice, the order of activities will be driven by the timing of daylight so as to maximize the period of time that the sampling teams can be deployed onto the ice. Once the ship is safely positioned next to the ice, a team of scientists (12) from the PI groups of Gradinger et al., Wu, Devol/Shull, Lessard/Harvey, and Hydro will be deployed onto the ice with equipment to begin the ice work (see more complete description below). The scientists will remain on the ice for up to 6 hours; during the first half of the cruise, a smaller team (Gradinger) will need to return to the ice ~12 hours after the deployment of sediment traps hanging below the ice surface. All ice work will be conducted during daylight hours and deployment of personnel to the ice will occur as soon as possible following the onset of daylight so as to potentially allow collection of the sediment traps 12 hours later. If the sun has set 12 hours after the deployment of the sediment traps and if the station is completed before daylight, the traps may be recovered during the following day by returning to the station location by helicopter. During the period of work on the ice, a small ROV will be deployed through a hole in the ice or potentially from the ship off of the stern at night, moving away from the ship under the ice (Shull).

5) Short station plus ice work only

At some locations, the Gradinger et al. team may need to conduct ice work for ~6 hours (standard activities) at a short station (rather than waiting for the next process station) in order to achieve 10 ice stations during the first portion of the cruise. These stations will be planned for days between process station dates.

Other Activities:

1) Small Boat Use

Moran: The small boat will be used to deploy and retrieve the floating sediment traps close to the ice edge at stations located over the slope (~300 m). For deployment, the

traps will be carried to the ice edge on the boat and deployed from the boat. For recovery, the small boat will secure the upper end of the trap string and gently move that upper end to the stern of the Healy where a line through a block off of the stern A-frame will be used to bring the full traps directly on board Healy. The traps weigh 300-350 #.

The small boat also will be used to recover the traps when deployed in open water (traps can be deployed in open water directly from Healy). As for the ice edge situation, the traps will be secured to the small boat and brought over to the stern of Healy where they will be lifted on board using the stern A-frame.

Gradinger: We would work within 1 mile around the ship with a science party of three for our project. The payload would consist of five action packers, two ice corers and a power generator (total weight about 150lbs). Everything fits nicely in the small boats we used frequently during our 2005 expedition. We only want to use the small boats during daylight hours.

We will bring our own gasoline for science operations as discussed during the planning meeting.

Lessard/Harvey: Will work in conjunction with other PIs using the small boat to sample krill and ice biota (using hand nets and slurp guns) at the ice edge.

2) Sampling Activities on the Bridge

Both the Kuletz group (seabirds) and the Gradinger et al. group (sea ice) will post observers on the bridge during daylight hours to monitor ice conditions and to enumerate and identify seabirds. Both groups will use laptops on the bridge. Kuletz requires a GPS feed to her laptop. Gradinger et al. requires a feed of ship position, heading, speed etc. that will be arranged by Chayes.
The Moran team, led by Kelly, will need to install a "Gonio" box and antenna on the bridge in order to track the floating sediment traps (RDF tracking). Kelly has discussed antenna installation with Chayes. Both the Gonio box and the antenna are quite small (1.5' x 1.5' x 8" for the box).

3) Acoustic detection of plankton using a fish sonar (Simrad EK 60)

This will be conducted by Alex De Robertis. As for HLY0701, the sonar will be installed in the sonar well by Alex working together with D. Chayes. Data will be collected on a computer in the Future Lab. **We request that the ship minimize the use of the Sperry SRD500 Doppler speed log when not required for navigation as this device interferes with scientific acoustic equipment (Simrad EK60 echosounders).** During HLY0701, the Sperry SRD500 was turned off except when entering or leaving port.

4) Open-Water Deep Sediment Trap Deployment (Moran Group)

Number of sediment trap stations

We anticipate at least 5 deep sediment trap stations as part of HLY-08-02 (not to be confused with the Gradinger ice sediment trap). Deep traps consist of a trap line (5/8" dia poly-dac rope) that is 110m long with samples collected at 25 m, 40 m, 50 m, 60 m and 100 m (Fig. 1). Stations will be limited to shelf-slope locations with water depths greater than 300 m, and deployments will last approximately 24 hours. Several of these stations may be conducted in ice conditions requiring the sediment traps to be anchored to ice floes.

Operational procedure of typical sediment trap deployment:

(1) Preparation for deck operations

Prior to arriving on station - Fantail should be prepared for sediment trap deployment. This includes: (a) placement of deck snatch-block, (b) start-up for the capstan hydraulics, (c) setting the trap line in the A-frame block and (d) placement of ballast, sub-surface, surface and spar buoys on fantail where they can be accessed (Fig. 2).

On station – The Healy's bow should be directed into the wind/swell (whichever is dominant), and the stern props should be used as little as possible to maintain this orientation. The sediment trap holders, tubes, will then be brought out and placed near the transom. Trap ballast (135 – 150 lbs) will be secured to trap downline.

(2) Bridge permission

Prior to be deployment of sediment traps, the bridge will be contacted to confirm permission to put equipment over the side. It may be deemed necessary to drop the life-lines spanning the transom at this time.

(3) Sediment trap deployment

Using the capstan to control payout, the trap ballast will be lifted and passed over the transom. If sea conditions require, a tagline may be used to stabilize the load. The ballast will be lowered to the first trap stop, where the first crosspiece will be attached to the line and the first set of tubes inserted into the crosspiece. The traps will be lowered until all 5 stops are completed. Following the last set of traps, 3 sets of sub-surface buoy strings will be attached to the downline. After the shock cord and back-up trap line pass through the A-frame block and the trap top is at deck height, the array will be secured to the vessel with a tagline. Finally, the surface buoy string will be attached.

(4) Sediment trap release

At this point contact will be made with the bridge to verify permission to release the sediment traps. The strobe light, RDF beacon, and ARGOS beacons will be activated at this time, then the buoys will be cast into the water. The tagline will be released, and the capstan will be used to allow the trap array to drift ~10 m from the ship, at which point a slip knot will be released to allow the array to drift freely.

(5) Sediment Trap Tracking
The position (lat and long) of the sediment trap will be recorded every 15 min using the Gonio 400P receiver and a laptop. If the array drifts beyond the vessels line-of-sight, the positions will also be relayed every 6 hours via email to shipboard scientists via the ARGOS satellite network. In addition, the spar buoy will be fitted with an RDF beacon, strobe light, and radar reflector to aid in tracking and recovery.

(6) Sediment Trap Recovery
After the 24 hour soak time, the traps will be recovered. The Healy will steam to the last known position of the sediment traps, and begin to search for them from there. Upon their sighting, a small boat will be launched to tow the traps to the stern of the Healy. Again, the Healy should be positioned with its bow into the wind/swell. A lead line will be connected to the trap downline, and the capstan will be used to haul in the traps. When the top of the downline is at deck height, the surface buoys will be disconnected and recovered. The sub-surface buoys and traps will be hauled in and removed from the downline as they are brought to the surface. Finally, the trap ballast will be brought on deck and the lifelines made secure on the transom.

It may be helpful to deploy a helicopter to assist with searching for the sediment traps. This should not be necessary for every deployment, but should remain an option if circumstances require it.

Additional request for support from ship
(1) Additional array tracking
It would be helpful for drifter recovery if the trap GPS positions, radar bearings, or RDF bearings could be logged into the electronic navigation chart if possible/when available.
(2) The Gonio box will need to be installed on the bridge.

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5) Helicopter

The primary use of the helicopter for science will be by R. Gradinger who will need it to return to locations where he has deployed under-ice sediment traps to recover the traps after Healy has left that station (during daylight the day following the deployment of the traps). Gradinger may also use the helicopter for 1 hour trips to sample ice floes while the ship is underway.

The helicopter also may be used for personnel transfers at St. Lawrence Island and at St. Paul. At the moment, it is anticipated that a minimum of 11 people will disembark at St. Paul and 10 will embark in their place. It is also anticipated that 2 additional people will disembark at St. Lawrence. Additional people (press, local community members, teachers) may also need to embark or disembark at mid-cruise. These needs will be identified.

Ashjian and the Captain, XO, or Ops have been invited to visit Gambell by Merlin Koonooka to discuss the science of the cruise with the whalers. If our scheduled closest approach to Gambell does not coincide with whaling, we will make this trip. We will coordinate this with Merlin Koonooka during the cruise. One-two people may disembark (see preceeding paragraph) at St. Lawrence Island.

The helicopter may be used to search for the floating sediment traps deployed by the Moran group (Kelly contact). See sediment trap section.

The helicopter also may be used by the ship for ice reconnaissance. It is anticipated that this will be a particularly heavy ice year, based on conditions now and the ongoing La Niña event.

6) Ice Station Detailed Operational Plan

Teams Working on the Ice
Gradinger (2-3 people)
Rember (2 people)
Shull (2 people)
PMEL (2 people)
Lessard/Harvey (1-2 people)
Media (1-2 people; will join one of the teams and not work alone)
Sambrotto (1-2 people)
Prokopenko (1 person)

Number of off-ship ice coring sorties (ice stations)
(1) At least10 stations; each with a mean time of 6 hours on the ice, depending on ice conditions (snow and ice thickness, dimensions of the ice floe, weather) and progress of work. Stations can be conducted *mainly in parallel* to the water column and benthic stations.
(2) Recovery of sediment traps by helicopter 12-24 hours after each ice station.

Operational procedure of typical ice station:

(1) PMEL team notified of arrival at ice station 1 hour prior to arrival.

(2) Selection of ice floe to be sampled
R. Gradinger and R. Rember will be notified 40 min prior to arrival at selected position. Gradinger and Rember select together with ship officers a suitable ice floe for the sea ice

research. Shull, Sambrotto, PMEL, and Lessard/Harvey teams will sample ice floes selected by Gradinger.

Ashjian will resolve disputes regarding location (of course, there will be no disputes).

(2) Safety briefing
Prior to be deployment on ice a safety briefing will be held on the bridge for final approval by the ship's command. A polar bear watch will be identified by the CG. All science teams will attend.

(3) Transfer of equipment and personnel
- *Personnel:*
Gradinger Team: At each station 2-3 people will be transferred to the ice at the start and end of the station (typically 6 hrs duration).
Rember Team: 2 people to the ice for ~ 2 hours.
Shull Team: 2 people on ice for ~ 6 hours, depending on the CTD and multicore sampling schedule.
PMEL Team: 2-3 people on the ice for ~4 hours
Lessard/Harvey Team: 1-2 people for ~1-2 hours at some point during Gradinger's time on the ice (Lessard/Harvey will join the Gradinger team for their sampling)
Sambrotto Team: At each station 1-2 people will be transferred to the ice at the start and end of the station (typically 6 hrs duration).
Prokopenko: 1 person on ice for 1-2 hours

- *Access to ice during ongoing work:*
To allow intermediate sample transfer, access to the ship by crane/basket needs to be available at any time, also for safety reasons.

- *Equipment and samples*:
At each station the following pieces of equipment would have to be hauled to the ice and back:

Gradinger Team:
- 1 ice corer (4 ft long, 20 lbs), 1 ice auger (4 ft long, 20 lbs), coring equipment (3 boxes 3x2x2 ft, 60 lbs each), electric generator (3x2x2 ft, 80 lbs)
- 2 boxes (3x2x2) containing biological sampling and measuring devices, (ca 15 lbs each)
- 1 box with video equipment, camera, monitor etc. (ca. 30 lbs)
- 2 10-gallon containers for samples (100 lbs full each on way back to ship)
- 3 coolers (4x2x3 ft, 70 lbs full), 1 sample box (2x2x2 ft, 30 lbs full)
- 3 sleds
- 2 sediment traps with floatation and mounting equipment (4x3x2 ft, 10lbs)

Rember Team:
-1 ice corer (20 lbs)
-1 cooler for sample collection (20 lbs full)
-1 cooler with battery (50 lbs)

At some stations we may collect water and will require:
-1 ice auger (10 lbs)
-1 box with inverter, pump, tubing and sample bottles (40 lbs)

Shull Team:
- 1 crate containing a mini ROV with oxygen microprofiling adapter, control box, light meter, picoammeter, and 100m cables (about 40 lbs).
- 1 ROV control box (in pelican case, 25 lbs.)
- 1 marine battery with transformer for powering ROV in a case (about 40 lbs.)

PMEL Team:
-Red box (4x0.5x0.5 ft, ~30 lbs) containing: ice corer, core sun shade, meter stick
-White box (2x2x1 ft, ~20 lbs) containing: gasoline engine for ice corer
-Blue equipment bag (4x1x1 ft, ~25 lbs) containing: ice auger, ski poles, slurp gun, water-sampling bottle, ice screws, rope, ice cutting board, radiometer stand, electric drill, etc.
-Orange Pelican box (~20 lbs) containing: GPS, compass, camera, ice-thickness gauge, ice saw, air and water PAR sensors, Zip-Loc bags, thermometer, drill bits, log sheets
-2 coolers (4x2x3 ft, 30 lbs full)
-2 sleds (brought by PMEL)

Lessard/Harvey Team:
- 3 coolers (4x2x3 ft) for ice, krill and water samples (ca 80 lbs. on return trip)
- 2 boxes (2x3x2) of biological sampling devices (small nets, slurp gun, bags, containers) ca 20 lbs.
- 2 10L containers for water (ca. 45 lbs on return trip)

Sambrotto Team:
- 1 box with 8 - 2.4 L bottles (20 lbs.)
- 1 spool of 3/8" cable with weight (30 lbs.)
- 2 floats (5 lbs)
- 10 L carboys; plasticware (10 lbs.)

Prokopenko Team:
- 1 box with car battery and power inverter (50 lbs)
- 1 box peristaltic pump + computer + tubing (15-20 lbs)
- 1 box with glass bottles + optode (< 5 lbs)
- 1 box with Winkler reagents (< 5 lbs)

(4) Work on ice

Gradinger Team:
The progression of a typical ice station is as follows:
a) select final sampling location on ice
b) take two ice cores
c) deploy primary productivity incubation (for four hours)

d) deploy sediment traps (about 50m from sampling site) – no other sampling can take place close to the trap, - if floe is very small than they will be deployed at the very end of the station.
e) collect water and ice samples
f) make snow measurement transect (200x200m around the sampling area

After completion of all sampling, walk to second and a third sampling site on same ice floe (if of sufficient size) and repeat e and f).

After completion of three sampling sites (total time demand about four hours) return to site 1 and recover primary productivity incubation. Take ice cores for other working groups interested in ice samples – return to ship.

Rember Team:
Select ice sampling location in conjunction with other researchers. We will require that other researchers maintain some distance (50-100 ft) from our sampling sight so that we can maintain a somewhat cleaner environment. Others may use our locations for snow sampling etc once we have completed our sampling.
We will likely take 5 ice cores from each station.
If we collect water then we drill an auger hole and pump water into bottles from varying depths.
We are available to collected cores and water once our work is completed at most stations.

Shull Team:
a) select final sampling location on ice based on Gradinger's assessment
b) create opening for ROV (with help from Gradinger group)
c) calibrate microelectrode probe with water from station (compare to optode)
d) fly ROV under ice for O2-profile measurements and PAR measurements at several stations (about 2 hours)
e) fly video/PAR transects under ice (about one hour)
After completion of all sampling, and if time remains, walk to second or a third sampling site on same ice floe (if of sufficient size) and repeat d and e).
After completion of sampling (about four hours) return to ship.

PMEL Team:

a. select final sampling location on ice
b. observe ice conditions and snow depth
c. drill chlorophyll core, characterize, photograph, measure ice thickness, sample in 10 cm increments, measure PAR above and below ice
d. auger sequence of brine holes 20, 40, … cm deep,
e. drill salinity/nutrient core, characterize, photograph, measure ice thickness, sample in 10 cm increments
f. drill temperature/productivity core, characterize, photograph, measure ice thickness, measure temperature at 5, 15, … cm depth, sample in 10 cm increments, measure PAR above and below ice

g. sample brine holes
h. drill a fourth core if requested by other investigators

After completion of all sampling, walk to a second sampling site on same ice floe (if of sufficient size) and repeat (b) to (h).
After completion of two sampling sites (total time demand about four hours) drill other cores if requested by other parties. Return to ship.

Lessard/Harvey Team:
a) At sample location designated by Gradinger, take 1-3 ice cores, depending on biomass. Sample the bottom section of ice cores.
b) Take water samples
c) Take net tows
d) Return to ship
Work will be conducted in consultation with Gradinger.

Sambrotto Team:
The progression of a typical ice station will follow that of the Gradinger team. We will sample at the locations selected at an appropriate distance from other sampling activities.
a) create ice hole with help from the Gradinger team.
b) deploy nitrogen productivity incubation (for four hours)
c) collect water and ice samples

Prokopenko Team (will work with PMEL team):
1) Get an auger hole drilled into the ice (will use auger from PMEL team)
2) Lower the optode into the hole
3) Observe [O2] for 10-15 minutes
4) Lower the tubing into the hole and pump for brine samples for 45 minutes

(4) Use of helicopter for ice access

Gradinger Team:
A helicopter is requested for recovery of ice sediment traps. Dale Chayes still needs to provide information regarding locating the ice floes after 12 to 24 hours.
Also we would like to use helicopters for short time ice sampling (<1h) to collect ice samples while the ship is underway if approved by chief scientist.

PMEL Team:
Some *ad hoc* experiments may be devised and left behind on the sea ice for 12 to 24 hours and retrieved via helicopter. Loads will be the size of 1 or 2 ice chests.

(5) Additional requests for support from ship

(a) Equipment

Gradinger:

- radio communication (hand-helds) for communication with ship (2 radios on the ice)
- 3 larger sleds for transport of equipment on the ice) – had been available on the Healy in 2002, 2004 and 2005.
Shull: Request the use of a Healy sled for moving equipment on the ice (if available).
PMEL Team: as per Gradinger. PMEL group has own hand-held radio.
Lessard/Harvey: Same equipment as Gradinger.
Sambrotto: radio communication (hand-helds) for communication with ship (1 radio on the ice).

(b) Polar bear watch
As we are limited in the number of personnel in our team, we would require polar bear protection support from the ship. Ideally, this would consist of one additional person on the ice and a person on the bridge responsible for scanning the vicinity of the ship for polar bears and communication with the ice team.

Other Operational Considerations

We will be working near four NOAA moorings. The positions are listed below. Note that there are additional moorings within 1 nm of NOAA mooring M2.

Bering Sea 2 (M2) 56.877°N, 164.057°W, 73m water depth. There are some other moorings nearby, within 1 nm
Bering Sea 4 (M4) 57.853°N, 168.870, 71m water depth
Bering Sea 5 (M5) 59.898°N, 171.711°W, 72m water depth
Bering Sea 8 (M8) 62.194°N, 174.668°W, 73m water depth

Appendix F: Twelve Days of Healy

The Twelve days of Healy.

On the first day of the Healy cruise, my Chief Scientist gave to me,
a sediment trap deployment.

On the second day of the Healy cruise, my Chief Scientist gave to me,
2 cut loops on the trap line,
and a sediment trap deployment.

On the third day of the Healy cruise, my Chief Scientist gave to me,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the fourth day of the Healy cruise, my Chief Scientist gave to me,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the fifth day of the Healy cruise, my Chief Scientist gave to me,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the sixth day of the Healy cruise, my Chief Scientist gave to me,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the seventh day of the Healy cruise, my Chief Scientist gave to me,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the eighth day of the Healy cruise, my Chief Scientist gave to me,
8 overflowing incubators,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the ninth day of the Healy cruise, my Chief Scientist gave to me,
9 night time pages,
8 overflowing incubators,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the tenth day of the Healy cruise, my Chief Scientist gave to me,
10 unanswered alarm clocks,
9 night time pages,
8 overflowing incubators,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the eleventh day of the Healy cruise, my Chief Scientist gave to me,
11 presses of the snooze button,
10 unanswered alarm clocks,
9 night time pages,
8 overflowing incubators,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

On the twelfth day of the Healy cruise, my Chief Scientist gave to me,
12 all night shifts,
11 presses of the snooze button,
10 unanswered alarm clocks,
9 night time pages,
8 overflowing incubators,
7 frozen outflow hoses,
6 frozen inflow hoses,
5 flooded decks,
4 hours in a small boat,
3 refrigerator breakdowns,
2 cut loops on the trap line,
and a sediment trap deployment.

Appendix G: Bo-Healy-an Rhapsody

(to the tune of Bohemian Rhapsody)

Is this the North Sea,
Or is it the Bering Sea?
Caught in an ice floe
No escape from the Healy
Open your eyes
Long along the ice and see...
I'm just a poor tech, I need your sympathy
Put the A-frame in, A-frame out,
Winch it up, winch it down.
Any way the Healy goes, doesn't really matter to me...
To me.

Mama, just killed a krill
Put a scalpel to his head
Took his eyeballs now he's dead.
Mama, my HPLC had just begun
But now the valve has gone and drained it all away.
Mama, oooo
Deployed my sediment traps
If they're not back again this time tomorrow,
Carry on, carry on.
It's not as if they mattered.

Too late, the cold has come.
Ice clogging up the drain,
Hoses freezing all the time.
Goodbye, incubator. You've got to go!
Gotta defrost you first and try again.
Mama, oooo
I don't want to freeze,
I sometimes wish I'd rigged the hoses right.

I see a multi-corer on the deck!
Aft con – Bridge, Aft con – Bridge, will you get the speed right?
Bongo nets are winching, very very frightening me.
In the water (In the water)
In the water (In the water)
In the water, there they go, magnifico

I'm just a poor tech, nobody loves me
He's just a poor tech from a poor PI

Spare him his life from his low budget gear!

Now the heads are secure, we won't let you go!
But what the? No! I really want to go! (Let me go!)
But what the? No! I really want to go! (Let me go!)
But what the? No! I really want to go! (Let me go!)
We will not let you go! (Let me go!)
We will not let you go! (Let me go!)

No, no, no, no, no, no!
Oh my captain (oh my captain),
Oh my captain let me go!
Carin Ashjian has a net tow put aside for me, for me, for meeeeeee!!

<Insert head banging guitar solo here...>

So you think you can freeze me and my seawater line?
So you think that the mess deck is a good place to dine?
Oh, baby! Mesozooplankton, baby!
Just gotta get back, just gotta get right back to Dutch.

Nothing really matters,
Anyone can see...
Science doesn't matter,
Science doesn't matter to me.

Any way the Healy goes.